





AUGUST 1981 Vol 3 No 10

Editor: Hugh Davies Senior Art Editor: Andrew Sawyer Advertisement Sales Executive: Melanie Mackenzie-Aird

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Ready for use — the HE Electronic ignition project (see page 10) which when complete requires only four connections to your car's ignition system. (The project shown on this month's cover was the prototype, with its high-power resistor mounted in the case. The final version has a surface-mounted resistor as shown above, for better heat dissipation



Ready for flight — one of the radio-controlled model 'planes at Sandown Race Course on 9th and 10th May. See Radio Control, this month's special feature, on page 15, followed by the report on Sendown on page 20



Ready for measurements special-offer HE Multitester (see page 51), which complements into Electronic Components, a naw series starting this month on page 47

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Which amplifier?

I.L.P. Amplifiers now come in three basic types, each of which is available with or without heatsink. Having decided the system you want - home hi-fi (models HY30, 60 or 120 for example), super quality hi-fi with extra versatility (MOS120, MOS200) or Disco/PA/Guitar (HD120, HD200 or HD400) you will then decide whether amplifiers housed within their own heatsinks or plate amplifiers for bolting to a metal chassis will suit. With choice such as this and a brilliant new range of I.L.P. functional modules to choose from you now have the chance to build the finest audio system ever offered to the constructor.

G FUNCTIONAL NODULES

BIPOLAR Standard, with heatsinks

*1	DISTORTION		DISTORTION		DISTORTION										
MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D. Typ at 1kHz	LNLD. 66HZ/7kHz 8:1	SUPPLY VOLTAGE TYPIMAX	SIZE mm	WT gms	PRICE	VAT	MOOEL NUMBER	SIZE in mm	WT gms	PRICE	VAT		
HY 30	15w/4·8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09							
HY60	30w/4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					-		
HY120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33		
HY200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77		
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	E4.77	HY400P	120x26x70	375	£28.33	£4.25		

S/N ratio: 100db Frequency response (- 3dB): 15Hz - 50kHz Damoing factor: (8Ω/100Hz)>400

HEAVY DUTY with heatsinks							Without heatsinks											
H0129	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	H0120P	120x26x50	265	E19.84	£2.98					
H0200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	E4.11	HD200P	120x26x50	265	£23.63	E3.54					
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	E34.28	E5.14					

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent). τı

1e l	Heavy	Duty	range ca	n claim	additional	i output po	nver devi	ces and	complet	nentary	protection	i circuitry	with p	ertormanci	e specs. a	as for	standard	l types

MOSFET Ultra-Fi, with heatsinks								Without heatsinks									
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50				
M05200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	E4.28				
M05400	240w/4Ω	<0.005%	<0.006%	±55±60	120x 78x 100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84				

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).

Ultra-fi specifications: Slew rate: 20Vius

Frequency response (- 3dB): 15Hz - 100kHz Demping lector: (8Ω/100Hz)>400 S/N ratio: 100db Rise time: 3µs Input sensitivity: 500 mV rms Input impedance: 100k Ω

EL

POWER SUPPLY UNITS

FOR USE WITH	PRICE	VAT
+ 15V combinations of HY6/66 series to		
a maximum of 100mA	£4.50	£0.68
The following will also drive the HY6/66		
series except HY67 which requires the PSU30.		
1 or 2 HY30	£8.10	£1.22
1 or 2 HY60	£ 10.94	£1.64
1 x HY 120/HY 120P/HD 120/HD 120P	£13.04	£1.96
1 x MOS120/1 x MOS120P	£13.32	£2.00
1 or 2 HY 120/HY 120P/HD 120/HD 120P	£15.92	£2.39
1 or 2 MOS120/MOS120P	£ 16.20	£2.43
1 x HY 200/HY 200P/HD 200/HD 200P	£ 16.20	£2.43
1 x MOS200/MOS200P	£16.32	£2.45
2 x HY 200/HY 200P/HD 200/HD 200P or		
1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
1 or 2 MOS200/MOS200P/1 x MOS400/		
1 x MOS400P	£21.46	£3.22
	FOR USE WITH ± 15V combinations of HY6/66 series to a maximum of 100mA The following will also drive the HY6/66 series except HY67 which requires the PSU30. 1 or 2 HY30 1 or 2 HY60 1 x HY120/HY120P/HD120/HD120P 1 or 2 HY60 1 x HY120/HY120P/HD120/HD120P 1 or 2 HY60 1 x HY120/HY120P/HD120/HD120P 1 or 2 HY120P/HD120/HD120P 1 or 2 HY120P/HD120/HD120P 1 or 2 HY120P/HD120/HD120P 1 or 2 HY120P/HD120P/HD120P 1 or 2 HY120P/HD120P/HD120P 1 or 2 HY120P/HD120P/HD120P 1 or 2 HY200/HY1200P/HD200/HD200P 1 x HY200/HY200P/HD200/HD200P or 1 x HY400P/HD400P 1 or 2 MOS200/MOS200P/1 x MOS400/ 1 or 2 MOS400P	FOR USE WITH PRICE ± 15V combinations of HY6/66 series to a maximum of 100mA £4.50 The following will also drive the HY6/66 series except HY67 which requires the PSU30. £8.10 1 or 2 HY30 £10.94 1 or 2 HY60 £13.04 1 x HY120/HY120P/HD120/HD120P £13.04 1 x HY120/HY120P/HD120/HD120P £15.92 1 or 2 HY60 £16.20 1 x HY20/HY120P/HD120/HD120P £16.20 1 x HY200/HY200P/HD200/HD200P £16.20 1 x HY200/HY200P/HD200/HD200P or £16.32 2 x HY200/HY200P/HD200/HD200P or £21.34 1 or 2 MOS200/MOS200P/1 x MOS400/ £21.46

FP480 BRIDGING UNIT FOR OOUBLING POWER

Without heatsinks

Designed specially by I.L.P. for use with any two power amplifiers of the same type to double the power output obtained and will function with any I.L.P. power supply. In totally sealed case, size 45 x 50 x 20mm, with edge connector. It thus becomes possible to obtain 480 watts rms (single channel) into 8Ω. Contributory distortion less than 0.005%. Price: E4.79 + 72p. V.A.T.

TD.

FREEPOST, 6 Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP Telephone (0277) 54778 (Technical (0227) 64723). Telex 965780 vailable also from MARSHALLS, TECHNOMATIC, WATFORD ELECTRONICS and certain other selected retailers.

ECTRONICS



5



NER IIP

20 POWER AMPS

WATTS RMS Single Channel

AMPLIFIER WITH **HEAT SINK**



Protection: Load line, momentary short circuit (typically 10 sec) Slew rate: 15Vlps Rise time: 5ps Input sensitivity: 500mV rms Input impedance: 100kΩ

J F A A E A E

Which modules?

In launching eighteen different units all within amazingly compact cases to help make complete audio systems using I.L.P. power amplifiers, we bring the most exciting, the most versatile modular assembly scheme ever for constructors of all ages and experience. Study the list - see how these modules will combine to almost any audio project you fancy - and remember all I.L.P. modules are compatible with each other. they connect easily. Modules HY6 to HY13 measure 45 x 20 x 40mm, HY66 to HY77 measure 90 x 20 x 40mm. They are so reliable that all I.L.P. modules carry a 5 year no quibble guarantee.

ti m q	Tey connect easily. Module neasure 90 x 20 x 40mm. T uibble guarantee.	es HY6 to HY13 measure 45 x 20 x 40mm. HY They are so reliable that all I.L.P. modules carry	66 to HY77 7 a 5 year no	THE	initititititititi	Nition 1
MODEL NO.	MODULE	DESCRIPTION/FACILITIES		PRICE	VAT	ALLEN
HY6	MONO PRE AMP	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Volume/Bass/Treble	10 m A	£6.44	£0.97	
HY7	MONO MIXER	To mix eight signals into one	10 m A	£5.15	£0.77	
HY8	STEREO MIXER	Two channels, each mixing five signals into one	10mA	£6.25	£0.94	The modules are encapsulated and include
HY9	STEREO PRE AMP	Two channels mag. Cartridge/ Mic + Volume	10 m A	£6.70	£1.01	latest design high quality clip-on edge connectors.
HY11	MONO MIXER	To mix five signals into one + Bass/Treble controls	10 mA	£7.05	£1.06	
*HY12	MONO PRE AMP	To mix two signals into one + Bass/Mid-range/Treble	10 m A	£6.70	£1.01	For easy mounting we
*HY13	MONO VU METER	Programmable gain/LED overload driver	10mA	£5.95	£0.89	R6 Mounting board for
HY66	STEREO PRE AMP	Mic/Mag. Cartridge/Tape/Tuner/Aux + Volume/Bass/Treble/Balance	20 mA	£12.19	£1.83	modules HY6 - HY13 78p+12p. V.A.T
HY67	STEREO HEADPHONE	Will drive headphones in the range of $4\Omega~=~2K\Omega$	80 m A	£12.35	£1.85	B66 Mounting board for HY66 - HY77
HY68	STEREO MIXER	Two channels, each mixing ten signals into one	20 m A	£7.95	£1.19	99p+13p. V.A.T
HY69	MONO PRE AMP	Two input channels of mag. Cartridge/ Mic + Mixing/Volume/Treble/Bass	20mA	£10.45	£1.57	
HY71	DÚAL STEREO PRE AMP	Four channels of mag. Cartridge/Mic + Volume	20mA	£10.75	£1.61	full connection data.
*HY72	VOICE OPERATED STEREO FADER	Depth/Delay	20 m A	To be a	nnounced	
*HY73	GUITAR PRE AMP	Two Guitar (Bass/Lead) and Mic + separate Volume/Bass/Treble + Mix	20 m A	£12.25	£1.84	
+HY74	STEREO MIXER	Two channels, each mixing five signals into one + Treble/Bass	20mA	£11.45	£1.72	
†HY75	STEREO PRE AMP	Two channels, each mixing two signals into one + Bass/Mid-range/Treble	20mA	£10.75	£1.61	
†HY76	STEREO SWITCH MATRIX	Two channels, each switching one of four signals into one	20 m A	To be ar	nnounced	I.L.P. Products
+HY77	STEREO VU METER DRIVER	Programmable gain/LED overload driver	20 mA	£9.25	£1.39	Design and

Ready August – may be ordered now †Ready September - may be ordered now

All the above modules operate from ±15V minimum to ±30V maximum – higher voltages heing accommodated by use of dropper resistors. HY67 can only be used with the PSU 30 power supply unit

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G

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MONITOR

EDITORIAL

When we announced the postponement of Hobby Electronics '81 - the exhibition that we had planned to hold at the Bristol Exhibition Centre from 29th to 31st May - we had hoped that everybody would

receive notice of its cancellation. We were sorry to hear that, despite our attempts to spread the news, several readers suffered a wasted

Why was it cancelled? We simply had insufficient trip to Bristol.

support from the trade to make it worthwhile. This lack of support puzzled and disappointed us, because the media covering South Wales and the West of England had shown great interest in an Exhibition dedicated to electronics hobbyists. We even had en-

quiries from a local hospital radio station.

Despite the cancellation, the Wales and West Schools' Electronics Project Competition, which was to have been judged at the Exhibition, went ahead as promised. Details of the winning entries are given on

page 28.

Hugh Davies Editor

35 MHz R/C News

ON 1ST JANUARY 1981, a band of frequencies between 35.010 MHz and 35.200 MHz was made available for model aircraft radio control use. Radio-controlled boats and cars are still restricted to either 27 MHz, or the UHF band around 459 MHz.

In order to make best use of this new band, and to maintain compatibility with the rest of Europe, 10 kHz channel spacing was adopted, as opposed to the nominal 25 kHz spacing in use on the 27 MHz band. The Society of Model Aeronautical Engineers (SMAE) representing the aeromodellers, and the Model Hobby Trade Federation (MHTF) representing the manufacturers and importers of R/C equipment, jointly drafted a code of practice to ensure that transmitters sold to operate on the new band would be capable of safe operation at these close spacings.

Unfortunately, some enterprising importers have taken advantage of a loop-hole in the typeapproval procedures. Some of their equipment, although nominally meeting the transmitter specifications, appears unable to perform satisfactorily at 10 kHz spacings and In-terference to other modellers is being caused. This clearly breaks both the spirit of the code of practice, and its intention.

Angry rumblings have been heard, from other manufacturers and also from the modellers themselves. The equipment in question has, in fact, been banned by some clubs.

Moves are afoot to close the loop-hole by introducing typeapproval procedures for receivers as well as transmitters. In the meantime, most reputable manufacturers are offering written guarantees for their receivers' performances at 10 kHz spacings.

Repair Service For Electronic Games

CIRCOLEC, UNDER THE joint partnership of John Bell and Richard Ansell, is offering a repair service for all types of video, computer and hand-held electronic games.

John Bell told HE that his company specialises in the repair of games such as those from Videomaster (Waddington), Computer Games, Atari and Grandstand. Circolec has had two years' experience in servic-'tens of thousands' of ing Videomaster games.

'We have six engineers here doing this sort of work' said John. He has had 30 years' experience in electronics and he is a member of the Institute of Quality Assurance.

Graphic Equaliser

John Bell also mentioned a 100 W (4 x 25 W) graphic equaliser designed by Circolec. Its features include a three-colour LED display for each channel and the use of touch-sensitive controls. We hope to report on this product in a later issue.

Circolec is based at 1 Franciscan Road, Tooting, London SW17 88R (tel 01 767 1233).



Bins That Don't Rattle

STORING COMPONENTS, small tools, nuts and bolts etc, can be a problem for any hobbyist. The choice seems to be: either make your own system of storage bins, or buy an expensive racking system.

Well, HE heard of a completely new (and cheap) method of storage bins for the home handyman, from Bankers Box of Doncaster. The bins are made of fibreboard and come in seven sizes from 51 mm wide by 102 mm high by 305 mm long,

Spectacular TV **Light Show**

CEL ELECTRONICS HAS introduced two video synthesiser products, one of which will add new light to domestic colour TVs.

Chromoscope C-101 (domestic model) and Chromoscope P-135 (professional model) are claimed by CEL to be all-British inventions. When HE was shown both models by Robin Palmer, director of CEL and designer of the two products, we were impressed by the high standard of design and by the spectacular effects produced.

Chromoscope C-101, priced at £295 including VAT, can be connected to your TV and will generate a sequence of coloured

up to 203 mm by 102 mm by 457 mm. As a price example the 102 mm by 102 mm by 305 mm bin will cost about £3.75 for a pack of 10, and will be available from major retailers, office stationers and garage forecourts. At these prices, the bins are likely to be very attractive to the hobbyist.

Delivered in flat-pack form, the user folds the storage bins into shape himself - the whole process takes only a few seconds - and no clips or staples are needed.

More information from: Bankers Box, Record Storage Systems, Doncaster (tel no. 0302 884566).

shapes and patterns which merge and blend on the screen. The controls on the C-101 allow an almost infinite adjustment of pattern shape, colour and sequence. And the patterns become even more exciting when you connect the C-101 to your hi-fi system: the modulation effects provide an impressive sound-to-light show. Chromoscope P-135, priced at £675 including VAT, offers studio facilities, such as video and audio inputs, mixing and the insertion of colour into black-andwhite images.

We have been given a C-101 to review and will present our findings in next month's Gadgets, Games & Kits supplement. We will also be offering the C-101 at a special price to HE readers, so don't miss next month's issue!



Electronics News



Latest Personal Cassette Player From Sony

WELL, WE TRIED, jogging a distance – about 15 metres – while listening to the machine. Then we tried walking doing the same -- even further – and after getting our breath back decided that the Sony Walkman-2 is a nice piece of equipment.

Walkman-2 is the latest of the mini personal cassette players, complete with headphones, to hit the market from Sony — the company which fi. You may remember that the first personal cassette player to be released in this country was Sony's Stowaway (which later became known as Walkman-1).

The smallest of any such player we've seen yet, the Walkman-2 is about the same size as a standard cassette case but just under twice the thickness. We doubt whether any further size reductions will be possible (using standard sized cassettes, that is) but it's a fairly safe bet to rely on Sony to do it if it can be done.

Do Your Own Thing

If you've never listened to a personal cassette machine before then you haven't yet lived! Using one is easy: you simply choose your own music (not that imposed by supermarket muzak speakers, and not that forced on you by the fellow-next-door's tranny tuned in to Radio Gunge) on a cassette, slot the cassette into your player, put on the headphones, switch on and - wham! - you're in another world. You're walking around the streets with Gary Glitter or Grieg; you're jogging with the Beatles or Bach; you could even be playing tennis with the Rolling Stones or Ravel. Whatever you are doing, it's your own sound.

Walkman Is Fil

Hi-fi, in fact. Using metal tapes the frequency response of the player is an impressive 40 to

15,000 Hz.

It comes complete with a pair of MDR-4L1S dynamic stereo headphones, a demonstration cassette, batteries, carrying case with shoulder strap, and a battery case for external larger batteries. The headphones give excellent results and quality, and are so light that after listening to your music for a while you almost forget you have them on. If somebody around wants to talk to you but you can't be bothered to take off the 'phones, by pressing a conve-nient 'mute' button (at the junction where the two separate leads to each 'phone meets) you can cut down the volume so you can hear the real world again.

Two alkaline AA-sized cells fitted into Walkman-2 give approximately nine hours' playing time but if that's not long enough then two D-sized alkaline cells in the handy external battery case give you an unbelievable 60 hours of playing time.

The carrying case looks somewhat odd at first sight, but

Digital Multimeter Has Higher Accuracy

When we described the DMM600D digital multimeter, from Danesbury Marketing, under Monitor in last month's issue, we under-rated its accuracy. On the DC voltage ranges the specified accuracy is 0.2%, not 0.5% as stated.

is very versatile. It can be slung over the shoulder with a detachable strap or (more conveniently) clipped to a beit, weistband or pocket edge.

band or pocket edge. Walkman-2 itself folds apart to allow cassette insertion and one or two pairs of headphones can be used with it. (A second set of MDR-4L1S headphones will cost you £16.44 including VAT.) Controls on the player are simple and self-explanatory: forward, fast-forward, rewind, stop and volume, and here lies our one and only cause for concern. Unlike Welkman-1 (ie, Stowaway), which had separate volume controls for each chan-nel, Walkman-2 has only one volume control with no means of channel balance adjustment. Fine, if you have evenly matched lug'oles, but not fine otherwise. It is worth remembering next time. Sonv!

Our overall impression is that Walkman-2 is a lovely machine, well designed, well mede, and well priced (considering its quality) at £99.50 including VAT or less.

Technomatic Tie-up With Texas

COUPLED WITH THE opening of a new, large retail sales shop at 305 Edgware Road, London W2, Technomatic Ltd announces a new deal whereby the company is offering a nationwide distribution service of Texas Instruments' components to the greatly expanding hobbyist market.

One of the early projects which Technomatic will be tackling will be the marketing of Texas Instruments' new solid-state speech synthesiser ICs. These integrated circuits are already available to industry — but Technomatic's aim is to bring the chips to the hobbyist.

The company believes that its success in the field of component distribution stems from a policy of supplying the customer from large stocks of prime grade components, at highly competitive prices, and by return of post. This sort of service ideally suits the hobbyist.

To launch the two new ventures, a set of special prices has been prepared and these will appear in Technomatic's magazine advertisements. The meter is pocket-sized, covers 21 ranges and is available at a special introductory price of £49.95 for orders of one to four and £47.45 for orders of five to nine. (These prices include VAT and carriage in the UK.)

Carrying case, test leads and handbook are included with the meter.

Danesbury Marketing Ltd, 22 Parkway, Welwyn Garden City, Herts AL8 6HG (tel 07073 29112).

