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ROGER HARRISON'S AUSTRALIAN ELECTRONICS Monthly

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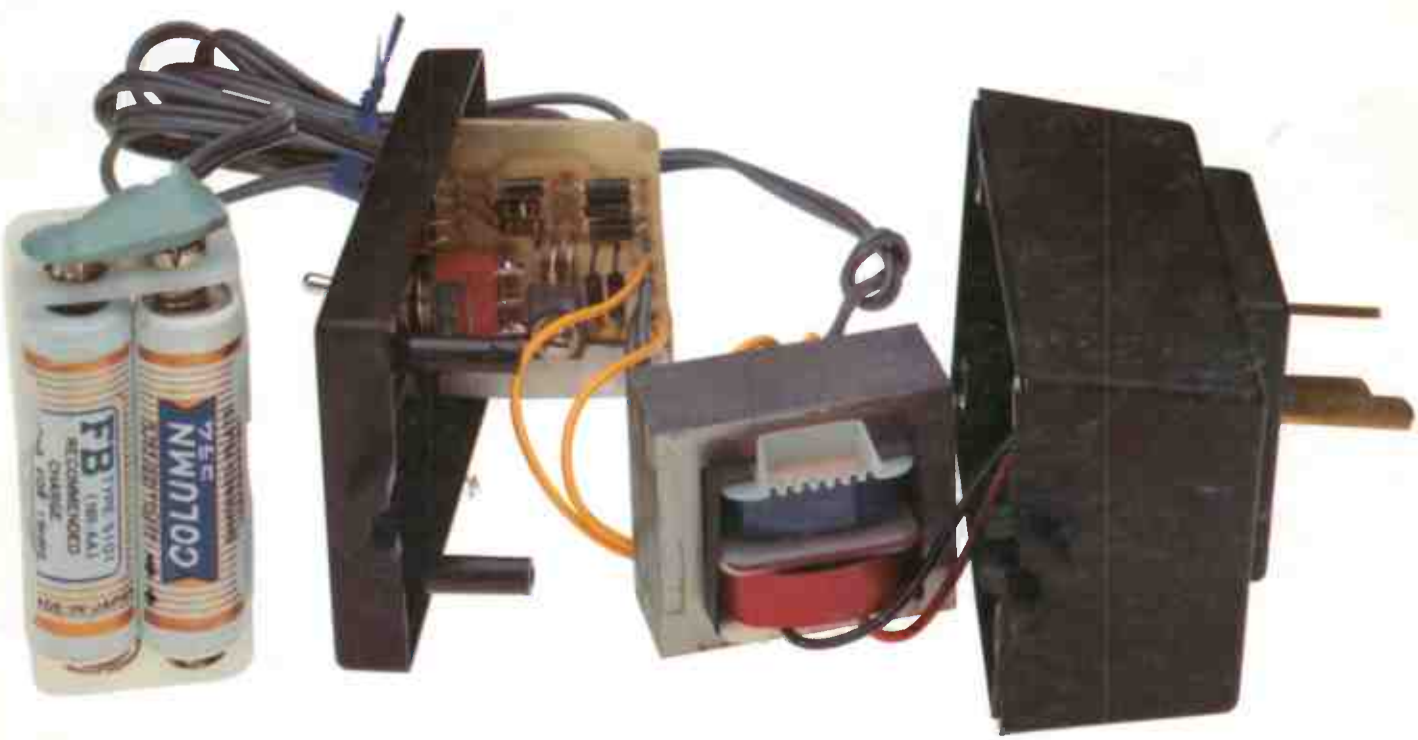

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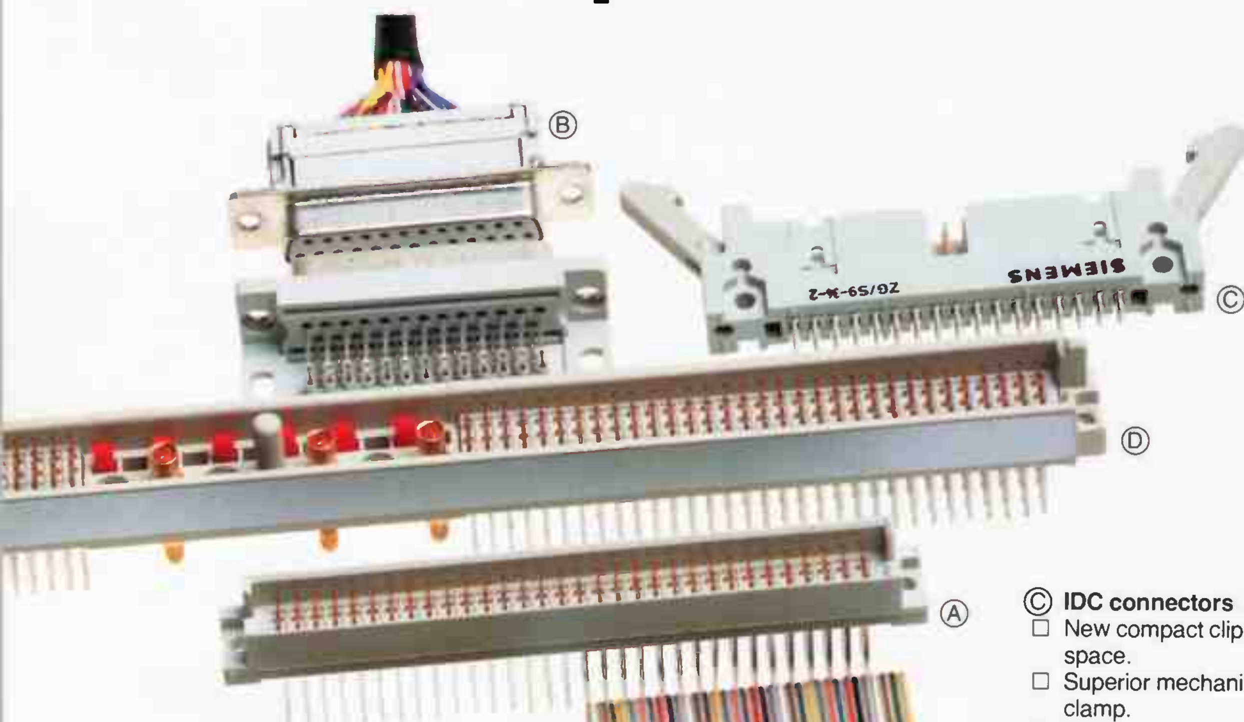

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Siemens. A higher technology

CSA 3282

RESPONSE to our recent series of practical, low-cost "space technology" projects has been pleasantly surprising. We embarked on these projects with the belief that there were readers who would be interested in getting involved in the nuts and bolts and the excitement of space science and technology, just out of interest's sake, at a level that didn't require a big bank balance or a specialised technical background.

We were right. And that's great news. As I said in my October editorial, in the not too distant future we're going to need young scientists, engineers, technical officers and technicians for our space industry. Anyone entering a career or a job with the slightest interest or experience in the subject stands at an advantage to their fellows – motivation. Motivated people invariably have a more positive approach to their job. Interest generates motivation and if we can influence the career choice or path of even a small number of people through articles and projects published in these pages, then we will have fulfilled what we believe to be one of our functions.

Response to the Super Computer project, we are very pleased to report, has also been great. And orders for the kit have come from some surprising areas, both from within the electronics industry and 'outside' it, as well as hobbyists. Coincidentally, we learned more than one reader planned to use the project for real time processing of satellite data!

There's no doubt about it, hands-on experience with today's electronics technology – at any level – can generate an excitement and satisfaction that few other fields can offer.

Au Revoir

Probably one of the industry's best-known "identities", Geoff Wood – from the shop of the same name, has gone into semi-retirement due to health reasons. I say semi-retirement because Geoff Wood and retirement are mutually exclusive terms! Having been in the trade since "the year dot", there'd be few in Australia's electronics industry who didn't know Geoff from his many years at the now defunct Radio Despatch Service, to the last four-or-so years in his own firm. You'll be missed, Geoff. Now if only we could arrange an RS232-to-brain interface we'd be able to store that veritable encyclopaedic memory of yours on a CD-ROM – or ten!

Roger Harrison
Editor

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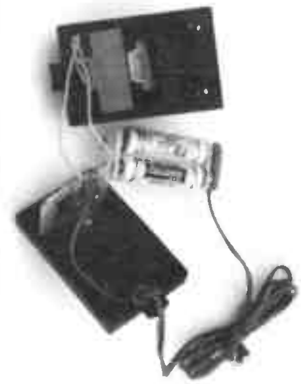
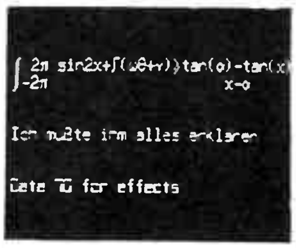


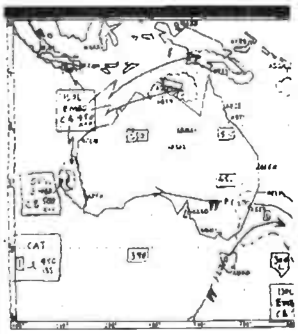


CIRCUITS & TECHNICAL

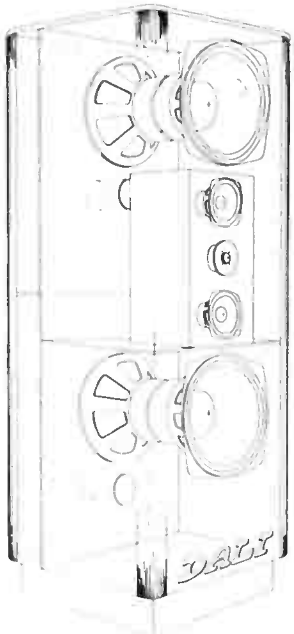
ELEKTOR IN AEM

PRACTICAL COMPUTING

COMMUNICATIONS SCENE



CONSUMER ELECTRONICS



NEWS & GENERAL

NEXT MONTH!

TWO-SPEED MODEM WITH BIT RATE CONVERTER

Build this great little low-cost direct-connect modem you can interface to any computer with a serial port and not worry about split baud rate operation. Provides 300/300 and 1200/75 bps operation. An ideal 'starters' modem.

TWO-WAY 'SATELLITE' SPEAKERS

Here's what you've been waiting for – a small pair of high quality two- way loudspeakers. Based on two top-range Vifa drivers, they can be used alone as bookshelf speakers or teamed with the SW-1 Band Pass Subwoofer we published last September.

INTRODUCING THE "SUPERbis 2400" MODEM!

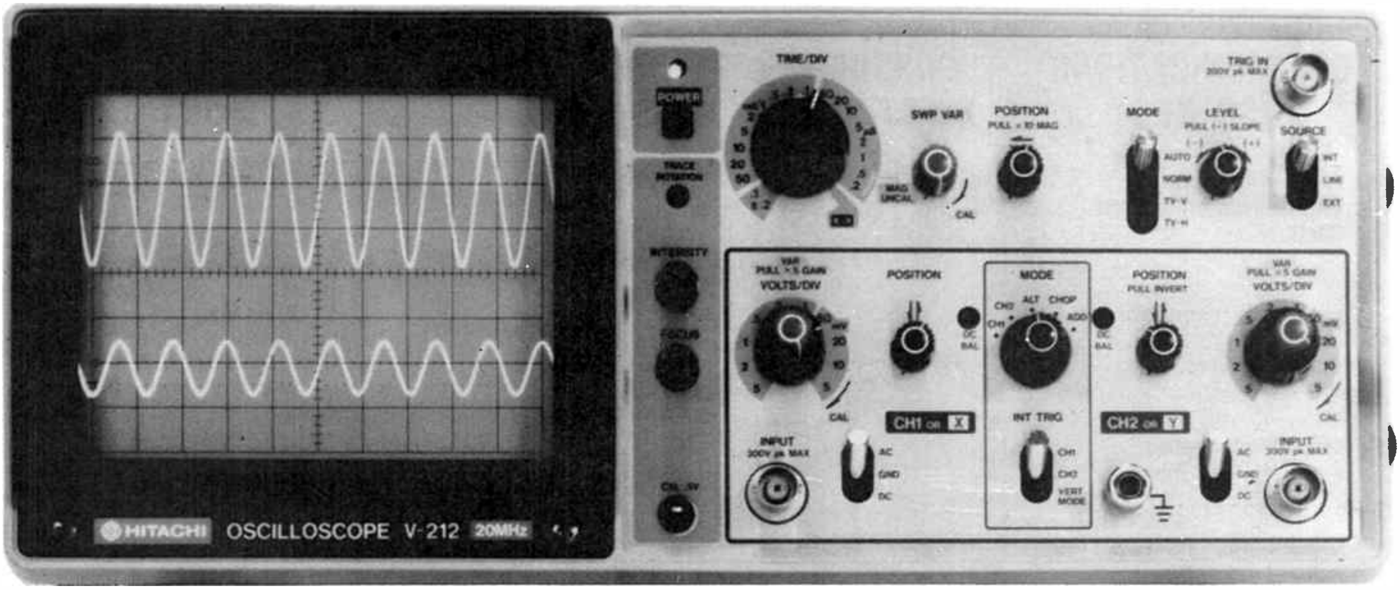
Next month we introduce you to the latest in modem technology, followed in June with full project constructional details. Based on the Exar XR-2400 chip set, which employs digital signal processing (DSP) this new Maestro design is really one out of the box!

HANDHELD MULTIMETERS – 1988 SURVEY

Whoa, boy! Seems we jumped the gun a bit with this one as so many suppliers were not quite ready to release their 1988 products. All the news on new gear fit to print – coming up!

While these articles are currently being prepared for publication, unforeseen circumstances may affect the final contents of the issue.

FEATURE



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<table>
<tr><td>Display
CRT
Graticule

Accelerating Potential
External Intensity Modulation</td><td>6-inch rectangular.
Internal, 8 x 10 div (1 div = 1 cm), Horizontal and vertical center lines further marked in 0.2 div increments, marking for measurement of rise time
2 kV.
Voltage: 5V or more.
Effective bandwidth: DC to 2 MHz.
Max. input voltage: 30V (DC + AC peak).</td></tr>
<tr><td>Vertical Deflection
Sensitivity

Bandwidth

Rise Time

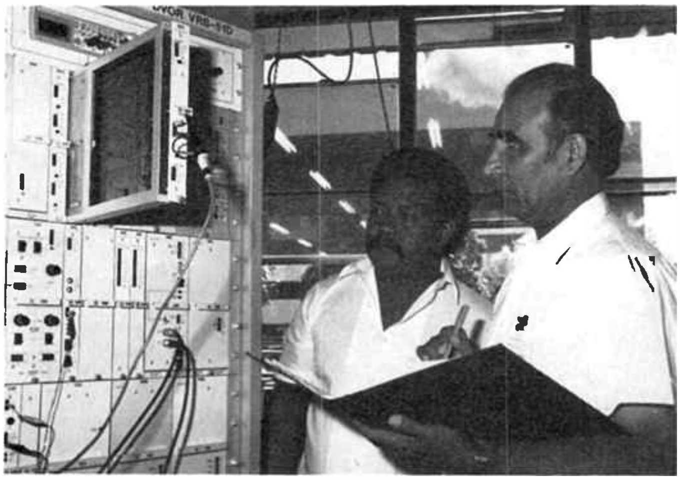
MAX. Input Voltage
Input Coupling
Input Impedance
Display Mode
CH1 Vertical Signal Output</td><td>5mV/div to 5V/div in 10 calibrated steps ±3%.
1mV/div, 2mV/div ±5% when using x5 magnifier.
Uncalibrated continuous control between steps 1 : < 2.5.
DC to 20 MHz (−3 dB).
DC to 7 MHz (−3 dB) when using x5 magnifier.
17.5 ns.
50 ns when using x5 magnifier.
300V (DC + AC peak) or 500Vp-p AC at 1 kHz.
AC, GND, DC.
1MΩ approx. 25 pF.
CH1, CH2 (normal or invert), ALT, CHOP, ADD
Voltage. approx. 20mV/div into 50Ω
Bandwidth: 50 Hz to 5 MHz (−3 dB) into 50Ω.</td></tr>
<tr><td>X-Y Operation
Sensitivity

Bandwidth
Phase Difference</td><td>CH1: X-axis, CH2: Y-axis.
5mV/div to 5V/div.
1mV/div, 2mV/div when using x5 magnifier.
DC to 500 kHz (−3 dB).
3° or less from DC to 50 kHz.</td></tr>
<tr><td>Horizontal Deflection
Sweep Time Range</td><td>0.2 μs/div to 0.2s/div in 19 calibrated steps ±3%.
100 ns ±5% when using x10 magnifier (20 ns and 50 ns uncalibrated).
Uncalibrated continuous control between steps 1 : < 2.5.</td></tr>
<tr><td>Trigger
Trigger Mode

Trigger Source
Trigger Sensitivity

Trigger Coupling
Trigger Slope</td><td>Automatic (sweep runs in absence of a triggering signal and for signal below 30 Hz), Normal (sweep runs when triggered), TV-V, TV-H.
CH1, CH2, V-MODE, External, Line.<table><tr><td></td><td>20Hz to 2MHz</td><td>2MHz to 20MHz</td></tr><tr><td>CH1 and CH2</td><td>0.5 div</td><td>1.5 div</td></tr><tr><td>External</td><td>20mV</td><td>800mV</td></tr></table>AC.
+ or −</td></tr>
<tr><td>Calibrator</td><td>Square wave. Voltage: 0.5V ±3%
Frequency: Approx. 1kHz</td></tr>
<tr><td>Power Supply</td><td>Voltage: 100/120/220/240 V ±10%.
Frequency: 50/60/400 Hz.
Power consumption: approx. 30 W.</td></tr>
<tr><td>Ambient Temperature</td><td>Rated range of use: +10 to 35°C.
Limits of operation: 0 to 50°C.
Storage and transport: −20 to 70°C.</td></tr>
<tr><td>Dimensions</td><td>310(W) x 130(H) x 370(D) mm.
12.2 x 5.1 x 14.6 in.</td></tr>
<tr><td>Weight</td><td>Approx. 6 kg/13.2 lb.</td></tr>
<tr><td>MTBF</td><td>20,000 hours for target value.</td></tr>
<tr><td>Accessories Supplied</td><td>Two AT-10AJ1.5 probes, Fuse, Power cable, Operation manual.</td></tr>
</table>

Export orders to flow from AWA airnav contract with Papua New Guinea



Substantial export orders could flow from a sale in February of AWA air navigation equipment to Papua New Guinea's Department of Civil Aviation who purchased dual-unit Doppler VOR equipment from AWA Defence and Aerospace in a deal worth some A$400 000.

A VOR station comprises a ground-based radar "lighthouse", transmitting a continuous signal in all directions which gives pilots crucial course information. Doppler VOR is specially designed to eliminate problems of signal interference caused by mountains, buildings or trees.

The unit sold to PNG will be installed at Port Moresby airport and is set up in a dual configuration to provide absolutely fail-safe operation. It is expected to be operational this month.

AWA are also competing strongly for a much larger contract to install another form of 'en route' flying aids in PNG.

The new contract would involve the replacement of more than 20 distance measuring equipment (DME) units in PNG, and the current contract places them in a strong position, according to AWA's business unit manager for airways and communications systems, Wes Oke.

Almost every commercial aircraft uses the DME system; using both DME and VOR equipment, a pilot can get a precise fix of his position relative to the DME beacons.

AWA was the first country in the world to employ DME as a navigational aid and AWA supplied about 80 of the existing 100 DME ground stations in Australia, the 22 in PNG and six in NZ.

New regulations will bring the existing DME units into line with international standards and the Department of Transport and Communications has approved a conversion program for Australia.

AWA has already developed and sold DME units meeting the new standard. The 80 Australian stations and the 22 PNG stations needing upgrade cost a little less than A$200 000, making the conversion program worth tens of millions of dollars.

AWA has started an aggressive export campaign, with India showing interest, while Wes Oke has been to China for negotiation with authorities there.

Agreement on new magnets

Magnets made from a new material – a combination of neodyium, iron and boron – will be manufactured and marketed under the name of "Neodure" by Philips following the finalisation of a licence contract agreement between Philips and Sumitomo of Japan.

The material is currently the strongest known permanent magnetic material in the world. It allows more powerful and more compact magnetic assemblies to be built for consumer, automotive, industrial and telecommunications applications.

The new magnets will be used in small, lightweight motors, braking systems, measuring equipment, switching equipment and floppy disc drives.

Thin-walled radial rings for dc motors using magnets of Neodure are already being sold by Philips.

Rare earth Samarium/Cobalt magnets were the strongest magnets before Sumitomo developed the NdFeB material. Philips rare earth magnets, including the new Neodure, are made at Southport in the UK.

Million dollar OTC contract

Local company Mitec Ltd has been awarded a $1.29 contract by OTC to supply specialised microwave communications equipment for installation at OTC's Sydney, Ceduna and Perth Earth stations.

The equipment comprises C-band frequency conversion equipment together with switching equipment to be used for transmission and reception of digital carriers at these Earth stations.

A wholly Australian-owned company, Mitec specialises in the design, development and production of microwave subsystems covering a wide range of applications in ground and satellite communications systems, Earth resource sensing, air navigation, defence, security and transport systems.

Vicom acquires Scalar

Melbourne- base telecommunications company, Vicom International P/L, has acquired the assets of the Scalar Group of companies. A new company has been formed – Vicom Scalar P/L – to take over the manufacturing, exporting and marketing activities of Scalar.

The Scalar Group ran into financial difficulties last year, culminating in the liquidation of the company.

Mr Michael Goode has been appointed General manager of Vicom Scalar and new R&D programs have been established to ensure that the operation continues to expand its market position.

Electronics for NSW trains

A new electronics factory built by Mitsubishi Electric Australia at Rydalmere in Sydney, NSW, will provide design and manufacturing facilities for the electronic equipment in the NSW State Rail Authority's new "Tangara" trains, cellular mobile telephones and spacecraft equipment.

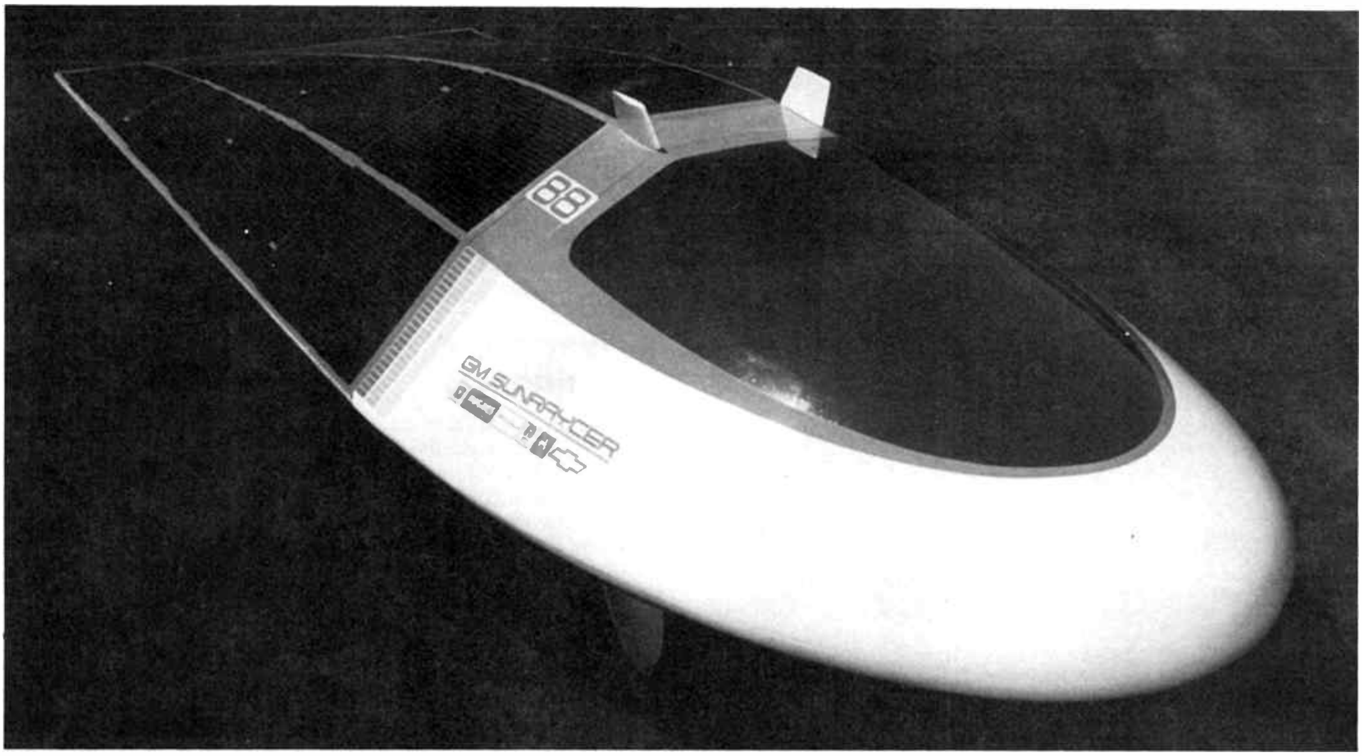
Claimed to be the world's most advanced commuter train, the Tangara rolling stock goes into service in NSW this year, in a program to replace the older rolling stock. This project involves more than 50 per cent local content.

The new Mitsubishi factory was opened by the federal Minister for Science and Small Business, the Hon. Barry Jones.

Equipment for working with surface mount devices has been installed, along with a clean room suitable for the manufacture of spacecraft components. The factory will initially focus on cellular radio production.

Solar Magic!

Dave Jeanes



– the story of the 1987 Pentax World Solar Challenge and the remarkable winner – Sunraycer

Take a vehicle weighing less than 250 kg, including driver. Propose a journey of 3000 km. Limit road travel time to less than 45 hours. Ban all fuel sources other than direct energy from the sun. An unlikely recipe for success? Read on to see how the incredible was achieved!

The race route – 3005 km through Australia's desert centre, Darwin to Adelaide via Alice Springs.

THE 1987 PENTAX World Solar Challenge attracted 25 vehicle entries from seven countries, seven entries alone from Australia. Sixteen vehicles completed the gruelling Darwin to Adelaide course. It's natural to assume all entries utilised electrical energy obtained from solar cells. Surprisingly, the Clisby Team entry proposed using solar energy to generate steam power.

This inaugural event was promoted and organised by Energy Promotions of Mona Vale, NSW, with Director Hans Tholstrup at the helm. Starting date from Darwin was November 1st 1987. It was estimated the first vehicle would pass the finish line in Adelaide within ten days. Other entrants would have to complete the course within five days of the winner to qualify as a 'finisher'.

The General Motors entry, 'Sunraycer' crossed the finish line on the morning of the 6th day. This remarkable vehicle averaged 66.92 km/h for the 3005 km journey, and was underway for less than 45 hours to gain the winner's plaque.

The race

The rules limited vehicle travel time to the hours between 8 am and 5 pm. During the two-hour segments immediately before and after these times, the vehicle solar panels could be used to provide extra charging for the onboard batteries, and maintenance could be carried out. Overnight, from 7 pm until 6 am the vehicle had to be covered by an opaque sheet, with the official observer sleeping alongside. The official weight for each driver (up to four could be nominated) was 85 kg. Drivers weighing less than 85 kg would have lead ballast fitted in the vehicle to make up the 85 kg total.

The organisers provided a passenger vehicle, fitted with two-way radio and flashing lights, to follow closely behind each solar vehicle entry, carrying the observer in the front seat. Many entrants used low powered UHF handheld transceivers to communicate between the observer vehicle and the solar car.

Before the race each entry had to undergo a 'stability test'. The rules outlined this rather hair-raising procedure: "*Two lines will be marked on the roadway, 3.0 metres apart. The vehicle, in its 'ready to go' condition, will be required to travel at maximum speed between these lines. A 38 tonne truck, carrying a pantech, will travel in the opposite direction at 90 km/h and if the (solar) vehicle cannot stay within the lines it will be deemed to be unstable.*"

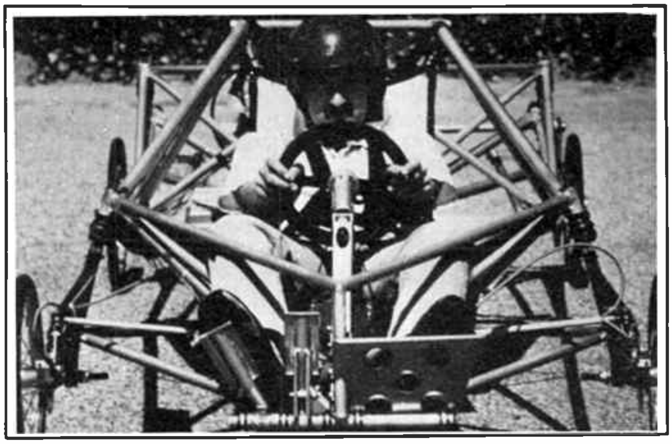
Starting pole positions were allocated from the speeds achieved at these stability tests, just to keep the entrants honest. Sunraycer gained the front starting spot with a speed of 113 km/h (and still accelerating). With the ability to accelerate from zero to 100 km/h in only 25 seconds, Sunraycer shot ahead of the field from the start. By the end of the second day Sunraycer was over 250 km ahead of the nearest rival, the Swiss entry, 'Spirit of Biel'.

This head start gave the leader a tremendous advantage, as cloud and rain began overtaking the tail-end of the field, robbing them of the life-giving solar energy. Sunraycer continued casting a shadow all the way to the finish line, to complete a remarkable win in the inaugural Pentax World Solar Challenge.

Sunraycer

The Sunraycer was developed and built by General Motors and the Hughes Aircraft corporation in the United States – a major vehicle manufacturer and a major aerospace research and manufacturing organisation. The chassis of the Sunraycer is a welded aluminium tube space frame, built along

The body of Sunraycer was made up of a composite material comprising a sandwich of Kevlar-Nomex-Kevlar, which was strong, rigid and very light (3 oz per square foot).



The lightweight aluminium tubing space frame of the Sunraycer weighs less than 7 kg.

the lines of many racing cars. The chassis weighs less than 7 kg, yet supports a total vehicle weight, with driver, of almost 250 kg.

The body has a sandwich construction using Kevlar outer layers with a honeycomb-like core of Nomex, developed by DuPont. This layup gives great strength and rigidity with amazing lightness – typically 3 oz per square foot, according to the US literature.

The gold plated driving compartment canopy cuts out 98% of infra-red rays, protecting the driver from the hot sun. The gold film also blocks out 90% of visible light, but the remaining 10% is sufficient for safe daylight driving. The driving seat is a sling of nylon mesh, which further aids in keeping the driver cool. A full racing safety harness is fitted.

Suspension

The 17-inch spoked wheels have aluminium rims and quick mounting hubs for rapid wheel changes. The spokes are covered with plastic discs to reduce drag. A range of tyres for various road conditions are custom made, with BMX style tyres being used for rough surfaces. The four wheel independent suspension comprises MacPherson struts at the front with trailing arms for the rear wheels. Steel coil springs and conventional gas shock absorbers are used.

The primary braking system is regenerative. With the driver's foot lifted from the accelerator, the forward motion of the vehicle drives the propulsion motor which then acts as a generator, recharging the batteries. Secondary braking is provided by hydraulic disc brakes on the front wheels and a mechanical disc brake (emergency) on the rear righthand wheel. The lefthand rear wheel provides traction via a sprocket and chain from the electric motor.

Aerodynamics

The body shape was refined using an advanced computer program from NASA called VS-AERO. The body configuration reduces upward and downward forces to a minimum, aiding high speed stability. The goal was to provide a teardrop shape with very low aerodynamic drag, and with low side forces during cross winds (which come from road trains doing 120 km/h).

Dr. Paul McReady, famous as the designer of the Gossamer series of pedal and solar powered aircraft, helped the design team 'fine-tune' the body during wind tunnel testing. Two small fins called *strakes* were eventually fitted just above the driver's head to reduce upward lift during strong cross winds. Six ventral fins were located in the lower trailing edge of the body. To avoid the drag from a rear vision mirror, a tiny optical fibre pickup tube looked rearwards, and presented its image, via optical fibre cable, on to an LCD screen in the cockpit. ▷

The World Solar Challenge rules limited the size of vehicles to 6 m long by 2 m wide and 2 m high, of which the solar panel collection area could not exceed eight square metres in the horizontal plane. This latter rule permitted the solar array surface to curve downwards, and to include vertical sections, although these are not efficient gatherers of solar energy in tropic latitudes.

The GM Sunraycer design provided the maximum allowed solar panel area, an extremely low coefficient of drag, a minimum total all-up weight, plus high speed safety, driver comfort, and mechanical reliability.

Solar power

The complete Sunraycer array contains 7200 gallium- arsenide solar cells, manufactured by Spectrolab, a Hughes Aircraft Co. subsidiary. Spectrolab also made the solar cells installed in the Aussat satellite. Each cell measures 6 cm by 2 cm by 0.2 mm thick, and they are arranged in 20 strings of 360 cells connected in series, providing an unloaded terminal voltage of approximately 150 volts (360 x 0.42 volts). The whole array produces about 1000 watts under a noonday tropic Sun!

Batteries

A bank of 68 silver-zinc cells, each providing 1.5 volts and 25 Amp-hours of current, are carried in the vehicle. Providing a terminal voltage of 102 volts, these cells weigh only 27 kg, one-fifth the weight of equivalent capacity lead-acid cells. Fully charged, the battery bank holds over 2.5 kilowatts of power!

The batteries play a vital role in obtaining maximum overall speed. Prior to departing Darwin, they were fully charged and on arrival in Adelaide they were again found to be fully charged, thanks to good onboard management! The batteries obtain a slight charge from the traction motor whenever the vehicle is coasting.

The batteries augment the solar panel power on hill climbs and when overtaking, and they assist in maintaining high speed in overcast conditions. During the two-hour periods before and after the day's racing the batteries can be recharged from the solar panel, which is hinged upwards to gain maximum direct energy from the waning sun.

Vehicle monitoring

A variety of sensors were fitted at key locations in Sunraycer to enable constant monitoring of performance. At five second intervals data from the sensors was radioed by telemetry equipment to the observer vehicle, where they appeared on a display. This information allowed the Sunraycer driver to be advised, by UHF voice radio, about battery useage and charging procedures.

Drive electronics

The motor drive electronics connect the power source to the accelerator and the traction motor. These circuits allow the driver to select cruise control, to charge and discharge the battery bank, and they also provide regenerative braking to feed power back into the batteries. The system comprises a three-phase, pulse-width modulated motor drive circuit, using 20 power MOSFETs in each phase.

Traction motor

A technology called the 'Magnaquench Process' is used in manufacturing the permanent magnets of the traction motor. The name is derived from the technique of quenching, or cooling, a stream of molten metal as it is sprayed on to a spinning wheel in an oxygen-free environment. The metal is a composite of Neodymium, Iron and Boron, and the quenching rate of one million °C per second creates magnetic metal flakes which are the basis of these new high powered magnets.

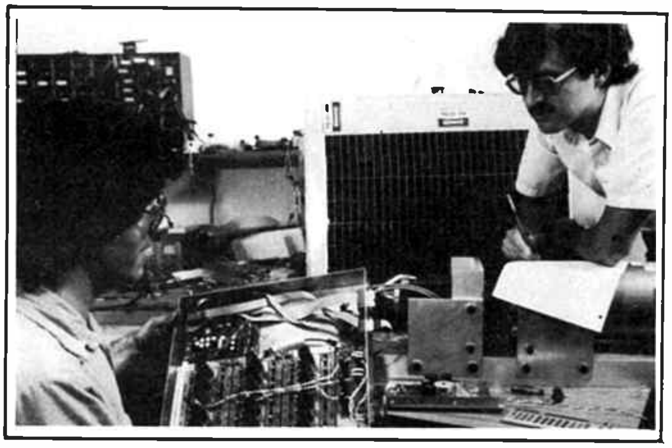
Magnetic properties from two to ten times greater than the best ferrites are possible. This has enabled engineers to reduce the size and weight of the Sunraycer motor to less than 3.7 kg, yet still produce two HP (1.5 kW) at 4000 rpm, which is 35% greater than conventional motors.

The magnaquench motor employs a stationary outer winding and electronic commutation, eliminating the electrical and frictional losses associated with brushes. Special low friction bearings further reduced motor losses. The motor has a very high torque capability, ideal for hill climbing or pulling off the road shoulder when starting. Claimed efficiency is a staggering 92%!

Race communications

The GM SunRaycer entourage vehicles were fitted with Codan HF/SSB land mobile transceivers, and communications were maintained with a base station (also using Codan gear) set up at the GMH test facility at Lang Lang near Melbourne. UHF transceivers were used for contact between mobiles, and with helicopters chartered to cover the race.

Aussat provided their Transportable Earth Station (TES) mounted on a large semi-trailer with special air cushion suspension. The TES, which accompanied the race, provided a TV uplink and downlink, with associated sound and ▷



The drive electronics was a crucial part of Sunraycer's power system. It comprised a three-phase, pulse-width modulated motor drive circuit, using 20 power MOSFETs in each phase.

The "magnaquench" dc motor develops two horsepower (1.5 kW) continuously at 4000 rpm but weighs less than 4 kg! It has a stationary outside winding and no brushes. It was connected to the left rear wheel via a 4:1 chain drive.

STANDBY POWER

We have a large range of sealed lead-acid rechargeable batteries available from stock, ideal for use in uninterruptible power supplies, telecommunications backup, security systems, etc.

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SECOND GENERATION

MOS-FET PROFESSIONAL POWER AMPLIFIERS

EHT

ELECTRON HANDLING TECHNOLOGIES

EHT-2000 : OVER 1000 WATTS RMS/CHANNEL — BOTH CHANNELS DRIVEN
EHT-1000 : OVER 500 WATTS RMS/CHANNEL — BOTH CHANNELS DRIVEN

Just 3 rack units high — super strong, ultra light all alloy chassis — EHT-2000 weighs only 24 Kg — Toroidal Transformers — fully independent power supplies — fully protected against shorted outputs and thermal over-load — power-up anti-surge circuitry eliminates excessive current drain at switch-on — switch-on thump suppression — transformerless balanced inputs protected against excessive input voltage and R.F. interference — fully complementary/balanced and thermally stabilised Octa-differential driver network — Bipolar clipping indicators — plus many more features too numerous to mention.

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On the road – changing a wheel.

The communications vehicle – dubbed "The Porcupine" – was outfitted with both HF and UHF equipment, all locally supplied.

engineering channels, for the Channel 9 TV coverage.

Telecom's ITERRA portable earth station provided high grade telephone, Telex and Facsimile services along the route, setting up at each evening camp site, and even plugging in the ubiquitous Gold Phone. Telecom, with a 25% ownership in Aussat, and permanently leased satellite capacity, offer a whole range of satellite communications facilities, anywhere, 'at the drop of a hat'.

The future

Hans Tholstrup plans the next Solar Challenge for 1990, along the same route. Many of the original contenders are already well into the redesign phase, with new vehicles appearing on the drawing boards. What will GM do to improve the Sunraycer ? Will we see a new flock of Sunraycer look-a-likes from the competition? Will the Japanese entries be much more innovative, in a race they have set their hearts on winning ?

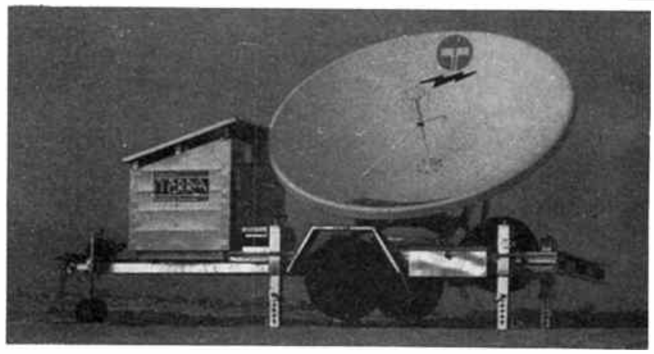
The next Solar Challenge will certainly create far more interest than the first, but what an act to follow!

RACE RESULTS

Place	Vehicle	Country	Hrs/Mins	Avg. Speed
1	GM Sunraycer	USA	44:54	66.92 kph
2	Ford Motor Co	Australia	67:32	44.63
3	Spirit of Biel	Swiss	69:58	42.94
4	Aust. Geographic	Australia	81:26	36.90
5	Darwin Institute	Australia	95:27	31.48
6	Chisholm Inst.	Australia	98:12	30.60
7	Solar Res. Synd	Australia	117:05	25.64
8	*Crowder College	USA	distance 2424km	
9	*Solectria 4 MIT	USA	distance 2399km	
10	Chariot of the Sun	Denmark	150:35	19.95
11	Alarus	Australia	146:27	20.51
12	Hoxan Corp.	Japan	153:31	19.57
13	Photon Flyer	Australia	189:04	15.89
14	SEL	Japan	279:21	10.75

* Position 5 days after first vehicle finished.
Vehicles 10 thru 14 continued on to finish line.

AUSSAT provided a Transportable Earth Station (TES) for television coverage of the event via satellite.



Telephone, telex and fax communications was made available in the remote outback via a Telecom ITERRA satellite Earth station link like this, towed from place to place behind a 4WD vehicle.

1 kW/channel power amp

In PA applications, power output and reliability are the two top requirements called for in an amplifier, but seem to be mutually exclusive when it comes to actual practice. This Australian designed and manufactured unit is the result of a rather unusual research program which "... spawned an amplifier with unusual technical characteristics and a performance which puts it in the heavyweight league."

OVER THE PAST 20 years I have tested and reviewed some rather exciting power amplifiers. Quite a few of these were produced in Australia by local designers. The EHT2000 series is one of the most exciting amplifiers to hit the market and will undoubtedly raise a few eyebrows.

The EHT2000 is the result of a rather unusual research program which spawned an amplifier with unusual technical characteristics and a performance which puts it in the heavyweight league.

An amplifier that can simultaneously produce a full kilowatt of power from each channel is a rather awe- inspiring piece of equipment. One that can provide that sort of power reliably and safely, with very low distortion, would appear to be something of a rarity in Australia.

The design philosophy underlying the development of the EHT2000 is likely to be just as interesting to you as it was to Mike Davis of Electron Handling Technologies, who was given a set of calculated commercial guidelines for each stage of the program.

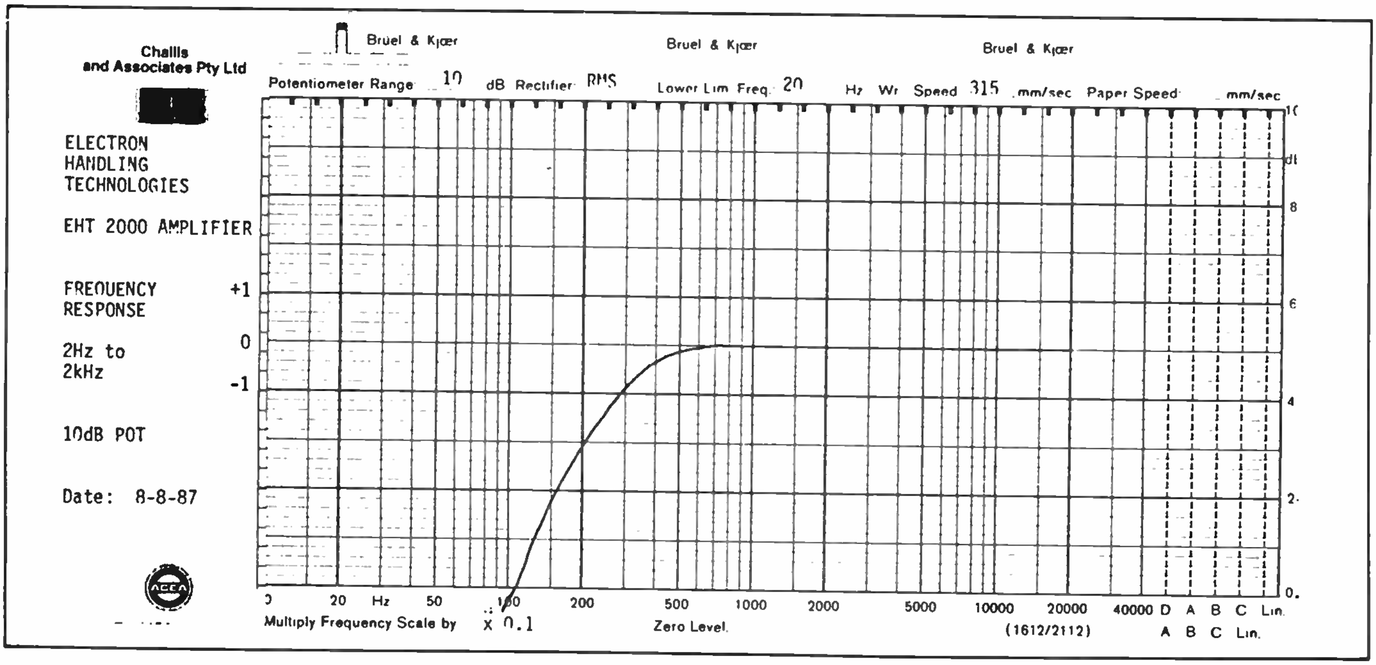
Mike adopted the prosaic approach and methodically evaluated the options, one by one, before he stepped out of the veritable frying pan. His directors had already carried out their own preliminary market survey to assess the design criteria that the intending purchasers would probably be seeking. Armed with this data, they deftly laid down the design parameters which he had to achieve.

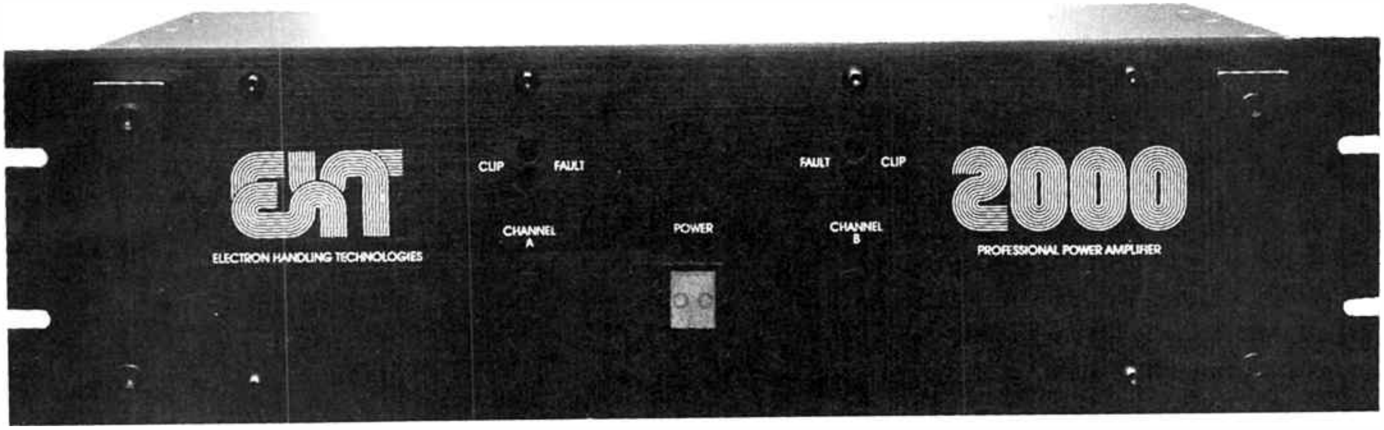
REVIEW ITEM:	2-channel power amplifier
MANUFACTURER:	Electron Handling Technologies
MODEL:	EHT2000
DISTRIBUTOR:	Etone, 6-12 Stanley St, Peakhurst 2210 NSW. (02)534 3569.

The goals they had set firstly related to size and weight, which were to be as small and low as possible. Secondly, they wanted the best possible reliability, which is of extreme importance for every professional user. They specified the power output, which they insisted be 1 kW into a 4 Ohm load, and wanted the amplifier to be able to withstand abnormal abuse, which is essential. It had to be able to withstand the sort of abuse generated by shorted outputs, blown input stages and by fuse substitution of the wrong type.

Next, the unit was to be easy to service, easy to assemble, be mechanically sound and should achieve performance characteristics that were better than or, at worst, the equal of any amplifier produced in competition. Etone then apparently evaluated every single competing amplifier currently available in Australia and decided that none of appeared to

Bass-end roll-off. The 3 dB point is about 16 Hz.





satisfy all of the parameters which they had set themselves as requirements for the EHT2000.

There were a number of critical design issues to be considered to achieve these results. Foremost of these was the type of output power stage to be used. There were at least eight variants available, each of which had to be considered before making the correct selection.

In the end, the availability of the appropriate output devices, with reasonable cost and adequate reliability, made the choice quite straightforward. The choice came down to a complementary symmetry MOSFET configuration, particularly as this provided the order of reliability, overcame the problem of secondary breakdowns, provided an excellent bandwidth, good slew rates and most importantly, very significant current gain.

Power supply

Various suppliers tried to convince Etone that E-cores and C-cores would provide a more cost effective and practical power supply.

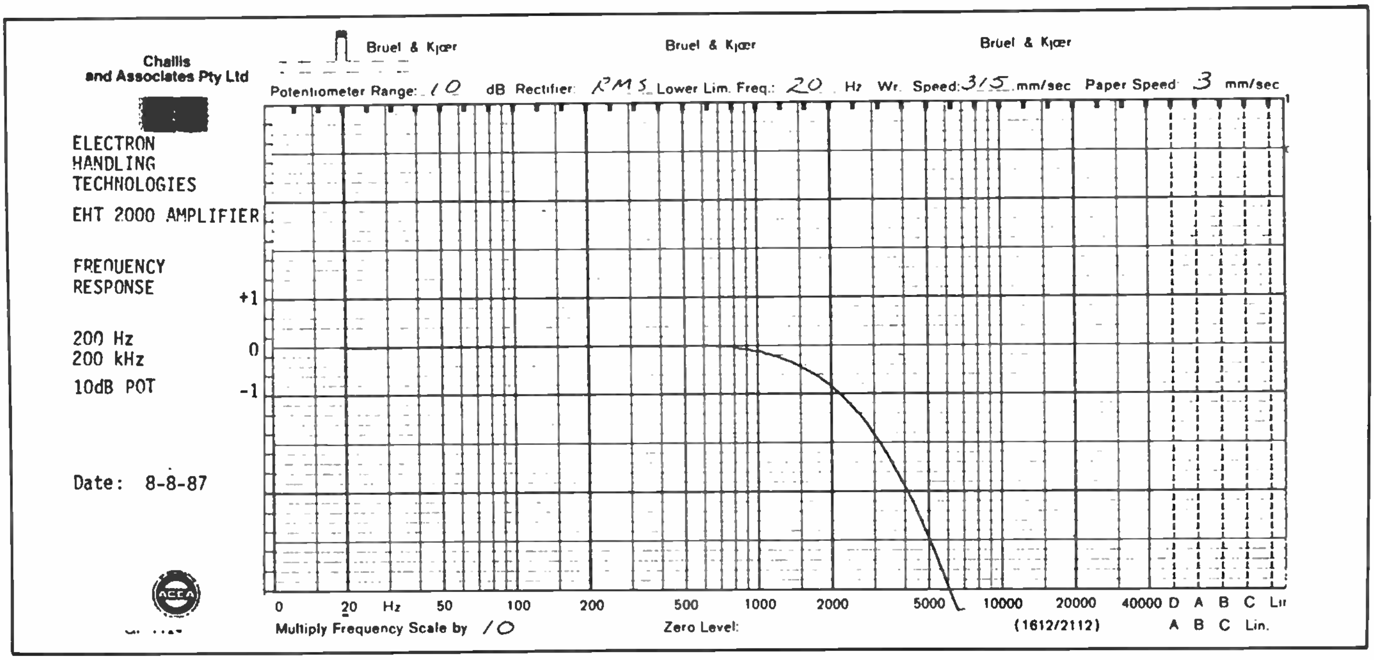
Mike Davis tells the anecdote about one of his learned technical friends who advised him in all sincerity that he should not use toroidal transformers but should rather go for double "C" cores because if their superior regulation. This was evaluated and much to his friend's surprise, it was soon shown that the original advice was somewhat misguided.

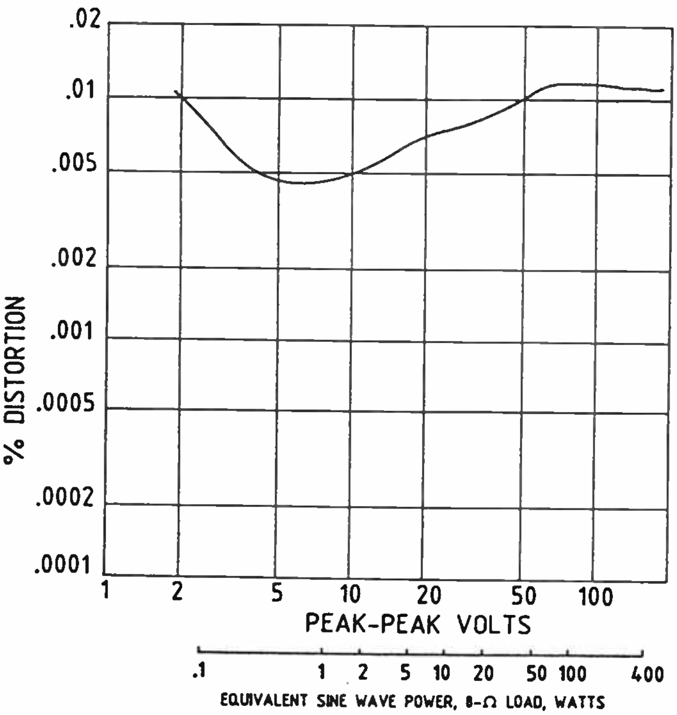
As a result of his investigations, Mike decided a pair of 800 VA toroidal power transformers, each providing 160 volts with a centre tap and bridge rectifier configuration to develop two rails of ±115 volts for each of the separate amplifier circuits.

One of the next problems Mike found was the need to avoid the destructive problems produced by the in-rush current and the potential damage that this could cause the output circuitry or the power supply capacitors. Mike developed a simple but effective "slow power-up" circuit, utilising a pair of series dropping resistors on the active side of the mains input leads feeding the transformers. These neatly provide a two second delay before full power is supplied to the transformers. This was only one of many simple protective circuits which were developed to obviate a wide range of potentially nasty problems which would otherwise shorten the life of the amplifier.

In formulating the features of the EHT2000, emphasis was placed on short circuit protection. The output stage protection circuit had to be cheap, simple, reliable and would ide- ▷

Top-end roll-off of the frequency response. It's down 3 dB at 40 kHz.

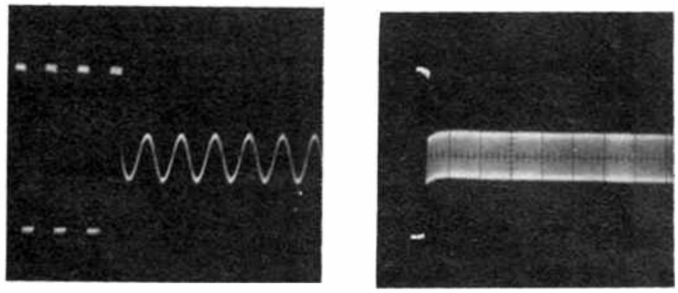




Distortion performance of the EHT2000 – hi-fi performance from a kW PA amp!

ally incorporate appropriate foldback characteristics to avoid introducing added distortion.

The solution was rather neat and effective. By incorporating a reed switch inside a wire loop carrying the output current, Mike found it was possible to disconnect the input circuit in less than one millisecond so that no high current switching needed to be performed. This had the added advantage that it could activate the clipping circuit which would then flash in synchronism with the reed relay. The panel light would then indicate that the output circuit was being subjected to a short circuit or an overload condition.



1 ms/div. **50 ms/div.**

Transient overload recovery results (IHF-A-200 test). These results are very good.

Overload circuit

An equally important feature was the provision of a thermal overload protection circuit. This circuit should ideally have variable or gradual onset characteristics, rather than providing an "on/off" characteristic.

