ETI

ELECTRONICS TODAY INTERNATIONAL

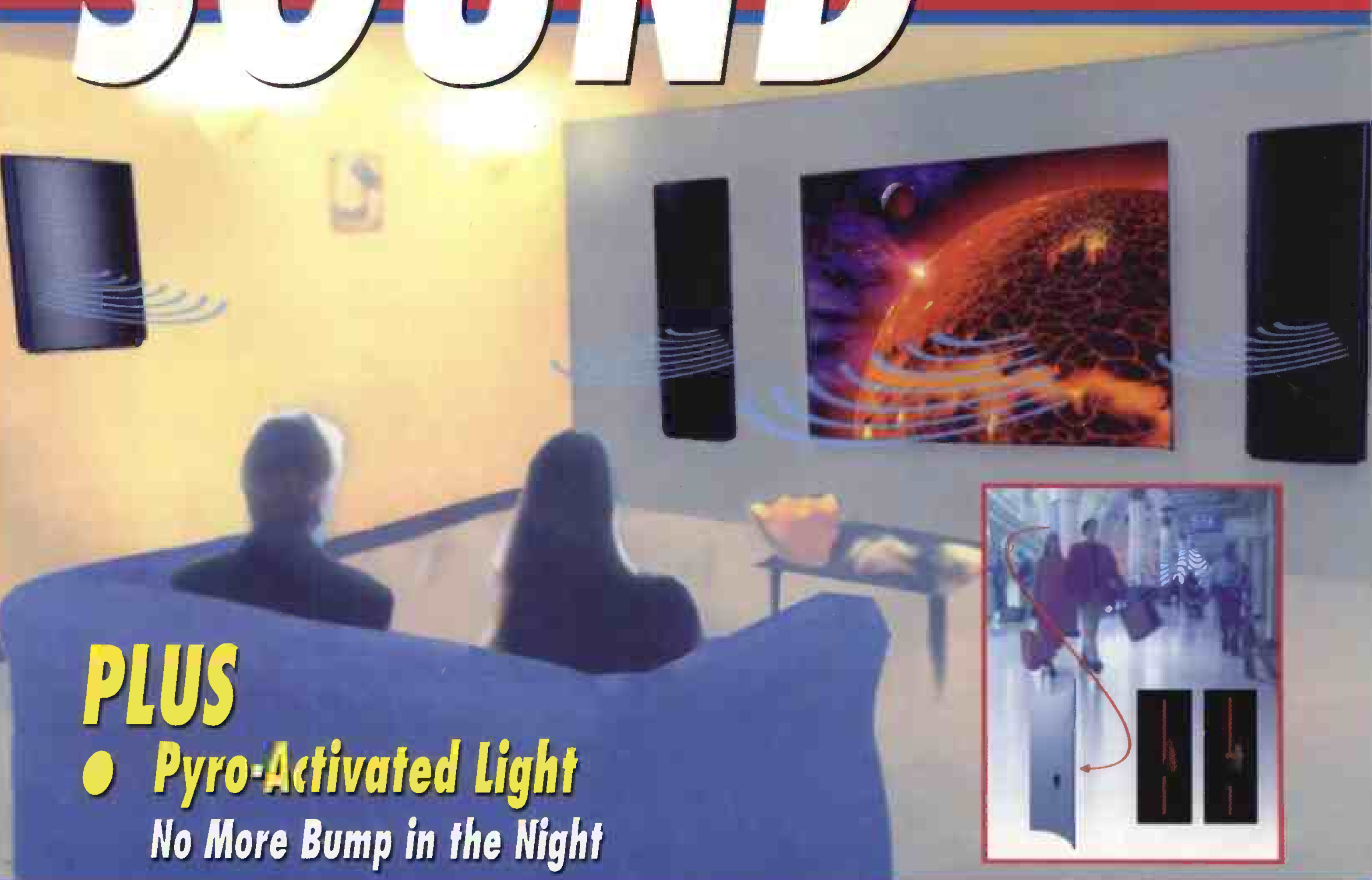
WIN Two Tickets for the Air Tattoo
See Page 47

VIRTUAL pH METER
For PC computers

PIC PROGRAMMER REVISITED
More features, easier to operate

WALL OF SOUND

THE NEW LOUDSPEAKERS WILL BE HEARD AND NOT SEEN



PLUS

- **Pyro-Activated Light**
  No More Bump in the Night
- **Light-powered Continuity Quick-Tester**
- **Handy Moisture Meter**

VOLUME 26 No. 6 £2.35 USA $4.95

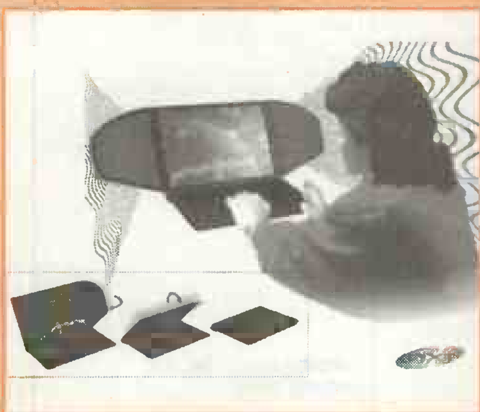
FOR ENTHUSIASTS BY ENTHUSIASTS NEXUS

Contents

Volume 26 No.6

& Features Projects

Next Issue 20th June 1997



Regulars

DIGITAL MULTIMETERS

CM2300 DIGITAL MULTIMETER

FEATURES:
- 3.5 LCD DISPLAY
- HEIGHT 12mm
- MAX READING 1999
- HV INDICATION FOR HIGH VOLTAGE
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- ALL RANGES OVERLOAD PROTECTED
- 10A DC CURRENT TEST,
- DC VOLTAGE 2V/20V/200V/500V,
- AC VOLTAGE 200/500V
- DC CURRENT 200mA,
- RESISTANCE 2kΩ /20kΩ /200kΩ /2MΩ
- SUPPLIED WITH TEST PROBES

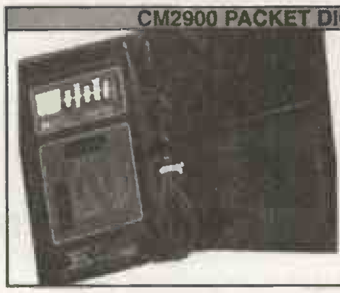
ORDER CODE: CM2300
PRICE: 975p

CM2400T DIGITAL MULTIMETER WITH TEMP MEASUREMENT

FEATURES:
- 3.5LCD DISPLAY
- HEIGHT 12mm
- MAXIMUM READING 1999
- 10A DC CURRENT TEST
- DC VOLTAGE 200mV/2V/20V/200V/1000V
- AC VOLATE 200/750V,
- DC CURRENT 0.2mA/200mA/20mA/200mA/20A
- RESISTANCE 200Ω /2KΩ /20KΩ /200KΩ /2MΩ
- SUPPLIED WITH TEST PROBES
- TEMPERATURE MEASUREMENT
- CONTINUITY TEST
- DIODE TEST & CONTINUITY CHECK
- ALL RANGES OVERLOAD PROTECTED

ORDER CODE: CM2400T
PRICE: 1450p

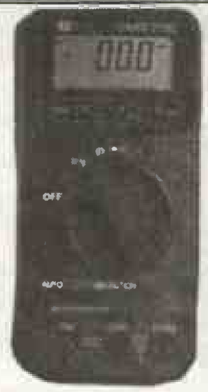
CM2900 PACKET DIGITAL MULTIMETER



FEATURES:
- 3.5 LCD DISPLAY
- COMPACT AND LIGHTWEIGHT POCKET SIZE
- MAXIMUM READING 1999
- DC CURRENT 7 RESISTANCE OVERLOAD PROTECTED
- SLIDE SWITCHES FOR FUNCTION AND RANGE OPERATION
- SUPPLIED IN WALLET WITH TEST PROBES
- DC VOLTAGE 2V/20V/200V/500V
- AC VOLTAGE 200V/500V
- DC CURRENT 200mA
- RESISTANCE 2KΩ /20KΩ /200KΩ /2MΩ

ORDER CODE: CM2900
PRICE1150p

CM2700 AUTORANGING DIGITAL MULTIMETER



FEATURES:
- 3.75 LCD DISPLAY WITH DECIMAL POINT
- 33 SEGMENT BARGRAPH DISPLAY
- OVERRANGE INDICATION
- ROTARY SWITCH FOR FUNCTION SELECTION
- AUTO POWER OFF (APPROX 15 mins)
- AUTO POLARITY WITH INDICATION
- DIODE TEST & CONTINUITY TEST WITH BUZZER
- ALL RANGES OVERLOAD PROTECTED
- LOW BATTERY INDICATION
- SUPPLIED WITH TEST PROBES
- DC VOLTAGE: 320mV/3.2V/32V/320V/600V
- AC VOLTAGE: 320mV/3.2V/32V/320V600V
- DC CURRENT A: 320μA/3200μA/32mA/320mA/10A
- AC CURRENT A: 320μA/3200μA/32mA/320mA/10A
- RESISTANCE: 320Ω/3.2KΩ/32KΩ/320KΩ/3.2MΩ/32MΩ

ORDER CODE: CM2700
PRICE: 4050p

CM3230 DIGITAL CAPACITANCE METER

FEATURES:
- 3.5 LCD DISPLAY
- HEIGHT 18mm
- MAXIMUM READING 1999
- CAPACITANCE 9 RANGES FROM 200pF-20000μF
- MEASURING FROM 1pF - 20000μF
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- ZERO ADJUST KNOB

ORDER CODE: CM3230
PRICE: 3950p

CM3900A DIGITAL MULTIMETER

FEATURES:
- LARGE LCD DISPLAY
- HEIGHT 18mm
- MASIMUM READING 1999 + UNIT
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- AUTO POWER OFF (APPROX 15 min)
- DIODE TEST FUNCTION
- ALL RANGES OVERLOAD PROTECTED
- SUPPLIED WITH TEST PROBES
- DC VOLTAGE: 200mV/2V/20V/200V 700V ACCURACY ±0.5%
- AC VOLTAGE: 200mV/2V/20V/200V/700V
- DC CURRENT A: 200μA/20mA/200mA/2A/20A
- AC CURRENT A: 200μA/20mA/200mA/2A/20A
- RESISTANCE : 200Ω/2kΩ/200kΩ/2MΩ/20MΩ/200MΩ

ORDER CODE: CM3900A
PRICE: 2900p

CM3920 DIGITALMETER WITH TEMP MEASUREMENT

FEATURES:
- TEMPERATURE MEASUREMENT
- DIODE & TRANSISTOR HFE TEST
- LARGE LCD DISPLAY
- HEIGHT 18mm
- MAXIMUM READING 1999 + UNIT
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- AUTO POWER OFF (APPROX 15 mins)
- DIODE TESWT FUNCTION
- ALL RANGES OVERLOAD PROTECTED
- SUPPLIED WITH TEST PROBES
- DC VOLTAGE: 200mV/2V/20V/200V/1000V ACCURACY ±0.5%
- AC VOLTAGE: 200mV/2V/20V/200V/700V
- DC CURRENT 2mA/20mA/200mA/20A
- AC CURRENT A: 200mA/20A
- RESISTANCE : 200Ω/2KΩ/200kΩ/2MΩ/20MΩ/200MΩ
- CAPACITANCE: 2nF/20nF/200nF/2μF/20μF

ORDER CODE: CM3920
PRICE: 4100p

8 Way Preprogrammed Universal Remote Control

A single remote control to operate Television, Videos and Satellite Receivers. Plus Auxilary Options!!

- Replaces up to 8 remotes with one
- Simple 4 digit setup routine
- Controls 1000's of models
- Teletext functions with Fastext
- Clear (large key) layout
- Code Search Facility
- Stylish and easy to operate
- Replace broken or lost remotes
- Original Remote note required

Order Code: 8 WAY
Price: 1450P + VAT

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PLEASE PHONE US FOR TYPE NOT LISTED HERE AS WE ARE HOLDING 30,000 ITEMS AND QUOTATIONS ARE GIVEN FOR LARGE QUANTITIES

Please send £1 P&P and VAT at 17.5%. Govt, Colleges, etc. Orders accepted. Please allow 7 days for delivery. Prices quoted are subject to stock availability and may be changed without notice.
TV and video parts sold are replacement parts.
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WE STOCK TV AND VIDEO SPARES, JAPANESE TRANSISTORS AND TDA SERIES. PLEASE RING US FOR FURTHER INFORMATION.

SATELLITE POWER SUPPLY REPAIR KITS

ALBA	CODE
SAT660	SATPSU2

AMSTRAD	CODE
SRD510, SRD520, SRD540, SRD550	SATPSU3
SRDR45	
SRD500	SATPSU4
SRX320, SRX340, SRX345, SRX350	SATPSU5
SRX100	SATPSU6
SRD600	SATPSU14
SAT250, SR950, SRD700, SRD950, SRX1002, SRX2001, SRX301, SRX501, SRX502	SATPSU16
SRD2000	SATPSU18

BRITISH TELECOM	CODE
SVS300	SATPSU17

BUSH	CODE
IRD150	SATPSU12
IRD155	SATPSU19

CHURCHILL	CODE
D3MAC DECODER	SATPSU7

ECHOSTAR	CODE
SR5500 EARLY PSU WITH ADJ	SATPSU12
6500, SR7700, SR8700	SATPSU13

FERGUSON	CODE
SRD 5, SRD16	SATPSU1
SRV1	SATPSU2
SRDE4	SATPSU11

FINLUX	CODE
SR5700	SATPSU12

GOODMANS	CODE
ST700	SATPSU1

GRUNDIG	CODE
STR1	SATPSU1
GIRD200, FIRD3000	SATPSU2

MANHATTAN	CODE
850, 950	SATPSU1

MASPRO	CODE
SRE250S/1, SRE350S/1	SATPSU1
SRE250S, SRE350S, SRE450S	SATPSU2

MIMTEC	CODE
SOPRENSON TYPE PSU ONLY	SATPSU15

NETWORK	CODE
9000, 9200	SATPSU2

NOKIA	CODE
SAT1500	SATPSU2

PACE	CODE
PRD800, PRD900, PSR800, PSR900	SATPSU1
MRD920, SS9000, SS9010, SS9200, SS9210, SS9220	SATPSU2
D100, D150,	SATPSU6
MSS100	SATPSU8
APOLLO, MSS200, MSS300	SATPSU9
MSS500, MSS1000	SATPSU10

PHILIPS	CODE
STU802/05M	SATPSU1
STU801	SATPSU2

THOMSON	CODE
SRS4	SATPSU2

TOSHIBA	CODE
SAT99, TU-SDU200	SATPSU1

CODE	PRICE	CODE	PRICE	CODE	PRICE	CODE	PRICE
SATPSU1	650p	SATPSU6	650p	SATPSU11	835p	SATPSU16	730p
SATPSU2	650p	SATPSU7	650p	SATPSU12	1735p	SATPSU17	850p
SATPSU3	650p	SATPSU8	730p	SATPSU13	3125p	SATPSU18	1175p
SATPSU4	650p	SATPSU9	900p	SATPSU14	3135p	SATPSU19	650p
SATPSU5	650p	SATPSU10	1230p	SATPSU15	77.5p		

PACE SATELLITE TUNERS

MODELS	CODE	PRICE
PRD800, MSS200 (2GHZ) (221-2077062)	TUNER01	1650p
PRD900, MSS500, MSS1000 (2Ghz) (221-2177012)	TUNER02	1650p

PACE SWITCH MODE TRANSFORMERS

MODELS	CODE	PRICE
PACE9000	PACE9000	800p
PACEPRD800, PRD900	PRD800	550p

SATMETER

THE SATMETER IS A PROFESSIONAL PORTABLE SATELLITE STRNGTH METER DESIGNED FOR THE INSTALLATION AND MAINTENANCE OF SATELLITE TV SYSTEMS. THE SATMETER CAN BE USED AS STAND ALONE METER WITH POWERING THE LNB AS WELL AS IN LOOP. THROUGH OPERATION WITH SATELLITE RX POWERING THE LNB.

ACOUSTICAL SIGNAL: ON SIGNAL STRENGTH
INPUT IMPEDENENCE: 75 Ohm
MAX.INPUT SIGNAL: -10 DBM

LED INDICATOR: VERTICAL/HORIZONTAL
POWER AMPLIFIER: 18 DB

FREQUENCY RANGE: 900 TO 2050 MHZ
DETECTION RANGE: -60 TO -10 DBM

ORDER CODE: TOOL 22 PRICE: 8500p

SATELLITE LNB'S

MAKE & MODEL	ORDER CODE	PRICE
Cambridge AE22/AE5 0.8dB standard 10.95-ll.70 GHz Gold Range	LNB1	2160p
Cambridge AE14 Universal LNB 10.7-11.7/11.7-12.75 GHz	LNB2	2500p
Cambridge AE21/AE5 Single O/P Switching LNB 1.0dB Standard	LNB3	2050p
Cambridge AE19/AE6 Single O/P Switching LNB 1.0dB Enhanced	LNB4	2050p
Cambridge AE23/AE12 0.8dB Enhanced 10.7-11.8GHz Gold Range	LNB5	2160p
Cambridge AE8 Dual O/P H-V Separate Enhanced	LNB6	4000p
Cambridge AE7 Twin O/P H+V Both Enhanced	LNB7	4000p
Cambridge AE2 Dual O/P H-V Separate Enhanced	LNB8	3550p
Grundig Super Universal 'Anis' 10.7-12.75 GHz 0.8dB	LNB9	2600p
Grundig Universal 'Anis' 10.7-12.75 GHz 1.0dB	LNB10	2250p
Cambridge AE1 Twin O/P H+V Both Standard	LNB11	4000p

FUSES

	TIME LAG (20MM)		QUICK BLOW (20MM)	
CURRENT RATING	ORDER CODE	PRICE	ORDER CODE	PRICE
100mA	FUSE36	75p	FUSE37	60P
160mA	FUSE01	75p	FUSE17	60p
250mA	FUSE02	75p	FUSE18	60p
315mA	FUSE03	75p	FUSE19	60p
400mA	FUSE04	75p	FUSE20	60p
500mA	FUSE05	75p	FUSE21	60p
630mA	FUSE06	75p	FUSE22	60p
800mA	FUSE07	60p	FUSE23	60p
IA	FUSE08	60p	FUSE24	60p
1.25A	FUSE09	60p	FUSE25	60p
1.6A	FUSE10	60p	FUSE26	60p
2A	FUSE11	50p	FUSE27	60p
2.5A	FUSE12	50p	FUSE28	60p
3.15A	FUSE13	55p	FUSE29	50p
4A	FUSE14	55p	FUSE30	50p
5A	FUSE15	60p	FUSE31	50p
6.3A	FUSE16	60p	FUSE32	50p

NB.
ALL FUSES ARE MADE IN THE UK AND FULLY MEET BS4265 & BS1362 SAFETY STANDARDS AND SHOULD NOT BE COMPARED WITH CHEAP IMPORTED TYPES.

CERAMIC PLUG TOP

CURRENT RATING	ORDER CODE	PRICE
3A	FUSE33	100p
5A	FUSE34	100p
13A	FUSE35	100p

20mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
6.3A	FUSE38	100p
8A	FUSE39	100p
10A	FUSE40	100p
3.15A	FUSE41	85p
4A	FUSE42	85p
5A	FUSE43	85p

38mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
10A	FUSE48	815P

32mm CERAMIC SLOW BLOW

CURRENT RATING	ORDER CODE	PRICE
8A	FUSE44	185P
10A	FUSE45	185p
15A	FUSE46	185p
20A	FUSE47	210p

****ALL THE ABOVE PRICES ARE FOR PACKS OF 10 FUSES****

TRANSISTORS

PART	PRICE
AC125	30P
AC126	30P
AC127	30P
AC128K	40P
AC141K	45P
AC176	22P
ACY18	48P
ACY19	48p
AD149	60P
AF125	50P
AF139	30P
BC107	8P
BC108	8P
BC109	8P
BC109C	10P
BC140	20P
BC142	20P
BC143	20P
BC147	8P
BC149	8P
BC159	8p
BC160	30P
BC171	10P
BC172	10P
BC177	14P
BC178	14P
BC179	14P
BC182	7P
BC182L	7P
BC183	7P
BC183L	7P
BC184	7P
BC184L	7P
BC212	7P
BC212L	7P
BC213	7P
BC213L	7P
BC214	7P
BC214L	7P
BC237	7P
BC238	7P
BC239	7P
BC300	20P
BC301	20P
BC302	20P
BC303	20P
BC304	25P
BC327	7P
BC328	7P
BC337	7P
BC338	7P
BC441	28P
BC446	8P
BC477	18P
BC516	22P
BC537	25P
BC546	8P
BC547	8P
BC548	8P
BC549	8p
BC550	8P
BC556	8P
BC557	7P
BC558	8P
BC559	8P
BC560	8P
BC637	20P
BC639	20P
BC640	20P
BCY33	200P
BCY34	200P
BCY70	16P
BCY71	16P
BCY72	16P
BD115	30P
BD124P	50P
BD131	25P
BD132	25P
BD133	50P
BD135	20P
BD136	20P
BD137	20P
BD138	20P
BD139	20P
BD140	20P
BD144	90P
BD157	38P
BD166	30P
BD175	30P
BD177	30P
BD179	32P
BD181	45P
BD182	60P
BD184	60P
BD187	30P
BD201	33P
BD202	38P
BD203	42P
BD204	42P
BD222	31P
BD225	31P
BD232	31P
BD233	30P
BD234	32P
BD235	28P
BD236	30P
BD237	21P
BD238	24P
BD239	30P
BD240	40P
BD241A	40P
BD243A	50P
BD244	50P
BD245	50P
BD246A	50P
BD265	45P
BD267	45P
BD269	45P
BD278	50P
BD311	100P
BD314	100P
BD315	150P
BD317	150P
BD331	40P
BD332	40P
BD361	60P
BD362	60P
BD370	30P
BD371	30P
BD410	50P
BD433	28P
BD434	30P
BD435	31P
BD436	30P
BD437	28P
BD438	36P
BD439	40P
BD440	40P
BD441	40P
BD533	50P
BD534	38P
BD535	38P
BD536	38P
BD537	40P
BD538	40P
BD643	50P
BD645	50P

PART	PRICE
BD647	50P
BD649	50P
BD675	40P
BD676	40P
BD677	38P
BD678	40P
BD679	40P
BD680	40P
BD681	45P
BD682	45P
BD705	50P
BD707	50P
BD709	50P
BD711	50P
BD736	50P
BD826	50P
BD828	50P
BD839	55P
BD897	50P
BD899	50P
BD977	50P
BDX33	60P
BDX37	100P
BDX44	100P
BDX47	75P
BDX54C	75P
BDX62C	150P
BDX63C	175P
BDX64C	175P
BDX65	80P
BDX66C	175P
BDX67C	275P
BDX71	70P
BDX77	175P
BDX87C	175P
BDX88C	150P
BDW24	55P
BDW93	50P
BDW94	50P
BDY29	225P
BDY56	225P
BDY58	500P
BDY90	125P
BDY92	100P
BF137	35P
BF187	30P
BF181	18P
BF183	20P
BF195	7P
BF199	8P
BF200	16P
BF225	30P
BF240	16P
BF245	25P
BF254	15P
BF255	12P
BF256	18P
BF257	18P
BF259	18P
BF262	25P
BF270	18P
BF273	15P
BF311	21P
BF336	20P
BF337	20P
BF338	20P
BF362	30P
BF367	13P
BF371	17P
BF421	18P
BF422	21P
BF423	25P
BF455	12P
BF458	19P
BF462	50P
BF471	28P
BF472	28P
BF479	30P
BF494	16P
BF495	16P
BF595	16P
BF596	16P
BF615	30P
BF617	30P
BF760	40P
BF763	40P
BF870	22P
BF871	22P
BF960	38P
BF961	35P
BF964	38P
BFQ232	75P
BFQ252A	60P
BFR90	85P
BFR91	99P
BFT43	30P
BFX29	20P
BFX84	20P
BFX85	20P
BFX87	15P
BFX88	15P
BFX89	60P
BFY50	14P
BFY51	24P
BFY52	14P
BFY56	25P
BFY64	25P
BFY90	45P
BLY48	85P
BR100	14P
BR103	37P
BR303	85P
BSX20	15P
BU105	80P
BU108	100P
BU109	80P
BU110	90P
BU111	100P
BU124	60P
BU125	100P
BU126	65P
BU128	125P
BU133	125P
BU137	150P
BU180	100P
BU184	100P
BU204	65P
BU205	70P
BU206	100P
BU207	150P
BU208	70P
BU208A	75P
BU208AT	200P
BU208B	200P
BU208D	130P
BU209	90P
BU225	120P
BU226	120P
BU312	90P
BU325	55P
BU326A	75P
BU406	60P
BU406D	85P
BU407	55P
BU407D	75P
BU408	60P
BU408D	75P

PART	PRICE
BU409	85P
BU412	175P
BU413	175P
BU414B	250P
BU415A	170P
BU426A	70P
BU433	120P
BU500	100P
BU500D	225P
BU505	90P
BU505D	90P
BU505DF	90P
BU506	100P
BU506D	70P
BU506DF	120P
BU508A	70P
BU508AF	95P
BU508APH	80P
BU508D	90P
BU508DF	115P
BU508DR	130P
BU508V	110P
BU508VF	100P
BU526	75P
BU536	100P
BU546	125P
BU603	125P
BU606D	225P
BU608D	120P
BU626	120P
BU705	130P
BU706DF	175P
BU706F	150P
BU724A	100P
BU801	70P
BU806	70P
BU807	60P
BU807F	75P
BU808DF	300P
BU810	110P
BU824	450P
BU826	120P
BU826A	160P
BU902	110P
BU903	110P
BU910	80P
BU912	100P
BU920	100P
BU922	110P
BU930	130P
BU932	175P
BU941	250P
BU2508A	130P
BU2508AF	130P
BU2508D	130P
BU2508DF	150P
BU2520AF	225P
BU2520DF	225P
BU2525A	325P
BU2525AF	325P
BU2527AF	400P
BUF405A	200P
BUH315	200P
BUH15D	250P
BUH515	200P
BUH515D	250P
BUH517	275P
BUH517D	175P
BUH715	425P
BUV93	375P
BUK444/ 500B	200P
BUK444/ 800B	200P
BUK445/ 600B	200P
BUK446/ 800B	400P
BUK455/ 600B	200P
BUK456/	200P
BUW81A	150P
BUR51	1900P
BUR52	1900P
BUS11A	200P
BUS12A	200P
BUS14A	500P
BUS23	225P
BUS48A	175P
BUT11A	55P
BUT11AF	55P
BUT12	80P
BUT13	310P
BUT18	80P
BUT18AF	80P
BUT30V	1700P
BUT56A	100P
BUT76A	80P
BUT90	1300P
BUT92	1200P
BUV18	650P
BUV20	650P
BUV21	400P
BUV23	475P
BUV24	350P
BUV25	110P
BUV26	150P
BUV27	125P
BUV28	110P
BUV37	175P
BUV46A	75P
BUV47	120P
BUV48A	175P
BUV48AF	325P
BUV48C	250P
BUV50	425P
BUV61	100P
BUV70	200P
BUV90	175P
BUZ30A	475P
BUW11A	200P
BUW1AF	225P
BUW12	125P
BUW12A	150P
BUW12F	250P
BUW13A	200P
BUW32A	500P
BUW48	550P
BUW49	550P
BUW50	400P
BUZ73AF	60P
BUW84	75P
BUW85	85P
BUX10	150P
BUX11	200P
BUX12	150P
BUX20	350P
BUX21	450P
BUX22	450P
BUX23	900P
BUX32	175P
BUX37	200P
BUX39	450P
BUX40	210P
BUX41	200P
BUX42	200P
BUX47A	200P

PART	PRICE
BUX48A	150P
BUX55	800P
BUX80	180P
BUX81	160P
BUX84	50P
BUX85	50P
BUX86	30P
BUX87	50P
BUX98A	350P
BUY18S	150P
BUY47	150P
BUY57	125P
BUY69A	200P
BUY71	250P
BUZ10	65P
BUZ11	200P
BUZ11A	175P
BUZ14	550P
BUZ20	225P
BUZ21	250P
BUZ24	350P
BUZ25	450P
BUZ32	125P
BUZ36	800P
BUZ44A	525P
BUZ45A	800P
BUZ50B	500P
BU53A	800P
BUZ71	75P
BUZ71AF	100P
BUZ72A	100P
BUZ72AF	100P
BUZ73A	150P
BUZ76A	110P
BUZ80	200P
BUZ80AF	200P
BUZ83	200P
BUZ90A	180P
BUZ91A	400P
BY448	20P
BYT11	25P
C106D	28P
CQY80	40P
IRF120	225P
IRF130	475P
IRF140	550P
IRF230	550P
IRF240	425P
IRF250	375P
IRF330	600P
IRF340	325P
IRF350	750P
IRF450	650P
IRF10	150P
IRF520	150P
IRF530	150P
IRF540	200P
IRF610	150P
IRF611	150P
IRF620	160P
IRF630	150P
IRF640	350P
IRF642	200P
IRF650	200P
IRF710	150P
IRF720	150P
IRF730	150P
IRF740	150P
IRF820	150P
IRF830	160P
IRF840	150P
IRF9140	1000P
IRF9510	150P
IRF9511	150P
IRF9520	150P
IRF9530	400P
IRF9531	200P
IRF9540	300P
IRF9541	200P
IRF9610	150P
IRF9620	150P
IRF9622	200P
IRF9630	325P
IRF9640	375P
IRFD9220	100P
IRFBC30	200P
IRFBC40	400P
IRFP140	250P
IRFP150	300P
IRFP240	300P
IRFP250	400P
IRFP350	325P
IRFP450	400P
IRFP460	775P
IRFP9140	1450P
IRFP9240	500P
IRFPC50	600P
IRFRC20	250P
IRFZ20	65P
IRFZ42	275P
IRFZ44	275P
MJ900	200P
MJ10001	200P
MJ1001	200P
MJ2501	100P
MJ2955	55P
MJ3000	100P
MJ3001	100P
MJ4032	175P
MJ4035	175P
MJ4502	300P
MJ10012	300P
MJ11015	250P
MJ11016	300P
MJ11032	800P
MJ11033	800P
MJ15003	250P
MJ15004	300P
MJ15015	250P
MJ15016	350P
MJ15022	250P
MJ15023	400P
MJ15024	400P
MJ15025	700P
MJE29A	30P
MJE30A	30P
MJE210	70P
MJE340	25P
MJE350	80P
MJE520	30P
MJE2955T	65P
MJE3055T	65P
MJE13004	100P
MJE13005	60P
MJE13007	100P
MJE13009	100P
MJE15028	200P
MJE15029	200P
MJE15030	250P
MJE15031	400P
MJE18004	125P
MJF18004	175P
MJF18204	350P
MPSA05	15P
MPSA06	15P
MPSA10	15P
MPSA13	15P

PART	PRICE
MPSA14	15P
MPSA20	15P
MPSA42	15P
MPSA43	15P
MPSA44	40P
MPSA55	12P
MPSA56	12P
MPSA70	15P
MPSA92	20P
MPSA93	20P
MPSU10	200P
MPSU45	550P
MPSU56	400P
MPSU60	350P
MR510	35P
MR856	36P
OC28	350P
OC29	250P
OC35	350P
OC36	250P
OC45	50P
OC200	180P
R2008B	100P
R2010B	100P
S2000A3	175P
S2000AF	175P
S2055A	175P
S2055AF	200P
S2530A	100P
S2800M	72P
TIP29	15P
TIP29A	22P
TIP29C	25P
TIP29E	40P
TIP30	25P
TIP30C	25P
TIP31A	22P
TIP31C	27P
TIP32	24P
TIP32A	21P
TIP32C	28P
TIP33	50P
TIP33C	60P
TIP34	65P
TIP34C	60P
TIP35C	65P
TIP36C	65P
TIP42A	20P
TIP41C	22P
TIP42A	20P
TIP42C	22P
TIP47	40P
TIP48	40P
TIP50	60P
TIP51	80P
TIP52	80P
TIP54	85P
TIP102	70P
TIP105	65P
TIP106	65P
TIP107	65P
TIP110	40P
TIP111	40P
TIP112	35P
TIP112H	50P
TIP115	30P
TIP116	30P
TIP117	30P
TIP120	37P
TIP121	35P
TIP122	30P
TIP125	30P
TIP126	40P
TIP127	35P
TIP130	30P
TIP131	30P
TIP132	30P
TIP136	40P
TIP137	65P
TIP162	110P
TIP141	65P
TIP143	75P
TIP145	50P
TIP146	70P
TIP147	80P
TIP150	90P
TIP151	60P
TIP2955	50P
TIP3055	50P
TIPL760	100P
TIPL762A	200P
TIPL763A	200P
TIPL791A	80P
TIS61	15P
TIS90	15P
TIS93	20P
ZTX107	11P
ZTX108	11P
ZTX109	12P
ZTX212	20P
ZTX300	10P
ZTX301	16P
ZTX302	10P
ZTX303	20P
ZTX304	10P
ZTX320	20P
ZTX501	13P
ZTX502	10P
ZTX503	18P
ZTX504	25P
2N696	26P
2N697	22P
2N698	40P
2N78	22P
2N914	28P
2N918	30P
2N930	18P
2N1131	28P
2N1132	28P
2N1304	350P
2N1305	225P
2N1613	24P
2N1711	24P
2N1893	30P
2N2102	50P
2N2218A	24P
2N2219	24P
2N2221	23P
2N2222	23P
2N2243	40P
2N2369	15P
2N2484	15P
2N2646	40P
2N2894	50P
2N2904	20P
2N2905	20P
2N2906	18P
2N2907	18P
2N3019	28P
2N3053	18P
2N3054	40P
2N3055	38P
2N3055H	50P
2N3439	40P
2N3440	45P
2N3441	175P
2N3442	85P

PART	PRICE
2N3553	100P
2N3585	650P
2N3702	9P
2N3703	9P
2N3704	9P
2N3705	9P
2N3706	9P
2N3707	9P
2N3710	12P
2N3711	12P
2N3771	85P
2N3772	90P
2N3773	100P
2N3792	150P
2N3799	18P
2N3819	29P
2N3820	70P
2N3823	40P
2N3866	110P
2N3903	11P
2N3906	11P
2N3924	375P
2N3958	375P
2N4031	25P
2N4033	25P
2N4036	29P
2N4220	175P
2N4347	130P
2N4391	60P
2N4392	50P
2N4393	55P
2N4399	200P
2N4401	12P
2N4403	12P
2N4416	120P
2N4420	75P
2N4427	75P
2N4920	50P
2N4922	30P
2N4923	30P
2N5038	175P
2N5061	20P
2N5088	20P
2N5109	100P
2N5116	175P
2N5154	150P
2N5160	600P
2N5179	40P
2N5192	50P
2N5241	500P
2N5245	45P
2N5294	30P
2N5296	30P
2N5320	50P
2N5322	55P
2N5401	10P
2N5416	40P
2N5448	12P
2N5457	45P
2N5458	55P
2N5460	55P
2N5461	75P
2N5462	45P
2N5484	55P
2N5551	12P
2N5671	350P
2N5672	400P
2N5680	55P
2N5884	175P
2N5886	325P
2N6031	250P
2N6049	55P
2N6059	150P
2N6098	50P
2N6099	45P
2N6107	40P
2N6109	40P
2N6211	400P
2N6248	150P
2N6284	250P
2N6287	225P
2N6292	40P
2N6385	120P
2N6403	160P
2N6427	25P
2N6476	250P
2N6488	90P
2N6491	90P
2N6547	300P
2N6609	375P
2N6660	375P
2N6675	175P
2N6678	225P
4N35	50P

RECTIFIER DIODES

PART	PRICE
BY127	8P
BY133	8P
BY164	40P
BY179	35P
BY184	32P
BY206	11P
BY207	20P
BY227	19P
BY228	28P
BY298	15P
BY299	18P
BY329-1200	150P
BY448	20P
BYT11	25p
BYT13-1000	30P
BYV96E	25P
BYW96E	36P
BYX10	15P
BYX55/600	25P
OA47	10P
OA91	10P
IN4001	3P
IN4002	3P
IN4003	3P
IN4004	3P
IN4005	3P
IN4006	3P
IN4007	4P
IN4148	2P
IN5400	9P
IN5401	8P
IN5402	8P
IN5403	8P
IN5404	8P
IN5405	11P
IN5406	12P
IN5407	12P
IN5408	12P
RGP10	25P
RGP15	25P
RGP30	16P
SKE4F2/06	60P
SKE4F2/08	80P
SKE4F2/10	100P
SR2M	60P

TRANSISTORS

PART	PRICE
I.C. SOCKETS	
8 PIN	4P
14 PIN	5P
16 PIN	6P
18 PIN	9P
20 PIN	10P
22 PIN	12P
24 PIN	13P
28 PIN	13P
40 PIN	15P
ZENER DIODES	
400m	WATT
2V7 TO 39V	5P
1.3	WATT
2V7 TO 39V	9P
VOLTAGE REGULATORS	
7805	25P
7806	25P
7808	25P
7812	25P
7815	25P
7818	25P
7824	25P
7905	25P
7906	30P
7908	30P
7912	30P
7915	30P
7918	30P
7924	30P
78L05	24P
78L08	24P
78L12	24P
78L15	24P
78L18	24P
78L24	24P
79L05	35P
79L08	35P
79L12	35P
79L15	35P
LM309K	100P
LM317T	100P
LM323K	350P
78H09KC	800P
79H12KC	700P
79HGKC	800P
L.E.D.'s 3mm	
RED	5p
YELLOW	8p
GREEN	8p
5mm	
RED	5p
YELLOW	8p
GREEN	8p
RECTANGULAR LED's	
5mm x 2.5mm	
RED	5p
YELLOW	8p
GREEN	8p
BRIDGE RECTIFIER	
W005	16p

PART	PRICE
1A/50V	
W01	18p
1A/100V	
WO2	19p
1A/200V	
W04	21p
LA/400V	
W06	23p
LA/600V	
W08	28p
1A/800V	
BR81D	33p
2A/100V	
BR82D	33p
2A/200V	
BR84D	37p
2A/400V	
BR86D	43p
2A/600V	
BR88D	43p
2A/800V	
BR32	43p
2A/200V	
BR34	43p
2A/400V	
BR36	44p
2A/600V	
BR62	80p
6a/200V	
BR64	72p
6A/400V	
BR251	150p
25A/100V	
BR252	165p
24A/200V	
BR254	185p
25A/400V	
BR2156	200p
25A/600V	
BR258	240p
25A/800V	
BR351	185p
35V/100V	
BR352	200p
35V/200V	
BR354	220p
35V/400V	
BR356	230p
35V/600V	
BR358	260p
35V/800V	
BY164	40p
1.5A/100V	
BY176	40p
1.5A/800V	
TRIACS	
TIC206D	60p
4A/400V	
TIC225D	69p
6A/400V	
TIC226D	68p
8A/400V	
TIC235D	85p
12A/400V	
TIC246D	105p
16A/400V	
TIC253D	190p
20A/400V	
TIC263D	205p
25A/400V	
THYRISTORS	
2N5061	20p
0.8A/60V	

PART	PRICE
TIC116C	59p
8A/300V	
TIC116D	70p
8A/400V	
TIC126D	75p
12A/400V	
TIC126M	90p
12A/600V	
C106D	28p
4A/400V	
BR103	37p
BR303	85p
BT106	180p
BT119	100p
17088	200p
17089	200p
17127	200p
15/80H	230p
15/85R	230p
SG 264	800p
SG613	1500p
COMPUTER IC's	
Z80ACPU	100p
Z80ADMA	200p
Z80ACTC	140p
Z80ASIO-1	210p
Z80ASIO-2	210p
75107	65p
75110	75p
75113	100p
75122	110p
75154	100p
75162	700p
75182	95p
75183	95p
75195	185p
2114	150p
2532	200p
26LS32	75p
2716	100p
2732	200p
2732A	220p
2764	150p
27C64	200p
27128	150p
27256-25	150p
27512	300p
4116	40p
4164-15	80p
4164-12	90p
41256-15	80p
41256-12	100p
41256-10	110p
41464-12	150p
6116	80p
6264-10	210p
62256-12	300p
6502A	360p
65C02	930p
6522	280p
6800	210p
6802	220p
6803	500p
6808	500p
6809	500p
6810	150p
6818	380p
6821	130p
6840	290p
6845	200p
6850	90p
74F244	35p
8085A	300p
8086	500p
8088	480p

PART	PRICE
8156	300p
8224	240p
8226	240p
8250	750p
8251	200p
8253	160p
8257	220p
8271	340p
8279	270p
8283	400p
8284	440p
8287	260p
8288	650p
82C206PLCC	500p
8748	700p
8755	800p
8T26	95p
8T28	110p
CMOS IC's	
4000	13p
4001	13p
4002	13p
4006	34p
4007	13p
4009	20p
4010	21p
4011	13p
4012	13p
4013	19p
4014	32p
4016	18p
4018	30p
4019	28p
4020	33p
4021	36p
4022	36p
4023	13p
4024	25p
4025	13p
4026	60p
4027	18p
4028	29p
4029	34p
4030	17p
4032	52p
4033	60p
4034	76p
4035	42p
4038	46p
4040	30p
4041	36p
4042	30p
4043	36p
4045	72p
4046	42p
4047	45p
4048	26p
4049	18p
4050	20p
4051	38p
4052	35p
4053	35p
4054	53p
4055	52p
4056	52p
4060	40p
4063	52p
4066	20p
4067	120p
4068	13p
4069	13p
4070	13p
4071	13p
4072	13p
4073	13p

PART	PRICE
4075	13p
4076	42p
4077	13p
4078	13p
4081	13p
4082	13p
4085	36p
4086	30p
4089	75p
4093	18p
4094	44p
4094	58p
4098	50p
4099	42p
4501	26p
4502	36p
4504	35p
4505	80p
4506	58p
4507	30p
4508	67p
4510	32p
4511	30p
4512	38p
4514	65p
4515	65p
4516	36p
4517	100p
4518	36p
4519	28p
4520	36p
4521	86p
4526	38p
4527	41p
4528	38p
4529	65p
4532	48p
4553	140p
4555	29p
4556	36p
4557	140p
4583	60p
4584	30p
4585	40p
40103	120p
40105	140p
40106	35p
40107	50p
40110	170p
40114	180p
40160	55p
40161	55p
40174	48p
40192	48p
40193	48p
40194	58p
40257	120p
74 SERIES	
7400	20p
7401	16p
7402	18p
7403	20p
7404	35p
7405	10p
7406	30p
7407	30p
7408	25p
7409	20p
7413	30p
7414	45p
7416	32p
7417	32p
7420	20p
7421	25p
7425	15p

PART	PRICE
7430	25p
7437	28p
7438	30p
7442	38p
7447	60p
7450	22p
7451	10p
7454	25p
7473	25p
7481	90p
7482	60p
7485	25p
7489	75p
7493	35p
7495	48p
74132	42p
74141	55p
74145	70p
74157	45p
74160	50p
74HC SERIES	
74HC03	14p
74HC08	18p
74HC10	20p
74HC11	14p
74HC14	26p
74HC20	19p
74HC27	20p
74HC51	20p
74HC73	24p
74HC74	24p
74HC76	28p
74HC77	35p
74HC85	33p
74HC86	29p
74HC107	28p
74HC123	35p
74HC125	32p
74HC126	33p
74HC132	33p
74HC133	33p
74HC137	52p
74HC138	33p
74HC147	42p
74HC153	32p
74HC154	90p
74HC157	34p
74HC158	34p
74HC160	44p
74HC161	44p
74HC162	44p
74HC163	44p
74HC164	44p
74HC165	56p
74HC166	60p
74HC174	38p
74HC175	38p
74HC190	46p
74HC192	53p
74HC193	41p
74HC194	46p
74HC195	46p
74HC221	80p
74HC238	55p
74HC240	48p
74HC241	47p
74HC242	55p
74HC243	60p
74HC245	48p
74HC251	25p
74HC257	40p
74HC259	52p
74HC273	42p
74HC280	61p
74HC283	61p

SERVICE AIDS

DESCRIPTION	VOLUME	CODE	PRICE	DESCRIPTION	VOLUME	CODE	PRICE
VIDEO HEAD CLEANER	75ML	SP01	180p	EXCEL POLISH 80	250ML	SP18	150p
VIDEO HEAD CLEANER	200ML	SP27	250p	ADHESIVE 120	400ML	SP19	190p
SWITCH CLEANER	176ML	SP02	180p	LABEL REMOVER 130	200ML	SP20	240p
SUPER 40	400ML	SP15	250p	REFURB 140	400ML	SP21	240p
SILICONE GREASE	200ML	SP03	210p	TUBE SILICON GREASE	50 GRAMMES	SP11	220p
FREEZE IT	170ML	SP04	320p	TUBE TUBE SILICON			
FREEZE IT	400ML	SP16	600p	SEALANT WHITE	75ML	SP22	280p
FOAM CLEANER	400ML	SP05	200p	TUBE SILICON SEALANT			
ANTI STATIC	200ML	SP06	190p	CLEAR	75ML	SP23	280p
AEROKLEANE	200ML	SP07	220p	TUBE HEAT SINK COMPUND	25 GRAMMES	SP12	150p
AERO DUSTER	150ML	SP08	310p	DRIVE CLEANER	200ML	SP24	150P
AERO DUSTER	400ML	SP17	550p	SCREEN CLEANER	200ML	SP25	150p
PLASTIC SEAL	200ML	SP09	250p	COMPUTER CARE KIT		SP26	2100p
GLASS CLEANER	250ML	SP10	160p	ANTI STATIC FOAM CLEANER	400ML	SP28	175p
COLDKLENE	250ML	SP13	230p	AIR DUSTER	400ML	SP29	450p

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ETI ELECTRONICS TODAY INTERNATIONAL News...

Young Electronics Designers of the Year Award

His Royal Highness the Duke of York, Patron of the Young Electronic Designer Awards, presented the Young Electronic Designer Awards for 1997 to the winners in front of 200 guests at a special presentation dinner at the Science Museum, London, on 26th March. Earlier in the evening, TV Personality Sally Grey announced the winners. The Awards which are sponsored by Mercury Communications and Texas Instruments in association with the Institution of Electrical Engineers, challenge young designers to invent and produce an innovative device or system based on electronics to meet an everyday need.. The competition is open to students between the ages of 12 and 25 in secondary schools, colleges and universities.

The winner of the Duke of York's Award for the most imaginative concept is 18-year-old Michael Brown of Bancroft's School, Woodford Green, Essex for his "Gremlinator" circuit testing aid. The "Gremlinator" was also highly commended in the Senior overall category. The Mercury Communications Prize for the best communications-based project went to 14-year-old Emily Collins of Ridley High School, Blyth. Northumberland, for her SAFE (Sensory Alert For Everyday), ingeniously combining flashes and vibration to give smoke, intruder, doorbell and telephone alarm warnings for the deaf, and designed to be worn on the wrist. Her project also received a Highly Commended award in the Junior overall category. The Texas Instruments Prize for the most commercially viable project went to 17-year-old Simon Todd of Bolton School, Bolton, Lancs, for a domestic iron safety device. Simon's project also came first in the Intermediate (15-17 years) overall category. The winner of the IEE Award for the best new entrant to YEDA is Mark Gould, 14, of Gryphon School, Sherborne, Dorset, for a detector to indicate whether electric fences are turned on or off, which also took the second prize in the Junior overall category. The first prizewinner in the Senior (18-25 years) category is James Smith, 22, of Brunel University for his "Manta" through-water communication device for recreational scuba divers.

Other winners are Peter Smith, 23, of the Bangor University of Wales, second in the Senior category for an integrated low-cost noise badge dosimeter for people working in noisy environments; Leighton Spicer, 21, of the Bangor University, third in the Senior category for an electronic system to reduce the incidence of pressure sores in older or disabled people; David Marson, 16, of St Joseph's College, Trentvale, Stoke on Trent, second in the Intermediate category for an electronic hand-held pedestrian crossing sign; Susannah Baker, 15, and Elizabeth Humphreys, 14, of Bishop's Castle Community College, Shropshire, for their 'Braille Rail' talking electronic map of the London Underground; Edward Brocklebank, 14, of Radley College, Abingdon, Oxon, first in the Junior category (under 15 years) for a safety device for a bicycle providing enhanced visibility at night and including left/right turn indicators; Rachel Downing, 13, Kerry-Anne Devlin, 13, Anna Burke, 12, and Anne-Marie Gaillaed, 12, of St Mary's Junior High School, Lurgan, Northern Ireland, third in the Junior category for an educational toy to enhance knowledge of the earth and solar system.

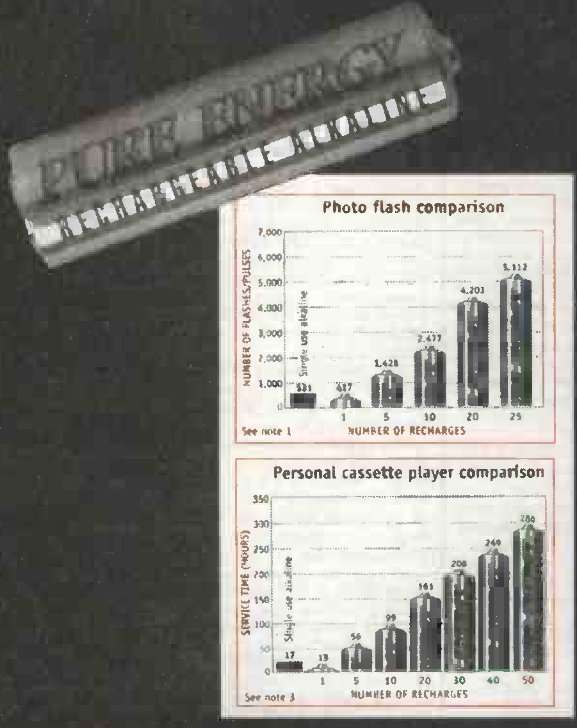
Also Highly Commended in the Senior category was Gwyn Jones, 22, of Bangor University for a pre-enclampsia monitoring system; in the Intermediate category Sumit Rai, 17, of Dulwich College, London, for an opto-electrical swipe entry card for a public gym; Jonathan Taylor, 15, of Bryanston School, Blandford, for the "Coxbox" device to give the rowing cox and steersmen a stroke rate readout; Andrew Buckmaster, 16, of Radly College, Abingdon for a device for measuring and displaying the quantity of water used by showers and hose pipes (an increasingly topical subject these days); John Morton, 16, and Max Kendall, 16, for a bath temperature warning device in the form of a toy and Andrew Early, 16, of Ravens Wood School, Bromley, for a model rocket launch controller. Highly Commended in the Junior category were also Guy Kewish, 13, Philip Reid, 13, and Alasdair Lynch, 13, of Merchiston Castle School, Colinton, for BASICS (Babies and Safety in Car Seats) and Stephen Wyber, 13, of Bancroft's School, Woodford Green, for his kitchen weighing scales for the blind.

All the competition entrants had to exhibit awareness of the ease of use, commercial applicability and production engineering of their projects, as well as the basic electronics concepts. We congratulate them and wish them good progress in their chosen careers in the future...

Mercury-free batteries ready to change the market

The first mercury-free rechargeable batteries have been released in the UK. Allied Battery Technologies has announced the cells, known as RAM (tm) (Rechargeable Alkaline Manganese) cells, for use in all kinds of electronic and home equipment, including power toys, cameras, radios, audio equipment, remote controls and torches. As they are being marketed as "Pure Energy Rechargeable Alkaline", we can hope that the already thinly-stretched "RAM" acronym will not confuse buyers into thinking that these are specialist computer batteries.

The RAM cells are designed as long-life rechargeables and the company stresses that they are not to be confused with attempts to recharge conventional alkaline manganese batteries in "universal" chargers. The charge and recharge characteristics of the new batteries are such that the useful life is 10 to 50 times that of a conventional alkaline battery, or more. The simple purpose-designed RAM charger, which fits into a normal 13 amp wall socket, hold batteries ready for use. The cells can be recharged from 10 to over 50 times, and have a shelf life of five years. They come charged, and so do not have to be charged up before first use.



RAM cells have the major "green" advantage that they contain no toxic chemicals such as mercury or cadmium, used in most other types of dry cell. They have a similar application pattern to NiCads, but without the threat of pollution. The company found that the new technology captured 53% of the NiCad rechargeable market within six months.

Initially, AA cells will be available in the UK with AAA cells to follow later this year. The RAM cells are based on patented technology developed by Professor Karl Kordesch, the inventor of the single-use disposable alkaline battery so well known today. They represent to performance characteristics of disposable alkaline batteries and the economic benefits of rechargeability, along with the environmental advantage of low toxicity. The Pure Energy branded RAM calls are completely interchangeable with conventional, non-rechargeable alkaline batteries, and also suitable in many cases as an alternative to rechargeable NiCads. They can also be used in equipment labelled "unsuitable for rechargeable nickel cadmium batteries", because the do not deliver "overcurrent" that is potentially damaging to some consumer electronics. There is, in addition, no "memory effect" as occurs with NiCads - RAM cells perform best when "topped up" in their charger when not in use. The Ram cell is a 1V5 cell rather than a 1V2 cell, and therefore more efficient in 3V and 6V applications.

Chargers

Two chargers will be available for the new batteries: the MegaCharger is a table-tiop charger which will take up to eight AA or AAA cells for high-volume use, fully charging eight batteries in six hours. The EnviroCharger is a compact unit that will take up to four AA or AAA cells, and plugs into a 13A wall socket. It will charge four batteries overnight from a fully discharged state, and will recharge partially discharged batteries much sooner.

The Pure Energy RAM cells are described as being rechargeable from 10 times up to 25 times or more. In a high-discharge application such as a child's toy or other motor drives, the RAM cell can be recharged giving it a total life of more than 17 times a single-use alkaline battery. Tests under low-current drain conditions simulating the use of a personal cassette player in stop/start mode showed a total life more than 50 times longer than a conventional alkaline manganese battery.

The batteries will be on retail sale. Further enquires to Allied Battery Technologies, 14 Bates Industrial Estate, Wycombe Road, Stokenchurch, Bucks HP14 3RJ.

Low-profile meter needs no soldering

First in a new family of low-profile, DIN-cased digital panel meters, Lascar Electronics' DPM 390 is housed in a snap-in DIN case and features 200 mV full scale reading, auto-polarity, auto-zero and 14.2 mm digit height. Designed to be used without the need for soldering, the DPM 390 contains internal DIP switches for selection of input mode and decimal points. Connection is made via an optional T/blk-1 screw terminal blockboard. Lascar are recommend the DPM 390 for high and low volume applications.

For more information tel. 01794 884567.

DIFFERENTIAL THERMOSTAT KIT Perfect for heat recovery, solar systems, boiler efficiency etc. Two sensors will operate a relay when a temp difference (adjustable) is detected. All components and pcb. £29 ref LOT93

MAGNETIC RUBBER TAPE Selfadhesive 10 metre reel, 8mm wide perfect for all sorts of applications! £15 ref LOT87

MAINS POWER SAVER UK made plug in unit, fitted inseconds, can reduce your energy consumption by 15%. Works with fridges, soldering irons, conventional bulbs etc. Max 2A rating. £9 each ref LOT71, pack of 10 £69 ref LOT72

YUASHA SEALED LEAD ACID Batteries, ex equipment but ok bargain price just £5.99 each ref YA1. 100 or more £3.50 each.

DC TO DC CONVERTERS
DRM58 input 10-40vdc output 5v 8A £15 DRM128 input 17-40vdc output 12v 8A £18 DRM158 input 20-40vdc output 15v 8A £18 DRM248 input 29-40vdc output 24v 8A £12 DRS123 input 17-40vdc output 12v 3A £10 DRS153 input 20-40vdc output 15v 3A £20 DRS243 input 29-40vdc output 24v 3A £8

HITACHI LM225X LCD SCREENS 270x150mm, standard 12 way connector, 640x200 dots, tec spec sheet. £15 each ref LM2

VARIABLE CAPACITORS Dual gang, 60x33x45mm, reduction gearing, unknown capacity but probably good quality (military spec) general purpose radio tuner. £9 ref VC1

ELECTRONIC FLASH PCB Small pcb fitted with components including a flash tube. Just connect 12vdc and it flashes, variable speed potentiometer. £6 ref FLS1

THIEF PROOF PEN! Amazing new ball point pen fitted with a combination lock on the end that only you know! £2.49 ref TP2

JUMBO BI COLOUR LEDS PCB with 15 fitted also 5 giant seven segment displays (55mm) £8 ref JUM1

HOME DECK CLEARANCE These units must be cleared! leads, a n infra red remote qwerty keyboard and receiver, a standard UHF modulator, a standard 1200/75 BT approved modem and loads of chips, capacitors, diodes, resistors etc all for just £10 ref BAR33.

6.8MW HELIUM NEON LASERS New units, £65 ref LOT33

COINSLOT TOKENS You may have a use for these? mixed bag of 100 tokens £5 ref LOT20.

PORTABLE X RAY MACHINE PLANS Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies can be used for experimental purposes. Not a toy or for minors! £6/set. Ref F/XP1.

TELEKINETIC ENHANCER PLANS Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing phychic phenomenon. £4/set Ref F/TKE1.

ELECTRONIC HYPNOSIS PLANS & DATA This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/set. Ref F/EH2

GRAVITY GENERATOR PLANS This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means- cause it to levitate. £10/set Ref F/GRA1.

WORLDS SMALLEST TESLA COIL/LIGHTENING DISPLAY GLOBE PLANS Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece. £5/set Ref F/BTC1/LG5.

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commision of NEGEV in Israel. £10/set Ref F/CVL1.

VOICE SCRAMBLER PLANS Minature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/set Ref F/VS9.

PULSED TV JOKER PLANS Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound! works on FM too! DISCRETION ADVISED. £8/set Ref F/TJ5.

BODYHEAT TELESCOPE PLANS Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/set Ref F/BHT1.

BURNING, CUTTING CO2 LASER PLANS Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/set Ref F/LC7.

MYSTERY ANTI GRAVITY DEVICE PLANS Uses simple concept. Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece, magic trick or science project. £6/set Ref F/ANT1K.

FRUIT POWERED CLOCK Just add a fresh orange, tomato, banana or any other fruit plug in the probes and the clock works! £9.95 ref SC154

DYNAMO FLASHLIGHT Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

ULTRASONIC BLASTER PLANS Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquides. Many cleaning uses for PC boards, jewllery, coins, small parts etc. £6/set Ref F/ULB1.

ULTRA HIGH GAIN AMP/STETHOSCOPIC MIKE/SOUND AND VIBRATION DETECTOR PLANS Ultrasensitive device enables one to hear a whole new world of sounds. Listen through walls, windows, floors etc. Many applications shown, from law enforcement, nature listening, medical heartbeat, to mechanical devices. £6/set Ref F/HGA7

WOLVERHAMPTON ELECTRONICS STORE NOW OPEN IN WORCESTER ST TEL 01902 22039

ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of accoustical energy that dogs cannot tolerate £6/set Ref F/DOG2

LASER BOUNCE LISTENER SYSTEM PLANS Allows you to hear sounds from a premises without gaining access. £12/set Ref F/LLIST1

LASER LIGHT SHOW PLANS Do it yourself plans show three methods. £6 Ref F/LLS1

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PSP4

INFINITY TRANSMITTER PLANS Telephone line grabber/room monitor. The ultimate in home/office security and safety! simple to use! Call your home or office phone, push a secret tone on your telephone to access either. A) On premises sound and voices or B) Existing conversation with break-in capability for emergency messages. £7 Ref F/TELEGRAB.

BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/set Ref F/BD1.

ELECTROMAGNETIC GUN PLANS Projects a metal object a considerable distance-requires adult supervision £5 ref F/EML2

ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND! £5/set Ref F/EMA1.

PARABOLIC DISH MICROPHONE PLANS Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS Operates on 9-12vdc, many possible experiments. £10 Ref F/HVM7/TCL4.

MEGA LED DISPLAYS PCB fitted with 5 seven segment displays each measuring 55 x 38mm. £5 ref LED5.

MOD TRANSMITTING VALVES 5J180E £80 ref LOT112

SWITCHED MODE PSU'S 244 watt, +5 32A, +12 6A, -5 0.2A, -12 0.2A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 d/drive connectors 1 m/board). £15 ref LOT135

HYDROGEN FUEL CELL PLANS There is a lot of interest in using Hyrogen as the fuel of the future, Hydrogen is easy to produce using chemicals and surplus solar generated electricity. It is also easy to store with little or no loss. Hyrogen fuel cells are designed to store hydrogen and weight for weight will hold twice as much energy as a full petrol tank. Our plans give you loads of information on Hyrogen production, storage and practical plans to build your own Hydrogen fuel cell! you will need access to a well equiped workshop for this but full construction details and drawings are included. Ful cell plans £9 ref HY1

VIDEO PROCESSOR UNITS?/6v 10AH BATTS/24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v torroidial transformer (mains In). sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

RETRON NIGHT SIGHT Recognition of a standing man at 300m in 1/4 moonlight, hermatically sealed, runs on 2 AA batteries, 80mm F1.5 lens, 20mw infrared laser included. £325 ref RETRON.

MAKE YOUR OWN CHEWING GUM KIT Everything you need to make real chewing gum, even the bowl and tree sap from the Sapodilla tree £7.99 ref SC190

MINI FM TRANSMITTER KIT Very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but easily changed to cover 63-130 Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £9 Ref 1001.

3-30V POWER SUPPLY KIT Variable, stabilized power supply for lab use. Short circuit protected, suitable for profesional or amateur use 24v 3A transformer is needed to complete the kit. £14 Ref 1007.

1 WATT FM TRANSMITTER KIT Supplied with piezo electric mic. 8-30vdc. At 25-30v you will get nearly 2 watts! £15 ref 1009.

FM/AM SCANNER KIT Well not quite, you have to turn the knob yourself but you will hear things on this radio that you would not hear on an ordinary radio (even TV). Covers 50-160mhz on both AM and FM. Built in 5 watt amplifier, inc speaker. £18 ref 1013.

3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £17 Ref 1014.

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £24 Ref 1028.

STROBE LIGHT KIT Adjustable from 1-60 hz (a lot faster than conventional strobes). Mains operated. £17 Ref 1037.

COMBINATION LOCK KIT 9 key, programmable, complete with keypad, will switch 2A mains. 9v dc operation. £13 ref 1114.

PHONE BUG DETECTOR KIT This device will warn you if somebody is eavesdropping on your line. £9 ref 1130.

ROBOT VOICE KIT Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

TELEPHONE BUG KIT Small bug powered by the 'phone line, starts transmitting as soon as the phone is picked up! £12 Ref 1135.

3 CHANNEL LIGHT CHASER KIT 800 watts per channel, speed and direction controlssupplied with 12 LEDS (you can fit triacs instead to make kit mains, not supplied) 9-12vdc £17 ref 1026.

12V FLOURESCENT LAMP DRIVER KIT Light up 4 foot tubes from your car battery! 9v 2a transformer also required. £8 ref 1069.

HELPING HANDS Perfect for those fiddly jobs that need six hands. 6 ball and socket joints, magnifier. £7.99 ref YO57A

VOX SWITCH KIT Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £10 ref 1073.

PREAMP MIXER KIT 3 input mono mixer, sep bass and treble controls plus individual level controls, 18vdc, input sens 100mA. £15 ref 1052.

SOUND EFFECTS GENERATOR KIT Produces sounds ranging from bird chips to sirens. Complete with speaker, add sound effects to your projects for just £9 ref 1045.

15 WATT FM TRANSMITTER (BUILT) 4 stage high power, preamp required 12-18vdc, can use ground plane, yagi or open dipole. £69 ref 1021.

HUMIDITY METER KIT Builds into a precision LCD humidity meter, 9 ic design, pcb, lcd display and all components included. £29

PC TIMER KIT Four channel output controlled by your PC, will switch high current mains with relays (supplied). Software supplied so you can program the channels to do what you want whenever you want. Minimum system configeration is 286, VGA, 4.1,640k, serial port, hard drive with min 100k free. £24.99

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GI/R20

NICKEL PLATING KIT Proffesional electroplating kit that will transform rusting parts into showpieces in 3 hours! Will plate onto steel, iron, bronze, gunmetal, copper, welded, silver soldered or brazed joints. Kit includes enough to plate 1,000 sq inches. You will also need a 12v supply, a container and 2 12v light bulbs. £45 ref NIK39.

Minature adjustable timers, 4 pole c/o output 3A 240v,
HY1230S, 12vDC adjustable from 0-30 secs. £4.99
HY1260M, 12vDC adjustable from 0-60 mins. £4.99
HY2405S, 240v adjustable from 0-5 secs. £4.99
HY24060m, 240v adjustable from 0-60 mins. £6.99

BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £12.00 **REF: MAG8P2.**

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt. 12v fan, iec inlet and on/off switch. £12 Ref EF6.

VENUS FLY TRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

ROCK LIGHTS Unusual things these, two pieces of rock that glow when rubbed together! belived to cause rain! £3 a pair Ref EF29.

3' by 1' AMORPHOUS SOLAR PANELS 14.5v, 700mA 10 watts, aluminium frame, screw terminals, £55 ref MAG45

ELECTRONIC ACCUPUNCTURE KIT Builds into an electronic version instead of needles! good to experiment with. £9 ref 7P30

SHOCKING COIL KIT Build this little battery operated device into all sorts of things, also gets worms out of the ground! £9 ref 7P36.

HIGH POWER CATAPULTS Hinged arm brace for stability, tempered steel yoke, super strength latex power bands. Departure speed of ammunition is in excess of 200 miles per hour! Range of over 200 metres! £8.99 ref R/9.

COMPAQ POWER SUPPLIES WITH 12V DC FANS Ex equipment psu's, some ok some not but worth it for the fan alone! probably about 300 watt PC unit with IEC input £3.50 each ref CQ1

BALLON MANUFACTURING KIT British made, small blob blows into a large, longlasting balloon, hours of fun! £3.99 ref GI/E99R

9-0-9V 4A TRANSFORMERS, chassis mount. £7 ref LOT19A

MEGA LED DISPLAYS Build your self a clock or something with these mega 7 seg displays 55mm high, 38mm wide. 5 on a pcb for just £4.99 ref LOT16 or a bumper pack of 50 displays for just £29 ref LOT17.

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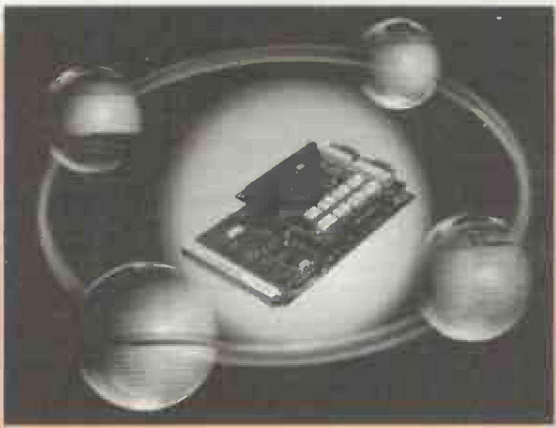
Multi-tasking kernel assists embedded systems



Arcom Control Systems has ported an efficient multi-tasking kernel from US Software onto its new range of low-cost 16- and 32-bit embedded controllers. The software will assist in upgrading embedded control systems to much higher levels of computing performance to meet the need for greater control flexibility, connectivity and user ergonomics, while keeping down costs, timescales and the difficulties of migration.

In conjunction with Arcom's PC-based development tool, the software provides the same kind of simplicity and speed as developing a PC-based target, but without the overheads needed by a PC running Windows. This can save significant costs in hardware and software licensing for each control system installed. The Arcom controller range is based on the latest 25 MHz 188EB and 33MHz 386EX embedded processors from Intel, giving high computing performance and large memory-addressing ranges at price levels designed to attract designers currently using microcontroller chips.

For example, compared with popular 8-bit devices like the 8051, these new processors offer very considerably higer performance. The CPUs are packaged on single Eurocards with a range of real-time-oriented hardware, as well as PC/104 and (optionally) STEbus expansion interfaces.

The multi-tasking kernel, SuperTask!, allows designers to divide application programs into structured tasks which interface with a real-time database, such as control algorithms, communications, and human interface routines. The kernel ensures that each routine is serviced regularly according to user-defined priority criteria. The use of the kernal can greatly reduce the complexity of programming for advanced control systems. Benchmarks for the 396EX board show that task switching occurs in 20 microseconds, for example, with interrupt latency of less than 80 us, giving designers true determinism for critical segments of code - apparently debugged code segments can occasionally give unpredictable results due to interrupt timing; the low latency in this system addresses this problem.

Run time licenses are just £16 for medium-volume applications.

For further details contact Arcom Control Systems Ltd., Clifton Road, Cambridge CB1 4WH, UK. Tel 01223 411200 email sales@arcom.co.uk Web www.ussw.com

Government plugs new information programmes

The UK Government (as we write) is promoting a potentially wide-ranging package of programmes under the aegis of the ISI (Information Society Initiative) "to help the UK take its place as a leading nation in the development of the Information Society ... it is an initiative which will continue unitl the end of the decade".

Among other things, the Government will " a new Information and Communications Technology fund which will enrich our lives ... but no money from the new fund will be available until 2001 at the earliest," reported Minister Ian Taylor.

The main ISI activities include: Programme for Business: a partnership with business to encourage development of new technologies and applications; IT for All: access opportunities for citizens to help overcome technology barriers; Education Department Superhighways Initiative: raising awareness of computer networks in education (computer networks In schools); and government.direct (electronic delivery of government services to homes and businesses). (Information from the Cabinet Office).

The Government is supporting the IT Industry Training Organisation in developing "rigorous standards" of competence at all levels of IT skill. According to the Government, this has already been done with regard to the National Curriculum. The UK is one of the few countries in the world in which IT must be used in all curriculum subjects. UK Education Departments will be publishing purchasing and good practice guidance later this year. A working knowledge of IT "to at least Level 8 in the National Curriculum for Pupils" will be integrated into teacher training qualifications. Industrial sponsors are sought for the DTI's Schools OnLine project.

Other areas to be addressed are the extension of the UK's telecommunications capabilities through investment by cable and telecomms companies. BT is investing around £2M a year to upgrade its network to fibre-optic cable to street-cabinet level. Fixed price ISDN packages are in the meantime available from telephone providers. Much of a record amount of direct foreign investment in the UK has been in information and communications technology (such as Siemens, Fujitsu, Morotola, Nortel, Samsung and LG).

A forum is to be established for industry, academia and other bodies to work together to maximise the UK's research, development and learning capabilities, "with a goal of creating a positive balance of trade in IT-related intellectual property rights by 2005. The DTi has made efforts to improve the protection of intellectual property rights (although participants still find that the situation is far from clear in many cases, the last major redraft being the Copyright, Designs and Patents Act of 1988, before many Internet services went on-line).

The ISI Programme for Business Publicity Centre Tel 0171 828 1593

OVERSEAS READERS

To call UK telephone numbers, replace the initial 0 with your local overseas access code plus the digits 44.

MODSMODSMODSMODSMODSMODS

In the **Freezer Alarm** (Vol 26 issue 4), a wire link is missing in figure 3 (the component layout). This runs from pin 8 of IC3 to the power rail on track 12 and is clearly shown on the far right of the photograph on page 26 of the article. The link can be inserted to the right of R9 without moving the resistor.

In **The Little Mule** (Vol 26 issue 3). The "missing" IC1 is a 4093 nand Schmitt trigger, available from Maplin and other suppliers.

Wall of Sound

The loudspeakers of the future are thin, flat and could be built into your wall. The first ones are more likely to be built into your laptop. They disobey the wave equation. They are the first serious competition for traditional loudspeaker design. Andrew Armstrong reports.

It appears that the days of the conventional loudspeaker may be numbered, and that for the most part flat panel loudspeakers will be used in the future. If you remember our editorial challenge to make a real improvement in loudspeaker performance - well, the NXT design looks like the most serious contender to provide the answer. This is an account of a visit to the labs where the loudspeakers were developed.

I went to see and hear the new loudspeakers as a sceptic, open minded enough to ask for a demonstration of this new type of technology, but not suspecting the far reaching consequences of the new developments.

V Labs at Huntingdon is a shared R&D facility for several well respected hi-fi brands including Mission, Quad, and Roksan. This in itself inspires some confidence in the quality of the work to be expected.

The working conditions are ones which would delight most designers: the computer equipment is upgraded regularly, and the "old" equipment is passed on to less critical areas of the company. I was particularly taken with the mechanical design section, in which the casework is designed with CAD software able to display any stage of the assembly and which can also show the finished equipment displayed with other hifi items to see if the styling is compatible with other respected models on the market, as hifi products are frequently "mixed and matched" by discerning users. The CAD can also provide an animated display of the casework being assembled.

This is not simply about style and marketing, however. When sample mechanical parts are needed, laser stereo lithography is used. The process uses numerical data to control laser beams directed into a tank of a plastic material which is polymerises at the crossing point of the laser beams. Thus, the lasers can draw a mechanical shape required in 3D, and this shape forms in the tank. The data to control the laser beams is generated straight from the design in the computer, and a physical drawing is not needed. Assuming that the part produced by stereo lithography is correct, data from the same CAD file is used to control the CNC machines which manufacture the final parts (or which manufacture the moulds for plastic parts). This level of simulation cuts down the stages of development.

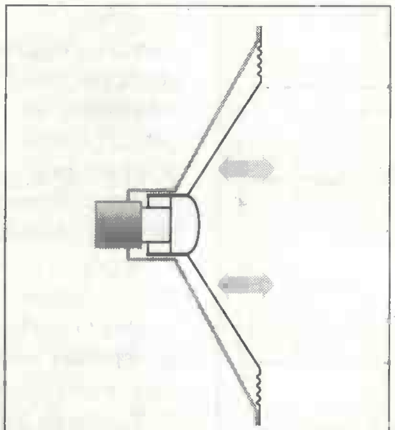


Figure 1: the piston action of a conventional loudspeaker

Many people will be relieved to hear, however, that the actual electronics prototyping is carried out in traditional manner with prototype assemblies.

The start of the project

Before the project first began in 1994, a scientist from the Defence Research Agency (DRA) noticed that panels intended for sound deadening in airframes were acting as loudspeakers. He developed this effect into a working loudspeaker which functioned by principles not properly understood, and which were not good enough for serious use. It was only able to work over a limited frequency range, and then not very smoothly. He asked Mission if they could develop it far enough to become useful. The engineers examined it and concluded that it was too far from being useful to be worth pursuing. However, Henry Azima, the Chairman of V-labs, was not satisfied with this answer. Clearly, something worked in a way which could not be explained and he wanted to know more about it before rejecting it.

He set two mathematicians who were experts in the field of finite element analysis to see what they could find out. After two months of work, they developed a finite element analysis program which analysed the vibrational modes of the panel. It was then seen to be possible to use a different but related vibrational principle to make a loudspeaker good enough to be of use.

V-labs still licenses the original patent from DRA, and has a total of 22 patents and 450 claims on their own new technology going forward to date.

Pistons and other vibrations

An ordinary loudspeaker works as a piston, pushing backwards and forwards a volume of air. This principle is illustrated in figure 1.Virtually all loudspeakers have worked on this principle, and a modern loudspeakers of this type would be largely familiar to a sound engineer as far back as 70 years ago. Refinements such as new cone materials, more compliant suspension, and ferro-fluid, are incremental advances which would seem very logical to the sound engineer of the past.

The NXT flat panel loudspeakers do not work anything like this. Instead of the whole panel acting like a piston and moving a mass of air, it vibrates in an apparently incoherent fashion. The analysis of this is very complicated and can probably only be understood by a few mathematicians. The computer program which is used to help design loudspeakers to this principle is said to take many hours to run even on the fastest currently available Pentium.

Figure 2 illustrates the vibration pattern of a conventional stretched panel, and figure 3 shows that of an NXT flat panel loudspeaker. The conventional stretched panel has an easily comprehensible pattern, very much like the pattern of ripples caused when a stone is dropped in a pond. Radiation from the back face is out of phase with that from the front, and therefore tends to cancel.

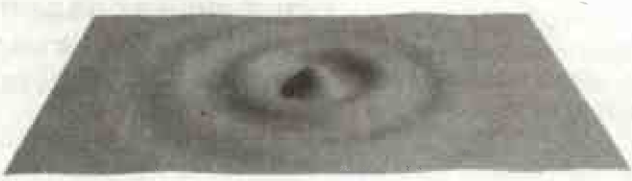


Figure 2: the vibration pattern typical of an electrostatic loudspeaker

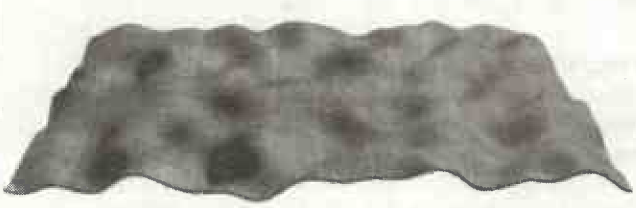


Figure 3: the vibration pattern typical of an NXT loudspeaker

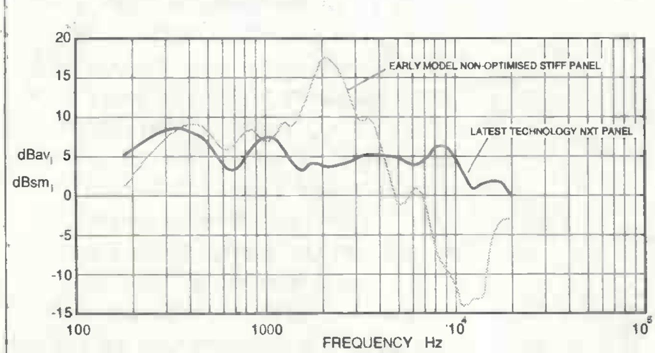


Figure 4: the frequency response of an early panel compared with a later, optimised, design

The NXT loudspeaker, on the other hand, has an apparently incoherent vibrational pattern, which is not the same front and back. This apparently chaotic pattern adds at a distance rather in the way that white lights add, while the addition of conventional loudspeakers is more like that of phase coherent laser beams.

Acoustic characteristics

The acoustic characteristics of an NXT flat panel loudspeaker depend very much upon how well it is designed and built. As far as NXT are prepared to tell us how the technology works, the design is done so that the vibrational modes at different frequencies, though they may appear very different when shown as a vibrational pattern, transfer power to the air with similar efficiency.

Factors which have to be correct in order to make the transducer work efficiently and with an even frequency response include:

- the shape of the panel
- the position of the driver
- the bending stiffness
- the surface density
- the sheer modulus of the core
- the damping factor
- the method by which the panel is suspended

Inevitably, the discontinuity represented by the edge of the panel gives rise to the possibility of resonance, and so adds to the complexity of the equations that must be solved to design the panel. Equally, some parts of the panel vibrate at a higher amplitude, and any damping at these points would impair the performance. It is vital that suspension points are chosen so that they affect the vibrational pattern of the panel as little as possible or in a predicable fashion which is taken account of at the initial design stage.

If the design parameters are slightly wrong, the performance is considerably reduced. Figure 4 compares the performance of an earlier design in which some of the parameters were not optimum, with a later design which is much nearer to optimum. The earlier design has a very uneven frequency response, for instance, a resonance in the middle region and a steep falling off of response at the treble end - around 15dB at 10kHz (triangles and cymbals lose sharpness). The subsequent design has a much more even frequency response. Although DSP frequency response correction could have made the earlier design sound reasonable, as a general rule using frequency correction to get rid of large peaks and troughs in the frequency response of a loudspeaker results in poorer performance than if the loudspeaker response is nearer to flat in the first place, because an unsuitably configured transducer is being forced to respond in a way that is unnatural to it and will add distortion of its own in the process.

One of the valuable characteristics of the flat panel loudspeaker is that it is not highly directional even at high frequencies. Figure 5 shows the radiation pattern from an NXT panel at a range of frequencies from 250 Hz to 16kHz showing a reasonably even pattern at all these frequencies.

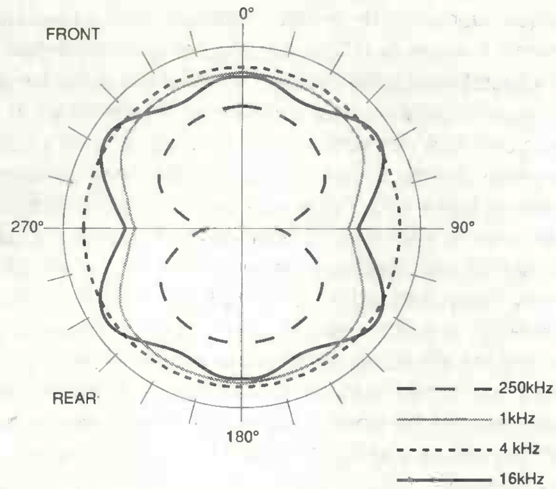


Figure 5: the radiation pattern for an NXT panel

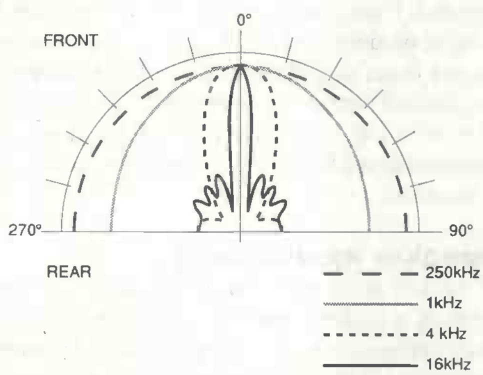


Figure 6: the radiation pattern typical of a 6.5-in cone loudspeaker in a baffle

In contrast, figure 6 shows the radiation pattern typical of a 6.5in diameter cone loudspeaker in a baffle. Even at 4 kHz, this shows a very directional pattern while at 16kHz you would be very lucky to be able to locate the optimum position to hear that frequency.