NEXT MONTH IN HE — NEXT MONTH IN HE — NEXT MONTH IN HE



METAL DETECTOR

So you think you might have a treasure trove underneath your lawn, eh? Well, next month we've got a super metal detector project to help you strike it rich. It's simple to build and even simpler to operate.

A complete kit of parts for the HE Metal Detector will be made available — all you'll need to supply is the spade.



Now where *did* Great-Grandfather bury his gold sovereigns? Carol Ann is seen here using the HE 'Diana' metal detector, described in next month's issue

MAINS ADAPTOR

How often have you found that the battery in your portable radio/cassette player/calculator or such like is defunct of life, and you have no more cells? Wouldn't it be handy if you could run the device from mains? The HE Power Pack will do the job nicely. Preset voltage control gives a regulated output between 5-15 VDC and current supply is up to about 350 mA. So you see, most battery-powered devices can be run from this handy project.

The HE Power Pack will save you the expense of batteries for many electronic gadgets, such as the transistor radio shown here





No, it's not a robot on wheels but a diagnostic scanner from Advanced Technology Labs Inc. This is just one example of the diagnostic equipment described in Electronics In Diagnostic Medicine

ELECTRONICS IN DIAGNOSTIC MEDICINE

Doctors may still use traditional methods to diagnose your illness or, depending on what is wrong with you, also make use of the electronic diagnostic equipment at their disposal. Guest writer Graham Thirsk, in this special feature for HE, describes some of the more interesting diagnostic equipment developed as a result of advances in diagnostic techniques and advances in electronic technology.

SHORT WAVE RADIO

Our Short Wave Radio next month may not be the most complex or expensive receiver ever designed, but it is fun to build and use, and it will pull in some of those faraway broadcasts from around the world.

The radio is based on a simple tuned radio frequency (TRF) design covering frequencies of about 1.5 MHz to 33 MHz. Naturally, we hope to have an automatic cutout, inherent in the design, of all frequencies in that nasty, illegal 27 MHz band (although we're not sure if this facility will get past the design stage — nudge, nudge, wink, wink, say no more!)

CHROMOSCOPE REVIEW

In the Gadgets, Games & Kits supplement supplied free with the September issue we review the Chromoscope C-101, a video synthesiser for home use from CEL Electronics (see under Monitor in this month's issue). The C-101, when coupled to your TV and audio system, will provide a display of coloured shapes and patterns that merge and blend — in harmony with the music.

Items mentioned here are those planned, but unforeseen circumstances may affect the actual contents

		-	-		The subscription of the su	A REAL PROPERTY.
WATEODD ELECTDONICS	7400 TT	L 74126	40 LS48 42 LS55	80 4015 6 30 4016 3	6 4412 800 2 4415 480	LM300HX 170 LM301A 26
WATTORD LLLCTRONICS	7401	74136	46 L303 35 LS73 70 LS74	25 4018 6 25 4019 4	8 4419 280 8 4422 770 2 4422 770	LM308 95 LM318 200
35 CARDIFF ROAD, WATFORD, HERTS, ENGLAND	7403	14 74142	190 LS75 250 LS76	28 4020 6 20 4021 7	1 4435 850 0 4440 999	LM324 50 LM339 68
All DEVICES PRAND NEW FILL COSC AND ENLINE WAITON 40568/9	7406 7407	28 74145 28 74147	70 LS83 99 LS85	50 4022 6 70 4023 2	6 4450 350 0 4451 350	LM349 115 LM358 50
DESPATCHED BY RETURN OF POST. TERMS OF BUSINESS: CASH/CHEQU	RS 7408 E/ 7409	16 74148 16 74150	80 LS90	35 4024 4 35 4025 1 36 4026 12	5 4490 350 9 4500 675	LM379 375 LM380 80
INSTITUTIONS' DEFICIAL DRDERS ACCEPTED, TRADE AND EXPORT INQUI	AL 7410 RY 7411	20 74153 20 74154	45 LS93 75 LS95	36 4027 34 45 4028 54	8 4502 90 8 4503 50	LM381 145 LM382 125 LM384 99
POSTAGE AT COST, AIR/SURFACE, ACCESS ORDERS WELCOME.	RS 7413 7414	24 74156 32 74157	75 LS96 45 LS107	43 4030 5	7 4504 105 0 4506 65	LM386 99 LM387 120
VAT Export orders no VAT. Applicable to U.K. Customers only. Unless stated otherwise, prices are exclusive of VAT. Piezes add 15 % to the total cost including p&p.	All 7416 7417	25 74159 25 74160 74161	50 LS112 50 LS113	30 4031 17 30 4032 129 40 4033 16	0 4507 40 5 4508 265	LM1458 45 LM2917 195
Vise stock mousands more stema. It pays to visit us, We are situated behind Watford Footbell Grou Nearest Underground/BR Station: Watford High Street. Open Monday to Saturday, 9 a.m. to 6 p Amole Free Car Parties space available.	nd, 7421 .m. 7422	20 74162 20 74163	62 LS114 64 LS122	35 4034 19 44 4035 9	5 4510 68 5 4512 75	LM3909N 70 LM3911 125
POLYESTER CAPACITORS: Axiel lead type	7423 7425	22 74164 28 74165	64 LS123 62 LS124	55 4036 279 105 4037 111	LINEAR ICs	LM3914 220 LM3915 220
220n 30p; 330n 42p; 470n 52p; 680n 60p; 1 + F 68 p; 2 + 2 82p; 4 + 7 65p. 160V: 10nF, 12n, 100n 11p; 150n, 220n 17p; 330n 470n 30p; 680n 38p; 1 + F 42p; 1 + 5 45p; 2 + 2 4	7425 7427	27 74167 74170	185 LS126 168 LS132	30 4038 11 45 4040 54	0 2114 175 0 2708 250	M252 625
4μ 7 58p. 1000V: 1nF 17p; 10n 30p; 15n 40p; 22n 38p; 33n 42p; 47n 42p; 100n 42p; 470n 99p.	7430 7432	16 74172 26 74173	290 LS133 85 LS136	35 4041 71 28 4042 64	8 2716 275 4116 140	MC1304P 260 MC1310 150
POLYESTER RADIAL LEAD CAPACITORS: 280V: 1005, 15n, 22n, 27n 1, 31n, 47n, 68n, 100n, 7n, 150n, 220n, 10n, ULTRASONIC TRANSDUCE	7433	27 74175	72 LS138 72 LS139 55 LS145	35 4043 70 38 4044 65 75 4045 170	6522 570 6800 275	MC1455 150 MC1458 45
330n, 470n 13p; 680n 19p; 1pF 23p; 1p 5 40p; 2µ 2 46p; 4µ 7 60p. 40kHz 395p/pr	7438	17 74177 68 74178	75 LS147 95 LS148	199 4046 79 99 4047 79	709C 8 pin 35 710 48	MC1488 75 MC1489 75 MC1494 694
ELECTROLYTIC CAPACITORS: (Values are in µF) 500V: 10 52p; 47 78p; 250V: 100 65p; 63V: 0,47, 1 1.5, 2.2, 2.5, 3.3 8p; 4.7 9p; 6.8, 10 10p; 15, 22, 12p; 33 15p; 47 12p; 100, 19p; 1000 70p, 50V: 47 12p; 20p; 330 24p; 470 32p; 1000 70p, 50V: 47 12p; 33 15p; 47 12p; 100, 19p; 1000 70p, 50V: 47 12p;	.0, .7442 68 7443	38 74180 90 74181	65 LS151 140 LS153	39 4048 55 39 4049 30	733 75 741 8 pin 14	MC1495 350 MC1496 92
9p: 47 8p; 100 11p; 150 12p; 220, 15p; 330 22p; 470 25p; 680, 100, 34p; 220, 50p; 3300, 76p; 41 9p: 47 8p; 100 11p; 150 12p; 220, 15p; 330 22p; 470 25p; 680, 1000, 34p; 2200, 50p; 3300, 76p; 41 92p: 16V; 40, 47, 100 9p; 125, 12p; 220, 13p; 470, 200; 680, 4100, 34p; 2200, 50p; 3300, 76p; 41	33 7444 00 7445	90 74182 65 74184	99 LS155 99 LS157	35 4050 30 35 4051 78 36 4052 78	747C 78 748C 36	MC1648 290 MC1709G 90
74p; 4700 79p. TAG-ENO TYPE: 70V: 4700, 245p; 64V: 3300 198p; 2200 1390; 50V: 3300 154o: 2200 110n: 40V: 41	00 7440 7447 00 7448	50, 74188 50, 74190	290 LS160 70 LS161	41 4053 78 41 4054 125	810 159 81LS95 135	MC3340P 120 MC3360P 120
TAN ALUM BEAD CAPACITORS POTENTIOMETERS: Bolary Carbon OPTO	7450	16 74191 16 74192	70 LS162 70 LS163	41 4055 125 41 4056 120 48 4057 120	81LS96 135 81LS97 140	MC3401 52 MC3403 89
35V: 0.1μF, 0.22, 0.33 15p; 0.47, 0.68, Track 0.25W Log & 0.5W Lin 1.0μF, 1.5 16p; 2.2, 3.3 18p; 4.7, 6.8 500(), 1KΩ & 2KΩ (Linear only) Single LEDCTRONIC	5 7453 7454 7460	16 74193 16 74194 16 74195	75 LS165 65 LS166	4057 1915 4059 480 85 4060 m	AY-1-0212 675 AY-1-1313A660	MFC6040 97 MK50398 635 MM5303 635
4.7µF, 6.8. 10 18p; 15, 36p; 22 30p; 33, 5K0, 2MQ Single Gang 29p TiL209 Red 4.7µF, 6.8. 10 18p; 15, 36p; 22 30p; 33, 5K0, 2MQ Single Gang 29p TiL209 Red	13 7470 7472	35 74196 30 74197	65 LS173 65 LS174	72 4061 1225 72 4062 995	AY-1-1320 225 AY-1-5050 99	MM5307 1275 NE543 210
26p; 33, 47 35p; 100 55p; 6V; 100 42p; 5KQ; 2MQ Double Gang 88p TiL211 Gm. MYLAR FILM CAPACIYORS	18 7473 7474	30 74198 25 74221 74245	99 LS175 80 LS181	58 4063 99 30 4066 36	AY-1-5051 160 AY-3-8500 390 AY-3-8500 390	NE544 185 NE555 17
100V: 1nF, 2, 4, 4n7, 10 5p; 15nF, SLIDER POTENTIOMETERS 2'Yllow., Grn. 22n 30n, 40, 47 7p; 56 100n, 200 9p; 0-25W log and linear values 60mm Square LEDs	10 7476 20 7480	30 74247 74248	150 LS191 150 LS192	58 4067 395 58 4068 22 58 4069 20	AY-5-1224A235 AY-5 1230 450	NE556 325 NE561 398
470n/50V 12p. 5KD-500KD single gang 70p 0RP12 MINIATURE TYPE TRIMMERS 10KD-500KD dual gang 110p 2N5777	46 7481 1 7482 1	20 74LS	LS193 LS195	65 4070 26 40 4071 20	CA3018 68 CA3020 186	NE562 410 NE564 435
2-6pF, 2-10pF; 22p; 2-25pF 5-56pF	7483 7484	50 74LS00 80 LS01	12 LS196 13 LS197	58 4072 20 85 4073 20	CA3023 191 CA3028A 80 CA3025 235	NE565 120 NE566 180
COMPRESSION TRIMMERS 3-40pF, 10-80pF 20p; 20-250pF 28p; 0 1W 500-50M Miniature 7p 7 Segment Display	54 7485 7486 7489 7	26 LS03	14 LS240 15 LS241	96 4075 20 96 4076 60 96 4077 26	CA3045 365 CA3046 70	NE570 450 NE571 420
POLYSTYRENE CAPACITORS: 0-25W 100() -3.3M() horu. 10p TIL321 CA.5 1 POLYSTYRENE CAPACITORS: 0-25W 200() -4.7M() vert. 10p TIL322 C.C.5 1	16 7490 15 7491	28 LS05 45 LS06	15 LS242 15 LS243	85 4078 26 85 4081 26	CA3048 214 CA3059 195	RC4136 99 S566B 245
10pF to 1nF 0p; 1.5nF to 10nF 10p RESISTORS — Carbon Film, High DL707 CA. 3 31 VER MICA (Values in pE) 2, 2,3 31 Green CA. 1	7492 7493	30 LS08 30 LS09	15 LS244 15 LS245 1	80 4082 21 18 4085 65	CA3080E 65 CA3081 190 CA3085 95	SAB3209 425 SAB3210 275
4.7, 6.8, 8.2, 10, 15, 18, 22, 27, 33, 5%, 39, 47, 50, 56, 86, 75, 82, 85, 100, 5%, 94, 100, 100, 100, 100, 100, 100, 100, 10	80 7495 20 7495	34 LS10 50 LS11 45 LS12	15 LS248 15 LS249	65 4080 140 68 4093 43	CA3089E 215 CA3090AQ 375	SN76003 240 SN76013 170
120, 150, 180pF 15p each. 200, 220, 250, 270, 300, 330, 360, 390, WW 2Ω2-4M7 E12 2p 1p 10 Sig Bargraph 2 WW 2Ω2-4M7 E12 2p 1p 10 Sig Bargraph 2	75 7497 1 26 74100	20 LS13 85 LS14	30 LS251 48 LS253	40 4094 168 40 4095 90	CA3123E 150 CA3130 90	SN76023 170 SN76033 195
470, 600, 800, 820 21p each; 1000, 1200, 1800, 2200 30p each; 3300, 2%Metal Film 100-1M Sp 4p SWITCHES	74104	54 LS15 55 LS20	15 CMOS	4096 90 4097 320 4098 80	CA3140 48 CA3189 295 ICL7106E 795	SN76477 175 SP8629 299
CERAMIC CAPACITORS 50V: 0-5pF 100+ price applies to Resistors of each Red, Gre, Blue, SRI Lething	Py, 74109 74109 74110	35 LS22 40 LS26	15 4000 18 4001	14 4099 95 14 4160 95	ICL7107 975 ICL8038CC 340	TA7205A 225 TAD100 159
to 10nF 4p; 22n to 47n 5p. 100n 7p. 5-Dec 350p U.Dec B 699p TOGGLE: 2A 250	96 74111 V. 74112 1	55 LS27 70 LS28	15 4002 20 4006	14 4161 99 66 4162 99	ICM7205 1150 ICM7216A 1950	TBA120 70 TBA641 250
VOLTACE DECKU ATODS	33 74116 44 74118 54 74119	88 LS30 80 LS32 90 LS33	15 4007 15 4008 16 4009	18 4103 99 62 4174 99 35 4175 105	ICM7555 80 LA4032 295	TBA810 95 TBA820 70
1A TO3 + ve -ve 1A TO3 + ve -ve 1A TO3 + ve -ve 1A TO3 + ve -ve 1A TO3 + ve -ve	E 74120 74121	75 LS37 30 LS38	16 4010 16 4011	40 4194 105 15 4408 790	LC7130 495 LD130 452	TCA965 120 TDA1004 290
12V 7815 145p 7912 220p Magazine. SPST on/off	54 74122 54 74123 54 74123 54 74123 54 74123 54 74123 55 75 74123 55 75 74123 55 75 74123 55 75 74123 55 75 74123 55 75 75 74123 55 75 75 75 75 75 75 75 75 75 75 75 75	45 LS40 50 LS42	16 4012 35 4013	18 4409 790 34 4410 725	LF351 48 LF355 75	TDA1008 310 TDA1022 575
18V 7818 145p ACCESS DPDT c/off 14 10220 Plastic Gauge Just phone your order DPDT Biased	80 TRANS	ISTORS	BSX20	20 TIP41A	55 2N3053 20	TDA1490 290 TDA2020 320
12V 7812 60p 7912 65p through We deal with SLIDE 250V: 12V 7812 60p 7912 65p the rest (but min. £10 1A DPDT	14 AC125	35 BC2144	10 BSY65 BSY95A	35 TIP418 25 TIP42A	60 2N3054 54 60 2N3055 44	TLO61 46 TLO63 95
16V 7815 60p 7915 65p 14 DP c/off 18V 7818 60p 7918 65p 14 DP DT 24V 7824 60p 7918 65p	16 AC126/7 13 AC128	35 BC328 25 BC338	5 8U205 15 8U208	190 TIP120 200 TIP121	90 2N3133 49 99 2N3135 30	5 TLO71CP 45 5 TLO74 140 7 TLO81 42
100mA T092 Plastic Casing Push to Make 18 Plash Break 2 54, 73105 200 Plastic Casing Push to Make 19 Plash Break 2	AC14172 AC142 AC176/187	30 BC461 28 BC477	34 E113 34 E176	45 TIP122 50 TIP142	99 2N3252 44 120 2N3442 144	TLO82 70 TLO83 95
6V 78152 30p ROCKER: Illuminated (black) chrome bezel, light 8V 78182 30p ROCKER: Illuminated (black) chrome bezel, light when on DPST 3A 240V	AC188 ACY17/18	30 RC516/7 70 BC547/8	40 MJ2955 14 MJE340	90 TIP2955 54 TIP3055	60 2N3568 2 60 2N3663 1 60 2N3702/3 1	5 UAA170 170
12V 78L12 30p 79L12 65p ROTARY: (ADJUSTABLE STOP) 1 pole/2-1 15V 78L15 30p 79L15 65p www. 2p/2-6 way, 3p/2-4 way, 4p/2-3 way 4	ACY20/21 ACY22 AD140	75 BC549 60 BC556 120 BC557/9	14 MJE370 15 MJE371	100 TIS43 100 TIS44	32 2N3704/5 10 45 2N3706/7 10	XR2206 350 XR2211 575
CA3085 95p LM323K 825p TAA550 50p LM300H 170p LM325N 240p TBA625B 75p	AD149 AD161	79 BC559 42 BCY70	15 MJE520/ MJE2955	99 TIS88A 99 TIS90 70 TIS91	30 2N3708/9 10 32 2N3710/11 10 32 2N3710/11 10	Z80 780 Z80A 899
LM309K 1350p LM326N 240p TDA1412 150p UL SOCKETS; 8-pin 8p; 14-pin 10p; 16-p LM309K 135p LM327 270p 78H05 550p 10p; 18-pin 16p; 20-pin 22p; 24-pin 25p; 2 LM317K 350p LM273 200 78H05 550p 10p; 18-pin 16p; 20-pin 22p; 24-pin 25p; 2	In AD162 8 AF115	42 BCY71 60 BCY72	18 MPF102 20 MPF103	66 ZTX107/8 36 ZTX109	11 2N3771 171 12 2N3772 195	Z80CTC 595 Z80P10 575
JACKSONS VARIABLE CAPACITORS DIDDES	AF178 AF180/86	75 80133 70 80135	60 MPF104 45 MPF105	36 ZTX300 36 ZTX301/2 40 ZTX301/2	13 2N3773 270 16 2N3819 22	280APIG 550 ZN1034E 200
Dielectric 0 2 365pF with slow BY126 12 Range 2V7 to Thyristom	AF239 BC107/8	78 BD136/7 10 BD138/9	40 MPSA05 40 MPSA12	06 25 ZTX304 30' ZTX314	17 2N3820 49 17 2N3822/3 65 25 2N3866 90	ZN1040E 685 ZN414 95 ZN424E 130
Octope 250p 00 208/176 395p CR033 250 Bp each 1A200V 61 Ball Drive 00 208/176 with OA9 40 Range: 3V3 to 54/400V 54/400V	70 BC1088 40 BC109	12 BD695A 10 BD695A	40 MPSA55 85 MPSA56 85 MPSA56	30 ZTX326 30 ZTX341	30 2N3903/4 18 30 2N3905 18	ZN425E 415 ZN426E 325
Dial Drive 4103 motion drive 450p OA47 12 33V 1 3W 5A/600V 6 1/36.1 775p CB04-5pF 10 15 0A70 12 15p each 8A/300V	BC109B BC109C	12 8DY17 12 8DY60	195 MPSU56 160 OC28	60 ZTX501/2 120 ZTX501/2	15 2N3906 17 2N4037 44	ZN427 625 ZN428 478 ZN429 310
Orum 54mm 59p 25 50pF 278p 0A79 18 0-1.385pF 325p 100 150pF 350p 0A85 15 0.0.000 150pF 350p 0A90 18 0A90 150pF 350p 0A90 18 0A90 18 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	BC117 78 BC119 BC137	24 80Y61 38 8F115	160 OC35 35 OC36	125 ZTX504 120 ZTX531	25 2N4058 10 25 2N4061/2 10 25 2N4069 40	2SC2029 180
00.3x25pF 550p 0A91 8 Diode 195p 12A/800V 1 0A95 8 Diode 195p 12A/800V 1 0A95 8	B BC140/3 BC147	30 8F173 9 BF177	27 OC44 25 OC45	120 27X550 120 2N526 40 2N606	25 2N4859 78 58 2N4871 55	2SC2078 155 2SC2091 85
DENCO COILS RFC 5 chokes 04202 8 BRIDGE C1060 1 DP'VALVE TYPE 1400 IN914 4 BRIDGE C1060	BC 148 BC 149 BC 149	9 BF178 9 BF179	30 OC70 35 OC71	40 2N697 40 2N698	23 2N5135/6 20 20 2N5138 10 2N5138 10	2SC2314 85 2SC2166 165 2SC1679 190
Range 1 to 5 BL. RFC 7 (19mH) IN916 F RECTIFIERS TIC44 RD, TIWht 122p 160p IN4001/2 5 (plastic case) p TIC45	29 BC153/4 BC157/B BC159	10 BF194/5	12 OC72 12 OC76 12 OC81	40 2N699 50 2N706/8	48 2N5180 49 19 2N5180 49 2N5191 7	JN128 112 JN140 112
0+78+1+77 1190 13; 14; 15; 16; 17 1.5 Green 150p 120p IN4004/5 6 1A/100V 22 2N5062 17 type 1 to 5, 81 18/16 135 14: 14:000 7 14:4000 26 14:4000 27 14:4000 20 14:4000 27 14:40	32 BC160 38 BC167A	45 BF198 10 BF200	16 OC82 30 OC83	50 2N930 40 2N961	20 2N5305 24 65 2N5457 30	40311 60 40313 130 40316 95
Rd. Wht. YI 150p 18/465 152p IN4148 4 1A/600V 34 2N4444 1	30 BC168C	10 8F224A	25 OC84	40 2N1131/2	24 2N5458 36 55 2N5459 36	40317 60
B9A Valve Holder TOC1 124p IN5401/2 15 2A/50V 36	BC159C	10 BF244	26 00170/7	2141 31.14	2N5485 16	40324 100
B9A Valve Holder TOC 1 124p INS601/2 15 2A/ 50V 35 RDT2 145p MW5FR 122p INS605 16 2A/ 200V 46 3A100V INS406 17 145p MW/LW SFR155p INS606 17 24/ 200V 46 3A100V	BC169C 8C170 BC171/2 BC177/8	10 8F244 15 8F256 11 8F257/8 20 8F259	35 TIP29 32 TIP29C 35 TIP30	34 2N1305 60 2N16718	60 2N5485 30 120 2N6027 32	40324 100 40326 60 40327 70
B9A Valve Holder TOC 1 124p INS607 / 2 15 2A/ 50v 35 RD12 145p MW5FR 122p INS604 16 2A/ 200V 46 RD12 145p MW7LW SFR 154p INS606 17 2A/ 400V 46 3A100V VEROBOARD 0 1546 16 6A/ 400V 46 3A100V 0.1 Pitch clad 164 1546 16 6A/ 400V 3A400V	BC159C BC170 BC171/2 BC177/8 BC179 BC182 BC182	10 8F244 16 8F256 11 8F257/8 20 8F259 20 8F594/5 10 8FR39/4	35 TIP29 32 TIP29C 35 TIP30 40 TIP30C 10 23 TIP31A	34 2N1305 60 2N16718 48 2N2160 58 2N2219A 45 2N2220A	60 2N5485 36 60 2N5777 49 120 2N6027 33 350 2SA715 60 28 2SC495 70 23 2SC496 30	40324 100 40326 60 40327 70 40348 120 40360 40 40361/2 40
B9A Valve Holder TOC 1 124p INS607/2 15 2A/50v 35 RD12 145p MWSFR 122p INS604 16 2A/200v 46 3A100V VEROBDARD MWV/LW SFR154p INS406 17 2A/400v 46 3A100V VEROBDARD O1 Pitch clad Plan 5A/20V 46 3A100V VEROBDARD O1 Pitch clad Plan 5A/20V 46 3A100V VEROBDARD CoPPER IS321 6A/400V 5A 5A/400V 46 8A400V 2Vi + 5 S3p Club Boards 6A/400V 40 6A/400V 10A/200V 15A400V 10A/200V 15A400V 10A/200V 15A800V 13A800V 13A800V 13A800V 13A800V 13A800V 13A800V 13A800V 15A/400V 5A400V 15A/200V 13A800V	BC169C BC170 BC171/2 BC177/8 BC177/8 BC179 BC182 BC182 BC182 BC183 BC183	10 BF244 16 BF256 11 BF257/8 20 BF259 20 BF594/5 10 BFR39/4 10 BFR39/4 10 BFR39/4	23 TIP29 35 TIP29 35 TIP30 40 TIP30C 40 TIP30C 40 TIP31A 23 TIP312 23 TIP32A 23 TIP32A	34 2N1305 60 2N16718 48 2N2160 58 2N2219A 45 2N2220A 55 2N2222 46 2N2369A 60 2N216	30 2N5485 31 60 2N5777 49 120 2N6027 32 350 2SA715 60 28 2SC495 70 23 2SC496 70 25 2SC1996 85 18 2SC1173 125	40324 100 40326 60 40327 70 40348 120 40360 40 40361/2 40 40361/2 40 40407 60 40408 70
B9A Valve Holder TOC 1 124p INS607 (2 15 2A/50V 35 RDT2 145p MW5FR 122p INS607 (2 16 2A/200V 46 RDT2 145p MW5FR 122p INS406 17 2A/200V 46 3A/00V VEROBDARD INS406 19 6A/400V 46 3A/00V 43 3A/00V 0 1 Pitch Clad Boards 6A/100V 83 3A400V 46 8A/00V 24 8A/00V 24 8A/00V 25 8A/20V 128 8A400V 24 8A/00V 128 8A400V 25 8A/20V 158/21 9 6A/400V 95 8A/20V 258 8A/20V 128 8A400V 258/40V 128 8A400V 128 8A400V 16 12A/200V 128 8A400V 158/21 136/20V 158/21 8A00V 158/21 8A00V 158/21 136/20V 158/21 8A00V 128/20V 128/20V 158/21	BC169C BC170 BC171/2 BC177/8 BC177/8 BC182 BC182 BC182 BC182 BC183 BC183 BC183 BC183 BC183 BC184 BC184 BC184	10 8F244 16 8F256 11 8F257/8 20 8F259/5 10 8FR39/4 10 8FR39/4 10 8FR41 10 8FR49 10 8FR49 10 8FR29 10 8Fx29 10 8Fx29	23 000000000000000000000000000000000000	34 2N1305 60 2N16718 48 2N2160 58 2N22190 55 2N22204 55 2N22204 60 2N2456 65 2N2483 78 2N2493	20 20/5485 31 60 20/5777 44 120 20/60/27 33 350 25A715 66 23 25C496 70 25 25C1096 85 18 25C1173 125 500 25C1306 155 27 25C1307 256 267 25C1307 256 267 25C1307 256 25C1307 250 25C1307	40324 100 40326 60 40327 70 40348 120 40360 40 40361/2 40 40361/2 40 40361/2 40 40407 60 40408 70 40412 65 40412 65
B9A Valve Holder A2p RDT2 TOC 1 124p RW5FR INS60/12 15 2A/50V 36 RDT2 145p MW5FR 122p MW5FR INS60/12 16 2A/200V 46 3A100V 40 3A100V 46 3A200V 46 3A200V 46 3A100V 40 3A400V 46 3A400V 48 A100V 50 3A400V 84 86/4/100V 83 3A400V 15921 9 6A/400V 84 800V 124 800V 124 800V 125 88400V 124 124/50V 124 800V 124/50V 124 800V 124 800V 124 800V 124/50V 124/50V <td>80.1690; 80.170; 80.170; 80.170; 80.179; 80.179; 80.1621; 80.1821; 80.1821; 80.1821; 80.1831; 80.1831; 80.1844; 80.1844; 80.1875; 80.187; 80.1875; 80.212; 80.1875; 80.212; 80.187; 80.212;</td> <td>10 8F244 16 8F256 11 8F257/8 20 8F594/5 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/8 10 8FX89/8 10 8FX84 10 8FX85/8 10 8FX84</td> <td>28 OC17077 35 TH29 32 TH29C 35 TH29C 40 TH29C 40 TH23CC 40 TH23CC 40 TH23CC 41 TH23C 41 TH23C 45 TH232C 26 TH234C 45 TH234C 46 28 TH234C</td> <td>34 2N1305 60 2N16718 48 2N2160 58 2N2160 55 2N2220 46 2N2360 60 2N2476 65 2N2483 78 2N2483 78 2N2483 78 2N2483 78 2N2483 78 2N2483</td> <td>2015 2015 2015 2015 2015 2015 2015 2015</td> <td>$\begin{array}{cccccccccccccccccccccccccccccccccccc$</td>	80.1690; 80.170; 80.170; 80.170; 80.179; 80.179; 80.1621; 80.1821; 80.1821; 80.1821; 80.1831; 80.1831; 80.1844; 80.1844; 80.1875; 80.187; 80.1875; 80.212; 80.1875; 80.212; 80.187; 80.212;	10 8F244 16 8F256 11 8F257/8 20 8F594/5 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/4 10 8FR39/8 10 8FX89/8 10 8FX84 10 8FX85/8 10 8FX84	28 OC17077 35 TH29 32 TH29C 35 TH29C 40 TH29C 40 TH23CC 40 TH23CC 40 TH23CC 41 TH23C 41 TH23C 45 TH232C 26 TH234C 45 TH234C 46 28 TH234C	34 2N1305 60 2N16718 48 2N2160 58 2N2160 55 2N2220 46 2N2360 60 2N2476 65 2N2483 78 2N2483 78 2N2483 78 2N2483 78 2N2483 78 2N2483	2015 2015 2015 2015 2015 2015 2015 2015	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
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Electronic