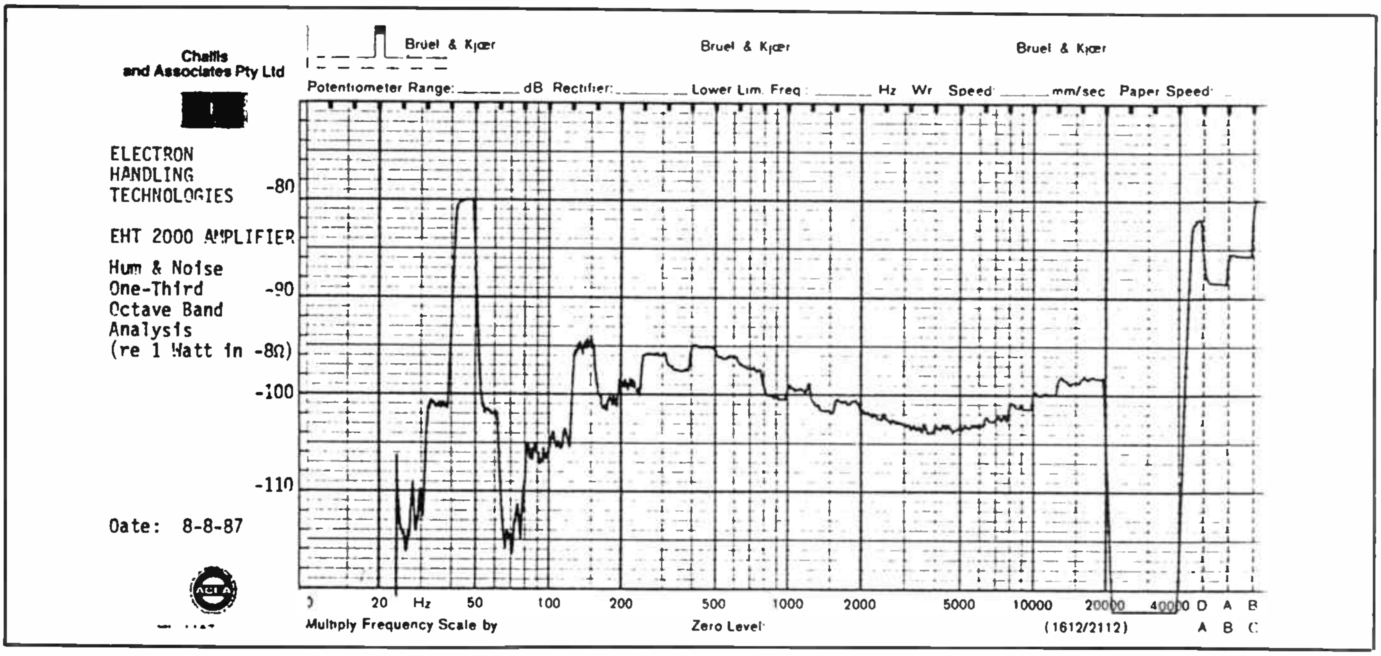
The solution was a two terminal device which exhibits very sharp rollover characteristics at 75 °C. This was mounted in direct thermal contact with the main heatsink and then used to control the circuit gain simply by paralleling it with the signal input to the volume control. The resulting effect was then progressive, reliable and avoided the sudden "shutdown characteristics" that many other amplifiers currently exhibit.

In order to avoid the introduction of conventional output filtering and load capacitance isolation networks, which most other amplifiers use, the network was removed completely. Instead, the overall amplifier stability was optimised to ensure that the output impedance was as low as possible. This approach provided results which were better than expected.

The clipping indicators were then tied in with the short-circuit protection network because, to use Mike's words, "they offered another dimension of distinction, while implementing the clipping indication."

Instead of using washers between the MOSFETs and the output heatsink, he decided to directly connect each device

Hum and noise performance of the EHT2000, measured across the audio band.



straight onto the heatsink, as this not only reduces the thermal resistance, but also reduces the multiplicity of insulators, washers and the associated labour costs involved in fitting them.

To ensure thermal stability in the output circuit, the hollow heatsink assembly utilises a reliable industrial cooling fan which provides the amplifier with the ability to dissipate copious quantities of heat when the unit is feeding 2 kW of output power into a pair of 4 Ohm loads.

Construction

The front panel of the amplifier is a dark grey anodised aluminium with white silk screen lettering which is smart, attractive and clear. Apart from two indented level controls for channels A and B, a large self-illuminated power switch and a pair of LEDs which indicate clipping and fault for each channel, the front panel is relatively bare.

The front handles on the amplifier are large, sensible and smooth, to protect your fingers, which is a feature I like. The rear of the amplifier does not have handles, only two extensions of the side chassis channels to provide mechanical protection for the plugs, terminals, fans and fusers.

The rear panel incorporates a fan which provides plenty of air and produces 54 dB(A) at a metre, which is okay for a PA amplifier or one installed where the public can hear it.

The front panel chassis of the amplifier is very solidly constructed from heavyweight aluminium extrusion, while the side channels have adequate area of the ventilation slots on both sides.

The output loads may be connected by means of either two pairs of relatively small universal terminals, or by two pairs of standard male Cannon sockets for each channel.

Inputs are provided by a pair of male and parallel female Cannon XLR sockets. This allows multiple "piggy-back" stacking or interconnecting the multiple amplifiers using a single input source.

MEASURED PERFORMANCE:

SERIAL No.: Nil — laboratory label affixed with designation S18.

FREQUENCY RESPONSE (−3dB re 1 watt):
Input = 0.5 V — Left 17.0 Hz to 42 kHz; Right 20.0 Hz to 44 kHz

	Left (A)	Right (B)
SENSITIVITY (for 1 watt in 8 Ohms):	57 mV	58 mV
INPUT IMPEDANCE (at 1 kHz):	5.0 k ohms	5.0 k ohms
OUTPUT IMPEDANCE (at 1 kHz):	12.6 milliohms	

NOISE AND HUM LEVELS (re 1 watt in 8 ohms):
Input 0.5 V — −79.0 dB (Lin) 88.5 dB(A)

HARMONIC DISTORTION

at a power of 10 W into 4 ohms (minimum allowed):

	100 Hz Actual	1 kHz Actual	6.3 kHz Actual
2nd	96.7	95.7	79
3rd	100.5	96.2	80.3
4th	102.4	106.1	88.4
5th	105.1	103.4	—
T.H.D.	0.002	0.0024	0.015
= dB	94.1	92.4	76.3

at a power of 1,000 W into 4 ohms:

	100 Hz Actual	1 kHz Actual	6.3 kHz Actual
2nd	88.5	85.8	75.0
3rd	82.9	93.3	90.5
4th	100.4	104.3	92.6
5th	102.9	101.7	—
T.H.D.	0.008	0.0057	0.018
= dB	81.9	84.9	74.8

MAXIMUM OUTPUT POWER AT CLIPPING POINT (1HF-A-202):
(20 msec burst repeated at 500 msec intervals) (190 V p-p in 4 ohms = 1128 W
(240 V supply) (200 V p-p in 8 ohms = 625 W

IEC HIGH FREQUENCY TOTAL DIFFERENCE FREQUENCY DISTORTION:

8 kHz and 11.05 kHz mixed 1.1

At rated power	0.012%
At 1 W	0.005%

The inside of the amplifier is very well constructed with the toroidal power transformers stacked near the front and, to my surprise, proper heavy Litz-type wiring and braided wiring selected between critical elements to achieve the required low impedance for power supplies and output circuitry.

The electronic circuitry is sensibly designed for ease of maintenance, ruggedness and rigidity; all essential when you consider the type of abuse to which it will be subjected.

Performance

I was intrigued to see how this 2 kW amplifier would perform in a laboratory as the manufacturers claims were tantalising to say the least. The first series of tests conducted were to assess its frequency response. This has been deliberately limited to 20 Hz at low frequencies and 42 kHz at the high end.

The low frequency response has been limited to avoid dissipating high power into the output speakers with unwanted low-frequency content. At the high frequency end this limitation minimises the possibility of high frequency signals destroying the tweeters as a result of unwanted RF or other oscillation.

However, the frequency responses between 25 Hz and 10 kHz are particularly "flat".

The output impedance is moderately low at 12.6 milliohms while the hum and noise figures are extremely good at 79 dB Linear and 88.5 dB(A) for 1 W output into 8 Ohms. The harmonic distortion characteristics of the amplifier at low powers (10 watts into 4 Ohms) are extremely good. Even at 1000 watts into 4 Ohms the total harmonic distortion figures are still exceptionally good.

At 100 Hz this is particularly low at –81.9 dB, at 1 kHz it is –84.9 dB and at 6.3 kHz is still only –74.8 dB. These are really high fidelity figures and far better than I would expect for such a powerful amplifier.

The IEC total difference frequency distortion figures are somewhat better than I would have expected so that with 180 V peak-to-peak output swing into 4 Ohms, the distortion was still only 0.012%. The maximum output power at clipping (using a 240 V power supply) was 190 V peak-to-peak into 4 Ohms (corresponding to 1128 W) and 200 V peak-to-peak into 8 Ohms (corresponding to 625 W per channel), not 250 V as is erroneously stated in the manufacturer's literature. The dynamic headroom re 1000 W output is precisely 1 dB.

The transient overload recovery test is reasonable, exhibiting only a slight trace of assymetry, but displaying a very fast and reliable recovery performance.

I took the amp home and coupled it to four pairs of speakers in a series-parallel arrangement to achieve an 8 Ohm load (rather than a 4 Ohm load) so that I could drive it to peak outputs without fear of destroying my speakers. The results were devastating, with peak sound pressure levels being produced in excess of 125 dB in my living room. I found I had to turn my preamplifier level down to avoid the complaints from my neighbours and the need to wear ear muffs.

Conclusion

The EHT2000 is an exceptional amplifier. It is one of the few PA amplifiers available that can provide 2 kW of output power reliably, safely and with a reproduction which is in most respects far better than could be reasonably be expected from a PA amplifier.

The EHT2000 is the first of a series of professional amplifiers to be marketed by Etone. On the basis of its exceptional performance it is likely to become a first choice for many professional musicians.

Louis Challis

$1988 gets you a 1988 Video 8 camcorder

Sony staged a delightfully whimsical press release to launch their 1988 range of three 8 mm camcorders and one new Beta 'homedeck' VCR last February.

Bedecked in colonial finery, Sony staff launched the latest video products at a La Perouse restaurant not far from Captain Phillips' 1788 landing spot.

First ashore was the CCD-V50 Digital Video 8 Handycam. Targetted at videcam beginners, this new Handycam is fully automatic and features a digital superimpose function and a 6x power zoom lens.

Captain of the fleet is the CCD-V90 Video 8 Handycam Pro. Weighing just 1.3 kg (inc. battery and cassette!), this unit features 495 000 pixels (picture elements) for clear, sharp pictures, a double azimuth head (normally found only in professional video decks) and Edit Search – a new feature that allows forward or reverse playback while in the camera mode so you can shoot over any unnecessary scenes on tape.

To mark their involvement as the official supplier of video cameras to the Australian Bicentenary 1988, Sony has released a Limited Edition CCD-AU200 Video 8 Handycam. Packaged in green, gold livery and featuring the Bicentennial logo, the CCD-AU200 will sell at a recommended retail price of – wait for it – $1988!

There was some speculation that the "go" price (that price to which goods are discounted below rrp after going on-sale) would be $1788! But it remains speculation.

Maintaining the Beta flag flying, Sony introduced the SL-S2000 Super Betamax homedeck VCR. It features a "long-life" head, colour switch and sharpness control, automatic functions, real-time counter, wireless remote control, Betascan and a 7-day, single event programmable timer.

Five-speed VCR

A new video recorder featuring five slow motion playback speeds and a number of other new, innovative features has been released by JVC, aimed at sports fans who like to see the action 'blow-by-blow'.

A result of extensive research of the Australian market, the HR-D300EA recorder has five slow motion speeds, 1/6, 1/2, 1/187, 1/24 and 130th of normal speed and super fine still quality.

According to JVC's research, Australian are top sport watchers, resulting in the incorporation of the multiple slow motion speeds and high quality still pictures.

Many other features are supported in the machine, some previously unheard of in the domestic video recorder industry. e.g: An indexing system which allows the viewer to mark special points on the recording facilitates fast, reliable searching for particular places on the tape.

Instant time recording is also incorporated in the HR-D300EA recorders design.

Tape head demagnetiser

A cassette tape deck doesn't perform its best with heads magnetised as a result of use. As TDK has long been involved in tape and cassette production, they well understand the importance of regular tape head demagnetisation. Accordingly, they recently released a new tape head demagnetiser, model HD-30.

Sophisticated in design, but low-priced, the HD-30 looks like an ordinary audio cassette, yet inside it contains the necessary electronics for demagnetising the heads.

In operation, the HD-30 provides more than your average head demagnetiser, TDK claim. By just putting it in your tape deck and pressing the PLAY button, a continuous tone will be heard, changing to a series of short beeps when it has finished its job.

Designed and priced towards use in car stereo and personal "Walkman" type tape decks, TDK say that its effects will be heard immediately after use.

See your local TDK dealer.

New Fuji audio cassettes

Fuji has released a new range of cassettes packaged to attract young cassette buyers. In keeping with the image of "crystal clear" sound, the new cassettes are housed in a clear plastic, wide-bodied shell.

While exceptional in looks, the plastic packaging is revolutionary in design. Able to withstand temperatures up to 230 °F while upholding the quality of the recording.

The new cassette is ideal for bashing around on the dashboard of your car, taking to the beach for the Walkman, or just as a rugged, high quality audio cassette, Fuji say. Definitely designed for Australian conditions!

Your local Hanimex dealer will show you the range.

The 'push-me-pull-you' loudspeaker

Roger Harrison

Getting deep bass response and good bass transient performance in a reasonably sized enclosure has long been a problem for loudspeaker designers. And where the tweeter is mounted in the same cabinet, eliminating the effect of phase modulation of the tweeter's output by bass driver vibration coupled through the cabinet has long been the goal of designers the world over. Danish loudspeaker manufacturer Dali has tackled these problems, and others, in a unique way with their recently released Dali-40.

SPEAKER DESIGN advances rather in the manner of peeling an onion. As you remove the outer layers, ever more layers – previously hidden from your perception – are revealed. In the advances made in speaker design over the past decade, while a number of fundamental problems have been brilliantly solved, a number of other problems have remained to plague listeners and engineers.

The technique for obtaining deep bass response from a reasonably-sized enclosure was demonstrated by Laurie Fincham of KEF in 1979, where he mounted a woofer in a bass reflex box and enclosed the front of the cone with a sealed box, obtaining radiation from the port alone. This combined the characteristics of a bass reflex and a sealed enclosure, giving a "band pass" frequency response in a relatively small enclosure with the added advantages of good transient response and low distortion. There went several layers of the onion.

Problem was – next layer of the onion – the system exhibited an inherent top-end rolloff around 100 Hz. Good for subwoofers, but little else.

All the while, it has been known that modulation of the tweeter output, caused by vibration transmitted from the woofer cone to the cabinet, was a source of top end colouration; like earlier layers of the onion left behind.

The latter problem is brought about by Newton's third law of motion – to every action, there is an equal and opposite reaction; when you push on a wall it doesn't fall over because there is an equal and opposite force generated in the wall – pushing back on you.

When the voice coil of a woofer moves out, the cone moves out and stretches the "surround" that holds it to the rim. The rim, which is mounted on the cabinet, exerts a force in the opposite direction. But the cabinet must exert a force on the rim to hold it in place. If the cabinet is at all flexible – and virtually all materials are to some extent, then the cone vibrations are transmitted to the cabinet. As in most multi-way speaker systems, the tweeter is mounted on the cabinet. The flexing of the cabinet in sympathy with the woofer excursions moves the tweeter back and forth – causing slight, but noticeable, modulation of the sound it is reproducing. The cabinet also radiates some energy. For these reasons, designers in the past resorted to using "dead" materials such as concrete for speaker enclosures. Concrete speaker enclosures never caught on as a domestic hi-fi product, despite this advantage.

The onion, seen afresh

In 1983, intrigued by Fincham's band pass bass system, Dali set out to implement this new technique in a loudspeaker which they wanted to possess the following qualities:

1. Excellent bass reproduction with a low cutoff frequency and good transient response;
2. Natural, detailed reproduction throughout the whole frequency range;
3. Wide and deep stereo imaging;
4. Smooth sound radiation in the room;
5. Worthy of the best amplifiers.

Admirable qualities for any loudspeaker. So they started with Laurie Fincham's bandpass technique, with the aim of extending its upper frequency response being a prime goal, among others.

Any driver mounted on a baffle or in a box behaves as a filter of some sort. Now, a driver mounted on a sealed box constitutes a 2nd order high pass filter that can have a response ranging anywhere between a 1st order roll off (very gradual, 6 dB per octave), a 2nd order Butterworth to a 3rd order Chebychev. (See *Practical Filter Design* by Jack Middlehurst, AEM Oct. 1987 to the present issue, for a clear explanation of these terms). A 2nd order Butterworth (usually called a 'B2') system will have a Q factor of 0.707. Such a system gives the best transient, or impulse, response. In systems having a Q higher than this, there is a tendency to "ringing" (the "one-note" bass), while systems with a Q lower than 0.707 exhibit an over-damped response, sounding "lifeless" and decidedly dull.

A bass reflex system exhibits a 4th order response, having quite a steep roll off below the cutoff frequency. Thiele and Small analysed bass reflex systems in their now "landmark" papers. The response of different bass reflex "alignments" ranges across sub-Chebychev 2nd order, quasi-Butterworth 3rd to 4th order and 4th order Chebychev.

When it comes to transient response, it is widely acknowledged that the best bass reflex systems are those having Qs between 1.0 and 1.3. Unfortunately, they're also the worst when it comes to getting deep bass in sensible enclosures with existing drivers.

The bandpass system of Fincham's uniquely combines the best of both worlds – very low cutoff with excellent transient response. But, as mentioned earlier, Fincham's original system has an inherent roll off above about 100-150 Hz. Dali wanted a system with a response that extended to 1000 Hz.

Following considerable work, they evolved a system using two drivers – one beaming into the air from the front of the cabinet with the driver's rear controlled by a bass reflex system, and the second driver also mounted in the bass reflex box, but with the front of the cone loaded by a sealed enclosure. See Figure 1.

In order to obtain a B2 bass response, and thus gain the advantage of its superior transient performance, Dali first arranged that Driver 1 operated in an enclosure that was too large. This resulted in a dip below system resonance and a peak at resonance. Driver 2 and its sealed enclosure were then "tuned" to "fill-in" the dip below resonance and "dampen-down" the peak at resonance. The drivers then remain in phase up to the natural roll off of the system. Goal No.1 achieved.

This is clearly a very complex system with many interacting components and Dali found it necessary to construct a complex computer program to predict critical performance parameters such as lower limit frequency, rectilinearity (which determines distortion) and filter type.

Next, extend this system's top end response. This required work on the driver construction. The most important component of the bass driver, when considering bandwidth, is the cone – it must act just like a piston over the widest possible frequency range. Dali engineers tried many different materials for the woofer cones before finally settling on 1 mm thick polypropylene. With this they were able to achieve the

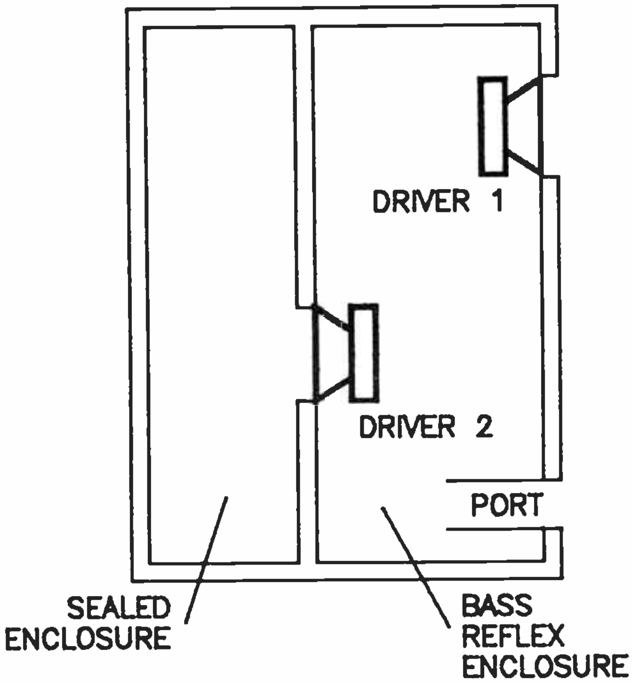
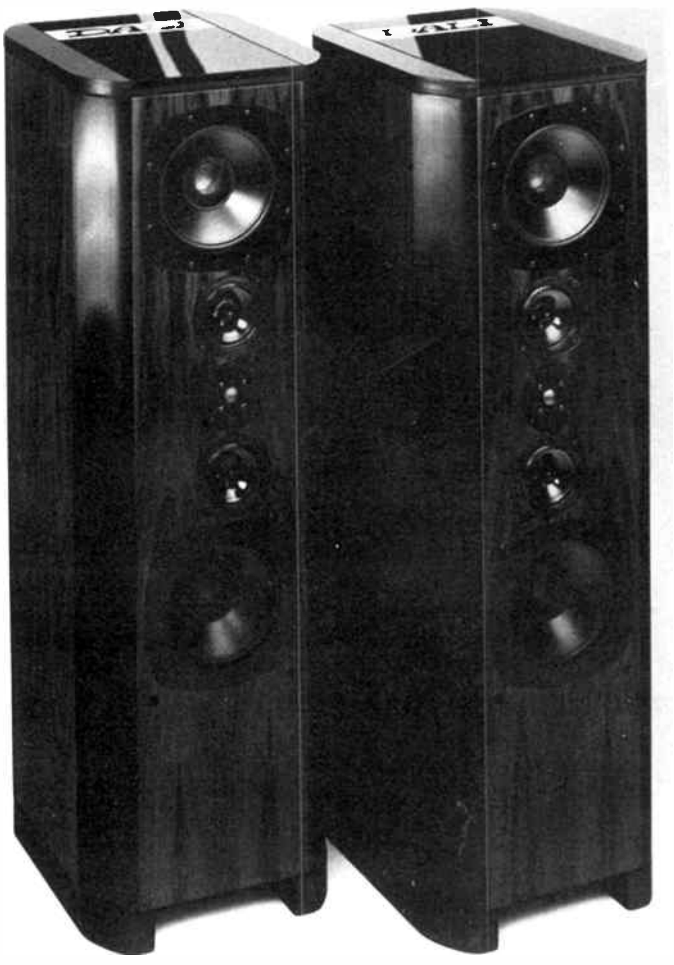


Figure 1. Dali's development of Fincham's band pass bass reflex system.



The Dali-40 – the unusual driver arrangement gives wide horizontal dispersion and restricted vertical radiation.

required plane piston action up to 800 Hz with a 200 mm (8") cone, with first breakup of the cone occurring at around 1 kHz.

To maintain the required response at the bottom end with such a relatively small diameter cone, Dali need a long-throw design. This necessitated a special voice coil and magnet assembly to maintain the driver's linearity. A very magnet assembly was devised for the special four-layer voice coil. To compensate for the relatively high self-inductance of this voice coil, an aluminium ring was incorporated in the magnet system surrounding the voice coil. This absorbs energy in eddy currents generated in the aluminium ring by the voice coil's field and proved a "perfect solution", says Dali.

Right. Having got the bass end under control, how to stop, reduce or eliminate bass driver vibration coupling to the cabinet and causing phase modulation of the tweeter? Dali's solution is ingenious for its simplicity – mount the drivers back to back and drive them in phase. The opposing cone motions tend to cancel (even if they are not equivalent), bringing about considerable reduction in phase modulation of the tweeter – and cabinet radiation – as a result of Newton's reactionary law.

The menagerie of Dr Doolittle (memorably played by Rex Harrison) contained a strange beast with a head at either end, facing in opposite directions. Inevitably, while one 'head' pulled in one direction, the other 'head' pulled in the opposite direction. He dubbed it the "push-me-pull-you". Now you see why I've dubbed the Dali 40 the push-me-pull-you loudspeaker!

The critical mid-range

The mid-range response is perhaps the most crucial element in a loudspeaker's performance. It is the region where our ears are most sensitive. Having achieved the required extension of the bass drivers' response, Dali turned their attention to the mid-range.

As the bass system had a response extending beyond 800 Hz, the first crossover point was set at 450 Hz, permitting a rather small mid-range driver to be used, having inherent advantages. However, this meant that part of the mid-range spectrum had to be handled by the bass system – after all, ▷

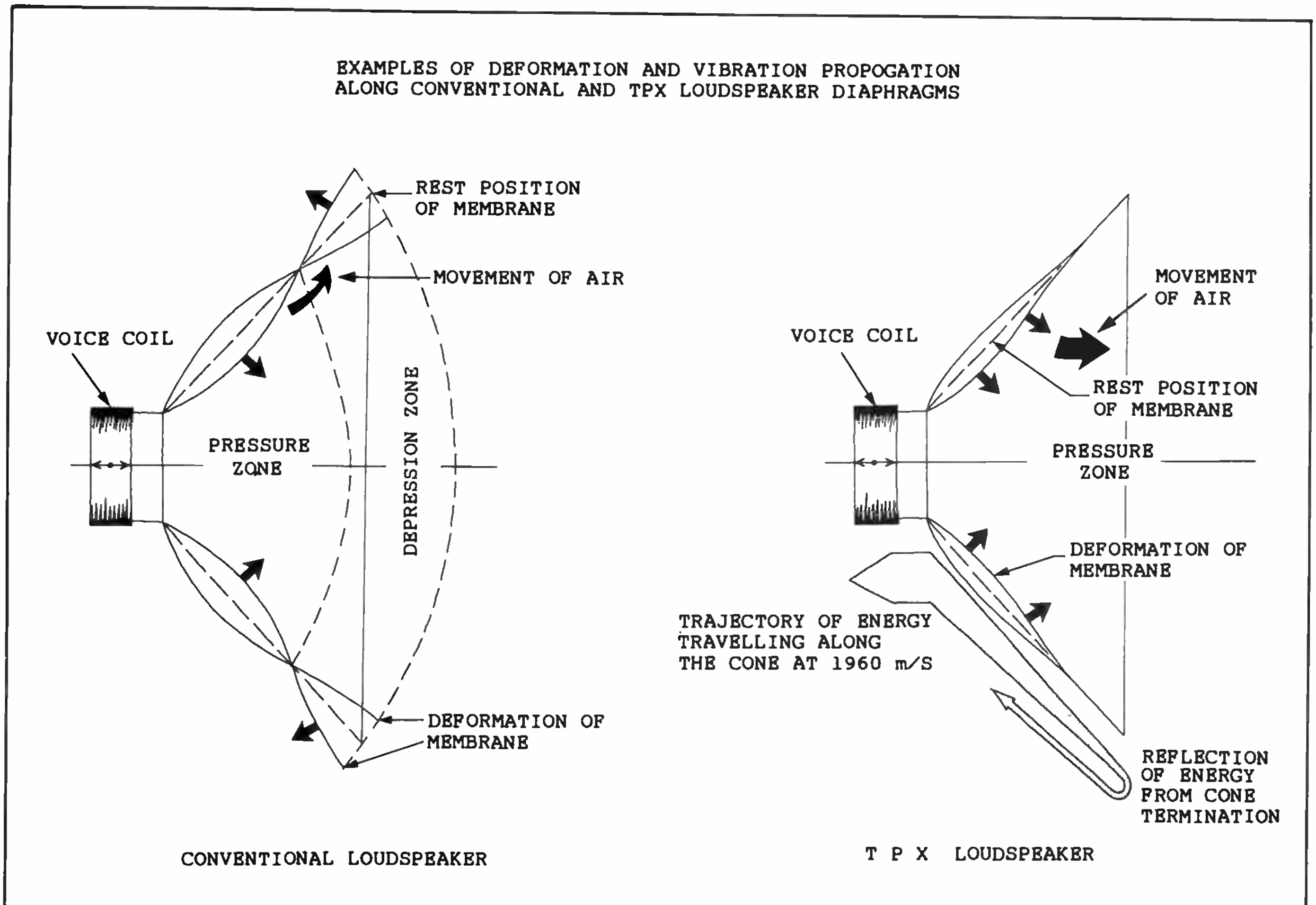


Figure 2. This illustration shows how a conventional speaker diaphragm (left) deforms in action, compared to a speaker cone made from 'TPX' material (right). A part of the energy reaches the suspension and is reflected back to the voice coil. This phenomenon results in standing waves in the diaphragm. The sum of the transmitted and reflected waves in the diaphragm results in "hangover" which is evident in the tone-burst tests in Figure 3.

middle C is around 261 Hz. Having the crossover placed about an octave below the bass drivers' roll off allows the crossover to entirely control the loudspeaker's output in the crossover region.

The cone material of a mid-range driver has a tremendous influence on its performance. Dali experimented with paper, polypropylene, titanium and a new material called "TPX". This has a density a little below polypropylene, but above that of paper. It also exhibits better stiffness and damping.

When the voice coil of a driver moves the cone, it excites sound waves that travel through the material. When a sound wave travels along the cone it can either be absorbed by the suspension at the rim or be 'reflected' there and travel back along the cone. Reflections can result in 'standing waves' on the cone which produce undesirable effects particularly noticeable on transients – the driver "rings". This phenomenon is readily seen on tone-burst tests as "overhang". Figures 2 and 3 illustrate.

It is here that the edge suspension plays its most important role. Dali chose a new material for their mid- range driver sus-

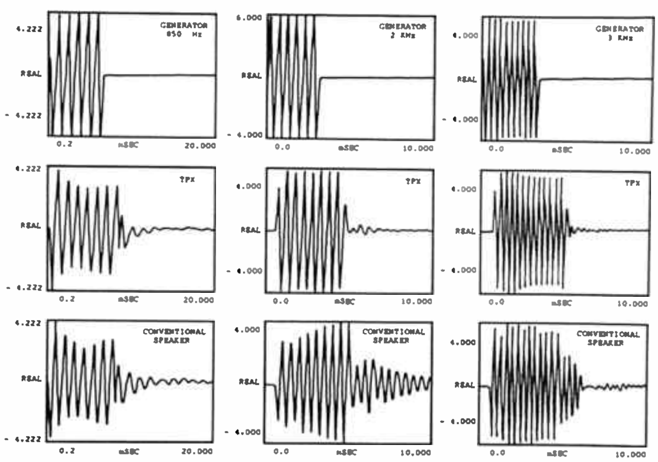


Figure 3. Comparison of tone-burst tests on two drivers, one with a TPX diaphragm (centre) and one with a conventional diaphragm (bottom). Note how the signal "hangs on" at 2 kHz with the conventional diaphragm.

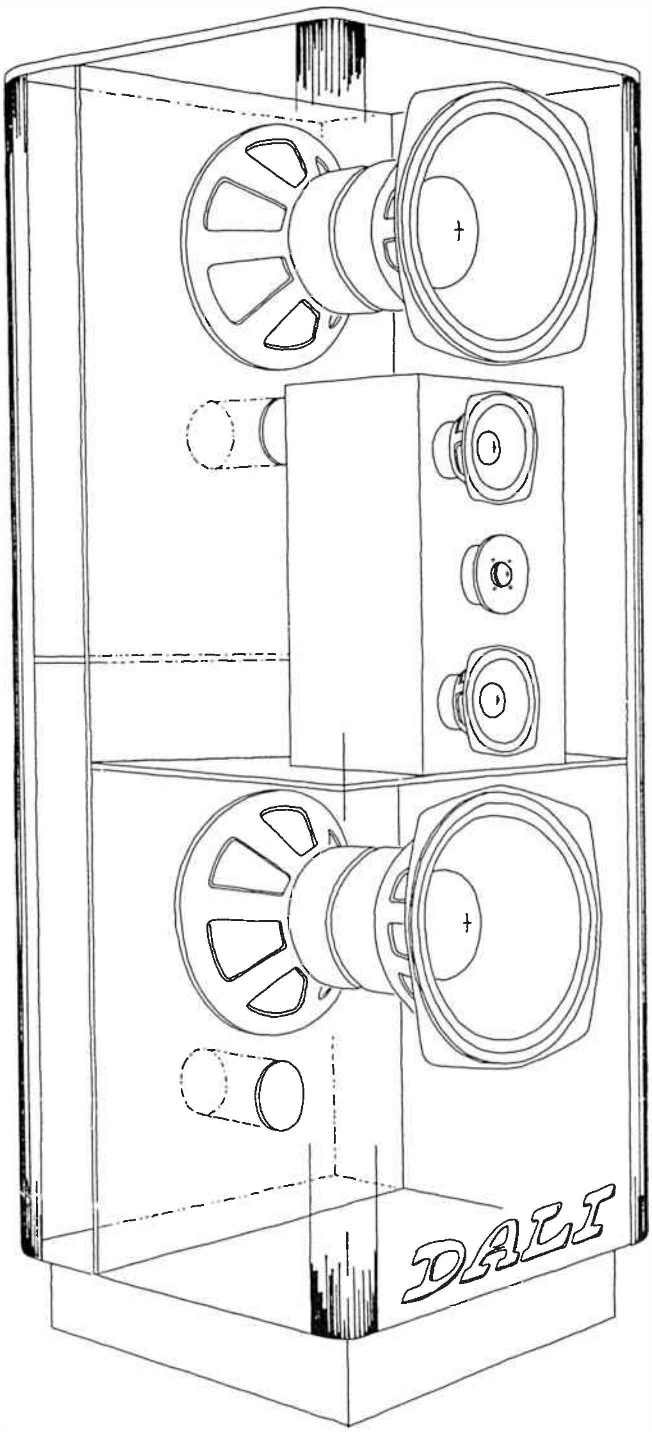


Figure 4. Construction of the Dali-40, showing the location of the drivers and the arrangement of the internal enclosures.

pension as well, called Norsorex. It is so energy-absorptive that a ball of Norsorex dropped onto a stone floor will land completely flat – no bounce! Goal 2 dispensed with.

Radiation and stereo imaging

Dali required a design which would have very wide and controlled radiation in the horizontal plane and limited, but defined, radiation in the vertical plane. The horizontal radiation depends on choosing drivers of the right size and employing a crossover with characteristics to match the driver's size and dispersion characteristics.

Controlling a loudspeaker's radiation in the vertical plane is a more complicated exercise. Traditionally, drivers are located in a more or less vertical plane, one above the other, with the tweeter at the top. This locates the tweeter (or should) at about the height of the listener's ears when sitting, so that the listener is within the main beam.

The tweeter and mid-range drivers need to be located physically close so that sounds with frequencies in the crossover region apparently come from a common source. As both drivers contribute to the sound field, they also need to be located physically close to avoid interaction at the wavelengths in this frequency range.

Dali chose to place the tweeter in the centre of the cabinet with mid-range/bass drivers above and below to achieve a well-defined sound coverage in the horizontal plane whilst limiting the vertical radiation pattern of the whole system; drivers mounted in a vertical line compress the radiation pattern in the vertical plane. This scheme minimises floor and ceiling interactions, according to Dali, making the loudspeaker as independent of the room as possible.

Peaks and dips in the off-axis frequency response of a loudspeaker restrict the listening area and subjectively degrade the sound quality when heard away from the centre field. American acoustic expert Floyd E. Toole has shown that speakers with smooth radiation characteristics are always preferred to speakers with an uneven off-axis response.

It is not only the choice of drivers that affects this, but the choice of crossover as well. Dali chose to match the characteristics of the drivers' radiation characteristics with the filter slopes to meet the above requirements, also carefully choosing capacitor types for best performance. they settled on metallised paper capacitors in the treble and polyester film capacitors in the mid-range filters.

The specifications for the Dali-40 indicate that they achieved a listening window (±2 dB) of 170° horizontally and 15° vertically.

Rounding off

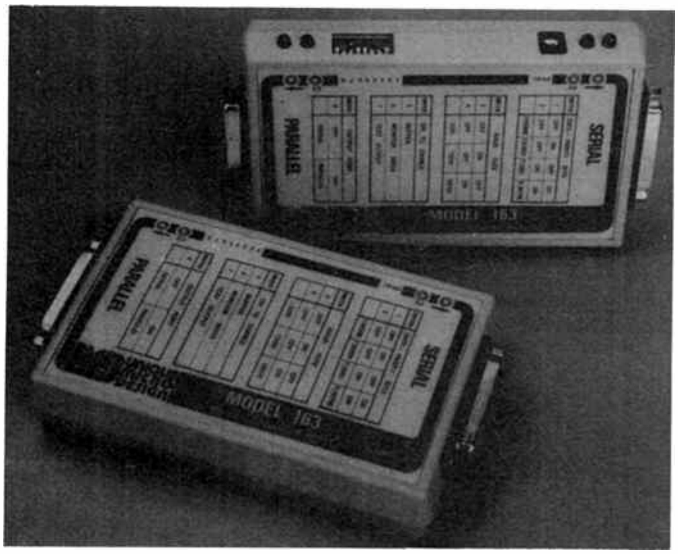
The enclosure of the Dali-40 is built as five separate chambers, illustrated in Figure 4. The bass system consists of two completely separate systems with two drivers in each, placed back to back. The internal drivers face to the rear and work in a band pass reflex configuration, where the front of their cones are loaded by a sealed enclosure. The forward-facing drivers operate in the bass reflex enclosures which have the port facing the rear of the cabinet, passing through the sealed enclosures.

The two mid-range drivers are positioned above and below the 25 mm dome tweeter (which is based on an Audax unit), the mid-range drivers' rears being confined by a separate internal enclosure.

The boundaries of the separate chambers support the cabinet, the modular construction making for a rigid assembly in which standing waves are well controlled, according to Dali. The cabinet corner pieces are quarter-round sections of anodised aluminium and a large glass plate sits atop the column on each cabinet. These elements are designed to add aesthetic appeal to the Dali-40's design.

The panels are finished in Rosewood veneer. Each cabinet stands 1240 mm high and measures 380 mm wide by 480 mm high. While they are rated at 300 W RMS, Dali recommend an amplifier rating of 50-500 W per channel. Overall frequency response is quoted as 25 Hz to 20 kHz, ±2 dB. Impedance is quoted as 4 ohms and sensitivity as 89 dB/1 W/1 m.

Printer buffer for serial or parallel systems



Unique Micro Design has released a – shall we say it – "unique" printer buffer and converter. The device provides a data buffer of 8 Kbytes and supports the commonly used XON/XOFF protocol. With both serial and parallel inputs and outputs, it can accept serial or parallel data and output on either serial or parallel ports.

Configurable externally by a set of switches on the side, the buffer supports printer test and monitor modes. In the test mode the buffer outputs known test lines to the printer, the monitor mode accepts data from the host computer and outputs the corresponding hexadecimal codes for each character received.

The wholly Australian designed unit is powered from a 9 Vdc plugpack and is quite quite cheap, according to the makers. More information is available from **Unique Micro Design, Unit 2/23 Wadhurst Drive, Boronia 3155 Vic.(03)887 1022.**

AT supply at half price

Electronic Solutions, of Lane Cove in Sydney, provide a wide range of IBM compatible products, ranging from complete computers to add-on cards. The company recently released an IBM/AT compatible power supply at around half the

price of competing units, they claim.

With equivalent power output to most other AT-type supplies around, the unit from Electronic Solutions features some superior features. Accepting two input voltage ranges, 85-130 Vac and 180-265 Vac at 47-63 Hz, means that the supply is highly tolerant of adverse mains supply conditions.

The power supply also sports in-built EMI filtering, over voltage and short circuit protection with a 68% typical efficiency, it is claimed. It is covered by a 14-day money back guarantee.

Contact **Electronic Solutions Pty Ltd, PO Box 426, Gladesville 2111 NSW. (02)427 4422.**

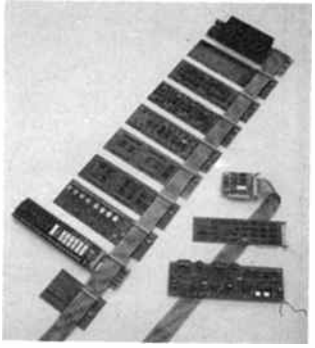
16-channel thermocouple board

Novatech Controls has released a new product, the MTHERM-16, a 16-channel input thermocouple board that plugs into an expansion slot of an IBM PC/XT/AT or VME Bus computer. One or more MTHERM-16s may be subsequently connected to the board, which performs all the necessary amplification.

Depending on the type of thermocouple used, accuracy ranges from ±0.2 °C to ± 1.0°C, according to Novatech.

A DIP-switch is used to select which type of thermocouple is used; J, K, T, E, S, R or B type thermocouples can be used for all channels. The board also compensates for the "thermocouple cold-junction error" and provides digital filtering on-board.

All inputs are updated at least once per second for all channels. Physically, the device accommodates a wide range of



attached thermocouples as the input screw terminals will accept wire up to 14 AWG.

Owing to its design, the MetraBus system can address up to 256 thermocouple channels, or 16 MTHERM-16 boards per computer expansion slot, making for a simple, yet powerful industrial data acquisition system.

Further information, and a new Data Acquisition Handbook, may be obtained from **Novatech Controls (Aust) Pty Ltd, Melbourne, (03)645 2377 or Sydney, (02)758 1122.**

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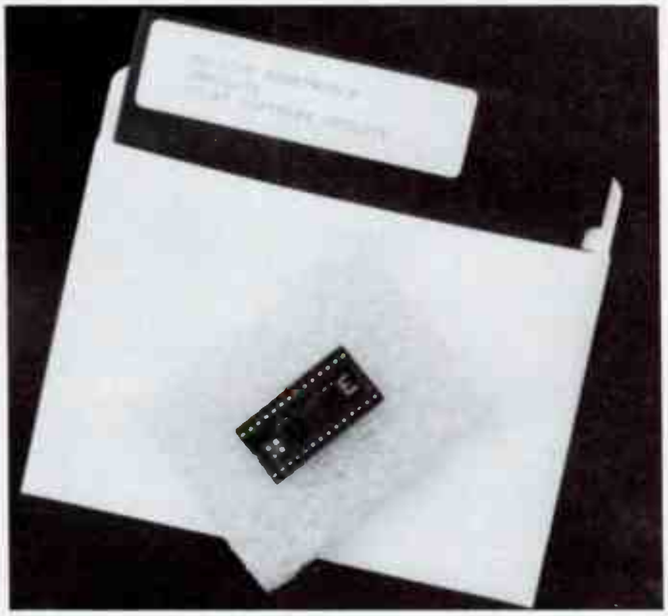

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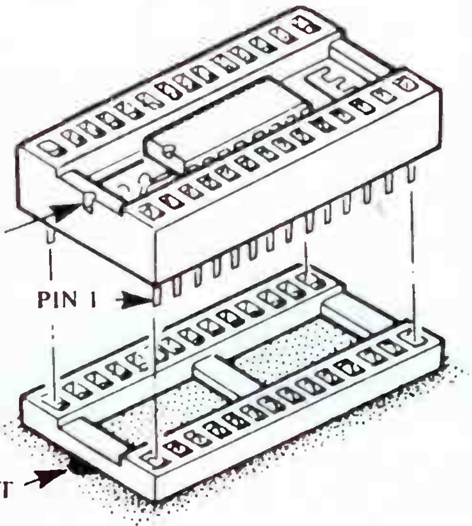

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The Amstrad PC1640

Amongst the flood of 'Turbo-XT' type clones has emerged an exceptional machine offering many features above and beyond the no-name, no-frills XTs being touted around at the moment.

AFTER AMSTRAD released their first personal computer in 1984, it seems they have gone from strength to strength, launching their attack on the IBM-PC market in 1986 with the PC1512. In October last year they released the PC1640, available in four configurations comprising a range of different monitors and disk drive options, making for a modular, well-priced system suited to a wide variety of applications.

Overview

The system we reviewed consisted of a PC1640 system unit, 20 Mbyte hard disk drive, floppy disk drive and an enhanced colour display. As is considered conventional with all Amstrad systems, they are supplied as a complete system, computer, monitor, keyboard and data storage, the 1640 being no exception to the rule.

Despite the already impressive product the basic computer is feature packed, with some exceptional equipment which on most other machines would be considered as options. Probably the most impressive of these 'extras' is an integrated, on- board display adaptor, th1tse kind you would normally be expected to add separately at extra cost.

The display adaptor is of a high standard, supporting a host of conventional video card emulations. These include EGA (640 x 350 and 640 x 200 pixels), CGA, MDA, EGA (monochrome), Monochrome Hercules (half mode), Monochrome Hercules (full mode), Plantronics (16-colour mode) and a special CGA mode allowing screen blanking. This means, of course, that you are well covered in supporting just about any PC/MS-DOS applications software that you could wish to run.

The Enhanced Colour Display is of superior quality, being well suited to the inbuilt EGA display mode. The manual included with the system is well written, although maybe a little disorganised. Also included is a host of software, supplied on four disks. Keeping in line with their "complete system" policy, MS-DOS 3.2 is included, along with the GEM suite of software, providing sophisticated painting software and a user-friendly 'shell'-type interface for inexperienced users.

Also supplied, onboard, is a parallel printer interface and serial communications port. On the back of the keyboard there is also an IBM standard joystick interface. As if that weren't enough the Amstrad PC1640 also comes packaged with a mouse (plastic, not furry) and inbuilt interface.

Operation

The PC1640, apart from the common operations supported by all MS-DOS machines, supports other operational features specific to itself, fully supporting its extra functions. Firstly, the display type and mode is hardware and software switchable. A set of DIP switches are provided on the rear of the system unit for hardware switching of the display. Software-wise a utility, appropriately named "DISPLAY", permits software selection of the display mode. This is done simply by executing a command such as: C:DISPLAY CGA, this would of course set the display mode to CGA emulation.

Another option supported by the DISPLAY command is implemented with the parameter "BOOT". This is useful, say, when using a copy protected game which needs to be booted from the floppy it is on, but requires a different video mode to be used. Instead of resetting the DIP switches each time you want to play the game, all that needs to be done is include the word "BOOT" on the same command line to change video modes, (ie. C:DISPLAY CGA BOOT). What happens is, the video mode is changed, and the system reboots using the floppy drive.

The floppy drive which was supplied with the Amstrad was quite noisy. In a hard disk system this is not a serious consideration for most users. However, I was told by Amstrad that there is a program around that will remedy this by altering the stepping rate of the drives.

I also had an opportunity to evaluate the service back-up which distributors Mitsubishi-AWA provides for the PC1640, something you don't often get to try out in a real situation. What had happened was that I had run a program which caused the hard disk and controller not to update the information on the disk, although it appeared to work. After I tried to remedy the situation myself, but failed, I rang the company's service department that afternoon and explained the problem. The next morning a service technician was at our office with a spare machine, who then methodically replaced different components of the system until he got it to work. The computer was effectively out of action for less than half a day. NOT BAD!

Another feature which is rare to find on any MS-DOS type machine is a volume control for the internal speaker. This was included in the Amstrad machine, by means of a potentiometer, accessed on the side plate of the main unit.

Getting into the machine was also not a problem. Without even moving the monitor off the top of the unit, the three expansion slots are easily accessed by removing two small plates from both the side and top of the case. Also, the top of the system unit box has an indent to seat the monitor in, making for a good-looking, functional set-up.

The PC1640 was given an extended workout using a wide variety of software, including AutoCAD, and a number of wordprocessing and communications packages. On AutoCAD the PC1640 showed up distinctly faster than our IBM PC/XT, particularly in the critical area of screen rewrites, where you spend a lot of time waiting for things to happen. The monitor showed up well, being visibly better than the Taxan III used on the IBM PC/XT in the office. Ergonomically it's better too, as it is swivel-and-tilt adjustable.

The keyboard was a little "light" I thought, compared to the IBM keyboard, but is otherwise unremarkable. One thing I noted though, the keyboard connector is non-standard and you'd have to make up an adaptor cable to be able to plug-in an off-the-shelf keyboard. The interface connectors are, thankfully, quite standard. Plugging-in modems, printers and other peripherals presented no problems.

Internally, the unit is well-constructed, though not like the "brick outhouse" you see inside a genuine IBM. As the PC1640 is meant to live on a desktop, built-like-a-tank construction is both unnecessary and expensive.

Conclusion

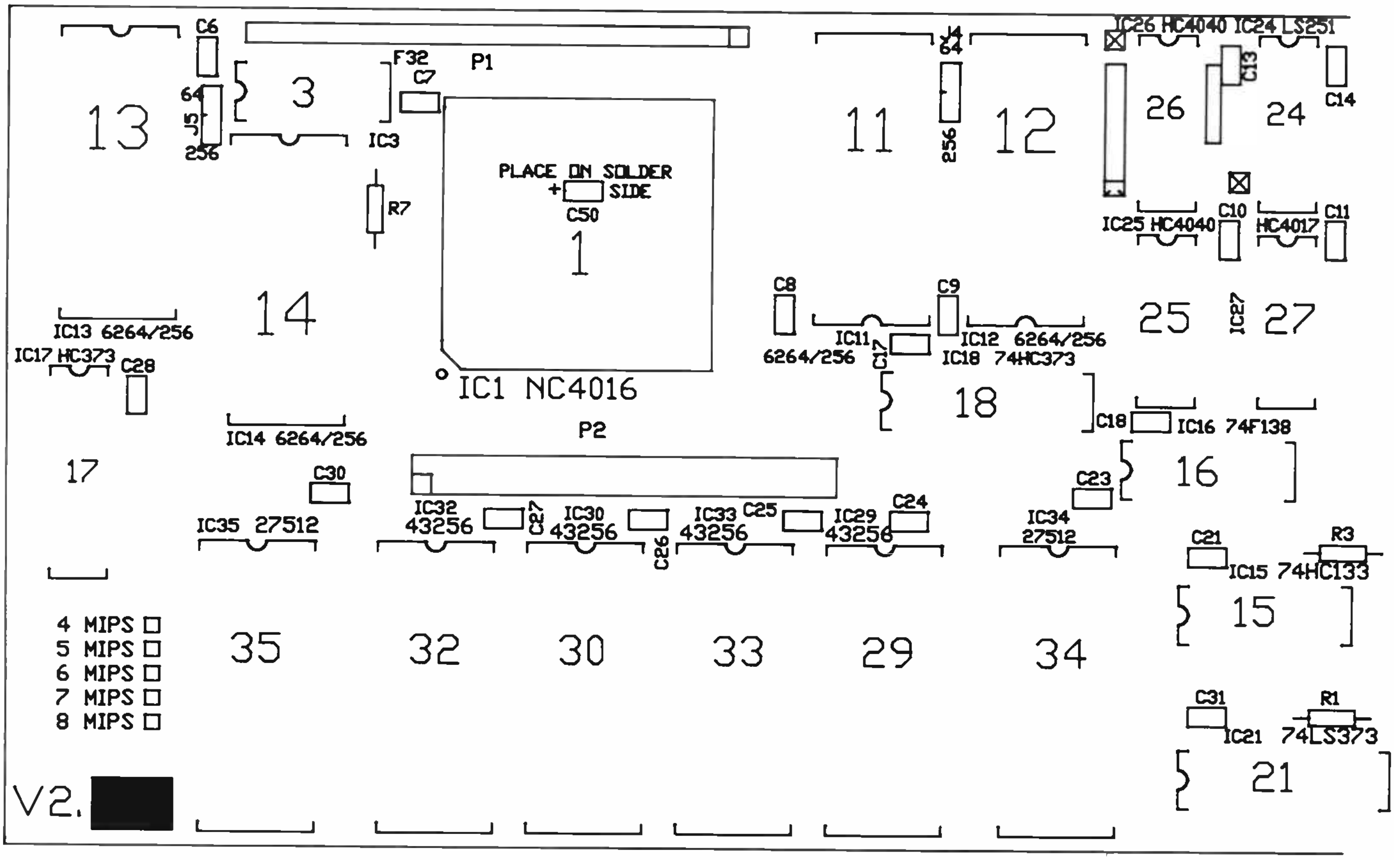
Overall the Amstrad PC1640 is a well presented computer systems, offering many facilities supplied as standard that you would expect to be added only as options. Some users may find only three expansion slots to be a bit limiting, although for most applications this is fine, because a video adaptor, serial and parallel ports and a disk controller are already included, not needing to impinge on any available slots.

The PC1640, with an enhanced colour monitor, 20 Mb hard disk and one floppy drive is priced at $2885. This seems a bit expensive considering the price of those "nameless" brand turbo XTs around at the moment. However, at that price you get an excellent enhanced colour monitor, a mouse and a suite of good, useful software plus the service back-up and support that the distributors provide – something most people don't consider when buying a system.

If you're in the market for a compatible computer in the XT class and you want painless plug-in-and-go operation, the PC1640 is worth close consideration.

Jamye Harrison

The review unit was kindly supplied by Mitsubishi-AWA. However, from 1st June 1988, Amstrad Australia will take over marketing and distribution of the Amstrad computer range. They are located at 19A Boundary St, Rushcutters Bay 2011 NSW. (02)360 3144.



The "Supermicro" computer project

Roy Hill

Now you get to hook-up the project to the 'outside world' and put it through its paces. Once you've successfully completed this stage, you're ready to fly!

IT IS SUGGESTED that ALL first time users try the board in *external* mode, even if you will be installing it in an IBM. The following instructions apply to any constructor connecting the SuperComputer to another computer using an RS232 port; this includes *ALL* IBM first time users.

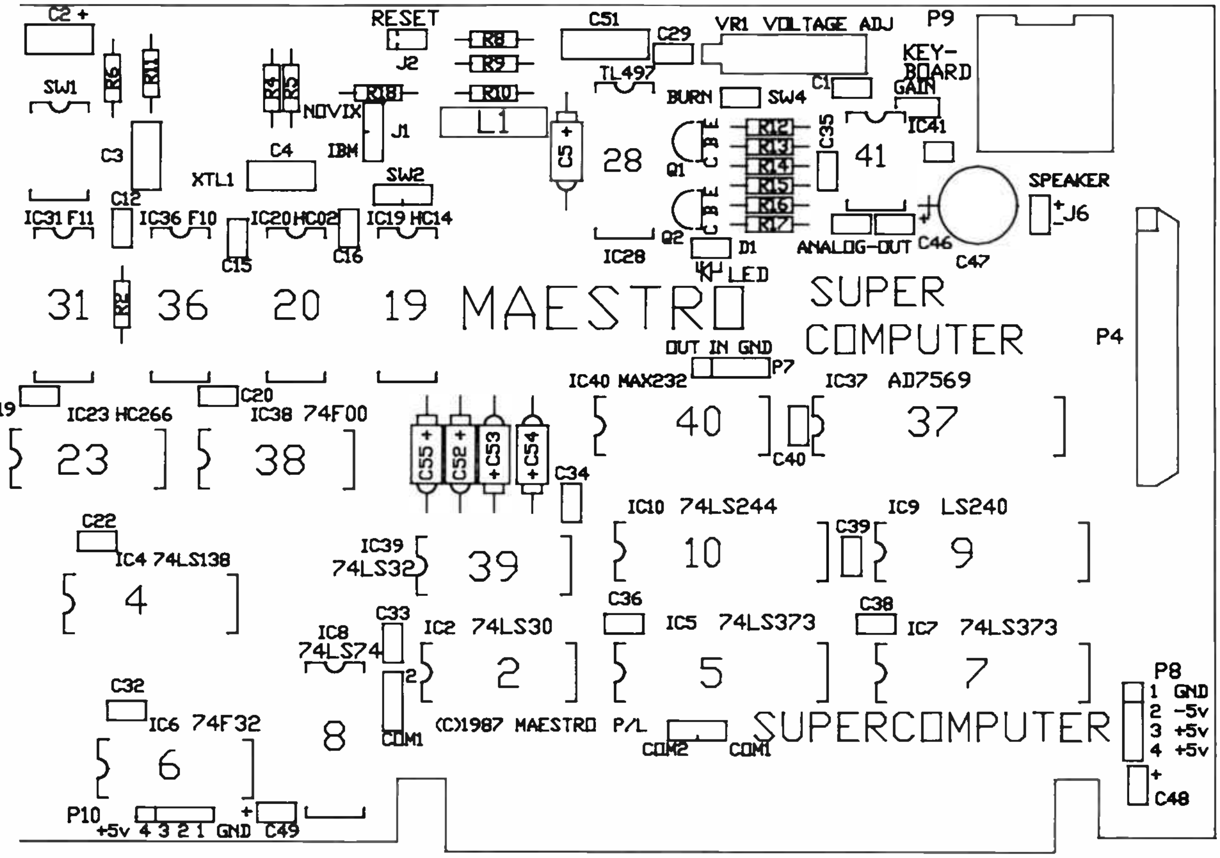
The first step is to connect the serial link to the host. P7 is the external serial link (a SIP plug is supplied). Pin 1 (on the LHS) is *Tx Data* from the SuperComputer (that is, *out* of the SuperComputer) and goes to the *Rx Data* of the host computer or terminal. Pin 2 is *Rx Data* into the project. Pin 3 is *GND* and Pin 4 is not connected.