What is also noticeable from these diagrams as well as from the frequency response in figure 4 is that the one drawback the NXT panel displays is a limited low-frequency response. A very big panel can provide a tolerable low frequency response, but the people at verity labs say that at around 80 to 100 Hz the panel is working more as a piston rather than using the complex vibrational 'distributed mode' characteristic of NXT. On this evidence it is likely that conventional cone loudspeakers will retain their popularity at sub-woofers.

Power drop with distance

With conventional loudspeakers the aim has been to approximate the effect of a point source transducer. A point source would suffer from a halving of sound level with each doubling of distance, the well-known "inverse square law". The NXT however approaches a linear law over a limited range, as is illustrated by the comparative curves in figure 7.

The effect of this linear law is that people near to the loudspeaker are not deafened, while people who are farther away can still hear clearly. Public address systems will benefit greatly, and the area of the living room in which you get good stereo sound will expand. In an ideal world, it may even be that you will be able to get the TV loud enough to hear clearly without disturbing the neighbours.

While meaningful accurate comparative measurements are not at present available, it is clear that less ampiifier power is required to give sufficient sound level over a listening area than would be required with conventional loudspeakers.

Another fundamental difference between NXT and conventional loudspeakers is that while the sound radiation from a conventional loudspeaker is focused and, in the technical sense, coherent, the radiation from an NXT panel is diffuse. While this might appear to be a drawback, what it means in reality is that interference to sound quality caused by room boundaries is much reduced. This effect minimises the peaks and troughs normally associated with sound reflecting from the walls of the room.

This also means that hanging one of these flat panel loudspeakers on the wall like a picture will not cause unpleasant resonances, although it will cause a reduction in sound level of about 3dB, due to the loss of radiation from the rear of the panel. And hanging the panels on the wall will be a reality, as the panels can be as thin as 2mm and any area from 25 square metres to 100 square metres.

Listening tests

In the listening room, varied program material was played including some CDs I brought along myself. As I sat in the normal listening position that one would pick for hifi loudspeakers I could not immediately hear any difference between the NXT flat panel speakers being demonstrated and any true hifi standard loudspeaker system. At that stage the most impressive thing was that there were no big bulky boxes in evidence.

On more careful consideration, I reckoned that the clarity and sense of openness in the sound was better than I would normally expect even from a good set of loudspeakers. I suspect that this is a characteristic of the NXT panels, but I cannot say for sure until I hear a set in a room which is less acoustically good than the demonstration room.

I was encouraged to walk around the room to hear how the sound intensity changes as you move up closer to the loudspeakers. In fact, it changes very little, so that with the four channel home theatre demonstration, you could hear all four channels over most of the room. The loudspeaker you were standing next to did not drown out the sound from the other channels. This sounds absurd, but the reason, at least in part, is that as you get close to a large flat-panel loudspeaker, a lot of the sound being radiated from it goes

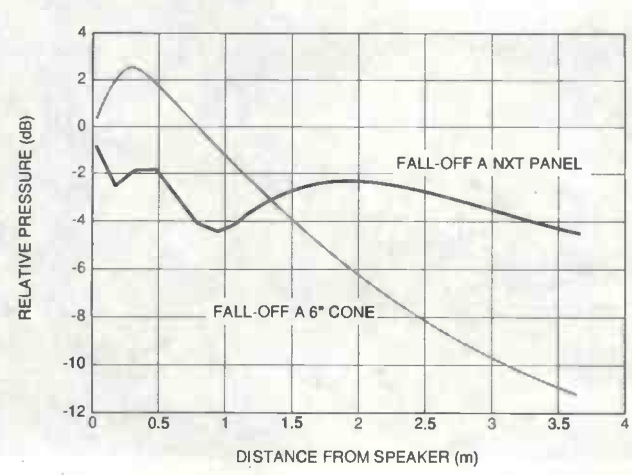
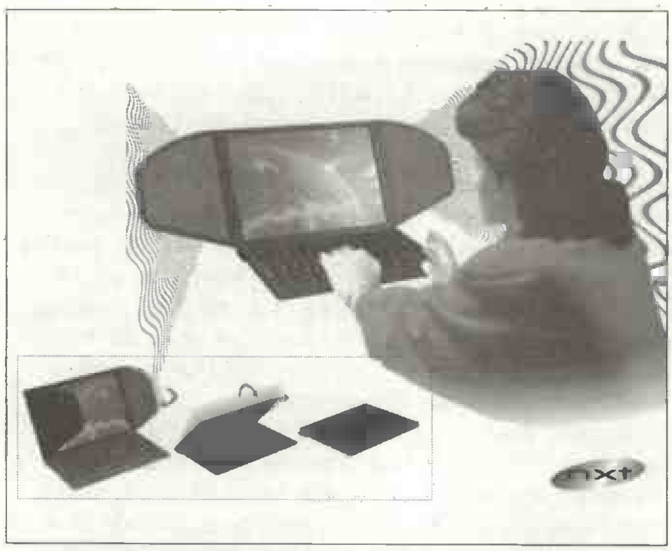


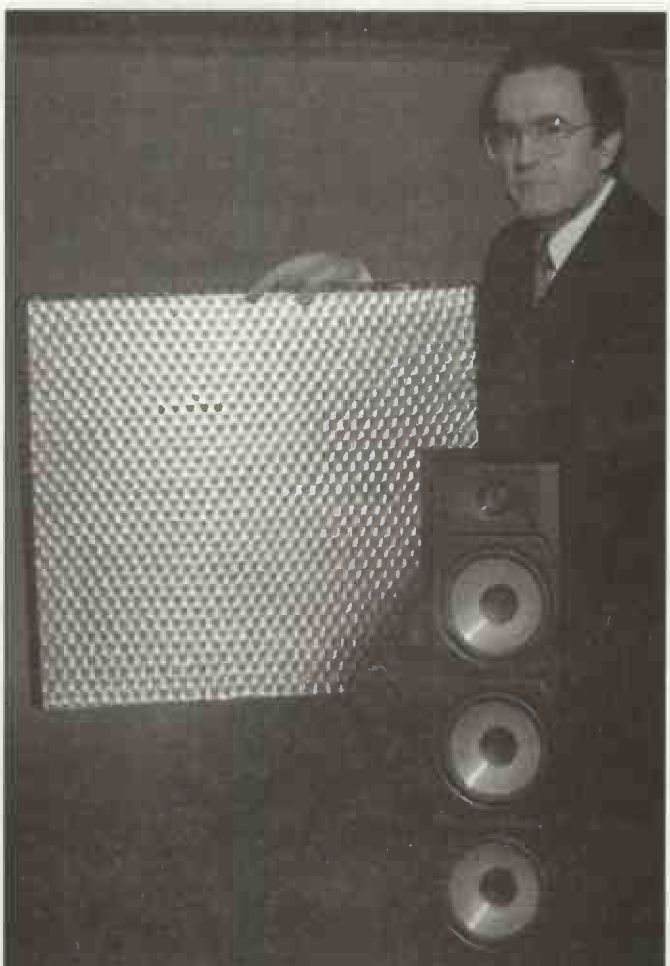
Figure 7: power drop with distance



I don't believe your ears! Design for a fold-out laptop with thin panel speakers.

past you and does not reach your ears. It is also partly a function of the very complex vibrational mode.

One of the many effects of this is that if you are using NXT flat panel speakers as part of a public address system, the microphone can get close to the loudspeakers before feedback occurs, because the sound intensity at a point does not rise in the same way that it does when you approach a small area piston-type loudspeaker. Other implications of this effect are discussed below.



Chief Executive Farad Azima with an improbable-looking but remarkable-sounding NXT flat speaker panel.

I was given a flat panel speaker to handle while it was actually working. The model I handled was rectangular and roughly 1 metre by 0.5 metre, and being made almost entirely of a secret composite material of about the same weight as corrugated cardboard (and indeed appeared similar in structure) was very light, and as I turned it round I noticed very little change in sound level or quality until it was almost edge-on to my ears. There was very little sound vibration to feel, even at a reasonable listening level, though the quality of the sound was affected by where I held the panel. Holding it in a way that would disturb its complex vibrational pattern could noticeably impair the sound quality. The transducer which excites the vibrations in this panel was only noticeable as a slight ripple in the surface. Unsurprisingly, given the extreme complexity of the vibrational mode, it was off-centre rather than central as you would expect with a piston-type loudspeaker.

One part of the demonstration which made an impression upon me was the use of a mock ceiling tile in the foyer for an announcement. I first heard it while I was in the listening room, through the open door, and for something that was plainly audible under these circumstances it was not exceptionally loud when I stood right underneath the NXT tile. This really brought home to me the point about how much the very even volume dispersion will be able to improve the quality of public address systems.

Loudspeaker applications

Although the first application which may come to many peoples minds is for flat panel hifi loudspeakers for domestic use, a likely application to come first is that of multimedia laptop computers. The loudspeakers in laptop computers are inevitably small, with an inevitably shrill tone. The picture here shows a possible application, with flat panel loudspeakers as pull out ears from the sides of the display.

In fact, it may turn out to be possible to make displays with the right mechanical characteristics to work as the loudspeakers. Yes, the plural was deliberate. If two drivers are used, one to each side of the screen, then although the whole panel will radiate the sound from each driver, the sound straight from the driver will reach the ear before that which has travelled across the panel before being radiated. This timing information has been shown to give the ear directional cues, hence stereo.

Obviously, public address or, more correctly, sound reinforcement with little tendency towards feedback will be a great boon, the other aspect of the acoustic characteristic, that of less reduction of sound intensity with distance, is equally valuable. What it means is that fewer loudspeakers are needed to give audible sound over a wide area. A particular plus point from many peoples point of view is that there is not a specially loud area just under a roof loudspeaker.

Recently we ended up leaving a bar in which the only unoccupied tables were those directly under loudspeakers, but the bar staff would not turn the sound any lower otherwise some people couldn't hear it. NXT loudspeakers, in place of the occasional ceiling tile, would have gone a long way towards solving this problem. A ceiling tile as a sound source will likely be welcomed in airport waiting rooms and the like, ensuring that all can hear the announcements without the need to deafen those near the loudspeakers.

Of course, if unobtrusive loudspeakers can look like ceiling tiles, then so can microphones. Bugging in plain sight might be the next fashion in international espionage

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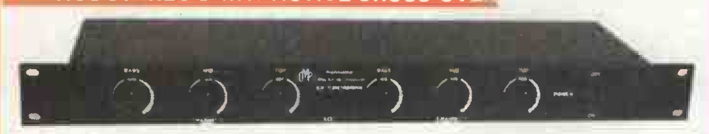

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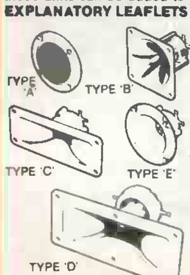

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The Japanese intend to go a large step better. In overcrowded Japan, space is at a premium, and a company which makes pre-formed bathrooms - the whole thing, washbasin, floor and all - is now planning to make pre-formed wall panels which will be NXT type loudspeakers. Then the stereo speakers will not occupy any room space - just connect the hifi system to the wall and listen in comfort. Of course, sound will also be radiated from the other side of the panel, into the adjoining room, but I do not doubt that when the time comes there will be an answer to this - perhaps a second panel to cancel the sound from the first in one direction only.

This brings me to another application. With the drive for quieter machinery, it is likely that active sound deadening will be incorporated, within the next few years into a number of products. The less directional response at high frequencies will make the NXT panel more effective as an active sound cancellation source. While it is unlikely that the distribution pattern of the NXT loudspeaker will exactly match the source of noise, it is likely to do so reasonably over a wider angle and thus be more effective than an ordinary loudspeaker.

Electrical characteristics

The energy transfer from the loudspeaker to the air is complex and fairly efficient. It is also similar over a wide range of frequencies. The effect of this is that there are no mechanical effects of the sort which make the graph of the impedance of an ordinary loudspeaker far from smooth. The curves supplied look like simple resistance plus the inductance of the moving coil transducer.

This means, of course, that it is very likely that fancy loudspeaker cables will be less relevant, and that amplifier distortion will be lower because the impedance being driven is so much nearer to a plain resistance.

Why should loudspeaker cables matter less? Well there has for some time been controversy as to whether loudspeaker cables do have a significant effect on sound, but it is increasingly accepted that some difference between cables does exist, and it seems plausible that the differences are caused by resistance, inductance, and capacitance reducing the ability of the amplifier to damp resonances of the loudspeaker. A loudspeaker which has a resistive impedance and little in the way of resonances is less likely to be affected by a little extra impedance between it and the amplifier.

There are two ways to excite the NXT panel using moving coil drivers, and these are illustrated in figures 8 and 9. The first is an inertial magnet driver in which the mass of the magnet must be sufficient that the majority of the vibration is transferred to the panel and not to the magnet, while the other sort of driver is a clamped driver which bends the panel. This has a much higher mechanical impedance. It would also be possible to drive an NXT panel with a piezo-electric transducer, but this would not match well with ordinary hifi amplifiers.

In any event, the magnitude of vibration of a panel is typically a few microns over the middle frequency range, well within the elastic limit of the material. Thus, the panel itself adds negligible distortion to the signal. Also, the magnet and coil move very little relative to each other, so that distortion caused by any unavoidable non-uniformity of magnetic field is minimised.

Figure 10 shows second and third harmonic from a typical conventional loudspeaker compared with that from a typical NXT.

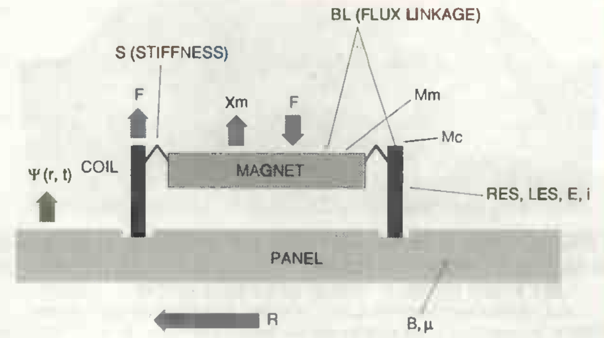

Figure 8: an inertial magnet driver

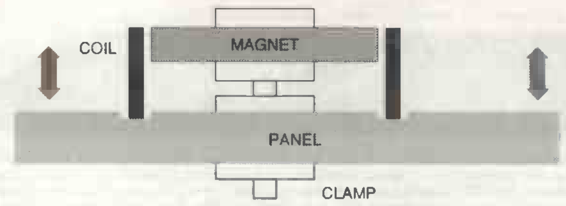

Figure 9: a clamped (bender) driver

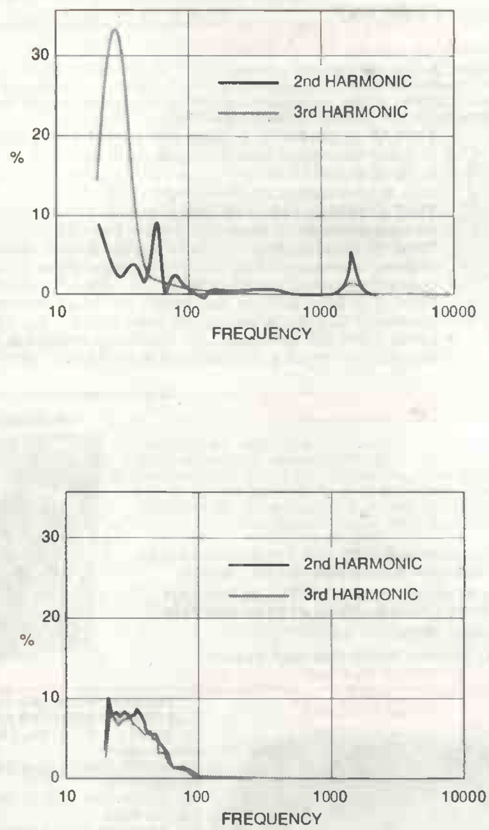

Figure 10: comparative distortion.

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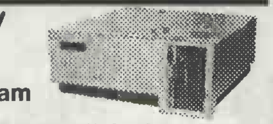

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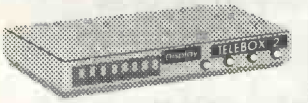

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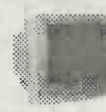

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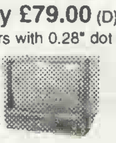

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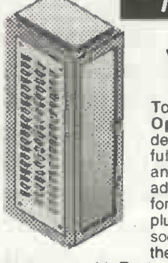

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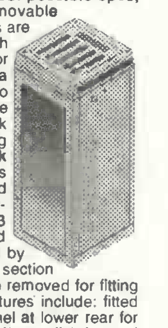

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Commercialisation

NXT have licensed their sister companies Mission and Wharfedale to make loudspeakers with this technology, but they are also licensing other, unrelated, companies worldwide, such as NEC and the pre-formed wall panel manufacturers mentioned above. They have recently licensed Samsung. A cross-licensing agreement has also been signed with United States company Noise Cancellation Technologies (NCT), with NCT, which has developed its own piezo-electric Flat Panel Transducer technology, sublicensing the joint intellectual property in the automative and transportation sectors allied to noise cancellation issues, while NXT expands its sub-licensing activities in all other fields. Each company will be able to include the other's technology in its own sub-licences

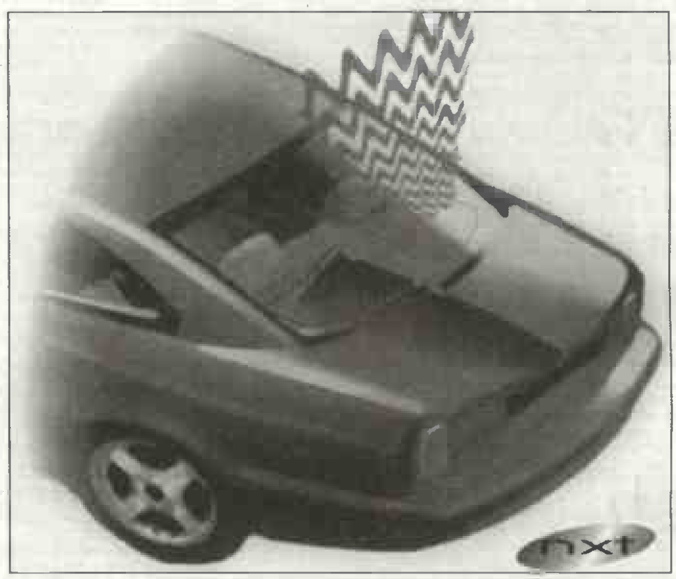
What the licensee gets is design software, and the right to use the technology in a particular product area. Without the software it would be effectively impossible to design an NXT type loudspeaker, and even with the software it may be difficult first time round. The NXT team have been able to advise licensees on how to get the results they need on their introduction to the new technology.

They have also suggested a machining technique. It is necessary for the correct functioning of the loudspeakers that the edge is free to vibrate normally. Cutting methods which cause irregularities on the edge, or which melt the edge of the material to form a stiffer rim around the cut, interfere with the correct functioning of the panel. NXT has found that cutting with high pressure water jets is most effective.

The folks at NXT reckoned that products incorporating the next flat panel technology might be available as early as July 1997, perhaps in the USA. The first application on the market is quite likely to be - yes - a multimedia laptop PC. The first hifi applications may be available by the end of 1997.

The design and the tuning of the manufacturing process to produce loudspeakers that work well may be much more difficult than for conventional loudspeakers, but it is also likely that the unit costs in volume production will be much less than for conventional speakers, at least for the higher quality applications. Maybe this will not initially translate to lower prices, but rather to higher ones due to the novelty value. In the long run, however, I expect top quality loudspeakers which I can place on the wall, or in the wall, or even *instead of* the wall, to be available prices comparably lower than the traditional loudspeaker technology.

NXT speakers with their lightweight nature and superior sound quality, are a natural match for all mulitimedia computing applications, in particular notebooks and PDAs.



NXT speakers integrated with rear parcel shelf of a car, acting as a structural member. The nature of NXT sound provides uniform sound distribution in the car environment without any hot spots.

Below: NXT's table of applications for the first products expected on the market

Application	Response	Sensitivity	Characteristics
SonTile™	100Hz-12kHz	87db	Unique voice intelligibility; concealed speaker mounting; lightweight; exceptional sound distribution; very low installation cost.
Multimedia and laptops	200Hz-12kHz	84dB	Much superior to conventional speakers computers fitted to laptops and mm computers
Stereo audio (.6msq)	100Hz-18kHz	88dB	High quality stereo sound, slimline, matched to decor
SoundField™	120Hz-18kHz	87dB	Exceptional ambient sound field creation, most suitable for rear channel AV; cinema and domestic
SoundVu™	60Hz-18kHz	88dB	Unique performance and combination of diffuse soundfield loudspeaker with video screen; large audience coverage.

Construction Authors

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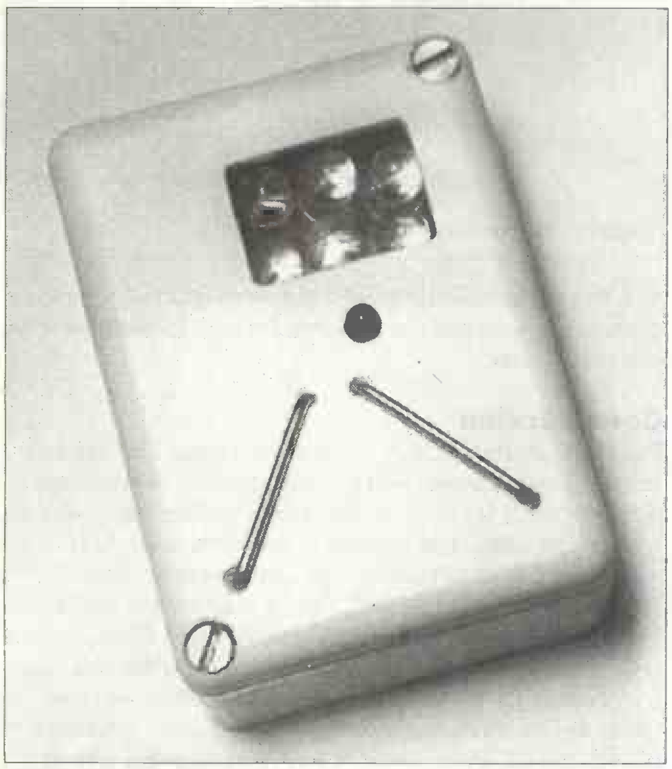
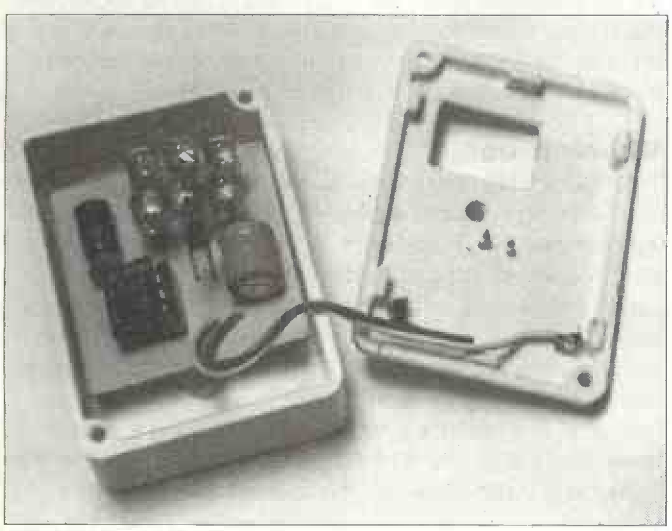
Low power, light-powered

By Terry Balbirnie

Continuity Quick-Tester

Hold it up to a light - and presto! Needs no batteries.





A continuity tester is a device that indicates a low resistance path. It would be useful having one in the home or workshop for testing fuses and filament lamps, to identify switch and relay contacts, to look for breaks in pieces of wire or PCB tracks and to find faulty connections in plugs and sockets. You could also use one to check situations where there should not be continuity - for example, where a blob of solder has bridged adjacent PCB tracks.

Using a meter

Of course, if you have a multi-tester you could set this to a low resistance range and use it for the purpose. A low reading would indicate continuity. Using a meter would be fine if it was always to hand and if it was to be used by an experienced person. However, someone who did not have the necessary knowledge would not be able to set the range correctly and they might have difficulty interpreting the reading. To have an instrument specially made for the job is definitely a good idea. The traditional type has the disadvantage of being battery-operated - as it will probably be used only occasionally, the battery is likely to be found missing just when you need to make a test (having been "borrowed" for something else), or gone flat from being left on or just from old age.

Testing - with a difference

This continuity tester is different because it does not use batteries and has no on/off switch. This is because it uses light as an energy source! Even artificial room lighting will be sufficient to make it work. Normally, the tester will be left in a position where light can reach it, such as on a window sill, and it will then be available for instant use. If it has been kept in the dark - in a drawer, for example, it will be ready to operate in a minute or two. This circuit is principally a one-shot device intended to give one test at a time. This is because, after providing a positive result, there is a delay before it will respond again. This "dead" time will depend on the brightness of the ambient light - in normal room lighting it will be about one or two minutes but in bright daylight it may only be a second or two. There is a trick which enables several tests to be made in quick succession and this will be explained at the end.

The circuit will respond to resistances from zero to about 200 ohms. This makes it suitable for checking lamp filaments (whose cold resistance will be a few ohms or tens of ohms), many transformer windings, chokes and relay coils in addition to "straight" continuity tests. It will even identify a good diode (because this will show continuity when connected one way but not the other). The Continuity Quick-Check is very versatile and, no doubt, readers will find other uses for it.

The object to be tested is used to bridge a pair of wire rails arranged in the form of an inverted "V" on top of the box. A red LED will then flash to show continuity. Most fuses, switch tags, bulbs and connectors will bridge the rails quite easily. Where this is not possible, a pair of extension leads may be made, as described at the end.

How it works

The circuit for the Continuity Quick-Check is shown in figure 1. The components labelled D1 - 6 are silicon photodiodes (LEDs). However, in this circuit they are used as photovoltaic cells. When light shines on them, they develop a small voltage between their ends. This voltage will be some 0.2V to 0.4V over a wide range of light levels. The ability of this type of device to deliver current is very limited and will depend on the brightness of the light reaching it. In sunlight, for example, it may reach 1mA or more. In room lighting it will fall to 2mA or less. Photovoltaic cells make a convenient and compact power source when only a small current is needed. @B:Conventional solar cells appear to be available only in larger sizes and since several of them would be needed, the finished device would be rather large. Also, they do not respond as well as the specified devices in room lighting. Note that not all photodiodes will work in this circuit, and it is essential to use the type shown in the parts list unless you are prepared to experiment.

The photodiodes are connected in series. Thus, the voltage across the set will be six times greater than that across one. With an average value of 0.3V, this will provide a nominal 1.8V. This charges capacitor C1, which is then used to power the rest of the circuit. If the LEDs are shaded so that light can no longer reach them, the charge stored in C1 cannot easily drain back through the diodes. This might appear to be possible because they are forward biased (see figure 1). However, each one needs about 0V6 across it to conduct (that is, 3V6 for the set of six) but the maximum voltage across the capacitor is only 2V4 (with 0V4 across one photodiode) or thereabouts. The photodiodes can therefore "pump" charge into the capacitor but, once there, it can only escape by leakage or, of course, by being used. In the prototype unit, the capacitor self-discharges in 30 minutes approximately. After having charged up, the tester will therefore be capable of working for some time even in darkness.

When the rails are bridged by a low resistance, the positive end of C1 will be connected to IC1 input, pin 5, and establishes a supply to it. This component is an LED flasher/oscillator and C2 is the capacitor needed to make the circuit oscillate (provide pulses). There is also a voltage-doubling effect whereby the pulses applied to light-emitting diode, LED1, are of double supply voltage (nominally 3V6). Note that no series resistor is necessary here because current limiting takes place on the chip. LED1 will continue to flash until C1 has discharged to about 1V. Below this, the ic stops working and also (taking into account the voltage doubling effect) there will be insufficient to operate the LED. Normally, the charge arriving will be much less than that being drawn so that C1 will be substantially discharged during each test - hence the need for recovery time referred to earlier.

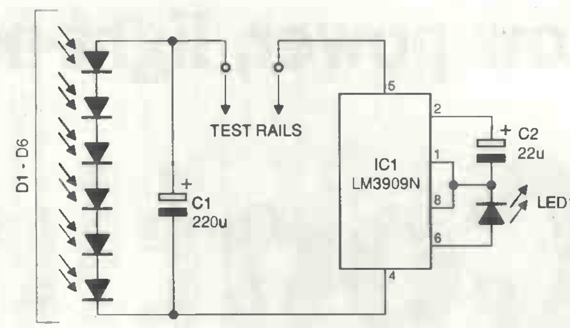


Figure 1: the circuit

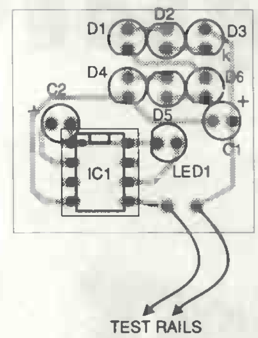


Figure 2: the component layout

Construction

The PCB component layout is shown in figure 2. Begin by mounting the ic socket and photodiodes D1 - 6 (these are simply labelled "1" to "6" in the diagram). Take care, because it is easy to solder one or more of them the wrong way round and this would prevent the circuit from working. The cathode (negative) of each ("k" in the diagrams) is identified by a slightly shorter lead and by a "flat" on the body. Add the LED, again, taking care over the polarity. Note that, although a standard LED will work, a high-brightness type will give better results. Both capacitors are electrolytics - check the polarity. Solder short pieces of light-duty stranded wire to the pads labelled "test rails". Insert the ic into its socket with the correct orientation. Since this is a CMOS device, it can be static sensitive - it is wise to touch something earthed (such as a water tap) before handling the pins.

Check it out

The PCB should now be checked before it is mounted in the box. Keeping the wires separated, place it on a table so that light reaches the photodiodes. Allow about two minutes for the capacitor to charge sufficiently for a test to be made. Touch the wires together. The LED should flash a few times showing that there is a low-resistance path between them. If this test does not work, allow more time for the capacitor to charge or use brighter light.

If all is well, the box may be prepared. Begin by measuring the positions of the photodiodes and LED on the PCB. Mark these places on the lid and make holes to

correspond. The two wire rails should now be cut out. In the prototype, pieces of paper clip were used with their ends bent through right-angles. Small holes are drilled in the lid so that, when the ends of the wires are passed through, they form an inverted "V". Leave a small space between each rail and the lid of the box. The wires from the PCB should now be soldered to one end of each rail on the inside. Paper clip material is not the easiest to solder to, and care must be taken to use sufficient heat to make good electrical connections without melting the plastic. If necessary, the ends may be locked in position using a little quick-setting epoxy-resin adhesive or they may be carefully bent over. The PCB may be secured inside the box using an adhesive fixing pad and raised as necessary so that the LED protrudes slightly through its hole.

Short pieces of wire with a small crocodile clip on one end a test probe on the other will be useful for checking items where it would be difficult bringing them into direct contact with the test rails. The crocodile clips are simply clipped on to the rails. This method will be useful when checking the continuity of PCB tracks.

Multiple tests

There may be times when several tests need to be made in quick succession. This may be done by holding the unit within 1ft (30cm) of an ordinary, say 60W, light bulb for two or three seconds each time. This will make the unit ready for use again almost instantly. Note that when using the tester, the best sources of light are daylight and tungsten filament bulbs. Fluorescent light is rather poor for the purpose.

All components for the Continuity Quick-Check were obtained from Maplin.

PARTS LIST

Capacitors

C1	220u 10V radial electrolytic
C2	22u 10V radial electrolytic

Semiconductors

IC1	LM3909N
D1 - 6	SFH2030 silicon photodiodes, Maplin order code CY90X
LED1	3mm high-brightness red LED

Miscellaneous

PCB materials, 8-pin dil socket, plastic box.

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1N4149	£0.06
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2N2219A	£0.25
2N2222A	£0.18
2N2646	£1.12
2N2904A	£0.25
2N2905A	£0.25
2N2907	£0.20
2N2907A	£0.20
2N2926	£0.16
2N3053	£0.27
2N3054	£0.85
2N3055	£0.58
2N3439	£0.62
2N3440	£0.50
2N3702	£0.09
2N3703	£0.10
2N3704	£0.10
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.70
2N3819	£0.42
2N3820	£0.66
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
2N4036	£0.34
2N5245	£0.80
2N5296	£0.57
2N5321	£0.57
2N5322	£0.57
2N5401	£0.11
2N5551	£0.11
2N6107	£0.60
2N6491	£1.58
2SB548	£0.30
2SD1730	£1.44
AC126	£0.44
AC127	£0.50
AC128	£0.40
AC187	£0.48
AC188	£0.48
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AD149	£1.67
AD161	£0.92
AD162	£0.92
BC107	£0.16
BC107B	£0.17
BC108	£0.17
BC108B	£0.16
BC108C	£0.15
BC109	£0.17
BC109C	£0.19
BC114	£0.19
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.16
BC159	£0.17
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.18
BC179A	£0.17
BC182	£0.11
BC182A	£0.11
BC182B	£0.12
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC207B	£0.74
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213B	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC225	£0.15
BC237B	£0.09
BC238B	£0.09
BC238C	£0.09
BC239C	£0.10
BC250A	£0.15
BC251	£0.13
BC252	£0.13
BC261B	£0.30
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC319C	£0.13
BC327	£0.10
BC327-25	£0.10
BC328	£0.10
BC328-16	£0.10
BC337	£0.10
BC337-25	£0.12
BC338	£0.10
BC338-25	£0.10
BC348B	£0.14
BC357	£0.25
BC393	£0.73
BC414C	£0.13
BC441	£0.40
BC461	£0.46
BC463	£0.29
BC478	£0.32
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BC490	£0.24
BC516	£0.22
BC517	£0.17
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546B	£0.08
BC546C	£0.08
BC547B	£0.09
BC547C	£0.09
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557B	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
BC560A	£0.09
BC560B	£0.09
BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.13
BCY70	£0.22
BCY71	£0.20
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BD124P	£6.86
BD135	£0.21
BD136	£0.21
BD137	£0.23
BD138	£0.22
BD139	£0.25
BD140	£0.25
BD150C	£0.82
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BD166	£0.35
BD187	£0.39
BD201	£0.40
BD202	£0.40
BD203	£0.40
BD204	£0.40
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BD225	£0.42
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BD238	£0.44
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BD246C	£1.18
BD283	£0.61
BD284	£0.61
BD400	£0.79
BD441	£0.41
BD442	£0.37
BD534	£0.47
BD535	£0.50
BD536	£0.65
BD581	£0.62
BD597	£0.92
BD646	£0.52
BD648	£0.52
BD650	£0.53
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BD708	£1.04
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BF194	£0.31
BF194B	£0.19
BF195	£0.19
BF244	£0.35
BF244B	£0.40
BF244C	£0.35
BF257	£0.33
BF259	£0.33
BF337	£0.40
BF355	£0.38
BF423	£0.13
BF451	£0.19
BF459	£0.33
BF469	£0.36
BFX29	£0.29
BFX84	£0.31
BFX85	£0.32
BFY50	£0.30
BFY51	£0.25
BFY52	£0.28
BS107	£0.21
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TIP50	£0.53
TIP121	£0.48
TIP122	£0.48
TIP125	£0.46
TIP127	£0.40
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VN10KM	£0.48
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No Minimum Order Value

	Electrolytic Radial					Electrolytic Axial						
µF	16v	25v	40v	63v	100v	16v	25v	40v	63v	100v	250v	450v
0.47	---	---	---	£0.05	---	---	---	---	---	---	---	---
1.0	---	---	---	£0.05	£0.05	---	---	---	£0.13	---	---	£0.22
2.2	---	---	---	£0.05	---	---	---	---	£0.13	---	---	£0.30
4.7	---	---	£0.05	£0.05	£0.05	---	---	---	£0.13	---	---	£0.41
10	£0.05	£0.05	£0.05	£0.05	£0.09	£0.12	---	£0.12	£0.13	£0.17	£0.40	£0.51
22	£0.05	£0.05	£0.05	£0.07	£0.11	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	£0.05	---	£0.05	---	---	---	---	---	---	---	---	---
47	£0.05	£0.05	£0.07	£0.10	£0.19	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	---
100	£0.06	£0.06	£0.10	£0.13	£0.26	£0.14	£0.16	£0.19	£0.26	£0.44	---	---
220	£0.08	£0.09	£0.13	£0.25	---	£0.19	£0.20	£0.27	£0.39	£0.48	---	---
330	£0.09	---	£0.19	---	---	---	---	---	---	---	---	---
470	£0.12	£0.17	£0.24	£0.33	---	£0.24	£0.28	£0.43	£0.53	---	---	---
1000	£0.15	£0.33	£0.34	---	---	£0.33	£0.43	£0.59	£1.08	---	---	---
2200	£0.27	£0.55	£0.70	---	---	£0.53	£0.66	£1.11	£1.55	---	---	---
3300	---	£0.94	---	---	---	---	---	---	---	---	---	---
4700	£0.67	£1.05	---	---	---	£0.86	£1.11	---	---	---	---	---

Ceramic Mini Disc
1.0,1.2,1.5,1.8,2.2,2.7,3.3,3.9,4.7,5.7,6.8,8.2

1.0pF to 22nF 100V	£0.06
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330nF 100V	£0.16
470nF 100V	£0.22
1.0µF 100V	£0.29

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Dual Gang - ¼" Shaft, 20mm Dia.	1K0-2M2 Logarithmic	£1.71 Each
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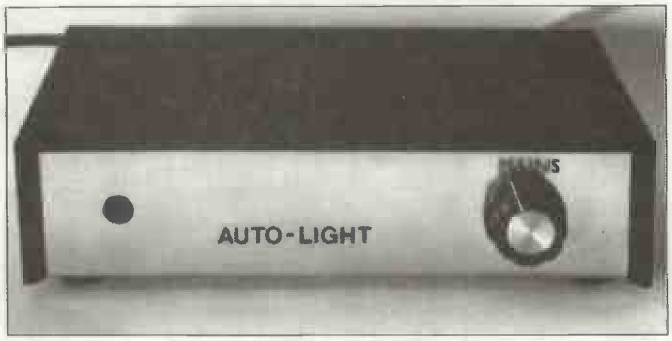
Infra-red Activated Auto Light



Robert Penfold's auto light switch is driven by a low-sensitivity, low-power pyro detector to provide movement-sensitive indoor lighting for night-time wanderers.

This project will be of interest to anyone who has got up in the middle of the night and stumbled around looking for the light switch. It is essentially the same as an outside security light, but it has much lower sensitivity as it is only intended for indoor use. Simply moving around near the sensor results in the controlled light being switched on. You can climb the stairs with your Once switched on, the light remains on for about one minute after the last activation of the sensor. This delay is sufficient to ensure that the light does not get a bout of the "flickers", but it is short enough to prevent the light from staying on for long periods of time when no one is present. The delay time is easily altered to suit individual requirements.

Like security lights, this unit uses a passive infra-red detector, but as only a limited range is required it does not use any form of lens system. Even so, a range of a few metres can be achieved. One disadvantage of using a lens-free detector is that the angle of view is not very large. However, this will not normally be of any great significance, and good results should still be obtained provided the unit is installed in a suitable place. Of course, a lens system can be used if either high sensitivity or a wide angle of view are essential, but a lens should not normally be required. This type of sensor is activated by the body-heat of someone moving within its area of coverage. An advantage of this type of sensor is that it is not easily "fooled", and false alarms are rare occurrences. Something like a moth flying around the room will not activate the light!

The pyro-sensor

The infra-red sensor, or "pyro" sensor, as this type of component is normally called, is a ceramic device. It is in some respects similar to a Piezo-electric component such as a crystal microphone, and consists of a slice of ceramic material with an electrode on each surface. However, rather than the twisting of the ceramic material producing a voltage across the electrodes, it is heat that produces an output signal. Normal semiconductor infra-red detectors are sensitive to wavelengths of around 900nm, which is close to the visible red part of the spectrum. Pyro sensors operate at much longer wavelengths of around 1 to 20 micrometres. In other words, pyro sensors carry on where ordinary infra-red devices leave off.

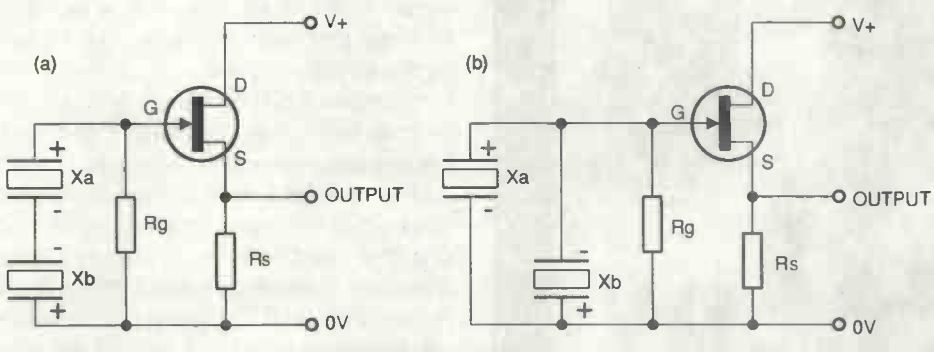


Figure 1: two-element pyro-sensors use anti-phase sensing elements to reduce sensitivity to background infra-red

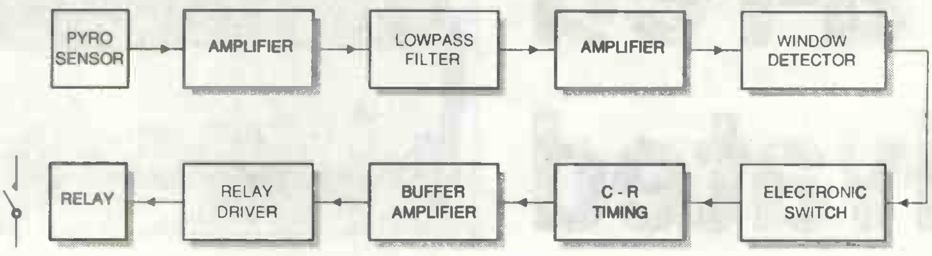
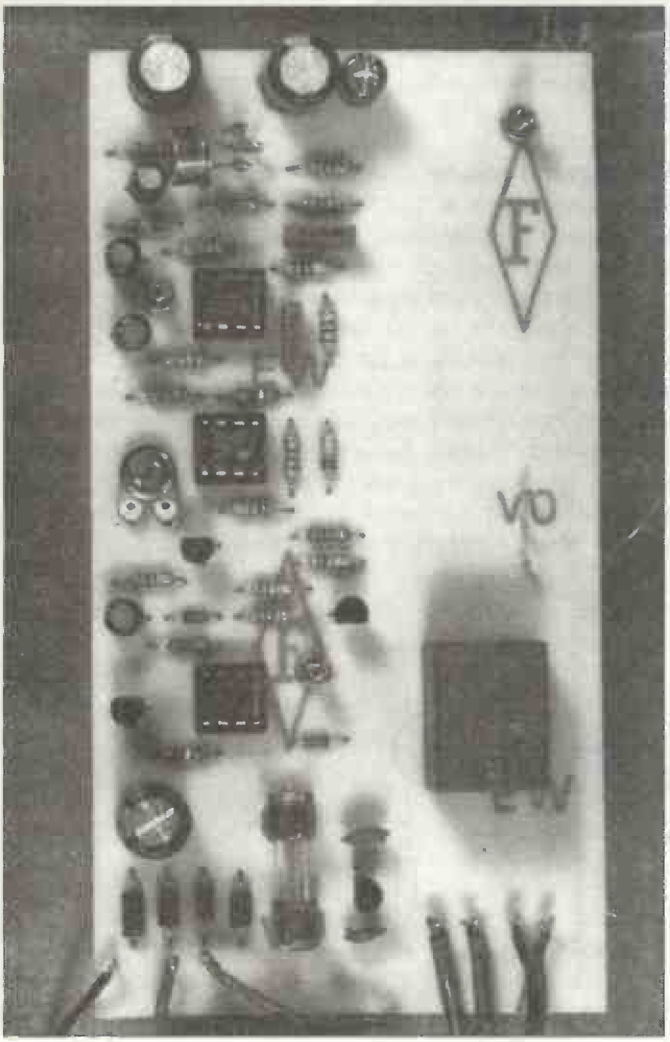


Figure 2: the block diagram for the auto-light

Most pyro sensors have two sensing element connected out-of-phase. Some data sheets show the two elements connected in series (figure 1a), while others show them connected in parallel (figure 1b). In either case the effect is much the same, with the output from one element tending to cancel out the signal from the other element. This may seem to be of little practical value, but you have to bear in mind that the purpose of a pyro sensor is not to detect a steady level of infra-red. It is designed to detect a moving infra-red "target", and in normal use the infra-red "light" is swept across the sensor as the detected person moves across the field of view. The infra-red signal is therefore detected by one element and then the other. This gives a positive signal from the first element followed by a negative signal from the second element, or vice versa.



In either event, the result is a strong output signal from the sensor. The point of using two sensing elements is that it provides a cancelling effect on any changes in the background infra-red level, which will affect both elements simultaneously, it but provides good sensitivity to anyone crossing the field of view. As a result, it is possible to achieve high sensitivity with only very infrequent spurious triggering.

Practical pyro sensors invariably include a jfet buffer amplifier, which provides a relatively low output impedance despite the high output impedance of the sensing elements. The load resistor for this amplifier is sometimes included in the sensor, but in most cases it is a discrete component. The gate bias resistor is invariably built into the sensor. A pyro sensor has a strictly limited frequency response which typically extends from about 0.3 hertz to around 3 hertz. The low frequency response is limited by the value of the bias resistor in the buffer amplifier.

The high frequency response is limited by the time it takes for the sensing elements to heat up and cool down. The slices of ceramic material are made very thin in order to maximise the high frequency capabilities, but an upper limit of a few hertz is the best that can be achieved. In practice this very limited response is adequate, and is actually well matched to the frequency of the signals generated in this application.

System operation

Figure 2 is the block diagram for the automatic light. The output level from the pyro sensor will usually be extremely small, and may sometimes be under one millivolt peak to peak. A large amount of amplification is therefore needed in order to provide reliable operation of the main circuit. The output signal from the sensor is therefore boosted by two high gain amplifiers. These provide an output level of a few volts peak to peak even if the output signal from the pyro sensor is very weak. With such a high level of gain there can be major problems with noise. This noise is in part generated by the amplifiers, but it is to a large extent produced by the pyro sensor. It can be greatly reduced by lowpass filtering, and the filter cut-off frequency can be set very low due to the low signal frequencies involved in this application.

This enables a large amount of attenuation to the obtained at the mains frequency of 50 hertz. Direct pick-up of mains "hum" from mains powered lighting seems to be absolutely minimal, but it is difficult to avoid a small amount of stray pick-up in the wiring. The lowpass filtering avoids problems with spurious triggering due to stray pick-up of "hum" and noise spikes in the input wiring.

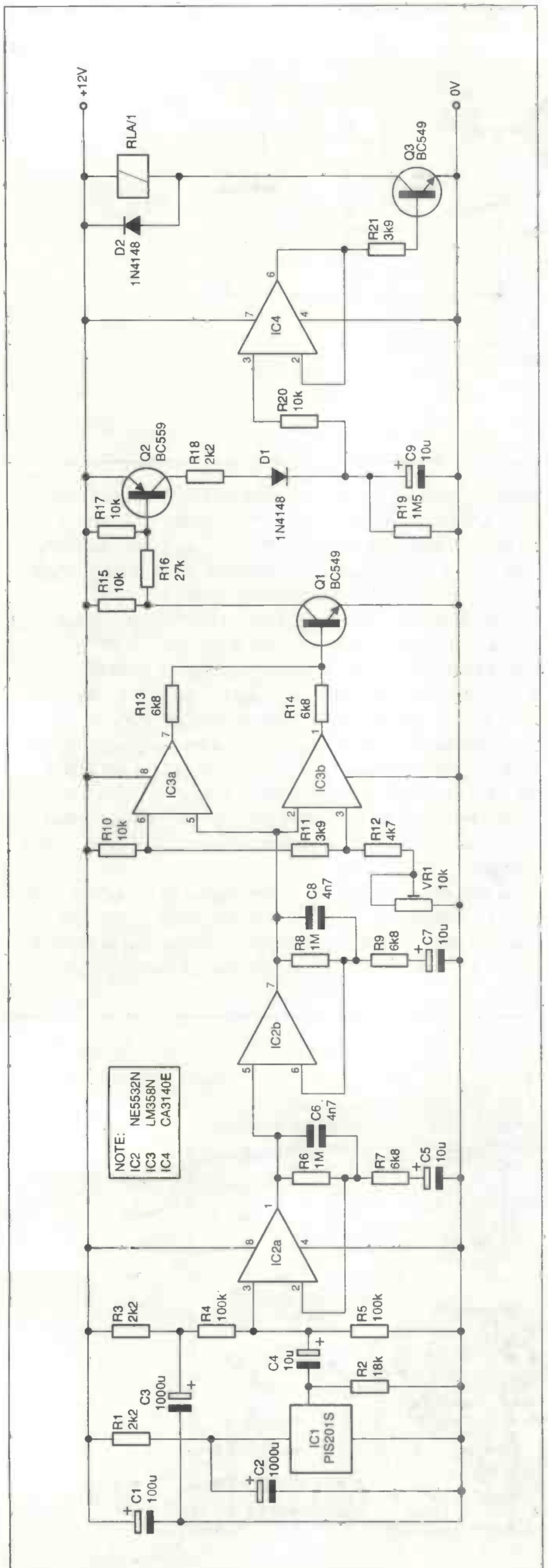


Figure 3: the main circuit diagram for the auto-light

The output potential from the second amplifier is normally about half the supply voltage, but it varies around this level when the unit is activated. A window discriminator detects when the voltage potential of the amplifier strays by about one volt or more from its quiescent level. It then turns on an electronic switch which in turn drives a C-R timing circuit. This circuit has a fast attack time so that the light is switched on almost at once when the unit is activated. Its decay time is very much longer so that once the light is switched on it does not switch off again for about half a minute. If the unit is activated before the voltage on the timing capacitor has decayed, the charge voltage will be boosted to its maximum level again. In this way the time that the light is switched on is controlled by a combination of the timing circuit and whether or not the unit continues to be activated.

The timer stage feeds into a buffer amplifier which ensures that loading on the timing capacitor does not significantly affect the circuit's decay time. The output of the amplifier controls the relay via a simple driver stage. A normally open relay contact connects power through to the controlled lamp while the relay is switched on.

Circuit operation

Figure 3 shows the main circuit diagram for the auto-light. The circuit for the mains power supply unit and the other mains wiring is shown separately in figure 4. Taking figure 4 first, IC1 is the pyro sensor, and it is a type which requires a discrete load resistor (R2). The circuit should work well with any similar pyro detector, but R2 should obviously be omitted if a sensor having an integral load resistor is used. C4 couples the output from IC1 to a two stage non-inverting mode amplifier based on IC2. The two sections of IC2 are used in identical amplifiers which each provide a voltage gain of about 150. The lowpass filtering is provided by C6 and C8, which provide increased feedback and reduced gain at frequencies of more than a few hertz. Biasing for these direct coupled stages is provided by R4 and R5. With such high gain there is a risk of feedback through the supply lines causing low frequency oscillation. Both IC1 and the bias circuit for IC2 are fed from the positive supply line via a decoupling network which has a long time-constant, and this avoids problems with low frequency instability.

IC3 is used in a conventional window discriminator which has R10, R11, R12, and VR1 to produce the two reference voltages. VR1 enables the reference voltages to be adjusted to suit the exact output voltage of IC1 under standby conditions. The output of IC3a goes high if the upper reference level is exceeded, and the output of IC3b goes high if output of IC2b drops below low lower reference potential. In either instance, Q1 is switched on, and it in turn switches on Q2. C9 is then rapidly charged via R18 and D1, but when Q2 switches off again D1 ensures that no current can flow back into Q1 and Q2. The only significant discharge path for C9 is through the high value of R19. The voltage on C9 is used to control switching transistor Q3 via a simple voltage follower (IC4). Q3 drives the relay coil, and the relay remains switched on while the voltage on C9 remains at more than about 0.6 volts. It takes roughly one minute for the charge on C9 to decay from its maximum level to the point where the relay switches off, but this time is easily changed as it is proportional to the value of R19. For example, changing the value of R19 to 750k gives a hold-on time of about 30 seconds.

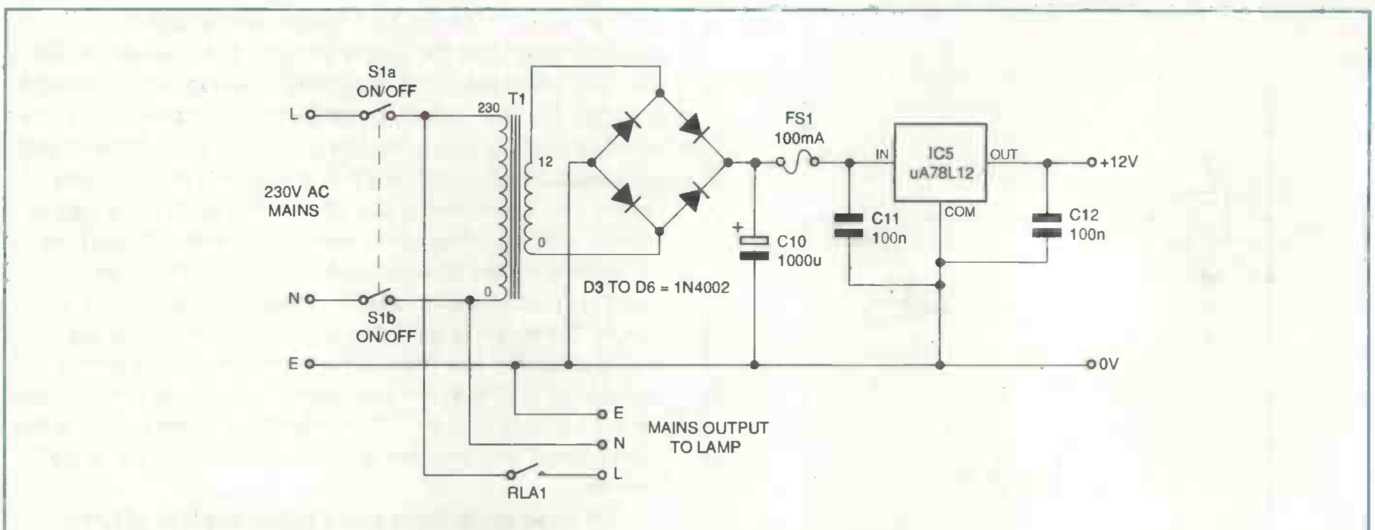


Figure 4: the circuit diagram of the mains power supply

The mains power supply unit (figure 4) has T1 to provide isolation from the mains and a voltage step-down. D3 to D6 form a bridge rectifier which full-wave rectifies the output from T1. Smoothing is provided by C10, and IC5 then provides regulation and electronic smoothing of the output. IC5 incorporates current limiting which protects the supply in the even of an overload, and further protection is provided by fuse FS1. The current consumption of the main circuit is only a few milliamps under standby conditions, but it rises to around 45 milliamps when the relay is switched on.

Construction

The component overlay for the printed circuit board appears in figure 5. This board is reasonably simple to construct, but there are one or two points that require some amplification. As far as the electrical characteristics are concerned, any relay that has a coil resistance of about 300 ohms or more and a 12 volt coil is suitable for use in this circuit. The only other proviso is that it must have at least one normally open contact having adequate ratings for this application. This means a contact rating of at least 230 volts AC and one amp. On the other hand, only the specified relay on an exact equivalent will fit this printed circuit design properly. This makes it extremely difficult to use an alternative relay, and I would strongly advise against doing so.

The CA3140E used for IC4 has a PMOS input stage, and consequently requires the normal anti-static handling precautions. The most important of these is to fit the device in a holder, and it is not a bad idea to use holders for the other to DIL integrated circuits even though they are not static-sensitive. The CA3140E should be supplied in some form of anti-static packaging, and it should be left in this until it is time for it to be fitted into its holder. Try not to handle the pins any more than his really necessary when fitting this device, and avoid any obvious sources of static charges.

One way of arranging the general layout of the unit is with the circuit board mounted on the rear panel of the case and the pyro sensor "looking" through a window cut in the front panel. If this approach is used the pyro sensor can be

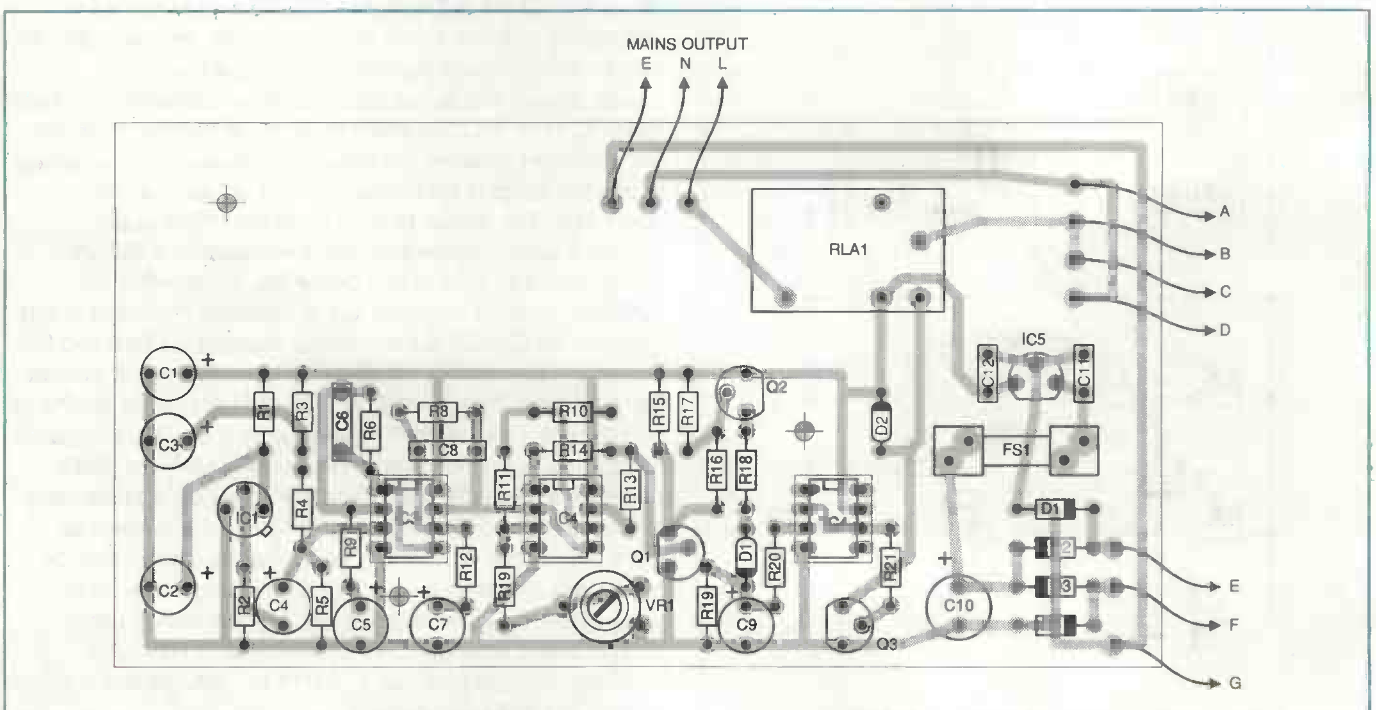


Figure 5: the component layout for the auto-switcher

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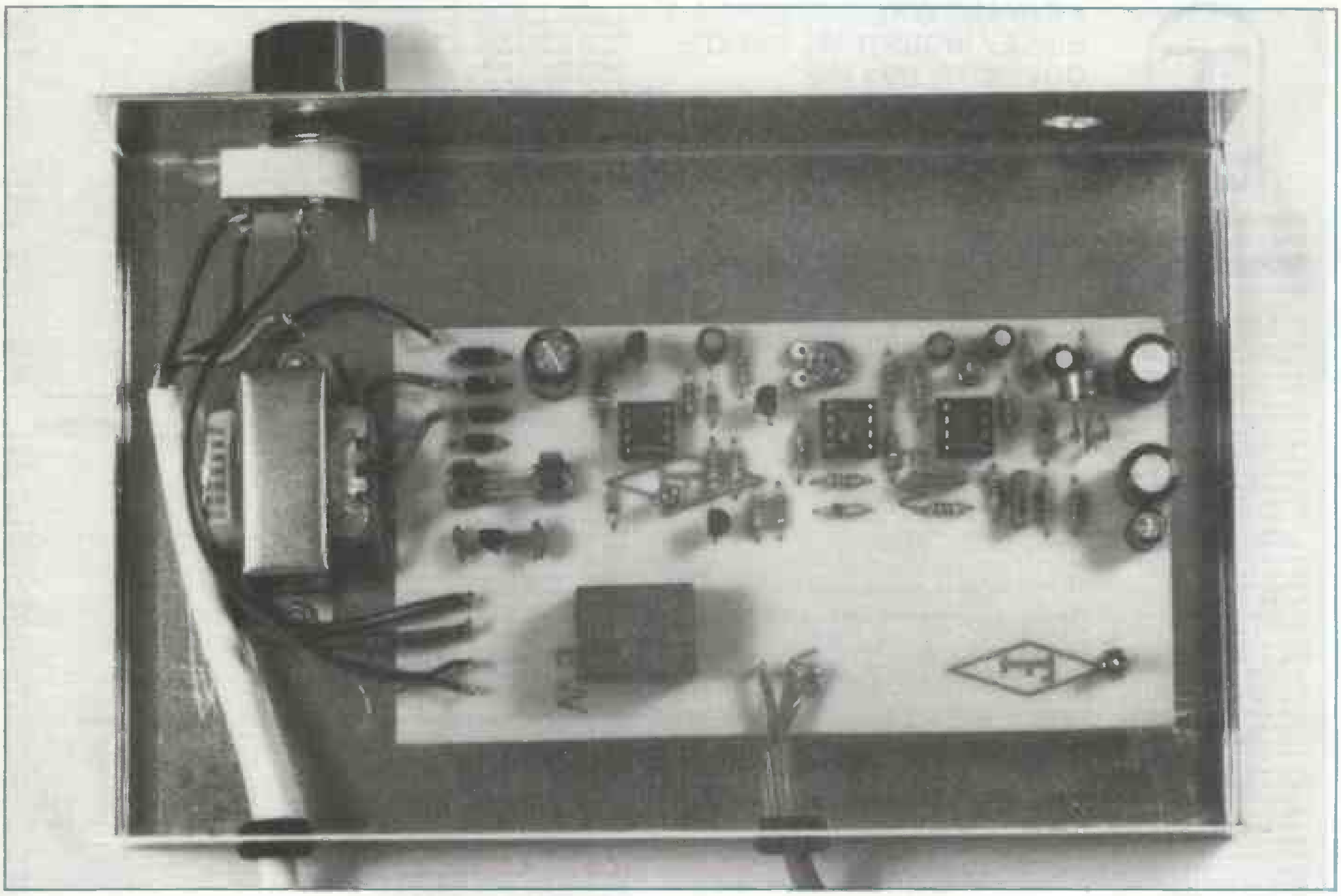

mounted on the circuit board in the usual fashion. For optimum result it should be twisted slightly so that its window is precisely horizontal. The alternative approach is to have the printed circuit board mounted on the base panel of the case. The pyro sensor still "looks" through a window cut in the front panel of the case, but the sensor will obviously have to be mounted on perpendicular to the circuit board. Probably the easiest way of doing this is to first it three solder pins to the board in place of the sensor. It should then be easy to fit the sensor on to the pins so that it is perpendicular to the board. Avoid touching the pyro sensors window as this could reduce its sensitivity. If you should accidentally touch the window use a soft cloth to clean away any finger marks.

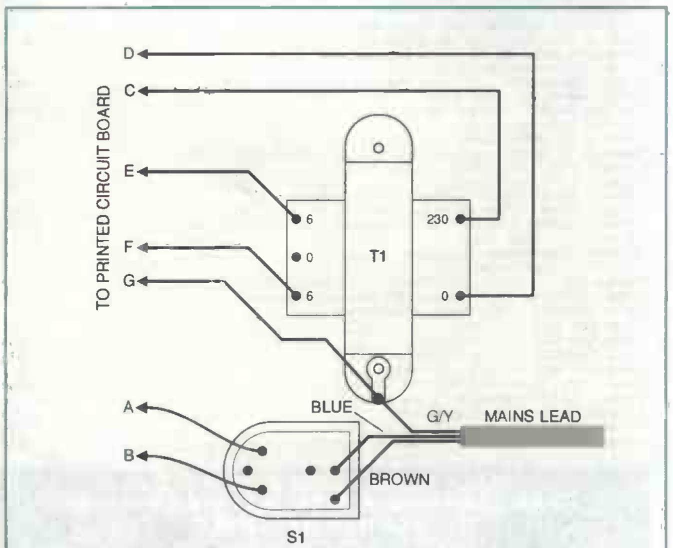

Figure 6: details of the hard wiring (use in conjunction with figure 5)

The fuse is mounted on the board via a pair of fuse-clips. The clips must be the type that has two pins, and not the single pin variety. C5 and C7 must be good quality electrolytic capacitors, or the biasing of the amplifier may be well off centre. Tantalum capacitors are ideal, but good quality electrolytic capacitors should suffice. In other respects construction of the printed circuit board is perfectly straightforward, but be careful to fit the diodes and rectifiers the right way round as mistakes here could cause damage to some of the components. Fit single sided solder-pins to the board at the points where connections will be made to the mains transformer, etc.

As this project connects to the dangerous mains supply it is essential that it is housed in a metal case that is reliably earthed to the mains earth lead. The case must also be a type which has a screw fitting lid or cover, and not one that has a clip-on lid that provides easy access to the mains wiring. Although it is not particularly complex, this project is definitely not suitable for beginners and it should only be undertaken by those who have the necessary experience. The general layout used is not overly important, but it is advisable to have on/off switch S1 and mains transformer T1 situated as far away from the pyro sensor as possible. A solder-tag fitted on one of the mains transformer's mounting bolts provides a chassis connection point. As some tracks of the printed circuit board carry the mains supply it is essential that the board is mounted securely. It is also essential that it is held about 10 millimetres or more clear of the case. Plastic stand-offs can be used, but I prefer 6BA or metric M3 screws plus spacers for boards that carry the mains supply.

The size of the window for the pyro sensor is not critical, but in theory a small hole gives longer operating range, and a larger hole produces shorter range with a wider angle of

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view. In practice small windows seem to give poor results, and it seems to be better to use a hole having a diameter of around 10 to 20 millimetres. Of course, if the sensor is mounted very close to the front panel, a much smaller hole will be required. It might be worthwhile making a large cut-out in the front panel, and pieces of card having apertures of various sizes can then be tried over the cut-out to determine the aperture which provides the best results in your particular set-up. Ideally some transparent material should be used to "glaze" the cut-out, but material that is transparent to visible light might not be transparent to long wavelength infra-red. It might be necessary to experiment a little in order to find a suitable window material.

The lamp can be hard wired to the circuit board or connected to the unit via a mains socket mounted on the case. This depends on whether the lamp will always be used with this unit or if it will sometimes be used on its own. The hard wiring method is used on the prototype and this is the more simple method to implement. It simply requires a hole for the mains output lead to the drilled in the rear panel of the case. A hole is also needed for the mains input lead. Both holes should be fitted with grommets to protect the leads.

Fitting a mains socket on the case is slightly awkward as a large and irregular cut-out is required. The shape of the cut-out must be determined by taking measurements from the socket itself. The cut-out can be produced using a miniature round file, Abrafile, fretsaw, etc. With this type of thing it is always advisable to cut just inside the perimeter of the required cut-out, and then enlarge the hole to precisely the required size and shape using a file. The fixing screws supplied with the sockets are unlikely to be of much use in this case and should be replaced with M3 bolts about 12 to 25 millimetres long. Together with a couple of M3 nuts these should enable the socket to be firmly fixed to the front panel. Details of the hard wiring are provided in figure 5, which should be used in conjunction with figure 4. This wiring is very simple indeed, but as the mains supply is involved it is essential to proceed with due care. Thoroughly checked the finished wiring for errors. A mains transformer having a single 12 volt secondary winding is required, but most modern mains transformers either have twin secondary windings or a centre-tapped winding. Probably the best choice is a transformer having a 6-0-6 volt secondary winding, with the centre-tap being left unused. The wiring diagram assumes that this type of transformer will be used.

It is possible for the mains transformer to heat up the air within the case, causing turbulence which will give spurious triggering. The easiest solution to this problem is to use some tissue paper or other wadding inside the case, between T1 and IC1, so that they are largely sealed off from one another. Make sure that the wadding does not block IC1's view.

Mains voltage is potentially dangerous. Constructors who are not experienced in fitting mains circuitry should seek the assistance of an experienced mains constructor.

PARTS LIST for the IR Auto Light

Resistors (All 0.25 watt 5% carbon film)

R1,3,18	2k2 (3 off)
R2	18k
R4,5	100k (2 off)
R6,8	1M (2 off)
R7,9,13,14	6k8 (4 off)
R10,15,17,20	10k (4 off)
R11,21	3k9 (2 off)
R12	4k7
R16	27k
R19	1M5
VR1	10k min hor preset

Capacitors

C1	100u 16V radial elect
C2,3	1000u 16V radial elect
C4,5,7,9	10u 25V radial elect
C6,8	4n7 polyester, 7.5mm lead spacing
C10	1000u 25V radial elect
C11,12	100n ceramic

Semiconductors

IC1	PIS201S or similar pyro sensor
IC2	NE5532N
IC3	LM358N
IC4	CA3140E
IC5	uA78L12 12V 100mA positive regulator
Q1,3	BC549 (2 off)
Q2	BC559
D1,2	1N4148 (2 off)
D3,4,5,6	1N4002 (4 off)

Miscellaneous

RLA1	12 volt 300R or more coil resistance, single changeover contact rated at 230V ac and 1A or more (Maplin YX97F recommended)
FS1	20mm 100mA "quick-blow" fuse
T1	Standard mains primary, 12 volt 100mA secondary (or 6V - 0 - 6V 100mA secondary with centre-tap ignored)
S1	Rotary DPST mains on/off switch

Metal case about 203 x 127 x 51mm, printed circuit board, mains lead and plug fitted with 2A fuse, pair of 20mm fuse-clips, 8-pin DIL holder (3 off), control knob, wire, solder, etc.

Adjustment and use

The easiest way of giving VR1 a suitable setting is with the aid of a multimeter. First cover the sensor with (say) some Bostik Blue-Tack so that you can make measurements and adjust VR1 without activating the unit. After the circuit has had several seconds to settle down, measure the output voltage at pin 7 of IC2. Next monitor the voltage at pin 6 of IC3, and adjust VR1 to set it one volt higher than the voltage at pin 7 of IC2. If you do not have access to a multimeter, temporarily connect a resistor of about 27k in value across R19. This will shorten the hold-on time to only about one second. Trial and error can then be used to find a setting for VR1 that gives good freedom from spurious triggering.

When installing the unit, bear in mind that it is most sensitive to someone crossing the field of view, and least sensitive to someone moving directly towards or away from the unit. It is a matter of installing the unit where it will work effectively, and not simply mounting it on any wall or shelf that happens to be handy. There seems to be no major problem with optical feedback, but it would not be a good idea to have the unit aimed at the light it is controlling.

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PIC Programmer Re-Visited

Robin Abbott has developed a more powerful and updated version of the popular ETI PIC programmer

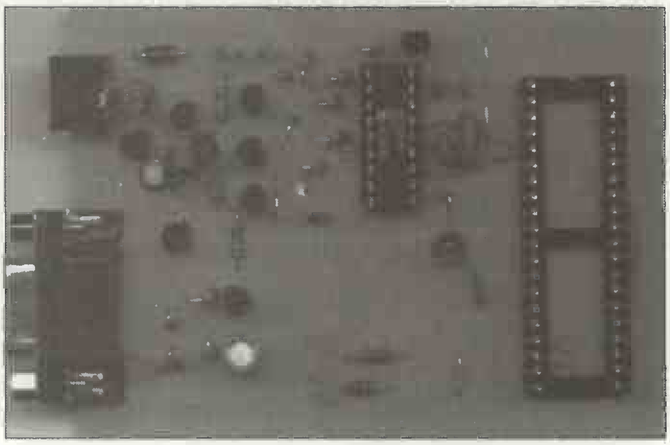
In the June 1995 issue of Electronics Today International, I presented a PIC programmer which at the time was highly successful. It used a single PIC16C57 and a handful of other components to implement a programmer capable of programming all 12 and 14 bit core PICs in standard DIP packages which were available at the time. @B:Several hundred of these programmers have been built, either in the original form, or in kit form from Forest Electronics. The programmer was designed at the time to be as cheap as possible, and consequently it lacked certain advantages that might be available in a more sophisticated model. For instance:

18pin, 28pin and 40pin devices were all programmed in their own individual sockets, therefore a constructor requiring to use all 3 types of device would require 3 relatively expensive ZIF sockets for large scale programming. Although In-Circuit Programming (also known as In Service Programming (ISP)) was supported, PIC16C84 devices could not be erased in circuit as at the time Microchip had not published the serial programming specification for these devices.

At the time the programmer was designed to be expandable, and in fact many PIC devices released since the programmer was designed are able to be programmed, changing only the initialisation file used in the PC. However the newer 8 pin devices - the 12C508 and 12C509 cannot be programmed by the original programmer as they use a different algorithm from other devices in the series.

To overcome these disadvantages, and to bring the programmer up to date I have redesigned the original programmer to produce a new version with the following features:

- The programmer is now fitted with a single 40 pin multi-width ZIF socket which can accommodate the following PIC device types: 12C50X (8 pin), 16C55X (18 pin), 16C6x, 16C7x, 16C8X, 16F8X, and PIC14000 (with an adapter), in fact, all the current serially programmed 12 and 14 bit core PIC devices in packages with 40 pins or less.
- The programmer supports in-circuit programming of all serially programmed devices, including in-circuit erasure of the 16C8X series.
- The programmer is on a board approximately 2/3 the size of the original programmer.
- The new version is based itself around a PIC, either the 16C84, 16C56, 16C58, 15C556, or 16C558 PIC's may be used.



- The programmer operates on a serial link to a PC running either Windows 3.1 or Windows '95. I particularly dislike programmers (or indeed any peripherals) which use the parallel port, most PC's are only fitted with one parallel port and therefore need either a printer switch or an additional parallel card, parallel cables are also considerably more expensive, and are physically inflexible.
- The programmer supports standard HEX files produced by the Microchip MPASM assembler, or other assembler environments such as the FED PICDESIM assembler/simulator.
- The new programmer also switches Vdd to the chip being programmed (the original programmer always maintained Vdd).
- The programmer supports reading and programming of the eeprom data areas in those PICs which have an eeprom data area.
- The programmer supports Program Readable Identities (PRIDs). This allows the programmer to write a serial number to the program store in the PIC in the form of RETLW instructions which may be read by the application program. The serial number may be unique for each chip programmed with each application, or may be defined as the code checksum, or as a random number.

The only feature offered by the original programmer which is not provided in this version is support for programming in parallel mode. This mode is only used with the 16C5X series devices which are now becoming more expensive than more capable serially programmed devices, thus the 16C556 can be used as replacement for the 16C56 (with some minor code modifications), but has 4 times as much RAM as the 16C56, and is about 10% cheaper (at current UK distributor prices).

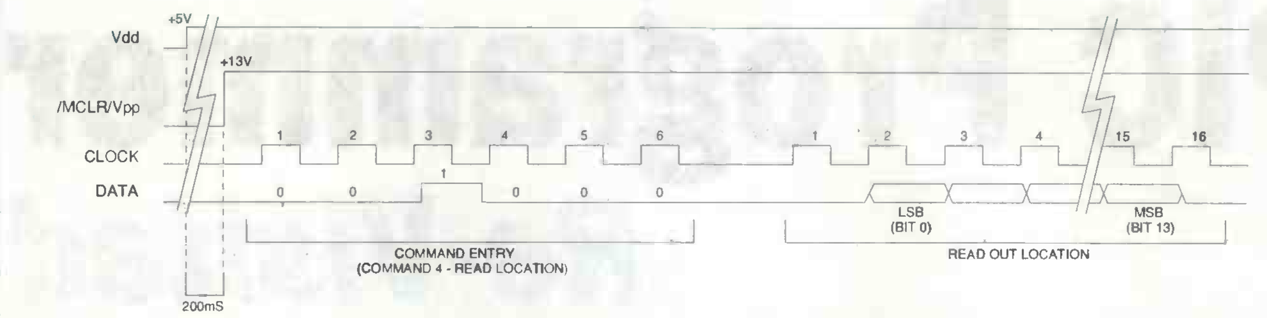


Figure 1: signals required on PIC to read the contents of the current location

PIC devices

The Microchip PIC microcontroller has proved to be highly popular in the educational and amateur markets. This is because it is cheap, easily programmed, and development tools are widely available at a reasonable price. The low and medium capability PIC devices are 12 and 14 bit core respectively. The core size refers to the width of the instruction word. As the instruction word includes the address of the file register (RAM byte) then the wider instruction word allows a bigger range of file registers to be addressed without having to page RAM, and allows jumps and subroutine calls directly to a wider range of addresses.

The instruction memory of the PIC is totally separate from the RAM area, and it is this that gives the PIC its tremendous speed in instruction execution. The next instruction may be fetched from the instruction memory at the same time as the current instruction is being executed, and all instructions (barring program jumps) are performed in 4 cycles of the external clock. This results in very fast code for which timed loop and real time software is extremely easy to program. The only disadvantage of the PIC architecture is that since the program area cannot be written from within the program then in-circuit emulators and monitors are very expensive as they normally require special bond out chips.

Table 1 presents an overview of those members of the PIC series which are programmed by this project.

Programming the PIC

The PIC devices addressed by this project are the serially programmed controllers. These devices require five pins on the device to be driven. These are the ground and positive supply lines, the programming supply voltage (Vpp), and the data and clock lines. To place the PIC into programming mode Vdd is applied, a delay of 200mS is executed, and then the Vpp pin is raised to 13V. The Vpp input pin is a shared function with the reset input pin and should be held at ground whilst waiting to program the chip, thus the chip is held in reset until Vpp is raised when the chip holds its reset state as there is no input oscillator. In the reset state all I/O pins are in the input state, thus during programming all unused I/O pins are maintained as inputs.

The clock and data lines are used to serially address the chip. Commands are 6 bits and to perform any action the command is clocked into the chip, optionally followed by a

Device	Memory Size (ROM/RAM)	I O port bits	Pins	Other Features

Table 1: PIC devices programmed

↑ SEE ETI AUG VOL 35 NO 7 1997 P9

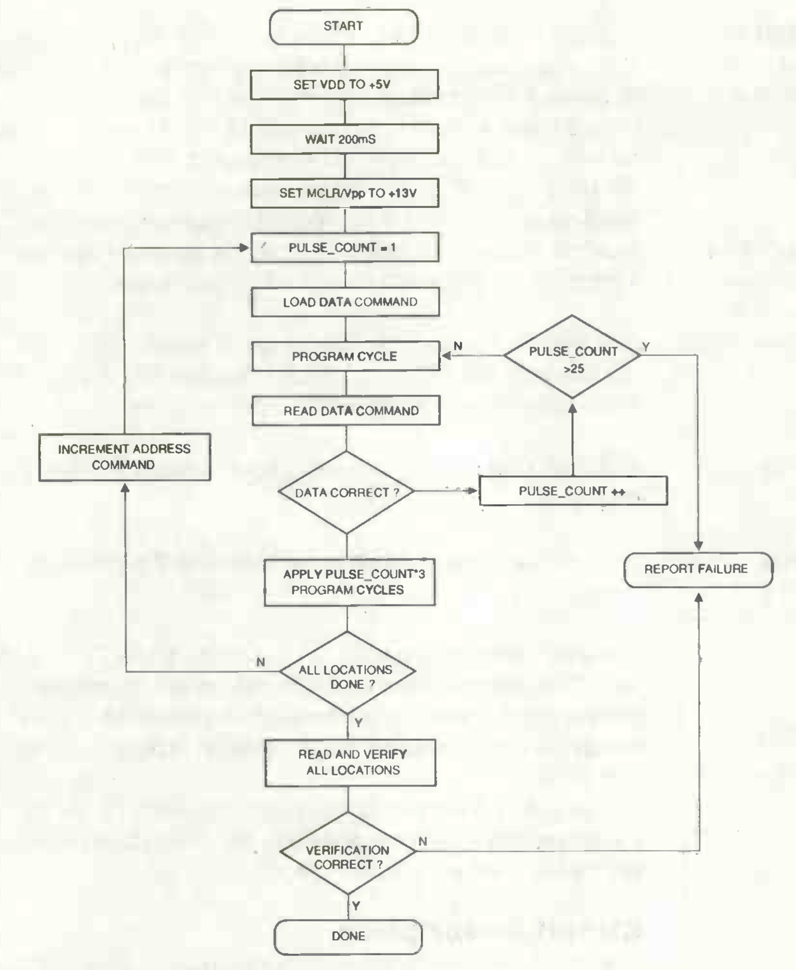


Figure 2: programming algorithm

further 16 clocks which are used to clock data into or out of the chip to the 14 bit wide program store (The first and last clocks are unused). For example figure 1 shows the signals applied to a PIC to read the contents of location 0 in the program store.

