

ROGER HARRISON'S AUSTRALIAN ELECTRONICS

Monthly

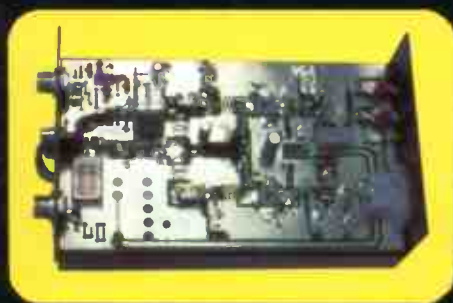


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OUR 'SPACE INDUSTRY' NEEDS WILLING BODIES

By all reports, Australia's 'space industry' revival is proceeding at a cracking pace. Which is quite encouraging. All the development in this area creates new jobs and opportunities for technology transfers to our industry and export earnings on products developed and manufactured here and sold overseas.

In the early phase of 'new' industries growth occurs by grafting together elements from existing industries. And Australia's space industry revival is no exception. A significant proportion of the developing space industry involves electronics and to support the necessary growth, talent and expertise is being co-opted from positions in the electronics industry. But all too soon, the number of individuals (and companies) with the appropriate expertise necessary to support the required growth will dwindle, placing strains on both the established electronics industry and the growing space industry.

In such situations, the solution is often to import the talent and expertise. Now that's not bad thing, in itself. Except that Australia's been exporting talent and expertise for years! And importing it costs. Our space industry has hardly developed sufficiently to afford substantial importing of talent and expertise.

I can see that, in the short- and medium-term future – and I'm talking about a three to eight year time frame – we are going to need young scientists, engineers, technical officers and technicians to enter our growing space industry. It's a fact that most people who choose a technical career and undertake tertiary training, and in my experience this particularly applies to electronics, are motivated to do so from a personal interest and involvement – often from an extracurricular, or hobby, interest pursued during their school years.

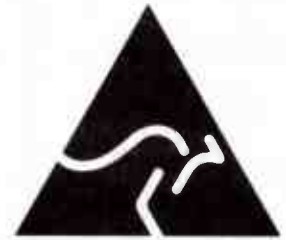
And that's where we come in. To encourage such interest, as foreshadowed in my August issue editorial, we're embarking on a series of practical, low-cost projects that enable readers to get involved in the nuts and bolts – and the excitement – of space science and technology without requiring mountains of money or a university degree. We've already published several practical articles in this area, and this month's feature project is a simple data decoder for the UoSat satellites. In addition, we're working-in with Paul Butler, a science teacher from Mentone Girls Grammar in Victoria, who's successfully introduced some space science at his school and who's developing a "curriculum module" for secondary school science courses. (See article this issue). We're confident that, in this and other ways, we can contribute something to our reviving space industry.

Roger Harrison
Editor

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ADVERTISERS INDEX

COVERS

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INSIDE

Arista 8
 Chipspeed Electronics 50
 Datacom 13
 David Reid Electronics 13
 Dick Smith Electronics 51-57
 Emona 97
 Emtronics 93
 Energy Control 16
 Geoff Wood Electronics 7
 Hi-Comm Unitronics 30-31
 IPS Radio & Space Services 89
 Jaycar 10-11
 Kenwood 88
 Laserlink 86
 Maestro 78, 87
 Micro-Educational 97
 Powersonic 9

COVER

Our two feature projects feature this month. Design by Val Harrison, satellite illustration by Kym Baillie.

PROJECTS TO BUILD

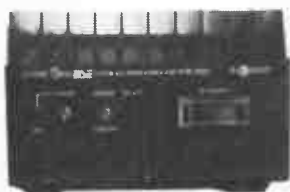


AEM3506 Simple Satellite Data Decoder 58

Join in the space age. This simple project allows decoding the data transmissions from the UoSAT satellites using any computer running a simple "terminal" program.

AEM6006 Servo-Feedback Adaptor for the 6000 Amps 64

Ensure the output dc offset of these direct-coupled amps is always within 5 mV of zero.



STAR PROJECT An All-Mode Power Amp. for Six Metres 67

Delivers 100 W output from a few watts drive. Ideal for the shack or mobile.

CIRCUITS & TECHNICAL

NEW SERIES: Filter Design - without fears or tears 18

First in a practical series explaining filters, their applications and how to design them to suit your own requirements - using simple GWBASIC computer programs.

NEW COLUMN! Semiconductor Scene 16

Its second appearance: News and notes on what's happening on the semis front. A 'must' to keep in front.

PRACTICALITIES An Analogue Music Synthesiser - Part 5 22

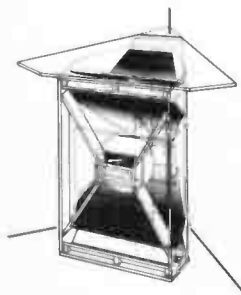
Author John East covers the keyboard controller.

DATA SHEET 76

The MRF492 low-band RF power transistor employed in this month's Star Project.

ELEKTOR IN AEM

Contents 33



Horn Loaded Speakers Revisited 35

Horn loaded speakers still offer remarkable advantages over vented or pressure box designs.

PRACTICAL COMPUTING



Amstradder 80

Disk drive double-up for the 6128.

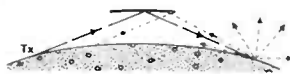
Dial Up 86

Roy Hill's popular column for data communications devotees.

SPECIAL OFFER 84

A special offer on modem kits and a comms package!

COMMUNICATIONS SCENE



Getting amongst the DX fun on VHF this summer
..... 90

Tips and techniques for making the most of long distance contacts via summertime sporadic E propagation.

Build a 100 W All-Mode Power Amp. for Six Metres
..... 67

Put a bit of 'sting' behind your signal.

CONSUMER ELECTRONICS



The Ninth Perth Electronics Show
..... 95

The times are a-changing for the Perth Show, and the consumer electronics industry.

NEWS & GENERAL

Satellites in the Schools Curriculum
..... 12

A Victorian science teacher has a blueprint for introducing practical satellite technology into the science curriculum which could be of far-reaching importance.

News Review
..... 6

Professional Products
..... 15

Parameters' new 'scopes.

Retail Roundup
..... 50

Bargains for the bits-hunters.

Project Buyers Guide
..... 50

Where to get kits and bits for this month's projects.

Bytewide
..... 79

Nice small in-modem.

Spectrum
..... 89

Return of the low-cost rig.

Consumer Electronics
..... 94

A knob-twiddlers VCR!

Letters
..... 8

Subscriptions
..... 32

Back Issues
..... 34

The Last Laugh
..... 98

NEXT MONTH!



MARINE ELECTRONICS

What's new in marine electronics. Well-known boating writer and identity, Dave Jeans, takes us on an overview of the latest in marine electronics. If you're intending to spend a little time on the water this summer, don't miss this feature!

IEC-CENTRONICS INTERFACE

The use of an IEC or IEEE bus for driving a Centronics compatible peripheral device calls for a special interface circuit to ensure the correct timing of handshaking signals. It is readily accomplished with three common 74LS-series ICs.

BUILD AN ACTIVE LOUDSPEAKER

This project marries the 6102 Two-way Speakers with the 6503 Electronic Crossover and the 6500 MOSFET Amp modules to produce a superlative electronic loudspeaker.

AN ADD-ON BAUD RATE CONVERTER FOR YOUR MODEM

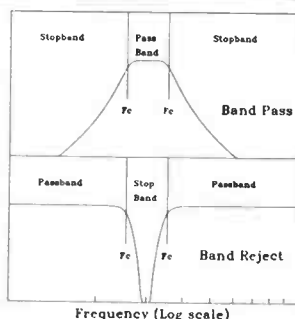
While your modem might cope with 1200/75 bps communications, your computer might not – especially if it's a Commodore 64 or an IBM/compatible. This project can be wired into any modem which employs a 7910 'world modem' chip and automatically provides fixed speed communication between your modem and your computer.

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

FEATURE

Filter Design - without fears or tears
..... 18

First in a practical series explaining filters, their applications and how to design them to suit your own requirements – using simple GWBASIC computer programs.



Australian scientists develop vanadium battery

Researchers at the University of New South Wales have developed a new type of rechargeable storage battery. Originally funded by the Federal Government's National Energy and Development Council, the cell has taken three years to develop.

The battery is based on the NASA "redox" flow cell concept which uses two different solutions pumped separately through adjacent half-cells where they are charged and recharged. Redox is a term used to describe chemical reactions involving reduction and oxidation in which electrons are exchanged between the two solutions.

Previously developed redox cells employing solutions of iron and chromium suffered from problems with solution contamination caused by diffusion through the separating membrane. The Australian developed cell overcomes this problem by using two separate vanadium solutions, differing only in their state of oxidation.

The redox cell has a number of significant advantages over traditional lead-acid storage cells. Because redox cells only involve simple oxidation and reduction, no losses due to electrode stripping occur. This means that the redox cell can be fully charged and fully discharged without damage to the cell.

Lead-acid cells, by contrast, can be damaged by complete discharge over over charging. Another advantage of redox cells is that their capacity can be increased by increasing the quantity of solutions pumped through them.

The newly developed cells would be ideally suited to applications where relatively low powers (a few hundred watts)



and low maintenance are required. Applications such as remote microwave transmitters which currently use high maintenance lead-acid batteries charged by solar or wind generators would be a good example.

The team working on the project at the University of New South Wales is led by Dr Maria Skyllas-Kazacos and includes

Dr Miron Rychcik and associate professors Tony Fane and Bob Robbins.

A world-wide licensing agreement has been negotiated between the University and Agnew Clough Limited to develop and market the newly invented cell. Agnew Clough Limited are owners of Australia's only vanadium mine.

Skylark flight no flash in the pan

On August 25th 1987, British Aerospace celebrated the latest launch and 30th anniversary of its upper atmosphere sounding rocket, Skylark.

The launch, which took place at 2.00 am from South Australia's re-commissioned Woomera Rocket Range, provided scientists with the opportunity to observe from space a recently discovered supernova. The supernova, some 155 000 light years distant in the Large Magellanic Cloud (LMC), is only visible from the southern hemisphere.

Customer for the launch was the German Aerospace Research Establishment which was responsible for the procurement of the rocket and co-ordination

of the launch. The German Max Planck-Institut was responsible for procurement and management of the payload, whilst funding was provided by the German Ministry of Research.

The Skylark's payload consisted of an X-ray telescope and camera to provide astronomers with a colour X-ray image of the supernova. The results should provide valuable information about the matter expelled during the explosion of the star as well as increasing understanding of the supernova remnant.

The first Skylark rocket was launched in 1957 and since 1964, British Aerospace has supplied a complete family of the rockets. The success of the Skylark program is further reflected by continuing orders for the rocket, with 11 being ordered in 1986.

New GM for Goldring

The directors of Goldring Audio Industries Pty Ltd announced the appointment of Mr. Ken Tait as General Manager of the company on 10th August 1987. Ken joined Goldring in August, 1979 and prior to this appointment served as National Sales Manager.

A Darling of an exhibition

An international exhibition demonstrating technological achievements and innovations from both Australia and overseas will be held in June next year at Sydney's new multi-million dollar Exhibition Centre at Darling Harbour.

The primary objectives of the exhibition are to stimulate awareness of available technologies for all industries and to encourage industry's recognition of new opportunities and commercial advantages offered by the use of new technologies. Undoubtedly, the Darling Harbour development will attract a teensy bit of attention also.

The second Australian International Technology Exhibition (A.I.T.E) will be open from 10:00 am to 6:00 pm over four days from Tuesday June 7th to Friday June 10th 1988.

All enquiries regarding display space should be directed to Mr. Jim Hopkins, National Sales Manager, Total Concept Exhibitions, PO Box 1221, Crows Nest 2065, NSW. Telephone (02)436 3266.

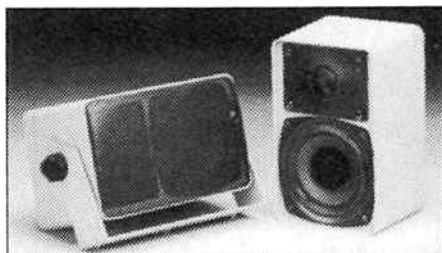
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letters

Query on caps in 6506 amplifier module

Dear Sir,

Your AEM6506 Workhorse Power Amplifier project article (January '87 issue) was shown to me by a friend and I thought it ideal as the basis for PA as I help out with a lot of community sporting and social groups. Subsequently, I purchased a kit from Jaycar and it's this I have a query on.

As supplied, the kit came with two 2500u electrolytic capacitors for C12 and C13. Now the circuit and parts list shows these as 4700u. I queried this with Jaycar and was told it was OK, but I'm not so sure. I don't mind if the capacitors are more expensive, I'd rather get the right thing.

B. Preece,
Newcastle NSW

Capacitors C12 and C13 are the power supply rail filter/bypass capacitors. Their value is not particularly critical as large value electrolytics have a substantial tolerance range in any case, typically up to +100%, -25%. While 4700u capacitors were specified and used in the prototype, that was principally because they happened to be available when the project was designed and represent the maximum so far as value and physical size in an axial lead construction is concerned. Lower values may be used, although we would not recommend values below about 2000 uF as supply regulation will be affected to some extent.

Jaycar are right. In fact, they enquired of us about substituting the 2500u capacitors which they wanted to use as there are problems with supply of the 4700u types. We gave them the OK.

Roger Harrison

The 6011 and XLR standards – again

Dear Roger,

I have had great interest in the article in the July issue on the AEM6011 Audio Balanced Line Driver.

My parallel interests in audio electronics and rock music have served me to much financial advantage in the last two decades and I'm sure that the 6011, in suitably modified form, will be of great interest to a number of bands/sound technicians.

However, I would dearly love to see an industry standard in the wiring of XLR/Cannon-type plugs and sockets. There has been confusion in the musical/audio field as to wiring, even as to the numbering of the pins. (One brand has pin numbers 2 and 3 reversed).

However, the most common configuration I have found has pin 1 as earth, pin 3 as hot and pin 2 either inverse for balanced and earth/open-circuit for an unbalanced circuit.

This is a different configuration to the 6011 which has no doubt been set up to suit your own interfacing requirements, and I'm sure that any sonic trog worth his salt would be sure to make the appropriate modification to suit his own rig. Even so, I would like to hear your comments about the appropriate wiring standard (if any).

Could I take this opportunity to express my thanks and appreciation for the articles in your magazines over the years. I have had years of faithful service from the ETI480 since its inception, and am still using a pair for drivers in the upper ranges, recently aided by AEM6506s which promise to be just as reliable. Bottom end at the moment is a pair of (beefed-up) ETI499s. All amps are driving the most efficient horn loaded speaker systems I can devise. As must be evident, I am more interested in sheer grunt and absolute reliability than in the utmost fidelity.

As a fairly impecunious muso, I must be careful to balance my investment in equipment with the expected returns from a local band – I would dearly love to be able to afford a Series 6000, but I'm still behind the 8-ball. I'm sure that there must be many of your readers in my situation, and in view of the prohibitive prices of imported PA gear, I'm sure that any future projects along these lines would be warmly welcomed.

Once again, many thanks for a great mag. Keep the presses rolling!

J. Boetje,
Brooweena, Qld

The question of XLR standards, the connectors and their wiring in the AEM6011 Balanced Line Driver was covered in this column last month in a letter from Mervyn Jack of Cobram, Victoria. To recap: the XLR output connectors should be male, not female; the wiring diagram has the XLR pins shown incorrectly; the connector should be wired pin 1 – ground, pin 2 – hot (+), pin 3 – cold (-).

It's pleasing to hear you've had such success with the ETI480 amplifier module. It was actually published a little before I was Editor of Electronics Today (Feb. 1979 – Dec. 1984). Barry Wilkinson of Nebula was the man who engineered that project, which has surely had the most remarkable lifetime of just about any electronic project published.

ETI was not "my" magazine, that imprimatur could only be held by the

founding Editor, Collyn Rivers. I was associated with ETI as a freelance writer since its first year (1971), when it was published by the Modern Magazines group, who were taken over by Murray Publishers in the late '70s. ETI was sold to Federal Publishing in late '82 and I departed in late '84 shortly after the publishers purchased its then competitor, Electronics Australia.

I started this magazine in 1985, in conjunction with several partners (forming

the company Kedhorn Holdings Pty Ltd), and it was initially associated with Westwick-Farrow Pty Ltd, publishers of the "trade" magazine What's New In Electronics and other titles. My partner, Val, and I purchased Kedhorn Holdings in March this year and AEM is now wholly independently published by us.

So, thanks for your encouraging remarks, we'll certainly keep the presses rolling!

Roger Harrison

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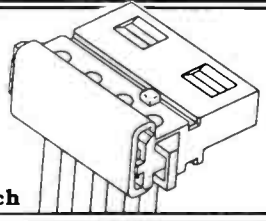
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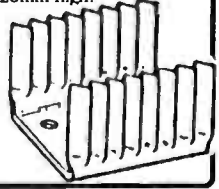
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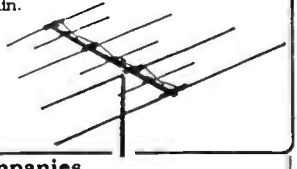
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Satellites in the school curriculum

If Australia is to source space scientists, engineers and technicians to provide the necessary people in the near to medium future in order to maintain the space industry revival currently under way, then a Victorian teacher's proposal to introduce satellites as part of the school curriculum deserves serious consideration.

OVER THE PAST few years, students at Mentone Girls' Grammar School in Melbourne have been learning about satellites in a hands-on programme initiated by the Head of Science, Paul Butler. Activities have included tracking satellites, receiving and recording their radio emissions and decoding and interpreting the data collected.

A variety of satellites have been used in the programme, some launched and used by agencies in the US and USSR, such as the NOAA and METEOR weather satellites, others developed specifically for amateur use, such as the OSCAR and UoSAT series.

Weather satellites

The polar-orbiting APT (automatic picture transmission) weather satellites transmit data in the 137 MHz band which is readily received on commonly available equipment and these have been regularly monitored by the students at Mentone. The APT data may be decoded and displayed using common microcomputers to produce images showing cloud formations and land mass details.

The Japanese geostationary weather satellite, GMS, is visible (in radio terms) from Australia. It transmits pictures of the Earth, from its position some 35 000 km above the equator, on 1690 MHz. Its transmissions are more difficult to receive because of the higher frequency, but has the advantage that a fixed antenna may be used. A system to receive GMS is planned for the school in the near future.

Amateur satellites

The radio amateur satellite community, having been involved in the design, launch and operation of satellites since 1961, has reached a high level of expertise. Amateur spacecraft are powerful and reliable, offering a range of facilities including two-way exchange of speech and data (data exchange may be in real time or by a "store-and-forward" technique), transmission of engineering data on the state of on-board systems and dissemination of information from

a variety of experiments carried on board.

Girls at MGGs have been closely involved with the two University of Surrey (UK) satellites, UoSAT 1 and 2 (otherwise known as UoSAT OSCAR-9 and UoSAT OSCAR-11). These provide bulletins from the University of Surrey ground station (store-and-forward data), engineering data and whole-orbit data, collected over one or more orbits, concerning a range of measurements made by the satellite's sensors.

The recent installation of digital communications equipment at the headquarters of the amateur satellite organisation, AMSAT Australia, in Adelaide is of particular interest. This facility will enable students to send messages from the school's amateur station VK3CMG to the ground station in Adelaide. From there they will be forwarded to UoSAT 2, stored electronically and retrieved by the University of Surrey's ground station. Finally, the messages will be sent, via the terrestrial radio network, to students in English schools.

Equipment

The ground station at Mentone Girls' Grammar School has been constructed using relatively low-cost equipment readily obtained commercially or made from kits. An AR2001 scanner loaned to the school has been used to receive most of the satellites. A Yaesu FRG9600 will soon provide a permanent facility for this purpose. A Yaesu FRG7 shortwave receiver allows reception of the Russian RS series satellites which provide HF band operation.

The UoSAT series satellites are monitored using a single channel receiver/decoder obtained from England, which provides an automatic recording facility, virtually essential given that most UoSAT passes occur out of school hours. Improved decoding is available from a device built in the school from an AMSAT UK design and recordings of transmissions are made on an ordinary domestic cassette recorder.

Simple antennas are employed. A fixed VHF dipole is mounted on the roof

and, with a simple preamplifier, provides good signals from the polar-orbiting satellites. Even better results are obtained by tracking the satellites manually with a handheld 9-element VHF beam, made from a readily obtained kit.

Tracking the satellites is done using prediction programs from the amateur satellite community, run on the school's Apple II and BBC computers. Orbital reference data is obtained from AMSAT UK newsletters and the AMSAT network broadcasts each Sunday on 3685 kHz at 8.00 pm.

Interpretation of data, particularly from the UoSATs, has been done manually, with students plotting graphs point by point. This tedious task is now assisted with computer software, providing hard copy graphs.

Classroom activities

Satellites have provided a focus for a variety of activities in the classroom. Tracking and decoding have provided opportunities for using computers in a practical rather than an artificial way, and opened up possibilities for software design.

The study of the development of electronic systems is closely allied with the existing science curriculum and students have been able to research into applications of electronics, instead of merely studying the theory of electricity. The physics of satellite motion is another area in which theory may be applied to real situations.

Paul Butler plans to extend the satellite programme developed at MGGs to other schools around the country in the near future, using the knowledge and experience gained over the past few years. Demonstrations are being undertaken at several educational conferences late this year, and the World Science Education Conference in 1988.

As 1988 is Australia's bicentennial, Paul Butler says it will be important, while the nation is reflecting on its history and heritage, to look forward to our future, which will inevitably involve science and technology. To this end, a "Satellites in Schools" programme is being proposed by MGGs as part of the bicentennial celebrations. Low-cost, Australian designed hardware and software is being sought with the aim of establishing satellite ground stations at schools Australia-wide (the AEM3506 UoSAT Decoder featured this issue was designed for just this role). Teaching materials will be prepared and published to help teachers and students become involved with satellite technology.

We think it's not just a step in the right direction but an essential move if Australia is not to be swamped by borrowed technology and imported technologists. ▲



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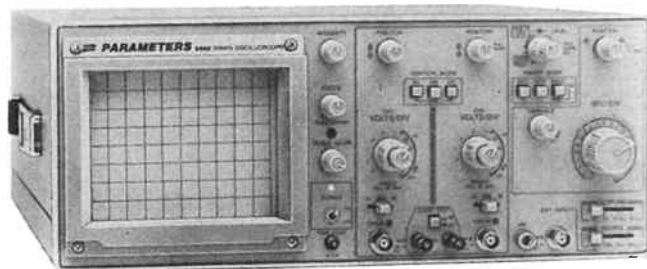
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New portable 'scopes from Parameters



Parameters Pty Ltd has announced the release of their own new range of oscilloscopes for 1987. The new family covers the general purpose market from 15 MHz to 40 MHz.

The range starts with the PA 615S "super portable" dual-trace model. This instrument offers 2 mV sensitivity up to 15 MHz, automatic selection of chopped or alternate modes and auto selection of TV line or frame display. A choice of ac, external dc (11 to 30 V) or internal NiCad battery operation is provided.

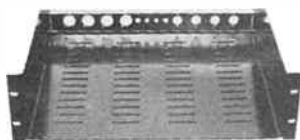
The Parameters 5502 20 MHz, dual-channel oscilloscope provides 1 mV sensitivity, a built-in component tester, channel 1 output for use with a frequency counter and variable trigger hold-off for observation of waveforms with complex trigger points. In addition, TV line and frame trigger is standard.

The model 5504 is a 40 MHz, dual channel instrument offering 1 mV sensitivity, channel 1 output, variable trigger hold-off, delayed timebase, single sweep operation and scale illumination. As with all the Parameters oscilloscopes, the 5504 is supplied with handbook, probes and a full 12 month warranty.

For further information, contact: Parameters Pty Ltd in Sydney on (02)888 8777, Melbourne (03)579 0622 or Perth on (09)242 2000.

Rack mount shelves from Amber

Professional audio equipment which cannot be rack mounted presents a number of problems. By simply being stacked on other equipment,



additional weight and strain is placed on the bottom unit and heat build-up and hum can become a problem. In addition, access for service is restricted.

A solution to this problem is the professional standard rack-mountable shelf from Audio Visual Designs, distributed exclusively by Amber Technology.

Made from strong, lightweight 2 mm steel and finished in durable baked enamel, the shelves feature cut-outs at the rear for eight Cannon type audio and four video connectors, whilst air vents allow for improved air circulation and heat dissipation.

For further information, contact: Amber Technology, Cnr Skyline Place and Frenchs Forest Road, Frenchs Forest 2086 NSW. (02)498 2799.

Squeaky clean mains filters

Most modern personal computers and peripheral equipment are fitted with basic type filtering components. In most instances, these filters only offer minimal protection against mains supply problems.

The problems facing the personal computer user include high levels of RF interference, voltage spikes and frequency modulation. The supply

authorities actually superimpose a range of frequencies on the mains for the control of hot water systems and other industrial remote control services.

KCC of Pymble NSW offer a range of mains filters to overcome these problems. The model LF-4 provides four individually filtered power outlets and will handle a continuous load of 10 Amps. A built-in mains circuit breaker is included and the filter will clamp voltages to 390 V peak or 275 VRMS.

The model LF-2 provides two outlets and will handle a total load of 10 amps. Neither model will trip a 20 mA earth leakage breaker and both models will handle a peak impulse current of 2000 A. The protection mode for both filters is Active-Neutral, Active-Earth and Neutral-Earth models are available on special order.

The filters are manufactured by KCC, 18 Beechworth Road, Pymble 2073 NSW. Telephone (02)44 7394. Enquiries from prospective dealers would be welcomed, KCC tell us.



Digital temp. meters

The AIC range of Australian-made digital display panel meters includes models for temperature measurement. These instruments can be supplied with a large 18 mm display or a smaller 12.5 mm display.

Input types include thermocouple, RTD or semiconductor sensors and options include up to two control/alarm relays, recorder output and various power supply configurations.

For further information, contact Amalgamated Instrument Company Pty Ltd, Unit 7, 21 Tepko Road, Terry Hills 2048 NSW. (02)450 1744.

Multi-use loudspeakers from Rebel

Rebel Audio Pty Ltd has been appointed exclusive Australian distributor for Community Light and Sound, one of the best known names in the US for sound reinforcement.

Rebel themselves are a newly launched pro audio company, set up to cater for the audio installation and contracting market. The company has available a range of products for the broadcast, sound reinforcement and recording studio markets and has representative agents in all states.

One of Community's first products on the Australian market is the newly launched series of loudspeakers, the CS25 and CS35. These multi-use, high sensitivity loudspeakers are said to be reliable and cost-effective, making them ideal for working musicians and the sound contracting market.

The CS25 features a ferro fluid-cooled 300 mm driver with a single high frequency horn, while the CS35 has a ferro fluid-cooled 38 cm driver with an integral high frequency horn and ducted port assembly.

Constructed of rugged but lightweight 20 mm fibreboard, the CS25 and CS35 cabinets are covered with a durable, non-woven black carpet that protects the speaker and anything it might bump into.

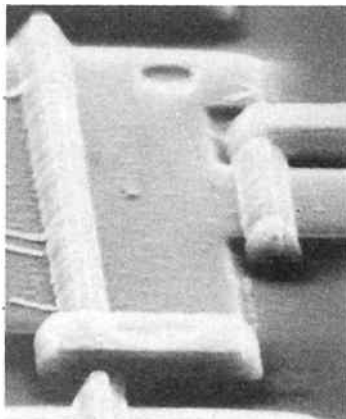
Both the CS25 and CS35 feature socket-stand adaptors, so the speaker can simply be slipped over a stand to raise them up for better sound dispersion. Three mounting points also allow for wall or ceiling hanging.

Weighing in at 14.5 kg for the CS25 and 19.5 kg for the CS35, the cabinets are light enough for a single person to pick up using the single, rear mounted handle.

For further information, contact: Rebel Audio Pty Ltd, 104-106 Hampden Road, Five Dock 2046 NSW. (02)713 6866.

semiconductor scene

IBM scientists have moved computer chip technology into unexplored dimensions by making the world's most powerful experimental silicon transistors with features one thousand times thinner than a human hair.



View of the tiny new transistor structure developed by IBM.

Although others have made transistors in which an individual key part has been as small, IBM scientists are the first to miniaturise all the critical parts – some to less than a tenth of a micron, only a few hundred atoms wide.

Such small, powerful transistors could lead to future computers many times faster and more compact than previously thought possible. Logic chips based on tenth-micron technology could hold millions of logic elements that switch in as little as 10 picoseconds, ten times faster than those used today.

Experimental techniques used to make and test the transistors include advanced lithography for writing ultra-thin lines and cooling the devices during operation to 321 degrees below zero (Fahrenheit) in liquid nitrogen.

The IBM transistors were designed with the high performance needed for ultra-large-scale integration (ULSI) in mind. Using such technology, advanced computer applications such as weather forecasting and continuous speech recognition – a challenge for today's large mainframes – might run on machines the size of today's personal computer!

The Novix NC series of chips

The NC4016 was the first of a series of chips co-designed by Charles Moore and Novix. The NC series is built using pin-grid type HCMOS gate array devices. These devices (manufactured by Mostek for Novix and now second sourced by Harris) are simply a series of HCMOS gates with fusible I/O gates, which can be blown by supplying a sufficiently high voltage to the appropriate pin of a chosen gate. HCMOS gate arrays provide a very economical method of building a chip which is not expected to sell in high volume, whilst at the same time, keeping the production cost to a fairly low figure.

The three current chips are the NC4016, the NC5016 and the NC6016. The NC5016 is pin compatible with the NC4016 and has the advantage of providing extended addressing space. Both of these chips are on a 120 pin grid array package, whilst the NC6016 is on a 144 pin grid package.

Let us first look at the broad details of all members of the set, before examining specific chips. Firstly, the chips are all HCMOS gate arrays. This means that they all operate over a fairly wide voltage range and require only a single polarity power supply. The chip requires 5 V (+ or – 10%), which is easily provided by a standard 7805-type circuit. Again,

being HCMOS, they are low power devices.

I have an IBM PC/AT clone at home with a 20 MHz crystal driving the 80286 at 10 MHz. The size of the heatsink on top of this chip is quite impressive. The NCX016 chips can run all day without raising a sweat. This, of course, also means that one does not require a power supply that looks as though it was designed to drive lightning bolts. The chips draw about 350 mW of power in the operating condition (7 mA/MHz) and about 25 mW in the standby mode. A complete computer (RAM, EPROM, NC4016 and other support chips) runs at 1.8 W!

The second feature that makes these chips different from the current batch of processors is that they run on a variable rate clock. The chip can therefore be driven at any speed from static (with the clock halted and the processor in standby mode) to the full operating speed. Chris Darling (designer of the Maestro Supermodem) has been playing around with the NC4016 for several months now and has had the chip running quite happily at speeds as low as 3 kHz.

A programmable clock is really a marvellous idea for controlling operations that MUST be run at relatively slow speeds (e.g: programming an EPROM, or accessing slow memory etc.) A variable speed clock also means that anyone who wants a fast, non-expensive computer, can first select the most cost effective RAM chips and then drive the processor at the speed required to meet the performance specifications of those RAM chips.

Finally (for this month, anyway) the chips are based on the RISC (reduced instruction set computer) concept, with Forth as their "machine code." The complete instruction set for the chip only runs to about 40 instructions (I always say "about" to avoid semantic arguments with purists).

Combining all of the above features yield a chip that operates at blinding speed (up to 12 MIPS), has low power consumption and which has a high level language (Forth) as its native code.

Next month I shall discuss the features of individual members of the set.

High speed buffer/driver amplifier

Reserve Electronics of Western Australia are able to offer a second source for the LH0033 amplifier, known as the TP0033, a high speed, high input impedance, unity gain buffer amplifier that is a pin, package and performance equivalent to the LH0033.

This device matches or exceeds the performance of its counterpart in all intended applications, including coaxial cable signal driving, high speed A/D input buffering and delivering fast-changing linear current waveforms for precision CRT graphic displays.

The TP0033 has a FET-input stage to provide high (100 Gigohms) input impedance, low (0.5 nA) input bias current and low (± 10 mV) input offset voltage (externally adjustable to zero). The device operates from a non-critical ± 5 V to ± 20 V supply with single supply operation permitted. With the nominal ± 15 V supplies, the TP0033 delivers a guaranteed output of ± 12 V into a 1000 ohm load.

Other key large signal specifications include a typical 1500 V/microsecond slew rate and a 25 nanosecond settling time, during which the device settles a 2 V step (typical "flash" ADC full scale input) to within one per cent of final value.

A 100 MHz bandwidth, 2.9 nanosecond rise time and 1.2 nanosecond propagation delay are key typical small-signal

semiconductor scene

specifications which further suit the TP0033 for high frequency signal buffering applications.

Reserve also stock a range of high power VMOS output operational amplifiers. The 1460 has a 1 GHz gain-bandwidth product, a 300 V/microsecond slew rate and a full ± 30 V, ± 150 mA output. It is a full differential input, single ended output device with internal current limiting and is ideally suited for high speed, high gain configurations that require a ± 30 V high current output.

The 1461 is an extremely fast, FET input, VMOS output, power op-amp. It operates from ± 15 V to ± 40 V supplies and has output voltages up to ± 34 V and currents up to ± 750 mA. The 115 dB open loop gain, 1 GHz gain-bandwidth product and 1200 V/microsecond slew rate make it an outstanding device for a power op-amp, the makers claim.

The 1463 is a high speed, high power op-amp which operates from supplies between ± 15 V and ± 40 V. The device has a guaranteed output of ± 28 V at one amp with ± 36 V supplies. The 1463 achieves an 80 V/microsecond slew rate, 7.5 MHz gain-bandwidth product and 250 nanosecond settling time to 0.1%. Input bias current and offset voltage are guaranteed less than ± 200 picoamps and ± 5 mV respectively.

For further information, contact: Reserve Electronics Pty Ltd on (09)328 9755 or (09)328 9422.

High accuracy, low noise 5 V reference

Analog Devices has released a precise +5 V reference featuring low initial offset error, low drift and low cost in an 8-pin hermetic CERDIP. The AD586 provides offset and drift as low as 2.5 mV and 5 ppm respectively and is suitable for use as a system reference with 16-bit DACs, power supply controllers and autocalibration systems.

A proprietary noise reduction feature lets the user reduce the already low wideband noise by adding a single capacitor. A proprietary buried zener diode and production laser trimming provide low error, low noise and high stability over time and temperature, according to AD.

Long term stability is typically 15 ppm/1000 hours, whilst the output noise of the AD586 achieves a low 4 μ V peak to peak (p-p) value in the 0.1 to 10 Hz band and is only 200 mic-

rovolts p-p to 1 MHz. An external 1 μ F capacitor connected to the Noise Reduction pin of the IC reduces this wideband noise to 160 microvolts p-p.

The reference value can be "fine trimmed" with a single external potentiometer to provide exactly 5.000 V, or to provide an output voltage that differs from nominal for particular applications. A total trim range of plus 300 mV to minus 100 mV is available.

The load regulation of the AD586 (100 microvolts/mA) provides output stability as the amount of load current changes, such as when a DAC or ADC switches internally or when varying loads occur on the reference output. Up to 10 mA can be supplied by the AD586. The chip requires a 10.8 V to 36 V power supply to provide the +5 V output and power dissipation is typically 30 mW.

New 1500 volt PIN diode chips

The Semiconductor Division of Alpha Industries has announced a new high voltage PIN chip, model CSB3779. The device features 1500 V minimum V_b at 10 microamps, low RF resistance and low thermal impedance.

Capable of meeting screening up to JANS, the CSB3779 PIN chips are ideally suited for applications including high power phase shifting and radiation detection.

Device specifications include:

Power dissipation	35 Watts max.
Breakdown voltage (V_b)	1500 V minimum at 10 μ A
Junction capacitance (Cj)	2.5 pF max at 100 V
Series resistance (R_s)	0.5 ohms typical at 100 mA

Alpha Industries are represented in Australia by: Benmar International Pty Ltd. Telephone (02)233 7566.

Electrically erasable PROM from SEEQ

SEEQ's 2804A is a 5 V only, 512 x 8 electrically erasable programmable read only memory. EEPROMs are ideal for applications which require non-volatility and in-system data modification. The endurance, the number of times that a byte may be written, is ten thousand cycles for the 2804A.

The device has an internal timer which automatically times out the write time. A separate erase cycle is not required and the minimum write enable pulse width needs to be only 150 nanoseconds.

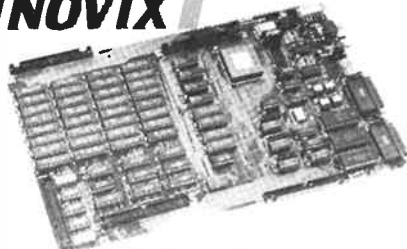
The on-chip timer, along with the inputs being latched by a write- or chip-enable signal edge, frees the micro-computer system for other tasks during the write time. The write time is 10 ms and once a byte is written, it can be read in 250 nanoseconds. The inputs are TTL for both the byte write and read modes.

There are four operational modes and only TTL inputs are required. To write a byte into a particular location, a TTL low is applied to the write enable pin of a chip enabled device. This, combined with output enable being high, initiates a write cycle. An automatic byte erase is performed internally in the byte write mode and the 2804A ignores attempts to read or write while the internal write cycle is in progress.

The 2804A incorporates power up/down protection circuitry and consumes only 80 mA active current and 40 mA standby current. Data retention is quoted as ten years.

For further information on the 2804A and other SEEQ devices, contact the Australian representative: RAE Industrial Electronics Pty Ltd in Sydney on (02)232 6933 or Victoria on (03)277 4033.

"FANTASTIC FORTH" AT 12 MIPS FROM NOVIX



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Practical filter design — without fears or tears

Jack Middlehurst
Part 1 — introduction

One of the many weapons in the armoury of the electronics engineer is the use of filters. While it is possible, particularly in engineering textbooks, to get carried away with mathematics in the design of filters, they are basically easy to understand and design, although you wouldn't get this impression reading any of the standard textbooks. Most of them seem to set out to convince the reader that you have to be a genius even to get to first base.

THERE IS NO REASON at all why filter design should remain the province of those with an extensive background in mathematics. But it seems many people involved in electronics, at all levels, avoid the subject of filter design more, I suspect, from lack of familiarity (fear of the unknown) than lack of ability. No matter whether you pursue electronics as a career or purely as a hobby, filters are particularly useful circuit blocks that can simply be "plugged into" many projects to solve quite a wide range of problems.

In this series we will look at the circumstances where you would need filters, indicate which ones to choose for which applications, and discuss their limitations. We will give listings of programs in GWBASIC that will allow anyone with a simple computer to design their own filters and predict their properties. We will also describe how to align filters so that they have the frequency response that they are supposed to have. All of the filters we describe can be designed and built by the usual hobbyist. Some of the designs will be a bit too complicated for beginners, but that is no reason why they shouldn't look at them and try to understand how they work so that later on, when they acquire more experience, they will be able to take them in their stride.

We will limit our filters to frequencies below about 100 MHz since above that frequency special techniques are needed to cope with stray inductance and capacitance. So we will not be dealing with transmission line or microstrip filters nor will we venture into microwaves.

What is a filter?

A filter can be thought of as a black box that changes the frequency range of whatever is fed into it. What comes out of the box always has a frequency range less than that going in. For example, we may have a range of frequencies from 2 Hz to 36 000 Hz going into an amplifier, but only want to use frequencies from 20 to 20 000 Hz. So we include a filter to remove the unwanted frequencies. This restriction of the frequency range is often essential if we are not to overload electronic equipment by feeding it signals outside the range for which it was designed.

Filters come in two basic forms. The first, the passive filter, is simply a combination of resistors, capacitors, and usually inductors. The second, known as an active filter, consists of one or more amplifiers with resistors and capacitors. Active filters were invented to overcome the limitations of inductors so they rarely contain one. These days, with the low cost of IC amplifiers, active filters are used for most applications below 100 kHz and occasionally up to 1 MHz, and passive filters are only used from about 100 kHz up.

The main cost in passive filters is the price of the ferrite pot-cores used for the inductors, and possibly some precision capacitors. For high frequencies, passive filter costs are usually negligible unless you want to put lots of power (from a transmitter) through them. Active filters, if fed from an already existing power supply, are relatively inexpensive, since they usually only contain a few cheap ICs, some 1% resistors and some capacitors.

Why are filters needed?

The first real need for filters came with the introduction of intercity telephone cables. It was rapidly realized by the telecommunications engineers of the day that the problem of getting many telephone conversations simultaneously down the one cable could be solved by having a different frequency range for each conversation. So filters were introduced that restricted the frequency range of each conversation to 300-3000 Hz. Then the various conversations were frequency changed to occupy 300-3000 Hz for the first, 3300-6000 Hz for the second, 6300-9000 Hz for the third and so on. At the receiving end the conversations had their frequencies returned to the original 300-3000 Hz range so that they were intelligible again. To make all of this possible, a whole range of filters was necessary so an enormous amount of effort was poured into the mathematics of filter design.

These days, there is hardly a circuit designed that does not contain a filter of some sort. Any circuit that has negative feedback within it invariably needs a filter within the feedback loop to compensate for the other filters that are inadvertently included. These other filters are caused by the base capacitance of transistors or the gate capacitance of FETs, as well as wiring capacitance. Without a filter to compensate for these, the feedback would become positive at some frequency and the circuit would oscillate near that frequency.

All power supplies have filters to remove hum from their dc output; switched-mode supplies need powerful filters to remove the higher harmonics of the switching pulses. For computer users, a particularly useful filter is the mains filter, designed to stop hash from the 240 V mains supply getting

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into the computer, and interference from the computer getting back into the mains. An excellent design for one of these is the "Hash Harrier" in the April 1986 issue of AEM. An integrator is a filter. Circuits containing integrators include analogue timers, temperature controllers, music synthesizers, electronic tachometers, and all phase-locked loops. By now you will have realized that tuned circuits are filters, so all transmitters and receivers must contain filters.

Even though all tuned aerials are filters, it is often necessary to put a filter between a transmitter and an aerial to improve the purity of the signal being broadcast. For untuned aerials, an aerial tuner (an LC filter) is essential to reduce the occurrence of spurious radiation from the aerial. Overloading of radio and TV receivers can occur if you are close to a transmitter of some kind, even though it is radiating a pure signal. The solution is to put a filter, tuned to reject the transmitter

frequency, between the aerial and the receiver. From all this you can see that filters really are an all-pervasive component of electronics.

Properties of filters

There are four main properties of a filter: its frequency response, its phase response, its time delay and its cost. For many applications such as the telephone problem described above, the frequency response is the most important. However, for negative feedback use, the phase response can be critical, while for loudspeaker crossover networks all of the first three properties are important. For commercial users the fourth property is often the prime consideration, particularly if there are going to be thousands of filters in a project.

Figure 1.1 shows the frequency response of the four standard types of filter. In each case the passband is that range of frequencies for which the attenuation of the filter is less than 3 dB. The stopband is the range of frequencies where the attenuation is greater than 3 dB. The cutoff frequency, labelled F_c in the figure, is where the attenuation is exactly 3 dB. You will notice that there are two cutoff frequencies in band pass and band reject filters. These are simply called the upper and lower cutoff frequencies.