Power is supplied by a 5 V regulated power supply that should be able to deliver 400-500 mA. Actual power drawn by the board is 200 mA. The extra *oomph* is to drive external devices and ports. If you already have a plugpack supply capable of delivering +5 V at 200 mA, then by all means use it. If you need to build or buy a supply however, you would be better to aim for future enhancements (Maestro plan to use a dual supply, 12-bit A/D converter, for example) and have + and –5 V and +12 V available.

P8 is the power supply input, vertically mounted at the bottom RHS. Pin 1 (closest to the top) is *GND*. Pin 2 is *Vdd* (–5 V) – not used by the board at present, but reserved for future daughter boards. You might put it in now to save additional expense later. Pins 3 and 4 are connected as is, +5 V in.

Setting the DIP switch

There is an on-board four-position DIP switch which controls the mark/space ratio of the clock. This will need to be set if you use any other than 100 or 120 ns RAM. Ensure that Pin 2 is **on** and pins 1, 3 and 4 are **off** for this combination. All possible combinations of mark/space settings are shown in Table 1 here.



The shorting lugs

1) **SW2** – This shorting lug controls clock select. Position the jumper on the two pins on the far RHS. This jumper is used select the Mark/Space inversion. In the default position, it provides for a fast Novix chip and (relatively) slow RAM (that is, a shorter Mark than Space time). In the alternative position, a slow (relatively) Novix and faster RAM are catered for (that is, a longer Mark than Space time).

2) **J1** – This shorting lug selects either internal or external reset. It is immediately above and to the left of SW2 and should be set in the lower position. It is internal reset (that is, internal to the SuperComputer).

As a point of convenience, J2 above and to the right of J1 provides a connection point for a normally open momentary contact switch. Connect both points of the switch to each of the pins on this jumper. THIS PROCEDURE IS HIGHLY RECOMMENDED, as it makes it possible to quickly reset the system after a crash. This prevents the processor from being held in an indeterminate state, with unknown addresses being selected. The processor should not be held in reset for more than ten seconds and it is for this reason that a momentary contact switch is required, rather than an SPST switch.

SW1	SW2	SW3	SW4	MARK:SPACE
off	on	x	x	1:1
off	off	on	x	1:2
off	off	off	on	1:3
on	off	off	off	1:4
off	off	off	off	1:9

TABLE 1. **Mark:Space switch settings**
(x – "don't care")

When J1 is selected in the other position (upper two lugs shorted), external reset is selected. This setting is used when the card is installed inside the IBM and is driven by a reset signal from the IBM (i.e. by Power Good or by CTRL/ALT/DEL). When used in this position, the external switch has no effect.

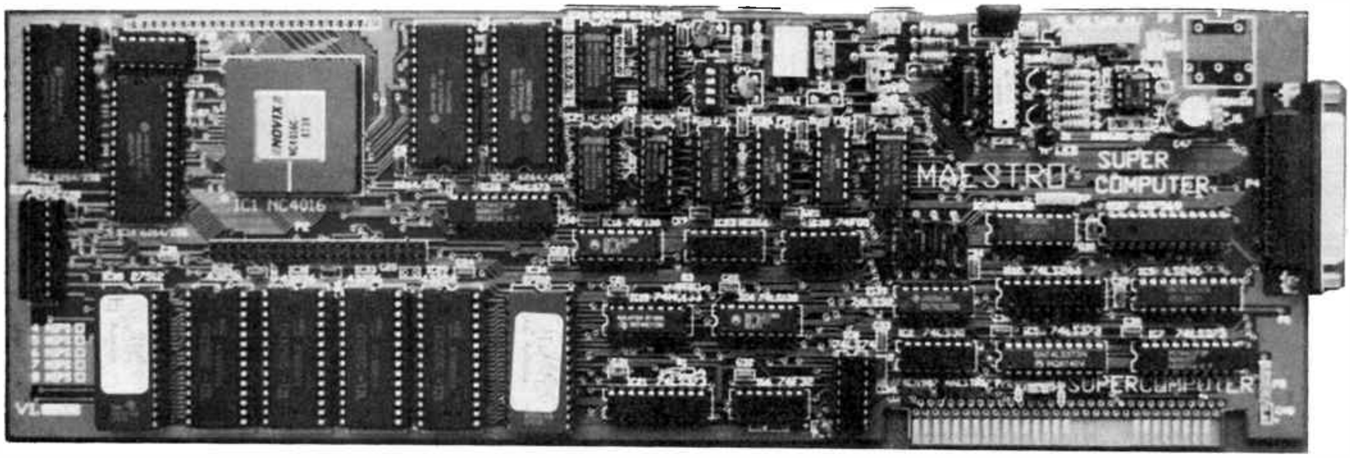
3) **SW3** is the COM PORT1/2 selector and is for internal IBM use (SW3 is located just above and to the left of the IBM edge connector contacts). With the shorting link in the upper position, COM2 is selected and in the lower, COM1 is selected. It is suggested that the card be selected for COM2.

Please note that during the testing process, the SuperComputer will tie up both COM1 and COM2 of your IBM. Please ensure that all boards *and device drivers* (e.g: mouse drivers) that address these ports are either removed from the system or disabled. On completion of testing, you may then select which of the two COMS ports you wish to dedicate to the SuperComputer.

4) **SW4** just above the IBM edge connector is used to select either COM1 or COM2 interrupt port address and should be selected in conjunction with SW3. Ensure that the setting chosen matches that for SW3. Both should either be COM1 or COM2.

After ensuring that all of the above jumpers and switches are correctly set, you are ready to try out the board. We will do this in a step-wise fashion. PLEASE DON'T RUSH AHEAD AND OMIT STEPS. The sight of someone who has just blown up a $300 Novix chip because they didn't follow instructions is indeed woeful.

The instructions here apply to all users of the board. Where there are differences that apply *ONLY TO IBM* users, they will be clearly identified. ▷



STEP 1

Ensure that the power to both the SuperComputer and the host are off. Connect the serial link from the SuperComputer to the host, as described above. *CHECK YOUR CONNECTIONS.*

STEP 2

Power up the host computer and boot your favorite comms package (e.g: Procomm, Telix, Red Ryder, ASCII Express etc). Connect the Maestro SuperComputer board to the appropriate connection point on the host computer (e.g: Slot 2, COM1, RS232 OUT, SERIAL 1 etc.), using the three wire serial cable.

STEP 3

Select the fastest baud rate available and select the following protocol:

no parity, 1 stop bit, 8 data bits

select Full Duplex (no local echo) – if you see everything you type doubled, then your duplex setting is incorrect.

STEP 4

Select upper case (that is, capital letters). For those that are new to Forth, the language is case sensitive. This means that the Forth words DUP, Dup, dup and dUp are all different.

STEP 5

Switch on power to the project and observe the LED. It should blink twice at a relatively slow rate. This indicates that the Novix is booting satisfactorily from the ROM. The LED should then blink more rapidly to indicate that Forth is now being executed from RAM. The LED will then cease blinking and will follow the Tx data from the host. This means that whenever a key is pressed on the host, the LED will blink to indicate that the keycode has been acknowledged by the SuperComputer.

If it all works as described, you may proceed to Step 6. If not, *IMMEDIATELY SWITCH OFF THE POWER* and see the troubleshooting instructions in a later issue. Note that there are two Power Supply connection points for the board. PLEASE NOTE THAT **BOTH** POWER CONNECTION POINTS MUST BE PROVIDED FOR. There are two separate power rails on the board which are isolated from each other. This is done to reduce noise problems for the A/D converter. When installed inside the IBM, both of these power rails are catered for by the IBM card connector.

STEP 6

Wait two seconds and then press the letter "B." Notice that it is a capital letter. The computer should respond with "hi." If this is the case, then everything is working as it should. If the "hi" message is not returned, once again, *SWITCH EVERYTHING OFF* and run through the troubleshooting instructions.

STEP 7

If you have come this far, then SUCCESS!! Everything is working exactly as it should. You can now test some simple Forth words. I have provided several examples here for you to test (responses from the Maestro are shown in **bold** – CR means to type the letters as shown CR means to hit the ENTER key or RETURN key):

1 CR
ok
. CR
ok

3 2 1 + * . CR CR
9
ok

Notice that the **ok** is printed on a separate line in the second example, due to the **CR** forcing a carriage return/line feed after the calculation is completed. A final example using loops will help to show how Forth works:

: TEST CR 10 FOR I . CR NEXT ; CR

will produce a row of numbers, from 10 to 0, when the word TEST CR is typed from the keyboard.

For those of you who are not using an IBM, Maestro supply a source listing of a simple host interface in Forth-83 which is written for the IBM but can easily be modified for any other computer. Public Domain Forths are available for most computer systems.

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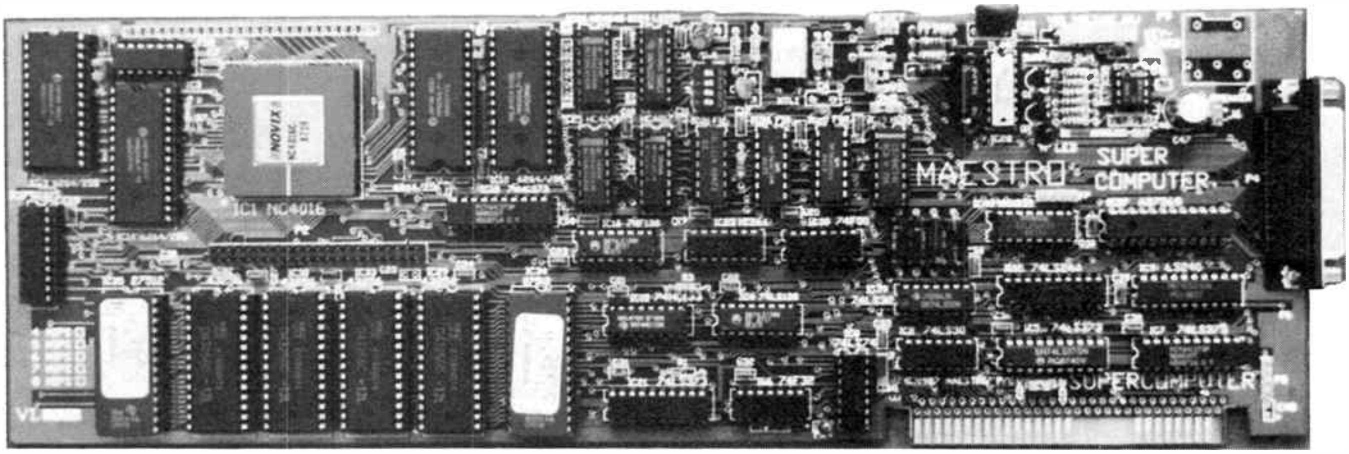

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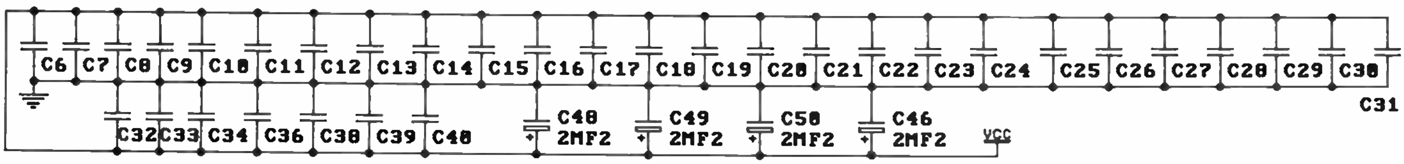

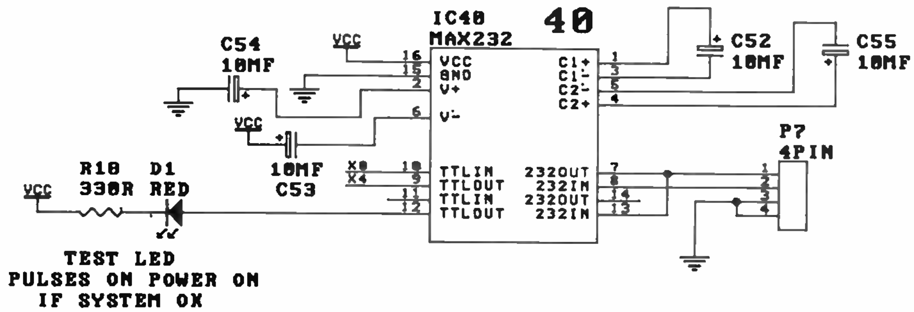

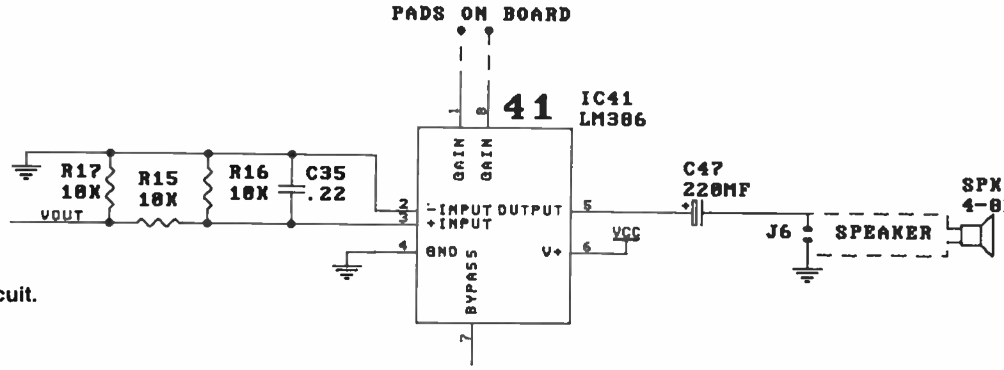

Here are the last bits of the circuit.

Inside the IBM

Switch off the power to the computer and the project and make sure that correct comms selections have been made. Disconnect the external power supply, reconfigure the reset pin and remove the external reset switch (if desired – it becomes inoperative, anyway).

You could use the external RS232 interface, following the same procedure as above. This means that the only difference from the above steps is that the IBM is now the power source, not the external source.

ENSURE THAT NO OTHER BOARD (OR MOUSE) INSIDE THE IBM CONFLICTS WITH THE COMM PORT SELECTED (also change the mouse driver)

TO SWITCH BETWEEN THE INTERNAL/EXTERNAL MODES

Type in the command SERIAL and switch the comms package to COM2 (remember that you set it up for COM2 back in Instruction 3 under "Shorting Lugs"). We are now communicating directly with the Maestro board via a simulated serial link, which is in reality a parallel link. So, baud rate limitations no longer exist – the baud rate set by the comms package has no effect. The Forth word SERIAL toggles between the simulated serial link in the internal mode and the actual, physically connected external serial cable, which is driven through the comms package.

Fire up the supplied Forth program by exiting from the comms package and returning to the DOS prompt. Place the Maestro disk in one of your floppy drives and copy all the files to your hard disk (if you have one). It is strongly suggested that you create a separate directory (maybe even a separate partition) for use by the SuperComputer.

As a warning to those whose own slow computers (e.g: Apple II series), slow computers may lose CRs with the SuperComputer when used in an external mode. This may be overcome by ensuring that all I/O to the slow computer is suitably buffered, either by hardware or software.

Now you're ready to go Forth – and fast!

Elektor Electronics in AEM

The projects and circuits chosen for inclusion in the Elektor section are selected on the basis of interest, local relevance and component availability. Intending constructors should consult our 'PROJECT BUYERS GUIDE' in this issue for a guide to component sources and possible kit suppliers.

CONTENTS

PROJECTS

ARTICLES

A 256-COLOUR ADAPTER FOR THE EGA

by Peter Balch

The IBM-PC enhanced graphics adapter (EGA) can display a maximum of 16 colours at a time. For many applications, such as the creation of realistically shaded three-dimensional images, this is simply not enough.

The 256-colour board described in this article is offered as a design idea to advanced users of the IBM-PC XT equipped with an EGA. The extension board plugs into the EGA feature connector. It produces *analogue* RGB signals, and *TTL-level* Hsync and Vsync. Many popular colour monitors accept either TTL signals from the EGA, or RGB signals from the 256-colour board, and can, therefore, be used both for the normal EGA modes and the new 256-colour modes.
By default, the colour extension board is inactive, and the EGA works as normal: installing the board does not, therefore, affect the execution of existing programs.

EGA modes

A complete description of all the display modes offered by the EGA is, unfortunately, beyond the scope of this article. In mode 14, the card produces 640 by 200 pixels, each of which can be assigned 1 of 16 colours. In mode 16, it produces 640 by 350 16-colour pixels. The 256-colour board combines pairs of these to give 320×200 or 320×350 pixels, each of which can be assigned 1 of 256 colours. This is similar to the performance of the VGA card used in the new PS/2 range of IBM PCs. In 256-colour mode, a VGA can display only 320×200 pixels.
In modes 14 and 16, the EGA outputs each pixel as four TTL signals called R, G, B and I. The 256-colour board combines pairs of pixels to give single 8-bit pixels. These eight TTL signals are converted to red, green and blue analogue signals by three D-A (digital to analogue) converters.

Feature connector

The EGA card contains a 32-pin socket called the *Feature connector*. This allows access to several signals on the EGA card. The proposed colour extension uses 11 of these signals—see the pin assignment in Fig. 1.

- **GND** and **+5 V** provide power to the 256-colour board.
- **R, G, B** and **I** are the EGA pixel colour signals. R, G and B are the primary red, green and blue signals, while I is used for either the secondary green, or the intensity signal.
- **14 MHz** is a clock running at one cycle per EGA pixel. The EGA pixel colour signals change on the falling edge of each clock cycle.
- **ATRS/$\overline{\text{L}}$** is the attribute shift load signal. This is a short, active low, pulse that indicates the loading of each byte into the EGA's pixel shift registers.
- **HIN** and **VIN** are the active high horizontal and vertical synchronization signals (note: signals going into the 256-colour board are labelled 'IN')
- **$\overline{\text{INTERNAL}}$** enables and disables the 256-colour board. The signal is high when the EGA has disabled its internal video drivers.

1

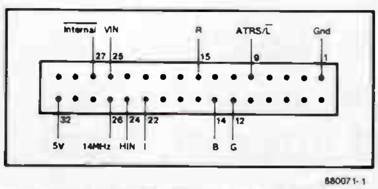

Fig. 1. The Feature connector on the IBM Enhanced Graphics Adapter (EGA).

Circuit description

The circuit diagram of the 256-colour board is shown in Fig. 2. The RGBI bits of the odd-numbered pixels of the EGA are latched into IC_1. When the RGBI bits of the even pixels arrive, they are latched into IC_2 along with the odd-numbered pixel bits now stored in IC_1. This means that 8 bits of pixel information appear at the outputs of IC_2 for every two cycles of the 14 MHz clock. Clocking of IC_1 and IC_2 takes place on the rising and falling edges of a 7 MHz signal, obtained by IC_4 dividing the 14 MHz signal by 2.

It is important that IC_1 stores the odd-numbered pixels, and IC_2 the even-numbered ones, not vice versa. IC_4 is cleared by the low level on ATRS/$\overline{\text{L}}$ every 8 pixels to maintain the correct phase relationship.

Timing

The timing of the clock signals applied to IC_1 and IC_2 is critical. The clock pulses must arrive when the RGBI signals are stable. Delaying and inverting the 14 MHz signal in a 7404 gate ensures the right timing and polarity. Similarly, the CLEAR signal for IC_4 is obtained by delaying the ATRS/$\overline{\text{L}}$ signal in two 7404 gates. Do not use a 74LS04 in this application: its propagation delay is too short. The way in which the correct delays are obtained may be frowned upon for good reasons, but it is the only reasonable way of getting the timing right, given the signals available on the EGA's feature connector. The timing diagram of the circuit is given in Fig. 3.

D-A converters

An 8-bit pixel appears at the outputs of IC_2 every 143 ns. These digital signals must be converted to analogue RGB levels that drive the monitor. The most advanced way of obtaining analogue RGB signals would be to use a chip that combines the functions of colour palette and multiple D-A converter. There are several such chips available, for instance the Type TMS34070 from Texas Instruments (reference [1]), or the Type IMSG170 from Inmos, which can display any 256 out of 262,144 colours at a clock rate of up to to 50 MHz. A palette chip would require an interface to the PC bus, address decoding circuitry, and

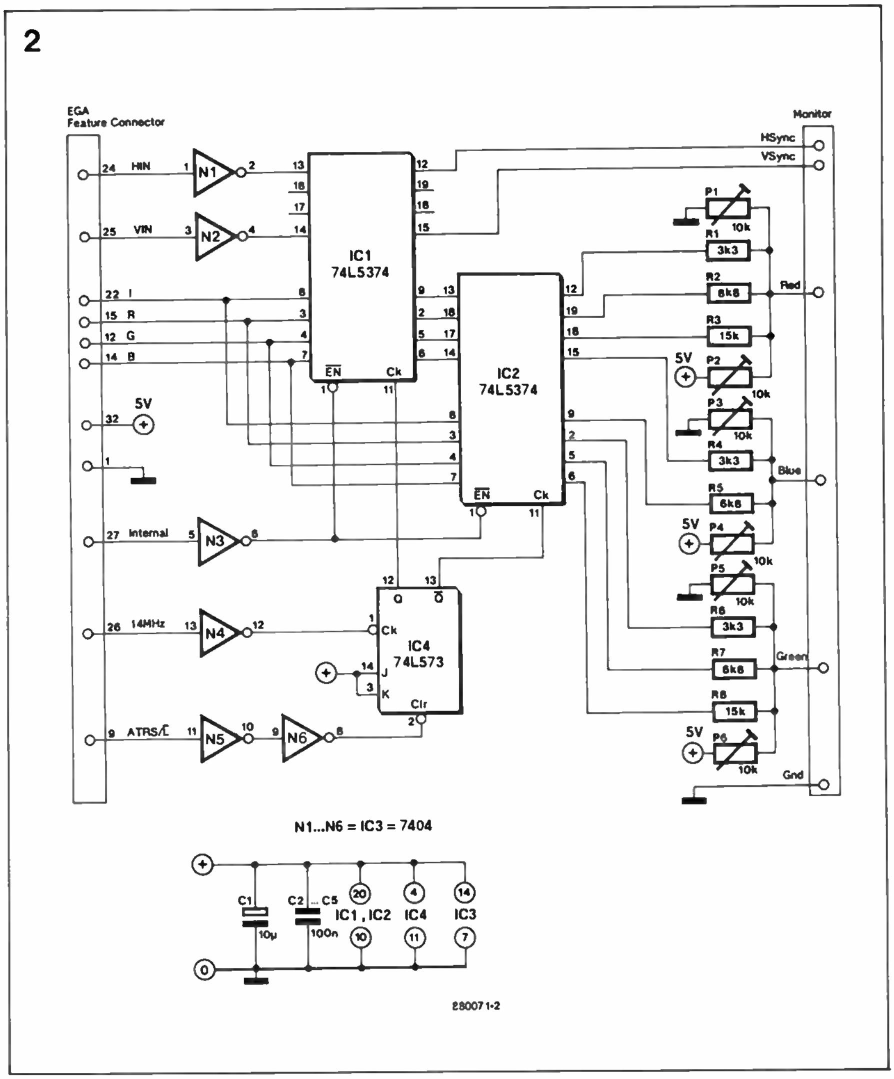

Fig. 2. Circuit diagram of the low-cost 256-colour extension for the EGA.

so on. The actual design of a palette interface is quite straightforward, requiring the data sheets of the palette chip, the technical reference manual of the IBM prototype card, and that for the PC-XT (part numbers are 1525015 and 6938833, respectively).

In fact, for realistic images, a variable palette is often less useful than a fixed one, because it is always difficult to decide what colours to put into it. This made the author decide to do without a palette and use three D-A converters instead.

Of the eight pixel bits, three determine the red intensity, another three the green, and the remaining two the blue (the human eye is less sensitive to blue light). With so few bits for each analogue signal, it is easy to build a D-A converter from resistors. In Fig. 2, $R_1 \ldots R_8$ incl. and $P_1 \ldots P_6$ incl. form the three D-A converters, which are dimensioned for driving a Taxan Type KS12R RGB monitor (V_{in} = 1.5 V_{pp} in 600 Ω). Different resistor values may be required for other types of monitor, and it is, therefore, recommended to plug the resistors in a 16-way IC socket with turned pins to facilitate establishing the right values. Presets P_1, P_3 and P_5 control the overall gains of the D-A converters, while P_2, P_4 and P_6 define the brightness of each colour when the pixels are set to zero.

Sync signals

A colour monitor typically requires horizontal and vertical synchronization signals. The horizontal sync tells the monitor when to end each horizontal scan line, and when to start the next. Similarly, the vertical sync signal indicates the end of the vertical scan of the screen, and the start of the next. Some monitors require the horizontal and vertical sync to be combined to give *composite sync*.

The horizontal sync signal produced by the EGA is an active high TTL pulse. The polarity of the vertical sync signal is not fixed, however, and depends on the monitor and video mode used. In the 16-colour 640×200 mode, the vertical sync is an active high TTL pulse, while in the 640×350 mode it is active low.

The Taxan Type KS12R monitor can work in three modes. In mode 1 (IBM-PC mode), it displays 16 colours using active high TTL horizontal and vertical sync signals. It can also be switched to mode 2 (Apple-II mode), which displays analogue signals and uses active low TTL horizontal and vertical syncs. There is a separate connector on the monitor for each of these modes. The two sets of sync signals may not be applied simultaneously.

The HIN and VIN signals from the EGA are inverted by N_1-N_2, and buffered by IC_1. When IC_1 is disabled, the Hsync and Vsync outputs are switched to high impedance, and no longer drive the monitor. When IC_1 is enabled, the EGA sets its own horizontal and vertical retrace output signals to high impedance. The control of IC_1 is reverted to below.

Be sure to check the specification of the monitor used in respect of the polarity of the sync signals. If it needs positive going syncs in both modes, the inverters on the HIN and VIN lines must be removed. Alternatively, set the sync signal ▷

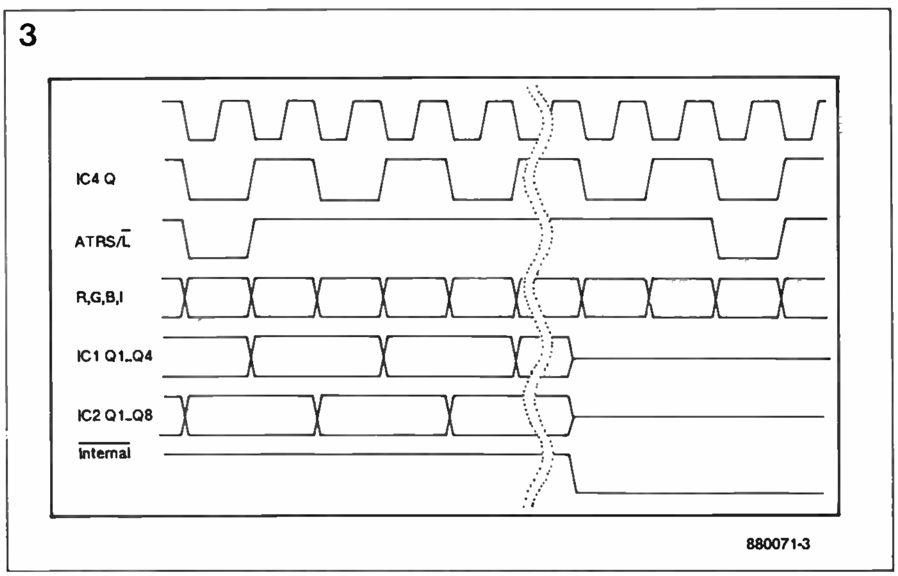

Fig. 3. Timing of the main signals on the colour extension board.

polarities under software control by writing to the Miscellaneous Output Register of the EGA.

Enabling the board

The 256-colour board can be switched on and off under software control. Bit 4 of the EGA's Miscellaneous Output Register controls the video and sync drivers of the EGA. A logic 1 disables the output drivers on the EGA, and causes INTERNAL on the Feature connector to go logic high. On the 256-colour board, this high level is inverted by N_3 and used for enabling the sync and pixel outputs on latches IC_1 and IC_2. By default, INTERNAL is logic low, so that the 256-colour board is inactive at power-on, and the EGA works as normal.

Table 1

```
procedure graph_mode;
   var Regs: record
      case boolean of
         true:  (ax,bx,cx,dx,bp,si,di,ds,es,flags: integer);
         false: (al,ah,bl,bh,cl,ch,dl,dh: byte);
      end;
begin
   with regs do
   begin
      ax:=14;
      intr($10,regs);
   end;
   port[$3C2]:=$23+$10;
end;
```

Construction and setting up

The construction of the colour extension card will present no difficulties to anyone who has completed any previous hardware project. The physical layout of the board is not critical.

The prototype was constructed on Veroboard, and plugs into the Feature connector of the EGA as a daughter-board. Figure 4 shows a suggested arrangement. The board is suppported by an indirect connector which plugs into the Feature connector, and by a bracket bolted to the EGA 9-pin D-type video connector.

The outputs from the 256-colour board should be taken to a separate connector. It is suggested to use a 15-pin D-type so as not to confuse it with any of the other sockets on the rear panel of the computer. Remove the cover for the slot next to the EGA to give access to the 256-colour board.

The even-numbered presets are adjusted so that each colour is just off when the pixels are all zero. Then adjust the odd-numbered presets so that the screen is a bright white when the pixels are all set to 255 (FF_H).

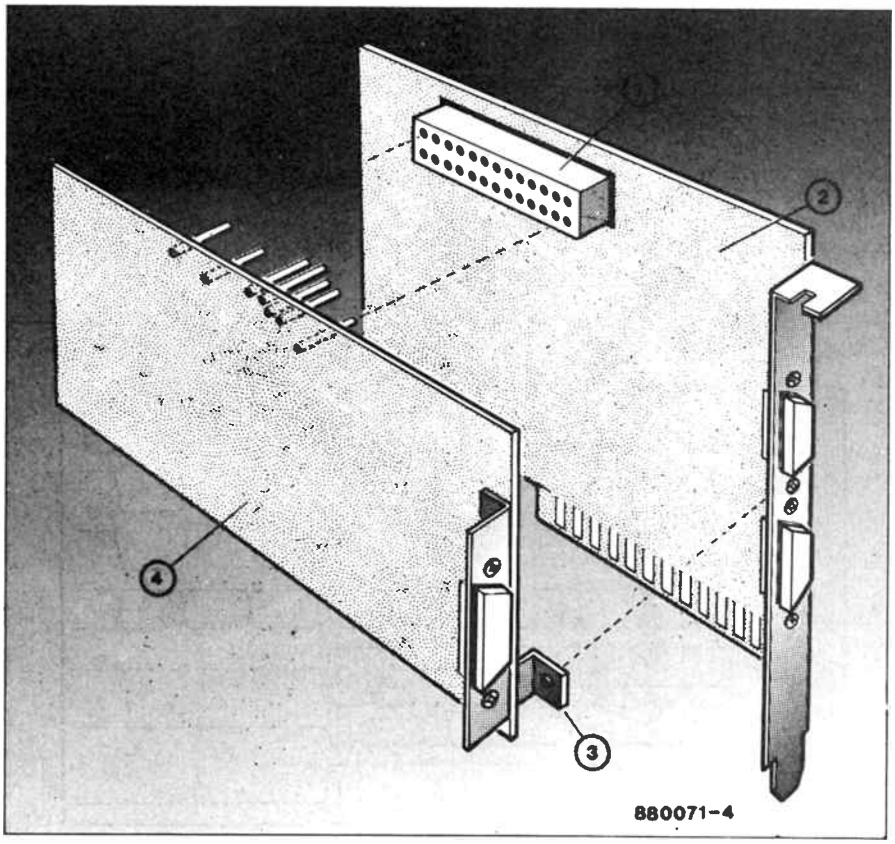

Fig. 4. Suggested mounting of the 256-colour board. 1: Feature connector. 2: EGA board. 3: Bracket. 4: 256-colour board.

Software

A complete description of the EGA hardware and software is available from IBM. The comprehensive document is called *Update Number 1 for the IBM Technical Reference Options and Adapters*. The IBM reference part number is 6138280.

To get started with the colour extension board, use the BIOS calls to control the EGA, and write to the Miscellaneous Output Register. Setting bit 4 in this register disables the video and sync drivers on the EGA and enables the drivers on the 256-colour board.

Table 1 shows a Turbo Pascal procedure which puts the EGA into 640×200 16-colour mode, and enables the colour extension. The procedure uses BIOS interrupt $1Ø, function $ØØ, to set the display to video mode 14. It then writes $33 to the EGA Miscellaneous Output Register. For mode 14, the BIOS normally sets this register to $23, but bit 4 must also be activated here to enable the 256-colour board (for video mode 16, the BIOS normally sets the Miscellaneous Output Register to $A7).

Table 2 shows a Turbo Pascal procedure which draws a single pixel in one of 256 colours. It uses integer variables r, g and b to calculate the value of the two "pixel" bytes to be written, then calls BIOS interrupt $1Ø, function $ØC, to write the lower and upper halves of the 256-colour value to the even and odd-numbered pixels of the EGA. Using the BIOS to set the display mode always disables the colour extension board, making it easy to return to the standard 16-colour graphics.

It should be noted that the BIOS is extremely slow to write pixels. Eventually, users of the colour extension board will want to write software that gives direct access to the EGA hardware. For this, the above mentioned IBM manual on the EGA is indispensable.

Reference:

[1] Digital colour palette. *Elektor Electronics*, April 1986, p. 68 ff.

---

* Peter Balch is with Analogue Information Systems Limited.

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Taxan is a trademark of Kaga Electronics Company Limited.
Veroboard is a trademark of BICC-VERO Elelectronics Limited.

Table 2

```
procedure draw_point(x,y,r,g,b: integer);
   var pixel_A,pixel_B: integer;
   Regs: record
      case boolean of
         true:  (ax,bx,cx,dx,bp,si,di,ds,es,flags: integer);
         false: (al,ah,bl,bh,cl,ch,dl,dh: byte);
      end;
begin
   pixel_A:=(g and 7)+(b and 3)*8+(r and 7)*32;
   pixel_B:=pixel_A and 15;
   pixel_A:=pixel_A div 16;

   with regs do
   begin
      ah:=$0C;
      al:=pixel_B;
      bh:=0;
      cx:=x+x+1;
      dx:=y;
      intr($10,regs);
   end;

   with regs do
   begin
      ah:=$0C;
      al:=pixel_A;
      bh:=0;
      cx:=x+x;
      dx:=y;
      intr($10,regs);
   end;
end;
```

UNIPHASE LOUDSPEAKER SYSTEM

A loudspeaker system that is based on Audax drive units and uses a 12 dB Linkwitz filter. The closed box design enables the drive units to be located in a straight acoustical line.

The use of a Linkwitz filter (Ref. 1) in a loudspeaker system makes sense only if the drive units are positioned in straight acoustical line.

The three-way system presents nothing new, but the drive units have some special characteristics as will be seen later. Total costs for two loudspeakers (drivers, crossover, but less boxes, etc) is around about $1300. Listening tests in which the uniphase system was compared with commercially available products show that the quality is roughly the same as that of a commercial system costing twice as much.

The most noteworthy aspect of the box is the staggered front, which is essential to get the drive units in a straight acoustical line. This means that the drive units are positioned in a manner which ensures that the acoustical output of each of the three drivers reaches the listener at exactly the same time.

It might be thought that to achieve this it is sufficient to measure the depth of each cone to be able to calculate by how much each drivers must be displaced with reference to one another. It's a good start, but unfortunately not sufficient. This is because the phase behaviour of each drive unit is far from ideal—see Fig. 1 for a typical phase characteristic of a bass driver in a closed box. Although W. Marshall Leach published a very interesting article on the phase behaviour of drive units in the Journal of the AES as long ago as 1980, it appears that in the practical systems of most manufacturers no notice has been taken of the findings of Mr. Leach.

1

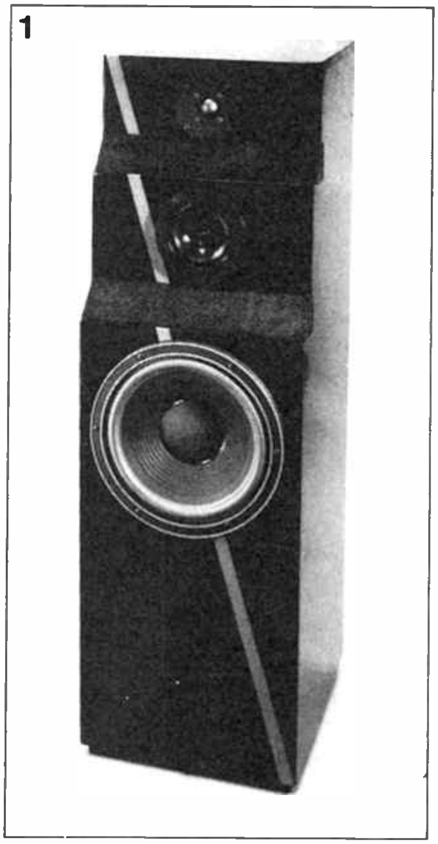

Fig. 1. Prototype of the uniphase loudspeaker system.

In an ideal loudspeaker system $d\phi/d\omega$ must be a constant to obtain optimum pulse behaviour. With reference to the curve of Fig. 1, it is seen that this is virtually impossible to attain. Any box that contains more than one drive unit and a cross-over filter will have a phase behaviour that causes impulse distortion. Even in a wideband system without filter, it is very difficult to attain optimum impulse behaviour.

Is phase shift audible?

During the past few years, there have been a number of investigations into the question whether phase errors are audible or not. These investigations have failed to agree. It is probable that the sensitivity to phase errors varies from one person to another. And what about the test methods? Our own experience shows that serious phase deviations can definitely be detected in the reproduced sound. Particularly the pronounced phase jumps around the cross-over point of the filter seem to be the culprits. These jumps also cause the loudspeakers to produce a different sound pattern at different positions around the room. This is because the acoustic radiation pattern around the cross-over points shows large variations along its axis.

We have the impression—shared with a number of researchers—that most listeners are not not so much sensitive to absolute phase deviations, but rather to sudden phase differences.

A matter of less than an inch

Above resonance, the loudspeaker behaves capacitively at first and then, at higher frequencies, inductively. This behaviour is caused by the voice coil.

2

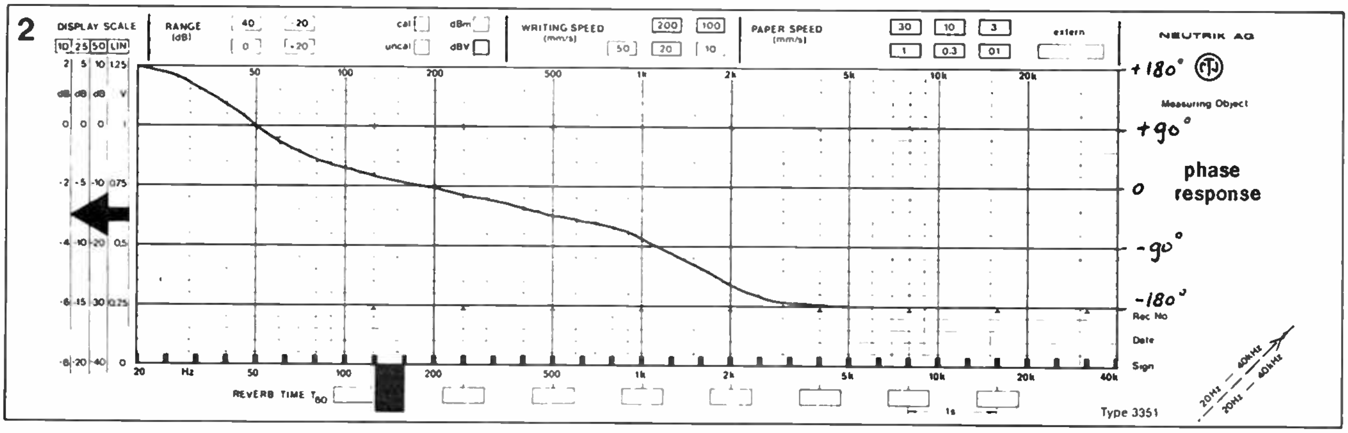

Fig. 2. Phase characteristic of a typical bass drive unit.

The phase behaviour of each driver can be measured with a good standard microphone. On the basis of the results, the drivers are then displaced with reference to one another until their phase characteristics meet smoothly at the cross-over points. This cannot be achieved with 100% accuracy, but the resulting over curve approaches the theoretical one very closely. Fig. 2 shows the overall phase behaviour of the uniphase system after these corrections had been introduced. In practice, the drive units were positioned such that the points of origin of their cones lay in a straight line. This implies that only the specified Audax drivers should be used, since otherwise the distances between the drivers would be incorrect. In other words, if drivers other than the Audax units are used, the phase behaviour must be measured again, and the design of the enclosure adapted accordingly.

Three-way: an acceptable compromise

A loudspeaker system in which account is paid to the phase behaviour and the separation of the drive units cannot very well be realized with fewer than three drivers. Also, the cross-over points should be chosen at other than the standard frequencies. In the present system, they lie at 370 Hz and 3,200 Hz. The latter frequency was chosen deliberately because a middle frequency driver, even if it is small, gives more and more problems with its phase behaviour above that frequency. Moreover, a 25 mm tweeter performs very well at that frequency, particularly if it is remembered that the cross-over points here lie at −6 dB. It should be noted that the distances between the drive units were determined for these frequencies: other values must, therefore, not be used.

The drive units

The bass unit is a 24 cm type on a cast aluminium chassis. The magnet, although of reasonable size, is not particularly large. Since the enclosure is a closed box (which has better impulse behaviour than a bass reflex), the magnet should be not too large to avoid the frequency response characteristic falling off too early.

The middle frequency driver is a splendid unit. To all outward appearances, it looks like a conventional model, but its magnet is the same size as that of the bass unit, and its cone is made of TPX. An aluminium cone in the centre ensures a better spread of the high tones. Its cost is similar to that of the bass unit. It should, however, be borne in mind that this unit takes care of the most important part of the audio range. In our prototype, it performed beautifully.

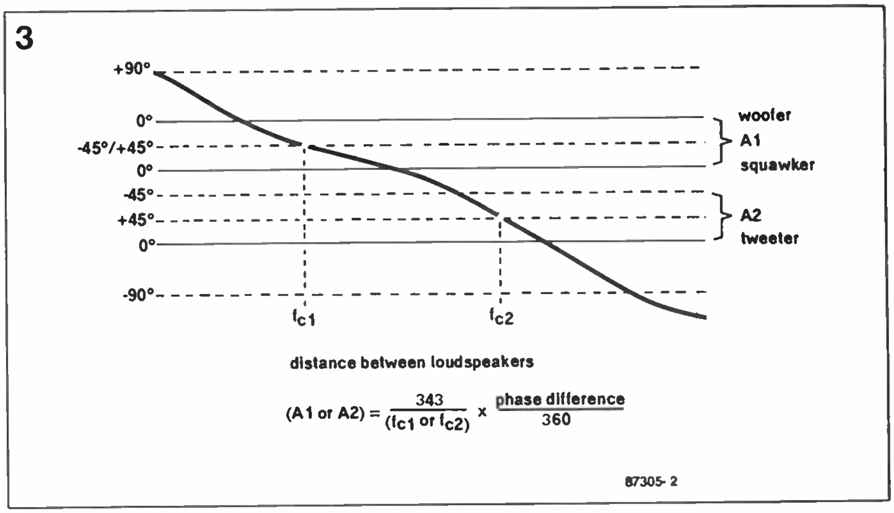

Fig. 3. Displacing the drive units with respect to one another makes the phase characteristics meet more evenly.

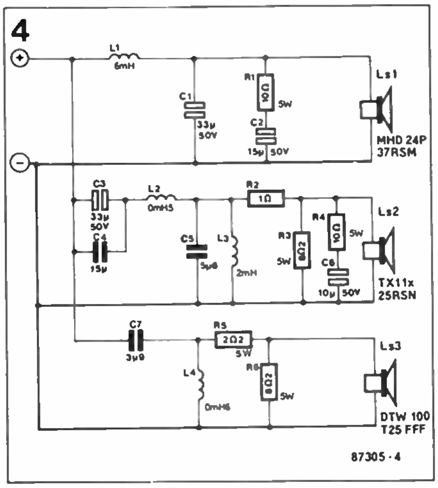

Fig. 4. Circuit diagram of the Linkwitz filter.

Components list

Resistors:
(all 5 W)
R_1;R_4 = 10 Ω
R_2 = 1 Ω
R_3;R_6 = 8Ω2
R_5 = 2Ω2

Capacitors:
C_1;C_3 = 33 µ; 50 V bipolar
C_2 = 15 µ; 50 V bipolar
C_4 = 15 µ MKT or MKC
C_5 = 5µ6 (4µ7//1µ) MKT or MKC
C_6 = 10 µ; 50 V bipolar
C_7 = 3µ9 MKT or MKC

Inductors:
L_1 = 6 mH (wind on 20 mm pot core from 0.9 mm dia. enamelled copper wire)
L_2 = 0.5 mH (air-cored: 10 mm dia.; wind from 1 mm dia. enamelled copper wire)
L_3 = 2 mH (wind as L_1)
L_4 = 0.6 mH (wind as L_2)

Miscellaneous:
Bass drive unit: Audax Type MHD24P37RSM
Middle frequency driver: Audax Type TX11×25RSN
Tweeter: Audax Type DTW100T25FFF
Synthetic cotton wool wadding (see text)

Fixing bolts, nuts, and crinkle washers for drive units
Loudspeaker terminals (4)

The tweeter is a modernized version of a well-established unit, which has formed part of Audax's range for many years. It is, without doubt, still one of the best tweeters available. This version has ferrofluid cooling and damping of the voice coil. It reproduces the very high frequencies with just a little better definition than the original model.

The filter

The present system uses a 12 dB Linkwitz filter—see Fig. 4, which is one of the best passive filters. Next month we intend to publish an active version of the loudspeaker system that will make use of the active network published last year (Ref. 2). However, for those who are not ▷

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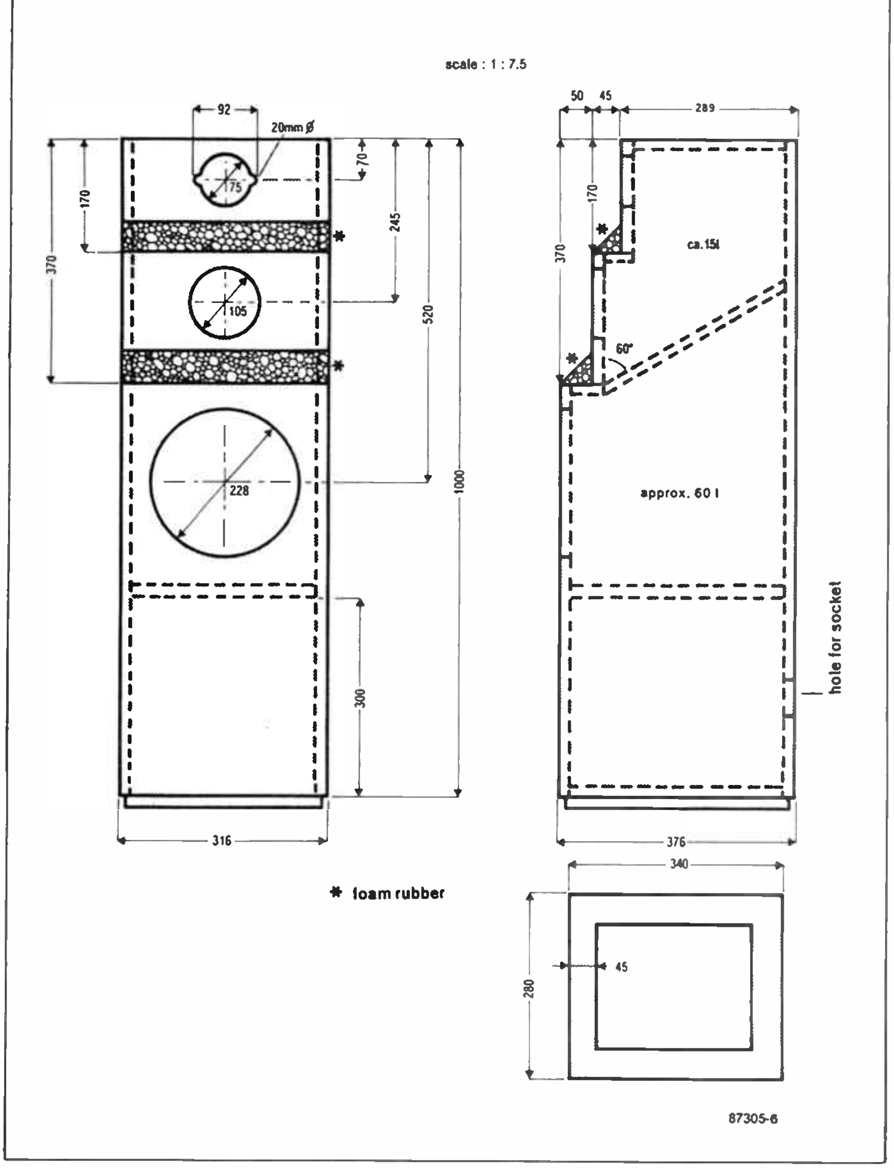

Fig. 6. Construction plan of the enclosure. Required MDF board or chipboard, thickness 18 mm.

prepared to spend the extra money for an active system with six output amplifiers, the passive system is an excellent choice that offers very good sound quality.

The design of the filter follows the earlier article (Ref. 1) fairly faithfully. The increasing impedance presented by the bass unit at higher frequencies is compensated by R_1 and C_2. A similar network is provided for the middle frequency drive unit, otherwise the filter would not behave as predicted by theory. Furthermore, the middle frequency driver and the tweeter have been given a small attenuation network to match them more closely to the woofer.

The resistances in parallel with the drive units effectively flatten the resonance peak of the impedance characteristic of the middle and high frequency drivers, since these peaks are close to the respective cross-over points.

Readers who check the values of the network components will find that those of C_3 and L_3 do not correspond with the theoretical values. The cause for this discrepancy is that the impedance of the middle frequency unit rises sharply in the vicinity of the cross-over point, in spite of the 8.2 ohm shunt resistor: consequently, during the design it was found that the practical values deviate sharply from the computed ones.

The enclosure

The enclosure is an upright, narrow box of such a height that the middle and high frequency drivers are roughly at ear height. The narrow front keeps the number of reflections to a minimum. As already mentioned, the front surface is staggered to make it possible for the drive units to be placed at the correct distances from one another.

Otherwise, the construction is fairly con-

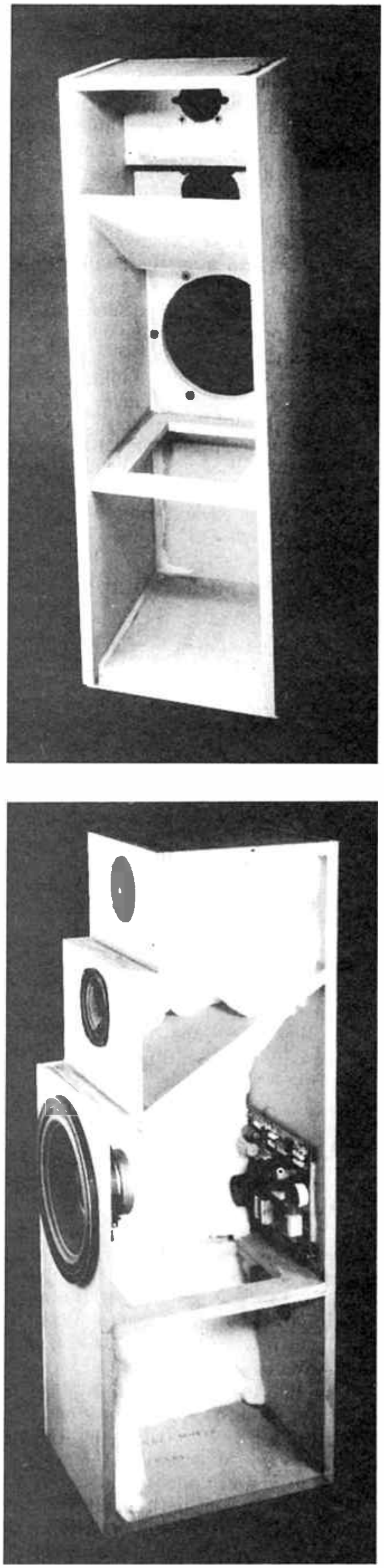

Fig. 7. Some stages in the construction of the prototype.

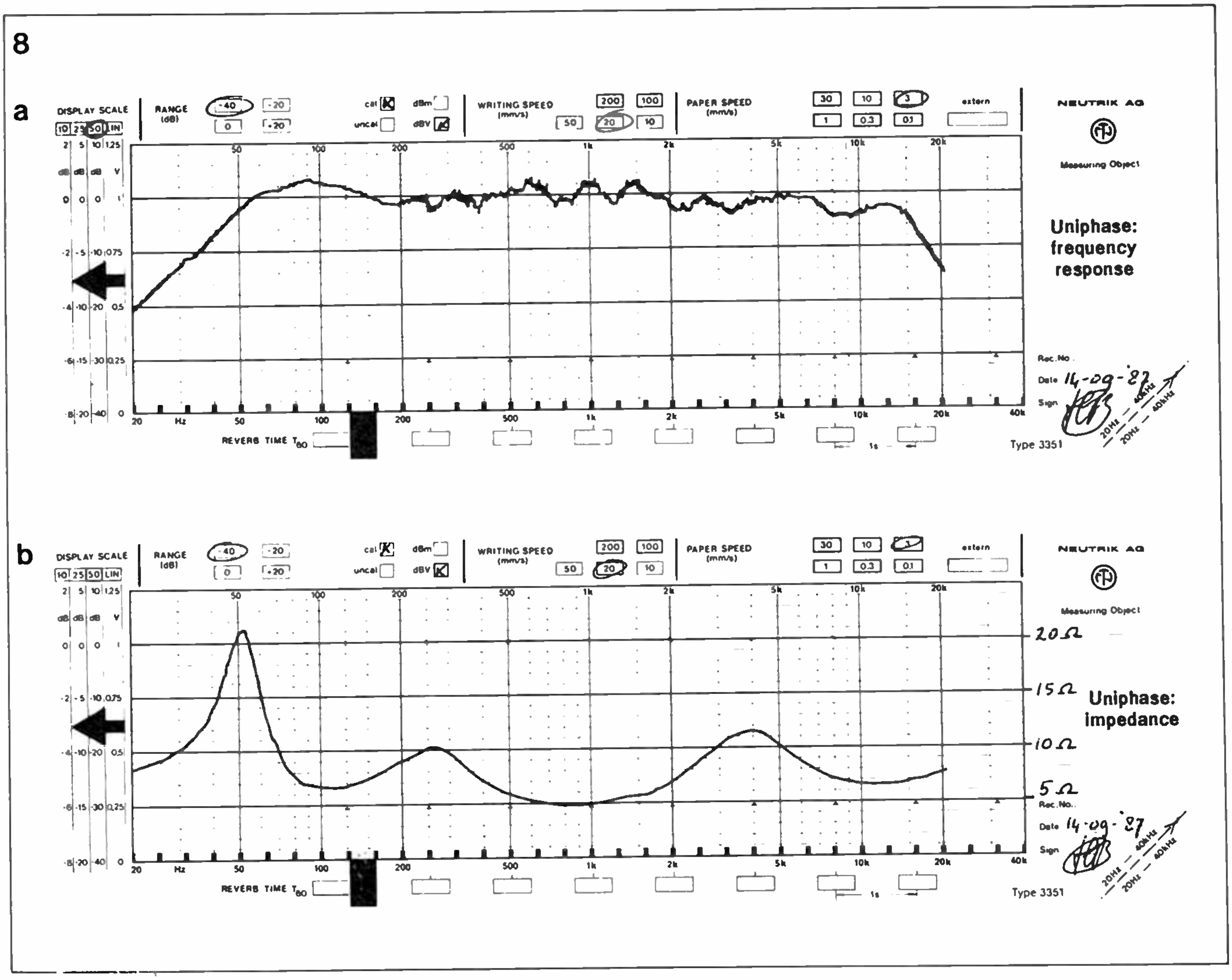

Fig. 8. Frequency characteristic (a) and impedance curve (b) of the uniphase loudspeaker system.

ventional. The volume of the woofer compartment is about 60 l, which is sufficient to obtain a Q_{TC} of 0.7. The −3 dB point of the combination lies at around 45 Hz. The section for the middle frequency unit has a volume of some 15 l. Again, that is necessary to obtain a Q_{TC} for this section of 0.7. Furthermore, it ensures good impulse behaviour over the middle frequency range.