There are 6 commands used to program the PIC. When Vpp is raised the address pointer is positioned to location 0. The load Data and Read Data input or read data for the current programming address respectively. Increment address moves the address location to the next address. The Begin and End programming commands start and end a programming pulse. Finally the load configuration command positions the address pointer at the configuration area (described below). The eeprom devices have additional commands to erase the eeprom device, and to program and read the eeprom data area.

The programming algorithm used is a fast program/verify/overprogram method, similar to fast algorithms used for standard eproms. Each location is programmed with a short pulse, and read to verify it. If the location fails then it is programmed again. When the location is correctly verified, then the location is programmed again with three times as many pulses as that required to program it in the first place. The algorithm is shown in figure 2.

Please note that the Microchip programming specification requires that the programming

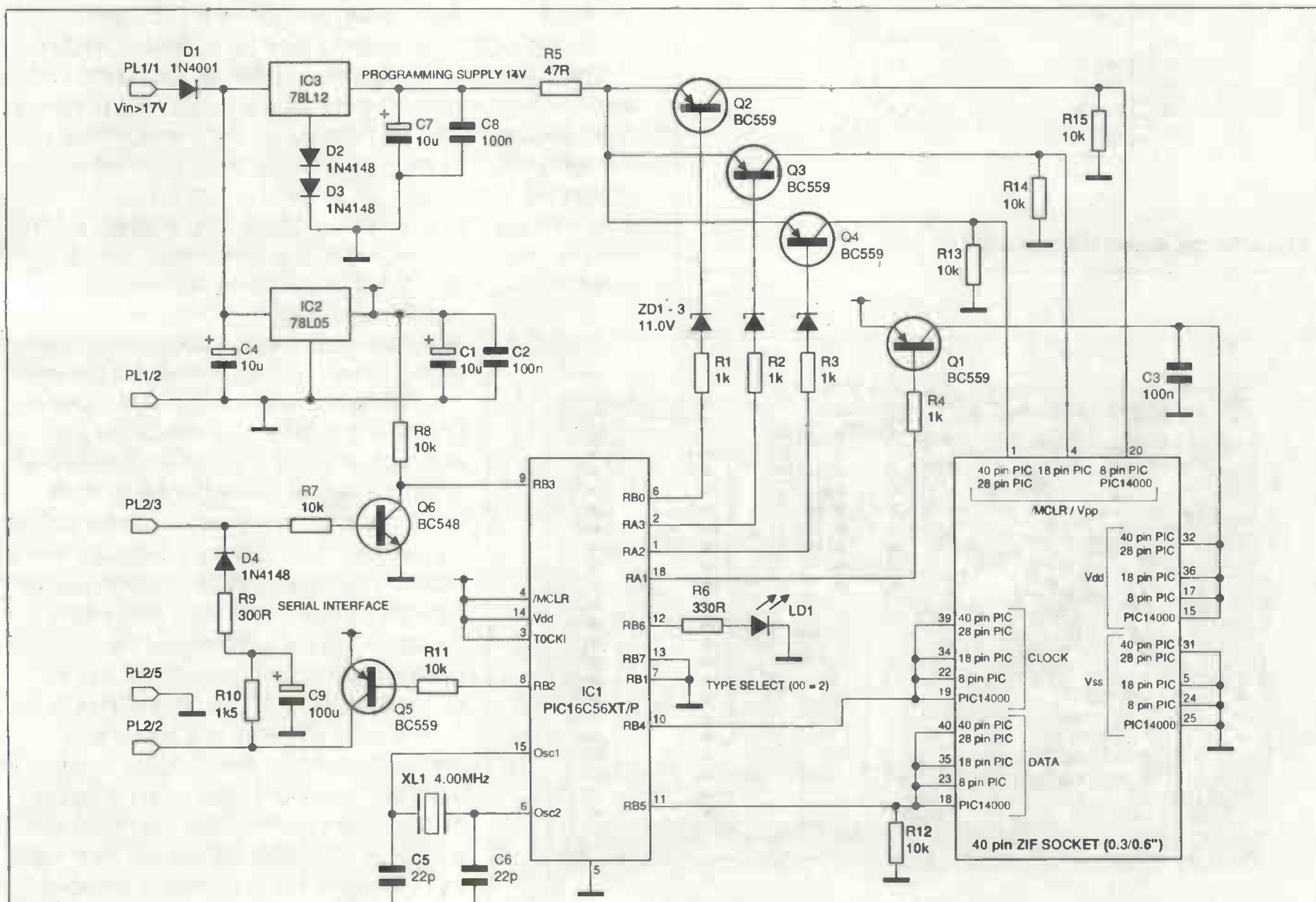


Figure 3: Pic Programmer Type 2: circuit diagram

should be performed at Vdd=5V, and verified at both 4V and 6V to ensure that the device has programmed correctly. This programmer only verifies at Vdd=5V, and therefore is classified by Microchip definition as a development programmer.

Configuration fuses

Each PIC device has a configuration fuse which defines its operation in the application circuit. Any PIC programmer must allow the configuration fuse values to be set. The configuration fuses allow the following device features to be set:

1. Oscillator type, as one of the following items:
LP - Low power crystal oscillator, for instance 32768 kHz
XT - Crystal Oscillator
RC - Resistor/capacitor based oscillator
HS - High speed crystal oscillator (more than 4MHz)

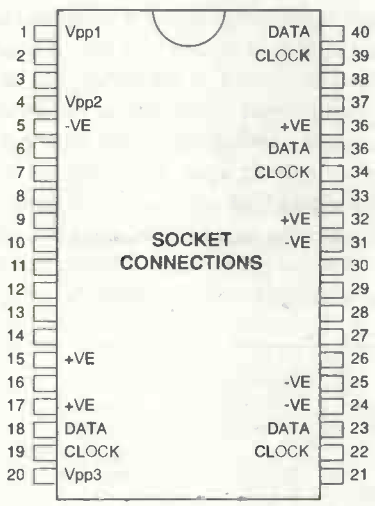


Figure 3a: the socket connections

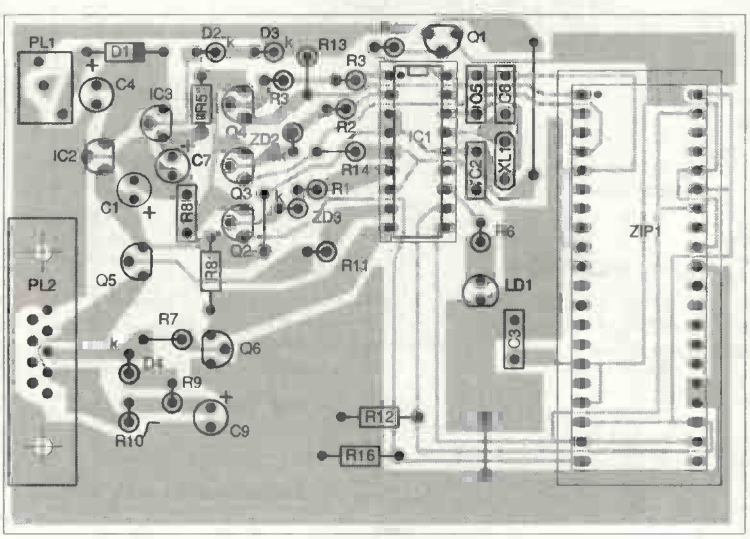


Figure 4: the component layout

2. Code Protect (CP) bit. When set the CP bit forces the PIC, when read, to return a scrambled version of the code to prevent unauthorised copying. The PIC cannot be programmed in this state, however EEPROM versions may be erased. User words may be written or read when the CP bit is set. CAUTION - some devices (particularly the most recent PICs) have non-erasable code protect fuses, thus the expensive /JW variant may be rendered useless for further development once the CP fuse is set.

3. Brown Out Enable Bit. This is set to enable the brown out circuit in the PIC. This circuit holds the PIC in reset if the supply voltage drops below a pre-set level.

4. Watch Dog Enable. This bit is set to enable the watch dog timer.

5. Power up timer. This bit is set to enable the power up timer.

The user words may be set to any value as specified by the user. They may be used to define the version of software, or to provide a serial count for each individual chip. User words cannot be read by the application program running in the PIC.

The user words and configuration fuse may be set by the programmer PC host software, the dialog box used to set these is shown in screen shot 1.

Circuit Description

The circuit diagram is shown in figure 3.

The programming algorithm is implemented in IC1 - a PIC16C56, 16C556, or 16C84. This device also includes the serial interface software, and drives an LED which is illuminated when the subject PIC is being read or written.

The power supply requires a stable 5V supply for Vdd, and 13V for the programming supply Vpp. The 13V supply is obtained by a 78L12, boosted by two signal diodes in the earth return of the regulator (the output voltage is referenced to the earth pin of the regulator). The programming supply is applied to the chip through a 47R resistor - R5, and switched to any of 3 pins of the ZIF socket by Q2, Q3 or Q4. The switching of these transistors is achieved through 11 V zener diodes - when the output of the controller PIC is high (+5V) the voltage differential between the PIC output and the transistor base is insufficient to bias the zener diode into conduction and the transistor is turned off, when the output is low the zener diode conducts and the transistor conducts. This type of circuit is necessary because the PIC outputs have static protection diodes forward conducting to Vdd, and without the zener the transistor would be permanently turned on by these diodes. Q1 switches +5V to the programmed PIC.

The serial interface is a cheap and simple 2 transistor circuit based around Q5 and Q6. The input of the circuit is driven by the output of the PC which in the idle state is at -12V. D4, R9 and C9 filter the input from the PC to provide a negative supply for the output of the interface which

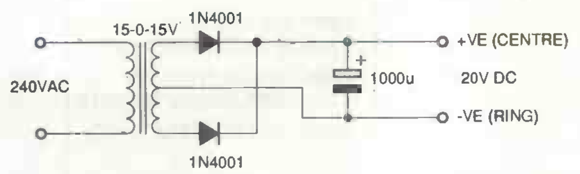


Figure 5: a mains power supply circuit if required. Batteries can also be used. See text.

PROGRAMMER	PC CONNECTOR TYPE:			
PL1	9 - WAY FEMALE	9 - WAY MALE	25 - WAY FEMALE	25 - WAY MALE
2 3 5	3 2 5	2 3 5	2 3 7	3 2 7

Figure 6: serial cable connections from the programmer to the host PC

is required to swing between -1V and +1V for the input of the PC. This circuit has proved to operate very well in practice, however on a very small number of PC's the input impedance is too low, and R10 may be reduced to 1k, or lower.

There are five different PIC pin-outs driven by this circuit. 18 pin devices, 28 pin devices and 40 pin devices are all programmed in the top of the ZIF socket. 8 pin devices and the PIC14000 are programmed in the bottom of the socket (The PIC14000 requires an adapter - see later section). Figure 3a shows the socket positions for the various devices programmed.

The two pins RB6 and RB7 are connected to ground to indicate to the controller PIC the type of programmer that is in use, this is because the same software load is actually used for a number of different programmer types.

Construction and test

Figure 4 shows the PCB overlay. Construction is straightforward, there being no special components or assembly required.

There are three links which should be fitted to the board first. Follow with the horizontally mounted resistors, D1, and then the IC sockets. The 40 pin ZIF socket should be fitted into an IC socket. Mount (in order) the vertical resistors, diodes, and capacitors, and finally the sockets and other components.

Once construction is complete the board may be tested. Do not fit IC1 at this stage.

The power supply required is 17V or greater. In practice power consumption of the programmer is so low that two 9V batteries may be used as a supply, or a 12V battery eliminator (they usually have an off load voltage in excess of 20).

Figure 5 shows the circuit diagram of a suitable mains power supply. If using a mains power supply, inexperienced mains constructors should ask for assistance from someone with mains experience.

Connect power to the circuit and check that the power supply on pins 5 and 14 of the socket for IC1 is +5V. Check that the power supply on the emitter of TR2 is about 13V, finally check that there is no significant voltage on any pin of the ZIF socket. Disconnect power and insert IC1, reconnect power, and the LED should flash five times which is a power up check implemented in the PIC.

The cable connection between the programmer and the PC is three-wire. Figure 6 shows the cable connections required for a self built cable, however any standard PC cable may be purchased. The programmer software will operate on any of the serial ports on a standard PC.

If you have a terminal emulator then set up your terminal emulator to the correct port which you are using for the programmer. Set the emulator to run 9600bps, no parity, no flow control, 8 bits, one stop bit. In Windows terminal this is the menu option under Settings /I Communications. Enter a capital D, the programmer should respond with 'L' which is the 'OK' report from the programmer. Enter an 'F' character and LD1 should illuminate. Enter 'K' and LD1 will go out. Finally check that all the pins on the ZIF socket are close to 0V.

Now install and run the host software to check the programmer with some real devices. Initial programming for all device types should be performed with erasable devices in case of problems with the construction.

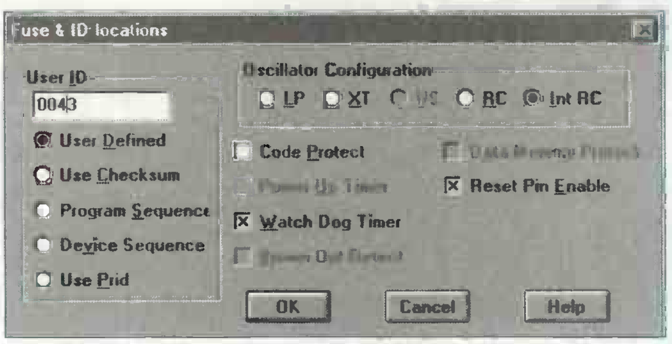


Figure 7: screen shot sample from the software

PC host software

The host software is installed by from Windows 3.1 or Windows '95 by running the program "INSTALL.EXE" on the supplied disk. This is achieved from Windows Program Manager by selecting the File, Run menu option, and then typing A:\INSTALL.EXE in the command line edit box. In Windows '95 use the start button then the run option and type A:\INSTALL.EXE in to the box. The software my be installed in any directory on your hard disk, but defaults to installation in a directory called "C:\PICPROG". Once installed then double click the icon called PICPROG to start the program. Figure 7 shows a screen shot of the PC program when running.

Once running the Options I Communications menu option may be used to connect to the programmer. The programmer software is supplied with a guide to its use, and with help files.

Programmer interface specification

For those users who wish to produce their own host software for the programmer this section defines the protocol used for the serial interface to the programmer.

COMMAND LETTER	FUNCTION	INPUT DATA	RETURNED DATA
A	SET MODE	SINGLE BYTE MODE DATA - SEE TEXT	ACKNOWLEDGEMENT BYTE
B	READ ENTIRE PIC	NONE	SIZE* WORDS + ACKNOWLEDGEMENT BYTE
C	READ CONFIGURATION WORD	NONE	CONFIGURATION WORD + ACKNOWLEDGEMENT BYTE
D	CHECK PROGRAMMER	NONE	ACKNOWLEDGEMENT BYTE - 'L'
E	PROGRAM 4 WORDS AT THE CURRENT LOCATION, MOVE THE CURRENT LOCATION ONWARD 4 WORDS	4 WORDS + SINGLE BYTE CHECKSUM	SINGLE BYTE COUNT OF OVERPROGRAM PULSES FOR ALL 8 WORDS + ACKNOWLEDGEMENT BYTE 'F' IF PROGRAM FAILED
F	ENTER PROGRAMMING MODE, SET CURRENT LOCATION TO 0	NONE	ACKNOWLEDGEMENT BYTE
G	PROGRAM USER WORDS	4 WORDS + SINGLE BYTE CHECKSUM	ACKNOWLEDGEMENT BYTE
H	CHECKSUM ENTIRE PIC AND CONFIGURATION WORD, EXCLUDES USER WORDS	NONE	16 BIT CHECKSUM IN LOW-HIGH FORMAT +ACKNOWLEDGEMENT BYTE
I	SET PIC PROGRAM OR EEPROM DATA SIZE	SIZE OF PROGRAM AREA IN LOW-HIGH FORMAT. LOW BYTE MUST ALWAYS BE ZERO EXCEPT FOR EEPROM DATA AREA WHEN LOW AND HIGH BYTES MUST BE IDENTICAL AND SET TO THE 8 BIT SIZE OF THE EEPROM	ACKNOWLEDGEMENT BYTE
J	READ USER WORDS	NONE	4 USER WORDS + ACKNOWLEDGEMENT BYTE
K	LEAVE PROGRAMMING MODE	NONE	ACKNOWLEDGEMENT BYTE
L	PROGRAM CONFIGURATION FUSES	SINGLE CONFIGURATION WORD + SINGLE BYTE CHECKSUM	ACKNOWLEDGEMENT BYTE
M	INCREMENT PROGRAM LOCATION (ONLY NEEDED TO STEP PAST CONFIGURATION IN PARALLEL DEVICES WHEN PROGRAMMING DATA - SEE TEXT)	NONE	ACKNOWLEDGEMENT BYTE
N	BLANK CHECK PIC	NONE	RETURN 'L' IF THE PIC IS BLANK, 'F' IF IT IS NOT BLANK
O	BULK ERASE EEPROM DEVICE PROGRAM AND DATA	NONE	ACKNOWLEDGEMENT BYTE
P	READ EEPROM DATA	NONE	SIZE* WORDS + ACKNOWLEDGEMENT BYTE
Q	PROGRAM 4 BYTES AT THE CURRENT EEPROM DATA LOCATION, MOVE THE CURRENT LOCATION ONWARD 8 BYTES	4 BYTES SENT AS WORDS IN PIC PARALLEL FORMAT, FOLLOWED BY A SINGLE BYTE CHECKSUM	ACKNOWLEDGEMENT BYTE

* SIZE IS PROGRAMMED BY THE SETSIZE COMMAND ('I')

Figure 8: table of commands and responses used by the programmer

Please note that the interface for this programmer is different to the original project, the programmers may be differentiated in host software by sending a D character to the programmer, the original programmer will respond with a 'K', this programmer will respond with an 'L'.

Communication to the programmer relies on a command/acknowledgement protocol driven by the host machine. Commands are given as a letter from 'A' to 'Q', and any bytes required by the command follow the command letter. The programmer responds with any bytes to be sent as a result of the command followed by an acknowledgement byte. The acknowledgement byte is either an 'L' or an 'F'. 'L' indicates the command was successfully obeyed, 'F' indicates that an error occurred such as a checksum failure on data sent to the programmer. Commands may take up to 100ms before the acknowledgement byte is returned, and if this time expires then an error may assume to have occurred, the time-out in the prototype was set to 1s.

To initialise the programmer from any state then this sequence should be followed: Send 'D' 18 times, wait 1S and discard any bytes returned from the programmer. Send 'K' and wait for the acknowledgement - 'L', the programmer is now guaranteed to be in a waiting state. This sequence needs to be followed only at the beginning of an application program.

Figure 8 shows the list of commands which can be sent to the programmer, and the expected responses. The following paragraphs describe commands in more detail.

The Set mode command ('A') and the Size command ('I') should be sent before any other command is sent to the programmer. These set the type of PIC and the size of the program area. The Set mode command ('A') is followed by a single byte. The bits of this byte are as follows:

Bit 0 - Set if the configuration register is being programmed
Bit 1 - Set for an eepromdevice (10ms program pulses)
Bit 2 - Set if Vpp is to be applied to pin 1 of the ZIF socket
Bit 3 - Set if Vpp is to be applied to pin 4 of the ZIF socket
Bit 4 - Set if Vpp is to be applied to pin 20 of the ZIF socket
Bit 5 - Set if the device contains a 12 bit core

For example the PIC16C84 has the mode command definition value 10 decimal, the PIC16C74 has the value 4, and the PIC12C508 has the value 48 decimal.

All data words written to the programmer for programming (commands 'E', 'G', and 'L') are in PIC parallel format sent as the low byte followed by the high byte. This format has the upper 8 bits of the word in the upper byte, and the lower bits in the lower byte which should be padded with 0s. Thus the hex word "1EC7" for a 14 bit device is written to the programmer as the byte "07" followed by the byte "7B". Regardless of the number of words written to the programmer they are always followed by a single byte checksum which is the 8 bit sum of the data words. If the checksum fails then the programmer will return 'F'. 12 bit core devices are written in the same 14 bit format, however the two most significant bits are always set to 0.

All data read from the programmer in response to the 'B', 'C' or 'J' commands is in the PIC parallel format as for data written, but there is no checksum. All other 8 bit data is returned as a single byte. 16 bit data is returned in the normal low byte followed by high byte format.

To program data locations the Enter Program command ('F') is given. This sets the program counter to address 0. Now 4 words can be programmed at a time using the Program Data command ('E'). Each command returns the overprogram count (a single byte) followed by the acknowledgement. The overprogram count is the total number of pulses required to initially program the 4 words. Thus if the first three words all required one pulse to initially program the word, and the fourth word required 2 initial pulses, then the overprogram count returned will be 5. After each word is programmed the internal counter is incremented ready to write the next 4 words. After the entire program area is written then the End Programming command ('K') is given. Note that for 12 bit core devices the first word after the Enter Program command is the configuration fuse.

In similar fashion the user words may be programmed by sending the Enter Program ('F') command followed by the Program ID locations command ('G'), followed by the End Programming command ('K').

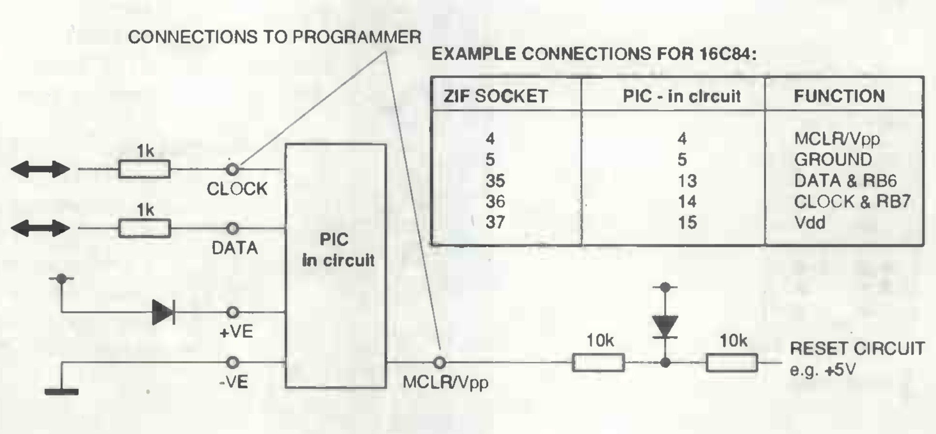
The user words are programmed by sending the Enter Program ('F') command followed by increment address commands to take the program counter to the correct address (2007 Hex) and then the Program configuration fuse command ('L'), followed by the End Programming command ('K'). Note if the Code Protect fuse is set to 0 (entering protect mode) then the program command may fail due to the inability to read back the correctly programmed value. Fuses must always be programmed after the program and user words.

The User configuration fuses are programmed by sending the Enter Program ('F') command followed by (7) increment address commands ('M') to take the program counter to the correct address (2007 Hex) and then the Program configuration fuse command ('L'), followed by the End Programming command ('K'). Note if the Code Protect fuse is set to 0 (entering protect mode) then the program command may fail due to the inability to read back the correctly programmed value. Fuses must always be programmed after the program and user words.

Data eeprom is written in the same way as program eeprom, using the F, Q and K commands. Note that data sent for data eeprom is still be sent and received as 8 words in PIC parallel format even though only 8 bit bytes are being sent. Thus the byte "FF" is sent as the byte "3F" followed by the byte "03". Note for reading and programming data eeprom the size command must be used to send the size of the eeprom data area, and not the program area. Also there is no check of eeprom data after it has been written - use the read command to verify it.

In-service programming

The in service programming facility requires a header to be constructed to connect the programmer to the device in the circuit. Figure 3 should be consulted to determine the connections from the ZIF socket to be used for each PIC type. For example to program the 16C84 in circuit, requires pins 4,5 and 35 to 37 of the ZIF socket to be wired to pins 4,5,13,14 and 15 of the 16C84 in the application circuit respectively. Use the shortest wires possible.



ZIF SOCKET	PIC - in circuit	FUNCTION
4	4	MCLR/Vpp
5	5	GROUND
35	13	DATA & RB6
36	14	CLOCK & RB7
37	15	Vdd

Figure 9: in-circuit programming

Figure 9 shows the wiring of the chip in circuit and the connections to the programmer. The clock and data pins of the PIC (which are usually port pins on the PIC) should be decoupled from the application circuit by 1k or greater resistors, if they can be left unused in the application so much the better. The power supply to the PIC in circuit is shown as an isolated supply by a diode, however if the application circuit can be powered then this connection is not required, however care is required in this case to check that no side effects will be generated by the PIC being programmed (all I/O pins in high impedance state, and programming waveforms on the clock and data pins). The MCLR/Vpp connection must be carefully handled to avoid the programming voltage being applied to other points in the application circuit.

PIC 14000

A special adapter is required for the PIC14000, this can be constructed on a small piece of Vero board. This is shown in figure 10.The adapter uses a 14 pin DIL socket, and 5 wire wrap pins. The adapter is inserted in the very bottom of the ZIF socket, and the PIC14000 inserted in the DIL socket so that pin 1 of the 14000 is towards pin 1 of the ZIF socket, only pins 8 to 21 of the PIC14000 are inserted in the DIL socket.

Finding out about PICs

The PIC data book is available from Maplin, or information may be downloaded from the internet at the Microchip Web Site: see http://www.microchip2.com/products/micros which allows all the datasheets to be downloaded. There are a number of good introductory texts on the PIC, for example "A beginner's guide to the Microchip PIC" from Maplin - Code AD31.

PIC-based Basic control systems including compilers are available from Parallax, or from Forest Electronics. This type of system allows rapid prototyping in BASIC, and then the program may be compiled, or re-written in assembler.

Obtaining components

The ZIF socket is available from Farnell on 0113-263-6311, their order code is 178-238. Farnell are quite prepared to sell to individuals for home or work use.

The author is prepared to supply programmed PICs for the project as well as to supply host software, The software supplied includes the Microchip assembler and simulator, the Windows based development environment PICDE, and a data sheet for the 16C84 in Acrobat format is also supplied. The host software is supplied on 3.5in High Density floppy disk suitable for use with Microsoft Windows version 3.1 or 3.11 and Windows '95. To receive the programmed PIC and the software send an SAE and a cheque for £20.00 to **Robin Abbott, 37 Plantation Drive, Christchurch, Dorset, BH23 5SG**. The author is also happy to answer any queries on the use of the programmer, but please put them in writing.

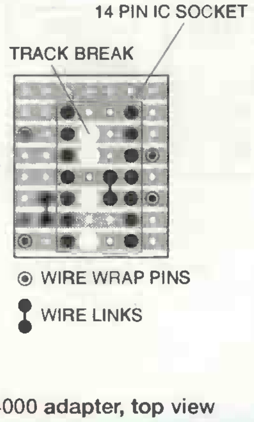


Figure 10: the PIC 14000 adapter, top view

A complete kit of parts including PCB, PIC and ZIF socket is available from Forest Electronics for £40.00+£3.00 P&P, 10 Holmhurst Avenue, Christchurch, Dorset. BH23 5PQ. 01425-270191. Please DO NOT direct any technical queries regarding this article to Forest Electronics, but to the author directly.

Note: **Farnell Electronic Components**: Farnell E C have a minimum order charge of £10 for cash orders before VAT. If the 40-pin ZIF socket, which is not otherwise widely available, is combined with XL1, this should meet Farnell's minimum order requirements. XL1 is also available elsewhere. For Sales, phone 0113 263 6311 and say that you are a cash order (cheque or credit card), not an account.

There is no postal charge for normal delivery.

PARTS LIST for the PIC Programmer

Resistors

All 1% 0.25 W

R1-4	1k
R5	47R
R6	330R
R7,8,11-15	10k
R9	300R
R10	1k5

Capacitors

C1,4,7	10uF 25V electrolytic radial
C2,3,8	100nF disc ceramic
C5,6	22pF disc ceramic

Semiconductors

IC1	See Text
IC2	78L05
IC3	78L12
TR1-5	BC559
TR6	BC548
D1	1N4001
D2-4	1N4148
ZD1-3	11.0V Zener
LD1	Red led, 5mm

Miscellaneous

XL1	4MHz resonator Farnell part number 170-230 £1.20 ex VAT
PL1	Power socket PCB mounted
PL2	9 pin D-socket PCB mounted IC socket DIL, 18 pin
ZIF socket	40 pin multi-width Farnell part number 178-238 £9.87 ex VAT.
PCB	
Rubber feet for PCB	

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ETI and RIAT 97 are giving away 15 pairs of adult tickets to the first 15 readers of ETI who can correctly identify the 10 differences between the two action-filled cartoons on this page.

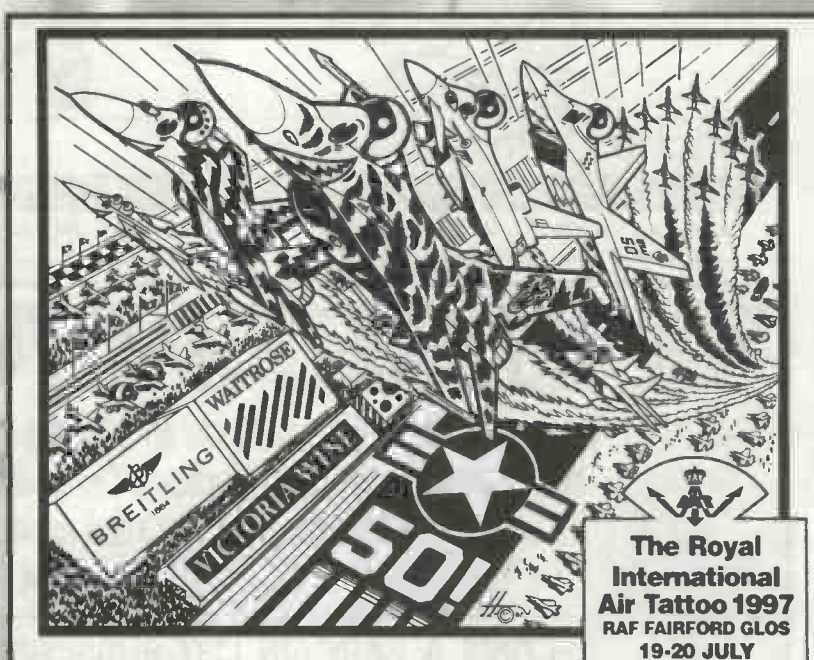
For enquires about RIAT 97, contact the RIAT Hot News Line on 0891 122999 or multiple-choice switchboard at 01285 713268. (Calls on 0891 numbers are charged at 50p per minute of which 15p per minute is donated to the RAF Benevolent Fund Enterprises, PO Box 1940, Gloucester GL7 4NA.) If you don't fancy your luck at spot-the-difference, want to make sure of getting to Fairford, or want to take the whole family, adult advance tickets are £16 each (£20 on the day), accompanied children (aged 15 and under) get in free. The RIAT 97 ticket hotline is 0891 122997 (credit card sales), or drop into your local Waitrose or Victoria Wine branch (who are selling advance tickets).

Competition rules: Entries must arrive at Nexus House on or before 12th June 1997. Winners will be notified by post following the judging. The judges' decision is final and no communication will be entered into concerning the results. Employees of Nexus Special Interest Ltd. and Swift Design Ltd., associated companies and family members are not eligible to enter. Multiple entries will not be accepted. The prize is two complimentary adult tickets to the Royal International Air Tattoo, RAF Fairford, Gloucester 19th & 20th July 1997, to be sent by post to the winners. No other goods, services or expenses will be supplied in connection with the competition. For further information about the RIAT 97 please contact the RIAT Hot News Line 0891 122999. Calls on 0891 numbers are charged at 50p per minute of which 15p per minute is donated to the RAF Benevolent Fund Enterprises, PO Box 1940, Fairford, Glos GL7 4NA. No communications can be entered into regarding the competition.

Look carefully at the two pictures. In the bottom one you will see that the artist has omitted a few details. Clearly ring the area where you think the details have been missed out on the lower picture, cut it out (or send a clear photocopy of both pictures) and send it to us to reach the ETI office at the address below ***no later than*** Thursday 12th June 1997. The first 15 entries to reach us that clearly identify all 10 differences correctly will receive two complimentary adult tickets to the show. So get flying!

Good luck!

Send your entries to RIAT Competition, ETI, Nexus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST by 12th June at the latest. Please clearly mark your envelope RIAT COMPETITION.



Fast Fivers

Adaptable, affordable - handy circuits for around £5. By Owen Bishop

3. Electronic Put-and-Take

Put-and-Take originated in medieval Germany and has been popular in one form or another ever since. The playing piece is a four-sided top, the dreidel, which has markings on each side. Players spin the dreidel in turn and then play according to which side is uppermost when it stops. In this electronic version there is a 7-segment LED which displays one of four characters:

0	Do nothing
1	Put one chip in the kitty
H	Take half the kitty
A	Take all the kitty

Players (two or more) draw lots or spin the dreidel to decide who is to play first. They each contribute two chips to the kitty, then play begins. The chosen player spins the dreidel (more about that later) and 'puts' or 'takes' each time until the spin gives a '0', when the turn passes to the next player. Players contribute another two chips to the kitty every time it becomes empty.

How it works

The circuit consists of an oscillator (figure 1, IC1), a counter (IC2), a decoder (IC3) and the LED display. IC1 is actually an ic for building a phase-locked loop but there is no PLL in this circuit. We are using only one of the several useful items on this chip, the voltage controlled oscillator. The central frequency of this oscillator is determined by the values of C2 and R2, according to the equation:

$$f = 1/(C2.R2)$$

It is not just that the rate falls slowly because C1 and R1 are high-valued. The rate of fall at any instant is proportional to the charge on C1. The rate falls rapidly when S1 is first released, but falls more and more slowly as C1 discharges. We describe the rate of fall as exponential. This may sound like a dull mathematical relationship, but its effect is to add an substantial element of nail-biting suspense to the game, as we shall see later.

The stream of pulses coming from IC1 is counted by IC2, which is a 14-stage binary counter. Once again, we do not use everything that is on the chip. We need the output from two consecutive stages and, as the outputs from stages 2 and 3 are not available at the pins, we use stages 4 (pin 7) and 5 (pin 5). Given that a high voltage (close to 6V) is '1' and a low voltage (close to 0V) is '0', these outputs run through the four binary numbers 00, 01, 10 and 11, repeating until the oscillator stops. The outputs spend equal times in each state and are equally likely to stop in any one state. In this way the circuit appears to behave in a random way, just like the spinning dreidel.

The four characters have been chosen to make decoding easy. Segments b and c (figure 2) are to be switched on for all characters, so can connected directly to the positive rail through a resistor R4. We need to decode only for segments a and c to g. This truth table shows the logic:

Inputs from IC2		Segment (logic equation in brackets)					
B (pin 5)	A (pin 7)	a (= A)	d (= A+B)	e (= A+B)	f (= A+B)	g (=B)	Character
0	0	0	0	0	0	0	1
0	1	1	1	1	1	0	0
1	0	0	0	1	1	1	H
1	1	1	0	1	1	1	A

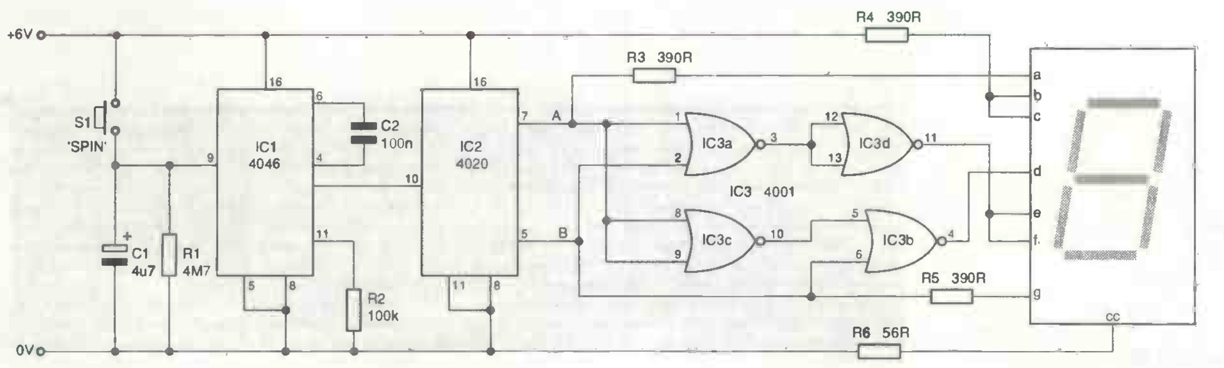


Figure 1: electronic Driedal, or Put'n'Take: the circuit

The '+' sign represents the OR operation, while a bar over a letter or pair of letters means NOT (invert). To get 'e' and 'f' we simply NOR A with B. To get 'd' we invert A with gate 3, then NOR it with B in gate 2.

Summing up what happens during a spin, pressing S1 starts the oscillator at 100Hz but, because we dividing the rate at stages 1 to 3 before taking the outputs from stages 4 and 5, the display cycles through the set of characters just over 3 times per second (if you want it faster, decrease the value of R2). At first the display is changing a little too fast to distinguish the characters but after a few seconds we can begin to pick out the characters. Towards the end, each characters remains displayed for several seconds each time. They remain longer and longer and longer ... Eventually one (but which one?) remains permanently displayed, and the payout (or in!) begins.

Construction

Figure 3 shows the stripboard layout. The connections to the LED display follow the pattern of commonly-available types, but check this with the component catalogue, since there are other ways in which the pins are designated. Note that is essential for the display to be of the common cathode type; the common anode type does not work in this circuit. The strips are cut beneath the board as indicated by crosses on Fig 3, but note that there are NO cuts at E31, G31, F35 and H35, since we are making use of the strips for two inter-pin connections and two connections to the display. Solder blobs between adjacent strips are used to connect: B14 to C14, B24 to C24, B33 to C33, C33 to D33, D43 to E43, H33 to H33, K11 to L11 and K21 to L21. The board has connections to a 6V battery, which may be a battery box for four 1.5V cells, if preferred. S1 is connected to the 0V supply and to the pin at E1.

PARTS LIST for the Put,n,Take

Resistors

(all 5% tolerance, 0.25W)

R1	4.7 megohm
R2	100 kilohm
R3, R4, R5	390 ohm (3 off)
R6	56 ohm

Capacitors

C1	4.7μF, electrolytic
C2	100nF, polyester

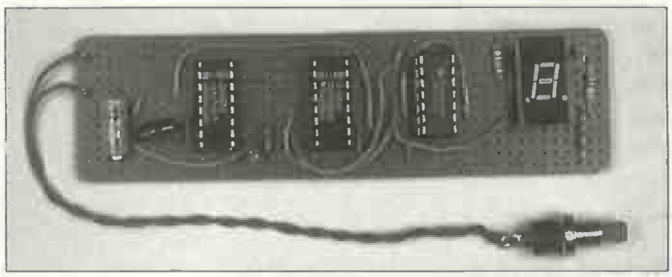
Semiconductors

IC1	4046 CMOS phase-locked loop
IC2	4020 CMOS 14-stage binary counter/divider
IC3	4001 CMOS quadruple 2-input NOR gate

Miscellaneous

S1	Push-to-make push-button

7-segment LED display, common cathode, 0.3-in (7.62mm), preferably low-current; 2.5 mm stripboard, 119mm ◊ 30mm (46 holes ◊ 12 strips); 1mm terminal pins (3 off); 14-pin dil IC socket; 16-pin dil IC sockets (2 off); battery clip or 6V battery box.



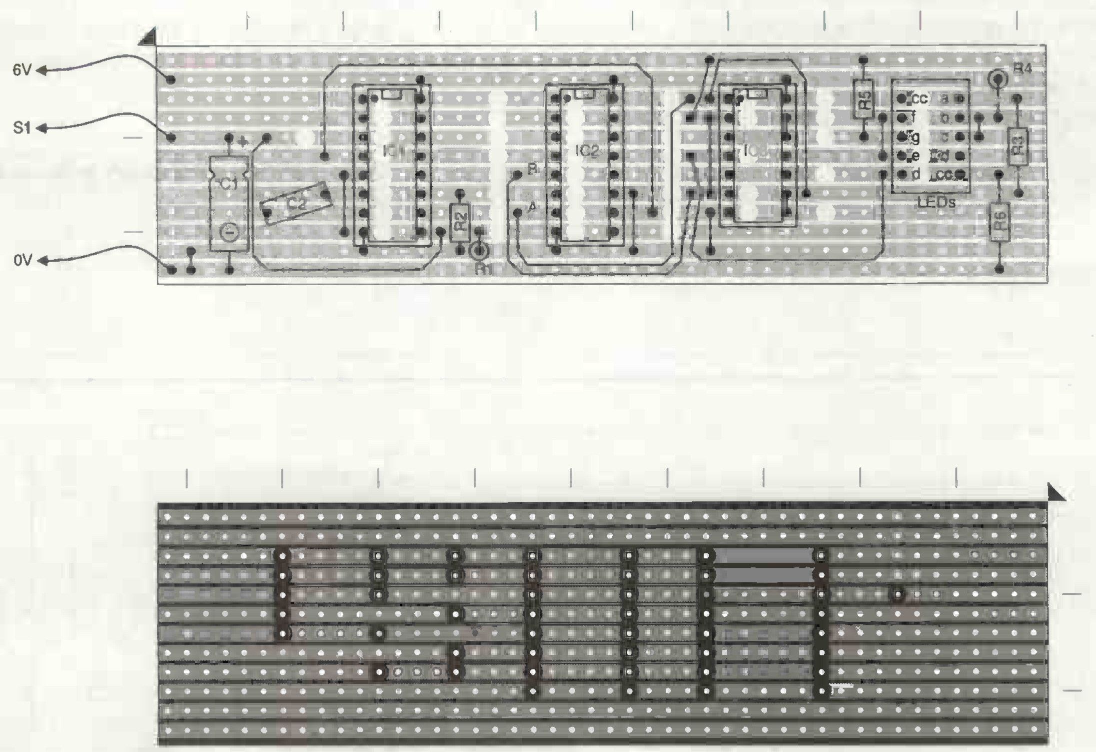


Figure 2: the segments of the LED display

Figure 3: the stripboard layout

Virtual pH METER for PCs

Following the trend to PC-controlled scientific instruments, this design uses a low powered circuit operated via the serial port of the PC

By Ronaldo Bruno and Valentin Obac Roda
Institute of Physics of Sao Carlos/University of Sao Paulo, Brazil

The increasing use of personal computers in the most diverse areas of activity has radically changed the face of electronic instruments. Many instruments that were self contained a few years ago, such as oscilloscopes, voltmeters, spectrum analysers and so on can these days be bought as boards to be plugged in personal computers. The display, keyboard and mouse of the PC perform the control and data visualisation of the instruments. This new trend in instrumentation is known as 'Virtual instrumentation'.

One of the drawbacks of using dedicated instrumentation boards inside the computer is the lack of portability. To move the instrument for one place to another it is necessary to move the computer or to take the board and use it in another computer. There is also a restriction in the use of laptop computers, because most instrumentation boards do not fit inside them. In this article we present a virtual instrument connected to the computer via the serial port of the PC. To increase the portability we used a low power consumption circuit fed by the serial port of the PC. The instrument that we developed is a pH and temperature meter widely used for chemical analysis, the food industry, geochemistry, water treatment, biomedical and industrial applications.

PH is a measure of the acidity or alkalinity of solutions. The pH scale ranges from 0 to 14. Seven is the neutral point, and solutions that have pH less than seven are acid solutions. The glass electrode is the most common sensor used to measure pH. In the pH range, the pH glass electrode develops a voltage proportional to the pH of the solution. The glass electrode is used in conjunction with a reference electrode. There are electrodes available, known as combination electrodes, that combine the glass electrode and the reference electrode.

The electrical response of the electrode is linear and follows the equation:

$$E = E0 + 2{,}3026\ RT/F$$

known as the Nernst equation, where: E is the response of the electrode in V/pH and E0 is the asymmetry potential, characteristic of the electrode and varying with its age. T is the temperature in absolute degrees. F is the Faraday Constant and R is the gas constant. Figure 1 shows the response of the electrode.

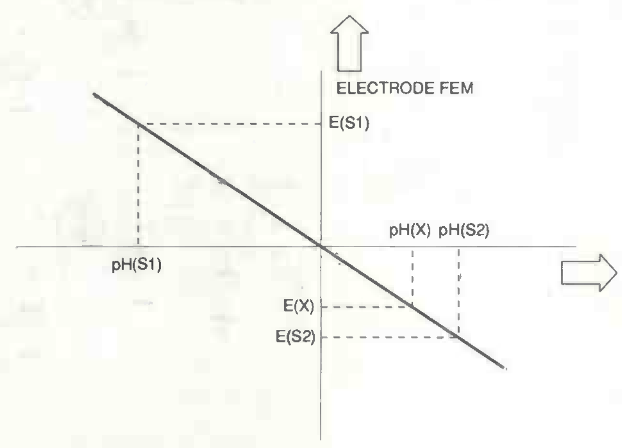


Figure 1: the fem response of the pH electrode

The internal resistance of the pH electrode is very high, around hundreds of megohms, and it is very sensitive to variations of temperature. pH meters should use a very high impedance input circuit. Before the pH measurements, the pH meter is calibrated according to the response of the electrode. This procedure is known as standardisation of the instrument. The pH meter requires the use of one or two of these standard calibration solutions according to the precision required (one- or two- point standardisation).

The Virtual pH meter that we developed has hardware controlled by a PIC microcontroller and software that runs under windows to control the instrument and visualise the data. The PC software was written in Visual Basic.

Hardware

Figure 2 shows the schematic diagram for the circuit of the pH meter. The input circuit of the pH meter is a high impedance, low consumption operational amplifier (LF442A). A LM35 integrated sensor is the temperature sensor. An analogue switch (CD4066) creates two analogue channels, one for the pH and another for the temperature. The circuits of the power supplies and the RS232 hardware implementation were built with discrete components.

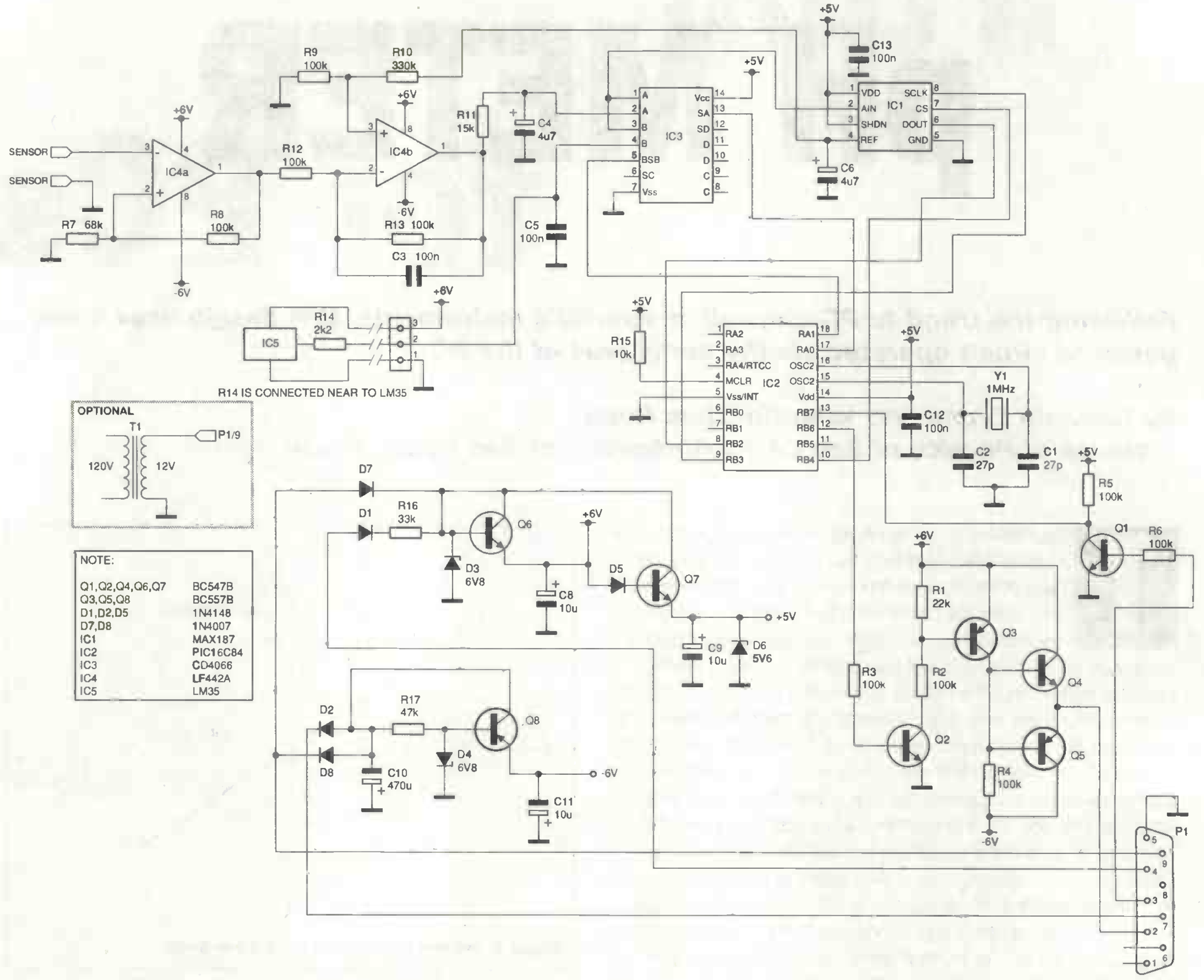


Figure 2: the circuit diagram

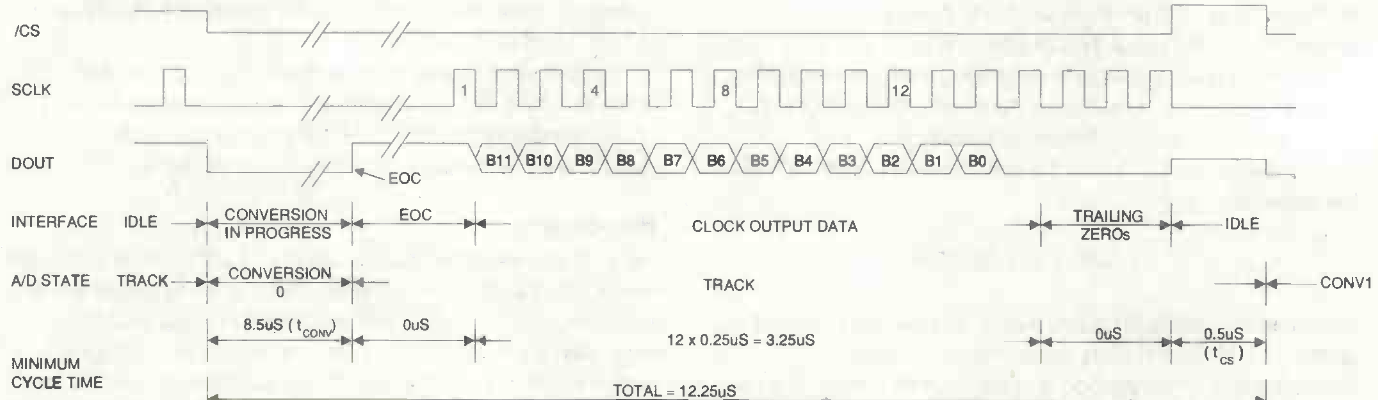


Figure 3: MAX187 interface timing sequence

The MAX187 12-bit A/D converter has a serial output, internal reference of 4.096V (available externally) and sampling rate of 75000 samplings/sec. There are no gain and offset adjustments in the A/D converter. The conversions are performed for voltages in the range 0 to 4.096V. The MAX187 has three control pins, CS, SCLK and DOUT. Figure 3 shows the converter communications protocol.

A P1C16C84 8-bit RISC microcontroller with internal eeprom controls the instrument, including the A/D converter, the analogue switches and the RS232 communication interface. The P1C16C84 has internally a ram, a real time clock counter, a watchdog timer and 13 I/O pins. The watchdog timer resets automatically the system on the occurrence of an internal program lock.

In the input circuit there are two operational amplifiers to amplify the pH sensor output to the A/D converter input. The first operational amplifier is a high input impedance, 2.5x gain, voltage follower. The output voltage of the first op amp goes, in the pH sensor range, from -1.5 V to + 1.5 V. The second op amp adds 2 V to the first op amp output, resulting in a single-polarity converted pH signal in the range of 0 to 3.5 V. An LF442 double op amp operational amplifier was used to implement the pH input circuit. The LF442 has a high input impedance of 1 terra-ohm (10 to the power of 12 ohms) and a low current consumption of 400 kA.

The transistor Q1 and the resistors R5 and R6 convert the level of the R232 input signal (-12V to + 12V) to the 0 to 5 V range. Although the RS232 is specified to work in the -12V to + 12 V range, it can work in the -6V to + 6V range. Q2, Q3, Q4, Q5, R1, R2, R3 and R4 convert the level of the RS232 output signal from TTL (0 to 5 V) level to the -6V to + 6V range.

Finally, we have the power supply circuit, supplying the -6V, +6V and +5V voltages. The MAX187 ic works with voltages from 4.75 to 5.25V and the PIC16C84 works with voltages from 2 to 6V. For the LF442A -6V and + 6V were used, considering that it has to have outputs going up to 3.5V.

The power supply was fed from the hand shaking signals of the RS232 DTRenable and RTSenable. When the instrument is initialised, RTSenable is set to -12V and DTRenable is set to +12V. The current capacity of DRTenable and RTSenable is low, about 8mA. When the current consumption grows the available voltage drops. For this reason the circuit was conceived to minimise the power consumption. The current for the P1C16C84 working on 1MHz is 600A The MAX187 consumes 1.8 mA and the LF442 consumes 400uA. The other parts of the circuit, including the regulators and level converters consume 1 mA more. The total current consumed by the circuit is only 3.8 mA which makes the voltage on the DTRenable drop to about 9V.

Optionally, you can feed the circuit with an AC 120/12V - l00mA transformer as shown in figure 2. This can be useful if the pH meter is going to work with a dedicated system, instead of a standard PC, that has the RS232 protocol communication but doesn't have the handshaking signals.

Seek assistance from a knowledgeable person when working the mains circuits if you not an experienced mains constructor.

Software

The software of the P1C16C84 implements basically the communications protocols of the MAX187 ND converter and of the RS232 serial interface. The serial communication is at 2400 baud, without parity, 8 data bits and one stop bit.

During the initialisation, the program waits a communication from the PC which sends the number 1 as a code to the microcontroller. During the wait loop the port pin of the PIC connected to the RS232 receive line is read continuously until data is received. When the PIC reads the number 1 it communicates with the MAX187 asking for two conversions (pH and temperature). The conversion time of the MAX187 is 8.5 us. Because we did not need to work at full conversion speed we waited a fixed time, longer than the conversion time of the MAX187, instead of waiting for its end-of-conversion signal. The 12-bit converted information is packed in two bytes. An XOR operation of the two conversion bytes generates a third byte used to detect possible communication errors. The pH and temperature values are transmitted to the PC, using six bytes of information according to the protocol shown in figure 4.

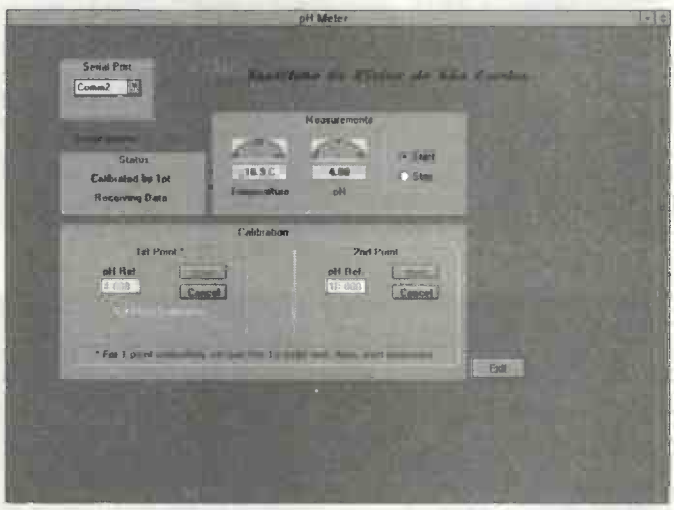


Figure 5: the virtual panel of the pH meter

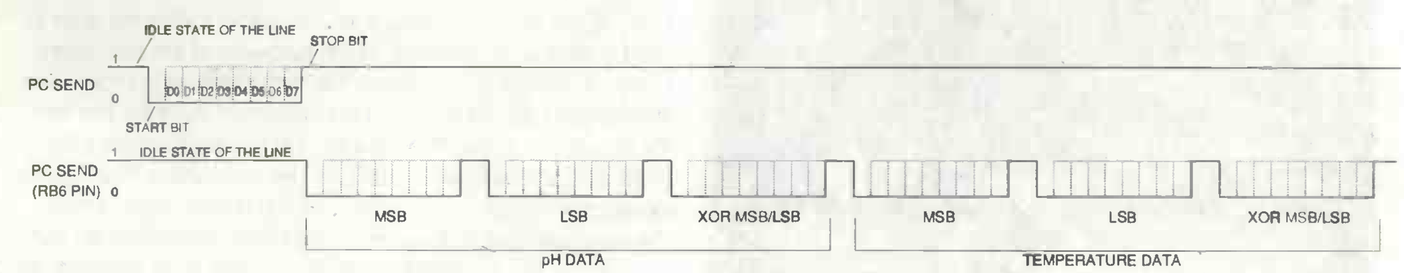


Figure 4: PC to PIC communication protocol

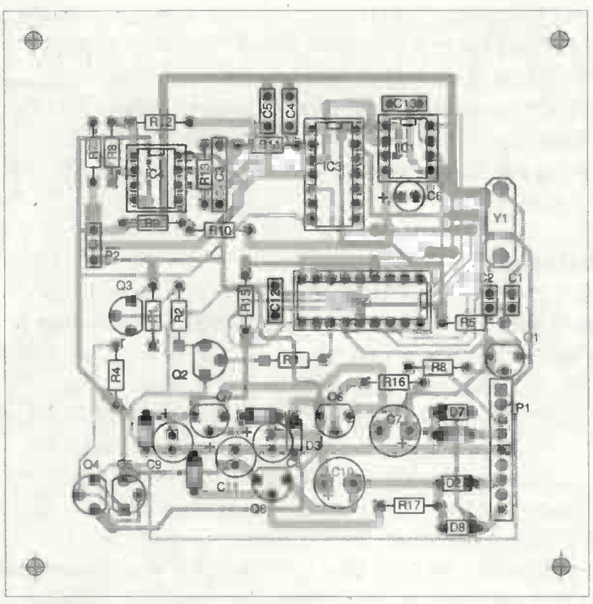


Figure 6: the component layout.

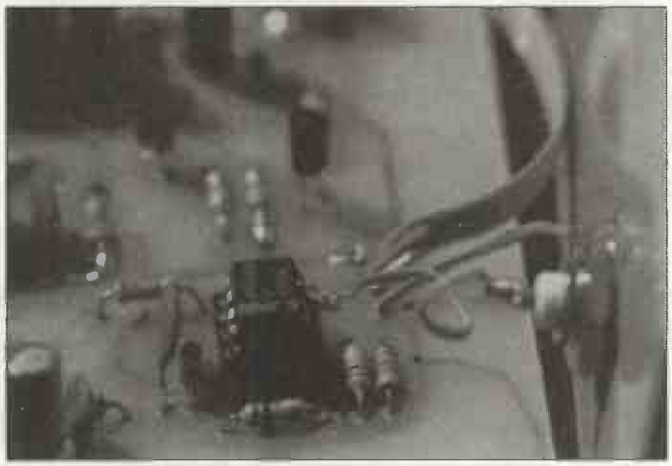
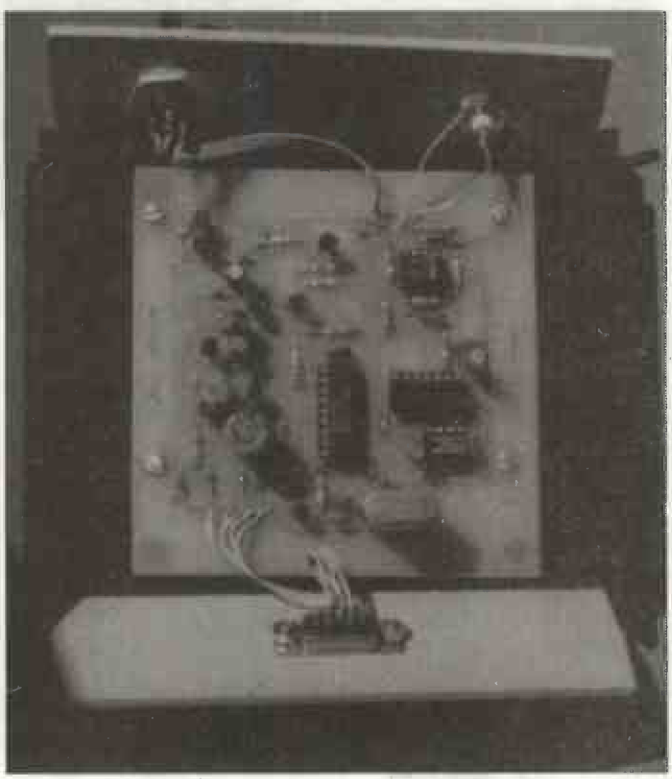


Figure 7: Above construction detail of the pH input



After sending the six bytes of information to the PC, the program returns to the initial wait loop. To avoid deadlocks, the program uses the watchdog timer of the PIC that is basically a counter driven by an internal RC oscillator. When the counter overflows, it resets the PIC, restarting the program. During the program execution on the PIC the watchdog timer counter is constantly reset. When the program enters in a deadlock, the watchdog timer counter is not set to zero and the PIC is then reset.

The software for the PC was developed in Visual Basic 3.0. The program includes routines for calibration, data visualisation and control of the instrument. Figure 5 shows a view of the screen of the instrument. Error treatment routines were included, user errors are trapped and helpful error messages are supplied. Also, when a communication fault is detected it is pointed on the screen. The program recovers automatically when the communication fault is corrected.

Construction details

For the construction of the pH meter a double sided PCB was used. Figure 6 shows the layout of the printed circuit boards including the component layout. To keep the input for the pH sensor high avoiding current leakage through the printed circuit, pin 3 of the LF442 operational amplifier was directly connected to the BNC connector (pH connector), as shown in figure 7. A photo of the hardware of the instrument is shown in figure 8.

To connect the pH meter to the PC, it is necessary to have a RS232 cable. You can build one connecting a DB25 female to a DB9 female following table 1, which shows the pins for each connector.

Table 1 - RS232 Cable

DB25	DB9
2	3
3	2
4	7
20	4
7	5

Operating instructions

After installing the software, the user should choose an available serial port on the PC and connect the hardware of the instrument to the port. Avoid using COM1/COM2 or COM2/COM4 simultaneously, as this can cause conflicts. For example, if you have a mouse connected to COM1, choose COM2 for the pH meter. If you have the mouse at COM1 and a modem at COM2, choose COM4 for the pH meter and do not use the modem while using the pH meter. When the hardware setup is ready, install the PC software routines and start running the program by clicking the pH meter icon.

As shown in figure 5, we can see four distinct regions: Serial Port, Status, Measurements and Calibration. Initially we have to set the serial port according to the hardware of the instrument. The second step is to calibrate the instrument using one or two standard pH solutions. Before the calibration we have to insert the pH and temperature sensors in the standard solution. To measure the temperature standard click the button "Start" in the measurement region. After this, click the button "Stop" in the measurement region and enter in the Calibration reference first point, the pH of the standard solution. At this point you have to press "start" in the calibration region and wait until the calibration is ready, that is, when the message "1st Point Calibrated" appears on the screen.

The time necessary for the calibration varies according to the pH sensor. In general, it takes less than 30 seconds. If the instrument is calibrated with only one pH solution, the "Start" button in the Measurement region should be pressed. If a two-point calibration method is used, repeat the above calibration procedure for the second pH solution.

In the "Status" region there is available information about the operation of the system. There is a small circle that blinks, changing its colour between red and green, when the serial port is working. If the communication between the instrument and the PC fails, the Comm Monitor stops blinking until the communication problem is corrected.

The LF 442 op amp can be replaced by other dual low power high input resistance op-amps. The TL062 (Texas Instruments), RS/Electromail 638-908, Farnell TL062CN, and the MAX407 (Maxim), RS/Electromail 248-191 have the same pin configurations.

Agents for the **MAX187** 12-bit serial A/D converter (8-pin dil package) are:

2001 Electronic Components tel 01438 74 2001

HB Electronic tel 01204 525544

Both agents will take cash orders if the device is in stock. The list price is £10.48 ex VAT, post and packing and any credit card charges if applicable. At time of writing, HB have slightly lower charges, but 2001 have larger stocks and order more frequently.

Farnell Electronic Components Tel 0113 263 6311 have a minimum order charge of £10 for cash orders (cheque/credit card) before VAT. There is no postal charge for normal delivery.

The INSTALL software for the PC is available at the following WEB site:

http://www.ifqsc.sc. usp. br/virtph

or by anonymous FTP at the following address:

www. ifqsc.sc. usp.br/pub/valentin/vi rtph directory: /pub/valentin/virtph

Or contact the authors at the following address. The authors can also send by mail additional information about the instrument, including a 3 5-in disk with the programs.

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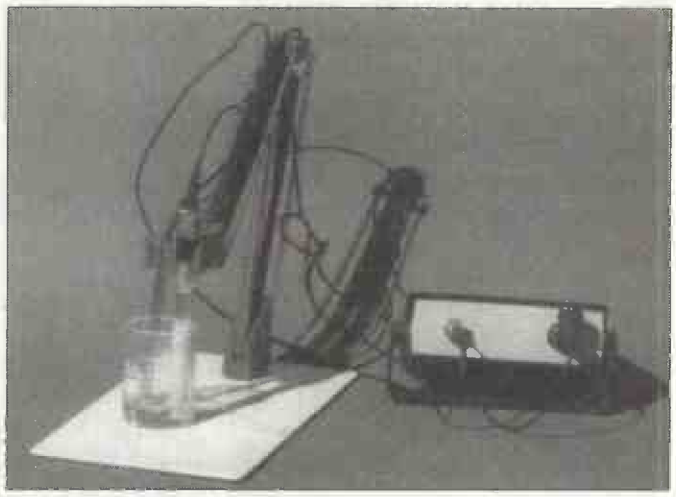
or by email at:

VALENTIN @ IFQSC.SC.USP.BR

Acknowledgements. The authors are grateful to the IFSC-USP, CNPq and PADCT, Brazil for the support for developing the present work and to MAXIM for the samples of the A/D converter.



PARTS LIST for the pH Meter

Resistors

All resistors are 1/8 - watt, 5%.

R1	22K
R2 to R6	l00k
R7	68K
R8,R9, R12,R13	l00k
R10	330k
R11	15k
R14	2k2
R15	10k
R16	33k
R17	47k

Capacitors

Cl ,C2	27pF, 25 volts, ceramic disk
C3, C5, C12, C13	l00nF, 25 volts, ceramic disk
C4, C6	4.7uF,16V, radial electrolytic
C7, C10	470uF, 16V, radial electrolytic
C8, C9, C11	l0uF, 16V, radial electrolytic

Semiconductors

Q1 ,Q2,Q4,Q6,Q7	BC547B NPN transistor
Q3,Q5,Q8	BC557B PNP transistor
D1,D2,D5	1N4148 signal diode
D3,D4	Zener 6V8, 400mW
D6	Zener 5V6, 400mW
D7,D8	1N4007 rectifier diode
ICl	MAX187 12-bit ND converter
IC2	PIC16C84 microcontroller RS/Electromail 831-501; Farnell PIC16C84-04P
IC3	CD4066 analog switch RS/Electromail 640-908; Farnell 385-451
IC4	LF442A low power, high input impedance operational amplifier Farnell LF442CN (see below for alternatives)
IC5	LM35 integrated temperature sensor RS/Electromail 317-960 Farnell LM35DZ

Miscellaneous

X1	1MHz Crystal RS/Electromail 307-761 Farnell 170-859
P1	DB9 Panel Male Connector
P2	Three-pin Cannon Male connector

BNC connector for pH input

RS-232 Cable DB25 (female) to DB9 (female) - See text.

5 x 5-in box

```
Listing: Picsoft.obj
#pragma object MPASM V01.21 6-Dec-
1996
"C:\USERS\RONALDO\PICSOFT.ASM"
#pragma interface
P 16C84
#pragma object
0   LINK101
10  START
11  LINK704 0180 0X0B
13  LINK703 3000 0X8E
14  LINK704 0080 0X81
16  LINK703 3000 0X87
17  LINK714 0060 0X6
19  LINK710 1000 0X6,3
20  LINK710 1400 0X6,4
21  LINK710 1000 0X6,6
23  LINK703 3000 0X0
24  LINK714 0060 0X5
26  LINK703 3000 0XFF
27  LINK704 0080 0X5
39  L3
39  LINK703 3000 0X2
40  LINK704 0080 0X15
42  LINK705 0800 0X15,1
43  LINK711 2000 P_ANALG
45  LINK704 0080 0X5
47  LINK703 3000 0X8E
48  LINK704 0080 0X81
50  L7
50  LINK711 2000 RXPIC
52  LINK705 0800 0X20,0
53  LINK702 3C00 0X1
55  LINK710 1800 0X3,2
56  LINK711 2800 L1
58  LINK711 2800 L7
61  L1
61  LINK711 2000 LECONV
63  LINK705 0300 0X15,1
64  LINK705 0800 0X15,0
66  LINK711 2000 P_ANALG
68  LINK704 0080 0X5
72  LINK705 0800 0X13,0
73  LINK704 0080 0X20
74  LINK711 2000 TXPIC
76  LINK705 0800 0X12,0
77  LINK704 0080 0X20
78  LINK711 2000 TXPIC
80  LINK705 0800 0X13,0
81  LINK705 0600 0X12,0
82  LINK704 0080 0X20
83  LINK711 2000 TXPIC
85  LINK705 0800 0X15,0
86  LINK710 1C00 0X3,2
87  LINK711 2800 L1
89  LINK711 2800 L3
96  P_ANALG
97  LINK705 0700 2,1
98  LINK702 3400 0X1E
99  LINK702 3400 0X1D
100 LINK702 3400 0X1E
108 RXPIC
109 C1
109 LINK710 1C00 0X6,7
111 LINK711 2800 C2
113 LINK701 0064
114 LINK703 3000 0X8E
115 LINK704 0080 0X81
117 LINK711 2800 C1
120 C2
120 LINK711 2000 DELAY2
122 LINK711 2000 DELAY1
124 LINK703 3000 0X8
125 LINK704 0080 0X14
127 C7
127 LINK710 1C00 0X6,7
128 LINK711 2800 C4
129 LINK710 1400 0X3,0
130 LINK711 2800 C5
131 C4
131 LINK710 1000 0X3,0
133 C5
133 LINK705 0C00 0X20,1
135 LINK711 2000 DELAY2
137 LINK705 0B00 0X14,1
139 LINK711 2800 C7
141 C8
141 LINK710 1C00 0X6,7
142 LINK711 2800 C8
144 LINK701 0008
152 TXPIC
153 LINK710 1400 0X6,6
155 LINK711 2000 DELAY2
157 LINK703 3000 0X8
158 LINK704 0080 0X14
160 B5
160 LINK705 0C00 0X20,1
163 LINK710 1C00 0X3,0
164 LINK711 2800 B2
165 LINK710 1000 0X6,6
166 LINK711 2800 B3
167 B2
167 LINK710 1400 0X6,6
169 B3
169 LINK711 2000 DELAY2
171 LINK705 0B00 0X14,1
173 LINK711 2800 B5
175 LINK710 1000 0X6,6
177 LINK711 2000 DELAY2
179 LINK701 0008
195 LECONV
196 LINK710 1000 0X6,4
198 LINK711 2000 DELAY3
201 LINK711 2000 RECDADO
202 LINK705 0800 0X0F,0
204 LINK704 0080 0X13
207 LINK711 2000 RECDADO
208 LINK705 0800 0X0F,0
210 LINK704 0080 0X12
212 LINK710 1400 0X6,4
213 LINK701 0008
220 RECDADO
221 LINK703 3000 0X8
222 LINK704 0080 0X14
224 E1
225 LINK705 0D00 0X0F,1
227 LINK710 1400 0X0F,0
229 LINK710 1C00 0X6,2
231 LINK710 1000 0X0F,0
234 LINK710 1400 0X6,3
236 LINK701 0000
237 LINK701 0000
238 LINK701 0000
239 LINK701 0000
240 LINK701 0000
241 LINK701 0000
243 LINK710 1000 0X6,3
246 LINK705 0B00 0X14,1
247 LINK711 2800 E1
248 LINK701 0008
255 DELAY1
256 LINK703 3000 0X0F
257 LINK704 0080 0X21
258 G1
258 LINK705 0B00 0X21,1
259 LINK711 2800 G1
260 LINK701 0008
262 DELAY2
263 LINK703 3000 0X1F
264 LINK704 0080 0X21
265 G2
265 LINK705 0B00 0X21,1
266 LINK711 2800 G2
267 LINK701 0008
269 DELAY3
270 LINK703 3000 0X02
271 LINK704 0080 0X21
272 G3
272 LINK705 0B00 0X21,1
273 LINK711 2800 G1
274 LINK701 0008
```

```
;########################################
;        Software for The pH Meter
;        MAX187 e PIC16C84 CLK=1MHz
;########################################
;        Initialisation routine
;########################################

START
        CLRF        0X0B        ;Desable
                                Interruptions

        MOVLW       0X8E        ;Programs
                                WatchDogTimer =1seg.
        MOVWF       0X81

        MOVLW       0X87        ;Programs Port B
        TRIS        0X6

        BCF         0X6,3       ;Initial level of the
                                SCLK signal
        BSF         0X6,4       ;Initial level of the
                                CS signal
        BCF         0X6,6       ;Initial level of
                                serial port

        MOVLW       0X0         ;Programs Port A
        TRIS        0X5

        MOVLW       0XFF        ;Desable all analog
                                inputs
        MOVWF       0X5


;########################################
; Main routine: receives serial data sent by host.
; Starts 2 conversions, sending 3 bytes each
; conversion. 2 bytes (16-bit data word) and
; 1 verification byte based in a XOR of the 2 data
bytes
; Send protocol: MSB, LSB and verification Byte.
; It sends input AN0 and then AN1 (pH and Temp)
;########################################

L3      MOVLW       0X2         ;Starts analog inputs
                                counter (F15H)
        MOVWF       0X15

        MOVF        0X15,1
        CALL        P_ANALG     ;Converts counter in
                                bits from 0 to 1 at
                                port A (analog input
                                selection)
        MOVWF       0X5         ;Sends selection to
                                port A

        MOVLW       0X8E        ;Refresh OPTION
                                register
        MOVWF       0X81

L7      CALL        RXPIC       ;Waits for the Host
                                (PC) communication

        MOVF        0X20,0      ;Verifies if received
                                byte = 01h
        SUBLW       0X1         ;If positive, starts
                                conversion routines

        BTFSC       0X3,2
        GOTO        L1

        GOTO        L7          ;If received byte
                                isn't = 01h waits for
                                new communication

L1      CALL        LECONV

        DECF        0X15,1      ;Decrements F15 once
        MOVF        0X15,0

        CALL        P_ANALG     ;Converts counter in
                                bits from 0 to 1 at
                                port A (analog input
                                selection)
        MOVWF       0X5         ;Sends selection to
                                port A


        MOVF        0X13,0
        MOVWF       0X20
        CALL        TXPIC       ;Sends MSB byte

        MOVF        0X12,0
        MOVWF       0X20
        CALL        TXPIC       ;Sends LSB byte

        MOVF        0X13,0      ;Creates verification
                                byte
        XORWF       0X12,0      ;verification byte =
                                f13 XOR f12
        MOVWF       0X20
        CALL        TXPIC       ;Sends verification
                                byte

        MOVF        0X15,0
        BTFSS       0X3,2       ;Tests analog input
                                counter ending.
        GOTO        L1

        GOTO        L3          ;restarts the main
                                routine


;########################################
;Routine to convert the analog input counter in
bits of port A
;########################################

P_ANALG
        ADDWF           2,1
        RETLW           0X1E
        RETLW           0X1D
        RETLW           0X1E


;########################################
;Routine to implement the RS232 serial receiv
ing at 2400 baud
;Byte received is stored in F20h
;########################################

RXPIC
C1      BTFSS       0X6,7       ;Waits for "Start
                                Bit"

        GOTO C2

        CLRWDT                  ;Clears WatchDogtimer
        MOVLW       0X8E        ;Refresh OPTION
                                register
        MOVWF       0X81

        GOTO        C1


C2      CALL        DELAY2      ;Inserts a 416us
                                delay

        CALL        DELAY1      ;Inserts a "1/2"
                                delay (208us)

        MOVLW       0X8         ;Loads counter (f14H)
        MOVWF       0X14

C7      BTFSS       0X6,7       ;Reads  bit at RB7
        GOTO        C4
        BSF         0X3,0       ;Places "1" in Carry
        GOTO        C5
C4      BCF         0X3,0       ;Places "0" in Carry

C5      RRF         0X20        ;Locates read bit

        CALL        DELAY2      ;Inserts a 416us
                                delay
```

```
        DECFSZ      0X14,1      ;Checks counting
                                ending (1-8)

        GOTO        C7

C8      BTFSS       0X6,7       ;Verifies "Stop Bit"
        GOTO        C8

        RETURN

;########################################
;Routine to implement the RS232 serial
sending at 2400 baud
;It reads a byte in F20h and then sends it
;########################################

TXPIC
        BSF         0X6,6       ;Sends "Start Bit"

        CALL        DELAY2      ;Inserts a 416us
                                delay

        MOVLW       0X8         ;Loads counter (f14H)
        MOVWF       0X14

B5      RRF         0X20        ;Locates , in Carry,
                                the bit that is going
                                to be read

        BTFSS       0X3,0       ;Reads bit through
                                Carry
        GOTO        B2
        BCF         0X6,6       ;Sends "1" at serial
                                port
        GOTO        B3
B2      BSF         0X6,6       ;Sends "0" at serial
                                port

B3      CALL        DELAY2      ;Inserts a 416us
                                delay

        DECFSZ      0X14,1      ;Checks for counting
                                ending (1-8)

        GOTO        B5

        BCF         0X6,6       ;Sends "Stop Bit"

        CALL        DELAY2      ;Inserts a 416us
                                delay

        RETURN

;########################################
; Routine that controls MAX187
; The MAX187 12-bit converter works with 16-bit
words made up of 2 bytes
; Data word: F13h (MSB) and F12h (LSB)
; The words are received serially (from MAX187)
 at the port RB2
; The LECONV routine place the data read in the
registers F13h e F12h
; The conversion starts when CS signal goes
 to low level
; (CS=0)
;########################################

LECONV
        BCF         0X6,4       ;Sends CS=0

        CALL        DELAY3      ;Waits about 50us for
                                conversion (Tc=8.5us)

        CALL        RECDADO
        MOVF        0X0F,0      ;Receives the 1st
                                data byte and stores
                                it in f13h
        MOVWF       0X13
```

```
        CALL        RECDADO
        MOVF        0X0F,0      ;Receives the 2nd
                                data byte and stores
                                it in f12h
        MOVWF       0X12

        BSF         0X6,4       ;Sends CS=1
        RETURN

;########################################
; Routine that reads one data byte from MAX187 and
stores in f05h
;########################################

RECDADO
        MOVLW       0X8         ;Counter (1 byte)
                                f14h
        MOVWF       0X14

E1
        RLF         0X0F,1      ;Rotates 13h register
                                (locates bit0 for
                                write)
        BSF         0X0F,0      ;Sets bit0=1. If bit
                                at DOUT=0 then the
                                next BFC do the
                                change
        BTFSS       0X6,2       ;Reads data at RB2
                                port (converter DOUT)
        BCF         0X0F,0      ;Locates bit read at
                                register f13h bit=0
                                position

        BSF         0X6,3       ;Sends SCLK=1

        NOP                     ;The following NOPs
                                are inserted to make
        NOP                     ;the SCLK signal a
                                50% duty cycle signal
        NOP
        NOP
        NOP
        NOP
        BCF         0X6,3       ;Sends SCLK=0

        DECFSZ      0X14,1      ;Decrements counter e
                                jumps if reg=0
        GOTO        E1
        RETURN

;########################################
;Delay Routines
;########################################

DELAY1
        MOVLW       0X0F        ;Inserts "1/2" delay
                                (208us)
        MOVWF       0X21
G1      DECFSZ      0X21,1
        GOTO        G1
        RETURN

DELAY2
        MOVLW       0X1F        ;Inserts a 416us
                                delay
        MOVWF       0X21
G2      DECFSZ      0X21,1
        GOTO        G2
        RETURN

DELAY3
        MOVLW       0X02        ;Inserts a 50us delay
                                approx.
        MOVWF       0X21
G3      DECFSZ      0X21,1
        GOTO        G1
        RETURN

        END
```

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Handy Moisture Meter

Going house-hunting? Raymond Haigh's inexpensive, easy-to-construct device could help you to avoid making the mistake of a lifetime.