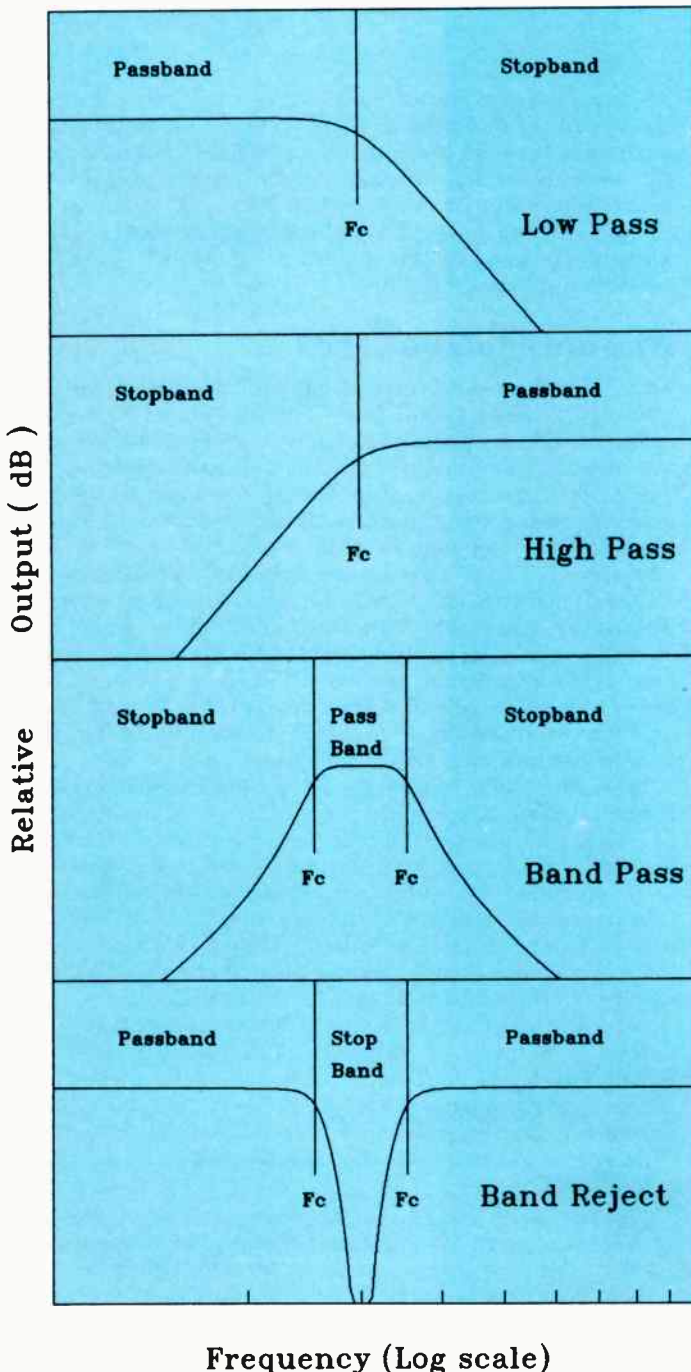
The names of the four filter types are simple and descriptive. The low pass filter passes low frequencies and attenuates high frequencies. The high pass filter does the opposite. The band pass filter passes a band of frequencies and attenuates those above and below that band. The band reject filter passes all frequencies except for a (usually narrow) band that it attenuates. The bandwidth of a band pass or band reject filter is the difference in frequency between the upper and lower cutoff frequencies.

It was bandpass filters that were the solution to the telephone problem. Looking at Figure 1.1, you can see another property of filters that can be important. This is the slope of the frequency response in the stopband. If bandpass filters have a shallow slope, they cannot be put close together in frequency without overlapping. Clearly for telephone work, the steeper the slope of the frequency response in the stopband, the more filters can be fitted in a given frequency range, so the more conversations can be sent down a given cable. Sets of adjacent band pass filters with very steep cutoff slopes are known as multiplexing filters.

For frequency divider filters for loudspeakers, too steep a slope causes serious subjective distortion of the sound, mainly caused by changes in the phase of the signals near the cutoff frequencies. So the design of the filter is quite different, even though the reason for dividing up the frequency range into several consecutive segments is basically the same. In general, the steeper the slope in the stopband, the greater the phase shift near the cutoff frequency. So one would not use sharp cutoff filters within the audio range in high fidelity equipment. For amateur radio, where getting through the interference is more important than high fidelity, sharp cutoff audio filters can make all the difference between success and failure.

All filters introduce a time delay. In other words, if a signal is introduced to the input, it will be some time before the signal appears at the output. The size of the time delay is usually frequency dependent. For many applications this is of no importance, but for high fidelity work the placing of the low, mid, and high frequency loudspeakers can become very much dependent on the crossover networks driving them. Time delay is of particular importance when filtering fast pulses since the shape of the pulse can become severely distorted. There are special filter designs available that give an almost flat frequency response but have a frequency-dependent time delay. This permits some degree of compensation for the time delay caused by a sharp cutoff filter.

Figure 1.1. Frequency response of the four standard types of filter.



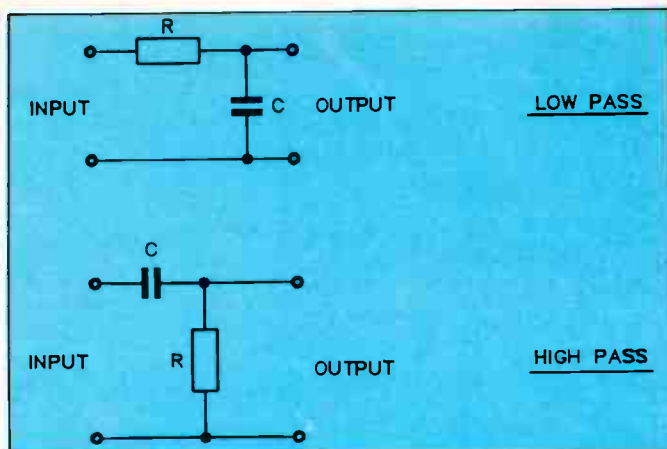


Figure 1.2. The simplest low pass and high pass filters.

The simplest filters

Figure 1.2 shows the simplest low pass and high pass filters. They each consist of one resistor and one capacitor. In calculating the properties of these filters, it is assumed that the source supplying the signal to the input has zero driving impedance, and that the load attached to the output is an open circuit i.e. has an infinite impedance. If the source has a finite resistance then it is a simple matter to add its resistance to that of the filter resistor and use the total resistance as the filter resistance in the calculations. If the load has a capacitance, that can be added to the capacitance of the filter. A GWBASIC program to calculate the frequency response and phase shift of these circuits is given in Figure 1.3. However, this programme will not give the correct answers if the load puts a resistance in parallel with the filter capacitor.

FIGURE 1.3

Attenuation and phase of the circuits of Figure 1.2

Since all these GWBASIC programs are optimized for speed, they are a bit hard to follow, so they will be preceded by comment such as this.

Line 2 LGE converts log to base e into log to base 10, since GWBASIC doesn't have log to base 10. The # simply means double precision. Line 30 sets up the output for display.

Lines 70-100 Each time an input is requested there is a trap to allow for hitting the wrong key. If an impossible answer is entered (e.g. a negative frequency), the question is simply repeated.

Line 110 XC is the reactance of the capacitor, DEN is an abbreviation of denominator. The factor 1000000 converts microfarads to Farads.

Line 120 'A' is the attenuation.

```

10 PRINT "Calculate the attenuation & phase of RC LP & HP filters."
20 PI=3.141592654# : LGE= 434294481#
30 AS="The attenuation is " : BS=" dB" : CS="The phase shift is " : DS=" degrees"
40 INPUT "Would you like to calculate:"
50 PRINT "1. an RC (low pass) filter ?"
60 PRINT "2. a CR (high pass) filter ?"
70 INPUT "Please enter the appropriate integer: ",N:IF (N#1 OR N#2) THEN 40
80 INPUT "What is the value of R [ Ohms ] ? ",R:IF R<=0 THEN 80
90 INPUT "What is the value of C [ microFarads ] ? ",C:IF C<=0 THEN 90
100 INPUT "What frequency [ Hz ] would you like to use ? ",F:IF F<=0 THEN 100
110 XC=1000000#/(PI*F/C) : DEN=SQR(R#R+XC#XC)
120 IF N=1 THEN A=-20*LGE*LOG(XC/DEN) ELSE A=-20*LGE*LOG(R/DEN)
130 IF N=1 THEN PHASE=ATN(R/XC)*180/PI ELSE PHASE=ATN(XC/R)*180/PI
140 PRINT USING "\ \###.# \ \:AS.A.BS
150 PRINT USING "\ \###.# \ \:CS.PHASE.Ds
160 INPUT "Would you like to try another frequency ? ",E$
170 IF (E$="Y" OR E$="y")THEN 100
180 END

```

Figure 1.4 is a printout of the frequency response and phase shift of these two filters when the resistors are 10 000 Ohms and the capacitors are 1 nF. You can see that the cutoff frequency is 15 915 Hz and that the slope of the curve gets close to 6 dB per octave, i.e. 6dB each time the frequency is doubled for the low pass or halved for the high pass filter. It is typical of such filters that the phase shift is $\pi/4$ radians (45 degrees) at the cutoff frequency and that the phase shift becomes $\pi/2$ radians (90 degrees) a long way into the stopband. The phase of the output voltage of the RC filter lags the input voltage whereas that of the CR filter leads the input voltage.

FIGURE 1.4

Attenuation and phase shift of low pass and high pass filters shown in Figure 1.2, calculated using the program of Figure 1.3

Frequency (Hz)	Low Pass		High Pass	
	Attn (dB)	Phase (deg)	Attn (dB)	Phase (deg)
100	0.0	0.4	44.0	-89.6
200	0.0	0.7	38.0	-89.3
400	0.0	1.4	32.0	-88.6
800	0.0	2.9	26.0	-87.1
600	0.0	5.7	20.0	-84.3
3200	0.2	11.4	14.1	-78.6
6400	0.7	21.9	8.6	-68.1
12 800	2.2	38.8	4.1	-51.2
15 915	3.0	45.0	3.0	-45.0
25 600	5.5	58.1	1.4	-31.9
51 200	10.5	72.7	0.4	-17.3
102 400	16.3	81.2	0.1	-8.8
204 800	22.2	85.6	0.0	-4.4
409 600	28.2	87.8	0.0	-2.2

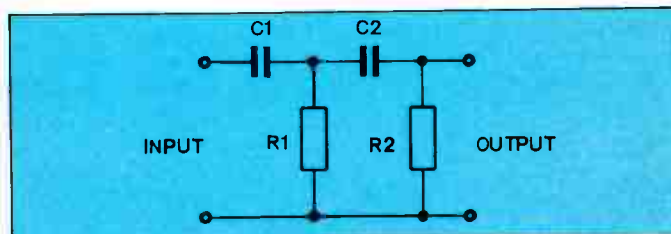


Figure 1.5. Two high pass CR filters in series.

In Figure 1.5, two identical high pass filters have been connected in series. Now the second filter will have an effect on the properties of the first, since the second filter represents a substantial load on the first. The program for this circuit is in Figure 1.6 and the attenuation is compared with that of two independent filters in Figure 1.7. You can see the effect of the loading by noting that the attenuation would be simply twice that for one filter (given in Figure 1.4) if there was no interaction. Notice also that the cutoff frequency has been altered. You can arrange to have no interaction by putting an amplifier with a gain of one between the two filters. Then the attenua-

FIGURE 1.6

GWBASIC program to calculate the attenuation of two CR high pass filters in series as shown in Figure 1.5. The mathematical expression giving the attenuation is derived from the time constants of the various RC combinations. Since $1M \times 1u = 1$ second, the units of R & C should be megohms and microfarads. The megohm is inconvenient so ohms are used and a factor of a million included in the program.

Line 20: LGE converts log to base e to log to base 10.

Lines 40-80 contain traps against hitting wrong keys.

Line 90: 'W' is omega, the frequency in radians per second. WT1, WT2, and WT3 are the time constants of the Rs and Cs in seconds multiplied by omega. NUM is short for numerator.

Line 120: DEN is short for denominator.

Line 130: 'A' is the attenuation.

```

10 PRINT "Calculate the attenuation of 2 CR high pass filters in series."
20 PI=3.141592654# : LGE= 434294481#
30 AS="The attenuation is " : BS=" dB" : CS="The phase shift is " : DS=" degrees"
40 INPUT "What is the value of C1 [ microFarads ] ? ",C1:IF C1<=0 THEN 40
50 INPUT "What is the value of R1 [ Ohms ] ? ",R1:IF R1<=0 THEN 50 ELSE R1=.000001#R1
60 INPUT "What is the value of C2 [ microFarads ] ? ",C2:IF C2<=0 THEN 60
70 INPUT "What is the value of R2 [ Ohms ] ? ",R2:IF R2<=0 THEN 70 ELSE R2=.000001#R2
80 INPUT "What frequency [ Hz ] would you like to use ? ",F:IF F<=0 THEN 80
90 W=2*PI*F : WT1=W*R1*C1 : WT2=W*R2*C2 : WT3=W*R1*C2 : NUM=WT1*WT2
100 DEN=1+NUM*(NUM+4) : WT1=WT1+WT2 : WT3=(2*(WT1+WT2)+WT3) : NUM=NUM*2
110 A=-20*LGE*LOG(SQR(NUM/DEN))
120 PRINT USING "\ \###.# \ \:AS.A.BS
130 INPUT "Would you like to try another frequency ? ",E$
140 IF (E$="Y" OR E$="y")THEN 80
150 END

```

tion will be the sum of the attenuations of the two filters, but the cutoff frequency will still change. At frequencies well into the stopband, the attenuation tends towards 12 dB per octave. Although it is not shown, the phase shift tends towards 180 degrees.

Where would you use such simple filters? All high fidelity amplifiers use a low pass filter at their input to reduce the effects of extremely fast peaks outside the audio range. This removes the chance of transient distortion that arises when the time delay caused by filters in the negative feedback network is large compared with the rise time of the incoming signal.

FIGURE 1.7

Attenuation of two CR high pass filters in series as shown in Figure 1.5, compared with the attenuation of two filters in series without any interaction.

Frequency (Hz)	COUPLED FILTERS		INDEPENDENT FILTERS
	Atten. (dB)	Atten. (dB)	
100	88.1	88.0	
200	76.0	76.0	
400	64.0	64.0	
800	52.1	52.0	
1600	40.4	40.0	
3200	29.5	28.2	
6400	20.3	17.3	
12 800	13.1	8.2	
25 600	7.3	2.8	
51 200	3.2	0.8	
53 000	3.0	0.7	
102 400	1.0	0.2	
204 800	0.3	0.0	
409 600	0.1	0.0	

All small transistor radios use one or more high pass filters to prevent low audio frequencies from overloading their small loudspeakers, and they often use a low pass filter as the "tone" control. In addition, all ac-coupled amplifiers effectively have exactly that type of high pass filter wherever there is a coupling capacitor between stages. Pickup preamplifiers use simple RC filters for RIAA compensation either as passive filters or as components within an active feedback amplifier.

Limitations of simple filters

The main problem with simple RC filters is that the attenuation is limited to 6 dB per octave for each section. Consequently it is not possible to achieve a sharp cutoff without seriously degrading performance near the cutoff frequency. By the time the full 6 dB is achieved, you have to be about three octaves from the cutoff frequency. The situation is further complicated if there is any significant load on the filter.

One often overlooked point is that the low pass filter has a direct dc connection from its input to its output. This can be a nuisance in some amplifiers, particularly where low level signals are being amplified, since any DC level on the input will be transferred to the following high gain amplifier which can then be driven into saturation.

How do filters work?

The simple filters that we have been looking at can be used as an example of how all filters work. Figure 1.8 shows the general circuit of all filters. It consists of a two component voltage divider. Each of the boxes can contain resistors, capacitors, and/or inductors, or indeed any form of frequency-dependent components.

If both boxes contain a pure resistor, the attenuator is not frequency dependent and therefore not a filter. An excellent example of this is the RF attenuator box described in the April 1987 issue of AEM. The frequency response is flat from

dc to 300 MHz: that is certainly not a filter!

For our low pass filter, Box 1 contained a resistor and Box 2 contained a capacitor. As the frequency is increased, the impedance (the resistance to ac current flow) of the capacitor decreases whereas that of the resistor remains unchanged. So the attenuator (filter jargon for a voltage divider) has an output that decreases as the frequency increases: it has now become a filter. We will be looking at much more complicated filters later on, but they can all be broken down into a series of blocks like the one shown in Figure 1.8.

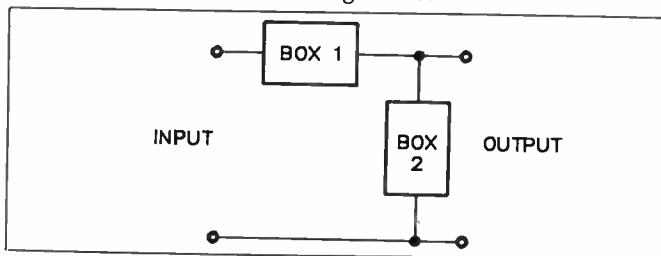


Figure 1.8. General circuit of one section of any filter.

The design of filters

Designing a filter can be as easy or as hard as you like. There are some excellent cookbooks available containing charts and tables that can be used to design many standard filters. What happens, of course, is that the filter that you need is not in the book, and there is no way to tell what the filter components should be other than by guessing from similar filters. The actual mathematics needed to calculate components of some filters is downright difficult. If you are not up in elliptic integrals, forget it!

What we have done is to put all the necessary mathematics into computer programs that have been tested to make sure they give filters that work. These programs can involve the computer in a fair bit of hard work, so they are all written to give maximum speed. Since they are in GWBASIC which is an interpreter language, speed is increased in several particular ways. There are no comments, as many statements as possible are jammed on each line, all constants or variables capable of being pre-calculated are removed from FOR . . . NEXT loops, and nested FOR . . . NEXT loops are avoided wherever possible. Subroutines are avoided if possible in the mathematical parts, any essential subroutines being placed as close as possible to the lines calling them. However, subroutines are used extensively where they don't affect the speed, such as in the display of results.

All of this makes the programs a bit hard to follow. This isn't serious unless you are trying to find out in detail how they work or to alter them. If you really want to do either of these, it is strongly recommended that you study one or more of the reference books listed at the end of each article before starting to fiddle with the programs. The output of the programs is in the form of tables so, if you want your output to go to a printer, simply replace the word PRINT with LPRINT in the output routines.

Computers tends to be a bit individual when it comes to graphics, which is why we have left it to you to add your own graphics subroutine to convert the frequency or phase responses to graphical form should you so wish. If you have a suitable monitor and graphics card, the graphics commands in GWBASIC can be used to do this. For example, in the program of Figure 1.3, to plot the attenuation, you would insert the following:

```

100 INPUT "What is the start frequency [ Hz ] ?".FSTART:IF FSTART=0
    THEN 100
101 INPUT "What is the finish frequency [ Hz ] ?".FEND:IF FEND<0
    THEN 101
102 S=(FEND-FSTART)/100
109 FOR I=1 TO 101 : F=FSTART+(I-1)*S
130 IF I=1 THEN ( your graphics command to MOVE to the
    point FSTART.A ) : GOTO 150
140 ( Your graphics command to DRAW to the point F.A )
150 NEXT I
Delete 160 and 170.

```

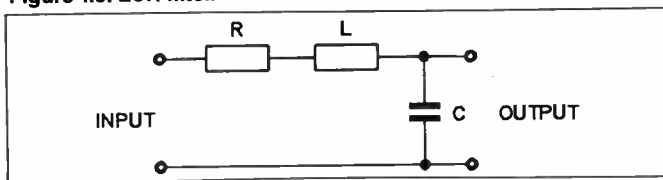

All of the graphs, such as those in Figure 1.1, were produced in this way using a graphics program called SCIPLOT, the only difference being that the frequency scale has been made logarithmic to fit more of the graph into the figure and to show that, on a log scale, frequency responses are usually linear in the stopband. For a logarithmic plot change the following lines in the above piece of programme:

```
102 RATIO=FEND/FSTART : IF RATIO<1 THEN RATIO=1/RATIO
103 RATIO=RATIO*(1/100):F=FSTART
109 FOR I=1 TO 100
150 F=F*RATIO : NEXT I
```

Getting a steeper slope

For many problems involved in removing unwanted frequencies, it would be nice to have a filter with a slope greater than six or even 12 dB per octave, and to have that slope much closer to the cutoff frequency. To try to do this, let's put an inductor into Box 1 and a capacitor into Box 2 of Figure 1.8. While we are about it, we had better give the inductor a resistance as well. The circuit now looks like Figure 1.9. The programme that calculates the attenuation and phase shift for this filter is in Figure 1.10 and the calculated values are in Figure 1.11.

Figure 1.9. LCR filter.



```
10 PRINT "Attenuation & phase shift of LC filter."
20 AS="The attenuation is "BS" dB":CS="The phase shift is "DS" degrees"
30 A1S="The gain is "
40 INPUT "What is the value [ millihenries ] of L ?":L:IF L<=0 THEN 40
50 INPUT "What is the resistance [ Ohms ] of L ?":R:IF R<=0 THEN 50
60 INPUT "What is the value [ microFarads ] of C ?":C:IF C<=0 THEN 60
70 INPUT "What frequency would you like to use ?":F:IF F<=0 THEN 70
90 PI=3.141592654#:LGE=-.434294481#:XC=1000000/(2*PI*F/C):XL=2*PI*F*L/1000
90 A=-20*LGE*LOG(XC/SQR(R#R+(XL-XC)^2)):PHASE=-ATN((XL-XC)/R)*180/PI-90
100 IF A>0 THEN 110 ELSE 120
110 PRINT USING "\ \###.# \":AS,A,BS : GOTO 130
120 PRINT USING "\ \###.# \":A1S,-A,BS
130 PRINT USING "\ \###.# \":CS,PHASE,DS
140 INPUT "Would you like to try another frequency ?":ES
150 IF (ES="Y" OR ES="y")THEN 70
160 END
```

FIGURE 1.10

GWBasic program to calculate the attenuation and phase shift of the LCR filter shown in Figure 1.9. With this type of filter the output can be larger than the input. This makes the attenuation negative, so line 100 provides for displaying the "gain" of the filter.

Lines 20 & 30 set up the expressions for the display.

Lines 40-70 contain traps against hitting wrong keys.

Line 80: LGE converts log to base e to log to base 10.

XC is the reactance of C, XL is the reactance of L

The numerical factors in XC & XL convert mH to H and uF to F.

Line 90: 'A' is the attenuation.

The improvement over the RC filters is considerable. With an inductor having a resistance of 10 kOhms, the attenuation in the first octave after the cutoff frequency (15915 Hz) is already 12.8 dB, and 12 dB or more from there on. This shows the considerable advantage of having inductors in filters. But there is a price to pay. You will have noticed that there is a slight peak (negative values of attenuation represent peaks) at about 12 500 Hz. There are many occasions where this is an advantage, since such a peak can be used to cancel out a dip in the response elsewhere. Unfortunately such peaks can be a problem since the phase changes rapidly in their vicinity. The problem of the peak is made much worse if the inductor has a resistance of only 1k Then the inductor has a Q of 10 so it generates a peak of 20 dB (10x the input voltage) which can lead to ringing and other nasty effects.

FIGURE 1.11

Attenuation & phase shift of the LCR filter of Figure 1.10.

L = 100 mH C = 1nF R = 1k or R = 10k

Frequency (Hz)	RESISTANCE 1k		RESISTANCE 10k	
	Atten (dB)	Phase (deg)	Atten (dB)	Phase (deg)
100	0.0	0.0	0.0	-0.4
500	0.0	-0.2	0.0	-1.8
1000	0.0	-0.4	0.0	-3.6
5000	-0.9	-2.0	-0.4	-19.2
10 000	-4.3	-5.9	-1.2	-46.1
12 500	-8.2	-11.6	-1.2	-64.0
15 000	-16.7	-40.1	-0.5	-83.2
15 915	-20.0	-90.0	0.0	-90.0
17 000	-15.0	-142.8	0.6	-97.5
20 000	-4.5	-167.8	2.8	-114.7
32 000	9.7	-176.2	11.2	-146.5
50 000	19.0	-178.0	19.5	-160.5
100 000	31.7	-179.1	31.8	-170.7

As you can see by comparing Figures 1.4 and 1.11, even though the LCR filter is a low pass filter, its phase shift is entirely different from that of an RC filter. The phase shift starts at zero and falls to -90 degrees at resonance, continuing to -180 degrees well into the stopband. Notice that the phase shift near resonance changes quite rapidly for the low Q (R 10 000 Ohms) inductor, but changes very rapidly indeed for the high Q inductor.

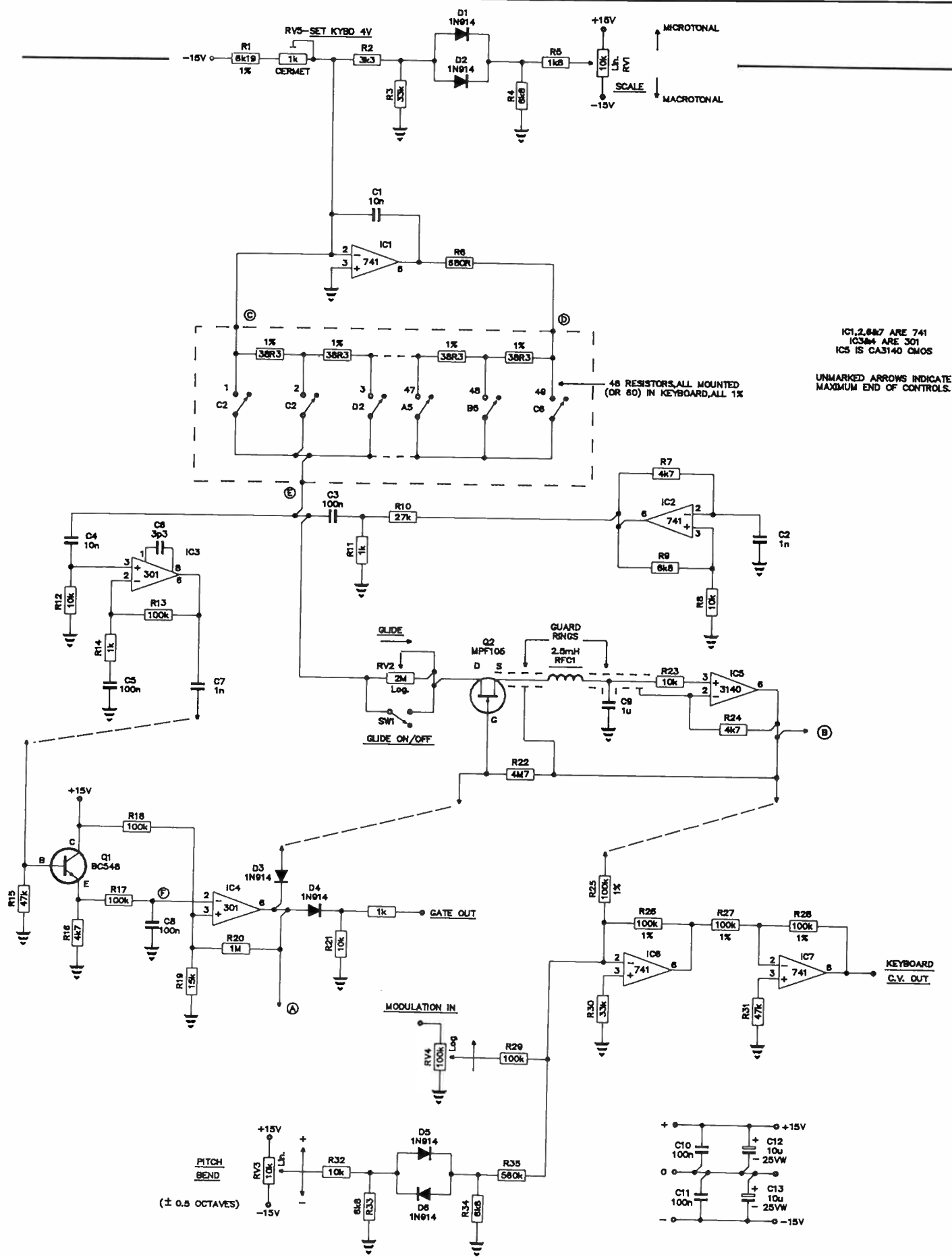
Component properties

The properties of the RCL filter that we have just described depend quite markedly on the resistance of the inductor and on the load that we put on the output terminals. The resistance of the inductor controls its Q. In the same way, the load resistance across the output terminals controls the Q of the capacitor. Q is simply an abbreviation of quality factor, the higher the value of the Q of a component, the less are its losses. The frequency response of many of the filters we will describe later depend to a large degree on the use of high Q components. This is the case even for those filters where the Q must be low, since the calculations of the loading to put on the circuits components to give them their prescribed Q assumes that their natural Q before loading is infinite.

This means that, when constructing passive filters, it is not a good idea to find some old coils in the junk box and press them into service. If you are lucky enough to own a Q meter you can check the coils before using them, but if not, toss them back in the box. The construction of filters requires care if you are to get the result that you planned. If you use good quality components you will have no trouble.

For passive filters, 1% capacitors are needed and the inductors are made tunable so that the circuits can be aligned. For active filters it is best to use 1% resistors and 1% capacitors. This class of component is both accurate and more stable than the normal types. For frequencies below about 10 MHz ordinary printed circuit boards can be used, but if you are using complicated filters with high Qs, or higher frequencies it is best to use fibreglass board. Then the board will not introduce any unexpected losses. ♣

Note: GWBasic is the latest implementation of interpreter BASIC produced by Microsoft Inc. for microcomputers.



An experimenter's modular music synthesiser

Part 5 — keyboard controller John East

Here's where you get to play it! Here is described a 49-note keyboard controller, readily extendable to 61 notes. It's a simple monophonic design, in keeping with the analogue approach.

AS PROMISED in Part 4, here is a design for a keyboard controller, the facilities of which are those that have become standard for synthesizer keyboards. These facilities have evolved more by convention than by any determined effort on the part of designers to achieve the best possible monophonic controller. For instance, there is no depth or velocity sensor, although it would greatly increase the playability of the synthesizer as a musical instrument. Those who are keen on the idea could do worse than try the Veloci-Touch Controller kit, made by PAiA Electronics, Inc: no sense in re-inventing the wheel, so to speak.

Also included in this article are designs for a control voltage processor and voltage controlled low frequency oscillator, so the emphasis is heavily on control. The use of these modules will result in an instrument much more at home with "conventional" music styles.

Design

Historically, the keyboard was designed to allow easy access to a large number of pitches, as in the pipe organ for instance. It is very obviously a controller for a polyphonic instrument, in which the amount of control over any particular pitch is small, but the number of pitches available is great. About the best you can hope for is an easily used single control parameter, such as loudness, to also be obtainable on every key. A good example is the piano. A pianist has his hands full, just to make best use of the piano's velocity sensitivity!

Contrast this with the violin, where the nature of the instrument allows a very great degree of control over a single pitch, giving the means (if not the ability!) to a musician for producing very expressive music. Note that the violin is basically a monophonic instrument, it's four strings are used principally to extend the pitch range of the instrument, not for playing polyphonically. To produce real-time music of more than one musical line simultaneously, requires the efforts of more than one musician, each with an expressive, monophonic instrument. Thus was born the symphony orchestra.

Now we can begin to see what has happened to the original concept of the synthesizer. As a monophonic instrument, it was equipped with a basically polyphonic controller, the keyboard. This keyboard was adapted by left-hand controls such as pitch-benders to function as a monophonic controller. With the addition of other sensitivities such as the previously mentioned depth and velocity sensors, it can be a very practical monophonic controller, as long as it's now basically monophonic nature is not forgotten. There is also the additional advantage that musicians are familiar with it. However,

due most probably to the above historical associations, the keyboard is still viewed as a polyphonic controller, and thus people have naturally wanted a polyphonic synthesizer.

Generally, satisfying this demand in the marketplace has meant equipping a keyboard with at least four voices which are electronically simple (and thus produce acoustically simple sounds, which our ears find boring), and separate control over which is limited to that obtainable on any polyphonic keyboard instrument. So what we end up with is just another polyphonic keyboard, with virtually all the advantages of having gone electronic in the first place, lost completely!

Because of its acceptance by musicians, probably the best we can now do is to use the keyboard, but to treat it strictly as a monophonic controller, and simply suffer some of the conventions that must therefore arise. "Lowest note" priority is one that arose due to the necessity of sorting out which note should sound if more than one key is pressed. This was decided on because it is the simplest to provide if analogue circuitry is used.

A digital design could allow for "last note" priority, but at the expense of greatly increased complexity and cost. With musicians now familiar with lowest note priority, and in conjunction with the above factors, it has been decided to use the relatively simple analogue approach; it seems a waste of time to design a technically perfect digital circuit for a controller which is not ergonomically anywhere near perfect. I feel that more effort should be expended in the design of other types of instrument-musician interfaces, such as breath controllers.

All right, let's have a look at the circuit details.

Keyboard controller

A resistive divider chain consisting of 48 (or 60) 38.3 ohm 1% resistors, is driven by the constant current generator IC1, R1 and RV5. As point C is held at 0 volts irrespective of how much resistor chain is shorted out, a voltage corresponding to the lowest note held is obtained at point E when more than one key is held down simultaneously. Components RV1, R2-R5, D1 and D2 allow the voltage across the keyboard to be varied from the calibrated value, resulting in microtonal or macrotonal scales when the keyboard is used to control a VCO.

IC2 and associated components produce a supersonic "gate detector" signal which is attenuated by R10 and R11, and applied to the keyboard buss via C3. This signal is shorted to earth via the low impedance of the keyboard resistor chain, when a key is pressed. IC3 and associated components form

an ac amplifier to boost the level of the detector signal, and it is rectified and buffered by the unbiased emitter follower Q1, R15 and R16. This rectified signal is lowpass filtered by R17 and C8 to give a dc level of +4.5 V to +0.3 V at point F, key up and key down respectively. (Voltages are as measured on the prototype only.) Applied to inverting comparator IC4, a gate signal is obtained via D4 that goes high for the key down condition, and is 0 V for all keys up.

The gate is also used to turn FET Q2 on, allowing sample and hold capacitor C9 to charge to the voltage at point E in a time principally determined by the setting of RV2, the glide control. RFC1 and C9 also form a lowpass filter to remove the supersonic detector signal from the key control voltage. Because of the lack of low resistance paths to earth, the dc voltage is held on C9 and buffered by voltage follower IC5 after the key is released. Due to the restoration of the supersonic detector signal path however, comparator IC4 turns off Q2 after about 10 ms ($R17 \times C6$), removing any possibility for leakage of charge off C9.

IC6, IC7 and R25-R31 form a non-inverting mixer to sum the keyboard control voltage and externally applied modulation voltages. A pitch-bending voltage is also derived from a pitch-bend control pot and summed into the mixer. D5, D6 and associated resistors form a dead-band circuit as with the Scale control, to avoid unwanted error voltages at "centre", and also for easy location of "centre".

Retrigger and joystick

Changes in the keyboard control voltage due to overlapping key presses (which do not allow the gate to go low), are differentiated by C1 and R1 into short (approximately 5 ms) spikes. Comparators IC1/d and IC1/c go negative for the duration of these spikes, according to whether the spikes are +ve or -ve respectively. These short negative pulses are coupled through D1 or D2 and SW2 to force the gate voltage low for the duration of these spikes, allowing the envelope generators to retrigger.

IC1/a and IC1/b are simple inverting amplifiers to scale the ± 15 volt input of the joystick controller to ± 5 V at the X and Y outputs. C2 and C3 form simple lowpass filters to smooth any noise from scratchy pots.

Voltage processor

IC1 is an inverting summer with a maximum gain of -2 from the x2 CV Input to the output. An adjustable offset of up to 10 V with selectable polarity is also summed in from RV1 and SW1, via R1. IC2 is configured such that with the wiper of RV3 at top, the circuit functions as a voltage follower with a gain of +1; when the wiper is at bottom, IC2 is an inverter with a gain of -1. Thus a gain function is available which is continuously variable from +1 through zero, to -1. This is also summed into IC1 via R5, at a gain of -1.

Voltage controlled LF oscillator

A current controlled integrator consisting of IC2/c, C1 and reset switch circuitry comprise the heart of the LFO. Control voltages are summed and scaled by IC2/b and associated resistors and converted to an exponentially related drive current by Q1 and Q2 to drive the integrator. As the output voltage of the integrator ramps up, it eventually exceeds the voltage threshold set by R9 and R10 at pin 2 of IC1, which is a monostable with a period of approximately 0.5 ms.

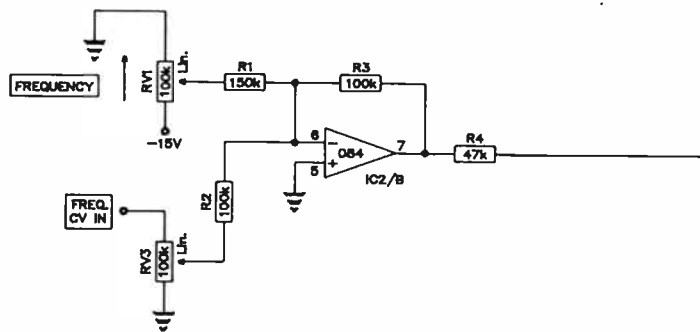
When pin 6 of IC1 goes high, D2 is forward biased, D1 is

reverse-biased, allowing R7 to pull up pins 13 and 5 of the CMOS switches IC4/a and IC4/b which are then turned hard on, and C1 is completely discharged during this 0.5 ms period. IC1 then returns to its idle state and the integrator ramps up from 0 volts again, and so on. Q3 allows reset "syncing" of the LFO by converting a positive-going transition at the Reset Sync input to a negative-going spike on pin 2 of monostable IC1, taking the threshold to -0.5 V, the forward voltage drop of D3. As this will always be less than any voltage at the integrator output, IC1 must go into reset mode, thus the sawtooth output is returned to 0 V.

IC2/d is a Schmitt trigger comparing the sawtooth with a control voltage summed by IC2/a and associated resistors, allowing voltage control of the duty cycle of the resulting pulse waveform at the output of IC2/d. D5, R21, R22 and CMOS switch IC4/c drive LED D6 to give a visual indication of LFO frequency and duty cycle.

Transistor Q4 forms a sawtooth-to-triangle shaper. Emitter follower Q4 is reverse-biased by RV6 and R25-R27 for the lower part of the sawtooth cycle, and conducts for the remainder, so a waveform like the first in Figure 3 appears on pin 3 of IC3. Meanwhile, the normal sawtooth is applied to pin 2, with a dc offset provided by RV7 and R28; IC3 is a differential amplifier and outputs the difference between the two waveforms, which is a triangle balanced about 0 V. (See Figure 3). Capacitor C4 decreases the slew rate of IC3 to smooth the "glitch" in the triangle peak at the reset point of the sawtooth. ►

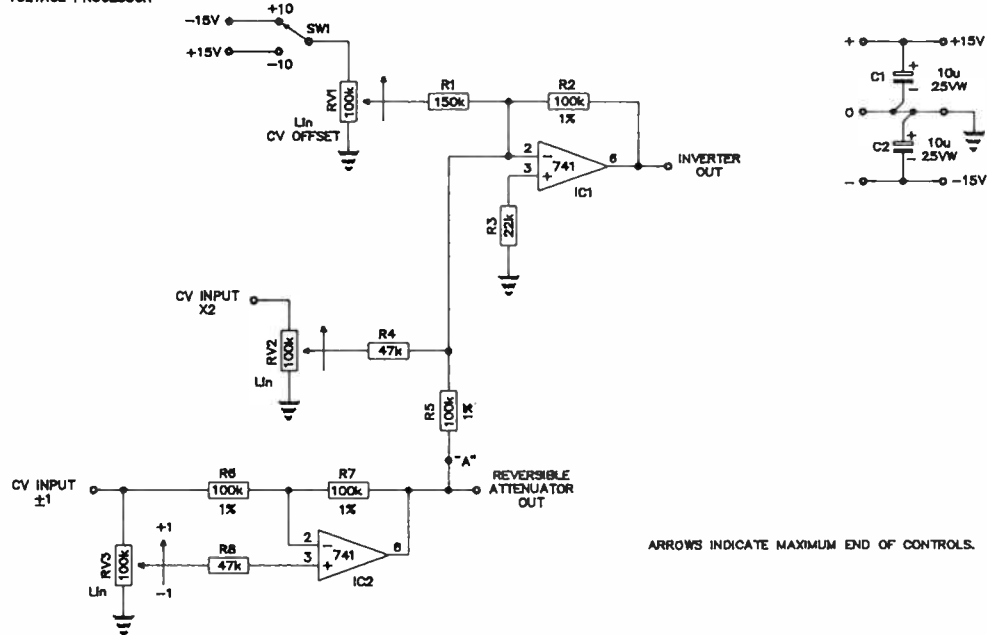
VOLTAGE CONTROLLED LOW FREQUENCY OSCILLATOR



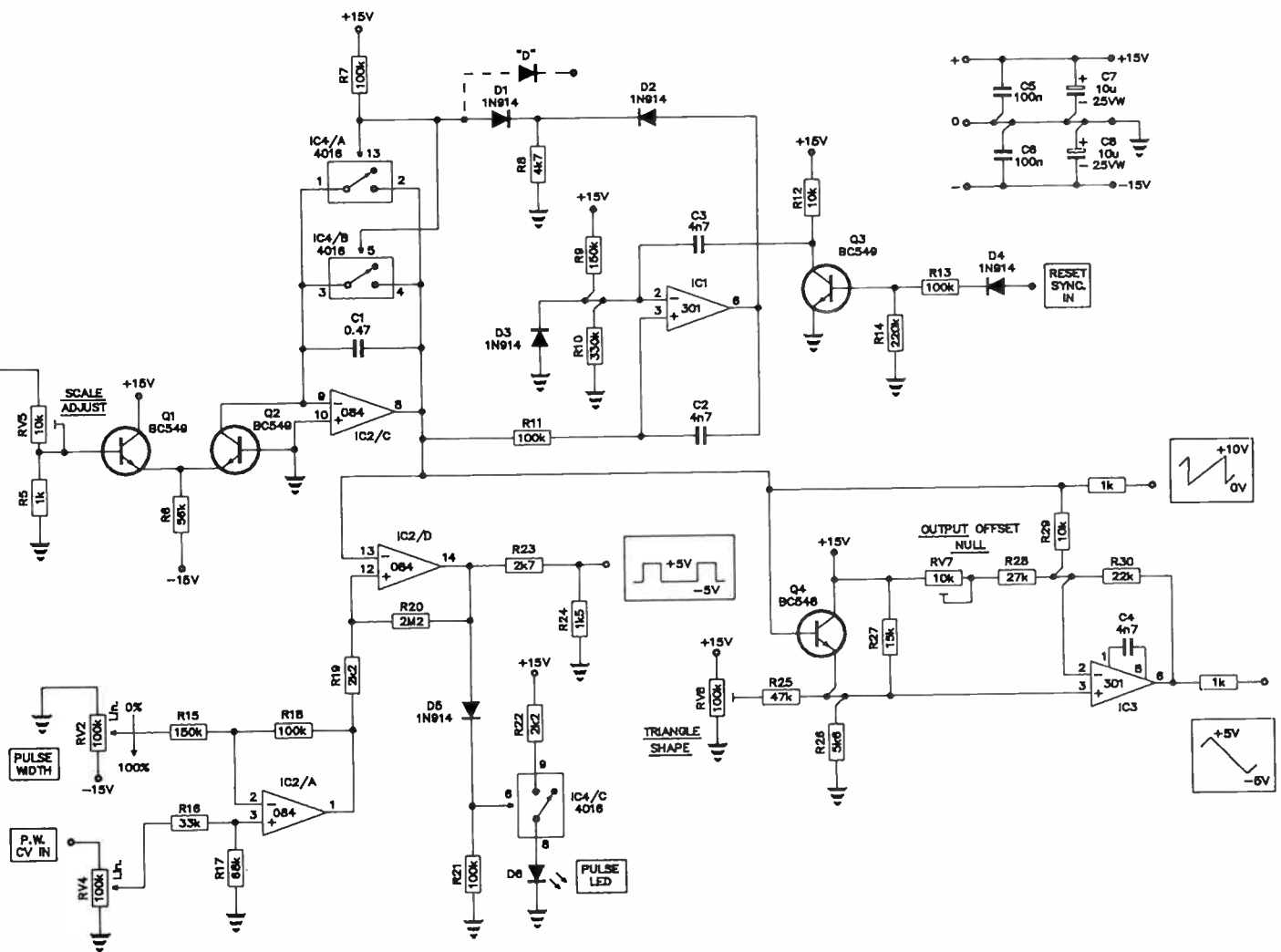
IC1 & IC2 ARE 301
IC2 IS TL084
IC4 IS 4018 CMOS

ARROWS INDICATE MAXIMUM
END OF CONTROLS.

VOLTAGE PROCESSOR



ARROWS INDICATE MAXIMUM END OF CONTROLS.