An easily-built Veroboard project which can give advantages of better, more reliable engine starting, particularly in damp weather, and more consistent performance for many thousands of miles. Circuit design by Des Armstrong, who has driven over 100,000 miles in his car with the prototype fitted

THE CONVENTIONAL CAR ignition system has remained virtually unchanged since the early days of motoring. It was, in fact, invented by Charles Kettering about 60 years ago. The system uses a transformer (known as a coil), a contact breaker (the points) and a capacitor (sometimes called a condensor).

ELECTRONIC

A typical Kettering type of ignition circuit is shown in Fig.2. The coil, points and capacitor are all shown and the whole system operates in the following way:

 As the ignition switch is operated, current is applied simultaneously to the coil and to the starter motor. The starter motor turns the engine, which turns the rotor cam in the distributor, opening and closing the points.
 When the points are closed, current builds up in the coil, reaching a maximum of 4 A after about 4 ms. The current then remains steady.
 After the cam turns far enough to push open the points, the circuit is broken. A voltage V is generated which is given by the basic coil formula:
 V = It.

where I is the inductance of the coil in henries (see Famous Names this monthl) and t is the rate of change of current in seconds. This voltage at the primary of the coil induces a much higher voltage at the secondary (it's a 'step-up' transformer) which is applied to the spark plug in the engine. A fast break of the points thus gives (in theory, at least) an infinite voltage at the primary. However, in practice an arc (spark) occurs at the points and the voltage is limited.

• The capacitor fitted across the points limits the rise of voltage, thus preventing too great an arc at the points gap. The value of this capacitor is chosen to give a compromise between the amount of energy at the spark plug and the amount of energy at the points. (Remember that too much energy at the points causes a lot of arcing which will burn the points out quickly.)

Why Electronic?

As we've said, the Kettering system has been around for some time and has consequently been refined to a very high standard. But two major weaknesses are still inherent and are difficult to eliminate in such a mechanical system. These are: contact breaker points bounce at high engine speeds, and wear of the points — due to high currents through them and arcing across them.

Some electronic ignition systems use solid-state devices to provide switching thus doing away entirely with the points. But there is little need to do this because we can both prevent wear and eliminate the effects of points bounce electronically, by good design.

To this end, the HE Electronic Ignition system maintains the use of the car's contact breaker points. The points will, with its use, be subject only to mechanical wear and will need changing much less often. A further benefit of retaining the points is their use when timing the engine — they can be, in fact, more accurate than many other methods, such as optical or reluctance sensing.



Figure 1. Circuit of the HE Electronic ignition project

Ignition



Construction

First, cut the Veroboard to exactly 21 strips by 31 holes. Cut and carefully file out the two corners of the board so that it fits into the case, flush to one side. Now drill the board and the case to fit ½" PCB mounting pillars remember that the Veroboard is to be mounted 'upside down' ie, copper side facing up — then remove the board. Figure 2. The standard (Kettering) ignition circuit

SPARK PLUG

Now, mark and drill the case to fit transistor Q1. The transistor must be bolted on with a mica insulating washer between it and the case, so that when the Veroboard is put in again the three transistor leads fit into the board, as you can see in **Fig.3**. The metal tab (on one of its faces) must be towards the case side.

Using the mica insulating washer for Q2 as a guide, mark and drill the case

Figure 3. View of the project as the circuit board fits into the case. Note how the three leads of transistor Q1 fit into the board, and how the left-hand lead from resistor R3 comes out from underneath

to fit the power transistor. Make sure you drill the case and mount the transistor the right way round as shown in Fig.4. Bolt the transistor to the case as shown in Fig.5, preferably smearing both sides of the mica washer with a small amount of heatsink compound to aid heat conduction.

Next mark and drill the case for the %" grommet hole (in the side), and the two %" grommet holes and mounting

How It Works

The HE Electronic Ignition can be simply thought of as an electronic power switch. The car's contact breaker points are used only to turn the power switch on and off — they no longer switch heavy currents to the primary winding of the coil.



Resistor R1 provides a current of about 60 mA through the points when they are closed. This current is necessary to ensure that any tamishing or oil droplets on the contacts do not ceuse a problem.

Transistor Q1 provides an inversion of the pulse from the points, and the output from its collector drives the output transistor Q2. Resistor R2 limits the base current of Q1.

Transistor Q2 is easily capable of handling the 4 A or so of current which passes through it from the coil and it has a voltage rating of 400 V. It is therefore well suited to this application. Nevertheless, to make certain the transistor cannot be damaged by high voltage spikes, zener protection is included. Zener diodes ZD1-5 in series give a total zener protection voltage of 375 V (5 x 75 V).

Under certain conditions 'ringing' occurs (the voltage at the coll oscillates, first positive then negative). Diode D1 is included to short out this voltage when negative.

Diode D2 and resistor R5 cope with situations of points bounce which can cause problems, in the Kettering system, at high engine speeds.

Parts List

RESISTO R1 R2 R3 R4 R5,6	RS 220R 1 W 68R ½ W 18R 10 W wirewound 100R ½ W 120R 2.5 W wirewound					
CAPACII C1 C2	TORS 1n0, 1000 V mixed dielec- tric 22n, 1000 V mixed dielec- tric					
SEMICO Q1 Q2 D1 D2 ZD1-5	NDUCTORS BD132 PNP transistor BUX80 NPN power transistor BYW54 diode BYW95B diode 75 V, 400 mW zener diode					
MISCELLANEOUS Case, diecast aluminium (114 mm x 64 mm x 30 mm) Veroboard, 21 strips x 31 holes, 0.1" matrix 3 x ½" PCB mounting pillars Fixing kits for Q1 and Q2 transistors Hardware, nuts, bolts, solder tag, washers, self-tapping screws %" rubber grommet %" rubber grommet %" rubber grommet Cable tie						



holes for resistor R3 (in the top). Push all grommets into position.

Solder 4" lengths of cable (thick enough to carry at least 4 A of current) to each end of R3 so that when it is finally bolted to the case the two pieces of cable go vertically down through the grommet holes. Cover these connections with 1" lengths of heat-shrink or push-fit sleeving to provide insulation.

Mark and drill the case to fit the transistor cover over Q2. Use self-tapping screws to fasten it down.

Now make up the Veroboard, carefully following the layout diagram in Fig.6. Track breaks can be made using a cutting tool or a small (about ½ ") hand-held drill bit. Make sure no swarf lies across adjacent tracks, forming unwanted short circuits. Resistors R1,2,5, and 6 should be mounted in position about % " above the level of the board, to allow air to circulate. These resistors will get warm when the project is in operation, but this precaution will prevent damage occurring due to heat build-up.

Enlarge the two holes, where diode D2 goes into the board, using a 1.5 mm drill. Now fit D2 making sure it is the correct way round.

Insert and solder all other components and the link, as shown in Fig.6.

Position the board upside down (ie, copper side up) so that three leads of Q1 fit into the correct holes of the board and then screw the board down onto the PCB pillars, making sure the left-hand lead of resistor R3 (the resistor on the outside of the case)



goes between the corner of the board and the case. You can see this stage in the photograph of Fig.3.

Now solder transistor Q1 to the board and cut off any excess leads.

Following the internal connection diagram in Fig.4 first solder resistor R3's two leads to the board.

Connect the emitter and base of Q2 to the board using (at least) 4 A cable. Put heat-shrink sleeving over the connections at the transistor end to provide insulation.

Now using 4 A cable, connect the solder tag (which is Q2's collector connection) to the board.

Finally, solder four adequate lengths of 4 A cable to the board according to Fig.4. These leads should go through the % " grommet and should be colourcoded or marked so you know which is which. Our colour code is shown in Fig.4 but you needn't use the same as " long as you know the difference.

Tightly fasten a cable tie around the four leads to prevent them from being accidentally pulled out.

Screw on the case bottom. Your project is now complete.

Installation

Figure 7 shows how the original Kettering system of a car is adapted using the HE Electronic Ignition. Comparing this with Fig.2 you will note the insertion of our system in the low tension lead, between the points (in the distributor) and the negative side of the coil. The capacitor has also been removed from across the points.

Mechanical installation of our circuit is left to the builder as this will depend on the car on which the system is to be fitted.

Electrical installation is as follows: 1. Disconnect the low tension lead

Electric Ignition



Figure 7. How the HE Electronic ignition fits into the standard Kettering ignition circuit. The iead colours shown are those adopted in Fig.4. If you use a different colour code when wiring up your project simply change the suggested colours in this diagram to your own



Figure 6. Veroboard layout of the project.

4. Connect the black lead of the electronic ignition to a *good* earth — preferably somewhere on the engine block or directly to the negative terminal of the battery.

Now you can try starting your car. It should run without any problem. After satisfying yourself that everything is OK, stop the engine and then remove the capacitor from the distributor.