The box is made of MDF (medium density fibre board), a material that resembles chipboard but has a much greater density. If this material cannot be obtained, chipboard of the best quality may be used.

Construction

The filter is constructed on Visaton's Type UP70/3 universal filter PCB as shown in Fig. 5. Some additional holes will have to be drilled in this board.

Inductors L_1 and L_3 should be made with a pot core, otherwise they become too large for PCB mounting. All other inductors are air-cored. Capacitors C_1, C_2, C_3, and C_6 are bipolar electrolytic types; all other capacitors are MKT (metallized polytherephtalate) types (MKC—metallized polycarbonate—types are suitable alternatives).

The construction plan for the box is shown in Fig. 6. The panels are interconnected with the aid of suitable dowels and wood glue: bear in mind that the finished box must be airtight. Apart from the panel separating the woofer from the other speakers and the panel halfway up the bass unit compartment, no struts are required.

The drive units are mounted with the aid of nuts, bolts, and crinkle washers. Subsequently, the cables between the drivers and the filter are put in. Take care that the hole in the slanting separating panel through which the cables from the middle and high frequency units to the filter are fed is made airtight after fitting the cables.

The rear of the box is provided with a good quality terminal board.

The filter is mounted on the inside rear panel of the woofer compartment: take care that all cables are connected correctly!

Next, the box is filled with wadding, for instance, synthetic cotton wool which is sold in bags. About 1 bag is needed for the top compartment and 3 bags for the woofer section.

When all that is done, the box is closed, again using good quantities of wood glue to ensure an airtight closure. Finally, the enclosure is finished to individual taste (cloth, veneer, varnish, etc.).

Finally

The enclosures may be positioned against a wall, but preferable not in a corner.

References:

1. *Linkwitz Filters, Elektor in AEM*, May 1987.

2. *Active Phase Linear Crossover Network, Elektor in AEM*, October 1987.

LOW-NOISE PREAMPLIFIER FOR FM RECEIVERS

First in a short series of articles on simple to build RF preamplifiers is a tuneable aerial booster for the FM band.

The RF preamplifier described here is intended for fitting as close as possible to the FM band aerial. It is a tuneable, rather than a wideband, amplifier, which is fed and tuned via the downlead coax cable. The amplification and the noise figure of the FM aerial booster are 25 dB and about 1 dB, respectively. All preamplifiers described in this series are powered and tuned by a common supply/tuning unit installed at an appropriate location in the home.

Circuit description

The circuit diagram of Fig. 1 shows that the preamplifier is a conventional design based on a VHF MOSFET tetrode Type BF981. The preamplifier input can be connected to unbalanced (60...75 Ω) as well as balanced (240...300 Ω) aerials or feeder systems. The balanced input allows the preamplifier to be connected direct to the dipole element. In this case, the preamplifier can take the place of the balun removed from the ABS, water-resistant, enclosure that houses the dipole terminals. This solution ensures the lowest possible input loss, and obviates the need for a separate preamplifier enclosure on the mast.

The balanced or unbalanced aerial signal is applied to winding **a** of tuneable inductor L_1. Varactors D_1-D_2 form the adjustable capacitance across winding **b**, so that the tuning range of L_1 is about 86...109 MHz. Gate 2 of DG MOSFET T_1 is held at about +4 V by potential divider R_2-R_3. The bias voltage is effectively decoupled by surface mount capacitor C_1. Blocking capacitor C_6 takes the amplified RF signal from a half-impedance tap on drain inductor L_2.

The MOSFET is fed with a constant operating voltage of 12 V, supplied by regulator IC_1. The direct voltage on the downlead coax can be varied between 15 V and about 26 V by means of the supply/tuning unit near the receiver. Zenerdiode D_3 in the preamplifier ensures that the tuning voltage for varactors D_1-D_2 is the voltage on the downlead coax minus 12 V. Example: if the downlead coax carries +18 V, the tuning voltage at junction D_1-D_2 is +6 V with respect to ground. The lowest downlead voltage is about 15 V to ensure the minimum voltage drop across regulator IC_1. Choke L_3 forms a high impedance for the amplified RF signals superimposed on the tuning/supply voltage.

Construction

Commence the construction of the preamplifier with winding the inductors.

Input inductor L_1 is wound on the former in the Type 10V1 inductor assembly from Neosid—see Fig. 2. First, close-wind L_{1b} as 11 turns, ∅0.6 mm enamelled copper wire. Study the component overlay on the PCB (see Fig. 3) to find the 2 pins on the base that connect to L_{1b}. Close-wind L_{1a} as 4 turns, ∅0.6 mm enamelled copper wire onto L_{1b}, starting at the base of the plastic former. The tap is made after 2 windings. Stretch the turns, and carefully scratch off a small area of the enamel coating approximately half-way the inductor. Solder a short wire to this point, and point it down towards the base. Press the inductor together again. Connect the end wires and the tap wire to the base pins, and verify continuity and orientation of the completed inductor.

Drain inductor L_2 is wound as 4 turns ∅0.3 mm enamelled copper wire through a small ferrite bead. The centre tap is made after two turns by twisting

1

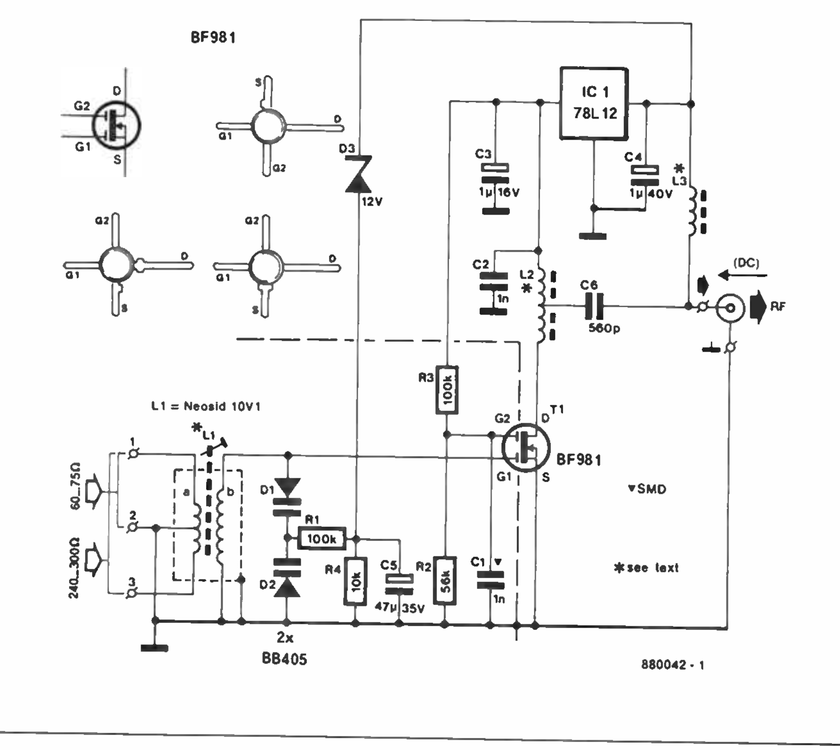

Fig. 1. Circuit diagram of the tuneable VHF preamplifier.

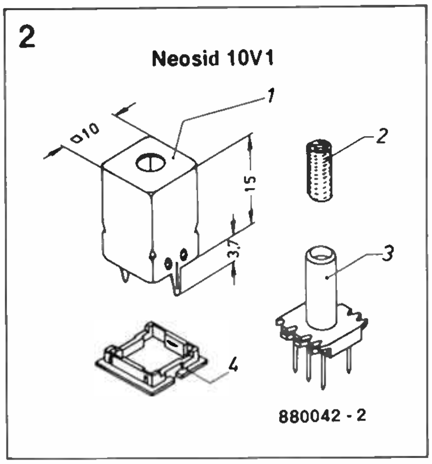

Fig. 2. The Type 10V1 inductor assembly from Neosid.

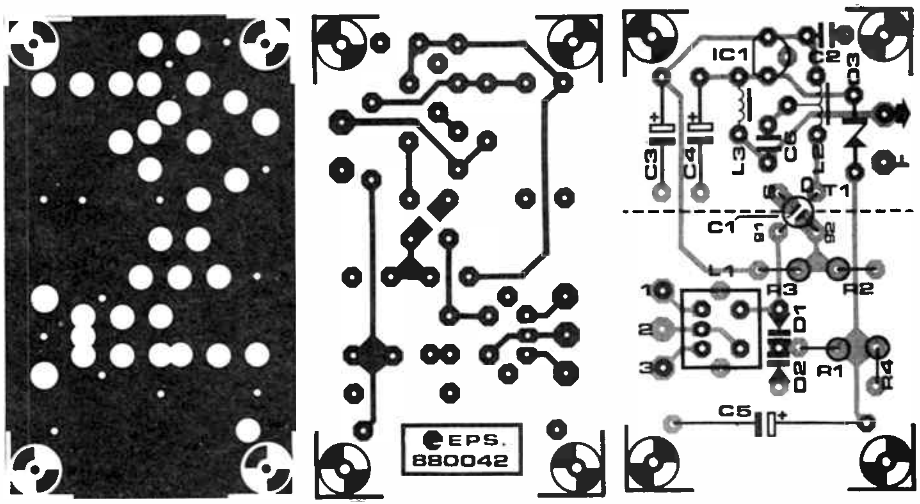

Fig. 3. The PCB for building the VHF preamplifier.

3

Parts list

FM BAND PREAMPLIFIER. CIRCUIT DIAGRAM: FIG. 1.

Resistors (±5%):

R_1;R_3 = 100K
R_2 = 56K
R_4 = 10K

Capacitors:

C_1 = 1n0 (surface mount assembly)
C_2 = 1n0 ceramic (pitch: 5 mm)
C_3 = 1μ0; 16 V; axial
C_4 = 1μ0; 40 V; axial
C_5 = 47μ; 35 V; axial
C_6 = 560p ceramic (pitch: 5 mm)

Semiconductors:

D_1;D_2 = BB405
D_3 = zenerdiode 12 V; 400 mW
IC_1 = 78L12
T_1 = BF981

Inductors:

Winding data are given in the text.

L_1 = inductor assembly Type 10V1. Neosid part number: 15955100.

2 off small, single-hole, ferrite beads (length: approx. 3 mm).

Miscellaneous:

Suitable waterproof enclosure.
PCB Type 880042
5 off soldering pins.

3 cm or so of the wire before making the third and fourth turn. The twisted wire is then cut to length, the enamel coating is scratched off, and the connection is carefully pre-tinned.
Choke L_3 is the simplest to make: it is wound as 6 turns ∅0.2 mm enamelled copper wire through a small ferrite bead. The three home-made inductors in the preamplifier are shown in the photograph of Fig. 4.

The PCB for this project is a double-sided, but not through-plated, pre-tinned type. The four resistors are mounted upright. Ascertain the pinning of MOSFET T_1 before fitting it on the printed circuit board: depending on the make of the device, it may be necessary to mount it with the type indication facing the PCB.
The ground terminal of R_2, R_4, IC_1, C_2, C_3, C_4, C_5, the source terminal of T_1, the anode of D_2, input pin 2, the 2 solder tabs on the shielding can of L_1, and the output ground terminal, are soldered *at both sides of the PCB*. The only component at the track side of the board is SMD capacitor C_1. This is soldered direct across the GATE 2 and SOURCE connections of the MOSFET. Fit a 15 mm high brass or tin metal screen with a small clearance for the MOSFET as shown on the component overlay.

Supply/tuning unit

The circuit diagram of the simple, regulated and adjustable, power supply for the downlead-powered preamplifiers is shown in Fig. 6. The output voltage of integrated regulator IC_1 is adjusted between 15 V and 26 V with tuning control P_1. The tuning and supply voltage for each preamplifier is applied to the centre core of the respective downlead coax cable by a choke-resistor combination.
The tuning/supply unit is built on the double-sided, pre-tinned printed circuit board shown in Fig. 7. Construction should not present problems: grounded component leads or terminals are soldered at both sides of the PCB. Fit IC_1 with a TO220-style heat-sink, but make sure that this is insulated from the ground area.

The winding data for the 3 chokes on the board are as follows:
L_1;L_2;L_3 = 6 turns ∅0.2 mm enamelled copper wire through a small ferrite bead (length: approx. 3 mm).
The tuning control, P_1, is conveniently fitted onto the 3 soldering pins to go round a 3-wire connection. The assembled board, the 24 VAC power transformer, mains switch and fuse are housed in a small enclosure with a sloping front panel. Omit D_1...D_4 incl., and C_1-C_2, when a 24 VDC source, such as a ▷

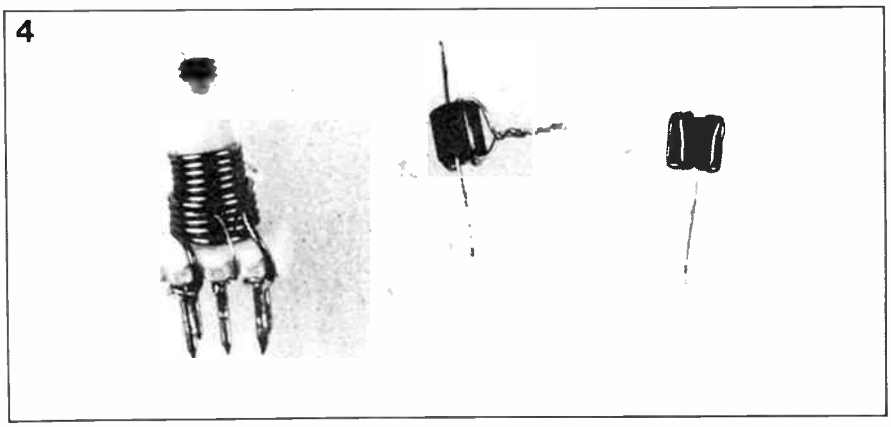

Fig. 4. A close look at the home-made inductors.

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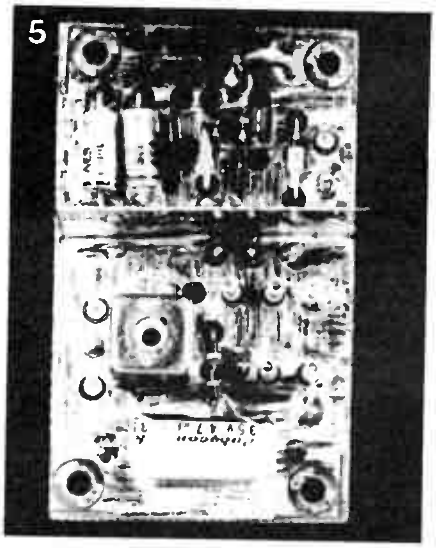

Fig. 5. Prototype of the completed low-noise preamplifier.

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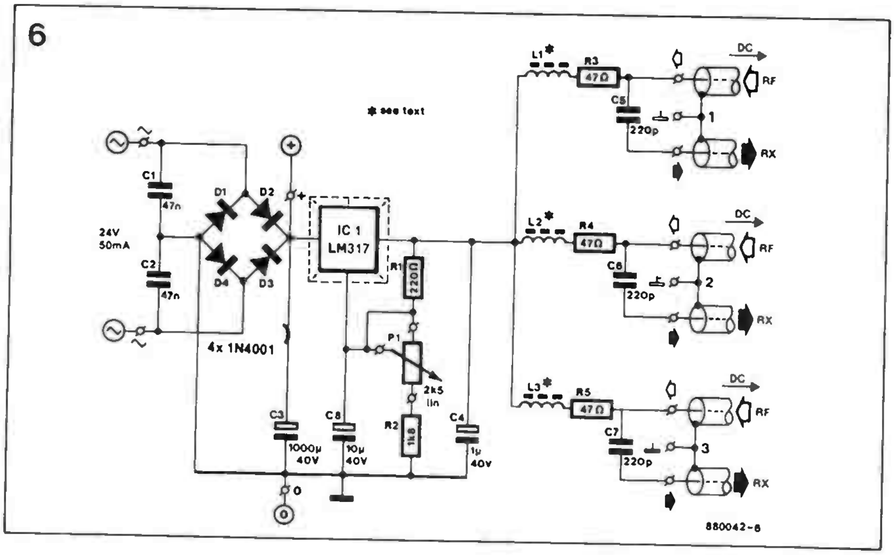

Fig. 6. Circuit diagram of the tuning/supply unit.

mains adapter, is already available—connect this to the points marked + and 0. The tuning control can be fitted with a vernier and a scale for the frequency range of each preamplifier.

Testing

Connect the AC input of the completed tuning/supply unit to the secondary of the 24 VAC mains transformer, apply power, and verify the presence of the adjustable direct voltage on the three DC/RF terminals. Check whether P_1 sets the voltage between +15 V and +26 V.

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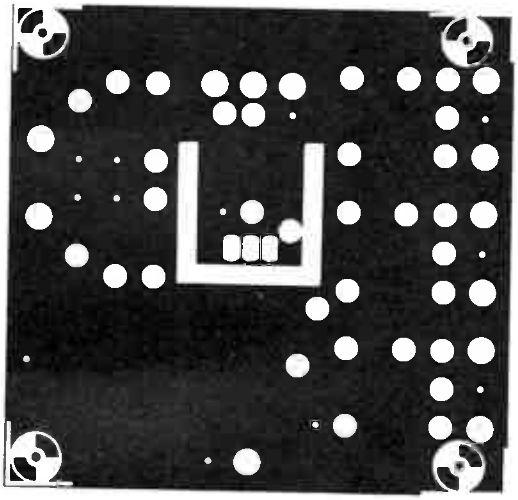
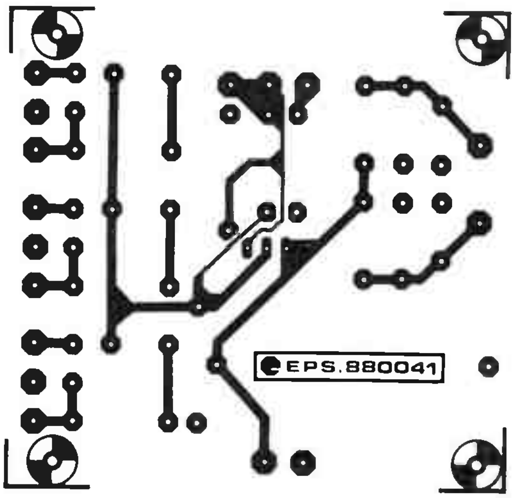
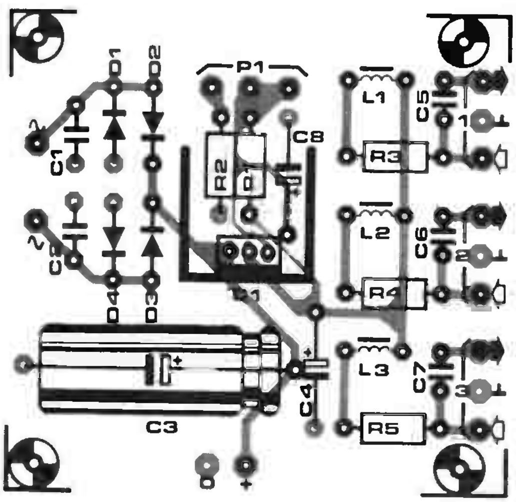






Parts list

TUNING/SUPPLY UNIT. CIRCUIT DIAGRAM: FIG. 6.

Resistors (±5%):

R1 = 220R
R2 = 1K8
R3;R4;R5 = 47R
P1 = 2K5 or 2K2 linear potentiometer

Capacitors:

C1;C2 = 47n
C3 = 1000μ; 40 V
C4 = 1μ; 40 V
C5;C6;C7 = 220p
C8 = 10μ; 40 V

Inductors:

L1;L2;L3 = home made on 3 mm ferrite beads – see text.

Semiconductors:

D1 . . . D4 incl. = 1N4001
IC1 = LM317 (TO220 enclosure)

Miscellaneous:

TO220-style Heat-sink for IC1.
11 off soldering pins.
PCB Type 880041

Fig. 7. The printed circuit board for the tuning/supply unit.

THE VALUE OF SILENCE

by Dr Dylan Jones and Dr Chris Miles, Department of Applied Psychology, University of Wales Institute of Science and Technology, Cardiff

Most people would agree that their concentration on reading and attempts to memorise information are made more difficult when someone nearby is speaking. One reason stems from the part that hearing has played as a warning system in the course of human evolution. Recent laboratory studies have produced data showing the disruptive effect that speech can have in open plan offices, control towers and even on the flight decks of aircraft, causing serious losses of efficiency. Research is also helping psychologists to chart the flow of information in the brain.

"Under all speech that is good for anything there lies a silence that is better. Silence is deep as Eternity; speech is as shallow as Time."
Critical and Miscellaneous Essays, vol. IV, Sir Walter Scott, by Thomas Carlyle.

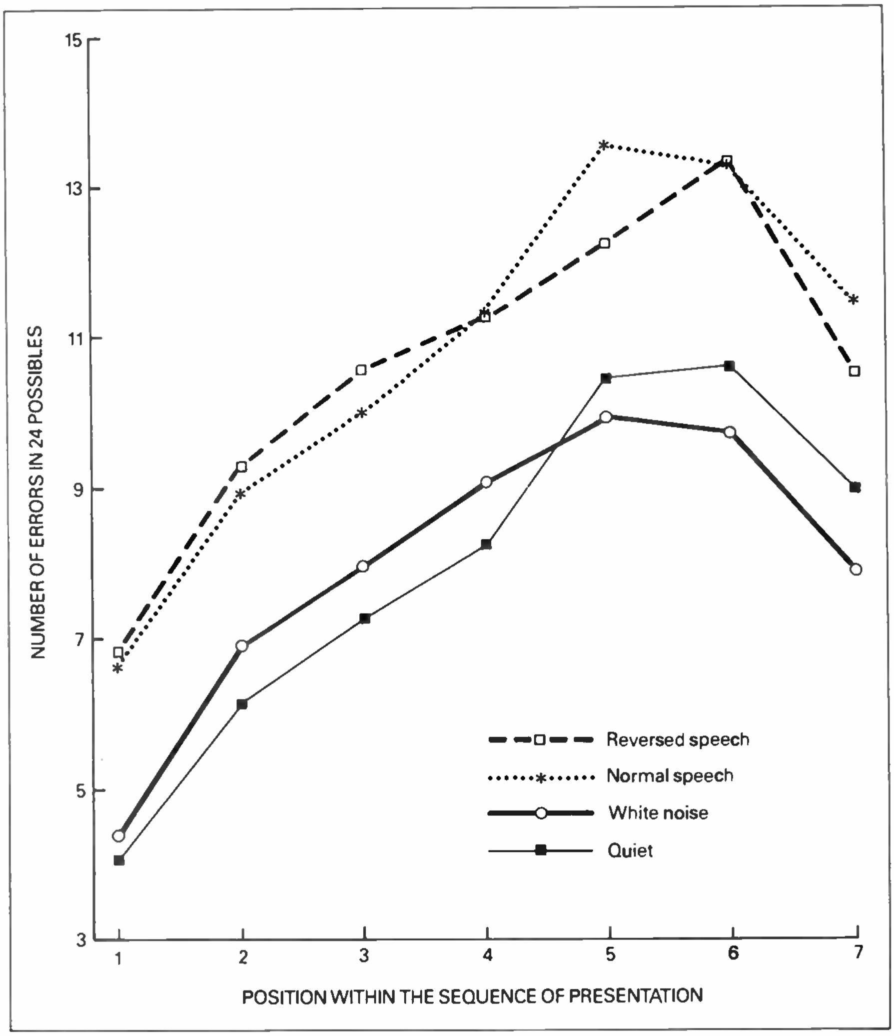
Silence is a precious commodity, the more so when we are trying to think clearly or read. Religious orders insist on it for periods of devotion and contemplation. Librarians demand it, too, but are often frustrated by people who insist on whispering.

At our place of work we may find that our ability to understand the written word, or the clarity of our thought processes, is muddied by ringing telephones and the babble of voices in the background. Of all the sounds that impinge upon us, the human voice is especially intrusive; from what is known of the psychology of hearing there are good reasons to suppose that speech is treated in a slightly different way to other sounds.

Abundant anecdotal evidence suggests that the human voice, even when whispered, makes reading difficult; this is true even when the person tries to ignore the sound, so it is clear that speech can intrude without invitation upon our consciousness. Although interference between the written and spoken word is obvious and natural to the layman, it poses a range of significant questions for the psychologist interested in how the brain processes information. First, we must ask why it is that information delivered to two separate sensory organs, the eye and the ear, somehow get mixed in the brain. For interference to occur, the streams of information coming from the two sense organs must share some common pathway in the brain. Part of the psychologist's interest is in locating the precise point at which the interference takes place. Second, what are those features of speech which make it so difficult to ignore, and why are our strenuous attempts to suppress it usually of no avail?

Disrupting memory

From a series of experiments in various laboratories, a fairly clear picture is beginning to emerge of the way in which ir- ▷

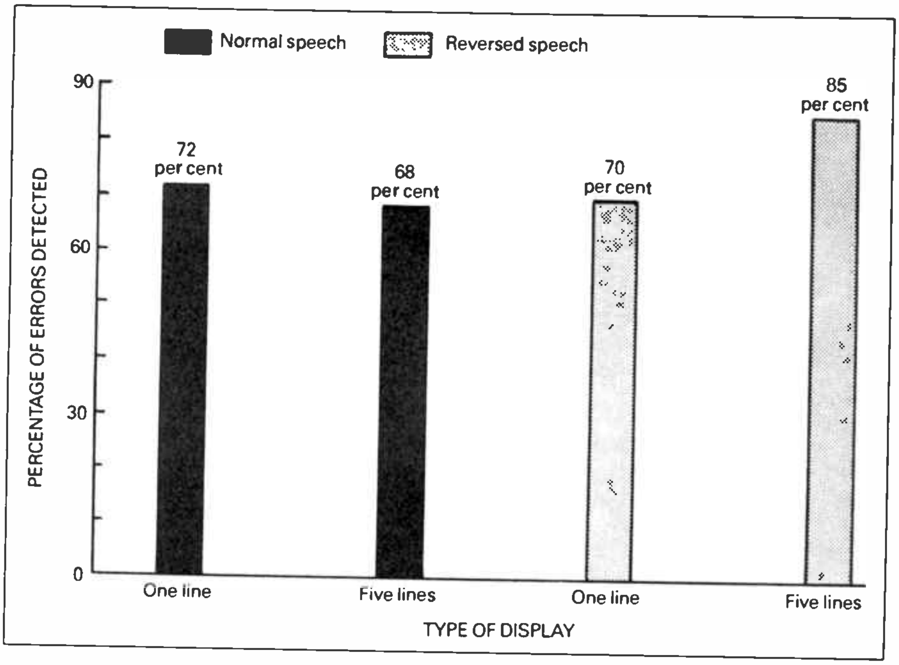


Effects of different types of sound on memory. Speech, even when reversed, is seen to have a more disruptive effect than white noise, which has a similar effect to quiet. This shows that disruption is not simply due to acoustic stimulation.

relevant speech interferes with reading. Studies have proved fruitful for the academic psychologist interested in the workings of the brain and for all those interested in the abatement of noise. Two distinct strands of research on irrelevant speech are discernible: the first examines an effect, now well established in the literature, of irrelevant speech on short-term memory; the second focuses on the more recently discovered effects on the reading process.

Typically, short-term memory is tested by asking a person to recall a list of items such as letters, short words or digits. Each list comprises up to nine items, presented visually at a rate of about one per second. At the end of the list, or soon thereafter, the person is asked to write down the items in the order in which they were presented. The presence of irrelevant speech during the presentation of the items appears to reduce the number recalled by about 20 per cent. By any standards this is a significant degree of impairment. The failure to remember is roughly the same over the whole list; it is apparent only when ordered recall is required, but not when the items can be recalled in any order.

Over the last ten years several features of this disruption have become more clearly understood. First, the loss of efficiency does not depend upon the meaning of the interfering speech; the degree of impairment is similar if the speech is in a language that the person does not understand. Furthermore, reversed speech produced by running a tape backwards through a tape recorder is as disruptive as proper speech. Second, it has been shown that while the intelligibility of speech does not matter, sounds that are not speech do not interfere. For example, white noise (which is a random mix of hissing sounds like those heard from a radio or television set that is not tuned to a transmitting station), is not disruptive. Perhaps this is because white noise and speech are composed of different kinds of acoustic signals. But there is at least one exception to this general finding, which arises from a study we made of the disruptive effect of singing. We have shown that the effect of sung words is similar to that of spoken words. But if the tune is hummed rather than sung the effect is less marked, which suggests that the sound has to be word-like rather than more broadly speech-like. Finally, the intensity of the speech is unimportant: speech as loud as a shout or as low as a whisper disrupts memory to the same degree.



The influence that the number of lines in a visual presentation to a reader has on the effects of irrelevant speech. There is a reduced advantage in viewing the text five lines at a time when normal speech is interfering, but the reader can gain a 15 per cent advantage if the speech is meaningless.

Phonological form

What does this pattern of results tell us about the processes responsible? The findings indicate that the brain mechanism discriminates on the basis of how closely the incoming signal approximates to speech. The more similar the sound and speech are to one another, the greater the disruption. However, this mechanism fails to discriminate on the basis of meaning, for the disruption occurs whether the passage heard is meaningful or not. More recent experiments have shown that it is the similarity between the irrelevant speech and the sound of the material being remembered that is crucial. Words which are read are converted into a code which has a sound-like basis, as if the person was producing 'inner speech'. For example, if the list of words has the sounds of *run, new, tree, sore,* in common with irrelevant speech such as *one, two, three, four,* then the disruption will be severe. This points to the possibility that the two streams of information, one originally visual and the other auditory, are converging at a point where they are both held in a so-called phonological form.

The need for this conversion process becomes evident if we reflect for a moment on the way that we read. One way of understanding reading is to think of it as a conversion process from letters and words into sounds, into what we have already referred to as inner speech. When learning to read, the child has to appreciate the appropriate set of rules for converting shapes on the page into this inner speech. Some of the sounds associated with words, and therefore inner speech, may already be known to the child through hearing the language. So hearing and reading share a common level of analysis within the brain. In adult life, whenever we are confronted with the particularly difficult task of remembering a list of words or letters in the correct order, we make this type of analysis. Intrusion of a similar signal *via* the ear will lead to confusion; the more similar the codes used in the two streams are, the greater is the confusion when they are stored in memory.

Susceptibility of reading

Another line of our work has focused on the effects that irrelevant speech has on reading. At the outset we suspected that the effects of speech on reading would be different from those on memory. To investigate this possibility we used the technique of playing speech of different sorts while the person was proof-reading a text for spelling and grammatical errors. Typically, a volunteer would spend 15 minutes or so looking for errors which we had deliberately and carefully introduced into the text. We measured how many of these errors they could detect under various conditions of ambient sound.

There are three main features to the outcome of these experiments. First, meaning of the speech in this instance *is* important. This has been shown by manipulating the speech in a variety of ways. For example, reversed speech produces a roughly similar effect to silence. We were able to confirm this by demonstrating that people bilingual in Welsh and English were disrupted by irrelevant speech in either Welsh or English when they read English text. But the reading of those English speaking readers unable to understand Welsh was not disrupted by irrelevant Welsh. Second, intensity of speech is not important; just as in the results to do with memory, a whisper has as much effect as a shout. Third, the effect does not depend on other physical features of the speech, such as the number of voices, or whether its source is stationary or moving. The main point seems to be that meaning is important.

Discrete effects

The conclusions from these findings are that it is the meaning of the speech that affects proof-reading. In contrast, short-term memory is affected by speech-like properties of the acoustic signal. So there seem to be two discrete effects, one on reading and the other on memory.

We were able to check this by developing a variant of the proof-reading task. We used a computer-based system, in which two forms of the task were developed. In one, a single line of text was displayed. The reader could examine each line and use an electronic pointer to mark errors. When each new line was written-up on the screen the old line was erased, preventing the reader from looking back. The other form displayed the two lines preceding and the two lines following the line under correction. The reader was free to check backwards and forwards.

The two versions were used to examine whether reading was being disrupted through reliance of reading on memory. Offering the reader five lines of text necessarily reduces the immediate burden on working memory; the reader may check whether the grammar is correct by glancing back or forward to the entire sentence under scrutiny. In contrast, by providing one line of text only, the reader is forced to remember parts of the sentence while examining it for errors.

If reading is disrupted through the effect that speech has on memory, it would be thought that the effect would be more pronounced where the burden on memory is greater. The results of our experiments show just the opposite. The five-line version proved to be more susceptible to disruption. We think that the fluency of reading is important: the more fluent the reading, as with five lines of text, the more likely it is to be disrupted by speech.

Evolution

We are now left with the question of precisely why speech-like sound intrudes into our thoughts. Part of the answer comes from an understanding of the role that hearing has played in human evolution. It has the characteristics of an early warning system and has been described as the sentinel of the senses. It can receive information through the auditory channel in darkness; it can wake a sleeping person and, unlike the eyes, the ears are omnidirectional. The way we use our eyes is far more purposeful and directed; the ear, in comparison, is a passive and automatic recipient of information. We know, too, that nerves from the ears connect with those parts of the brain to do with alertness. Signals passed on by the ear are far more likely to be significant to a person's survival. All of these features suggest a system tuned to act as a vigilant guardian but one through which, nevertheless, a great deal of intelligent information is transmitted. So speech may take advantage of the ear's guardianship of our consciousness because it can gain privileged access to our thoughts.

The next stages of our research will focus on what it is in the nature of the speech signal that determines the degree of disruption. To begin with, this will mean looking at two features of the speech signal, both of which have the potential to interfere. The first is the possibility that speech has a certain combination of sounds, spaced at particular intervals, that characterise speech only. It is likely that the nervous system is tuned to receive such features while rejecting others. The second is that the so-called prosodic features, those increases and decreases in intensity of speech that give it a rhythm of its own, might be responsible. These changes of intensity, which are peculiar to speech, might also be subject to tuning by the nervous system.

Practical outcome

What are the practical implications of our findings? Wherever people are engaged in activities like those we have already described, it seems likely that they run the risk of being distracted by irrelevant speech. Workers in open-plan offices, where there is little or no acoustic isolation, are likely to have their efficiency impaired. Activities such as reading, composing text and performing mental arithmetic are all likely to suffer to some extent.

Most recommendations for the office environment take scant regard of what has already been found out by psychologists. It is usually assumed that the degree of interference by speech is similar to that induced by white noise. That is, it is taken for granted that the interference can be predicted by knowing the ratio of the intensities of signal and noise. But we know that the effect of speech does not depend on its intensity and is therefore largely independent of its distinguishability from background noise. This probably explains the discrepancy that has often been found between objective acoustic measurements in offices and complaints by the people working there.

Control rooms

In any complex system where an operator is exposed to material which has to be read and interpreted, the intrusive effects of speech may be at work. More important is that in control rooms, where streams of speech and text are mixed haphazardly, there is a chance that irrelevant speech will impair the memory of instrument readings and sequences of events. In air traffic control towers and in the control rooms of power stations the intake of visual information is at risk. In these settings, only some of the speech heard will be relevant to the task at hand, so there is good reason to recommend that some kind of control be exercised over incoming spoken messages. In person-to-person communication it could be done by channelling speech *via* microphones and headphones, so that there is some degree of control over reception.

In control systems using advanced technology, machine-generated speech will be used more and more to pass messages from the machine to the user. Interference from such sources can be kept down by queuing messages within a computer system so that the operator can listen to them at a convenient time when the workload is low enough.

Most profound

It is during the development of reading skills that the effect of irrelevant speech may have its most profound effects. In primary schools the trend has been toward classrooms of the open-plan type. Though data are not yet available, there is every possibility that in such settings fluent reading is being disrupted and the faltering steps of learners are being impaired.

Of all our experimental findings, the single most important is that the disrupting effect of speech is independent of intensity. This means that the traditional idea of abating it ought to be supplanted by eliminating it. Reducing the level of noise by modest degrees is relatively cheap; getting rid of ambient noise altogether is an extremely difficult and expensive enterprise. Yet there may be settings such as the flight deck of an aircraft where the potential costs of disrupting work might be so high that such a course should be seriously considered.

"And silence, like a poultice, comes To heal the blows of sound." The Music Grinders, by Oliver Wendell Holmes.

SENSORS & ACTUATORS

Radiant, mechanical, thermal, magnetic, and chemical effects in our environment are nowadays normally detected and measured by electronic means. The conversion of these (analogue) effects into (digital) electrical signals is invariably effected by sensors. These transducers have become so important that without them life on earth would almost literally come to a standstill.

Sensors come in a wide variety: it is estimated that there are close to 20,000 different types produced by thousands of manufacturers all over the world. The most important types are used in the detection or measurement of temperature, pressure, gases, radiation, humidity, magnetism, acceleration, direction, angle, flow, level, presence, position, displacement, and many more.
The operation of most sensors depends on optics (lasers, optical fibre, infra-red emitters and detectors), semiconductivity (photo transistors, photo diodes), thermoelectricity (thermocouples), or piezoelectricity.
The demands made on most sensors are high: they must be sensitive, corrosion-resistant, inexpensive, precise, stable, easily integrated into a microelectronic circuit, and preferably have a linear input/output characteristic.

A **sensor**, the popular name for transducer, is a device that converts a non-electrical parameter into an electrical signal or vice versa. The variations in the electrical signal parameter are a function of the input parameter.
Most transducers provide a linear, analogue output, but some provide a digital output in the form of discrete values. Most transducers are linear devices, i.e., they provide an output that is a linear function of the input.
Like many networks, transducers may be considered as quadripole devices, but one pair of terminals is not necessarily electrical.
Most transducers require external electrical excitation for their operation; exceptions are piezo-electric, photovoltaic, and electro-magnetic sensors.

An **actuator** is a device that converts an electrical signal into another form of energy, normally mechanical. It is thus a special type of transducer. Typical examples are loudspeakers, electronic switches, and many measuring instruments.

Optic sensors

Fibre optic sensors can be regarded as comprising three parts: the optical transmitter, the optical modulator, and the optical receiver. Each of the three parts has one major "active" component. The transmitter has an emitter (such as the LED or a laser); the modulator has the stimulus sensor mechanism (such as a diaphragm or a specific optical property material); and the receiver has a photodetector.
The emitters employed in fibre optic sensors can be classified as broadband (incandescent), narrowband (LED), coherent (lasers), or blackbody radiators (emitting from inside or outside the fibre). The choice of which one to select depends solely upon the modulator mechanism being employed. For instance, fluoroptic thermometers use temperature dependent fluorescence of materials at the end of a fibre optic probe. Many sensors for high temperature measurements rely upon blackbody radiation for ranges from 300 to 2000 degrees Celsius. However, the vast majority of applications use their own external light sources in the form of an LED or a laser, primarily because of the specific need to accurately control the emitter wavelengths, power outputs, and modulation frequencies.
Fibre optic sensors have been helped significantly by developments in LEDs, super luminescent diodes (SLDs), and lasers used in the fibre optic communications and optical disc industry. Semiconductor LEDs can emit from either their surfaces or their edges, depending upon their design. Surface emitting LEDs (SLEDs) have a wide solid angle on the output beam, and the beam intensity is Lambertian. Edge emitting LEDs (ELEDs), on the other hand, have a waveguide mechanism inherent in their structure (as do lasers) and thus have a narrower Gaussian intensity beam.
An SLD lies midway between an LED and a laser. It possesses only a single pass gain. As the current density is increased, even though an SLD shows a greater (super) luminescence than an LED, it still does not reach the threshold for multiple pass gain. However, because light is designed to undergo a single pass in the active area of the SLD, its spectrum is narrower than the LED's.

TABLE 1.

Comparison of Surface LEDs (SLEDs), Edge LEDs (ELEDs), SLDs, and Lasers

Characteristics	SLED	ELED	SLD	Laser
Spectral width (nm)	80-100	75-80	10-20	0.8-2.5
Typical optical power output (mW) at 100 mA (except lasers)	0.5-0.75	0.4-0.5	0.6-0.8	5-10
Coupling efficiency of optical power into fibers	Mediocre, needs lensing	Small	Better	Best
Response time (ns)	10-50	5-15	5-15	1-2.5
Stability to ambient temperature	Least changes	Sensitive	Sensitive	Least sensitive
Lifetime expectancy in years	1000	1000	100	100
Package options				
– Lenses	Yes	No	No	Special cases
– Fibre connectors	Yes	Yes	Yes	Yes
– Fibre pigtail	Yes*	Yes	Yes	Yes
– Thermoelectric coolers & stabilization modules	No	Seldom needed	Special cases	For all critical applications

The amount of power an emitter needs to generate for a fibre optic sensor application is a function of several design factors. The power from an emitter must first be transferred into an optical fibre. In many cases, it must be tailored appropriately (e.g., through a polarizer, as in the case of a fibre gyroscope) prior to such introduction.

LEDs, SLDs, and lasers are not only made of the same semiconductor materials but also have the same basic device structure. In principle, these semiconductor devices have a p-n junction, which upon being forward biased leads to a recombination of holes and electrons with the simultaneous emission of photon energy. The wavelength of this emitted light is in turn governed by the composition of the semiconductor material. Thus, the amount of aluminium determines the center wavelength of the emitted light.

LEDs, SLDs, and lasers are in an ascending order of sophistication (see Table 1). An SLD can be regarded as an emitter that is half-way between an LED and a laser. An LED produces spontaneous emission in its "active" region and thus has a wide spectrum about a central wavelength. A laser has a built-in mechanism in its structure so that light produced in its active region is made to oscillate between its specially designed front and back facets, thus leading to a primary wavelength or mode of operation.

An important application of the optic sensor is in robotics, since it makes possible artificial vision, without which robots can not reach their full potential. Another application of the optic sensor is in seam tracking and process control in arc welding. The sensor is inherently insensitive to the arc light.

An interesting application is the oxygen sensor that measures oxygen saturation in the human blood so as to control the rate of a pacemaker. The sensor is integrated in the stimulation catheter and located in the right ventricle of the heart.

A new line of intelligent sensors promises to rid cars, buildings, aircraft, and factories of most of the increasingly complex wiring. One of these sensors uses a multiplexable optical encoder chip produced for Honeywell by its Optoelectronic Division in Richardson, Texas. This chip combines sensors and analogue and digital circuits on a single wafer. The on-chip sensors can determine direction or rotation, rotational velocity, and angular position.

A new technique to measure physical correlations in multi-use fluid transportation systems has been developed by the Berg Akademie Freiberg in Federal Germany. In this, fibre optic probes are used to accurately measure particle concentration, fluctuation, speed, size, and cross-sectional distribution — all critical in process control and regulation. Among the measurement said to be possible with the system are impurities in water, organic or inorganic liquids, gas bubbles in liquids, crystals in saturated solutions, and flocculants in pipes and other apparatus.

Japan's Sofia University has developed an optic sensor that controls on-off switching for use in optical computers. The optical switch needs no electric circuits, since the optical signals are controlled by light beams. Remote control and information exchange are possible. The development is expected to accelerate the development of optical information processing technology, which forms the basis of optical computers and optical communications.

Semiconductor sensors

Semiconductor sensors have two important advantages over other types: they are invariably produced from silicon, which is a plentiful and well-researched material, and they can easily be integrated with amplifier and logic circuits onto a single wafer.

These sensors are normally encountered in the form of photo transistors or photo diodes. A photo transistor is a detector that consists of a bipolar junction transistor operated with the base region floating. The potential of the base region is determined by the number of charge carriers stored in it. The electromagnetic radiation to be detected is applied to the base of the transistor and produces the base current. The transistor is operated essentially in a common-emitter configuration.

A photo diode produces a current when it is illuminated. There are two main classes of photo diode: depletion-layer and avalanche. Depletion-layer diodes consist commonly of a reverse-biased *p-n* junction operated below the breakdown voltage. The *p-i-n* and Schottky photodiodes are versions of the depletionlayer type. Avalanche photo diodes are reverse-biased *p-n* junction diodes that are operated at voltages above the breakdown voltage.

Sensors for the detection of gases are normally manufactured from other semiconductors materials, such as tin oxide, zinc oxide, titanium oxide, and others.

Thermocouple sensors

Thermocouple sensors depend on the phenomenon that when two dissimilar metals are joined at each end and the two resulting junctions are maintained at different temperatures a voltage is developed between them. Copper-constantan or iron-constantan thermocouples can be used up to 500 °C. Temperatures up to about 1500 °C may be measured with the aid of a platium/platinum-rodium alloy thermocouple, and even higher temperatures may be measured with an irridium/irridium-rhodium alloy thermocouple.

Piezoelectric sensors

When certain materials are subjected to mechanical stress, an electrical polarization is set up in the crystal and the faces of the crystal become electrically charged. The polarity of the charges reverses if the compression is changed to tension. Conversely, an electric field applied across the material causes it to contract or expand according to the sign of the electric field.

Piezoelectric sensors are important since they couple electrical and mechanical energy and, therefore, are used as gramophone pick-ups, loudspeakers, microphones, to name but a few.

Practical applications

Temperature sensors. As already mentioned, many temperature sensors are based on the Seebeck effect that occurs in a thermocouple. They are normally produced in the shape of a probe: a wide variety of such probes is shown in Fig. 1.

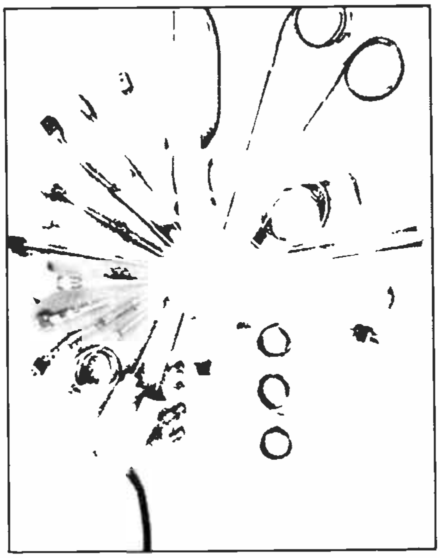


Fig. 1. A selection of thermocouple temperature probes. (Photograph courtesy Omega International Inc.)

Another well-known type of temperature sensor is the thermistor. This is basically a resistor, made from semiconductor material, that has a negative temperature coefficient. This means that when the ambient temperature rises, the element becomes more conductive (its resistance decreases) and the consequent change in voltage across it is a measure of the temperature rise. It should be noted that there are also thermistors with a positive temperature coefficient, whose resistance, therefore, increases when the temperature rises.

Temperature may also be measured by ▷

measuring infra-red (heat) radiation, for which an infra-red sensor as shown in Fig. 2 is used. This technique, called

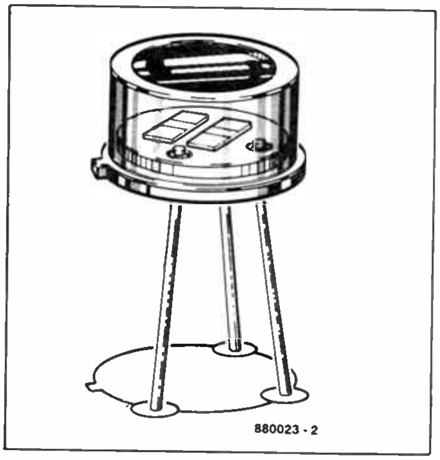


Fig. 2. Typical infra-red sensor.

thermal imaging or thermography, is based on the property that each body or object radiates heat. The technique, for which a camera with a suitable lens system may be used, does not require any external source of illumination. It is used, for instance, in production tests to determine whether any component heats up too quickly (and is, therefore, almost certainly faulty). It is also used in medicine for diagnostic purposes to determine whether any areas of the body have an unusual temperature distribution.

Pressure/force sensors. Although there are various methods of measuring pressure and force, the most common one makes use of the piezoelectric effect as discussed earlier in this article. The most widely used material for the manufacture of pressure/force sensors is quartz. This material has some important advantages over others: (1) it is strong; (2) it is cheap; (3) it is a good electrical insulator so that the electric charge caused by the pressure collapses only slowly.

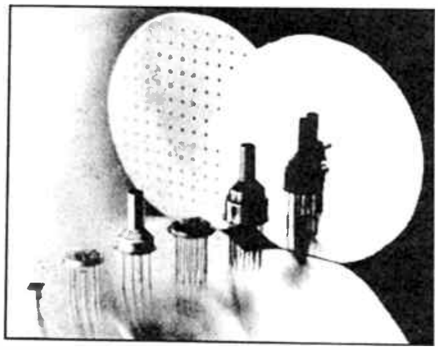


Fig. 3. Constituent parts of a piezo-electric pressure sensor. (Photograph courtesy Telefunken AG).

The parts making up a typical piezoelectric sensor are shown in Fig. 3. It consists of a wafer of silicon only 1 mm in diameter, onto which a tiny piezoelectric crystal and four resistive tracks have been etched with the aid of ion implantation. When pressure distorts the crystal, the resistance value of one or more of the legs of the resistance bridge changes. This type of sensor is versatile: it can be used for measuring absolute or relative pressure, overpressure, and pressure difference. It is suitable for pressures up to 40 MPa.

This type of sensor is, of course, widely used in all sorts of weighing machine. Other areas of use are hydraulics, water works, refineries, filter plants, pressure chambers, and loudspeakers.

Pressure sensors are also used in accelerometers, but there they operate somewhat differently. Such a sensor for measuring mechanical vibrations or impact contains a freely moving seismic mass and a piezoelectric element (normally quartz)—see Fig. 6. When the seismic mass is accelerated in the direc-

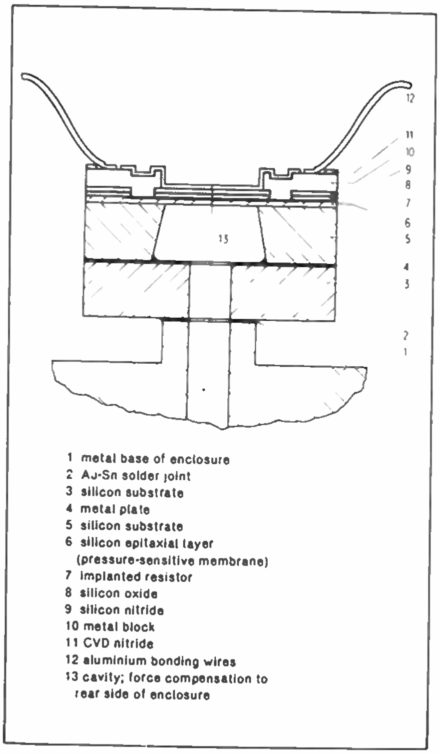


Fig. 4. Construction of a typical piezo-electric pressure sensor. (Courtesy Siemens AG).

tion of its axis, it exerts a force onto the quartz element that is proportional to the acceleration. The element is then distorted and the consequent piezoelectric voltage is used to charge a capacitor. This charge can be measured, but this has to be done quickly as otherwise some of the charge leaks away. At frequencies below the resonant frequency of the sensor, the seismic mass follows the vibrations faithfully. This type of sensor usually contains an integrated preamplifier.

Humidity sensors. Humidity sensors are used almost exclusively in hygrometers,

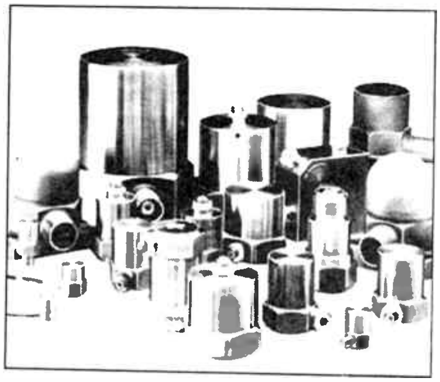


Fig. 5. A selection of typical pressure sensors. (Photograph courtesy Bruel + Kjaer).

i.e., instruments for measuring the humidity of air. In the past, these sensors used a human hair, or a strand of silk, but nowadays they use a capacitor, a dew point mirror, or optical means.

The dew point mirror sensor depends on the effect that when a smooth surface is cooled it mists up. The moment this misting up starts is determined optically. Since it is accurately known at which pressure and temperature gases condense, this technique yields very accurate results.

Another type of dew point sensor consists of a very small wafer of resistive material which has been coated with a hygroscopic chemical. The wafer is fitted with two electrical terminals. When mist forms on the coating the resistance of the wafer increases. This type of sensor is quite vulnerable, but because of its very small dimensions, it is used in Sony's 8 mm Camcorder.

Optical humidity sensors make use of the property that gas molecules absorb energy at certain frequencies: water vapour does so in the infra-red region. It is thus possible with the aid of an infra-red sensor to determine how much energy is absorbed. The higher the humidity, the more energy is absorbed. This technique has the disadvantage that the infra-red sensor soils up easily and then becomes unusable.

Nowadays, the most important and best-value-for-money type of humidity sensor

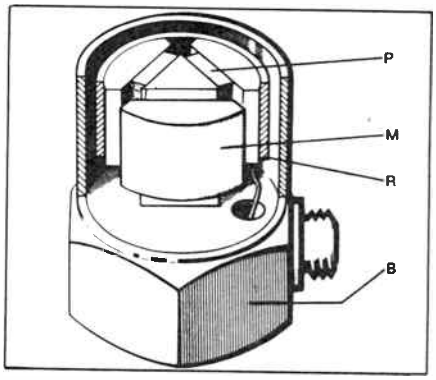


Fig. 6. Construction of accelerometer sensor. M = seismic mass; P = piezo-electric element; B = underside; R = initial tension. (Courtesy Bruel + Kjaer).

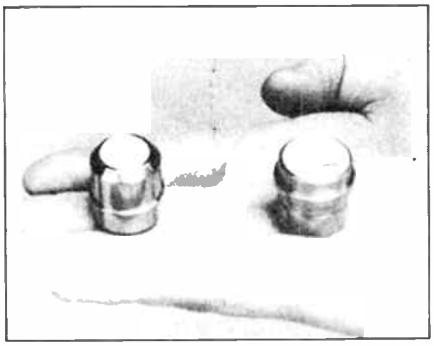


Fig. 7. These twin axis gyros belong to a range of inertial sensors that includes rapid start coasting displacement gyros, rate gyros, Dynamically Tuned Gyros, and linear accelerometers. (Photograph courtesy British Aerospace).