Hardware details

Now we get down to the actual componentry. Although the circuit shown uses 48 resistors in the keyboard chain to allow for a 49 note keyboard, 61 note keyboards can be used by simply increasing the number of resistors to 60. The constant current source IC1, assures the required 5 volts across the resistor chain. Note also that if 38R3 1% resistors are unobtainable in the required quantity, the nearest value above or below can be used, but R1 might need to be varied. The setting up procedure later on assumes C-C keyboards, if you have another type, bear it in mind when tuning up.

Some keyboard designs use a double contact scheme for separate control voltage and gate switching. This was avoided as unduly complicated, to say nothing of the difficulty of obtaining the necessary contacts. Simple "make" contacts will suffice for this design, so long as they are kept clean. Dirty contacts will play havoc with the retrigger facility. R17 and C8 provide a degree of debouncing to ensure clean gate pulses, but there is no substitute for cleanliness in a fairly simple circuit such as we are using. More about retriggering later.

A supersonic "gate detector" system simplifies the contact requirements and also eliminates contact timing problems. IC2 is the high frequency oscillator whose slew rate limits the normally square output waveform to a triangle, which simplifies the filtering requirements. RFC1 and C9 form the lowpass filter to remove the detector signal, C9 doing double-duty as the sample and hold capacitor. Note that "guard rings" should be employed around IC5, connected to the output of voltage follower IC5. These "bootstrap" the leakage resistance of any board, socket etc, extending the time that the sample and hold will accurately store the keyboard control voltage. IC6 and IC7 not only perform the keyboard, modulation and pitch-bend control voltage summation, but also buffer IC5. If too much output current were drawn from IC5 the chip could heat up, and as mosfet inputs are notorious for their rapid increases of input current for even small increases in chip temperature, we keep this to a minimum by loading IC5 and R25 only.

The Scale control allows equal-tempered scales of other than 12 tones per octave to be set up, by varying the voltage across the keyboard from 0 V to about 8 V, in lieu of the normal 4 V. This will result in microtonal and macrotonal scales, from an infinite number of tones/octave (at 0 V), to 6 tones/octave (at 8 V), respectively. Dead band circuits on this and also the pitch-bend control, allow reasonable ease in finding centre. However, it would be well worth chasing pots with a mechanical centre detent, they are much easier to use, especially when performing on the keyboard. These pots usually have an electrical centre tap also, this should be connected to 0 V. If it is found to be unsuitable, the range of the pitch-bend pot can be increased or decreased by decreasing or increasing the value of R35.

Resistors R1, and R25-R28 and the 48 (or 60) keyboard resistors are metal film for stability, all others can be 5% carbon film. RV5 is the only preset; a 15 turn cermet. Capacitors C1-C5, C7, C8, C10 and C11 can be greencaps, C6 ceramic, C12 and C13 electros. C9 is the sample and hold capacitor and must be a good quality plastic variety for minimum leakage. Q2 is an MPF105, but MPF102 or equivalent should be okay as they are functioning only as switches. IC5 is a CMOS input type, used for it's extremely low input bias current. Note that the control voltage output has no 1k series resistor, as this would upset the accuracy of keyboard to VCO patches.

When playing the keyboard using a "horn" type envelope (full sustain, with the decay thus ineffective), it is perfectly possible to play legato i.e: overlap notes, so that new pitches are produced without a new gate rise being produced; the gate simply remains high, the low note priority ensures accurate semitones are produced. This is desirable as it allows slurred notes to be played, as is possible on most monophonic acoustic instruments. Slurs are not generally desirable however, on percussive-type envelopes (short attack and decay times, and minimal values of sustain), as their effect is virtually lost in the low volume portion of the decay. These types of envelopes should be played on the keyboard so a new gate begins with every key press. This is not always easy, and results in "missed" notes.

The ideal solution would probably be to have a keyboard with some sort of mechanical interlock mechanism that would prevent more than one key at a time being pressed. This facility would only be enabled for playing percussive voices. Note that it would, by it's very nature, provide a "last note pressed" priority as previously mentioned in relation to digital circuit implementations. In practice however, such a keyboard would be a mechanical monstrosity, so we use an electronic substitute.

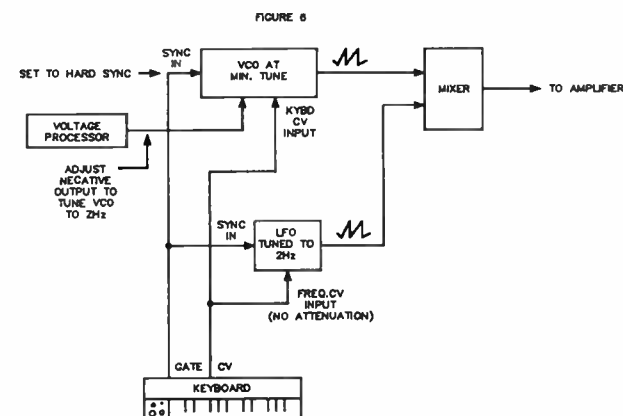
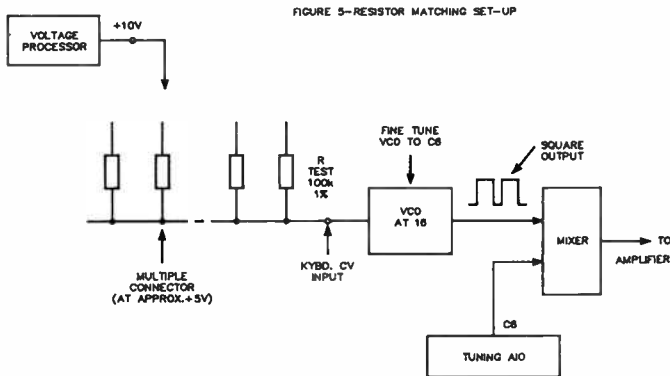
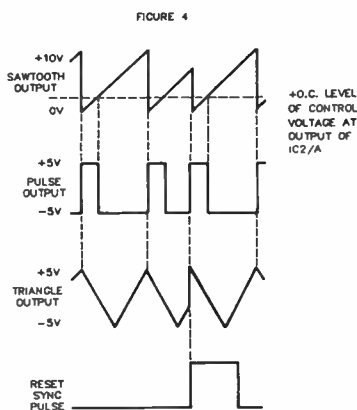
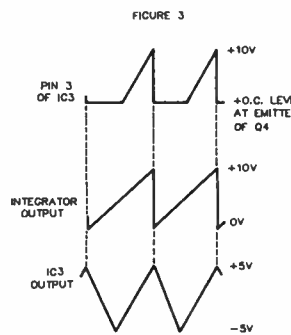
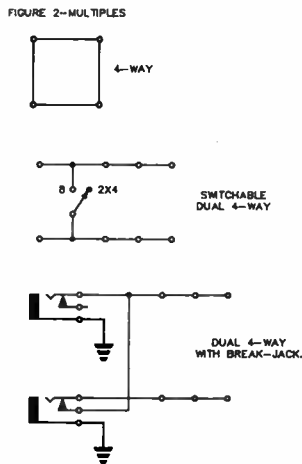
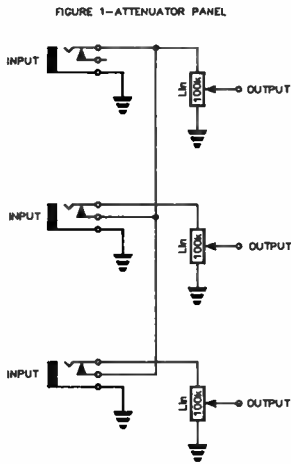
Basically, we need a circuit which "restarts" the gate whenever the keyboard control voltage changes value but the gate remains high; that is, when key depressions are overlapped. As this removes the slur, we also must be able to switch off the facility, and regard its use as optional if difficulty is experienced when playing percussive sounds. For this reason it was regarded as an optional extra over and above the basic keyboard facilities, and combined therefore with the joystick circuits on a "daughter board".

Note also that because the retrigger circuit differentiates the control voltage changes, it will restart the gate whenever it receives a control voltage change, as from noisy or dirty key contacts. It has been found that contact cleanliness is very important to the correct operation of this type of circuit. As the control voltage transitions must also be fairly fast, the retrigger ceases to function if the setting of the glide control is too great; this is not much of a problem as percussive tones don't work very well with slow, gliding pitch changes.

The two-axis joystick circuit is designed to give ± 5 V at the extremes of travel of the control, so the joystick must be of the type that outputs ± 15 V. If it's output is less than this, you will have to vary resistor "R" to accommodate it. "R" (in kilohms) = $10 \times V_{in}$, where V_{in} is the total range of the "In X" or "In Y" joystick voltage. ($V_{in} = 30$ V in the prototype). This type of joystick is readily available however, you may only have to fiddle "R" if "rolling your own". This may be necessary however, if you want to incorporate a third axis of control. The author once made up a joystick for use in a vocal simulator, where the X and Y axes controlled the formant filter centre frequencies, and the twist axis of the joystick shaft controlled the voice pitch. Difficult to learn to use, but lots of control in one hand. Thus the "Law of Perversity of Musical Controllers" rears it's ugly head i.e: the degree of control is inversely proportional to the ease of use!

No critical components are used here; 5% carbon film resistors and plastic capacitors, except for electrolytics C4 and C5, will be quite alright.

The Voltage Processor is designed to allow a range of summing, inverting, offsetting and attenuating operations on input voltages. As it was principally intended for use with control voltages, no output 1k resistors are used, and it is desirable that R1 and R2 are matched, and also R6 and R7. This will enable for instance, the keyboard control voltage



to be accurately inverted. The following general operations can be carried out.

An input voltage can be amplified and inverted to a gain of two, attenuated to zero, and offset up to ± 10 V. The resulting signal can also be mixed with another input which can have a gain from -1 to +1. Thus, a non-inverted signal could be offset by plugging into the ± 1 input, setting RV3 to -1, and using RV1 to offset the output at the Inverter Out. If it is desired to occasionally use the reversible attenuator totally separate from the inverter, a break jack could be installed at "A" to allow this, but don't forget to make the front panel space available. Other uses for the processor will become obvious as the necessity arises.

Incidentally, the ring modulator in Part 3 can be used as a voltage controlled reversible attenuator in the dc coupled mode. A control voltage changing from -5 to +5 at either input will cause the gain from the other input to the output, to change from -1 to +1.

The only critical components here are R1, R2, R6 and R7. The matching procedure for these resistors will be described in the Setting Up section.

The Low Frequency Oscillator (LFO) has a range optimized for control and modulation applications, which will be approximately 0.025 Hz to 25 Hz using the frequency control and even lower by the use of negative control voltages. The use of the Reset Sync input enables modulation to begin at a fixed point of the waveform cycle (see Figure 4), and the pulse LED allows easier setting of particular pulse widths or frequencies for control purposes. The pulse width can also be set by an external control voltage, which can be useful for constructing "sound events" where different control voltage paths are made to interact and control one another. These facilities should enable the LFO to be used for applications which previously required a VCO, allowing the VCO to be used as a pitch source.

For modulation purposes the sawtooth, pulse and triangle waveshapes can be roughly described as producing sweeps, trills and vibrato respectively. The effects can range from the sublime to the ridiculous, the exact result depends greatly on the modulation frequency and depth employed. The phase relationships of the output waveforms and their voltage limits are shown in Figure 4, note that the triangle is of opposite phase to that shown for the VCO in Part 1.

There is nothing sacred about either phasing, they arise due to the two different circuit implementations. The sawtooth voltage limits are also different, due also to the different circuit topology. It was considered trivial to provide waveforms identical in every respect to the VCO, as any offset or waveform inversion can be had by use of the voltage processor.

For those interested, a different kind of synchronisation known as "gating" can be implemented by applying a logical "1" (+15 V) or "0" (0 V), to the cathode end of the dotted diode "D"; this turns the LFO on or off respectively. When such an input is controlled by a flip-flop, it is possible to start or stop the LFO with successive or separate pulses, depending on the flip-flop used. This type of oscillator is generally employed as the clock in analogue sequencers.

Ordinary 5% carbon film resistors will be okay for the LFO, including the frequency control voltage and scaling resistors. RV5-RV7 are large carbon presets. Capacitors C1-C6 are greencaps, C7 and C8 electrolytics. Transistors Q1 and Q2 need not be matched, but glue them together for best thermal compensation. Q3 is a BC549 or equivalent, so that it saturates properly with +5 V levels at the Sync input, allowing reset by standard oscillator waveforms.

practicalities

Referring to Figure 1, you may wish to make up one or more attenuator panels as shown, especially if your modules are short on control input attenuators due to lack of panel space. Note the multiple break jack wiring to save unnecessary use of external multiples. Any number of attenuator pots could of course be used, three or four is a handy number. Multiples are shown in Figure 2, and a few of these scattered around wherever they will fit are essential if you are not using stackable banana plugs. Note the various configurations, especially the break jack method. Multiples can consist of any number of jacks, and the individual may well have his own variations in mind for attenuators and multiples; as the construction of them is quite simple, they will not be mentioned again in the following section.

Construction hints

Standard modular synthesizer practice is to build the keyboard into a separate case, and to interconnect this and the synthesizer main console with a multi-wire cable. This is the most flexible approach, and allows the keyboard to be supported at the optimum height for playing, while the console can be placed elsewhere at the most convenient location in the studio. The prototype keyboard case was constructed from particle board and covered with vinyl, with wood veneered ends and a plastic panel to the left of the keys for the controls. Leave plenty of room inside for the keyboard circuitry and also for the retrigger and joystick circuitry, if used; making the left-hand control panel fairly long will take care of this.

Reliable multi-way connectors for the keyboard to console cable are a must. The prototype used a 9-way Cannon plug on each end of the cable, with 9-way sockets on the console module panel and the back of the keyboard case; the in and out connections are detailed with the circuit diagram. A 15-way Cannon might be better if you require extra facilities such as velocity and depth outputs. The cable itself should have multi-strand wires for maximum flexibility. Note that unused pins are all carrying the earth connection, the lower the earth resistance the better, as unwanted voltage drops on the earth wires could result in keyboard control voltage errors. Another good reason to use 15-way connectors, although no problems were experienced with the 9-way prototype.

It is recommended the voltage processor panel be part of the console panel containing the keyboard input and outputs, as the ± 15 V supplies required for the keyboard can be obtained from the processor. Alternatively, this could be the LFO. Don't forget earth straps.

As the keyboard has both a console panel containing input and output sockets, and a left-hand control panel on the keyboard itself, these are listed separately below.

KEYBOARD CONSOLE FRONT PANEL

Sockets

Keyboard CV Output
Gate Output
Modulation Input
9- or 15-pin Cannon for Keyboard Cable
X Output) — Optional — only used
Y Output) — if joystick fitted.

Note that the keyboard control voltage and gate outputs should be provided with multiple sockets; four or five each is not too many if you are not hard-wiring them to the VCOs and VCEs respectively, as detailed in Parts 1 and 4.

LEFT-HAND KEYBOARD CONTROL PANEL

KNOBS

Scale
Glide
Pitch Bend
Modulation
Joystick — Optional

SWITCHES

Glide On/Off
(SW1)
Retrigger On/Off — Optional
(SW2)

VOLTAGE PROCESSOR

KNOBS

Control Voltage Offset
x2 Input Attenuator
 ± 1 Attenuator

SOCKETS

x2 CV Input
 ± 1 CV Input
Reversible Attenuator
Output
Inverter Output

SWITCHES

± 10 volt Selector
(SW1)

VCLFO

KNOBS

Frequency
Pulse Width
Frequency CV Input Attenuator
Pulse Width CV Input Attenuator

SOCKETS

Sync Input
Frequency CV Input
Pulse Width CV Input
Sawtooth Output
Pulse Output
Triangle Output

LED Pulse

Setting up

After switching on the keyboard, check that the control voltage output changes from 0 V on the bottom key to several volts positive on the top key. If not, check the voltage at point "F" (the input of comparator IC4), with a 100k/volt meter. It should be more positive than the comparator threshold (about + 2 V) with all keys up, and close to 0 V with a key down. If the "key up" voltage does not exceed about + 2 V, simply reduce R19 until the comparator threshold voltage lies comfortably between the two voltage extremes. ($V_{\text{threshold}} = \frac{R19 \times 15}{R19 + R18}$ volt)

$$R19 + R18$$

Check also the voltage stability of the sample and hold by patching the keyboard control voltage to a VCO, and checking for pitch drift after key release. Changing and uncertain pitch as keys are released is caused by dirty contacts or the previously discussed comparator threshold being too close to the voltage extremes at point "F".

Now we can calibrate the keyboard and VCOs. This is a rather tedious procedure, and requires a musical ear and a deal of patience. Done with care, it will prevent endless tuning problems when the system is in use. A C-C, 49 or 61 note (four or five octave) keyboard is assumed.

Bottom C should be within a few millivolts of 0 V, top C can be adjusted to + 4 V with RV5. (+ 5 V for a five octave keyboard with 60 resistors.) Before adjusting RV5, be certain the Scale and Pitch Bend controls are set for 0 V on their wipers and the Glide is switched out. All measurements must be at the actual keyboard control voltage output, any mismatches in resistors R25-R28 are then irrelevant. It is not necessary that RV5 be set for exactly 4 volts (or 5 volts) at the output with an expensive digital voltmeter; as near as possible with an analogue multimeter is sufficient if the synthesiser is not to be interfaced with commercial modules. It is more important that it be stable after calibration.

To save having to refer to Part 1, here is the entire VCO tuning procedure from go to whoa. Firstly however, it is a good idea to allow the VCOs and power supply to "warm up" for about 10 or 15 minutes before starting. Allow the Tuning Aid to warm up also, then set it accurately against an organ, tuning fork, or whatever is your tuning standard. Set presets RV6 and RV7 in the VCO to be calibrated, to mid-point; RV8 must be adjusted so it's wiper is at 0 volts for now. Listen to the Pulse output and set the Pulse Width pot RV3 for a square wave, easily distinguished by its characteristic "hollow" sound. Use this waveshape for tuning up, as it is identical to that produced by the Tuning Aid. Set the Fine Tune to centre, or 0 V on the wiper, and switch the Octave Selector to 8'.

Now label the "C" keys of the keyboard, starting with the bottom key as C2, on up to C6 for the top key. (C7 need not be labelled on five octave keyboards, as the tuning procedure is the same, and C7 is not involved). Adjust Idle Frequency preset RV6 to the same pitch as the C2 output of the Tuning Aid, while pressing the C2 key. Now press key C3, and adjust Scale preset RV7 for the same pitch as the C3 Tuning output. Go back to key C2, and re-adjust RV6 to the C2 pitch. Keep doing this with RV6 and RV7 until this octave is right. Press key C4 now, and tune against the C4 standard with RV7; then go back to key C2, adjusting RV6 to give the same pitch as the C2 standard.

Repeat this procedure with the C4 and C2 keys, as for the previous C3 and C2 procedure, until these two octaves are right. Lastly, do this procedure with C5 and C2 also. This ensures that the error resulting from gain changes in the precision multiplier on IC1 is negligible over the keyboard range.

The High Frequency Tracking preset adjustment can be done now. Set the Octave Selector to 1', and adjust the Fine Tune to make key C5 produce the same pitch as C8 from the Tuning Aid. Press key C6 and the VCO should be flat compared to the C9 standard. Adjust RV8 to bring the VCO pitch up to C9. Press key C5 again and fine tune VCO to C8, then key C6 and adjust RV8 to C9. Keep this up until this octave is spot on. This corrects for bulk resistance effects in the exponential converter and also comparator switching delays, both of which only become significant at high frequencies. This completes the VCO tuning.

There is no setting up for the retrigger/joystick facility, other than the possible need to vary "R" for different joysticks. This has already been detailed in the previous section, and so need not be repeated here.

If it is required of the voltage processor that it be capable of very accurate gains of -1, either in the inverter or reversible attenuator sections, then R2 and R5 and also R6 and R7 will have to be accurately matched. This may be necessary for instance, if the keyboard voltage is to be inverted but still give an accurate 1 V/octave from VCOs. It would probably be unnecessary for most other applications however.

If you require matched resistors, use a selection of 1% metal films and set them up as in Figure 5. The aim is to match them to 0.1% or better. The voltage processor must first be built up, as it produces the +10 volts for testing; 5% carbon film will suffice for R2, R5, R6 and R7, you can solder in the matched resistors later. The idea is to use an accurately calibrated VCO as the test instrument, rather than having to beg, borrow or buy a very expensive digital ohmmeter. This is possible because the ear is very sensitive to pitch changes, especially when it has a fixed reference to compare with, and can discern a beat rate. Credit for this technique must go to an article by Carl Fravel in *Electronotes* No. 63, which also

contains the mathematical treatment that need not be repeated here. Suffice to say that if the test frequency is 577 Hz, then a beat rate of less than or equal to 1 Hz will result in resistors matched to 0.1% or better. We will use a test frequency of about 1kHz, so results should be well on the safe side of 0.1% matching. Note that the important thing is the degree of matching, not the actual resistance value itself; 5% carbon film resistors could be matched using this technique, but long-term and temperature stability would suffer, as well as the initial matching being more difficult due to the wider tolerance spread.


Connecting the +10 V on the flying lead to a test resistor will result in +5 V on the VCO control input, due to the 100K input impedance. With the VCO switched to the 16' octave, this will bring the VCO pitch to around C6. Use the Fine Tune to zero beat against the Tuning Aid. Now move the flying test lead around to other resistors. A beat rate of 1 Hz or less, indicates a match of better than 0.1% between the resistor currently under test and the resistor initially used for the zero beat. With a little practise, it is possible to line up the resistors in order of increasing resistance.

Note that if you fine tune the VCO up to zero beat, it indicates the current test resistor has a higher value than the initial test resistor, and vice versa for tuning down. It is rather a fiddly procedure, but is well worth doing for your entire stock of 100K 1% resistors, in case of future need of closely matched resistors.

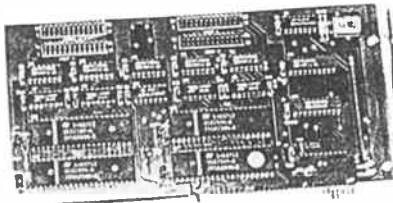
To set up the LFO, we use the "audible oscilloscope" technique again, as in Parts 1 and 4. Patch the LFO triangle waveshape into the control input of a VCO, and listen to the VCO output. Set the LFO Frequency control to give a period of several seconds, and adjust the VCO pitch and control input attenuator so the "bump" on the positive peak of the LFO triangle is clearly audible. This will take some close listening and a deal of "fiddling". Adjust RV6 to minimize the bump. Now increase the LFO frequency to maximum, and measure the dc offset of the triangle output. This is minimised with RV7. Go back to the beginning and repeat both these adjustments until correct, as they interact.

RV5 need only be adjusted if it is important for the LFO frequency scale to be an accurate 1 V/octave; setting it to mid-point is near enough for most applications. The procedure is as follows for those who need it. Set up the patch in Figure 6. The VCO and LFO should "tick" at about 2 Hz when key C2 (bottom key) is pressed; adjust the negative voltage from the voltage processor to get the VCO down to this frequency. The gate "syncs" the oscillators so they tick together initially, the rate at which they drift apart being indicative of the tuning error. Press key C3 repeatedly, and tune the LFO until it ticks at the same rate as the VCO, and stays "in time" reasonably well. This takes some practise and is not easy to do initially, so be patient. When this is right, press key C2 and adjust RV5 for the same result, at half the "tick" rate. Now back to C3, re-adjusting the LFO tuning, and then C2 again to re-adjust RV5.

Repeat this until the "octave" is okay, then try it all again with keys C4 or C5 and C2. It is asking a lot of the exponential generator in the LFO to get it as accurate as the VCO, so it is not much use trying for more than about three octaves tracking. It is difficult to think of an application where accuracy in the LFO is this important, so ignoring the adjustment of RV5 altogether would not matter much.

The next and final part of this series will describe a "universal" filter to round out the timbral facilities of the system, meanwhile you can try playing a tune on the beast! 

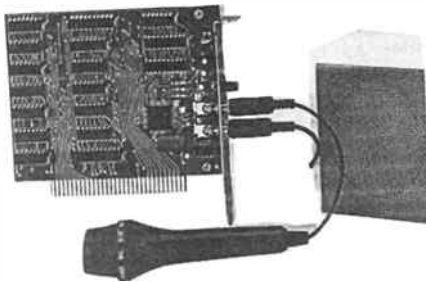
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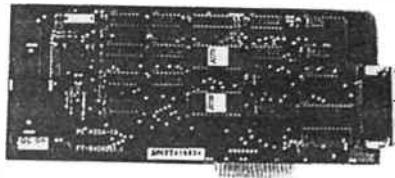


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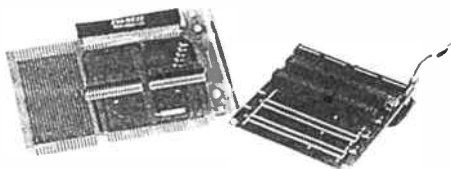


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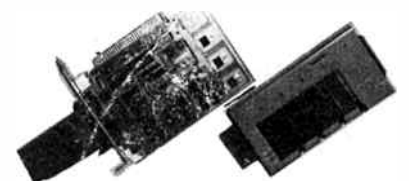


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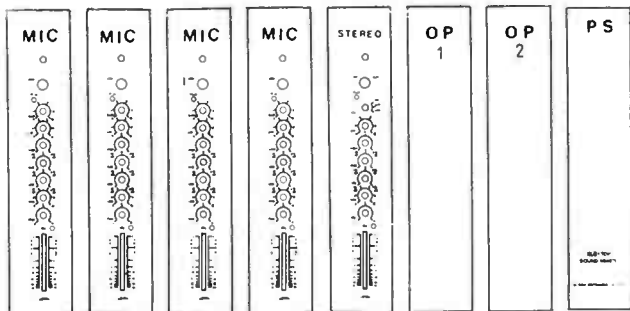
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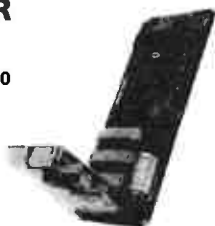
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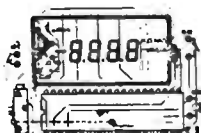
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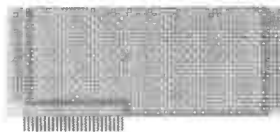
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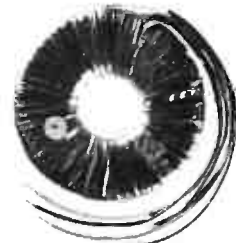


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


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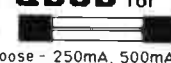


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


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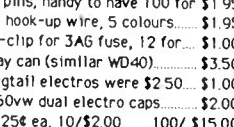
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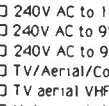
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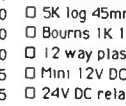
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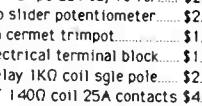
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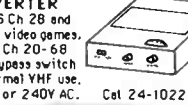
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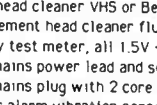
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CONTENTS

PROJECTS

Battery-backed RAM Module for the C64
..... 35

Build a Horn Loaded Loudspeaker
..... 38

Active Crossover
..... 45

ARTICLES

Horn Loading Revisited
..... 35

Two-Tone RF Test Oscillator 49

Corrections
..... 49



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.

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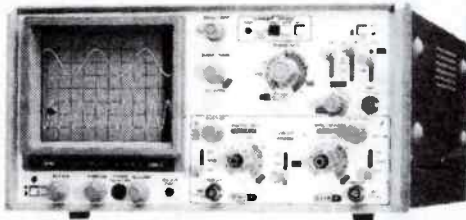
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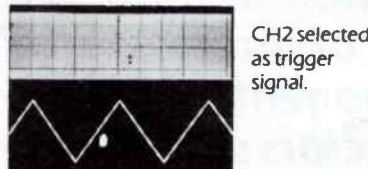
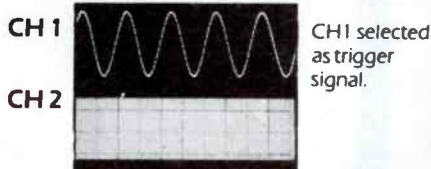
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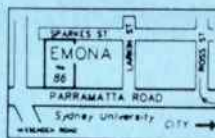


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16 KBYTE CMOS RAM FOR C64

by P Verhoosel

A non-volatile block of RAM or pseudo-ROM for plugging into the Commodore 64's expansion slot.

The expansion port at the rear of the Commodore 64 micro-computer is a 44-pin (22+22) female edge connector. The expansion slot—also referred to as bus, cartridge or module port—enables plugging in extension modules that require direct access to the address bus, data bus, and a number of control lines, of the Type 6510 CPU and its support chips inside the computer. Because of this direct connection, due care should be taken not to damage the system by inappropriate connections, overloads, or short-circuits. The signal functions and pin assignment of the expansion port are shown in Table 1 and Fig. 1 respectively. Viewed from the computer's keyboard, and counting from the left to the right, pins 1-22 inclusive form the upper row, and pins A-Z inclusive the lower row. Notice that letters G, I, O and Q are not used. Connections GAME and EXROM make it possible to gain external control over the C64's memory configuration, and have special significance for the present memory module.

The system configuration

At the heart of the C64's memory decoding circuitry is integrated circuit U₁₇, a Programmable Logic Controller (PLA), manufactured specifi-

cally for the C64. A total of 16 lines are fed into this IC, including GAME and EXROM, giving $2^{16}=65,536$ (64 K) possible combinations. The 8 output lines of the PLA connect to internal devices including the BASIC ROM, the SYSTEM ROM, the character generator, CIA1, CIA2, and the RAM. The PLA's input/output ratio, 256:1, already indicates that a number of input combinations are necessarily duplicate and/or illegal to give a useful configuration of the C64's memory map, which is shown schematically in Fig. 2. The decimal and hexadecimal address notations are given to the left and the right of the 4 Kbyte memory blocks, respectively. When the C64 powers up with the original operation system, the following PLA inputs are driven logic high: LORAM, HIRAM, EXROM, GAME, CHAREN.

Also shown in Fig. 2 are switches for controlling the logic level on the GAME and EXROM inputs of the expansion connector. EXROM is active in memory area \$8000 - \$9FFF (32,768 - 40,959), GAME in the next higher 4 Kbyte block, \$A000 - \$BFFF (40,960 - 49,151). The switches for EXROM and GAME offer four possible logic configurations:

- GAME = 1; EXROM = 1.
- GAME = 0; EXROM = 1
- GAME = 1; EXROM = 0
- GAME = 0; EXROM = 0

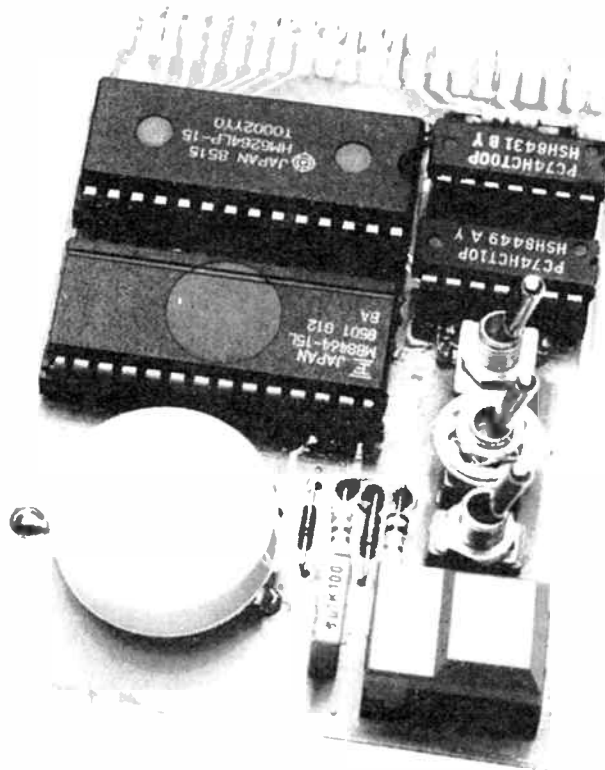
Although not harmful to the C64 hardware, combination **b** produces a hang-up, which can only be ended by altering the switch configuration and resetting the computer.

Combination **a** is valid when the computer is powered up, while **c** can be selected with

the aid of switch S₂ on the present board. An additional switch, S₃, can be closed following S₂, and enables selecting combination **d**. Combination **b** is impossible to select thanks to the practical switch configuration.

Circuit description

The circuit diagram of the RAM extension is shown in Fig. 3. When S₃ is opened, the RAM module is switched to the write protect mode, and resistor R₁ ensures a fixed level at the WE (write enable) inputs of RAM chips IC₃ and IC₄, which then behave as ROMs, since they can only be read from, not written to. Gates N₃ and N_{5-N₇} combine address lines A₁₃, A₁₄ and A₁₅ into a CS (chip select) line for each of the 8 Kbyte RAMs. Gate N₁ plus switches S_{2a} and S_{2a} ensure the correct set-up times for read operations in the RAMs. Parallel combination R_{2-D₁} charges the on-board 3.6 V NiCd battery from the computer's 5 V supply. When the computer is off, the battery supplies the (very low) data retention current for the CMOS RAM chips. Components C_{1-R_{2-D₂}} prevent dips and transients on the RAM supply lines when the computer is switched off, and the battery takes over. It should be noted that a dry battery is preferable over a NiCd cell when the computer is not used for periods longer than



about a month, because a NiCd cell inevitably loses its charge due to its self discharge current. R₃ is omitted when a dry battery is used.

Applications

Switched to configuration c, the battery back-up RAM makes it possible to slightly modify the resident BASIC interpreter for individual purposes, copy parts of it into the RAM/ROM module, develop and store new utilities, or have machine language programs permanently available. Memory area 32,768 to 40,959 is covered entirely by IC₃, and is fully accessible to the programmer. Configuration d selects the full 16 KByte RAM block, which then takes the place of the 8 KByte Microsoft BASIC ROM and the internal memory block in this area. When RESET switch S₄ is pressed, the operating system in the C64 searches for the following tokenized code starting at \$8004:

\$8004	\$8005	\$8006	\$8007	\$8008
C3	C2	CD	38	30

Translated into ASCII, this stands for *CBM80* if the MSB, D7, is ignored. If this 5-byte string is found (cold boot), the CPU jumps to the address stored in location \$8000 (L) and \$8001 (H). The 16-bit vector for a warm start is located in the next two higher locations, \$8002 and \$8003.

Construction

The compact, ready-made printed circuit board for constructing the RAM extension is a double-sided, but not through-plated, type, which holds all the components—inclusive of the battery and the switches—and plugs straight into the C64's expansion slot. The track layouts and component mounting plan are given in Fig. 4. Commence the construction with fitting the resistors, capacitors, diodes and the wire link. Note that some components, including the IC sockets, are soldered at both sides of the PCB to effect through-plating. At the copper side, all connections are soldered, at the component side only those whose solder islands are not covered

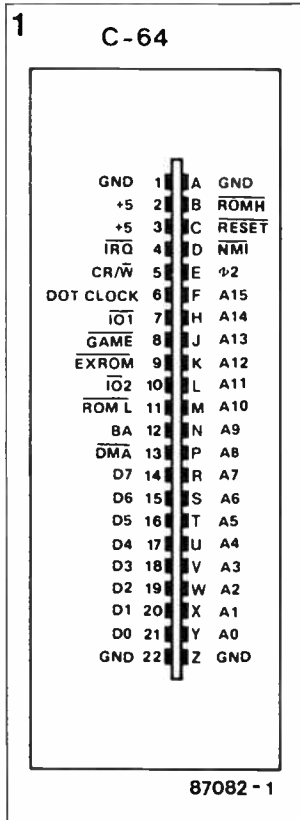


Fig. 1. Pin assignment on the expansion port at the rear of the C64 computer.

by the component overlay. The 2 holes in between S₃ and IC₂ are through-plated with the aid of component wire. The miniature switches can be fitted direct onto the board with the aid of bits of left over component leads. RESET key S₄ is a Type Digitast from ITT/Schadow, and should not present problems as to mounting. The 3.6 V NiCd battery should be fitted securely to make for a compact and sturdy extension module. Finally, plug in the integrated circuits, and the back-up memory is ready for use.

Note: Always switch off the computer before inserting or removing the 16 Kbyte RAM module. *St*

Table 1

Signal functions on the C64 expansion port:

Pin	Signal	Function
1		
22	GND	System ground
Z		
2/3	+5 V (V _{cc})	Power supply for User Port and Cartridge devices (450 mA max.)
4	IRQ	Maskable CPU interrupt request line (active low).
5	R/W	CPU output line. Memory read: 1; memory write: 0.
6	DOT CLOCK	8.18 MHz dot clock signal from video controller.
7	I/O1	Active low outputs for memory control.
11	ROML	
10	I/O2	
8	GAME	Active low inputs for memory control.
9	EXROM	
12	BA	Bus available signal from the VIC-11 controller.
13	DMA	Direct memory access request line.
14	D7	Unbuffered 6510 databus.
:	:	
21	D0	
:	:	
:	:	
C	RESET	Direct CPU reset line for initialising the computer.
D	NMI	Non-maskable CPU interrupt line.
E	φ2	CPU clock signal.
F	A15	Unbuffered address lines.
:	:	
:	:	
:	:	
Y	A0	

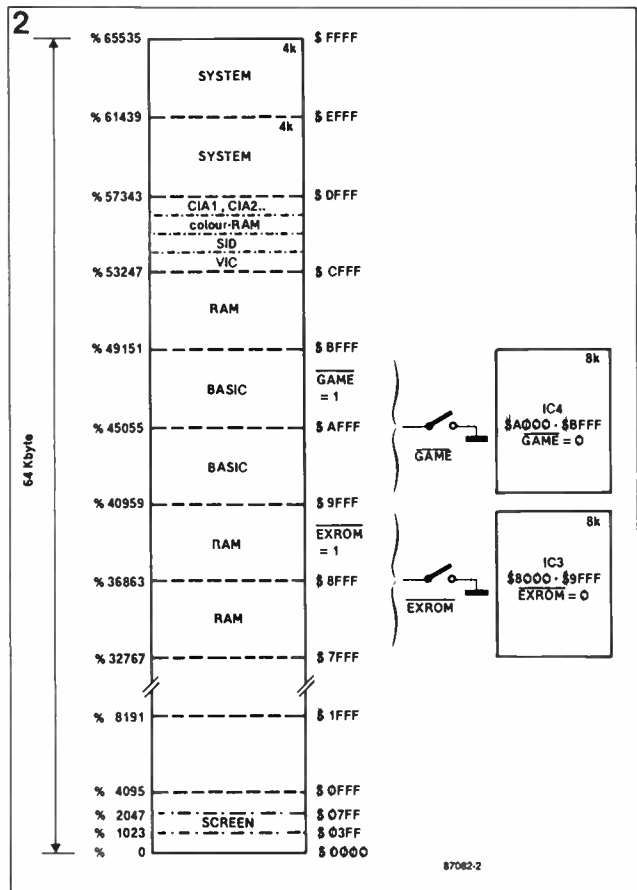


Fig. 2. Essentials of the C64's memory map.

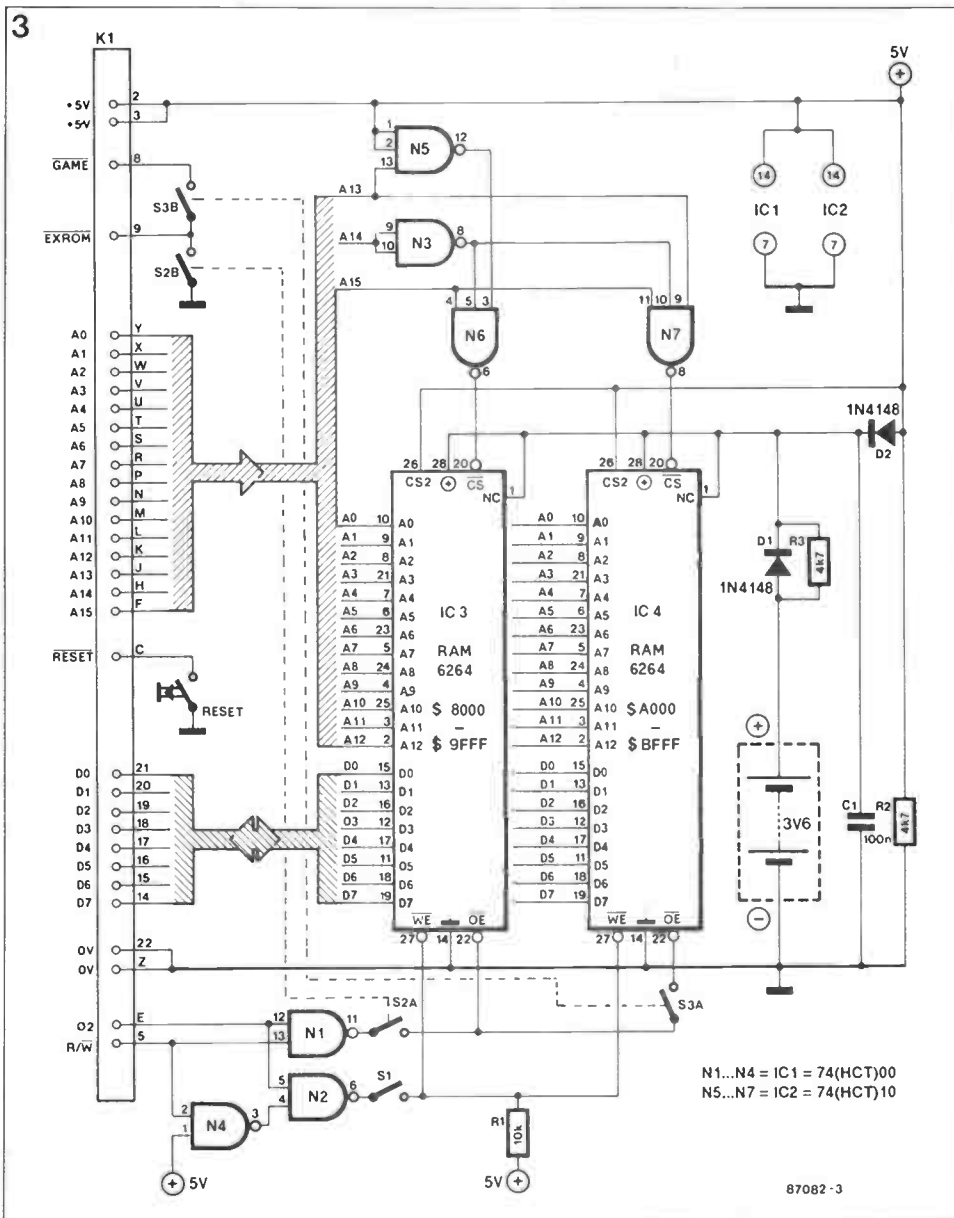


Fig. 3. Circuit diagram of the non-volatile 16 Kbyte RAM module.

Parts list

Resistors ($\pm 5\%$):

R₁ = 10K

R₂; R₃ = 4K7

Capacitor:

C₁ = 100n

Semiconductors:

D₁; D₂ = 1N4148

IC₁ = 74HCT00

IC₂ = 74HCT10

IC₃; IC₄ = 6264 8K x 8 static CMOS RAM

Miscellaneous:

S₁ = miniature SPST switch.

S₂; S₃ = miniature DPDT switch.

S₄ = Digitast momentary action key, Electromail stock no.

337-368.