Dampness in buildings is usually costly to eradicate. Equally important, it can create conditions which promote the establishment and growth of wood rotting fungi, and this can have serious structural consequences. Levels of dampness too low to be detected by touch or sight or smell can be sufficient to cause problems of this kind, and surveyors use a moisture meter when inspecting premises. Experience and judgement are needed to interpret the significance of the readings in a given situation, but the presence of dampness is always a warning sign. Even in inexperienced hands, therefore, a simple moisture meter may alert the user to potential problems.

If you think the property you're looking over could be the house of your dreams, but you suspect that there may be "damp spots", at least you'll be made aware of the need to call in a surveyor to check it out before you buy what could become a costly nightmare.

The instrument described here is inexpensive and easy to construct: indeed, most readers will already have suitable components in their spares boxes. Calibration couldn't be simpler, and guidance is given later on how to use it. The unit will detect low levels of moisture in common building materials. It will also give a clear indication of the relative moisture content, and this feature is often invaluable in establishing the source or cause of the dampness.

Principle of operation

Most porous, non-metallic building materials such as wood, brick, plaster and stone have a high electrical resistance when dry. As their moisture content increases, their electrical resistance reduces. This phenomenon is exploited by almost all of the moisture meters used by surveyors in order to provide a rapid and non-destructive means of measuring dampness in buildings.

The resistances involved are quite high, above 10 megohms at very low moisture levels, and early instruments of this kind used a sensitive moving coil meter and a high voltage battery (75 - 90V) in order to obtain a reading. By connecting a transistor in a simple circuit it is possible to eliminate the need for the high voltage battery, and a more compact unit can be constructed and operated at modest cost.

The circuit.

The circuit of the unit is given in figure1.

The resistance of the wood or other material across the probe tips, in combination with R1 and R2, fixes the voltage on the base of Q1 and determines the current flowing through the base-emitter junction. This small current initiates a larger current flow through the collector circuit which is read on the meter placed in series with the power supply.

Pre-set resistor R2 enables the instrument to be calibrated; and pre-set R4 acts as a variable shunt across the meter so that the pointer can be set to full-scale when the probe tips are shorted together (that is, zero resistance). R5 limits the action of R4 and ensures that the pre-set is easy to adjust. The emitter resistor, R3, makes the circuit relatively immune to spreads in transistor characteristics.

The action of the circuit is extremely simple. The lower the resistance across the test probes, the greater the voltage on the base of Q1. This increases the current flowing through the transistor and the reading on the meter. The lower the resistance the higher the moisture content of the material under examination, and so the meter scale reads conventionally, from left to right.

Very little current flows when the probe tips are open circuit, (a tiny fraction of a micro-amp) and an on/off switch is not required.

Components.

The components are widely available and non-critical, and no difficulty should be encountered in obtaining them. Almost any low- frequency, small-signal, NPN silicon transistor should be suitable for Q1. If the specified BC171 is not to hand, try a BC107, 108 or 109.

Any moving coil meter with a FSD within the range 50 to 500uA will be suitable. A Maplin 60 x 45mm pan type meter with a 100uA movement is fitted in the prototype instrument, and the values of R4 and R5 have been chosen to suit its current range and 3750 ohms internal resistance. If a more sensitive unit is fitted, R5 may have to be shorted out in order to reduce the shunt resistance. Conversely, if a less sensitive meter is used, pre-set, R4, may need increasing to 2 or even 4K7 ohms in order to secure full scale deflection with the probe tips shorted. Constructors who do not wish to modify the meter scale would be wise to install an instrument with a scale calibrated 0 - 100, as this will make it easier to interpret the readings.

The probe tips have to be sharply pointed and hard enough to resist blunting when pressed into timber, plaster or the mortar joints in brickwork. Hardened steel picture hanging pins are used for this purpose in the prototype instrument. These pins have brass heads and this makes it easy to solder them to the probe leads.

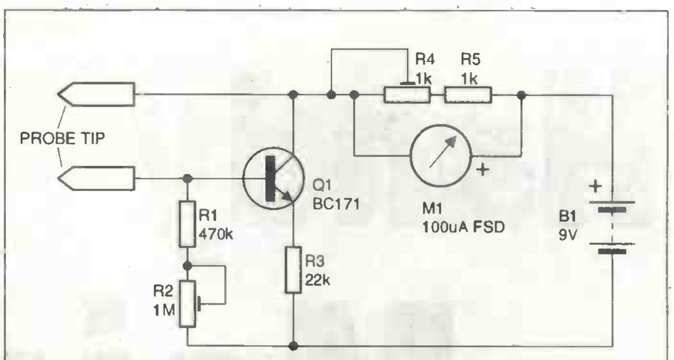


Figure 1: the circuit diagram of the moisture meter

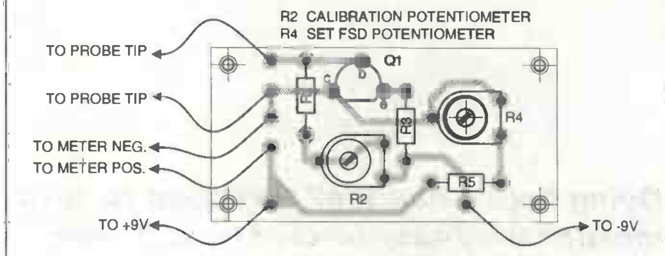


Figure 2: the component layout and wiring

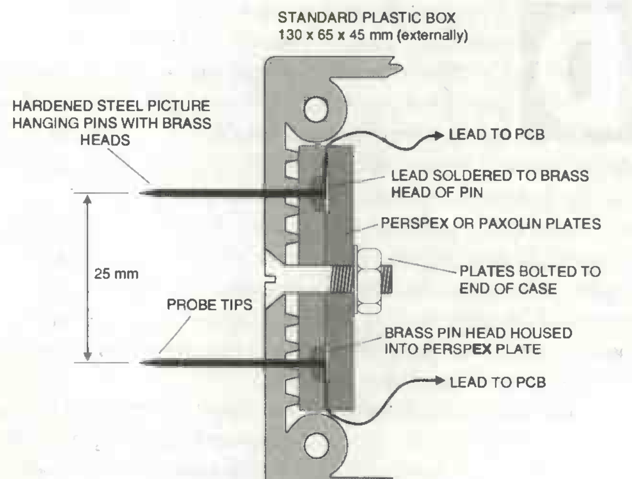


Figure 3: a method of fixing the probe tips to the end of the plastic case

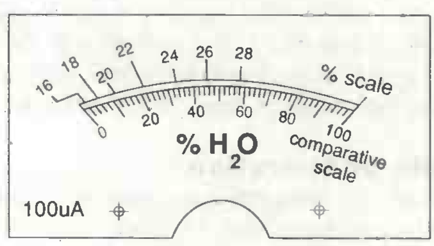


Figure 4: a scale template for the meter movement suggested in the article

Construction.

The components are mounted on a small PCB. The component side of the board is illustrated in figure2, and the foil side in figure3. Vero pins inserted at the lead-out points ease the task of off-board wiring.

Meter, battery and PCB should be housed in a small plastic box. The arrangement adopted for the prototype is shown in a photograph. The PCB and meter are mounted on the lid, and the battery is held in place by a Paxoline partition across one end of the box. A fretsaw or coping saw can be used to form the hole for the meter.

Attach the PCB to shallow stand-offs by means of short, self-tapping screws, then Superglue the stand-offs to the lid of the box, taking care to align the holes which access the adjustment slot of R4.

The probe tips project through the end of the box, and the method of securing them is illustrated in figure 4. The probe has to be pressed fairly hard into the material under examination, and the pin fixings must be able to resist this. If the pins are a tight fit into the piece of Perspex or Paxoline, it may be possible to hold them securely in place with cyanoacrylate adhesive (Superglue) and dispense with the nut, bolt and second piece of Perspex.

Setting up

Check the PCB for poor soldered joints or bridged tracks, and check the orientation of Q1. If all is in order, connect the meter, rotate the pre-sets to minimum resistance and connect a fresh 9V battery. The meter pointer should remain at zero.

Short the probe tips together and rotate R4 to increase the amount of resistance in circuit until the pointer is at full-scale.

Connect a 2M2 resistor across the probe tips and adjust R2 to set the meter pointer at 20 on the comparative (0-100) scale.

Check again for full-scale deflection with the probe tips shorted, and refine the adjustment of R5, if necessary. Check again for a scale reading of 20 with the 2M2 resister across the probe.

The setting-up process is now complete and the sensitivity of the instrument has been fixed in the critical 20 - 22% moisture content region. A 620k resistor connected across the probes should now bring the pointer to 50 on the comparative scale (centre scale). This final test is desirable in order to check that the unit is functioning correctly.

If a 500uA meter, or a transistor with a low hFE, has been used, and full-scale-deflection cannot be obtained even with R5 shorted out, try reducing the value of R3 to 10k.

Battery life is its shelf-life, but falling voltage affects the sensitivity of the unit. Check, from time-to-time, that full-scale deflection is obtained with the probe tips shorted, and adjust R4, as necessary, to ensure this.

Calibration

With the instrument constructed and set up as described, the moisture content percentages, at various points on the 0-100 meter scale, are as tabulated below:

Moisture content percentage						
16	18	20	22	24	26	28
Reading on 0-100 scale						
2	6	12	22	34	46	58

Readers can use the above information to re-calibrate any suitable meter. Alternatively, if the data is pasted onto the case of the unit, it should be reasonably easy to operate it without re-calibration provided the meter has an 0-100 scale.

The calibrated scale of the meter fitted in the prototype unit is reproduced in figure5. If the specified meter is used, a photostat could be stuck to the rear of the existing aluminium scale plate with a smear of Durofix adhesive.

Gently prise off the clear acrylic meter cover, remove the two self-tapping screws which secure the aluminium plate and slide it from beneath the pointer. There is generous clearance between the pointer and the surface of the plate, and the extra thickness of the new scale will not cause problems. Sticking the new scale to the reverse of the existing enables the original meter function to be restored, without difficulty, should this be desired. Before the plate is re fixed, colour the central band of the new scale bright red, from 20 percent to maximum, as a visual reminder of the danger zone.

Moving coil meters are very delicate things and the above operation should be carried out with the utmost care so as not to damage the pointer or the bearings of the movement.

For reasons which are explained later, the calibration of the unit is inevitably approximate, as, indeed, is the calibration of all moisture-measuring instruments of this kind.

Using the Moisture Meter

In order to check for dampness, simply press the probe tips into the timber or plaster and note the reading on the meter scale. When checking moisture levels in brickwork, press the probe into a mortar joint. If the material is too hard to permit penetration, press the probe tips firmly against the surface.

Try the unit out at home before boldly going forth to check moisture levels in someone else's property. If your house is free from dampness, the meter pointer will not shift from zero and you will have to try exterior woodwork or timber left lying around outside in order to experience a visible reading. (Pressing a finger across the probe tips should drive the pointer across the scale.) The testing procedure will, of course, leave tiny marks on surface decorations, and it is courteous and wise to obtain the approval of the house owner before using the moisture meter.

The following notes should help you to make some sense of readings you might obtain (and give you a few technical terms to help build up your 'street-cred' when talking to the experts).

(1) If the material is acceptably dry, there will be no deflection of the meter pointer. Any noticeable deflection, no mater how slight, is, therefore, an indication of dampness.

(2) The meter indicates the approximate moisture content of timbers commonly used for building purposes. Moisture content is the weight of absorbed water divided by the dry weight of the wood.

(3) The critical moisture level is 20% (12 on the 0-100 comparative scale). Above 20%, dry rot (Serpula lacrymans) can establish itself. Once established, it can survive with moisture contents as low as 14-15% (a slight deflection of the meter pointer).

(4) Wet rot (usually Coniophora puteana) requires a moisture content in excess of 40% (moving towards full-scale-deflection of the meter pointer) before it can become established and develop.

(5) Timber joists and beams are built into walls. Readings on plaster or brickwork will, therefore, reveal the possibility that hidden timbers may be exposed to excessively damp conditions.

(6) The moisture meter indicates relative dampness levels in plaster, brick, concrete and stone, and this makes it a useful diagnostic tool. Rising dampness in a wall is indicated by readings close to full-scale at ground floor level petering out to near zero about one metre up.

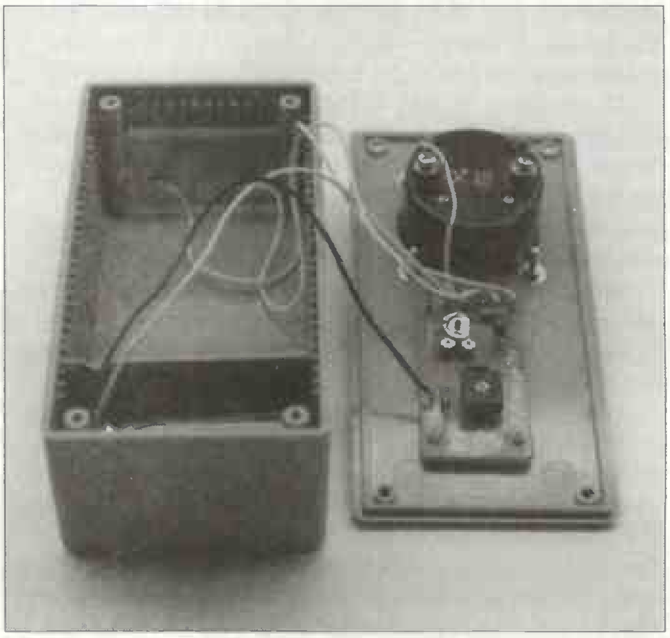
(7) Condensation may be the culprit if fairly similar readings are obtained over the entire surface of a wall.

Limitations

Timber moisture content for a given resistance between the probe tips varies from species to species and, to a lesser extent, from tree to tree and within a single board or plank. The temperature of the wood, surface contamination, and impregnation with preservatives, also affect the readings obtained, and all of these factors combine to impose limitations on the accuracy of instruments of this kind. Resistance measuring moisture meters do, however, permit the rapid and non-destructive assessment of dampness levels, and they are standard items of equipment for surveyors who carry out detailed inspections of property.

Knowledge, skill and experience are needed to correctly interpret the significance of the readings in a given situation. In the case of a house you're only marginally interested in, however, discovering dampness could be the clincher that makes you decide not to proceed any further. If you find dampness in a property you've fallen in love with, call in an independent expert to carry out an inspection and prepare a report before you make an offer.

Provided you bear in mind the limitations of the instrument (and, perhaps, your own limitations, too) an evening spent with a soldering iron could help you to avoid making the mistake of a lifetime.



PARTS LIST

Resistors

All 0.25 Watt, 5% tolerance unless otherwise stated.

R1	470k
R2	1M pre-set potentiometer.
R3	22k
R4	1k pre-set potentiometer.
R5	1k
R6	2M2 1% for calibration purposes.
R7	620k 1% for calibration purposes.

Semiconductors.

Q1	BC171

Meter

M1	Moving coil type, 50 - 500uA FSD. See text.

Sundry items.

PCB making materials, Vero pins and hook-up wire. PP3 battery and connector. Plastic box. Brass-headed picture-hanging pins. Small pieces of Perspex or Paxoline. Small self-tapping screws and stand-offs. Cyanoacrylate adhesive (Superglue).

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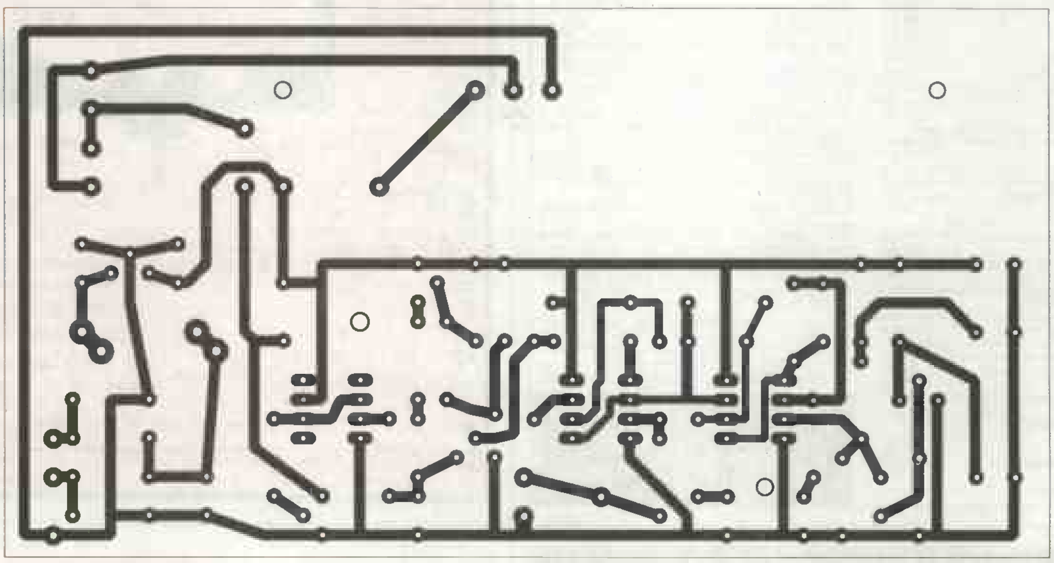

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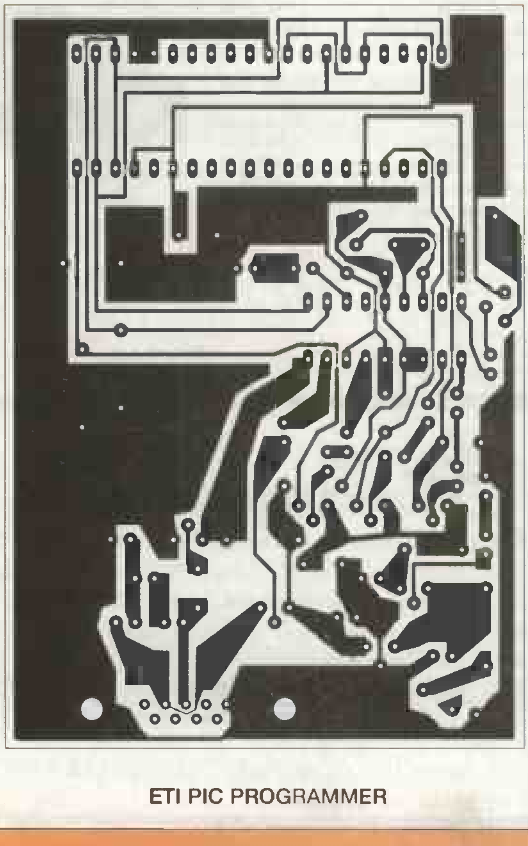

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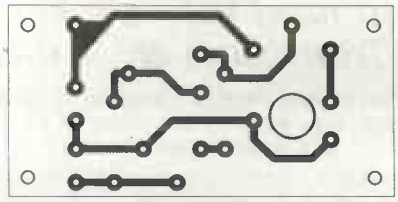

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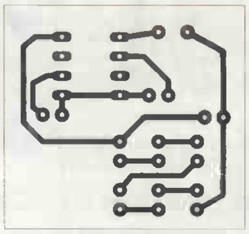

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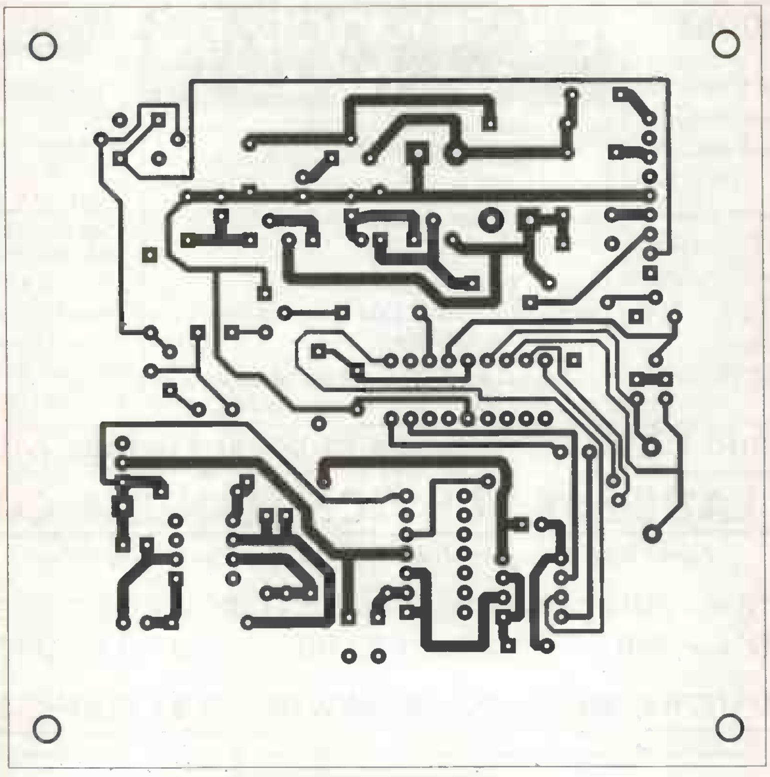

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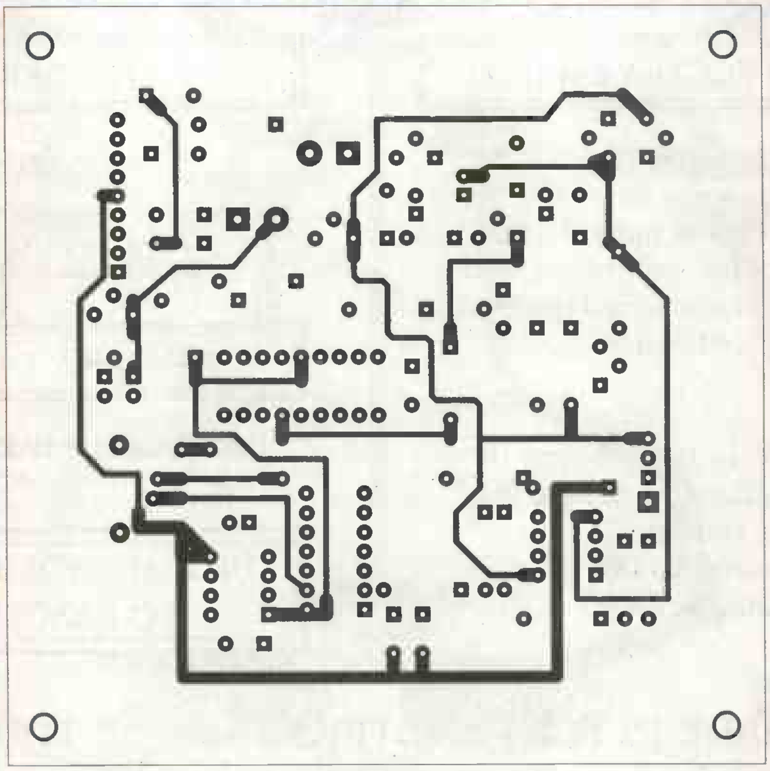

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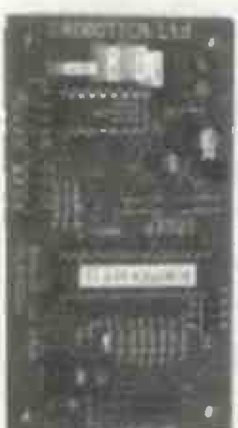

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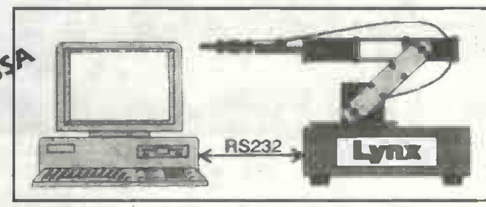

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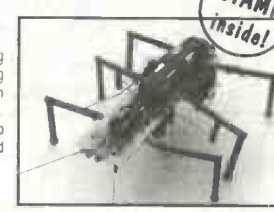

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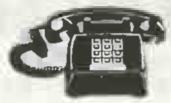

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Around the Corner

I This issue reports the results of the Young Electronic Designer of the Year Awards. YEDA is for full time students, mainly from the electronics disciplines, and it lays some fairly strict criteria for entrants: originality; technical competence and reliability; sound construction (and presentation); usefulness; and commercial feasibility. The young designers must consider who is going to use their design, and how practical it will be to operate. They must think about the cost of construction, where the parts are to come from, and how best to package and promote it to the eventual user. People from age 12 to 25 are encouraged to work in teams or as individuals to look at all aspects of electronics design and come up with something of their own. It is a fine and encouraging effort and a credit to the students and the sponsors,Mercury Communications, Texas Instruments and the Institution of Electrical Engineers.

In a nutshell, most of the criteria that apply to design in the wider world are the same criteria that apply to designing and publishing a project for constructors who want to build their own devices, equipment and machinery at home.

We have a slightly easier task, in fact, because most constructors are not upset if they have to do some calibration, or if the design does not include a mega-matt machine moulded heat-sealed non-reflective front panel, or even if they have to look a bit further for a specialised part (as long as we warn them, and tell them where to start looking).

But they, too, want something that works and something that will be useful or entertaining or just intriguing. In our fraternity there is more room for the personal design, the useful widget that sits in a corner of the bench/car/attic and does something that no-one else really needs doing (but have you asked them?) in a way that is slightly different from the commercial norm. But once you have put your efforts into making your design useful, safe, reliable and maybe (but not necessarily) even attractive - not only have you met many of the criteria that determine the winners of design awards, but you may have something that others would like to build for themselves.

(There was quite a rumpus in a nearby household when the time came to replace the insulating jacket on the hot tank and the designer-in-chief suggested chucking out the widgit he had built in a tobacco tin 10 years ago to monitor the hot water level. The household had come to rely on it to avoid squabbles about the hot water running out - but no-one had told him.)

If you do, we are always pleased to hear from people who have built an original-project and are thinking of writing it up. For more information, see the small ad. on page 23, or write to the editor for our Potted Project Production sheet.

Two pieces of news: author Bob Noyes reminds us that the LM3911 replacement board published last month for the Shake'n'Etch has been designed so that it can replace the discontinued LM3911 in any normal application with minimal tweaking.

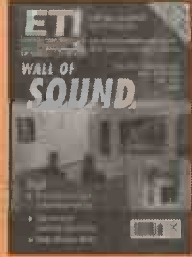
The other piece of news is that negotiations for a new ETI PCB Service are far advanced, and the new service currently looks set to begin next month.

The Challenge - Things that electronics hasn't fixed yet

I wonder if it would be possible to convert electricity to light with integrated circuits, by having a very high frequency oscillator and a microscopic antenna, and generating the light in the same way as conventional radio frequency. The laser and the LED provided part of the answer, but if you could make a nano-size transmitter and receiver for light, then an array which responded to phase and frequency suitable could, for example, function as a camera without the need for a lens. Or it could be the ultimate flat screen display, with 3D capability inherent in its functioning. But how?

Next Month...

Volume 26 no. 7 of *Electronics Today International* will be in your newsagent on 20th June 1997 ... Robin Abbott will be describing the new Universal Serial Bus PC serial standard that can address up to 127 devices and is the contender to replace RS232 in the next few years. ... A new EEPROM programmer with personality modules for different devices from Keith Wardill ... our cryptic car-alarm look-alike ... a switched sine- and square-wave generator from Robert Penfold ... another Spiced Circuit ... the results of our EdWin competition ... and more ...
Contents are in preparation but are subject to space and availability.



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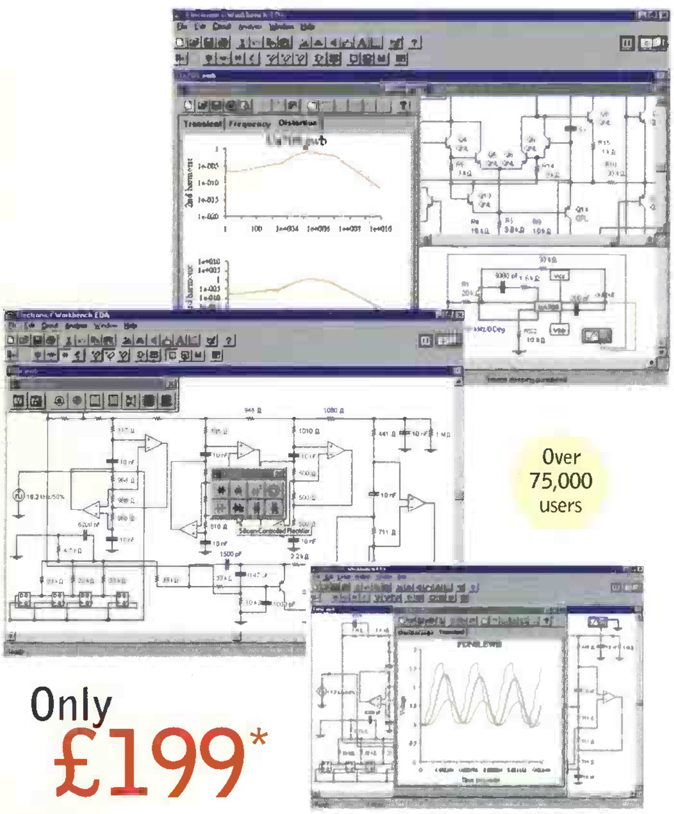

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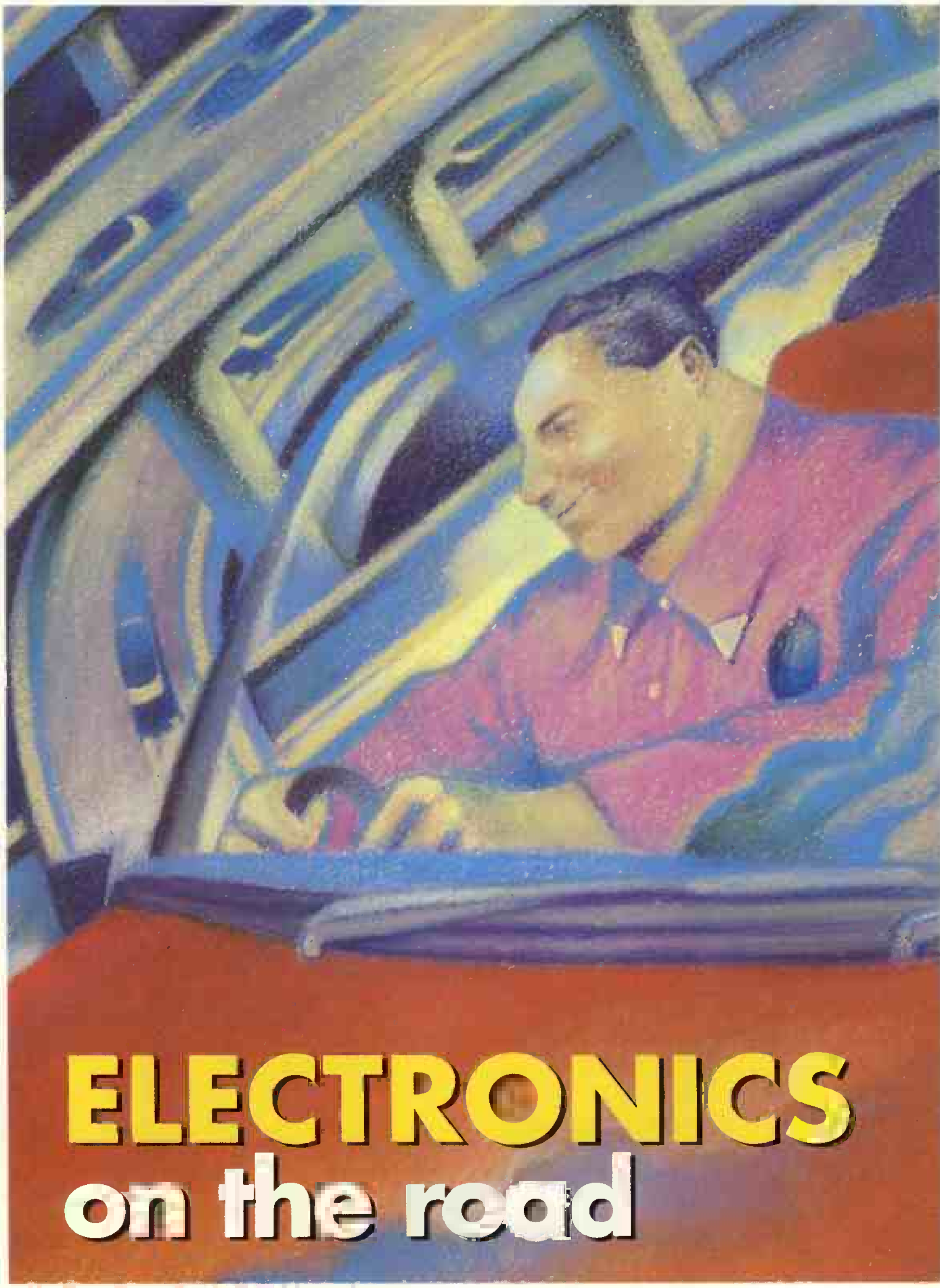

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Electronic systems keep this car going in a straight line on ice at 50km/h – page 372.

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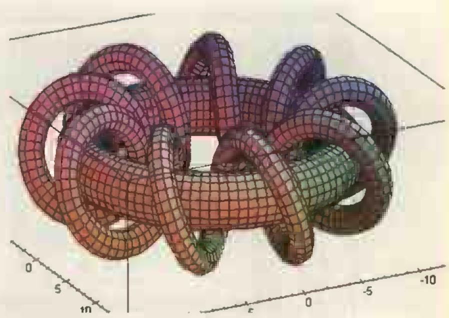
REGULARS

Cover Illustration Hashim Akib

Solar winds cause electricity supply problems, but new research could help make them more predictable – page 370.



Mathematical modelling software Maple V even produces animation, which can help provide an insight into temporal behaviour. – page 379.

Next month:

Douglas Self presents a completely new amplifier concept, Steve Webb describes a low-cost video digitiser, Cyril Bateman explains Internet and Jeff Macaulay describes the microreflex loudspeaker that we were unable to publish last month.

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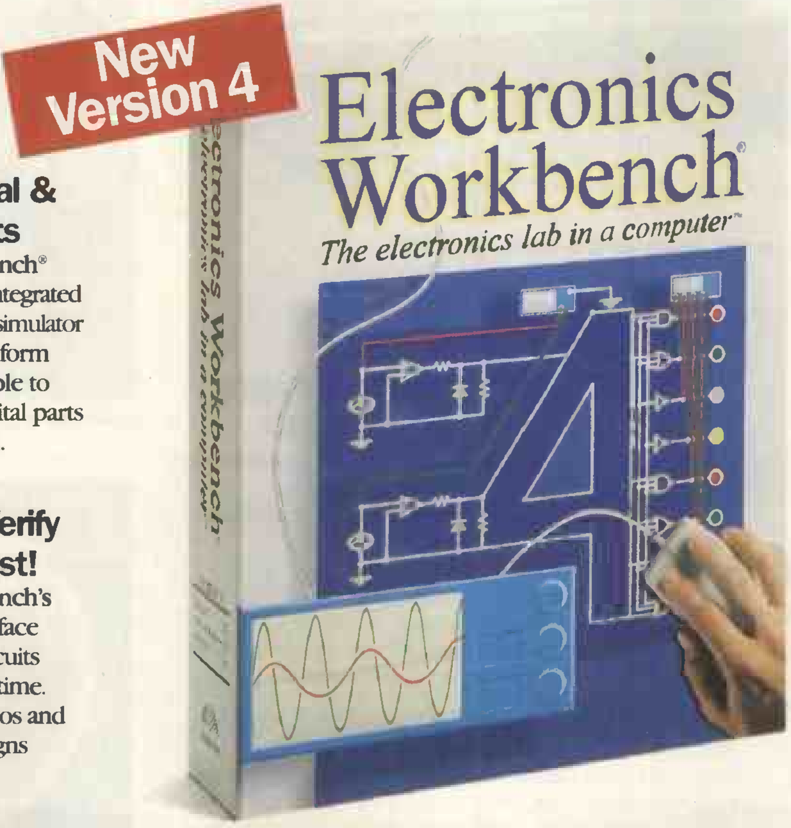

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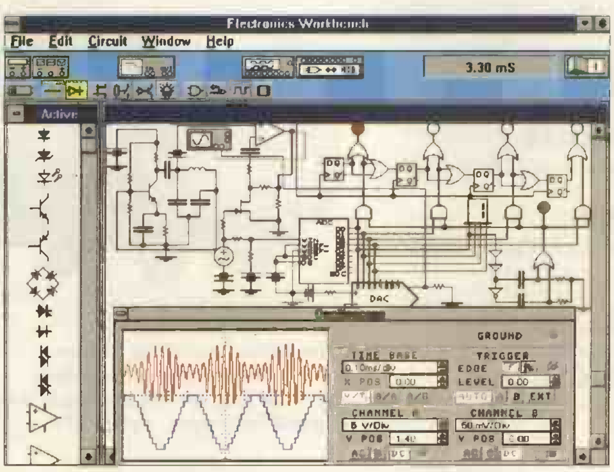

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A sorry foresight saga

Academic scientists have always had a disproportionate influence on the UK government's attitude to technology. That could be one reason why we have such a tiny microelectronics industry in the UK.

Earlier this month, the ITEC (Information Technology and Electronics) panel of the Government's Foresight programme looking at the UK's technological future, decided to write off the UK semiconductor industry.

As with the Alvey catch-up technology programme of the 1980s, the ITEC panel was dominated by academic scientists. Of the 25 man panel, 11 are working academics at universities, others are of an academic bent working on the boundaries of academia, and industry and not one of the 25 is a career semiconductor man.

The panel's principal microelectronics recommendation – that the UK needs a microelectronics R&D centre on the lines of the IMEC microelectronics research centre at the University of Leuven – will leave those people in the UK who struggle to make a living out of semiconductors, gasping for breath at its irrelevance.

The misdirection of government aid for the microelectronics industry has resulted in the UK having a chip industry made up mostly of design houses. These companies have world-class design skills – but they have nowhere in the UK to go to get leading-edge manufacturing services to turn their world-class designs into world-class products.

At a conference organised by the Federation of the Electronic Industry a couple of years back, delegates bemoaned the fact that there was no accessible, sympathetic British foundry facility where they could go for leading edge silicon – except for GEC Plessey Semiconductors (GPS). But now GPS has adopted a strategy of staying a year or two behind the leading technological edge, not even that exists.

But ITEC does not even purport to be aiming its microelectronics centre at helping the UK semiconductor industry – it is intending it as a support facility for inwardly investing foreign semiconductor companies. In effect, ITEC does not see the UK semiconductor industry as worth support and does not regard an indigenous capability to manufacture first-class silicon as being of any importance.

Instead, the scientists of ITEC are directing the Government's thinking to other spheres – how to use the rapidly accelerating power of computers and the Information Superhighway to deliver the UK's undoubted strength in media products to Britain and to the world.

This is proper work for scientists! Conceptual, theoretical, intellectual stuff on which papers can be written, conferences attended and jobs for more scientists created.

But will it deliver any useful, practical technology to help the many entrepreneurial UK design houses or encourage the start-up of new high tech businesses? As with Alvey and with all previous scientist-driven initiatives, one doubts it.

David Manners

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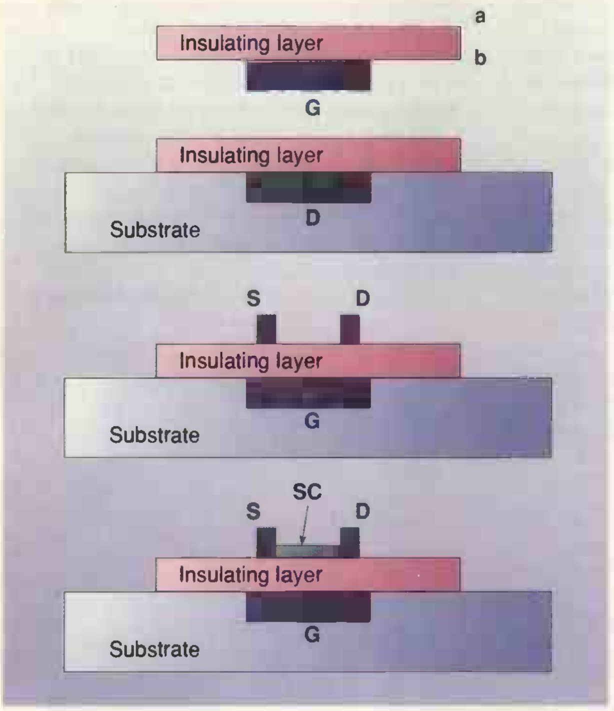
Focus on polymer transistors

With an all-polymer fet, it is easiest to begin with the insulating layer. This needs to have high homogeneity and good dielectric properties. Such fets could prove very useful for flat-panel display and smart-card type applications.



At least five major electronics firms are developing products based on all-polymer transistors, amid claims that the technology could eclipse amorphous silicon in applications such as flat panel displays and smart cards by the end of the century.

Japanese giants Matsushita and Mitsubishi, US-based Motorola and IBM and European firm Philips are working on all-polymer transistor systems. Matsushita and Mitsubishi have already published research papers on the subject, and Mitsubishi is rumoured to be very close to producing the world's first all-polymer-transistor based flat panel display type for laptops.

FLexible polymer transistors have been pioneered by a team of researchers at the CNRS centre in France, led by Francis Garnier. The team has been working on the devices for the last five years, but now the technology is being taken up by electronics giants worldwide.

The main advantage of polymer transistors over silicon ones is their flexibility, which may allow complete bending or rolling without affecting their electrical properties. They should also be cheap to make in volume, and the devices can be made transparent, suitable for windshield applications in planes and cars. "Organic semiconductors will be available at lower cost", insisted Garnier. "They can be applied with web printing techniques and this will open the field for cheap, flexible electronics".

At present, polymer transistors are slower, larger and have lower output current than silicon transistors but these characteristics are expected to be improved with further development. Garnier expects the first commercial products, probabLy in the form of displays for domestic appliances, as soon as 1996/7 and for these low-end applications to open the way for large-area, low-cost polymer electronics systems.

Unlike earlier work, where only the substrate was made of polymer, the latest transistors also have polymer-based electrodes made from graphite-based ink.

Svetlana Josifovska
Electronics Weekly

Video on the radio

Engineers at Racal Radio have developed a video compression technique said to be efficient and robust enough to transmit pictures reliably over a radio link. The technique, designed for immediate application in military surveillance systems, can transmit a real-time video stream over a 25kHz 16kbit/s radio link.

The compression algorithm used is a Racal-developed version of the lapped orthogonal transform, coupled to an error resistant entropy code. The combination is said to be able to recover from 20 percent data loss. For worse losses, rather than an image failure, there is a gradual degradation of the received image quality as the channel error rate increases.

Low cost route to silicon modelling

As feature sizes continue to shrink and devices become more complicated, chip designers may have to resort to virtual reality techniques in which they can literally immerse themselves in a 3D simulation of a chip, according to a top researcher.

Interactions between electrons and the edge of devices have become more important in determining chip performance. These require complex equations to model the effects, which is why the key to 3D simulations will be the development of very fast, cheap parallel computers capable of processing millions of equations.

Stanford University researchers, working with scientists at IBM, claim they have developed special algorithms that boost the performance of low cost parallel computer systems without the need to build specialised parallel computer systems costing tens of millions of dollars. The researchers have demonstrated the ability to solve 1.5 million equations at a speed of 9.5Gflops using an IBM Powerparallel SP-2 computer.

Robert Dutton, professor of electrical engineering and chief scientist at Stanford University's Center for Integrated Systems says that, "At these rates, 3D will take about the same time to run as current two-dimensional simulations".

The new algorithm has been incorporated into Pisces – a commercial program that simulates the behaviour of microscopic electronic elements in complex semiconductors.

Dutton said the algorithm could be ported to desktop workstations where it can speed up 2D chip modelling tasks. Stanford has said it will license its technology to other companies.

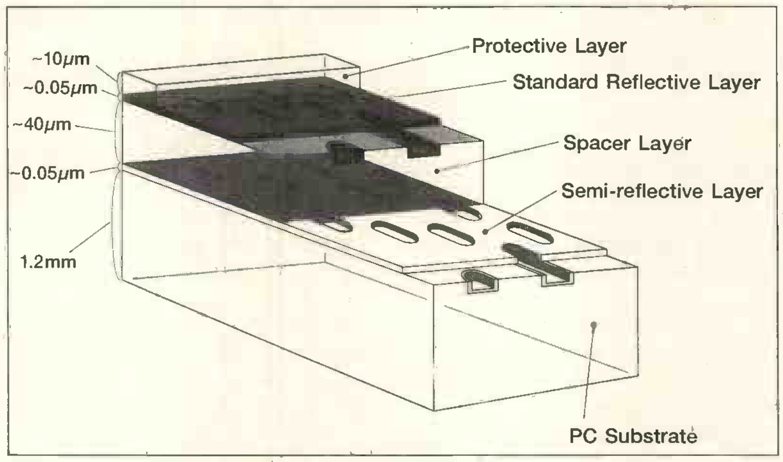
Philips/Sony fight back on high density CD

The chances of Philips and Sony conceding victory to Toshiba in the battle of high-density cd systems seem remote. Philips has been mounting a major information offensive in support of its system with demonstrations at CeBIT, the Audio Engineering Society convention in Paris and its home base, Philips Research Laboratories in Redhill.

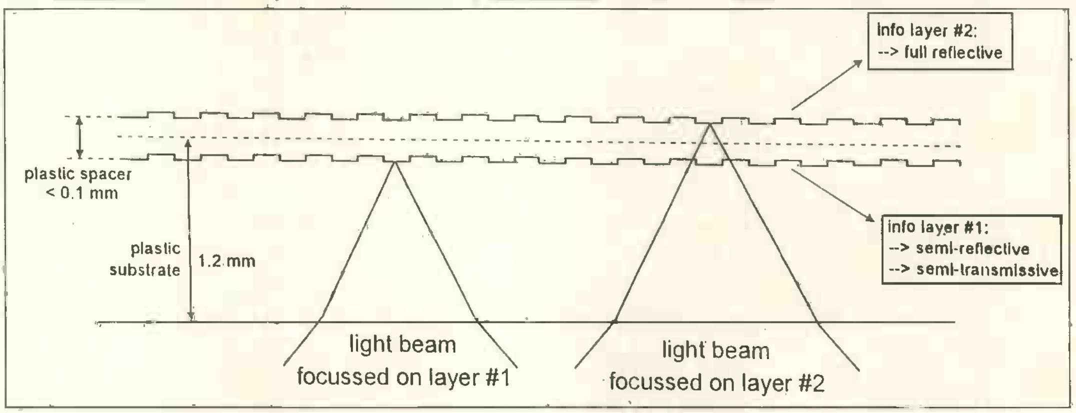
Players using the single-sided dual-layer system will be on sale next year, Philips promises, whether the film industry supports it or not. Increasingly Philips/Sony are looking to the professional computer market – a potentially much larger user base – to back the system. "We do not believe this is a technology which is a mass market proposition that's just around the corner," said John Hawkins, world head of Philips Media Distribution, at Redhill.

The demonstrations revealed some aspects of capability, such as the dual-layer system which was first used on Laserdiscs as far back as 1977, but also showed the complexity of the agenda which Philips is now grappling with. Although it needs to counter the Toshiba double-sided system, Philips also wants to create some space for the development of CDi, assisted by existing MPEG 1 CD Video. Hence its insistence on the high initial cost of high-density which, it contends, will preclude mass sales to begin with.

MPEG 2 will require four times as much memory as MPEG 1, and far greater processing complexity, to say nothing of the HD drive and new laser and optics. All of these combined will push the price of hardware up into the no-go area, well above £400.



Dual layer construction of Philips high-density CD system, whose complexity indicates initial take-up by the computer, not consumer, industry. Light beams will need to be focused separately on the two layers; each layers offers different read-out characteristics.



Thus, initial uptake of high density technology is likely to be by the computer, rather than consumer, community, where increased storage capacity is always in demand. Only after start-up costs have been amortised in that market, so the Philips argument runs, will high-density become affordable enough to go mass-market.

Both proposed high-density standards can carry more than ten times the current 650Mbyte capacity of CD-Rom. Philips/Sony will hold 7.4Gbyte in two layers; Toshiba, 10Gbyte, split between two sides. Both will use red laser technology with a wavelength of 635nm. Philips/Sony now promise backwards compatibility with existing formats. Apart from additional costs involved in accessing two sides of a disc, Toshiba has yet to work out where the label could be accommodated.

Peter Willis

Silicon coils for even smarter cards

While smart cards may give the impression of being easy to use, they can give rise to problems, usually associated with the way they are made. The rigidity of the antenna coil, which is wrapped on a chip fixed on a flexible fixture like a plastic card, means that it is possible to break some of the connecting wires within the chip if the smart card is flexed.

Micro Sensys, a German-based radio identification specialist, has come up with a simple, low-cost way of building coils onto chips by growing them onto the silicon wafer, which avoids the traditional bonding processes. The monolithic microstructure employed is used in rf chips for contactless smart cards and other identification and access control applications. It integrates completely all of the analogue functions, a high-frequency rectifier, antenna coil and an EEPROM on a single chip.

In a conventional contactless smart card chip, the transceiver coil is applied using cmos metal layer technology. This method produces structures 1μm thick and below. These very thin layers introduce high surface resistance, inconsistent quality and inhibit the placement of active circuit elements (the logic gates, EEPROM and the transmitter) in the coil area. These drawbacks can be rectified by using thicker structures (around 100μm), produced by X-ray lithography, which although technically feasible is expensive.

Instead, Micro Sensys uses a modified straight wall bumping process. This process is normally used in tape-automated bonding for chips with many contacts (between 200 and 300). A single metal layer is applied to the silicon substrate in the form of 'bumps', leaving structures that look like tower-blocks behind. This is achieved by raising the metal layer higher than the silicon substrate; passivation-layer channels still run in between. The metal layer forms the coil between the bumps.

1Gbit DRAMs nearing production stage

Sony has combined two leading edge chip fabrication devices – one a quadrupole light source and the other a phase shift mask, to stretch optical lithography towards 0.18μm feature fabrication. This is the feature size that will be needed to make the first generation of 1Gbit DRAMs in production quantities.

The surface of a wafer is not flat, but deviates up to 1μm. The image of the production mask must be in focus for all 'altitudes' on the wafer surface, so the projection optics must have a minimum depth of field (DOF) of 1μm.

The size of image that can be clearly focused onto the surface of the wafer is proportional to the wavelength of light used. For 0.35μm lithography (current state-of-the-art for production), specially-developed krypton fluoride (KrF) excimer lasers are used that emit ultraviolet light at 248nm . For a given optical system, both the minimum image size and the depth of field are proportional to wavelength. These limitations restrict KrF lasers to feature sizes of 0.35μm.

Beyond the DOF, a circular spot projected on the wafer becomes a larger and larger circular blur. Sony has used a trick to reduce the effect of this problem by altering the characteristics of the laser beam.

Sony's modified optics split the laser beam in four, diverge the sub-beams using a prism array, then recombine them, creating a quadrupole light source. This replaces the normal circular light source with four smaller overlapping image ones. In sharp focus, the image looks like four spots but outside the DOF the blurred image has more energy in the centre and looks much more like a 'normal' focused spot.

This technique raises the effective DOF more than two times, allowing the optics to be changed and trading the increased DOF for smaller feature size.

If a feature size of 0.28μm is required, conventional illumination only gives a DOF of 0.77μm. The new source gives a 1.1μm DOF, suitable for production techniques of the near future.

The second feature Sony has incorporated is a phase shift mask. A normal mask has transmissive and non-transmissive regions. The sharp transitions between these regions result in diffraction patterns over the wafer surface around the image. Diffraction effects can be reduced by deliberately phase-shifting light by different amounts at different points in the mask.

There are some limitations to phase shift masks: not all image shapes can be made and there can be a strong secondary image net to the primary one. On their own, phase shift masks can improve image resolution, but the quadrupole light source can be optimised to suppress most of the secondary image. The new light source and mask together allow 0.22μm features with a 1μm depth of field.

Sony has demonstrated that its combination technology can produce 0.22μm features and claims it can be developed to make first generation 0.18μm chips using optical lithography.

Steve Bush
Electronics Weekly

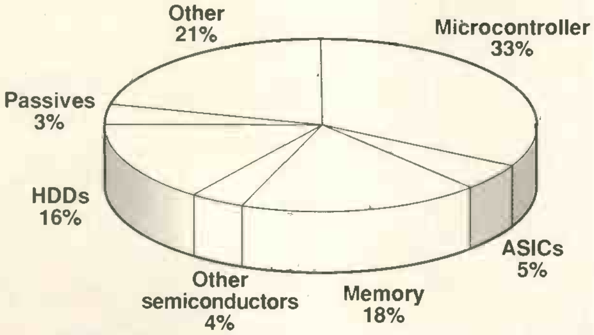
PCs fuel demand for electronic components

Industry analyst BIS Strategic Decisions reports that demand for electronic components continues to be fuelled by the booming markets for PCs, monitors and printers.

The BIS report, European Computer and Office Automation Equipment Production, expects the European computer market to be worth $13.5billion this year, up $3.3 billion since 1993. In 1993, $7.4 billion (around 72 percent) was accounted for by components in desktop and portable computers.

1995 European market for computer and office automation equipment.

1995 European Component Market in Computer/OA Equipment



Total European Market in 1995 = US$13.5 billion

Source: BIS Strategic Decisions

Low cost single-chip demodulator

A single chip digital tv demodulator based on the 64/256 QAM systems used in North America's Grand Alliance HDTV trials has been introduced by VLSI Technology. The quadrature amplitude modulation (QAM) system, which could also be the basis of European terrestrial digital tv transmissions, was developed by Californian developer Applied Signal Technology and integrated by VLSI Technology into its library of functional system blocks.

The quadrature down converter equaliser demodulator (QED) would be used in QAM cable tv set-top box receivers. It sits between the cable and the MPEG compression functions and extracts the digital video and audio data streams from the 64/256 QAM modulated signal on the cable tv network.

Operating at an IF of 43.75MHz, it supports symbol rates up to 5.4Mbaud and implements the Reed-Solomon forward error correction algorithm. The QAM protocol combines traditional amplitude modulation and quadrature phase shift keying (QPSK) to put the digitally coded tv signal on the carrier frequency.

An advantage of QAM is the relatively large number of phase and amplitude states, 64 and 256, used to represent the digital tv signal. As a result, QAM supports a high capacity data channel, equivalent to 40Mbit/s, by assigning 64 and 256 phase and amplitude states to represent the digital signal at 8 bits per symbol. The 40Mbit/s 256QAM digital channel can support up to five 8MHz PAL analogue tv signals or seven 6MHz US NTSC analogue television signals.

The QAM device is one of a number of chips VLSI is offering for low cost set-top box receiver designs. It is developing a separate QPSK demodulator with ComAtlas of France, and an MPEG-2 codec with US specialist, Mediamatics. ■

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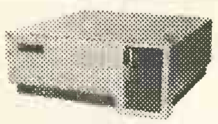

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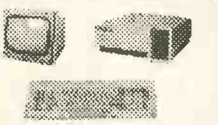

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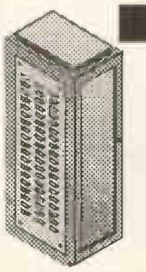

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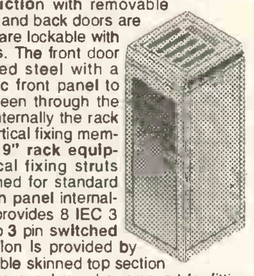

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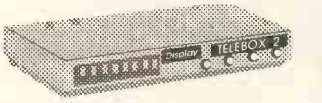

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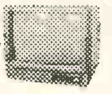

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CIRCLE NO. 105 ON REPLY CARD

RESEARCH NOTES

Jonathan Campbell

Thin film cell packs a punch

Weight is so often a limiting factor in design of rechargeable batteries. But researchers at Tokyo University and Matsushita Electrical Industrial have announced development of a low cost solid state rechargeable battery that can store 50% more electrochemical energy in its electrodes than the best conventional technology available.

Key to performance of the new battery is an organic thin-film cathode. Organic materials have been proving particularly attractive to battery designers because they offer large theoretical energy storage capacity, combined with low weight and high strength.

The Tokyo cell is made up of a Dimercaptan (DMcT) and polyaniline (PAn) cathode with a lithium anode – compounds already known to have had a complementary effect on performance, though the precise chemistry of the reaction is not yet definitively agreed. However, cells fabricated along these lines have been reported before.

The advance made by the Japanese team has been to prepare a solution containing the electrode materials which can be printed or painted by conventional techniques. Not only does that make for easy manufacturing, but, importantly, it allows excellent molecular-level mixing of the DMcT and PAn, leading to much higher efficiencies than have been achieved before.

Gravimetric energy density of the composite cathode is reported to be >600Wh/kg cathode (Dimercaptan-polyaniline composite electrodes for lithium batteries with high energy density, N Oyama *et al* (*Nature*, 373, pp.598-600). This compares to a figure of 400Wh/kg for the cathode in one of best commercial lithium-ion cells. So energy density of the DMcT-PAn cathode is 1.5 times better.

No deterioration in capacity was observed in 30 cycles for the test cell, with the cathode charged at 4.5V and discharged at 0.1mA/cm^2 down to 2.25V. That compares with a loss of 15% in capacity by previous designs of this type of cathode.

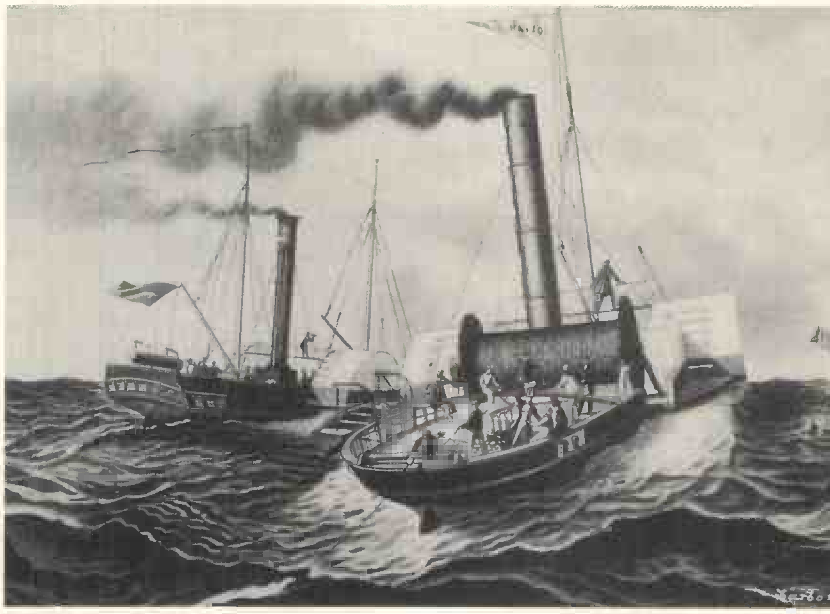
At present the maximum useful current density looks to be 0.1mA/cm^2 – which is undeniably small. But because the cathode is a film, a large electrode area can easily be obtained without weight penalty.

Expected applications will be in areas where weight rather than volume is the crucial factor, as high gravimetric density is offset by low physical density.

Deep conversations

Confidence in ultra-long-haul optical cable systems using cascaded erbium-doped fibre amplifiers has been boosted with news that Japanese workers have successfully made 5.3Gbit/s transmissions across 11,300km of installed submarine cable. This is the longest distance yet achieved using the technology. T Otyani *et al* (5.3Gbit/s 11,300km data transmission using actual submarine cables and repeaters, *Electronics Letters*, Vol 31, No 5, pp.380-381) from KDD Submarine Cable Systems, made use of two fibre pairs in a real cable 2850km long that had 48 repeaters and a repeater spacing of 60km. By joining the fibres together at their ends with optical attenuators, the researchers were able to create a 11,300km transmission line.

The long distance success of using a cable made up of dispersion-shifted optical fibres and erbium-doped amplifiers – designed to operate under the sea for at least 25 years – clearly demonstrates that the low-cost and high reliabilities of such a system



Exploiting the full potential of submarine cables already laid will be vital to the development of optical fibre comms.

Ultrasonics open up memory capacity

Development of a simple and convenient ultrasonic method for manufacturing very small cobalt particles – magnetic nanocluster – could have an immediate effect on high-density recording media.

The process, developed by Charles Gibson and Kathy Putzer at the University of Wisconsin (Syntheses and characterisation of anisometric cobalt nanoclusters, *Science*, 267, pp1338-1340) produces single magnetic domain particles with considerable shape- and magnetocrystalline anisotropy so that a preferred magnetic field orientation is adopted in the final product.

Relatively inexpensive reagents are used in the procedure and flocs of the suspended particles are stable for several days, so easing manufacturing flexibility.

The basis for the process is reduction of Co^{2+} with hydrazine. Low temperature reaction has been attempted before, but despite looking thermodynamically possible, the reduction has not previously been successful.

Now Gibson's and Putzer's use of ultrasound to initiate the chemistry has made the reaction practical – and economical.

The result is the birth of a simple technique that could have immense importance for the manufacture of magnetic recording media and permanent magnets.

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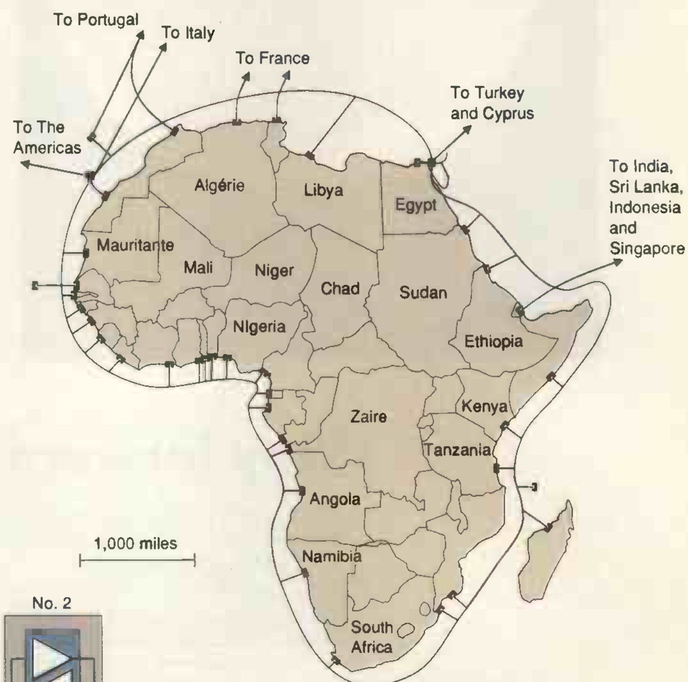
could be exploited in practice.

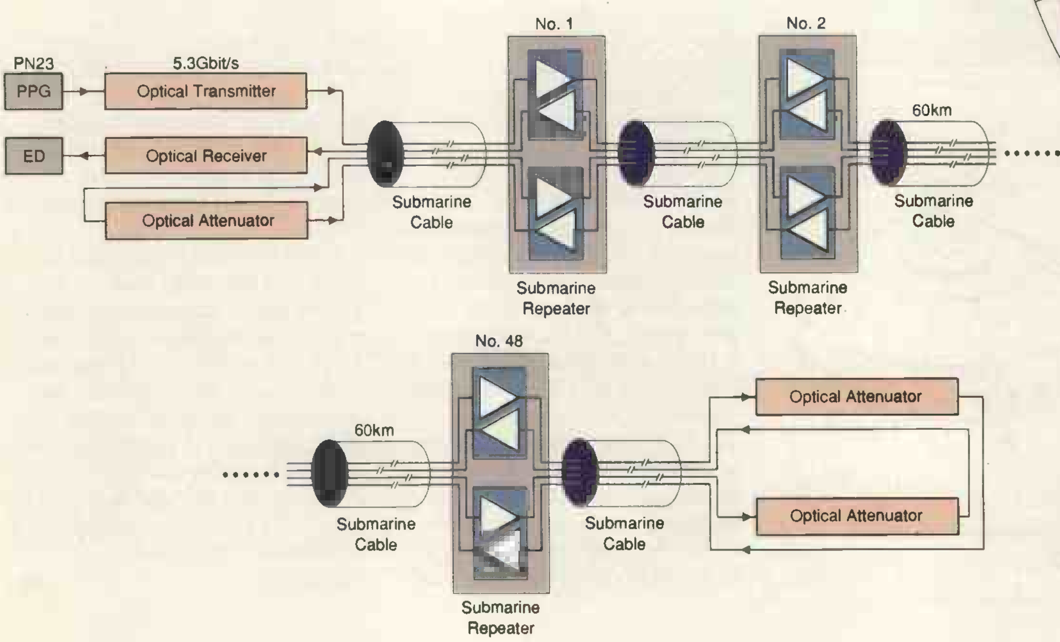
Other work currently going on is also helping to test the limits of undersea cables. For example, AT&T recently announced it had transmitted 10Gbit/s over a 2000km commercially installed undersea fibre-optic cable in the US. Normal operating limit for the cable was 2.5Gbit/s. AT&T achieved the increase through wavelength division multiplexing – the transmission of information on more than one wavelength of light on each fibre.

10Gbit+ transmission speeds greatly increase the capacity of undersea cable and AT&T says the test gives it the potential to upgrade installed fibre-optic communications systems without making adjustments to cable already sitting on the sea floor.

AT&T has already announced a proposal to build a 32,000km optical fibre ring around Africa, linking 40 countries. Practical architectures for such a project are still being considered though AT&T researchers say that experiment is demonstrating that such a large-scale all-optical network having many high speed channels is certainly possible.



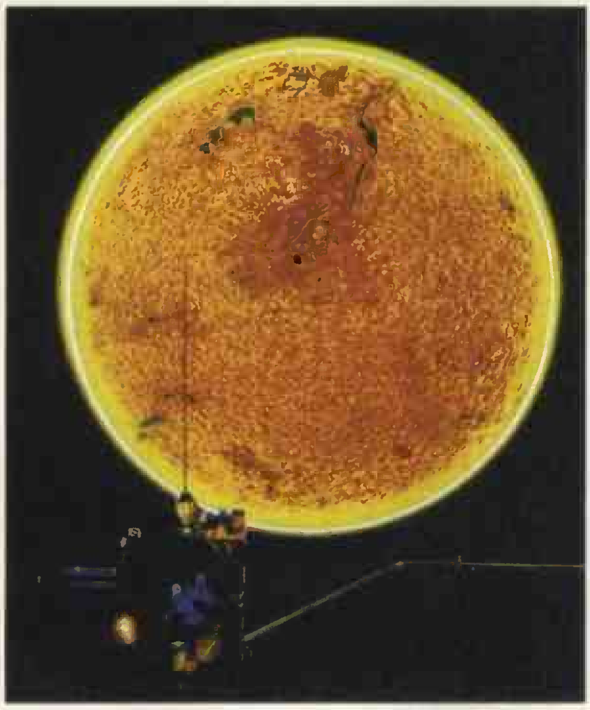
Continental drift: fibre optic technology is moving to make such projects as the 32,000km ring around Africa a reality.



11,300km is the longest distance yet for data transmission through commercial optical cable.

Getting the measure of solar wind

Ulysses on its mission to explore the heliosphere – the region of space dominated by the outward flowing solar wind. (Picture courtesy European Space Agency).



Quite apart from giving rise to the haunting northern lights, the million-mile-per-hour charged particles that make up the solar wind can degrade communications, disrupt power transmission grids, and damage satellites. Yet scientists are still unable to predict with any certainty when such activity is going to hit the earth. But data currently being processed from satellites belonging to the ISTP (International Solar Terrestrial Physics) programme could help change that.

ISTP involves coordinating experimentation aboard a number of space platforms, with different initiatives exploring key areas of geospace where the dynamics are controlled by Earth's magnetic field and its interaction with the solar wind.

For example Japan has been processing data from a satellite sitting in the magnetospheric tail formed by the solar wind as it rushes past the earth. Similarly, solar wind experiments (swe) aboard the 'Wind' satellite will measure properties of the solar stream before it reaches the Earth. Researchers are hopeful that Wind's location between the Earth and Sun could eventually give warning of magnetic storms.

Overall goal of the swe programme is to monitor how changes in the wind affect the environment around Earth, according to Alan J Lazarus, a senior research scientist in physics and head of the swe MIT team.

Since November, MIT's instruments have begun collecting samples of the charged particles that make up the solar wind, and measuring their speed, density, and other properties. Scientists from Nasa, the University of New Hampshire, and Boston University are cooperating on the swe project and six more experiments on the satellite are focusing on other phenomena associated with the solar wind.

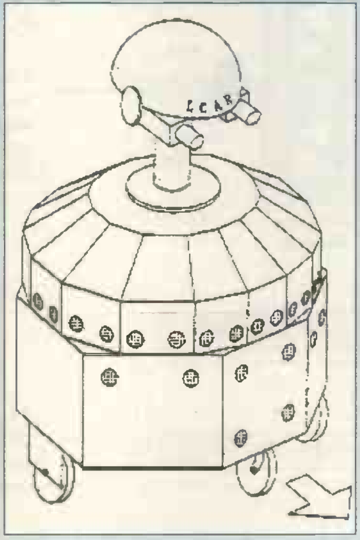
"There are efforts to return data in real time from this spacecraft, so we can report solar wind conditions to people who could be affected," says John T Steinberg, a research scientist at the Center for Space Research and also a member of the MIT team.

Ultimately, Wind will go into an orbit between the Earth and the Sun that will allow it to make continuous readings of the solar wind an hour before it reaches Earth.

The result would be that sensitive electronics on the spacecraft – which might otherwise be damaged – could be switched off. Varying magnetic fields can also have a serious effect on power grids, and have in the past caused massive power outages. One such incident occurred in Canada in 1989. With advance warning, power companies could make proper preparations for possible disruptions of their systems.

Way forward (or sideways) for robots?

Successfully negotiating our way around rooms full of furniture is a skill we learn as babies. For robots, the task is one some of them will never learn. But researchers at the Korea Advanced Institute of Science and Technology (Kaist) hope their work could lead to fewer bruised robot shins in the future.



Kaist's Lcar robot can switch between goal seeking behaviour and obstacle avoidance behaviour to negotiate obstacles in real time

A robot's navigational problem is that whenever it moves in an uncertain environment towards a goal, avoidance behaviour and goal-seeking behaviour always conflict. Avoidance behaviour is used to seek the goal position, until obstacles loom, when avoidance takes precedence, and goal-seeking behaviour is used to seek the goal irrespective of obstacle location.

Hee Rak Beom and Hyung Suck Cho at Kaist have been using fuzzy logic to describe both behaviours and have been working to develop a robot control system that switches to the best strategy based on the robot's local environment (A sensor-based navigation for a mobile robot using fuzzy logic and reinforcement learning, *IEEE Trans on systems, man and cybernetics*, 25, 3, pp.464-477).

Their Lcar robot has 26 ultrasonic sensors, stereo camera and sensors for dead reckoning.

Fuzzy logic is used to represent the mapping between the sensor input space and the mobile robot action space, with the correct mapping found by reinforcement learning.

So far the robot is managing to move around a 10 by 10m room packed full of obstacles towards its goal and is demonstrating an ability to adapt to unknown environments.

Importantly the small fuzzy-rule-base needed allows the method to be implemented in real time, while the reinforcement learning dispenses with the need to construct and tune the rule bases depending on the expert's knowledge. ■

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CIRCLE NO. 106 ON REPLY CARD

ELECTRONICS on the road

Eric Russell looks at innovations in electronic systems that automotive manufacturers are planning for the cars of tomorrow.

More vehicles come onto the roads each year and manufacturers are doing more and more to make them safer. The accent is moving away from mechanical developments towards electronic detection and control, with anti-collision radars, anti-skid systems and better anti-lock braking.

Aerospace technology has come down to road level, but the new technology is driving itself. More devices mean more wiring, which leads to intelligent harnesses, in turn resulting in more electronics. The automotive designer has to drive hard to keep up.

Driving on black ice

To be in full control while driving fast on black ice must be the ultimate motoring experience and it is promised for UK drivers this year by Mercedes-Benz.

Electronics is the key to this and other recent advances in automotive design in a trend which will shortly see more electronics than mechanics on the family saloon.

Mercedes-Benz calls its system Electronic Stability Program. It brings together traction control, intelligent brakes and aerospace technology to detect a car's direction of travel. ESP prevents skidding by braking individual wheels to maintain the car's balance. Control signals to the brakes derive from a computer which compares steering wheel position with the car's direction of travel.

When under- or over-steer is detected, the appropriate brakes are momentarily applied and engine torque is reduced. This brings the car back on line. The driver may not notice the system operating but a dashboard indicator illuminates, providing a warning.

Key to the system is a yaw detector. Housed under the rear seat of a car it gives an output signal proportional to the rate of rotation about a vertical axis.

Fig. 1. A car travelling on ice at 45mile/h is kept steerable and stable by the new Electronic Stability Program from Mercedes-Benz.

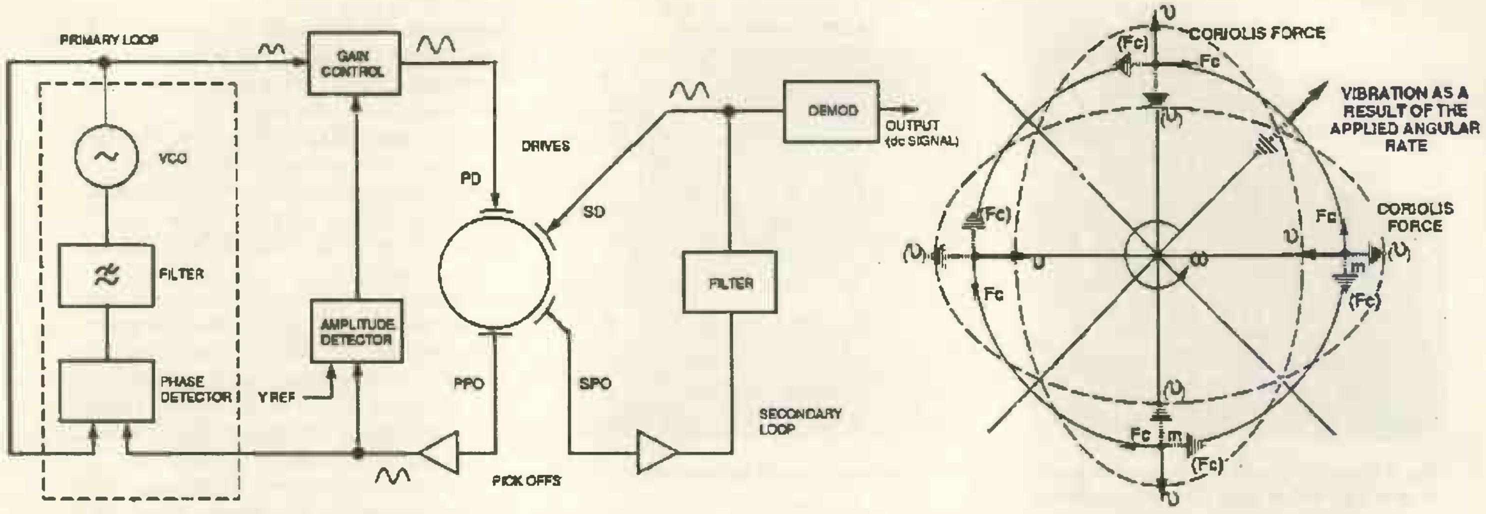

Fig. 2. Such a vibrating-structure gyroscope may be being used for yaw detection in Mercedes' electronic vehicle stabiliser. Output of the gyroscope is dc and proportional to the rate of rotation.

This data, together with steering wheel angle, individual wheel speeds, brake pressure and sideways acceleration are compared in a computer with a database which contains all the parameters for optimum stability.

The ESP control unit is linked to engine, automatic transmission, brakes, accelerator and sensors through a Controller Area Network data bus. The accelerator is electronically linked to the engine management system, bringing the new Mercedes close to drive-by-wire. A variable resistor is rotated as the accelerator is depressed to give a much finer control than with mechanical linkage.

ESP was recently demonstrated on a frozen lake in Sweden, Fig. 1. While a standard car was virtually uncontrollable at 30mile/h, the ESP car was steerable and stable at 45mile/h. Mercedes points out that such systems cannot beat the laws of physics and in unintended confirmation, a test driver promptly ploughed his vehicle into a snow bank.

The system was scheduled to become standard equipment in Germany in March on the *S600* coupe. The first cars for Britain are promised in the autumn – in time for our own snow. Details of the ESP system are not available, "Because the system is not yet in production," says a spokesman. But the key component, the yaw detector, could be similar to a unit produced by British Aerospace (Systems and Equipment) Ltd.

This is a solid state gyroscope using the piezo-electric principle and the coriolis effect. The sensing element is a cylinder of manmade ceramic, a lead zirconate titanate composite, which is electronically vibrated.

The coriolis effect refers to the distortion of an object's trajectory by the earth's rotation. The effect of the force can be seen when a person sits on a typist's chair holding a spinning bicycle wheel by the axle ends. If the person lifts their right hand, tilting the wheel, the chair will rotate towards the right.

A similar force can be generated when a vibrating object is rotated. In British Aerospace's Vibrating Structure Gyroscope the piezo-electric block is excited in one axis and electric output is taken from another axis. Output is dc and proportional to the rate of rotation, Fig. 2.

The solid state construction makes the VSG more robust than conventional mechanical gyroscopes with no maintenance requirement and minimal start-up time, which can be as low as 300ms. It can operate off a standard car power rail, Fig. 3.

At Lotus Engineering, the Active Technology Group uses vibrating-structure gyroscopes in active suspension designs. The company's system measures the load at the tyre contact patch once a millisecond and reacts to changes so a constant load is maintained. The VSG indicates when a road wheel is about to drop into a depression or rise over a bump and a hydraulic actuator is extended or retracted to keep the car body level.

This system is used in Arnold Schwarzenegger's Hummer, High Mobility Modular Wheeled Vehicle, but the price precludes its use in more popular cars. The servo valve on the actuator is an aerospace type, with an appropriate price tag, but if this could be manufactured in volume then active suspension would be seen on more vehicles.

Is ABS effective?

Research has shown that ABS is not often used in practice. Few drivers press the brake pedal hard enough to lock the wheels. In accident situations which demand hard braking drivers react in two stages: firstly a slightly harder than normal press of the pedal; then a heavier press when the situation is fully realised. Research also showed that if drivers reacted half a second earlier half of collisions would be avoided.

Advances in car control system

It is a development of ABS that forms part of Mercedes' ESP. A brake booster is activated when brakes need to be applied by the system and ABS prevents wheels locking up. When ABS is activated, brake fluid is taken out of the system, so reducing pressure on the brake

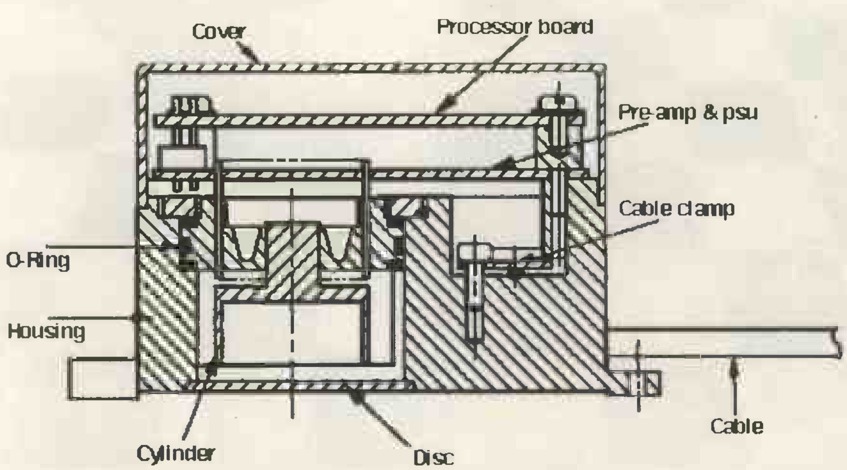

Fig. 3. Solid state construction makes the vibrating-structure gyroscope more robust than conventional mechanical types.