You now have a complete and working electronic ignition system in your car.

Buylines

Technomatic Ltd, who advertise in HE, are producing a full kit of parts for this project including case, insulating washers and Veroboard. The price is £18.50 including VAT, for callers. Mail-order customers please add 70p to cover p&p.

HE

Beasties /



Hobby Electronics, August 1981



The hobby of building land, sea and air models, operated by radio control, is increasing in popularity. Pete Christy* looks at what's entailed, particularly with airborne models

IT HAS BEEN SAID that a radio-controlled model aircraft is the ultimate case of putting your money where your mouth is. Certainly, to the electronics enthusiast a radio control system offers a unique challenge. To aviation enthusiasts it offers a cheaper, safer, and less rule-bound alternative to full-size flying.

Many of you, no doubt, will have witnessed radio-controlled models in action. Flying displays are rapidly becoming major attractions at local fêtes and carnivals. As with so many activities, the experts make it look so easy that many a spectator has been tempted to have a go. Sadly, without some experienced guidance, such solo efforts are almost invariably doomed to failure. Consequently, radio control has acquired a reputation of being a tricky and expensive pastime. Provided the right approach is adopted, neither of these criticisms is particularly true. The purpose of this article is to provide a bit of background information to assist would-be enthusiasts.

Early Flights

The first radio-controlled model aircraft were developed during the 30s. Until that time the only type of model aircraft around were those designed for free flight. As the name suggests these models were intended to fly untethered as were their full-sized counterparts. The absence of a pilot or any other control system required careful aerodynamic design to ensure that the aircraft was inherently stable. Once launched it was on its own, and its fate was determined by the skill that went into its design and trimming. Despite the apparent shortcomings of such models they represented an interesting challenge, and free flight thrives to this day. It was apparent even in these early days that the ultimate model aircraft was going to be radio-controlled. At the time no frequency allocations had been made for the purpose, and so aeromodellers teamed up with radio amateurs. It was this combination that finally brought success.

Most of these early developments took place in the USA and France, and even before the war the Americans were running radio control events at their national championships. One early American pioneer was Dr Walt Good. While most contemporary radio-controlled aircraft only offered control of one function (usually the rudder), he developed an amazing control system. It consisted of a rotating vane mounted behind the tailplane, and this vane normally rotated freely in the slipstream. On receipt of a coded command, it could be stopped in one of four positions, providing left and right rudder — plus up and down elevator. Using this system, he won several national championships before these activities were abruptly terminated by the Second World War.

After the war, development quickly took up where it left off, much aided by the ready availability of surplus war equipment. Most governments made an allocation in the 27 MHz band for model control at this time.

Perhaps 'radio-controlled' is too strong a term to describe many of these early efforts. Usually only one function, the rudder, could be controlled and on a fairly erratic basis.



This model is a Power House, a 1940s design. In its original form, it was intended for free flight but the model shown here is radioassisted

Move Towards Reliability

Reliability was not a word usually associated with these early systems. Most of these aircraft were designed for 'free flight' with occasional nudges from the 'pilot' to aim them in the appropriate direction — 'radio affected' may be a more accurate description. Transistors were unheard of in those days, and it required a fairly large model to haul aloft the valve receivers and associated high-voltage power supplies.

By the late 50s and early 60s, the transistor had arrived. Sizes came down, reliability improved and radio control started to come within the reach of the average modeller. More sophisticated control systems started to appear, and in the early 60s the legendary (or notorious) space control system appeared. For the first time a system offering smooth proportional control was available. In other words, the further the control stick was moved, the further the control surface moved. Previous radio control systems were of the 'bang-bang' variety: operating a switch on the transmitter caused the control surface to move over to its fullest extreme, returning to neutral when the switch was released. This was somewhat like trying to control the speed of a car by jamming the throttle wide open, and switching the ignition on and off. The space control system also allowed the pilot to operate all the controls simultaneously, instead of one, or at the most two, at a time. At last a system was available that offered (at a considerable price) all the control functions available to the pilot of a full-sized aircraft.

However, reliability was still a problem. Although much improved from the early days, the first proportional systems left a lot to be desired. Based on analogue computer principles, drift in response to temperature or battery voltage fluctuations was a major problem. Also the servo motors were controlled by vary-

* The author is technical consultant to a radio control equipment manufacturer

Feature

ing DC voltages. The ensuing soggy control response came in for much criticism. In response to this criticism two Americans, Don Mathes and Doug Spreng, developed a digital system. It was so successful that within two years analogue had been wiped off the market. It was this digital system that was the basis of virtually all currently available radio-controlled systems. Apart from its greater reliability compared with the analogue systems, it was able to make use of cheap integrated circuits that were just starting to become generally available.

Although the versions available now are much more highly developed, the basic principles of operation remain the same. Indeed, so successful and simple are the modern versions that they have replaced the old 'single channel' systems which once represented the bottom of the market.

Choice Of Model

Having acquired a radio control system, the next question is: what to control with it? Well, virtually any model of anything can be radio-controlled. The more usual applications are boats, cars and aircraft. In all three categories there are a wide variety of types for different applications. Perhaps the simplest examples are the 'toy' boats and cars that are now becoming cheaply and readily available. At the other extreme in the car and boat market are some extremely sophisticated machines capable of surprising speed. For example, one racing car kit now



Special pool laid for the model boats at Sandown Park Racecourse*



One of the radio-controlled model racing cars moving at high speed around the specially adapted circuit at Sandown Park Racecourse. Some of the crashes looked painfully realistic

*Courtesy of RADIO MODELLER, Model & Allied Publications

available features fully independent suspension, limited slip differential, and a top speed (on a suitable surface) that wouldn't disgrace a small family saloon! A kit like that costs over £100, less the engine and radio, and must be considered a specialist project. For boat and car use a two-channel radio control system is adequate, though some models may occasionally use three.

Incidentally, 'channel' in relation to a radio control system refers to the number of functions it will control, *not* the number of frequencies it operates on. My particular speciality is aircraft, and you will notice that this article is biased towards aircraft models. However, most of the principles apply to all radiocontrolled models.

Model Aircraft

Aircraft models cover a wide spectrum. The range of models that have been built span from simple gliders and low-powered trainers through to multi-engined scale replicas of famous aircraft. Probably the most sophisticated model aircraft is the helicopter. First demonstrated in the early 70s, model helicopters are now widely regarded as the ultimate challenge to a keen modeller.



A Garbo helicopter. This was built from a kit imported from Italy*

For control of a car, boat or glider, two-channel control is adequate. For a glider these two channels would normally control rudder and elevator. The minimum number of channels required for full control of a powered aircraft is three: rudder, elevator and throttle. For more sophisticated aircraft and helicopters four channels are required, adding aileron controls. Scale models may have retracting undercarriages, flaps, bombdrops and indeed anything else that your imagination can conjure up — the sky is literally the limit. Strictly speaking, these extras are luxuries and are not essential to the successful operation of the aircraft.

A typical 'standard' outfit will consist of a four-channel transmitter and receiver, four servos to operate the controls, and rechargeable nickel-cadmium battery packs. (The battery packs are often referred to as Ni-Cads or Deacs, for the same reason that all vacuum cleaners are called 'Hoovers'.) Radiocontrol systems can be run from dry cells, but this is usually a false economy. The capacity of dry cells is generally much less than good Ni-Cads, and the cost of replacing them every weekend is tremendous. A good set of Ni-Cads and a charger will pay for themselves inside a few months.

How Radio Control Works

Nearly all modern radio control systems use the standard 'digital' technique. Each control stick on the transmitter determines the width of a pulse generated by the encoder, and each pulse is transmitted in sequence to the receiver. At the receiving end a decoder sorts out the pulses and feeds each one to the appropriate servo.

When the pulse arrives at the servo, a pulse of the opposite polarity is generated, the width ('on' period) of which is deter-

mined by a potentiometer on the servo output shaft. The two pulses are then added. The result is a pulse with a width proportional to the amount of error between the two input pulses. It is the polarity of this pulse which indicates the direction of the error. Figure 1 illustrates the principle. Because the drive signal fed to the servo motor consists of pulses at full voltage, regardless of width, the servo develops its maximum torque even on very small errors. The result is excellent servo response.





Figure 1. Remote control, by means of digital pulses, of a servo system

The control pulses in the transmitter are generated sequentially, with the trailing edge of the pulse for channel 1 coincident with the leading edge of that for channel 2. Consequently it is not necessary to transmit the whole pulse, but simply a marker pulse to indicate the end of channel 1 and the start of channel 2. This simplifies decoding at the receiver considerably. Decoding can be achieved with a simple CMOS counter, or TTL shift register. Figure 2 shows the sequence of pulses.



Figure 2. Waveforms associated with encoding and decoding of control signals for a three-channel system

Radio Control I

Until a couple of years ago the pulses would have been transferred to the transmitted carrier wave by amplitude modulation (AM), but AM is rapidly losing ground in favour of frequency modulation (FM). The advantages of FM over AM are considerable. The range is generally improved, interference rejection is considerably increased and, because this mode of transmission is 'cleaner', it has proved possible to get more spot frequencies in a given band.

Wavebands For Radio Control

The future of radio-controlled modelling looked somewhat uncertain until recently. Government dithering over the allocation of wavebands for radio control has caused much anguish to modellers. At last three wavebands were specified, details of which are given in **Table 1**.

Band (MHz)	Maximum Output (W)	Usage
26.96 - 27.28	1.5	All models
35.005 - 35.205 458.5 - 459.5	0.5 0.5	Aircraft only All models

Note: Equipment for use on the 35 MHz band is subject to type approval procedures

Table 1. New frequency allocations for radio-controlled models

Some of you may have noticed that the 27 MHz allocation coincides with the band used for CB radio in many other countries. This has resulted in considerable problems over the past few years. The illegal operation of CB radios in this country has rendered the 27 MHz band virtually unusable near most big towns, and was a major factor in the granting of the new 35 MHz allocation for aircraft use. The 27 MHz band is also used by paging systems, and although pagers and modellers have peacefully coexisted for many years, 27 MHz must now be regarded as obsolete for aircraft use. I certainly couldn't recommend anyone intending to buy new equipment for aircraft to buy 27 MHz gear. Largely because of this situation, the price of 27 MHz equipment has come tumbling down of late. You can now buy a two-channel digital proportional transmitter and superhet receiver for £12. This is a great temptation to newcomers, but if you are thinking in terms of aircraft I would urge you to forget 27 MHz.

Virtually all modern equipment, whichever band it is designed for, will have a plug-in crystal facility. This enables the actual frequency of operation within the band to be changed quite simply. Some more expensive outfits also have a plug-in module facility which enables the equipment to be changed from, say, 27 MHz to 35 MHz.

Because of radio band congestion at many flying sites these days, and to prevent frequency clashes between individual modellers, it is normal practice to fly a pennant from the transmitter aerial. For the 27 MHz band, the colour of the pennant indicates the actual frequency in use. On the 35 MHz band, channel numbers are displayed on a square orange pennant.

The 35 MHz band is significantly smaller than the 27 MHz band. Also, the number of active modellers is increasing all the time. Because of this increased congestion, the channel spacing on the 35 MHz band is only 10 kHz. Previously, back on 27 MHz, the spacing had been 20 kHz. Unlike most other radio systems, a radio control system is almost always required to operate in the presence of very strong signals on the adjacent channels. The pilots are rarely more than a few yards from each other, and when a model is being carried to and from the pit area (space in which the pilots stand), it may be within a few feet of several transmitters putting out over 0.5 W within 100 kHz of each other. This obviously places severe strain on the front end of the receivers. At 10 kHz spacing the problems are even greater, and this was one of the main reasons for the switch to FM. Receivers operating on FM have much better immunity to interference in these high overload situations.

A bonus side effect was the almost total elimination of what is called 'glitching' in high speed models. In a very fast model, it is not unknown for the received signal strength to vary by over 120 dB (one *million* times) per second! Trying to build an AGC (automatic gain control) system to cope with changes as rapid and as large as this defeated many communications experts.

Feature

FM systems don't need an AGC, so they don't suffer from the dreaded 'high-speed glitch'.

However, to guarantee that the transmitters can operate safely with these narrow channel spacings, a type approval system is necessary. Consequently 35 MHz equipment tends to be more expensive. In radio control, as in anything else, you get what you pay for.

As can be seen from Table 1, an allocation in the ultra-high frequency (UHF) band has been made to modellers. Although long-distance transmission is possible at UHF for airborne models during flight, the ground range can be limited. (This can cause problems during take-off!)

No Need For A Licence

From 1 January 1981, it was no longer necessary to obtain a licence to operate radio-controlled models. Up to that time it had been possible, through the issuing of licences, to gauge the number of modellers operating in the UK. In January, the total issued was close to 100,000 and had been increasing at a rate of about 1,000 each month.

Flight Range

I am often asked, in connection with flying models, 'How far will they go?' As with most radio systems, the ground-to-air range will be considerably better than the ground-to-ground range. If everything is working correctly, the air range should be considerably in excess of visual range. In other words you will lose sight of the flying model before you lose radio contact. In terms of ground range this will translate to around one mile, depending on local conditions.

Flying Hazards

It is worth bearing in mind that an out-of-control model aircraft is a *potentially lethal missile*. Do not attempt to fly one in builtup areas, nor in parks unless you are under expert supervision! It may look easy when you see an expert do it, but the acquisition of these skills is not an overnight process. I strongly recommend taking out a third party insurance policy, no matter where you fly. These policies are very reasonably priced. Schemes are advertised in the modelling press, and most clubs offer club insurance schemes.

Equipment Cost And Lifespan

It is just about possible to get a radio-controlled model aircraft into the air for under £100, buying everything new. However, a more realistic figure is probably about £220. A good set of 35 MHz radio equipment, which will be a four-channel outfit, will cost around £150. For a little bit less you could get a two- or three-channel set that would be expandable at a later date. Anything substantially cheaper is likely to be either restricted to 27 MHz, or with two or three channels but incapable of being expanded as your skills grow. A first class engine (always a good investment) in the 0.19 to 0.4 cu in bracket is likely to be between £25 and £40. A trainer type aircraft kit will be around £30 to £40.

This may all sound horrendously expensive, but it is nearly all initial outlay. The actual running costs are very low. For example, a good engine, reasonably well maintained, can have an expected working life of 5 to 10 years. A radio control system should last at least 5 years. The model itself is likely to be the cheapest element in the system, and also will have the shortest life. A crash has to be extremely severe before any significant damage will be caused to the engine. Similarly if the radio is properly installed, you have to be very unlucky to damage it severely in an accident. Airframes are, of course, another matter and must be regarded as expendable.

Radio failure is extremely rare these days. Most cases of 'radio failure' can be traced to three causes: pilot error, outside interference, and structural failure. Since most of these causes can be eliminated through taking reasonable precautions, the initial outlay spread over a number of years' use looks more attractive.

*Courtesy of RADIO MODELLER, Model & Allied Publications



Model based on a monoplane in use before World War I

Making The Right Start

While it is possible to teach yourself to build and fly radiocontrolled model aircraft from scratch with no outside assistance, it is not a method I recommend. By far the best method is to seek assistance from the local club. Clubs are always ready to assist and welcome newcomers to the hobby. If you don't know where the local club flies, then contact the local model shop. It will be only too pleased to aim you in the right direction. If you don't know where the local model shop is, then a good guide is the modelling press. There are two magazines published monthly that specialise in radio control: Radio Modeller, and Radio Controlled Models and Electronics, both published by Model and Allied Publications (MAP). A third magazine, Aeromodeller, also from MAP, covers all aspects of model aircraft including radio control.

Another source of information relating to local clubs is the Society of Model Aeronautical Engineers (SMAE), Kimberley House, Vaughan Way, Leicester. The SMAE is the official body that represents modellers, and as such is well worth joining if you become an active modeller. It will be able to supply the addresses of any affiliated clubs that may be in your area.

For those more interested in the electronics behind radio control I thoroughly recommend a book entitled 'Theory and Practice of Model Radio Control' by Paul Newell. It's available from most good model shops and even from some public libraries.

It is said that pictures speak a thousand words, and so I leave it to the accompanying photographs to show the variety of models that can be built. *Please* don't attempt a fully detailed scale Spitfire as your first model...!

> An example of what you can build a World War II Japanese bomber from the Pilot range of kits*

Radio Control



Example of a plastic ready-to-fly model from Japan. It needs an engine and a radio to be ready for take-off

The pictures shown give some idea of the kinds of models that can be operated by radio control. They were all taken at the Sixth Model Symposium, organised by Elmbridge Model Club at Sandown Park Racecourse on 9 and 10 May 1981. A full story of the event is given on page 20.



David Wilshere, aged 14, is seen here holding an Italian Aviamodelli Mach-1 model. With its tuned-pipe engine, this model is designed for aerobatics



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Models Galore At Sandown

As a change to horse racing, Sandown Park Racecourse featured, for just two days, a multiplicity of models

ON SATURDAY AND SUNDAY, 9-10 May 1981, Sandown Park Racecourse in Esher, Surrey was transformed. Instead of the, sound of thundering hooves, the air was abuzz with model aeroplanes and helicopters.

This sixth model symposium, organised by Elmbridge Model Club, was reported as being the biggest yet.

HE made a visit at lunchtime on the Saturday when attendance seemed light, presumably because of the Cup Final. (A couple of TVs had been laid on in the grandstand bar area for football addicts.) Biggest attendance was, as in previous years, on the Sunday.

Events were taking place all round the grandstand. Part of the course was roped off for a continuous display of flying models, and this proved to be one of the greatest attractions. For instance, we were intrigued to see one helicopter hovering upsidedown above another which was flying the correct way up, with only a few feet between the blades.

Other outside events included radio-controlled model car racing (fast and furious with some sickening grating sounds as cars overturned at the corners of the tarmac track) and radiocontrolled model boats on a pool at the back of the grandstand. There was even a radio-controlled model duck!

It was possible to see all these radio-controlled models running side by side this year because the modellers had three frequencies at their disposal: 27, 35 and 459 MHz. (But see the comment under this month's Monitor on page 6 about modellers' fears over specifications for equipment coming into use on 35 MHz.)



Two entrusiests propering a scale model of a Britten-Norman Firecractur for flight. This model uses two engines working on a common gearing system. The aeroplane on which this model is based is a new design and is in use by the RAF as a trainer

Behind the grandstand, 'control line' flying displays were taking place, with the modellers pirouetting on sheets of board in the middle of the paddock, while their 'planes, held and controlled by double cords attached to the end of one wing, looped and d ved in the air around them.

Meanwhile, for the indoor enthusiast (or for those who wanted to escape from the occasional burst of rain) there was a railway hall. Here the clubs had laid out displays of all the popular track-gauges. Somewhat incongruously, a slot-car racing layout attracted a big audience in one corner of the hall.

After goggling at finished and working models it was time to visit the trade hall, where you could choose your kit or bag of components . . . and pay the necessary cash.

We thought that the event was a credit to the organisers. Plenty of car parking space was available (even though it was a five-minute walk from the car park, around the outside of the coursa, to the entrance). Food and refreshments were on sale, and the grandstand enabled you to sit under cover.

Ycu could take the family (we saw an abundance of kids, old and young), see the latest models, and have an enjoyable day out. Here's to number seven!