PCB mount sealed 3.6 V NiCd

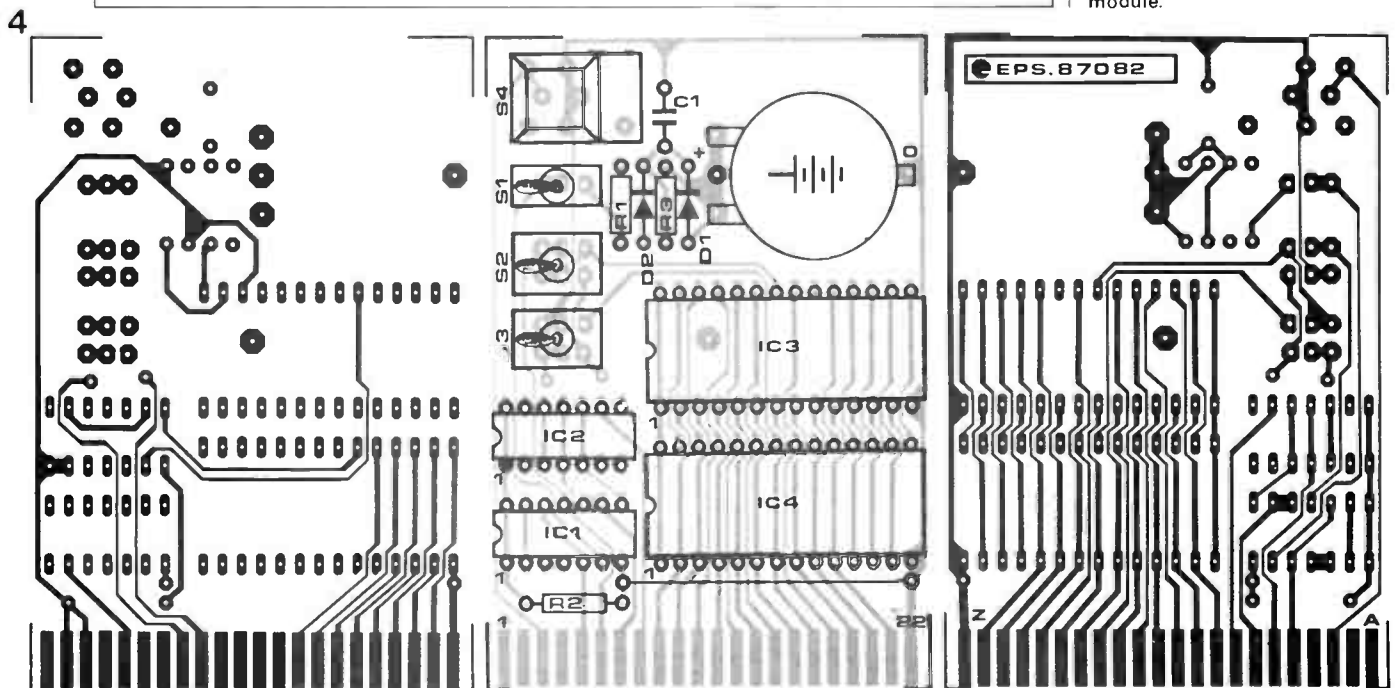


Fig. 4. The printed circuit board for making the RAM module.

HORN LOADING REVISITED

by R.M. Harris, B.Sc.

Horn loudspeakers provide good low-frequency performance and high efficiency, but are impractical for many uses because they are very large. However, R.M. Harris describes a design that is suitable for use in an ordinary living room.

The weakest link in any hi-fi system is undoubtedly the acoustical transducer or loudspeaker. Sound recording technology is reaching new levels of precision and noise reduction with digital recording and compact discs. Amplifiers can be perfected to almost any degree, if the price is right, with hitherto unheard of purity in terms of harmonic distortion and intermodulation products. In other words, it is possible to reproduce sound faithfully from DC to RF, but only in terms of electrical signals. For, while electronic technology has passed from thermionic valves through discrete transistors to integrated circuits, the loudspeaker has hardly changed in its essentials since its invention in 1925*.

Since middle- and high-frequency propagation is characterized by small-amplitude sound waves, which eases most engineering problems, this article is confined to the problem of obtaining good, clean low-frequency sound reproduction.

Two physical principles account for most of the engineering difficulties at low frequencies. The first is that for a plane propagating sound wave the pressure, p , and particle velocity, u , are related in terms of the specific acoustic impedance of the medium (air):

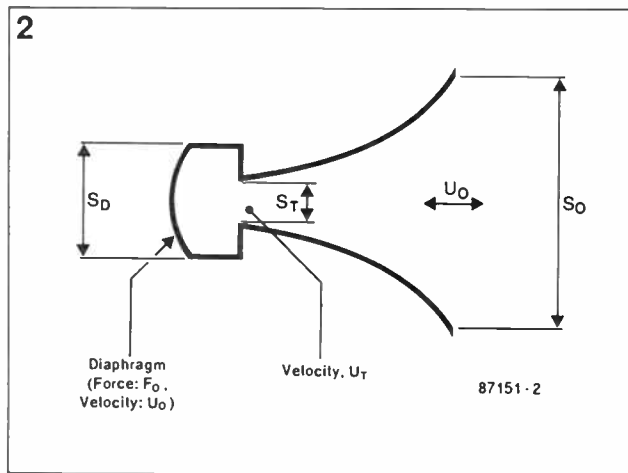
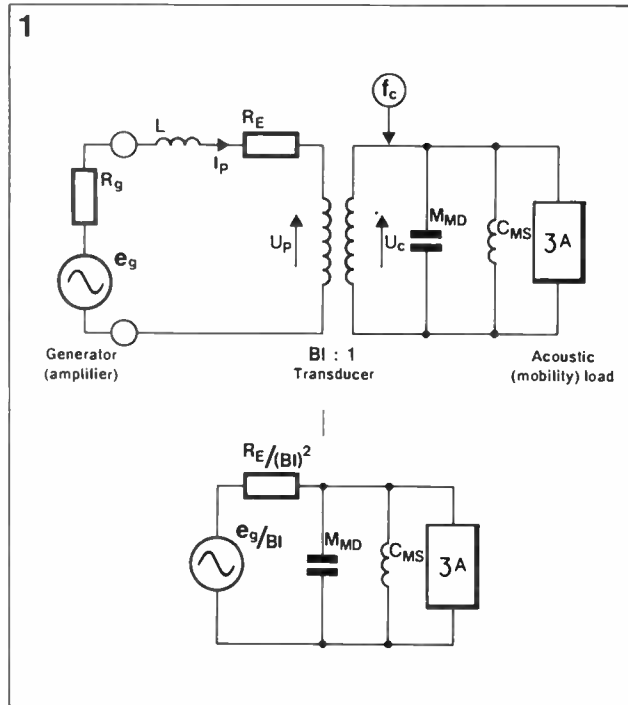
$$p/u = Z_0 \quad [1]$$

where

$$Z_0 = \rho_0 c \quad [2]$$

in which ρ_0 is the density of the medium and c is the velocity of sound in the medium.

At a point in space, the instantaneous particle displacement, y , of a sinusoidal sound wave of amplitude a and frequency f Hz, is given by



$y = a \sin 2\pi f t$ [3] and the instantaneous velocity is

$$u_t = dy/dt = 2\pi a f \cos 2\pi f t \quad [4]$$

and the maximum velocity is

$$u = 2\pi f a \quad [5]$$

For a given sound pressure level—SPL—of p , the amplitude is given by

$$a = u/2\pi f \quad [6]$$

$$= Z_0 p / 2\pi f \quad [7]$$

Both [6] and [7] simply state that

the amplitude increases as the frequency decreases.

The second principle is that at low frequencies the wavelength in air is much larger than the dimensions of the sound source. This results in the radiation of spherical wave fronts from what is, in effect, a point source. The specific acoustic impedance, Z_s , is not the same for diverging waves, as given by the general formula

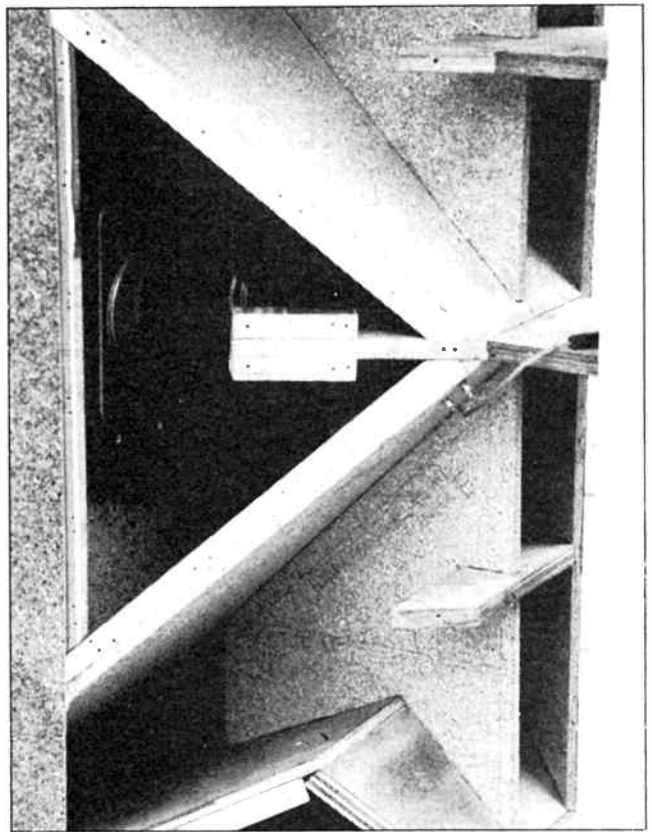
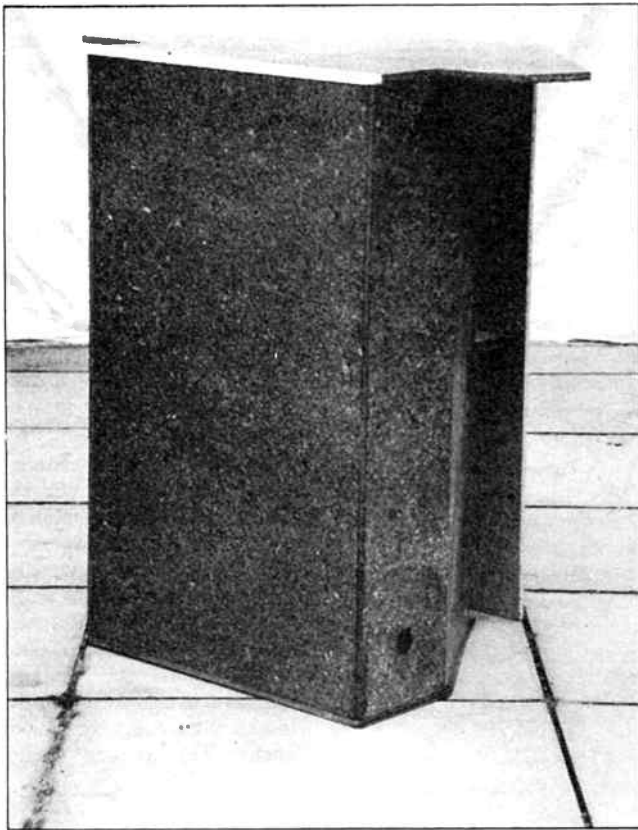
$$Z_s = \frac{p}{u} = \frac{\rho_0 c k r}{\sqrt{1 + k^2 r^2}} \quad 90^\circ - \arctan kr \quad [8]$$

where r is the radial distance from the point source, and $k = 2\pi/\lambda$.

When $kr \gg 1$ ($r \gg \lambda/2\pi$), the magnitude of Z_s approaches the value for a plane wave ($\rho_0 c$) with u in phase with p . For $k\lambda = 1$, Z_s goes to zero and u tends to be in phase quadrature with p . The real part of Z_s (which is generally complex) falls to zero as r^2 , which means that the mismatch between the transducer and the medium degrades in direct proportion to the square of the wavelength.

The corollary is that the speaker cone has to execute larger movements to maintain a constant SPL at lower frequencies if Z_s remains constant. If, however, Z_s (and in particular the real part of Z_s) falls at lower frequencies, the situation is exacerbated. So, all effects included, the cone amplitude needs to vary as λ^3 or as f^{-3} .

The foregoing general analysis clinches the central problem of designing for efficient bass reproduction. Large amplitudes are deprecated for moving-coil driver units: they introduce not only mechanical difficulties, but also distortion. It has been stated (Ref. 1) that any movement of the cone entails some distortion: the more it moves,



the worse the distortion. Unfortunately, the ear is adept at sensing very low levels of distortion, especially intermodulation distortion.

The concept of transforming electrical energy into acoustic energy introduces ideas of impedance matching and transducers. Without going into the intricacies of acoustics theory, the following simplified treatment of the method of "electrical analogy" may be helpful. The complete sound reproduction system from amplifier to air can be represented by an electrical equivalent circuit—see Fig. 1a. The constant-voltage generator has an internal resistance, R_g , which is typically 0.2Ω for modern amplifiers. The voice coil of the driver unit contributes inductance, L , and pure resistance, R . The essential function of the driver unit is that of energy transducer, which can be represented as a transformer with a turns ratio of $Bl:1$. The primary current, I_p , gives rise to a force f_p which, as it were, flows in the secondary circuit. The voltage induced back across the primary, V_p , reflects the velocity, u_c , of the voice coil. Thus, $I_p = f_c / Bl$ and $V_p = Bl u_c$.

The primary impedance, Z_1 , is related to the secondary impedance, Z_2 , as follows

$$Z_1 = V_p / I_p$$

and

$$Z_2 = u_c / f_c$$

so that

$$Z_1 = (Bl)^2 Z_2 \quad [9]$$

The term Bl is the magnetomotive force factor, which is measured in tesla per metre ($T\ m^{-1}$).

Note that in the secondary circuit impedance is the inverse of the better known mechanical analogue where voltage corresponds to force and current to velocity. In the present system, known as the mobility system (Ref. 2), inertia becomes a shunt capacitance and spring resistance becomes a shunt inductance. Hence, the moving mass of the speaker is represented by capacitance MMD , while the stiffness of the suspension and any enclosed volume (e.g. in infinite baffle designs) of air are represented jointly by inductance CMS . The acoustic load is represented by A , the acoustic mobility, which is the reciprocal of acoustic impedance.

For maximum energy transfer, the blocking effects of the mechanical inertia and stiffness have to be minimized. In the

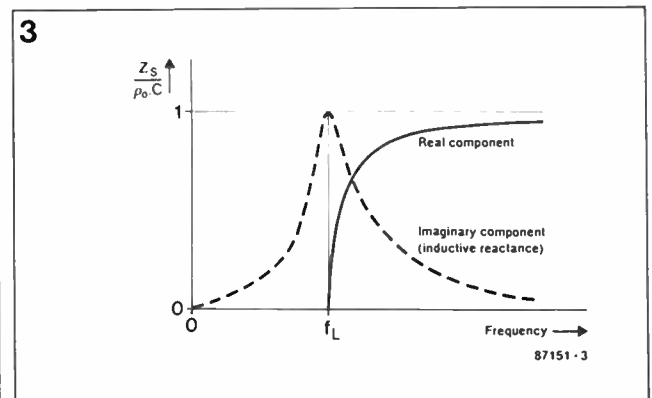
mobility system, this amounts to reducing the magnitude of $\beta-A$ (particularly the real part) below the shunt admittances of MMD and CMS . Then, $\beta-A$ will predominate in the secondary load.

The accompanying step is to reduce the size of the primary series impedances as reflected in the secondary—see Fig. 1b. At low frequencies, L may be disregarded. Considering the difficulty of achieving large enough values of acoustic impedance (i.e., low enough values of acoustic mobility, $\beta-A$), every effort has to be made to reduce the moving mass and stiffness of the suspension. Furthermore, Bl needs to be maximized to minimize the dissipative effect of Re . The closed cabinet or infinite baffle

design reduces stiffness by the use of a large enclosed volume, increases Z_A by the use of a large cone, and then fails to reduce the moving mass (which includes a cylinder of air in front of the cone that is about a third of the cone radius deep). Such designs seldom achieve energy efficiencies much above 4%, in spite of decades of research.

The horn as an acoustical transformer

For a sound wave propagating along an exponential horn, the particle velocity and pressure vary in proportion to the diameter of the horn. The specific acoustic impedance



therefore remains constant. On the other hand, the acoustic impedance is defined as the pressure divided by the flow (= velocity times cross-sectional area). So, in the exponential horn, acoustic impedance varies inversely as the cross-sectional area. The horn transforms a small flow at high pressure in the throat to a large flow at low pressure in the mouth. Conventionally, the horn is driven by a diaphragm (eg., the cone of a loudspeaker) of larger cross-sectional area, S_D , than that of the throat, S_T , as shown in Fig. 2. The force, F_D , acting on the diaphragm is related to the pressure, p_T , in the throat by:

$$F_D = S_D p_T \quad [10]$$

Also,

$$u_D = u_T S_T / S_D \quad [11]$$

where u_D is the velocity of the diaphragm and u_T is the particle velocity in the throat. The mechanical impedance, Z_M , is defined as force per unit velocity. So, for the diaphragm,

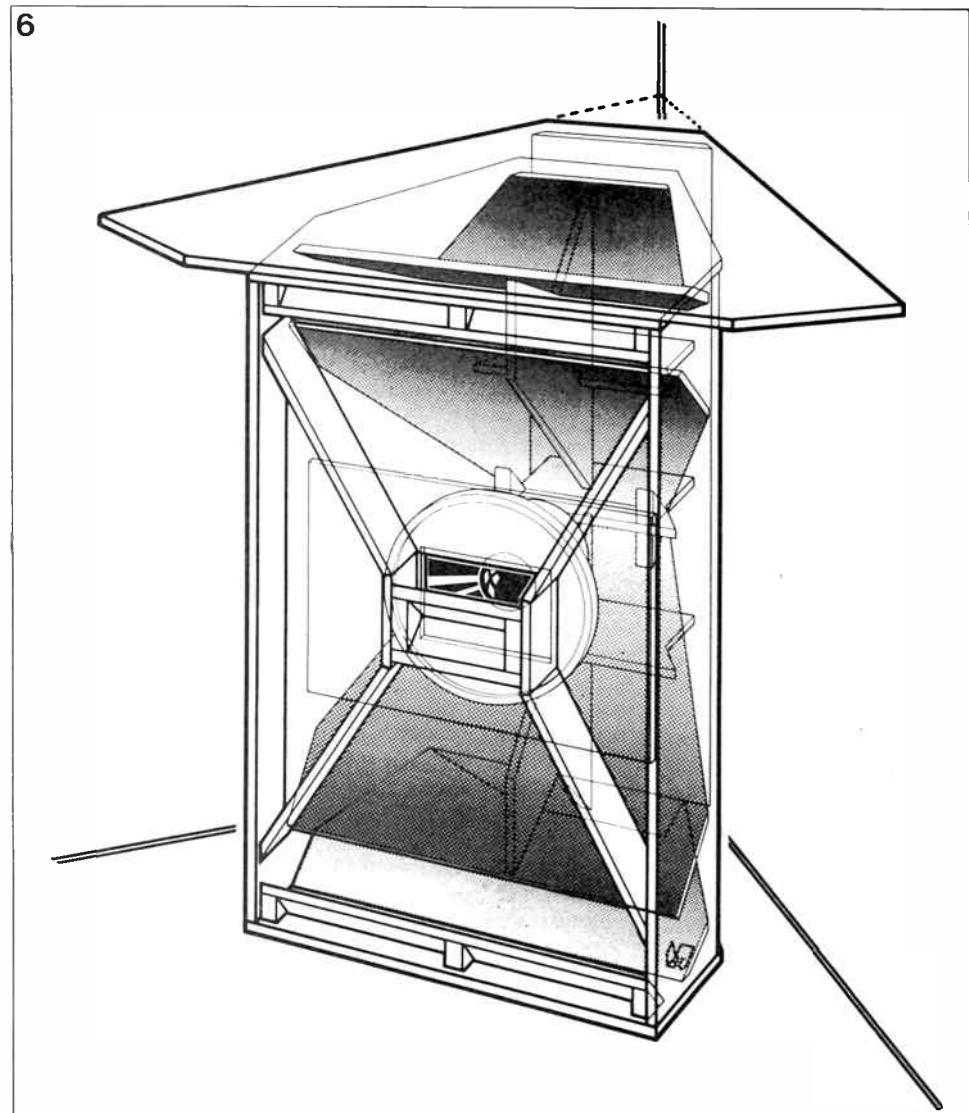
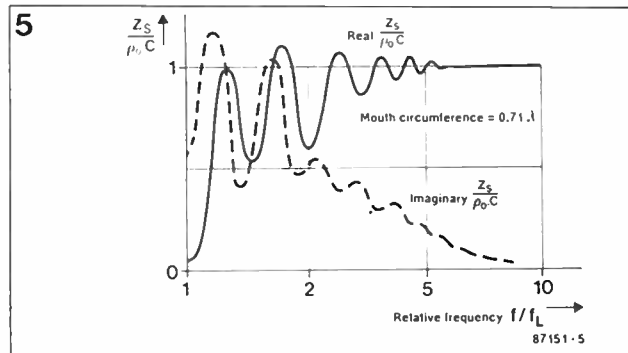
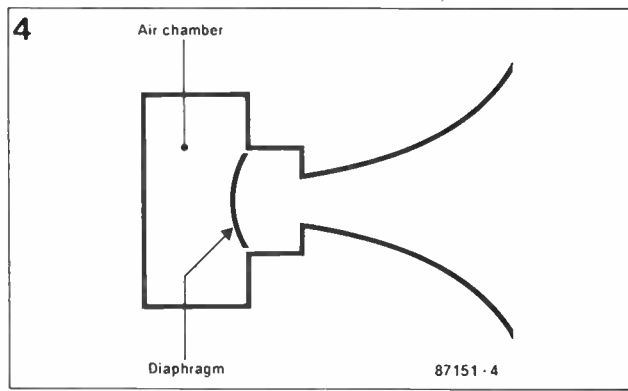
$$\begin{aligned} Z_M &= F_D / u_D \\ &= (S_D^2 p_T) / (S_T u_T) \\ &= (S_D^2 / S_T) (p_o / u_o) \end{aligned} \quad [12]$$

where p_o and u_o are the pressure and velocity respectively in the mouth of the horn. For a horn of sufficient dimensions, the coupling to the outside world becomes 100% and the specific acoustic impedance at the throat approaches $\rho_o c$. Strictly, this is true only for an infinite horn, but for practical purposes a horn of which the circumference of its mouth equals the wavelength of the lowest frequency to be propagated is adequate. Under these conditions, the mechanical impedance becomes

$$Z_M \approx \rho_o c (S_D^2 / S_T) \quad [13]$$

To equal this value of Z_M , an infinite baffle design would require a cone diameter of λ/π , where λ is the wavelength. At 40 Hz, $\lambda = 8.28$ m, resulting in an impractical cone of more than 2.5 m in diameter.

The most serious restriction relating to low-frequency applications of horns is the cut-off



frequency, f_L , below which sound will not propagate. If the cross-sectional area of the horn varies with the distance, x , along the horn as

$$S_x = S_T \exp(mx) \quad [14]$$

the parameter m , expressed in m^{-1} , is called the **flare** constant. The low-frequency cut-off is given by

$$f_L = mc / 4\pi \quad [15]$$

For instance, if $m = 0.3646 m^{-1}$, $f_L = 40$ Hz.

For an infinite exponential horn, the real part of the throat impedance falls abruptly to zero at the cut-off frequency—see Fig. 3. The imaginary (reactive) part rises to a maximum at f_L and then falls asymptotically to zero. Above f_L it resembles a mirror image of normal capacitive reactance, which is the reason that it is often called negative capacitance reac-

tance. It also indicates the way to compensate it, namely by the series connection of a positive capacitive reactance of the same magnitude. In acoustics terms, this amounts to placing a compliant volume of air behind the diaphragm, enclosed in an airtight chamber—see Fig. 4. Note that this action is not in any way a frequency-selective tuning operation: in principle, it is rather a broad-band reactance annulling process.

The volume of the air chamber is calculated by multiplying the throat area, S_t , by the length in which the horn doubles its cross-sectional area, and then by 2.9. Typically, this volume is small compared with the enclosed volumes required for infinite baffle designs.

For finite horns, the throat-impedance curves exhibit a degree of periodicity, with the depth of the oscillations increasing as the horn is made shorter and thinner. Fig. 5 shows the behaviour of the real and imaginary parts of the throat impedance, computed by Olson, for a horn with a mouth circumference of 0.71λ , where λ is the wavelength at the cut-off frequency. Once the flare constant and the size of the mouth have been decided, the length of the horn depends only on the size of the throat. Often, the desirable length is quite impractical at low frequencies.

Practical constraints

Ideally, the horn would possess a wide mouth, say, 8.3 m circumference for good matching to the room at 40 Hz: this would entail a length of around 5 m. Some design compromise is clearly indicated if horn-loaded enclosures are to be adopted for semi-fixed or even portable applications. A number of actions can be taken to ease the dimensional limitations. The best-known of these is to fold the horn back onto itself once or twice to make a more compact, box-shaped structure. Less well-known, perhaps, is the method used by Lee in his catenoid design (Ref. 3), or that of P.W. Klipsch, in which the mouth of the horn is made to illuminate the room from one of its corners.

The effectiveness of the Klipsch method can be understood by considering the fact that plac-

ing a sound source close to a solid plane produces an in-phase image behind the plane. Similarly, a source located near the intersection of two planes gives rise to two images, and near a corner of a rectangular box three in-phase images accompany the source. The effect of placing the mouth of a horn near a corner is to quadruple the effective mouth area, which very usefully relaxes the earlier stated conditions on mouth circumference: it halves the circumference.

The klipschorn

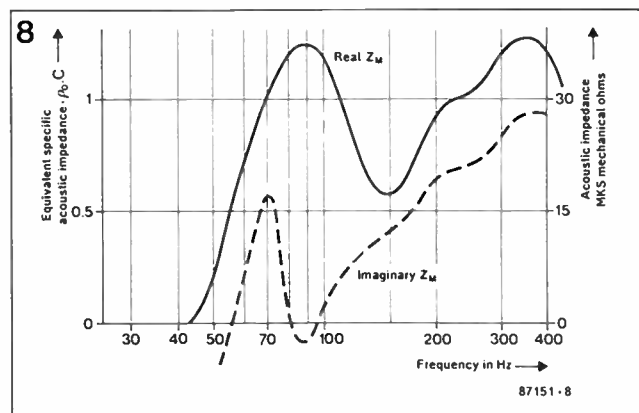
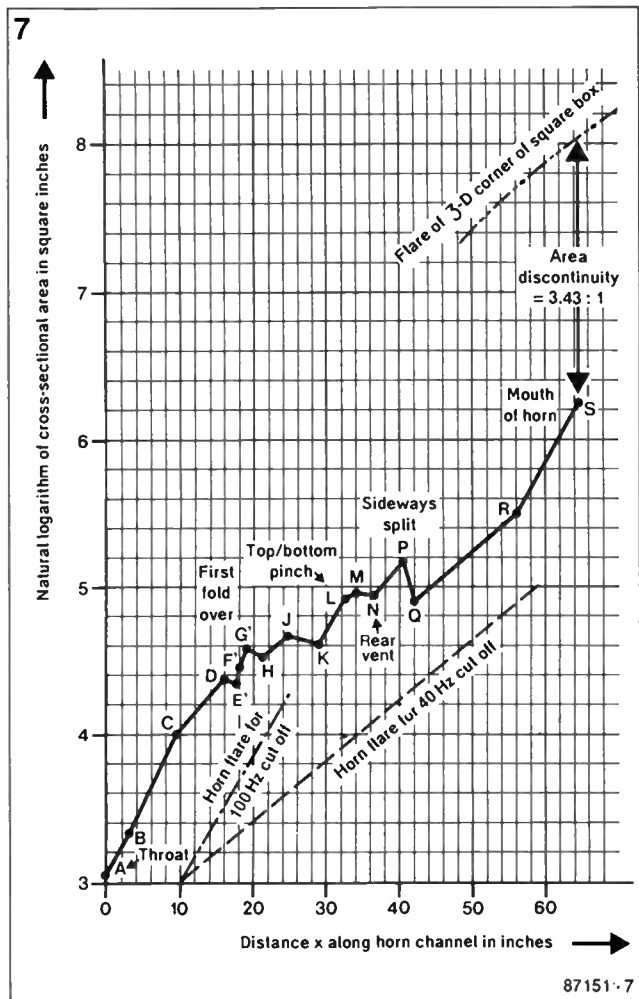
P.W. Klipsch described a *Low Frequency Horn of Small Dimensions* (Ref. 4) in 1941. His experimental work was cut short by the Second World War, but provided enough data to establish the final design with confidence. It included all the design improvements described in the foregoing section in an ingeniously designed cabinet pictured in Fig. 6.

The design cleverly conceals a doubly split reflex horn of over 1.5 m in length, and makes use of the room walls for two sides of the horn. The mouth of the horn is formed by two rectangular, vertical slots (including the contiguous images in the walls and floor) which make a phased array that helps to beam sound in the horizontal plane, and at the same time increases the specific acoustic impedance.

I shall not repeat or even summarize Klipsch's detailed analysis, but rather assume his measured results and apply them to the present project, which consists of a klipschorn enclosure and a Richard Allen CG12 driver unit. Klipsch used a mains energized Jensen 12, 12-inch driver, which enabled some acoustical measurements to be made via the voice coil terminals simply by switching on or off the magnetic field. The wedge-shaped air chamber has a volume of 64 l of which 9.8 l were taken up by the driver unit.

The chamber, by virtue of its pyramidal shape, was free of mid-range resonances and required no damping (which would reduce efficiency in any case).

The piston diameter of the cone (10.5 in) gave an area $S_b = 0.0558 \text{ m}^2$, which was re-



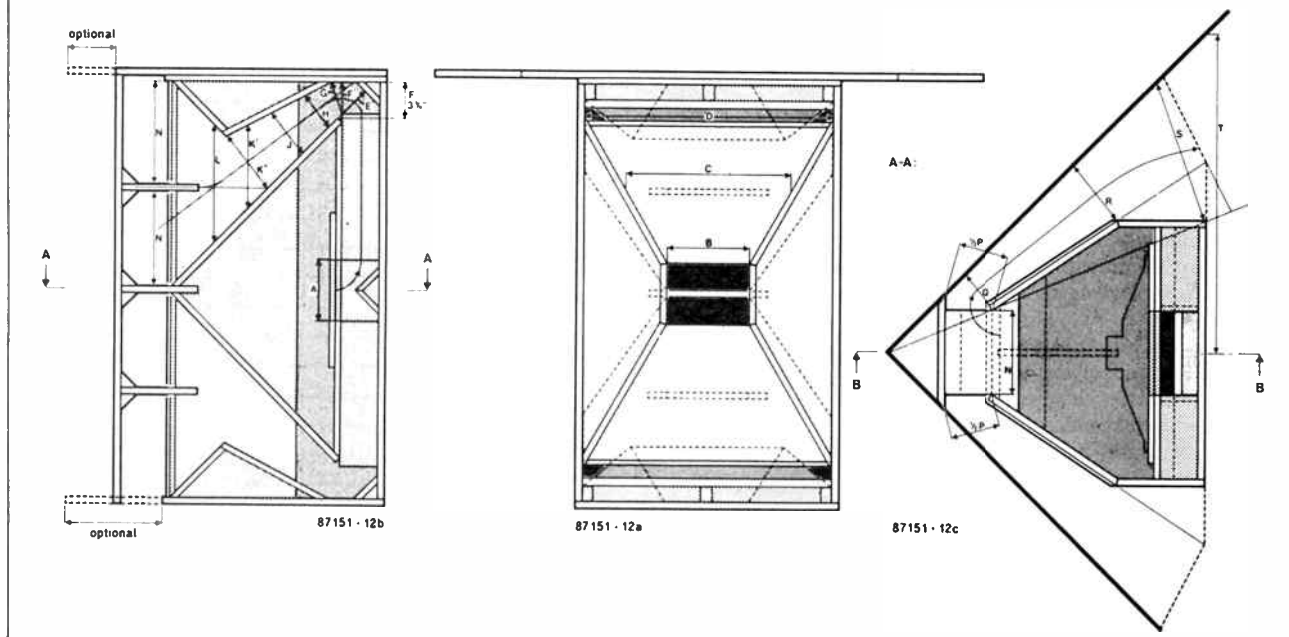
duced to 0.0322 m^2 at the entrance to the throat to give a ratio $S_b/S_t = 1.73$ in Eq. [11]. This was found to be too large at the lowest frequencies, and so a "rubber throat" was devised to give an effective throat area of 0.0644 m^2 at 40 Hz, reducing to 0.0322 m^2 at 100 Hz. The "rubber throat" was brought about by making the first section of the multi-flared horn cut off at 100 Hz, and the rest of the horn at 40 Hz.

The throat opened into a split horn with symmetrical channels pointing up and down for the

100 Hz cut-off section. The two channels folded around the top and bottom of the air chamber, constricting in the lateral dimension, but flaring in the vertical.

The 40 Hz cut-off flare constant was approximately maintained with the aid of a succession of short linear flares for ease of construction.

The sharp corner of the room was hidden by a fillet plate which deflected the now merged sound from upper and lower channels sideways between cabinet sides and walls. ▶



This time, the horn was split laterally and symmetrically if the cabinet was placed correctly. Fig. 7 shows the multi-flared profile, where the natural logarithm of the cross-sectional area has been plotted against channel distance.

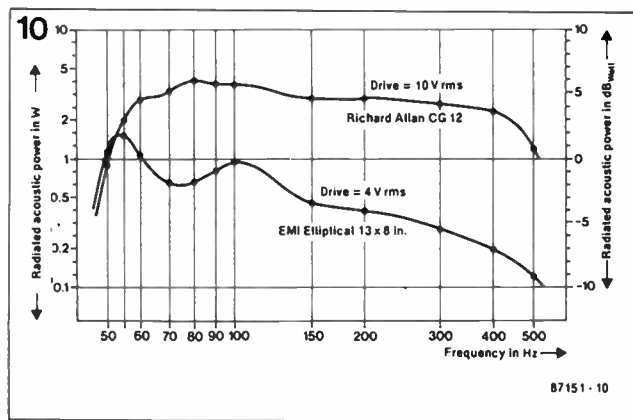
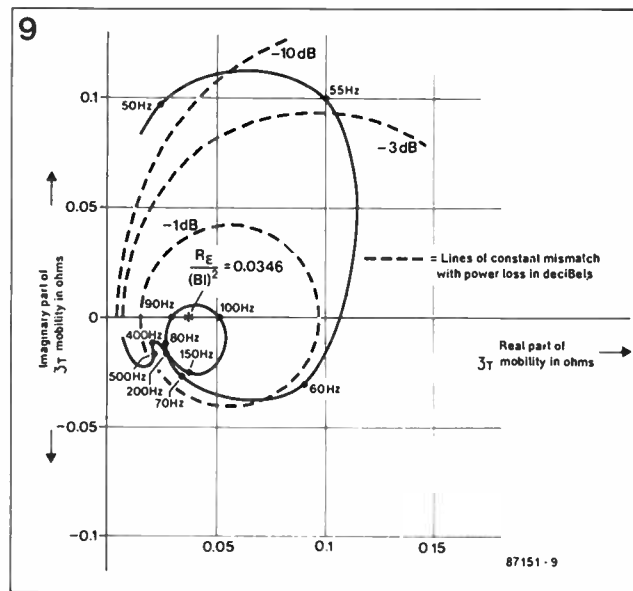
Calculated performance with a Richard Allen CG12 driver

Klipsch measured the acoustic impedance, Z_T , of the horn channel with and without the air chamber (which was external in his prototype). The air chamber certainly brought down the peaky reactive part of the impedance: the result, with chamber, is plotted in Fig. 8. More familiar to electronics engineers will be the Argand diagram in Fig. 9, where the measured acoustic impedance has been converted into its reciprocal, Z_T , "mobility ohms" as suited to the secondary circuit of Fig. 1b. The value of $RE/(BI)^2$ has also been plotted for the CG12, where $R_E=6.5\Omega$ and $BI=13.7 \text{ T m}^{-1}$. Maximum power is produced from a constant-voltage generator when Z_T equals $RE/(BI)^2$, and energy efficiency is just 50%. The degree of mismatch between Z_T and $RE/(BI)^2$ corresponds to acoustical power loss. If Z_T exceeds $RE/(BI)^2$, efficiency does, indeed, rise, but not enough to compensate the drop in load current. If Z_T is

less than $RE/(BI)^2$, efficiency falls rapidly, with more power being dissipated in the voice coil's ohmic resistance. The other parameters for the Richard Allen CG12, i.e., moving mass and spring constant, were inserted into the complete electrical network and the equations for acoustical power were solved with the aid of a personal TI-55-II programmable calculator. The resulting frequency response for a 10 V r.m.s. excitation has been plotted in Fig. 10. The maximum predicted output of 5 W may be compared with the 12.3 W that would be developed in an eight-ohm resistance. The 10 V r.m.s. corresponds to a 12 W personal amplifier: the audible effect for bass guitar and concert music is atypical of a domestic 12 W system. The author can credit Klipsch's claim to have achieved a ten-fold increase in loudspeaker efficiency over infinite baffle types. For comparison, Fig. 10 also shows the calculated performance of another driver unit (4 ohm), whose BI factor was much lower at 3.35 T m^{-1} . The lower excitation voltage of 4 V r.m.s. would not develop more than 5 W, but the point to notice is the much more peaky response, showing that the reflected voicecoil resistance has not been located centrally on the Argand diagram in Fig. 9. The klipschorn is capable of handling up to 100 W with less than 1% second-harmonic distortion at

40 Hz (which is mainly due to non-linearity of the air in the throat region (Ref. 5). The roll-off below 60 Hz looks at first like an admission of failure, but remember that

Fig. 10, and Klipsch's own prediction for his Jensen 12A, is based on measurements made on a prototype design. When Klipsch evaluated the final cabinet design, he found that



the whole characteristic had shifted fortuitously downwards in frequency, so justifying his claimed "smooth response from 40 Hz to 400 Hz". A crossover is indicated at 400 Hz to a conventional mid-range and tweeter unit: both could be horn-loaded, of course.

Construction

Before tackling this daunting task, the author made two scale models, a 1:8 in cardboard, followed by a 1:3.6 in 3-ply. The working model exhibited a roll-off below 180 Hz, which scaled down to 50 Hz for the full-sized unit. The intrinsically self-bracing structure indicated relatively thin panelling. For cheapness (but not light weight!), half-inch, high-density chip board was used, costing less than £9.00 in all. The truss and some fillets were made in marine 9-ply, while blocking, corner fillets, air seals, and so on were made out of oddments of hardwood and deal. Joints were glued and screwed except for the access door—one large side panel—which was secured with 14 wood screws. This was necessary for fitting (retrospectively) the CG12 and for possible maintenance. With the door off, the top and bottom fillets would have been precariously unsupported, were it not for centre-line fins, which were the author's distinctive (cf. Jecklin, Ref. 6) modification to Klipsch's constructional designs—see Fig. 11, 12, and 13, as well as the accompanying photographs.

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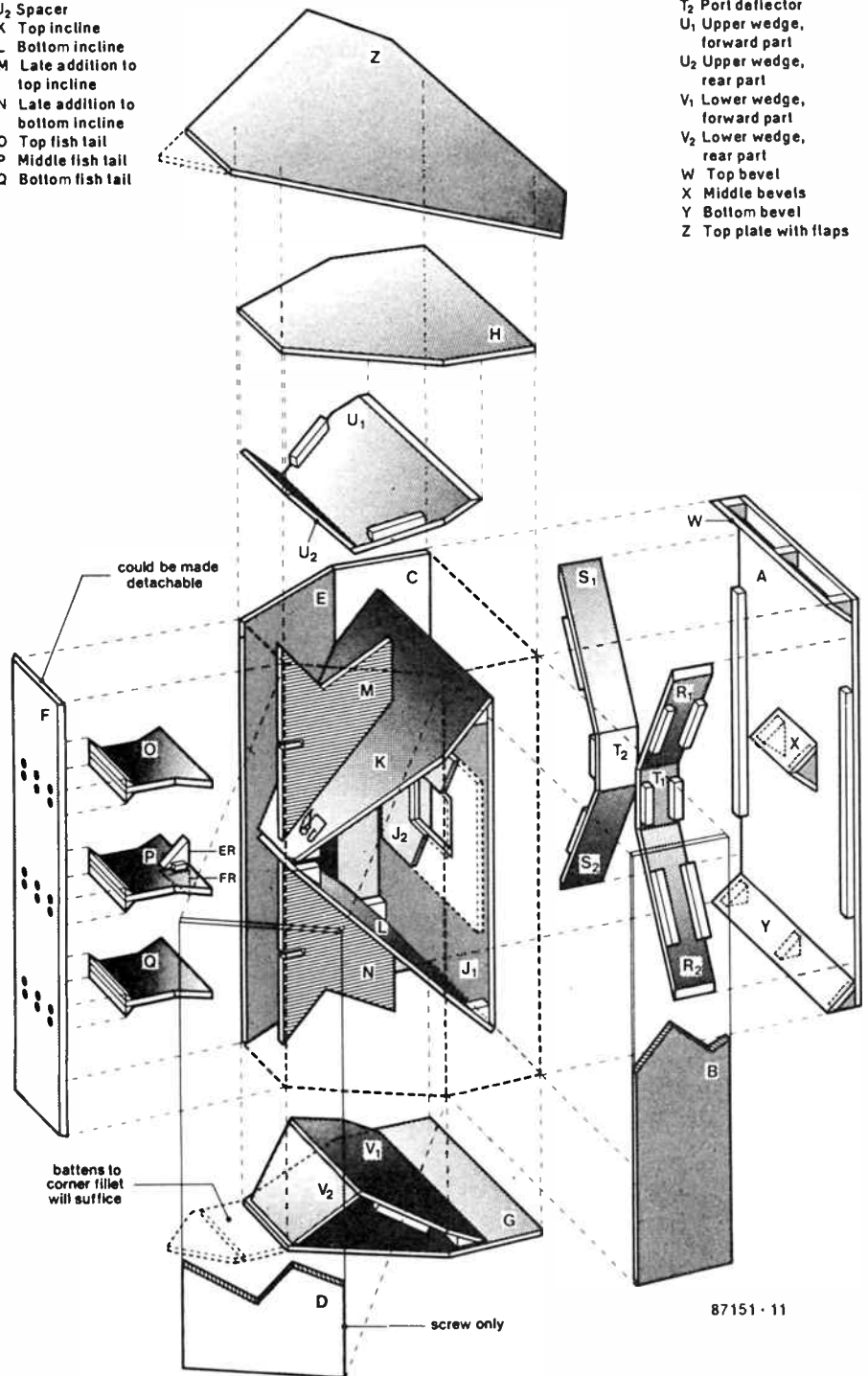
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4. P.W. Klipsch, *A Low Frequency Horn of Small Dimensions*, *Journal of the Acoustic Society of America*, Vol 13, pp 137-144 (1941)
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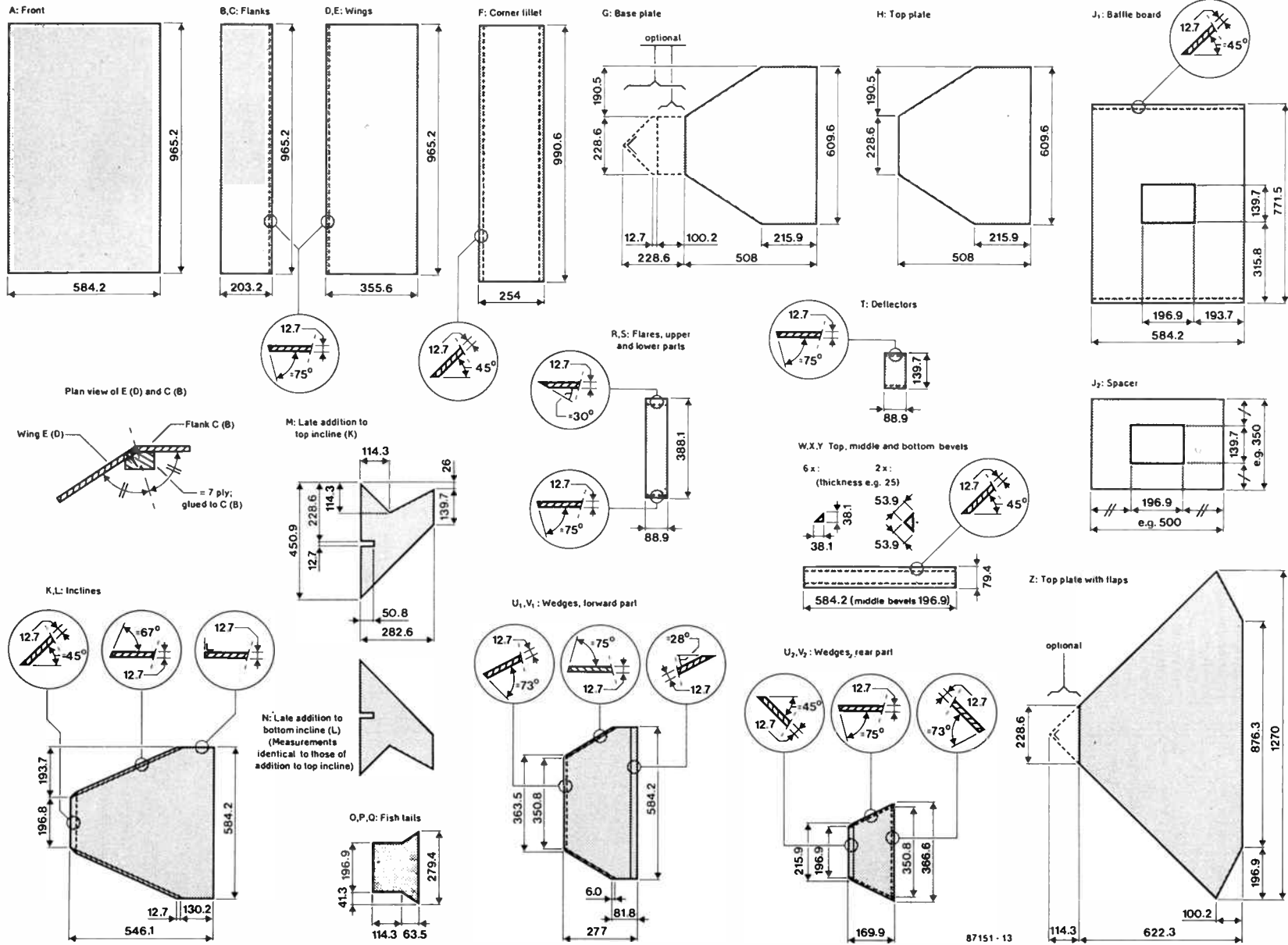
* C.W. Rice and E.W. Kellogg

11

- A Front
- B Starboard flank
- C Port flank
- D Starboard wing
- E Port wing
- F Corner fillet
- G Base plate
- H Top plate
- J₁ Baffle board
- J₂ Spacer
- K Top incline
- L Bottom incline
- M Late addition to top incline
- N Late addition to bottom incline
- O Top fish tail
- P Middle fish tail
- Q Bottom fish tail

- R₁ Starboard flare, upper part
- R₂ Starboard flare, lower part
- S₁ Port flare, upper part
- S₂ Port flare, lower part
- T₁ Starboard deflector
- T₂ Port deflector
- U₁ Upper wedge, forward part
- U₂ Upper wedge, rear part
- V₁ Lower wedge, forward part
- V₂ Lower wedge, rear part
- W Top bevel
- X Middle bevels
- Y Bottom bevel
- Z Top plate with flaps





87151 - 13

ACTIVE PHASE-LINEAR CROSS-OVER NETWORK

The ideal cross-over network is free of phase-shift, resulting in optimum pulse performance and radiation pattern. Although the ideal is not yet within reach, the work of Stanley Lipshitz and John Vanderkooy enables it to be approached very closely.