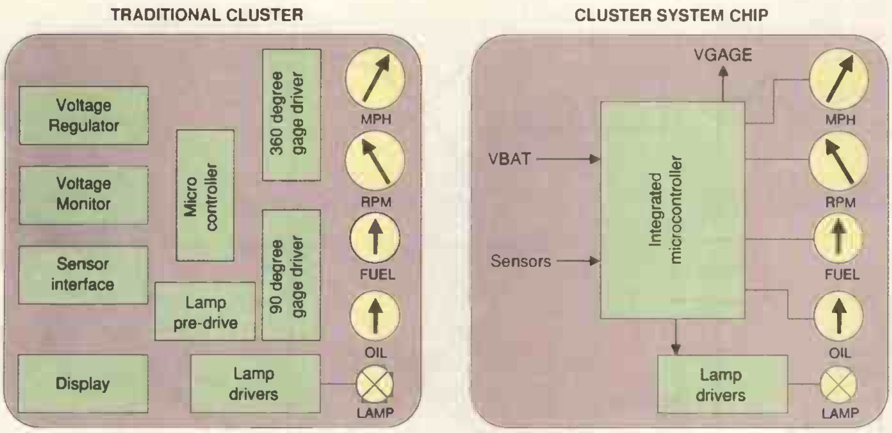

Fig. 4. Increasing microprocessor integration makes car electronics more reliable while improving compactness and maintainability.

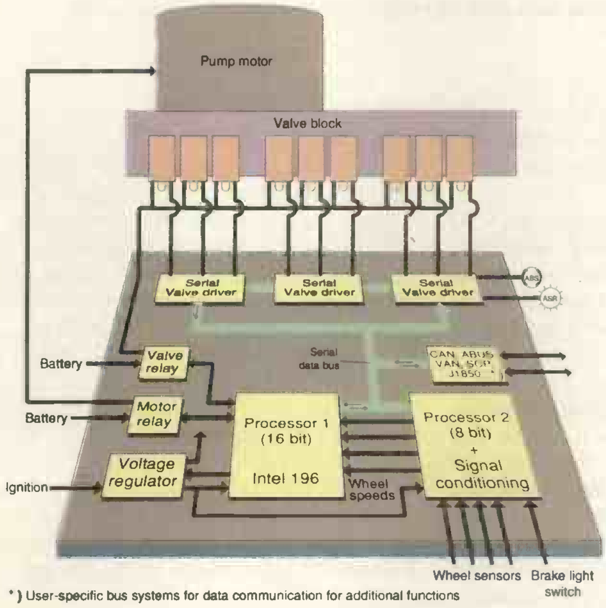

Fig. 5. In ITT's Teves Mk 20 ABS module, two processors – one of them 16 bits – work together, monitoring each other to eliminate the chance of a total loss of braking.

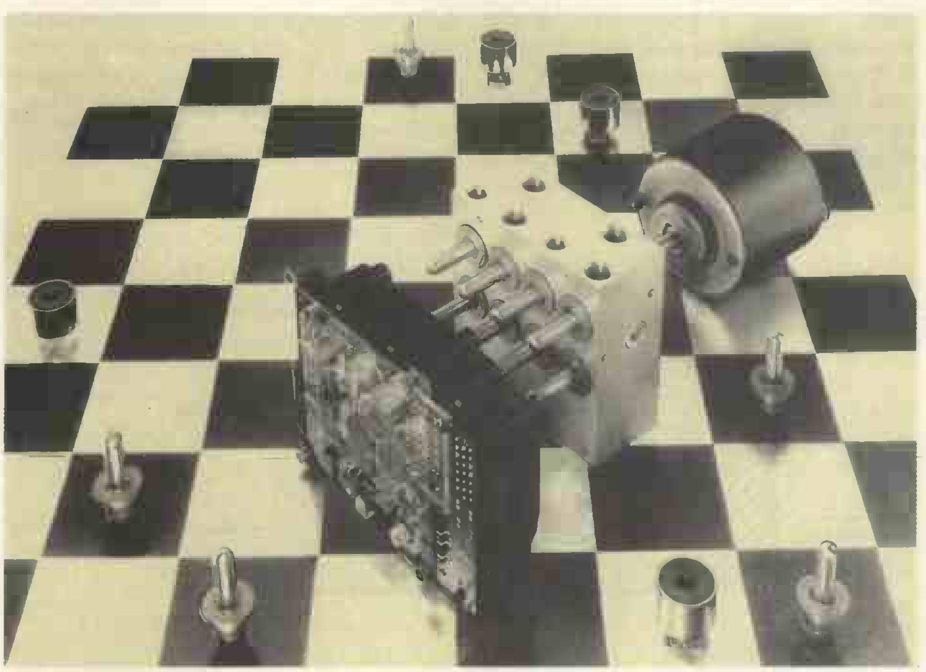

Fig. 6. ABS pump, electric motor, valves and a pcb containing two processors are all housed in a 16 by 10 by 10cm module – the Teves Mk 20 ABS system.

mechanism, be it disc or drum type. In an open system the brake fluid is returned into the master cylinder. In a closed system the fluid stays local to the wheel.

By the year 2000 ABS will be standard equipment on passenger cars according to a prediction from the Economist's Intelligence Unit. With 30% of cars fitted now, a compound growth for the technology of 22% per year is expected.

Against this background Texas Instruments recently announced a new customised microcontroller chip, the *cMCU370*. It will start to appear in a new design of ABS module from ITT subsidiary Alfred Teves, which is using some half dozen electronic subcontractors worldwide to assemble the modules.

TI has developed the microcontroller from the *TMS370* range of ICs. Sghaier Noury, TI's European Microcontroller Department Manager says: "It is part of a full product road map which includes many generations to come." The *cMCU370* has been designed under TI's Prism design methodology which evolved from a successful relationship with Delco Electronics. The principle of Prism is to steadily increase the number of functions that a chip can perform and to increase the different signal types it can handle, while using technology that has already been developed and proven, **Fig. 4**.

The *cMCU370* is an eight-bit device with a 16 bit version due next year and 32-bit architecture under development. At the launch of the new chip in Nice, TI also announced an agreement to supply ITT Automotive of Frankfurt with the product. The two companies have been co-operating for some six years using TI's knowledge of silicon and ITT's system experience. The *cMCU370* will be built into ITT's latest ABS module, the *Teves Mk 20*.

Under the agreement TI is expected to ship more than eight million microcontroller systems annually by 1997 rising to ten million by the year 2000. The first vehicles equipped with ABS using the new microcontrollers will be unveiled in 1996.

Teves' Mk 20 ABS module houses the electric motor, ABS pump, valves and pcb in a compact 16 by 10 by 10cm housing, **Figs 5, 6**. The system incorporates anti-skid control and electronic brake force proportioning. At the core of the hydraulic/electronic system is a lightweight aluminium block integrating the motor, pump and valves. Magnetic coils actuate the valves so there is no direct connection between controller and valve.

The pump conveys the brake fluid bled off by the ABS valves back to the master reservoir so the integration into one block saves installation time for the vehicle manufacturer.

Two microprocessor chips are carried on the pcb, a 16-bit Intel *196* and the Texas *cMCU370* 8-bit processor. These work together in 'asymmetrical redundancy' and monitor each other. This provides a high level of safety and protects against a failure which would open all the ABS valves, leaving the vehicle with no brakes.

Intel's chip processes the wheel speed and control algorithms. Complex mathematical formulae are written into the software, enabling the chip to calculate the best action to take from a given set of inputs. The TI chip simulates the calculations and then instructs the valve drivers. These are power semiconductors which replace the mechanical relays of previous designs and control current to the magnetic coils.

Within the pcb, the chips communicate via a serial data bus. This needs only three lines between each integrated circuit. The bits that make up each computer word are sent one after the other at a speed of two million bits per second. This communication system will link neatly into a vehicle's multiplexing harness whether the vehicle manufacturer has opted for CAN, ABUS, VAN, SCP or J1850 as the operating system.

Although both TI and ITT agree that multiplexing technology is both available and affordable, it awaits a change in outlook from the car manufacturers before being used regularly. There is also the consideration of higher after-care costs as a result of more complex systems.

The module could be a nucleus for the next project, a vehicle stability system. ITT Automotive anticipates its system arriving in the second half of the nineties.

More intelligence for ABS

Sensing the rotation of road wheels is a basic requirement of an ABS system and Siemens offers two sensor types – inductive and active. A toothed wheel is central to both systems. In the inductive version a magnet is fixed close to the wheel so as each tooth passes, the magnetic field is disturbed. These variations induce a current in a coil round the magnet

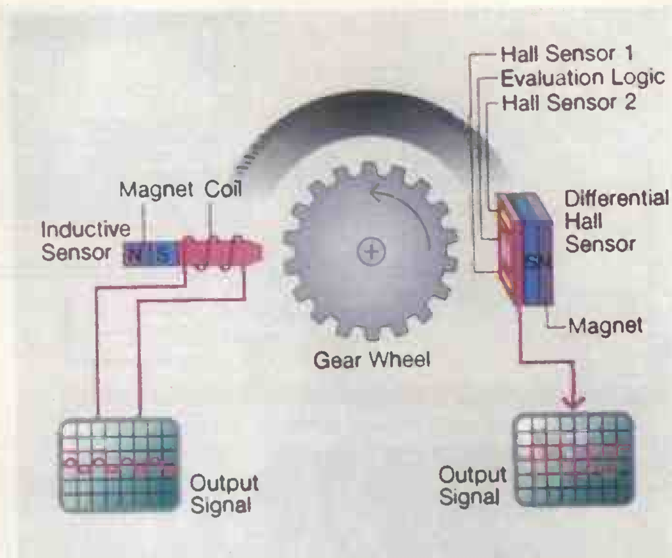

Fig. 7. Active speed sensor contains a highly sensitive inductive sensor combined with differential Hall IC to measure speeds almost down to zero. Output can be used for traction control, ABS and for driver information such as speed indication.

Fig. 8. One of the problems with ABS is that often, drivers only press the brake pedal hard enough to invoke ABS when it's too late. Lucas' new brake assistance system senses when the brake is pressed more rapidly than usual, and applies the brakes harder than would be the case if the pedal were depressed normally.

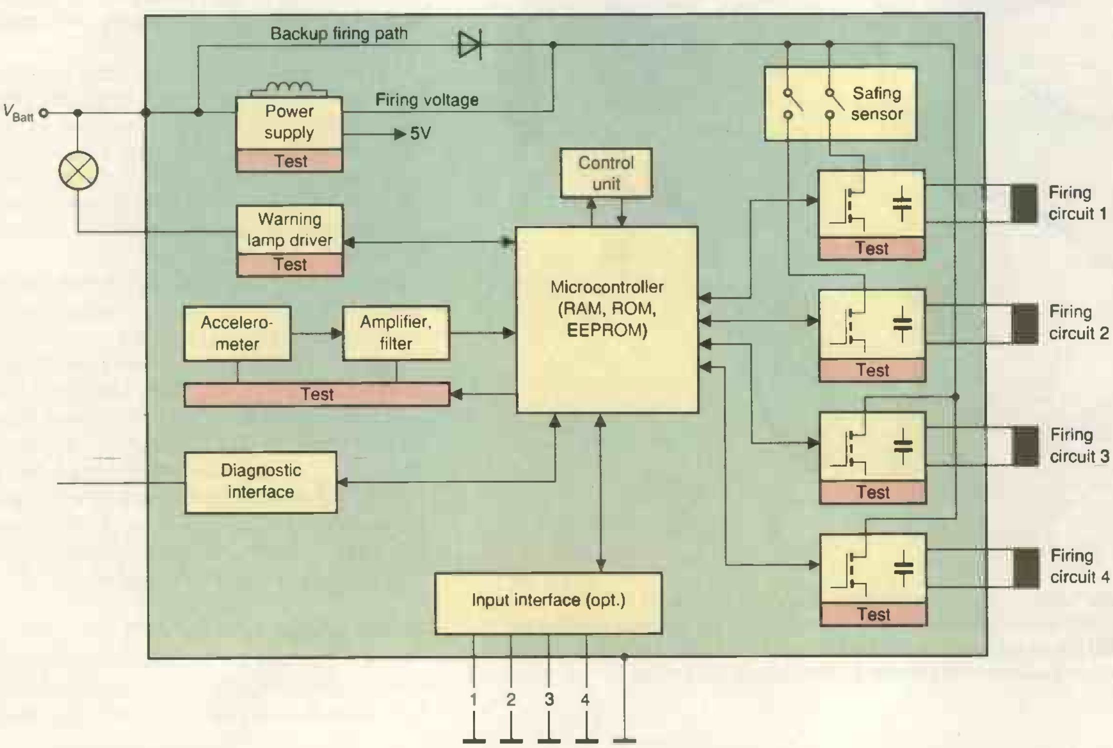

Fig. 9. Elements of a single-point sensing airbag electronic unit, courtesy Siemens. The system needs its own power supply in case the battery becomes disconnected due to the impact and there are multiple firing loops to cover for partial faults.

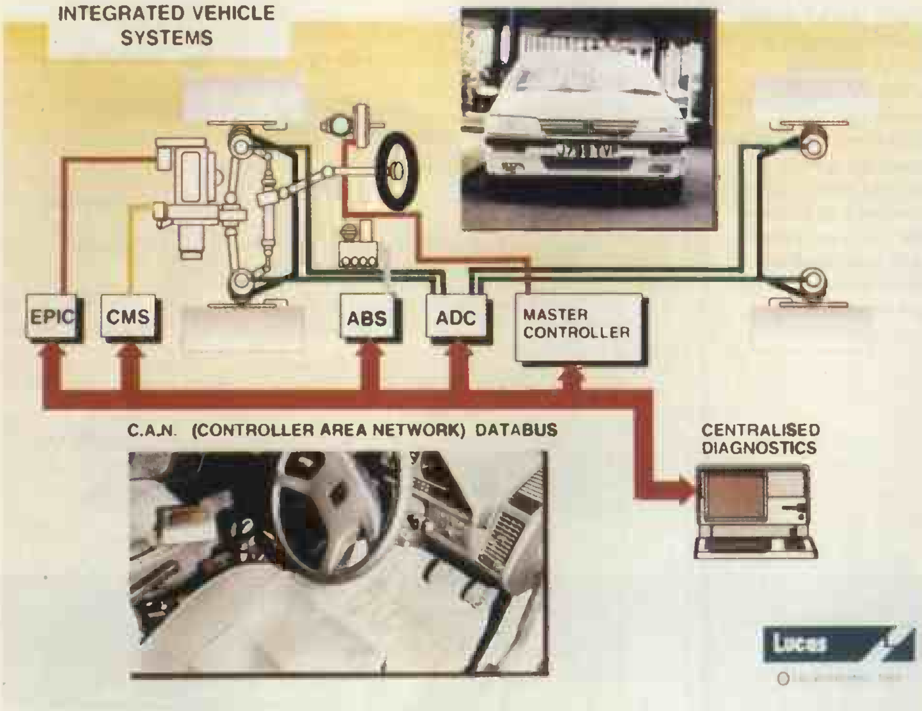

Fig. 10. Lucas's Advanced Prototype Vehicle, a Peugeot 605 turbo diesel, has completely integrated systems, controlled from a central processor via CANbus. EPIC is electronically programmed injection control and CMS is the clutch-management system.

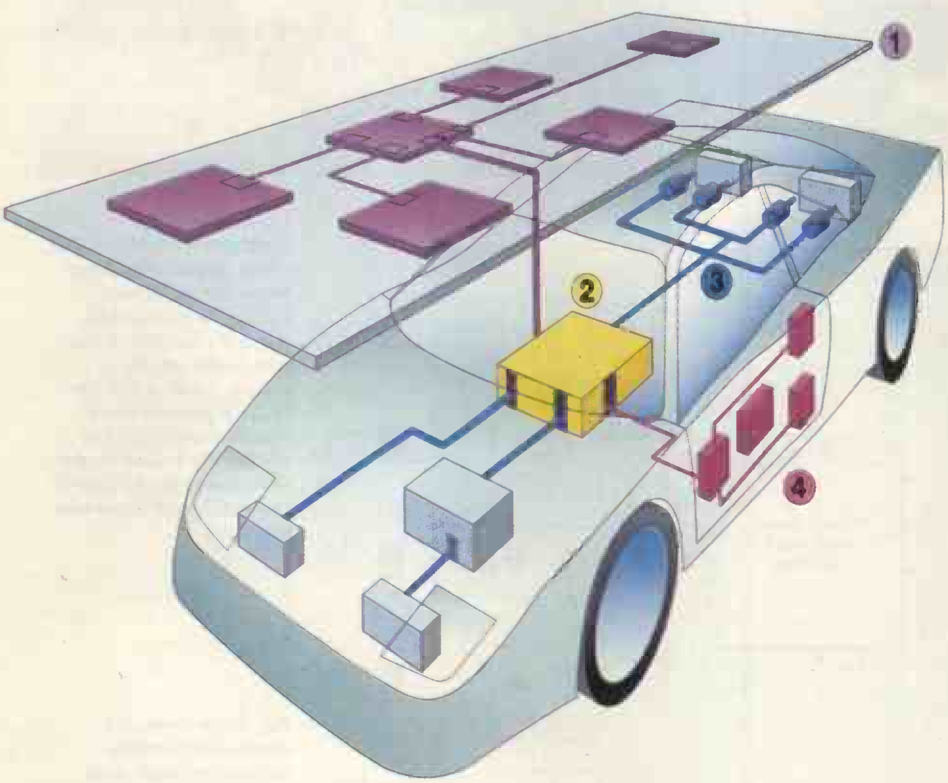

Fig. 11. With CANbus, cable harness requirements are greatly reduced since many switching and control signals can be multiplexed down one low-power bus. Conventional cabling for automatic windows, speakers, locking and mirror positioning means a lot of cabling between car and door, so this is one area where multiplexing is particularly attractive.

giving a sine wave output with each positive peak corresponding to a tooth on the wheel.

The active version, **Fig. 7**, uses a differential Hall sensor comprising two Hall switches and evaluation logic to provide a square wave output. In both systems the ABS computer counts the pulses and compares the result with time to provide an indication of road speed for the dashboard speedo and an indication of wheel lock to the ABS system.

Wheel bearing manufacturers are now producing intelligent bearings with on-board sensors and signal conditioning which reduces the effects of interference on the signal before it reaches the computer.

Grau's ABS system does not operate below 10km/h. This means that a stationary vehicle being held on a slope by the foot brake does not creep forward because the ABS system has detected an apparent wheel lock situation and reduces brake pressure.

To provide this extra margin needed to get round the drawbacks outlined in the ABS panel, Lucas is developing intelligent brakes. In an emergency, while the pedal may not be fully depressed, it is moved more quickly than normal. This can be detected and the signal used to operate an electronically controlled brake booster to apply the maximum servo force, **Fig. 8**. The controller compares pedal movements with the previous pattern of driver behaviour to assess an emergency situation. Operating the brake booster to its maximum invokes ABS, bringing the car to rest in the shortest possible distance.

This system could also work in conjunction with anti-collision radar, where microwaves or infra-red transmissions detect objects in front of a vehicle. The intelligence calculates when the distance is unsafe and, when intelligent cruise control is activated, reduces engine speed. Alternatively, the system can simply apply the brakes.

These electronic aids help when cars are well loaded with passengers or goods. The driver takes time to appreciate that longer braking is required in any given situation and may not have the space to stop in time. Intelligent brakes have an input from load sensors and the calculation includes the amount of load being carried.

Once all these functions are combined with a central computer, the brake holding system could also end hill start traumas.

Lucas's system has been developed within the Prometheus project. This concluded last year with a major demonstration of many new technologies at the Transport Research Laboratory. Prometheus – Programme for a European Traffic with Highest Efficiency and Unprecedented Safety – was a five year European initiative to develop automotive technology to a near-production state.

When it's too late for ABS

All these systems use electronics to help prevent accidents. When one does occur, the current spotlight is on airbags to protect the occupants. Basically, an accelerometer triggers the airbag inflation valve during abnormal deceleration. While a crash takes several seconds to complete, airbags react in milliseconds. Practically there are many considerations which demand that airbag systems are computer controlled, **Fig. 9**.

The system needs its own power supply in case the car battery becomes disconnected. This amounts to energy storage for a matter of seconds but the storage system needs topping up, measuring and checking.

The whole system must be self-checking on start-up with an output to warning lamps for system failure. Multiple firing loops provide redundancy in case of a single failure. A safing sensor disarms the system during safe situations, so while the accelerometer looks for crash signals, the safing sensor looks for non-crash signals. Seat belt status and passenger presence may be monitored and there could be a communications interface for external diagnostic testing.

Besides the physical considerations, the software has to be rugged. Like ABS, airbags are safety critical – causing danger when they fail or operate unexpectedly. Software has to reflect this. In conjunction with the British Standards Institute and others, the Society of Motor Manufacturers and Traders has just issued guidelines for the software that will be used increasingly on vehicles.

Linking it all together

Connecting all these systems is the car wiring harness. On a Mondeo there's 1.5km of wiring. It takes two people to lift the harness on some American models. In addition, harnesses can be a problem when many switches are mounted in doors and arm rests.

The simple version of dedicated point-to-point wiring is a two-wire ring main carrying serial information and a ring main carrying power. Operating an instrument switch sends an address followed by an instruction. All devices on the network listen to the address and the unit which recognises an address as its own will then act on the next set of pulses and operate as required.

The traditional way of providing a device with an address is a bit switch. The device compares the address pulses with the bit switch setting and enables the device when the two coincide.

A specification called Controller Area Network, CANbus, has been developed by Bosch for networking in automotive applications and this has been recognised by the International Standards Organisation. CAN protocol uses a multi-master, contention based bus configuration for transferring communication objects between nodes on the network. Multiple access raises the problem of collisions of data on the network. This is resolved in CAN by sensing a carrier denoting the network is carrying traffic.

A communication object consists of an identifier plus control data segments. The control segment contains all the information needed to transfer the message while the data segment contains up to eight bytes. Devices on the vehicle will only respond if their acceptance filter decides to receive a message. At each node the message identifier will have been set up in that controller's ram, **Fig. 10**.

The protocol can distinguish between permanent hardware failure and occasional soft errors. Defective nodes are switched off the bus, implementing a fail-safe procedure. To ensure robustness CAN uses non-return-to-zero bit coding. Ones and zeroes are indicated by a change in state, not the state itself. This produces fewer electromagnetic emissions at higher transfer rates than pulse width modulation or Manchester coding, which combine data and clock pulses.

One company manufacturing CAN control chips is NEC. Its *μPD72005* is a 52-pin flat package offering bi-directional two wire serial comms and two eight-bit i/o ports. Message memory space is 160 bytes and maximum data length is eight bytes – all of which highlights the relatively simple nature of car electronics compared with PCs.

Maximum transmission speed is 1Mbit/s. There are comprehensive error checking options including cyclic redundancy checking with a 15-bit crc generation polynomial, **Fig. 11**. The chip has been designed to fit into a large number of different networking configurations and the data book on it runs to some 96 pages.

Intel's CAN controller is the 44-pin *82527* fabricated in CHMOS III technology. Indicative of the harsh automotive environment, the *82527* copes with an ambient temperature range of –40 to +125°C.

In Russelsheim, Germany, Vauxhall says its car fitted with ISOTEC – Intelligent Safety and Orientation Technology – is currently being tested for reliability and suitability, before production sign-off. ISOTEC is a new research vehicle based on the recently launched Omega. On-board equipment includes distance radar, fog sensing, a night driving camera, and the latest navigation and guidance systems. Vauxhall says these are near-production electronic systems.

Distance measuring radar is connected to brakes, throttle and automatic transmission. The radar head is located behind the front bumper and detects other vehicles up to 140 metres ahead. Drivers can preselect a speed at which to travel and the distance radar will modify that according to the proximity of other vehicles. The required speed is selected on the indicator lever and a lamp in the speedometer indicates that speed.

When the Omega is too close to the vehicle in front, the distance controller first closes the throttle then applies the brakes. If the car reaches maximum automatic deceleration, an audible warning alerts the driver. Once the situation is stabilised the Omega automatically accelerates up to the preselected speed under guidance of the cruise control system.

Sensing obstacles by temperature

Infra-red is the technology used in the fog sensor. A beam of IR light from a black box mounted on top of the dashboard is reflected back by moisture droplets in the fog. The unit estimates the range of visibility, calculates a recommended speed and displays the figure on an led display once visibility falls below 200m. The fog sensor could be connected to the car's cruise control adjusting speed to visibility automatically.

An infra-red camera, located in the radiator grille of the Omega, records images of objects emitting heat. This applies to virtually all objects and the image is built up by making the screen brighter where more heat is being emitted. Should two objects be at the same temperature they will merge in the same way that similar tones merge in a conventional photograph, particularly when the scene is not well lit.

With infra-red systems it is possible to overlay the infra-red image with another taken by a conventional camera with light amplification. Combining the two technologies means that merged objects on one system will be separated on the other system. General Motors is assessing infra-red cameras in several highway patrol police cars in America at the moment.

Infra-red is also used on the ISOTEC to receive route navigation information. A sensor positioned behind the rear-view mirror picks up infra-red light from beacons at the side of the road. Vauxhall is using the Euro-Scout system. The driver programmes in the destination and direction symbols appear on the special dashboard information display during the journey.

In the case of collision avoidance, the computer in the distance measuring radar will have a choice of reducing speed by closing the throttle, operating the brake or selecting another ratio in the automatic gearbox. Its chosen course of action will depend on road speed and closing speed as the vehicles approach each other. This means a continuous set of calculations to cause least disturbance to the car's occupants and to keep the car stable.

Electronics are pervading cars in other areas that are near to production: automatic gearboxes and clutches, automatic lane keeping, speed limiters, side impact detection for airbag systems, blind spot detection systems, electronic deadlocks, solid state tachographs and electronic dashboard displays. This is in addition to navigation systems, route guidance, traffic warning systems, electronic tolling, satellite telephones and road side displays. Plus the electronics in 'red-light' cameras and automatic number-plate reading. Not forgetting in-car entertainment with a serial link between the cd holder and player in the boot and the dashboard radio. And the smart cards in your wallet, and the black box 'flight recorder' available from Mannesmann Kienzle. No wonder we need electronic pacemakers. ■

Model software for *problem* solving

Allen Brown has been assessing the latest upgrade of a powerful modelling package capable – among other things – of solving equations analytically.

The low cost of powerful pcs hosting 486 or Pentium microprocessors, combined with highly visual graphics facilities, makes them very attractive tools for modelling applications. To match the performance of the pc, the engineer now has a variety of software modelling packages to choose from and one that merits consideration is *Maple V* from MathSoft of Massachusetts.

Now issued as Release 3, *Maple V* has over 2500 predefined operations and library functions, evokable as commands from the keyboard. These include such options as polynomial factorisation, equation solving, indefinite integrations and matrix manipulations. The package is capable of performing symbolic, numerical and graphical processing. In fact the 3D plotting is spectacular, and fast. *Maple* will work within dos or Windows although to access the full graphing features of the product a super-vga monitor, preferably with a graphics accelerator, is needed.

Maple V comprises three components: the kernel, the library and the interface. The kernel is the mathematical engine behind *Maple V*'s calculations. This is a compact, highly optimised set of routines written and compiled in the C programming language, and performs the large part of the basic computations done by the system.

Most of *Maple V*'s built-in procedures are written in the product's own programming language. Code written in *Maple V* is not compiled, but interpreted as it is read or entered, allowing users to create their own *Maple V* procedures interactively within the program. The interface is *Maple V*'s eyes to the world and defines, to a large extent, how the user interacts with the commands and procedures. In effect *Maple V* makes the whole discipline of mathematics more accessible for general usage such as engineering applications.

The method of entering instructions is by means of directly keying in commands. These commands form part of the native extensive command language. For example, to construct a sine function ranging from $-\pi$ to $+\pi$, you would enter on the prompt symbol (>),

```
>        f(x) : = (sin(2*Pi*x), x=–Pi..Pi);
```

Maple would respond by writing,

> $f(x) := (\sin(2\pi x), x=-\pi..\pi i);$

All further operations on this function would refer direct-

```
> readlib(laplace) ;

  proc(expr,t,s) ... end

> dif1 := L11*diff(i1(t), t$1) + L12*diff(i2(t), t$1) + R11*i1(t) = E , L22*diff(i2(t), t$1
> ) + L12*diff(i1(t), t$1) +R22*i2(t) = 0 : fns := { i1(t),i2(t) } ;
```

$$fns := \{ i2(t), i1(t) \}$$

```
> dsolve( {dif1, i1(0) = 0, i2(0) = 0 }, fns ) ;
```

$$\Big\{ i2(t) = -\frac{\%2\, e\, L12\, e^{\left(1/2 \frac{\%3\, t}{L12^2 - L11\, L22}\right)}}{\%4} + \frac{\%2\, e\, L12\, e^{\left(1/2 \frac{\%2\, t}{L12^2 - L11\, L22}\right)}}{\%4}$$

$$, i1(t) = -4\, R22 \Big(e\, L12^2 - e\, L11\, L22 - \Big(2\, R11\, R22\, L12^2 + \frac{1}{2} L11^2\, R22^2 - \frac{1}{2}\sqrt{\%1}\, R22\, L11 + \frac{1}{2}\sqrt{\%1}\, R11\, L22$$
$$- L11\, R22\, R11\, L22 + \frac{1}{2} R11^2\, L22^2 \Big) \%2\, e\, L11\, L22\, e^{\left(1/2 \frac{\%3\, t}{L12^2 - L11\, L22}\right)} / (\%4 \sqrt{\%1}) - \Big(-2\, R11\, R22\, L12^2$$
$$- \frac{1}{2} L11^2\, R22^2 + \frac{1}{2}\sqrt{\%1}\, R22\, L11 - \frac{1}{2}\sqrt{\%1}\, R11\, L22 + L11\, R22\, R11\, L22 - \frac{1}{2} R11^2\, L22^2 \Big) \%2\, e\, L12^2$$
$$e^{\left(1/2 \frac{\%3\, t}{L12^2 - L11\, L22}\right)} / (\%4 \sqrt{\%1}) + \%2\, e\, (-2\, L12^2\, R22 \sqrt{\%1} - R11\, L22^2 \sqrt{\%1} + L11\, R22\, L22 \sqrt{\%1}$$
$$+ 4\, R11\, R22\, L12^2\, L22 - 2\, L11\, R22\, R11\, L22^2 + L11^2\, R22^2\, L22 + R11^2\, L22^3)\, e^{\left(1/2 \frac{\%2\, t}{L12^2 - L11\, L22}\right)} L11\, R11$$
$$L22 / \%4^2 - \%2\, e\, L12^2 (-2\, L12^2\, R22 \sqrt{\%1} - R11\, L22^2 \sqrt{\%1} + L11\, R22\, L22 \sqrt{\%1}$$
$$+ 4\, R11\, R22\, L12^2\, L22 - 2\, L11\, R22\, R11\, L22^2 + L11^2\, R22^2\, L22 + R11^2\, L22^3)\, e^{\left(1/2 \frac{\%2\, t}{L12^2 - L11\, L22}\right)} R11 / \%4^2$$
$$\Big) / (\%3\, \%2) \Big\}$$

$$\%1 := 4\, R11\, R22\, L12^2 - 2\, L11\, R22\, R11\, L22 + L11^2\, R22^2 + R11^2\, L22^2$$

$$\%2 := L11\, R22 + R11\, L22 - \sqrt{\%1}$$

$$\%3 := L11\, R22 + R11\, L22 + \sqrt{\%1}$$

$$\%4 := -\sqrt{\%1}\, R22\, L11 - \sqrt{\%1}\, R11\, L22 + R11^2\, L22^2 + 4\, R11\, R22\, L12^2 - 2\, L11\, R22\, R11\, L22 + L11^2\, R22^2$$

```
>
>
```

Listing 1. Maple also produces analytical solutions to differential equations. This example shows the solution from a model of a simple transformer.

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2N5088	20p
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2N6107	40p
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2N6385	120p
2N6403	160p

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BY133	8p
BY164	40p
BY179	35p
BY184	32p
BY206	11p
BY207	9p
BY227	19p
BY228	28p
BY298	15p
BY299	18p
BY448	20p
BYX10	15p
BYX55/600	25p
BYX70/500	
OA47	10p
OA91	10p
OA202	10p
IN4001	3p
IN4002	3p
IN4003	3p
IN4004	3p
IN4005	3p
IN4006	3p
IN4007	4p
IN4148	2p
IN5400	9p
IN5401	8p
IN5402	8p
IN5403	8p
IN5404	8p
IN5405	11p
IN5406	12p
IN5407	12p
IN5408	12p
RGP15	25p
RGP30	16p
SKE4F2/06	60p
SKE4F2/08	80p
SKE4F2/10	100p
SR2M	60p

I.C. SOCKETS

Part	Price
8 PIN	5p
14PIN	6p
16PIN	7p
18PIN	10p
20PIN	12p
22PIN	13p
24PIN	14p
28PIN	16p
40PIN	18p

ZENERS

Part	Price
400 mWatts	
2V7 to 39V	5p
1.3 Watts	
2V7 to 39V	9p

VOLTAGE REGULATORS

Part	Price
7805	25p
7806	25p
7808	25p
7812	25p

Part	Price
7815	25p
7818	25p
7824	25p
7905	25p
7906	30p
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78L08	24p
78L12	24p
78L15	24p
78L18	24p
78L24	24p
79L05	35p
79L08	35p
79L12	35p
79L15	35p
LM309K	100p
LM317T	100p
LM323K	350p
78H08KC	800p
79H12KC	700p
79HGKC	800p

LEDs

Part	Price
3mm	
RED	5p
YELLOW	8p
GREEN	8p
5mm	
RED	5p
YELLOW	8p
GREEN	8p

RECTANGULAR LEDs

Part	Price
5mm × 2.5mm	
RED	5p
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ly to $f(x)$. For example if a plot was required then you would enter,

```
>       plot( f(x) );
```

The software responds by creating a 2D plot, autoscaled from $-\pi$ to $+\pi$. Alternatively by ending each line with a colon (:), you can effectively cascade a list of operations which are executed once the end semicolon (;) is reached.

All operations and functions are accessed in this way. However I must stress that the learning curve is quite steep. Owing to the low-level nature of *Maple V*'s command language, it is unforgiving and will require a fair amount of time and patience to master its rigid syntax.

Symbolic processing

It has often been said how useful it would be if computers could solve equations analytically, performing differentiations and integrations. Well, this software is able to perform just that. No matter how complex the equation, *Maple V* will find a solution – of sorts. It is very effective at expanding expressions, **Fig. 1**, and generating series terms, or for that matter factorising expressions.

With a package like this, one wonders why it is necessary to learn integration and differentiation techniques when the pc can find the answer in a fraction of the time. No more looking up tables to perform Laplace transforms and their inverse; *Maple V* performs these operations quite comfortably. However on occasions the answers do not agree with tabulated versions and it is difficult to know if there is an error or just an ambiguity. As expected, *Maple V* also performs numerical evaluations of equations and is particularly strong on the numerical evaluation of integrals and series.

Procedures

Maple V allows procedures to be created. These comprise a sequence of instructions. Like any other programming language, *Maple V*'s procedures incorporate conditionals, loops and exit loop conditions. The syntax is not too dissimilar to that of programming language Pascal.

An example of *Maple V* procedure is shown in **Fig. 2**. It calculates the transfer functions of different order low pass Chebychev filters. The iterative procedure shown for calculating the Chebychev coefficients from the recurrence relation is,

$$T_{n+1}(x) = 2\,x\,T_n(x) - T_{n-1}(x)$$

with starting conditions $T_0(0) = 1$ and $T_1(x) = x$. Although the procedures can be quite powerful they do have quite a steep learning curve associated with them and the syntax is very precise. However there are thousands of functions in the *Maple V* libraries which can be used within the procedure framework.

Solving differential equations

Maple V is quite effective for solving differential equations of any order. It will also solve coupled differential equations analytically, however the answer may appear to be somewhat unwieldy as illustrated in **Fig. 3** which is a printout of the solution of circuit with mutual conductance – whoever said that transformer design was simple?

In line 2 *difl* defines the coupled equations and line 3 performs the evaluation with the boundary conditions (no initial current in either the primary or secondary). Although not an immediately useful solution it does illustrate the analytical capability of *Maple V*. However by attaching numbers to the L, R and E values, numerical solutions will be produced. *Maple V* does not like nonlinear coupled differential equations to solve, in fact in several instances it refuses to do any processing on them.

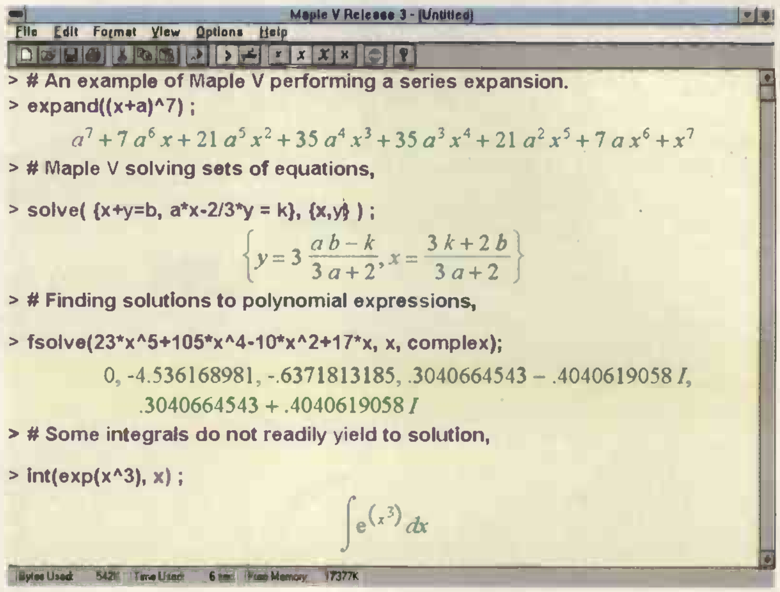


Fig. 1. Maple V is very effective at expanding expressions and generating series. In fact it performs many of the operations that an engineering student toils for hours over.

Old hacks at differential equations will know that there are several ways of solving them and *Maple V* offers the user the choice of a solution method. Electronics engineers would probably opt for using the Laplace Transform method for finding a solution and this is requested by augmenting the dsolve instruction by,

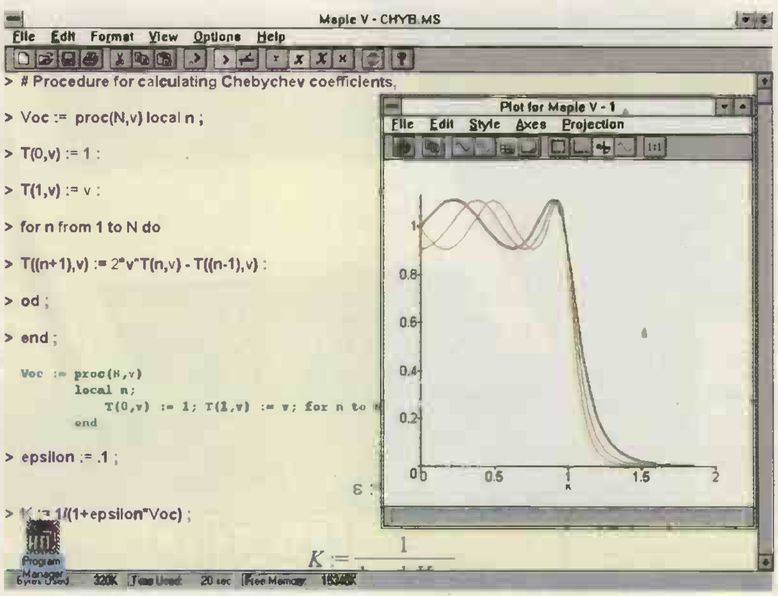
```
dsolve( diff_eq, y(x), method=laplace ) ;
```

Although *Maple V* seems to tackle linear differential equations quite well, like a number of other maths software packages, nonlinear maths usually proves to be a little too testing and solutions are not always provided.

2D graphics

An essential aspect of any mathematical modelling package is its ability to generate graphs. These days such a task is no big deal as most numerical software can generate 2D graphs. An example of the 2D output from *Maple V* is shown in Fig. 2, displaying the Chebychev filter transfer functions with their characteristic ripples in the pass band. It is relatively easy to overlay several plots on the same graph and the scaling is performed automatically.

Fig. 2. Modelling performance of a Chebychev analogue filter is easy with Maple V. As seen in this example, increasing the number of poles improves the roll-off of the filter.



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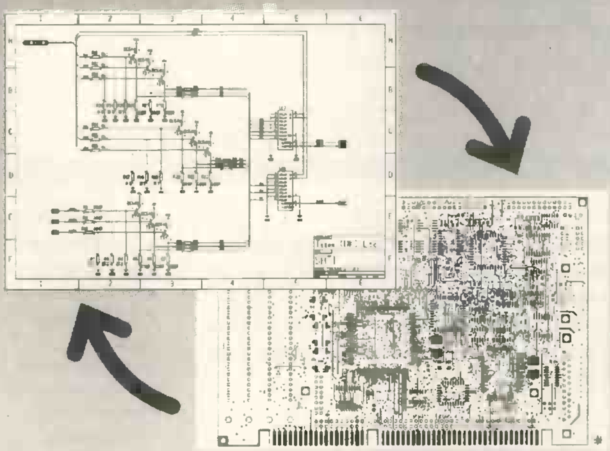

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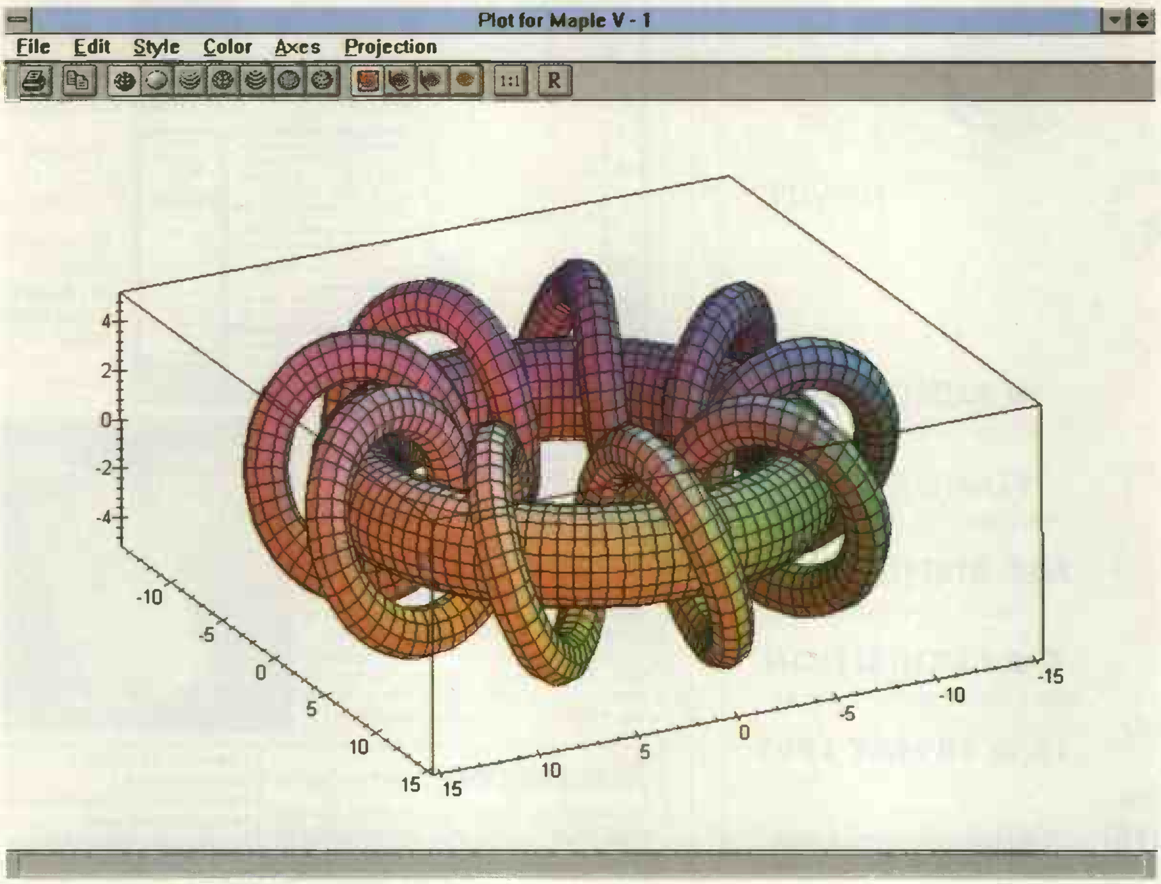

Fig. 4. 3D plot generation with Maple V can produce some fascinating solid modelling. Animation can also be added to the modelling to give an insight into temporal behaviour.

Provisions are available for plotting in cylindrical coordinates and performing contour plots. It would however be helpful if more control could be exercised on the plotting features, axis definition and labelling for example as it is likely that you will require a printing of 2D plots.

3D graphics

Features for performing the now commonplace function of 3D plotting are available in *Maple V*. But one of the extraordinary features of *Maple V* is its ability to plot in a variety of coordinate systems – spherical coordinates for example. This allows true solid modelling to be realised. For example, the complex mode structures in graded index optical fibres can be represented pictorially. They involve a lot of unfriendly Bessel functions, however with *Maple V* they can become somewhat more accessible and easier to work with.

There is an impressive range of 3D plotting features but it does require a push of the imagination to realise their usage. The 3D surfaces also have a variety of colour shading as can be seen from the example given in **Fig. 4**; although pretty to look at, it is not terribly useful.

However if there was a need to model the 200MHz pulse propagation along pcb tracking, then *Maple V* could be used to determine the 3D impedance profiles along the length of the tracking (including reflections). Being able to visualise solutions such as these must be one of the main benefits of using modelling packages like *Maple V*.

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Conclusion

There are very few areas of engineering where *Maple V* would not prove useful. Although the package is very powerful and undoubtedly applicable to a variety of modelling purposes a word of caution must be expressed.

New users must be prepared to spend a lot of time learning how to use the package proficiently. It will probably be several hours before they will be in a position to apply *Maple V*. A number of manuals are provided to help the learning process, including the Reference Manual and a Tutorial Introduction.

The Tutorial presents many examples, which are necessary for a package with such rigid syntax rules. Working through these manuals is an absolute must. There is also a well-designed screen-based tutorial which should prove helpful to the new user. Also available for *Maple V* are a number of text books written by third parties. It is certainly pleasing to know that if you have a pc on which you want to perform complex mathematical operations, *Maple V* will certainly put it through its paces and uses all of its memory and calculating power. ■

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Following the success of 1994's Writers Award, ***Electronics World*** and **Hewlett-Packard** are launching a new scheme to run from January to December 1995.

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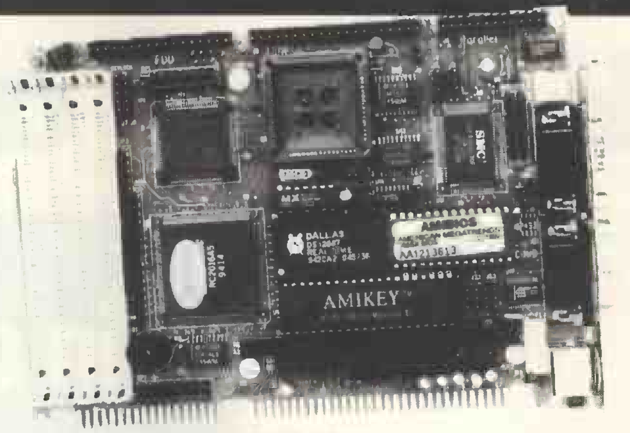

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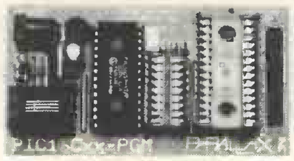

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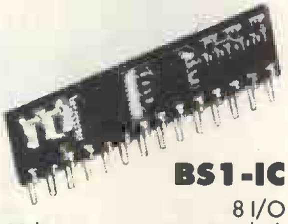

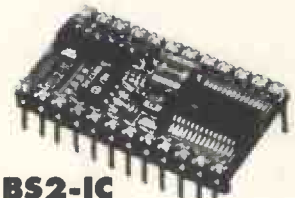

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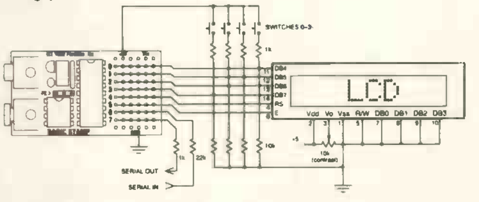

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Fets versus bjts
the linearity competition

"Had bipolar transistors been invented before power mosfets, they would have been heralded as a major step forward in components for power amplification," suggests Douglas Self.

There has been much debate recently as to whether power fets or bipolar junction transistors (bjts) are superior in power amplifier output stages. Reference 1 is a good example. It has often been asserted that power fets are more linear than bjts, usually in tones that suggest that only the truly benighted are unaware of this.

In audio electronics it is a good rule of thumb that if an apparent fact is repeated times without number, but also without any supporting data, it needs to be looked at very carefully indeed. I therefore present my own view of the situation here, in the hope that the resulting heat may generate some light.

I suggest that it is now well-established that power fets, when used in conventional Class-B output stages, are a good deal less linear than bjts.[2] Gain deviations around the crossover region are far more severe for fets than the relatively modest wobbles of correctly biased bjts, and the shape of the fet gain-plot is inherently jagged, due to the way in which two square-law devices overlap.

The incremental gain range of a simple fet output stage is 0.84 to 0.79, range 0.05, and this is actually much greater than for the bipolar stages in Reference 2; the emitter-follower stage gives 0.965 to 0.972 into 8Ω, with a range of 0.007, and the complementary feedback pair gives 0.967 to 0.970 with a range of 0.003. The smaller ranges of gain-variation are reflected in the much lower thd figures when PSpice data is subjected to Fourier analysis.

However, the most important difference may be that the bipolar gain variations are gentle wobbles, while all fet plots seem to have abrupt changes. These are much harder to linearise with negative feedback that must decline with rising frequency. The basically exponential I_c/V_{be} characteristics of two bjts approach much more closely the ideal of conjugate mathematical functions, – ie always adding up to 1. This is the root cause of the much lower crossover distortion.

Close-up examination of the way in which the two types of device begin conducting as their input voltages increase shows that fets move abruptly into the square-law part of their characteristic, while the exponential behaviour of bipolar devices actually gives a much slower and smoother start to conduction.

Similarly, recent work* shows that less conventional approaches, such as the common-collector/common-emitter configuration of Bengt Olsson, also suffer from the non-conjugate nature of fets. They also show sharp changes in gain. Gevel[3] shows that this holds for both versions of the stage proposed by Olsson, using both N and P-channel drivers. There are always sharp gain-changes.

Class A stage

It occurred to me that the idea that fets are more linear was based not on Class-B power-amplifier applications, but on the behaviour of a single device in Class-A. You might argue that the roughly square-law nature of a fet's I_d/V_{gs} law is intuitively more 'linear' than the exponential I_c/V_{be} law of a bjt, but it is difficult to know quite how to define 'linear' in this context. Certainly a square-law device will generate predominantly low-order harmonics, but this says nothing about the relative amounts produced.

In truth the bjt/fet contest is a comparison between apples and aardvarks, the main problem being is that the raw transconductance (g_m) of a bjt is far higher than for any power fet. **Figure 1** illustrates the conceptual test circuit; both a TO3 bjt *MJ802* and an *IRF240* power fet have an increasing dc voltage, V_{in}, applied to their base/gate, and the resulting collector and drain currents from PSpice simulation are plotted in **Fig. 2**.

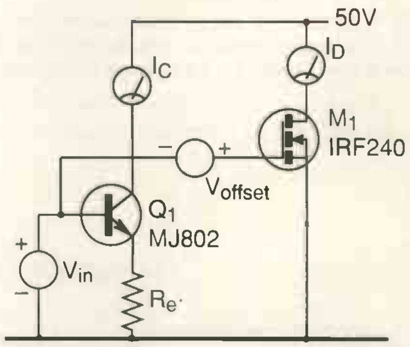


Fig. 1. Linearity test circuit. Voltage V_{offset} adds 3V to the dc level applied to the fet gate, purely to keep the current curves helpfully adjacent on a graph.

Voltage V_{offset} is used to increase the voltage applied to fet M_1 by 3.0V because nothing much happens below a V_{gs} of 4V, and it is helpful to have the curves on roughly the same axis. Curve A, for the bjt, goes almost vertically skywards, as a result of its far higher g_m. To make the comparison meaningful, a small amount of local negative feedback is added to Q_1 by R_e. As this emitter degeneration is increased from 0.01 to 0.1Ω, the I_c curves become closer in slope to the I_d curve.

Because of the curved nature of the fet I_d plot, it is not possible to pick an R_e value that allows very close gm equivalence; a value of 0.1Ω was chosen for R_e, this being a reasonable approximation; see Curve B. However, the important point is that I think no-one could argue that the fet I_d characteristic is more linear than Curve B.

This is made clearer by **Fig. 3**, which directly plots transconductance against input voltage. There is no question that fet transconductance increases in a beautifully linear

* The subject of an article by Douglas to be published in *EW+WW* in the near future – Ed.

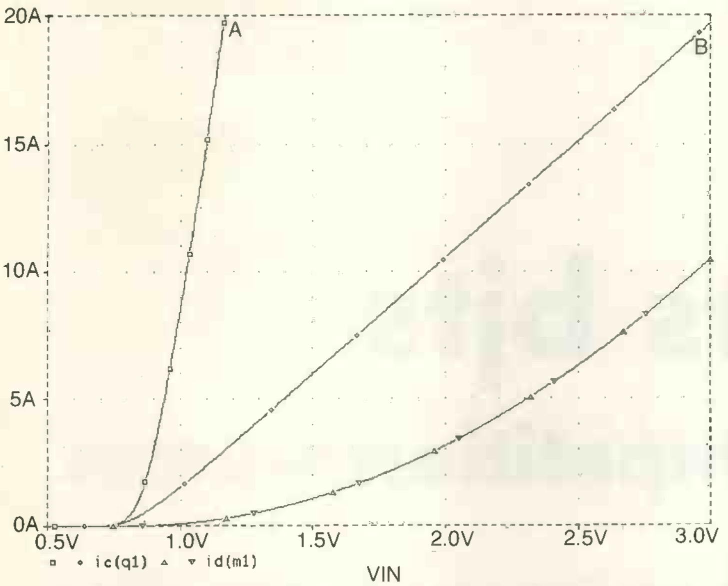


Fig. 2. Graph of I_c and I_d for the bjt and the FET. Curve A shows Ic for the bjt alone, while Curve B is the result for R_e=100mΩ. The curved line is the I_d result for a power fet without any degeneration.

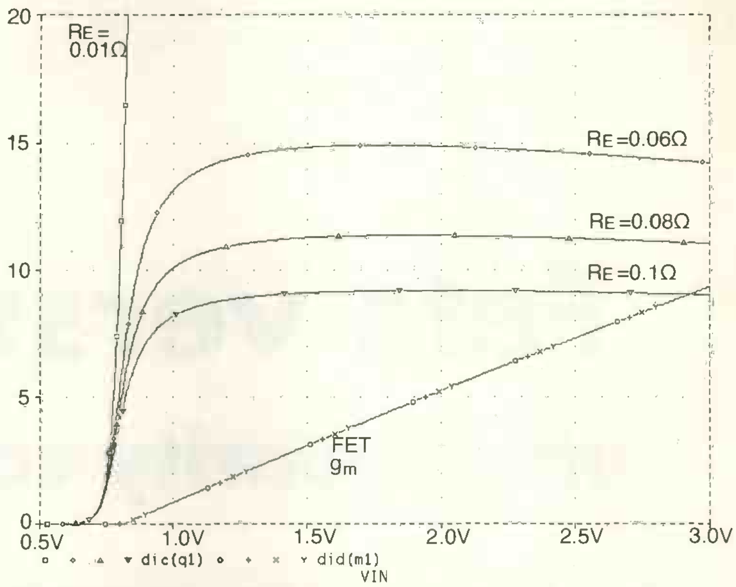
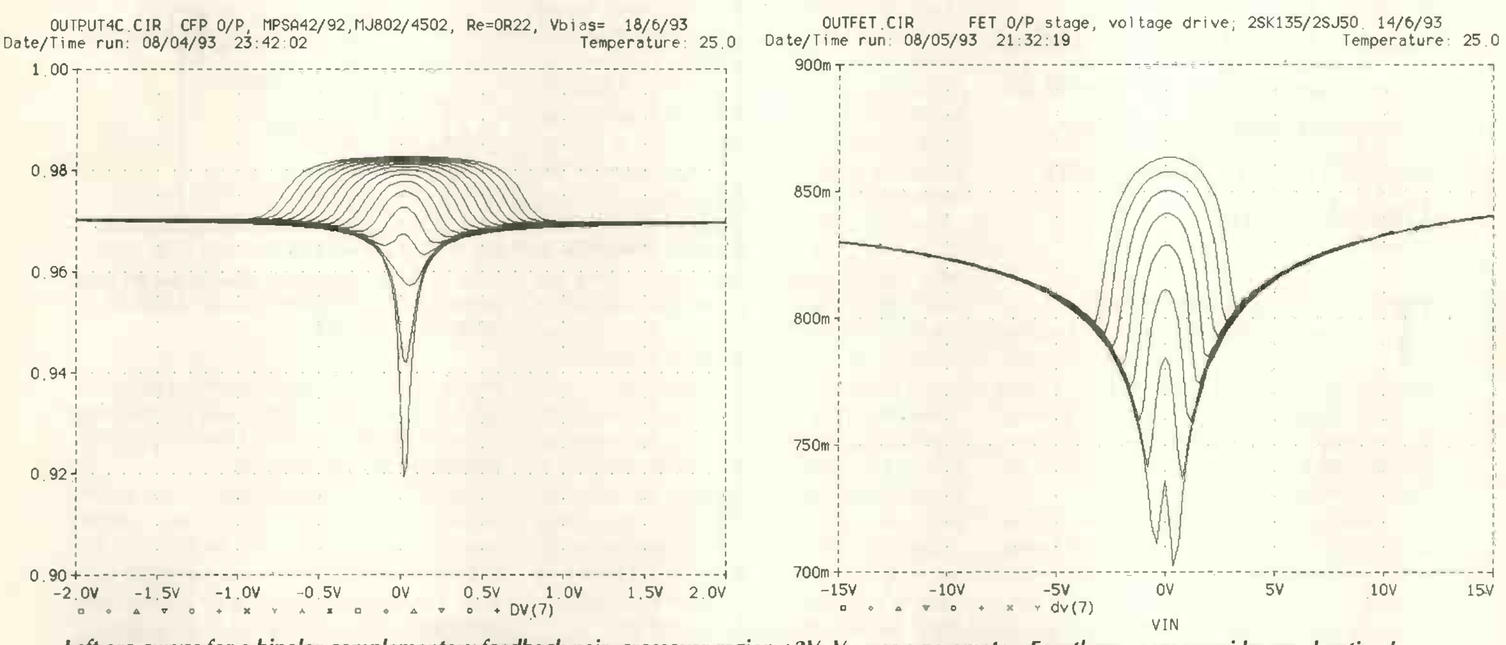


Fig. 3. Graph of transconductance versus input voltage for bjt and fet. The near-horizontal lines are bjt g_m for various R_E values.



Left are curves for a bipolar complementary feedback pair, crossover region ±2V, V_{bias} as a parameter. Fourth curve up provides good optimal setting – compare with curves on the right, for a fet source follower crossover region with ±15V range.

manner- but this 'linearity' is what results in a square-law I_d increase. The near-constant g_m lines for the bjt are a much more promising basis for the design of a linear amplifier.

To forestall any objections that this comparison is nonsense because a bjt is a current-operated device, I add here a small reminder that this is untrue. The bjt is a voltage operated device, and the base current that flows is merely an inconvenient side-effect of the collector current induced by said base voltage. This is why beta varies more than most bjt parameters; the base current is an unavoidable error rather than the basis of transistor operation.

The PSpice simulation shown was checked against manufacturers' curves for the devices, and the agreement was very good – almost unnervingly so. It therefore seems reasonable to rely on simulator output for these kind of studies; it is certainly infinitely quicker than doing the real measurements. In addition, the comprehensive power-fet component libraries that are part of PSpice allow the testing to be generalised over a huge number of component types without you needing to buy them.

To conclude, I think it is probably irrelevant to simply compare a naked bjt with a naked fet. Perhaps the vital point is that a bipolar device has much more raw transconductance gain to begin with, and this can be handily converted into better linearity by local feedback, ie adding a little emitter degeneration.

If the transconductance is thus brought down roughly to fet levels, the bipolar has far superior large-signal linearity. I must admit to a sneaking feeling that if practical power bjts had come along after fets, they would have been seized upon with glee as a major step forward in power amplification. ■

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120	21.54	15.08	11.35	8.39	8.15	7.89
150	25.98	18.19	13.70	10.12	9.82	9.53
160	23.83	16.68	12.56	9.28	9.00	8.73
225	30.10	21.07	15.87	11.73	11.39	11.04
300	34.32	24.02	18.09	13.38	12.98	12.58
400	46.19	32.32	24.35	17.99	17.47	16.94
500	50.48	35.34	26.61	19.67	19.09	18.51
625	53.09	41.36	31.14	23.02	21.24	20.57
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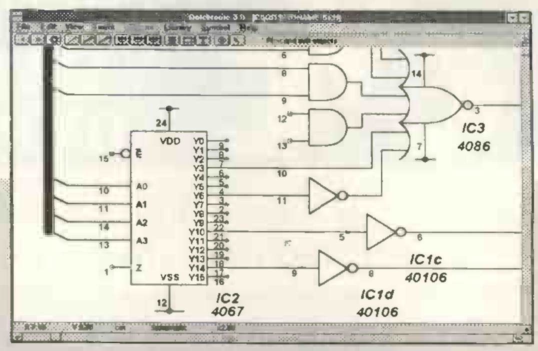

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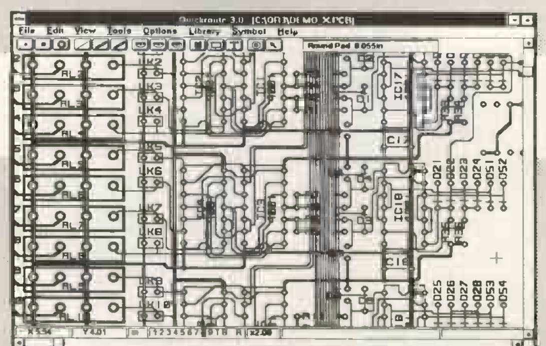

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Delayed audio signals

Too many audio designs are deeply flawed in the bass, says ***Ben Duncan****, recalling recent work of Douglas Self and Edward Cherry. Here Duncan uses simulation to explain the reasons and ramifications for the entire audio chain.*

Dependence of the quality of reproduced sound on the number of components through which it is passed still seems to be doubted by some commentators[1]. But how many have actually bothered to examine exactly what happens to a given signal between the mic terminals – via multitrack recording process and recording media - and its emergence from a domestic power amplifier?

A realistic record-to-reproduction path could include six gain stages with dc blocking in input and feedback paths; three high pass (–12 and –18dB/octave) filters; and 52 other dc blocking capacitors, **Fig. 1**. In a typical consumer grade path, capacitor values for assorted random f_{3L}s ($\omega_{low}/2\pi$) will be centered around 4-6Hz, and up to 16Hz. In fact this is a specification that is becoming increasingly prevalent even in supposedly professional equipment.

Analysing the frequency responses of 50 of these paths, **Fig. 2**, at different points shows the gain stages, high pass filters and buffers to range from –3dB, at from below 3Hz, up to 63Hz in the worst case. Uncorrected response at the end of the chain is –3dB at 45-200Hz.

This doesn't mean that bass is absent by so much: it is compensated for during the recording production process. But compensatory equalisation means the real path experiences even more phase corruption.

The figures nonetheless suggest the kind of roll-off commensurate with the delay and waveform distortion existing.

Delay problems can be appreciated by examining the contribution of a solo gain stage, **Fig. 3**. Just this one type of stage clearly exhibits more delay than the 52 buffers (otherwise the sum would exceed the upper plots in Fig. 3).

The effect of this aurally significant delay is mistiming of

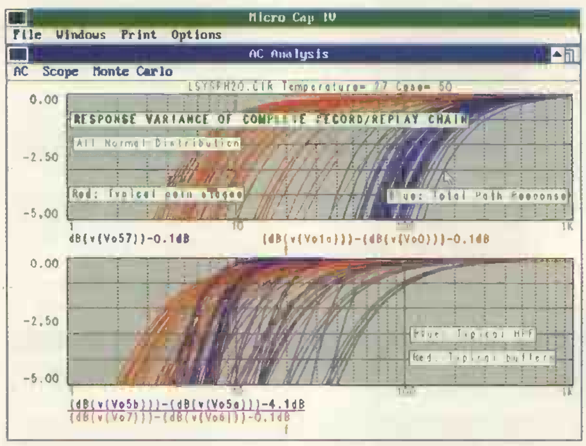

Fig. 2. Unequalised frequency responses of a possible complete consumer-grade audio reproduction path (upper panel, blue plots). Upper panel red plots, and blue and red lower panel plots, show typical responses of constituent gain stages, high-pass filters and buffers. Each Monte Carlo run represents myriad design differences, as nearly all audio chains are made from effectively random equipment assemblies. There are no standards for f_{3L}. Y axis is decibels.

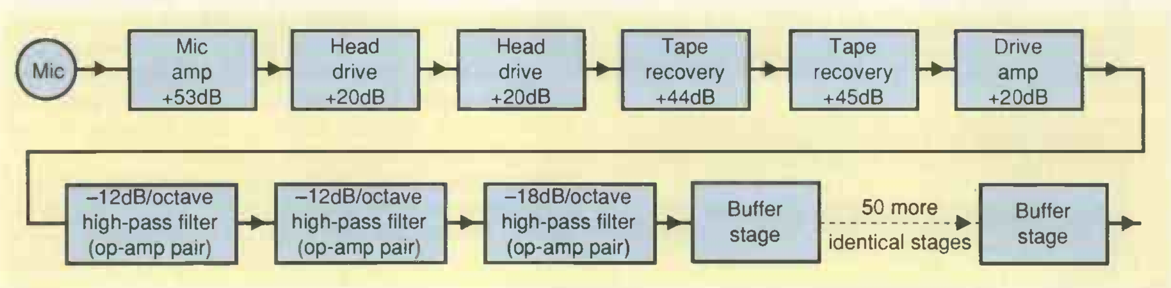

Fig. 1. Over 70 cascaded RC high-pass elements model a complete (electronic portion of an) audio record-to-reproduction path. Capacitor tolerances are engaged to simulate random equipment combinations, as well as tolerance, temperature and drift variables.

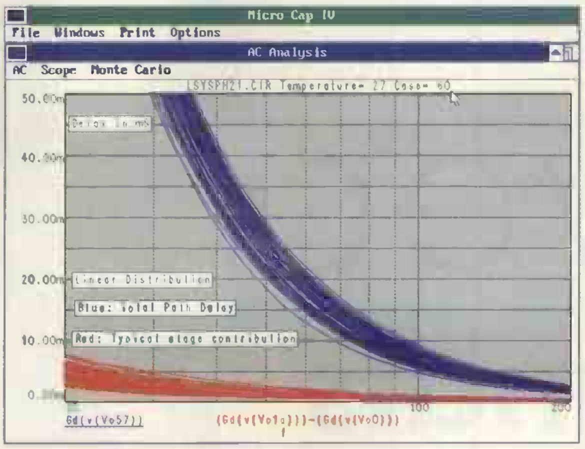

Fig. 3. Group delay vs frequency, individual and total, for a complete, consumer -grade reproduction path. Note the convergence on linearity only at extreme frequencies. Y-axis is milliseconds of delay.

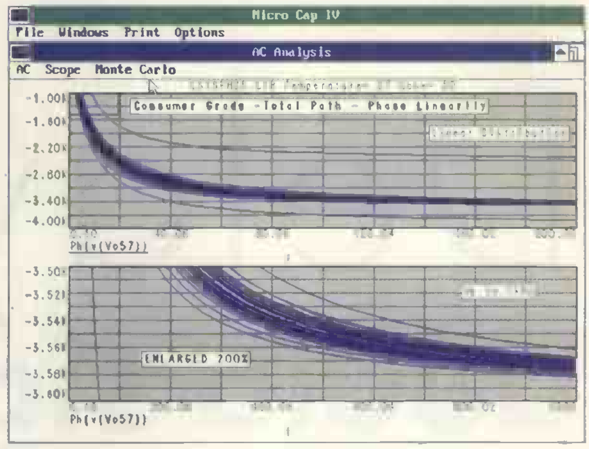

Fig. 7. Phase disaster at path output. With consumer values, the phase response of the whole path is truly non-linear, and the rate of phase shift changes at hundreds of degrees every few Hz around 40Hz. In the lower panel, the phase change rate (enlarged x30) isn't even linear by 1kHz. Note also the wild singleton – a disparate of excess phase. Y-axis is degrees.

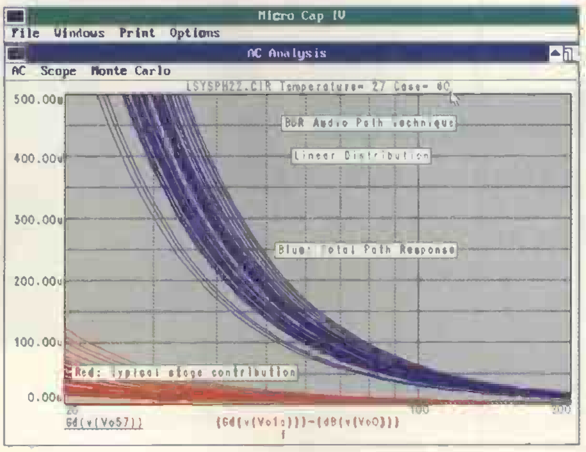

Fig. 4. The BDR method: like Fig. 2, but with 100 times less signal delay. Note Y-axis scale change.

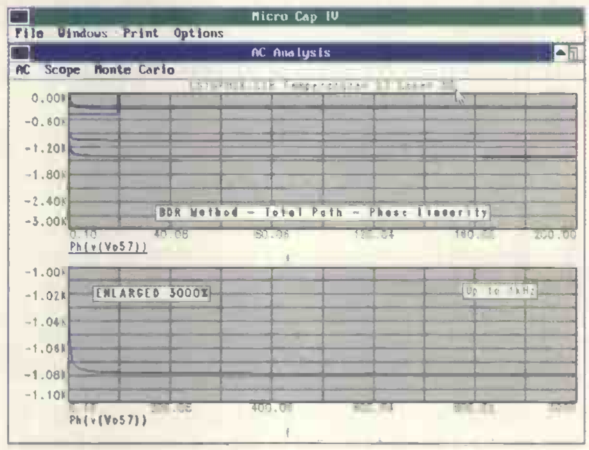

Fig. 8. Attaining global phase linearity. With bdr, the rate of change of phase is far, far less at the end of a full audio reproduction chain. In the lower panel, even x30 enlargement fails to reveal any visible curvature above 100Hz.

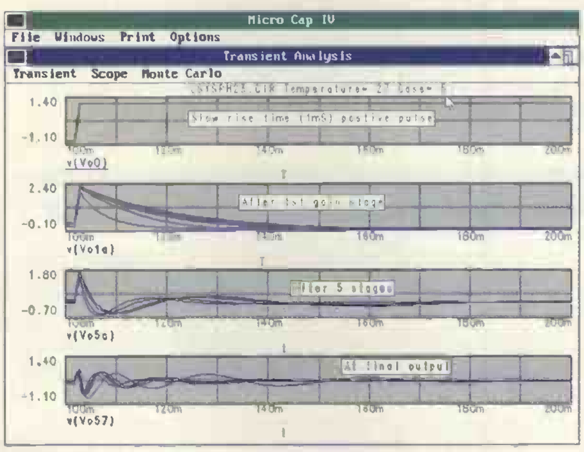

Fig. 5. Complete consumer path again. A pulse goes down the chain, with just five Monte Carlo runs for clarity. The emerging wave should not seem 'suitable for its intended purpose'. Fortunately, music productions only occasionally comprise such waveforms and 'data corruption' to the ears may be less fundamental than it appears to the eyes. Y-axis is volts.

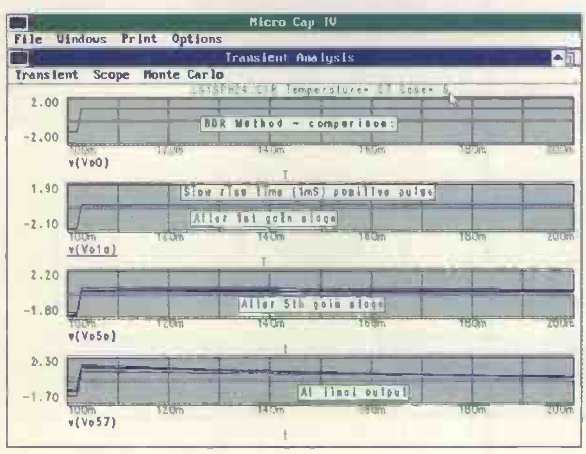

Fig. 6. Keeping the pulse. How bdr handles a pulse – something that looks very like the input pulse emerges at the output (lowermost).

the music – here as much as 43ms at 40Hz – while the higher harmonics of a note at this frequency can have periods many times shorter than this.

Clearly, the music is playing out of step with itself, and any *RC* components that add hp filtration will compound this delay. The real test of a design is to measure delay after passing a signal through seventy (of Douglas Self's 'blameless') power amplifiers – with appropriate interstage attenuation.

Distortion suffered by wideband audio waveforms (10Hz to 20-100kHz, Fig. 3) resulting from this delay is horrific: 'smeared' is a fair description.

Phase compensation suggested by Cherry[2] ought to help, but will it? Compensation must be in use in not just one stage, but throughout a fair fraction of – if not all – the audio chain. Plainly this would prove unworkable as each stage's inevitable xdB of subsonic gain would accumulate, soon eating up headroom. Also, any compensatory equalisation circuit would require further critically-toleranced *RC* parts, and its own phase relations and tolerance deviations would destroy Cherry's compensation's benefits.

The problems of the consumer approach are self-inflicted. To demonstrate what would happen if the bdr (see panel, **BDR *vs* Cherry and Self**) approach were used throughout the audio path, the capacitor values can simply be increased by ×167.

Effect on group delay is to make it 100 times smaller, Fig. 4 and contribution of the solo gain stage also ranges higher.

So what would be the fate of a simple positive pulse as it passes through the chain, Fig. 5? After the 57th high-pass function, the edge reduces to something like a damped oscillation. But using the bdr method, Fig. 6, although the final output may be a little tilted, at least it's recognisable and quite faithful.

Similarly, phase linearity for the consumer path is a disaster at all frequencies below 1kHz, Fig. 7, with the rate of change of phase per hertz accelerating. This can be compared with the bdr method, Fig. 8, which demonstrates an almost text book model of phase linearity. No significant curvature is visible above 100Hz.

Ironically, without the expense of hindreds of volts of lf headroom extension, Cherry's phase compensation scheme can in practice only be used once or twice. It is only in this almost phase-linear environment that it would have significant objective effect. Yet, in ordinary signal chains the effect would readily be heard as an improvement. But the same phase correction of just one stage in 60+ would be nearly invisible in any objective measurement of the whole chain due to phase jitter.

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Ben vs Self and Cherry: simulated contest

Ben Duncan wonders if he's the only designer left who really cares about the effects of phase and group delay on bass response.

Simulation of the Ben Duncan Research (bdr) simple and low-compromise approach to low frequency reproduction accuracy[3] can quickly provide a straightforward picture of phase and group delay, audio aspects of which are evidently still only foggily understood by some. Simulation also allows the design to be compared with those of Douglas Self[4] and Edward Cherry[2].

First step is to enter the three circuits into *MicroCap IV* to compare different approaches to low frequency reproduction (**Fig. I**). In the bdr approach, topology is minimal and f_{3L} (alias $\omega_{low}/2\pi$) is made extremely low, typically <0.1Hz.

The "consumer grade" version of the same topology, has lean *hp* capacitors to save pennies (eg Self[4], though to be fair, far worse examples are extant) and f_{3L} is typically 3-10Hz. In this and the bdr circuit, the main resistive arm values have been scaled to be identical to those specified by Cherry so like is being compared with like.

In practice, I would use a 1000µF – not 3300µF – lower arm capacitor, and scale the associated *R* values by a factor of three. In Cherry's circuit, extra parts have been introduced, apparently to compensate for having used too lean a principal elcap value in the first place. One practical problem with Cherry's method is that an exact ratio of three between electrolytics requires some messy paralleling when only E3 series values (10, 22, 47, 100µF etc) are available, as is often the case.

Plotting lf frequency response and phase using conventional log frequency scale (**Fig. II**, upper panel) for the three circuits does not give meaningfully view of phase behaviour for reproduction errors. In *MicroCap*, while simultaneously plotting by frequency, the scale for the phase data can be set to linear with 0Hz ('dc') as the origin, **Fig. III**. This will remove the delay[5] independent of frequency,

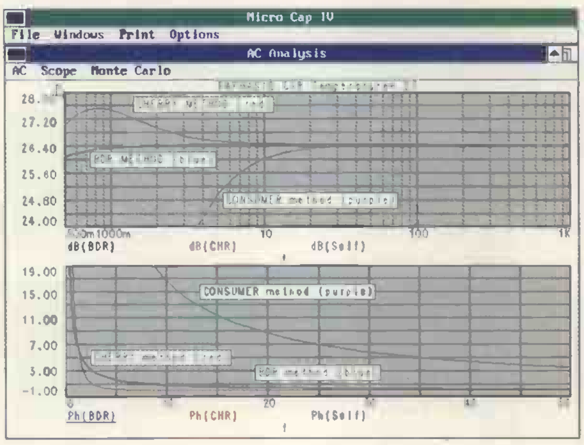


Fig. II. Frequency responses (upper panel) of the three contrasted circuits all provide negligible roll-off in the audio band >20Hz, but with true, frequency-dependent phase shift visible for a change (lower panel), the consumer/Self circuitry commits phase crime well within the ear's most sensitive domain.

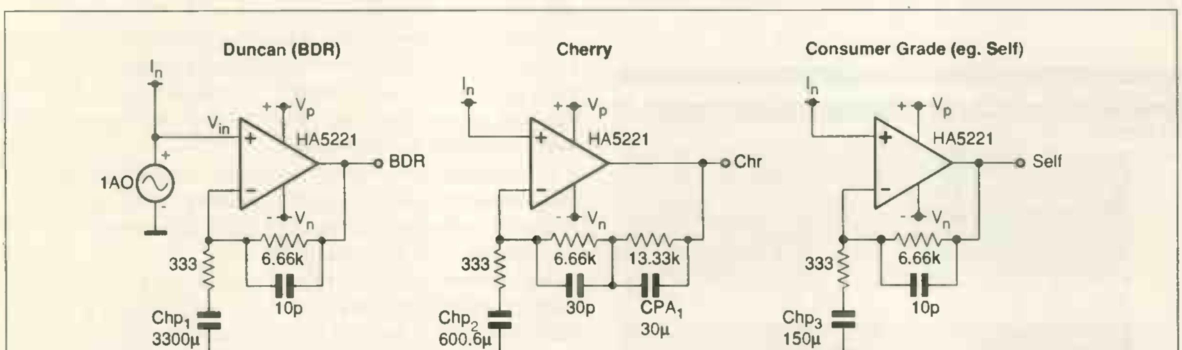


Fig. I. Three bass response approaches compared. Centre is Prof Cherry's "phase compensation" scheme. Note ac test source (left) drives all three. Measurements are referred to node labels; nodal numbering in MicroCap is automatic and transparent. Left and right circuits vary only in their elcap size. The Harris HA5221 IC model parameters are Level 1 for speed, and have been over tweaked but these factors have no appreciable effect on simulation accuracy or validity in our strictly lf arena.

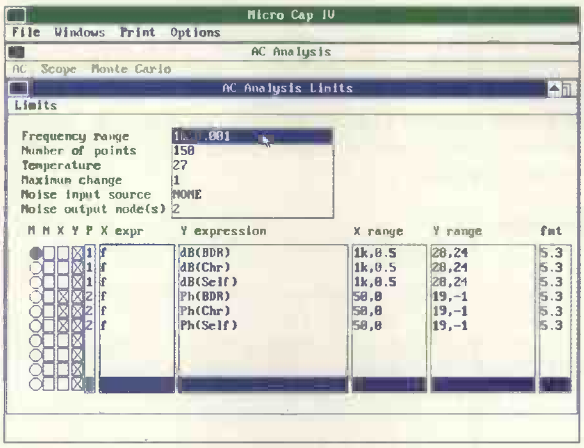


Fig. III. MicroCap's ac analysis prolog screen. Note the frequency range origin is set at 1mHz, not quite dc but near enough, to speed up plotting. Also, the the decibel and phase plots are set logarithmically and linearly, respectively. Y-axis is milliseconds of delay.

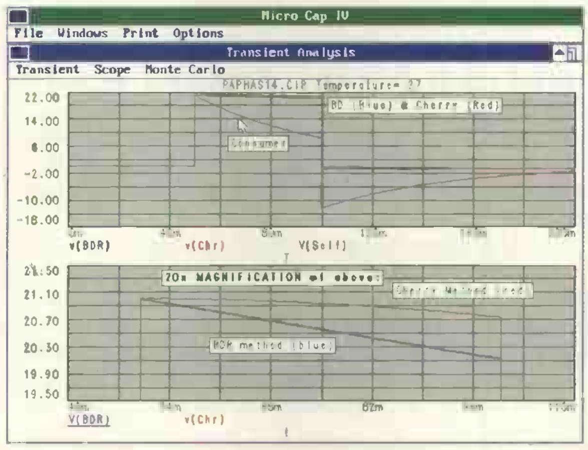


Fig. IV. Square wave responses compared. Upper panel shows all three. Lower panel magnifies the positive pedestal and abstracts it in time too, to clarify the differences between the Cherry (convex) and bdr (near-linear) methods. Y-axis is volts.