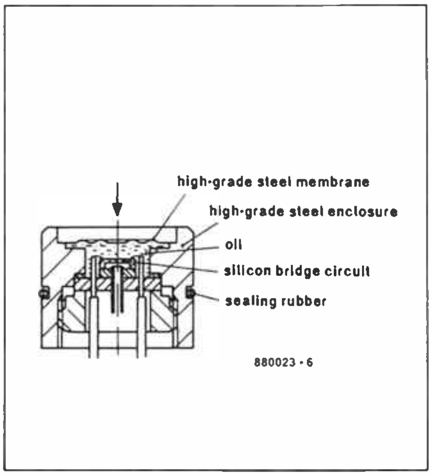


Fig. 8. Construction of a combined pressure and temperature sensor. (Courtesy Sensortechnik Widemann).

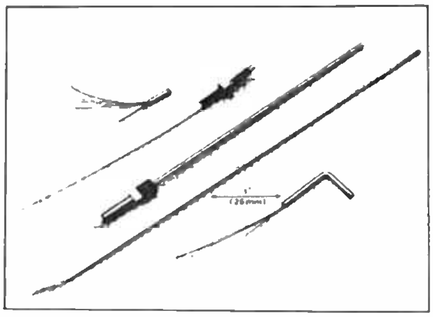


Fig. 9. Selection of EPI Series pressure probes. (Photograph courtesy Entran Ltd).

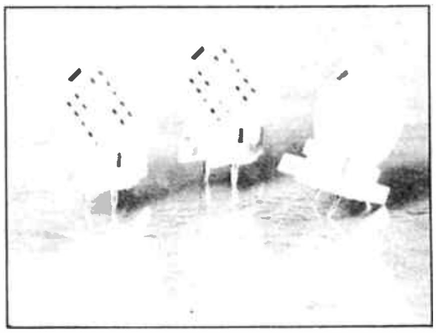


Fig. 10. Some tiny semiconductor humidity sensors. (Photograph courtesy Valvo Philips).

is based on a capacitor. This is, of course, a special capacitor which as a dielectric that is sensitive to humidity. In the Valvo sensor—see Fig. 10—the dielectric is in the form of a foil that has been coated at both sides with gold, which forms the electrodes. Humidity changes the dielectric constant of the foil and thus the capacitance of the capacitor. Since this capacitor forms one of the legs of a capacitive bridge, the change in capacitance can be readily converted into an electrical voltage.

Gas sensors. As stated before, gas sensors are normally based on a variety of semiconductor materials. Such materials have the property that their resistance decreases when certain gases are present in the surrounding air. This effect is caused by adsorption of gas molecules on the surface of the semiconductor material. The consequent layer of gas molecules influences the conductivity, and thus the resistance of the element. These sensors are very sensitive: concentrations of only 1 ppm of the relevant gas in air are readily detected.

A variant of this type of sensor is Telefunken's ISFET—see Fig. 12. Basically, this is a modified MOSFET in which the usual metal gate has been replaced by a layer that reacts to the ions of certain gases. ISFETs are unbreakable, small, have a low-impedance output, have a large linear range of operation, are temperature compensated, and provide an output signal that is suitable for driving a microprocessor.

Many gas sensors still depend (and will continue to do so) on a chemical reaction to generate an electrical voltage, current, or resistance change. Yet other sensors use the heat generated by the combustion reaction when a gas hits the surface of the sensor. This heat is applied to a platinum wire whose resistance then changes.

There are also optical gas sensors and these are used particularly for the detection of fire or smoke. They normally use a photo diode or photo transistor to monitor the light absorption behaviour of the surrounding air. When smoke darkens the air, the photo transistor switches off and this operates an appropriate actuator.

Light sensors. Popularly probably the best known type of sensor is the light sensor. This can be based on a photo diode, photo transistor (see Fig. 13), p-i-n diode, photo varistor, or solar cell. All of these are made from the same material, silicon, and function in similar fashion at wavelengths from about 400 nm to around 1000 nm.

Photons enter the silicon and cause a number of electrons to jump to a different energy level. This in turn causes a photo current which can be used to operate an actuator.

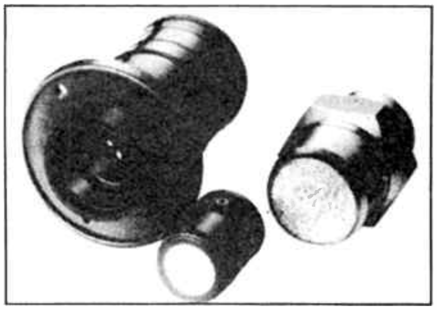


Fig. 11. Some typical gas sensors. (Photograph courtesy Drägerwerk AG).

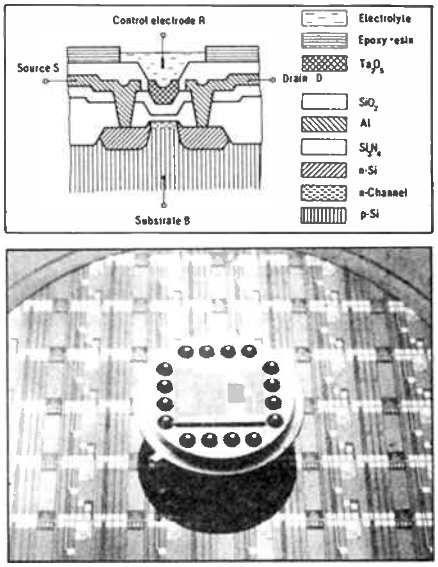


Fig. 12. The ISFET is a modified MOSFET used as a gas sensor. (Courtesy Telefunken AG).

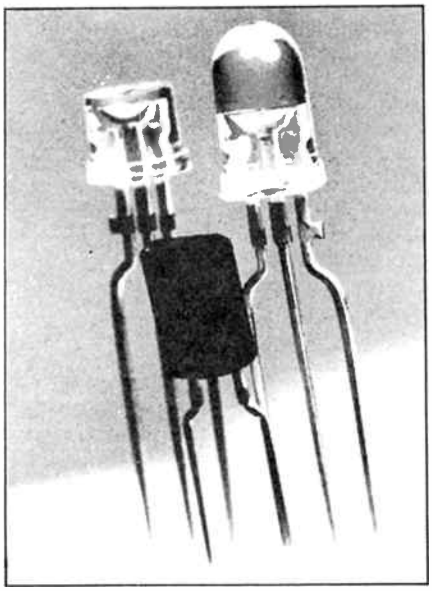


Fig. 13. Some typical photo transistors with in the centre an infra-red photo diode.

For wavelengths below 400 nm (ultraviolet light), photomultipliers are used. These are normally constructed as a valve and have the usual advantages of electron tubes: good bandwidth, low noise factor, high amplification. Primary electrons, emitted from the ▷

cathode as a result of photon bombardment, are accelerated by the field between anode and cathode and arrive at the anode with great energy, causing a current in the anode circuit. The anode current is much greater than the original cathode current, whence the name photomultiplier.

Photo detectors as described were also used as light sensors in camera tubes, but nowadays they are largely superseded by CCD (charge-coupled device) sensors, particularly in video cameras, medical cameras, and robotics. CCDs are small: typically, one the size of a 28-terminal IC has a resolution of 60,000 elements. Each of these elements consists of a photo diode with a light-sensitive area of only a few micrometres. Each photo diode is accompanied by a MOS capacitor that stores the generated photo electrons. The charge on the capacitors is read at regular intervals by a shift register. Suitable circuits integrated on the device process the information to a suitable level for driving a microprocessor.

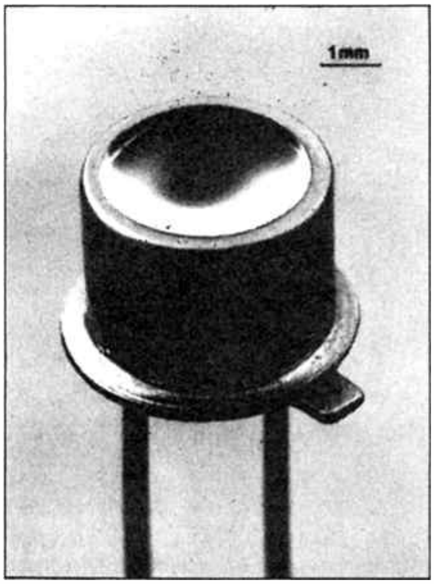


Fig. 14. Photo diode used as a gas sensor. (Photograph courtesy Plessey Semiconductor).

Biological sensors. During the past few years, a new type of sensor has entered the fields of biology and medicine. These so-called biosensors consist of biological molecules, such as enzymes and antibodies. When such sensors react to other substances, a small electric signal is generated that can be detected with the aid of a suitable electrode (probe).

Remote sensing. Another interesting new field where sensors are indispensable is that of remote sensing. This exciting new technique has been made possible by the routine availability of satellite information for the entire surface of the earth. Remote sensors on board satellites provide digital data in seven wavebands of visible light, reflected infra-red radiation, and thermal infra-red radiation.

Different surfaces reflect different amounts of radiation, which is why they appear in different colours and light intensities to us. In the same way that we distinguish objects by their appearance (but in a more sophisticated manner), these remotely sensed images can be used to identify the land-cover types which exist in an area. Since they record in the infra-red region, many things we cannot normally see are shown. Crop condition and the thermal properties of buildings or water can be 'seen' and displayed, for instance.

Remote sensing enables scientists to study the earth's surface on a scale which was until recently only dreamed of. For a very small part of the time it would take to survey a large area by conventional methods, digital information can now be used to identify and measure the extent of crop types, major land uses, soils, properties of water bodies, geological structures, and vegetation conditions. In sparsely populated areas, the existence of certain surface features is being established for the first time, and over all areas of the world, what were previously partial surveys can now be completed. A great attraction of remote sensing is the relatively low cost of large-scale surveys. For instance, images with ground resolution down to 10 m and covering 50 km × 50 km can be obtained for less than £1,000.

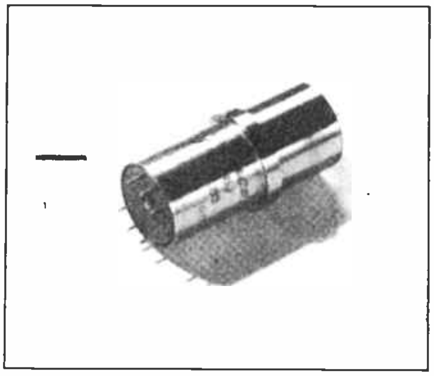


Fig. 15. The DART (Dual Axis Rate Transducer) is a miniature gyro particularly suited for stabilization of laser, infra-red, and radar seeker systems. The sensor, which is only 40.6 mm long and has a diameter of 18 mm, uses a rotating piezo-electric crystal to sense the applied rate. (Photograph courtesy British Aerospace).

Much pioneering work on remote sensing has been carried out in Britain by Salford University.

A final thought. Although the science and technology of sensors and actuators has made vast strides in the past few decades, the most complex, reliable, and versatile sensor system remains man. Coupled with his intelligent data processing unit which almost certainly will not be emulated during the life of anyone alive today, he forms a formidable system of intelligence. A pity we do not always appreciate it.

We acknowledge with thanks the cooperation and help received from the following organizations in the preparation of this article: British Aerospace; Bruel + Kjaer; Drägerwerk AG; Entran Ltd; Hawker-Siddeley; IGI Consulting Inc.; Omega International Corporation; Plessey Semiconductor; Salford University; Sensortechnik Wiedemann; Siemens AG; STC Mercator; Telefunken; Valvo Philips.

▷ – FM Preamp, from page 44. ▷

Tune the FM receiver to a relatively weak transmission at about 108 MHz, and make a note of the signal strength. Connect the input of the completed preamplifier to the aerial, **not** a cable network outlet. The preamplifier output is connected to the appropriate soldering terminal on the tuning/supply board via a short length of coax cable. Similarly, connect the unbalanced (75 Ω) input of the FM receiver to the RF (RX) output on the tuning/supply board. Set P_1 to +26 V on the cable to the preamplifier. Verify the presence there of +12 V on C_3, and +14 V on C_5. Use a plastic trim tool to adjust the screw core in L_1 for optimum reception. Vary the supply voltage between 22 V and 26 V to check that this tunes the preamplifier.

Set the supply to +15 V, and tune the receiver to a signal at the lower band edge, i.e., approximately 88 MHz. Check that L_1 is still adjusted for optimum reception by carefully adjusting the core. Tune to a number of stations at regular frequency intervals in the FM band, optimize reception by adjusting P_1 in the tuning/supply unit, and make notes of the downlead voltage. If necessary, redo the adjustment of L_1 to ensure that the span of the tuning voltage covers the entire FM band. For optimum tracking of the resonance frequency with the tuning voltage applied to the varactors, the core in L_1 should be turned to about halfway the aerial winding. This completes the initial adjustment of the FM band preamplifier, which is ready for fitting into a waterproof enclosure.

The next instalment in this series will deal with preamplifiers for the shortwave, VHF and UHF TV bands. *B*

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Arista call their new cable stripper "Model No. CS100". It is designed to simultaneously strip the insulation and eject it.

The CS100 can strip insulated cables with outer diameters of 1.0 mm, 1.6 mm, 2.0 mm, 2.6 mm and 3.2 mm, all the common hookup wires – without causing fractures to the wire conductors, Arista claims.

The tool features PVC insulated handles and is constructed entirely of metal which is finished off in heavy duty grey paint, all ensuring it has a long service life, says Arista.

For more information, or the name of your nearest stockist, contact **Arista Electronics, 57 Vore St, Silverwater 2141 NSW. (02)648 3488.**

Bargain in DB connectors

Anyone who dabbles with computer equipment always needs DB connectors – particularly DB25s and DB15s. There's no way you can get by for long without spares on-hand.

Adelaide-based Force Electronics has bargains in all the popular DB-series connector bits and pieces at present, at under half their usual cost!

DB25 male connectors, DB25 females and DB25 back shells are all down to a lousy dollar, from $1.95. Unbeatable! Plus DB15s and DB37s are down to 50¢!

It'd be a waste to let them go. Force has five stores in Adelaide, and they do mail order. Contact their main store at **203 Wright St, Adelaide 5000 SA. (08)212 5400 for further details.**

Lead-Acid battery bargain!

Rechargeable, sealed lead-acid batteries find wide application in electronics, from powering radio-controlled models to backups in burglar alarms.

Adelaide's major retailer, Force Electronics has 12V, 1.2 amp-hour sealed lead-acid batteries for under $20 at present. A bargain when you expect to pay around $30 even when you shop around!

Force has five stores, at Enfield, Brighton, Christies Beach, Findon and Adelaide. Ring the city store if you need further details. **(08)212 5505.**

PROJECT BUYERS GUIDE

Kits for the AEM9505 Plug Pack NiCad Charger will be stocked by Jaycar. The components are widely available and printed circuit boards will be obtainable from All Electronic Components in Melbourne. Jaycar distribute the plug pack case employed in our prototype.

The AEM4512 VZ Ultragraphics Adapter will be available in kit form from Dick Smith stores; Jaycar has also indicated they're interested in stocking it as a kit. Printed circuit boards should be obtainable from All Electronic Components in Melbourne if you're assembling the project from parts on hand, while EPROMs are available from the author.

If you're interested in the Uniphase Loudspeaker design in this month's Elektor section, the drivers are available from Audax Loudspeakers, 295 Huntingdale Rd (PO Box 100, Huntingdale 3166 Vic., (03)543 5266. We contacted the proprietor, Bill Webb, who advises that, while the Audax drivers are expensive, they provide very high performance. Early costings indicate that a complete kit of drivers and crossover components would cost between $1100 and $1350 per pair.

Components for the Elektor FM Preamp this issue are available from Stewart Electronic Components, 44 Stafford St, Huntingdale 3166 Vic. (03)543 3733. Technical Director John Day advises that the semiconductors are available ex-stock (BB405B and BF981), as is the 1n ceramic chip capacitor. For the L43-10 coil former set specified, Stewart's coil former stock No. FC598 should do for L1 (but you may need to re-drill the board to accommodate it). For L2 and L3, John suggests an FB101-43 (stock No. FC540) would with 32 swg wire for L2 and 28-30 swg wire for L3. The same goes for L1, L2 and L3 in the Tuning & Supply unit.

Aghast! In March's column, we omitted Adelaide's Eagle Electronics as a supplier of the AEM1502 FM "Minder" Wireless Mic. They have kits in stock now.

Low-cost 3-pin IEC mains connectors

Dick Smith Electronics currently has a bargain on 3-pin IEC mains connectors, the type now widely used on so much equipment – computers, transceivers, test equipment, etc.

Both line sockets and chassis-mount plugs are available, and they cost just $2.95, down from almost $5.

Rip into your nearest Dick Smith store and stock up, they'll never go astray.

Mini relay handles 240 V

A double-pole changeover relay that can switch 240 Vac at up to 2 A that fits in a standard dual-in-line IC socket? You better believe it!

We spotted these in Geoff Wood Electronics not long ago. Made by Matsushita (National), these relays measure just 20 x 10 x 9.3 mm and feature a 12 V coil.

Ideal for mounting on crowded boards, they're a bargain at just $3.50. Check them out at **Geoff Wood Electronics, 229 Burns Bay Rd, Lane Cove West 2066 NSW. (02)427 1676.**

KITS KITS

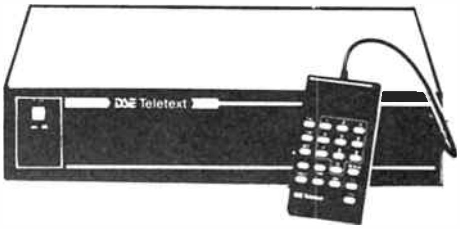
KITS KITS

Free Teletext!

Yep, the Teletext transmissions are yours absoutely free of charge, courtesy of your local TV station (not in all areas — sorry!). All you need is a Teletext decoder to pick up the latest news, sports results, financial info, stocks and shares, recipes, etc.

Build your own Teletext decoder — it works through your VCR so you save a fortune. Complete with hand controllers. Cat K-6315

$269



Cat FAX/RTTY

Wow! This easy-to-build decoder enables your CAT or Apple computer to print out weather maps and data received from AXM broadcasts — based on the facsimile principle. Cat K-6335

$29.95 **½ price**

LIMITED STOCK

Interested In Robotics?

Biometal Starters Kit

Save $80! Get in on a new science. The perfect place for the beginner to learn all about Biometals and their uses (mainly in robotics). Kit comes complete with pre-assembled circuits, matrix board, wire, etc. and comprehensive text giving the history, principles and structures of biometal actuators as used in most spheres of robotics. Cat K-7000

WAS $179 **LIMITED STOCK**

NOW ONLY $99

Build an amplifier: economically!

Here's a great first "big" project. When you've finished mucking around, build an amplifier! It's not too difficult — our new Economy Amplifier Kit makes it a cinch! Kit is "short form" — does not include case (H-1900) or transformer (M-6672). Over 8W per channel at <0.05% distortion, CD, tuner, disc and aux inputs. Cat K-4001

$99.95 SHORT FORM KIT

Colour TV Pattern Generator

The serviceman's right hand man!

If you're in the trade, then you'll find this one a cinch to build! Designed to be as close as possible to the Australian standard, but can easily be constructed for NTSC operation as well.

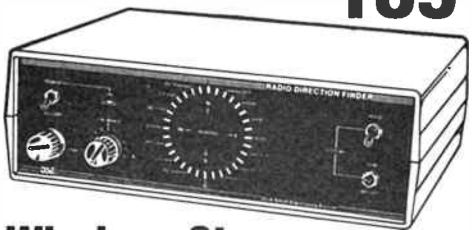
Portable, the pattern generator is powered by a 12 volt AC plug pack and provides 8 patterns — colour bars, red/white/black screen, cross-hatch, vertical/horizontal lines and dot pattern. It's sure better value than ready made models! Cat K-3473

$139 **NEW!!**

Radio Direction Finder

When coupled with a suitable FM receiver it rapidly indicated the direction of the RF signal being received. 32 LEDs represent the 32 points on the compass, indicate the direction of the received signal. Cat K-6345

$159



Wireless Stereo Headphone Link **New!**

Enjoy high quality sound reproduction on your headphones without messy cables — with the DSE Stereo Infrared Headphone link! It saves having your ears ripped off when someone trips over the cable, allows you to listen to your favourite program while the rest of the family listens to theirs and it's ideal for anyone who's hard of hearing!

Both the Transmitter and Receiver are packaged in a compact case, which can be held in one hand, so they're not going to clutter up the table, television and benchtop. Use it on your stereo, TV... anything!

FEATURES

- Volume control on both transmitter and receiver
- Compact case — 68 × 136 × 26mm (both)
- Screened aluminium front panel
- Great range
- Suits 32-100 ohm headphones or high efficiency speakers
- Transmitter power — 12V plug pack
- Receiver power — 9V battery
- FM stereo transmission

Transmitter Cat K-4005

Receiver Cat K-4006

ONLY $48.95 ea

Low cost alternative to pre-built amateur gear

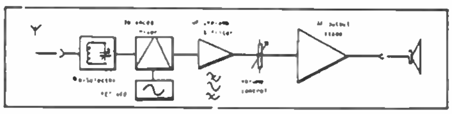
Here's amazing value: build your own 80 metre CW transceiver for under $150! And even more: you build it section-by-section — you don't have to buy the lot at once. Famous British quality kits from CM Howes Communications, these three kits (each a separate practical project) combine to form an 80 metre QRP transceiver with up to 5W output. Absolutely perfect for YRCS, Scout, school and club projects. And so affordable! And it's the perfect way to get into the fun and excitement of amateur radio.

Receiver Module Kit:

Operates over full 80 metre band with direct conversion receiver. Balanced mixer and FET VFO, all very easy to build on one pcb. 12V DC operated. Complete instructions with all components and pcb. Cat K-6328

Requires 2 × 50pF tuning capacitors. Cat R-2980 ($6.95 each)

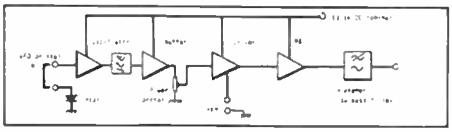
$59.95



Transmitter Module Kit:

Stand-alone transmitter or add to receiver for "transceiver" operation. Easy to build — all instructions included along with pcb and components. Adjustable output up to 5W — all you add is a power supply and key. It's that simple! Your choice of crystal locked (rock included) or optional VFO control. Cat K-6326

$49.95

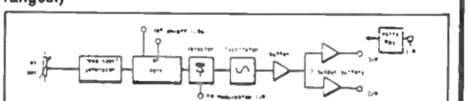


VFO Module Kit:

Gives full VFO control over 3.5-4MHz — designed especiallly for above transmitter, but can also be used as a general purpose variable frequency oscillator. Even has provision for FM modulation to give phone capability. Instructions include various modifications and options — and alignment details. Cat K-6327

$39.95

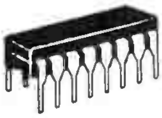
(Note: tuning capacitor not included in kit. Our R-2980 50pF tuning capacitor [$6.95] will give approx 300kHz tuning range. Other capacitors will give different ranges.)



LS IC Specials

You better be quick to grab some of these bargains in 100 lots only!

74LS00 **$10.00**/100
74LS02 **$10.00**/100
74LS21 **$10.00**/100
74LS93 **$15.00**/100
74LS109 **$15.00**/100
74LS390 **$15.00**/100



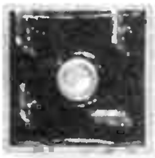
SUPER SPECIAL 6850 ACIA for $2.00?

Yes - this month you can have 'em in ten lots for just **$20.00!** Intended for 6800 systems the 6850 provides asynchronous comms interfacing. Optional even or odd parity, programmable control register, choice of clock modes, upto 1Mbps transmission. Double buffered. Interface includes select, enable read/write, interupt and logic to allow 8-bit bidirectional operation. Provides proper formatting and error checking. All this and only **$20** for ten!

Conductive IC Tubes

Hard to get conductive plastic IC tubes. Get yourself organised - Geoff has located a number of them and they're only **10c** each!!

Bridge Rectifier Bargain



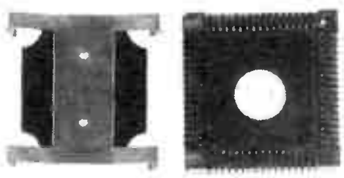
400V, 35A
$4.50 (**$40**/ten)

FND500 Replacement

So many projects have used the popular FND500 led display. Alas the FND500 is no longer available. But Geoff has found a direct replacement - the LTS543 from Liton. And they're only 80cents each. The catch is you have to buy ten of 'em! LTS543 - **$8.00/ten**

Chip Carriers

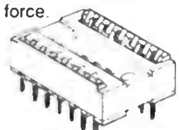
68 pin leadless chip carriers, gold-selective plated, stainless steel retaining clip.
Only **$10** each.



Robinson Nugent IC Sockets

These are prime quality RN low profile, single wipe sockets with anti-overstress contacts. They allow extremely high board densities and can be end stacked. They are self locking for wave soldering. Glass-filled polyester body. Berrylium copper side-wipe contacts with low insertion force.

18pin **$1.50**/ten
20pin **$1.50**/ten
22pin **$2.50**/ten
24pin **$2.50**/ten



Call us with your requirements- we have a full range at very competitive prices

For the professional user we have an extensive range of wire-wrap products such as OK quality tools -

Just Wrap

Handy wire wrap tool comes complete with 15m of wire which clips on to tool. No stripping required. Cuts wire from spool too Very limited quantity only at **$11.95** (Specify wire colour below)

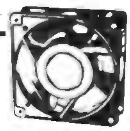
Wire 100ftx 30AWG **$12.00** per roll (specify colour - blue, red, white or yellow)

Hobby Wrap Tool **$29.90**

IC Socket Templates

These time savers slip over the pins on wire wrap sockets to aid identification - wire holds them on. Saves making mistakes! 8 pin **80c**/four,14, 16 and 18 pin **$1.10**/two, 20, 22, 24 and 28pin **$1.50**/two

Quality Fans slashed $6.00



Geoff needs the floor space as there are so many new lines coming in, so he's cut $6.00 off the price . Were $25.95, Now only **$19.95**

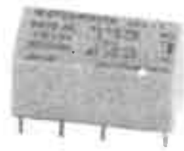
Motorola 12061 Crystal Oscillator IC Special

Geoff has found a way to use this IC in both parallel and series modes. Tests show that with a few extra components, it is usable upto 14MHz. Supplied with circuit for **$3.25.**

Variac Adjustable AC Supply

250V, 5A rating. Enables you to set ac supply to exact voltage you require. **$175** P&P $15.00 (It's very heavy!)

Watch out for Geoff's huge Semiconductor listing in the April Issue of Silicon Chip



National Miniature Relay Special

We goofed - the Matsushita relays we advertised a month or two back are double pole latching! 60W, 125VA. Will handle 240Vac and upto 2A switching. 12V coil. Measure only 20mmx10mmx9.3mm 1500V surge rating. Fits standard IC socket. Only **$3.50** each

Fluke Multimeters

A great investment for professional users. Geoff has the 20 series and 70 series. Check the prices!!

Model 73 **$192**
Model 75 **$205**
Model 77 **$339**
Model 23 **$365**
Model 25 **$545**
Model 27 **$625**

Fluke 70 Series
- 3200 count display
- 75 adds beeper
- 77 adds Touch Hold

Fluke 23
- 10A range
- Rugged, High energy safe
- Touch Hold

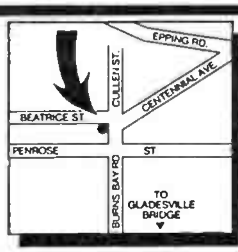
Fluke 25 & 27
- Touch Hold
- 0.1% accuracy
- Min-Max on 27
- Relative mode on 27

Piano Style Keyboard Switches $1.50

Available in Black only and from famous manufacturer - we can't say the name when the price is so ridiculous - **$1.50** with LED, **$1.25** without

GEOFF WOOD ELECTRONICS

GEOFF WOOD ELECTRONICS PTY LTD
229 Burns Bay Road, (Corner Beatrice St.) INC IN NSW
Lane Cove West, N.S.W. P.O. Box 671, Lane Cove N.S.W. 2066
Telephone: (02) 427 1676, Fax: (02) 428 5198.
8.30am to 5.00pm Monday to Friday, 8.30am to 12 noon Saturday.
Mail Orders add $3.00 to cover postal charges.
Next day delivery in Sydney add $5.00.
All prices INCLUDE sales tax.
Tax exemption certificates accepted if line value exceeds $10.00.
BANKCARD, MASTERCARD, VISA, CHEQUES OR CASH CHEERFULLY ACCEPTED



SUPPORT WORLD WILDLIFE FUND AUSTRALIA

An "ultra-graphics" adaptor for the VZ200/300 computers

Matthew Sorell

Are you sick of the graphics and text restrictions on your VZ200/300? Then this project is for you. Offering 256 new characters, including upper and lower case, Greek, DATA70, mathematical and other symbols, as well as graphics up to six times the normal resolution, the Ultra-Graphics extension board is a must for the serious VZ200/300 owner.

INSIDE THE VZ computer lies a very versatile video IC. Unfortunately, the designers were working on a low budget machine and so the graphics capabilities are quite limited. However, by extending the amount of video RAM used, adding a character generator EPROM and a few other ICs, the graphics capabilities of both the VZ200 and VZ300 can be fully realised.

The first problem, then, is to fit 6K of RAM into a 2K memory position. To do this, a latch was used to provide an extra two address bits to bank switch an 8K RAM into the normal 2K of video RAM space, in position 7000-77FFH (28672-30719). As an 8K RAM is used, but the highest resolution available only uses 6K, an extra 2K of general data storage RAM is available. This can be used, for example, to store character definitions for use in high resolution graphics.

The latch used was installed into I/O address 20-2FH (32-47), which is the same position as the joystick controller. However, as the joystick is a Read-Only device, a Write-Only Latch will not interfere with it. The latch also controls the new graphics and text modes.

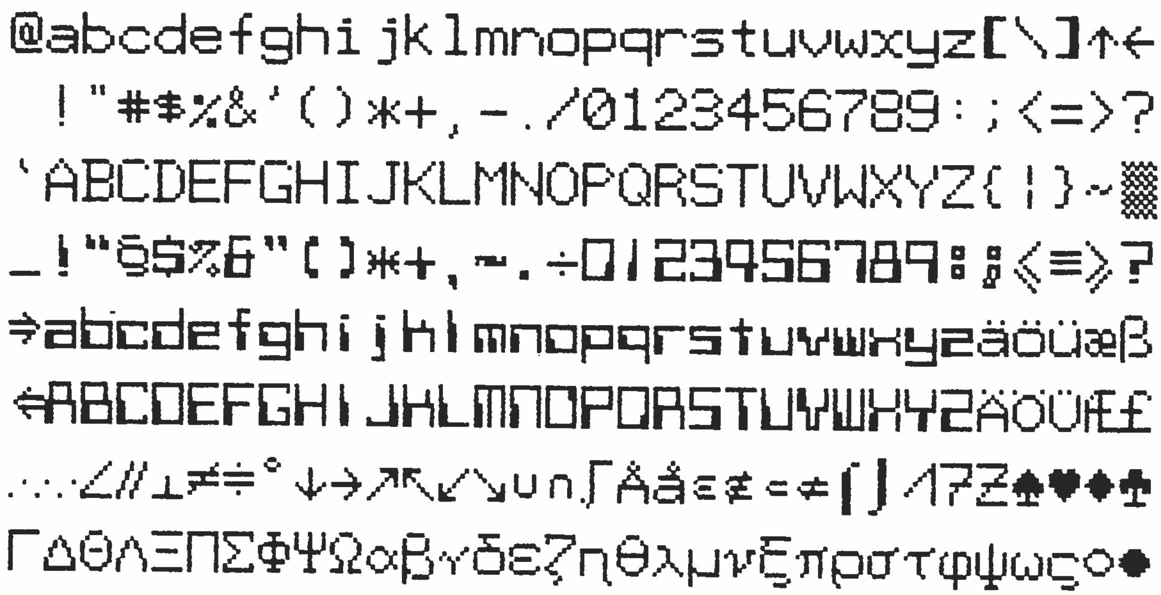
A word of warning: This project is an extensive internal modification to the VZ200 or VZ300 computers. If you are not confident about modifying the computer, then I recommend you do *NOT* attempt this project without experienced help. I also strongly recommend you obtain a copy of the "VZ300 Technical Manual", which will assist you if problems arise. Building this project also voids the manufacturer's warranty, so it's best tackled after your machine's warranty has expired.

New characters, extended graphics

The new character set is shown in Chart 1 here. It was originally designed to be compatible with the VZ word processor (tape version). Thus there is the 96 standard ASCII characters, which are slightly out of order to be more compatible with the standard VZ text. There is also a DATA70 ("computer" type) character set, a Greek character set, some international characters, and mathematical symbols which can be accessed by poking their code into video memory, or printing the correct semigraphics character in the right colour. A dedicated screen controller routine could also be used.

The new graphics modes serve many useful purposes. The highest resolution graphics mode (256 x 192 pixels), is equivalent to the resolution in text mode, and so can be used either for text, using a suitable driver routine, or for graphics,

CHART 1. The new character set. Note the addition of special symbols, Greek and maths symbols and Data 70 characters.



VZ-200/300 ULTRA GRAPHICS CIRCUIT DIAGRAM

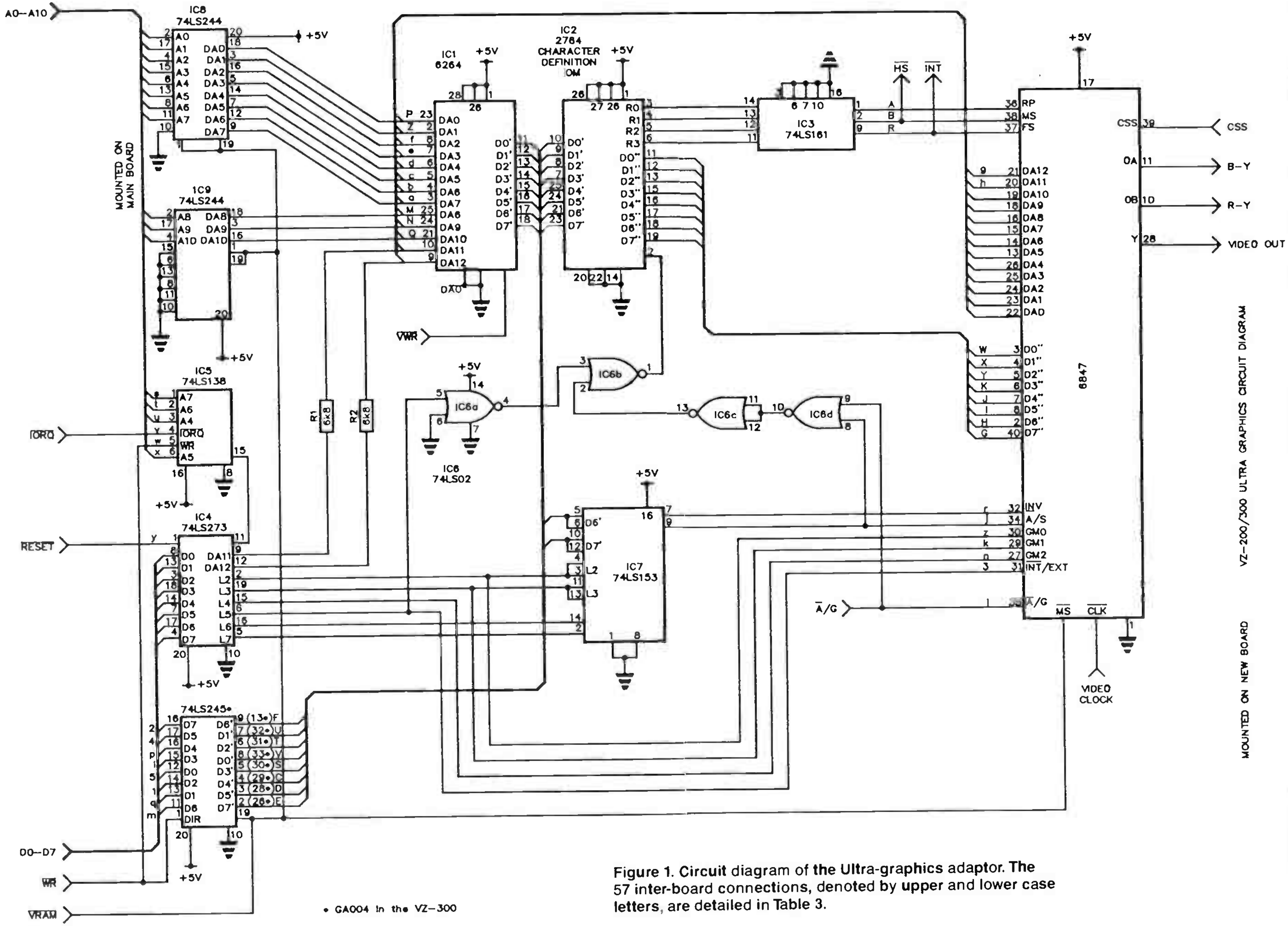
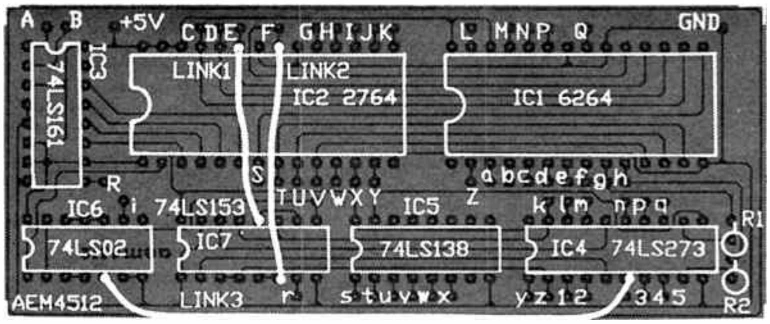
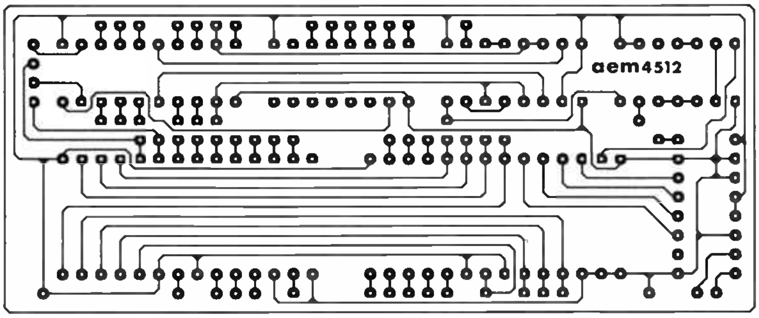


Figure 1. Circuit diagram of the Ultra-graphics adaptor. The 57 inter-board connections, denoted by upper and lower case letters, are detailed in Table 3.



Overlay for the printed circuit board showing the placement of components and where the inter-linking wires connect. Note the links on the board.



Full-size printed circuit artwork.

PARTS LIST

Resistors		¼W, 5%
R1,R2		6k8
Semiconductors		
IC1	6264	8Kx8 static RAM
IC2	2764	8Kx8 Char. Set EPROM
IC3	74LS161	
IC4	74LS273	
IC5	74LS138	
IC6	72LS02	
IC7	74LS153	
IC8,		
IC9	74LS244	

Miscellaneous

AEM4512 pc board; 2 x 28-pin low profile IC sockets; thin insulated hook-up wire (ribbon cable).

Price Estimate: $40-$50

* A fully programmable EPROM with the character set in Chart 1 is available from:

Matthew Sorell, 41 Mills St, Clarence Pk, 5034 S.A.

for $18 including postage. Customised character sets are negotiable. Kit suppliers may include pre-programmed EPROMs; check with your supplier first.

such as graphs or high resolution pictures. With an analogue to digital converter, the VZ computer could be easily used as a low cost laboratory computer, able to graph results with acceptable resolution. The highest resolution colour mode (128 x 192 pixels) is also similarly useful.

It is also possible to access the 3 x 2 semigraphics in text mode, which occurs when graphics characters are called while the external character generator is enabled. For more information on the graphics and text capabilities, see the two-part feature "Screen Handling on the VZ200/300", by Bob Kitch, in the September and October 1986 issues of AEM.

CIRCUIT OPERATION

IC5 (74LS138) decodes A4-A7, IORQ and WR to recognise I/O port 20-2FH(32-47). WHen this occurs, pin 15 goes low, causing IC4 (74LS273) to latch the contents of the data-bus (D0-d7). This latch is cleared on RESET to ensure that text is sent to the correct memory page. DA11 and DA12 are bits 00 and 1. They provide bank switching to fit the 8K RAM into the 2K video memory allocation (7000-77FFH (28672 to 30719)). L2, L3 and L4 signals control the graphics mode pins on the 6847 video IC, L5 controls the internal/external character sets and with this the 2 x 2 (normal) or 3 x 2 semigraphics modes. L6 and L7 control whether the inverse and semigraphics modes follow bits 6 and 7 of the character code (normal) or L2 and L3 respectively.

The output of IC1 (6264) controls address lines 4 to 11 of the character EPROM. The EPROM is programmed to mirror the output of IC1 UNLESS the external character set is specifically required. In this case, pin 2 of IC2 is sent high by IC6 (74LS02), which decodes when L5 is high and the video IC is in text mode. IC7 (74LS153) multiplexes the inverse and semigraphics control lines, and is controlled by L6 and L7 to decode L2, L3, D6' and D7'.

IC3 (74LS161) is a synchronous binary counter. It counts through the external character set in the EPROM, so that the correct character row data is released.

Construction

The first thing to do, no matter whether you've purchased a kit or assembled your own parts and made your own printed circuit board, is to check the pc board. See that all the holes are drilled and that there are no broken tracks or tiny copper 'bridges' between the closely-spaced IC pads. Correct any problems you find.

You can commence assembly by first installing the resistors, IC sockets and the non-socketed ICs into the printed circuit board, as shown in the overlay diagram here. The three links should be made on the solder side of the board using insulated wire. Now install the 57 interconnecting wires as required. Make these about 150-200 mm long for the time being. The wire used should be as thin as possible. Separated ribbon cable is quite suitable. The wires should be connect through the component side of the pc board.

Now open the computer by removing the six screws underneath. Remove the main board by undoing the four screws holding it in. Be careful not to flex the keyboard cable too much; if it breaks, it's the devil's own job fixing it. Note which wires go to the power switch and the loudspeaker, then desolder these, leaving the wires on the main pc board.

Desolder the RF shield covering the main board. Use solder wick to do this. Remove the 6116 RAM on the main board, near the TV modulator. The best way to do this is to cut the pins on one side of the IC and wobble it on the other side until the rest of the pins break. Just make sure you've got go the right chip! Now remove the pin stubs left in the pc board. ▷

LEVEL

We expect that constructors of an

INTERMEDIATE

level, between beginners and experienced persons, should be able to successfully complete this project.

TABLE 1. VZ200 – tracks to cut.

IC	Pin # to	IC	Pin#	Position
6847	29	+5v	-	Adjacent to pin 29 (top side)
6847	32	6847	2	Under 6847 (solder side)
6847	34	6847	40	
6847	40	74LS245	2	Between ICs (solder side)
6847	8	74LS245	3	Between ICs (solder side)
6847	7	74LS245	4	Between ICs (solder side)
6847	6	74LS245	5	Between ICs (solder side)
6847	5	74LS245	6	Between ICs (solder side)
6847	4	74LS245	7	Between ICs (solder side)
6847	3	74LS245	8	Between ICs (solder side)
6847	2	74LS245	9	Between ICs (solder side)
6847	27	Ground		Lift pin out of PCB
6847	30	Ground		Lift pin out of PCB
6847	31	Ground		Lift pin out of PCB

TABLE 2. VZ300 – tracks to cut.

IC	Pin# to	IC	Pin#	Position
6847	32	GA004	27	Under 6847 (solder side)
6847	3	GA004	33	Under 6847 (solder side)
6847	4	GA004	32	Under 6847 (solder side)
6847	5	GA004	31	Under 6847 (solder side)
6847	6	GA004	30	Under 6847 (solder side)
6847	7	GA004	29	Under 6847 (solder side)
6847	8	GA004	28	Under 6847 (solder side)
6847	34	GA004	26	Under 6847 (solder side)
6847	40	6847	34	Under 6847 (solder side)
6847	2	6847	32	Under 6847 (solder side)
6847	27,30,31	Ground	-	Cut, separate and remove track under 6847 (solder side)
6847	29	+5V		Lift pin out of PCB

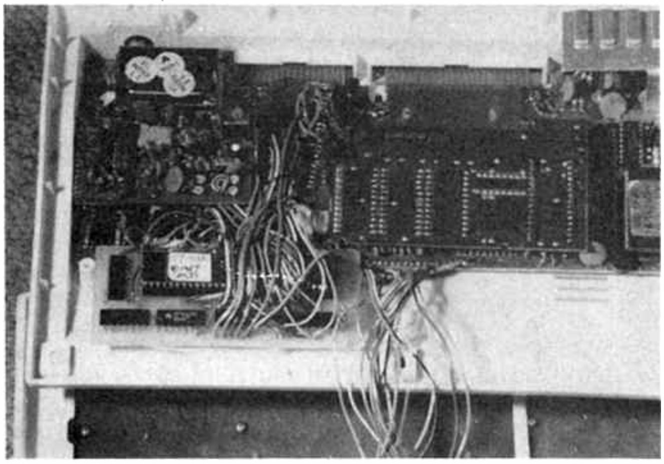


Photo 1. The Ultra-Graphics board installed in the VZ200.

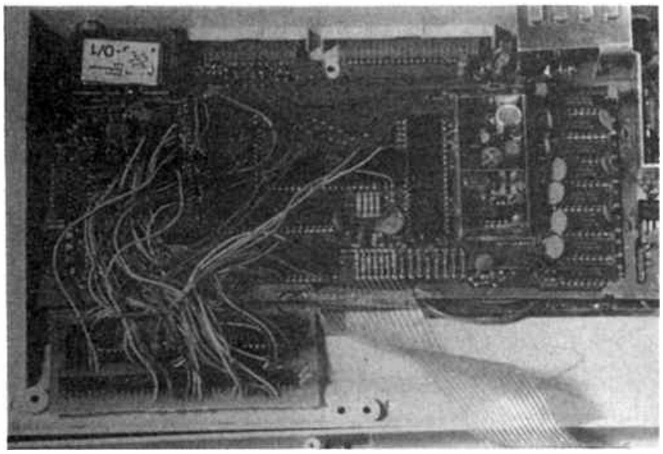


Photo 2. The Ultra-Graphics board installed in the VZ300.

TABLE 3. Interboard connections.

Wire #	VZ-200 IC	Pin #	VZ-300 IC	Pin #
A	6847	36	6847	36
B	6847	38	6847	38
+5V	SUPPLY RAIL		SUPPLY RAIL	
C	74LS245	4	GA004	29
D	74LS245	3	GA004	28
E	74LS245	2	GA004	26
F	74LS245	9	GA004	27
G	6847	40	6847	40
H	6847	2	6847	2
I	6847	8	6847	8
J	6847	7	6847	7
K	6847	6	6847	6
L	(6116)	21	(6116)	21
M	(6116)	23	(6116)	23
N	(6116)	22	(6116)	22
P	(6116)	8	(6116)	8
Q	(6116)	19	(6116)	19
GND	74LS245	10	SUPPLY RAIL	
R	6847	37	6847	37

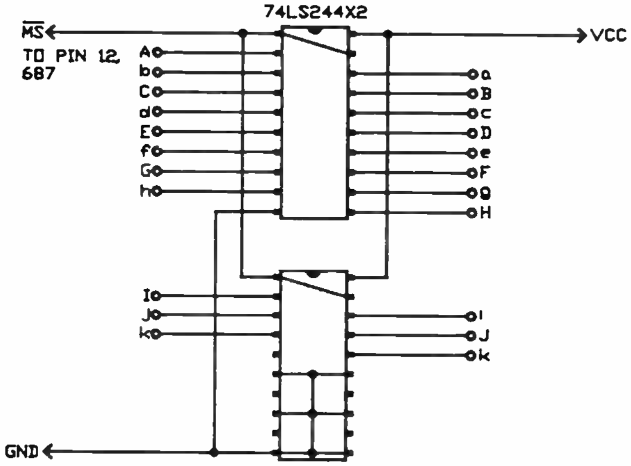


Figure 3. Wiring of the 74LS244 buffers – wrap them in insulation tape once you've got your computer working again.

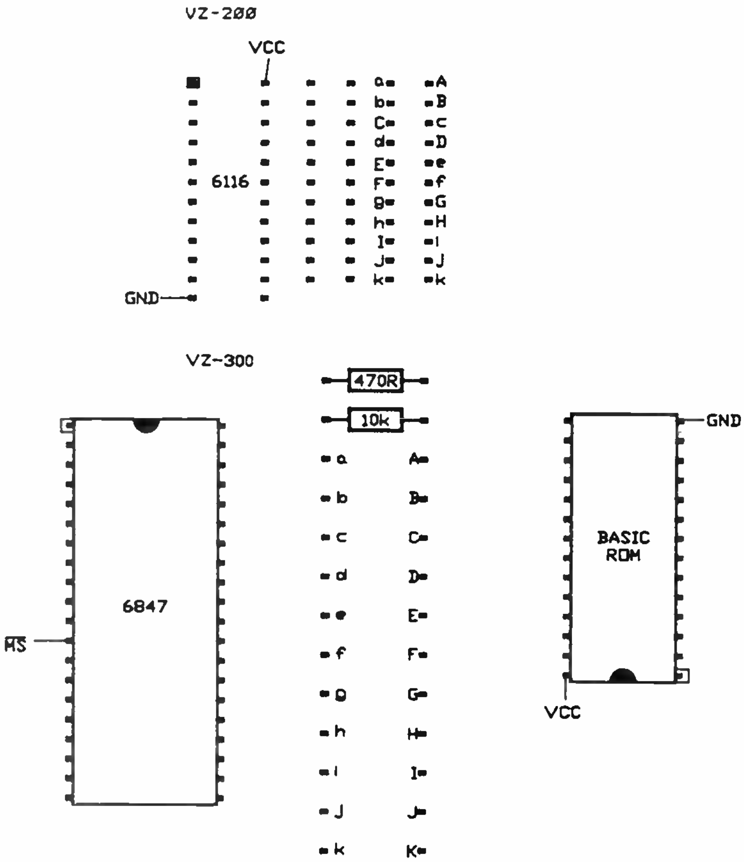


Figure 4. Showing the connection points for the 74LS244 buffers into the VZ200 and 300.

S	74LS245	5	GAØØ4	3Ø	l	74LS245	15	GAØØ4	1Ø
T	74LS245	6	GAØØ4	31	m	74LS245	11	GAØØ4	13
U	74LS245	7	GAØØ4	32	n	6847	27	6847	27
V	74LS245	8	GAØØ4	33	p	74LS245	16	GAØØ4	11
W	6847	3	6847	3	q	74LS245	13	GAØØ4	8
X	6847	4	6847	4	r	6847	32	6847	32
Y	6847	5	6847	5	s	I/O Connector	29	Z8Ø(78ØC)	37
Z	(6116)	7	(6116)	7	t	I/O Connector	12	Z8Ø(78ØC)	36
a	(6116)	1	(6116)	1	u	I/O Connector	27	Z8Ø(78ØC)	34
b	(6116)	2	(6116)	2	v	I/O Connector	5	Z8Ø(78ØC)	2Ø
c	(6116)	3	(6116)	3	w	I/O Connector	14	Z8Ø(78ØC)	22
d	(6116)	4	(6116)	4	x	I/O Connector	1Ø	Z8Ø(78ØC)	35
e	(6116)	5	(6116)	5	y	74LSØ4	4	Z8Ø(78ØC)	26
f	(6116)	6	(6116)	6	z	6847	3Ø	6847	3Ø
g	6847	21	6847	21	1	74LS245	14	GAØØ4	9
h	6847	2Ø	6847	2Ø	2	74LS245	18	GAØØ4	14
i	6847	35	6847	35	3	6847	31	6847	31
j	6847	34	6847	34	4	74LS245	17	GAØØ4	12
k	6847	29	6847	29	5	74LS245	12	GAØØ4	7

▷

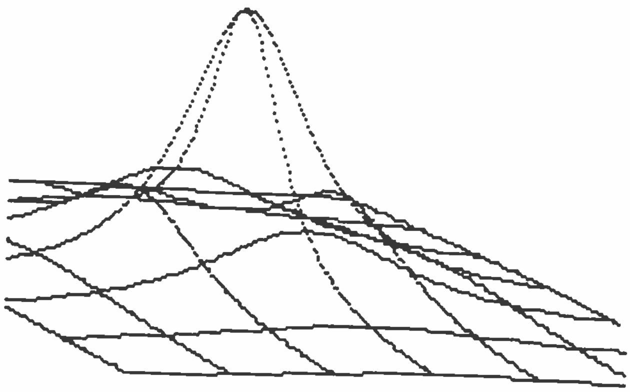


Figure 2. Three-dimensional graphics!

This method greatly reduces overheating problems. Missing tracks are an absolute no-no in computers!

In the VZ200, undo the two screws holding the PAL converter module behind the TV modulator and lift up, to reveal the 6847 video IC. There are two plastic screw mounts on the base of the VZ200. These should be broken off with pliers.

Now the fun begins! Cut the tracks listed in Table 1 (VZ200) or Table 2 (VZ300). Identify each track carefully! Note several IC pins are lifted. When doing this, heat them with a soldering iron and lever the pin out using a small precision screwdriver. Be careful not to break the pin at the IC or all will be lost! Clip off the narrow part of the pin.

Position the Ultra-graphics board in its approximate location relative to the main board. See Photo 1 (VZ200) or Photo 2 (VZ300). Connect each wire in order, as in Table 3, to the main printed circuit board on the *component* side. Cut the wires with a little leeway (about 10 mm longer than required). Tick each connection in Table 3 as it is made, to avoid errors.

Check and recheck all connections. Reconnect the loudspeaker and power switch, fit the main board back into the box (no screws yet) and the new board alongside, as in the photos. Plug in the RAM and EPROM, the video and power supply cables, and switch on. The display should be almost normal. Some characters may be incorrect. The computer should otherwise work correctly. If not, then check for short and open circuits, incorrectly oriented components, and incorrect inter-board wiring.

Unfortunately, the Z80 has trouble controlling the address lines through the resistor buffer with this new board, making the graphics only about 90% accurate. To correct this, power down and then remove the eleven 6k8 resistors on the main board (in the VZ300, do not remove the adjacent 10k and 470R resistors). Wire up IC8 and IC9 (74LS244) as shown in

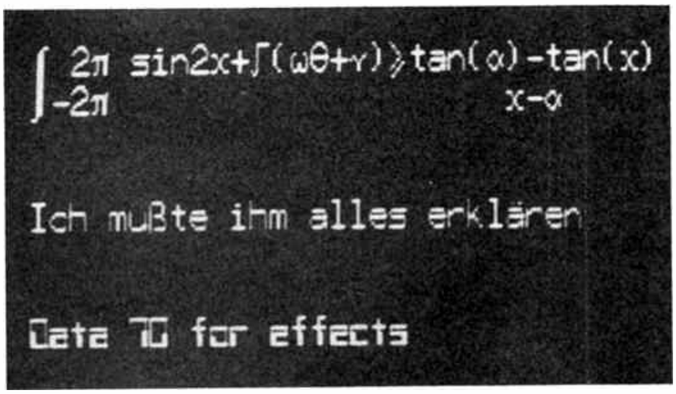


Photo 5. A small taste of what is now possible with text: mathematics, German and Data 70 characters.

Figure 3. Clip the narrow part of each pin, and connect these ICs to the board via short (20 mm) pieces of wire, longer for the power supply and enable signal. Connect them as shown in Figure 4. Wrap these ICs in insulation tape. Switch the computer back on, and when the computer is working, check the new board by typing in:

```
10 CLS:POKE 30744,96:OUT 32,224
20 FOR A=0 TO 255
30 POKE 28672+A,A
40 NEXT
50 PRINT @256,""
```

and running this little program. The new external character set should be displayed.