The most serious problem with ordinary cross-over filters is best illustrated with reference to a two-way system. This consists of a low-pass and a high-pass filter. One of the properties of a low-pass section is that it causes a time-delay of the signal. A high-pass filter on the other hand causes an acceleration of the signal. These actions result in a number of complications at the cross-over point:

- (a) the signals from the two sections partially cancel one another;
- (b) the strongly varying phase shift between the two signals adversely affects the radiation efficiency of the overall system;
- (c) the radiation pattern becomes frequency dependent.

Some years ago, Stanley Lipshitz and John Vanderkooy published a series of papers^(1, 2, 3) that have laid the foundation of the so-called phase-linear cross-over network.

Basically, the phase-linear network uses a low-pass section that also provides a high-pass characteristic with the aid of a time-delay and subtraction circuit. True, the time-delay is not constant over the entire frequency range, but it varies only slowly; moreover, there are no phase differences between the two output signals, even near the cross-over frequency.

A block schematic of a two-way, as well as a three-way, system based on the work of Lipshitz and Vanderkooy is shown in Fig. 1. It should be emphasized that the time-delay is an essential facet of the design. There are filters that make use of the subtraction method only, but these do not exhibit phase linearity. ▶

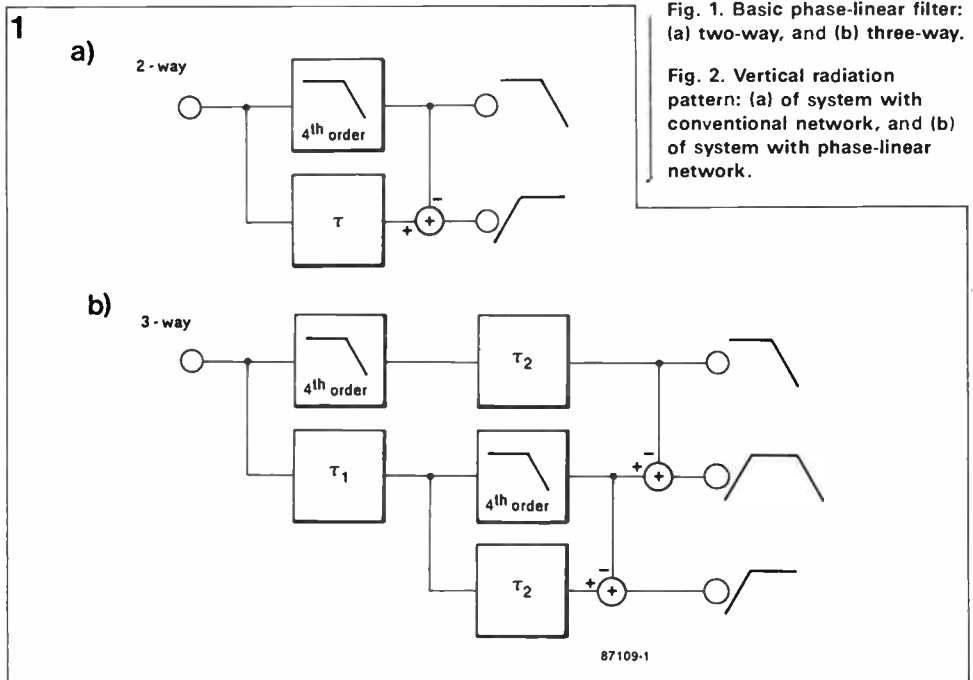
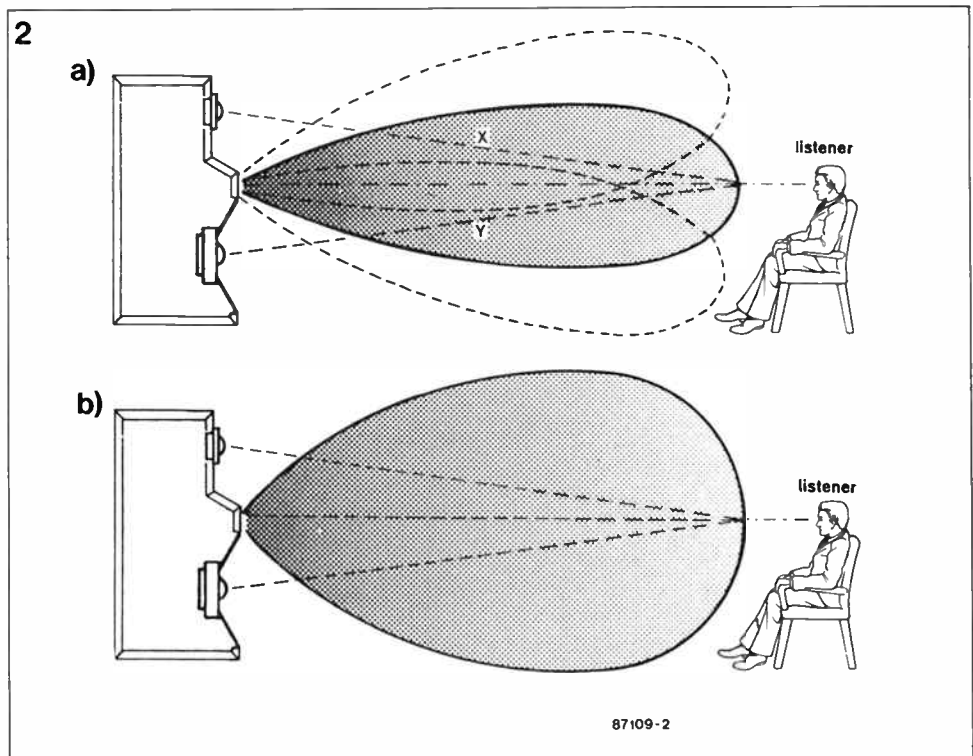


Fig. 1. Basic phase-linear filter: (a) two-way, and (b) three-way.

Fig. 2. Vertical radiation pattern: (a) of system with conventional network, and (b) of system with phase-linear network.



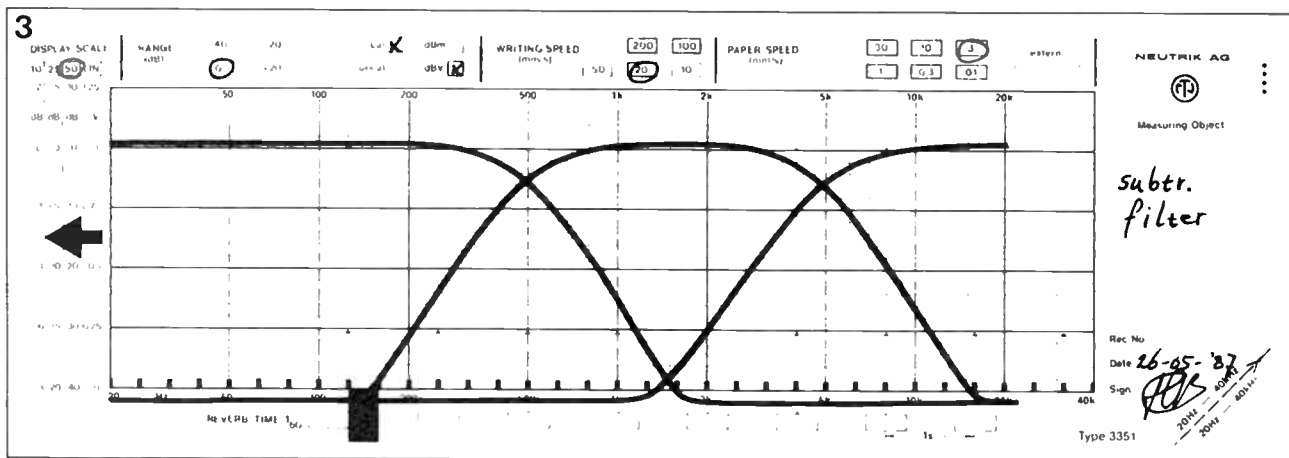


Fig. 3. Amplitude vs frequency characteristic of a three-way phase-linear network.

A customary fourth-order low-pass filter in the upper branch provides the normal low-pass performance. The delay, τ_1 , is designed such that it has exactly the same phase behaviour as the low-pass section, and functions as an all-pass section. When then the output signal of the low-pass section is subtracted from the delayed signal, the result is a high-pass characteristic that has the same phase behaviour as that of the

low-pass filter. Summing the two signals results in a perfectly straight line. The set-up of a three-way system—see Fig. 1b—is a little more complicated, because an additional low-pass section has to be provided in the centre limb to obtain a band-pass characteristic for the middle frequency loudspeaker. This additional section must be compensated by a second delay, τ_2 . Thus, in a three-way system, the

τ_1 circuit simulates the time delay of the usual bass filter, while the τ_2 delay simulates the delay of the low-pass filter in the middle-frequency section. The vertical radiation pattern (polar response) of a conventional loudspeaker system is shown in Fig. 2a. The dispersion is fairly small in the region where both speakers provide a signal. The spread also varies with frequency, which causes the lobe to either tilt or sag. The

pattern of the phase-linear system in Fig. 2b shows that the lobe is much broader and points forward at all frequencies. In all this it is assumed that the acoustic centres of the loudspeakers lie on a vertical line, otherwise the pattern deteriorates.

A practical network

In a practical network, it is not possible (at least with an ac-

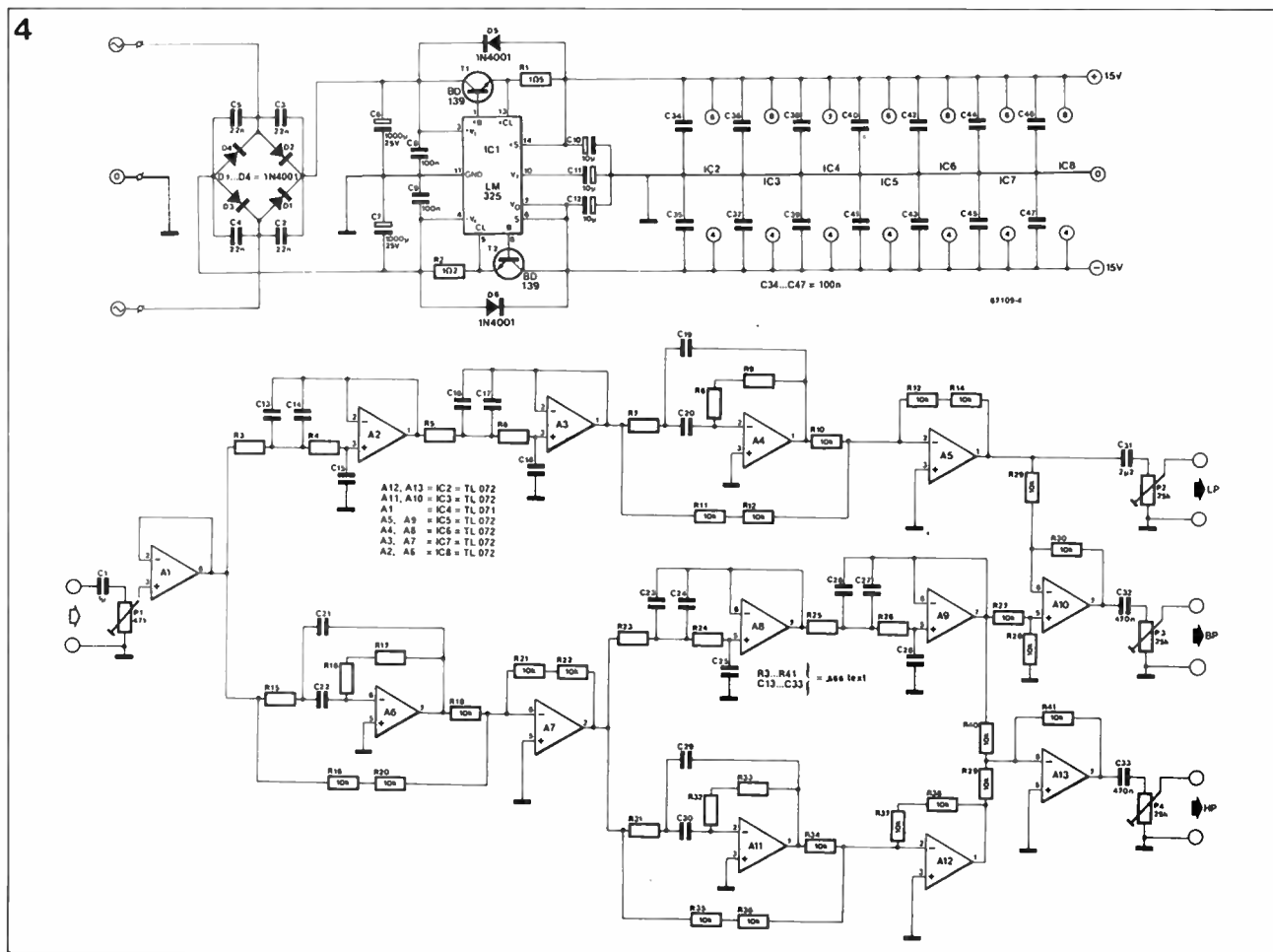


Fig. 4. Circuit diagram of the phase-linear network.

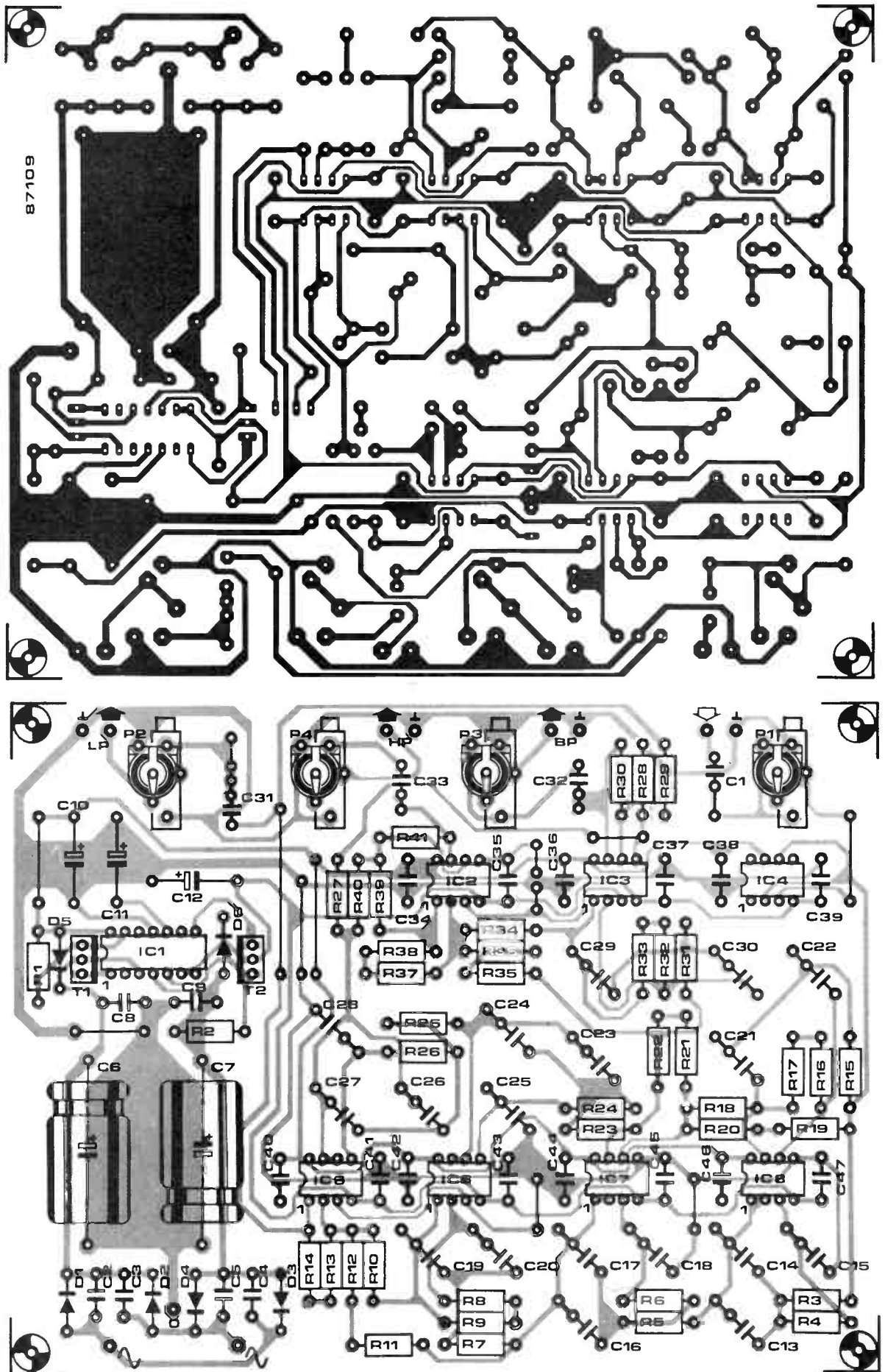


Fig. 5. Printed circuit board of the phase-linear filter.

ceptable number of components) to simulate any phase behaviour with the aid of a delay circuit.

All-pass networks have some interesting properties:

- (a) they cause a phase shift, but no signal attenuation over a given frequency range;
- (b) the phase shift caused by them is twice as large as that caused by a filter of the same order.

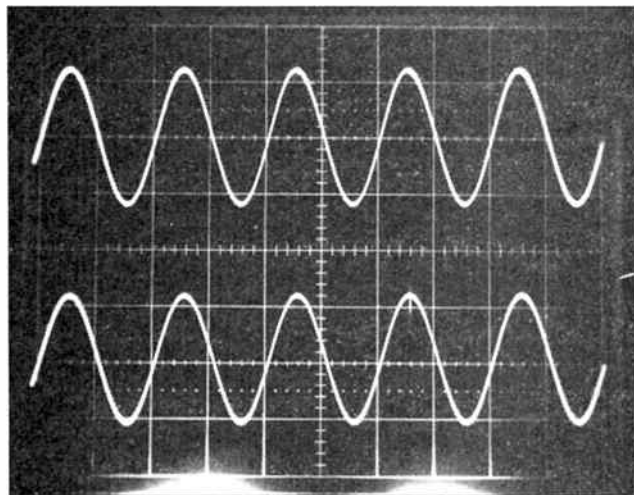
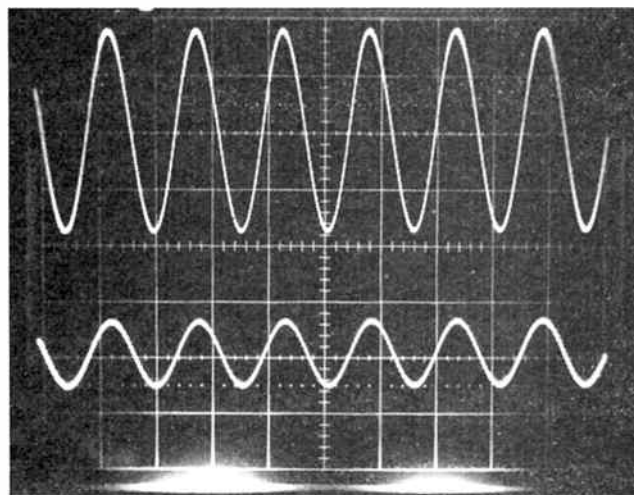
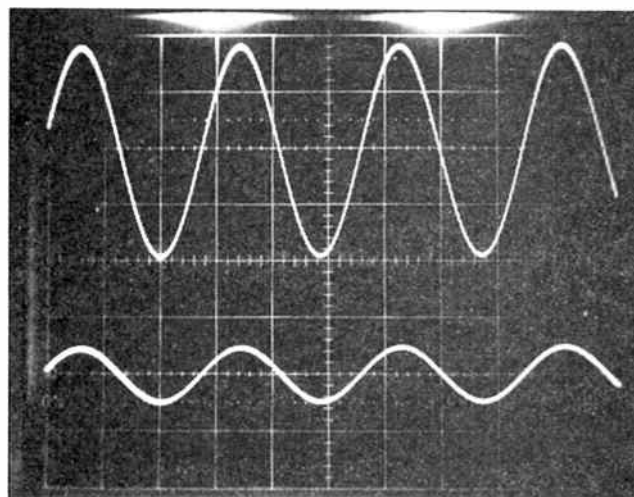
From this, it is evident that the low-pass section should be an even-order type, i.e., second-, fourth- or sixth-order. In the present network fourth-order filters are used, since these give a sufficiently steep roll-off and do not unnecessarily complicate the circuit.

Like all fourth-order networks, the present consists of a cascade of two second-order filters. For the present purposes, these should be identical to ensure that the phase behaviour of the all-pass network will be the same as that of the filter.

It was found that the Linkwitz-Riley (Squared Butterworth) filter is eminently suitable for the present network, because it allows a fairly simple all-pass to be designed with only two opamps. The resulting circuit has exactly the same phase behaviour as a fourth-order Linkwitz low-pass filter. Note that the cross-over frequencies are -6 dB points (as in all Linkwitz filters), since there is no phase shift between the two channels. The relative amplitude vs frequency characteristic is given in Fig. 3, while the three photographs illustrate the typical performance of the network. The photographs show the output voltage at the low- and middle-frequency terminals (a) slightly below the cross-over point, (b) at the cross-over point, and (c) slightly above the cross-over point. No phase differences between the two signals are discernible anywhere.

Circuit description

In the circuit diagram of Fig. 4, opamp A_1 is used as a buffer between the input signal and the filter proper. If necessary, the input signal may be attenuated by P_1 ; the total amplification of the network is unity. The low-pass filter is con-



structed around A_2 and A_3 , while the associated all-pass filter is based on A_6 and A_7 . The attenuation due to band-pass filter A_6 is compensated by A_7 . The low-pass section for the middle frequencies consists of A_8 and A_9 . Here, two identical all-pass filters are required, and these are formed by A_4 - A_5 in the low section and by A_{11} - A_{12} in the high section. That completes the low-pass filter.

For the middle-frequency section, the output signal of A_5 must be subtracted from that of A_9 , which is effected by A_{10} . Finally, the output signal of A_9 is subtracted once more from that of A_{12} , which is done by A_{13} . That completes the high-pass function.

The three outputs of the network are taken to preset potentiometers that enable matching

Parts list

Resistors:

$R_1, R_2 = 1K5J$
 R_3 to R_6 ; R_{15} to R_{17} ; R_{23} to R_{26} ;
 R_{31} to $R_{33} = 22K5F$
 R_{10} to R_{14} ; R_{18} to R_{22} ; R_{27} to R_{30} ;
 R_{34} to $R_{41} = 10KF$
 $P_1 = 47KJ$ cermet preset
 P_2 to $P_4 = 25KJ$ cermet preset

Capacitors:

$C_1 = 1\mu 0$ plastic film
 C_2 to $C_5 = 22n$ ceramic
 $C_6, C_7 = 1000\mu$; 25 V electrolytic
 C_8, C_9, C_{34} to $C_{47} = 100n$ ceramic
 C_{10} to $C_{12} = 10\mu$; 25 V electrolytic
 C_{13} to C_{19} ; C_{21} ; $C_{22} = 10n$; 2.5% polypropylene
 C_{19} ; C_{20} ; C_{23} to $C_{30} = 1n0$; 2.5% polypropylene
 $C_{31} = 2\mu 2$ plastic film
 C_{32} ; $C_{33} = 470n$ plastic film

Semiconductors:

D_1 to $D_6 = 1N4001$
 $T_1 = BD139$
 $T_2 = BD140$
 $IC_1 = LM325$
 IC_2 ; IC_3 ; IC_5 to $IC_8 = TL072$;
 NE5532; LF353; LM833, OP215
 $IC_4 = TL071$; NE5534; LF356;
 OP27; OP15

each of them to the efficiency of the associated loudspeaker. The quality of the power supply matches that of the cross-over network itself. Circuit IC_1 is a voltage regulator, which, in conjunction with two external series transistors, provides symmetrical output voltages. Diodes D_5 and D_6 ensure that the regulator is not damaged at switch-off.

Construction

The network is most conveniently constructed on the ready-made PCB Type 87109 shown in Fig. 5. The values of the components given in the parts list pertain to cross-over frequencies of 500 Hz and 5,000 Hz. Different frequencies may be calculated with the aid of the Linkwitz formulas in Ref. 4.

In several places, capacitors are shown in parallel and resistors in series: this is done to enable the use of as many components of the same value as possible. As usual, the choice of capacitors is determined mainly by their loss factor and cost, which

normally results in plastic film types.

It should be noted that each PCB has its own regulator IC: this is convenient where the network is fitted in the loudspeaker enclosure.

The impedance at the network outputs, depending on the position of the presets, has a maximum value of 12 kilohm. Since this may be on the high side for certain output stages, the value of the presets may be reduced to 5 kilohm, which results in a maximum output impedance of 2.5 kilohm. Where this is done, the value of C_{31} should be increased to $4\mu\text{F}$. A useful rule of thumb is that the input im-

pedance of the output stage must be at least ten times as large as the output impedance of the network.

The PCB may be used to construct a two-way network, in which case the following components are omitted: IC₂; IC₅; IC₆; R₇ to R₁₄; R₂₃ to R₂₆; R₃₁ to R₄₁; C₁₉; C₂₀; C₂₃ to C₃₀; C₃₃; P₄. Furthermore, a wire link should be fitted between pin 1 of A₃ and another between pin 7 of A₇ and C₃₂.

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over Networks of High Slope Derived by Time Delay (Journal of the Audio Engineering Society, Jan. & Feb. 1983).

2. S. Lipshitz and J. Vanderkooy, *Is Phase Linearization of Loudspeaker Cross-over Networks Possible by Time Off-set and Equalization?* (JAES, Dec. 1984)

3. S. Lipshitz and J. Vanderkooy, *Use of Frequency Overlap and Equalization to Produce High-slope Linear-phase Loudspeaker Cross-over Networks*, (JAES, March 1985)

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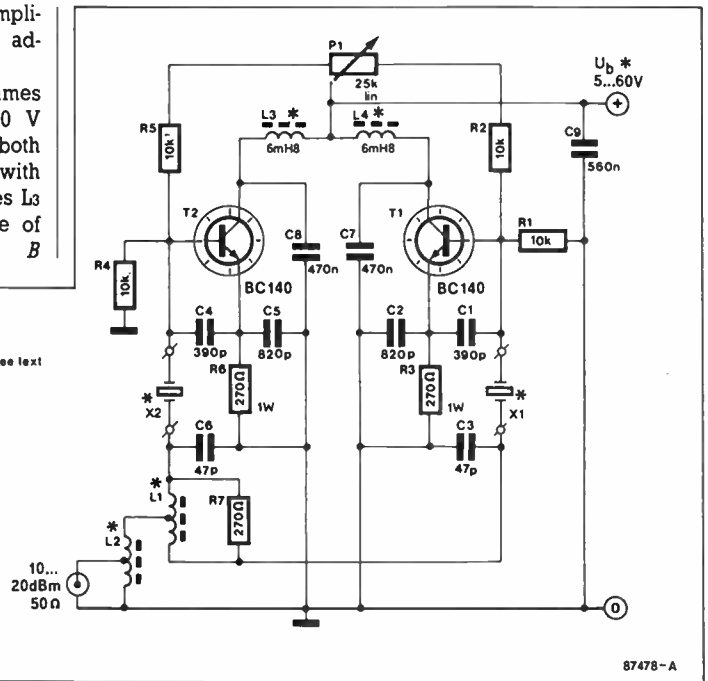
TWO-TONE RF TEST OSCILLATOR

This test oscillator is useful to ensure optimum operation of RF amplifier stages designed to work on the short-wave bands. Based on two crystal oscillators, it provides considerable output power (10 to 100 mW) to enable measuring intermodulation characteristics of high level and RF power stages. The quartz crystals used here not only serve as the frequency determining elements (2...20 MHz), but also as output filters to prevent one generated signal being lost in the other oscillator. With this in mind, tapped inductors L_1 and L_2 ensure freedom of mutual interference when the oscillator is used for frequencies higher than 10 MHz. Both inductors are wound as 12 turns of enamelled copper wire with a centre tap, on either a small balun or a suitably rated core with an air

gap. Outputs of equal amplitude can be obtained by adjusting P1.

The test oscillator consumes about 250 mA from a 60 V supply. This means that both transistors should be fitted with a heat-sink, and that chokes L_3 and L_4 should be capable of carrying about 150 mA. B

* see text



CORRECTIONS

Headphone amplifier

The Parts list should be amended as follows: $R_6 = 2R7$.

Printed Resistors

The unit of resistivity is $\Omega\text{mm}^2/\text{m}$, not $\Omega/\text{mm}^2/\text{m}$.

Rack mount cabinets from David Reid

David Reid Electronics are stocking the range of quality rack mount cabinets from Altronic. Included in the range is the innovative "high energy" rack case in which the side panels are constructed from specially extruded heatsink sections.

This chassis would be ideal for high power amplifiers or big power supplies. Each heatsink will accommodate an audio output stage of approximately 120 W with normal efficiency and dissipation.

The design of the "high energy" rack case also allows the straightforward mounting of computer type fans inside the back panel, adjacent to each heatsink. This will provide adequate cooling for very high power equipment.

Also in the Altronic range available from David Reid are the one-unit (44 mm) and two-unit (88 mm) rack boxes. These are available with either black anodised or natural finish aluminium front panels and importantly, conform to the International rack sizing standard.

The "high energy" rack case retails for \$89.00 which is very appealing considering the price some places charge just for heatsinks similar to those incorporated in the design. The one unit rack case costs \$59.95 and the two unit model costs \$69.95.

If you are contemplating building some high power gear and are looking for a professional finish and efficient stacking method, call in at David Reid Electronics, 127 York Street, Sydney and take a look at the Altronic range of rack mount cabinets.

Super feedthrough

All Electronic Components of Melbourne have available some gold plated, stud mount, 1000 pF (1n) feedthrough capacitors from the respected British manufacturers, Cambion.

These capacitors are ideal for passing signals or voltages in

and out of "RF tight" enclosures. The capacitor can be mounted through a suitable panel and secured in place with the plated nut and lock washer. This mounting style is especially useful for feeding power to externally mounted preamps and lend an appearance of real quality to any RF project.

Although All Electronic Components has good stocks of the capacitors, this is a one-time offer at the special price of \$4.50 each. If you would like the best available feedthroughs for that "special" project, contact: All Electronic Components, 118-122 Lonsdale Street, Melbourne 3000, Vic. Telephone (03)662 3506.

All Electronic components also carry a comprehensive range of passive components, power devices, semiconductors, inductors and valves. Mail orders are welcomed, just write to the address above.

High quality, high value electrolytics

Jaycar Electronics has stocks of genuine Roederstein brand electrolytic capacitors. These are long life, high ripple current, etched electrode types fitted with screw terminals.

These prime quality components are ideal for power supplies in high performance amplifiers and other applications when only the "best" will do.

The capacitors are 6800 uF/63 V and measure 50 mm diameter and 80 mm high. Termination is by 5 mm screws and the capacitors conform electrically to the DIN 41332 standard. Tolerance is -10% to +50%.

See your nearest Jaycar store or dealer for more information.



Altronic's new headquarters is located at 174 Roe, Perth, right on the edge of Perth's central business district, across the railway line from the Entertainment Centre. It houses their retail store, warehouse and administrative operations and features off-street customer parking. The building is all-white with prominent columns at the front, giving rise to its local nickname of the "Taj Mahal".

Dual JFETs for the 6000 amp.

Constructors seeking supplies of the NTE461 dual JFET specified for use in the input stage of the AEM6000 Ultra-Fidelity Power Amp can source them from a Melbourne firm.

Stewart Electronic Components in the southeast suburb of

Huntingdale are the importers and they maintain stocks which can be purchased in "one-offs" over the counter.

Stewart Electronic Components' store is located at 44 Stafford St, Huntingdale 3166. Interstate residents can write to PO Box 281, Oakleigh 3166. Phone enquiries on (03)543 3733.

PROJECT BUYERS GUIDE

This month's feature project, the AEM3506 Satellite Data Decoder, employs components which are generally readily obtainable. Kits are being stocked by Jaycar (stores in Sydney, Brisbane and Melbourne) and one or two other suppliers may kit-up for it shortly, we believe. The XR211 is widely available from many electronics retailers, but the MAX231, less so. If you're assembling the project components yourself, try Geoff Wood Electronics in Sydney for the ICs, or Force Electronics in Adelaide. Jaycar carries the XR2211 as a stock line and we understand they may make the MAX231 a stock line, also. Printed circuit boards should shortly become available through All Electronic Components in Melbourne and Force Electronics in Adelaide.

The Star Project this month is from Dick Smith Electronics who will be stocking both full kits and "short form" kits, the latter being easier on the personal cash flow. Just order a short form kit through your local Dick Smith store and pick it up when it comes in a week or so later.

The 6006 Servo-Feedback Adaptor uses off-the-shelf components so you should have no trouble sourcing parts. Printed circuit boards, as for the AEM3506, should shortly become available through All Electronic Components in Melbourne and Force Electronics in Adelaide.

For those seeking to build the C64 Battery Backed RAM from this month's Elektor section, components will be easy to source as the 6264 RAM chips are quite common in most electronics retailers' inventories. For least power consumption, 74HCT00 gates are recommended, though not essential. Geoff Wood Electronics carries a range of HCT ICs.

The pc-mount 3.6 V Nicad battery is available from a few sources, but you'll need to shop around a bit to find a retailer who has one on the shelf. A variety of package styles may be accommodated on the board. RS Components stock one, cat. no. 591-477.

The Active Crossover should present few difficulties in component sourcing. The semiconductors are generally widely available, but you'll have to try some specialist retailers for the 2.5% capacitors - see Geoff Wood Electronics in Sydney or Stewart Electronic Components in Melbourne. Adelaide readers should try their nearest Force Electronics store, or Protronics.

**IT HAD
TO HAPPEN!**

BUILD-IT-YOURSELF 'AT' COMPUTER!



At last! The perfect opportunity for the hobbyist to build the perfect computer. . . Perfect because it has in it what YOU want! All the features of the "AT" - blinding speed, high expandability, and so on - but you put it together yourself - and \$ave!

There's more: each board or module comes with a full 12 month warranty PLUS individual, professionally prepared manuals - no Jingles to decipher!

And best of all, you don't have to buy it in one hit: add what you want, when you want it (and when the pocket allows it!)

Look at the features:

SUPERB QUALITY HINGED CASE

"Baby AT" case in heavy gauge steel, heavily covered in damage-resistant bone crinkle finish. The lid is hinged and locks up for instant internal access - no more undoing screws! Large enough for expansion - but features a footprint of just 430mm square! Cat X-1005

ONLY \$175

200W POWER SUPPLY

Completely pre-assembled - even to the on/off switch and input sockets! Simply slots into place in cutouts provided in case. Heavily plated steel case for minimum RFI with integral whisper-quiet fan. 200W capacity is ready for . . . anything! Cat X-1010

ONLY \$275

"BABY AT" MOTHERBOARD

Again, completely pre-assembled. No risk of dry joints - you just connect appropriate cables (as described in detailed manual included). On-board capacity for 1Mb RAM and 7 slots for expansion in true "AT" format. Offers 6, 8, 10 & 12MHz speed (switch & software selectable) giving outstanding software compatibility PLUS blinding speed when you need it, and time & date memory with battery back-up. Cat X-1000

JUST \$995

PLUG-IN CARDS

Cards for the various graphic standards, printer ports, serial ports, etc etc. Choose the one that suits your requirements - and remember, you can always upgrade later!

CGA plus Parallel Printer Card Cat X-2010 \$129

MGA plus Parallel Printer Card Cat X-8141 \$149

EGA Card with Hercules compatibility Cat X-2013 \$399

Serial/Parallel/Game Card Cat X-2012 \$139

DISK CONTROLLERS

Your choice of hard/floppy or floppy disk controller card: choose the one that suits your needs best. Both plug in to motherboard.

Floppy Controller (up to 4 1.2Mb or 360Kb) Cat X-2014 \$129

Hard/Floppy Controller (2 of each) Cat X-2008 \$399

DISK DRIVES

Also include appropriate cables.

1.2Mb Floppy Disk Drive Cat X-2014 \$269

20Mb Hard Disk Drive Cat X-2201 \$795

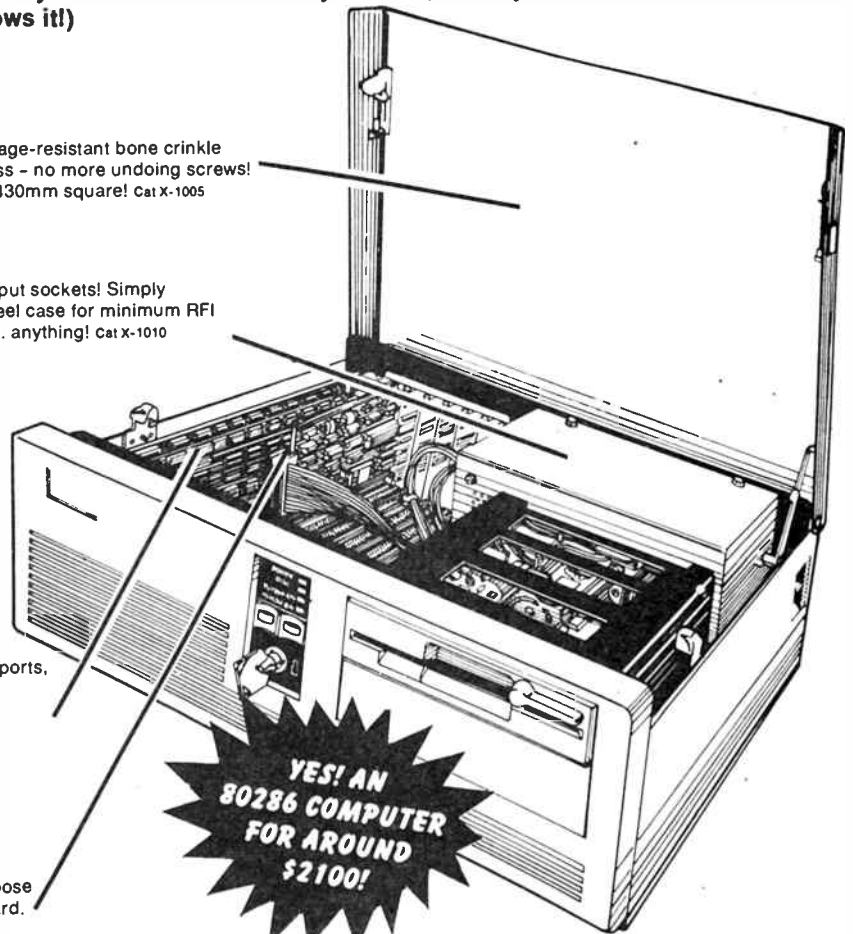
(Other higher capacity Hard Disks available if required)

KEYBOARDS

Two types available:

84 Keys with top quality "Alps" keyswitches Cat X-3820 \$129.00

101 Keys - with numeric keypad Cat X-3821 \$149.00



WHERE ELSE BUT

**DICK SMITH
ELECTRONICS**

PTY LTD

DSEB450/RT1087

Do it yourself

Heathkit®

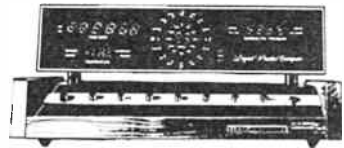
Robotics Trainer!

Build yourself the most advanced robot kit available! With Hero Jr you'll get first hand experience in the fascinating world of robots. He's used as a trainer in many institutions around the world. Program Hero with his own keypad or with your home computer. He'll remember dates, wake you in the morning, he can even be linked to your security system! Cat G-1005

\$1395



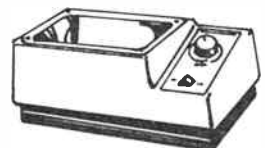
Computerized Weather Station



From the most respected kit builders in the world, comes the most advanced computer weather station! Features digital clock/4 year calendar, 4 digit accuracy, barometer, thermometer, wind vector, memory and more!
Cat G-2000

ONLY \$999

Ultrasonic Cleaning Bath!



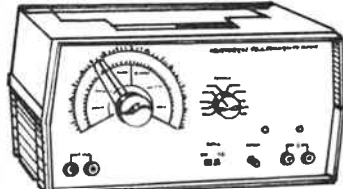
Ideal for jewellery, coins, components... almost anything! Cleans ultrasonically — without rubbing or scratching. 150mm x 100mm tray. Uses ordinary soap or softener. Cat G-2010

\$299 Needs external 110V transformer

RF Generator

Hobbyist or technician you won't find better quality! Modulated and unmodulated signals from 310kHz to 110MHz with calibrated harmonics to 220MHz. Cat G-4005

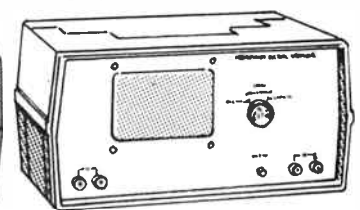
\$199



Signal Tracer Kit

Save a heap of time on repairs! The signal tracer kit will check RF, IF, even audio circuitry quickly and easily. Ideal for any workbench! Cat G-4015

\$189⁹⁵



DSE MAKES DOING IT YOURSELF — EASY!