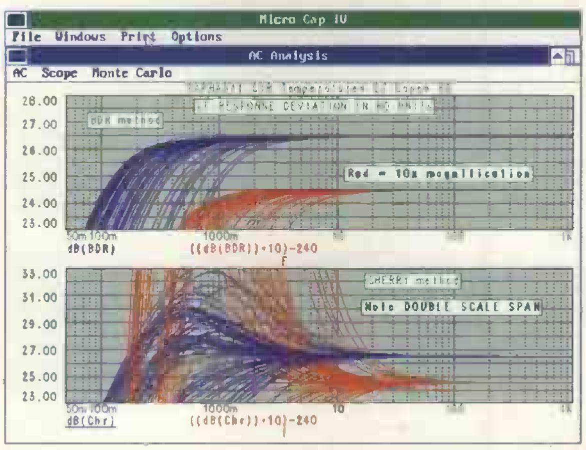


Fig. V. Mass frequency responses. Upper graph covers half the amplitude of the lower. The Monte Carlo linear run shows what could occur in a real population. Y-axis is decibels.

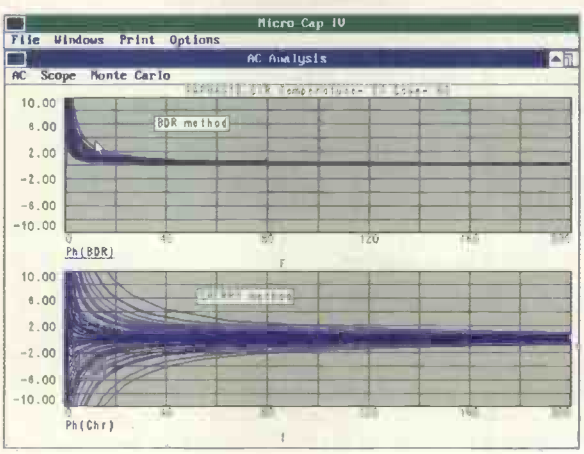


Fig. VI. Cherry's phase disaster: A Monte Carlo run showing true phase response after Jensen, in a production population. Note linear frequency scale. The vertical step just discernible in the origin of the upper plot is because frequency was set to begin at 0.1Hz rather than 0Hz. This speeds the run. Y-axis is degrees.

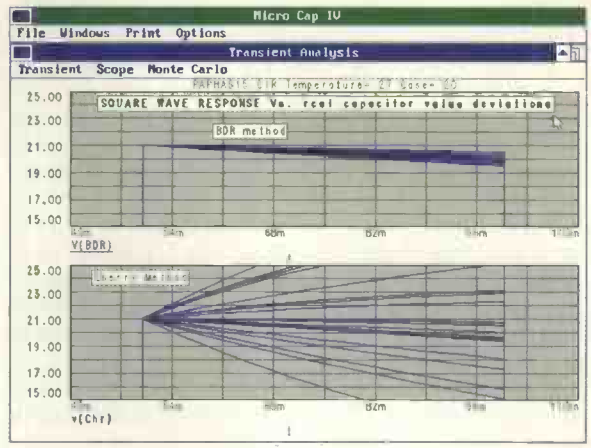


Fig. VII. Effect on the two square waves shown in the lower panel of Fig. IV when capacitor values are stepped over real world tolerances. The lower set of plots shows how – with most variations – Cherry's method fails to achieve the flat top that is its goal. The bdr method is clearly much less sensitive to part tolerance, though with more than 20 plots (a limit imposed for visual clarity) a few 'wild' plots will occur. Y-axis is volts.

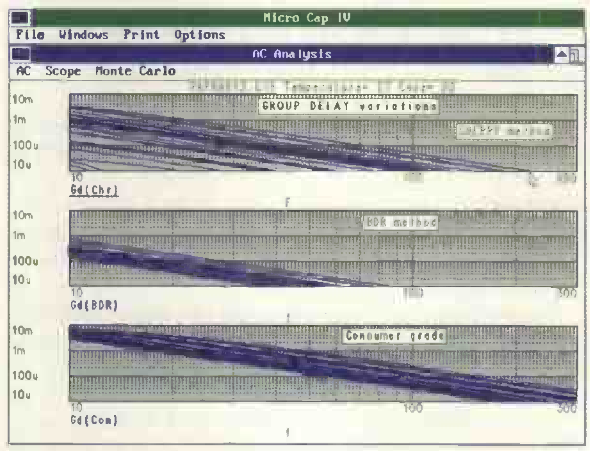


Fig. VIII. Three signal delay patterns. Group delay is plotted with the 'Gd' operator. For clarity with the three, smaller, scales and because smooth Gd plotting demands slower runs than phase or amplitude, the number of Monte Carlo runs has been reduced from 60 to 30.

revealing true phase linearity so that a straight line on this linear scale, whether sloping or level, indicates absence of waveform distortion. Anything bending is slurring the signal with respect to frequency.

Using this technique, both the Cherry and bdr methods can be seen to have (Fig. II, lower panel) audio band, to 20Hz, true phase linearity well within 1°. But the consumer approach shows almost 4.5° of tilt at 42Hz – the lowest fundamental from a bass guitar.

Cherry is certainly more linear at sub-sonic frequencies than bdr, and that would improve the accuracy of say, an earthquake or explosion (for hi-fi video entertainment). But we must ask: "Is it really worth it?"

Square-wave responses, **Fig. IV,** show a major tilt in the consumer approach, while a 20 times magnification is needed to see that the BDR method tilts more than Cherry's and the slope is almost linear. A sign of Cherry's phase compensation can be seen in the slightly convex curvature, whereas the consumer tilt is concave.

The lower arm dc blocking capacitor is inevitably electrolytic – Douglas Self agrees[1] – even if for sonic reasons a far smaller valued polypropylene capacitor is shunted across. Scaling *R* up and *C* down is just not practical on grounds of noise, microphony and increased electrostatic/EMI sensitivity[3].

Electrolytic tolerances may have improved greatly over the years, but they are still commonly as poor as ±30% and most are ±20% at best. Electrolytics also have the poorest temperature coefficients of any capacitor type. Typically the value will change from that at switch on by at least +10%, and possibly to over 50%, after the unit's internal temperature has risen by 35°C. Equally, faradic value could drift by 25% with time.

Taking the midpoints of these, we have 25% + 30% + 25%. So in real use the two elcap values on which Cherry's scheme depends may realistically and independently vary by ±80% (ie from ×0.2 to ×1.8). To reflect this, all capacitors definition statements for the simulation (Fig. I) have been appended with `LOT=80%`. For clarity, resistor values are assumed to be invariant.

Re-running the simulations with Monte Carlo analysis, using linear distribution, shows the effect of real world capacitative value variation.

Amplitude response variation across 60 units for bdr (**Fig. V**) shows no peak, nor any aberration above 0.1dB in the audio band.

But Cherry's scheme shows that the response and damping (*Q*) varies all over (so badly that the scale is halved to see just a bit of it) and the variation infects frequencies considerably above 20Hz.

In the worst-case true phase error at 20Hz, **Fig. VI**, bdr varies just 1.8° between +0.2 and +2°. Yet Cherry's scheme varies over 16° from at least +8° to –8°. Worse, the phase error varies by more than ±0.75° at 200Hz, a far more critical and phase-sensitive midrange frequency.

Looking again at the square wave response, even with only 20 Monte Carlo runs, **Fig. VII**, bdr shows only mild changes while Cherry already varies wildly. In fact Cherry's response – completely different from the slight tilt intended – makes it most dubious where anything but individually-selected oven-mounted electrolytics, measured and calibrated monthly, are available.

Finally, we should consider group delay. Plotted against logarithmic frequency, this displays frequency-dependent signal delay directly.

At first sight, delay varies almost linearly with frequency using all three schemes, **Fig. VIII**. However, both Cherry and the consumer method exhibit plots that are non-monotonic: try a ruler against them.

What matters most though, is the excess absolute delay. The consumer scheme is worst, with the largest delay (in only 30 random production units remember) being nearly 400μs. With Cherry, the worst delay at 80Hz is below a quarter of this, 70μs. Again, bdr is best, with barely 10μs. For an 80Hz partial to be lagging 70 or 300μs behind the mid-range may not sound much, and even those with critical ears will not easily hear this difference. But, clearly, few audio designers have ever thought through the entire-path ramifications. ■

Migrating to C++

Object-oriented design has been heralded as offering radical benefits in the software development cycle. However, without adequate appreciation and management of the process, the gains expected may materialise, as Gerard Maloney explains.

In theory if not in practice, software development has traditionally been based on 'structured' design methods, which emphasise the procedures by which a solution is achieved. But the ever increasing size and complexity of software systems, not to mention the demands in areas such as graphical interfaces, cad/cam, artificial intelligence and distributed systems, has increasingly highlighted the inadequacies of this approach. As a result, alternative design methods are coming increasingly to the fore.

Of these alternative methods the 'object oriented' approach is the one currently gaining ground across a wide diversity of applications. Here, we will outline the underlying philosophy of object-oriented programming, looking in particular at what has become the dominant programming language for implementing such designs – C++.

Fig. 1. In the traditional structured design cycle, progress is linear.

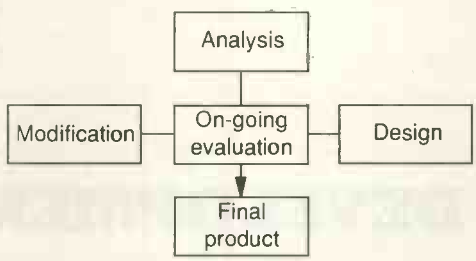


Fig. 2. Object oriented design cycle involves an iterative approach throughout the design cycle.

Programming with objects in mind

Object oriented design has as its basis a key shift in emphasis away from concentrating on how a task is achieved to identifying the key abstractions within an application. It also takes into account how these abstractions interact with one another.

From this basis it is hoped to model a more effective and intuitive solution to the task at hand. Coupled with this shift in emphasis is a movement away from the 'top-down' approach to the development cycle, to an approach whereby the development cycle is seen as an iterative process. Each phase in the cycle is reviewed, as the design evolves to fulfil its final requirement.

Figures 1 & 2 outline the change in emphasis. For a great number of engineers Fig. 2 only sets out precisely how they currently approach their development work. Within an organisation however, the change from a structured to an object oriented approach requires a review of the overall management of technical projects in order to implement the changeover effectively.

The use of object-oriented design has gathered apace over the past ten years, to the point where it now looks set to become the dominant design methodology within the software industry. This has no doubt been aided immeasurably by the emergence of C++ as a commercially available and mature language. Although not the 'purest' of object oriented languages, C++ has evolved to directly support the paradigm, while maintaining its roots in C.

Of itself, object oriented design is not a panacea for bad design. Likewise its adoption will not be effective unless project team structures and management practices change to enable its correct implementation.

The language requires a more fluid and evolutionary approach to design, and the extent to which its introduction benefits companies is largely dependent upon the recognition of this fact. Used correctly, object oriented techniques implemented in an appropriate language, will result in designs that map directly onto the applications domain, enabling increased software re-use, ease of maintenance and an evolutionary approach to future development.

Object oriented design – key concepts

To be effective any design methodology requires tools that support it directly. In this case these are the 'object oriented programming languages', a wide range of which are available. However, in order to be able to model and organise abstractions effectively, which concepts and mechanisms ought these languages support?

In his book 'Object Oriented Design with Applications', Grady Booch outlines the concepts which are fundamental to what he terms 'the object model'. These are direct support for abstraction, encapsulation, hierarchy and modularity. To these ought to be added support for parameterised types, which have the potential of adding significantly to software

Applications Domain:	Software Implementation:
Waveforms:	A range of waveform types.
Sine, Square, Triangle, Ramp	
Processes:	
Acquisition, Filtering, Output	Arrays, filter types, output drivers.

Fig. 3. Mapping abstractions. Object-oriented design allows 'types' to be created. These map directly into the application's. domain.

Gerard Moloney is MD of October Developments, 0181 968 3586.

re-use. Secondary properties which he outlines as desirable are strong 'typing', and support for concurrency and object persistence. A brief outline of each of these concepts is given below.

(i) **Abstraction:** in order to support abstraction a language must allow for the creation of user defined types which map directly onto concepts within the application domain. In a signal-processing application you might need to create waveform and filter types; in a graphics library, matrix and transformation types. **Figure 3** illustrates the concept.

(ii) Encapsulation: any abstraction can be said to have two major attributes: its structure and its behaviour. Within software this translates to a representation and an associated set of functions (procedures/methods). Generally, the functionality is of interest; the representation/implementation should not be accessible except through a strictly defined set of functions implementing the interface to the user.

In effect the representation should be 'encapsulated'. **Figure 4** illustrates how encapsulation might be achieved for a type representing a sinewave.

(iii) Hierarchy: within object oriented software, creating hierarchies of user types is of prime importance. The base of the hierarchy provides generalisation with further specialisation provided by the lower layers. Support for hierarchical types allows for designs that are highly intuitive and efficient, and provides a basis for further evolution. **Figure 5** is an example of a partial hierarchy for geometric transformations.

(iv) Modularity: any complex system needs to be modular. Within object-oriented systems, modularity exists to keep related abstractions together.

Modularity exists at a number of levels; libraries provide re-usable collections of domain specific abstractions, source files provide modularity at the application level while encapsulation provides modularity at the abstraction level.

(v) Parameterised types: often, structures and functions are required that can be used across a range of types. As an example, consider matrices. The structure of a matrix and its operations have a generality across a range of algebraic structures. The ability to capture this type of generality is a powerful aid to extended re-use.

(vi) Typing: static type checking can ensure errors are caught at compile time, and it can introduce a strong discipline into programming. Not all object oriented languages support static typing, but in most instances the benefits far outweigh the perceived loss in flexibility.

(vii) Concurrency and persistence: support for concurrent processes is not inherent within object oriented languages. However a process itself can be viewed as an abstraction and therefore concurrency can be implemented. Likewise the need for objects which exist over extensive periods of time – as in database and distributed systems – can easily be supported at the abstraction level.

Having outlined these concepts I will now look specifically at language support for these within C++.

Objects and C++

C++ was developed as a general purpose programming language which would directly support object-oriented programming in an efficient and straightforward manner. By guaranteeing that C++ would maintain C's inherent low-level strength and by maintaining a high level of compatibility with C, C++ has been in a unique position as developers looked to adopt object oriented methods.

In his work 'The Design and Evolution of C++', Bjarne Stroustrup says that in his view, C had successfully addressed the 'computational' aspects of a language. In developing C++, one criteria was to maintain this, while dealing effectively with the 'organisational' aspects.

A further criteria was to remove the necessity for the unsafe practices used widely in C, such as casts and the proliferation of pre-processor directives and global data.

Object oriented development support

Within C++, there are various structures, included to aid object-oriented development.

(i) **Classes**: Within C++, a 'class' is the fundamental mechanism by which user defined types are implemented and they receive almost identical support within the language as the built in types such as 'int', 'char' etc.

Classes not only represent the abstractions within the application, but within the class 'encapsulation' is enforced. A class defines a scope, and is the fundamental organisational component in C++. Below is a simple sinewave class showing the separation of the representation from the interface to it.

```
class sinewave{
   //the representation
   float frequency;
   float amplitude;
public:
   //the interface to the representation.
   sinewave(float x,float y){frequency=x;amplitude=y;}
   ~sinewave();
   //other appropriate functionality.
};
```

C++ allows for different levels of access to be defined and very efficient and intuitive interfaces can be built, given features which allow for in-line code and the defining of operators on a class specific basis.

A user of a sinewave class requires only the interface to use the class, and application specific class libraries are the toolsets to be used by application developers.

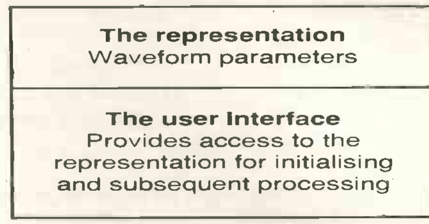


Fig. 4. Example of encapsulation. The representation and the interface parallel two major attributes of an abstraction – its structure and its behaviour.

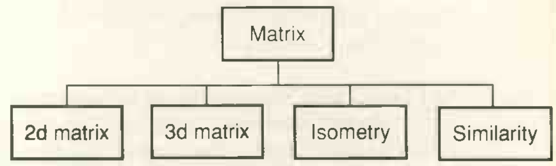


Fig. 5. A matrix hierarchy supporting geometric transformations. The root matrix provides generic behaviour while the derived classes provide for specific functionality.

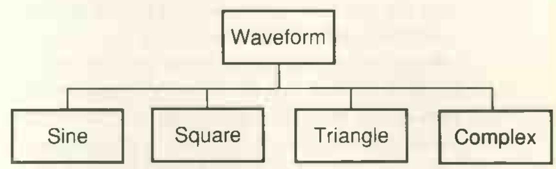


Fig. 6. Example of simple hierarchy structure for waveform generation.

(ii) Derived classes: Given an application, generally hierarchies of related types exist. Below is a hierarchy of waveform types, with the 'base' of the hierarchy being the 'waveform' class and the 'derived' classes being 'sine', 'square' etc, **Fig. 6**.

Hierarchies allow related types to share common functionality and to be viewed in many instances as objects of their common base class. Below the sinewave class has been derived from a waveform class allowing a large measure of its functionality to be expressed in terms of its base class.

```
class sinewave : public waveform{
//representation in base class.
//common to all wavetypes.
public:
sinewave(float x,float y):waveform(x,y,){
//only need sinewave specific functions.
//otherwise view as a generic waveform.
};
```

Whatever their type, waveforms share a great deal in common and are thus able to use a great deal of generic code. With an appropriate class library, C++ enables the following to be written:

```
complexwave1=sine1+square3+ramp5+sine7;
complexwave2=(mybandpass)(complexwave1);
```

Not only is this semantically clear but it is as

Requirements:	Solution:
general lists of	
employees	a list type that can
accounts	hold any type for which
waveforms in	a list makes sense
a complex wave	

Fig. 7. Parameterised types allow for the creation of generic classes and functions.

Fig. 8. Organisation using header files.

```
//App.cpp
#include "waveform.h"
//two header files for accessing
        waveform and processing stuff
#include "process.h"
//the application accesses required
functions via header files
sine sine1(1000,1.125);
```

efficient if not more so than code written in C.

Hierarchies, therefore have a crucial role to play in organisational terms and introduce a high degree of code re-use .

(iii) Templates: Whereas hierarchy supports re-use through derivation, templates support re-use through parameterised types. Thus you define a class or function to provide services across a range of types which may not necessarily be related to one another. **Figure 7** illustrates the general requirement and solution.

Initially, they arose from the requirement to provide a library of container classes which is a fundamental requirement within most development environments. Assume we need lists; but lists of what exactly? How is it possible to provide for the lists that may be needed in the future? Templates fulfil this requirement, below we look at the outline of a matrix template:

```
template <class T> class matrix{
   int col;
   int row;
public:
   matrix(int x,int y){col=x;row=y;}
   ~matrix();
   //other matrix stuff
};
```

A developer can now declare matrices of any type;

```
matrix <int> intmatrix(2,2);
matrix <complex> complexmatrice(5,3);
```

and given that those types are available matrix algebra can be applied to them. Likewise at a future date matrix algebra could be applied to as yet unspecified types.

Used together with derivation the potential for re-use and the impact on program organisation are enormous. Taking as a case in point, in our matrix example we can derive from matrix and apply templates to a specific type of matrix. I may perhaps wish to optimise for geometric transformations which are derived from a matrix and are able to take a variety of types as their parameters.

Together, classes, the related subjects of hierarchies, and templates, form the basis of support for object oriented techniques within C++. Also incorporated within the class concept are features to encourage semantically meaningful syntax, the efficient creation and deletion of objects and the minimisation of global data and pre-processor directives. In addition, there is the introduction of static typing, which is equally applicable to stand-alone functions. Static typing enforces compile-time checking of arguments, and can go a long way to eliminating run-time errors. It is to be recommended in almost all cases.

Finally, modularity is supported in C++ by the use of libraries and separate source and header files. Organisation is in terms of abstractions, related abstractions reside in the same files and are interfaced through their header files, **Fig. 8**.

Application specific libraries can then be generated from these files and made available for general use. With a good library of classes that map well onto the application's domain it should not generally be necessary to access the source code in order to use or add further speciality.

In summary

Without a doubt C++ is rapidly becoming the language of choice in many areas, and given its excellent support for object oriented programming coupled with its association with C it looks set to be a major development language in all spheres.

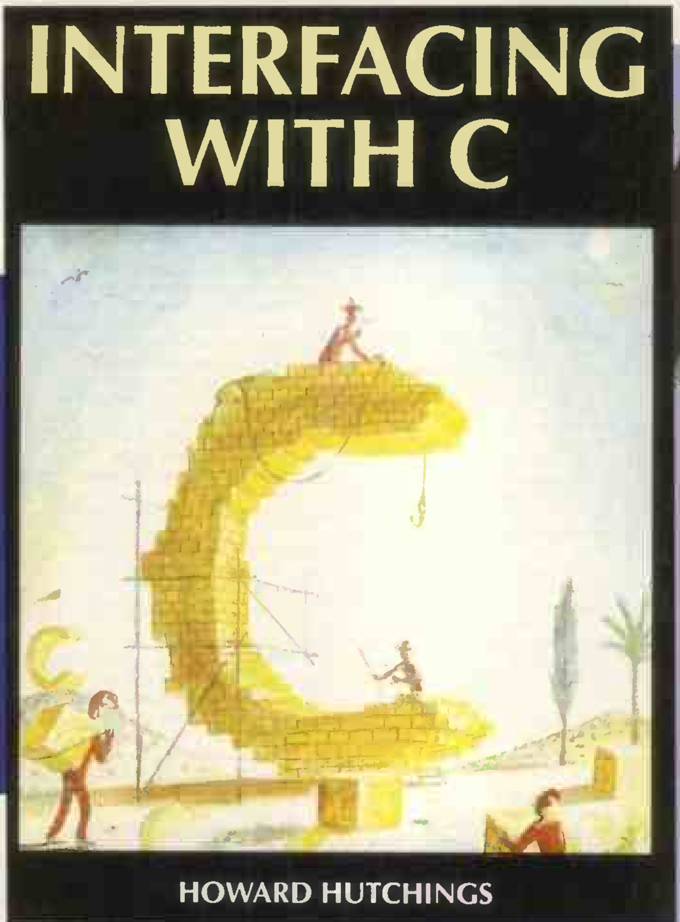
What is often overlooked, however, is that C++ also addresses those areas in which C is deficient. Features such as static typing, class specific dynamic memory allocation, static class members, exception handling are radical improvements when viewed from a software engineering perspective.

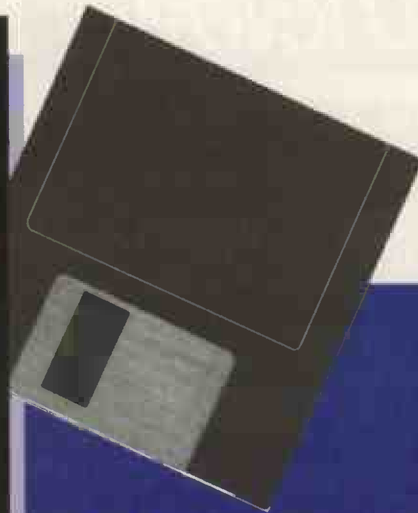
C++ also supports mixed-language development with a simple linkage model, allowing previous software investment to be fully used. Given these advantages there is a strong case both commercially and technically for companies to considering C++ seriously as the basis for their future software development.

However, while the benefits to be gained by adopting an object oriented approach to development – whether C++ based or otherwise – can be enormous; unfortunately without an adequate understanding of the issues involved, these benefits may not be achieved.

With no informed strategy for the adoption of C++, the net result within organisations will be disenchantment amongst development staff, and a discrediting of the whole process. Such a strategy should deal directly with the change in emphasis that the philosophy requires. It should set out a program in which object oriented design methods and programming are introduced over a period of time at both a project and individual level. Given such a strategy the resultant impact on design and implementation are indeed significant. ■

Further reading
Grady Booch, 'Object Oriented Design with Applications', Benjamin Cummings.
Bjarne Stroustrup, 'The Design and Evolution of C++', Addison Wesley.
The C++ Programming Language, Addison Wesley.





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Transient storage for ANALOGUE SCOPES

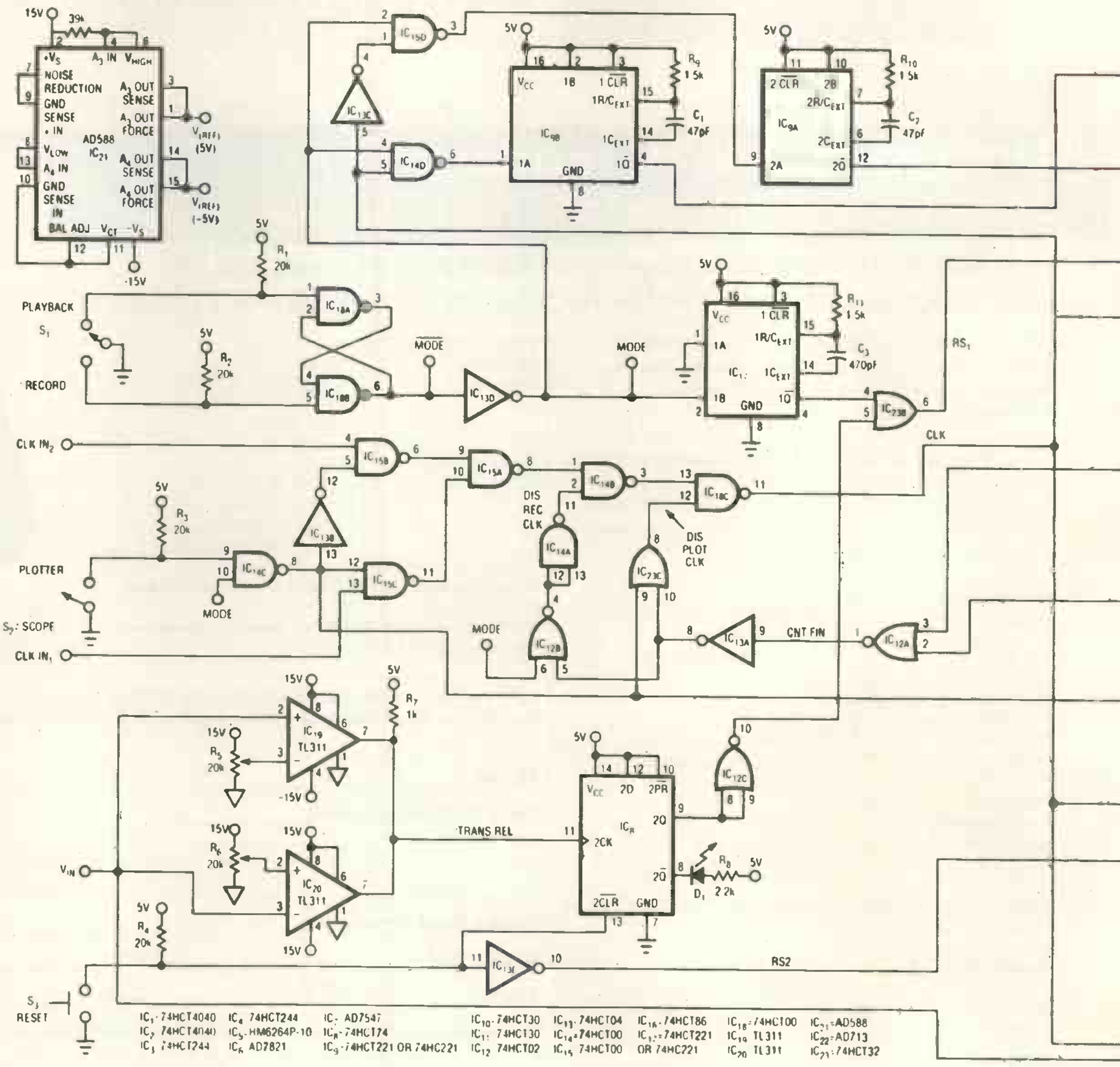
Rather than tie up an expensive dso looking for infrequent transients, Ken Deevy, Dan Sheehan and Mike Byrne show how to use a low-cost, dedicated transient recorder with an ordinary analogue oscilloscope or XY plotter.*

One of the difficulties in capturing single-shot events is the speed at which the transient recorder circuit responds once the input signal has crossed a predetermined trigger point. If the recorder circuit responds too slowly, it can miss fast transients altogether.

To capture fast events accurately, you need a high-speed a-to-d converter and a wide-bandwidth track/hold amplifier. For example, an eight-bit a-to-d converter having a 1μs conversion time can capture 1μs transients only when not preceded by a track/hold amplifier. With a 100kHz track/hold amplifier, the converter can recover 6μs-wide 5V transients.

To simplify fault detection or to take corrective measures, a transient recorder must be able to capture pre-transient information, which you can use to discover timing relationships between the transient and another waveform. Additionally, the recorder should be able to react to both positive and negative transients.

Another important criterion is cost. There is little point in replacing one expensive instrument with another. **Figure 1** shows that two counters, IC_1 and IC_2, determine where the circuit stores pre-transient and transient data, also clocking out data to the oscilloscope or X-Y plotter. You can use the



*Ken Deevy, Dan Sheehan and Mike Byrne are with Analog Devices Inc. This article first appeared in *EDN*.

fast clock input, CLK IN_1, for the clock source in record mode or when displaying stored data on an oscilloscope. A slower clock input, CLK IN_2, is for use when printing data on an X-Y plotter.

Switch S_1 selects the two basic modes: record and playback, IC_{18a} and IC_{18b} providing debouncing. With the MODE output of IC_{13d} low, one input of both IC_{15d} and IC_{14d} is low, so the clock inputs of IC_{9a} and IC_{9b} are disabled, ensuring that the 1Q\ and 2Q\ outputs of IC_{9a} and IC_{9b} are high. Besides disabling the chip-select inputs of the d-to-a converter, CSA\ and CSB\, the circuit disables the output enable signals of IC_3, IC_4 and IC_5, the *HM6264* memory chip, ensuring that the playback portion of the transient recorder is turned off.

Input CLK IN_1 serves as the clock source for the counters via IC_{18c}, IC_{14b}, IC_{15a} and IC_{15c}. While the MODE signal is low, CLK is the clock input for both counters and provides the RD\ (convert) signal for the *AD7821* a-to-d converter, IC_6. At the same time, IC_6's CS\ input is active, ensuring that the device is selected. After a reset from S_3 initialises the circuit, counter 2 begins counting. Monostable IC_{17} and IC_{23b} hold the reset (CLR) input of counter 1 high from power-up, keeping it in reset until the circuit detects a transient.

Connecting pin 7 of the *AD7821*, labelled Mode, to ground, sets the operating sequence in which, when the CLK signal toggles its RD\ input, the a-to-d converter executes continuous conversions of the input signal, V_{in}. (This Mode pin is in no way connected with the mode signal in the circuit diagram.) Counter 2 provides the memory addresses for the a-to-d conversion results. Data transfers from the digital outputs of IC_6 to IC_5 employ the INT\ output of IC_6 to drive the WE\ input of IC_5.

The circuit automatically loads the first conversion result after reset into location 0 of memory and the second into location 1. After transferring the result of the 4096th conversion to memory location 4095, the counter resets and stores the next conversion result in location 0. Memory always, therefore, contains the most recent 4096 samples of the input waveform.

Fast transients

Input signal V_{in} goes directly to two *TL311* comparators and the analogue input of the a-to-d converter. Comparator IC_{19} detects positive transients and IC_{20} negative ones, threshold levels being adjusted by R_5 and R_6. Wiring the outputs of the comparators together ensures that they produce a rising edge to the clock input of IC_8 when either a negative or a positive transient occurs.

Once the circuit detects a rising edge at pin 11 of IC_8, it illuminates a led, D_1. At the same time, it releases counter 1 from its reset condition by taking RS_1 low and both counters clock as a-to-d conversions continue, counter 2 counting up from the value it held before the transient was detected. Memory locations determined by the output of counter 2 store the transient data while overwriting the oldest 2048 samples of pre-transient data already stored in memory.

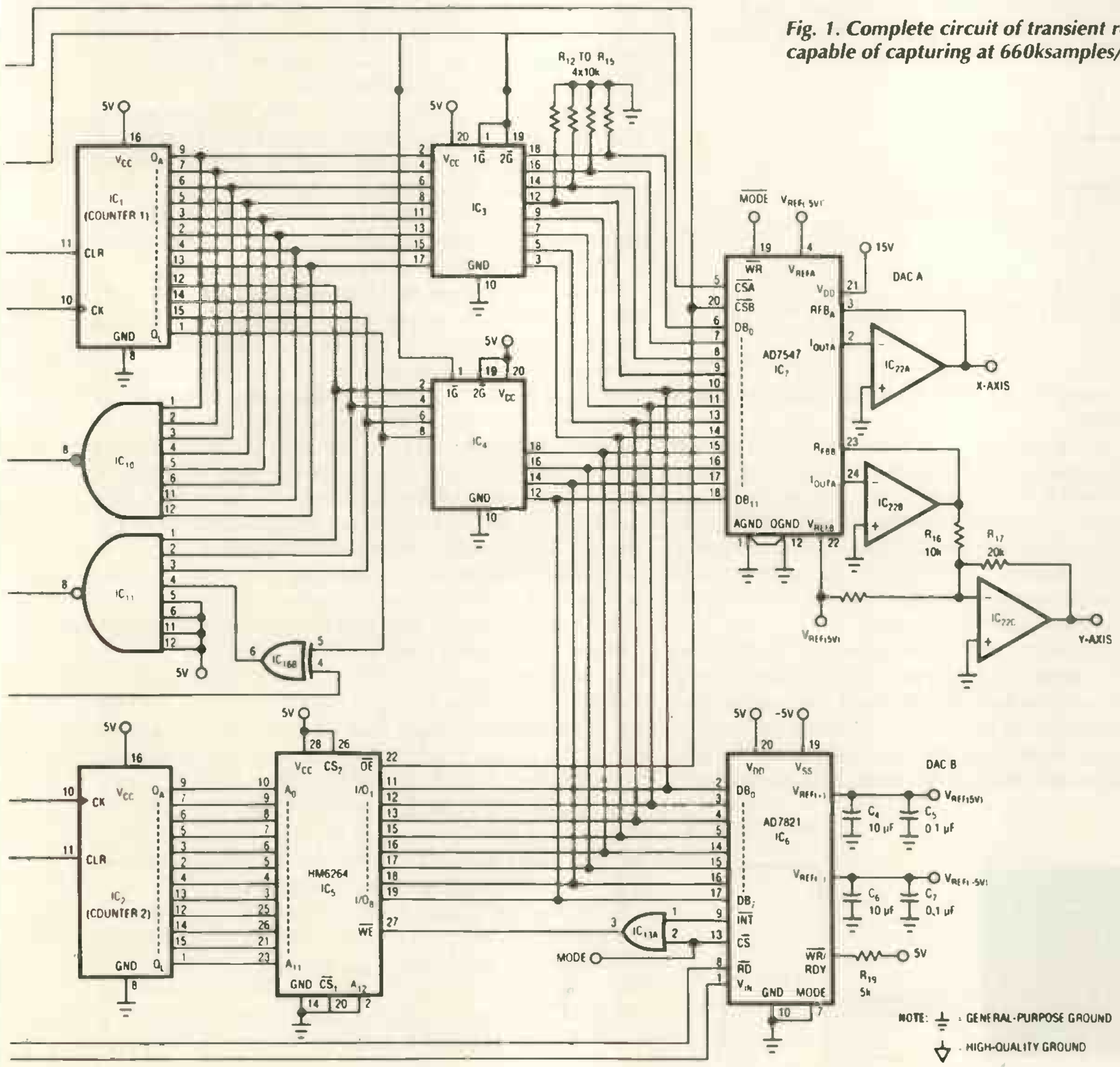


Fig. 1. Complete circuit of transient recorder capable of capturing at 660ksamples/s.

Transient recording

A transient recorder or burst-mode event sampler consists of a high-speed a-to-d converter, a wide-band track/hold amplifier, and an antialiasing filter. The a-to-d converter needs a sampling rate of at least twice the bandwidth to satisfy the Nyquist criterion, although at this rate the filter needs an infinite roll-off rate to avoid aliasing effects. With three times oversampling, the roll-off requirement drops to 50dB/octave in an eight-bit system and oversampling at a ratio of 10:1 requires a filter roll-off of only about 16dB/octave.

High-speed, sampling a-to-d converter chips often include track/hold amplifiers on the same chip; the *AD7821* is an example of this trend, combining a 100kHz track/hold amplifier with a 1Msample/s, eight-bit a-to-d converter. Because the a-to-d conversion rate is ten times the input bandwidth, there is no need for a complex antialiasing filter; indeed, if the input signal exhibits only a low-power spectral content at and above 500kHz, no filter is needed at all.

The *AD7821* uses a half-flash conversion technique to perform an eight-bit conversion in 660ns which, with the requirement of a 350ns signal-acquisition period between conversions, results in a maximum acquisition rate of 1Msamples/s. It accepts either single or dual supplies for unipolar or bipolar inputs.

Figure A1 is a block diagram of a transient recorder, showing the minimum hardware needed to build a high-speed transient recorder with playback. For simplicity, the design uses a clock with an even mark/space ratio, which limits the acquisition rate to 660ksamples/s rather than the a-to-d converter's 1Msample/s maximum rate, the oversampling ratio now being 6.6:1. A memory chip stores the digitised data for later playback on an X-Y plotter or oscilloscope, via a dual, 12-bit d-to-a converter and a quad op-amp. Half the samples are pre-transient information and the other half transient data.

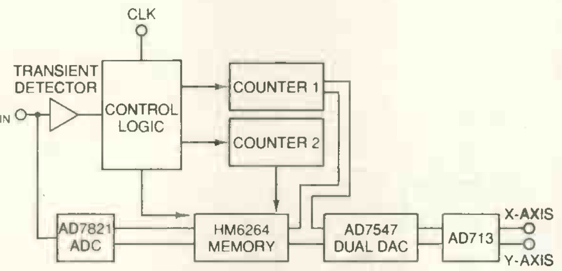


Fig. A1. Block diagram of the transient recorder – mainly digital, but with data converters at each end.

Counter 1 counts off the 2048 clock states that correspond with the samples.

Because the output of IC_{16b} is always high in the record mode, when counter 1 reaches 2047, all inputs to IC_{10} and IC_{11} are high and the outputs of both ics go low. As a result, the output of IC_{12a} goes high, causing the output of IC_{14a} to go low via IC_{13a} and IC_{12b}, this DIS REC CLK signal gating off CLK IN_1 from the rest of the circuit in IC_{14b}. The output of IC_{18c} ensures that the CLK signal is held low, stopping both counters and the a-to-d converter.

At the end of the transient-record cycle, the memory will contain 4096 samples of the input waveform. Half of these samples are transient data, the other half representing pre-transient information. Whatever value is in counter 2 will be the last memory location for the transient data and the next memory location will hold the first of the 2048 words of pre-transient data; when playback mode starts, the first output from the counter will correspond to the memory location of the first pre-transient sample. To alter the ratio of transient to pre-transient samples, simply alter the connections from counter 1 to IC_{10} and IC_{11}.

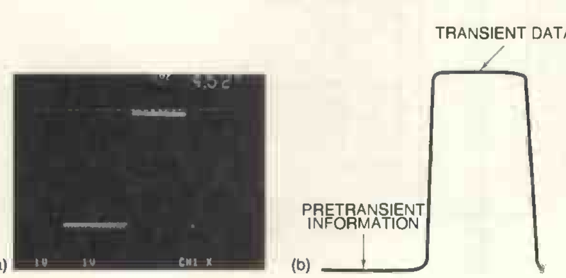


Fig. 2. Recorder presents results on either an analogue oscilloscope (a) or on a plotter, as at (b). Pre-transient information occupies the first half of the trace, the second half being the data after the trigger.

To convert the input waveform to stored data accurately, you must pay close attention to the circuit. Use a precision reference, IC_{21}, to generate 5V and –5V references for the V_{ref}+ and V_{ref}– inputs of the a-to-d converter. Make sure that these reference voltages are properly decoupled, along with the V_{DD} and V_{SS} lines of the a-to-d converter. Connect the GND pin of IC_6 to the star ground of the system, ie the point in the circuit at which you connect the analogue and digital grounds. Make sure that the conductor between the a-to-d converter and the star ground is as wide as circuit board lay-out constraints allow. Further, ensure that the WR\/RDY line is pulled high via R_{19} to avoid noise pickup on this pin.

Playing back captured signals

Information is retained as long the power remains on or until you depress the reset button. Select play-back mode with S_1. This takes the MODE\ signal low, activates the WR\ input to IC_7, and deselects IC_6 by taking its CS\ high. Display the transient on either an analogue oscilloscope or an X-Y plotter, depending on the position of S_2. Make sure to select the oscilloscope or the plotter before starting playback.

For the oscilloscope display, the clock source for the circuit is the same as in the record mode. If you use a plotter for playback, the clock frequency is much lower and is applied via the CLK IN_2 input. CLK, from either CLK IN_1 or CLK IN_2, passes through gates IC_{15d} and IC_{14d} because the MODE signal is high. IC_{9a} and IC_{9b} generate the CSA\ and CSB\ pulses for IC_7 from this CLK signal.

Monostable IC_{9a} drives the CSA\ input of IC_7 as well as providing the enable signals for IC_3 and IC_4. In playback mode, counter 1 resets and starts counting from 0 to 4095, its output being the digital input code to DAC A of IC_7, which drives the X axis of either the oscilloscope or the plotter. d-to-a converter A produces a unipolar output range from 0 to 5 V, with a resolution of 4096 steps.

Output of IC_{9b} drives the CSB\ input of IC_7 and also sets the logic level on the output-enable line of IC_5, OE, to latch the data from memory into DAC B, which drives the Y axis of the oscilloscope or plotter. Use of dual supplies allows DAC B to be set for a bipolar output range to reconstruct both positive and negative transients.

Counter 2 starts its count from the point at which it stopped at the end of the record mode; the first memory output word to IC_7 is the oldest sample in memory. Scanning then proceeds through the 2048 samples of pre-transient information and the 2048 samples of transient information. Output of each sample from memory to the Y axis, via DAC B, corresponds to the output of a count value from counter 1 to the X axis via DAC A. In this way, the circuit reconstructs the pre-transient and transient waveforms.

For oscilloscope display of waveforms, place S_2 in the 'oscilloscope' position. Doing so locks out CLK IN_2 from the rest of the circuit but allows CLK IN_1 to operate as clock signal for the circuit. Unlike the operation of plotter display, where counter 1 runs through once and then stops, CLK runs continuously. CNT FIN does go high when counter 1 reaches a count of 4095 but, because the output of IC_{14c} is high, the DIS PLOT CLK signal does not go low. **Figure 2(a)** shows a typical oscilloscope waveform display.

Switching S_2 to 'plotter' locks out the CLK IN_1 input from the rest of the circuit and permits CLK IN_2 to generate the clock signal for the circuit. IC_{16b}, IC_{10}, IC_{11} and IC_{12a} generate a high CNT FIN signal function, as in record mode, but this time IC_{10} and IC_{11} go low when counter 1 reaches a count of 4095. IC_{13a} goes low and, because the output of

IC_{14c} is already low, the DIS PLOT CLK signal goes low, turning off CLK IN_2 at IC_{18c} and holding the CLK signal high. Figure 2(b) shows a captured transient displayed using a plotter as the display method.

Record-mode timing and clock waveforms

Figure 3 shows the logic relationships for the record mode, when MODE (not shown) is low and the DIS REC CLK signal is high. Signal RS_2 goes high when the recorder receives a reset command via S_3, resetting counter 2. The next falling edge of the CLK signal clocks out an address for IC_5 from counter 2 and initiates a conversion. Within 700ns, the INT\ signal of IC_6 goes low, activating the WE\ input of IC_5. The rising edge of CLK resets the INT\ line 50ns later.

When the circuit detects a transient, TRANS REC goes high, causing the RS_1 line to go low and releasing counter 1 from its reset state, the next falling edge of CLK clocking out the contents of counter 1. When the output from counter 1 reaches 2047, CNT FIN goes high and causes the DIS REC CLK signal to go low, shutting off the CLK signal.

Since, in record mode, the a-to-d converter needs a CLK-low time of 750ns to convert and latch the data into IC_5, the 50:50 mark/space ratio of the clock signal limits clock frequency to 660kHz. However, the CLK-high time can be as short as 350ns, the time required between conversions by the *AD7821*. Therefore, if the input to CLK IN_1 has a low time of 750ns and a high time of 350ns, the circuit can make one conversion every 1100ns – equivalent to approximately 900ksample/s.

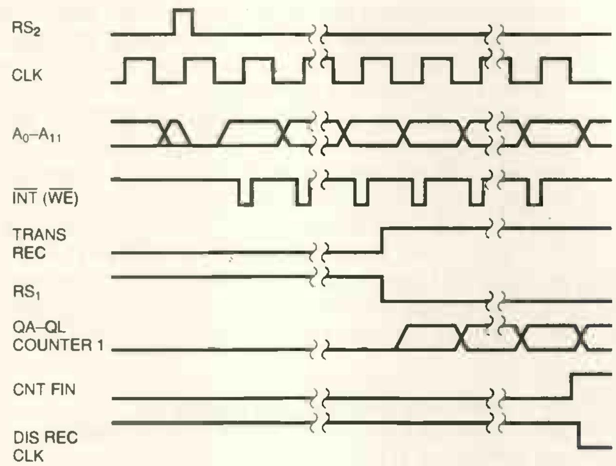


Fig. 3. Record-mode timing waveforms, the process beginning at the first falling edge after RS_2 goes high.

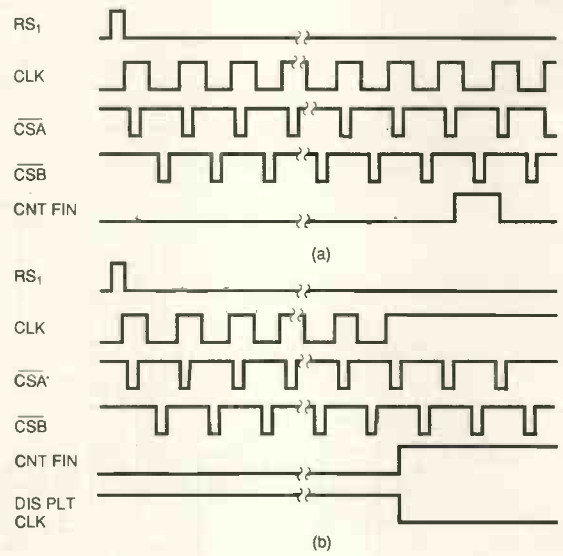


Fig. 4. Waveforms in play-back configuration, which runs once in plotter mode (b) and continuously for oscilloscope play-back (a).

Record-mode timings

Figure 4 shows waveform timing during playback to an oscilloscope. MODE, the WE\ input of IC_5, and the DIS REC CLK signal are high and, with S_1 in the playback mode, RS_1 goes high, resetting counter 1. CLK generates a CSA\ signal for IC_7 on its rising edge and a CSB\ signal on its falling edge. Data from counter 1 is clocked out on the falling edge of the CLK signal and the rising edge of CSA\ updates the X axis; the falling edge of OE\ outputs stored data from memory and the rising edge of CSB\ updates the Y axis. CLK runs continuously when the circuit is in oscilloscope play-back mode.

Figure 4(b) shows circuit operation for play-back on a plotter. Once again, MODE, the WE\ input of IC_5, and the DIS REC CLK signals are high. The circuit generates CSA\ and CSB\ to update the X and Y axes. Compared with oscilloscope play-back, the difference in the circuit's operation is that when the output count from counter 1 reaches 4095 and the CNT FIN signal goes high, the DIS PLOT CLK signal goes low, forcing the CLK signal into a high state.

Sampling in burst-mode

Burst-mode event sampling places requirements on an a-to-d converter similar to those for transient recording. In burst-mode sampling, the recorder looks at the input waveform infrequently, but when it does, it must acquire a large number of samples in a short time. With slower microprocessors or microcontrollers, timing constraints impose a much lower throughput than the a-to-d converter can deliver.

Timing limitations in a burst-mode sampler are reduced by using a direct-memory-access, dma, controller to initiate a-to-d conversions and transfer conversion data to memory, allowing the a-to-d converter to run at or near its maximum sample rate and permitting high oversampling ratios and the acquisition of short transients.

Building a burst-mode sampler is relatively easy with the popular *8052* microcontroller, shown in the circuit diagram of **Fig. 5**. Although the *8052* does not support hardware dma, it does support what is termed 'fake dma'. However, the response time to dma requests is much slower than is possible with microcontrollers that support genuine dma.

Memory chip IC_3, an *HM6264P*, stores the control program for IC_1, of which the first part is the initialisation routine. This routine, **Listing 1**, sets up the sense of the DACKO line of the *8237* dma controller, IC_2, to be active high and loads the starting data address into it for the first conversion results. Microcontroller IC_1 initialises the counting register to control the number of conversions before IC_2 returns control to IC_1. The program must also set up IC_1 for 'fake dma'.

After running the initialisation program, IC_2 is ready to take control when requested to do so. Although IC_2 has four

Listing 1. Initialisation routine for the burst-mode sampler.

```
10   XBY(8008R) = 80H        :SETS DACK SENSE ACTIVE HIGH
20   XBY(800FH) = 0EH        :CLEARS DREQ0 MASK REGISTER
30   XBY(800BH) = 94H        :SETS MODE REGISTER
40   XBY(800CH) = 00H        :CLEARS FIRST/LAST FLIP-FLOP
                             :(ONLY NEEDED IF 8237 IS
                             :NOT RESET BETWEEN DMA REQUESTS)
50   XBY(8000H) = 00H        :LOADS LOWER BYTE OF STARTING DATA
                             :ADDRESS TO BASE AND CURRENT ADDRESS
60   XBY(8000H) = 08H        :LOADS HIGHER BYTE OF STARTING DATA
                             :ADDRESS TO BASE AND CURENT ADDRESS
70   X8Y(8001H) = 00H        :LOADS LOWER BYTE OF COUNTING NUMBER
                             :TO COUNT REGISTER
80   XBY(8001H) = 02H        :LOADS HIGHER BYTE OF COUNTING NUMBER
                             :TO COUNT REGISTER
90   DBY(38) = DBY(38).OR.02H
100  IE = IE.OR.81H
110  GOTO 10
```

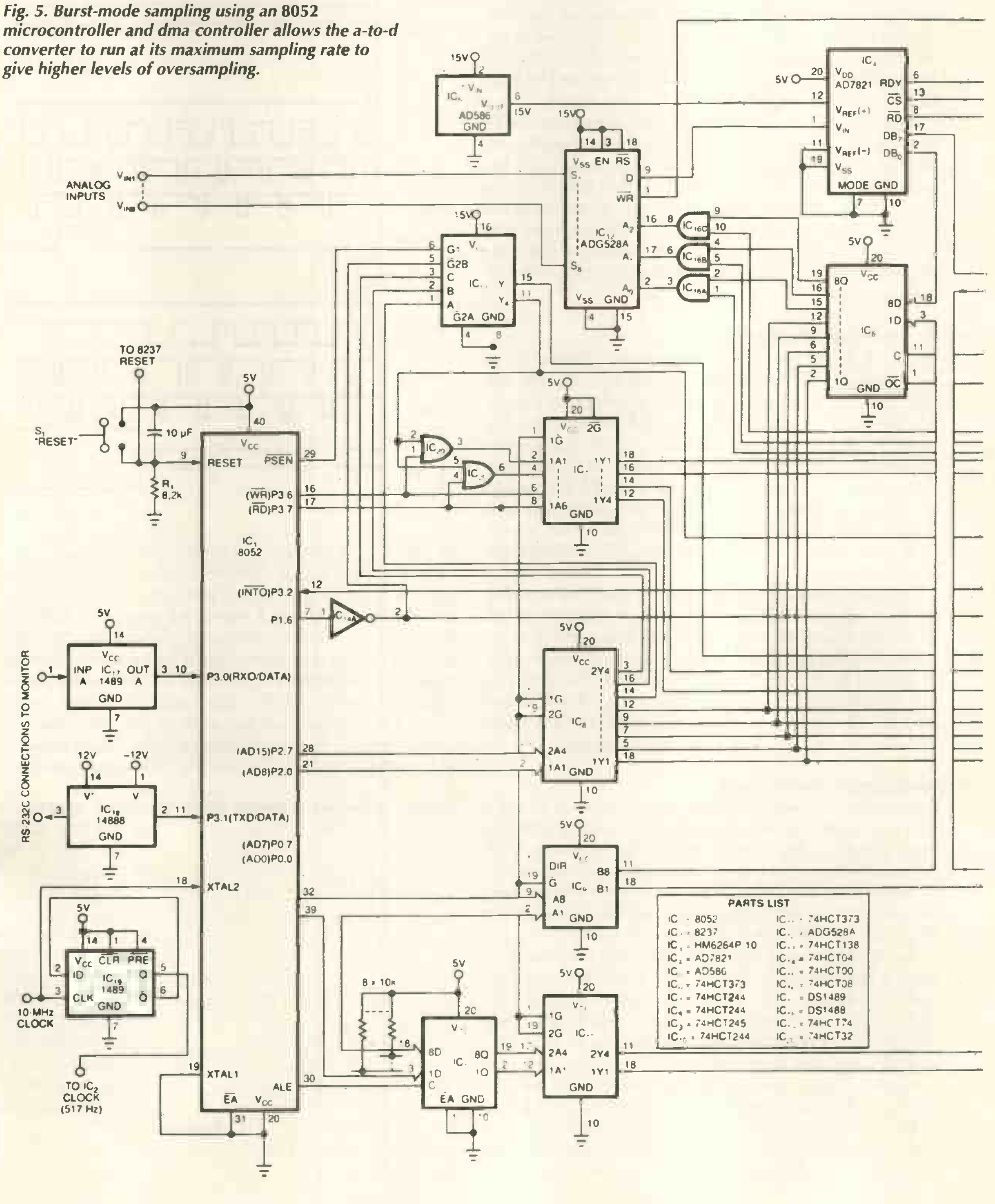
interrupt-request lines, this circuit uses only one, DREQ0. An external command signal drives this interrupt line high, telling IC_2 to take control of the circuit and start the a-to-d converter sampling the input waveform.

When IC_2 receives the DREQ0 request, its HRQ line goes high and IC_{14c} output, which drives the INT0\ line of IC_1 low, which takes the INT0\ line of IC_1 low, its P1.6 line low and the output of IC_{14a} high, selecting inputs of IC_7, IC_8, IC_9 and IC_{10}. When the output of IC_{14a} goes high, it shuts off IC_1's address and data lines from the rest of the circuit and deselects the output's address decoder, IC_{13}. The inverted P1.6 line also feeds the HLDA input of IC_2, acknowledging IC_2's request for control, IC_2 then taking control of the address and data bus and sampling of the input waveform.

To reduce pin count, IC_2 multiplexes the eight higher-order address bits on the data lines, an external device being needed to latch these address bits. Address strobe signal, ADSTB, takes AEN high to switch the OC\ line of IC_6 low; ADSTB drives the C input of IC_6 to latch the higher address lines to the outputs of IC_6. The inverted AEN line also drives one input of IC_{16d}, the other input of this gate being fed by the decoded output of IC_{13}, Y0. Therefore, because both IC_2 and IC_1 must be able to access IC_3, either a high on AEN or a low on the decoder output selects it.

Acknowledge line DACK0 goes high at about the same time that ADSTB latches the address and drives one input of

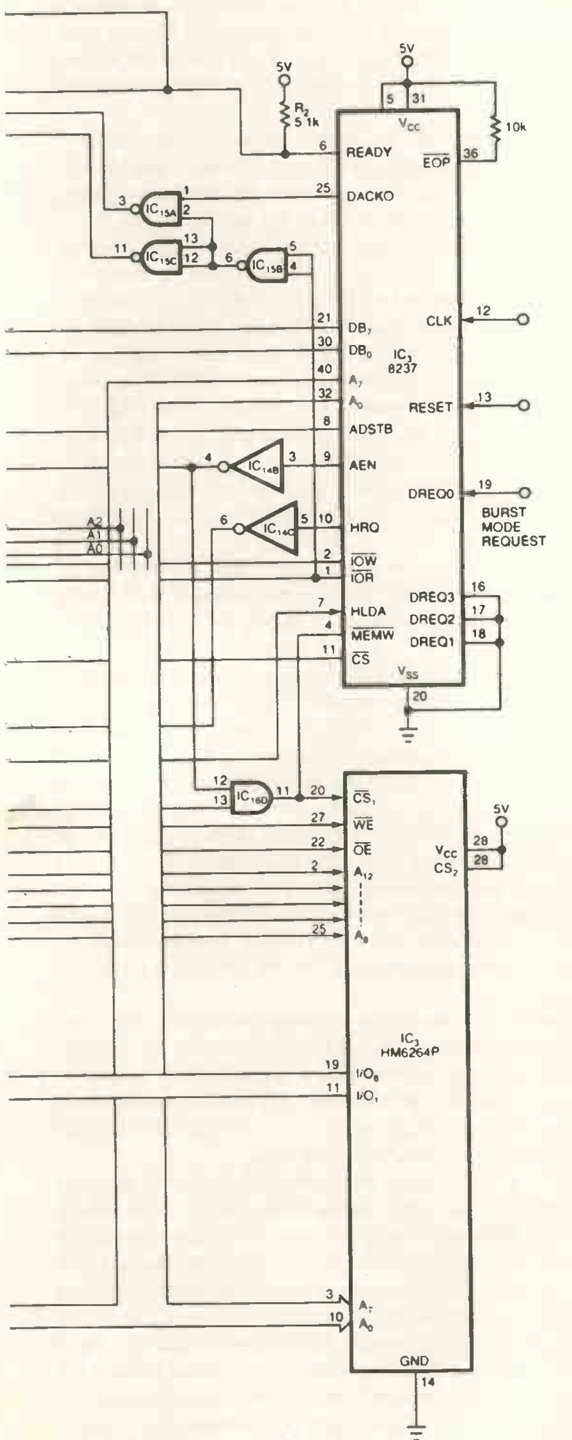
Fig. 5. Burst-mode sampling using an 8052 microcontroller and dma controller allows the a-to-d converter to run at its maximum sampling rate to give higher levels of oversampling.



IC_{15a}, this and IC_{15b} ensuring that the CS\ line of IC_4 goes low only when an input/output read operation of IC_2 occurs. IC_{15c} provides the correct polarity for the RD\ input and equalises the delay paths for the CS\ and RD\ lines, ensuring that the circuit obeys the CS\-to-RD\ setup time.

Once IC_4 receives a CS\ signal, it acknowledges receipt of the signal by bringing its RDY line low, placing the controller, IC_2, into a wait state for as long as its RDY input is low. When the device completes a conversion, the RDY line goes high, releasing IC_2 from its wait state; pull-up resistor R_2 takes account of IC_4's open-drain RDY output.

When the circuit releases IC_2 from its wait state, data from IC_4 is valid and the address lines of IC_2 determine where data



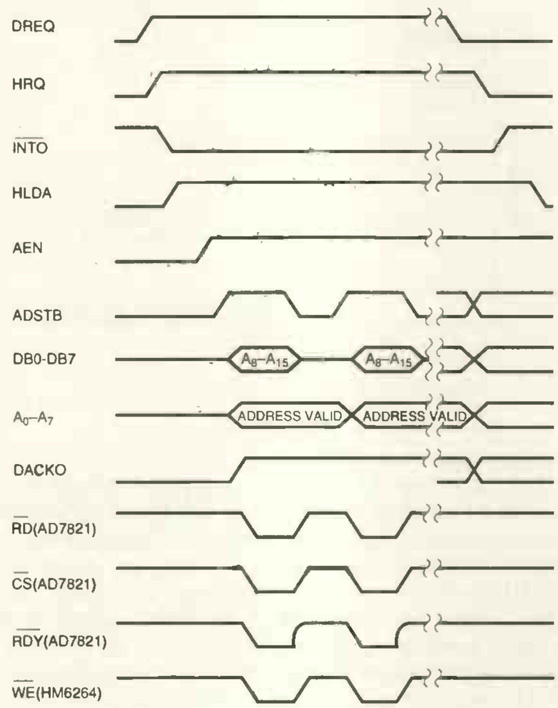


Fig. 6. 'Fake dma', used because the 8052 does not support true dma, allows rapid data transfer to memory.

loads into memory. Controller IC_2 performs all of these operations automatically because a memory write accompanies each input/output read. Depending on the value loaded into the counting register, IC_2 will continue to issue read commands to IC_4 until the circuit completes the required number of conversions, automatically incrementing the memory address after every write operation.

Multiplexer IC_{12} accommodates eight input channels, selected by the three highest and three lowest address lines of IC_2, gated through IC_{16a}, IC_{16b} and IC_{16c}. If the three upper lines are all at 1, IC_4 will convert each channel in sequence and the conversion results will be stored in consecutive memory locations. For example, if the first conversion takes place on the channel 1 input voltage, V_{in1} and the result is stored in location M of IC_3, the next conversion will take place on V_{in2} and the result will be stored in location M+1. If the three uppermost address bits are set to 011_{16}, the circuit will sequence through channels 1 to 4 only.

Ready or not

The RDY line of IC_4 drives the WR\ input of IC_{12}, loading the address for the next channel to be converted into the multiplexer. If there is only one input channel to convert, remove IC_{16a}, IC_{16b} and IC_{16c} and drive the A_{0-2} inputs of IC_{12} directly from the three uppermost address lines. With this arrangement, the program chooses the input channel.

Microcontroller IC_1 selects the device it talks to using a 1-of-8 address decoder, IC_{13}, the outputs of which provide signals for IC_{12}'s write line and chip-select inputs of IC_3 and IC_2. One of the outputs also gates read line P3.7 and the P3.6 outputs from the controller to drive the IOW\ and IOR\ inputs of IC_2.

Three upper address lines of IC_1 select the required device, the lower address lines being multiplexed with the data lines in a similar manner to those of IC_2. Decoder IC_{10} demultiplexes the lower eight address lines, the microcontroller's ALE signal latching them in IC_{11}; tri-state buffers, IC_2, IC_8 and IC_{10} isolate the microcontroller outputs from the address bus when IC_2 takes control, since it cannot place its address and data buses into a high-impedance state when IC_2 takes control of the circuit. IC_9 also acts as a buffer, but is bidirectional because the microcontroller must read data from

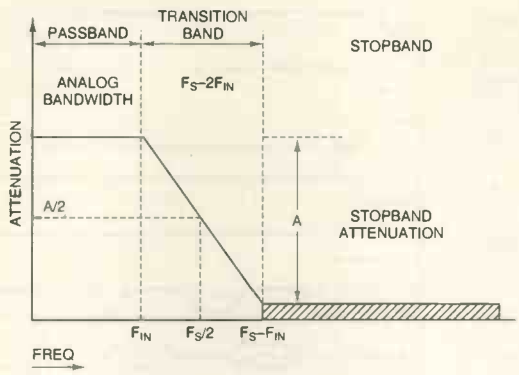


Fig. 7. Requirements of an antialiasing filter depend on the degree of oversampling. Since 10 times oversampling allows three octaves for roll-off, and since an 8-bit a-to-d converter needs 48dB of attenuation, a three-pole filter giving 18dB/octave will suffice.

and write data to memory.

The microcontroller uses a 10MHz input-clock frequency, a *74HCT74* counter (IC_{19}) dividing this frequency to form the clock input to IC_2. As the standard *8237* operates from a 3MHz maximum clock frequency, you can divide the 10MHz clock by four to give an acquisition rate of 608ksample/s. A faster version of the *8237*, the *8237-5*, operates from a 5MHz input clock, allowing you to divide the clock frequency by two and enabling the circuit to take 812ksample/s. If IC_1 were used on its own to control the sampling of the input waveform, the best acquisition rate would be approximately 100ksample/s.

The entire circuit operates from 15V and 5V supplies. If there is no 5V supply in your system, add a regulator to generate 5V. In addition, use a precision 5V reference (IC_5) for the a-to-d converter, allowing an input range of 0-5V. To obtain accurate conversion results, obey the usual guide lines regarding decoupling and grounding in both the circuits described.

Slow and medium speed microprocessors that support direct memory access requests can be used in this circuit to provide a much faster dma response than that of the *8052*'s 'fake dma'. Because microprocessors that support genuine dma will tri-state their address and data lines during a dma transfer, you can eliminate the tri-state driver chips.

Oversampling and antialiasing

In the spectrum of a periodically sampled waveform, the spectrum of the (unsampled) input signal repeats around harmonics of the sampling frequency. Any frequency contained in the input signal is repeated above and below each harmonic of the sampling frequency. Therefore, in the spectrum of the sampled signal, the band between 0 and f_{in} (the input spectrum) appears, among other places, between f_s–f_{in} and f_s, where f_s is the sampling frequency.

Although you may be under the impression that the input-signal bandwidth is 100kHz, if the sampling frequency is 1Msample/s, a signal at 991kHz in the input spectrum would appear as a 9kHz alias component in the spectrum of the sampled signal.

An antialiasing filter removes or at least attenuates any noise or spurious signals that could be aliased back into the bandwidth of interest. **Figure 7** shows the frequency response of such a filter for a generalised a-to-d converter. Determine the filter roll-off by drawing a straight line between the highest signal frequency of interest, f_{in}, and the stop-band attenuation frequency, f_s–f_{in}. As the ratio of f_s to f_{in} increases (that is, as the oversampling ratio increases) the slope of the line decreases.

In an eight-bit system. an ideal a-to-d converter's signal-to-noise ratio (s:n) is slightly greater than 256:1 or 48dB. To prevent noise limiting the system performance, the ratio of the input signal-to-noise ratio should exceed the approximate 48dB limit imposed by the converter. Here, the signal is the peak-to-peak value of the signal within the band of interest, and the noise is the square root of the sum of the squares of the amplitudes of all the frequency components outside that band.

Attenuation required for signals outside the band of interest depends on the application and the expected magnitude of the out-of-band signals. In most cases, the magnitude of these signals is much lower than that of the desired signal.

Usually, eight-bit systems require 50dB of attenuation for signals that can be aliased into the band of interest. Even if 50dB is not the desired number, the following calculations show the kind of reduction in antialiasing filter requirements brought about by oversampling. With 2× oversampling, i.e. with $f=2f_{in}$, f_s and f_{in} are at the same point and the filter has to have infinite roll-off to attenuate signals at f_s–f_{in}. With $f_s=3f_{in}$, (3× oversampling), the filter's attenuation must drop from 0dB at f_{in} to 50dB at $2f_{in}$. In other words, the slope of the attenuation *vs* frequency curve must be 50dB/octave; the filter (if it has a Butterworth characteristic) must have more than eight poles.

With 10× oversampling, there are three octaves for the attenuation to drop from 0 to 50dB; the required slope is a little more than 16dB/octave and a three-pole Butterworth filter will do the job.

This analysis of the antialiasing filter holds true regardless of the type of a-to-d converter that follows the filter. No matter what the conversion technique, oversampling reduces the antialiasing filter requirements. Oversampling also reduces the converter noise within the signal bandwidth because it spreads the quantisation noise over a wider bandwidth. Oversampling has recently gained considerable popularity in connection with sigma-delta a-to-d converters. In the case of these converters, the advantages of oversampling are much greater than with successive-approximation or flash converters because noise shaping produces dramatic improvements in noise performance as the oversampling ratio increases.

However, the relationship between antialiasing-filter performance and oversampling is exactly the same for an oversampled sigma-delta modulator as for half-flash or successive-approximation alternatives; sigma-delta and half-flash a-to-d converters with the same oversampling ratio place the same demands on the antialiasing filter.

Pipelining or averaging inherent in sigma-delta converters is a disadvantage of the sigma-delta process for transient recording. Because of the pipelining, a step change requires a significant time (the settling time of the converter's digital filter) to ripple through to the output. Therefore, there is a delay before a sigma-delta converter produces an output that represents an input change. Between the time the input changes and the sigma-delta converter's output reflects the change, the a-to-d converter's output does not accurately represent the converter's input. Such performance is not appropriate for transient recorders of the type discussed here. ■

LOW POWER single-chip fm receiver

With fm receivers designed for battery-powered equipment, disconnecting the audio amplifier from the supply when it is not in use saves power and eliminates unnecessary audio hiss. Ed Baker describes an fm receiver ic designed to disconnect its own audio power stage.

This article describes how to apply the *ULN3883A*, a low-power, narrowband fm receiver ic providing the second converter, second IF demodulator and audio amplifier circuitry for communications and scanning receivers.

The device offers a number of advantages over other types of narrowband frequency-modulated receiver circuits, particularly for cordless telephones and other battery-operated receivers. Most such units operate in a mode in which the receiver is muted by removal of the audio input to the amplifier driving the loudspeaker, while still leaving this amplifier drawing a considerable current. This current can often be many times greater than that drawn by the rest of the receiver.

A more sensible way to mute the receiver is to disconnect the audio amplifier from its power supply so that it draws little or no current. This not only improves battery life (or intervals between charging), but also removes what can be a very annoying hiss from the loudspeaker.

This is exactly what is achieved in the *ULN3883A*. During normal operation, with no input present, the ic draws up to 15mA. Once the mute is operated, this drops to typically 3mA, drawn by the rest of the circuit: i.e. the mixer, IF amplifier, detector and filter amplifier. This current reduction extends battery life considerably, depending on the operate-standby ratio of the equipment. In an extreme case, where a receiver spends 95% of its life in standby mode, battery life would be increased by a factor of ten.

Functional description

The device, which contains a number of distinct on-chip functions, **Fig. 1**, was originally designed for use as the second IF stage of a dual-conversion superheterodyne receiver with a first IF of 10.7MHz and a second IF of 455kHz. The high performance of the input circuitry, which exceeded its designer's expectations, also allows it to be used as a single conversion receiver for frequencies up to the low end of the vhf band. A typical application of the device in this role is the cordless telephone receiver shown in **Fig. 2.** Functions included in the *ULN3883A* are as follows:

Double balanced mixer. The active mixer, because of its nature, has an extremely high rejection of both input and oscillator frequency feedthrough, as well as reduced local-oscillator re-radiation. The circuit also exhibits a very wide dynamic range; in excess of 80dB.

Since the input circuitry is internally biased,

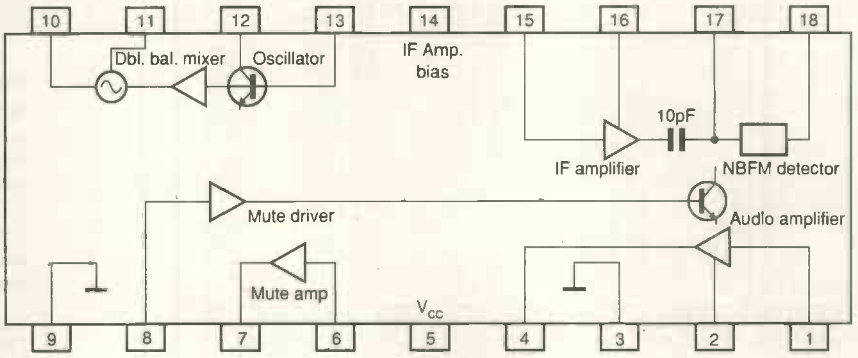


Fig. 1. Schematic of the ULN3883A fm receiver ic shows the three subsections – converter, If demodulator and audio amplifier.

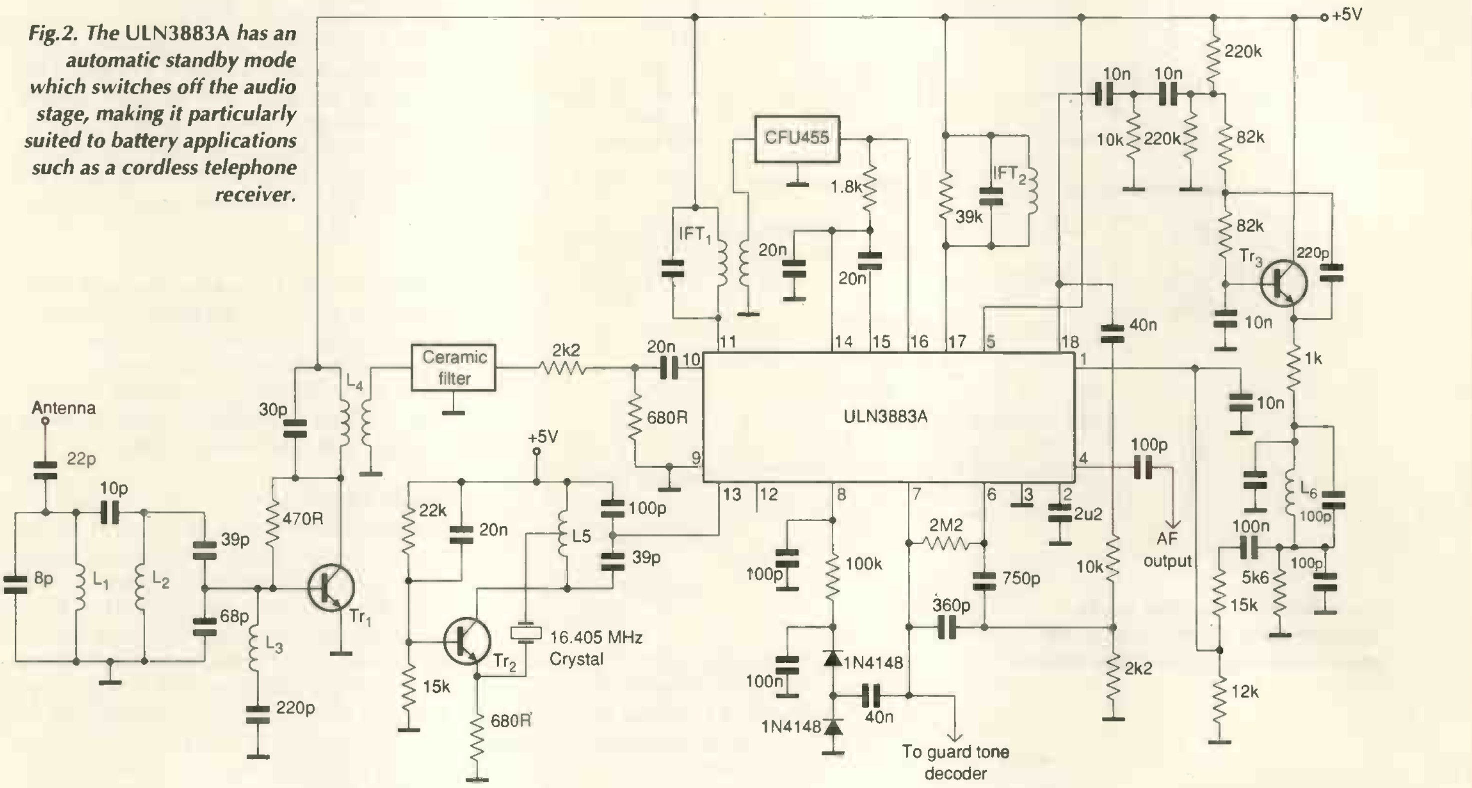


Fig.2. The ULN3883A has an automatic standby mode which switches off the audio stage, making it particularly suited to battery applications such as a cordless telephone receiver.

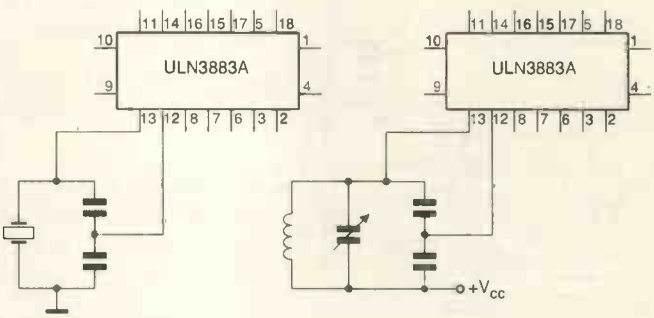


Fig.3. Two possible oscillator configurations: (a) crystal for fixed frequency operation; (b) tuneable LC circuit. An external oscillator can also be used, see text.

an input coupling capacitor is required for the purposes of dc blocking. However, its small-signal impedance equates to a 3kΩ resistor in parallel with a 20pF capacitor. The input ground is separate from the rest of the ic circuitry, and is connected to pin 9. It should be connected via the shortest possible path to the input-circuit grounding. The small-signal output impedance is approximated by a 100kΩ resistor in parallel with a 3pF capacitor, and it has an output drive capability of about 400μA. For correct operation, a dc path to the positive supply rail is required. Converse transconductance is typically 600μmho; however, if required, the mixer can be disabled and used as an amplifier by connecting pins 12 and 13 together. Under these circumstances, the transconductance is typically 1.4mmho.

Oscillator. This circuit is configured as a standard Clapp oscillator, and the base pin 13 and emitter, pin 12, are brought out of the ic for connection to the external circuitry. This can be either a crystal, shown in **Fig. 3a** or an *LC* circuit for instances where a tuneable circuit is required (Fig. **3b**).

Since the transistor is a pnp type, the bottom end of the coil must go to the positive rail, unless a capacitor is connected between pin 13 and the tuned circuit. If required, the oscillator can be disabled by leaving pin 12 open circuit and injecting an external oscillator signal into pin 13.

In the circuit shown in Fig. 2, a crystal oscillator operating in a third-overtone mode is used. The base input circuitry exhibits a stray capacitance of about 7pF, and has to be taken into account when designing the external oscillator circuitry.

IF amplifier. Pin 15, which is the input stage, is internally biased by a 2kΩ resistor connected to pin 14. However, an external resistor is normally used to give good impedance matching with the rest of the circuitry. In the example shown in Fig. 2, a 1.8kΩ resistor is used to accommodate the *CFU455* filter requirements. Although there is internal biasing, an external resistor of between 0 and 10kΩ has to be used for correct balance of the IF amplifier.

The amplifier has a response of –3dB at about 1.5MHz, and rolls off at 6dB per octave above this. The 3dB limiting sensitivity is 13μV at 455kHz.

Noise-blanking fm detector The square-wave output of 570mV from the IF amplifier

Table 1. Performance of receiver Fig. 2.

maximum sensitivity	1μV for a signal to noise ratio of 12-20dB
quieting sensitivity	3.6μV at 3dB
limiting sensitivity	<1μV
apparent peak separation at 1mV input	12kHz
overload capacity	3000mV
am rejection (m=30%)	
at 100μV input	41dB
at 1mV input	38dB
distortion at 2.5kHz deviation	4%
adjacent channel rejection at ±30kHz	76dB

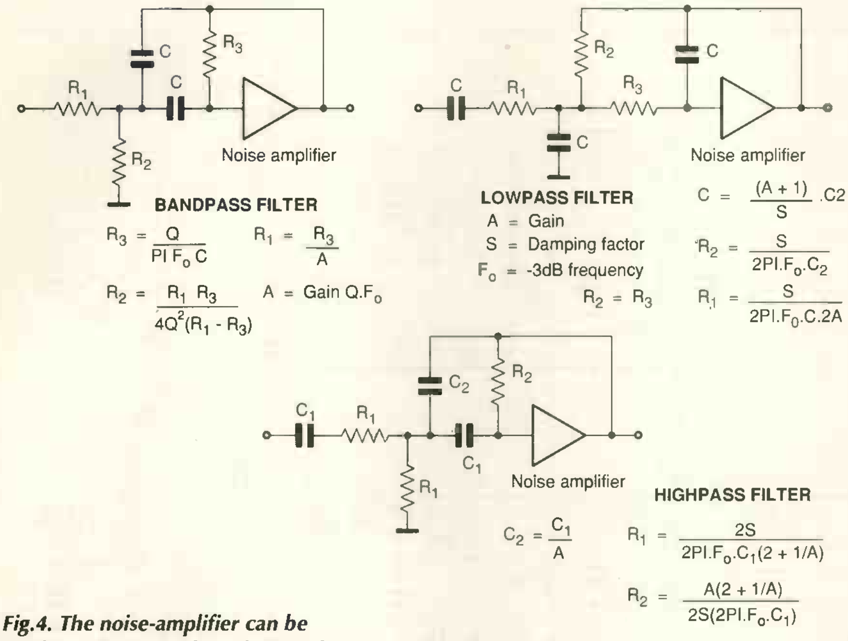


Fig.4. The noise-amplifier can be configured in a number of ways, the most common being the highpass filter.