Screw the board into the box, and the cover on top. Voila. Ultra-Graphics!

The RF shield can be reinstalled, but creates a few problems with mounting the new board. It is not *essential* for the computer's operation and can be left out if you wish.

Applications

It's no use having a set of useful new features without suitable applications with which to exploit them.

The Word Processor

The character set has been designed to be used in conjunction with the tape version of the word processor. Not having used the cartridge version, I don't know how the new character set should be enabled, or if it is compatible with this word processor. To enable a suitable character set, type in:

```
POKE 30744,96:OUT 32,160
```

before loading the word processor. Upper and lower case will be enabled, and semigraphics characters will be used as markers. You will find that the word processor is now considerably easier to use.

Text in BASIC

When using the external character set with BASIC, the white-on-black screen should be enabled. BASIC revision 1.2 uses only this mode, but version 2.0 boots up in black-on-white (inverse mode). Since characters 96 to 127 are non-standard, the white-on-black mode should be enabled by typing POKE 30744,96; or by keeping CTRL depressed when turning the computer on.

As mentioned earlier, characters 128-255 can be accessed by poking the correct code onto the screen, or by printing the correct graphics character in the correct colour. This is how photo six was produced. Characters 64 to 127 can be accessed as inverse characters. The character sets available are listed in Table 5.

Using Graphics

The computer now boots in graphics mode 0, so before any commercial software (games) can be loaded, you should type in:

```
OUT 32,8
```

to enable the normal graphics mode.

If you have a GP-80 printer, which is compatible with the graphics dump screen, then it is possible to dump games screens by playing the game in graphics mode 6 (128 x 192) on the second RAM page (OUT 32,25). Connect a reset pushbutton to ground on pin 13 (VZ200) or pin 11 (VZ300) of the 74LS04. Reset the computer at a suitable point in the program, and print the screen by typing in:

```
MODE (1):OUT 32,25: COPY:OUT 32,0
```

Using Extension Graphics

The following graphics modes are available:

GM0	OUT 32,0	64x64	Colour	1024 Bytes
GM1	OUT 32,4	128x64	Monochrome	1024 Bytes
GM2	OUT 32,8	128x64	Colour	2048 Bytes
GM3	OUT 32,12	128x96	Monochrome	1536 Bytes
GM4	OUT 32,16	128x96	Colour	3072 Bytes
GM5	OUT 32,20	128x192	Monochrome	3072 Bytes
GM6	OUT 32,24	128x192	Colour	6144 Bytes
GM7	OUT 32,28	256x192	Monochrome	6144 Bytes

The COLOUR command is valid for all colour modes. To set or reset a pixel in each mode, in mode 1, refer to Table 4. To clear the screen in modes 4 to 7, MODE(1) must be enabled on all RAM pages used. This means that the GM7 screen is cleared by using:

OUT 32,30:MODE(1):OUT 32,29:MODE(1):OUT 32,28:MODE(1)

The method is similar for the other modes. A three dimensional plot, based on a Microbee program, but using Graphics Mode 7 instructions is reproduced here.

Listing 1 is a graphics dump routine for Graphics mode 7, written for Shinwa-compatible dot matrix printers, such as the BMC BX-80. The author would appreciate hearing from anyone writing applications software for this graphics modification.

TABLE 4. SET/RESET in graphics modes.

GMØ:	SET(X+64*(Y AND1),INT(Y/2))
	RESET(X+64*(Y AND1,INT(Y/2))
GM2:	SET(X,Y)
	RESET(X,Y)
GM4:	OUT 32,16+INT(Y/64)AND1:SET(X,Y AND 63)
	OUT 32,16+INT(Y/64)AND1:RESET(X,Y AND 63)
GM6:	OUT 32,24+INT(Y/64)AND3:SET(X,Y AND 63)
	OUT 32,24+INT(Y/64)AND3:RESET(X,Y AND 63)
GM1:	A=28672+INT(X/8)+16*Y
SET:	POKE A,PEEK(A) OR 2^(7 AND (NOT X))
RESET:	POKE A,PEEK(A) AND (NOT 2^(7 AND (NOT X)))
GM3:	Same as GM1
GM5:	OUT 32,2Ø+INT(Y/64)AND1
	Then same as GM1
GM7:	OUT32,28+INT(Y/64)AND3:A=28672+INT(X/8)+32*(YAND63)
	Then same as GM1

```
1Ø REMARKABLE GM7 GRAPHICS DUMP    BY MATTHEW SORELL 17/1/88
2Ø REM FIND TOP OF MEMORY
3Ø TM=PEEK(3Ø897)+256*PEEK(3Ø898):TM=TM-2Ø1:TL=TM-65536
4Ø POKE3Ø897,(TL AND 255):POKE3Ø898,TM/256
5Ø REM PUT PROGRAM AT T.O.M.
6Ø TM=TM+1:IFTM>32767THENTL=TM-65536 ELSE TL=TM
7Ø FOR A=TL TO TL+2ØØ
8Ø READ D:POKE A,D:NEXT
9Ø 'CORRECT ABSOLUTE ADDRESSES
1ØØ FORI=1TO2Ø
11Ø READA,D:POKE TL+A,(TL+D)AND255:POKE TL+A+1,(TM+D)/256:NEXT
15Ø POKE3Ø862,TL AND255:POKE3Ø863,TM/256
16Ø REM X=USR(Ø) STARTS DUMP
17Ø CLEAR 5Ø:END
18Ø 'MACHINE CODE DATA
19Ø DATA245,197,229,62,27,2Ø5,186,58,62,49,2Ø5,186,58,62,13,2Ø5
2ØØ DATA186,58,175,5Ø,Ø,Ø,198,28,211,32,175,5Ø,Ø,Ø,62,13,2Ø5
21Ø DATA186,58,62,27,2Ø5,186,58,62,75,2Ø5,186,58,175,2Ø5,186
22Ø DATA58,62,2,2Ø5,186,58,175,5Ø,Ø,Ø,62,7,5Ø,Ø,Ø,175,5Ø,Ø,Ø
23Ø DATA175,5Ø,Ø,Ø,33,Ø,112,237,75,Ø,Ø,2Ø3,56,48,2,2Ø3,249,9,58
24Ø DATA2ØØ,192,7,7,7,7,7,79,6,Ø,9,58,Ø,Ø,71,62,1,7,16,253,166
25Ø DATA4Ø,22,58,Ø,Ø,237,68,198,3,7,71,62,3,7,16,253,71,58,Ø,Ø
26Ø DATA128,5Ø,Ø,Ø,58,Ø,Ø,6Ø,254,4,32,185,58,Ø,Ø,2Ø5,186,58,2Ø5
27Ø DATA186,58,58,Ø,Ø,61,254,255,32,16Ø,58,Ø,Ø,6Ø,254,32,32,147
28Ø DATA58,Ø,Ø,6Ø,254,16,194,Ø,Ø,58,Ø,Ø,6Ø,254,3,194,Ø,Ø,6,8
29Ø DATA62,13,2Ø5,186,58,16,251,225,193,241,2Ø1,Ø,Ø,Ø,Ø,Ø,Ø
3ØØ 'ABSOLUTE ADDRESS CORRECTION DATA
31Ø DATA2Ø,197,28,196,56,195,61,198,65,199,69,2ØØ,76,195,86,2ØØ
32Ø DATA98,198,11Ø,2ØØ,125,199,129,199,132,2ØØ,14Ø,199,149,198
33Ø DATA157,195,165,196,171,27,174,197,18Ø,19
```

LISTING 1

TABLE 5. Useful OUT expressions (OUT 32,N).

N	GM	Page	Chr Ø-63	Chr 64-127	Chr 128-192	Chr 192-255
Ø	Ø	Ø	IntNorm	IntInv	SG4	SG4
4	1	Ø	IntNorm	IntInv	SG4	SG4
8	2	Ø	IntNorm	IntInv	SG4	SG4
12	3	Ø	IntNorm	IntInv	SG4	SG4
16	4	Ø	IntNorm	IntInv	SG4	SG4
17	4	1	-	-	-	-
2Ø	5	Ø	IntNorm	IntInv	SG4	SG4
21	5	1	-	-	-	-
24	6	Ø	IntNorm	IntInv	SG4	SG4
25	6	1	-	-	-	-
26	6	2	-	-	-	-
28	7	Ø	IntNorm	IntInv	SG4	SG4
29	7	1	-	-	-	-
3Ø	7	2	-	-	-	-
32	Ø	Ø	ExtNorm	ExtInv	SG6	SG6
64	Ø	Ø	IntNorm	IntInv	IntNorm	IntInv
72	2	Ø	SG4	SG4	SG4	SG4
96	Ø	Ø	ExtNorm	ExtInv	ExtNorm	ExtInv
1Ø4	2	Ø	SG6	SG6	SG6	SG6
128	Ø	Ø	IntNorm	IntNorm	SG4	SG4
132	1	Ø	IntInv	IntInv	SG4	SG4
16Ø	Ø	Ø	ExtNorm	ExtNorm	SG6	SG6
164	1	Ø	ExtInv	ExtInv	SG6	SG6
192	Ø	Ø	IntNorm	IntNorm	IntNorm	IntNorm
196	1	Ø	IntInv	IntInv	IntInv	IntInv
224	Ø	Ø	ExtNorm	ExtNorm	ExtNorm	ExtNorm
228	1	Ø	ExtInv	ExtInv	ExtInv	ExtInv

Int=Internal Chr   Inv=Inverted Text   Norm=Normal Text
SG4=2x2 Graphics   SG6=3x2 Graphics   Ext=External Chr

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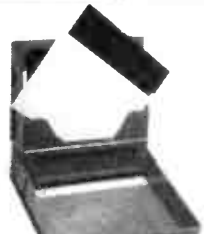

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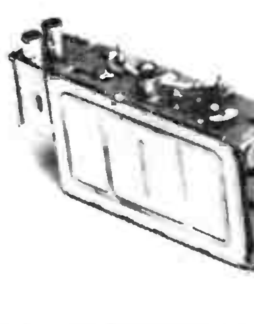

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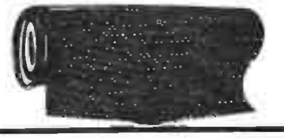

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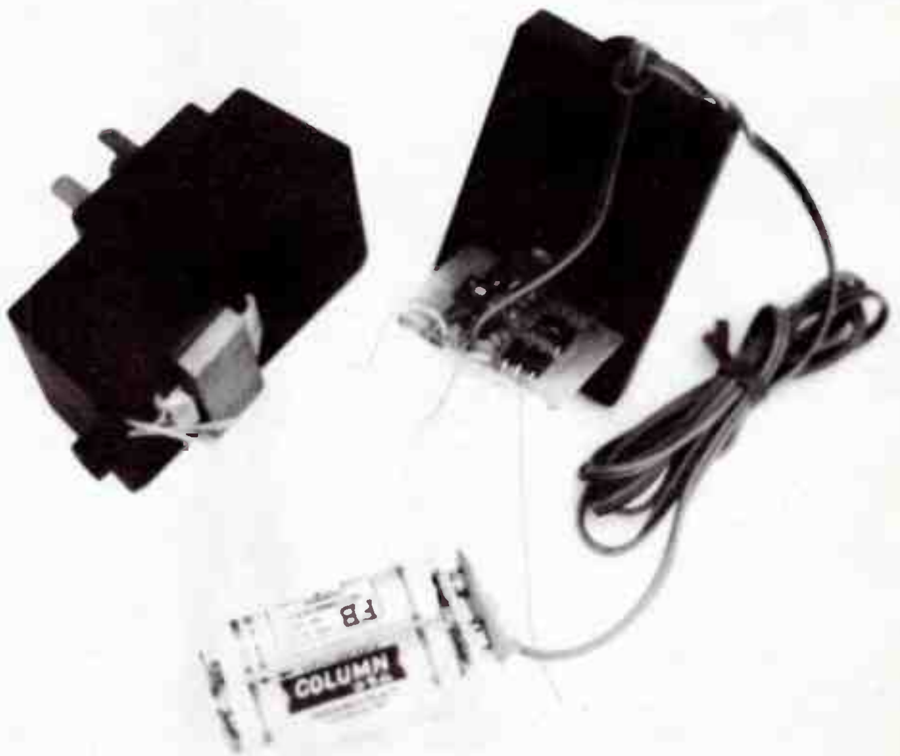
3. It has both a full charge rate and a trickle charge rate;

4. It gives full indication of good contact and thus successful charging;

5. It is cheap, using no capacitors, the cheapest mains transformer available in local suppliers' stocks, and only a dozen or so readily available components.

The majority of NiCad chargers, and this one is no exception, deliver a constant current to the batteries. In order to save the space and cost of an electrolytic capacitor, this charger only delivers current during an interval of about 8 ms during the positive half cycle of the supply. The current actually delivered to the cell(s) is 2.5 times the average current drawn from the transformer secondary.

Using the charger is elementary. There is a switch which sets the current to either its nominal full value, or to the "trickle" level. NiCads are normally charged at a rate of one-tenth their "capacity" (the ampere-hour capacity specified by the manufacturer) for 15 hours. A cell rated at 500 mAh would normally be charged at 50 mA for a period of 15 hours. ▷



For compactness and convenience, we housed the charger in a plug pack case available from Jaycar. Despite its compactness, it fits easily in this case, the board containing the electronics on the lid with the 2851 transformer sitting in the body. Common battery holders are used to hold the batteries for charging as well as helping to ensure correct polarity connection.

It is not possible to continuously charge NiCads at this rate without eventually impairing their charge storage ability. Trickle charging is the process of very slowly charging cells so that once they come to full charge they stay there but do not suffer any harm.

If you are not in a hurry, you can charge from dead flat to full charge at the trickle rate, which would take about three days. The advantage of this is that, if you forget about the charger, no damage is done, and the batteries will not have prematurely aged. This approach is very suitable if you keep, say, three sets of cells for the Walkman you use going to work every day, or you have a flashgun with a set of NiCads. In the case of the three sets of Walkman batteries, you can leave them for a weekend, or go away for a week, and they will be ready when you get back, and you don't have to remember to take them off charge. In the case of appliances such as flashguns, which sometimes aren't used for days or weeks at a stretch, you can rely on the batteries being ready whenever you need them.

If you want to charge at the 'full rate', the switch is set in the "full" position. The common AA cells rated at 450-500 mAh will be charged in 14 hours if you build the charger with the component values we recommend, which deliver the manufacturers' 'recommended' current rate. You must, however, remove them when charged. The manufacturers generally indicate that 24 hours is the limit before nasty things start to happen.

Now, 14 hours is a silly time interval. If it was 7-8 hours, it would be the time from when you go to bed to when you get up, for which it is easier to remember what you have to do – you just put them on when you go to bed, and replace them in the appliance when you get up. For those who find this more attractive from the point of view that it fits better with your lifestyle or application, we suggest alteration of the value of the 10 Ohm resistor (R4) to 4.7 Ohms.

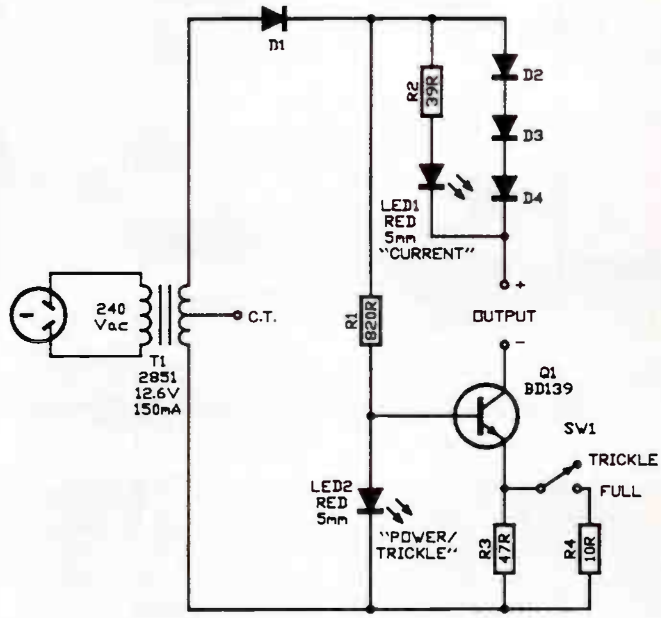
Construction

Our prototype was constructed in a "plug pack" case recently released by Jaycar. It makes for a compact, convenient unit that has only one trailing lead, which carries the battery connector. As NiCads cells are generally devoid of suitable contacts, they must be held in a battery holder having suitable connectors. Commonly available plastic battery holders that can take 2, 4, 6 or 8 cells have a No.216-type "snap" connector so it was decided to terminate the trailing lead with one of these, also permitting charging of No.216-type 9 V NiCads. An added advantage of this is that it pretty well ensures you get the polarity right, avoiding charging the batteries in reverse and damaging them.

It is not essential to build the NiCad charger into a plug pack case. The circuit is quite capable of operating with lots of different transformers, and will charge at higher or lower currents, up to 250 mA, depending upon the value of the resistance from Q1's emitter to ground (see the circuit). It may be built in any suitably-sized case, like a jiffy box, or a metal instrument case. The transformer you use will determine the case size.

However, the project is designed to provide all the functionality you need and to fit inside the limited space of the Jaycar plug pack shell. The assembly description here assumes that you want to take advantage of the small size, and so describes how to safely fit it in the plug pack case. After we've described how to copy our prototype, we will mention a few variations you may care to try if you wish, so it's not all cut and dried.

Now the main problem with using the plug pack case is fitting all you need to into it. In this case, the problem is getting



CIRCUIT OPERATION

The charger circuit can be broken up into two sections, the current source and the current monitor. The current source rectifies the incoming ac voltage from the transformer secondary and supplies an approximately constant current to the load (the batteries), while the current monitor indicates that this current is flowing. The current monitor consists of diodes D2-D4, R2 and LED1, while the rest of the components provide the actual charger itself.

Dealing with the charger first, it consists of a source of low voltage, which in our prototype consists of a 2851 transformer. The output of this is half wave rectified by D1. For the time being, assume that D2-D4 are not present, and that the batteries are connected directly between the junction of D1 and R1 (positive) and the collector of Q1 (negative). The half wave rectified output supplies current to LED2 via R1 during the positive half cycles of the mains. When conducting, LED2 has a forward voltage drop of about 1.7 V.

Transistor Q1 is connected as a current sink. The voltage on its emitter will be about 1 volt or a little more, and the collector current (the battery charging current) will be set by the emitter resistor. This in turn is set by SW1 to be either R3 or, when SW1 is closed, R3 in parallel with R4. The values selected give peak currents of about 22 mA and 120 mA (0.12 A), respectively. Because conduction only occurs for a little less than half of each half cycle, the average current delivered to the batteries becomes about 8-9 mA and 45-50 mA, respectively.

These currents correspond to the recommended normal and trickle charge currents for AA NiCads which are rated at 450-500 mAh capacity. Some NiCad C size cells are rated at this capacity, while others are typically rated at 1.2 Ah (1200 mAh). This charger will charge the latter cells, but on trickle it will take quite a period, at "full" it will take 14-18 hours (depending on the state of charge to start with). The values of R3 and R4 may be changed to accommodate D cells if they're the main type you use.

Returning to the monitor circuit, note that it will be in series with the current drawn by Q1 through the batteries. D2-D4 drop about 2 V when conducting. Resistor R2 allows a current of a few mA to be diverted through LED1, whose voltage drop will again be about 1.7 volts. Thus LED1 will indicate that a charging current is flowing. The monitor circuit is not at all necessary for operation, and can be deleted if not required with no modification to the charger proper.

PARTS LIST AEM9505

Semiconductors

D1-D4	1N4001, 1N4002
LED1, LED2	5 mm red LED
Q1	BD139

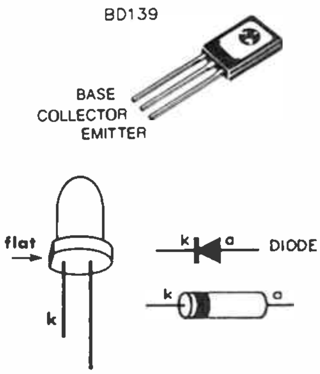
Resistors	**¼ W, 5%**
R1	820R
R2	39R
R3	47R
R4	10R

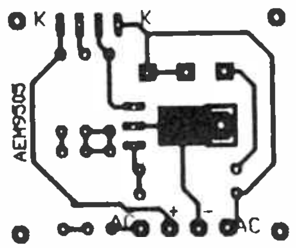
Miscellaneous

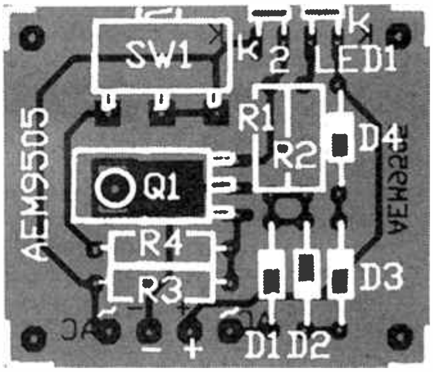
AEM9505 pc board; SW1 – min. toggle switch; plastic plug pack case, Jaycar HB-5950 or other case to suit; mains transformer to suit application – 12-18 Vac at 100 mA, e.g: 2851 type; connector to suit application, e.g: 216-type battery snap; battery holder(s) to suit application; Scotchcal front panel label; wire, solder, Superglue or similar, silicone sealant (e.g: Silastic), heat-shrink tubing, small piece of metal for heatsink, 6 BA nut and bolt, etc.

Estimated cost: $18-$25

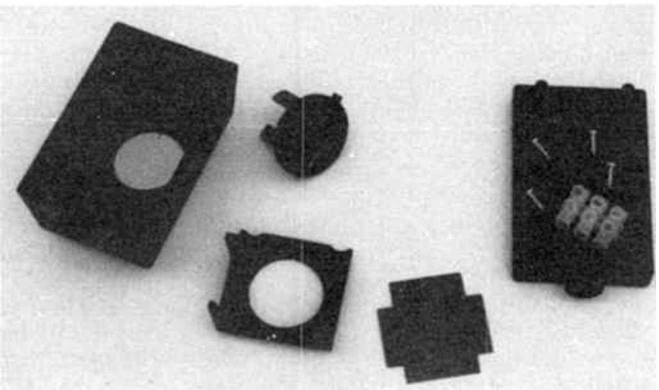
COMPONENT PINOUTS







Component overlay showing placement of the components.



The plug pack case in pieces. The main body is at left, the lid at right, with the screws and screw terminal supplied sitting in it. The screw terminal is not needed. Between the body and the lid are the plug disc, top left, a piece of paper protective insulation and a bracket. The bracket is not needed in this project.

a mains transformer that is small enough. The ONLY one we found that will do is the 2851 which, fortunately, is a pretty common one. In addition, to make it fit, you have to strip off its mounting bracket, which is easily accomplished with a screwdriver.

This is the first step in construction. Looking at the bottom of the transformer, you will see that the bracket which includes the mounting lugs is held on by some flanges bent over the core. Prise these up and remove and discard the soft metal bracket entirely.

Having prepared the transformer, turn your attention to the case. It consists of a base section, a lid, four screws which will eventually hold these two together (but which are supplied inside), and two internal pieces. The first of these is the disc which carries the three terminals which go into the wall socket. The second is a bracket designed (rather roughly) to hold the plug-disc in place and yet leave it free to travel through 180 degrees, so the body of the plug pack can swivel.

We feel that it is unwise to leave this plug-disc rotatable since it could fatigue the cables connected to the plug. In addition, the space left after fitting the 2851 is so small that it is potentially hazardous to have the terminals moving about in what air remains in the case. The next step is to remove and discard the bracket which holds the disc in place. Remove the disc.

Before proceeding, it is best to solder the transformer mains wires to the active and neutral connections of the plug-disc. Determine which wires from the transformer are the mains wires. On our 2851 they were red and black. They will be the pair which emerge near each other, as different from the group of three. Trim them if necessary to be about 80 mm long, bare the ends and solder them to the active and neutral pins. The active and neutral are the two oblique pins, while the earth pin is the longer one lying on a radius of the disc.

Having made the connections to the plug-disc, check that it fits into the case with the transformer. This required the earth pin to be oriented to the end of the case which will contain the transformer, and from which the wires will emerge. Once you are satisfied of the required position, glue the disc in place with "Superglue" or another cyano- acrylate glue. Smear the glue all around the ridge of the disc and seat it firmly in place. Allow time for it to cure. In fact, the Superglue will be sufficient by itself to hold the disc in place, but we recommend that you take further care as detailed shortly.

Next, turn your attention to the printed circuit board. Check that all the holes are drilled and of the right diameter, and that there are no tiny cracks in tracks or copper "whickers" bridging tracks or pads – you should do this whether or not you made the board yourself or purchased a ready-made board. Assemble the components on it according to the overlay diagram here. Be sure to get the polarities of the diodes and LEDs correct.

Connect the switch to the board with some tinned copper wire, or possibly the trimmed leads from D1-D4. You may be able to obtain a suitable switch with right-angle pins. The transistor, Q1, should be able to operate without a heatsink (it dissipates only 650 mW worst case with our current setting), but we have made provision for one and used one in the prototype. It consists of a small T-shaped chunk of 3 mm thick aluminium, cut from scrap lying around the workshop. We ▷

will not be using mounting bolts on the PCB, since it is so small and is easily held in place by the switch. We have left space for mounting by bolts, but you can see that the posts in the plug pack case run up against the pc board in our version.

The reason we have made provision for a heatsink is that you may wish to use other resistor values to get different charging currents. If the 10 Ohm resistor is replaced by a 4.7 Ohm one, the average charging current will be boosted to almost 100 mA. This will charge penlite (AA) NiCads in about 7 hours. This is often more convenient than the 14 it takes at the nominal 45-50 mA recommended. The price you pay is that if you forget about the batteries they may suffer from severe overcharging (depending on the length of your forgetfulness), reducing their lifespan. In this case the transistor could dissipate over a watt and would need a little help getting rid of the heat.

Incidentally, even if you choose to use the higher current, we recommend that you leave the trickle charge current at the same level (the 47 Ohm resistor unchanged). This is the "50 hour" rate, at which you are supposed to be able to leave the batteries charging indefinitely without stress.

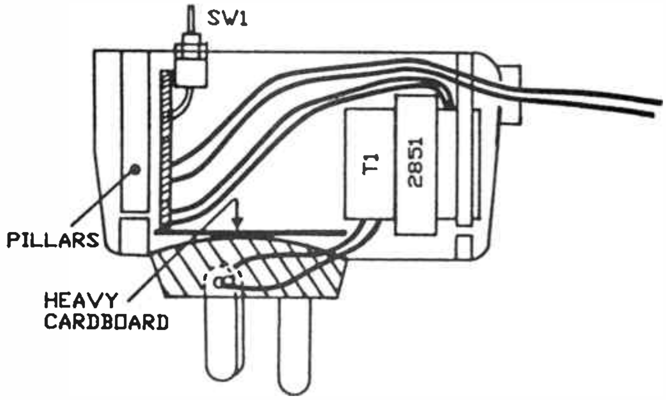
Anyway, having assembled the board, it is time to drill the case top. The pc board will be held in position by its connection to the case top, so it is important to get the holes in the right place. When assembled, the pc board is situated with the two mounting posts which protrude from the lower half of the case riding up against one side or other, depending which way around you drill the holes. You will note that the components are situated so that they can actually fit between the posts if required, so it does not matter which way around you put the board. You can use the board to determine where to drill the holes in the case top, or you can use the front panel artwork reproduced here as a template. If you're using a Scotchcal front panel label, this may be used as a template before fitting it.

With the case top drilled, the front panel label may be attached. With Scotchcal, peel the backing from it and soak it in water, sticky side up, for a while. Then wet the case top with a sponge and place the now-wet Scotchcal label on it and slide it into position. Sponge off the excess water. Next, fit the pc board onto the case top and secure it with the toggle switch mounting nut. See that it is held firmly but take care not to damage the front panel label.

Now connect the transformer secondary to the pc board. The centre connection can be clipped off and ignored. The remaining two wires go to the pc board's "ac in" pads, either way around. Also connect the cable which is to run out to the batteries.

The final step before assembly of the case is to fill the area around the mains active and neutral pins with silicone-rubber sealant, such as Silastic. Squeeze a suitable amount of the sealant onto the back of the pins, embedding them in the sealant, effectively "potting" them. Place a piece of the shiny sided cardboard which came with the plug pack over the sealant. Push the shiny side down on to the pins. This provides added protection against the risk of the active connection contacting the electronics. Leave to cure.

While this cures, make what connection you want to the end of the cable leading to the batteries. We used a 216-type snap, as mentioned earlier. To connect the cable to the snap connector, slit the plastic sheath of the clip with a sharp blade and unsolder the wires with which it came. Solder the ends of the cable you have leaving the pc board onto the spots from where you took the original leads. Be sure *to get the polarity* correct! If you wish to have a neat product, place a bit of heatshrink tubing around the re-wired clip. Heat it, and let it contract a little. Then cut away near the metal terminals of the clip with the blade, and finish shrinking the plastic.



Having completed this and allowed the Silastic to cure, assemble the transformer and lid of the case, being sure not to pinch any of the wires in the gap. Leave the spare cable between the pc board and the transformer so as to wedge the transformer in place. Drop the lead going to the batteries into the cable gripping slot in the end of the case. If necessary, knot the lead so that it cannot be pulled outwards.

After screwing down the lid, check that nothing rattles. If it does, you might need to put a small amount of paper or cotton wool under the transformer to secure it from moving. Ours fitted very well without this aid.

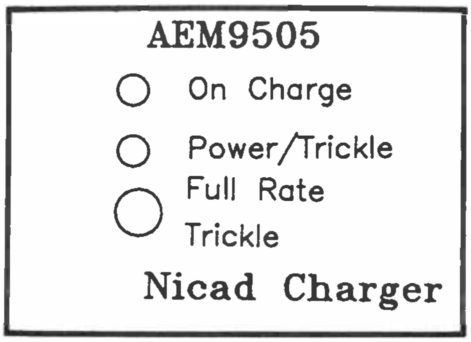
Finally, test the charger. Check that LED2 illuminates with power but no load applied in the trickle charge switch setting. It will probably extinguish in the full charge setting. Put some batteries in the holder, or just short the leads. Note that now LED1 and LED2 both illuminate in both switch settings. This indicates satisfactory operation.

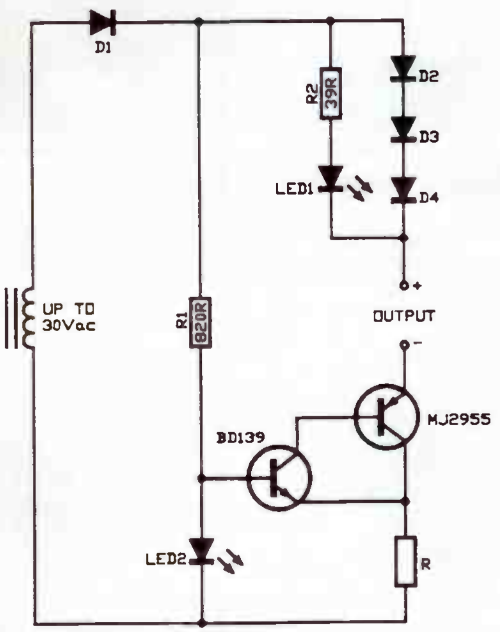
In use

If you ever lose the panel markings on the charger (or omit to use and you forget which position of the switch is the full rate position, there is a way of telling. With no batteries connected, and the leads open circuit, the power/trickle indicator LED will light up when the switch is in the trickle ('safe') position. In either position it will illuminate when batteries are connected or the leads shorted.

When charging cells or batteries it is important to get them the right way around, which is why we recommend using a 216-type battery snap and putting the cells in a small plastic battery holder as these have a 216-type battery snap connector. Having done that all you have to do is ensure that the correct connection LED is illuminated, and away you go!

It is always a wise idea to fully discharge NiCads before charging them to avoid the "memory" effect which reduces their capacity. If you have NiCads that haven't been fully discharged each time before recharging, or that have been let





stand for some months, their capacity can be restored by charging and then discharging them some four or five times.

Variations

As we promised earlier in the article, here are a few ideas that may be of use to those who want to "tinker". In fact, the charger can be easily "beefed-up" to charge up to 20 cells at up to one amp average. The circuit is changed by the addition of Q2, an MJ2955, as shown in the drawing captioned "Variation 1" and by the use of a larger transformer, giving 24-28 volts at 1 A (e.g: a "6672" type). The transformer's rated RMS voltage should be equal to about 1.25 times the number of cells maximum, but less than 30 volts.

The emitter resistor should have a value of 0.4 divided by the required average current (in amps), and should have a power rating equal to the reciprocal of its resistance. i.e: For 400 mA average current (0.4 A) it should be a 1 Ohm, 1 watt resistor, and for 750 mA average charging current it should be about half an Ohm at 2 W. The MJ2955 will need a few square inches of heatsink.

If you want to use the existing charger to charge AAA NiCads, which are generally rated at 180 mAh capacity, the "full" charging current needs to be 18 mA average, trickle charging current about 3 mA. This means R3 should be changed to 120 Ohms and R4 to 27 Ohms. The charger could be used as-is, but you run the risk of overcharging.

Another way to accommodate charging AAA And AA cells would be to use a 120 Ohm resistor for R3 and a 47 Ohm resistor for R4. The project would then simply be a trickle charger for AAA and AA cells.

The No.216-type 9 V NiCad batteries are typically rated at 100 mAh. These may be charged with SW1 set in the "trickle" position, and should take some 7-8 hours to come to full charge. (In other words, the trickle position for AA cells is equivalent to "full" charge for 9 V No.216 NiCads.)

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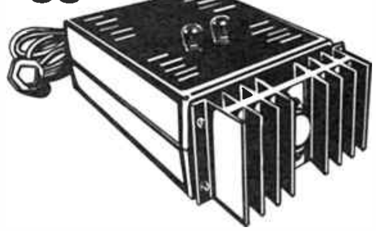

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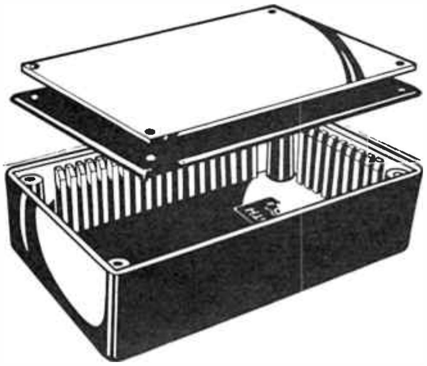

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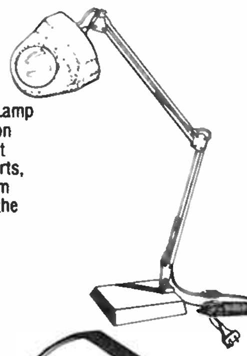

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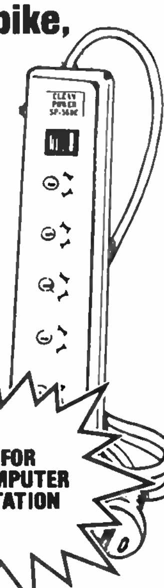

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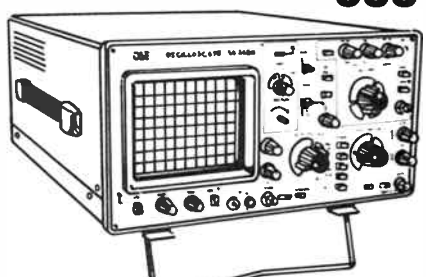

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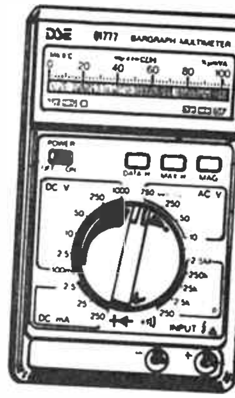

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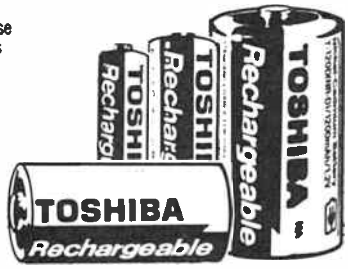

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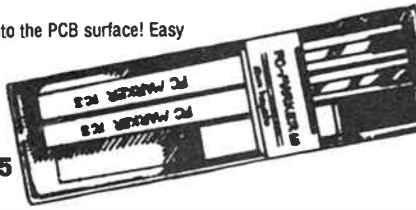

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Notes on the AEM4509 TTY-computer interface

Some of the information which was added to the text of my article (no doubt with the best of intentions) was unfortunately incorrect, and may lead to damage of the interface if wrongly used.

The use of a transient protection diode across the selector magnet coil was recommended, but this is unnecessary because the design of the interface already incorporates automatic spike absorption. The circuit works in the following manner:

The idle current is interrupted by saturating Q4, which grounds the base of Q5 and cuts off the emitter followers Q5 and Q6. At this time, the selector magnet coil is effectively open circuit and the stored magnetic field collapses, generating a negative-going transient. When this transient voltage reaches –1.2 V, the emitter-base diodes of Q6 and Q5 turn on. A path to earth is then established through the emitter-base diode of Q6, R10, the emitter-base diode of Q5, R8 and then the collector of Q4, which is at earth potential. The small current which flows cannot pull down the potential at the collector of Q4, because of the much larger current flowing due to R7. As a result, the transient voltage excursion at the emitter of Q6 cannot exceed –1.2 V. Both Q5 and Q6 operate well within their ratings at all times.

The use of an additional diode connected as described is therefore not required.

In the interface circuit, an opto-isolator has been introduced between Q3 and Q4. R1 was originally dimensioned for switching Q3's collector load, which was previously R6 (10k). With the inclusion of the opto-isolator, Q3 is now being called upon to switch somewhat more current. If the gain of Q3 is slightly below specifications (– hardly likely, unless "seconds" transistors are bought and used; Ed.), saturation may be marginal. I would recommend that you check the collector voltage of Q3 in the 'Idle' condition, and if it is not close to 0 V, decrease the value of R1.

Incidentally, there is a typographical error in the circuit voltage table. The voltage at the collector of Q3 should be near 0 V, not 9.9 V as stated.

DRIVING OTHER TELEPRINTERS

I doubt that, in its present form, the interface would be suitable for teleprinters other than the Siemens 100, as suggested. The reason for this is that the low resistance and inductance of the Siemens' selector magnet coil enables the use of a safe, low voltage interface with constant-voltage output characteristics. Owing to the inductance of the coil, the current swing at 50 Bd is 95% of the static idle current, and falls to 84% at 75 Bd. Whilst the waveform isn't ideal, it is more than adequate for reliable operation, even at the higher speed.

However, all is not lost because the 4509 interface can be easily modified to more than double the available output voltage. Replace the full wave rectifier with a bridge configuration connected to the 15 Vac winding. Modify the regulator by replacing RV1 with a 5k type, and insert a 2k2 resistor in series with the top of RV1. To avoid excessive power dissipation, connect the feed resistor for the LED part of the opto-isolator to the 5V rail in the Commodore, as described in the article. Finally, fit a small to Q6. These modifications will enable the output voltage to be varied between 7.5 V and 18 V, thus making it able to drive a wider range of teleprinter.

If you don't mind the extra heat generated, the Siemens 100 machines can benefit from using this configuration. You will need to connect a 150 Ohm, 1 W resistor in series with the selector magnet coil. This will modify the drive circuit to give a pseudo constant-current characteristic, which results in a superior signal current swing (100% at 75 Bd). It would be a good idea to place the 150 Ohm resistor inside the teleprinter itself, to avoid raising the temperature in the interface case.

MORE ABOUT TELEPRINTERS

Some additional information has come to light. Whilst the LTRS mode of the Baudot code is standard, there are a number of variants in the FIGS mode where differences in character assignments occur. My information was that the FIGS equivalent of the letter D had been used in the past as a 'STOP' control code.

However, both the Siemens 100 and the current Australian telex machines use it as WRU (Who aRe yoU?). When the WRU key is operated, the distinctive cross symbol is printed and the FIGS equivalent of D is sent. This causes the remote teleprinter at the receiving end to automatically transmit a short, pre-coded message giving details of its identity. The Siemens 100 performs this task mechanically, by means of an 'answer-back' drum which is set in rotation when the FIGS-D code is received. Since BAUDPRINT makes use of the WRU character, some comments are necessary. Firstly, the 75 Bd printer-only machines do not have this drum, so no problems arise. If you are using a keyboard machine, the answer-back mechanism can be de-activated by placing a sleeve on the spigot of the answer-back code-bar.

PROGRAM NOTES

1. Those readers converting the program for disk operation may be confused by the typographical error in the first line. The word READ: should not be entered! The following three not cover miscellaneous items which I didn't make clear in the article.

2. When preparing disk files for access by BAUDPRINT, it is safer to close the file by using PRINT#8:CLOSE8 instead of CLOSE8 alone.

3. The LF and WRU-by-graphics option should only be disabled when you are using the File & List Printing facility. If this option is disabled, SDC codes will be printed instead of the required functions in the Screen Dump and TTY Test facilities.

4. When using BAUDPRINT-MC directly from machine code, the printer must be initialised during the start-up sequence by using JSR 50594 (CR with LCC reset) and JSR 50697 (unconditional shift to FIGS). These subroutines ensure that the printer carriage starts off at a known position (the LH margin) and that the shift is in a known mode (FIGS).

5. After extensive use of BAUDPRINT, only one very 'subtle' bug has come to light. There is a flaw in the program flow of the 'Print SDC' routine, which results in a confusing printout on occasions. Fixing it will be a lot easier for you than it was for me! After you have finished entering the hex code program, enter in the block below. The first two lines will overwrite the program already in memory, creating a patch to the following five lines which are appended to the end of the program. Note that your SAVE will now be from 49200(C030) to 51623(C9A7).

```
49776   C270   00  00  00  00  00  4C  80  C9    405
49808   C290   E4  A9  3A  CD  13  C3  F0  0A   1529
51584   C980   A9  3A  CD  13  C3  F0  03  4C   2494
51592   C988   B8  C2  A9  30  8D  13  C3  EE   3682
51600   C990   12  C3  A9  3A  CD  12  C3  F0   4780
51608   C998   03  4C  B8  C2  A9  30  8D  12   5613
51616   C9A0   C3  EE  11  C3  4C  B8  C2  55   6797
```

New packet radio TNC from local group

A new terminal node controller (TNC) for packet radio operation is being made available by the Melbourne Packet Radio Group. Known as the TNC-220+ and designed by Ray Gardiner VK3YNV from Shepparton in Victoria, the entire hardware and software was developed locally by Ray to further the development of the Australian Packet Radio Network.

The controller section employs a Zilog Z80A running at 2.457 MHz which can be optionally increased to 4.9152 MHz but this needs faster support chips and is not normally necessary. Onboard memory comprises a 32K 27C256 EPROM and 32K of RAM (43256).

The modem section employs two '7910 chips to provide baud rates for either HF or VHF usage, software selectable. As the '7910 incorporates digital filtering it performs far better than most PLL-type modem, it is claimed.

The serial interface is a two-channel Zilog Z8530 SCC which has one channel for serial communications to the terminal and one for communications with the onboard modem. Terminal baud rate can be 300 to 9600 bps with 1200 bps being the cold boot speed.

Also on the board are two watchdog timers. The power supply is well thought out. It can be powered from either 9 Vac supply or a 9 or 12 volt dc supply and is not polarity sensitive.

Connectors for Rx audio, Tx audio, PTT and Ground are all standard 5-pin 180° DIN sockets. Six indicator LEDs line the front panel, showing Power Connected, Status, PTT, DCD, and RESET.

Fully built and tested units or kits are available for $275 and $200, respectively. Contact the **Melbourne Packet Radio Group, PO Box 299, St. Albans, 3021 Vic.**

Summerland packet repeater

Summerland Amateur Packet Radio Society (SAPS), now has operational its digital repeater, VK2RPL, on 145.050 MHz. It provides connects into the VK4RBT-3 repeater in Brisbane, and beyond.

VK2RPL is located on Mt Nardi in the Nightcap range, 800 metres above sea level, and runs 20 watts into a half wave colinear.

Connects have been established via VK2RPL to AX4BBS-1 and AX4XBB, plus VK2RPM Port Macquarie. The repeater has been logged at S9+ in Tenterfield and 2RPL has logged 2XY and 2RPS.

The SAPS expected to have a second digital repeater operation on 147.575 MHz in March. SAPS held a symposium at the recent Gosford Amateur Radio Club Field Day.

Amateurs who assisted in the installation of VK2RPL were VK2's AGE, JWA, KGK and BEV.

Commercial base/repeater

Melbourne-based company Imark has recently released a base/repeater unit intended for commercial usage designed and built by Kyodo.

Known as the KG110, it employs a PLL synthesiser that provides 99 channel capability. The transmitter can provide 50 W RF output, rated for continuous duty. An optional 120 W unit can be supplied. The PA section includes protection for high VSWR and overheating.

The receiver incorporates two front-end band pass filters, each with triple resonators and double conversion using 21.6 MHz and 455 kHz IFs.

The KG110 is a supplied as a 19" rack-mount unit which can also be used on a desk-top. The receiver, the transmitter and the PA section are each housed in separate diecast boxes inside.

A variety of accessories is available, providing remote control, selecall, ANI and queuing, telephone interfacing, automatic ac/dc changeover, automatic base/repeater changeover etc.

Full details are obtainable from **Imark P/L, 167 Roden St, West Melbourne 3003 Vic.**

Low-cost weather satellite receiver

A low-cost weather satellite receiver from Feedback Instruments, model WSR524, is said to break new ground in the field of weather satellite image reception.

Distributed here by the Measurement and Control Division of the AWA Technology Group, the WSR524 receives live images (not computer simulated graphics) from the VHF automatic picture transmission (APT) polar orbiting satellites.

These images, in the visible and infra-red format, can be displayed on a standard monitor or TV set, it is claimed. A built-in microprocessor control system and ease of installation provide the user with a number of unique advantages the makers claim.

Full details available from **AWA Technology Group, Measurement and Control Division, Unit C, 2-8 Lyon Park Rd, North Ryde 2113 NSW.**

Assembling your VHF weather satellite ground station

Roger Harrison

So you're getting together a 'ground station' to receive the polar orbiting weather satellites based on our project AEM3520 VHF Satellite Receiver? Well here's a few pointers, hints and tips to make the road a little smoother for you.

IF YOU'RE UNFAMILIAR with VHF receiver systems, there are a few pitfalls you need to know about to achieve the performance of which your system is capable. That old saying, "it's easy when you know how" is applicable to the situation here. There's little to compare with the thrill you get when success is yours for the first time and you receive your first satellite transmission. If you follow the guidelines here and carefully set up your system, you'll be well on your way to achieving that.

The technique to be used in receiving and recording the satellites' signals determines the elements of the system. Because the satellites pass overhead at all sorts of hours of the day and night, it is more convenient to arrange automatic recording of them than having to be on-hand at each satellite pass – you wouldn't get much sleep! So, for your weather satellite ground station you'll need an ordinary audio cassette recorder and a means of switching it on and off when a satellite passes over. The recordings you make can then be played back and decoded employing a suitable decoder system, such as that described by Tom Moffat VK7TM in the July 1986 issue of AEM.

The satellites transmit their 'pictures' as modulated tones. The AEM3503 decoder converts the tones to pulses which are then re-assembled into a representation of the picture from the satellite using a computer which outputs to an ordinary dot-matrix printer. The technique strips the "grey scale" from the transmitted picture data so that you only get black or white, but enough of the detail is preserved to show cloud formations, coastlines etc. This is not the only means of decoding weather satellite pictures, but that's beyond the scope of this article.

Tom also described a suitable switch to automatically operate the recorder from the receiver – the AEM3502 Signal-operated Cassette Recorder Controller, published in our March 1986 issue. This is operated by the squelch line in the receiver. When a signal is not being received, the receiver output is muted by the squelch circuit. When a signal is received at suitable strength (set by the squelch control), the audio output is un-muted, or turned on. The squelch line is sensed by the '3502 and the relay operated when the squelch opens, starting the recorder. Whatever is coming through the audio output at that time is then recorded on the cassette.

So, an overall view of the ground station system would be something like that shown in Figure 1. Let us have a look at it

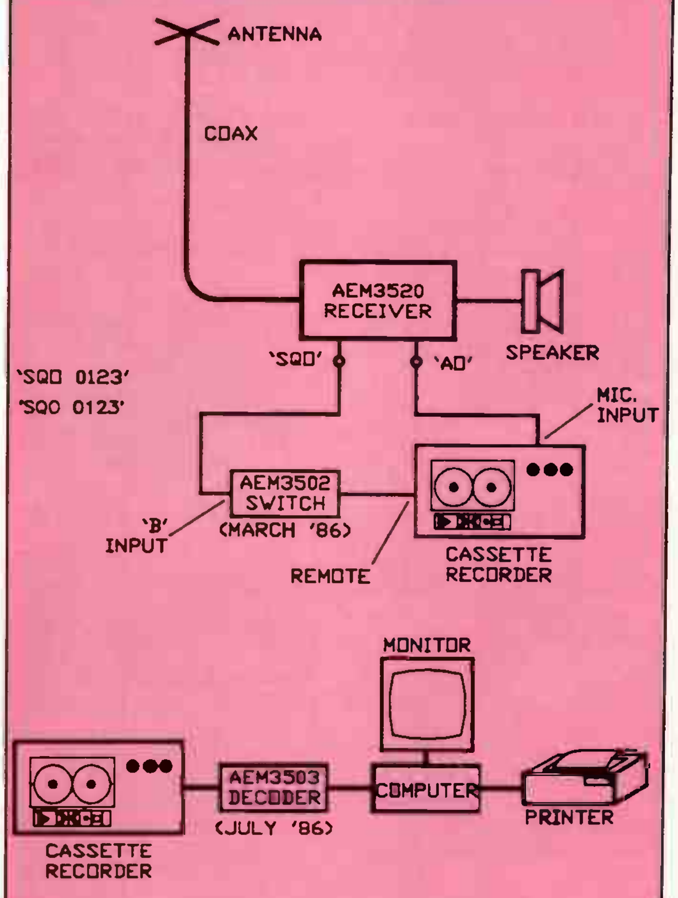


Figure 1. Block diagram of the system, as proposed. The satellite signals are recorded automatically for later playback. When a signal is received, the squelch output (SQO) operates the AEM3502 switch, turning the recorder on. The tape is then used for playback through a suitable decoder, the results being displayed by a computer. Signals could be decoded direct off-air if you wish, however.

bit by bit, starting with the receiver which is at the 'heart' of the system.

The receiver

Construction of the AEM3520 was fully described in John Day's article in the February issue. Housing it was left to individual preferences. But before we get around to discussing the housing, we need to discuss a few gremlins that crept into John's article. Firstly, in the Parts List, the values for R26 and R27 were transposed, they should be 4k7 and 10k, respectively. A number of components were also missed out of the Parts List: RFC6, a 10 μH RF choke (as per RFC5), ZD1 – an 8.2 V zener, and C64 – a 10n ceramic capacitor. C65 was given as 10n when it's a 100n, and it was actually missed from the circuit diagram. It goes in series with the input to IC1, pin 16, from the junction of RFC2 and C33. Also, details of the 'tap' connection on L1 were omitted. All you have to do is take a short length of tinned copper wire from the pad on the board adjacent to the coil (see the overlay) and carefully solder it to the coil one and a quarter turns up from the pin soldered to the topside groundplane.

In addition, following experience with aligning a few receivers since publication of the original article, John Day suggests soldering a 4k7 resistor in parallel with L8 to reduce its Q, which makes it easier to align. If you experience any instability or tendency to oscillation in the NE604 (it has a *lot* of gain!), solder a 10n ceramic capacitor on the under side of the board, between pin 7 of the NE604 and the groundplane track that runs down between its pins. Keep the capacitor leads very short.

While the receiver could be housed in any suitably-sized case, it would be best to use an all-metal type to shield it from possible interference from other nearby equipment, in particular, computer equipment. You could use one of the commonly available metal instrument cases, but not a type which has slots cut in the lid for cooling purposes. A diecast box is pretty well ideal. For best results, **any** external connections – such as power supply, loudspeaker, squelch, audio out etc, should be made via feedthrough capacitors. The antenna connection should be made via a suitable coaxial connector, such as a BNC or N type socket. While you could 'get away' with TV-type antenna connectors, or an SO-239 ('CB') socket, they are not recommended. The antenna connection on the pc board should be linked to the antenna socket via a short length of 50 Ohm coax, such as RG58 (¼") or RG178 (⅛") coax.

The AEM3520 board could be mounted in a diecast box and then this mounted in a suitable instrument case, with the controls mounted on its front panel and a small speaker mounted in the lid. Note that, in wiring the volume control, shielded cable should be used. You could also fit a small power supply in the instrument case. Alternatively, as suggested, the project could be powered from a 12-14 Vdc/200 mA plugpack supply. You could install a connector for an external monitor speaker if you wished. The speaker only serves as an audible monitor when you're actually in attendance while a satellite is being received, so having an external plug-in speaker would be a convenient way to do it.

The squelch output, SQO, audio output, AO, and signal strength indicator, SSI, outputs should all be brought out to external connections mounted on the case. The AO output goes to your cassette recorder input; SQO is used by the Signal-operated Cassette Recorder Controller.

The SSI output can be used to indicate received signal strength, and can also serve as a good tune-up indicator. The voltage here varies between about 100 mV (weak signal) and 4-5 V (strong signal). You can't drive a milliammeter with it directly, although a high input impedance voltmeter or multimeter could be used. To drive a, say, 1 mA panel meter you would need to buffer the SSI output with an op-amp connected as a voltage follower, the op-amp's output could then drive the panel meter, as illustrated here.

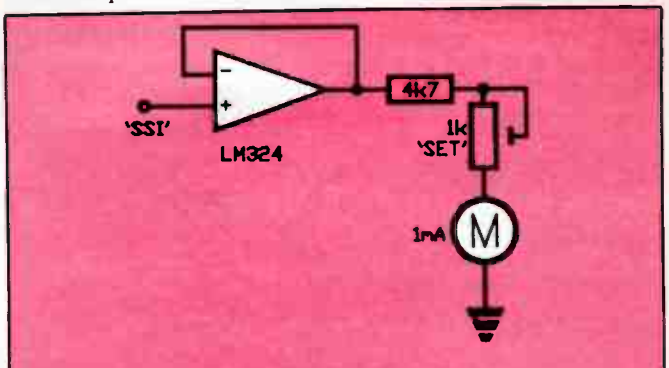


Figure 2. Signal strength meter circuit suggestion.

Undoubtedly, you could get away with just mounting the receiver in an ordinary low-cost plastic instrument case and not worrying about possible interference problems. Indeed, such a setup may serve quite well as a temporary arrangement. Barring problems, it could well become permanent!

The antenna

Simple dipole or groundplane antennas can be successfully used to receive the VHF weather satellites. They do have their drawbacks however, and not all the satellite passes available at your location may be properly heard with such antennas. Probably the all-round best an simplest antenna for this application is the turnstile, or crossed-dipoles antenna. Suitable construction details were given in "Practicalities" in the July 1986 issue, page 72.