DSE Metric Clock

Stay one step ahead! Metric time isn't far away so you'd better get used to it now. This brilliant kit gives highly accurate time with a large LED display. That's right!... a metric day is only ten metric hours long.
Cat K-3000

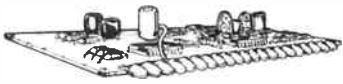
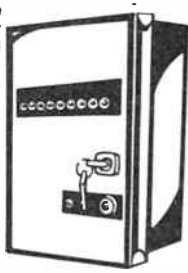
\$59⁹⁵

4 Sector Home Security

Where else could you get 4 sector security at this ridiculous price? It's a bare bones controller but it's packed with features. Complete with on-board pcb connectors and instructions!
Cat K-3254

Value Plus! \$29⁹⁵

Short Form Kit Case not supplied



LED Tacho

Build your own LED Tacho. Displays engine speed with a row of LED's. Full instructions included. Watch the revs and get more life from your car!
Cat K-3240

\$26⁹⁵

RF Attenuator

Any amateur will know how valuable an attenuator is and how expensive they normally are. Build it yourself and save! 0 to 63dB attenuation from 50 to 500MHz.
Cat K-6323

\$37⁹⁵



Optical Motion Detector

Perfect as part of your alarm system or as a door minder etc. An optical IC detects movement by changes in light level. Self contained and battery operated!
Cat K-2721

\$29⁹⁵



Zener Diode Tester

Can't make out the markings on those diodes? Well, here's the answer! The Zener Diode Tester gives direct readout of Zener voltage of 400mW and 1W Zeners from 3.3 to 50 volts (2 ranges). Cat K-3051

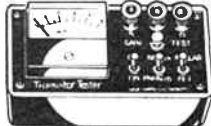
\$29⁹⁵



Fault Finding in a Flash

This low cost Transistor Tester Kit tests bipolar transistors, diodes, F.E.T.'s — even S.C.R.'s and P.U.T.'s. Simple enough to be built by a beginner!
Cat K-3052

\$26⁹⁵



Accurate LCD Panel Meter

A versatile accurate panel meter with large LCD display. Ideal as a readout device on many projects for amateurs or professionals! PCB design allows for maximum flexibility. Cat K-3450

\$49⁹⁵

3 1/2 digit



DICK SMITH ELECTRONICS

PTY LTD

Get it up!

For the best picture — Quality antennas from DSE.

Perfect for Fringe Areas
Get The Picture



\$79⁹⁵

Super Band 5 UHF for a great picture in fringe areas. 16 elements with 15 element reflector for minimum ghosting, maximum gain! Easy to install and great value! Cat L-4045

Ghost Buster!



\$99 **No Fuzz**

Picture a little fuzzy? Do you live too close to a signal source? The incredible Ghost Buster UHF (Band 4)/VHF antenna features a ghost cancelling box which will clean up that picture — once and for all! Cat L-4023

For the Country Estate



The Phase Array VHF Antenna is ideal for country areas! Receives signal over 100km from transmission source. You can have the full choice of stations! Easy to install... you can do it yourself! Cat L-4025

ONLY \$99

3 Element FM **\$34⁹⁵**



For top performance from your FM tuner! Try to find better value than this for a quality FM antenna — don't waste too much time though. Easy to erect with 300 ohms impedance. The reception will amaze you! Cat L-4064

UHF Band 4 Perfect for SBS 28! With Reflector!



\$49⁹⁵

Ideal for coupling with your existing VHF antenna — especially if SBS Channel 28 reception is poor. Saves buying an expensive combined model! Lightweight, easy to install and quality construction. Cat L-4040

For Boat, Camper, Caravan, etc!



\$49⁹⁵

Here's the go! Superb TV/FM antenna ready for the holiday! Comes with 'gutter gripper' bracket, mini mast and 7 metres of 300 ohm ribbon. Cat L-4026

Indoor or Out! **75 Ohm 2-way Splitter**



Need to run two devices off one antenna? Here's the inexpensive way to do it! Designed for indoor use it covers 50-890MHz. Cat L-4472

Matches 75 ohm coaxial cable to the 300 ohm ribbon terminals on you TV, tuner or antenna. Weather resistant for either indoor or outdoor use. Comes complete with coaxial plug connector! Cat L-4465

\$4³⁵ **\$5⁴⁵**

4-way 75 Ohm Splitter



Run up to 4 sets (when using 75 ohm cable) from one antenna! Quality plastic box with snap lid and nickel plated screw terminals for easy connection. Cat L-4474

Value \$7⁷⁵

Universal Balun

Can be used for either 300 ohm ribbon cable or 75 ohm coaxial cable! Use it any-which-way. Ideal if you don't know which type to use! Cat L-4456

The Picture Fixer



Is the signal lousy and your picture about the same? The DSE Mast Head Amplifier could easily put an end to the problem. Won't help clean up the rubbish but it's perfect for a weak signal. Comes with amplifier box and power supply! Cat L-4200

Great! \$75

This Is A Hold Up! **Chimney Mount**



No, it's not the sort of thing that Santa is after — unless his antenna's falling down! Double arm with single strap is easy to mount on most chimneys. Complete mast mount assembly. Cat L-4154

\$11⁹⁵ **\$18⁹⁵**

Barge Board Mount



Quality galvanised construction it's designed to mount any antenna from a vertical surface — barge board, chimney, wall, etc! 139cm long. Cat L-4150

Super Saver Cables!

<p>300 Ohm Flat Ribbon</p> <p>Low loss 300 ohm ribbon for good reception areas! Cat W-2070</p> <p>30¢ pm!</p>	<p>75 Ohm Coaxial Cable</p> <p>Ultra-low-loss air dielectric 5C-2V. Ideal for long runs where minimum loss is required. Cat W-2082</p> <p>50¢ pm</p>	<p>75 Ohm Cable Set</p> <p>2 metres of quality 75 ohm coax fitted with TV coax plugs. Ideal for units, flats, etc! Cat L-4506</p> <p>\$440</p>
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SUPER SAVER!
Indoor UHF/VHF Diplexer



Got both UHF and VHF antennas but only one TV antenna input? Now the problem's solved! The indoor UHF/VHF Diplexer accepts lead-ins from both antennas and successfully combines them. Cat L-4470

\$4⁹⁵

DICK SMITH ELECTRONICS



PTY LTD

WHICH SWITCH?

Toggle Switches

Ultra Miniature DPDT

The contact rating to size ratio is very high with this miniature toggle switch. Ideal for models, miniature portable instruments, or any use where a high quality miniature switch is required. Cat S-1245

\$350

1.5A 240V



SPDT

Body 8mm x 13mm, clearance 17mm. Cat S-1173

\$465

2A 240V



DPDT

Body 13mm x 13mm, clearance 17.5mm. Cat S-1174

\$480



4PDT

Body 13mm x 21.5mm, clearance 20.5mm. Cat S-1175

\$595

2A 240V



Heavy Duty DPDT

Amazing contact capacity! Although this switch is miniature in size, it offers an enormous contact to size ratio. Ideal for use where high power levels are involved and small size is of prime importance. Cat S-1168

\$375

10A 125V



Right Angle PCB Mounting

With extended right angle lugs for soldering direct to pcb. No mounting nuts required (there's no thread anyway!) Cat S-1180

\$250



Standard DPDT

Same general features as SPST Cat S-1215. Cat S-1216

\$225

1.5A 240V



PCB Mounting Push Button

Has right angle legs for pcb mounting through panel. 120V AC. Cat S-1253

\$295



Waterproof Toggle

Fully sealed SPST toggle for low voltage applications. Toggle has rubber boot to ensure complete waterproofing. Ideal for marine use and other hostile environments. Cat S-1195

10A 12VDC **\$765**



Standard DPDT Centre Off

Rugged bakelite case, chrome toggle, red and black On/Off/On indicator plate and heavy duty solder lug terminals. This switch features heavy duty contact rating. Makes ideal motor reversing switch eg electric aerial on cars. Cat S-1217

\$250

1.5A 240V



Piano Key DPDT

Ideal for audio and electronic projects. Superbly engineered and has a white toggle. Cat S-1393

\$350



Illuminated SPST (12V)

Intended for automotive use. The soft glow from the toggle is not distracting, but means the switch can quickly be located. 12V lamp operates from supply being switched. Cat S-1214

\$395

16A 12VDC



1987 ARRL Handbook

All the updates on basic and advanced information, theory and a fascinating section on satellites.

Cat B-2220
WAS \$49.94
\$39⁹⁵

UHF/VHF Manual

This huge hard covered manual deals with the techniques and equipment applicable to frequencies above 30MHz with particular emphasis on microwaves. Cat B-2054

\$39⁹⁵

Encyclopedia of Electronic Circuits

This comprehensive reference book is the A-Z of electronic circuits: It will save you valuable time searching for a particular circuit, plus eliminates all guess work in deciding whether 'that' circuit will meet your requirements.

Cat B-1760

\$59⁹⁵

Basic Electronics Theory

With projects and experiments. Starts with very basic principles and ends with computers — with just about all aspects of electronics in between. Ideal reference work for tech, school students, etc. Cat B-1615

\$27⁴⁵



Line Switch

High impact plastic moulded switch for insertion in any cord for remote on/off. Ideal for putting on/off switch in a floor standing lamp. Cat P-5515

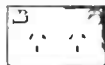
\$595



Double Power Point 10A Rating

Replace old single outlets with a double: much more convenient. Cat P-5560

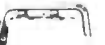
\$1150



Wall Board Clip

Can be mounted from the front. Mount power outlets, switch plates, on any cavity wall (other than brick) without the need for a mounting block. Cat P-5530

99¢



Blank Plate

Same size as power point, but blank: ideal for gap-filling when you move points, switches etc. Cat P-5535

\$499



Em-Bezel Away!

Miniature LED Bezel

Low current drain (20mA @ 2 volts) but offering high visibility. Smart chrome bezel, needs a 7mm hole. Red Cat S-3528
RGreen Cat S-3529

\$420



12V Bezel

A very attractive medium size bezel using a 12V LES bulb. The body of the bezel is chrome plated. Requires an 11mm mounting hole, and obviously 12 volts AC or DC. Red Cat S-3510
RGreen Cat S-3512

\$165



Dual Colour LED Bezel

Two LEDs in one bezel — ideal for two-state indication (on/off, etc.). Operates on 1.3-1.5V @ 25-30mA. Cat S-3530

\$460



240V Neon Bezel

Intended for 240 volt projects, this bezel can be wired direct to the mains. It has a series resistor actually mounted inside the bezel case. Cat S-3550

\$425



Miniature Neon Bezel

A favourite because of its tiny size. Requires only 7mm mounting hole, and the bezel itself is chrome-coloured. Cat S-3552

\$160



DICK SMITH ELECTRONICS

PTY LTD

IC Sockets

18 Pin DIL Socket 35¢
Cat P-4180 10 up 30¢
28 Pin DIL Socket 50¢
Cat P-4245 10 up 45¢
14 w/wrap Pin DIL Socket \$1.70
Cat P-4260 10 up \$1.80
14 Pin DIL Socket 25¢
Cat P-4140 10 up 20¢



16 Pin DIL Socket 30¢
Cat P-4160 10 up 25¢
24 Pin w/wrap DIL Socket \$2.99
Cat P-4268 10 up \$2.70
20 Pin w/wrap DIL Socket \$2.49
Cat P-4264 10 up \$2.25

Architrave Switch

Standard architrave switch — can be used to replace old, worn out units in your home. Positive action switching. Cat P-5570

\$455



Standard Mounting Box

Mount power points, plates, etc. on any surface including brick. Cat P-5531

\$199



Extension Cord

3 core cable already fitted with plug and socket. 7.5A rating.

5m: Cat P-5595 **\$6.25**
10m: Cat P-5600 **\$9.45**
30m: Cat P-5605 **\$33.95**



DSE Zippy Boxes

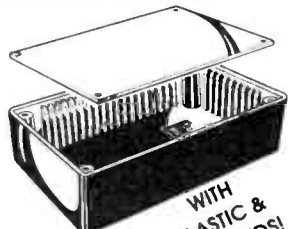
There is only one genuine 'Zippy' box — the one with the all round deep ribbing. Don't be fooled by inferior copies — this is the one used by the major electronics magazines because of its versatility. Insist on the one and only — genuine — Zippy Box which comes complete with both aluminium and plastic lids.

Small — UB5 (28 x 54 x 83cm)
Cat H-2855 **\$230**
10 up **\$2.05**

Medium — UB3 (41 x 68 x 130cm)
Cat H-2853 **\$315**
10 up **\$2.80**

Large — UB1 (50 x 90 x 150cm)
Cat H-2851 **\$380**
10 up **\$3.45**

Giant — UB2 (60 x 113 x 196cm) Cat H-2852 10 up **\$4.70** **\$525**



WITH PLASTIC & METAL LIDS!

You can't refuse

Fuses

Wide range of fuses in both popular styles: M-205 mini (approx. 20 x 5mm) and the popular 3AG (approx. 32 x 6mm). Remember, the lower the current rating of the fuse you use, the greater the protection afforded. All fuses 'fast blow' type for greatest protection.

3AG TYPE

100mA Cat S-4449 1.5A Cat S-4465 15A Cat S-4477
150mA Cat S-4451 2A Cat S-4467 20A Cat S-4479
250mA Cat S-4453 3A Cat S-4469 25A Cat S-4481
350mA Cat S-4455 5A Cat S-4471 30A Cat S-4485
500mA Cat S-4457 7.5A Cat S-4473 35A Cat S-4487
1A Cat S-4461 10A Cat S-4475

M-205 TYPE

250mA Cat S-4412 1A Cat S-4421 **25¢**
500mA Cat S-4415 2A Cat S-4423
5A Cat S-4425 10 up 32¢

Slo Blo Fuses

M-205 TYPE

250mA Cat S-4300 250mA Cat S-4350 **90¢**
310mA Cat S-4305 500mA Cat S-4355
500mA Cat S-4310 1 AMP Cat S-4360 10 up 85¢
1 AMP Cat S-4350 2 AMP Cat S-4365
2 AMP Cat S-4320 5 AMP Cat S-4370

3AG TYPE

250mA Cat S-4300 250mA Cat S-4350 **90¢**
310mA Cat S-4305 500mA Cat S-4355
500mA Cat S-4310 1 AMP Cat S-4360 10 up 85¢
1 AMP Cat S-4350 2 AMP Cat S-4365
2 AMP Cat S-4320 5 AMP Cat S-4370

Auto Blade Fuses

5 AMP Cat S-4505 20 AMP Cat S-4520 **50¢**
7.5 AMP Cat S-4507 25 AMP Cat S-4525
10 AMP Cat S-4510 30 AMP Cat S-4530
15 AMP Cat S-4515 10 up 45¢

Australian Radio Frequency Handbook

This is the second edition of this best selling introduction to scanning! This edition has been updated and contains hundreds of NEW frequency listings.

B-9600

\$6.95

Australian Marine Radio Handbook

This book will help boat owners find out just how simple choosing, fitting and using a marine radio can be. Cat B-9604

\$6.95

Australian CB Radio Handbook

A complete guide to CB Radio including latest marine radio service detail. How to conduct yourself on air. The latest edition includes the new regulations and channel allocations. Cat B-2325

\$6.95

Electronics Notebook Vol 3

The latest in the series. You've benefited by the information in the first two: now keep right up-to-date. Cat B-3634

\$3.25

Hobbyists . . . experimenters . . . bargain hunters . . .

Announcing a great new "seconds" centre at DSE!

Demo models . . . stock repairs . . . samples . . . etc. — all at discount prices at DSE's new Seconds Centre at our Chullora (Sydney) store. Most items have normal DSE 90 day warranty!

PLUS!!! Hobbyist's Junk Bins — full of economically unrepairable items, broken samples, etc. etc. — so popular for parts, bits'n'pieces — even to try repairing yourself! (Obviously, no warranty or repairs offered on items from junk bins).

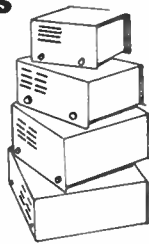
Only at DSE Chullora Store!

Pieces



Metal Cabinets

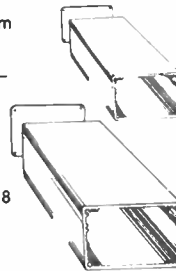
Beautifully made cabinets to suit a huge variety of projects, especially those with meters, control, etc. which need to be mounted on the front panel. They consist of an aluminium base, slots, and self-tapping screws complete with cup washers. All-in-all a case you'd be proud to put your prestige projects into. They come in an attractive two-tone finish.



10 up **\$5.50**
150 x 76 x 134mm
Cat H-2743 **\$7.65 each**,
10 up **\$6.55**
185 x 70 x 160mm
Cat H-2744 **\$8.90 each**,
10 up **\$7.55**

Aluminium Cases

Superb range of cases based on a specially made 18 gauge aluminium extrusion giving cases which are ultra strong, ultra reliable. The extrusion measures 76 x 102mm — and is available in three different lengths. Internally, there are four slots for insertion of pcb's without use of screws (pcb width 92 or 71mm). End plates fasten into corners of extrusion with PK screws. Includes 2 end plates and 8 screws.



76mm length Cat H-2420 **\$10.95**
102mm length Cat H-2425 **\$12.95**
153mm length Cat H-2430 **\$14.95**

Plastic Instrument Cases

This precision instrument case, exclusive to Dick Smith Electronics has a unique snap together design — no screws required. With front and back panels included this case is ideal for small projects. Cat H-2503

A superb case for all 'instrument' type projects, and many more. Case splits apart for ease of working, comes complete with 4 rubber feet and assembly screws. Cat H-2505

95 x 45 x 145mm 200 x 65 x 160mm

\$12.55

10 up **\$11.55**



\$16.95

10 up **\$15.25**

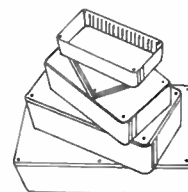


Semi Savings!

Cat No.	Description	Was	Now
R-7040	Capacitor Pack Polyester	-	12.60
R-7050	Capacitor Pack Ceramic	-	6.25
Z-1604	BF184 NPN Transistor	1.71	.99
Z-2072	2N3460 N-CH Fet	.25	.20
Z-2130	2N3053 Gen Purp Sw	.20	.15
Z-4070	LED 5mm Circ. Red/Green	.80	.70
Z-4912	74LS11 IC Triple 3 input AND Gate	.85	.15
Z-4931	74LS31 IC Delay Line	.35	.30
Z-4992	74LS92 IC Low Schottky	1.65	1.49
Z-5010	7400K Quad 2 input NAND gate	.55	.10
Z-5011	7401K Quad 2 input NAND open cct/coll	.55	.35
Z-5015	7405 IC Hex Inverter Open cct/coll	.70	.35
Z-5018	7408 IC	.35	.25
Z-5020	7410 IC Triple 3 in NAND gate	.50	.35
Z-5023	7413 IC DL4 in NAND Schmitt Trig.	1.05	.10
Z-5024	7414 IC Hex Schmitt Trigger	.81	.70
Z-5030	7420 IC D. 4 input NAND gate	.63	.25
Z-5035	7430 IC 8 input NAND gate	.63	.40
Z-5076	7476 IC TTL	.70	.60
Z-5085	7485 IC 4 Bit Mag Comp	1.00	.85
Z-5086	7486 IC Quad Excl OR gate	.30	.25
Z-5092	7492 IC Div by 12 Cntr	.90	.25
Z-5095	7495 4 Bit L-R Shift Reg	.70	.50
Z-5263	74123 IC DL, Re-Trig. Monostable	.70	.60
Z-5267	74157 IC Quad 2 Input Mplx. R	.70	.60
Z-5298	74LS240 Octal Buf/Line Dvr	2.00	.45
Z-5300	74LS95 Oct. Dvr Tristate	3.60	.80
Z-5374	74C157 Data Selector Quad 1 of 2	4.95	1.50
Z-5378	74C221 Monostable D. Schmitt	3.85	.70
Z-5644	4044 Flip Flop R/S Quad	1.65	.70
Z-5945	74HC240 Oct. Buff/Line Dvr	3.85	.25
Z-5965	74HC373 Oct. Transparent Latch	4.95	1.00
Z-6010	CA3100 Op Amp Wideband 36DB	7.95	7.16
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Stereo Socket Cat P-1240 **\$4.40** 10 up **\$1.30**

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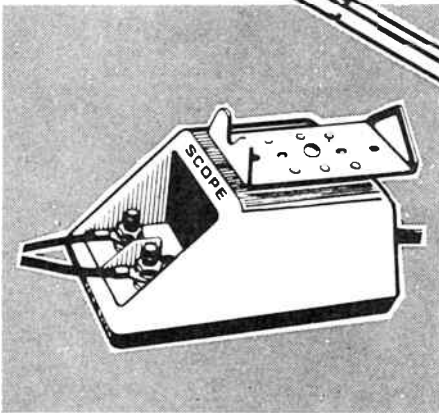
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6.5mm Socket to RCA Plug Cat P-6550 **\$1.30 (10 up \$1.15)**

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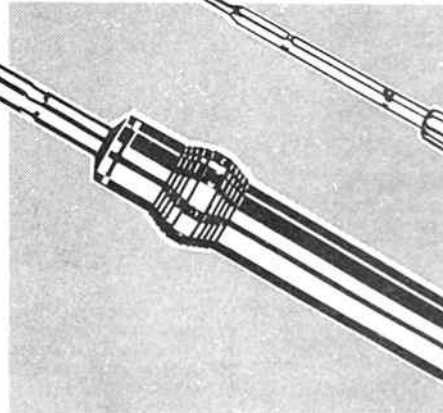


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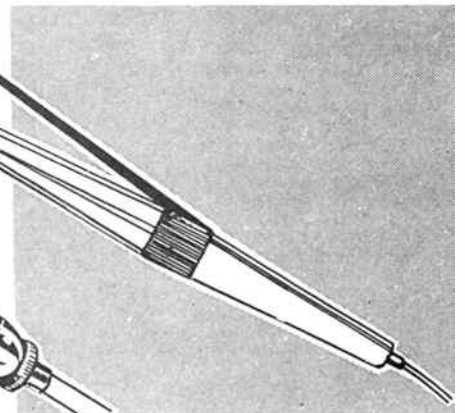
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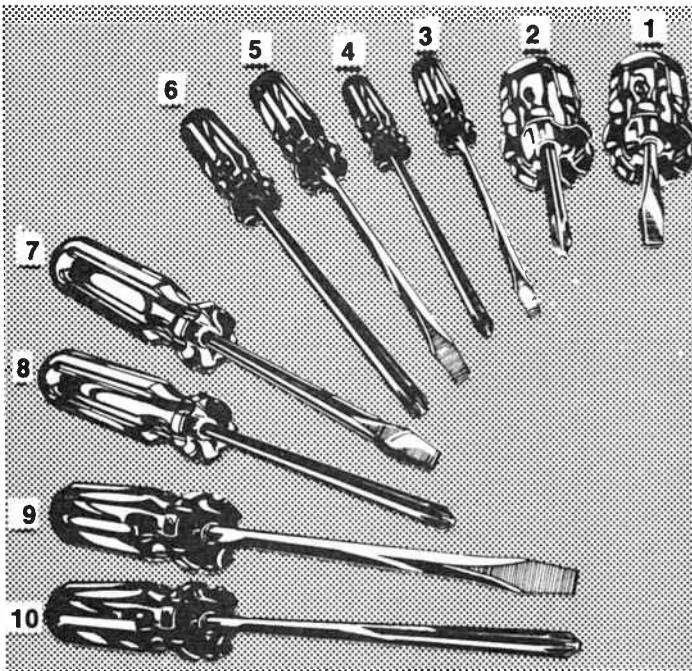
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TOOLS

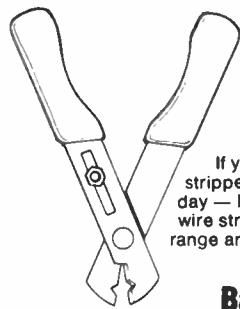
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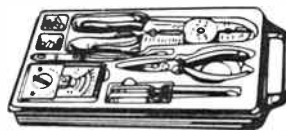
Cat No	Type	Pay Only	Cat No	Type	Pay Only
1	T-6020 Stubby-Flat head	\$1.95	6	T-6045 Popular-Phillips head	\$1.95
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3	T-6030 Standard-Flat head	\$1.95	8	T-6055 Long-Phillips head	\$1.95
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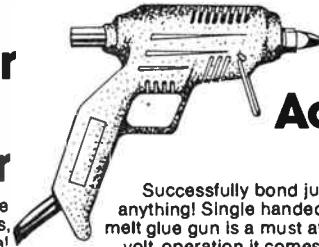


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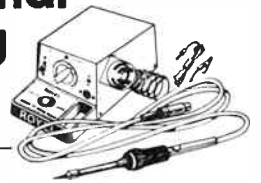
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A simple data decoder for the "Uosat" satellites

Andrew Keir VK2AAK

This project is designed to decode the telemetry and diary information from the very popular UoSat satellites, UO-9 and UO-11, which are maintained by the University of Surrey in the UK. These satellites are used by schools, educational establishments, radio amateurs and satellite enthusiasts world wide.

GETTING INVOLVED in the "space age" can be cheaper than you think! The two satellites known as Uosat 9 and Uosat 11, designed and constructed by a team at the University of Surrey, were designed so that anybody with modest, low cost equipment could exploit the "experiments" on board.

Both the satellites have a general "engineering beacon" which transmits data and telemetry using narrow-band FM compatible with amateur VHF transceivers and scanners. The format of the data from this beacon is normal ASCII using seven data bits, two stop bits and even parity so most "dumb terminal" programs used on personal computers will be able to display it. The data is transmitted using frequency-shift keying (FSK) in a format similar to the Bell 202 standard and this project describes a suitable demodulator to convert the transmitted tones to RS232 serial standard suitable for input to your computer.

The project is based around two ICs, an XR-2211 FSK decoder and a MAX231 TTL to RS232 level converter. The unit requires an external 12 V (nominal) supply which powers the XR-2211 and part of the MAX-231. A 7805 regulator is used to provide a 5 V rail for TTL level signals and the remainder of the MAX231.

Audio FSK signals from the external speaker jack of the receiver or scanner are fed into the unit via a panel mounted RCA connector and thence to the XR2211. The signals are demodulated by the XR2211 and sent as TTL levels to the MAX-231 which converts them to true RS232 levels suitable for connection to the serial port of a personal computer. A front panel switch is provided to allow inversion of the signals from the XR2211 due to the fact that the two satellites send their information in different sense.

We will commence with a description of how to construct the project and follow up with some hints on its use as well as some information on antennas and the satellites themselves.

Construction

Construction is quite straightforward using the AEM3506 pc board designed for the project. Start by mounting the resistors and capacitors, taking particular care with the orientation of the tantalum types. Do not fit resistor R10 or capacitor C8 until you have read the section on alignment, as one of the methods to be described requires pin 3 of the XR2211 to be left free. If you decide to use one of the other alignment methods, you can fit R10 and C8 now. Once the passive components have been fitted, you can continue with the semicon-

ductors. If you wish, you can use sockets for the XR2211 (IC2) and the MAX231 (IC1).

The board has been designed so that a standard "solder" type 25-pin "D" connector can be mounted on the board edge. This eliminates a lot of interconnecting wires and also serves as a convenient method for mounting the completed board in a suitable case. Take care when mounting the socket to ensure you have it the right way around and lined up with the "fingers" on the pc board.

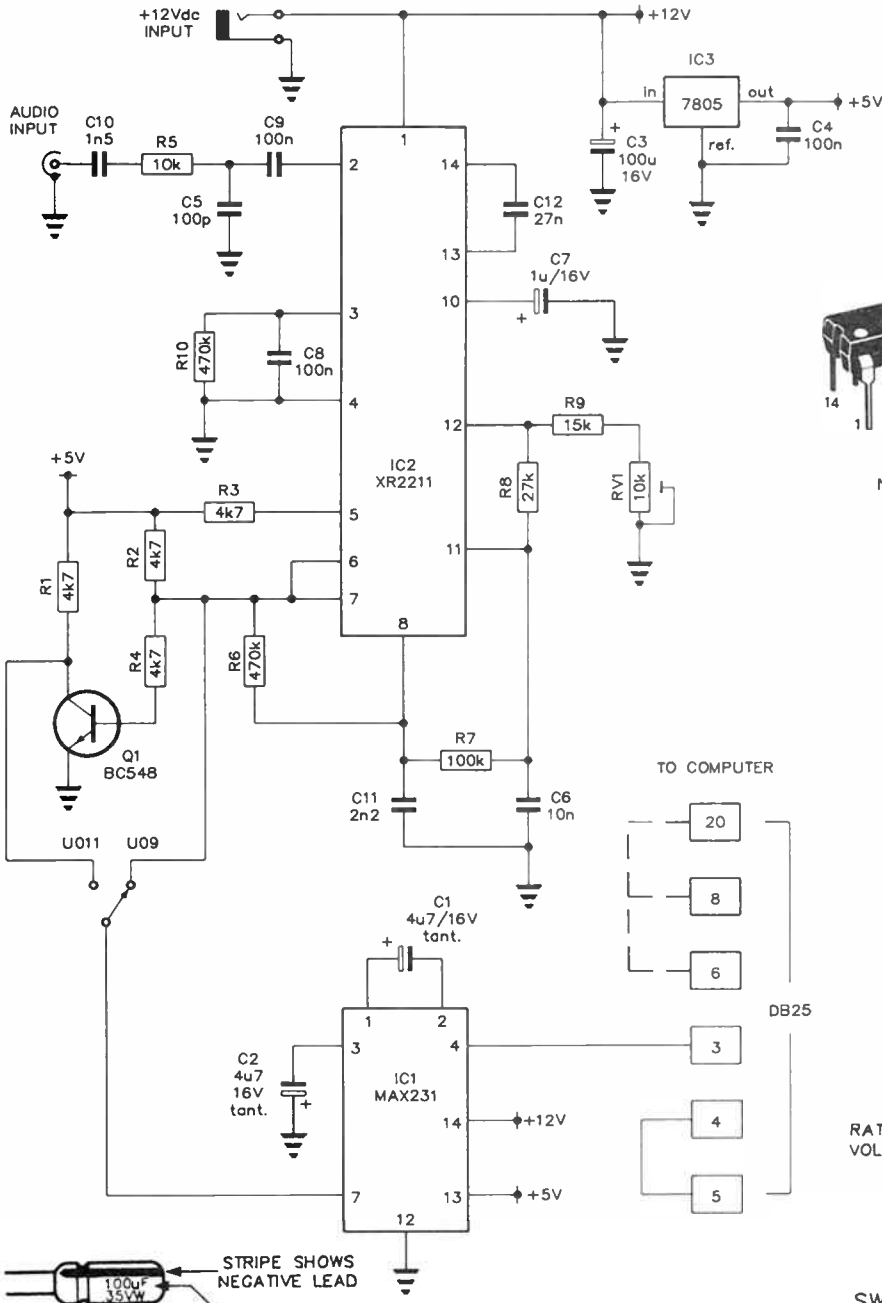
All that remains is to solder some suitable lengths of hookup wire to the respective pads for the switch SW1, the power supply input and the audio input. It is preferable, although not essential, that screened cable be used for the audio input connection. The other ends of these cables can be terminated at the switch, the panel-mounted dc connector and the RCA audio connector, although it may be easier to leave them unterminated until alignment has been completed.

Mounting the pc board in a case can be accomplished by bolting the DB-25 plug flange to the case. You will need to make a cutout in the case to suit the connector, but if you use a light gauge aluminium case, such as the type suggested this should not be too difficult. The pc board is small and light, so there will not be any undue strain put on the connector by using this mounting method. If you wish, some epoxy glue can be run over the connector pins and pc board edge after you have completed assembly.

Alignment

There are a number of methods which can be used to align the unit and your choice will depend on what sort of test equipment you have available. The only adjustment to be made is the setting of the free running frequency of the VCO in the XR2211. As the FSK data from the satellite is transmitted using the Bell 202 standard, the two "logic" levels will be represented by the tone pair of 1200 Hz and 2200 Hz. The VCO in the XR2211 needs to be set up so that its free running frequency is half way between these two frequencies at 1700 Hz.

The first alignment method requires the use of a frequency counter to measure the VCO frequency. For this method, you should not yet have fitted resistor R10 or capacitor C8 to the pc board and pin 3 of the XR2211 should therefore not be connected to anything. Start by connecting the 12 V supply to the unit and short the audio input wires together so that there is no input to the XR2211. Don't worry about the switch SW1 at this point, it isn't needed. Next, use a short jumper to connect



PARTS LIST AEM3506

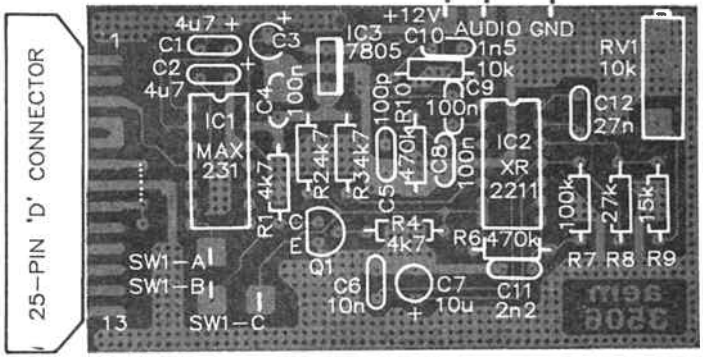
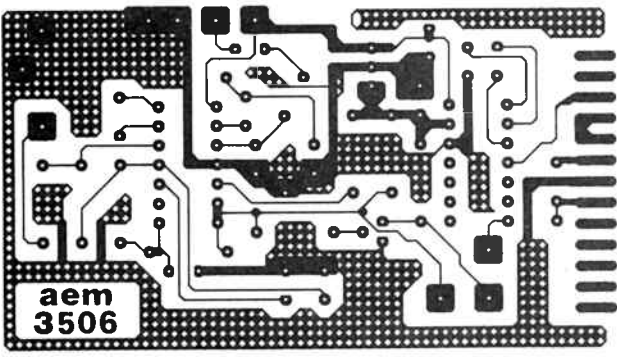
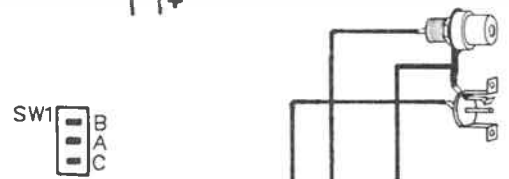
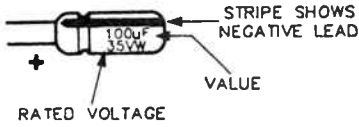
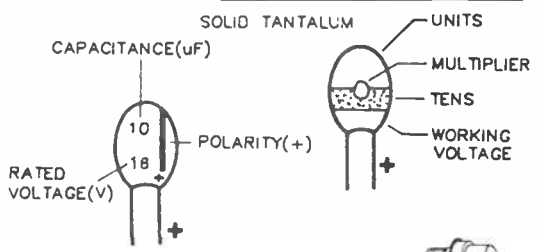
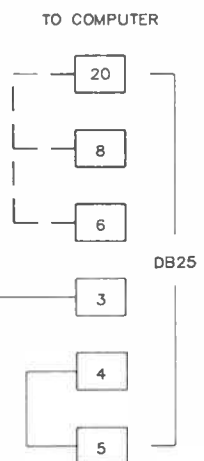
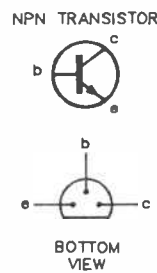
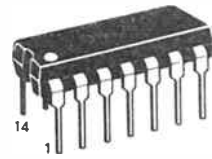
Semiconductors
 IC1 MAX231
 IC2 XR2211
 IC3 7805
 Q1 BC548

Capacitors
 C1-C2 4u7/16 V tant.
 C3 100u/16 V electro.
 C4 100n/50 V ceramic
 C5 100p greencap
 C6 1u/16 V tant.
 C7 10n greencap
 C8-C9 100n/50 V ceramic
 C10 1n5 greencap
 C11 2n2 greencap
 C12 27n greencap

Resistors all 0.25 W 5%
 R1-R4 4k7
 R5 10k
 R6 470k
 R7 100k
 R8 27k
 R9 15k
 R10 470k
 RV1 10k multi-turn horizontal trimpot

Miscellaneous
 DB-25 female socket, solder type no backshell; RCA plug; RCA panel socket; dc panel socket; dc plug; SPDT switch; Metal case approx. 100 mm x 80 mm x 50 mm; AEM3506 pc board; 300 mm light hookup wire; 100 mm single core screened cable.

Estimated cost: \$35-\$40



pin 2 of the XR2211 to pin 10. You can now use a frequency counter to measure the frequency at pin 3 of the XR2211 and adjust for a reading of 1700 Hz by means of the multi-turn trimpot RV1.

Once you are satisfied with the reading, you can disconnect the supply and the jumper wire. Fit resistor R10 and capacitor C8 on the board and solder the hookup wires to the switch, dc socket and RCA connector. You are now ready to mount the unit in its case.

The second method of aligning the unit assumes that you have access to an audio signal generator and an oscilloscope. A frequency counter is not required. For this method, all components should be mounted on the board and the unit can be mounted in the case, provided you can get at the trimpot RV1.

Connect the 12 V supply to the unit and apply a 1700 Hz signal from the audio generator to the audio input socket. The XR2211 demodulator will accept levels at its input (pin 2) of between 2 mV and 3 V, but remember that the audio is fed via two capacitors and a resistor before it gets to the IC so you should use a level of around 1 V p-p from the generator. Next, you should use the oscilloscope to examine the TTL output from the XR2211 at pin 6. This output will change state depending upon whether the input signal is higher or lower than the internal VCO frequency, so with 1700 Hz applied, you can adjust RV1 until you see the level wavering between a high and a low. When the unit is correctly aligned, you should see a square wave with an approximate 50% duty cycle.

You can check the demodulator by adjusting the output frequency of the signal generator either side of the 1700 Hz point and checking that the output from pin 6 of the XR2211 changes state accordingly.

The final method which can be used for alignment is simply to use an actual signal from the satellite. This method does not require any test equipment, simply connect the unit to the power supply and the computer with the signal applied to the audio input and adjust RV1 until you get meaningful data on the screen. Whilst this method might seem a little crude, you can achieve perfectly good results with a suitably clean input signal.

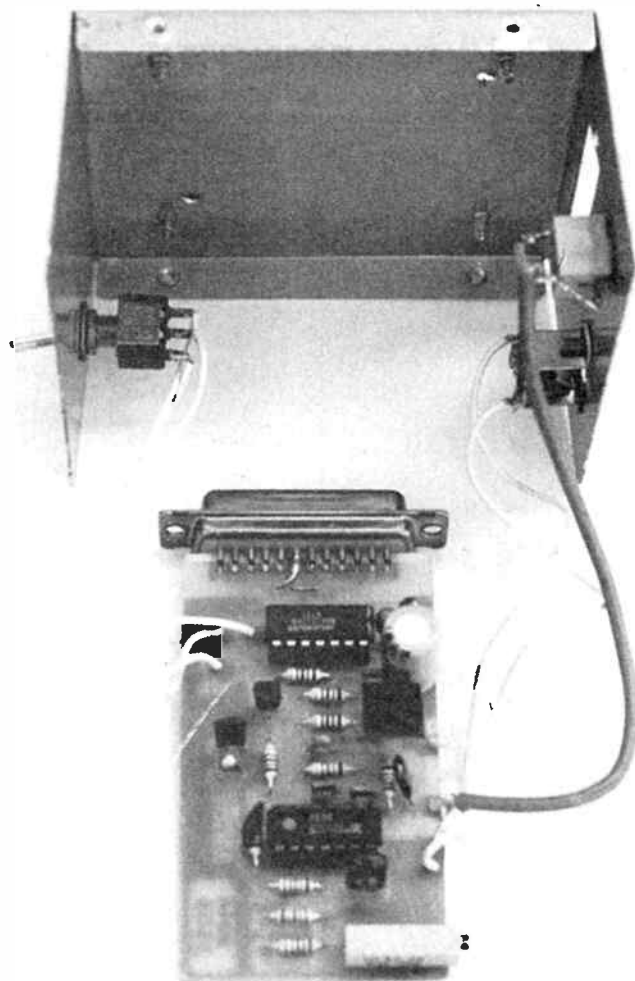
The simplest approach to this method of alignment is to use a tape recorder to store the satellite signal, which can then be used repeatedly until alignment is complete. With a known good signal, you can adjust RV1 first in one direction until the data becomes garbled and then in the other direction, past the point where data is correctly displayed, to the point where it once again becomes garbled. Count the turns of RV1 between these two points and set it to half way between the "garbled" points. If you have difficulty in obtaining meaningful data, you could try setting SW1 to the other position.

The last thing that needs to be done is to determine the setting of SW1 for the satellite you intend to receive. For correct reception of UO11, the input to pin 7 of IC1 should come from the collector of Q1 via SW1. For UO9, the input to pin 7 of IC1 should come directly from pins 6 and 7 of IC2. Refer to the circuit diagram, and label the switch accordingly for UO9 and UO11.

How to receive the signals

Both UO9 and UO11 transmit signals and beacons on a variety of frequencies, using a number of different modulation techniques. The signals we are interested in are the general engineering beacons, transmitted in the amateur two meter band near 145.825 MHz using narrow-band FM.

The two satellites are in "low earth" orbits, at an altitude of around 540 km. The RF output power of the beacons is only a

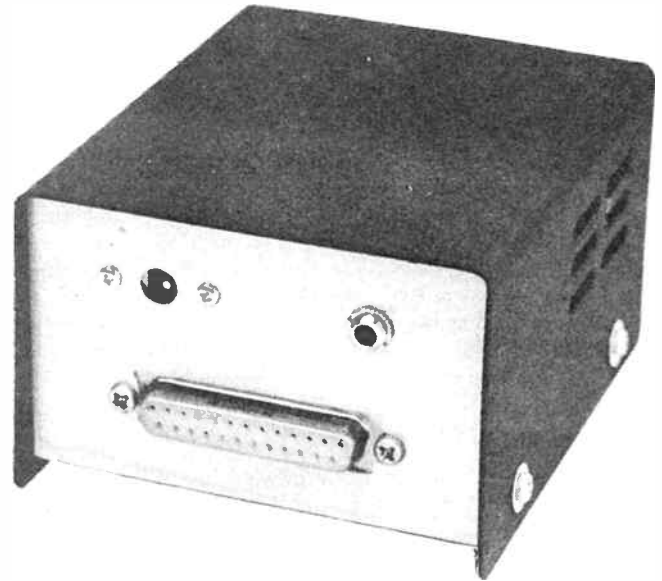
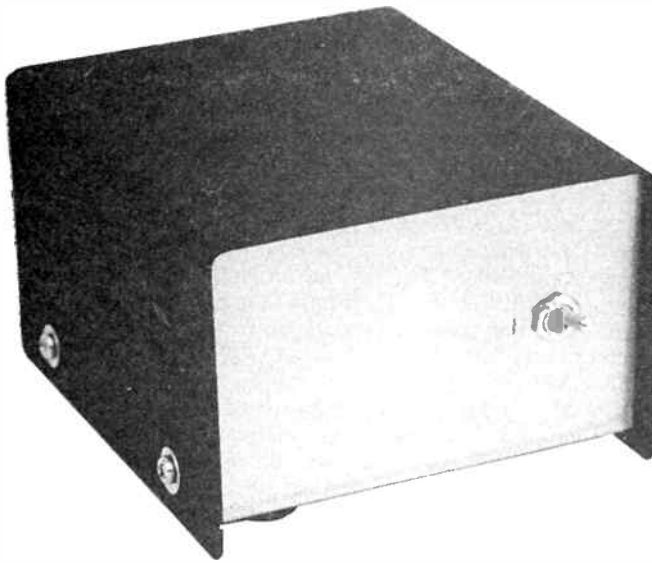


This shows the board dismantled from the case. It mounts with the component facing the case bottom. The board is supported entirely by the DB25 connector, being slotted between the rows of pins, with the row of 13 pins soldered to the appropriate pads on the track side of the board. As you can see, the switch is located on one end panel of the box (which becomes the 'front'), while the audio input and dc connectors mount on the other end panel, above the DB25 connector.