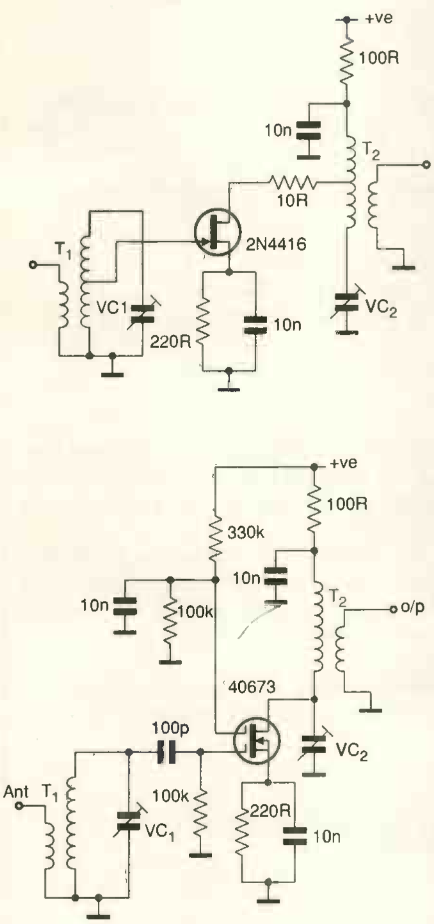


Fig.5,6. Improvements on noise factor and sensitivity of the receiver can be achieved using a jfet or a double gated mosfet in the rf input stage.

is fed into the detector output via an on-chip 10pF capacitor. This is brought out to pin 17, and connected to an external tuned circuit which is tuned to the IF frequency. The signal level on this pin should have a minimum level of 100mV rms for correct detector operation. The component connected to this pin is determined as follows:

$$V_{17} = V_1 Q_1[10\text{pF}/(10\text{pF}+C)]$$
$$R_1 = Q_0 C[Q_1/9Q_0-Q_1)]$$

where
V_1=140mV rms
C=detector tuning capacitance
Q_1=loaded Q of detector coil
Q_0=unloaded Q of detector coil
R_1=damping resistor across tuned circuit.

The output circuit of the detector is an emitter of 400Ω output impedance. Since some of the IF signal is still present, care needs to be taken with the circuit layout so that the circuitry connected to pin 18 does not associate with the components connected to pin 16.

Audio amplifier. The stage gain of the power amplifier is typically 35dB, and is designed to drive either a 4Ω or an 8Ω loudspeaker. With a supply voltage of 5V, it is capable of an output of 260mW at a third-harmonic distortion of 10%.

The output-circuit coupling capacitor should be selected to give the desired IF response and to reduce power consumption caused by unwanted IF drive to the loudspeaker. To ensure optimum stability, the ground side of the speaker return should be connected as close as possible to pin 3: the amplifier (and main) ground connection.

Noise amplifier. This is an inverting amplifier with an open-loop gain of 53dB at 4kHz, and requires a feedback resistor between the input and output (pins 6 and 7) to reduce the gain to a more practical level.

The amplifier can be configured as a lowpass filter, a bandpass filter or a highpass filter, the last being the most commonly used in applications of this type (**Fig. 4**). All capacitors used should be of a high-Q variety such as polystyrene or polycarbonate; if ceramics are used, the filter will not perform to the required specifications.

Muting switch. The input circuit is a 22kΩ resistor in series with the base of a transistor whose emitter is connected to ground. As expected, the threshold is the same as the forward bias point of a transistor (around 600mV). Since all muting functions are on the chip, this stage has no output pin.

Applications

The application shown in Fig. 2 is by no means definitive. Improvements in this design can be made by changing the rf input stage to a jfet (**Fig. 5**), a dual-gate mosfet (**Fig. 6**) or even a gaAsfet. Since receiver sensitivity is determined by the selection of this stage, a device must be chosen to give a noise factor and gain which presents sufficient input to give full limiting (8μV) and enough sensitivity for a reasonable signal to noise ratio with the signal being received. The market abounds with suitable alternatives to those given (e.g. *U310*, *BF800*, *BF981*, *3SK51*, *3N200*, *3N140* etc.). Depending on which is chosen, the component values will have to be modified to suit the transistor selected.

The ceramic filter connected to L_4 determines the degree of rejection of image signals and so should have a good out-of-band rejection characteristic, while the filter connected to IFT_1 determines the overall receiver bandwidth and adjacent channel rejection. The first filter could be replaced by a saw filter, and the second by a crystal filter, if improved performance is required.

The circuit shown in Fig. 2 has an audio filter which tailors the audio for speech reception in series with the af amplifier. If this is not required for reasons of cost or fidelity, it can be omitted, and a simpler circuit using a 50kΩ volume control can be used.

As shown in Fig. 2, the *ULN3883A* is used with (a) a crystal oscillator using the onboard circuitry; (b) a tuned *LC* oscillator, again using the onboard circuitry; or (c) either of the above using an external oscillator or a synthesiser. If option (c) is required, a signal with an amplitude of 500mV is required at pin 13 of the *ULN3883A*.

The device is, of course, not limited to acting as a single superheterodyne receiver. As indicated, it can also act as the second mixer/oscillator and IF amplifier in either a fixed capacity or as a tuneable If with a broadband front-end circuit. This practice is very common in vhf and uhf receivers where it is difficult and expensive to manufacture stable oscillators or synthesisers. ■

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Smash – simulation via Windows

Smash – the subject of this month's free disk offer – is a multi-level, mixed-mode simulator running under Windows and featuring true behavioural modelling.

The simple example, starting on the right, demonstrates the possible analyses in *Smash*. As it may be the first example you will try, it is kept simple, being purely analogue and using only primitives. However, it demonstrates features like parameter sweeping and Monte Carlo analysis. It is a simple *RC* network, the demonstration files for which are on the evaluation disk. The disk is a fully-working version of *Smash*, limited only to 25 analogue and 50 digital nodes.

Notes on behavioural modelling

Behavioural modelling is a term you have probably heard a number of times. The fact is that most often, people talk about behavioural modelling as soon as the model is not a low-level primitive – a transistor or gate.

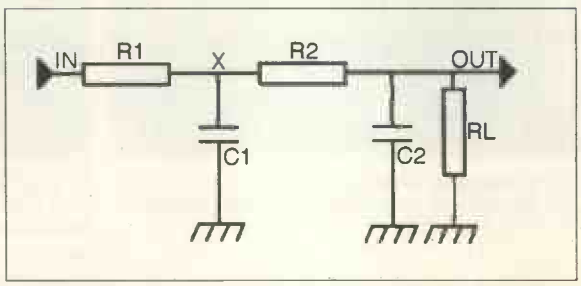
This is particularly true where analogue simulation is concerned. Some people even consider, or want you to believe, that a G device (i.e. Spice-device) is a behavioural model. But genuine behavioural modelling goes far beyond this.

The designation behavioural has long been reserved for a design method that describes parts of your systemvia a high-level programming language. Behavioural means that you describe the way a component works, without presuming the way it is actually implemented. The purpose of the method can be to make an architectural study of a system at early stages of the design, before implementation has been fully decided. Or you can use it simply to increase the speed of a simulation – a few lines of code can easily replace thousands of transistors or gates.

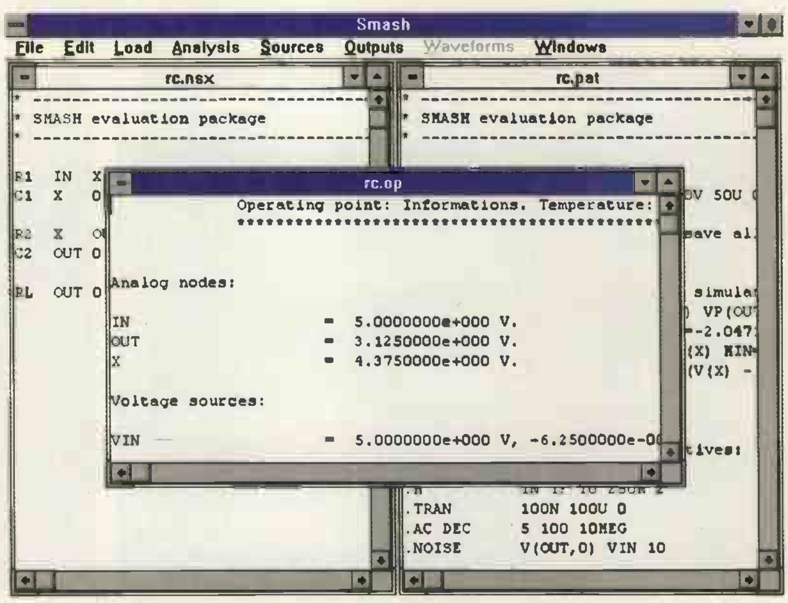
There is nothing wrong with using a different term (behavioural) for differentiating things which do not readily map to anything physical, like a G-device, a Laplace-defined block, or a non-linear equation. But you should be aware that behavioural modelling may have more than one meaning.

In *Smash*, you can use Laplace-defined blocks and non-linear conditional equations. But the true power of the software comes from its capacity to mix genuine behavioural models – both analogue and digital – with primitives. As the *Smash* HDL is based on the popular C language, you can use variables, complex control structures – loops, etc – and all the features available in a high-level programming language.

Since these models are compiled, not interpreted, they are highly efficient and you can simulate complete systems, ics and/or pcbs, that you would not be able to simulate with any other tool.



A: This is a simple RC circuit used to demonstrate some of Smash's features.



B: These three windows are the netlist, pattern and operating point files for the simple RC circuit. These files are contained on the evaluation disk in the 'eval' folder (example continued over)...

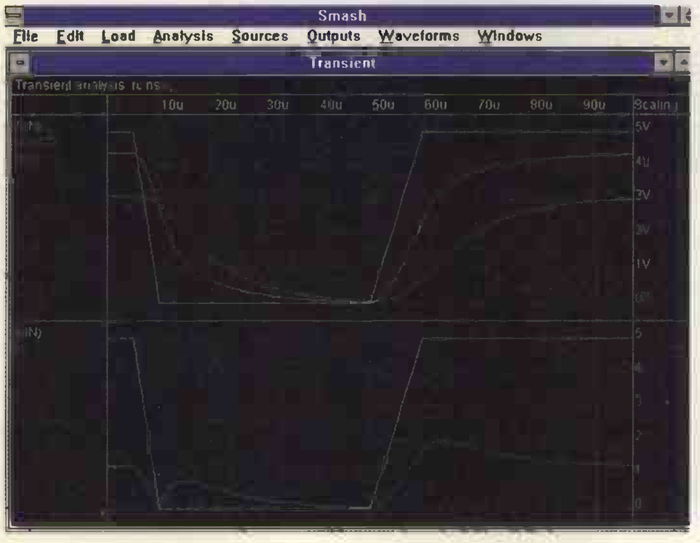
Free CAD software offer

The full version of the Smash multi-level, mixed-mode simulator costs £1500. The first 1000 EW+WW readers sending in the coupon opposite this page can obtain a size-limited but otherwise fully functional evaluation version of Smash free of charge.

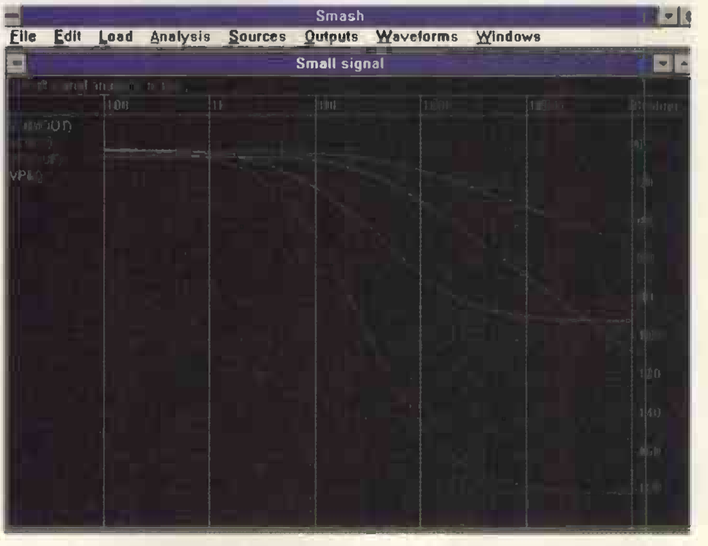
Smash and schematic entry

There is no proprietary schematic entry in *Smash*. Instead it interfaces at the netlist level with commercial schematic entry packages. Basically any schematic entry program with a Spice netlist output can be used with *Smash*.

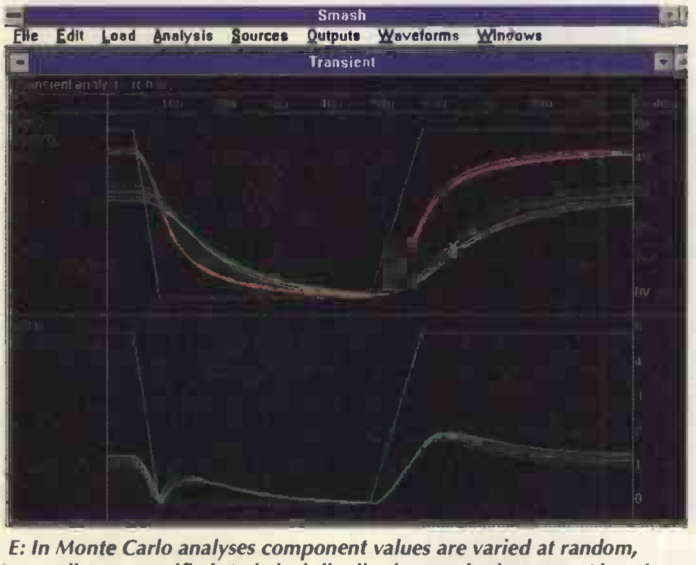
Some packages are tightly integrated with *Smash*, with libraries available etc. Among these are *DesignWorks* from Capilano Computing, *ECS/Synario* from Data I/0, and *Opus 4.2.2* from Cadence. The *DesignWorks* and *ECS/Synario* libraries for *Smash* are contained on the evaluation floppy. ■



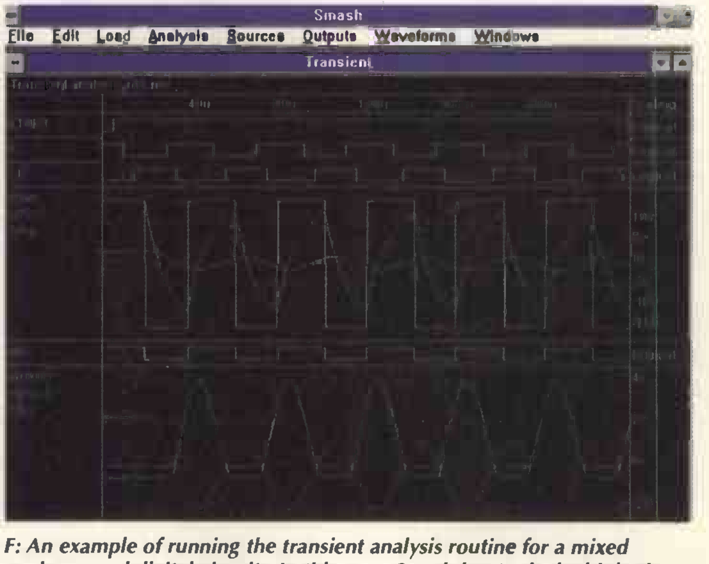
C: Analysing the circuit for transients is simply a matter of selecting the transient parameters under the Analysis menu and running the routine.



D: Small-signal analysis is equally simple. Note that running this analysis does not result in the previous transient analysis window being lost. Waveform processing – zooming, measuring etc – is available, even when a simulation is running, through the commands under the Waveforms menu. You may add new signals in the window with the Add analogue signals item. A dialog box displays a list of available signals. Simply double-click the name of the signals you want to view.



E: In Monte Carlo analyses component values are varied at random, according to specified statistical distributions and tolerances. Also, the analyses are re-run a number of times. In this way, you can simulate how off-the-shelf component tolerances affect the circuit's response.



F: An example of running the transient analysis routine for a mixed analogue and digital circuit. In this case, Smash has to deal with both analogue voltages and logic levels. Whenever a node connects to both analogue and digital components, it becomes an interface node.

Oscillating AT uhf

Two basic circuit configurations are responsible for most oscillator designs working at frequencies up to the uhf range. Ian Hickman describes the often conflicting requirements of uhf oscillators – including a disadvantage of the emitter-follower now put to good use.

Oscillators for frequencies to uhf and beyond have been built using all sorts of active devices, from valves onwards. Most of them use three terminal active devices, often connected to a simple tuned circuit in one of two basic ways, which were enumerated for my benefit as a student by an older colleague of many years experience with the aid of a sketch which I call *O'Connor's Universal Oscillator Circuit*, **Fig. 1**. It is drawn in an unconventional way to emphasise the following points.

For the circuit to function as an oscillator, Z_2 and Z_3 must be reactances of the same sign – both inductances or both capacitances – while Z_1 must be of the opposite sign. With this proviso, the diagram shows that, relative to the cathode (emitter, source), the voltages at the other two electrodes are in antiphase.

No earth connection is shown, since in principle the circuit could be provided with the necessary power supplies via ideal rf chokes of infinite reactance at the operating frequency, and *a*, *g* or *k* earthed as convenient, or the whole circuit left floating.

If Z_1 is an inductor with capacitors at Z_2, Z_3, the circuit is a Colpitts oscillator, whilst if a tapped inductor forms Z_2 and Z_3 with Z_1 being a capacitor then the circuit is a Hartley oscillator. One way or another, all three electrodes

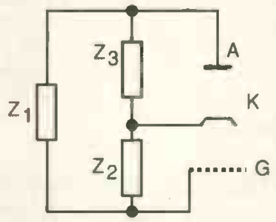


Fig. 1. O'Connor's universal oscillator circuit. Z_1 is a reactance of one sign while Z_2 and Z_3 are both of the other. For 'valve' read n-p-n bipolar, n-channel fet, hemt etc, as appropriate.

of the active device must be connected to the tuned circuit.

Many other circuit arrangements are possible, some using more than one active device, a variety being shown in **Fig. 2**. However, at uhf a circuit using a single device, connected as in Fig. 1, often proves best because additional phase shifts associated with a second active device or parasitics associated with coupled windings introduce additional complexities into the design process, effects that would be smaller or negligible at vhf or hf.

Colpitts oscillator

As a basis of a signal generator, an oscillator with a wide tuning range is required. While at one time this would have been tuned by a precision mechanical variable capacitor, in a more modern application varactor tuning will usually be employed, permitting accurate frequency control by means of a phase-lock loop. With a possible application in view, I experimented with what might be regarded as a Colpitts oscillator, if you draw in the transistor's internal base/emitter capacitance to go with the 3.3pF external collector/emitter capacitance as Z_2 and Z_3, **Fig. 3(a)**.

In a wide-range oscillator, one needs to be able to vary its frequency over a wide range at will, but then instantly have its frequency as stable as a rock once one has set it to a particular desired frequency. To start with, it pays at the outset to design the oscillator circuit to have very stable dc conditions, ensured in Fig. 3(a) by the supply regulator, and by the base bias chain with its low source resistance at dc, which is moreover well decoupled at rf. As first constructed, the oscillator covered from under 400MHz to over 600MHz, but was modified as shown for the intended purpose to cover well over 200MHz centred on 400MHz.

This is shown in Fig. **3(b)**. The oscillator was tuned back and forth across its range during the six-second exposure required by the home-made oscilloscope camera, which does duty also for my spectrum analyser. There is a general slope in level of several decibels across the tuning range. But the superimposed ripples are due to the connection to the spectrum analyser. This effect was demonstrated by doubling the length of coaxial cable used for the connection, which gave twice as many ripples. Clearly, the analyser's input impedance isn't exactly 50Ω on the most sensitive range used; switching in 10dB at the input attenuator largely removed the ripples.

Base-current phase shift

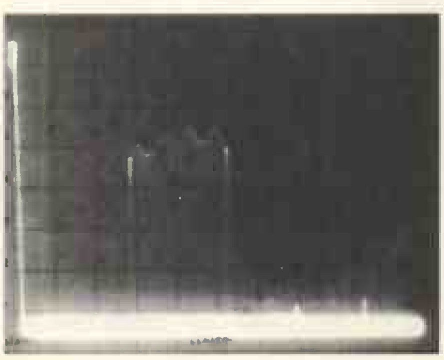
It is a convenient fiction that, in common-cathode, emitter or source mode, an active device is an inverting amplifier, i.e. that the voltages at the other two electrodes are in antiphase. This is true in the case of valves up to fairly high frequencies, since the velocity of electrons *in vacuo* is a good deal faster than minority carriers in silicon. But in a transistor, phase shifts start to show up even in high-frequency devices at a much lower frequency, as is illustrated in **Fig. 4**.

Figure **4(a)** shows the relation between the currents in the three electrodes of a transistor at dc, and recaps on the relation between the current gains α and ß. The latter is often also called α′ or h_{FE}. Figure **4(b)** shows how even a small phase shift in the collector current can result in a phase shift in the base current which is much larger, and moreover in the opposite direction.

In the simplified treatment given here, any phase shifts suffered by the base or collector currents after they part company, due to 'transmission line delay' in different regions of the bulk of the semiconductor, are assumed to be negligible.

The higher the dc value of ß, i.e. the more nearly the magnitude of the collector current equals that of the emitter, the smaller the phase shift in the collector current needed to give a 45° advance to the base current. For an audio-frequency transistor such as the *BC109* with its typical ß of 300 and f_T of 300MHz, this occurs at around 1MHz. At higher frequencies, the base current can lead the emitter current by not far off 90°.

An emitter follower is an extremely useful and widely used circuit, acting as a buffer and permitting a high-impedance source to drive a lower-impedance load. But the circuit has an unfortunate tendency to oscillate, particularly if the load is a bit capacitive. The phase advance suffered by the base current is the culprit.



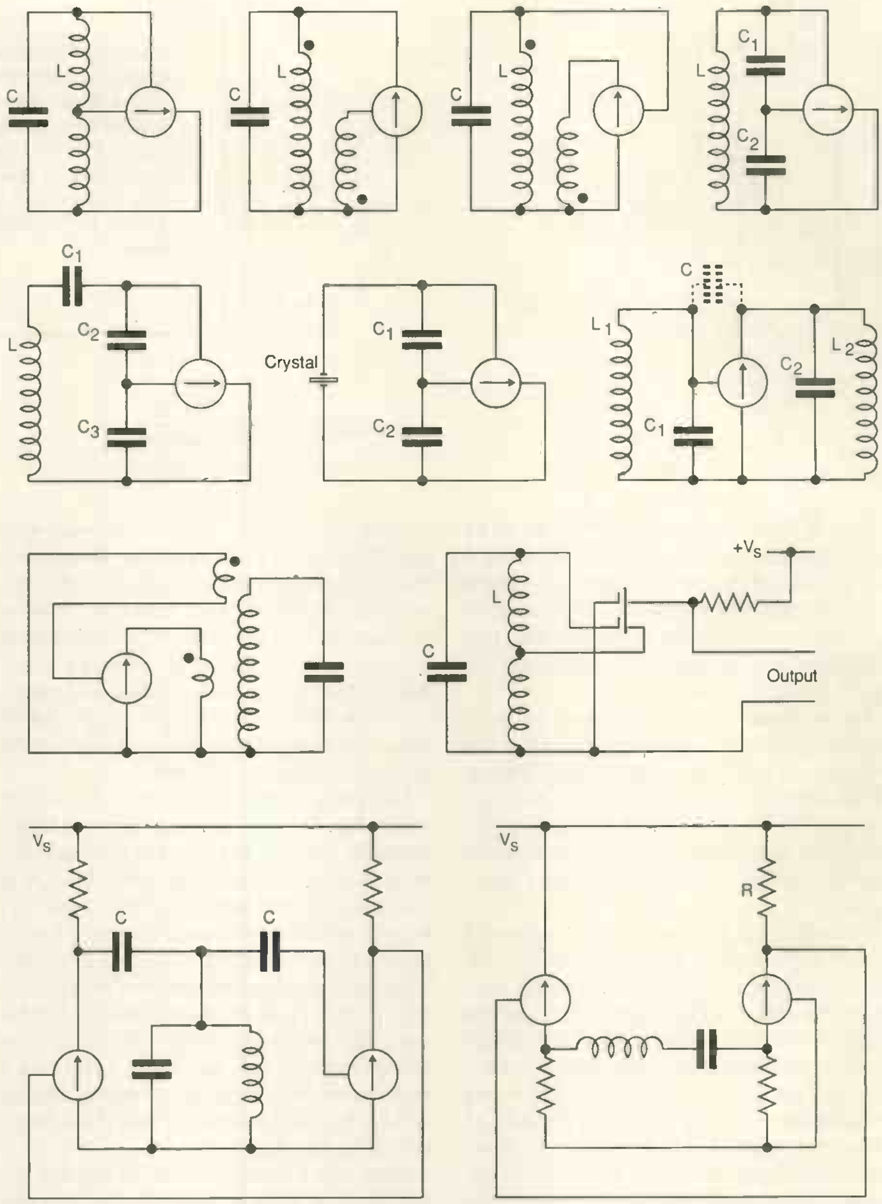
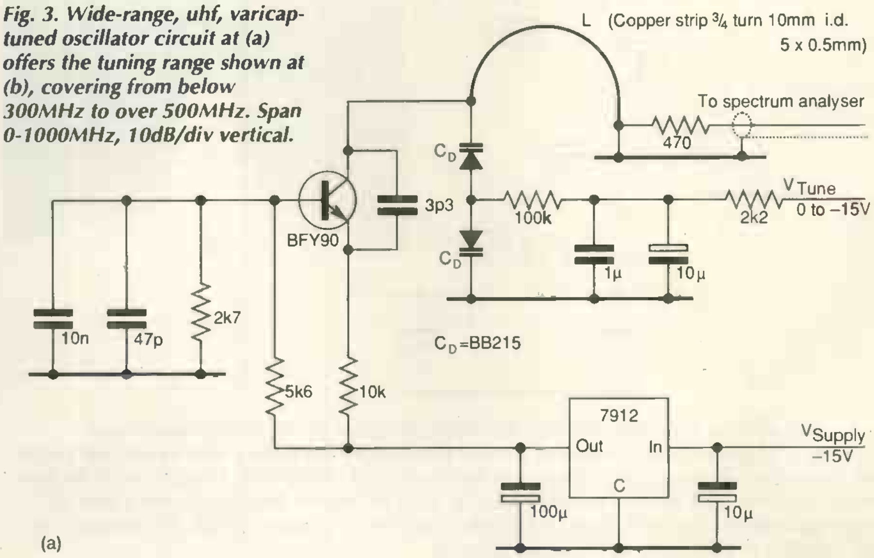


Fig. 2. A variety of oscillator circuits, some more suited to lower frequencies, reproduced from Newnes Practical RF Handbook *published by Butterworth Heinemann.*

Fig. 3. Wide-range, uhf, varicap-tuned oscillator circuit at (a) offers the tuning range shown at (b), covering from below 300MHz to over 500MHz. Span 0-1000MHz, 10dB/div vertical.



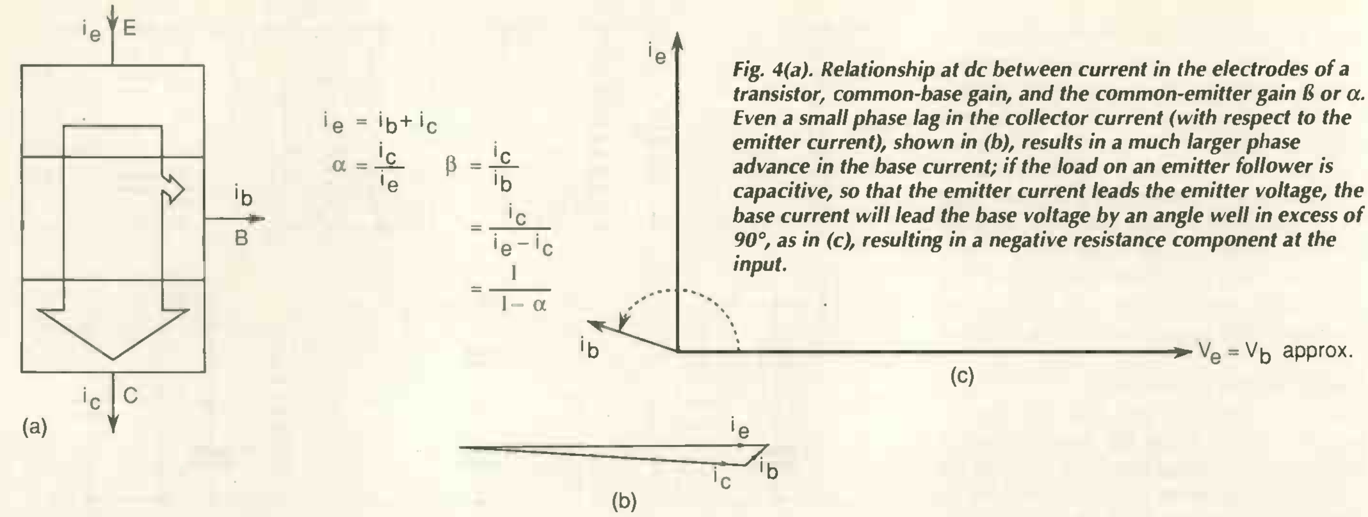


Fig. 4(a). Relationship at dc between current in the electrodes of a transistor, common-base gain, and the common-emitter gain ß or α. Even a small phase lag in the collector current (with respect to the emitter current), shown in (b), results in a much larger phase advance in the base current; if the load on an emitter follower is capacitive, so that the emitter current leads the emitter voltage, the base current will lead the base voltage by an angle well in excess of 90°, as in (c), resulting in a negative resistance component at the input.

This is illustrated in Fig. **4(c)**. Here an important assumption is made: the mutual conductance of the device is high (its output impedance low compared to the impedance of the load connected to the emitter) so that, to a first approximation, the voltage at the emitter equals that at the base.

As the emitter current is leading the base voltage by up to 90°, with a purely capacitive load, and the base current substantially leading the emitter current, it follows that the base current leads the base voltage by well over 90°. The input impedance consists of a negative resistive component in parallel with a capacitance.

This effect has been used as the basis of a microwave oscillator design producing over 100mW output at 2GHz[1]. It can equally well be used at uhf, and **Fig. 5** shows just such an application. The reactance of 18pF at 345MHz is 25Ω, doubtless effectively reduced somewhat by the inductance of the leads even though these were kept as short as possible, so the emitter circuit load is almost purely capacitive. The capacitance tuning the inductor consisted only of the capacitive component of device input impedance, and device and circuit strays.

If the circuit of Fig. **5(a)** is compared with that of Fig. 3, it will be seen to be almost identical. In both cases, the collector is connected to the opposite end of the tuned circuit from the base, while a capacitor is connected from the emitter to the collector end of the tuned circuit. Thus in fact most oscillators operating at vhf or above and using a single active device are likely to be found on analysis to be negative resistance oscillators.

Depending on the *Q* of the tuned circuit (and that in Fig. 5(a) was certainly not very high), the noise performance or short term stability of such an oscillator can be good, though of course the medium and long term stability will be poor unless the oscillator is used as a voltage-controlled oscillator in a phase-lock loop.

Figure **5(b)** shows the output of the Fig. 5(a) circuit, the centre frequency being 345MHz and the horizontal scale 5kHz/division. Analyser bandwidth was set to 1kHz and a great many sweeps occurred during the six second exposure needed to record the background and graticule.

Some noise modulation is evident but the overall shape is not so very different from that of the analyser's 1kHz filter. However, towards the end of the exposure the oscillator took it into its head to start wandering up in frequency; a stability of 1kHz in an open-loop uhf oscillator could be achieved, but only with a more sophisticated circuit, using a high-*Q* cavity resonator for example.

Line stabilisation

Another arrangement providing improved frequency stability without resorting to a phase-locked loop is the line-stabilised oscillator. Using a line consisting of 150cm of 50Ω miniature coaxial cable, believed to have a velocity ratio of around 0.66, with its far end shorted, the Fig. 5(a) was modified to work in this mode. A tuning capacitor was added to enable the tank circuit to be tuned to a frequency at which the emitter load looked capacitive. It oscillated at 235MHz, at which frequency the length of the line would be just over one and three quarter wavelengths, i.e. capacitive.

Clearly there are other frequencies, both higher and lower, at which the line looked capacitive, for example where the line length is 5/4λ, 9/4λ, 11/4λ etc, and the tuned circuit is used to pick out one of these as the operating frequency. If the tank circuit *Q* is high and the regeneration only just sufficient to ensure oscillation, then only one of these modes can be sustained. If the tank *Q* is lower and the negative resistance much lower than necessary to sustain oscillation, the circuit can oscillate in several modes at once.

This was the case when the collector supply was the same as in Fig. 5(a). Reducing collector voltage until it equalled the base voltage, as shown in **Fig. 6(a)**, prevented oscillation in several modes simultaneously. With a constant tail current generator or rf choke/resistor combination in place of the 10kΩ resistor to −12V, the oscillator circuit would work happily on a supply of a volt or two.

Output from the loosely coupled winding was as in Fig. **6(b)**, where the span is 0-1000MHz and the fundamental at **235MHz** is visible, together with the second, third and fourth harmonics. Figure **6(c)** zooms in on the fundamental, at 5kHz per division horizontal. At the selected video filter bandwidth, a single sweep took six seconds and at 60dB down, the

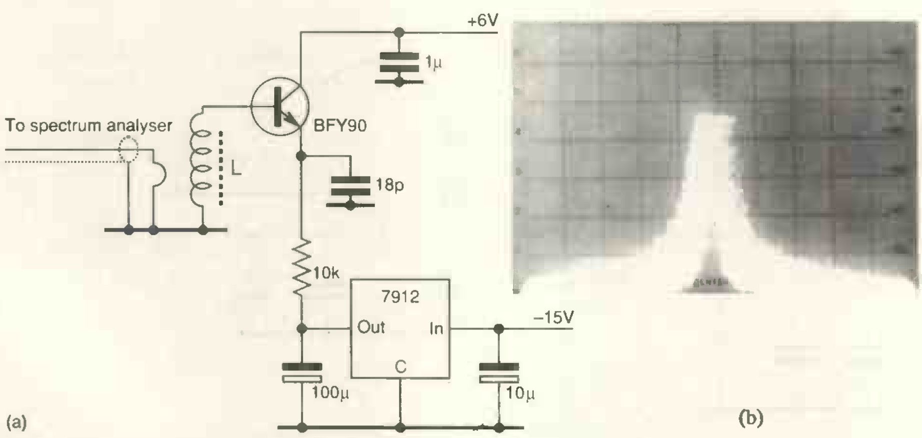


Fig. 5. Uhf oscillator at (a) uses the negative input resistance effect, tuning capacitance consisting of the capacitive component of base circuit input impedance plus device and circuit strays. Inductor L is three turns (spaced one wire width) of 16swg tinned-copper wire, on 5mm internal diameter with a 3.75mm ferrite slug. At (b) is the output from the loosely coupled, single-turn winding, centre frequency 345MHz, 5kHz/div. horizontal, 10dB/div. vertical, ref. level −10dBm, IF bandwidth 1kHz, video filter off.

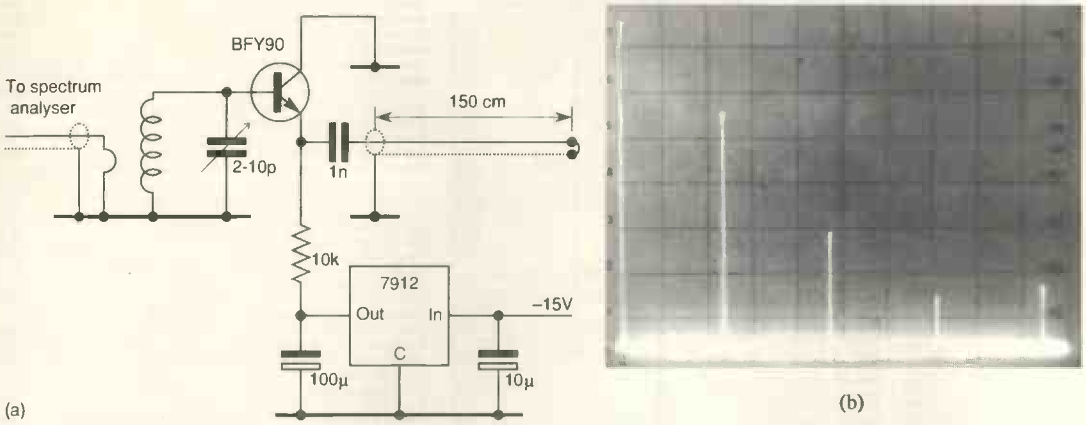


Fig. 6. Simple and fairly crude line-stabilised oscillator (a) gives output at (b); span 0-1000MHz, 10dB/div vertical, ref. level (top of screen) –10dBm. Fundamental component of (b) shown in (c), with centre frequency 235MHz and horizontal scale 5kHz/div, IF bandwidth 1kHz, video filter at max. (giving a post-detector bandwidth of 1.5Hz), 10dB/div. vertical, ref. level –30dBm.

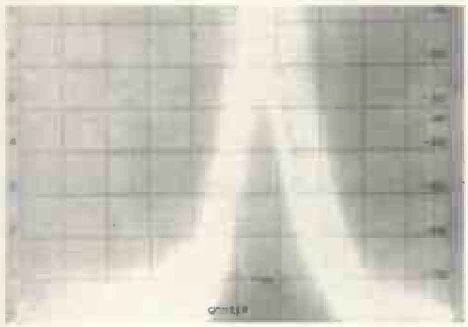
response is 15kHz wide, which is more or less identical to the analyser's 1kHz filter specification.

Of course, a length of coaxial cable does not make for a very convenient line stabilised oscillator. Even if semi-rigid, solid-outer coaxial were used, the stability of the oscillator with temperature would not be wonderful. But line stabilisaton is now very attractive and competitive, in the form of surface acoustic wave resonators.

Owing to the extremely slow propagation speed of acoustic waves in lithium niobate – slow at least compared with the speed of light – a compact package can contain a line length of many wavelengths. Such devices are used at uhf in lieu of crystals, where tight frequency control is required. An example is the range of 418MHz telemetry modules featured in Ref. 2.

Connecting a negative resistance across a tuned circuit results in an oscillator, and the negative resistance need not imply a three terminal device. Many years ago a two terminal device – the tunnel diode – was a popular means of making uhf oscillators. This was at a time when transistors with adequate performance were not available, or at best very expensive.

Now that transistors with more than adequate performance are common and cheap, the tunnel diode uhf oscillator has taken a back seat. But negative resistance two terminal oscillator circuits are still used at microwave frequencies, in the form of the Gunn diode oscillator. ■



(c)

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1. Partha and Krishnakumar. Oscillator design employs common-collector bipolars. *Microwaves and RF*, October, 1994 pp. 88-92.
2. Hickman I. Low power radio links, *EW+WW*, February 1993, pp. 140-144.

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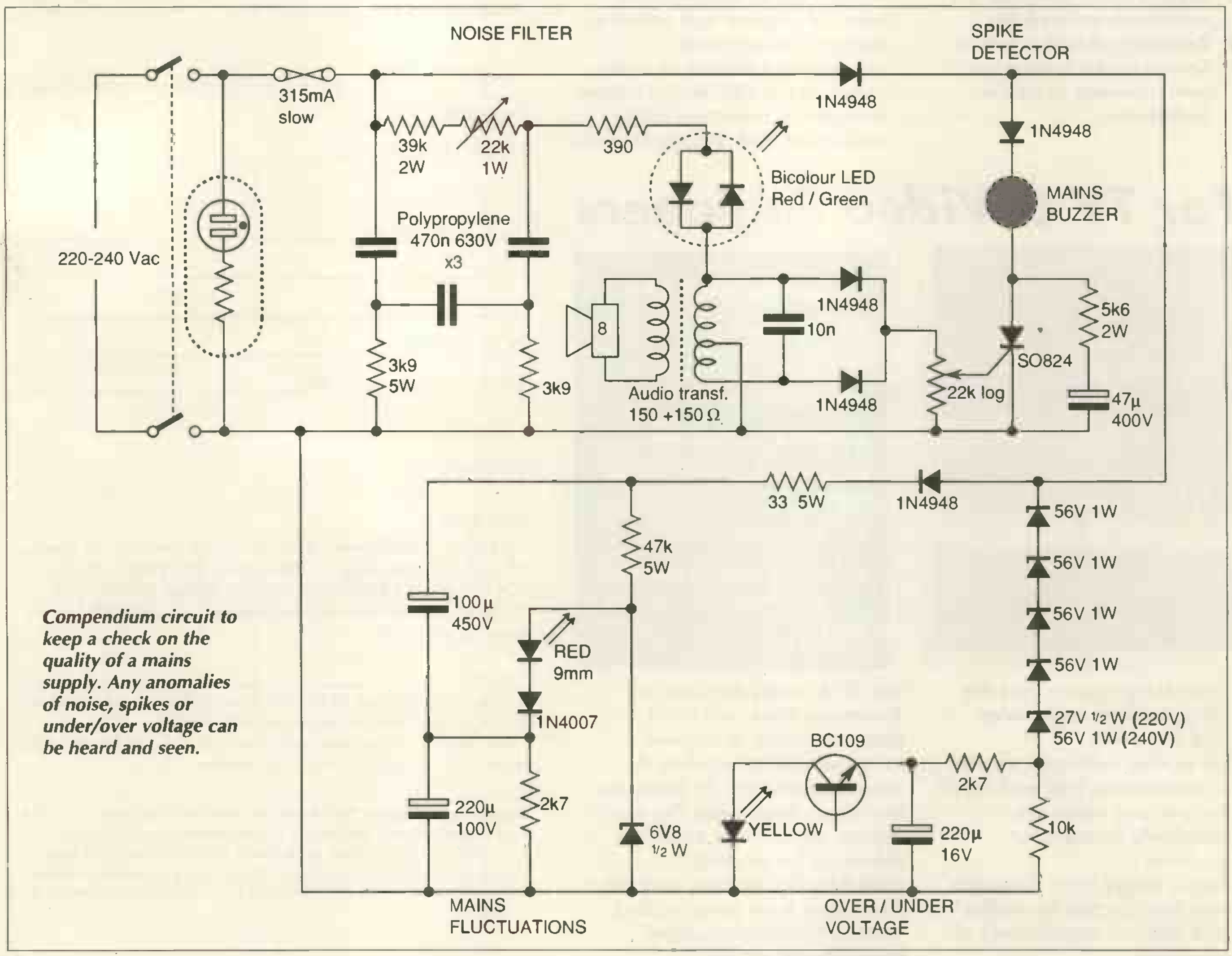
Over/under voltage. Normally, the led flashes at around 6Hz, this frequency doubling for a +10% mains voltage change and stopping for a –10% variation. Choose the correct zener for the relevant mains voltage.

Mains fluctuations. Significant variations in mains voltage modulate the red led heavily, from full on to off, independently of average mains voltage.

Bear in mind that the circuit is connected to the mains and that the large capacitors will probably stay charged for some time.

D Di Mario
Milan
Italy



Compendium circuit to keep a check on the quality of a mains supply. Any anomalies of noise, spikes or under/over voltage can be heard and seen.

Thermally stable current source

This thermally stable current source features very high dynamic impedance, high output voltage swing and wide bandwidth.

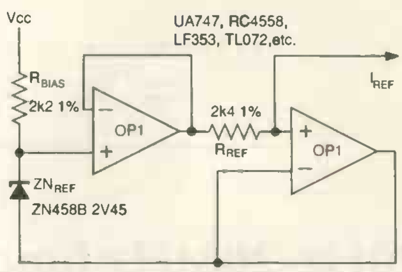
In the connection shown, the op-amps maintain the same voltage drop across R_{ref} as across the reference diode, so that the output curent is precisely determined. Op-amp OP_2 sinks bias current, which has therefore almost no effect on I_{ref}.

Highest instantaneous output voltage is given by the highest value of Rbias consistent with there being enough bias current to operate the diode, while the lowest R_{bias} value is determined by the maximum power from OP_2. Output current and reference voltage determine the value of R_{ref}.

With values given, a 24V supply and 1mA output, a 2.2kΩ R_{bias} gives 50mW of power in OP_2; R_{ref} gives the 1mA output when used with a Plessey *ZN458B* reference diode and the minimum diode current gives a 17V output swing.

Since both op-amps act as buffers, it is unnecessary to use high-performance types, although improvements would be seen. As it is, the circuit works well over the audio range with any op-amp and diode.

Andrea Scozzari
Livorno
Italy



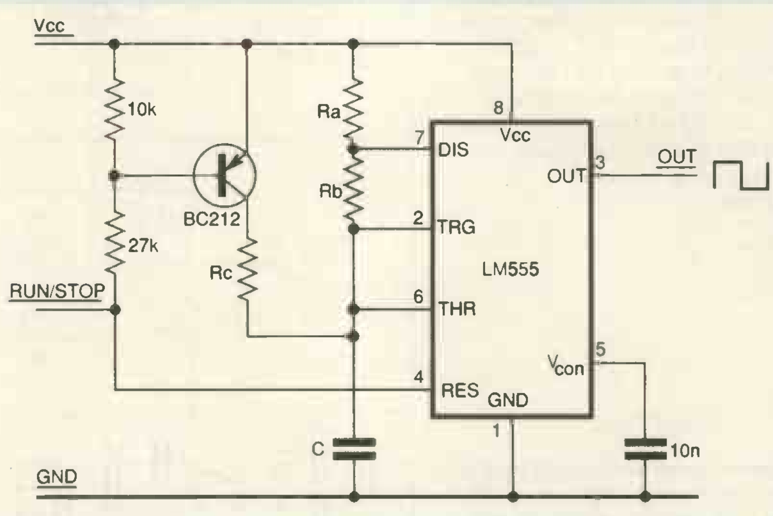
Current source provides very high thermal stability. Output current is determined by value of R_{ref} and diode voltage.

Positive start for 555 oscillator

Using a 555 as an astable oscillator in a digital delay circuit entails holding the reset pin low until the oscillator is required to start. Normally, this causes the timing capacitor to discharge completely via the timing resistor, so that the first charge is longer than succeeding ones at $1.1(R_a+R_b)C$ instead of $0.69(R_a+R_b)C$.

To avoid the effect, the capacitor must be held at $V_{cc}/3$ when the oscillator is stopped, by means of the p-n-p transistor controlled by the run/stop signal, R_c being $2R_b$.

Mike Aldington
Gillingham
Kent



Circuit prevents total discharge of timing capacitor in 555 astable oscillator when oscillator stops, ensuring time of first mark period same as subsequent cycles.

Prescaler functions to 1.3GHz

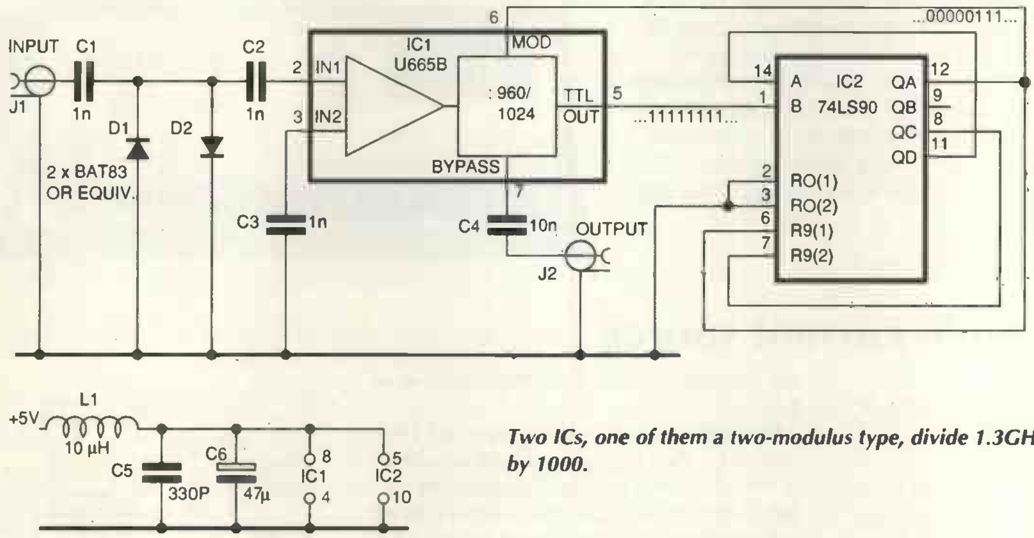
Using two ICs, a *74LS90* and a *TFK U665B* two-modulus (960/1024) divider, the circuit divides frequencies up to 1.3GHz by 1000.

A logic level on the *665B*'s mod input, pin 6, determines which modulus is used – logic zero gives 1024 and one, 960. Pulses from the QA output of the *74LS90* decade divider form the sequence 00000111 to give 5 at 1024 and 3 at 960 (5×1024+3×960=8000 input pulses for eight output pulses, or 8000/8=1000).

Biquinary connection of the *74LS90* allows forced resetting to 9, when its natural output is 7, by the connection of its reset-9 inputs to QA and QB. One's first thought, that a shift register might perform the function, is not valid, since glitches and noise have a tendency to cause errors.

For connection to a long output lead, use the prescaled output on pin 7.

Stefano Pigozzo
Belluno
Italy



Two ICs, one of them a two-modulus type, divide 1.3GHz by 1000.

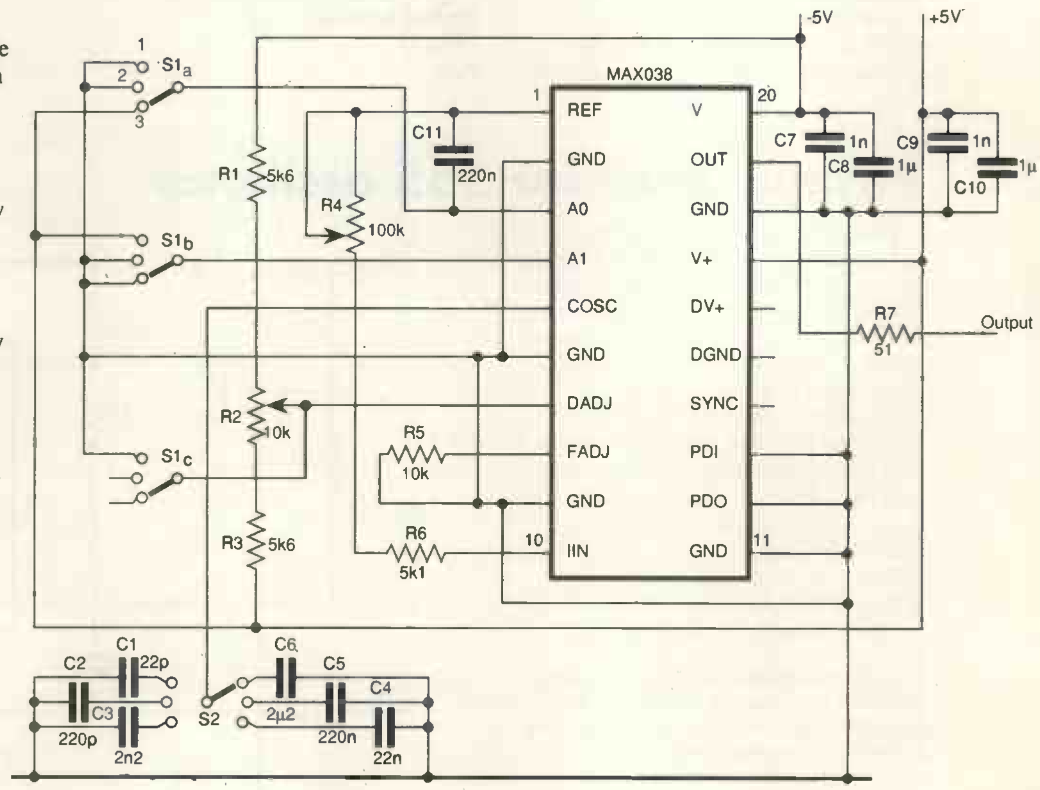
20Hz-20MHz function generator with duty-cycle adjust

Giving a 2V pk-pk output, the Maxim *MAX038* is a 20Hz-20MHz function generator providing sine, square and triangle waveforms with an adjustable duty cycle on squares and triangles of 15%-85%.

Logic levels on A_0 and A_1 pins select the output waveform; position 1 of *Sw*1 gives sine, 2 square and 3 triangle. Output frequency depends on current into I_{in}, set by $R_{4,6}$ and the 2.5V reference voltage output, and the values of $C_{1\text{-}6}$ on the C_{osc} pin, selected by Sw_2 to give six 10:1 ranges.

Varying the voltage on the DADJ pin between –2.3V and +2.3V by R_2 varies duty cycle from 15% to 85% when square and triangle waves are in operation.

Yongping Xia
Torrance
California
USA



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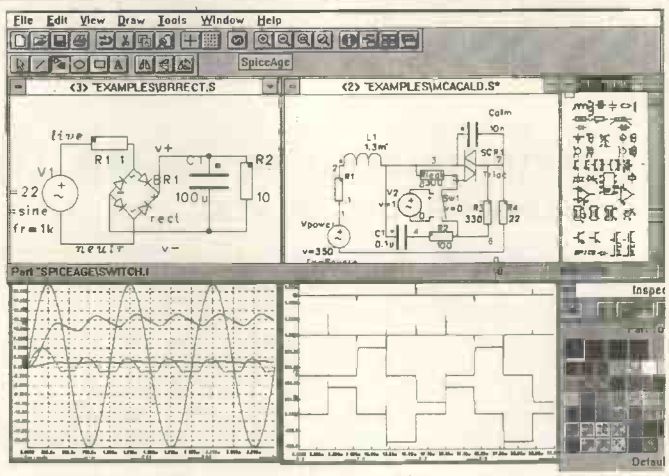
Tel: 01179 699352 Fax: 01179 872228

CIRCLE NO. 140 ON REPLY CARD

The new schematic capture program *Geswin* (*GESECA* for Windows™) adds more than a pretty face to *SpiceAge*. Upgrade for £100+VAT*



- *Geswin* DDE links with *SpiceAge* to provide instant circuit editing. Because this link enables *SpiceAge* to retain all its simulation settings, the schematic (produced by *Geswin*) is uncluttered so that you can create clean drawings that may be clipboarded into your other Windows applications.
- You can clipboard sections of your netlist from *SpiceAge* back into *Geswin*'s attribute Inspector if you wish to use patches of existing circuits.
- *Geswin* has inherited *GESECA*'s speed and ease of use. You will find it's best-loved *"bucket of bits"* components' store waiting for your instant use from a special self-replenishing window.
- The *SpiceAge* component library has been expanded and re-drawn into "stubbies". The new symbols allow more components to fit within a given screen area without compromising clarity.
- Multiple windows allow you to scratch pad your designs (simulating as you work) and clipboard them into a fair copy window.
- File compatible with *GESECA*: schematics and components from *GESECA* may be read.
- Comprehensive HELP provides reference material; tutorial style manual reassures you of your own intuition.
- *Geswin* automatically invokes (or switches to) *SpiceAge*; you can also invoke *Geswin* from *SpiceAge*.

Please contact Those Engineers Ltd, 31 Birkbeck Road,
LONDON NW7 4BP.
Tel 0181-906 0155, FAX 0181-906 0969.
*upgrade price from *GESECA*; £295 + VAT new

Those Engineers Ltd

CIRCLE NO. 141 ON REPLY CARD

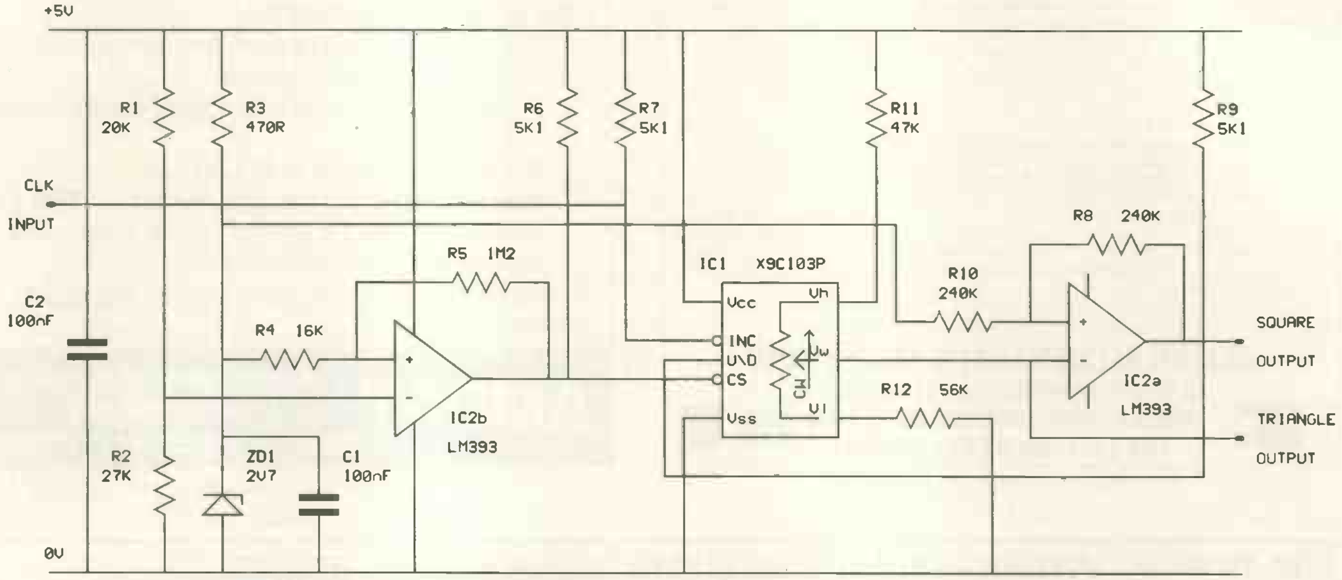
Bistable switch

Providing a bistable output that reverses after a set time in each state, this switch continues in the same state after a loss of power.

Digitally controlled potentiometer IC_1 – a *Xicor X9C103P*, for example – and comparator IC_{2a} are the basic elements, IC_1 wiper moving its complete travel when 100 pulses are applied; the values of the potentiometer and $R_{11,12}$ determine the full-scale output voltage. As the hunredth pulse arrives, the potentiometer output voltage to the comparator exceeds the reference voltage from the zener, the output changes state and the potentiometer changes the direction of travel.

To ensure that the chip-select line of the potentiometer is low after the power supply has settled and high before it falls below the 4.5V lowest working voltage of IC_1, IC_{2b} controls this input to the potentiometer.

A J Stephenson
Seaford
East Sussex



Bistable circuit changes output state after a given number of pulses are applied to the input, retaining its setting after power is removed.

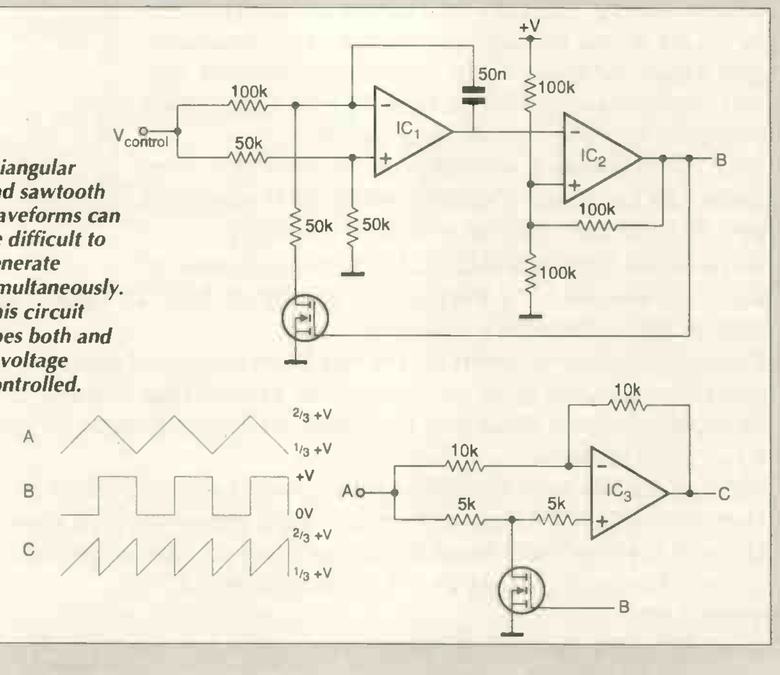
Simultaneous sawtooth, square and triangle waves from a vco

A voltage-controlled oscillator producing square and triangular waves was described by Horowitz and Hill in *The Art of Electronics*, published by Cambridge University Press. *CA3160E* op-amps $IC_{1,2}$ form the oscillator, supplied from a 5-12V rail and generating triangular and square waves at A and B respectively.

A third *CA1360E* operates as either a follower or as an inverter, depending on whether the mosfet conducts or is cut off. If the input to IC_3 is taken from the triangle wave and the mosfet drive comes from the square wave output, output C is a replica of the rising ramp of the sawtooth, followed by an inverted version of the falling ramp, the result being a sawtooth. Input voltage $V_{control}$ should conform to $0 \le V_{control} \le 2(V^+ - 1.5V)$, so that $f = 150 V_{control}/V^+$.

L Szymanski
Stamford
Lincolnshire

Triangular and sawtooth waveforms can be difficult to generate simultaneously. This circuit does both and is voltage controlled.



MONO VGA MONITORS
Some with slight screen burns but OK at £19.95 Ref EF40 and some without burns at £29.95 Ref EF39.

A4 DTP MONITORS Brand new, 300 DPI. Complete with diagram but no interface details.(so you will have to work it out!) Bargain at just £12.99 each!!!!

OPD MONITORS 9" mono monitor, fully cased complete with rasterboard, switched mode psu etc. CGA/TTL input (15way D), IEC mains. £15.99 ref DEC23. Price including kit to convert to composite monitor for CCTV use etc is £21.99 ref DEC24

PC CONTROLLED 4 CHANNEL TIMER Control (on/off times etc) up to 4 items (8A 240v each) with this kit. Complete with Software, relays, PCB etc. £25.99 Ref 95/26

COMPLETE PC 300 WATT UPS SYSTEM Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts. New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. SALE PRICE just £119.00.

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

HOW LOW ARE YOUR FLOPPIES? 3.5" (1.44) unbranded. We have sold 100,000+ so ok! Pack of 50 £24.99 ref DEC16

BRITISH TELECOMM MULTIMETERS SA9083 These are 'returns' so they may have faults but look ok. Complete with new leads and leather case. Price for two meters & 1 case is £10 ref DEC89.

5mw LASER POINTER. Supplied in kit form, complete with power adjuster, 1-5mw, and beam divergence adjuster. Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. Cheapest in the UK! just £39.95 ref DEC49

SHOP WOBBLERS! Small assemblies designed to take D size batteries and 'wobble' cardboard model signs about in shop windows! £3.99 Ref SEP4P2.

RADIO PAGERS Brand new, UK made pocket pagers clearance price is just £4.99 each 100x40x15mm packed with bits! Ref SEP5.

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

COMPUTER RS232 TERMINALS. (LIBERTY) Excellent quality modem units,(like wyse 50,s) 2xRS232, 20 function keys, 50 thro to 38,400 baud, menu driven port, screen, cursor, and keyboard setup menus (18 menu's). £29 REF NOV4.

OMRON TEMPERATURE CONTROLLERS (E6C2). Brand new controllers, adjustable from -50 deg C to +1,200 deg C using graduated dial, 2% accuracy, thermocouple input, long life relay output .3A 240v o/p contacts. Perfect for exactly controlling a temperature, Normal trade £50+, ours £15. Ref E5C2.

ELECTRIC MOTOR BONANZA! 110x60mm. Brand new precision, cap start (or spin to start), virtually silent and features a moving outer case that acts as a fly wheel. Because of their unusual design we think that 2 of these in a tube with some homemade fan blades could form the basis for a wind tunnel etc. Clearance price is just £4.99 FOR A PAIR! (note- these will have to be wired in series for 240v operation Ref NOV1.

MOTOR NO 2 BARGAIN 110x90mm. Similar to the above motor but more suitable for mounting vertically (ie turntable etc). Again you will have to wire 2 in series for 240v use. Bargain price is just £4.99 FOR A PAIR!! Ref NOV3.

OMRON ELECTRONIC INTERVAL TIMERS.
Minature adjustable timers, 4 pole c/o output 3A 240v,

HY1230S,	12vDC	adjustable from 0-30 secs.	£9.99
HY1210M,	12vDC	adjustable from 0-10 mins.	£9.99
HY1260M,	12vDC	adjustable from 0-60 mins.	£9.99
HY2460M,	24vAC	adjustable from 0-60 mins.	£5.99
HY241S,	24vAC	adjustable from 0-1 secs.	£5.99
HY2460S,	24vAC	adjustable from 0-60 secs,	£5.99
HY243H,	24vAC	adjustable from 0-3 hours.	£8.99
HY2401S,	240v	adjustable from 0-1 secs.	£9.99
HY2405S,	240v	adjustable from 0-5 secs.	£9.99
HY24060m,	240v	adjustable from 0-60 mins.	£12.99

PC PAL VGA TO TV CONVERTER Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. £49.95. Ideal for laptops or a cheap upgrade. We also can supply this in kit form for home assembly at £34.95 ref EF54.

DRINKING BIRD Remember these? hook onto wine glass (supplied) and they drink, standup,drink,standup ETC! £4 each Ref EF1

EMERGENCY LIGHTING UNIT Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11.

GUIDED MISSILE WIRE. 4,200 metre reel of ultra thin 4 core insulated cable, 28lbs breaking strain, less than 1mm thick! Ideal alarms, intercoms, fishing, dolls house's etc. £14.99 ref MAG15P5

300v PANEL METER 70X60X50MM, AC, 90 degree scale. Good quality meter. £5.99 ref MAG 6P14. Ideal for monitoring mains etc.

ASTEC SWITCHED MODE PSU BM41012 Gives +5 @ 3.75A, +12@1.5A, -12@.4A. 230/110, cased, BM41012 £5.99 ref AUG6P3.

TORRODIAL TX 30-0-30 480VA, Perfect for Mosfet amplifiers etc. 120mm dia 55mm thick. £18.99 ref APR19.

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £9.99 ea ref AUG10P3.

FLOPPY DISCS DSDD Top quality 5.25" discs, these have been written to once and are unused. Pack of 20 is £4 ref AUG4P1.

ECLATRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £9.99 ref APR10P5.

24v AC 96WATT Cased power supply. New. £13.99 ref APR14.

MILITARY SPEC GEIGER COUNTERS Unused anstraightfrom Her majesty's forces. £50 ref MAG 50P3.

STETHOSCOPE Fully functioning stethoscope, ideal for listening to hearts, pipes, motors etc. £6 ref MAR6P6.

OUTDOOR SOLAR PATH LIGHT Captures sunlight during the day and automatically switches on a built in lamp at dusk. Complete with sealed lead acid battery etc £19.99 ref MAR20P1.

ALARM VERSION Of above unit comes with built in alarm and pir to deter intruders. Good value at just £24.99 ref MAR25P4.

CARETAKER VOLUMETRIC Alarm, will cover the whole of the ground floor against forced entry. Includes mains power supply and integral battery backup. Powerful internal sounder, will take external bell if req'd. Retail £150+, ours? £49.99 ref MAR50P1.

TELEPHONE CABLE White 6 core 100m reel complete with a pack of 100 clips. Ideal 'phone extns etc. £7.99 ref MAR8P3.

MICRODRIVE STRIPPER Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. £2 each ref JUN2P3.

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit just £5.99 REF: MAG6P8

SOLID STATE RELAYS Will switch 25A mains. Input 3.5-26v DC 57x43x21mm with terminal screws £3.99 REF MAG4P10

BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

ULTRAMINI BUG MIC 6mmx3.5mm made by AKG, .5-12v electret condenser. Cost £12 ea, Ours? just four for £9.99 REF MAG10P2.

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. £79 each REF JUN79

ANSWER PHONES Returns with 2 faults, we give you the bits for 1 fault, you have to find the other yourself. BT Response 200's £18 ea REF MAG18P1. PSU £5 ref MAG5P12.

SWITCHED MODE PSU ex equip, 60w +5v @5A, -5v@.5A, +12v@2A,-12v@.5A 120/220v cased 245x88x55mm IEC input socket £6.99 REF MAG7P1

PLUG IN PSU 9V 200mA DC £2.99 each REF MAG3P9

PLUG IN ACORN PSU 19v AC 14w , £2.99 REF MAG3P10

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm £7 REF MAG7P2

GEIGER COUNTER KIT Low cost professional twin tube, complete with PCB and components. Now only £19 REF AUG19.

9v DC POWER SUPPLY Standard plug in type 150ma 9v DC with lead and DC power plug. price for two is £2.99 ref AUG3P4.

AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex equip, 55x32x32mm. £3 a pack. REF MAG3P11

13.8V 1.9A psu cased with leads. Just £9.99 REF MAG10P3

PPC MODEM CARDS. These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud dial up unit complete with leads. Clearance price is £5 REF: MAG5P1

INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 REF: MAG2

200 WATT INVERTER Converts 10-15v DC into either 110v or 240v AC. Fully cased 115x36x156mm, complete with heavy duty power lead, cigar plug, AC outlet socket Auto overload shutdown, auto short circuit shut down, auto input over voltage shutdown, auto input under voltage shut down (with audible alarm), auto temp control, unit shuts down if overheated and sounds audible alarm. Fused reversed polarity protected. output frequency within 2%, voltage within 10%. A extremely well built unit at an excellent price. Just £64.99 ref AUG65.

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

MAINSCABLE Precut black 2 core 2 metre lengths ideal for repairs, projects etc. 50 metres for £1.99 ref AUG2P7.

COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance. Complete kit £8.99.

MINICYCLOPS PIR 52x62x40mm runs on PP3 battery complete with shrill sounder. Cheap protection at only £5.99 ref MAR6P4.

ELECTRIC MOTOR KIT Comprehensive educational kit includes all you need to build an electric motor. £9.99 ref MAR10P4.

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. £18 each Ref EF88.

BOOMERANG High tech, patented poly propylene, 34cm wing span. Get out and get some exercise for £4.99 ref EF83

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80.

PEANUT TREE Complete kit to grow your own peanuts! full instructions supplied. £3 Ref EF45.

PLUG IN POWER SUPPLYS Plugs in to 13A socket with output lead. three types available, 9vdc 150mA £2 ref EF58, 9vdc 200mA £2.50 ref EF59, 6.5vdc 500mA £3 ref EF61.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 REF: MAG15P1

LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair REF: MAG 8P1 2 x PP3 req'd.

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £30.00 pr.REF: MAG30

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc etc In fact everything bar the case and electronics, a good stripper! £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

LED PACK of 100 standard red 5m leds £5 REF MAG5P4

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF:MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

GYROSCOPE About 3" high and an excellent educational toy for all ages! Price with instruction booklet £6 Ref EF15.

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt, 12v fan, iec inlet and on/off switch. £12 Ref EF6.

VENUS FLYTRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34.

PC POWER SUPPLIES (returns) These are 140x150x90mm. o/ps are +12,-12,+5 and -5v. Built in 12v fan. These are returns so they may well need repairing! £3.50 each ref EF42.

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £15 REF: EF62 Transmits to any FM radio. (this is in kit form with full instructions.)

***FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5 REF: MAG5P5

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert an ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 REF: MAG3P1

TOP QUALITY SPEAKERS Made for HI FI televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality. £2 each REF: MAG2P4 or 4 for £6 REF: MAG6P2

TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 REF: MAG2P5 or 4 for £3 REF: MAG3P4

AT KEYBOARDS Made by Apricot these quality keyboards need just a small mod to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 REF: MAG6P3

HEADPHONES Ex Virgin Atlantic. 8 pairs for £2 REF: MAG2P8

DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 REF: MAG5P8 Worth it just for the very comprehensive manual! 5.25" only.

GAS HOBS Brand new made by Optimus, basic three burner suitable for small flat etc bargain price just £29.95 ref EF73.

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 Ref EF82 extra pellets (500) £4.50 ref EF80.

CHRISTMAS TREE KIT Start growing it now! £3 ref EF53.

DOS PACK Microsoft version 5 Original software but no manuals hence only £5.99. 3.5" only.

PIR DETECTOR Made by famous UK alarm manufacturer these are hi spec, long range internal units. 12v operation. Slight marks on case and unboxed (although brand new) £8 REF: MAG8P5

MOBILE CARPHONE £6.99 Well almost! complete in car phone excluding the box of electronics normally hidden under seat. Can be made to illuminate with 12v also has built in light sensor so display only illuminates when dark. Totally convincing! REF: MAG6P6

ALARM BEACONS Zenon strobe made to mount on an external bell box but could be used for caravans etc. 12v operation. Just connect up and it flashes regularly) £5 REF: MAG5P11

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

HEATSINKS (finned) TO220, designed to mount vertically on a pcb 50x40x25mm you can have a pack of 4 for £1 ref JUN1P11.

STROBE LIGHT KIT Adjustable from 1 hz right up to 60hz! (electronic asssembly kit with full instructions) £16 ref EF28.

ROCK LIGHTS Unusual things these, two pieces of rock that glow when rubbed together! belived to cause rain! £3 a pair Ref EF29.

NEW HIGH POWER LASERS

15mW, Helium neon, 3 switchable wavelengths .63um, 1.15um, 3.39um (2 of them are infrared) 500:1 polarizer built in so good for holography. Supplied complete with mains power supply. 790x65mm. Use with EXTREME CAUTION AND QUALIFIED GUIDANCE. £349+Vat.

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PORTABLE RADIATION DETECTOR WITH NEW COMPUTER INTERFACE.

£59.00

A Hand held personal Gamma and X Ray detector. This unit contains two Geiger Tubes, has a 4 digit LCD display with a Piezo speaker, giving an audio visual indication. The unit detects high energy electromagnetic quanta with an energy from 30K eV to over 1.2M eV and a measuring range of 5-9999 UR/h or 10-99990 Nr/h. Supplied complete with handbook. Ref. NOV 18.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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VISA

CIRCLE NO. 142 ON REPLY CARD

Circuit round-up

Contributed by designer John Burnill, this collection of circuit ideas covers a variety of applications.

Meter response equaliser

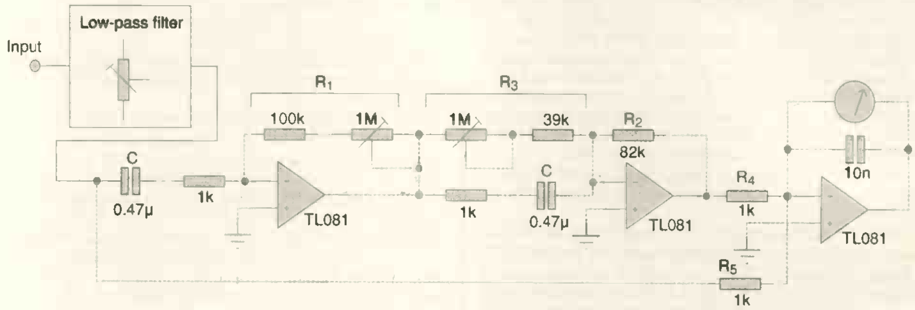
Pointer movement of dc milliammeters exhibits a second order response to changing current. This can be equalised by the circuit shown, speeding up the response typically by a factor of ten. Response time is limited by the low-pass filter on the input, which is there to prevent the subsequent circuitry clipping on full scale steps in amplitude.

Values shown are for a typical 200μA/1kΩ 'VU' meter. Resistor R_3 adjusts the Q. This is independent of R_1 which adjusts the corner frequency.

These equations give the corner frequency and the Q. Resistor R_4 is assumed equal to R_5.

$$f=\frac{1}{2\pi C\sqrt{R_1 R_2}}$$

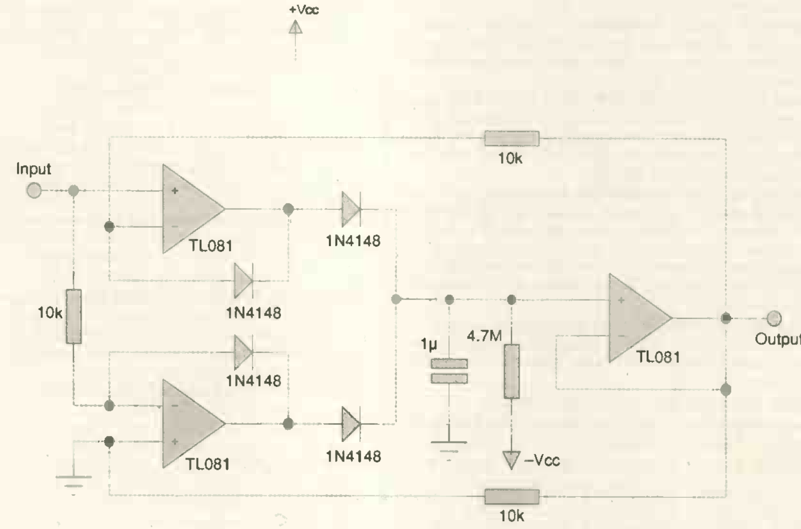
$$Q=\frac{R_3}{2\pi f R_1 R_2}$$



Meter Response Equalizer

Fast full-wave peak rectifier

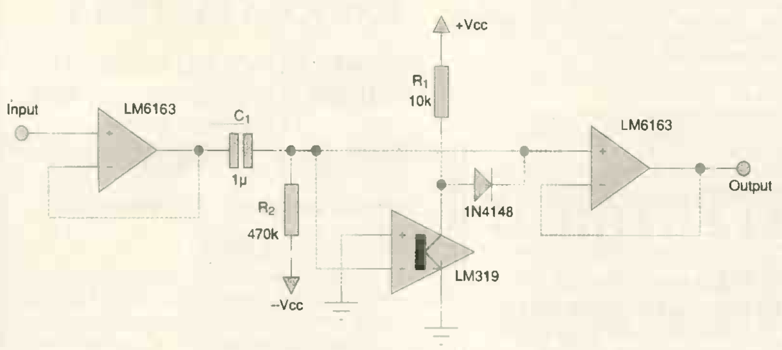
This full wave peak rectifier is fast due to the fact that none of the op-amps saturate. The circuit is accurate to 1dB to 300kHz using *TL081*s. Attack time is limited by the limited output current of the op-amps. Decay time is set by the 4.7MΩ resistor. Taking this resistor to the negative supply rail gives approximately linear decay against time.



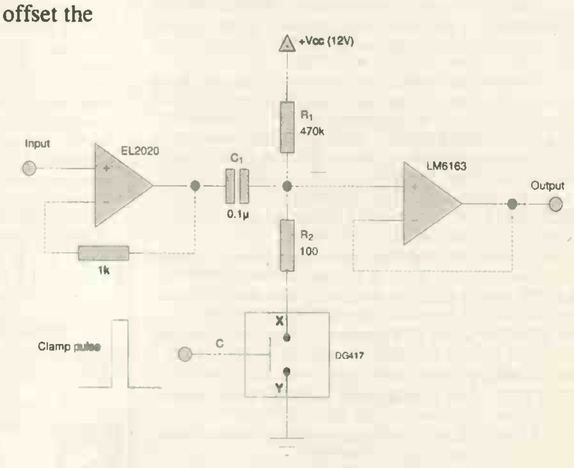
Video-signal processing

Two ideas related to each other in that they concern the processing of video signals. First is a precision dc restorer. Basic circuits using a diode can mangle the sync enough to cause loss of frame sync on some receivers. The circuit shown here solves the problem. Resistor R_1 controls the 'attack' time and R_2 the tilt.

The second circuit is a very simple clamp with more than adequate performance. Clamping time is determined by the time constant R_2/C_1. Resistor R_1 is to offset the input current of the output op-amp to minimise drift on the clamped wave form. The input amplifier is a *EL2020* because when the clamp is switched on it must drive a 100Ω load.



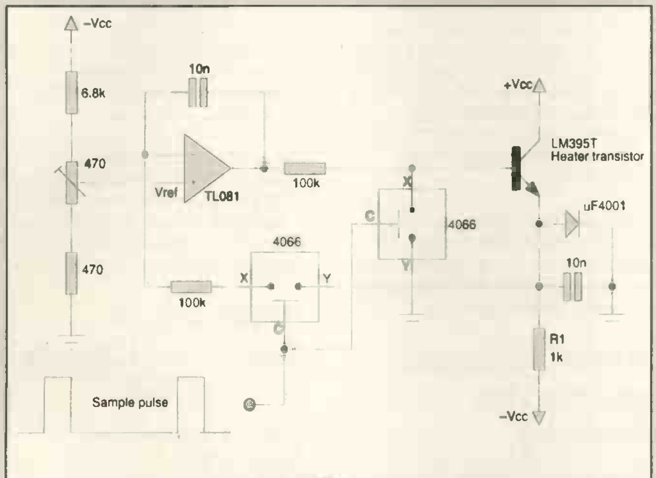
Precision Video DC Restorer



Oven for crystal stabilisation

A circuit to use as a heater for temperature stabilisation of a crystal. Base emitter junction voltage of the heater transistor is sampled as a measure of device temperature while collector current is held constant. Resistor R_1 provides reference current. The op-amp is the sample-and-hold and loop error amplifier. A reference voltage is applied to the non-inverting input to set the temperature.

The heater transistor used is a *LM395*. This device is overload and overtemperature protected, making temperature adjustment idiot proof. For best performance the crystal to transistor thermal resistance should be minimised and the thermal resistances from the two to ambient maximised. Power supplies are ±8V. Sample timing is not critical. A 1ms period and 0.2ms sample width are fine.