The Whitley bomber and its pilot from the Sprengbrook demonstration team. This model has been used over the last few years to drop 'toffee bombs' on the crowd at Sandown



▲ Model aeroplanes from Skyway in Bristol. These are supplied in kit form, with most of the components ready for assembly. The three models in the foreground are a Spinks Akromaster, a Percival Meuguli (a plane in use between the First and Second World Wars) and a Russian YAK18

Yes — model helicopters can fiv upside down! Here Len Mount from the Ripmax demonstration team is flying an inverted helicopter a faw feet above one the right way up. Len developed his helicopter to fly in both modes. Both helicopters in this demonstration of 'mirror hovering' are Schluter models from Germany*



One of the more unusual radio-controlled vessels (apart from the radio-controlled duck!). This is a beautifully-finished paddle steamer









Model trains can be very absorbing . . . This young observer is seen admiring just one of the many layouts in the railway hall



Dave Nieman Models' stand — helicopter specialists based in Wembley. The firm also acts as the main importer of the Hirobo range of models from Japan*

* Courtesy of RADIO MODELLER, Model & Atled Publications



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Tiny, easily hidden but which will enable conversation to be picked by with FM radio. Can be made in a matchbox — all electronic parts and circuit. £2.30.

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6 WAVEBAND SHORTWAVE RADIO KIT

VEBAND SHORTWAVE RADIO KIT spread covering 13.5 to 32 metres. Based on circuit which interd in a recent issue of Radio Constructor. Complete kit in s case materials, six transistors, and diodes, condeniers, resu-nductors, whiches, etc. Nothing effect buy if you have an dier to connect it to or a pair of high resistance heighbones ett as Price € 11 95

SHORT WAVE CRYSTAL RADIO

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ermometer

Convert your meter to read temperature with this simple add-on unit

USING THIS CIRCUIT you can convert any voltmeter capable of reading 0-1 V to a 0-100°C temperature probe. The device that makes this possible is National Semiconductor's LM335. This is a temperature-sensing integrated circuit housed in a TO-92 transistor type package which acts as a shunt regulator giving an output voltage of 10 mV per degree. The chip gives a 0 V output, not at 0°C as you might expect but at absolute zero, minus 273°C. This means that an output voltage of 2.73 V is obtained at freezing point. To get a 0 V output from the circuit at 0°C, all we need to do is compare the output of the chip with a reference voltage of 2.73 V, which we obtain from a second integrated circuit, the TL430C.

Construction

Begin by mounting resistors R1,2,3,4,5, integrated circuit IC1 and variable resistor RV1 into the printed circuit board (PCB), as shown in Fig.2. As IC1 and IC2 look alike make sure you've picked up the right device, the TL 430C. Check its orientation against the overlay diagram.

Now connect a voltmeter with its negative lead to 0 V and its positive lead to the junction of R4 and R5. With the unit connected to a 9 V battery you should be able to adjust RV1 to obtain

disconnect the meter and battery and a reading of 2.73 V. If all is well, solder R6, RV2 and IC2 into the PCB, taking care with IC2's orientation.

Reapply power and connect the meter this time with its negative lead to the junction of R4 and R5, and its positive lead to the junction of R6, IC2 and RV2.

By adjusting RV2 you should obtain a reading corresponding to the ambient temperature. If the temperature is 25°C adjust RV2 for a reading of 0.25 V.

Only one calibration is needed as this sets the chip accurate to within 1°C over a range of - 10°C to - 100°C.

Now, mark and drill the case to fit the panel meter and on/off switch. Mount the PCB, battery, switch and meter into the case and wire up the project as shown in Fig.2.

If you wish to make a temperature probe, you can mount IC2 remotely from the PCB. Choose a mounting to suit your application, taking care that the leads cannot be bridged or shortcircuited if measuring water temperature, for example. In fact, it is a good idea to encapsulate the complete IC in epoxy resin or similar, if you intend to use the probe to measure water temperature.

And there you have it. With just two comparatively cheap chips and a

handful of components, you have a complete linear temperature measurement system.



Parts List

RESISTORS (A R1 R2 R3 R4 R5 R6	NI ¼W, 5%) 120R 10k 1k8 330R 2k7 5k6
POTENTIOMET	TERS
RV1	2k2 miniature horizon-
	tal preset
RV2	10k miniature horizon-
	tal preset
SEMICONDUC IC1 IC2	TORS TL430C adjustable zener LM335Z temperature sensor
MISCELLANEC	us
M1	any meter capable of
	indicating 0-1 V (for
	0-100°C measure-
	ment range) — 566 Ruilding Site op
	page 39
Case to suit (se	e Buylines)



How It Works

The heart of the circuit is the LM335Z solid state temperature sensor. When a current of 400 uA to 5 mA is passed through this device, a voltage of 10 mV per degree is developed across it. At 25°C (room temperature) a voltage of 2.98 V will be produced, not the 0.25 V (0.01 x 25) that you might expect. This is because the output is proportional to absolute temperature and 0°C is 273 K so 25°C is (273 + 25 + 100) V, ie, 2.98 V. So that the meter will read zero for 0°C, we generate a reference voltage of 2.73 V corresponding to 0°C, 273 K (the 'K' is for Kelvin – Lord Kelvin, a physicist).



The reference voitage is produced using a special integrated circuit, the TL430C. This chip is connected just like the LM335Z and has a terminal which monitors the output voitage via potential divider R1, RV1, R2. The TL430C will regulate the voitage at its output until a voitage of about 2.7 V appears at its reference input. This occurs for an output voitage of about 3 V. Unlike the LM335Z whose output will change with temperature, the TL430C is designed to be temperature independent and its output will drift by less than 50 parts per million; per degree Centigrade (ie, not more than 150 uV/°C). The required reference voltage of 2.73 V is obtained from the 3 V output via potential divider R4, 5. This network is required because the reference voltage (and so the minimum output voltage) may range between 2.5 V and 3 V for different samples of the device. Preset RV1 accommodates this variation, enabling a 3 V output to be obtained from any sample. To obtain a temperature measurement, e 1 V FSD meter is simply connected between the reference voltage from IC1 and the output of IC2.

Buylines

Semiconductors for this project are being stocked by Technomatic. The approximate cost of components (excluding PCB, case and meter) is £8. Shop around for meters because they can vary a great deal in price. We used a case from Vero Electronics to house our prototype, stock number 202-21390.

Figure 2 (below). Printed circuit board overlay of the HE Thermometer and connection details. Make sure you don't confuse IC1 with IC2 as they are similar both in size and shape. Building Site on page 39 of this month's HE gives practical advice on meters

Below left. Internal view of the HE Thermometer. Keep all leads short and neat





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BOTALY SWITCHES BUP es. * ROTARY SWITCHES BUP es. * SW 673 Benk	UWINAMICD PACKS (10 asst) packs (2.59) 50 Silcon & Germanum Transstors. 40p 50 Silcon Diodes 40p 50 Silcon Diodes 40p 50 Germanum Diodes 40p 50 Germanum Diodes 40p 100 Polystyren Capacitors. 40p
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Part four of this series looks briefly at the life of Joseph Henry, whose name is associated with the unit of inductance

WE'VE BECOME quite accustomed in this century to remembering the names of famous scientists of the past by using these names for measuring units or instruments. This way, even though you may have only the faintest notion of who Ampere, Ohm or Volta were, you can't escape the familiarity of the names. Nevertheless, some names are not so well known as others, and Joseph Henry must rank among the names which very few of us would recognise except as the name of the unit of inductance.

Perhaps part of that unfamiliarity is because Henry was American, and he worked on many of the projects which, to us in the UK, were the province of Michael Faraday. The two men were, in fact, very often engaged in the same line of research at the same time but, because of the poor communications of the time, were unaware of each other's work. That'll teach us to complain about second-class post!

Let's start at the beginning. Joseph Henry, who was born in 1797, is regarded as the second most outstanding US scientist, taking second place only by a whisker to Benjamin Franklin. Let's see if we can catch some flavour of what he contributed to our knowledge of electricity.

Choice For Life

Joseph Henry intended to study medicine when he went to Albany Academy in New York in the 1820s, but medicine was a science in its infancy and Henry caught the excitement which surrounded the study of electricity. In 1825 he abandoned medicine and changed to a course of practical science, which we would now call engineering. He was brilliantly successful, and in 1826 was appointed to teach Mathematics and Physics at Albany Academy. This was a wise choice, both for him and for the Governors of the Academy. In Joseph Henry, Albany Academy gained an outstanding teacher and a brilliant scientist. Few discoveries have ever been made which have come as a complete surprise to anyone with a really good grounding in Mathematics and Physics — and there is nothing better than these subjects today to ensure an education which will set you up for life.

His work began to bear fruit in 1829. Until that time, electromagnets had been made by winding bare wire onto insulating formers which were threaded to ensure that one wire could not short against the next — we still wind coils for shortwave receivers this way. Henry demonstrated that by using insulated wire and by winding it closely, layer over layer, he could greatly increase the lift of an electromagnet. He proved the point by constructing a magnet which could lift nearly a ton, and gave it to Yale University.

Electromagnetism naturally led to the idea of generating continuous movement by using electricity, and to a form of electric motor in 1829. This was eight years after Faraday had first demonstrated the possibility of causing continual motion by using magnetic forces, but Henry's motor was a much more practical affair, quite capable of being built in larger form to drive machinery, as indeed it soon was.

Earty Telegraphy

By 1831 Henry was working alongside another famous scientist, Samuel Morse. Their task was the development of the electric telegraph, the invention which, along with the railway, was to open up the West and spread law and civilisation. The telegraph was the start of communications as we know them today. It's difficult for us now to appreciate what this must have meant in an age when the fastest communication between points too far apart to see was by a man and a horse.

The telegraph was initially a very simple device, consisting of an on/off key at one end and a current-detector at the other,



with lots of wire in between. The effect of all that wire in between was one of the problems which Henry decided to tackle. In practical terms, the greater the distance between two stations on the telegraph, the slower the operator had to transmit. If he didn't slow down, the receiver did not indicate a clear-cut dot or dash, up to the point where it might even have stopped moving altogether.

In 1831, Faraday had discovered electromagnetic induction. If you move a magnet near a wire, a voltage appears between the ends of the wire while the magnet is moving. Henry took up this idea, and reasoned that physical movement was not necessary, only a change of magnetism. When a current starts flowing through a wire, there must be a change of magnetism from zero (no current) to whatever amount is present when the current reaches its full value. This change of magnetism, Henry reasoned, should also cause a voltage to be induced in the wire - the same wire! He realised further that this induced voltage would oppose the current and try to stop it from increasing. It was this opposing voltage which was causing the odd effects on long telegraph lines, and the effects could be much more conveniently studied by winding the long wires onto electromagnets. Henry looked at some of his old electromagnets, and made measurements of the voltage across the terminals when the current through the coils was changed. He found that for a given shape of magnet, with a set number of turns, the ratio:

voltage across terminals rate of change of current

was constant.

This constant quantity had no relation to the DC resistance R of the wire. Henry called the quantity 'self-inductance', and another of the essential quantities of electronics was born.

In the same year of 1832, Henry was appointed Professor of Physics at the College of New Jersey — now Princeton University. Some idea of the breadth of his ability may be judged from the subjects he was expected to teach as well as Physics — Maths, Chemistry, Minerology, Geology, Astronomy and Architecture!

Mutual Inductance

He continued his research, looking now at the transformer effect in the light of his discovery of self-induction. He soon discovered what had been observed by Faraday earlier. If two separate coils of wire are wound around a ring of iron (an ar-

Famous Names

rangement we now call a toroidal transformer, and treat as if it had just been invented!), then a *change* of current through one coil causes a voltage across the other for as long as the current is changing. Once again, Henry made measurements, and showed that the ratio:

> voltage across second coil rate of change of current through first coil

was a constant for a given transformer. He called the quantity mutual inductance, so providing constructors of transformers with a method of measuring the 'goodness' of their construction. It was hardly surprising, then, that the units of both selfinductance and mutual inductance were to be called Henries, in his honour.

Early Radio?

The days of his great discoveries were almost over, for by this

time Henry was a senior scientist devoting his life to bettering science education, but one curious little experiment makes us wonder what might have been. He described coiling a wire round a needle, attaching one end of the coil to earth, and the other to a wire (we would call it an aerial) held up by a kite (see **Fig.1**). After a lightning-flash some eight miles away, he found that the needle had become magnetised. This was probably the first recorded action of radio waves — he might so easily have gone on to see if the needle would also have become magnetised by a spark generated at a distance by a battery and a coill

By the time he died in 1878 Henry had achieved all this, and just as important, served as the first secretary of the Smithsonian Institute. The Smithsonian was the agency by which US Government money could be channelled to support scientific research, the start of the process which put a man on the moon and which made the US the predominant force in world technology.



Competition Results

On Friday 29th May 1981, entries from the finalists in the Hobby Electronics Wales and West Schools' Electronic Project Competition were judged at the Unicorn Hotel in Bristol. We present

details of the winning entries

BECAUSE OF THE high standard — and diversity — of the entries, the final choice was a difficult one. We had to balance, for instance, originality with constructional skill and ingenuity with improvisation. Several of the designs had been built, out of necessity, strictly to a low budget and yet high standards had been maintained.

The Winners

FIRST PRIZE was awarded to Nicholas Murphy, aged 17, from Abingdon School, Abingdon, Oxon. His project was a Chemical Conductivity Computer Interface – called Datafeed 1 for short. When connected to two probes immersed in a solution, the instrument compares any detected change in resistance with preset calibrated values. The project was designed from first principles for a practical purpose; that is, to enable chemical reactions to be monitored continuously by a computer. (It

First Prize winner Nicholas Murphy, from Abingdon School





Front view of Nicholas's project, Datafeed 1, with the cover removed

has been used with an Apple computer.) Nicholas designed the printed circuit board (PCB) for his project.

He will receive a component voucher for £100, and Abingdon School will be presented with two Kikusui 538A oscilloscopes, from Telonic Berkeley (UK) Limited. The Hobby Electronics Award Trophy will also be presented to the school.



Project designed and built by Second Prize winner Paul Miller, from Filton High School. The project allows up to 10 power sockets to be switched on and off by ultrasonic remote control

SECOND PRIZE went to Paul Miller, aged 16, of Filton High School, Stoke Gifford, Bristol. His project was a device which could enable physically handicapped people to switch a variety of mains appliances on and off by remote control. The project had been designed by Paul and was among three finalists' entries which had been designed with the International Year of Disabled Persons in mind. Up to 10 power sockets can be controlled by means of a hand-held ultrasonic transmitter. The unit had been built in prototype form for around £12 and included some useful features such as visual (LED) indication of selected channels and manual override. Like the First Prize project this project had been designed from first principles, and made use of PCBs made by Paul.

Paul will receive a component voucher for £50.

THIRD PRIZE and TOP JUNIOR PRIZE both went to Pierre Varischetti, aged 13, of Ashmead School, Northumberland Avenue, Reading. His project was an electronic organ, where economy was the keyword (total cost was around £10). To stress this point, the keys had been retrieved from an old piano and the case had been built of

wood taken from the cabinet of an old TV — and yet the organ has an excellent



Pierre Varischetti, from Ashmead School, with his 'economy' electronic organ project. He was the winner of the Third Prize and Top Junior Prize

appearance, complete with four screw-in legs. It uses six oscillators, with one integrated circuit for each and, despite a simple circuit design and the use of only two HP2-size (1.5 V) cells, it produced a loud and impressive sound. The organ had been designed, as had the other two projects, from first principles, and used PCBs made by Pierre.

Pierre will receive a component voucher for £25 (third prize) and a Galactic Invaders television game from Tangerine Computer Systems Limited (under-15 age group prize).

A HIGHLY COMMENDED ENTRY was submitted by the Electronics Club of St Birinus School, Didcot, Berkshire. This project, described as a Stage Lighting Computer, was so large and consisted of so many parts (complete with back-up service and test gear) that it took the best part of an hour to set up in the room where the projects were being judged. Although it was still at the experimental stage, the computer was designed to control 16 channels (16 individual sets of stage lights) in 64 steps from a pre-programmed memory. (This step capacity could be expanded according to memory size.) When it is finished, it should be possible to program light sequences (on, fade up, fade down, and off) from a numeric keypad. We were given a demonstration of pre-programmed dimming on one channel.

The Electronics Club, under the supervision of Mr D Colvern PhD, Head of Physics and Electronics, built the computer and its peripheral electronic switch gear as a joint effort, including the design of the PCBs.

Estimated component cost was placed at £150, although much surplus hardware had been used in the prototype.



Mr D Colvern, Head of Physics and Electronics at St Birinus School, with members of the school's Electronics Club. The lads are seen busy at work setting up their Stage Lighting Computer project

Free Subscriptions

The first 25 schools which submitted entries will each receive a year's free subscription to HE.

Some of the entries will also be considered for use as HE projects.

We would like to thank all concerned – masters, pupils and parents – who took part in the '81 competition. Despite the cancellation of the Hobby Electronics exhibition at Bristol, we were determined that this competition would go ahead as planned. **Clever Dic** CD's got an answer for nearly everything this month. In fact, the only things he seems to be a bit short of are free binders

SIFTING THROUGH the mountains of mail I received this month, I came across some *really* interesting and stimulating letters (yawn). Anyway, I quickly threw them in the bin and took a look at more of the usual garbage I normally answer — sure enough, here they are:

Dear CD,

I am a flashing lights and weird noises fan. Please could you publish a sort of cross between the HE Super Siren and an interesting LED flasher circuit? I have been buying HE for three years now (grovel, grovel), and there are lots of copies lying around. I am now grovelling at your boots (lick, lick). The FREE binder has got to go somewhere, so why not unstick yourself from it. Stephen J Bernhoeft, Stockport, Cheshire

PS Well, it's nicer than D S Nightingale's letter — grovel, grovel, grovel, grovel.

Well, there's not much I can say after that one except that it's such a grovelling letter I reckon you should send *me* a binder! I'll pass your request for a project onto the project department.

The next letter pulls out an old boob.

Dear Clever Dick,

So you think you are clever enough you haven't found this mistake for two years. Yes, two years, back in July 1979. What I found is in Chit Chat (page 55). Figure 2 shows the diagram of a circuit which is exactly the same as Fig. 1 (page 54). The + and inputs on the 741 in Fig. 2 should be the other way round.

Do I get a binder for finding the record-breaking longest-delay mistake? Your sincerely, Dave,

Margate, Kent.

Mistakes from two years ago worth a binder — you've got to be kidding — I've enough problems coping with the mistakes this month!

Dear Sirs,

You mention in Clever Dick of June '81 that you hope to publish a much lower priced amplifier in a ''comming issue''. Could you please tell me roughly when this might appear and how much will it cost? Are you planning to publish another speaker design with it?

If you are designing it yourselves I feel that the Image Width control on the 5080 System is worth retaining, and that it is worth concentrating on an appearance which will distinguish it from commercially available systems. Your faithfully, R Hanbury, Windsor, Bucks.

Yess, everboddy maykes speeling misstakes now and agen yoo know. Actually our project lads haven't yet finalised designs for the new amplifier system so perhaps some of our other readers have a few suggestions to

At last, the first really sensible letter this month, and it's worth a sensible answer.

Dear Clever Dick,

make, too.

Thank you for your brilliant mag. As a beginner in electronics I am not sure of the different values of capacitors. What does 10u and 100n mean? Robert Preddy, Bristol

PS I'm not scrounging for a binder, but...

Capacitors are measured in farads (abbreviated as F) but farads are very large quantities of capacitance, so we divide the unit down into smaller bits:

• One microfarad (1u) is a millionth of a farad ie, 1 x 10⁻⁶ F. A large proportion of all the capacitors you are likely to see will be measured in microfarada, but some applications

microfarads, but some applications need smaller values:
Nanofarads, where 1n = 1 x

 10^{-9} F (ie, one thousandth of

a microfarad)

And smaller still:

• Picofarads, where $1p = 1 \times 10^{-12}$ F (ie, one thousandth of a nanofarad).