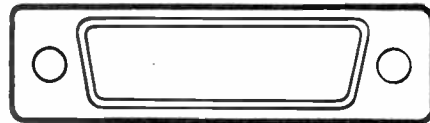
few hundred milliwatts and signal strengths are thus not particularly high. Even though the satellites can reliably be heard with quite modest equipment such as hand-held transceivers and scanners using "rubber ducky" antennas, you will need some sort of "gain" antenna to get a good "noise free" signal for successful decoding.

The signals transmitted by the satellites are left-hand circularly polarised, so the ideal antenna would be either an axial mode helix or a "crossed yagi" design. The helix antenna, whilst a good performer, can be quite awkward to build and cumbersome to mount when built for the VHF frequencies we are interested in. Most good amateur radio textbooks include a description of the helix antenna, but as this project is intended to be reasonably simple, we will confine ourselves to more traditional antennas.

The minimum suitable antenna would probably be the turnstile & reflector type. An example of this antenna was described in our July 1986 edition and consists of a "crossed" pair of dipoles mounted above a reflecting screen. The radiation pattern provided by this sort of antenna is almost ideal for satellite work and it has the added advantage of not requir-



Front and rear views of the completed decoder project. Note that a 3 mm jack socket was used for the audio input on this prototype although an RCA socket is specified in the parts list. A drilling template for the DB25 connector is reproduced at right.



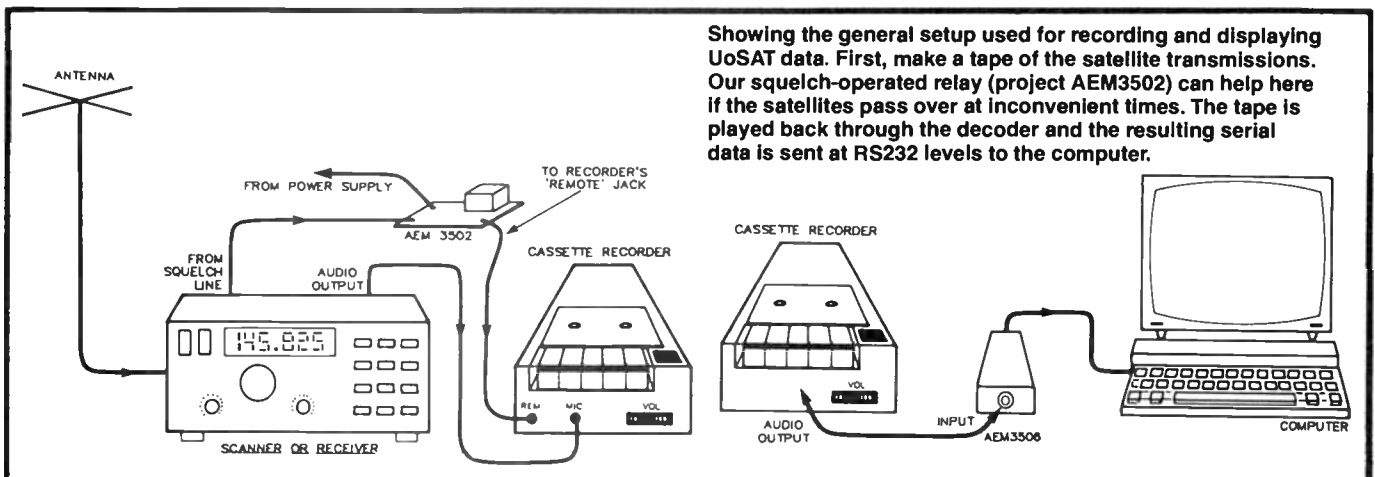
ing the antenna to move or "track" the satellite during the pass. The turnstile reflector antenna does not have any real gain, so it might be an advantage to use some sort of simple preamplifier to boost the signal strength if you can't quite get noise free reception.

The turnstile antenna does not need to be mounted in a particularly high position and as long as it is reasonably unobstructed above 10 to 15 degrees from the horizon, it will perform well. Good results have been obtained from these antennas when simply sitting directly on the ground.

The next antenna which could be used for our purpose is the well known Yagi design. A suitable example was published as the star project in our April 1986 edition and is available as a kit from Dick Smith Electronics. Although the basic Yagi is linearly polarised and the signal we are seeking is circularly polarised, the results are not affected to a great degree in this application.

There are two main parameters of the Yagi antenna which are of interest to us. One is the gain of the antenna and the other is the beamwidth. These two attributes are inter-related and basically speaking, the more elements a Yagi has, the higher it's gain and the narrower it's beamwidth. Obviously, high gain is an advantage as it will allow reception of weaker signals, but a narrow beamwidth makes it more difficult to point accurately and thus complicates the tracking requirements when used for satellite reception.

A good compromise between gain and beamwidth is a Yagi of six to eight elements. This will provide a gain of between 10 dB and 12 dB and still have a fairly wide beamwidth of about 40 to 50 degrees at the 3 dB points. A wider beamwidth can greatly simplify the tracking requirements if you mount the antenna at a fixed elevation and use a rotator for azimuth adjustment only. If you consider an antenna with a 50 degree beamwidth, mounted at a fixed elevation of say 45 degrees, ▶



Showing the general setup used for recording and displaying UoSAT data. First, make a tape of the satellite transmissions. Our squelch-operated relay (project AEM3502) can help here if the satellites pass over at inconvenient times. The tape is played back through the decoder and the resulting serial data is sent at RS232 levels to the computer.

the signal will only be reduced by 3 dB at 70 degrees elevation. As the satellite is closer to you when it is directly overhead, this slight loss is largely compensated for and is thus of little consequence. You can save quite a bit by using this method as specialised elevation rotators can be fairly costly.

If you want to go all out and have the best possible antenna system for satellite work, you should consider using a crossed Yagi design. Generally, these consist of two separate Yagis mounted on a common boom and arranged so that the two sets of elements are at 90 degrees to each other. By using a suitable phasing harness, you can arrange for the antenna to have either a left-hand or right-hand circularly polarised radiation pattern. A good example of a commercial antenna of this type is the Satracker SA270 from ZZV Antennas in Newcastle NSW, which we reviewed in the August 1987 issue.

How to find the satellites

As the two satellites we are interested in are in a fairly low orbit, they will pass from horizon to horizon quite quickly. How long they are visible for will depend where the pass occurs in relation to your location. If the satellite passes directly overhead, you can expect about 12 to 14 minutes, but if the pass is near the horizon, you may only get a couple of minutes access time. Obviously it is quite inconvenient and impractical to sit at your radio all day waiting for the satellite to fly past, so you need to have some method of determining when a pass will occur.

By far the best method of predicting satellite passes is the use of a personal computer running suitable software. The Amateur satellite organization, AMSAT, is able to provide suitable tracking software for a very wide range of computers at reasonable cost and you can contact them by writing to PO Box 2141, Adelaide 5001. Please include a stamped, self-addressed envelope for your reply as the organization is funded on a purely voluntary basis. Another source of suitable software is the many computer bulletin board systems which exist. Almost all the "packet radio" systems carry prediction software and so do many of the popular telephone systems. If there is sufficient interest, we may even consider publishing some basic programs in the magazine.

Before meaningful results can be obtained from a prediction program, you will need to supply some basic information about the satellite. For the simplest of programs, this consists of equator crossing times and longitudes from which times of suitable passes can be calculated. Whilst these programs are simple, they have the disadvantage that the data does not remain accurate for very long. After a week or so, you will find significant deviations from the predicted times will occur.

More accurate and longer lasting predictions can be obtained from programs which use what are known as Keplerian elements. These describe various parameters of the satellite's orbit and will allow accurate predictions to be made over a period of months before needing updating.

There are a number of sources for both the equator crossings and the Keplerian elements. AMSAT Australia publish a regular newsletter which often contains information and also they conduct a weekly "net" for satellite enthusiasts each Sunday evening at 1000 UTC on 3.685 MHz. Most packet radio bulletin boards will carry information and even the UoSat satellites themselves carry prediction information. There's a catch 22 for you!

If you are building this project, it is assumed that you will have a personal computer on which to display the decoded data. Unless you own a particularly old or obscure computer, there should be no problems in obtaining suitable prediction software. If you are stuck, you could always employ a different

method for obtaining the signals such as the squelch operated relay project, AEM3502, published in the March 1986 issue.

Using the decoder

Using the decoder is quite straightforward. Simply connect the RS232 serial connector to that of your computer and the audio output from the external speaker jack of your radio or scanner to the RCA connector on the decoder. The project is not particularly sensitive to volume level, so normal listening volume will be adequate. You will also need an external power supply of 12 Vdc for the project. The decoder only draws a few milliamps, so a simple plug-pack will suffice.

The satellites transmit their signals in part of the two meter amateur band. UO9 transmits on 145.826 MHz and UO11 on 145.825 MHz. As the satellite is moving rapidly towards you at the start of a pass and rapidly away towards the end of the pass, there will be some Doppler effect on the signal. This means that at the start of a pass, the signal will be slightly high in frequency and slightly low at the end of the pass. The maximum doppler shift for these two satellites is only about 3.7 kHz so if your scanner or radio is limited to tuning only in 5 kHz steps, it is best to leave it tuned to the nominal centre frequency. If you have a more sophisticated receiver, you could track the doppler shift through the pass.

The easiest method of operating the project is to use a normal audio tape recorder to record the signals from the satellite. In this way, you can re-use the data, experiment with volume settings or make adjustments to the decoder without having to wait for the next pass. It is not necessary to use a high quality recorder, a simple cassette recorder of reasonable quality will work perfectly well. If you are unable to decode any meaningful data, you may have a signal which is too noisy or perhaps you have SW1 set to the wrong position. Also, you should check that your terminal program is set for seven data bits, even parity and two stop bits. If your program can select the number of start bits, try setting this to one.

If you experience problems with the serial interface to your computer, you may find that it needs some "handshaking" signals to work correctly. The pc board has been designed so that the "request to send" (RTS) and "clear to send" (CTS) lines (pins 4 and 5 on the DB-25 connector) are already connected together. Some computers may also need the "data set ready" (DSR), "carrier detect" (DCD) and "data terminal ready" (DTR) lines to be connected together. These are pins 6, 8 and 20 on the DB-25 connector. Provision has been made on the pc board for jumpers to be inserted. The connection from pin 20 of the DB-25 plug (DTR) will need to be made from the component side of the board as this pin is on the other side of the DB-25 plug to the pins which are soldered to the pc board.

Further reading

If you would like to find out more about amateur satellites, there are a number of good sources of information available. Many of the popular amateur radio handbooks include a chapter on satellites and one in particular, The Satellite Experimenters Handbook by Martin Davidoff, is dedicated to the subject. The handbook is published by the American Radio Relay League (ARRL), ISBN 0-87259-004-6 and is available from many bookshops as well as the Wireless Institute of Australia.

Another source of information on the UoSat satellites is the University of Surrey who publish a number of handbooks concerning the operations of these satellites. Write to: UoSAT Mission Control Centre, University of Surrey, Guildford, Surrey, England GU2 5XH. 📧

UoSAT MISSION CONTROL CENTRE,
University of Surrey, Guildford, Surrey, England

** UOSAT OPERATIONS **

* UO-11 Operations *

The following WOD surveys are scheduled on UO-11:

Date	Channels
110987	1,2,3,61
120987	0,10,20,30
130987	52
140987	1,2,3,61
150987	1,2,3,61
160987	40,50,52
170987	1,2,3,61
180987	1,2,3,61

* UO-9 OPERATIONS *

Groundstation problems (combined with some confusion over the new UO-9 DIARY command schedule) resulted in UO-9 not being turned on in CCD mode on 090987. Normal operations were restored on 100987. In the future the new DIARY schedule, which turns off the satellite for groundstation control on both Wednesday and Thursday, should result in MORE reliable UO-9 operations and minimise the occasions where a tone replaces CCD transmissions!

** SHUTTLE MOTOR TESTS **

Some 19 months after the January 28, 1986 disaster that ended in the loss of the Challenger shuttle crew, NASA has successfully taken one great leap toward resuming launches of its Space Transportation System (STS). At 3 PM on Sunday, 30 August, the giant booster roared to life, consuming 1.1 million pounds of rubbery propellant in a scant 120 seconds. It takes only one half second for the internal pressure to build to its maximum of 930 pounds per square inch. First indications are that all went well, though it will take several weeks for the engine to be taken apart and studied.

Redesign of the booster segment field joints was directed by NASA following findings that a poorly designed joint was responsible for the Challenger disaster. Changes in the joint include addition of a third O ring, capture latch and permanent bonding. Engineers spent over one full year redesigning the sealing system for the 2.65 million pound thrust rocket motor.

Six more booster tests are expected before shuttle flights resume, possibly as soon as June 2, 1988.

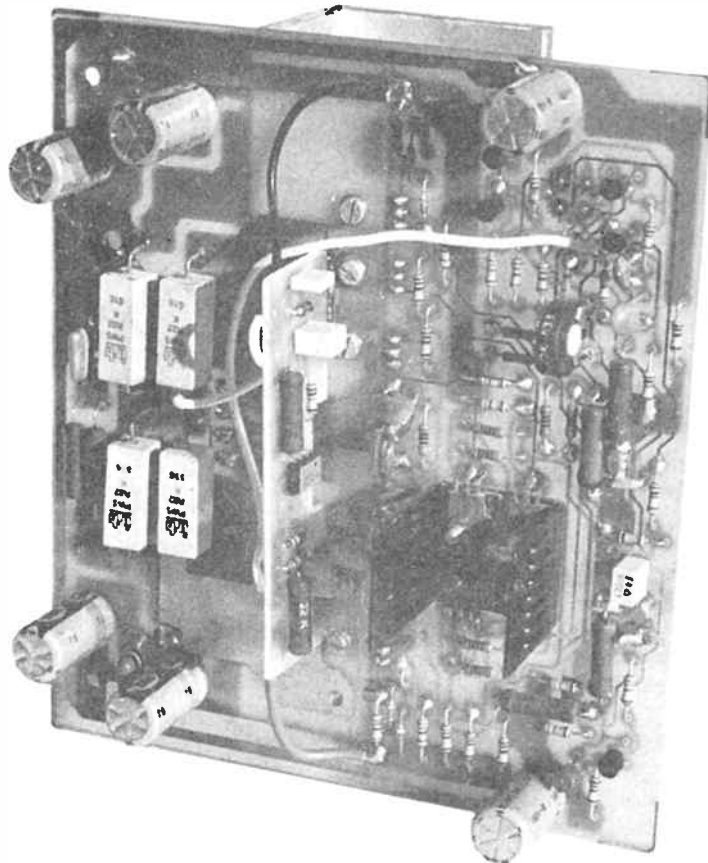
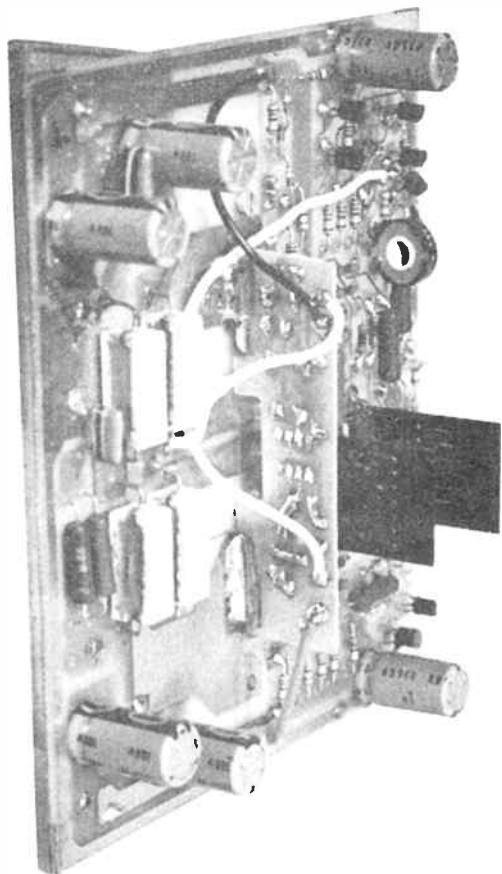
AMSAT is looking forward to the renewal of shuttle flights for several reasons. First, the EDSAT GAS can promised from Richland Community College is manifested on the shuttle. Moreover, several Shuttle Amateur Radio Experiments (SAREX) are either ready or in the planning stages. Astronauts Tony England, W00RE, and Ron Parise, WA4SIR, are both anxious to add a SAREX package to their missions.

** AMATEUR RADIO VIDEO CARRIED ON SATELLITE-TV **

"The New World of Amateur Radio", an instructional/promotional video prepared by Roy Neal in conjunction with the ARRL, is in final production and being readied for its premier airing September 20. Watch for it on GTE Spacenet 1, transponder 12-H (channel 23) at 2200 UTC on Sunday, 20 September. Amateurs are encouraged to tape it off the air for showing at club meetings and similar

This screen dump shows an actual "diary" transmission from UO11 made with our prototype decoder. The diary information is usually updated once a week on UTC Thursdays and

generally contains items of interest to satellite enthusiasts, experimenters and radio amateurs.



A dc servo-feedback adaptor for the 6000 series amplifiers

David Tilbrook

Technical Systems Australia Pty Ltd

This little add-on project will see to it that the output dc offset of the fully dc-coupled 6000 and 6005 amplifier modules is less than 5 mV, regardless of component tolerances, temperature variations or drift in the values of those critical components which affect the dc offset.

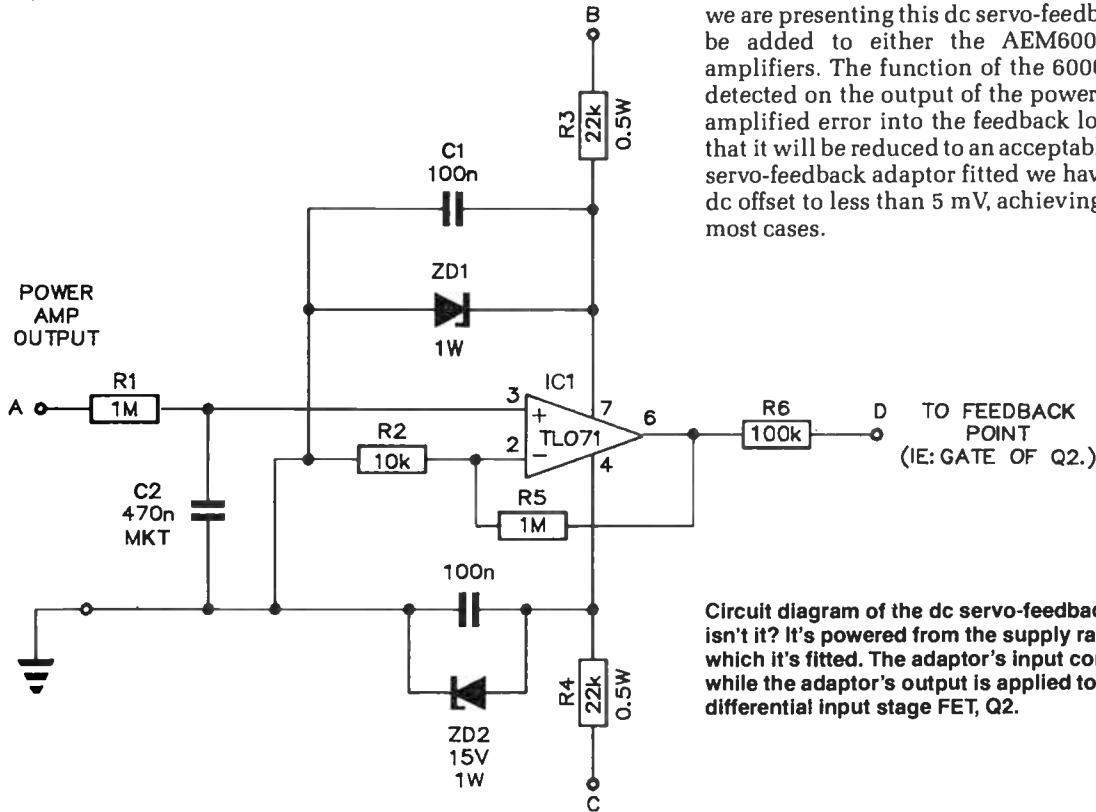
A NUMBER of constructors of the AEM6000 and AEM6005 dc-coupled power amplifiers have expressed concern about the setting of the dc offset on the output of these power amps. The dc adjustment preset potentiometer on these modules provides the largest amount of vernier around the centre of its setting. However, experience has shown that, on some modules, this preset needs to be set near either of its extremes, where an accurate zero setting of the dc offset can be difficult to achieve, or occasionally, the preset "runs out of range".

The 6000 and 6005 power amp modules are somewhat more prone to having small amounts of dc on their outputs since the design is entirely dc coupled. Most power amplifiers employ a large value electrolytic capacitor in series with the feedback resistor to ground to reduce the overall gain of the amplifier to unity at dc. In so doing, the dc

offset on the output of the amplifier is effectively reduced. The conventional power amplifier, for example, employing bipolar input devices and featuring unity gain at dc, would probably provide between 20 and 50 mV dc offset on its output. These are acceptable figures although a lower dc offset is obviously preferable.

In order to ensure the best possible sound quality, this electrolytic capacitor in the feedback loop is omitted in the design of the AEM6000 and AEM6005 power amplifiers. The input bipolar differential pair of the conventional amplifier is replaced here by a dual JFET which, as it is constructed on a single piece of silicon substrate, features highly matched characteristics, ensuring small drift and low dc offset. The dc offset is then adjusted using a preset dc offset adjustment potentiometer. The gains of these amplifiers at dc is therefore

The AEM6006 adaptor fits readily on the 6000 amp module. Note that the component side of the board faces the input end of the 6000 module. The same goes for the 6005. The cutout in the 6006 board visible here is to clear some resistors on the 6005 module.



48, the same as that provided by the amps for ac signals. Small dc offsets around the input circuitry will therefore be amplified 48 times and appear on the output of the power amp. However, it is usually not difficult to adjust an AEM6000 or AEM6005 so that its output dc offset is less than 50 mV.

In order to ensure that a very low dc offset can be achieved, we are presenting this dc servo-feedback amplifier which can be added to either the AEM6000 or AEM6005 power amplifiers. The function of the 6006 is to amplify dc errors detected on the output of the power amp and to reinsert the amplified error into the feedback loop of the power amp so that it will be reduced to an acceptably low figure. With the dc servo-feedback adaptor fitted we have found it easy to set the dc offset to less than 5 mV, achieving less than 1 mV offset in most cases.

Circuit diagram of the dc servo-feedback adaptor. Simple, isn't it? It's powered from the supply rails of the module to which it's fitted. The adaptor's input comes from the amp's output, while the adaptor's output is applied to the gate of the amp's differential input stage FET, Q2.

AEM6006 CIRCUIT OPERATION

The AEM6006 employs the JFET-input IC operational amplifier type TL071. This device features low input noise and very high-input impedance. The op-amp is configured as a non-inverting amplifier with a gain which is set by the two resistors R5 and R2 to be around 101, i.e. gain $(R2 + R5)/R2$.

Power supply for the IC op-amp is provided by the zener diodes ZD1 and ZD2 and their accompanying bias resistors R3 and R4. In the case of the AEM6005, the power amp supply rails are around 50 volts which applies around 38 V across R3 and R4. The resulting current of around 1.7 mA is sufficient to power the op-amp while not causing excessive power dissipation in the dropping resistors. In the case of the AEM6000, the higher supply rails of around 70 volts cause a somewhat higher current of about 2.6 mA and the power dissipation in resistors R3 and R4 will be approximately 0.15 watts, so half watt resistors are specified.

To filter the ac signal waveform from the dc component on the output of the power amp, a first-order RC filter is used which consists of resistor R1 and capacitor C2. The resulting -3 dB cutoff frequency is around 0.34 Hz which ensures a good frequency response for the power amplifier at low frequencies within the audio passband.

Resistor R6 isolates the low output impedance of the op-amp from the feedback point when the adaptor is connected to the amplifier. Without this resistor, the low output impedance of the op-amp would affect the ac signal gain of the power amp.

The adaptor

The adaptor is based on a TL071 JFET-input operational amplifier. This device features an exceptionally high input impedance which is necessary for this design since its non-inverting input is fed from a large value resistor. The adaptor is simply a non-inverting amplifier with a gain of around 101. Power is obtained from the power supply rails of the main power amplifier modules which are reduced by a pair of zener diodes to a voltage appropriate for the TL071.

The output of the power amplifier is applied to the input of the op-amp via a 1M resistor (R1) which, in conjunction with capacitor C2 forms a low-pass filter to remove the signal components from the dc feedback signal. The RC network provides a time constant of around half a second, so it takes approximately this long for the adaptor to reduce the dc offset on the output of the power amplifier to a suitably low level. This long time constant ensures that the 6006 does not introduce excessive low frequency phase errors which might otherwise cause a degradation of signal quality. The dc output of the dc servo-feedback amplifier is applied via resistor R6 to the feedback point i.e. to the gate of Q2 in the AEM6000 and AEM6005 power amplifier modules.

The 6006 works well and the dc offset on most 6000 and

AEM6006 PARTS LIST

Semiconductors

IC1 TL071
 ZD1, ZD2 15 V/1 W zeners

Resistors

all 1/4W, 5% unless noted

R1 1M
 R2 10k
 R3, R4 22k, 0.5 W
 R5 1M
 R6 100k

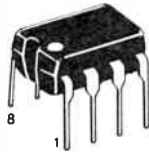
Capacitors

C1 100n MKT
 C2 470n MKP or MKT
 C3 100n MKT

Miscellaneous

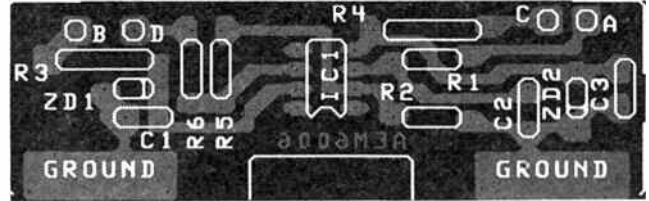
AEM6006 pc board; hookup wire; solder.

Estimated cost: \$9-\$11

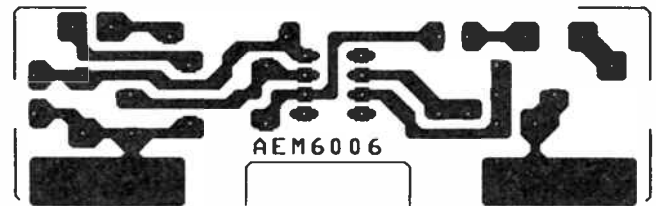


ZENER DIODES

See our 'PROJECT BUYERS GUIDE' this issue for a guide to component sources and kit suppliers.



Component overlay. Watch the orientation of the two zener diodes and the TL071 op-amp.



6005 power amplifiers with the adaptor fitted is easily adjusted to less than 5 mV as mentioned above. It is still necessary to optimise the dc offset using the dc offset adjustment pot provided on the power amplifier to achieve the best possible result.

Construction and assembly

Construction of the AEM6006 and assembly of it to a 6000 module is simple. We recommend that you use the AEM6006 pc board since it has been designed to be easily retro-fitted to both the 6000 and 6005 modules with minimum modification to the pc boards.

Start construction of the 6006 board in the usual way by soldering the resistors and non-polarised capacitors to the printed circuit board. The two zener diodes and the TL071 op-amp must be fitted to the board with the correct orientation. Take note of this from the overlay diagram. Pin 1 on the TL071 is marked as shown in the pinout diagram.

Once the pc board is fully loaded it is mounted into position on your 6000 or 6005 power amplifier modules by soldering the 6006 pc board so that it is perpendicular to the amplifier board on the earth track on the components' side of your amplifier board, between the input/driver section and output stage.

On the 6006 board, you'll see two large 'plates' of copper at opposite ends of one edge. The 6006 pc board is positioned perpendicular to the amplifier board over the earth track area, as shown in the accompanying photograph. This solder connection also provides a "clean" signal earth to the adaptor. For best results, it is a good idea to "tin" the appropriate areas of the two pc boards by first heating the track area with the iron and running a thin layer of solder across the area.

Be careful when fitting the adaptor to the AEM6005 since the noisy earth track is immediately adjacent to the clean earth track to which the adaptor must be soldered. Be careful not to solder the adaptor to the noisy earth on the 6005 since this could insert mains and other noise voltages into the feed-

back loop of the amplifier. Note that in the case of the 6005, the centre region marked on the 6006 pc board should be "nibbled" out to enable the 6006 pc board to straddle some resistors on the top side of the 6005 board. This is not necessary when fitting the unit to the 6000 board, although the photographs show the area on the 6006 board cut away.

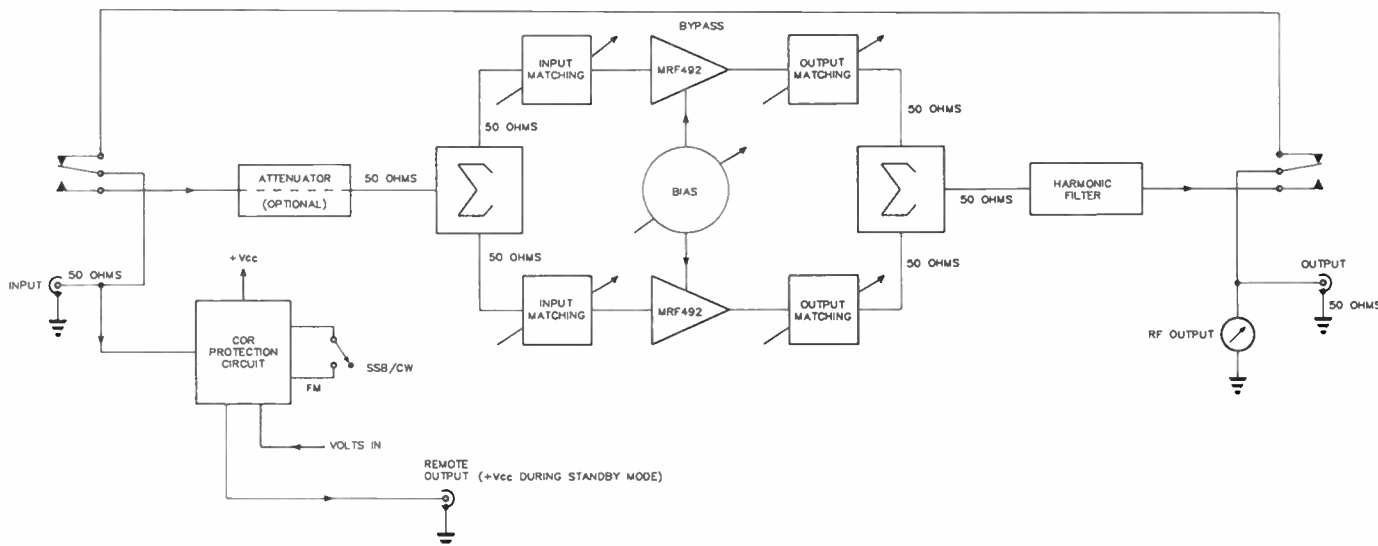
On the AEM6000 power amplifier module, the 6006 board is actually fitted to the noisy earth track area, but this is acceptable since this point on the 6000 pc board is substantially cleaner than the noisy earth track on the 6005.

Once the adaptor board is soldered into position on the power amplifier it can be wired-up to the appropriate points on the components' side of the power amp by the use of four flying leads. Two of these leads, each connected to points B and C on the 6006, are soldered to the power amplifier's positive and negative supply rails respectively. Point A on the 6006 pc board is connected to the output of the power amplifier while point D is taken to the gate of JFET Q2.

Setting up

Before powering up the power amplifier module check that the adaptor is soldered to the correct position on the amp pc boards and check all four flying leads. If all is well then power up and measure the dc offset on the output of the power amplifier. You should notice that the dc offset on the output of the power amplifier has been immediately reduced to a fraction of that present before the adaptor was fitted. Adjust the dc offset preset pot to obtain a minimum dc output. With the adaptor in place any thermal drift or drift of component values, with time that might otherwise cause a dc offset on the amplifier will be corrected by the servo-feedback action of the 6006.

Since the 6006 uses a single RC time constant to filter signal levels, and since C2 can be a high quality metallized polypropylene type capacitor, we have found that the dc servo-feedback adaptor introduces little or no discernible effect on the sound quality of the AEM6000 and AEM6005 power amplifier modules. ▲



A 100 watt all-mode power amp. for the six metre band

Dick Smith Electronics

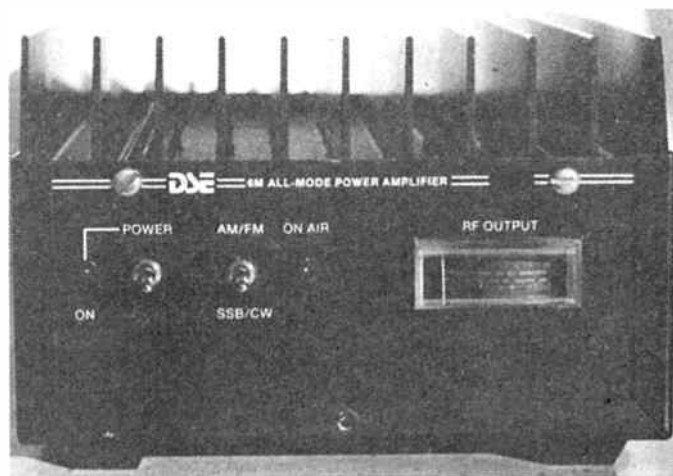
Here's a booster amplifier that will give your six metre signal a bit more "sting". It's straightforward to assemble and align, and won't break the bank balance.

THIS ALL-MODE POWER AMPLIFIER was designed by the R & D department of Dick Smith Electronics and complements their existing range of amplifier kits for the two meter and seventy centimeter bands. Intended for use in the six meter amateur band, it boasts a continuous power output of 100 watts for an input of under six watts and is thus compatible with many popular amateur transceivers from low power portables to base station rigs of 10 watts or more output.

As anyone who has ever operated on six meters will tell you, it can be one of the most fascinating of all the amateur bands. With the two "DX seasons" a year – winter and summer, the latter being the most spectacular – and the sunspot cycle once again on the rise, now is the time to start planning that station upgrade you promised yourself. Although there are times when some quite good DX can be worked

FEATURES

- Mobile or base operation
- Carrier operated relay (COR)
- Over-voltage and transient protection
- Reverse polarity protection
- Switchable between-syllable delay for SSB
- Power and on-air indication
- Relative output power metering
- Remote dc output for preamps etc.
- Optional attenuator



Styling of the 6m all-mode amp matches that of the 2m and 70 cm amps, with a topside heatsink and folded aluminium housing. The front panel meter indicates relative power output.

with very modest equipment, there is often no substitute for a bit more power and this timely project should prove a useful addition to many stations.

Design

Design of the amplifier is based around a pair of Motorola MRF492 transistors. These are a low-band VHF device and reference to the manufacturer's data (see the data sheet

This month's Star Project is from Dick Smith Electronics who will be marketing kits through their stores and dealers; cat. no. K-6349, \$349. Mail order enquiries to PO Box 321, North Ryde 2113 NSW. (02)888 3200.

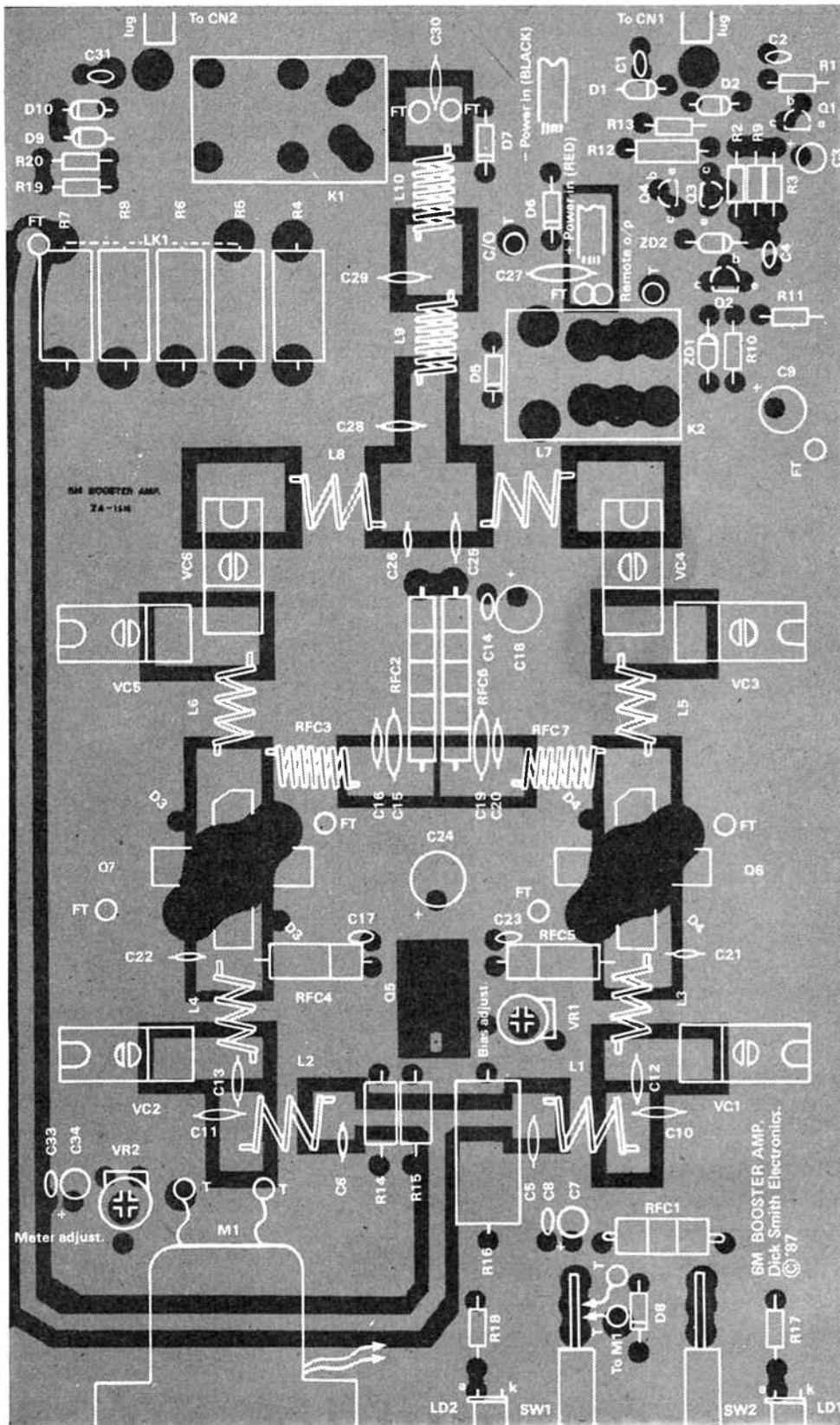


Figure 1. How the disc ceramic capacitors are prepared and installed.

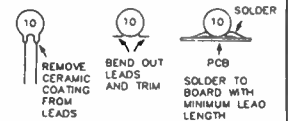
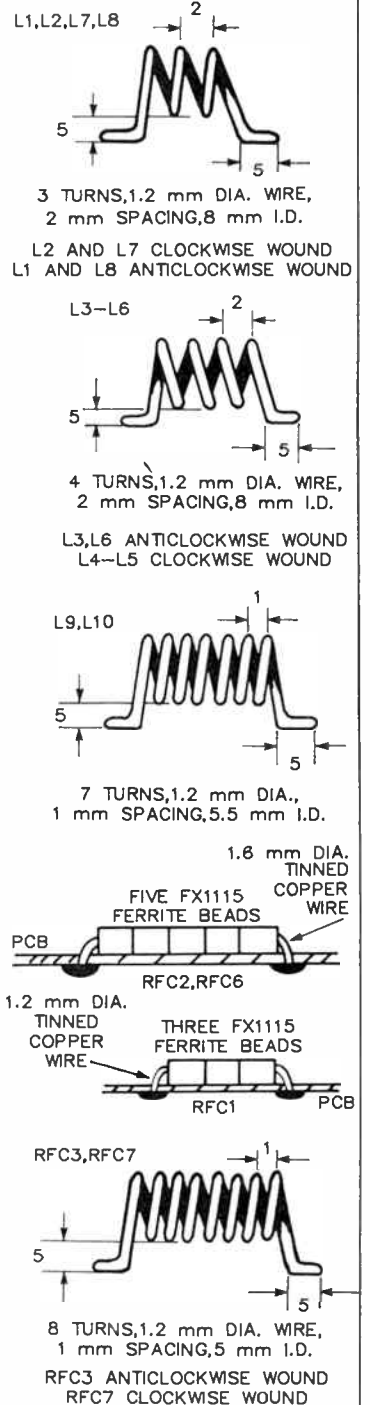
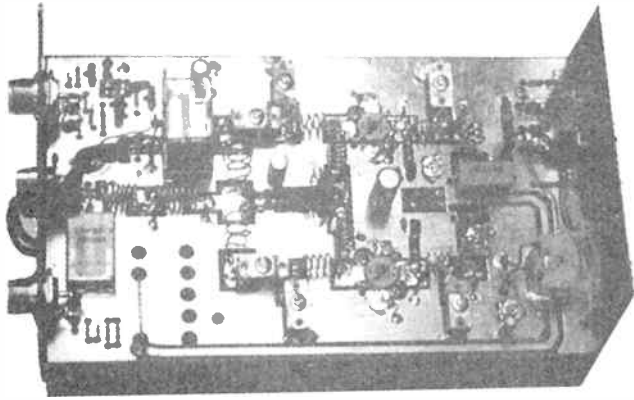


Figure 3.





On the inside. The layout is quite straightforward making assembly relatively easy. All componentry is mounted on a single double-sided pc board, the topside being virtually all groundplane.

elsewhere in this issue) shows that they are intended for FM power amplifier use. A closer examination of the data reveals that the devices exhibit sufficient linearity for SSB applications up to 60 watts when they are biased within the linear portion of their curve.

Tests performed on the prototype amplifiers indicate that optimum bias conditions exist when operated somewhere between class A and class AB where the idling current of the individual transistors is between 0.5 amps and 1.5 amps.

Construction

For ease of construction, all components are mounted on a printed circuit which features solder-tinned tracks and silk-screened component annotation. The board measures 218 mm x 130 mm and it is mounted on a large, anodised heat-sink to allow continuous operation of the output transistors at high power levels. You should first familiarise yourself with the layout of the board so that you have a good idea where all the components are sited.

Commence construction by first fitting all the pcb pins into the board. Note that the pin locations designated by the letters "FT" are feedthroughs used to connect the copper foil on both sides of the board. These must be soldered on both sides and can be cut short after fitting. The pin locations designated by the letter "T" are used for wiring terminations. Where possible, these should be soldered on both sides of the board, but they should not be cut short after fitting.

The resistors, capacitors and the two horizontal trim pots can be mounted next. Resistors R14, R15 and R16 (220 ohm/1 W and 39 ohm, 5 W) should be mounted 3 mm above the board to allow for heat dissipation and to prevent coupling effects from the RF track which runs underneath. If required, the five resistors for the input attenuator can be fitted at this stage. You should refer to the "input attenuator" section for details of this operation. If an input attenuator is not required, you can replace the resistors with a 27 mm long piece of 1.7 mm diameter tinned copper wire, indicated as LK1 on the component overlay.

The components C5, C6, C10-C13, C15-C16, C19-C22 and C25-C30 are all soldered to the top of the pc board with their leads spread out and cut to minimum length. Refer to Figure 1 for preparation and fitting of these components.

The trimmer capacitors can now be fitted to the board. Pay particular attention to their orientation as indicated by the component overlay. The trimmers VC1, VC4 and VC6 have their earth (screw) side soldered to the top surface of the pc board only, whilst trimmers VC2, VC3 and VC5 are soldered on both sides of the board. Take care to trim the soldered joints on the underside of the board to prevent possible shorts to the heatsink.

You can now fit all the semiconductors with the exception of D3, D4, Q5, Q6 and Q7. Take care with the orientation of these components and try to keep the leads as short as practicable. Where pads exist, you should solder the connections on both sides of the pc board, particularly with connections to the ground plane such as the emitter of Q1. The LEDs, switches and relays can also be installed at this point. Install the switches first and then position the LEDs and bend them so that they are on the same centre line as the switches.