Temperature Stabiliser

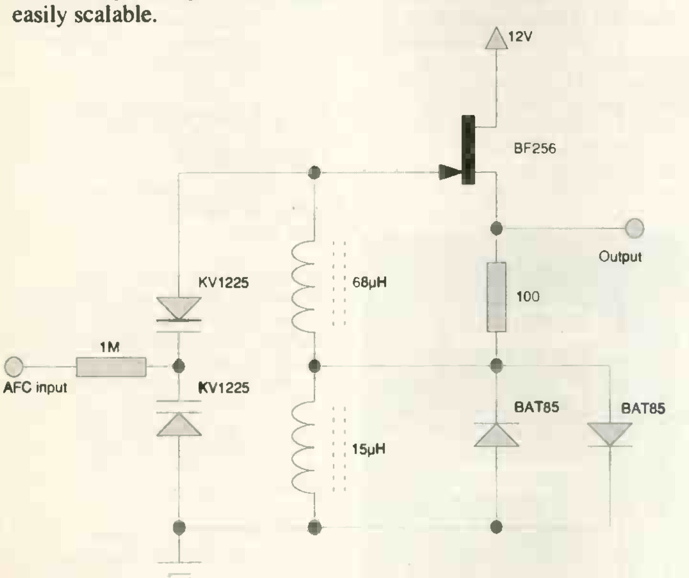
Narrow and wide-range voltage-controlled oscillators

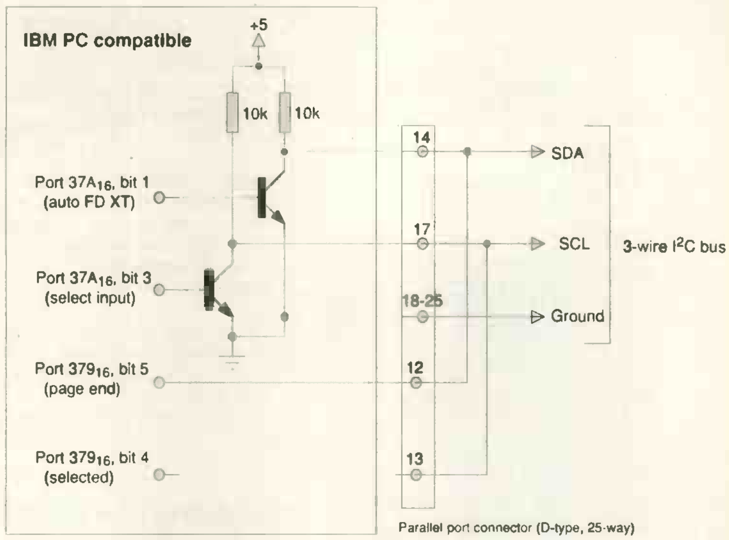
Two more related ideas. A voltage controlled crystal oscillator designed to maximise the pulling range of a parallel crystal. The two diodes decrease the rf voltage across the varicap.

Capacitor C_1 sets the centre frequency. This is done using the final layout to compensate for circuit strays. There is no need for a trimmer if all the crystals are cut to the same load capacitance. Pulling range is about ±50Hz for a typical 2MHz crystal.

A simple wide-range vco is shown in the second diagram. The diodes decrease the rf voltage across the varicap and have the added benefit of making the output waveform symmetrical.

Output is low impedance. Range for this circuit is 1MHz-3.5MHz for a voltage swing of 1-29V on the varicap. The arrangement is easily scalable.



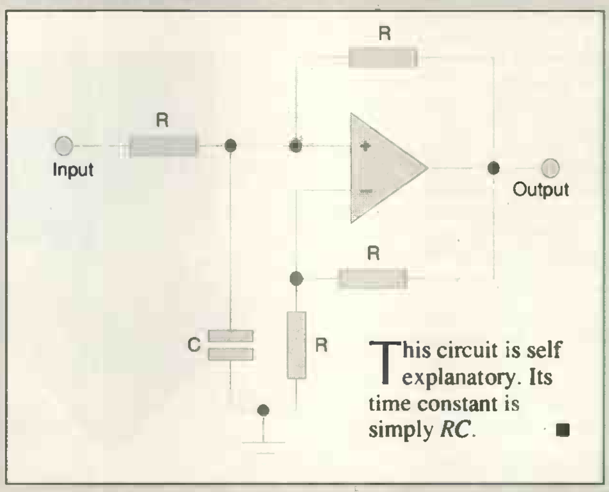


Simple I^{2}C interface for pcs

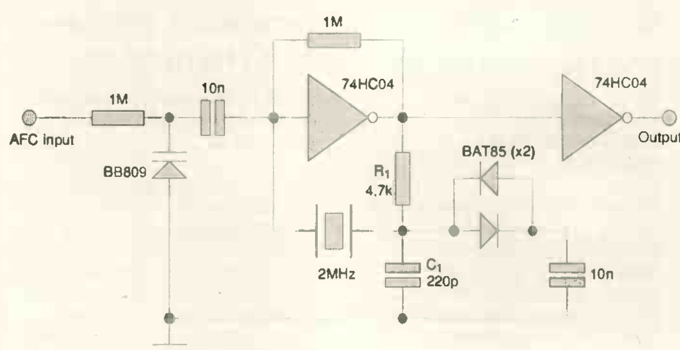
This is a way of interfacing an IBM pc compatible to the I^{2}C bus. The software is too lengthy to be given here. Port 379_{16} is used to read data in. The relevant output must be off (port $37A_{16}$ set low). Port $37A_{16}$ is for outputting data. Note there is polarity inversion.

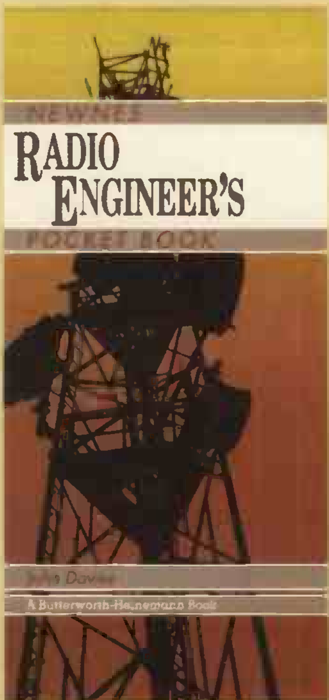
Both SDA and SCL lines need 1kΩ pull up resistors at the receive end if the bus is to be used at full speed over reasonable length connections.

Integrator with no signal inversion



This circuit is self explanatory. Its time constant is simply *RC*. ■





Radio Engineer's Pocket Book

by John Davies, 240pp, hardback
Order – ISBN 0 7506 1738 1
Price £12.99

Contains: Propagation; decibel scale; transmission lines; antennas; resonant circuits; oscillators; piezo-electric devices; bandwidth requirements and modulation; frequency planning; radio equipment; Microwave comms; information privacy and encryption; multiplexing; speech digitisation and synthesis; vhf and uhf mobile communication; signalling; channel occupancy, trunking; mobile systems; base station management; instruments; batteries; satellite comms; connectors and interfaces; broadcasting; abbreviations and symbols; tables and data; glossary.

Covers all aspects of radio and communications engineering from very low frequencies to microwaves, with particular emphasis on mobile communications. Wave principles and the decibel scale, instrumentation and power supplies, equipment types and encryption methods, connectors and interfaces, are all included in this book.

Audio Recording and Reproduction

Michael Talbot-Smith, 204pp, paperback
Order – 0 7506 1917 1
Price £12.99

Contains: Physics of sound waves; hearing; basic acoustics; microphones; loudspeakers; public address; stereo; simple mixing equipment; recorders; introduction to digital audio; music and sound effects; miscellaneous data.

This book gives a simple and straightforward approach to audio techniques, **detailing technical and practical information** for those with no specific training in the subject.

Circuit Designer's Companion

by T Williams, 320pp, paperback
Order – 0 7506 1756 X
Price £15.99

Contains: grounding and wiring; printed circuits; passive components; active components; linear integrated circuits; digital circuits; power supplies; electromagnetic compatibility.

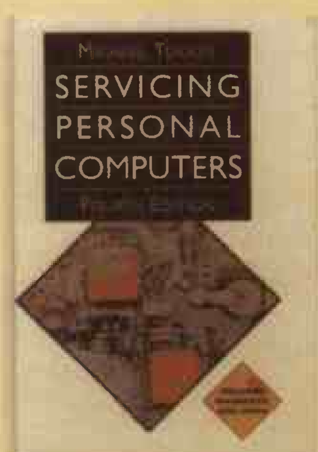
Valued by linear and digital designers alike, this guide explains and outlines solutions that take into account the imperfect behaviour of real components, interconnections and circuits.

Servicing Personal Computers

by Michael Tooley, 304pp, hardback
Order – ISBN 0 7506 1757 8
Price £25.00

Contains: Microcomputer systems; test equipment; fault diagnosis; tape and disk drives; printers and monitors; servicing IBM pc compatibles and 68000-based computers.

This completely rewritten fourth edition still covers the whole range of microcomputer equipment but now also **includes a guide to developments and trends** such as the new generation of diagnostic software – code included – and applications such as serial communication, and memory and hard disk management..



Newnes Audio and Hi-Fi Handbook

by Ian Sinclair, 656pp, hardback
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Contains: Sound waves and acoustics; studio acoustics; microphones; sound synthesis; introduction to digital principles; compact disc technology; other digital systems – DAT, NICAM, DCC, MD – analogue tape recording; noise reduction systems; LP records; disc reproduction; tuners and radio receivers; preamps and inputs; voltage amplifiers/controls; loudspeakers and enclosures; Headphones; public address; in-car audio; interconnections; the future.

Covers a wide perspective of **high-quality sound reproduction**, including reproduction under adverse circumstances, from less conventional sources and with regard to the whole technology from studio to ear.

TV & Video Engineer's Reference Book

by Boris Townsend, 876pp, paperback
Order – ISBN 0 7506 1953 8
Price £40.00

Contains: Materials; components and construction; colour tv fundamentals; broadcast transmission; distributing broadband; DBS; tv studios; mobile and portable equipment; tv sound; tv receivers; servicing tvs; video recorders; teletext etc; HDTV; other applications of tv; performance measurements.

Covers information on every aspect of modern broadcast technology. Of value to all practicing engineers and managers involved with broadcast, cable and satellite services.

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by Geoff Wiskin, 256pp, hardback
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Covers all aspects of information conveyance via radio-wave transmission. Invaluable to anyone planning for broadcast and mobile-radio coverage, or designing, installing and maintaining antenna systems.

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by Jiri Dostal, 400pp, hardback
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Contents: The operational amplifier; basic concepts; operational amplifier parameters; operational amplifier properties; the operational circuit; the ideal operational circuit; analysis of the real operational circuit; static and dynamic errors in the frequency domain; dynamic errors in the time domain; input and output impedances;

offset; noise; stability; good laboratory practices.

Presents an extensive treatment of applications and a practically oriented, unified theory of operational circuits. Provides the reader with practical knowledge necessary to select and use operational amplifier devices.

Servicing Video Cassette Recorders

by Steve Beeching, 250pp, hardback
Order – ISBN 0 7506 0935 4
Price £25.00

Contains: Vcr systems; azimuth tilt;.Frequency modulation; servo mechanisms; colour systems; systems control; long play; VHS-C & camcorders; a-v sockets.

Written for students and people involved with vcr servicing, this book is an invaluable guide and reference covering all aspects of modern vcrs. Contains new material on basic magnetic theory to C&G 224

Principles of Transistor Circuits

by S W Amos, 384pp, paperback
Order – 0 7506 1999 6
Price £17.99

Contains: Semiconductors and junction diodes; basic principles of transistors; common-base and common-gate amplifiers; common-emitter and common-source amplifiers; common-collector and common-drain amplifiers; bias and dc stabilisation; small-signal af amplifiers; large-signal af amplifiers; dc and pulse amplifiers; rf and if amplifiers; sinusoidal oscillators; modulators, demodulators, mixers and receivers; pulse generators; sawtooth generators; digital circuits; further applications of transistors and other semiconductor devices.

This seminal work has now been presented in a clear new format and completely updated to include the latest equipment such as laser diodes, Trapatt diodes, optocouplers and GaAs transistors, and the most recent line output stages and switch-mode power supplies.

Logic Designer's Handbook

by Andrew Parr, 488pp, paperback
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Contains: Simplified data on a comparative basis of ttl and cmos ics; storage devices; logic circuits; timers; counters; drivers; interface circuits; logic gates; definitions of ic characteristics; event driven logic; communication and highways; analogue interfacing; practical considerations; summaries by function of all relevant circuits; individual pin-out diagrams.

Easy-to-read, but nonetheless thorough, this book on digital circuits is for use by students and engineers, and is a readily accessible source of data on devices in the ttl and cmos families.

The Art of Digital Audio

John Watkinson, 490pp, hardback
Order – 0 240 51320 7
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Contains: Why digital?; conversion; AES/EBU; digital audio coding and processing; digital compact cassette (DCC); advanced digital audio processing; digital audio interconnects; digital recording and channel coding; error correction; rotary head recorders; stationary head recorders; NAGRA and data reduction; Digital Audio Broadcasting (DAB); the compact disc/mini disc.

New edition, completely updated to include all the latest developments, including DCC, the mini disc and digital audio broadcasting.

Microphone Engineering Handbook

by Michael Gayford, 384pp, hardback
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Contains: Microphone techniques; precision microphones; optical microphones; high quality rf microphones and systems; radio microphones and ir systems; microphone testing; ribbon microphones; microphone preamplifiers; stereo microphones; microphone standards.

Comprehensive and authoritative book for engineers, technicians, students and anyone else concerned with the design and use of microphones.

MIDI Systems and Control

by Francis Rumsey, 256pp, paperback
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Contains: Introduction to principles and terminology; synchronisation and external machine control; common implementations; systems control sequences and operating systems; implementation of midi with peripheral devices; practical systems designs.

Second edition is updated and enlarged to take MIDI evolution into account. More examples of real implementations, more diagrams and the whole book has been rewritten to include a far greater practical element, to complement its existing technical strengths. Several completely new sections and complete chapters have been added including a new opening chapter as an introduction to principles and terminology; MIDI timecode; librarians and editors.

Loudspeaker and Headphone Handbook

by John Borwick, 224pp, hardback
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Contains: This book brings together in a single volume every aspect of loudspeaker and headphone theory and practice in sufficient depth to equip students and practitioners alike with a solid working knowledge of the subject. A comprehensive technical reference on the theory and practice of loudspeaker and headphone performance, design and operation.

The Art of Linear Electronics

by John L Hood, 400pp, paperback
Order – 0 7506 0868 4
Price £16.99

Contains: Electronic component symbols and circuit drawings; passive components; active components based on thermionic emission; active components based on semi-conductors; practical semi-conductor components; dc and low frequency amplifiers; feedback negative and positive; frequency response; modifying circuits and filters; audio amplifiers; low frequency oscillators and waveform generators; tuned circuits; high frequency amplifiers/oscillators; radio receiver circuitry; power supplies; noise and hum; test instruments and measurements.

This practical handbook gives a complete working knowledge of the basics and technology of linear electronics – with application examples in such fields as audio, radio, instrumentation and television.

Servicing Audio and Hi-Fi Equipment

by Nick Beer, 304pp, hardback
Order – 0 7506 2117 6
Price £25 .00

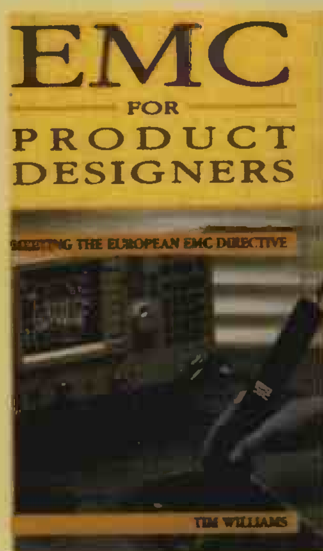
Contains: Introduction; tools and test equipment; radio receivers; amplifiers; power supply circuits; portable audio; cassette deck mechanics; cassette electronics; turntables; system control; motors and servo circuits; compact disc; mini disc; digital audio tape; digital compact cassette; speakers, headphones and microphones; repair, addresses.

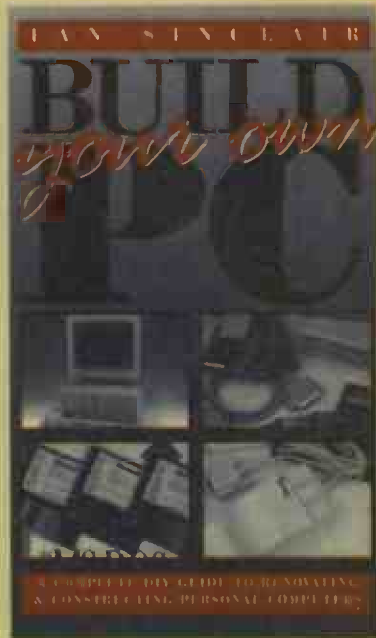
As a bench-side companion and guide, this work has no equal. Its purpose is to ease and speed up the processes of fault diagnosis, repair and testing of all classes of home audio equipment: receivers, amplifiers, recorders and playback machines.

EMC for Product Designers

by Tim Williams, 304pp, hardback
Order – ISBN 0 7506 1264 9
Price £25.00

Contains: What is EMC? standards; EMC measurements; interference coupling mechanisms; circuits; layout and grounding; interfaces; filtering and shielding.





'This book is likely to become essential reading for those designing electronic products for the European market,' according to *New Electronics*. Widely regarded as the standard text on EMC, providing all the information needed to meet requirements of the EMC Directive.

Build Your Own PC

by Ian Sinclair, 256pp, paperback
Order – ISBN 0 7506 2006 4
Price 16.95

Contains: Assembly from scratch – mainly for masochists; fundamentals and buying guide; case, motherboard and keyboard; disk-drive details; improvers and modifiers for graphics and i/o; DOS operation and hints; Windows; connecting printers; glossary.

Covers Building your own pc from scratch or from modules. Written at a level suitable for beginners *and* those with experience of computers or electronics. In addition, this work provides a useful guide for anyone wanting to save money by upgrading their pc themselves.

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LETTERS

Letters to *"Electronics World + Wireless World"* Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

UK mains change – any effects?

Kettles, toasters, electric ovens and any piece of domestic electrical equipment with an ac motor – even if it has a power stabiliser for its dc electronics – all have reduced power following the normalisation of Britain with the European Union's electrical standards body Cenelec, based in Brussels.

Electricity boards can take advantage of the new rules to supply more consumers from a single generator. This, rather than any change in hardware, reduces average supply from 240V to 230V.

The 8.2 per cent associated average decrease in power was too subtle to be obvious to everyone, but hundreds of complaints have been reported.

On the individual scale, last minute rushers have found themselves missing buses and trains in the morning after a slightly delayed breakfast.

These complaints may soon be forgotten as people adjust to get up a few minutes earlier, but the attempted cover-up was quite a remarkable piece of work. A Sunday tabloid editor was successfully fobbed off by an electricity board public relations spokesperson.

Only when a sackful of irate letters arrived at the tabloid's London office after the paper's editor wrote about his search for 'loose wires' or 'crumbs' in his kettle and toaster, were experts consulted as the media began to wonder whether January's regulations change could really be to blame.

Confusion has arisen over the difference in the changes in volts and power. Power is simply volts squared and divided by resistance. The latter varies with temperature, but this is usually negligible over the 4.2 per cent reduction in volts. Thus, the mains electric power has been reduced by around 8 per cent.

Concerns over hospital life-support systems, word processors and computers, and video recorders slowing down are mainly unfounded. All use regulated dc power from an in-built mains ac converter.

Old fashioned electric clocks are of course unaffected, because the alternating frequency of the generators, still 50 hertz, keeps them on time. Mains electronic clocks using crystal oscillators again have a power regulator which compensates easily for the reduction.

We may also be able to turn the oven up easily, but we can hardly take some windings off the coils of our electric motors, or reduce the electrical resistance of our kettles.

So vacuuming, boiling for tea or coffee, toasting, and lawn mowing will just have to take longer. At least, until manufacturers reduce the resistance of their products by 8.2 per cent, so that they deliver the same average power and speed of work as their specifications state, and until consumers buy the new appliances.

Nigel Cook
Addlestone
Surrey

IEE 'nonsense'

Many people working in the field of bioelectromagnetics research have been shocked and angered at the review published last year by the UK Institution of Electrical Engineers. The organisation published a similar study in 1991, I believe, which no-one took very seriously.

The latest conclusions are that there are no effects, either hazardous or beneficial, from weak elf em fields. This is not only an absolute nonsense but contradicts many thousands of cellular live animals and epidemiological studies. In my view it is simply propogandist material masquerading as science.

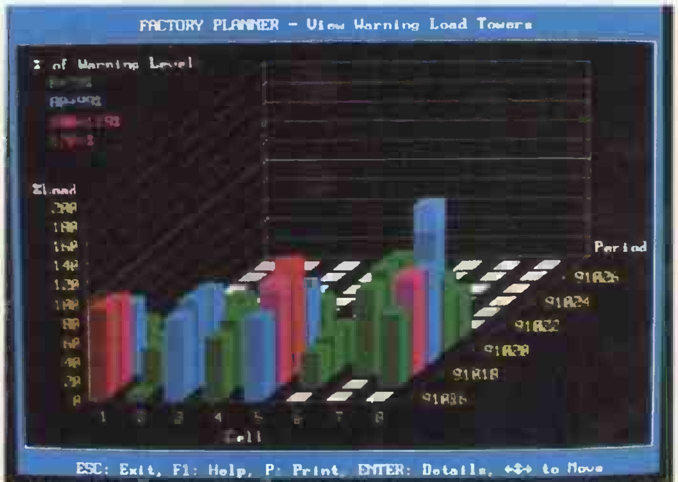
The IEE refuses to disclose the references on which it claims to rely. A look at the composition of its working committees shows that they are heavily weighted with power-utility-related personnel.

Roger Coghill
Gwent

Learning while earning

Andrew Ainger's leader 'Training Dinosaurs' in *EW+WW* March '95 expressed an interesting idea, but can he offer any clues as to how the idea of learning on the job might be work in practice?

H. Martinson
Newcastle



Cell-based factory: horizontal axis indicates manufacturing cells while the vertical axis gives overall load on the cells. 'Depth' axis is the time.

Andrew replies:

An example of human-centred technology – technology that enables staff to learn while they earn – is as follows.

Consider a very common industrial problem, that of planning what each machine has to do within a manufacturing organisation. For a manufacturer to remain competitive it has to remain profitable. To remain profitable the business has to maximise use of factory resources.

In the past this Manufacturing Resource Planning (MRP) was achieved by what has been termed MRPII computer systems. These systems attempted to plan out what each machine in the factory does, and when and how it does it. In theory, this approach works. In practice it may work well in companies where the products are relatively simple, but in the vast majority of cases, MRPII schedules are unrealistic, unreliable and – as many a manufacturing manager knows – often a work of fiction.

This is not really surprising as it only takes one small deviation from the plan to upset the rest of the downstream factory. It is rather like planning your car journey from Lands End to John O'Groats and telling your aunt, who lives in Birmingham, when she should put the kettle on for your cup of tea.

In modern manufacturing organisations there is now a move towards Cell-Based manufacture. This is rather like splitting the Lands End to John O'Groats journey into sections. In many ways this can be regarded as a way of remedying the planning problem via an organisational solution. There can be no doubt that cell-based manufacturing, with its added flexibility, has proved to be an extremely effective and profitable way of manufacturing products.

Traditional IT planning systems are trying to catch up and match this flexibility. However it is not only the IT systems that have to be flexible but also – and more importantly – the people.

For people to remain flexible they have to welcome change; in order to welcome change they have to gain new knowledge. Human Centred Systems appear to be the only solution to this problem.

Rather than presenting data to the manufacturing personnel, the human-centred way is to provide them with information.

The diagram depicts a cell-based factory: the horizontal axis indicates manufacturing cells while the vertical axis gives the overall load on the cells. The 'depth' axis gives the time, divided into periods, which may be shifts, days or weeks for example. Using this diagram and the information it embraces, three learning opportunities emerge:

- *First and most obviously, this view (map) of the factory enables the state of the factory to be judged at a glance, production hot spots* *identified and appropriate action initiated.*

- *Trends can be identified extremely quickly. For example, depending upon the work load and the factory's capacity, 'waves of colour' can be seen to ripple over the surface of the factory. These trends can alert the system operator to situations that have been hitherto undetected in traditional print-outs.*
- *Output of this particular planning system enables the 'sensitivity' of the factory to certain orders to be 'felt', just as the driver of a car can feel the difference when driving over different road surfaces. Over time the sensitivity to certain orders and the 'feel' of the factory can give advanced warning to the human-centred IT system operators when a particularly awkward product mix is being contemplated.*

This type of diagram adds credence to the saying that 'a picture is worth a thousand words'. It is these types of IT systems that enable users to assimilate and build knowledge while they work – a true learning earning environment. It is not easy to design IT systems that can be used in this human-centred way, but it is possible. The mindset of the design engineers concerned has to be woken up to this new design philosophy.

Bear in mind that although you cannot design human-centred technology you can design the opposite. Although the logic of this statement is initially surprising, it becomes quite straightforward when you consider that we cannot design a perfectly safe car but we can certainly design an unsafe one.

It is only by designing technology that can be used in a human-centred way – as will a true Human Centred System – that continued incremental learning can take place. By this I mean that the car may be designed with safety in mind, but it is the way it is driven that is most important.

The challenge is to design IT systems that can be used in a human-centred way, enabling people to learn while they earn. It is only through continued learning that organisations can continue to change, flex and survive. Engineers should take note. A new and powerful design philosophy has emerged, and if we fail to embrace it the 'future' may fail to embrace us.

Andrew Ainger
Human Centred Systems
Windsor

Beyond TV Sat 2

Reg Williamson's complaint (Letters, March '95) of arbitrary cessation of TV Sat and its 16-station service might cause a perceptive person to ask what are German listeners doing about it?

The answer must be that they, like me, are retuning to the lower powered Kopernicus transmission and receiving the same service – albeit with the odd flip if anything other than a very large dish is used. At my latitude, one metre is recommended, but an 80cm dish combined with an lnb made for the telecom band, is acceptable for my purpose, which is recording the audio on digital tape.

When the Kopernicus service ends, we will have to pay for digital audio satellite transmissions. But it will still be cheaper than buying cds, and preferable to Classic FM and its relentless commercials – not to mention Radio 3 fm, which varies from grand ole opry to children's hour, with cricket in the summer to induce total somnolence.

Hugh Haines
Sunderland

Roadside oxide

In a recent photovoltaics installation used for a display by the environmental group Common Ground, some components such as leds corroded and broke down after being exposed to the elements for a period of five weeks.

Can any of you say whether this is normal, or caused by adverse conditions such as acid rain? The installation was near a busy London road and quite a lot of rain fell during the five weeks.

Since we are planning a similar installation to coincide with the end of 1995, we would like to learn from this, especially if it involves a mistake on our part.

Nicolas Holliman
London

Cheap talk

I saw an article in Computing and Control Engineering Journal October 1994 about a development that could lead to entirely free electronic mail – once the equipment has been bought.

The problem with Internet is that it requires the use of the telephone system, which can never be free. However most broadcasting is free. Although some countries like the UK charge a licence fee, this is only to pay for the government station, in our case the BBC. The commercial channels are all free, as are foreign stations receivable here.

Although it sounds far-fetched, this freedom of broadcasting can be transferred to two way communication.

The secret is that every node is a transmitter and receiver of very low range, and the system relies on each node being able to send its message to the next node and so on. In addition, the message contains directional information, so nodes that are in the wrong direction can refuse it.

The system will not work in areas of low population density, but as humanity is fairly well concentrated in small areas of the planet most people should have access.

The article describes a wireless local area network. That is to say the network is limited to a particular business or other grouping of computers. However there is no reason why such networks shouldn't communicate with each other using a radio version of the Internet. The article also says that wireless lans would meet type approval so as to be licence free, as they are low power transmissions.

Initially the existing telephone-based Internet would be used to connect wireless lans that were out of range of each other, but as more and more are installed they would be able to communicate with each other directly and the use of the telephone Internet would fall.

John de Rivaz
Truro

Unknown rectifier materials

I know of no electrolytic rectifiers using the electrode combinations mentioned by 'unsigned' (*Letters*, February) being used as radio detectors. However, electrolytic rectifiers using similar electrodes were used with accumulator chargers and were described in 1920s radio books. So far, I have been unable to discover whether they evolved before or after Fessenden discovered the barretter, or the evolution of the crystal detector.

In 1935, when a schoolboy experimenter, I employed four electrolytic rectifiers in a bridge circuit to trickle charge 6V accumulators. Unfortunately I have long since lost my records but I seem to remember experimenting with aluminium/lead and aluminium/iron electrodes. Large jam jars served as cells and the electrolyte was ammonium phosphate.

'Unsigned' explains that with iron/zinc alloy electrodes, an insulating film develops on the alloy electrodes but this disappears when current flows from iron to alloy. Presumably the same applies to my electrolytic rectifiers.

On the other hand, rectification with the barretter seems to depend more on the movement of ions.

Nonetheless, I would like to experiment with the electrode combinations mentioned by 'Unsigned' and would be most grateful for any further information.

George Pickworth
Kettering

Hisses and glows from the past

George Pickworth's recent articles, *Detection before the diode*, and the unsigned letter from Middlesex in the February 1995 issue brought back memories of some seventy years ago.

In the very early days of domestic radio I had gradually acquired enough 12V lead-acid accumulator blocks to give me 120V ht. We lived out of town and I used to carry these on my bicycle to my grandmother's cellar where 220V dc was available.

Later on, electricity reached our house – ac of course – so I was able to recharge them at home when I'd made a rectifier. This was a chain of ten or twelve tiny sample jam jars with electrodes of aluminium strip and carbon rods from exhausted 4.5V batteries, in a solution of ammonium phosphate.

One could buy ammonium phosphate, sold as fertiliser, from the seed shop. These cells made a peculiar hissing noise and in the dark you could see a pulsating glow on the aluminium strips. I don't know what the reverse current was but it may have been good for the health of the battery. All this information must have come from *Wireless World* – happy days.

I was given a coherer some years ago and it still works. Put in series with a 1V cell and an AVO on the 3V range there was no visible deflection. Flicking 230V ac mains across a 4μF capacitor at a distance of 15cm gave an immediate deflection of several milliamps. A very light tap to the coherer and it immediately returned to its non-conducting state ready for the next burst of rf energy.

Ralph Wesr
Villereal, France

What conspiracy?

In a letter to *WW*, Nov. '81, JL Linsley Hood writes that "censorship has been effective throughout my own professional career...". He lists nine authors who could not have been published anywhere but in *Wireless World*.

As Pete Davis (*EW+WW Dec. '94*) asserts, there is usually no conspiracy to suppress heretical views. There is no need of one, except in some specific instances, because as Charles McCutcheon wrote in the *New Scientist* (itself a notorious suppressor, but not as bad as *Nature*) on 29 April 1976, p225, "An evolved conspiracy" suffices. For example, I ran into a discussion in the interval at the Royal Institution seminar to celebrate the centenary of the Michaelson-Morley experiment. An American who was setting up an international conference on relativity discussed with one of the lecturers whether ether buffs should be suppressed at that conference. He also asked the lecturer how Harold Aspden should be dealt with. They concluded that if Ether believers kept to Establishment mathematics, they should be allowed to put their case.

The American told me he regarded heresy in science much as he regarded heresy in religion. More generally, suppression in science results from fear that a new idea will disrupt the normal, calm progression of academic career progress and research funding.

Suppression is the norm rather than the exception. Even Maddox, editor of *Nature*, now says he is worried[1]. With his track record, that is mind-blowing. Scientists have successfully resorted to false authorship and false addresses to get into *Nature*.

The most interesting and most destructive aspect is the pandemic suppression of advances relating to the AIDS epidemic. Other experts, whose names I can supply, specialise in the allied subject of fraud in science. Stewart and Feder lead this field.

My first publication on suppression in science was 'The Rise and Fall of Bodies of Knowledge', published in *The Information Scientist* No 12 (4) Dec. 1978, pp. 137-144, where I discuss some of the cases of suppression which litter science. My article was re-published in my book 'Electromagnetic Theory vol 1', 1979, p. 117. All of the content of that book is suppressed, including the point that I raised at the Michaelson-Morley centenary seminar, asking about the apparent paradox in their experiment that although Michaelson-Morley pre-date wave/particle dualism, both wave and particle have to be assumed at different stages in the experiment to suppress anomalies.

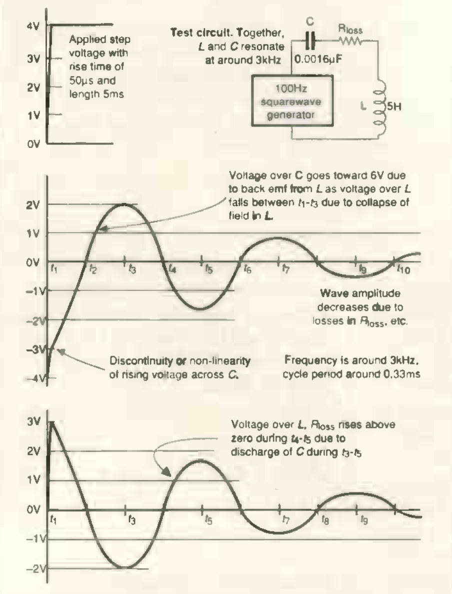
Sine waves – another turn

I see from the March issue of *EW+WW*, p. 215, that Ian Hickman has kindly accepted my challenge for an explanation of how sinewaves appear across an *LC* circuit from an applied step function of voltage.

In his case he prefers to use a very short and theoretically extremely high pulse of voltage from a generator with an extremely high internal resistance. He then proceeds with some high powered computer analysis and calculations which I do not understand at all. In fact, Ian admits that he may well be "simply solving the differential equations by stealth".

I agree, of course, that the terminal voltage across an inductor is proportional to the rate of change of magnetic flux linkage, and therefore current, within it. I also agree that the current through a capacitor is proportional to the rate of change of electric flux, ϕ_C, within it. This is in turn proportional to the rate of change of charge, q_C, across it. We may need to know, though, more about the Ether before we can fully explain these fluxes.

In the meantime however we can simply write the following equations. Voltage across inductor *L* is:



"Apart from the initiation waveform, which is non-linear and has a discontinuity, this waveform is explained by the mathematical analysis shown."

$$V_L = L\frac{d\phi_L}{dt} \equiv L\frac{di_L}{dt}$$

where ϕ_L is flux in the inductor, i_L is inductor current, d/d*t* is rate of change. Voltage across capacitor *C* is:

$$V_C = \frac{q_C}{C}$$

so,

$$\frac{dq_C}{dt} = C\frac{dV_C}{dt} + C\frac{d\phi_C}{dt} \equiv i_C$$

where ϕ_C is electric flux within the capacitor, and is proportional to the amount of charge, q_C, on it.

From these equations you can produce a second order differential equation whose solution is a sine function. I have discovered though that at the initiation of the oscillation, the rising voltage across the capacitance is non-linear since a small proportion of the initial voltage step appears across the capacitor before the sine oscillation gets underway. This seems to suggest that the capacitor also must contain some inductance which initiates the sine oscillation, then proceeding by the fall of voltage across the inductor which produces back emf to charge the capacitor.

Textbooks such as 'An Introduction to Electronics' by Dennis F Shaw, p 18, say though that initial voltage across the capacitor is zero, but I have found this not to be the case.

I conclude that simple mathematical analysis as outlined above gives the only explanation we can have at present for the waveforms produced. The exception is the initiation waveform across the capacitor, which is non-linear, containing a discontinuity.

Peter Dawe
Oxford

Ian replies:

On Mr Dawe's own analysis, there cannot be an instantaneous voltage step across an ideal capacitor, unless, that is, an infinite current flows – which was precisely the case with the delta function in Ref. 1. If Mr Dawe really seems to see an 'instantaneous' voltage step across the capacitor in his circuit, there is a limited number of possible explanations: i) the capacitor possesses significant series loss (possible, but unlikely, ii) The capacitor possesses significant inductance (as Mr Dawe himself suggests; was it a capacitor rated for pulse operation?), iii) The rise in voltage was not really instantaneous or, iv) There is a measurement error (it was not clear how Mr Dawe was measuring the voltage across the capacitor, which – from the diagrams – had neither end grounded.)

Analysis of the operation of his circuit is complicated by the fact that his 'step function' recurred, with alternating polarity, every 5ms; i.e. it was actually a 100Hz squarewave, while the resonant frequency of the tuned circuit to which it was applied was observed to be only some thirty times higher (approximately), with an unspecified Q. Furthermore, far from being instantaneous, the rise time of the 'step function' from zero to +4V was 50µs – around one sixth of the period of the tuned circuit's natural frequency.

A solution of the circuit's response to the given stimulation is straightforward, but could not be undertaken without exact values for the complex impedances of the components used. For example, the iron cored inductor doubtless had significant iron and copper loss in addition to its self capacitance. (The values of L and C – 0.0016µF and 5H – which Mr Dawe gives do not tally even approximately with his observed natural frequency of around 3kHz). The observed voltage step across the capacitor is probably due to the division of the applied step between the said 0.0016µF capacitor and the self capacitance of the inductor.

As the stimulus is a simple recurrent waveform, the circuit could be analysed in either the time or frequency domain though of course both analyses could give the same result. However, one important point is perhaps made clear more easily by consideration in the frequency domain. The squarewave drive signal will have significant harmonics up to the resonant frequency of the tuned circuit. If the tuned circuit has a high Q and resonates exactly at one of these harmonics, there will be no phase changes in the damped oscillatory response, only magnitude changes. However, slight mistuning either side of the harmonic can result in dramatic changes in the response, as was illustrated with actual measurements in Ref. 2. If, on the other hand, the circuit Q is so low that the response to one edge of the squarewave dies away completely before arrival of the next, then analysis of the effect of an isolated quasi-step function with a finite rise-time would give the complete solution. Either way, there is no need to invoke unknown effects of the Ether to explain the observed results.

1. Hickman, I, *Sinewaves step by step*, *EW+WW* March 1995, p. 215.
2. Hickman, I, Integrated creativity, *EW+WW* Jan. 1992, pp. 40-42.

It appears to me that for the experiment to have any value, the light must act as particles during its travel, because parallel waves would interfere with each other and ruin the experiment; but it has to act as waves on arrival in order to determine transit time difference by interference fringes. In the Michaelson-Morley centenary seminar, speaker Professor Kilminster said, "That has never been mentioned before". It has never been mentioned since – being suppressed for good reason.

To raise such questions, and there are many, is cheating, like making your pawn move as a combination of knight and bishop in a chess match. Science today is the manipulation of pre-agreed axioms and old knowledge; nothing more. Further, the request for more detailed statements of the axioms, as in my case with Michaelson-Morley, is resisted to the death. Today's science resembles the religious service, which should not be interrupted by the raising of theological questions.

My work on wafer-scale integration, described in *Wireless World* July 1981, was always rejected for publication by all learned journals, even though it attracted £16m of funding – including government funding – and became a widely praised product in the field. Of course, its suppression reduced the threat that it would upset the research funding being received in their universities by journal referees for their own approaches to WSI. In spite of my track record, my new WSI invention, *EW+WW* March 1989, for which I have worldwide patents, cannot be published in any learned journal.

In a letter in *Wireless World*, January 1983, I wrote that during 25 years of work, I have never succeeded in publishing any of my work on e-m theory in any British learned journal. This ban now extends to 35 years. However, Davis should particularly think about the refusal of the Establishment, when approached, to clarify the classical theory they are defending. Professor M Pepper FRS and his boss Professor A Howie FRS, head of Cavendish Laboratories, disagree with each other[2] as to where the negative charge comes from in the Catt Anomaly, *EW+WW* Sep '87. They refuse either to discuss it with us or with each other, or to say that the matter is of no importance.

Not only are new theories ignored and suppressed. We also find that the Establishment is nonchalant about its contradictory versions of old theory. See also the co existing, hopelessly contradictory, versions of a TEM wave pointed out in 'The Heaviside Theory', *WW* July '79, which has been totally ignored.

Ivor Catt
St Albans

1 Maddox says that suppression is increasing. "The epoch making paper by Francis Crick and James Watson outlining the structure of DNA, which appeared in *Nature* in 1953, would 'probably not be publishable today', Mr Maddox laments..." – *Daily Telegraph*, 1 May '89, p. 18.
2 Howie says it comes from the west. Pepper says that (since electrons would have to travel at the speed of light) it cannot come from the west, and must come from the south. Until this is resolved, we do not have a classical theory. Before it can exist, a theory has to be stated

Lend a golden ear

I followed Doug Self's series – and the debate that followed – with interest. As some of the statements expressed by readers that do not share Mr. Self's approach to amplifier design appeared to me at best biased, it is not surprising that Mr Self has lost his patience in the Feb. '95 letters column. True, the subjectivists' arguments have been around long enough, without much concrete progress, but could it be that engineers and the 'golden eared' are simply not speaking the same language?

To illustrate, one of my grammar school colleagues, who later became a professional musician, was able to detect signal level differences of a fraction of a decibel consistently, even if the changed level was presented to him after several minutes of silence. His ability was discovered accidentally. One of my stereo amplifiers had a 20.9kΩ resistor on one input and a 22.3kΩ on the other while the preamp output impedance was 1kΩ, and he noticed a difference in output levels between channels. No need to mention, he was able to detect absolute pitch, too.

Six years ago I owned an Alfa Romeo Sprint Veloce which developed a rattling sound in its engine. It turned out to be a loose screw on the air filter cover, but the mechanic noticed a hissing above 3000rev/min. Two days later I returned to him with a broken main bearing.

We are able to identify a familiar voice on the 'phone almost immediately, in spite of the badly distorted and band-limited signal, even if we have not heard the voice for many years.

Most of us will readily accept these impressive examples of performance of the ear-brain combination as a normal every-day experience. But when it comes to hi-fi equipment, our opinions change.

When discussing amplifier and speaker performance with musicians, I have often experienced that when I was talking of amplifier bandwidth, I had in mind the standard half-power definition, while they were referring to the frequency at which the phase is shifted by no more than a few degrees. When they were talking of clarity and presence, they were referring to being able to pin-point a sound source on the stereo image, while I was suspecting excessive 3 to 5kHz lift. When we were discussing transient performance, I was referring to the rise-time and overshoot of the response to a square-wave input, while they were referring to the attacking part of the complex waveform envelope which in most cases implied many waveform periods.

I'm certainly not advocating that audio engineers should rely on their ears only. But we should try to adopt the attribute of lawyers and doctors and listen carefully to what other people are saying before making a judgement. Indeed, we know the limitations of our instrumentation and we struggle hard to eliminate systematic errors when making sensitive measurements, so why not treat other people as sensitive instruments – albeit somewhat strange, sometimes unreliable ones?

Of course, the 'golden eared' must willingly accept being treated like instruments if they continue to seek credibility.

Erik Margan
Ljubljana
Slovenia

Supplies for audio power

I read with great interest the article 'Distortion off the rails' by D. Self in the March issue. While certainly not questioning Douglas' undoubted skills in audio amplifier design, may I draw attention to Douglas' statement, "I assume that any rail filtering arrangements will work with constant or increasing effectiveness as frequency increases; this is clearly true for resistor-capacitor filtering.

Taking as a base for availability the Farnell catalogue, data from Philips' 1994 Data Handbook, and assuming an axial capacitor of 100µF at 40V or more, as in Douglas' Figs 2&3, then the Philips 021 and 031 styles will have a self inductance of 40-50nH and an esr of some 0.55 to 1.2Ω at 10kHz, depending on exact choice. Also 47µF at 63V, depending on case size, can exhibit inductance up to 85nH.

Similar values of radial styles have less inductance, say 25nH. From Philips' data curves, these types have a self resonant frequency of around 20-50kHz. Above this they become totally inductive. Also at 100Hz, a typical esr of 1.25-2.5Ω must be expected.

As Douglas states, the amplifier internal loop gains will be reducing at frequencies when the capacitor starts to become inductive.

My two questions for Douglas are: what effect would a capacitor having 100µF, 50nH, 1Ω, as a series *LCR*, have on amplifier performance at 10kHz and above with regard to the simulation curves of Figs 2 & 3? Secondly, what effect would an esr of 2.5Ω, as a series *CR*, have on modelling or measurements at 100Hz?

Cyril Bateman
Acle
Norfolk

Douglas replies:
Mr Bateman is of course completely correct in pointing out that capacitors have parasitic inductance and esr, and that this is ignored in my article, which used only pure capacitance in the simulations However, a technical article is not a legal document; you cannot enumerate all the ifs and buts, and exceptions and caveats, without the prose becoming as uninformative as it would be unreadable. In this case, some of the concepts involved are not wholly straightforward (eg the change of reference in the voltage amplifier), and adding a further layer of complication simply to make the components more realistic would not have been a good idea.

The other point is that parasitic inductance, esr, etc, seem to make no difference in practice; ordinary electrolytics do the job very well. Ripple and signal voltages on the rails do not reach up into the rf regions, and even if they did, the series inductance of the supply conductors combined with the hf rail decoupling would reduce it. The only credible source of rf is commutation spikes in the bridge rectifier, and these need to be dealt with at source by the usual snubbing network.

Reflection on deflection

With reference to the piece 'Cathode-ray conundrum' in the April issue letters column, the proposition goes against provable laws of physics.

The effect described is of very small magnitude in relation to the others occurring at the same time – a potent source of error.

The flaw in Lerwill's proposition is that an electron beam which has been deflected off the precise axis of the acceleration system will have an effect in one or both of the orthogonal axes. There will be an electrostatic or electromagnetic interaction with the acceleration system, amounting exactly to the reaction which seems to have escaped – just too small to measure.

NPE Wheeler
Sutton,
Surrey■

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ACTIVE

Discrete active devices

Little mosfets. Meant for use on PCMCIA cards, Micrel's *MIC94030/1 TinyFETs* boast the lowest on resistance for their size, at 1Ω and 3.3V, and are contained in SOT-143 packages, being only a quarter of the size of current 8-pin SOIC mosfets. *MIC94030* is a basic 4-lead p-channel device, while the *MIC94031* has an internal gate pull-up resistor to turn the device off when driven by tri-state or open-drain logic. Solid State Supplies Ltd. Tel., 01892 836836; fax, 01892 837837.

Digital signal processors

NEC's *µPD7701X* family of general-purpose dsp chips has a new member with larger memory, the 3V *µPD77018*, which handles up to 250 million operations per second. Memory is 256 by 32 bit instruction ram and 24K by 32 bit rom, data memory consisting of two blocks of 3K by 16 bit ram and two blocks of 12K by 16 bit rom. The device has a 30ns instruction cycle time, a three-stage pipeline architecture and its instruction set enables eight operations to be performed in parallel. Development tools available operate through a workbench under Windows. NEC Electronics (UK) Ltd. Tel., 01908 691133; fax, 01908 670290.

Floating-point DSP. TI's latest digital processor, the *TMS320C32*, allows the use of floating-point techniques used for research and development in commercial products to eliminate the usual switch to fixed-point working for commercial use. It is available in 40MHz, 50MHz and 60MHz versions and uses new memory management and data packing features to allow the flexible use of 8-bit, 16-bit and 3-bit memory architecture. There is also a two-channel dma co-processor for data movement. SR Communications (Texas Instruments). Tel., 0181 692 7575; fax, 0181 692 8057.

Microprocessors and controllers

Miniature controller. Z World's newest C-programmable miniature controller is the *Little Genius*, with 26 i/o lines, intended for the OEM market for control and data acquisition use, although it also works as a core module interfacing with user-designed boards. Having 14 digital inputs and 12 digital outputs, seven of which handle high currents, and both RS232 and RS485, it is well suited to use in networked controllers. Features include an eeprom, battery-backed ram and real-time clock, programmable timers, a 9MHz processor clock, a watchdog timer and power-fail interrupt and an expansion port to the Z-World *PLCBus*, which allows the connection of a d-to-a converter or other boards such as the prototyping board on offer. If not in use for expansion, the bus will take eight more cmos inputs. The C development system for both dos and windows has many function libraries and program samples in source code. Greening Technology Ltd. Tel., 0116 2796500; fax, 0116 2796501.

Logic

3.3V logic devices. Quality Semiconductor announces seven 3.3V, 8bit logic elements, the *FCT3244* buffer/line driver, *FCT3245* transceiver, *FCT3373* buffered latch, *CT3240* inverting buffer, *FCT3540* flow-through inverting buffer, *FCT3541* flow-through buffer and *FCT3573* flow-through latch. They are all function and pin compatible with existing 5V devices and will accept 5V inputs while the outputs are at 3.3V. Speed is compatible with Bicmos and power consumption with cmos. Quality Semiconductor, Inc. Tel., 01420 563333; fax, 01420 561142

Memory chips

Low-voltage serial eeprom. New from Holtek of Taiwan, via Hero Electronics, is the *HT93LC46* 1Kbit serial eeprom, to which one can write to at 2.7V and read from at 2V. Operating current is 2mA and maximum standby 2µA. Data is retained for ten years. Hero Electronics Ltd. Tel., 01525 405015; fax, 01525 402383.

Mixed-signal ICs

Energy measurement. A range of five ICs from the South African firm of SAMES are for single and three phase ac power or energy measurement over a 60dB range, meeting the requirements of IEC 521/1036 for Class 1 ac watt-hour meters. They are protected against overvoltage and use shunt resistors or current transformers for current sensing, a voltage reference being built in. Output is either digital or analogue in form. Ginsbury (UK) Ltd. Tel., 01634 290903; fax, 01634 290904.

Optical devices

Laser measurement. Matsushita's *LM200* analogue laser is immune to surface irregularities and colour changes. This is because of its use of light feedback and triangulation range measurement to minimise analogue output error. An aspherical glass lens provides good linearity combined with low temperature drift. The measurement range is ±3mm or ±6mm while resolution is 1µm. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599.

Fibre pigtailed laser diodes. A series of diode laser assemblies designed to couple laser radiation into single and multi mode fibres is available from Melles Griot. Both visible and infrared diodes are used, the >700nm infra-red types being over 55% efficient and the <700nm visible diodes better than 30% efficient. Powers from 0.5mW to 30mW are offered. The housing is stainless steel and has a 1m length of fibre with a cleaved end, ST, FC and SC connectors being used. Melles Griot Ltd. Tel., 01223 420071; fax, 01223 425310.

Programmable logic arrays

Fast 128-cell device. AMD has brought out what it claims to be the fastest 128-macrocell complex programmable logic device, the *MACH231*. This is one of the new *Performance Plus* family of 7.5ns complex plds. The addition of power-down macrocells means that each macrocell can be configured into a low-power mode. Additionally, input/outputs and inputs have a latching facility to avoid the long pull-up times associated with resistors. Advanced Micro Devices (UK) Ltd. Tel., 01483 740440; fax, 01483 756196.

Oscillators

3.3V crystal oscillator. Q-Tech has a range of military-grade crystal clock oscillators, believed to be the first 3.3V types to operate over a –55°C to 125°C temperature range while preserving ±100ppm stability. Output is at logic level into 15pF with transient times of 3ns. Many package styles are available. Wavelength Electronics Ltd. Tel., 01843 602869; fax, 01843 862276.

PASSIVE

Passive components

Low-voltage tantalum. *Low-voltage Series* surface-mounted tantalum capacitors by AVX are rated at 2-10V and are meant for use in products needing 1.5-5V supplies. Packaging is of 1.2mm profile. AVX Ltd. Tel., 01252 770000; fax, 01252 770001.

Audio products

Audio codec. Crystal Semiconductor announces the *CS4225*, a multi-channel audio codec for automotive and surround-sound application, which replaces three stereo data

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converters, three volume-control ICs, an input multiplexer, a 12-bit a-to-d converter and numerous passive components, not to mention affording a reduction size over conventional equipment of around 90%. An on-board phase-locked loop generates clock pulses to reduce EMI. Crystal Semiconductor Corporation. Tel., (USA) 00 512 442 7555; fax, 00 512 445 7581.

Connectors and cabling

Board/board connector. Wieland pluggable board-to-board connector with 2-16 ways on a 5.08mm pitch is rated at 250V to VDE 0110 GR C and 10A. The female socket can be mounted vertically or at right angles to provide connection for daughter boards. Wieland Electric Ltd. Tel., 01483 31213; fax, 01483 505029.

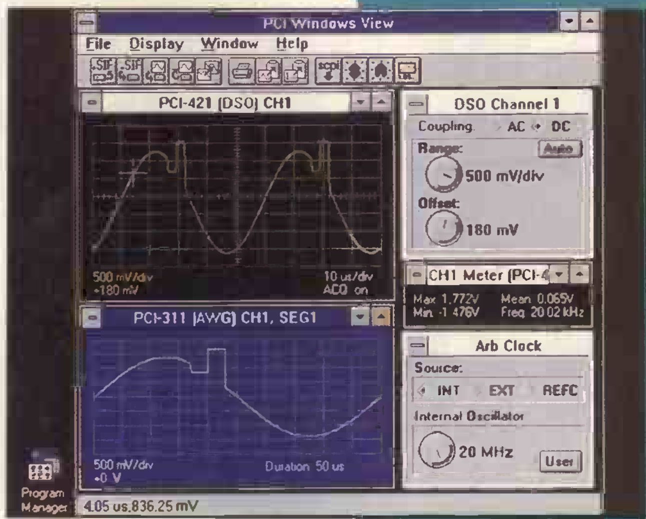
PCMCIA SM connectors. Methode *MCFK* Types I, II and III surface-mounting connector frame kits snap together without the assistance of glue or any other fixative. The connectors have stainless-steel covering, UL94V0 rating and electrical grounding via spring tabs. Surtech Interconnection Ltd. Tel., 01256 51221; fax, 01256 471180.

Bendy coax. From Belden comes *Conformable Coax*, an alternative to semi-rigid coaxial cable that can be hand manipulated into curves with radii down to 3.18mm, retaining its shape when formed. There are two types of microwave cable, *1671A* RG-405 type of 0.085in outside diameter and *1673A* (RG-402) of 0.138in od, both with 50Ω impedance. Type *1672A* is for video at 75Ω, having an od of 0.087in. Cables can be flexed many times without damage. Belden UK Ltd. Tel., 01483 726818; fax, 01483 771569.

IDC connector. Insulation-displacement connector blocks used by *Mod-Tap* in voice and data equipment are now available to network users. The blocks are designed for pcb mounting and can be used in wall sockets or patch panels. Termination tools are offered, but standard tools can be used. Blocks take two-pair and four-pair combinations and are in blue/orange, green/brown or in custom colour codes. MOD-TAP Ltd. Tel., 01703 701919; fax, 01703 704063.

Displays

Tft colour lcds. Ginsbury's *GE10* and *GE14* 10in and 14in thin-film transistor colour lc displays are said to give a stable image with no flicker. They may be driven by a dedicated graphics card for best quality or by an internal analogue card to emulate crt monitors. As an option, a capacitive touch screen can be fitted, RS232 and Windows mouse emulation is standard. A robust polystyrene enclosure suits industrial use and can be fully IP65 sealed on request. Ginsbury (UK) Ltd. Tel., 01634 290903; fax, 01634 290904



Waveform generator. Taking the form of a pc expansion board, the Scensys *PCI-311/2* occupy one slot and perform the functions of a stand-alone generator but rather more conveniently. Output from each channel is 12Vpk-pk into 50Ω from 12bit a-to-d converters with update rates to 50Msample/s to 0.01% frequency tolerance. A 99-segment waveform memory, each segment of which holding one waveform, allows the creation of irregular shapes such as video test patterns and encoded communications signals using *BenchTop* or *BenchCom* software, importing them from maths programs or from an oscilloscope card. Scensys Scientific & Engineering Systems Ltd. Tel., 01296 397676; fax, 01296 397878.

Filters

Programmable video filter. Raytheon's *RC6601* is an integrated continuous-time filter, fully programmable for video filtering, antialiasing, comms filtering and hdtv use. In addition, it costs about half as much as analogue filter alternatives. Cut-off frequency is voltage-variable in the 1 to 10MHz range and the device is phase-corrected to 0.2°; differential gain is 0.25%. It meets CCIR601 for NTSC and Pal signals, providing ±0.25dB pass-band ripple to 5.5MHz, with a –40dB pass-band starting at 8MHz. Ambar Components Ltd. Tel., 01844 261144; fax, 01844 261789.

Rf filters. Filters in the *BTF* range from BLP Components are for use in the protection of telephone networks, being flexible to accommodate future requirements, conforming to MIL-STD-220A and usable in all Tempest-rated networks as well as low-current control circuitry and audio lines. Configurations include two, four and ten line stand-alone forms and ten-line modules to fit 50, 100 and 200 line cabinets. They are in steel cases and are provided with idc connectors. BLP Components Ltd. Tel., 01638 665161; fax, 01638 660718.

Hardware

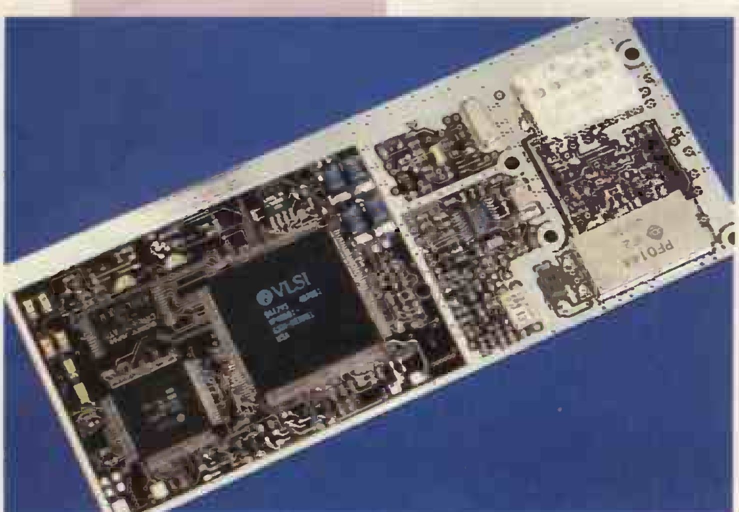
Control knobs. Attractive knobs in Sifam's *Trio* range are made using a technique whereby three shots of material are injected into the mould, providing a more versatile design and the opportunity for more detailed colour-coding. Material is nylon, with a matt body and contrasting gloss pointer. Two 11mm-diameter versions are made, with and without a nut cover, taking shafts up to 6mm diameter. The three-shot facility is also offered to customers needing custom-designed knobs, for which designs can be accepted in electronic form. Sifam Ltd. Tel., 01803 613822; fax, 01803 613926.

Instrumentation

Function generators. First members of Vann Draper's *H6000* series of function generators are the *H6000* and *H6001*, which produce sine, square, triangle, pulse and sawtooth outputs in the frequency ranges 0.1Hz-10MHz (*H6000*) and 0.2Hz-20MHz, prices being £149/199. Both allow external frequency control for modulation, sweep and pulse modulation. Outputs are ttl and 50Ω, with 600Ω as an option, controlled by switched attenuator and a continuous control. Thd is under 1% and triangular wave linearity better than 99%. Vann Draper Electronics Ltd. Tel., 0116 2813091; fax, 0116 2570893

Communications equipment

Two-chip GSM set. Two ICs from VLSI, the *VP22002* kernel processor and *VP22020* vocoder carry out all necessary baseband signal processing for a Global System for Mobile Communications (GSM) system, from speech vocoding to the radio system modular interface. The kernel processor contains the type-approved GSM blocks channel coder, equaliser, GSMK modulator and timing generator and VLSI's *Functional System Block* techniques including a 32-bit asynchronous response mode (ARM) microcontroller, operating at one instruction per clock cycle to give a processing power of 13Mips. Development tools are supplied. Operating at 13kbit/s, the vocoder provides fully asynchronous coding and decoding, having two asynchronous data ports and a host processor interface. The analogue front end has two low-noise input preamplifiers and a second microphone and speaker interface give hands-free operation. VLSI Technology Ltd. Tel., 01908 667595; fax, 01908 670027.



CPC – components. A new *circa* 1600-page catalogue from CPC – a company said to be UK's leading specialist spares distributor – is now available. Products carried include batteries, cables, capacitors, connectors, power supplies and semiconductors. This A4 publication also features industrial and office equipment, and, of course, a multitude of spares for consumer, office and industrial electronic equipment. CPC plc, Tel., 01772 654455, fax 01772 654466.

Digital video analyser. Rohde & Schwarz's *Video Component Analyser* is a video analyser and waveform monitor in one case, and said to be the first wholly digital instrument of its kind. Measurement of analogue television waveform monitors is combined with new functions to allow monitoring of digital encoding and signal transmission, detecting errors in transmission, showing bit errors and checking sync. frame. Features include the numeric dump function to allow video signals to be shown at bit level. Rohde & Schwarz UK Ltd. Tel., 01252 811377; fax, 01252 811447.

MIDI-Scope. Artistic Licence has the *MIDI-Scope*, a hand-held analyser for the Musical Instrument Digital Interface. When used as a receiver, the lcd screen shows data either in hex or as command icons, while received data can be stored for later analysis or re-transmission. The transmitter is used to regenerate received data or to transmit up to eight programmable messages. Other functions include cable testing, oscilloscope triggering and an RS485 output boost to drive long cables. Artistic Licence (UK) Ltd. Tel. and fax, 0181 863 4515.

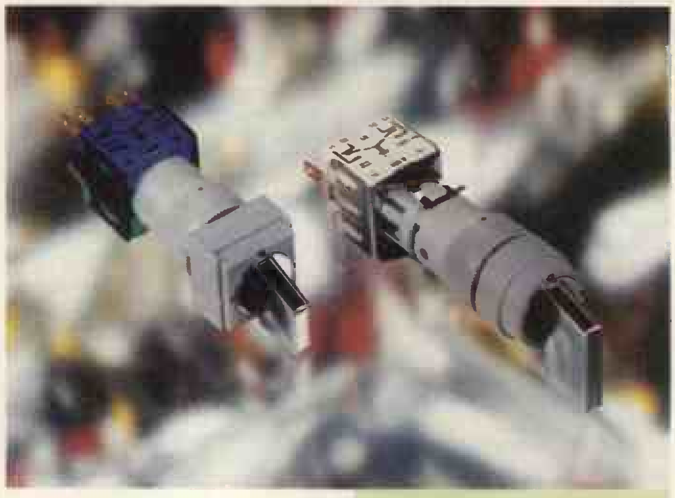
Cable simulator. Designed to simulate the effect of up to 500m of coaxial cable on serial digital signals, Faraday's *Cable Clone* is a hand-held unit, requiring no other equipment, that is simply connected in the cable. By means of eight switches, the effective cable length is increased in 5m steps until the signal deteriorates to an unacceptable point. The length of cable inserted indicates the margin. *Cable Clones* simulate amplitude and differential group delay of coax. with the SMPTE 267 360Mbit/s serial signal from 5MHz to 360MHz. Faraday Technology Ltd. Tel., 01782 661501; fax, 01782 630101.

Comms test set. H-P's *HP 8920B* communications test set has more than 22 functions to measure the performance of radio telephone equipment, including signal generator, modulation analyser, power meter, audio sources, digital oscilloscope, sinad meter, frequency meter and, as an option, a spectrum analyser with tracking generator. Measurement programmes are stored on a PCMCIA card. Hewlett-Packard Ltd. Tel., 01344 366666; fax, 01344 362269.

Nanovolt/micro-ohm meter. *HP 34420A* by Hewlett-Packard is a low-noise nanovolt-microhmmeter offering 7.5-digit resolution, 2ppm, 24-hour dc voltage accuracy and selectable filtering. There is a two-channel programmable scanner for ratio and difference measurement, and built-in conversion routines to display thermocouple, thermistor and rtd readings directly in degrees, resolved to 0.001°C. Features include scaling and statistics functions, 1024-reading memory, chart recorder analogue input, RS-232 and HP-IB interfaces and both SCPI and Keithley 181 programming languages. Hewlett-Packard Ltd. Tel., 01344 366666; fax, 01344 362269.

Direct recording oscilloscope. Gould's *DataSYS 765* dr oscilloscope has a 500Mbyte hard-disk drive and handles direct data recording to disk at up to 250Kbyte/s with no dead time. Recordings can also be made to paper or recalled from disk to paper. As a 150MHz digital storage oscilloscope, the instrument offers 100Msample/s single-shot acquisition on four channels. Although the *765* captures glitches down to 10ns, the storage provided allows recording for a period of 230 days, recordings being displayed as though on a paper roll, but with more control. Gould Instrument Systems Ltd. Tel., 0181 500 1000; fax, 0181 501 0116.

Conductive greases. Two types of grease from Planned Products of Santa Cruz not only lubricate and protect against moisture, but provide electrical and thermal conduction to drain away static and provide grounding and to dissipate heat. *Circuit Works Conductive Grease 7100* for low-to-medium loads and speeds is a silicone grease containing silver for greatest conductivity, giving a typical resistivity of <0.01Ωcm and high thermal conductivity. It is stable over the –57 to 252°C temperature range. Unworked and worked penetrations are 210 and 250, with steel-on-steel wear of 1.5mm. The *7200 Carbon Conductive Grease* has <30Ωcm resistivity, with penetrations of 335 and 338, wear measuring 2mm. Both types are chemically inert, thermally stable and non-flammable. Intertronics Ltd. Tel., 01865 842842; fax, 01865 842172.



Modular switches. Lever switches in the Swiss *SwissTac* range of modular types are now obtainable in the UK. Virtually all elements of the switches are interchangeable, contacts at the rear remaining in the same plane when switches are block mounted. Since contacts can be removed from the switch, it is possible to carry out the wiring as a separate process. Switches are available in five sizes from 18mm diameter to 24mm square, in grey or black, the actuators being black or chromed. EAO-Highland Electronics Ltd. Tel., 01444 236000; fax, 01444 236641.

Literature

SM oscillators. Surface-mounted crystals and oscillators by *M-tron* are now obtainable in the UK and are described in a new 40-page catalogue containing details of, among many other devices, crystals for use in extreme environments and oscillators for use as clock generators and in military application. Semi-Dice (UK) Ltd. Tel., 01494 488353; fax, 01494 771396.

RS Components. In its new catalogue, RS Components introduces over 200 new potentiometers from makers including Bourns, Meggit Piher and Spectrol. From Bourns, a 6mm, 0.5W pot. for machine adjustment and with a multi-wire wiper; by Meggit Piher, a series of 10mm, 150mW and 12mm, 200mW units with plug-in spindles and top or side adjusted edge wheels as options; and 12mm cermet pots by Spectrol rated at 1W and offering ±100ppm/°C temperature coefficient. RS Components Ltd. Tel., 01536 201234; fax, 01536 405678.

Batteries. Batteries by Univercell are described in a new loose-leaf brochure. The company, formed by a group of managers from Ever Ready, manufactures layer cell zinc-carbon types, NiCd, special packs using various types of cell and memory-protection NiCd batteries. It also undertakes packaging to order. Univercell Battery Company Ltd. Tel., 01952 580505; fax, 01952 680075.

Loughborough Sound Images. In 132 pages, LSI provides details of a comprehensive range of digital signal-processing hardware and software support for VMEbus, PCbus and SBus, and a product guide to equipment for industrial image processing and video multimedia. Loughborough Sound Images Ltd. Tel., 01509 634300; fax, 01509 634333.

Blue Micro. Blue Micro is IBM's representative company, dealing only in IBM products. On offer is the company's 20-page publication giving brief details of, for example, the *Blue Lightning 486* 32-bit microprocessor, the *Power PC* 64-bit and 32-bit risc processors and the *403GA* 32-bit risc embedded controller. Also covered are peripheral chips and sets, MPEG-2 decoding, memory and PCMCIA products. Free from Blue Micro Electronics. Tel., 01604 603310; fax, 01604 603320.

Materials

Insulation for semiconductors. *Thermaflex* tube by Warth is in a flexible plastic material designed to fit round semiconductor packages to allow them to meet higher flash test requirements while retaining good thermal performance. A 0.5mm wall takes most standard packages and grips the device for assembly. Tubes come in two sizes: 25mm long by

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10mm wide for TO-220 packages and 30mm long by 13mm wide for TO-218/3P/247 and SOT-93. Catalogues and samples available. Warth International Ltd. Tel., 01342 315044; fax, 01342 312969.

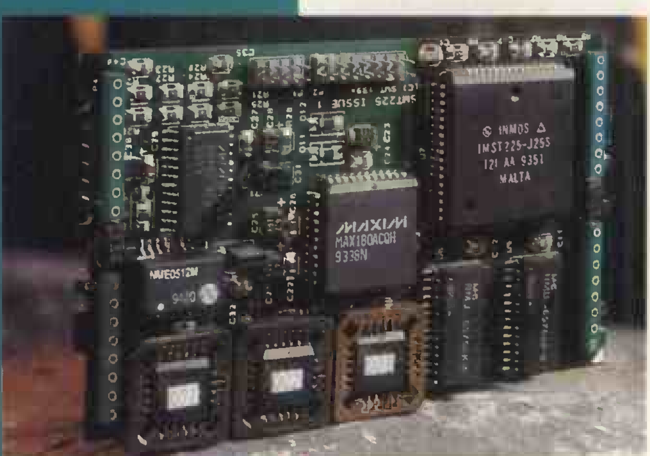
Power supplies

Power-factor correction. XP has provided power-factor correction on its *ZX series* 350/550W power supplies to meet the requirements of EN61000-3-2 and EN55022 without increasing unit size, so that they can replace uncorrected supplies with no mechanical redesign. The psus are universal-input types covering the 2V-60V range of outputs. XP plc. Tel., 01734 845515; fax, 01734 843423.

Radio communications products

Vhf transmitter/exciter. *SU 125* from Rohde and Schwarz is said to be the first true vhf transmitter/exciter, as opposed to those that are simply modulators, with driver stages and add-ons. This contains in one case the stereo coder, modulator, rf amplifier, deviation meter, transmitter control and monitor, the latter two facilities allowing the unit to be combined with any fm amplifier. The microprocessor would then monitor, protect and control the amplifiers and exciter. Inputs include af and auxiliaries such as RDS and interfaces for remote control. It is usable as a stand-alone 20W transmitter or can be used with an R&S 600W vhf amplifier. Rohde & Schwarz UK Ltd. Tel., 01252 811377; fax, 01252 811447.

Data converter interface. *SMT225* is a size 2 TRAM board (TRAnsputer Module in parallel processing systems) by Sundance that combines 12-bit d-to-a and a-to-d converters with a 25MHz transputer to provide a versatile interface for control. It is half the size of alternatives and about one-third the price. Sundance Multiprocessor Technology Ltd. Tel., 01494 431203; fax, 01494 726363.



Protection devices

3V transient protection. Protek's *SOT/SMDB* series of silicon avalanche transient voltage suppressors are expressly designed for 3V/3.3V use at up to 500W, protecting one or four unidirectional lines, being packaged in SOT-23 or SO-8 respectively. Theoretical response times are 8μs and 20μs. Hunter Electronic Components. Tel., 01628 75911; fax, 01628 75611.

Switches and relays

Power reed relays. *S series* vacuum reed relays made by Kilovac Corp. are high-voltage, high-power types for use at rf and with a mechanical life of 50 million operations. Voltage ratings are up to 10kV at 5A continuous, and the contacts switch 500W loads. Standard coils are 5V, 12V and 24V. LRE Relays + Electronics Ltd. Tel., 01962 734433; fax, 01962 734685.

Slow relay. With turn-on and turn-off times of 8.5ms and 4.1ms, Matsushita's *Soft-on/off PhotoMos* solid-state relay reduces the transients that occur when switching reactive or incandescent filament loads, thereby protecting itself and associated components; no other forms of transient protection are needed. Contacts handle 4A at 80V. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599.

Hf relays. *RK* and *RG* relays by Matsushita exhibit an insertion loss of 0.3dB at 900MHz and use only 200mW, or less when the optional latched type is driven by pulses. Contacts are single or double changeover and the footprint is 20.2mm by 11.2mm. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599.

Transducers and sensors

Low-pressure sensor. Higher sensitivity than is common, 100mV for $1lb/in^2$ compared with around 50mV, is offered by IC Sensors' new board-mounted, temperature-compensated device in TO-8 or HIT packaging. Two ranges cover $0\text{-}0.03lb/in^2$ and $0\text{-}1lb/in^2$. Linearity (best fit straight line) is around 0.01% of span. Eurosensor. Tel., 0171 405 6060; fax, 0171 405 2040.

COMPUTER

Vision systems

PCI-bus image capture. Image Technologies has the *IC-PCI* high-speed board offering 'plug-and-play' facility for image acquisition on the PCIbus, direct-memory access being provided. Transfer rate is up to 80Mbyte/s directly to a PCI VGA card and acquisition rate to local memory up to 40Mbyte/s. DataCell. Tel., 01628 415415; fax, 01628 415400.

Computer board-level products

Single-board computer. Motorola's *68360* processor with on-board Ethernet and the *68060* make Syntel's *SYN-SBC5* single-board computer suited to both communications and control applications. It has a processing speed of 60Mips and possesses up to 32Mbyte of dram, 16Mbyte of flash eprom and 2Mbyte of sram. There is a PCMCIA interface, a SCSI interface and an on-board 32-bit graphics controller supporting lcds, electroluminescent and crt displays. Syntel Microsystems. Tel., 01484 535101/2/3; fax, 01484 519363.

PC instrument control. National Instruments offers the *PC/104-GPIB*, an IEEE488 interface board for embedded pcs with *PC/104* expansion. It is compatible with NI's *AT-GPIB/TNT* plug-in interface and uses the *HS488* mode for GPIB transfers to 1.6Mbyte/s, enabling an embedded pc with the *PC/104-GPIB* to control, monitor and communicate with GPIB-based instruments. National Instruments UK. Tel., 01635 523545; fax, 01635 523154.

Computer systems

Single-chip PC core logic. NEC and Future Technology Devices collaborated to produce the *FTD 82C4591*, a single-chip device containing the core logic of a *386/486* pc-compatible embedded control system with bus speeds to 66MHz. It has ISA and VL-bus interfaces with programmable speed and only needs standard buffers for the ISA address lines. The device connects directly to an sram-based, direct mapped, bank interleaved cache, supporting write-back and through modes. Sunrise Electronics Ltd. Tel., 01908 263999; fax, 01908 263003.

PC-AT-compatible board. Arcom has a new PC-compatible single-board computer, the *VSCIM486DX*, using the 100MHz 486DX4 processor. A full VMEbus interface is complemented by ports to the SCIM mezzanine local expansion bus, the *Signal Conditioning Scheme* (SCIM), STEbus and two memory expansion buses. It can be provided with 68Mbyte of dram, 256Kbyte of cache sram, 128Kbyte of battery-backed ram dual-ported to STEbus and an accelerated SVGA graphics controller with 1Mbyte of ram; the chip incorporates a 32-bit maths co-processor. Since the board runs dos and windows, software such as *LabView* is accessible. Arcom Control Systems Ltd. Tel., 01223 411200; fax, 01223 410457.

Industrial workstations. H-P's *HP9000* workstations are based on the company's *PA-RISC* processors running at up to 100MHz and supporting H-P's version of UNIX, HP-UX. Models *745i/50* and *745i/100* are the basic types with four EISA slots and 50MHz or 100MHz *PA-RISC* processors, while *747i/50* and *747i/100* have six VME slots and two EISA slots. XP plc. Tel., 01734 845515; fax, 01734 843423.

Data communications

Digital packet radio. *PackNet-2* by the Swedish company Radius is a vhf/uhf packet radio for remote control telemetry and data transfer, providing a link between the components of computer networks and control systems. Radio transceiver, microprocessor control and modem are combined in one box and a built-in repeater or external repeaters allow for extension of a network. *PackNet-2* offers both serial and parallel connection, a full RS-232-C interface being provided. Radius Telecommunications (UK) Ltd. Tel., 01256 469460; fax 01256 842362.

Multimedia

Installation diagnostics. Developed to assist those installing or upgrading pcs with multimedia hardware, Eurosoft's *CD-Check Diagnostic Disk* tests the installation and operation of cd drives, memory, sound cards and

Media accelerators. *BtV MediaStream* by Brooktree is first in a family of products combining hardware and software to allow a pc to take full advantage of the facilities offered by multimedia offerings. It is a three-chip set enabling dos games-compatible audio or digital sound, 1280 by 1024 graphics and 30frame/s, television-quality, full-motion video windows. BtV MediaStream is intended for use with add-on cards, 486 VL local-bus systems and the new PCI-based *Pentium* pcs, either on cards or on the motherboard. An important feature is the provision to output all-digital audio directly to consumer equipment with digital ports, such as DAT and cd players. The system produces high-quality graphics even when multiple windows run and good video lip-sync. at 30frame/s. It also supports standards such as the Microsoft MCI and DCI extensions under Windows and Microsoft's Plug-and-Play. Brooktree Ltd. Tel., 01252 811358; fax, 01252 811505

display, supplying a report on the results. It checks all system components to the Multimedia PC Council (MPC) standards. Eurosoft (UK) Ltd. Tel., 01202 297315; fax, 01202 558280.

Programming hardware

In-circuit programmer. In-circuit, board-level programming becomes necessary in military or other critical applications when ICs must be programmed after assembly, to ensure nothing happens to the data during soldering. Stag has produced the *ICP 9000* board-level programming system which reduces the need for extensive mechanical work in interfacing to the board and for complicated software where the board contains ICs other than eproms. With the *ICP 9000*, the only interface needed is a removable interface adaptor and the software can be written much more easily, by a technician, using a purpose-designed high-level language, so that boards not designed to accept ICP are able to benefit. A library of definition files further reduces the programming needed and facilitates the writing of programs for future requirements. The time taken for the process is said to be reduced from weeks to hours. Stag Programmers Ltd. Tel., 01707 332148; fax, 01707 371503.

Software

Interconnection analysis. *IPA 510 Interconnect Parameter Analyser* by Tektronix is an expansion of the earlier *IPA 310*. In essence, it models and verifies the interconnections of semiconductor devices on boards and even from the chip to the pins of packages. The system consists of a time-domain reflectometry oscilloscope and associated software. *IPA 510* will extract and verify Spice models, perform tdr and td transmission and execute network analysis, presenting true impedance diagrams of purely passive interconnections from zero to 12.5GHz and modelling energy through dissipation or coupling to effects on adjacent traces on the board. Interfaces for *Contec-Spice* and *P-Spice* are available and, since the system links measurement and Spice simulation, Spice models can be developed by extracting models from overlay of time-domain results. The oscilloscope used is an *11801B* and the software runs under Windows. Tektronix UK Ltd. Tel., 01628 486000; fax, 01628 474799.

Development tools. *TNT Embedded ToolSuite* by Phar Lap is a set of tools, running under dos or Windows, for the development of 32-bit embedded systems based on the Intel *386/486* family. It supports 32-bit C and C++ compilers from Borland, Microsoft and MetaWare. Facilities include the *TNT* embedded kernel, *Visual System Builder*, a 32-bit linker/locator, embedded cross-debugging, C and C++ run-time libraries and a floating-point emulation library. Phar Lap Software Inc. Tel., 00 617 876-2972; fax, 00 617 661 1510.

Ice debugger for Windows. Nohau has introduced a Windows-based in-circuit emulator debugger for the *8051* emulator. The debugger uses an unlimited number of windows instead of the common single one, displaying data in up to 12 different forms simultaneously. In this way, the user can view at the same time C source code, disassembled code, data, assembler with comments and more. The debugger comes either as a package with the emulator or as a software update for existing users. Nohau UK Ltd. Tel., 01962 733140; fax, 01962 735408.

Fm noise analysis. The fm noise simulation package by Phasor Design includes the facility to determine bit error rate in digital communications systems from carrier-to-noise ratio and the ssb phase noise of oscillators, fm deviation, emphasis and noise weighting being included. It carries out numerical integration in the frequency domain to obtain s:n ratio, numerical summation of the amplitude distribution giving error probability to one bit. The package runs on a pc with a gui, and data files of system characteristics such as phase noise and de-emphasis are included or can be written by the user. Phasor Design. Tel., 01858 432148; fax, 01858 432109.

Instrument-to-program translator. *SoftwareWedge* takes serial input data from measuring instruments fitted with RS-232, parses it and filters it to suit any application program running on a pc, as though the data were being typed in. In the other direction, keyboard and program instructions to the remote instruments are also translated into the correct form. Dos and Windows versions are available, the Windows version also supporting OS/2, NT and DDE. Kyle Data Service Ltd. Tel., 01292 311169; fax, 10292 318005.

Bare-board tester. *FIXpert* is a windows-based package to make drill patterns and test programs for the testing of unpopulated printed-circuit boards to design data. Since the 'known good board' approach is not used, the possibility of a fault being perpetuated is avoided. Drill files and their test programs are automatically produced and the whole process of creating the test routine from input to production of files and test program takes under an hour. Dense boards are 100% tested in two passes and double-sided boards are tested for side-to-side connectivity. Circuitest Ltd. Tel., 01903 218086; fax, 01903 218689. ■

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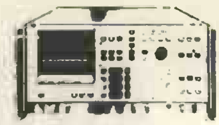

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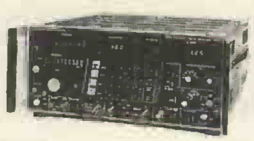

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