It'll probably all seem a bit complex at first, until you get 'wallpapered' (that's CD slang for 'the hang of it'), but once you do you'll be swapping between 0.01u and 10n as if you have been doing it all your life. PS It's just as well you're not

scrounging for a binder, because I'm not giving any . . .



Shut That Door!

Dear CD,

I have recently purchased a digital coded lock from one of your advertisers, and I wish to fit it to my street door. But I cannot seem to get hold of a solenoid type of lock which will operate with the 5-18 V output of the system. Could you help? Thanks for a great mag, keep up the good work. T Winters,

London

I asked around the lazy slobs who 'work' in the HE office and none could give me an answer to this problem. So I'm going to put out a plea to all our readers to see if you can help me with this one. If you know where Mr Winters can obtain a low-voltage operated solenoid lock, let me know and I'll forward the information.

The last letter this month is somewhat devious.

Dear CD,

Can you please tell me if RV2 in the HE Phase One Guitar Phase (September '80) is 470k or 47k? Also, where can I get one from, as it is antilog?

As a mag which is never BehIND othER mags, how about a kit review on J Bull's CB Monitor kit in G,G&K? Yours cryptically, Chris Hand,

Rochdale, Lancs.

I looked up 'cryptic' in the Oxford Dictionary and it means 'secret, mystical, mysterious, enigmatic, obscure in meaning'. Does this mean that you're secretly trying to persuade me to send you something? Well, it's too obscure in meaning for me - I don't kNOw what you mean!

The potentiometer RV2 should be 470k in value. You should be able to get one from Watford Electronics (who originally stocked the parts for the kit).

A kit review in GG&K on a CB Monitor sounds like a good idea to me. I'll pass on the suggestion to the relevant quarters.

I've got to go now, — but keep those letters rolling in . * HE



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Two items from Casio are reviewed in GG&K this month: the VL-Tone combined electronic musical instrument and calculator and the fx-3500P programmable calculator. Also under review this month is Adventures With Microelectronics, from Unilab, an educational kit containing a variety of experimental electronic projects

Casio VL-Tone – Electronic Musical Instrument And Calculator

Of all the gadgets that we've reviewed so far in GG&K, the VL-Tone from Casio has been the most fascinating because of the variety of its functions.

The VL-Tone comprises a 29-note keyboard (including sharps and flats), a panel with 5 slide controls and 10 push-button controls, an 8-digit liquid crystal display (LCD) and a built-in loudspeaker. The whole instrument is housed in a rugged cream-coloured case 300 mm long by 75 mm wide by 30 mm deep.

What the instrument does is almost unbelievable, considering its small size. Its functions are outlined below.

Manual play function — the

29-note keyboard comprises nearly two and a half octaves. It is a monophonic keyboard — only one note at a time can be played (in other words, you can't play chords).

Melody storage — up to 100 notes can be stored in the VL-Tone's memory, and each note number is indicated on the LCD as it is played and as it is replayed from memory. Two methods of replay are possible: 'one key play' and 'auto play'. For the first, the melody is tapped out, one note at a time, on two buttons designated for the purpose. Thus regardless of how badly the melody was keyed in, you can tap out the notes in perfect rhythm. In the second method, the melody is played back from memory automatically exactly as you entered it - although there is provision for tidying up its rhythm and for correcting any miskeyed notes. There is also a repeat function that will replay the melody four times.

• Auto rhythm function — the following rhythms can be selected to accompany your musical efforts: march, waltz, four-beat, swing, two rock rhythms, bossa nova, samba, rhumba and beguine. You can easily switch from one to another as you are playing, and vary the rate in up to 18 steps.

• ADSR — the letters ADSR stand for attack, decay, sustain and release, and with the VL-Tone you can use these functions together with other elements to configure sounds of your own choice by inserting eight code digits into the calculator memory. Believe it or not, up to 80 million combinations are possible!

• Preset sounds — apart from the ADSR function, you can select piano, fantasy, violin, flute and guitar. The tonal quality of these sounds is surprisingly realistic, and to change the pitch of each, the





whole keyboard can be shifted to one of three different octaves during play or replay.

• Demo melody — one press of the orange button on the VL-Tone produces a 'German folk song', complete with a variety of rhythm backings.

• Calculator — in this mode, the flat notes on the keyboard become calculator keys, working in conjunction with the LCD 8-digit display. Add, subtract, multiply, divide, square root, percentage, four constants and memory functions are available.

Power Supply

The VL-Tone uses four AA-size cells, and these are claimed to give 12 hours of continuous use in music mode and 4,000 hours of continuous use in calculator mode. Alternatively, the instrument can be operated

CASIO fx-3500P

Casio's new year calculator release was a set of three programmables. Although these do not quite come up to the FX501/502P standard, their low prices are bound to find them a wide market. Here, we review the best of the three models — the fx-3500P.

Presentation

The 3500 has a stiff ABS plastic case measuring $132 \times 72 \times 7$ mm which fits into an attractive leatherette wallet. The unit has 38 keys, most with two or three functions. The keys do not actually click, but have a positive feel and we always knew when a function had been activated.

The instruction booklet is not particularly helpful, but the use of a large number of examples should guide the user to a reasonable understanding of the calculator's operation. A card is provided (as with all Casio scientifics) giving physical constants and useful conversion factors, but there is no short form operation guide as provided with the FX501/502P. No program library is included and perhaps, if Casio is keen to keep its prices as low as possible, it could publish a program library separately.

Display

This unit is an LCD device which displays 10 digits plus a 2-digit exponent in slightly smaller figures (internal calculations are performed to 11 significant figures for accuracy). from a Casio mains adaptor. If the VL-Tone is left switched on without being used, its auto-power-off (APO) function automatically turns off the supply after about six minutes. The contents of the memory are protected when this happens.

On Test

This was one gadget that we couldn't put down once we started playing with it. It was uncanny to be able to hear our recorded melodies played back, complete with a backing rhythm. The ADSR function made it possible to invent some of the wierdest sound imaginable!

After a while, we found that our one-note-at-a-time dexterity on the keyboard improved, and we felt more confident with the pieces in the Casio VL-Tone song book.

The sound from the VL-Tone (particularly the bass notes) was

The display can be set to read out to any number of decimal places (FIX mode) or significant figures (SCI mode). The calculator maintains full internal accuracy, even when rounding the display, but the internal result can be rounded to match the display using INV RND. An engineering key is provided to move the decimal point in either direction, three places at a time, so that the exponent is always a multiple of three.

A range of indicators is provided for power on, inverse key, constant, mode, program, and data entry. Our only complaint was that there is no indication that the display is set to FIX or SCI modes. The display is easily read at any angle in any incident light.

Functions

The literature for the fx-3500P claims 61 functions. The calculator makes light work of all the usual jobs such as trig, logs, hyperbolics and their inverses, powers, roots, reciprocals, factorials, decimal sexagesimal and polar/rectangular conversions, random numbers, pi and percentages. There are 18 parentheses nestable in six levels, which basically means that the calculator can hold six separate answers, each evaluated inside up to three brackets. A capability unique to Casio is the fraction function which allows answers to simple arithmetic calculations to appear as fractions. This function also changes fractions to their lowest terms or to decimals, if required.

The 3500 has seven memories designated as six K-registers which

One useful facility was the pitch control. With this you could bring the VL-Tone into concert pitch with other musical instruments.

Comment

The VL-Tone performed admirably when put through its paces. One very small niggle was the 'plopping' sound it made when it was switched off (or turned itself off automatically). This was particularly noticeable when the instrument was played through a separate amplifier.

It is being offered at a discount price of £35.95 (normal RRP £39.95 by Tempus, Department HE, FREEPOST, 164-167 East Road, Cambridge CB1 1DB (tel 0223 312866). The songbook and a soft cover are included in this price.



allow full register arithmetic plus display/register exchange, and one M-register, which gives one-touch recall, but allows only M + and M - arithmetic. All seven memories are non-volatile as is program storage and calculator mode.

Statistical Functions

The 3500 offers two statistical modes; standard deviation as provided on most decent scientifics, and linear regression for computation using related pairs of data. In addition to the usual standard deviation functions for both sets of data, linear

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regression mode provides sum of. products of data pairs, slope (gradient), intercept, correlation coefficient, x-estimate and y-estimate. Casio literature claims the availability of logarithmic, exponential and power regression, but this can only be accomplished by correction of data - for example, with exponential regression it is necessary to input x and ln y. Unfortunately, it is impossible to write a program to handle the correction process because programs will not run in linear regression or standard deviation modes.

Integration

Computation of definite integrals is achieved by the familiar Simpson's rule. The user must write a program to evaluate f(x). He or she then chooses the number of sample points required from 2 to 512, enters the upper and lower limits of integration and within a reasonable time, the integral is displayed. If the' number of iterations is not set, the calculator decides for itself, weighing up execution time against accuracy of result.

We tried evaluating the integral for a first order Bessel function between 0 and 180° and found that in 16 seconds, the 3500P produced an answer accurate to six significant figures, and, if we waited 32 seconds, we received an answer accurate to nine significant figures. Similarly good results were achieved with other functions such as the sine integral.

Programming

The fx-3500P has 38 merged steps (ie, each step performs one function, no matter how many keystrokes). These are shared between two buttons, P1 and P2. Programming is limited in all respects — there is no

GOTO, GOSUB, INT, or FRAC capability although rounding to the nearest integer is possible in FIX mode. Limited jumping is also provided: RTN performs a jump to the first step of the program: x > 0 and $x \leq M$ jump to the first step, if met and continue otherwise. This limited jumping renders the branches almost useless although simple loop control is possible. As a programmable, the 3500 resembles recent models from Sharp which simply store and evaluate formulas. One good feature is the ease of programming: one simply has to select program mode and then perform a calculation in the usual way (the calculation is actually carried out as it is entered). Two forms of halt command are provided, one to display intermediate results and one which displays a prompt for data input.

No keycodes are provided for program checking and there are no editing facilities other than selective clearing of programs, which is rather annoying as it means that if you make one mistake you have to re-enter the entire program.

Comment

The fx-3500P is a powerful calculating machine with limited programming features at a very reasonable price. It will appeal to the engineer, 0 level statistician, A level mathematician/physicist, and low-level researcher. The fx-3500P costs £22.95, from Tempus.

In the same range as the 3500P we have the fx-180P, a beefier version running on two penlight cells which has the same features as the 3500P apart from hyperbolics, and costs £19.95. Also at this price is the fx-2700P which uses the same case as the 3500P, although it has no linear regression or integrate

modes, can only store one program, and has an eight-digit display.

The fx-3500P, fx-2700P and fx-180P are all available from Tempus, HE Freepost, 164-167 East Road, Cambridge CB1 1DB (tel 0223 312866).

Timings

A loop was written to run functions 100 times and the test results are tabulated below.

basic loop time: 12.5s

Function	Loop Tia (s)	ne Average Execution Time of Function (s)
multiply by 7	24.5	0.12
store in M	14.5	0.02
store in K3	15	0.025
square root	19	0.065
natural logarithm		
(ln)	38	0.255
sine	50.5	0.38
reciprocal (1/x)	17	0.045
extract 7th root	75	0.625

These results show the fx-3500P to be a very fast machine. In use, it is possible to work through a calculation at a reasonable pace without having to check the display to see that a scientific function has been calculated.

Good Points	Bad Points
Slim, stiff, attractive case and wallet Continuous memory Display Speed and accuracy Fraction capability Linear regression Integration	Instruction manual No program library or operation guide Poor program functions, jumps and editing



Adventures With Microelectronics

If you want to get used to handling electronic components, including integrated circuits, then Adventures With Microelectronics could be for you.

At a cost of £36.36, this selfteach introduction to electronic components and circuits comes complete in a single box 320 mm by 198 mm by 35 mm. When you lift the lid you are greeted with a handwritten warning sheet stating in bold black letters: 'STOP!!! TRAN-SISTORS ARE DELICATE! HAN-DLE THEM VERY GENTLY, AND

Supplement

Gadgets Games and Kits

READ ALL THE INSTRUCTIONS!' Well, at least that should discourage the absolute beginner from rushing in without reading the glossy hard-bound instruction book supplied with the kit and making a mess of things.

What's In The Box

Apart from the book, the box contains an inset tray holding a piece of Bimboard (solderless circuit board, similar to the Eurobreadboard described in Introduction To Electronic Components on page 47), resistors, capacitors, integrated circuits and a variety of other components, all sitting neatly in different compartments.

Choice Of Projects

You can use these components to make any or all of the following projects:

An astable, monostable or a bistable NAND, OR and NOR gates

Two-tone door bell Warbling-wailing siren Two-octave electronic organ Pulsed flashing lamp Light-operated alarm Electronic dice Traffic lights Pulsed bleeper Four-bit binary counter Reaction timer MW/LW radio receiver

Components for each project are simply plugged into the appropriate holes in the Bimboard, together with links and wires as necessary. In this way, the same components can

be used over and over again.

The Book

We found the instruction book, by Tom Duncan, to be well written, well printed and easy to follow. Drawings were made clearer by the use of twocolour printing (for example, on the Bimboard layouts the hole positions are shown in black, with the components overprinted in blue).

The book starts out by making you familiar with what the 'bits and pieces' — electronic components, that is — look like, what they do and how they are identified in a circuit.

Full details are also given on how to prepare components for insertion in the board.

Each project section is divided into:

• What you need — components to be retrieved from the box

• Here is the circuit — circuit of project, with pin functions of any ICs used

• How to build it — where to place the components, with any special precautions



• How it works — circuit description

• Things to try — a few experiments to try with the completed project, such as the effects of changing the value of induvidual components or of changing their positions in the board

One recurrent instruction throughout the book was CHECK THE CIRCUIT CAREFULLY. That bit of advice is equally applicable to HE projects!

Trying A Project

Back to the same kitchen table where the ZX81 kit was built (see last month's GG&K), and in close range of a supply of coffee, we had a bash at the Light-operated Alarm project.

All the components required for the project were selected from the box. We found that three types of resistor had been supplied but despite the different bodies for each, the colour codes were clearly visible.

The two types of 'disc ceramic' capacitor were *rectangular* (plate type), and the markings on each type might cause some confusion. Under the 'Bits and Pieces' section it says: 'On a capacitor, 0.1 uF may be marked as .1mfd and 0.01uF as 10n'. Under 'What You Need', you are asked to look for 0.01uF and 0.1uF. The capacitors in question were labelled 100nZ and 10K.

No problem was found in inserting the resistors, IC and miscellaneous components, although care was needed in manipulating the leads of the two transistors to ensure that they lined up with the holes in the board without shorting to each other.

We found that a pair of fine-nosed tweezer pliers were of great assistance in inserting such awkward leads.

On Test

After everything was inserted, including the links and connecting leads, the circuit was carefully checked. Everything looked correct, and so the switch link was connected. The LED gave a brief flash and then the circuit died. When the battery connector was twiddled the circuit perked up - and died again.

When the battery voltage was checked it was found to be well above 9 V (a PP3 battery was supplied with the kit.) But when it was tried again the circuit refused to work.

We tried another PP3-sized battery and the circuit came alive. As soon as the light-sensitive resistor was covered, the LED began to flash. By operating the slide switch, audible clicks could be heard from a loudspeaker connected to the board.

We tried the various experiments suggested and some interesting results were obtained. For instance, you could arrange for the circuit to operate as a light-sensitive 'alarm clock'. (When the dawn breaks the loudspeaker gives out a loud squeal.)

Opinion

We thought that Adventures With Microelectronics was a good educational kit, and it should give many hours of entertainment — without the need of a soldering iron. As mentioned above, some of the components need careful handling (hence the big notice that greets you when you open the box). Some hand tools (cutters and pliers) are all that are required in addition to what is supplied.

The kit also introduces you to solderless prototype circuit board, and this board is invaluable for circuit experiments.

Battery Post Mortem

We tracked down the cause of failure when the circuit was first switched on. When pressure was applied to the terminals of the battery supplied with the kit (Premium PP3-P Power Pack from Ever Ready) the voltage dropped to zero on an HE test meter. So we cut open the battery case and, sure enough, we discovered a dry solder joint at the base of the cell stack.

Adventures With Microelectronics is available from Unilab Limited, Clarendon Road, Blackburn BB1 9TA (tel 0254 57643). Cost is £36.36 with the book, or £34.16 without the book (these prices are inclusive of VAT and postage). HE







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This month, Keith Brindley looks at meters and describes how to adapt them to measure different voltages and currents

THE ELECTRONIC THERMOMETER on page 23 of this issue uses a meter to indicate the measured temperature. We have given the necessary specifications of this meter as being any meter which measures 1 V FSD. Now, 1 V FSD (FSD means full-scale deflection) meters aren't easy to come by. True, if you have a multimeter, chances are it *could* have a 1 V range. But what if you want to use a panel meter such as we have in our prototype, and you can't find one which specifically measures 1 V FSD?

Perhaps we should take a look at how meters work, and then we may be in a position to answer the questions. Most commonly used meters are of the moving-coil type and so we'll restrict ourselves to them. Figure 1 shows the external appearance and internal construction of a typical moving-coil meter.



Figure 1. Typical external appearance and internal construction of a moving-coil meter

When an electric current flows through a wire, a magnetic field is produced around this wire. The field is strengthened when the wire is wound into a coil.

It doesn't take an Einstein to realise that if the coil (plus magnetic field) is suspended in the magnetic field from a permanent magnet, the two fields will interact and the force will turn the coil. In fact, the coil will turn an amount proportional to the current through it. Thus, the pointer attached to the coil will point to a position which depends on the size of the current.

The characteristics of a meter are defined as:

- the current to produce end-of-scale (ie, full-scale) deflection. For example, if a meter is specified as 100 uA FSD then a current of 100 uA (1 x 10⁻⁴ A) will deflect the pointer to a full reading.
- the coil's resistance. From Ohm's law:

V = I R,

where V is the voltage in volts, I is the current in amps and R is the resistance in ohms. Using this fomula we can calculate the voltage which also produces FSD. Say, the coil's resistance R = 1k0 and the current for FSD (as before) is 100 uA then

$$V = 1000 \times 1 \times 10^{-4} = 0.1 V.$$

So this meter could be used to directly measure up to 0.1 V, ie, 100 mV.

So What?

t

What's the good of a meter which can only measure 100 mV or 100 uA? What happens if we want to measure 1 V or 1 mA? Do we have to go out and buy a new meter?

No! We can adapt the first meter to measure higher voltages or currents simply by adding a resistor to it — not any old resistor, mind you, but one specially calculated for the application.

Higher Voltages

To measure a higher voltage than 100 mV we add a series resistor, R, as in Fig.2. The coil resistance M of the meter is 1k0 and the FSD current I is 100 uA.

The voltage across the meter must reach a maximum of 100 mV, so we can work out from all this information that the voltage across the resistor R will be the voltage to be measured, 1 V, minus the meter voltage, 100 mV;

ie,
$$V_R = V_{measured} - V_M$$
,
= 1-0.1,
= 0.9 V.

The current around the circuit I = 100 uA (the current to give FSD),

herefore,
$$R = \frac{V}{I} = \frac{0.9}{100 \times 10^{-6}} = 9k0$$

So, with a series resistor of 9k0 the meter will indicate a measured voltage of 0-1 V.



Figure 2. A series resistor added to your meter allows it to indicate higher voltages

Higher Current

Similarly, we can adapt a meter to read higher values of *curlent*. How? By adding a *parallel* resistor, of course. Figure 3 shows the idea.

A voltage across our meter, of 100 mV, causes FSD. Now, because the resistor and the meter are in parallel, the resistor voltage $V_{\rm B}$ must also be 100 mV.