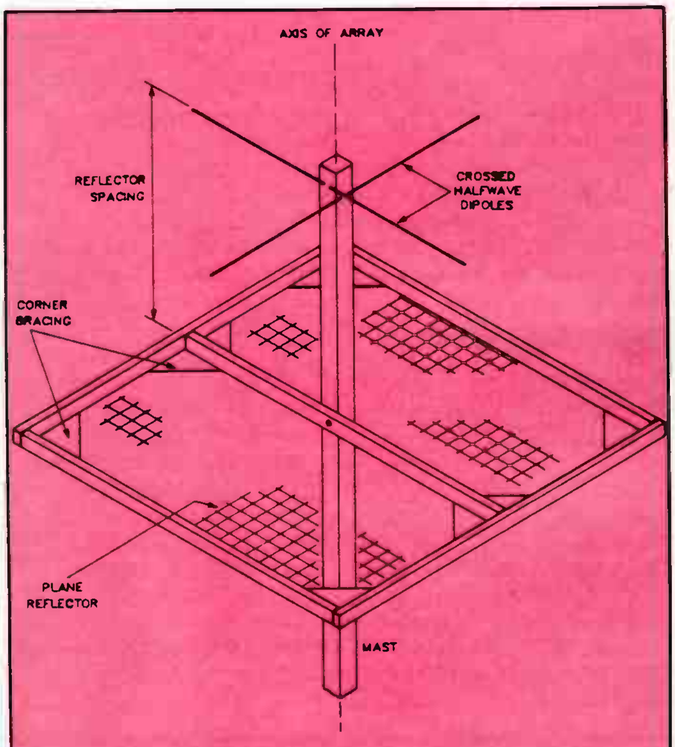
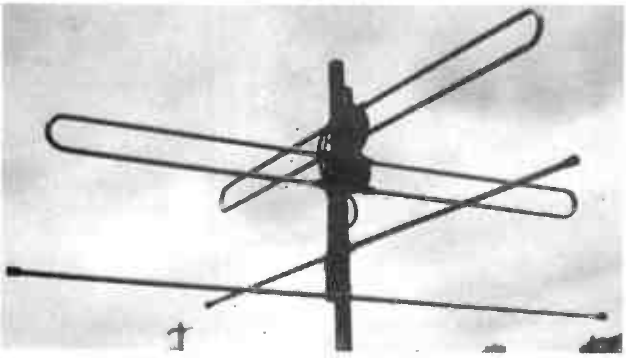


Figure 3. Drawing of a suitable turnstile antenna. (See AEM July 1986.)

A commercial turnstile recently became available from ZZV Antenna Farm, shown in the photograph here. This has sufficient bandwidth to be used on either the 136-138 MHz satellite band for receiving the weather satellites, or the 144- ▷

148 MHz amateur band for receiving the University of Surrey's "UoSAT" satellites. It is made by Satellite Antennas and distributed by ZZV Antenna Farm. It is available in both kit form (you have to make the phasing harness and terminate all the leads, then bolt the elements to the boom), as well as fully-built where all you have to do is bolt it together.



The turnstile antenna produced for ZZV Antenna Farm. It is ideal for this application. Contact ZZV Antenna Farm, PO Box 160, Cardiff South 2285 NSW. (049)54 8688.

A prototype was given to us for evaluation by Graham O'Brien VK2KZV of ZZV Antenna farm. We passed it on to a (then) local reader, Barry Quick, who was experimenting with satellite reception. Here's Barry's report:

"I recently built the AEM3506 UoSAT decoder and have been struggling to achieve a workable signal input to my Yaesu FRG-9600 receiver. My initial experiments involved an existing discone antenna (AEM3010) and whilst I was able to recover some useful data, the signal, not unexpectedly, was generally down in the noise.

"By comparison, the turnstile resulted in much improved reception, reduced noise level and more accurate reproduction of the satellite data. I am sure that the antenna would be a worthwhile investment to anyone experimenting with either the weather satellites or UoSAT."

The UoSAT 'birds' have transmitter outputs in the milliwatt region, while the APT weather satellites typically have 5 W output and are considerably stronger.

Whatever antenna you use, it need not be mounted very high above the ground, but it should have as clear and unobstructed a "view" as possible.

The feedline

The coaxial cable, or 'feedline', running from the antenna to the receiver is an important element in the system. In general terms, you should keep its length as short as practicable and use the best quality (lowest loss) cable you can afford, commensurate with the costs involved in the rest of the system.

You might get away with a relatively short length (5 m or so) of the small diameter (¼") coax such as RG58 (NOT 'CB' coax), but the inherent loss can seriously degrade the receiver performance, enough so that you couldn't hear satellites passing low on the horizon. The solid dielectric in this cable is what contributes to its loss at these frequencies. You'd be a bit better off installing a larger diameter (½") solid dielectric cable such as RG213.

Cables which have a dielectric which consists largely of air have much lower loss, but an attendant increase in cost. Generally such cables will have dielectric spacers threaded on the inner conductor, or the dielectric may be a 'foam' plastic. Low-loss 'TV' coax may be used, even though it's 75 Ohm where the antenna may be 50 Ohms and the receiver input matched to 50 Ohms. The small mismatch loss can be tolerated for the gain one makes with less loss in the feedline. Hills types DSC2.1 and DSC1.2 are good examples of suitable low- loss TV-type coax cables.

The connectors you use to terminate the cable at the antenna and the receiver are important, too. Once again, while you could get away with TV-type connectors, it's money well spent to install N-type connectors at the antenna and receiver. This connector is intended for use with the larger diameter cables.

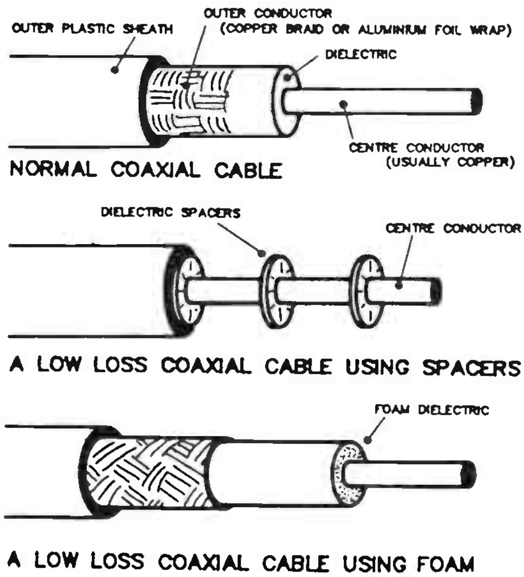


Figure 4. Coax cables. The top one is the least suitable as the solid dielectric has more loss than the other two. However, the latter two cables are more prone to damage during installation.

The N-type in-line connector incorporates a rubber pressure sleeve that seals the connector and prevents water getting into the cable – which can cause cable loss to rise dramatically. Even so, any connectors which will be outdoors and exposed to the weather should be wrapped in self- amalgamating tape (a 3M product).

Any connector should be carefully assembled to the cable (see, *Assembling Common RF Connectors*, AEM Sept. 1986). Ensure the cable and connector parts are clean before you start.

With low-loss coax, a longer run of cable can be tolerated before its loss significantly affects the receiver performance. Where a cable run of 20-50 metres may have to be used, good low-loss coax is *mandatory*. For good tips on cables and cable installation, see *Getting the Best TV Reception – Part 2, Cables*, by Les Cardilini in the December 1985 issue.

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Doubt over third-party traffic rules for radio amateurs

Roger Harrison VK2ZTB

If you work a DX station who tells you his operating schedule, and you then divulge that information to another local amateur in the course of a subsequent contact – are you in breach of "third party traffic" regulations? What about on-air "mailbox" messages? The rules are open to 'interpretation'.

DIGITAL TECHNOLOGY has wrought a number of changes to amateur radio operation in recent years. One significant development in this area, now burgeoning on the amateur HF and VHF bands, are "mailboxes" on radioteletype and packet radio bulletin board systems, rather like the ones available on dial-up telephone bulletin boards. An operator can leave a message for another operator in these electronic mailboxes for later retrieval.

The Australian federal communications authority, the Department of Transport and Communications (DOTC), has in force regulations, pursuant to the Radiocommunications Act, that expressly forbid Australian amateurs to exchange operator-to-operator messages via such mailboxes with overseas amateurs where a third-party traffic agreement between the two amateurs' countries does not exist.

To take an example, say there's an Australian station running a mailbox facility on the 14 MHz (20 metre) band. Australian amateurs can exchange messages between themselves via that mailbox, but an Australian amateur and a New Zealand amateur cannot – no matter what the content of the message, be it arrangements for a voice schedule next week or details of the latest DXpedition to South Kerguelen. The Australian and New Zealand authorities do not have a third-party traffic agreement for amateurs.

Doubts on the precise interpretation of the regulations have been expressed for some time, and increasing numbers of amateurs are asking questions and exploring the intent and consequences of the regulations.

In the breach

One prominent amateur, Sid Molen VK2SG, has had some correspondence on the matter with the DOTC and with overseas amateur organisations, seeking to clarify what can and can't be done for it seems that a 'strict' interpretation of our regulations in this area may mean that ordinary amateur-to-amateur exchanges breach the third-party traffic regs!

In a letter to Mr A. Jordan of the DOTC Operations Branch of the Radio Frequency Management Division early in February, following previous correspondence, Sid Molen said, in part: "*. . . I wish to suggest that there appears to be some discrepancy in understanding between your department and other departments of communications throughout the world. Primarily, the ITU* (International Telecommunications Union) *. . . has stated that amateur to amateur messages . . . in no way . . . breach third party traffic agreement between countries, and as such does not preclude the use of mailboxes for amateurs to pass messages to amateurs in other parts of the world, irrespective of whether any third party traffic agreement exists with that country.*"

The whole question hinges on the definition, or perhaps the interpretation of what "third party traffic" happens to be. Take this situation. You're talking to an amateur residing in some country overseas. He asks you to telephone his Aunt Mary who happens to live in your suburb/town/city and let her know that he has sent her a parcel for her birthday. Clearly, you recognise that as a request to pass a message to a third party – the aunt. If, on the other hand, he asked you to tell another amateur, whom you both knew, that the DXpedition on South Kerguelen would be on 14,215 kHz at 0800 UTC tomorrow, would you consider *that* third party traffic or just a fairly normal example of an exchange between amateurs?

Ponder the two examples. What is the difference? The difference is in what is called the "displacement" of the message. In the first instance, the message is not amateur related – that is, related to the amateur radio medium and process – you are *not* the recipient of the message which is intended for a non-amateur radio related party – the aunt. The displacement of the message goes beyond the amateur radio medium and activity. Theoretically, four parties may be involved, one non-amateur related party at each end.

In the second example, the displacement of the message stays entirely within the bounds of amateur radio activity and the amateur medium. If, however, you hear something on your scanner – not on an amateur band, that fire engines are attending an incident somewhere for example – and you divulge what you heard to another amateur on your local repeater, then that may be a breach of the regulations as it is *non-direct* traffic. It depends on whether what you heard is for public broadcast or public consumption.

The ARRL's legal representative, Charles C. Woodman K0KXR, in a reply to Sid's enquiries, points out that, where the third party is "*. . . totally non-related to the medium and process, and acts only as a recipient, then international third party regulations take precedent.*" **– continued on page 96 ▷**

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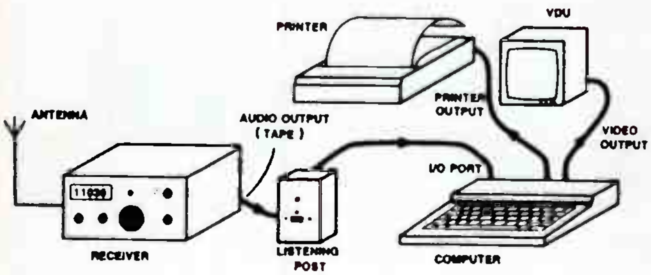

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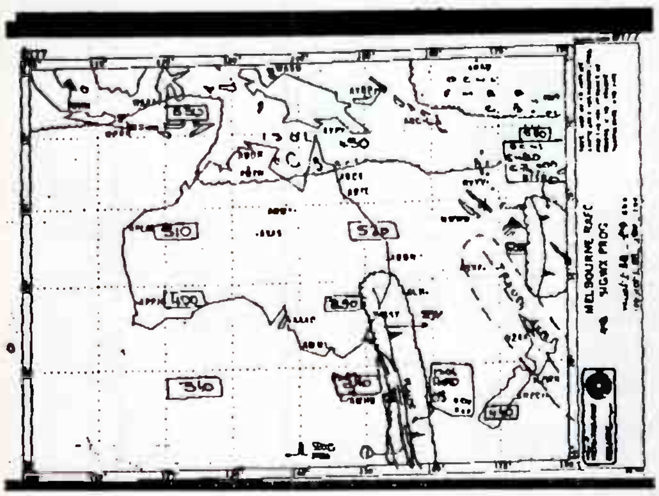

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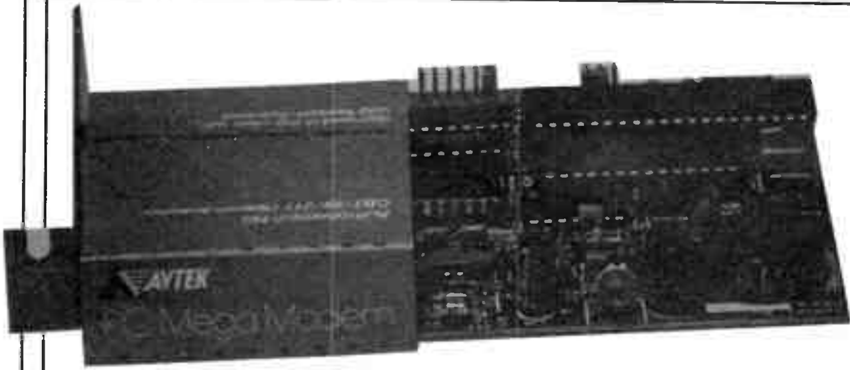

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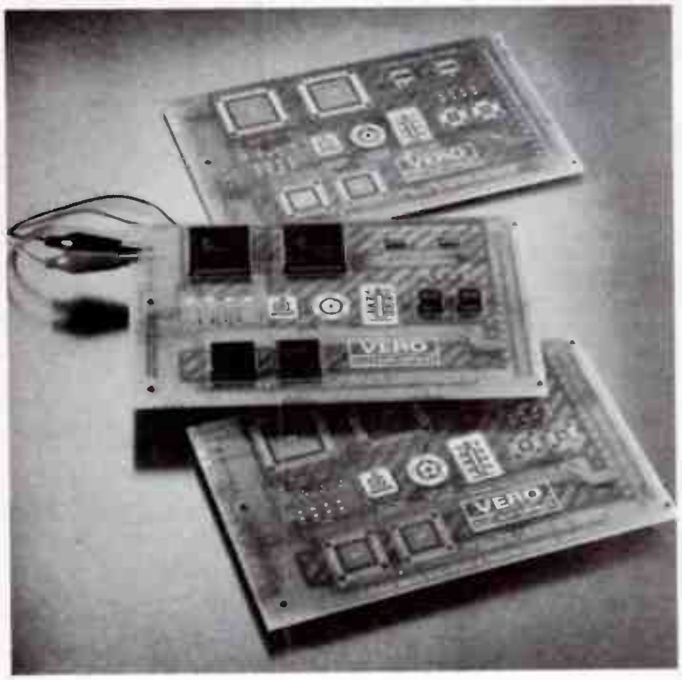

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The kit comprises a number of components designed to give a balanced range of component types for training and evaluating the use of surface mount technology, both in physically placing them and their electrical characteristics.

A circuit board, selection of surface mount devices, temperature sensors, solder mask stencil and solder paste are all included in the kit, they are also all available separately.

The kits are available throughout Australia and New Zealand from Anitech. Continued support is assured because a comprehensive range of Citec and Siliconix surface mount devices may be obtained from Anitech also, including potentiometers, chip resistors, indicators, networks, switches, multiplexers, FETs and MOSPOWER transistors.

Further information can be obtained from **Anitech, 1-5 Carter Street, LIDCOMBE 2141 NSW. (02)648 1711.**

Opto-digital experimenting

Adelaide-based distributor, Mayer Krieg & Co., has released a special experimenting and training system specifically developed to enable a wide circle of users to become familiar with opto- digital data transmission techniques.

The system that can be assembled from the kit provides a range of five metres and a bit rate of up to 0.5 Mbits/sec.

Although configured primarily for training purposes, the system is also suitable for use in laboratory research and product development programmes, the company says. Suitably installed, the system can operate as a full-scale interference free high speed digital link.

The system is supplied as a complete kit comprising optical connectors, five metres of polymer-based optical fibre and silk-screened pc boards. No additional components or special tools are required. Detailed assembly and installation instructions are included.

Contact **Mayer Krieg & Co., 50 Mary St, Unley 5061 S.A. (08)373 0444.**

New MD for ACL

Associated Calibration Laboratories Pty Ltd (ACL) recently announced the appointment of Mr. Len Heyward as Managing Director of their firm.

Mr. Heyward brings to the firm extensive technical experience from overseas and experience in marketing and sales of specialised communications and test equipment in Australia.

Peter Williams, the previous Managing Director of ACL, assured that Mr. Heyward's great and varied experience and knowledge of the electronics field and familiarity of Government policies would lend themselves well to the job and insure the growth and strength of ACL in the years to come.

Peter Williams will continue to work with ACL on a consulting basis, while also spending several years ocean cruising. Lucky dog, Peter!

Len Heyward – new MD.

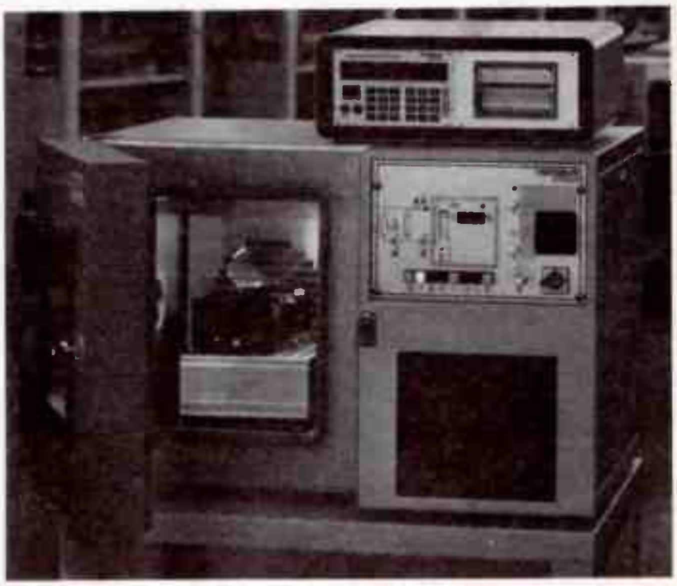
Hot and cold

A complete range of environmental simulation and test chambers are available from Foss Electric (Aust.) Pty Ltd. Detailed in their new catalog, the machines are designed and manufactured by Heraeus Votsch, pioneers and leaders in this technology, say Foss.

The brochure not only contains information about six different product groups, but has information about custom made and modified chambers and a range of accessories. It also offers information about the application and suitability of the products for a wide range of situations.

The six new product ranges comprises; temperature and climatic test chambers, walk and drive-in test rooms, systems to simulate various gaseous conditions and temperature shock and vibration chambers.

More information may be obtained from **Foss Electric Aust. P/L, 45 Booralie Rd, Terrey Hills 2084 NSW.**



Practical filter design – without fears or tears

Part 7 – other forms of active filter

Jack Middlehurst

Here we get an object lesson in guided democracy. Up till now, we could only control given factors in the various filters. Now we learn how to gain control over desirable factors without getting undesirable consequences. For the most part, anyway.

IN DESCRIBING active filters so far, the emphasis has been on ease of construction together with reliability. Like all things engineering, each form of active filter represents a compromise. The various properties that one might consider desirable are: simplicity, stability, ease of adjustment, ability to set the gain, reasonable range of element values, and the ability to generate high Qs. While all active filter designs based on a single IC amplifier aspire to having all of these virtues, none succeeds: each has its superior points and its failings.

For this reason there are a number of designs all intended to perform the same task, each claiming superiority in one or more of the desirable attributes. We will look at some of the more successful designs so that you can choose which you prefer to use for your particular application.

Stability

There are books devoted entirely to the subject of the stability of active filters of various forms. These books analyse each circuit and develop equations that show the variations of the filter characteristics that are caused by small changes in the value of each of the passive components and by large changes in the properties (e.g: gain, bias currents, cutoff frequency) of the IC amplifiers. This kind of analysis can show whether a particular combination will be susceptible to small temperature changes or component drift, for example.

Since this series is about practical filter design, we will only present those circuits that have good stability and combine enough good qualities to be of general use, and we will comment on their good and bad points.

Sallen and Key filter blocks

We are already familiar with the Sallen and Key form of second order filter, having used it in Butterworth and Chebychev filters. Its good points are its simplicity and stability. Some of the bad points have already been pointed out: difficulty of tuning, and a high ratio of component values if high Qs are needed. For our purposes so far, the gain has been fixed at unity, but this circuit is not restricted to that gain.

Figure 7.1 shows the general circuit for a Sallen and Key LP filter element; it differs from the one that we have used already only in having two additional resistors to set the gain. The values of the frequency and Q setting resistors are not changed by adding these two resistors. The only difference is that you, the designer, can choose the gain. Simply pick a value for Rf1 (say 10k) and then

$$Rf2 = (Gain - 1) \times Ra,$$

where Gain is the numerical gain, not the gain in dB. The

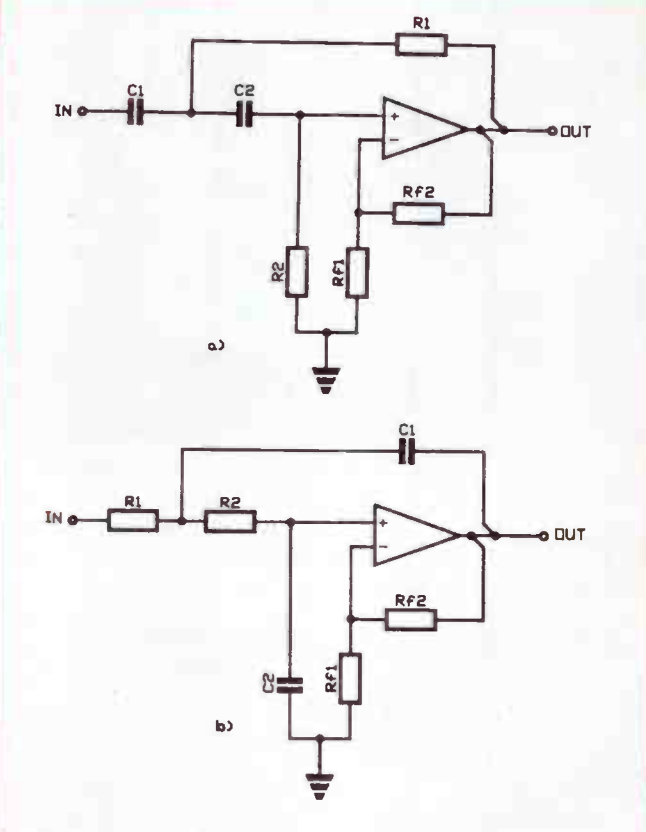


Figure 7.1. Circuits for Sallen and Key a) HP and b) LP filter blocks with gain. The differences from the normal Sallen and Key circuit are the fact that the two resistors are no longer equal, and the addition of the gain setting resistors Ra and Rb.

same two resistors can be added to the HP circuit, again with no change in the other element values. Because the gain is no longer unity, the stability of the circuits is not necessarily as good as before but, unless you choose a particularly high gain, the stability will still be adequate for most purposes.

A problem with the standard form of the Sallen and Key circuits is that high Qs are only obtained at the expense of very high ratios of resistors (for the HP) or capacitors (for the LP). In fact the Q is proportional to SQRT(R1/(2xR2)) in HP filters. This means that to get a Q of 20 requires a resistance ratio or capacitance ratio of 1600:1 which is, to say the least, a bit much. It is possible to avoid this problem by altering the circuit component values.

The normal LP circuit design uses two identical capacitors, but while this is done for convenience in design, it is not essential. By using different values for the two capacitors, the resistance ratio can be reduced. The circuit remains the same. It turns out that, if you choose particular values for the capacitors that reduce sensitivity to changes in component values, there is a particular gain for these circuits at which their sensitivity to changes in the gain of the IC is a also a minimum. This gain is 4/3.

If you find that the resistance or capacitance ratios of your design are getting too high, by all means use these circuits with a gain of 4/3. Selecting Rf1 = 82k and Rf2 = 27k gives this ratio sufficiently accurately. The optimum circuit values of the other components are then given by the program of Figure 7.2. You would also use these conditions if you wanted to make several identical filters and be able to plug ICs from different manufacturers into them, depending on whose ICs are available at the time. To reduce problems with drift, the program gives values for Rf1 and Rf2 that ensure that there is the same resistance from each amplifier input terminal to earth.

The fact that the gain is greater than unity means that the filter will overload with a smaller input signal, so it may be

```
10 PRINT "          Design of Sallen & Key LP & BP filters with gain.":PRINT
20 PRINT "Which type of filter would you like to design "
30 PRINT "1. Low pass":PRINT "2. High pass "
40 INPUT "Please enter the appropriate integer ",X:IF X<>1 AND X<>2 THEN 20
50 INPUT "What is the tuning frequency [ Hz ] for the filter block ?",FC:IF FC<=
0 THEN 50
60 INPUT "What is the value of the circuit Q ?". Q:IF Q<=0 THEN 60
70 REM ______________________ SELECT CAPACITANCE VALLUE ____________________
80 PI=3.1415927#:FACTOR=1000000!:IF FC>=5000 THEN FACTOR=1E+09:GOTO 110
90 IF FC>=500 THEN FACTOR=1E+08:GOTO 110
100 IF FC>=50 THEN FACTOR=1E+07
110 ON X GOTO 130,170
120 REM ______________________ LOW PASS CALCULATIONS _________________________
130 R1=FACTOR/Q/2/PI/FC:IF R1<2200 THEN FACTOR=FACTOR*2200/R1:R1=2200
140 C1=SQR(3)*Q/FACTOR:C2=1/FACTOR:R2=FACTOR/SQR(3)/2/PI/FC
150 RF2=4*(R1+R2):RF1=RF2/3:GOTO 200
160 REM _____________________ HIGH PASS CALCULATIONS _________________________
170 R1=FACTOR/SQR(3)/Q/2/PI/FC:IF R1<2200 THEN FACTOR=FACTOR*2200/R1:R1=2200
180 R2=FACTOR/2/PI/FC:C1=Q/FACTOR:C2=SQR(3)/FACTOR:RF2=4*R2:RF1=RF2/3
190 REM ___________________________ DISPLAY ___________________________________
200 C=C1:GOSUB 280:PRINT USING "C1 =###.###\ \";C,C$
210 C=C2:GOSUB 280:PRINT USING "C2 =###.###\ \";C,C$
220 R=R1:GOSUB 330:PRINT USING "R1 =###.###\    \";R,R$
230 R=R2:GOSUB 330:PRINT USING "R2 =###.###\    \";R,R$
240 R=RF1:GOSUB 330:PRINT USING "Rf1=###.###\    \";R,R$
250 R=RF2:GOSUB 330:PRINT USING "Rf2=###.###\    \";R,R$
260 PRINT "End of programme.":END
270 REM ______________ SUBROUTINE FOR CAPACITANCE UNITS ______________________
280 IF C>=.000001 THEN C=C*1000000!:C$=" uF":GOTO 310
290 IF C>=1E-09 THEN C=C*1E+09:C$=" nF":GOTO 310
300 C=C*1E+12:C$=" pF"
310 RETURN
320 REM ______________ SUBROUTINE FOR RESISTANCE UNITS ________________________
330 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms":GOTO 360
340 IF R>=1000! THEN R=R/1000!:R$=" kOhms":GOTO 360
350 R$=" Ohms "
360 RETURN
```

Figure 7.2. GWBASIC program to calculate the values of the components for the circuit of Figure 7.1 when the gain is set at 4/3 to improve stability.

necessary to attenuate the input before it gets to the filter. For LP filter blocks this is easy since the first element of the block is a resistor. This resistor is simply replaced by two resistors as in Figure 7.3. If the numerical gain of the block is G, and the value of the first resistor in the block was R Ohms, then the values of the two resistors are given by Ra = GxR/(G – 1) and Rb = G x R.

By using these values the input signal is divided by the gain, and then the filter block multiplies it by the gain, giving

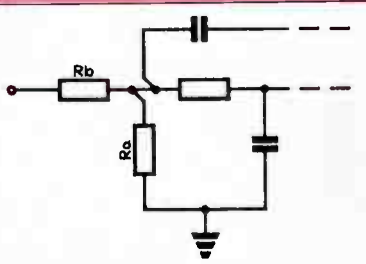


Figure 7.3. Input voltage divider for LP filter blocks. Ra and Rb act as a divider to reduce the input voltage. The resistance of Ra in parallel with Rb is equal to the resistance of the original input resistor.

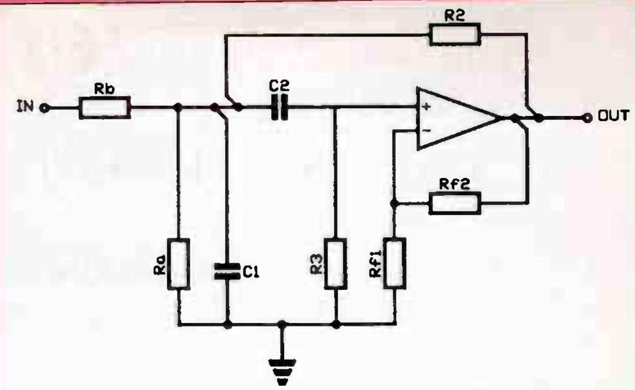


Figure 7.4. Circuit of Sallen and Key BP filter block with input voltage divider resistors Ra and Rb and with gain adjusting resistors Rf1 and Rf2.

an overall gain of 1 for the filter block. In addition, Ra in parallel with Rb is equal to the original value R, so the frequency response of the circuit is unaltered. For a gain of 4/3, the values of Ra and Rb become 4 x R and 4 x R/3 respectively.

There is also a Sallen and Key version of a BP filter block. This is shown in Figure 7.4 and it behaves exactly like a tuned circuit. Given the centre frequency, the Q and the requires gain, the program of Figure 7.5 will display the values of the components. Since this filter has a gain within the filter block, the input signal is reduced in the same way as for LP filters. The maximum gain of the circuit is related to the Q and the centre frequency, and if the gain requested is larger than the maximum gain for the circuit, an error message is displayed. This circuit can be use in Butterworth and Chebychev BP filters, but in elliptics it can only be used in BP filters for the block that does not need a notch.

As with all filters of this type, you can divide (or multiply) all resistors in the filter by a factor provided you multiply (or divide) all capacitors by the same factor. Since the program gives values of Rf1 and Rf2 such that the resistance from each input terminal of the amplifier is the same, it is necessary to divide (multiply) Rf1 and Rf2 by the same factor as well.

The Sallen and Key circuit is the simplest of a series of circuits based on the use of a single feedback network. In books on filters you will find more complicated circuits that have somewhat better stability. These circuits are often used by filter designers for this reason alone, but for non-professionals their use is not warranted, so we will stay with Sallen and Key. ▷

```
10 PRINT "          Design of Sallen & Key BP Filter with gain.":PRINT
20 INPUT "What is the centre frequency [ Hz ] ?",FC:IF FC<=0 THEN 20
30 INPUT "What is the value of the circuit Q ?",Q:IF Q<=0 THEN 30
40 INPUT "What is the numerical value of the desired gain ?", A0:IF A0<=0 THEN 4
0
50 REM __________ SET UP CONSTANTS, MAX GAIN, & CAPACITANCE ____________________
60 PI=3.1415927#:AMAX=2*SQR(2)*Q-1: IF A0>AMAX THEN PRINT USING "The maximum gai
n possible with this circuit is ###.#";AMAX:GOTO 40
70 FACTOR=1000000!:IF FC>5000 THEN FACTOR=1E+09:GOTO 110
80 IF FC>500 THEN FACTOR=1E+08:GOTO 110
90 IF FC>50 THEN FACTOR=1E+07
100 REM __________________ CALCULATE COMPONENT VALUES _________________________
110 G=A0/AMAX:RB=SQR(2)*FACTOR/2/PI/FC/G:IF RB<2200 THEN FACTOR=FACTOR*2200/RB:R
B=2200
120 RA=RB*G/(1-G):R1=SQR(2)*FACTOR/2/PI/FC:R2=R1:R3=R1:C1=1/FACTOR:C2=C1
130 K=4-SQR(2)/Q:RF1=R3*K/(K-1):RF2=R3*K
140 REM __________________________ DISPLAY ____________________________________
150 C=C1:GOSUB 250:PRINT USING "C1 =###.###\ \";C,C$
160 C=C2:GOSUB 250:PRINT USING "C2 =###.###\ \";C,C$
170 R=R2:GOSUB 300:PRINT USING "R2 =###.###\    \";R,R$
180 R=R3:GOSUB 300:PRINT USING "R3 =###.###\    \";R,R$
190 R=RA:GOSUB 300:PRINT USING "Ra =###.###\    \";R,R$
200 R=RB:GOSUB 300:PRINT USING "Rb =###.###\    \";R,R$
210 R=RF1:GOSUB 300:PRINT USING "Rf1=###.###\    \";R,R$
220 R=RF2:GOSUB 300:PRINT USING "Rf2=###.###\    \";R,R$
230 PRINT "End of programme.":END
240 REM ___________ SUBROUTINE FOR CAPACITANCE UNITS __________________________
250 IF C>=.000001 THEN C=C*1000000!:C$=" uF":GOTO 280
260 IF C>=1E-09 THEN C=C*1E+09:C$=" nF":GOTO 280
270 C=C*1E+12:C$=" pF"
280 RETURN
290 REM ___________ SUBROUTINE FOR RESISTANCE UNITS ____________________________
300 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms":GOTO 330
310 IF R>=1000! THEN R=R/1000!:R$=" kOhms":GOTO 330
320 R$=" Ohms "
330 RETURN
```

Figure 7.5. GWBASIC program to calculate component values for the circuit of Figure 7.4

Multiple feedback filter blocks

We have actually met the first of these circuits before in its BP form as the filter block without a notch that is necessary in odd order elliptic filters (see Figure 5.6). Multiple feedback filter blocks, with up to 8th order in a single block, are described in various texts. They are *horrendously* complicated. The one useful exception is that particular second order multiple feedback BP filter, the circuit of which is repeated in Figure 7.6. This circuit is simple and, provided the Q is limited to 20 or less, can be used as a filter block in any Butterworth or Chebychev BP design.

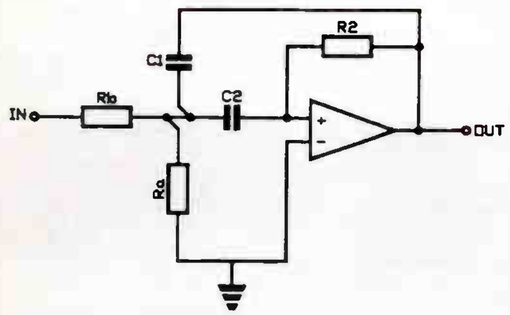


Figure 7.6. Multiple feedback BP filter block with input dividing resistors Ra and Rb.

The reason for limiting the Q is that the gain of the circuit is proportional to Q squared, so if Qs greater than 20 are used, there are two problems. The first is the obvious one of the amplifier overloading easily. The second is the limited gain of most ICs at high frequencies. This means that, if the filter is to be used at high frequencies, the IC may not have enough gain to ensure that the feedback works properly, since the IC gain must be at least 100 by Q squared at the tuning frequency of the filter. Not many ICs have a gain of 40 000 at 20 kHz! You would have noticed that, in our use of this circuit in elliptic BP filters, it was only used for the filter block having the lowest Q. The program to calculate the component values for this circuit is in Figure 7.7

The solution to the problem of getting high Qs will have occurred to those involved in amateur radio; use Q enhancement techniques. This is done by applying positive feedback to the circuit as shown in Figure 7.8. The simple addition of the two resistors feeding back from the output to the positive input terminal of the amplifier enhances the circuit Q and permits a reduction in component ratio by about a factor of 10.

```
10 PRINT "       Design of multiple feedback BP Filter with gain.":PRINT
20 INPUT "What is the centre frequency [ Hz ] ?",FC:IF FC<=0 THEN 20
30 INPUT "What is the value of the circuit Q ?",Q:IF Q<=0 THEN 30
40 INPUT "What is the numerical value of the desired gain ?", A0:IF A0<=0 THEN 4
0
50 REM ____________ CONSTANTS, GAIN, & CAPACITANCE ____________
60 PI=3.1415927#:AMAX=2*SQR(2)*Q-1: IF A0>AMAX THEN PRINT USING "The maximum gai
n possible with this circuit is ###.#";AMAX:GOTO 40
70 C=.000001:IF FC>5000 THEN C=1E-09:GOTO 110
80 IF FC>500 THEN C=1E-08:GOTO 110
90 IF FC>50 THEN C=.0000001
100 REM ____________ CALCULATE COMPONENT VALUES ____________
110 G=A0/AMAX:R2=Q/PI/FC/C:RB=R2/2/A0:RA=R2/2/(2*Q*Q-A0)
120 REM ____________________ DISPLAY ____________________
130 GOSUB 200:PRINT USING "C1=###.###\ \";C,C$
140 PRINT USING "C2=###.###\ \";C,C$
150 R=R2:GOSUB 250:PRINT USING "R2=###.###\   \";R,R$
160 R=RA:GOSUB 250:PRINT USING "Ra=###.###\   \";R,R$
170 R=RB:GOSUB 250:PRINT JSING "Rb=###.###\   \";R,R$
180 PRINT "End of programme.":END
190 REM __________ SUBROUTINE FOR CAPACITANCE UNITS ______________
200 IF C>=.000001 THEN C=C*1000000!:C$=" uF":GOTO 230
210 IF C>=1E-09 THEN C=C*1E+09:C$=" nF":GOTO 230
220 C=C*1E+12:C$=" pF"
230 RETURN
240 REM __________ SUBROUTINE FOR RESISTANCE UNITS ______________
250 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms":GOTO 280
260 IF R>=1000! THEN R=R/1000!:R$=" kOhms":GOTO 280
270 R$=" Ohms "
280 RETURN
```

Figure 7.7. GWBASIC program for calculating component values for the circuit of Figure 7.6

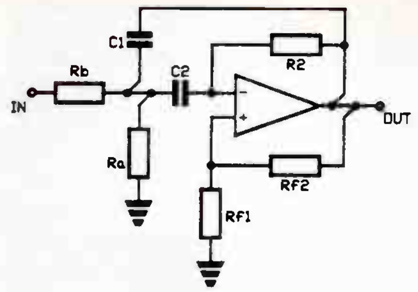


Figure 7.8. Delyiannis' circuit for Q enhancement of BP filter block by applying positive feedback via Rf1 and Rf2.

This circuit is often referred to as the *Delyiannis* bandpass circuit after its inventor and is only used where you need a Q of 10 or more. Figure 7.9 is a GWBASIC program that calculates the component values for this circuit. Again, as well as the filter requirements, the gain is requested. Incidentally, this circuit is even less sensitive to changes of IC gain than the Sallen and Key circuit with a gain of 4/3. In fact, there is an optimum value for the resistance ratio that depends on the likely scatter in component values and on the likely scatter in the gain x bandwidth product (commonly called GBW) of the IC amplifier.

For designers of filters where thousands are to be made, accurate records are kept of the scatter in the values of delivered components, so precise values for these numbers can be used to choose the optimum value of the resistance ratio. In the program of Figure 7.9 the values 1% and 50% have been taken as the likely scatter in the component values and the GBW respectively. This will put the design close enough to optimum for our use.

Because this circuit uses positive feedback, you can make it oscillate by using a poor layout. Also, it works best with ICs that do not have a particularly high value of GBW. For example, it is not a good idea to use it with the LF353/347 series of FET-input op-amps since the resistance ratio Rf2/Rf1 becomes unmanageable.

It is worthwhile making up a small piece of pc board with the circuit layout that you propose to use for this filter block and try the circuit out before committing yourself to a complete board layout. If your little board circuit oscillates you have some chance of fixing it and using the modified layout ▷

```
10 PRINT "       Design of Delyiannis BP filter block.":PRINT
20 INPUT "What is the centre frequency [ Hz ] ?",FC:IF FC<=0 THEN 20
30 INPUT "What is the value of the circuit Q ?",Q:IF Q<=0 THEN 30
40 INPUT "What numerical gain would you like ?",G:IF G<=0 THEN 40
50 INPUT "What is the value [ MHz ] of the GBW product of the IC ?",GBW:IF GBW<=
0 THEN 50
60 REM ____________ SELECT CAPACITANCE VALUE ____________
70 FACTOR=303030!:IF FC>5000 THEN FACTOR=FACTOR*1000:GOTO 110
80 IF FC>500 THEN FACTOR=FACTOR*100:GOTO 110
90 IF FC>50 THEN FACTOR=FACTOR*10
100 REM ____ Beta allows for 1% scatter in Rs & Cs and 50% in IC parameters ___
110 PI=3.1415927#:BETA=80000!*GBW/FC
120 REM ____________ CALCULATE COMPONENT VALUES ____________
130 C1=1/FACTOR:C2=C1:R=FACTOR/SQR(BETA)/2/PI/FC:R2=FACTOR*SQR(BETA)/2/PI/FC
140 RATIO=R*C2*2*PI*FC/Q
150 IF G>1/RATIO THEN PRINT USING "The required gain is too high, maximum gain p
ossible is ####.#";1/RATIO:GOTO 40
160 RATIO=RATIO*G:RB=R/RATIO:RA=R/(1-RATIO)
170 K=(Q*(BETA+2)-SQR(BETA))/(2*Q-SQR(BETA)):RF2=K*R2:RF1=RF2/(K-1)
180 REM ____________________ DISPLAY ____________________
190 C=C1:GOSUB 280:PRINT USING "C1 =###.###\ \";C,C$
200 C=C2:GOSUB 280:PRINT USING "C2 =###.###\ \";C,C$
210 R=RB:GOSUB 330:PRINT USING "Rb =###.###\   \";R,R$
220 R=RA:GOSUB 330:PRINT USING "Ra =###.###\   \";R,R$
230 R=R2:GOSUB 330:PRINT USING "R2 =###.###\   \";R,R$
240 R=RF1:GOSUB 330:PRINT USING "Rf1=###.###\   \";R,R$
250 R=RF2:GOSUB 330:PRINT USING "Rf2=###.###\   \";R,R$
260 PRINT "End of programme.":END
270 REM __________ SUBROUTINE FOR CAPACITANCE UNITS ______________
280 IF C>=.000001 THEN C=C*1000000!:C$=" uF":GOTO 310
290 IF C>=1E-09 THEN C=C*1E+09:C$=" nF":GOTO 310
300 C=C*1E+12:C$=" pF"
310 RETURN
320 REM __________ SUBROUTINE FOR RESISTANCE UNITS ______________
330 IF R>=1000000! THEN R=R*.000001:R$=" MOhms":GOTO 360
340 IF R>=1000! THEN R=R*.001:R$=" kOhms":GOTO 360
350 R$=" Ohms "
360 RETURN
```

Figure 7.9. GWBASIC program for calculating the component values for the circuit of Figure 7.8.

World Radio History

on your big board, but oscillation on a full sized filter board can be extremely frustrating.

General principles of modern filter design

All of the active circuits that we have been discussing are examples of what are known as *biquads*. In designing filters from first principles, filter theorists first find an approximation to the exact filter frequency response shape needed. The perfect filter for some purposes was thought to be a "brick wall" filter. The low pass version of this would have zero loss from DC to the cutoff frequency and infinite loss from the cutoff frequency upwards. In this series we have unintentionally been following the history of attempts to find the perfect brick wall filter, first the simple RC filter, then the Butterworth, the Chebychev, and finally the elliptic, each with ever increasing cutoff slope.

The approximations to a brick wall used by the various designers have been in the form of the equation that describes the ratio of the output of the filter to its input, in other words, the equation that describes the filter's frequency response. This equation takes the form of the ratio of two polynomial expressions in terms of frequency. Each polynomial can be factorized, so the approximation can always be put in the form:

Output/Input = (factors containing frequency squared)/(other factors containing frequency squared).

There might be one factor on the top line and several factors multiplied together on the bottom line.

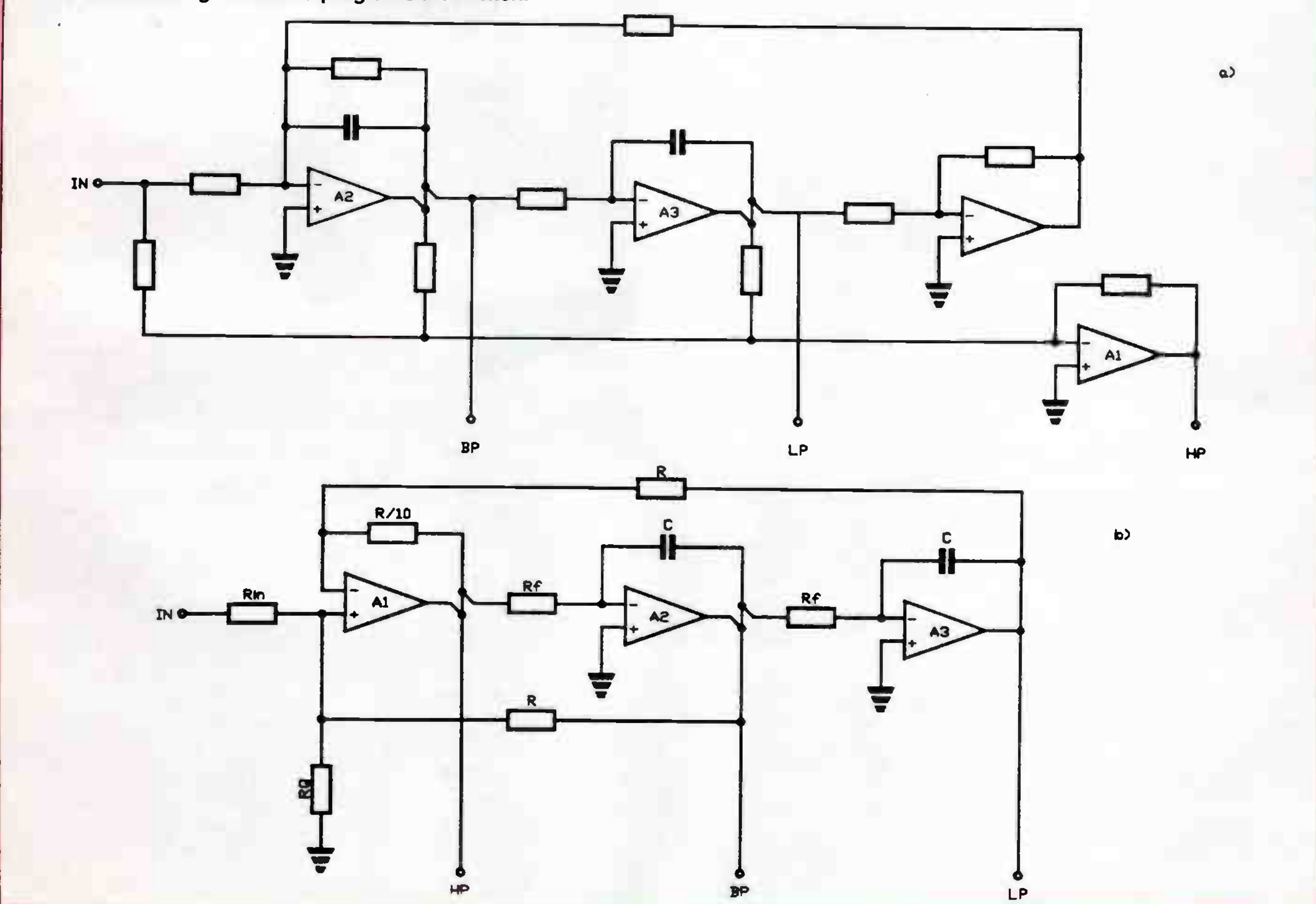
Using S for the (complex) frequency, each factor can be of the form (SxS+SxFc/Q+FcxFc) where Fc is the tuning frequency for that element of the filter and Q is its Q, although this exact form isn't essential. Each factor of the numerator corresponds to the frequency of one of the tuned notches, and the factors of the denominator correspond to the frequencies of the tuned circuits in the filter.

Since the frequency response equation can be broken up into factors, each of which consists of the ratio of two quadratic forms, each such factor is called a biquadratic or biquad for short. Each biquad block in the equation corresponds to each circuit block in the active filter, so each circuit block is also called a biquad.

This means that the whole object of filter design in recent years has been to find the set of biquadratics to put into the equation to describe the filter, then to try and find circuits whose output to input ratio is exactly described by this set of biquadratic factors. As far as the circuit is concerned, there are additional practical requirements. It would be nice if the tuning frequency and Q could be separately and easily adjusted. In addition it is essential that, once adjusted, the circuit should be stable. Also, it is best if the adjustments do not depend on the properties of the amplifiers.

The search for ideal circuits has continued for many years and will undoubtedly continue for many more. Since engineers are never satisfied with their work, the requirements for the circuits tend to become more stringent as time goes on. More general purpose circuits, with LP, HP, notch and other outputs from the same circuit are now demanded. A simple way of varying the cutoff frequency of a complete filter using a single control is now seen as desirable. And so on.

Figure 7.10. Two versions of the state variable filter. The circuit at (b) is the one on which the next circuits are based and for which the following GWBASIC programs are written.



Biquads

Because they can produce tuned circuits and notches simultaneously, the Antoniou circuits were our first example of modern biquads. They are by no means perfect since the tuning arrangements are difficult, although the tuning frequency, Q, and notch frequency can be changed independently. They are indeed the best of the two IC biquads, particularly when it comes to high frequency response, but if we want better overall performance, we will have to go to biquads using three or more ICs.

A number of different forms of three-IC biquads have been used in the past, each with its own virtues and failings. Indeed it is an interesting study of human nature to go through the literature seeing the inventor of each biquad pushing the reasons why his (there are no hers in this game, so far) particular circuit as the epitome of biquad design. In the end, two designs survived. The circuits are given in Figure 7.10. They differ chiefly in the order in which the elements occur. The first is treated in detail in Williams' book, and the design equations can be found there. The second form gives slightly better performance for our purpose so we will concentrate on its design.

Curiously enough, both of these circuits are derived from circuit elements used in the old analogue computers. These computers were used to solve simultaneous differential equations, mainly in heat flow, diffusion, and similar subjects. They consisted of banks of electronic integrators and summing amplifiers and could solve 50 simultaneous differential equations in 20 msec without any difficulty, a task only recently surpassed by digital computers.

The frequency response of a filter can be set up as a set of differential equations and that set of equations can be solved by what is known mathematically as the state variable method. This involves two integration processes of the equations that describe filters. The circuit of the state variable biquad, as it is known, can be seen to consist of a summing amplifier (A1) and two integrators (A2 and A3). Those who have had anything to do with PA systems or professional audio will recognize the summing amplifier simply as an audio mixer.

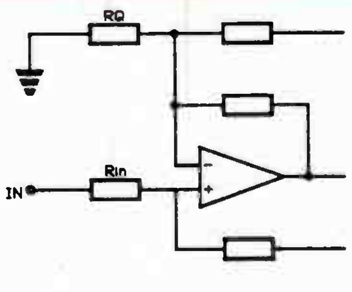
The state variable filter is the answer to a filter designer's prayer. It is stable, insensitive to component and IC drifts, easy to tune and easy to adjust. The principal limitations are an upper frequency of about 100 kHz for low Q circuits, a maximum FQ product of about 200 000, and a maximum Q of about 500 at low frequencies.

The circuit has three outputs, one for use as an LP filter block, one for HP and one for BP. The output level at the LP terminal of Figure 7.10b is 10 times that at the other two terminals. The state variable filter has two resistors, either of which can be used to control the tuning frequency, and a separate resistor to control the Q. There is no interaction between the frequency control and that of the Q.

If the Q is below a critical value, the Q tuning resistor becomes too large so the circuit of Figure 7.11a is used. The value of RQ is different and it is transferred from the non-inverting input of the first amplifier to the inverting input. Figure 7.11b shows the way in which, by using an extra summing amplifier, a notch can be generated for elliptic filters. The gain of the filter block can be controlled by Rg. The frequency of the notch can be adjusted by varying Rhp. For odd order HP filters a CR-amplifier circuit is needed at the input to the first block as in Figure 7.11c. For odd order LP filters an additional RC stage is needed for the first filter block as shown in Fig 7.11d; for odd order elliptic LP filters the addition of a single capacitor to the notch amplifier does the same thing so the extra stage is not needed.

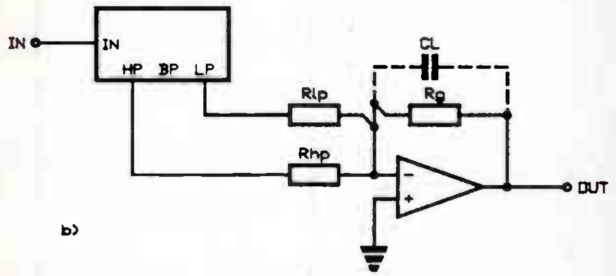
You can see why, for many years, this was THE filter circuit for professional electronics engineers, and indeed it still is for high quality audio use. National Semiconductor made a selection of these circuits into ICs as part of their AF series (the AF100, AF150, AF151, AF160, and AF161) with different frequency and Q ranges and different pin connections. The frequency and Q setting resistors were external to the ICs. These members of the AF series are no longer available in Australia since they were expensive, and for professional use in the telecommunications industry, the switched capacitor filter is cheaper.

The advantages of the AF series of ICs were that they had inbuilt precision matched capacitors, and the characteristics of their amplifiers were optimized for filter design. This means that they could be used with relatively high Q filters. The critical property of such ICs (and indeed for any ICs used ▷



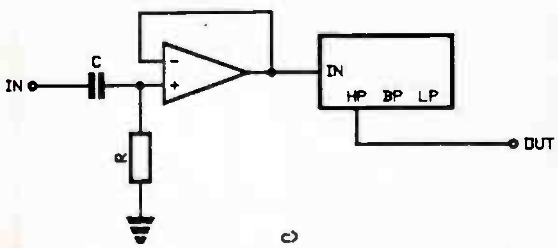
a)

Figure 7.11 (a). Modified circuit of the first amplifier for use with low Q filter blocks. The resistor RQ is transferred from the non-inverting input to the inverting input.



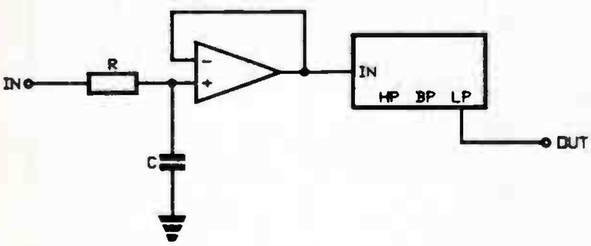
b)

(b) Additional amplifier to create a notch for elliptic filters. The resistor Rhp can be varied to change the location of the notch. For odd order elliptic LP filters an additional capacitor CL is needed.



c)

(c) Additional CR circuit needed for all odd order HP filters.



d)

(d) Additional RC circuit needed for all odd order LP filters except elliptics which simply use the extra capacitor shown in (b).

in filters) is the maximum attainable FQ product, i.e: the product of the resonant frequency of a circuit block and its Q. This number should be as high as possible. For example, a filter IC with an FQ product of 100 000 will only allow you to design a filter block having a resonant frequency of 10 kHz if the required Q of the block is 10 or less. It is possible to get FQ products as high as 200 000 using modern FET amplifiers, but this means that filters at 20 kHz are limited to a Q of 10, so you will not see active filters at this frequency with razor sharp cutoffs.

For high fidelity use, where many would argue that switched capacitor filters are not desirable, the state variable filter is the best of the general purpose filters. State variable filter blocks can be made using high frequency quad FET ICs such as the LF347/TL074 etc, and can be used in all classes of filters, LP, HP, BP, and BR, and in any form, Butterworth, Chebychev, or elliptic. The program of Figure 7.12 can be used to calculate the component values of the state variable filter blocks for use in Butterworth or Chebychev LP and HP filters.

In the case of elliptic filters, the program of Figure 7.13 has been written to be merged onto the end of yet another copy of the first part of the active elliptic filter program given in Figure 5.1, to form a complete active elliptic filter design package.