Figure 4. A selection of commonly available moving-coil meters

So, the resistance,

$$= \frac{100 \text{ mV}}{9.99 \times 10^{-4} \text{ A}},$$

= 100.1R,

 $R = \frac{V}{T}$

And for most purposes, a resistance of 100R will do, for our meter to indicate a current of 0-1 mA.

Finally, Fig.4 shows a collection of some available types of moving-coil meter. As you can see, they come in a variety of shapes and sizes but as long as you know their specifications you can adapt them to different ranges.



Figure 3. By adding a resistor in parallel with the meter, higher currents can be indicated

The current through the meter is 100 mA, so - you guessed it - the current through the resistor equals the measured current, minus the meter current:

$$I_R = I_{measured} - I_M,$$

= 1 mA - 1 uA,
= 9.99 x 10⁻⁴ A.



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The last part of our organ project gives details of final wiring up, tuning and adjustments to complete your own working model

IF YOU HAVE religiously followed our instructions to date, your organ will now be ready for final wiring up. This basically means: the interconnection of Board 2 (the top-octave generator) to Boards 3 and 4 (the dividing and keying boards); and the interconnection of Boards 3 and 4 to the keyboard contacts.

All these connections and their positions are critical so follow the diagram, given in **Fig.1**, starting with the 12 connections from the top-octave generator. Use a fairly stiff variety of multi-stranded wire and carefully form each piece: to come vertically up from Board 2; then, to bend back at 90° towards the back of the organ; to bend left at 90° along the back of the board; then, to bend forward at 90° towards the front; and finally, to bend down at 90° to the correct connection point on either Board 3 or Board 4. The view of the complete project (**Fig.2**) shows the idea.

Now, cable-tie (with lacing-cord,

plastic ties or string) the group of 12 interconnections together with all previously connected power supply leads, in a number of places. This should form a fairly thick and solid cableform running along the back of the organ.

Again following Fig.1, start to wireup the keyboard contacts to Boards 3 and 4. The 60 pins on the bottom of the two circuit boards each need a single multi-stranded wire connection to the corresponding keyboard contact underneath the keyboard. This job is quite straightforward but will be long and monotonous because of the number of connections.

A good tip here is to use coloured wire. If you only have a few different colours (after all, not many people will have 60 different coloured reels of wire) then group the leads into small numbers and stick to the same pattern of colours in each group eg, red, white, blue, green, black; red, white, blue, green, black, etc.

Now cable-tie each group of leads after connecting each lead of the group at both ends. The view in **Fig.3** shows the idea.

Finally, the common connection of all keyboard contacts should be taken via a single length of multi-strand wire to + 12 V. Make the connection from the far right-hand side of the keyboard contacts strip to the top right-hand edge of Board 4, where you will find a + 12 V





Wearing the smile during HE's special demonstration is Trevor Hawkins, designer of the HE Electronic Organ. Great interest was shown in the prototype instruments on display at St David's Church Hall, London N7. The event was organised by the Organ Constructors Society connection. Your organ should now be complete — it only remains to tune it and make final adjustments.

Connect a speaker or pair of headphones to the output and turn the organ on. If all is well, you should hear nothing!

Now make sure all five stop switches are pressed down and set all preset resistors on Board 1 to mid-position.

Press any note of the keyboard. You should hear it at the output. Potentiometer RV8 should control the volume.

Turn potentiometers RV1 and RV2 of Board 2 fully anti-clockwise and RV3 to mid-position.

With any available tuned reference (for example, pitch pipes, tuning-fork, another tuned instrument), adjust the slug of the coil on Board 2 till the organ is correctly tuned. You only need to adjust the coil until one note is correctly tuned, the rest are automatically then in tune.

The final job is to adjust presets RV1-6 on Board 1 so that the volume levels of each octave of notes are the same and there is no amplitude step between any B-note and the C-note immediately above it. Preset RV7 adjusts the overall volume and should be set so that when a quantity of notes are played together the amplifier is not overloaded, thus preventing distortion.



Project





Figure 2 (top). The complete HE Electronic Organ

Figure 3. Connections between Board 3 and 4, and the keyboard contacts should be cable-tied into small groups

Errata

A few minor errors in the first part of this project, back in the May issue of HE, have come to our notice. These are as follows:

• In Fig.2, capacitor C9 should have a value of 220u, not 220n as we show. The Parts List is correct, however. Also capacitor C12 can be 22n and capacitor C13 can be 10n, although neither are critical.

• Again in Fig.2, capacitor C3 should be turned around (ie, its positive plate should be at the bottom).

 In Fig.3, the positive plate of capacitor C3 should be at the right-hand side, and capacitors C28 and C32 should both be turned around.

We have no record of errors in following issues but we will obviously keep our readers up to date if we hear of any.

Buylines

A limited number of kits for the HE Organ can be obtained from:

Mr A T Hawkins 23 Blenheim Road St Albans Herts AL1 4NS

for £99 inclusive. The kits contain all metalwork, hardware and PCBs, as well as the keyboard and components. You only need to supply your own baseboard and case.

For those readers who prefer to buy the components themselves, Mr Hawkins is willing to supply the keyboards separately. None of the other items should be difficult to find.

Mr Hawkins also has some attractive ready-labelled panels for the organ. These can be glued onto the two main control panels to give a neat finish. The ready-labelled panels cost $\pounds 2$ per pair.

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VN67AF £1.21 2N381928p 2N3920_78p	BC214L11p BC214L11p BD13148p BEV50 25p	2N305325p 2N305559p 2N370211p 2N370411p	LF35699p LM301AN39p LM309KE2.99	C.MOS 4001
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Polyester (C280) capacitors 250V 10nF; 15nF; 22nF; 33nF; 47nF 7p ea. 68nF; 100nF 8p. 150nF; 220nF 12p. 330nF 15p. 470nF 20p. 680nF 28p. 1uF 33p. 1.5uF 49p. 2.2uF 65p.

Sub miniature plate ceramics 63V. Values in pF: 2.2; 3.3; 4.7; 5.6; 6.8; 8.2; 10; 15; 22; 33; 4.7 & 56pF 7p each. 68pF; 100pF 7p each. 150; 220; 330pF 11p. 390pF; 470pF; 1000pF 5p. 2200pF 6p. 3300pF; 4700pF 7p. 10mF 13p. 100nF 22p. 47nF 14p.

Electrolytic capacitors, AXIAL Electrolytic capacitors, AXIAL leads:- 1uF/16V 11p; 1uF/63V, 1uF/10V 12p; 2.2uF/63V, 3.3uF/63V, 4.7uF/63V 12p; 22uF/25V 12p; 22uF/63V 15p; 23uF/40V, 47uF/25V 12p; 47uF/25V 12p; 47uF/40V 15p; 100uF/25V 18p; 100uF/16V 12p; 100uF/25V 18p; 100uF/16V 18p; 100uF/25V 15p; 100uF/40V 15p; 220uF/10V 15p; 220uF/25V 19p; 470uF/16V 25p; 470uF/25V 36p; 470uF/40V 55p; 680uF/16V 32p; 1000uF/10V 30p; 1000uF/16V 33p; 1000uF/25V 46p; 2200uF/10V 58p; 1000uF/25V 46p; 2200uF/10V 54p; 2200uF/25V 64p;

22000F/10V 395; 22000F/25V 645; 22000F/63V £1.10. RADIAL leads:- 0.470F/25V 8½p; 100F/16V, 220F/16V,470F/16V, 1000F/16V, 1000F/25V 12½p; 2200F/63V 39½p; 10000F/16V 35½p; 2200F/16V 64½p.

Z2007/10/04/2p. Switches Switches Switches Min. toggle: spst 59p; spdt 69p; dpdt 79p. Min. push on 18p; push off Z2p. Footswitch alt. action: spcc £1.39; dpcc £1.88. Rotary switches: 1p 12 way, 2p 6w, 3p 4w, 4p 3w 69p each. 12V 185R dpcc relay £2.98.

Soldering Antex X25 soldering iron, 25W £4.98. Soldering iron stand £1.99. spare bits (for X25) small, std, large 64p each. How to solder sheet 12p. Solder bobbobbin 30p. Desolder pump £5.98. De-solder braid 69p. Solder, handy size 98p. Heat sink tweezers 15p.

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LM317T £2.55	4013 550
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LM381N. £1.98	4024
LM382N £1.62	4069
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Zener	diodes	400mW,	BZY88.	Range
2V7 to	33V 12p	each.		
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14 pin	17p	24 pin	48p
16 pin	18p	28 pin	45p
8 pin	16p	18 pin	22p

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Spaakers miniature, 8 ohm 87p; 64.75 ohm 89p. Crystal earpiece 65p. Mag-netic earpiece 15p. Mono headphones £2.98. Stereo headphones £4.35. Tele-phone pick-up coil 72p. FM aerial 49p. Min. buzzers 6V 50p; 9V £1.10; 12V 65p. 65p.

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Hobby Electronics, August 1981

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BENCH POWER SUPPLY UNIT	ZD87	Sept. '80	£25.00	MULTI OPTION SIREN	ZD36	Dct. '79	£10.50
DEVELOPMENT TIMER	ZD86	Sept. '80	£8.75	ANALOGUE AUDIO			
TOUCH SWITCH (on Vero)	ZD84	Sept. '80	£4.50	FREQUENCY METER	ZD35	Oct. '79	£15.00
AUTO PROBE	ZD83	Sept. '80	£3.00	COMBINATION LOCK	ZD29	Sent. '79	£12.50
REACTION TIMER	ZD82	Sept. '80	£26.50	*STARBURST	ZD30	Sent. '79	£14.50
MICROMIXER (on Vero)	ZD81	Sept. '80	£8.50	LAMP DIMMER	ZD31	Sept. '79	£6.50
EQUITONE CAR EQUALISER	ZD52	Aug. '80	£13.30	ULTRASONIC SWITCH	ZD32	Sept. '79	£21.00
GAS DETECTOR	ZD55	Aug. '80	£22.00	CONSTANT VOLUME AMPLIFIE	R ZD28	Aug. '79	£11.50
PASS THE LOOP GAME	ZD56	Aug. '80	£12.00	INJECTOR TRACER	ZD27	Aug. '79	£4.50
RADIO TIMER (on Vero)	Z057	Aug. '80	£5.50	LED TACHOMETER	ZD26	Aug. '79	£14.75
MOVEMENT ALARM (on Vero)	ZD 54	Aug. '80	£5.00	BABY ALARM	ZD25	July '79	£13.50
OP. AMP CHECKER (on Vero)	ZD53	Aug. '80	£4.00	POINTS SWITCH	ZD24	July '79	£12.50
CAR BOOSTER (no speakers)	ZD50	July '80	£18.00	LINEAR SCALE OHMMETER	ZD23	July '79	£14.00
HAZARD FLASHER	ZD48	July '80	£10.50	SHARK	ZD22	July '79	£22.75
*PUSH-BUTTON VOLUME				G.S.R. MONITOR	ZD 19	June '79	£10.50
CONTROL	ZD47	July '80	£19.50	ENVELOPE GENERATOR	ZD20	June '79	£11.79
SOUND FLASH TRIGGER (on Ver	o) ZD49	July '80	£3.50	DRILL SPEED CONTROLLER	ZD21	June '79	£7.00
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MICROBE R/C SYSTEM				DIGIBELL PROJECT	ZD 16	May '79	£5.00
(less Servos)	ZD45	June '80	£17.50	VARIABLE POWER SUPPLY			
FUGHORN	ZD44	June '80	£4.50	0.30V 1 AMP	ZD15	May '79	£30.00
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5080 PKE-AMP	ZD11	May '80	£32.00	MODEL TRAIN CONTROLLER	ZD74	April '79	£26.00
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*K/G SPEED GUN I KULLEK	ZD3	April '80	£9.60	TONE CONTROL	ZD72	March '79	£9.00
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DIGITAL SPECIIENCY METER	202	April 80	£18.25	SHORT WAVE RADIO	ZD66	Feb. '79	£12.50
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TOUCH SWITCH	2000	March 00	£19.50	GENERATUR	ZD67	Feb. '79	£22.50
	2079	March '90	10.UU	SURATCH AND RUMBLE	70.00		
SYSTEM 5080A	2070	March '90	129.3U	FILTER MUNU	ZU68	Feb. '79	£22.50
PASSION METER	706	Feb '90	£15.00	SUITED STEDEO	70.00	F.1. 170	
WIN INDICATOR	200 7n <i>4</i> 2	Feb '80	£3.00 60.00	CAD ALADM	2009	Feb. 79	£25.00
INER RED REMOTE CONTROL	707	Feb '80	£3.00 €10.25	CAN ALANM	ZU/U 7065	FeD. 79	£8.50
SCALEXTRIC CONTROLLER	7041	.lan '80	£13.33 £52.50	TOUCH SWITCH	2003	Jan. 79	£10.50
CROSSHATCH GENERATOR	704	Jan '80	£11 25	VARLWIDED	2003 7064	Jan. 79	£5.5U
DIGI-DIE	ZD5	Jan. '80	£5 50	GRAPHIC FOULLISER	ZU04 7D62	Jan. 79	20.UU
RING MODULATOR	ZDI	Dec. '79	£8.50	PUSH-RUTTON DICE	7061	Jan. 19 Dec 179	£23,00
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BARGRAPH CAR VOLTMETER	ZD40	Dec. '79	£6.60	BEDSIDE RADIO	7058	Nov '78	£20.30
GUITAR TUNER	ZD38	Nov. '79	£8.50	STEREO AMPLIFIER (HORIT)	7059	Nov '78	£12.50 £52.50
*R2 D2 RADIO	ZD37	Nov. '79	£8.60	WAA-WAA PEDAL	2060	Nov '78	630.00
TANTRUM	ZD33	DCt. '79	£37.50		2200		200.00

IONISER KIT: ZD13. This negative ion generator gives you power to saturate your home with millions of refreshing ions, without fans or moving parts it puts out a pleasant breeze. A pure flow of ions pours out like water from a fountain filling your room. The result? Your air feels like fresh ocean air, crisp and wonderfully refreshing. All parts p.c.b. and full instructions £10. A suitable case including front panel neon switch. etc., available at £8 extra.

PLEASE NOTE OUR NEW ADDRESS

LATE EXTRA

ZD89	OCT, '80	£15.75
ZD90	OCT 80	£9.00
ZD91	OCT '80	£8.50
ZD94	OCT '80	£12.50
ZD93	OCT. 80	£9.75
ZD92	OCT. '80	£5.50
ZD88	OCT. '80	£5.00
	ZD89 ZD90 ZD91 ZD94 ZD93 ZD92 ZD88	ZD89 OCT 80 ZD90 OCT 80 ZD91 OCT 80 ZD94 OCT 80 ZD93 OCT 80 ZD92 OCT 80 ZD92 OCT 80 ZD88 OCT 80

All kits contain components as specified plus Texas I C sockets where required, also connecting wire.

FAIRCHILD FLV150 red. 2 LEDS. 10 for £1.00, 100 for £7.50 DALY ELECTROLYTIC CAPACITORS 2000uF 100v £1.50 PHILIPS SCOPE Tube 5" CV2191/DG-13-2 £10 If you do not have the issue of H.E. which contains the Project, we can supply a reprint at 40p extra. Please add 30p post and packing. Add 15% VAT to total order. Callers please ring to check availability of kits.



Minimum Mail Order £1

MAKE A DISC LIKE THIS TO EXTEND THE SLOW SPEED RANGE TO 0-300RPM



Figure 1. Circuit of the HE RPM Meter

around the shaft or a radially patterned disc mounted on a rotating wheel. Ten black/white stripes per revolution give a 0-300 RPM range and so on. There are many techniques for measuring the speed of rotating objects. This unit is cheap and simple to build and calibrate providing an excellent introduction to electronic measurement systems. Build one for your lab or workshop or just for fun — amaze your friends with a 'revolution' in electronics!

Parts List

RESISTORS	
R1	10k
R2	10M
R3.8	33k
R4	22k
R5	1M0
R6	100k
R7	390R
POTENTION	AETER
RV1	22k miniature horizontal
	preset
×	
CAPACITOR	RS
C1.2	100n ceramic
C3	1n0 ceramic
C4	15n polyester
C5	22u, 16 V tantalum
SEMICONDU	JCTORS
IC1	3140E MOSFET
	operational amplifier
IC2	555 timer
01	TIL 78 photo-transistor
ZD1	5V6, 400mW zener
	diode
MISCELLAN	EOUS
SW1	single-pole, double-throw
	toggle switch
SW2	single-pole, single-throw
	toggle switch
M1	100 uA FSD moving-coil
	meter
3.5 mm jack	plug & socket (or similar)
Case to suit	(see Suylines)

How It Works

The input signal is 'squared up' by the Schmitt trigger whose output drives a monostable multivibrator; ie, each time the monostable is triggered by the Schmitt trigger it produces an output pulse whose period is determined by the associated resistor. A simple changeover switch selects the appropriate timing resistor for the selected measurement range. The output from the monostable is used to drive a meter — the closer the pulses (ie, a greater RPM), the more the meter needle moves.



Light falling on transistor Q1 causes a current to flow through it (because it is a photo-transistor) and a voltage is developed across resistor R1. If the light is moculated ie, goes brighter and dim-mer, the voltage across R1 will rise and fall in sympathy. Capacitor C1 removes any noise spikes which may have been picked up by the connecting leads and the resultant signal goes to the inverting input of IC1. This is an op amp used as a comparator; comparing the voltage at the inverting input. We obtain the reference voltage by low-pass filtering the input voltage with R2 and C2. An input signal producing a voltage across R1 which ranges from 1 V to 4 V will result in a reference voltage of about 2.5 V, the average of the peak and trough values. The exact reference voltage will also be a function of the input's mark-tospace ratio which should ideally be 50% (ie, equal light and dark areas on the rotating surface).

The output of IC1 consists of a squarewave at the same frequency as the input signal. This output signal triggers the 555 timer on each falling edge. A differentiating circuit C3,R3 and R4 is used to produce a short trigger pulse. The 555's monostable output pulse is a function of range setting resistors R5 and 6.

To make the unit less sensitive to falling battery voltage the output of IC2 is clipped by ZD1, a 5V6 zener diode, and the meter is driven from this voltage through a current-limiting series resistance comprising RV1 and R8.

Current pulses from IC2 are averaged in the meter, the deflection of which indicates the input frequency scaled in RPM. To allow for variations in component tolerances, full-scale deflection is obtained from an 80% duty cycle. The supply is smoothed by C5 which should be mounted close to IC2.

Project

RPM Meter



Your Letters

ALTHOUGH IT IS DIFFICULT to eliminate *all* the errors from a technical publication such as HE, sometimes it is our readers who have misunderstood what has been printed, as this first letter shows.

Dear Editor,

I have recently completed a project which you printed in HE in the April 81 issue. The project was the Windscreen Washer Alarm. In the section 'How It Works', you state that 'When the probe resistance is less than the internal resistance (as it will be if the level of fluid is above the bottom of the probes) — surely this is an error and it should be 'below the bottom of the probes'?

I would be pleased if you could inform me if it is an error as I have completed this project for an examination and on the 'write up' I have to explain its function. G Whalley Halesowen, West Midlands.

No mistake was made in the 'How It Works' section for this project. If the fluid is above the bottom of the probes (that is, when both probes are immersed in the fluid) then the resistance between them will be lower than the circuit resistance and no alarm will be given.

Dear Sir,

I am thinking of building a car radio. Could you please advise me if there are any kits available for a radio or cassette player and from whom I would be able to buy one? A D Wilson Knutsford,

Cheshire.

The only car radio kit that we are aware of is that being offered by RTVC, 323 Edgware Road, London W2 (tel O1 723 8432). This is a simple MW/LW receiver, with five push-buttons for tuning and with an audio output of 6 W. It uses an LP1181 IF module from Mullard Ltd. According to RTVC, the printed circuit supplied with the kit is undrilled, and the company cannot supply an after-sales service, apart from replacement of faulty components.

The kit (constructors' pack 7A) costs £10.50 plus £2 post and packing. Constructors' pack 7A contains a stainless steel retractable locking aerial and a loudspeaker, at an additional cost of £1.95 plus £1.15 postage and packing.

Dear Mr Davies,

I have just purchased a soldering iron but have no instructions with it. I am a beginner in Electronics and would be very grateful for a pamphlet or some notes on the operation and workings of

A selection of your letters to the Editor

a soldering iron. Leo McHugh Co. Dublin, Eire. PS I think your mag is the best on the market, keep up the good work.

We last covered soldering technique under Building Site in the December '80 issue of HE, on pages 62 and 63. I'll make sure that you receive a copy of this article. See Building Site next month, too.

Dear Sir,

In your May and June editions of HE you had a two part project of an Infrared Remote Controller. Under the Buylines section, it said that kits from TK Electronics were available, a receiver for £4.83 inc VAT and a transmitter for £10.35 inc VAT. Surely the transmitter and receiver prices are the wrong way round? P Robinson Middlesbrough, Cleveland.

Yes, it was a mistake — the prices were transposed under Buylines on page 50 of the May '81 issue and under Buylines on page 61 of the June '81 issue. The cost of the receiver should have been shown as £10.35 including VAT and the cost of the transmitter as £4.83 including VAT.

And we'll have to end it there for this month.



UOSAT – Britain's hobbyist satellite

In the run-up to the UOSAT launch, Bill Mitchell* outlines the functions of the satellite and the measurements it is to make. As he points out, the keen amateur will be able to monitor the radio and video transmissions from UOSAT using inexpensive equipment

THE FIRST SATELLITE built specifically to promote a greater practical interest in space science among educational establishments, and with facilities for use by radio amateurs and hobbyists, is now undergoing final test prior to its launch in September of this year. Designed and constructed by the University of Surrey with material and financial support from British industry, UOSAT (University Of Surrey SATellite) will transmit coded and voice-synthesised speech data that can be picked up by most amateur VHF FM communications receivers. It will also incorporate a charge-coupled device (CCD) camera for the transmission of pictures that can be received by an ordinary domestic TV set by the use of a simple adaptor circuit.

Unlike previous radio amateur satellites launched either under the auspices of AMSAT (Radio Amateur Satellite Corporation) OSCAR series, or by the USSR (RS1 and 2), which have been intended primarily for increasing the VHF and UHF range of transmissions by radio amateurs, UOSAT's function is to stimulate a greater practical interest in space science among schools, colleges and universities; to provide radio amateurs and hobbyists with a tool for studying the ionosphere through which the transmissions travel; and to establish an active body in the UK with the resources to contribute further to the amateur satellite programme.

As such, with the wide range of measurements it is capable of performing and the large volume of data that it will be transmitting back to earth, UOSAT represents a unique British achievement in space science for the masses, and can possibly be best described as a universal multimeter in the sky.

Vision And Voice

Much of the analogue and digital data being transmitted back to earth will require something more than a standard FM communications receiver, although their reception will not be beyond the capabilities of the keen amateur. What makes UOSAT so unique is the provision of earth pictures from its solid-state camera, and its synthesised speech transmission.

Covering an area of 500 x 500 km (300 square miles) of the earth's surface, the image from the earth-pointing camera will be formed on a charge-coupled device (CCD) and stored in the satellite's on-board computer until transmission to ground, a process that takes three to four minutes. Unlike images from conventional weather satellites, the picture will be transmitted in such a way that it may be readily received and stored by a simple receiver and displayed on any domestic TV set. The pictures will have a resolution of about 2 km and will show 16 grey levels, with land features and land/sea boundaries being enhanced. Experimental data in graphical form will also be available by the same link.

Once the satellite is in orbit and functioning correctly, the University of Surrey plans to make available full details and circuitry for the necessary ground receiving and display equipment that will enable a domestic TV set to receive these pictures. At present, the intention is that the circuit will be supplied by an appointed contractor, and will take the form of an easy-toassemble kit of parts costing around £150.

The speech transmissions will be made by means of an electronic voice synthesiser controlled by the on-board computer, and will include details of telemetry, experimental data and satellite operations using a vocabulary of about 150 words. Transmissions will be on 145.825 MHz, and any standard unmodified narrow-band FM amateur receiver should be able to receive them by means of a small, fixed pair of crossed dipole aerials.

Experiments For The Scientists

The satellite will also carry a number of experiments intended for scientific research. These include a series of beacons transmitting at different frequencies, two particle counters to provide information on solar activity and auroral events, and a magnetometer — identical to that used on the Voyager missions to Jupiter and Saturn — for measuring the earth's magnetic field. These experiments will make possible a detailed study of how phenomena such as solar activity affect the transmission of radio signals through the ionosphere.

On-board Micro Control

UOSAT will be controlled by a powerful on-board microcomputer, based around the RCA CDP 1802 microprocessor, which will have access to the satellite experiments, telemetry and command systems. It will enable telemetry surveillance, command and status management, experiment data storage and processing, dissemination of orbital data together with operating schedules and general news, and closed-loop attitude control using magnetorquers. It has direct high-speed data links with the magnetometer and radiation experiments to allow rapid data acquisition yielding fine time-resolution data, and also has access to the earth imaging experiment memory area for the purpose of image processing.

The computer software is resident in dynamic RAM loaded from the ground via the telecommand link, and can be modified or replaced during flight by a ground command station at the



Figure 1. The clean room at the University of Surrey in which UOSAT is being assembled. On the left is Steve Greenland and on the right is Dr Martin Sweeting, Project Manager

first educational &

University of Surrey. This will enable the accommodation of changes in the mission profile and allow for the rectification of possible software or hardware failures.

Launch Date

UOSAT will be launched as a secondary payload by a NASA Delta 2310 rocket from the Western Test Range at Vandenberg, California, the main payload being the NASA Solar Mesosphere Explorer spacecraft. The launch is currently scheduled for September this year, but this may be advanced to July depending on the readiness of the NASA rocket and prevailing weather conditions. An announcement on this will be made as soon as possible. However, whatever the launch date, UOSAT will be placed into a polar orbit with a period of 95 minutes, at a height of 530 km (about 330 miles), and the expected life before re-entry is estimated at four to five years.

Data And Transmission Frequencies

For those who may be interested in establishing their own receiving station for UOSAT, the following lists the types of data being transmitted and the frequencies of transmission.

Telemetry

To cater for a wide range of user ground-station facilities, 60 analogue telemetry channels and 45 digital status points will be available via the VHF (145.825 MHz) and UHF (435.025 MHz) data beacons in the following formats: 1200, 600, 300, 110 and 75 baud ASCII; 45.5 baud RTTY (Baudot); 10 or 20 words per minutes Morse code; and synthesised voice.

Any pair of these formats will be available simultaneously via the VHF and UHF data beacons. The 1200 baud telemetry option also has a CHANNEL DWELL facility.

Data Beacons

Two VHF/UHF beacons will provide the primary engineering and experiment data links to the outside world, and these have been designed to provide a healthy satellite-to-ground transmission link to enable reliable and straightforward reception by the simplest of amateur ground stations using a fixed pair of crossed dipole aerials.

The data sources available to these beacons are: telemetry, ASCII, Baudot, Morse code, satellite computer, primary output port, secondary output port, speech synthesiser, earth imaging experiment (CCD camera), and image data.

Details of the two beacons are as follows:

General data beacon –	Frequency: Modulation: Data format:	145.825 MHz CW audio frequency shift keving
	Power output:	450 mW
Engineering data beacon —	Frequency: Modulation: Data format:	435.025 MHz CW audio frequency shift keying
	Power output:	400 mW

Propagation Studies

Phase-referenced beacons on 7.001, 14.001, 21.001 and 28.001 MHz will support a wide range of ionospheric experiments and observations, while two microwave beacons on 2.401 and 10.470 GHz will encourage the study of super high frequency (SHF) propagation.

Two particle radiation counters (one detecting electrons of energies greater than 40 keV, and the other detecting protons greater than 2 MeV) will provide real-time information on solar activity and auroral events. A three-axis, wide-ranging, fluxgate magnetometer will examine the fine structure of the earth's magnetic field, any disturbances to it and their relationship to radio wave propagation.



Figure 2. The montage shows (top left) the simple crossed dipole aerial for receiving transmissions; (top right) the prototype of the equipment which stores and displays picture data; (bottom) the test picture used to develop the system

Education Experiments

The earth-pointing, CCD two-dimensional array will provide land and sea image data for digital transmission via the general data beacon, using minimum-shift audio frequency shift keying at 1200 bits s⁻¹ line synchronous. The image format is 256 x 256 pixels with 16 grey levels. The camera optics are organised to cover a 500 x 500 km area of the earth's surface yielding a resolution of around 2 km.

The digitally synthesised speech experiment module under the control of the satellite computer will 'speak' telemetry, experiment data and satellite 'news' with a limited vocabulary of around 150 words transmitted on either of the data beacons.

A Chance To Make Your Mark

If successful, these experiments should help to overcome the difficulties faced by most amateurs trying to enlarge their knowledge of space sciences. Any radio amateur will be able to use his or her equipment to gain interesting and useful knowledge about that area of space surrounding the earth which most affects the quality of radio transmissions.

The potential that exists for radio amateurs to make a contribution to space science will, through the use of UOSAT, be comparable with that of amateurs in fields such as astronomy and ornithology.

* The author is Editor of Electrotechnology and of the IEETE Bulletin, Institute of Electrical and Electronics Technician Engineers

Project



A cheap and easy-to-build project for use wherever you need a good-quality, low-voltage supply

WE KNOW THAT a bench power supply isn't the most original of projects, but we are sure that it *is* one of the most useful.

A good quality, well regulated power supply has a place on virtually every electronics hobbyist's bench. You see dry-cell batteries, while useful in self-contained projects, have their drawbacks: a limited range of voltages; an output which varies with battery age; low current; and last but not least — their cost. However, a power supply, because it is mains-operated, doesn't suffer from these drawbacks.

The HE Variable Bench Power Supply is a simple-to-build project using a minimum of components to provide an output which is an ideal voltage source for experiments, most projects, or car radios etc — in fact, it can be used for any circuit requiring a voltage between 1.4 V and 13.5 V and a maximum current of 1 A.

With series resistors the power supply can also charge Ni-Cd cells (by setting the output voltage to 12 V and selecting resistor values as shown by Table 1).

Resistor values for other currents and combinations of cells can be calculated from the formula:

$$R = \frac{12 - V_c}{I_c}$$

where V_c is the total voltage of the cells and I_c is the charging current. The resistor power rating is given by:

$P = I_c^2 \times R.$

After setting up the power supply with the resistor and the cells in series, simply adjust the power supply output voltage to trim the charging current to the exact value required.

Output voltage is fully variable within the upper and lower limits via a

Battery or cell type	Current 12-hour charge	Resistor value	Resistor rating
PP3§	9 mA*	470R	%W
PP9 §	100 mA	39R	12 W
AAA	20 mA	530R	% W
AA	66 mA	150R	1W
С	250 mA	39R	3W
D	500 mA	18R	6W

* - 17-hour rate

5 - 8.4 V batteries all others - single cells 1.25 V

in outers - single cens 1.21

Table 1. Values and powers of resistors to use in series with the power supply when charging Ni-Cd cells

calibrated control, which also serves as an on/off switch. The output current is indicated on a panel meter. Ripple (the variation in output voltage — greatest when the supply is fully loaded) is negligible ie, less than 5 mV peak-topeak, at full output.

The heart of the bench power supply is a voltage regulator integrated circuit LM317K — a simple threeterminal device (input — adjust output) — well tried and tested in industry for some years but still relatively new to the hobby marketplace. This IC monitors its own output current and limits it to 2 A in the event of a short circuit, thus avoiding any possible damage.

Two fuses are used — one within the mains circuitry, to cover transformer failure, and one in the lowvoltage circuitry to give protection in the event of a prolonged short circuit.

Construction

The first constructional step is the marking and drilling of the case. A mild steel case similar to that of our prototype is recommended to avoid electrical interference with equipment positioned near the power supply.

Cut out a round hole in the front panel for the panel meter — probably the most suitable tool for this is an Abraframe hacksaw — alternatively you can drill a circle of small holes and then file-out the large hole for the meter.



Figure 1. How to mount IC1 and its heatsink to the case

Drill and fit the two output terminals and the switched potentiometer onto the front panel.

Next, mount the transformer firmly to the base of the case not forgetting the solder tag for an earth connection.

Using the heatsink as a drilling guide mount the LM317K IC and heatsink using an insulating kit as shown in Fig.1. Remember to put a solder tag under one of the IC mounting screws.

Drill and fit the panel-mounting fuseholder and cable clamp to the rear panel.

Now, fix the tag strip, the chassismounting fuseholder and capacitor C1 into position. We found that the most convenient way to mount the capacitor was with a couple of double-sided adhesive pads.

Following Fig.3 wire up the project, including diodes D1 to D4, capacitor C2 and resistor R1. *Remember that the unit is mains-powered so be careful with all connections (the earth wires are particularly important), and sleeve or tape all mains connections*.

Finally your power supply is ready to test. If you have a multimeter, checking the output voltage is straightforward. If you haven't got a multimeter, then set the output to minimum and connect a 12 V bulb (max 12 W) across the output of the supply and check that the bulb brightness increases as you turn the control clockwise. The scale shown in **Fig.4** can be marked onto your front panel, and should give fairly accurate results.



Figure 4. Mark the front panel control with this scale to give an accurate indication of output voltage



Figure 2. Circuit of the HE Variable Bench Power Supply — it's very simple, because the complicated things happen inside IC1



Figure 3. Wiring and connection details of the project



Project

Parts List

How It Works

There are four basic changes taking place within the HE Variable Bench Power Supply:

- the incoming 240 VAC mains (point A) is reduced to 18 VAC (point B)
- the voltage at point B is changed to a pulsating DC voltage (point C)
- this pulsating DC voltage is smoothed to that at point D
- the smoothed voltage is regulated and adjusted to a variable DC output.



Trensformer T1 reduces the mains input voltage to 18 VAC. Full-wave rectification of this AC voltage is provided by bridge rectifier D1 to D4, end this full-wave rectified DC voltage is smoothed by capecitor C1.

Integreted circuit IC1 compares a proportion of the output voltege with en internal 1.2 V reference, and then allows more or less current to pass in order to keep the voltage output constant. Adjusting RV1 determines how much of the output is compared with the reference and therefore determines the output voltage. Capacitor C2 helps the regulator to give an extra smooth output by providing extra feedback of ripple voltage.

i agstrij		
Mains o	able clamp	
Cese to suit		
Heatsink + mounting kit for IC1		
Knob to	suit	
2 x output terminals		
M1	1 A panel meter	
FJZ	CHASSIS LUSTIOIDER + Z A	
562	500 mA fuse	
FS1	penel mounting fuseholder	
T1	240/18 V, 1 A transformer	
MISCEL	LLANEOUS	
D1-4	1N5404, 3A diodes	
IC1	LM317K voltage regulator	
SEMICO	ONDUCTORS	
C2	10 u, 35 V electrolytic	
C1	2200u, 63 V electrolytic	
CAPAC	ITORS	
R1	470R	
NL3131		

Buylines

A full kit of parts for the HE Veriable Sench Power Supply is available from Magenta Electronics, who advertise in HE. The kit will cost £23.35 and is complete with case, meter and all parts. This price includes VAT. Please add 40p to the kit price to cover p&p.

HE

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Feature



The publishers of HOBBY ELECTRONICS would like to point out that it is at present a contravention of the Wireless Telegraphy Act of 1949 and 1968 to use, manufacture, install or import CB transmitting equipment. It is not the intention of Modmags Ltd to incite, encourage or condone the use of such equipment.

Rigs coming down in price and interest growing in the UHF band: Rick Maybury gives the latest news on CB

I WAS HOPING to tell you all about a meeting between the Home Office and the CB lobbyists this month, but what with one thing and another and our very tight production schedule this just cannot be. However, all is not lost, there's no shortage of news this month. On the rig scene the prices just keep tumbling. To date the cheapest rig we have heard of will cost under £40 retail — if things keep up they'll be giving them away in cornflakes packets soon!

At last we have a manufacturer who will be building rigs in this country, and what's more, the retail price is expected to be under £50. We've seen some early prototypes and I can report that if the finished version looks and performs anything like the ones we've seen then the Japs had better look out!

I've also come across a couple of UK companies which are looking seriously at the 934 MHz CB band. At least one manufacturer is (at the time of writing) into the early prototype stage and first reports seem very favourable. However, this particular frequency is not really good for mobile work. On the other hand, it would be ideal for line of sight communication and I can see a promising future for business users wishing to communicate between buildings. As this frequency allows for higher power than 27 MHz and there is no apparent restriction on antennas, I can foresee parabolic dish antennas springing up all over the place. And here's another thought: the high frequency and fairly wide bandwidth would permit a reasonable picture to be transmitted over fairly large distances using slow scan techniques. Do I hear any offers for video CB?

Recent Accessories

Back to good old 27 MHz now. We have been literally inundated with new CB accessories lately. Some are good, many are dreadful but out of the morass a couple have really shone.

The first is an antenna, and it comes from none other than Philips — that's right, Philips the TV people. It doesn't half work well, and we'll be featuring a full review of it in a future issue of Citizens' Band magazine, so look out for it.

The second accessory worthy of note is a new antenna system that comes from Wintjoy. The system comprises a rather strange looking spider connector that will take a variety of different elements. Strangest of the lot is a combination made up of an aluminium rod for the main radiating element and three rubber ducky antennas acting as groundplane. We've never seen anything like it. Anyway, a number of different combinations are possible, enough in fact to suit virtually any kind of set-up, from mobile to base including, by the way, a marine option — very ingenious.

CB On A Plate

Well, that's about the lot for this month. Just time for a quick mention of London's first CB restaurant which'll be opening about the time you read this. It's called the Eyeball Bistro Club and can be found in Princes Street, near Oxford Circus. Lots of CB-flavoured food, cheap prices, and rigs on show (and, later in the year, in use).

I'm off now for Home Office Special, followed by Eyeball Chops, French Fire Stiks and Half Wave Platter. Catch you all next month! Now, where's my knife and fork?

HE



PCB foil pattern of the HE RPM Meter



HE Thermometer PCB foil pattern

Here are a sources and the sources of the motorist, the housebound, those who go for outdoor activities — and don't forget that CB can save lives!

With all this in mind **Citizens' Band** magazine, the country's leading CB publication, will be holding a **major** CB exhibition in September, timed as closely as possible to coincide with legalisation. If you want to know more about CB, or you are a CBer, come along to the Royal Horticultural Hall on 11th, 12th, 13th September and see Britain's biggest ever CB show.



There will be stands and exhibits from many of the country's leading CB accessory dealers plus, for the first time ever, working examples of the new legal rigs that will be on sale this Autumn. That's right, a number of manufacturers and importers will be on hand to show the new CB equipment that almost anyone can buy and use.

There's something for everyone, CBers old and new. The latest accessories and antennas, gadgets — in fact everything connected with CB including the new equipment.

Come along in September and see what CB can do for you. Even if you've never heard of CB, you soon will, so don't miss out — whether you're a motorist or a small businessman with an eye to the future, CB is for you! CB is the future of two-way communications....

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