Once again, wideband elliptic BP and BR filters can be designed as LP + HP filters but with state variable filters it is usual to construct each filter separately rather than to alternate LP & HP sections. Narrow band BP and BR filters are constructed as BP or BR sections. Again, odd order bandpass filters have a special circuit as their first block. The program mentions in the display that this is a block without a notch, and displays the values for the necessary components.

In contrast to the circuits of Figures 5.3 and 5.4, where the gain of each filter block is forced upon you by the design, the use of the state variable filter allows you to set the gain of each block to any value that you would like. In the program, the gain is set to 1. This reduces the complication of handling different signal levels at different parts of the filter and means that the output level is the same as the input level, as with the normal Sallen and Key filter blocks. If you need a different gain, change the value of Rg; this feedback resistor controls the gain and has no effect on anything else. If Rg has a capacitor, CL, in parallel with it, the product CL x Rg must be kept constant. So if you multiply Rg by a factor in order to change the gain, simply divide CL by the same factor.

Adjustment of active filters

All active filters need to be tuned in the same way that LC filters are tuned. However, you would have noticed that very little has been said about these adjustments when we were discussing Butterworth and Chebychev filters. There are two main reasons for this. Using 1% components will ensure that the filter is sufficiently close to its design for most purposes, and secondly, the Sallen and Key circuit does not lend itself to easy adjustment of either the tuning frequency or the Q.

Indeed, similar things can be said to some extent about the elliptic filter. In particular, the circuits of Figures 5.3 and 5.4 have too many components to change if you want to alter the frequency independently of the Q. So for these circuits, simply use 1% components and use the filter as is. Of course it is always necessary to check the frequency response just in case a component with an incorrect value has inadvertently been incorporated into the filter. *The best procedure is to measure the value of every component before using it in any filter.*

One of the many advantages of state variable filters is that they afford easy, independent adjustment of tuning frequency, notch frequency, and Q. In the display of the components given by the programs of Figures 7.12 and 7.13, the names Rf and RQ are given to the resistors that can be made variable to permit adjustment of the tuning frequency and Q respectively. This is done by using a fixed resistor of, say, 95% of Rf (or RQ), in series with a 10 or 40 turn trimpot having a resistance of 10% of Rf (or RQ). This will give an adjustment of ±5% of the design value and should be more than enough to cope with the variations in other components.

There is no need to use exact values here, use the nearest 1% fixed resistor and a trimpot with a resistance equal to or

```
2200 QMIN=.5747:ON X GOTO 2220,2220,2250,2330
2210 REM ____________________ LP & HP FILTER ____________________
2220 PRINT:FOR I=1 TO V:NUM=I:PRINT USING "Filter block number #";NUM:PRINT
2230 GOSUB 2440:J=V+1-I:K=I:IF P1(J)>5000 OR F1(K)>5000 THEN RIN=10000:R1=20000:
R2=2000:R3=10000:RG=RIN:C1=2.2E-10:C2=C1:GOSUB 2590 ELSE GOSUB 2490
2240 GOSUB 2750:RG=RIN:NEXT I:GOTO 3410
2250 REM ________________________ BP FILTER ________________________
2260 GOSUB 2440:IF ODD=0 THEN 2290
2270 K=0:J=2*V+1: GOSUB 2420
2280 PRINT:PRINT "Filter block number 1":PRINT "Tuned circuit without notch.":GO
SUB 2750
2290 PRINT:FOR I=1 TO V:NUM=I+ODD:PRINT USING "Filter block number #";NUM:PRINT
2300 GOSUB 2440:J=V+1-I:K=V+I:GOSUB 2500:GOSUB 2750:NEXT I
2310 FOR I=1 TO V:NUM=V+I+ODD:PRINT USING "Filter block number #";NUM:PRINT
2320 GOSUB 2440:J=2*V+1-I:K=I:GOSUB 2500:GOSUB 2750:RG=RIN:NEXT I:GOTO 3410
2330 REM ________________________ BR FILTER ________________________
2340 GOSUB 2440:IF ODD=0 THEN 2370 ELSE PRINT:PRINT "Filter block number 1 ":PRI
NT
2350 P1(J)=FC:F1(K)=FC:GOSUB 2420
2360 GOSUB 2750
2370 FOR I=1 TO V:NUM=I+ODD:PRINT USING "Filter block number #";NUM:PRINT
2380 GOSUB 2440:J=V+1-I:K=V+I:GOSUB 2420:GOSUB 2750:NEXT I
2390 FOR I=1 TO V:NUM=V+I+ODD:PRINT USING "Filter block number #";NUM:PRINT
2400 GOSUB 2440:J=2*V+1-I:K=I:GOSUB 2420:GOSUB 2750:RG=RIN:NEXT I:GOTO 3410
2410 REM _______________ SWITCH FOR FREQUENCIES ABOVE 5 kHz _______________
2420 IF P1(J)>5000 OR F1(K)>5000 THEN RIN=10000:R1=20000:R2=2000:R3=20000:C1=2.2
E-10:C2=C1:RG=RIN:GOSUB 2660 ELSE GOSUB 2570
2430 RETURN
2435 REM ____________________ INITIAL VALUES OF Rs & Cs ____________________
2440 RIN=100000!:R1=RIN:R2=10000:R3=RIN:RG=RIN:C1=.0000001:C2=C1
2450 IF FC>500 THEN C1=1E-09:C2=C1:GOTO 2470
2460 IF FC>50 THEN C1=1E-06:C2=C1
2470 RETURN
2480 REM ___________ CALCULATE REAL POLE FOR LOW FREQUENCIES ___________
2490 IF ODD=0 OR I>1 THEN 2570
2500 CC=.0000033/P1(V+1):CL=.0000022
2510 FOR I1=14 TO 1 STEP -1 :IF CS(I1)>CC THEN CL=CS(I1):GOTO 2530
2520 NEXT I1
2530 IF X=1 THEN RG=.5/PI/P1(V+1)/CL ELSE CL=C1:RR=.5/PI/P1(V+1)/CL:GOSUB 2570
2540 RQ=100000!/(3.48*Q(J)-1-100000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=10000!/
(.3162*(1+100000!/RIN)/Q(J)-1.1)
2550 GOSUB 2710:RETURN
2560 REM _________ CALCULATE COMPLEX POLE FOR LOW FREQUENCIES _________
2570 RQ=100000!/(3.48*Q(J)-1-100000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=10000!/
(.3162*(1+100000!/RIN)/Q(J)-1.1)
2580 GOSUB 2710:RETURN
2590 REM _________ CALCULATE REAL POLE FOR HIGH FREQUENCIES _________
2600 IF ODD=0 OR I>1 THEN 2660
2610 CC=.0000033/P1(V+1):CL=.0000022
2620 FOR I1=14 TO 1 STEP -1 :IF CS(I1)>CC THEN CL=CS(I1):GOTO 2640
2630 NEXT I1
2640 IF X=1 THEN RG=.5/PI/P1(V+1)/CL ELSE CL=C1:RR=.5/PI/P1(V+1)/CL:GOSUB 2660
2650 RQ=10000!/(3.48*Q(J)-1-10000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=2000!/(.3
162*(1+10000!/RIN)/Q(J)-1.1)
2660 GOSUB 2710:RETURN
2670 REM ________ CALCULATE COMPLEX POLE FOR HIGH FREQUENCIES ________
2680 RQ=10000!/(3.48*Q(J)-1-10000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=2000!/(.3
162*(1+10000!/RIN)/Q(J)-1.1)
2690 GOSUB 2710:RETURN
2700 REM ____________________ CALCULATE Rf, Rhp, & Rlp ____________________
2710 RF=.05033/P1(J)/C1:RLP=11*RG/(2+RIN/RQ):RHP=.1*RLP*(F1(K)/P1(J))^2
2720 IF X=3 AND I=0 THEN 2740
2730 IF RHP<2200 OR RLP<2200 THEN RHP=RHP*2:RLP=RLP*2:RG=RG*2:GOTO 2730
2740 RETURN
2750 REM ________________________ DISPLAY ________________________
2760 FQ=P1(J)*Q(J):PRINT USING "The FQ product of this block is ######";FQ:PRINT
2770 IF FQ>200000! THEN PRINT "This is too high for an active filter.":GOTO 120
2780 R=RIN:GOSUB 3140
2790 PRINT USING "Rin=###.###\    \";R,R$
2800 R=R1:GOSUB 3140
2810 PRINT USING "R1 =###.###\    \";R,R$
2820 R=R2:GOSUB 3140
2830 PRINT USING "R2 =###.###\    \";R,R$
2840 R=R3:GOSUB 3140
2850 PRINT USING "R3 =###.###\    \";R,R$
2860 R=RF:GOSUB 3140
2870 PRINT USING "Rf =###.###\    \";R,R$
2880 R=RQ:GOSUB 3140
2890 PRINT USING "RQ =###.###\    \";R,R$
2900 IF QQ=1 THEN PRINT "Use circuit for low Q."
2910 IF X=3 AND I=0 THEN 2940
2920 R=RHP:GOSUB 3140:
2930 PRINT USING "Rhp=###.###\    \";R,R$
2940 R=RLP:GOSUB 3140:
2950 PRINT USING "Rlp=###.###\    \";R,R$
2960 R=RG:GOSUB 3140:
2970 PRINT USING "Rg =###.###\    \";R,R$
2980 C=C1:GOSUB 3180
2990 PRINT USING "C1 =###.###\ \";C,C$
3000 C=C2:GOSUB 3180
3010 PRINT USING "C2 =###.###\ \";C,C$
3020 IF X=1 AND ODD=1 AND NUM=1 THEN 3030 ELSE 3060
3030 C=CL:GOSUB 3180
3040 PRINT USING "CL =###.###\ \";C,C$
3050 PRINT "CL is in parallel with Rg."
3060 IF ODD=1 AND X=2 AND I=1 THEN PRINT "CR circuit needed at input of filter."
:C=CL:GOSUB 3190:R=RR:GOSUB 3140:PRINT USING "C  =###.###\ \      R  =###.###\
 \";C,C$,R,R$
3070 W=P1(J):GOSUB 1850:PRINT USING "Tuning frequency  =###.###\  \";W,A6$
3080 QW=P1(J)*(.5/Q(J)+SQR(1+(.5/Q(J))^2))
3090 W=QW:GOSUB 1850:PRINT USING "Q tuning frequency=###.###\  \";W,A6$
3100 W=F1(K):GOSUB 1850:PRINT USING "Notch frequency   =###.###\  \";W,A6$
3110 PRINT:INPUT "To continue, press ENTER.",SS$:PRINT
3120 RETURN
3130 REM __________________ SUBROUTINE FOR RESISTOR UNITS __________________
3140 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms ":GOTO 3170
3150 IF R>=1000! THEN R=R/1000!:R$=" kOhms ":GOTO 3170
3160 R$=" Ohms  "
3170 RETURN
3180 REM __________________ SUBROUTINE FOR CAPACITOR UNITS __________________
3190 IF C>=1 THEN C$="  F":GOTO 3240
3200 IF C>=.001 THEN C=C*1000:C$=" mF":GOTO 3240
3210 IF C>=.000001 THEN C=C*1000000!:C$=" uF" :GOTO 3240
3220 IF C>=1E-09 THEN C=C*1E+09:C$=" nF" :GOTO 3240
3230 C=C*1E+12:C$=" pF"
3240 RETURN
3410 PRINT "End of programme.":END
```

Figure 7.12. GWBASIC program to calculate the component values of state variable filter blocks for Butterworth and Chebychev filters.

larger than the calculated value. Don't make the trimpot more than about 10% of Rf (or RQ); if you can only get a trimpot with too high a resistance, put a shunting resistor from the moving arm terminal to one end of the trimpot and connect the moving arm terminal directly to the other end. The value of the shunting resistor can be changed until you get the right amount of adjustment. Similarly, the resistor (Rhp) from the HP output to the input of the notch summing amplifier can be made variable to adjust the notch frequency of elliptic filters.

It is important to emphasize that adjustments should only be provided where they are essential. Variable resistors are inclined to do just that, i.e: vary. So a filter with adjustments is likely to be less stable than one using all fixed components. For complicated filters it may be essential to have some of the components variable, but it is rare to need them all variable.

```
10 PRINT "                State Variable Filter Components"
20 PRINT "          for Butterworth & Chebychev LP & HP filters."
30 PRINT "            Copyright Aguila Holdings Pty Ltd 1987 ":PRINT
40 PI=3.1415927#
50 DEF FNCOSH(X)=(EXP(X)+EXP(-X))/2:DEF FNACOSH(X)=LOG(X+SQR(X*X-1))
60 DEF FNSINH(X)=(EXP(X)-EXP(-X))/2:DEF FNASINH(X)=LOG(X+SQR(X*X+1))
70 PRINT "What type of filter would you like to design "
80 PRINT "1. Low pass"
90 PRINT "2. High pass"
100 INPUT "Would you please enter the appropriate integer ?",X:IF X<1 OR X>2 THE
N 70
110 PRINT "The passband ripple of a Butterworth filter is 0 dB."
120 INPUT "What passband ripple would you like ? ",RIPL:IF RIPL<0 THEN 120
130 A1=RIPL:IF RIPL=0 THEN A1=3
140 PRINT "At what frequency [ Hz ] is the attenuation ";A1;" dB ":INPUT FC:IF F
C<=0 THEN 140
150 INPUT "At what frequency [ Hz ] in the stopband is the attenuation known ? "
,FS:IF FS<=0 THEN 150
160 IF (X=1 AND FS<=FC) OR (X=2 AND FS>=FC) THEN PRINT "That frequency is not in
 the stopband.":GOTO 150
170 INPUT "What attenuation would you like at that frequency ? ",ASTOP:IF ASTOP<
=0 THEN 170
180 IF ASTOP<=3 THEN PRINT "The attenuation in the stopband must be greater than
 3 dB.":GOTO 170
190 ODD=0:FRATIO=FS/FC:IF X=2 THEN FRATIO=FC/FS
200 EP1=10^(.1*ASTOP)-1:EP2=10^(.1*A1)-1:IF RIPL>0 THEN 220
210 NBUTT=INT(LOG(EP1/EP2)/2/LOG(FRATIO))+1:IF NBUTT MOD 2<>0 THEN ODD=1
220 NCHEB=INT(FNACOSH(SQR(EP1/EP2))/FNACOSH(FRATIO))+1:IF NCHEB MOD 2<>0 THEN OD
D=1
230 N=NBUTT:IF RIPL>0 THEN N=NCHEB
240 PRINT:PRINT "Filter order is ";N
250 IF RIPL>0 THEN 300
260 REM ____________________ BUTTERWORTH FREQUENCIES & Qs ______________
270 V=INT(NBUTT/2):FOR I=1 TO V:F(I)=FC:NEXT I:IF ODD=1 THEN F(V+1)=FC:Q(V+1)=.5
280 FOR I=1 TO V:IF ODD=1 THEN THETA=PI*I/NBUTT ELSE THETA=PI*(2*I-1)/2/NBUTT
290 Q(I)=.5/COS(THETA):NEXT I:GOTO 360
300 REM ______________________ CHEBYCHEV FREQUENCIES & Qs ______________
310 EP=SQR(EP2):A=FNASINH(1/EP)/NCHEB:V=INT(NCHEB/2)
320 FOR I=1 TO V:SIGMA(I)=FNSINH(A)*SIN((2*I-1)*PI/2/NCHEB)
330 IOMEGA(I)=FNCOSH(A)*COS((2*I-1)*PI/2/NCHEB):OMEGA(I)=SQR(SIGMA(I)^2+IOMEGA(I
)^2):Q(I)=SQR(1+(IOMEGA(I)/SIGMA(I))^2)/2:F(I)=FC*OMEGA(I):IF X=2 THEN F(I)=FC/O
MEGA(I)
340 NEXT I:IF ODD=0 THEN 360
350 Q(V+1)=.5:F=FNSINH(A):IF X=1 THEN F(V+1)=F*FC ELSE F(V+1)=FC/F
360 REM ______________________ CALCULATE COMPONENT VALUES _________________
370 NUM=0:QMIN=.5747:START=1:FINISH=V:ST=1:IF RIPL>0 THEN SWAP START,FINISH:ST=-
1
380 PRINT:FOR I=START TO FINISH STEP ST:NUM=NUM+1:PRINT USING "Filter block numb
er #";NUM:PRINT
390 RIN=100000!:R1=RIN:R2=10000:R3=RIN:RG=RIN:C1=.0000001:C2=C1
400 IF FC>500 THEN C1=1E-09:C2=C1:GOTO 420
410 IF FC>50 THEN C1=1E-08:C2=C1
420 IF F(I)>5000 THEN RIN=10000:R1=20000:R2=2000:R3=10000:RG=RIN:C1=2.2E-10:C2=C
1:GOSUB 500 ELSE GOSUB 470
430 IF ODD=0 THEN 460
440 CL=C1:RR=.5/PI/F(V+1)/CL
450 IF RR<2200 THEN CL=CL/10:RR=RR*10:GOTO 450
460 GOSUB 530:NEXT I:GOTO 1010
470 REM ____________ CALCULATE COMPLEX POLE FOR LOW FREQUENCIES ________
480 RQ=100000!/(3.48*Q(I)-1-100000!/RIN):QQ=0:IF Q(I)<QMIN THEN QQ=1:RQ=10000!/(
.3162*(1+100000!/RIN)/Q(I)-1.1)
490 RF=.05033/F(I)/C1:RETURN
500 REM _________ CALCULATE COMPLEX POLE FOR HIGH FREQUENCIES _____________
510 RQ=10000!/(3.48*Q(I)-1-10000!/RIN):QQ=0:IF Q(I)<QMIN THEN QQ=1:RQ=2000!/(.31
62*(1+10000!/RIN)/Q(I)-1.1)
520 RF=.05033/F(I)/C1:RETURN
530 REM ____________________________ DISPLAY ____________________________
540 FQ=F(I)*Q(I):PRINT USING "The FQ product of this block is ######";FQ:PRINT
550 IF FQ>200000! THEN PRINT "This is too high for an active filter.":GOTO 130
560 IF ODD=0 OR NUM>1 THEN 620
570 ON X GOTO 580,600
580 IF I=START THEN PRINT "RC circuit needed at input of filter." ELSE 620
590 C=CL:GOSUB 900:R=RR:GOSUB 850:PRINT USING "R  =###.###\    \    C  =###.###\
 \";R,R$,C,C$:GOTO 620
600 IF I=START THEN PRINT "CR circuit needed at input of filter." ELSE 620
610 C=CL:GOSUB 900:R=RR:GOSUB 850:PRINT USING "C  =###.###\ \      R  =###.###\
   \";C,C$,R,R$
620 R=RIN:GOSUB 850
630 PRINT USING "Rin=###.###\    \";R,R$
640 R=R1:GOSUB 850
650 PRINT USING "R1 =###.###\    \";R,R$
660 R=R2:GOSUB 850
670 PRINT USING "R2 =###.###\    \";R,R$
680 R=R3:GOSUB 850
690 PRINT USING "R3 =###.###\    \";R,R$
700 R=RF:GOSUB 850
710 PRINT USING "Rf =###.###\    \";R,R$
720 R=RQ:GOSUB 850
730 PRINT USING "RQ =###.###\    \";R,R$
740 IF QQ=1 THEN PRINT "Use circuit for low Q."
750 C=C1:GOSUB 890
760 PRINT USING "C1 =###.###\ \";C,C$
770 C=C2:GOSUB 890
780 PRINT USING "C2 =###.###\ \";C,C$
790 W=F(I):GOSUB 960:PRINT USING "Tuning frequency  =###.###\  \";W,A6$
800 QW=F(I)*(.5/Q(I)+SQR(1+(.5/Q(I))^2))
810 W=QW:GOSUB 960:PRINT USING "Q tuning frequency=###.###\  \";W,A6$
820 PRINT:INPUT "To continue, press ENTER.",S5$:PRINT
830 RETURN
840 REM ____________________ SUBROUTINE FOR RESISTOR UNITS __________________
850 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms ":GOTO 880
860 IF R>=1000! THEN R=R/1000!:R$=" kOhms ":GOTO 880
870 R$=" Ohms  "
880 RETURN
890 REM ____________________ SUBROUTINE FOR CAPACITOR UNITS __________________
900 IF C>=1 THEN C$="  F":GOTO 950
910 IF C>=.001 THEN C=C*1000:C$=" mF":GOTO 950
920 IF C>=.000001 THEN C=C*1000000!:C$=" uF" :GOTO 950
930 IF C>=1E-09 THEN C=C*1E+09:C$=" nF" :GOTO 950
940 C=C*1E+12:C$=" pF"
950 RETURN
960 REM ____________________ SUBROUTINE FOR FREQUENCY UNITS ___________________
970 IF W>=1000000! THEN W=W/1000000!:A6$=" MHz":GOTO 1000
980 IF W>=1000 THEN W=W/1000:A6$=" kHz":GOTO 1000
990 A6$=" Hz"
1000 RETURN
1010 PRINT "End of programme.":END
```

Figure 7.13. GWBASIC program to calculate the component values for state variable elliptic filters. This program is intended to be merged onto the end of part 1 of the elliptic filter design program of Figure 5.1.

Use of the state variable filter

The filter that we are going to study in detail has been given adjustments to all of its tuning frequencies to enable us to discuss tuning methods. Since the only critical thing about this filter is the tuning frequency of one notch, it would be better to have this as the only adjustment, and, if you build this filter, that would be the way to do it. Then, instead of the other variable resistors, you would use 1% fixed resistors to make up the values given in the list of components displayed by the program. The only variable resistor would then be VN3 in Figure 7.14.

AM radio filter again

To show the difference between the elliptic design using the circuit of Figure 5.3, and that using a state variable filter, the program of Figure 7.13 has been used to calculate the values of the components for the circuit of Figure 7.14. There are lots of amplifiers in this circuit, but there are really only three ICs.

Despite the apparent complication of the circuit, it is much easier to tune and adjust than any of the circuits that we have used before.

Frequency adjustment

Tuning this filter is quite simple. Start by removing both links. This prevents overloading later stages while tuning early stages (FET ICs have been known to die when severely overloaded). Then connect a low impedance (Z100 Ohms) signal generator, tuned to 6.234 kHz, to the input. Connect a suitable AF voltmeter, or preferably a CRO, to terminal LP1. Increase the input signal until there are signs of clipping and then reduce the signal to *half* of the magnitude that it had when clipping first commenced. Connect the meter or CRO to BP1 and adjust VF1 for maximum output. It is essential to check the output at LP1 to make sure that there is still no clipping at this stage. If there is, reduce the input voltage by half and tune again. If all is well, transfer the meter/CRO to the terminal OUT1, change the frequency of the signal generator to 24.286 kHz, and adjust VN1 to get minimum output, always checking on LP1 to ensure that there is no clipping.

Connect the signal generator to the input of the second stage and the meter/CRO to LP2. The tuning procedure is repeated, this time tuning for a maximum at a frequency of 7.739 kHz by adjusting VF2. Then, with the meter/CRO connected to OUT2, minimum output is set at 10.620 kHz by adjusting VN2, again checking for clipping. The procedure is repeated for the third stage, setting the maximum at 8.221 kHz and the minimum at 9.000 kHz. After inserting both links the filter is ready for use. It is imperative that the tuning for a maximum is always done by measuring the output at the BP terminal of any state variable filter. Tuning for the notch minimum is always done at the output of each complete filter block, and checking for clipping is done at the LP terminal.

Q adjustment

You will have noticed that nothing has been said about adjusting the Qs of the various circuits. There are two reasons for this. First and foremost is that Q adjustment is not really essential for filters with Qs less than about 20, since a small ▷

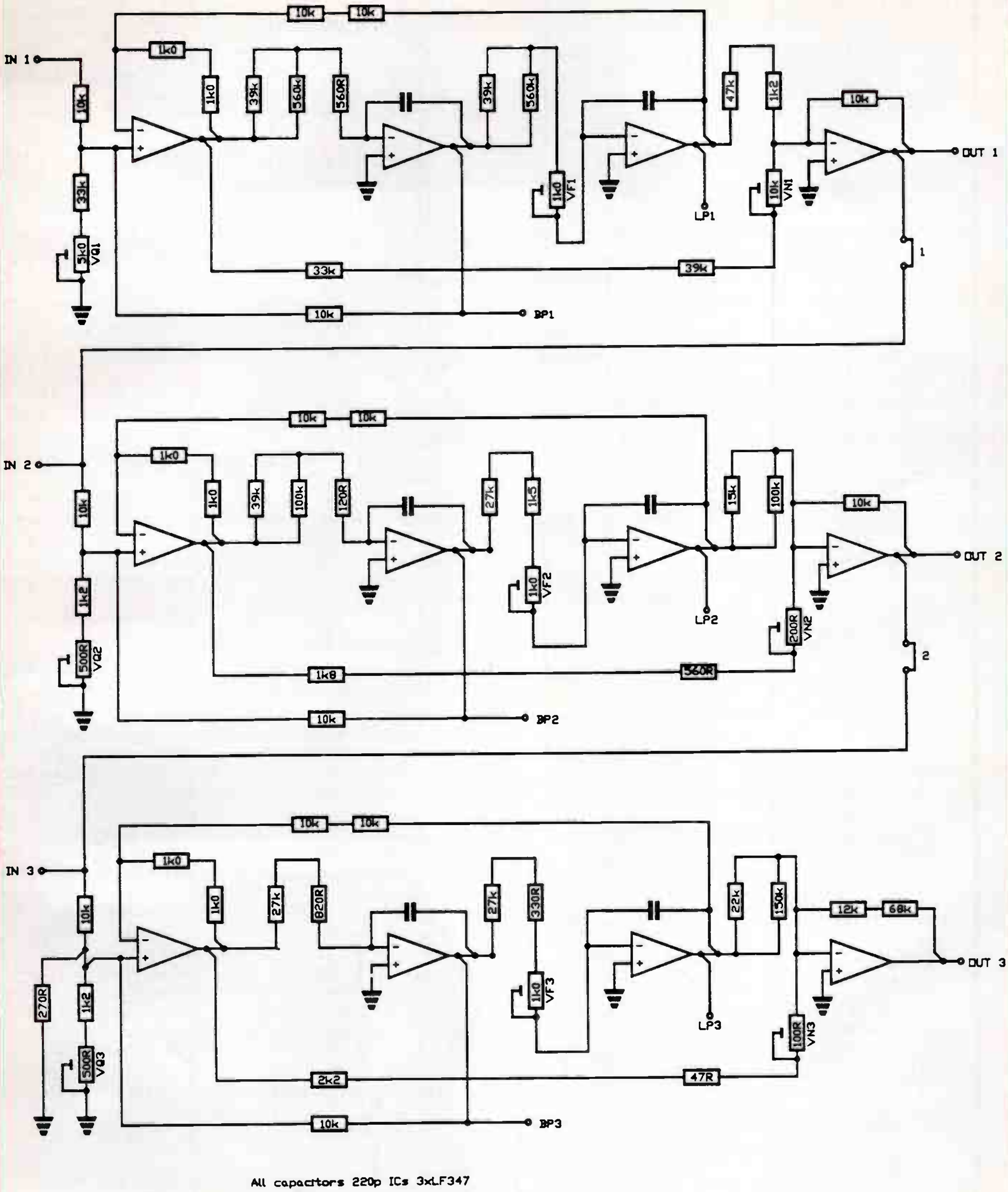


Figure 7.14. State variable filter version of the AM radio elliptic audio filter. All tuning frequencies, Qs, and notch frequencies have been made adjustable to illustrate tuning methods. If you build this filter, the only essential adjustment is VN3. All other adjustable resistors should be replaced with fixed resistors having the values displayed by the program of Figure 7.13.

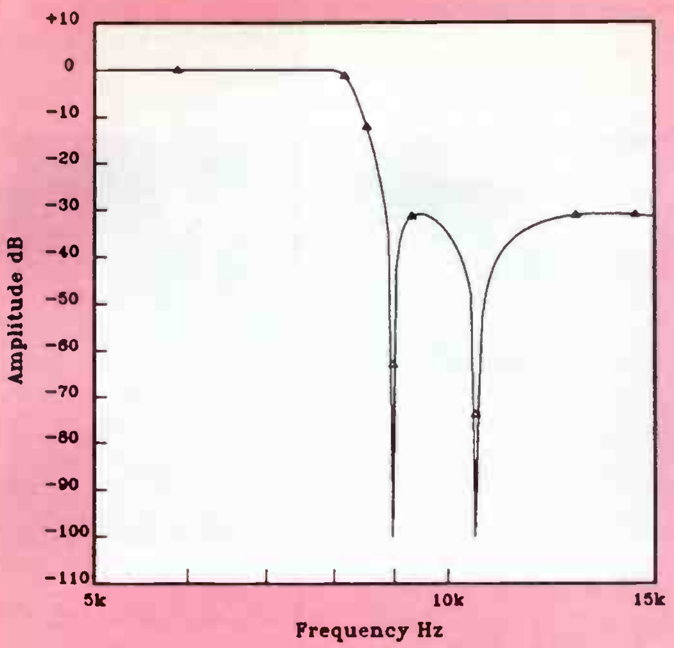


Figure 7.15. Theoretical (curve) and measured (triangles) frequency responses of AM radio filter. The depth of the notches on the curve has been restricted to 100 dB to prevent computer overflow.

change in Q has much less effect than a small change in the frequency of, for example, the notch nearest the cutoff frequency, so minor variations in Q can be tolerated. Secondly, Q adjustment is best done using a CRO or phase meter, and not everybody can afford such instruments. However it can be done with patience and an AF voltmeter.

The state variable filter is slightly prone to Q enhancement effects that depend on circuit layout, so for filters with calculated Qs higher than about 20, the Qs of each filter block should really be set accurately. To aid in the adjustment process, the programs of Figures 7.12 and 7.13 display a 'Q tuning frequency' for each filter block.

To adjust the Q, the block is first tuned accurately to its correct tuning frequency. Using an audio frequency voltmeter, the signal generator output voltage is measured and the output voltage of the filter block is measured as accurately as possible at its BP terminal (checking for clipping at the LP terminal). The signal generator is then set to the Q tuning frequency, and its output reset accurately to its previous output voltage. The Q adjusting resistor is then varied until the output at the BP terminal of the filter block is 0.7071 times the output that it was previously, i.e: the output is 3 dB down. It is worthwhile repeating both the tuning and Q adjustments to make sure all is well.

If you have a CRO, a more sensitive way of doing the Q adjustment is to look at the phase of the output signal at the BP terminal and compare it with the phase of the input signal. With the signal generator set to the Q tuning frequency, this can be done by turning off the timebase and applying the input from the signal generator to the X terminals of the CRO (and to the input of the filter at the same time) and the output from the BP terminal of the filter to the Y terminals of the CRO. Adjust the gains of the X and Y amplifiers until the amplitudes of the two signals on the screen are the same and adjust the Q resistor until the phase shift is exactly 45 degrees. Of course, if you have or can borrow an audio phase meter, you really can do the job easily by simply looking at the phase difference between the input and the BP output and adjusting for 45 degrees difference at the Q tuning frequency.

Figure 7.15 shows the theoretical frequency response of the AM radio filter together with the actual attenuation at a number of frequencies. Measurements were made on a breadboarded version of the filter using 1% capacitors and using all the adjustments shown in the circuit. The theoretical response assumes infinite Q for all components, in which case the depths of the notches should be infinite. To prevent computer overflow, the attenuation has been limited to 100 dB. In practice, the depth of the notches is even more restricted because of the finite Qs of the components used and the capacitative coupling associated with the breadboard layout. With a good printed circuit layout it is possible to achieve notch depths of 100 dB!

Visible light semiconductor laser

Philips Research Laboratories has just released information about a semiconductor laser that emits visible light. Particularly suited to digital optical recording, (the technology used in compact disc players), due to its high peak output power, (greater than 0.1 W), the laser emits light having a wavelength of 650 nm.

Philips say products such as optical data storage and telecommunications systems, and of course compact disc players, benefit from this breakthrough as a semiconductor laser which emits light at a particular wavelength can increase the density of information on a disc. Researchers at the Philips Research Laboratories in Eindhoven and at the Laboratories d'Electronique et de Physique Appliquee (L.E.P.), contributed to the development of the new semiconductor laser.

Single crystal layers of compounds of aluminium, gallium, indium and phosphorus go to make up the active medium of the laser, each layer is of different composition and doping. These layers are deposited on a gallium-arsenide substrate. In the development of the laser, researchers have now optimised the epitaxial deposition technology. As a result, the materials obtained are of high purity and have a near perfect structure, meaning that internal losses are minimal, so that the light is produced with a high luminous efficacy.

C.I.M.A. seminars and workshops

The Centre for Industrial Microelectronics Applications (C.I.M.A.) is offering a number of seminars and workshops throughout the year. The seminars and workshops cover a wide range of topics, ranging from general topics within the electronics and technology fields through to highly specialised IC design courses.

Of particular note are the following dates:

April 8	Surface Mount Technology – Part II
April 12 & 13	Hybrid Thick Film Workshop
April 20	Technical Update – Sensors & Transducers

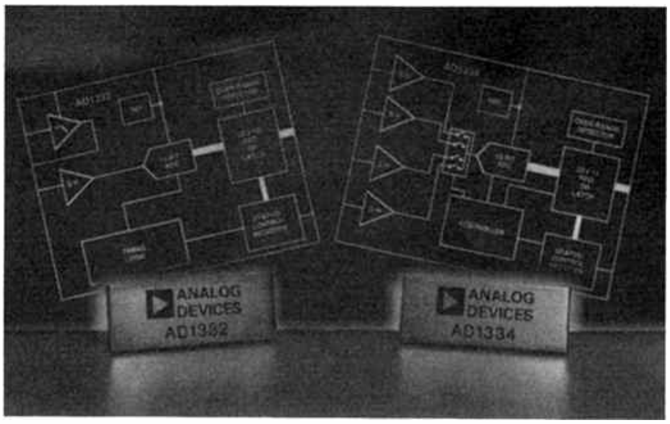
No doubt many readers will take an interest in these and other courses the centre has to offer. More in formation may be obtained from C.I.M.A., GPO Box 2476V, Melbourne 3001 Vic. (03)660 5111.

TRW Zeners

TRW Optoelectronics has just released two new LVA zener diodes to their range. The LVA devices have considerably sharper breakdown characteristics, in the 4-10 V range, than conventional zener diodes. The breakdown mechanism of zener regulators above 10 V is "avalanche", producing a very sharp 'knee' and good voltage regulation.

Below 10 V, the "field emission" phenomenon commences, as operating voltage decreases, field emission is accountable for an increasingly higher percentage of the device breakdown mechanism. In the LVA devices the field emission breakdown mechanism is suppressed, resulting in zeners below 10 V having a breakdown characteristic with a sharp knee, like zeners above 10 V.

The LVA zener diodes come in two packages, standard axial lead hermetic DO-7 and a surface mountable leadless chip carrier package. The LVA devices, say Total Electronics, are also competitively priced.



DSP A/D converters

Analog Devices released earlier this year the industry's first complete 12-bit sampling analogue-to-digital converters (ADCs). These have all the operating features to provide high-speed digital signal processing (DSP) in audio bandwidth applications and because the converter looks like high speed memory, existing systems don't require upgrades to their analogue interface.

The AD1332 and AD1334 devices have an asynchronous digital interface, eliminating the need for external timing, and buffer circuitry. A 15 ns maximum data access time makes these devices many times faster than most 12-bit ADCs on the market.

Single-channel conversion with onboard sample-and-hold amplifier and anti-aliasing filter is provided by the AD1332 chip. The AD1334 is a four-channel, 12-bit ADC for multichannel applications. Conversion of full-scale ±5V signals at programmable rates, up to 125 kHz is possible with the AD1332 device. Provided on-board is a 4th-order Butterworth anti-aliasing filter with selectable cut-off frequencies. This can be bypassed if not required.

The AD1334 has sampling rates up to 70 kHz (single-channel) with all four channels being simultaneously or independently sampled. Data output comprises a 14-bit digital 'word', 12 bits for the data and two bits for the channel address.

Packaged in a 40-pin DIP and manufactured with reliable hybrid circuit techniques, the two ADCs also feature a 32-word first-in/first-out (FIFO) memory store for conversion results. Both ADCs are specified over the 0 to +70°C and –55 to +125°C temperature ranges.

LM6161 family speedy op-amps

National Semiconductor has released three new high speed, low power consumption operational amplifiers. The devices are PNP-type and complement National's already existing high speed NPN devices. The high speed PNP devices are built with National's new Vertically Integrated PNP (VIP) process. This is an advanced junction-isolated process, delivering high speed performance without the need for complex and expensive dielectric isolation, the company says.

The three new chips, the LM6161/LM6261/LM6361, provide good speed-power characteristics, delivering 300V/μs, with 50 MHz unity gain and stability with a mere 5 mA of supply current, plus a wide dynamic range in supply voltage, extending down to +5 V.

World's fastest DRAM

IBM researchers at a technical conference in San Francisco on February 17th announced that they have made the world's fastest dynamic memory computer chips.

Still in their experimental stages, the new chips can retrieve a unit of information in 20 billionths of a second, three times faster than the latest generation of advanced DRAMs on the market, say IBM.

The IBM group presented other papers and announced other innovations at the conference. Mr Billy L. Crowder, the Research Director of Manufacturing Research, announced that semiconductor manufacturing was a "new science", outlining how the major computer industry trend will have long-reaching effects on computer designers and manufacturers, the blinding speed of the new DRAMs signalling a new direction in computer memory chip research.

Also announced were breakthroughs in the operating speed of many CMOS chips. IBM stated that scaling down entire logic and memory chips into one CMOS device could result in an overall performance increase of up to 70%. One particular application IBM has produced using this technique is an experimental RISC (Reduced Instruction Set Computer) fixed-point microprocessor, achieving a 60% increase in speed relative to its original form.

Breakthroughs in measuring very short pulses, or switchings in a circuit, using a short pulsed laser have lead to advances in the manufacture and testing of specialised computer chips. The pulsing laser generates a beam of electrons capable of measuring electronic signals switching in less than five picoseconds. Increased density and performance levels are being achieved by IBM researches as a result of these breakthroughs, especially in the manufacture and testing of specialised VLSI chips.

Also announced by Billy Crowder was an increased emphasis by IBM on manufacturing developments in the field of logic circuits. What has been happening is continuing breakthroughs were being made in the development of high-speed memory, but not so in the manufacture and design of the supporting logic circuits, which require a totally different manufacturing process. Mr Crowder reaffirmed IBM's continuing research and development in the logic fields.

Support for ASICs

Application-specific ICs (ASICs) is a developing technology of increasing importance to the electronics industry. Texas Instruments has set up a "technology centre" designed to provide support for their ASIC products range in their St Kilda Rd, Melbourne, premises.

The centre will provide services such as: seminar and one-to-one training facilities for first time users as well as updates on the latest technology releases, technical phone-up or drop-in enquiry service, quotations on customer designs, distribution of literature and support tools, transmission of customer designs to TI fabrication centres in Japan and the US and guidance as to the optimum technology for any given designs.

The centre is equipped with advanced workstations for design training, demonstration and communication of design data to other TI facilities.

The centre will be managed by Doug Mealy, Field Applications Engineer with design experience in both industrial and communications equipment fields.

Alternative source REF01 +10 V reference

An alternate source for the industry standard REF01 +10 V reference guarantees accuracy to +30 mV along with lower noise and low drift versus temperature. The Analog Devices' ADREF01 is a laser-wafer-trimmed temperature coefficient of 8.5ppm/°C maximum and noise below 4μV peak-to-peak typical from 0.1 to 10 Hz. A long-term drift of only 15 ppm/1000 hours typical and superior performance is achieved due to a buried zener-reference cell, AD claim.

The nominal output voltage can be fine-tuned over a +3%, –1% range, with minimal drift and noise variations, it is claimed. Power supply are 13.5 to 36 V, with a maximum current of 4mA. The device is suited to a number of application requirements as two performance level, with corresponding offsets can be selected. All ADREF01's are housed in hermetic 8-pin CERDIP packages, at prices comparable to non-hermetic plastic housing.

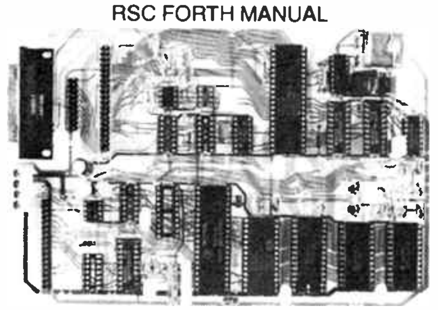
GE and IBM bedmates in special semiconductor development

General Electric and IBM have entered into an agreement for the cooperative development of new application-specific integrated circuit (ASIC) technologies and components for use in future IBM products. GE will also manufacture ASIC components for IBM based on designs resulting from the cooperative development effort. The agreement spans development and production through the early 1990s, but terms were not disclosed.

Specific GE ASIC components built for IBM will be exclusively IBM's property and will not be offered for merchant market sale.

Dale W. Rowe, gm of GE's semiconductor operations in Research Triangle Park, North Carolina, pointed out that the coordination between IBM's engineers and GE's semiconductor specialists "will result in a focussed development effort and an extended period of end-product competitive advantage."

What he meant to say was, the agreement will keep IBM in front of the copycats.



▷ – from page 80

We have a problem?

Sid Molen, in his letter to Mr A. Jordan of DOTC, points out that "*. . . South Africa has also indicated that messages between amateurs is within the bounds of the law as governs the amateurs in that country and third party traffic. They also state that information interchange of a personal or technical nature does not and cannot be classified as third party traffic.*"

He goes on to assert "*. . . The present interpretation by your department of third party traffic precludes Australian stations from receiving technical information from overseas stations, at times direct, but at other times due to conditions, with the necessary assistance of an intermediary station in some other country; such information is of a nature that it would not be passed via the normal commercial services.*

"*. . . If one classifies all messages between amateurs as traffic, we have the ridiculous situation where amateurs will not be able to contact each other without government approval. . . we are not against 'third party traffic' as such, but we are against the interpretation of all amateur messages being classified as traffic.*

"*. . . amateurs have been passing messages between each other for the past 80 years, since amateur radio first started, and that is part of amateur radio. The precedent having been set over that time, I feel that there is no logical reason for an interpretation change at this time.*

"*Considering the above, I therefore ask that the restrictions on mailboxes and bulletin board stations be removed and that they be allowed to operate in the same friendly way that they have for the past 80 years.*"

Through the mailbox

It seems, from here, that, so long as the mailboxes are used for amateur-to-amateur exchanges, the "third party" rules are not breached. The station providing the mailbox facility simply acts as a *relay*, as much as any station acting as a relay between to other stations. Take this situation: a station in Antarctica has a QSL manager in, say, VK4. However, for the appointed weekly sked to transfer log details to his QSL manager, conditions are poor to VK4, but a ZL3, who can hear the VK0 and the VK4, offers to take down the log details and pass them to the VK0's QSL manager in VK4 later.

This activity (apparently?) is quite "legal". No displacement of the "message" beyond the amateur medium occurs, but the VK4 is clearly a third party in this situation, being the recipient of the log details (the erstwhile message) from the ZL3.

If these three stations were on RTTY or packet, and the selfsame information were exchanged via an on-air mailbox run by the ZL3 – a breach of the regulations would have occurred.

An anachronism

Mr A. Jordan's reply to Sid Molen (reproduced herewith) is interesting as the fourth paragraph says that DOTC *includes* amateurs and amateur-to-amateur exchanges in the definition of "third party".

DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

Our Reference: 86/658
Your Reference:
Contact: A Jordan
(062) 48 3844

Mr S E Molen
13 Pendle Way
PENDLE HILL NSW 2145

Dear Sir

I refer to your further letter of 9 February 1988 regarding the Department's third party traffic policy.

To reiterate, the Department's policy is designed to take account of many other countries' sensitivities to this form of traffic.

It is useful to point out that of the thirty-nine countries initially contacted regarding the setting up of third party agreements with Australia, only five responded favourably. Others were adamantly opposed.

Given that international law absolutely forbids amateur international communications on behalf of third parties, not to have included amateurs in our definition of 'third party' could have been seen as a denial of other countries' rights to determine their own policies regarding this matter.

The Department does not agree that its policy in this regard is curtailing the normal interchange of communications between amateur stations.

Yours faithfully

A JORDAN
Operations Branch
Radio Frequency Management
Division
15th February 1988

GPO Box 594 Canberra ACT 2601 Telephone: (062) 641177 Telex: 62025 Facsimile: 644608

If you take the orbit and experiment schedules from UoSat 9 and divulge them to another amateur, would you be in breach of the regulations? Probably, if it was done via an on-air bulletin board or mailbox and the recipient were in another country and that country had no third party agreement with Australia. But it seems the same would not apply if you passed the information by voice or Morse.

Clearly, this is an anachronism. The sooner it is removed, the better for all concerned.

letters

Ferro-resonant transformers

Dear Sir,

Congratulations on the compact and informative article "Smoothing out the ruffles . . . " (AEM February 1988).

On the subject of ferro-resonant transformers ("line conditioners"), an important drawback, which the manufacturers seldom allude to, is their current limiting characteristic and high leakage inductance.

This can cause real problems in computer installations where several machines are fed from the same line conditioner: when an unused machine is turned on, sometimes (depending on actual phase angle at instant of turn-on) a very high in-rush current will occur for a brief time. There is then a corresponding voltage drop-out with frequently disastrous effects on digital equipment operation.

There are several possible solutions:

1. One piece of equipment to each line conditioner.

2. Ensure that all equipment connected to line conditioner is kept switched on at all times, or if auxilliary equipment must be connected that it is done when no critical operation is taking place.

3. Wire a suitable series current limiting component (carefully selected Brimistor or NTC thermistor) or current limiting circuit.

D.Butler,
Oakland Park, SA.

FM band antenna balun assembly

Dear Sir,

I am writing regarding the article in the May 1986 edition of AEM on the FM Band Antenna, project AEM3012.

As my Mum often listens to FM, I thought I would build it, and with the help of my Dad we constructed the project.

Having built the antenna itself, we proceeded onto the balun. On page 43, you explain how to go about construction of the necessary component. After buying the core from the local Dick Smith store, we proceeded to wind the coil.

Unfortunately, we cannot see how it is physically possible to mimic the diagram pictured. There is one end of the three wires entering at one side of the core, and the other end exiting again out of the centre of the other core side. No matter how we try it, we cannot wind the core in a similar fashion. The wires end up on the outside of the core. The way in which the wire is wound from one side of the core onto the other is perhaps the crucial point. Still, we cannot see any way to do it as was explained.

We attempted to seek out a 75 ohm to 75 ohm balun and found your comments very true; they are extremely difficult to find.

If you could clarify the construction details, or tell us of a store which would stock such a part, I would be very grateful as the antenna seems to be a good project and I would very much like to complete it.

Ben Low,
Labrador, Qld.

The wires are actually wound around the outside of the core. Pass the end of the three twisted wires through the left hand hole first, back over the outside of the core and through the left hand hole again – for three turns, crossing over to the right hand hole for a further three turns through that hole, emerging from the right hand hole on the far side of the core to finish.

Roger Harrison

UHF Colinear antenna problem

Dear Sir,

Could you help me with a problem I have in constructing the AEM3011 70 cm Colinear Antenna. *(AEM August 1985)*

Figure 5 shows the top end shorted out, but construction notes make no comment about it.

What formula do you use to obtain elements length, my formula out of the ARRL Handbook gives a longer length?

Finally, can you suggest a good book on Beam and Vertical Aerial construction?

G.O'Shea,(r)
Rosetta, Tas.

The diagram in Figure 5 does NOT show the top shorted, it is simply a diagram of the assemblage of the coax sections.

Incidentally, the groundplane is NOT optional, it should be included.

The formula given for a half wave dipole does not take into account the velocity factor of the coax dielectric in this application; the waves travel some two-thirds slower in the coax dielectric than they do in space. The lengths are thus around 2/3 of a "free space" half wave.

A good book is the ARRL Antenna Handbook, obtainable through Dick Smith stores.

Status Monitor problem

Dear Sir,

I would be grateful for your assistance with a problem I am having with the Power Amp Status Monitor, AEM6504.

When the Power Amp switch is turned on, the speakers go "bang", then there's a two second delay after which the speakers function.

I have given C5 a greater and smaller capacity to no avail. This means I have to switch the External Protect Input to 12 volts before I can put the main switch on. This is not satisfactory, although it temporarily alleviates the problem.

Other than this, I am pleased with the system and look forward to your help in clearing up this problem.

S.Overton,
Auckland, NZ

I would suspect that you have incorrectly wired the relay contacts. At power-on, the speakers should actually be totally isolated by the relay contacts for a period of two seconds. Are you using the AEM6505 Surge Limiter? If not, this may be part of the problem.

Roger Harrison

Amiga FAX software

Dear Sir,

I am highly interested in the AEM3520 Receiver kit as published in AEM in February 1988. Before I embark on such a project I would be grateful if you know of any computer software to decode the VHF satellite transmissions to suit a Commodore Amiga 1000.

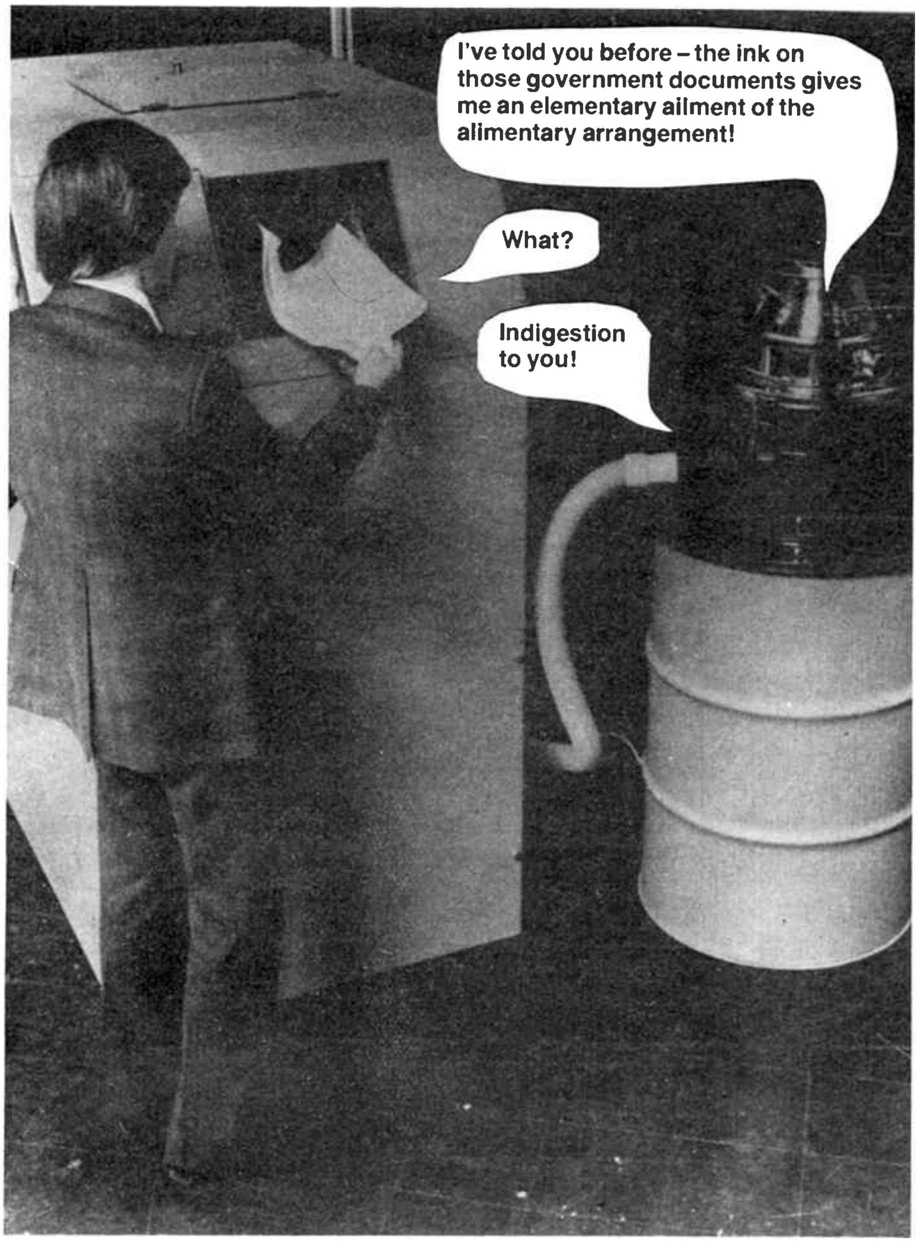
Also, could you advise of software available to decode transmissions from the AEM3500 Listening Post, again to suit the Amiga 1000.

J.Betts,
Gymea Bay, NSW

Unfortunately, we have not published, nor do we have "in the pipeline", Amiga software for decoding satellite FAX or for the Listening Post. However, we'd like to hear from Amiga programmers.

Roger Harrison

The Last Laugh



THE SILLY SEASON SAGA continues. We're not going to let you off lightly, you know! Judy Williams of Queensland came up with some interesting answers, all in "scientific notation" (i.e: ten to the whatever).

In answer to Question 1 on "how large is a poofteenth?", Judy simply replied: "ten to the minus poof". Well, we guess that's fair enough! Her answer to Question 2 was a little more subtle. To "how long is a femtofortnight?", she said: "that's the length of time it takes the light from a supernova in the constellation Virgo to become too weak to see, or Lo minus ten to the minus 2weak." (Lo being light output from the supernova at time zero).

Judy's answer to Question 3 – "what is infinitely shorter than a nanometre" – is unprintable here (not that she's alone in submitting such answers!). Suffice to say that it cast doubts on the virility of half the population. Perth reader, Richard Small, considered the answer to be the distance travelled by the impatient car behind you during the instant it takes the lights to go green and for the car behind to hit you in the rear.

To Question 4, "would you have time for a beer on an atto-arvo?", Judy replied: "No, I don't drink beer, therefore an atto-arvo is 10 to the zero divided by zero". Fair enough! This contrasts with Victorian reader, Roger Booth's reply of: "could they possibly make that much beer?" Roger's middle name is obviously 'Boastful'.

Question 5, "how long does a 'teratwilight' last?", was weakly answered by many entrants – maybe you all ran out of inspiration by then! Judy Williams answered that, "a teratwilight is the length of time it takes for the candles in Teheran to burn down – a Meccamoment, C x ten to the minus Mm." A few entrants were clearly inspired by the Hitchhikers Guide to the Galaxy – like Jeff Simons of Melbourne. To questions 1, 2 and 3, he merely answered – "42". To Question 4, he said: "Yes, but only 42"; to Question 5, he answered: "42 seconds"! We hope the labour of answering the questions did not result in a pain in all the diodes down your left hand side, Jeff.

No prizes yet – we still have two entries of a dozen pages to wade through, and more entries on top of them.

Watch out!

Do you get depressed in winter? Yes? Well, according to a recent report, you're suffering from SADness! Seasonal affective disorder – SAD – is what gives you the wintertime blues according to the theory. The alleged change of mood is attributed to seasonal changes in the amount of light we receive. This would explain why Queenslanders have such a reputation for being laid-back, and why they avoid Melbourne.

The inflatable loudspeaker is here. If you thought loudspeaker prices were inflatable in recent years, here's an idea to beat the trend. A Pennsylvanian inventor has filed worldwide patent applications for a a hi-fi loudspeaker that uses a modified balloon.

Theory has it that the best sound source is a pulsating sphere as it provides an omnidirectional sound source (funny that so few musical instruments are omnidirectional). The inventor proposes putting a strip of piezoelectric plastic around the outside of a balloon. When powered by the output from an audio amplifier, the winding receives a signal and pulsates the balloon in sympathy. The strip could go inside the ballon and be invisible.

How long will it be before you can stroll into your local audio store and walk away with a small packet which you take home and inflate? Great for parties (but make sure the ballon/speaker inflater doesn't have AIDs)!

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