The next step is to construct and install the RF chokes ▶

PARTS LIST

Semiconductors

D1-D2	1N4148
D3-D8	1N4004
D9-D10	1N4148
ZD1	15 V/400 mW zener
ZD2	3V3/1 W zener
LD1	TL4213, 5 mm red LED
LD2	TL4233, 5 mm green LED
Q1	BC337
Q2-Q3	BC557
Q4	BC337
Q5	BD139
Q6-Q7	MRF492

Resistors

	all 1/4 W, 5% unless noted
R1	100k
R2	56k
R3	10k
R4-R5	27R, 2 W
R6	180R, 2 W
R7	12R, 2 W
R8	180R, 2 W
R9	3k3
R10	100R
R11	150R
R12	270R, 1/2 W
R13	10k
R14-R15	220R, 1 W
R16	39R, 5 W
R17-R18	1k
R19	2k7
R20	470R
VR1	100R hor. trimpot
VR2	10k hor. trimpot

Capacitors

C1	1p disc ceramic
C2	100p disc ceramic
C3	22u/16 V tant.
C4	10n disc ceramic
C5	47p disc ceramic
C6	39p disc ceramic
C7	22u/16 V tant.
C8	10n disc ceramic
C9	100u/25 V RB electro.
C10-C11	47p disc ceramic
C12-C13	270p disc ceramic
C14	10n disc ceramic
C15	100n disc ceramic
C16-C17	10n disc ceramic
C18	100u/25 V RB electro.
C19	100n disc ceramic
C20	10n disc ceramic
C21-C22	1n disc ceramic
C23	10n disc ceramic
C24	1000u/16 V RB electro.
C25	49p disc ceramic
C26	39p disc ceramic

C27	100n disc ceramic
C28	68p disc ceramic
C29	120p disc ceramic
C30	68p disc ceramic
C31	1p disc ceramic
C32-C33	10n disc ceramic
C34	10u/25 V RB electro.
VC1-VC2	130p-450p trimmer, Arco C4210, "C" mounting type
VC3	95p-350p trimmer, Arco C428, "C" mounting type
VC4	55p-250p trimmer, Arco C426, "C" mounting type
VC5	95p-350p trimmer, Arco C428, "C" mounting type
VC6	55p-250p trimmer, Arco C426, "C" mounting type

Miscellaneous

SW1-SW2	Spdt toggle switch, pc board mounting'
RLA1	DPDT relay, Siemens V23012, 12 V coil
RLA2	DPDT relay, 10 A contacts, 12 V coil
CN1-CN2	SO-239 single hole mount, with earth lug
CN3	panel mount RCA socket
M1	500 uA signal strength meter with backlight
RFC1-RFC3	see text
RFC4-RFC5	47 uH axial
RFC6-RFC7	see text
ZA-1516 double-sided pc board; folded aluminium enclosure with front and rear panels; Black anodised and machined heatsink; Aluminium transistor mounting plate; 15 FX115 ferrite beads; two meters of 1.2 mm dia. tinned copper wire; 30 cm of 1.6 mm dia. tinned copper wire; 20 cm of small gauge hookup wire; one meter each of red and black 4 mm diameter power cable; 20 amp 3AG fuse with in-line fuseholder; one captive type cable grommet; four self-adhesive rubber feet; 20 pc board pins; one TO-220 mica insulator; silicone thermal grease; 15 off 3 x 8 mm machine screws; four off #6 x 6 mm self-tapping screws; two off #4 x 6 mm self- tapping screws; four x 4BA hex nuts.	

Kit price: \$349.00

CIRCUIT OPERATION

The operation of the amplifier is best examined by breaking the circuit down into a number of individual parts. We will begin by describing some of the "peripheral" parts such as the COR and protection circuit, the bias supply, the harmonic filter and the output metering circuit.

The COR and over-voltage protection

When the unit is first powered up, C3 charges to the supply voltage via R2. When drive is applied to the amplifier's input, a small part of the drive signal is coupled off via C1 and rectified by the two diodes D1 and D2. The resulting positive signal turns on Q1, thus discharging C3 and allowing Q3 to conduct. When the potential through the voltage divider comprised of R12 and R13 exceeds approximately 60 microamps, Q4 will also turn on which energises relay K2. Power to the main amplifier, as well as the coil of RF switching relay K1, is supplied through the contacts of K2. This is the "on-air" mode.

When drive is removed from the amplifier's input, Q1 is biased off by R1, allowing C3 to charge via R2 when the front panel switch is in the SSB/CW (long delay) position. When the front panel switch is set for AM/FM (short delay), C3 will charge up via both R2 and R3. With the component values used, the long delay is about 1.5 seconds which should be a suitable "between syllable" delay for SSB operation. The delay time can be shortened or extended by changing the value of R2 if so required. The turn off threshold for Q3 is about 9.3 V for a 13.8 V supply rail, thus when C3 charges up to about 63% of its final value, Q3 and Q4 will turn off, releasing the relays K1 and K2. This is the "standby" mode.

An over-voltage sensing circuit is provided by Q2, ZD1, R10 and R11. When a supply rail in excess of 17 V is applied and the unit is switched on, ZD1 will conduct, thus turning on Q2 and holding Q3 off. As Q3 controls the relays, power will not be supplied to the main amplifier circuitry, thus preventing damage due to over dissipation. Diode D8 protects the amplifier circuitry in the event of reverse polarity being applied and diode D6 prevents bias currents from being drawn in the opposite direction through relays K1 and K2 whilst in the standby mode.

Bias supply circuit

A single bias supply has been provided in the interests of pc board space conservation and ease of alignment. A trimpot allows adjustment of bias from class B to class A, although it is recommended that the bias is set to between class A and class AB for optimum performance.

With reference to the circuit diagram, R14, R15, D3, D4 and VR1 comprise a thermally compensated bias supply for the base of Q5. Adjustment of the base current of Q5 via the trimpot VR1 allows control over the amount of emitter current by a factor which is the transistor's hFE. The actual amount of current through the emitter of Q5 is determined by the current requirements of Q6 and Q7.

Diodes D3 and D4 are mounted across their respective power transistors for thermal compensation. The 100 mA diode current affects the amount of compensation and will tend to "throttle back" the RF output power by between 0.5 dB and 1 dB from initial cold start, to continuous operation over a period of some minutes. Trimpot VR1 can be adjusted during transmission to swing the output power by plus or minus 0.5 dB. Resistor R16 limits the bias current to 350 mA, whilst the two chokes RFC4 and RFC5 isolate the bias circuitry from RF present on the bases of Q6 and Q7.

Optional input attenuator

With reference to the power-in/power-out graph, it can be seen that an appreciable deviation from the linear portion of the curve occurs just after 100 watts output. It would thus be desirable to limit the amplifier's maximum output to this level so that suitable linearity for SSB operation is retained. If a low power exciter of 2-3 W output is employed to drive the amplifier, it will never be driven beyond the 100 W level and an input attenuator will not be needed. This is also the case for higher power exciters which have the facility to vary their power output, but care should be taken not to exceed the amplifier's 100 W output level.

If a high power exciter of 10 W-15 W output is to be used, some sort of attenuator will be required to prevent the amplifier from being driven into non-linearity. We will use the figure of 15 W drive to

demonstrate how to calculate the values required for such an attenuator.

Referring again to the power-out/power-in graph, you will see that 100 W output will require a drive of 5 to 6 watts. To allow for variations in the gain of the MRF492s, we will assume a drive of 5 W. Now that you have established the drive-available and drive-required figures, the following formulae can be used to calculate the resistor values for a T-network attenuator:

$$Z = 50 \text{ ohms}$$

$$K = \sqrt{P_{out}/P_{in}}$$

$$= \sqrt{15/5}$$

$$= 1.732$$

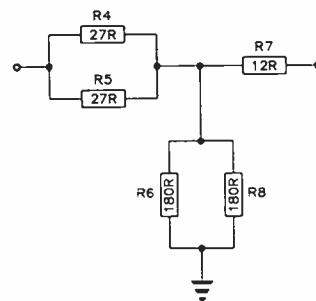
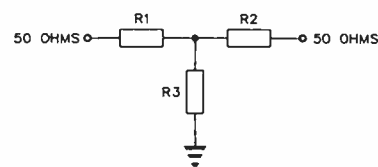
$$R1 = R2 = Z[1 - 2/(K + 1)]$$

$$= 50 \times 0.268$$

$$= 13.4 \text{ ohms}$$

$$R3 = \frac{2ZK}{K - 1}$$

$$= 86.6 \text{ ohms}$$



Giving consideration to the dissipation levels in each arm of the attenuator, the following configuration and values were chosen. All resistors are rated at 2 W and to minimise inductive effects, Allen Bradley hot moulded components were chosen.

In the case of the attenuator not being required, a link made from 1.7 mm tinned copper wire can be used and inserted in the LK1 position as indicated on the component overlay.

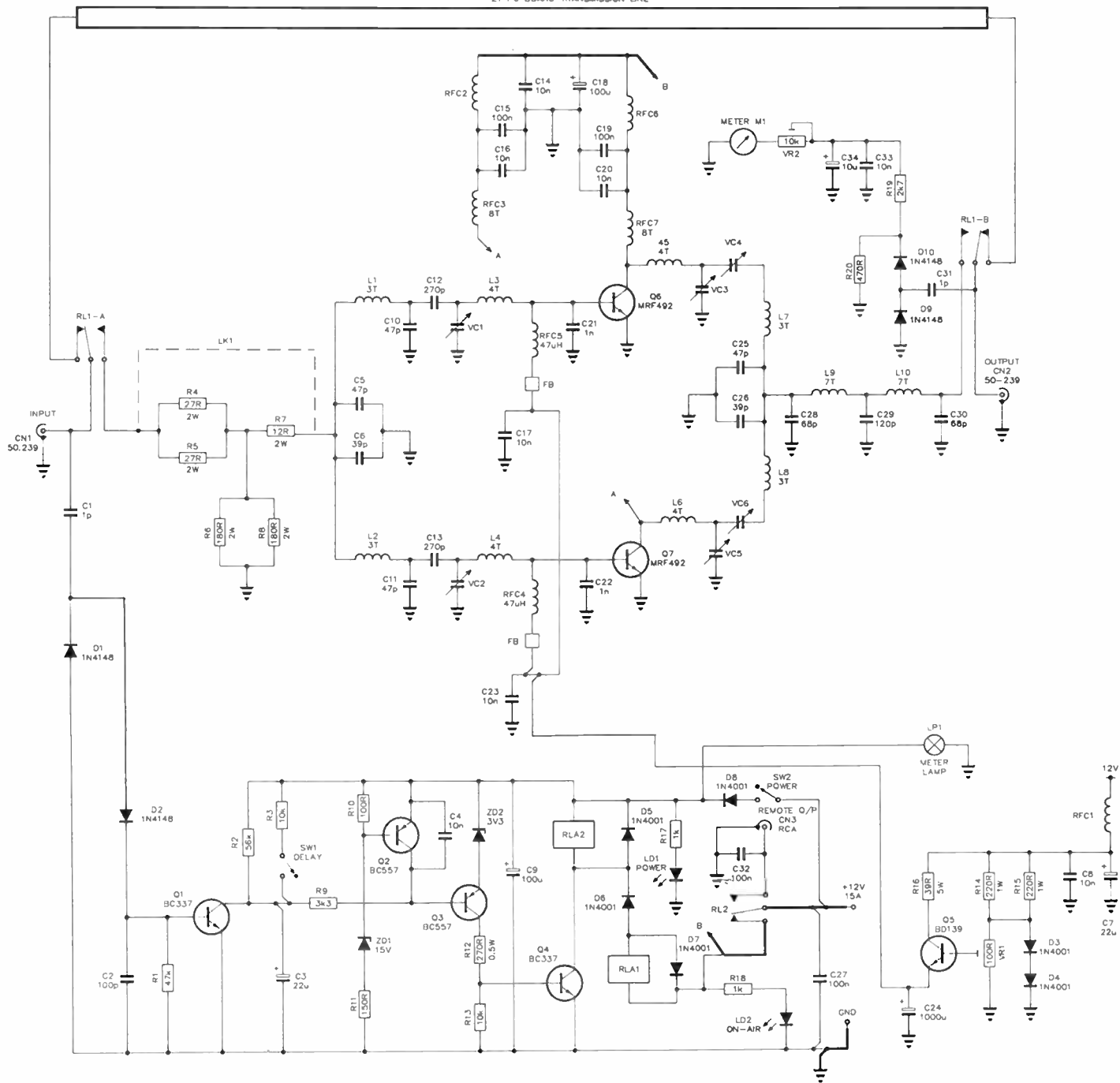
CAUTION! This amplifier is capable of delivering a saturated output of over 150 W when drive levels in excess of 12-14 W are applied without an attenuator fitted. Continuous operation under these conditions is almost certain to result in permanent damage to the power transistors and associated components due to over dissipation. The amplifier's output should be limited to a maximum of 120 W for safe continuous operation.

Harmonic filter

Before the harmonic filter was incorporated in the prototype unit, the second and third harmonics measured -25 dB and -55 dB respectively. The design specifications called for harmonics to be suppressed to better than -60 dB with respect to the carrier. To suppress the second harmonic would thus require a filter with a 40 dB/octave attenuation slope, allowing for construction tolerances. This could be easily achieved with a "Butterworth" response, but would require at least seven elements to obtain the desired attenuation result.

A "Chebychev" filter offers a faster initial rolloff for less elements and was chosen in the interests of conserving board space. Only five elements are required with the Chebychev arrangement to achieve a 40 dB/octave slope, and in this circuit these are L9, L10, C28, C29 and C30. The filter exhibits a characteristic passband ripple of only 0.1 dB.

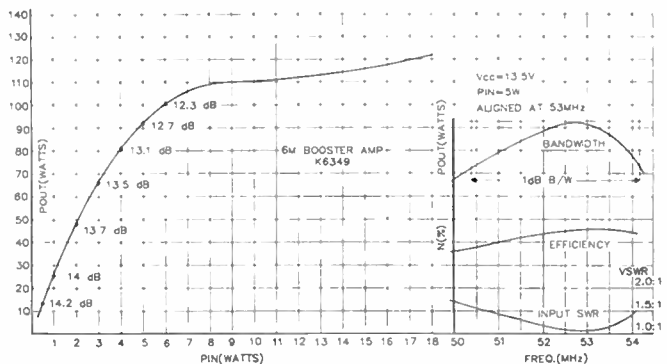
After determining the component values and fitting the filter to the prototype, a new set of measurements was made. The second harmonic measured -63 dB whilst the third harmonic was better than -70 dB with respect to the carrier. Insertion loss and the 0.1 dB passband ripple were not evident on the plotted response graph of the filter.



RF output meter

The front panel meter is intended to give a relative indication of output power and is thus not suitable for absolute measurements. Whether in standby or amplify mode, a small portion of the output signal is tapped off by C31 and then rectified by diodes D9 and D10. The resultant dc signal is attenuated by R19 and R20 and filtered by C33 and C34. Trimpot VR2 allows calibration of the meter by limiting the current through the coil.

If the range provided by VR2 is not sufficient, the ratio of R19 and R20 can be adjusted to increase or decrease the sensitivity accordingly. You should be aware that the indication on the meter will alter if the amplifier is driven into loads that depart from a 50 ohm impedance.



RFC1, RFC2 and RFC6. Refer to Figure 3 for details of the choke construction and check that you use the correct diameter tinned copper wire. RFC1 is made from three ferrite beads over a 19 mm long piece of 1.2 mm tinned copper wire. Before fitting the beads, bend one end of the wire at a right angle. You can then slide the three beads onto the wire and bend the other end to keep them in place.

RFC2 and RFC6 are constructed in a similar manner but use five beads on a 30 mm length of 1.7 mm diameter tinned copper wire. Be very careful when bending the wire, especially the 1.7 mm diameter wire used for RFC2 and RFC6, as the ferrite beads are fragile and it is easy to shatter them. Using a pair of needle-nosed pliers at the bend to grip the wire between the beads and the point of the bend is the best method. If you wish, a small amount of "Super Glue" can be used to stop the beads moving after the chokes have been soldered in place.

Mounting the power transistors

Mounting the power transistors requires a fair bit of care and the following steps should be followed closely to avoid causing permanent damage to the devices through mechanical stress.

Apply a very light coating of solder to the undersides of the leads of Q6 and Q7. You may also do the same for the areas where the leads of these devices will contact the pc board, as indicated by the overlay, although the tinning on the board should be sufficient. Do NOT install the transistors at this point. Next, prepare the bias transistor, Q5, by bending its leads at a right angle 3 mm from the bottom edge of the package such that the leads will point up and away from the metal side of the transistor package. Insert the leads of Q5 into their respective holes from the underside of the pc board as indicated by the overlay. Splay the leads a little to hold the device in place, but do NOT solder Q5 in position yet.

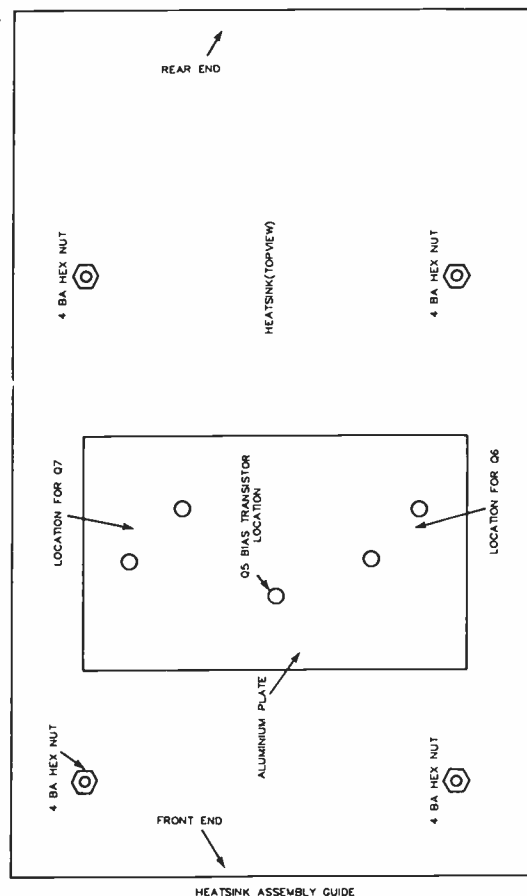
With reference to Figure 4, position the aluminium plate onto the heatsink. Position the four hex nuts as per the diagram and carefully position the pc board on top of the assembly. These nuts are used as spacers and are thus a clearance fit over the 3 mm x 8 mm machine screws which hold the pc board on the heatsink. Place the MRF429 transistors, Q6 and Q7, into their indicated positions, observing the correct polarity. The transistor mounting holes and the pc board mounting holes should be aligned with their respective holes in the heatsink.

The sides of the pc board should be parallel to the edges of the heatsink and there should be about 1 mm clearance from the ends of the board to the front and rear of the heatsink. With the assembly thus aligned, insert the nine 3 mm x 8 mm machine screws in their respective holes and tighten them down. Do not use excessive force, particularly when screwing down Q5, the case of which may shatter as a result.

The power transistors can now be soldered in place. Apply solder to the leads of the RF devices Q6 and Q7, using only the minimum amount required to make a good connection. "Sweat" the connections by pressing the flat of the soldering iron on the upper surface of each transistor's lead so that the solder on the undersides melts. This method allows the transistors to be mounted with the minimum mechanical stress.

Solder the collector of the bias transistor Q5 to its pad and cut off the excess leads protruding on the component side of the board. Now remove the board assembly from the heatsink. When removing and installing the pc board on the heatsink, always remember to loosen the transistors first and tighten them last. This prevents the transistors from becoming stressed by allowing the hex nut spacers to support the weight of

Figure 4.



the pc board. You may now solder the remaining leads of Q5 to their pads.

The board is now ready to accept the coils. Prepare RF chokes RFC4 and RFC5 by sleeving a ferrite bead over one end. The lead with the ferrite bead fitted is inserted into the pc board and soldered in place. The other lead is soldered on the component side of the board to the copper pads associated with the bases of the RF transistors.

Prepare the ten coils as per Figure 3, taking care to use the correct diameter tinned copper wire. Owing to the characteristic "symmetrical" layout of the amplifier, the opposing coils of each "half" should be wound in opposite directions to facilitate mounting. Note that L9 and L10 are wound in the same direction. The coils are mounted on the surface of the component side of the board by gripping with a pair of needle-nose pliers and soldering in place. It should not be necessary to re-locate any of the adjacent capacitors to accommodate the coils if you take heed of their position in the first place.

Apply a thin coating of silicone thermal grease to the ceramic tops of the RF transistors and install the two diodes D3 and D4 across the tops. It is best to pre-shape the diodes by bending their leads appropriately before soldering them in place. For optimum thermal tracking, the body of the diodes should make tight physical contact with the transistors. The protruding leads of the diodes should be trimmed as close as possible to the board on the underside to avoid the possibility of shorts to the aluminium plate.

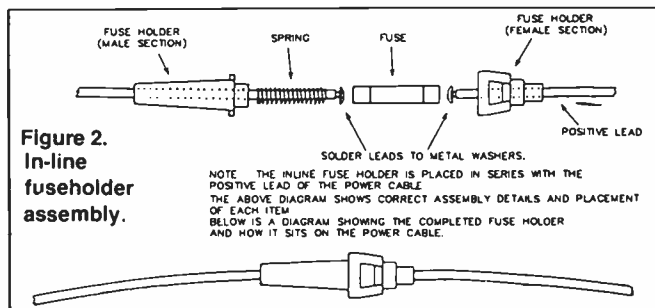
Insert two lengths of 1.7 mm diameter tinned copper wire into the RF connection holes at the rear of the board and solder them in place. Leave at least 20 mm protruding from the top of the pc board for later connection to the panel sockets.

The pc board can now be permanently installed on the heat-sink. The procedure for this operation is the same as before except that a mica washer insulator should be fitted under Q5 and a thin coating of silicone thermal grease applied to the undersides of the transistors, the mica washer and the aluminium plate. Ensure that the pc board is correctly aligned before tightening the screws and remember to tighten the transistor bolts last.

The front and rear panels can be mounted next. These are attached to the heatsink by means of #6 x 12 mm self-tapping screws which are screwed into the channels provided in the heatsink. As these screws require a fair amount of force to cut a thread in the channels, it is wise to pre-tap the channels by screwing in the self-tappers with the panels off, thus avoiding the possibility of damage due to the screwdriver slipping. Attach the SO-239 sockets and the RCA connector to the rear panel and ensure that the earth lugs on the RF sockets are fitted. Screw the panel onto the heatsink, then bend and position the earth lugs of the RF sockets such that they can be soldered to the top of the pc board.

Prepare the heavy duty red and black power leads by first installing the in-line fuse in the red lead as per Figure 2, then strip 10 mm of insulation from one end of each lead. Solder the red and black leads to their respective points on the pc board as indicated by the overlay. Feed the wire through the large centre hole in the rear panel and secure in place with the captive grommet.

Run a length of light gauge insulated hookup wire from the pcb pin marked "remote o/p" to the centre conductor of the RCA connector and install the 10n (0.01 uF) capacitor, C32, between the centre conductor of the RCA connector and the back panel. The two previously installed 1.7 mm diameter tinned copper wires are now bent over at a right angle and soldered to the centre conductors of their respective SO-239 sockets.



All that now remains of the construction is to fit the front panel and install the meter. Screw the front panel to the heat-sink after pre-tapping the channels as you did with the rear panel, then, after applying a small amount of contact adhesive to the top of the meter, seat it in place on top of the pc board such that it aligns with the cutout window in the panel. The switches and LEDs should also be protruding through their respective holes. Cut the leads for the meter backlight to the required length and terminate to the pcb pins indicated on the overlay. Use the off-cuts to connect the meter coil terminals to their respective pins.

This completes assembly of the amplifier. The next step is to test and align the unit.

Alignment

To align the amplifier, you will need the following test equipment: a 13.8 V power supply capable of delivering at least 18 amps and with current metering, a suitable VHF power/

VSWR meter reading to about 150 watts, a 50 ohm dummy load of suitable rating, a multimeter and a non-ferrous alignment tool.

The first step in the alignment process is to set the dc bias conditions for the power transistors. Turn the bias control trimpot VR1 fully clockwise and select the front panel mode switch to the AM/FM position. Apply dc power to the unit and observe the supply current. The relays should energise momentarily and the green "on-air" LED will illuminate for the same period. The supply current should now be about 50 mA. Test the VOX delay by selecting the SSB/CW mode and switching the unit off and then on. The relays should energise for approximately two seconds.

To set the dc bias, power must be applied to the transistors. To achieve this, the carrier operated relay (COR) circuit should be enabled by shorting the COR override pin (marked as C/O on the overlay) to ground. When this is done, the relays will energise and the "on-air" LED will illuminate. The supply current should be around 300 mA.

Adjust VR1 until the supply current increases by two amps. The collector currents of Q6 and Q7 will be about one amp each as large dc gain variations are not expected for these devices. This can be confirmed by opening the collector coils RFC3 and RFC7 one at a time and measuring the current to the collector. There is no reason for concern if variations are found as there will be negligible effect on the amplifier's overall performance. Disable the COR circuit by removing the jumper and remove power from the amplifier.

Having set the dc bias, you are now ready to perform the RF alignment. Some words of caution here; the output coils and capacitors will be "hot" at RF. You should take great care to avoid contact with these areas and use only an insulated aligning tool, or severe burns can result. The alignment steps should be performed as quickly as possible to avoid damage to the RF power devices and other components as there will be high circulating currents present, particularly when the transistors are driven into reactive loads. Finally, always ensure that whilst aligning the amplifier, it is terminated in a suitably rated, non-reactive dummy load. It is unwise to use an antenna, as misleading results can be obtained and there is a strong possibility that you will cause interference.

Commence by backing off all the trimmers two turns from their tight position. Terminate the output with a dummy load and a suitable power meter. If a suitable power meter cannot be obtained, it is possible to use the front panel meter of the amplifier, bearing in mind that it gives only a relative indication and can give erroneous readings if the amplifier is not terminated in the correct (50 ohms) load. Connect an exciter to the amplifier's input and apply a drive of one watt or less. As amateurs in Australia are now virtually unable to use the part of the six metre band between 50 and 52 MHz due to channel

- to page 77 ▶

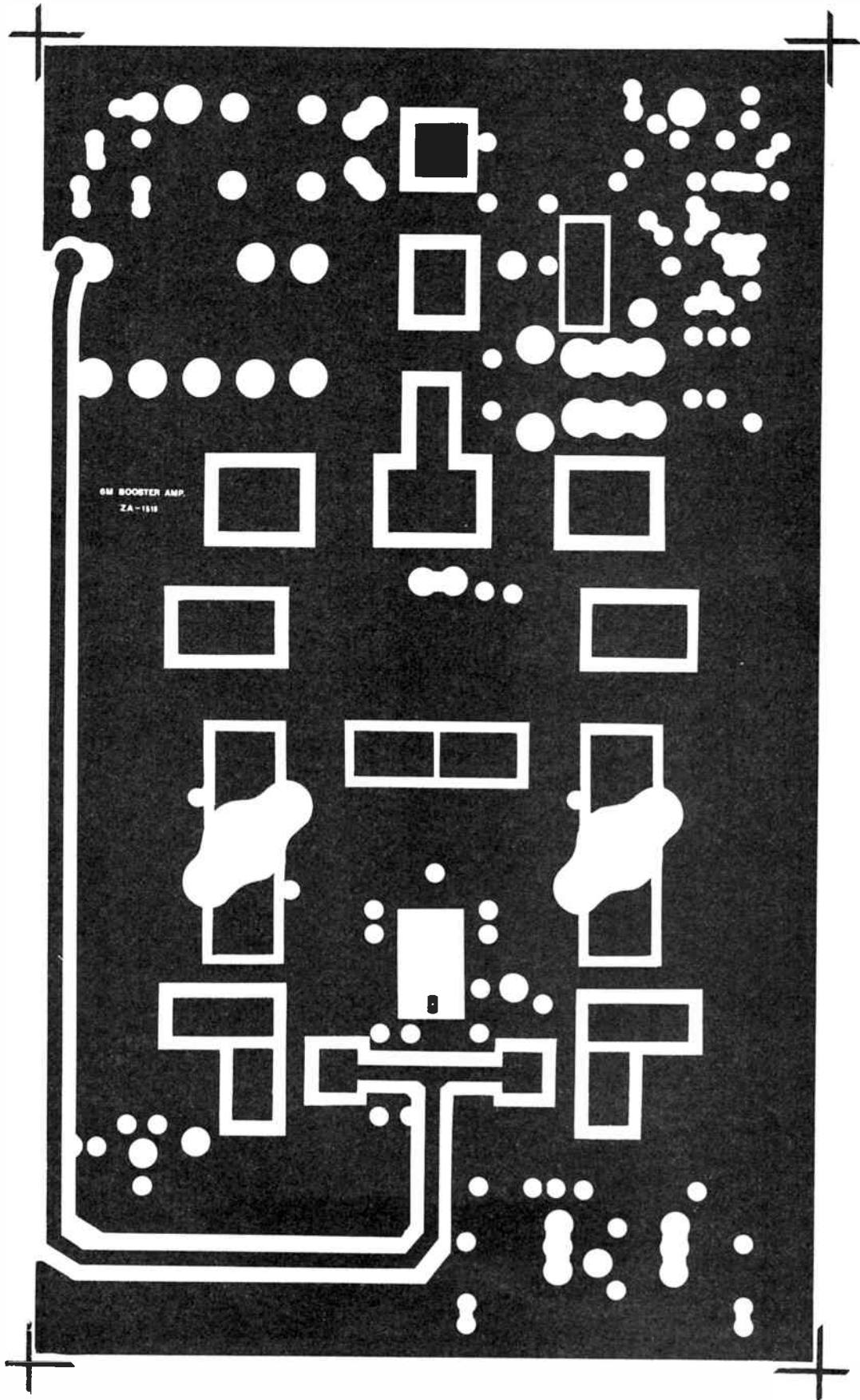
SPECIFICATIONS MEASURED ON PROTOTYPE

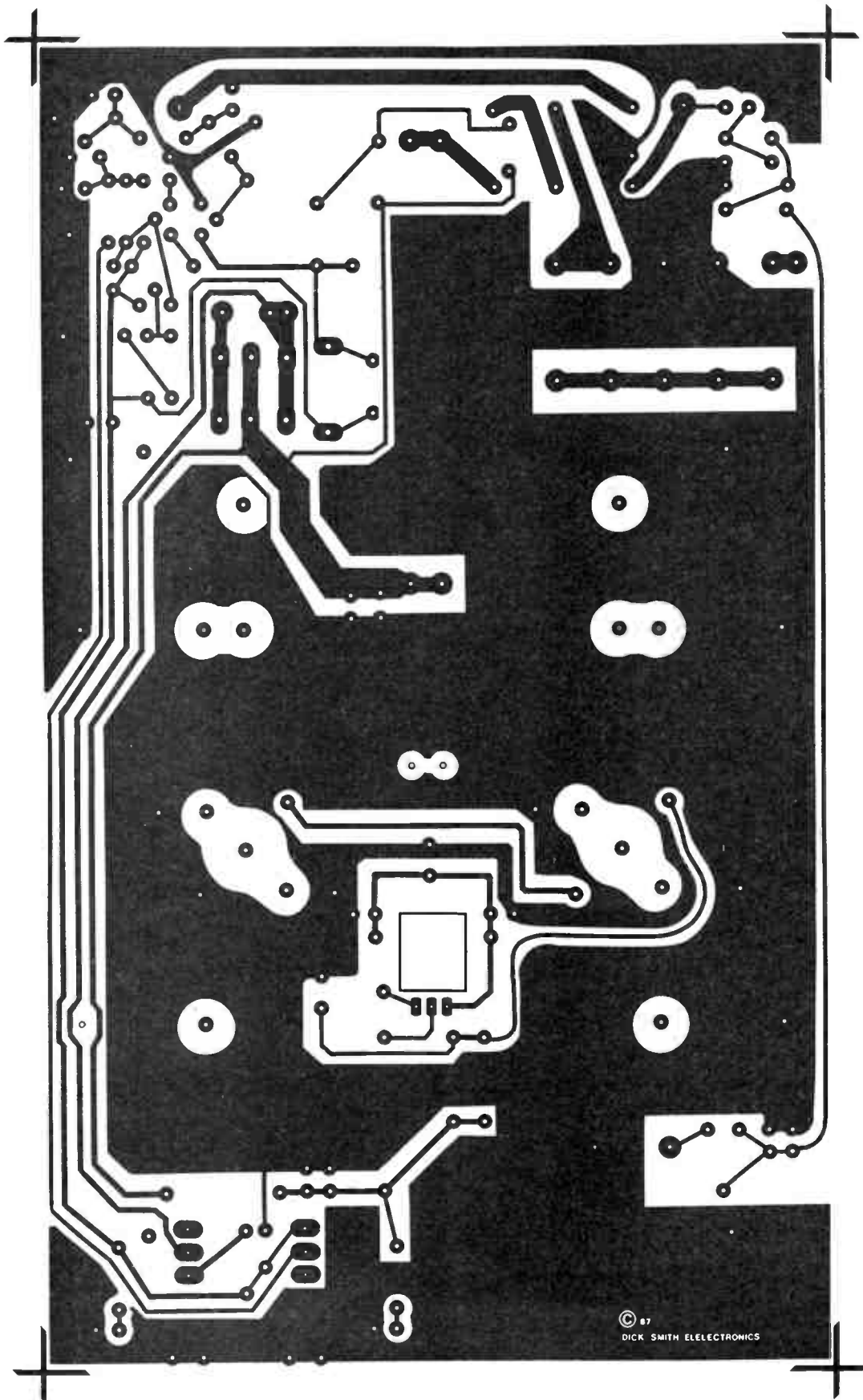
Amplifier mode:

Continuous power output	120 W CW
Saturated power output	150 W CW
Gain	12 dB to 14 dB
Efficiency	45% (15 A/13.8 V for 100 W)
Modes	CW, AM, FM and SSB
Bias	Variable
Input VSWR	1.5:1
1 dB bandwidth	50 MHz to 54 MHz
Harmonics	-63 dB (2nd harmonic)

Standby mode:

Input VSWR	1.1:1
Insertion loss	0.2 dB



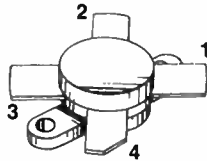


MRF492

NPN SILICON RF POWER TRANSISTOR

designed for 12.5 volt low band VHF large-signal power amplifier applications in commercial and industrial FM equipment.

- Specified 12.5 V, 50 MHz Characteristics —
Output Power = 70 W
Minimum Gain = 11 dB
Efficiency = 50%
- Load Mismatch Capability at High Line and RF Overdrive



STYLE 1
PIN 1 EMITTER
2 BASE
3 EMITTER
4 COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	18	Vdc
Collector-Base Voltage	V _{CBO}	36	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector-Current — Continuous	I _C	20	Adc
Total Device Dissipation @ T _C = 25°C (1) Derate above 25°C	P _D	250 1.43	Watts W/°C
Storage Temperature Range	T _{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

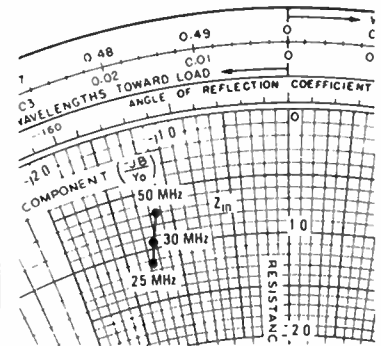
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	R _{θJC}	0.7	°C/W

- (1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.
(2) Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 100 mAdc, I _B = 0)	V _{(BR)CEO}	18	—	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 50 mAdc, V _{BE} = 0)	V _{(BR)CES}	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 mAdc, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CE} = 13.6 Vdc, V _{BE} = 0)	I _{CES}	—	—	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I _C = 5.0 Adc, V _{CE} = 5.0 Vdc)	h _{FE}	10	—	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V _{CB} = 15 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	275	450	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V _{CC} = 12.5 Vdc, P _{out} = 70 W, f = 50 MHz)	G _{PE}	11	13	—	dB
Collector Efficiency (V _{CC} = 12.5 Vdc, P _{out} = 70 W, f = 50 MHz)	η	50	—	—	%

FIGURE 5 — SERIES EQUIVALENT INPUT/OUTPUT IMPEDANCES

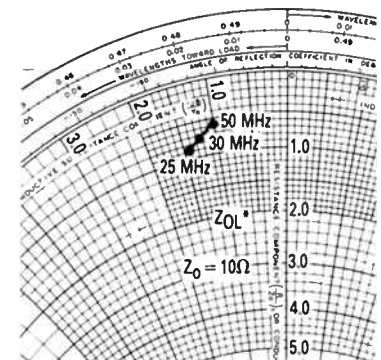
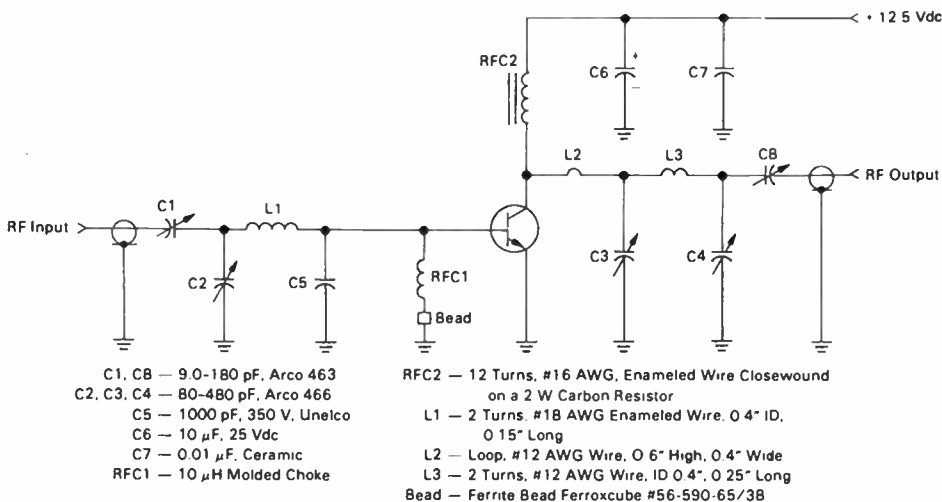


V_{CC} = 12.5 V, P_{out} = 70 W

f MHz	Z _{in} Ohms	Z _{OL} * Ohms
50	0.7 - j1.17	0.58 - j1.0
30	0.93 - j1.24	0.76 - j1.3
25	1.12 - j1.28	0.85 - j1.46

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency

FIGURE 1 — 50 MHz TEST CIRCUIT



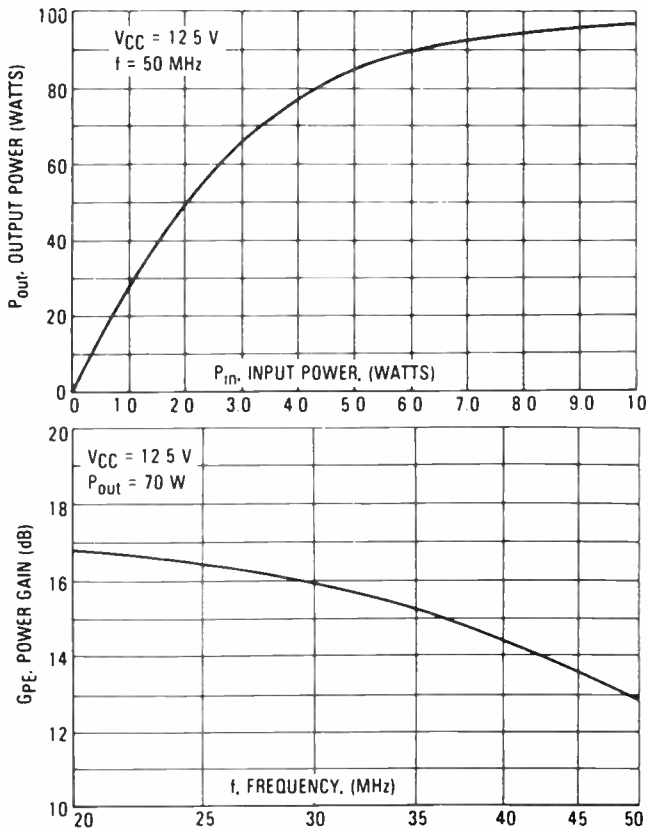


FIGURE 2 — OUTPUT POWER versus INPUT POWER

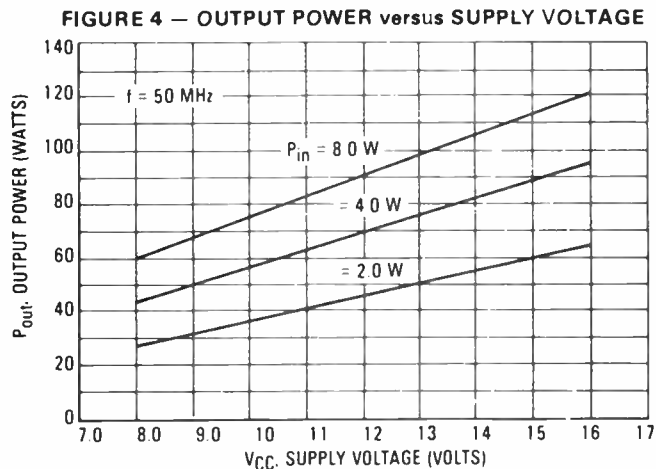


FIGURE 3 — POWER GAIN versus FREQUENCY

— from page 73

0 television, it would be best to align the unit at a center frequency of 53 MHz.

As the drive is applied, the COR circuit should be enabled and the relays should energise. Adjust the output trimmers VC3-VC4 and VC5-VC6 for maximum power output. Next, you should adjust the input trimmers, VC1 and VC2 for minimum input VSWR. If your power meter and VSWR meter are one and the same instrument, you will have to remove it from the output and connect it in series with the input. Don't forget to re-connect the dummy load to the output.

Repeat these steps several times, this time aligning one "half" of the amplifier at a time and tuning the input stage first and output stage last, i.e: adjust VC1, VC3 and VC4, then VC2, VC5 and VC6. The output power should now be 20 to 30 watts, assuming a drive of one watt, and the current drawn from the supply should be about nine amps. The maximum input drive can now be applied and the amplifier stages aligned as above. Refer to the input attenuator section for the maximum allowable input drive levels. Reference can be made to the graphs to obtain the expected levels of performance.

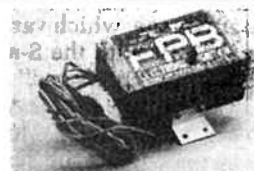
An approximate increase of 0.5 dB in power gain can be achieved with a slight sacrifice in efficiency by adjusting the bias trimmer VR1 towards class A (counter clockwise). This operation can be performed whilst transmitting, but make only small adjustments at a time.

To complete the alignment procedure, adjust VR2 so that the front panel meter reads full scale when maximum power output is being delivered. The aluminium cover can now be fitted and secured by the six 3 mm x 8 mm machine screws and two #4 self-tappers. Fix the four self-adhesive rubber feet to the bottom of the cover and the amplifier is ready for on-air operations. 🐘

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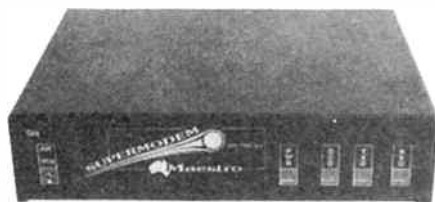
A "Hayes Micro-Modem Compatible" modem with 1200/1200 full duplex, plus 1200/75, 75/1200, 300/300, auto-answer and auto-dial.

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Step inside the USS Enterprise as it shifts from impulse to warp drive.

Capture the raw power of lightning before it plummets to the Earth. Stand on the flight deck and key-in the micro-code to control your destiny.

Cross the threshold between software and hardware — discover the "missing link"!

Very emotive stuff, right? But I did want to get your attention and now that I have it, read on — it gets more interesting.

This is a computer kit based on the Novix 4000 processor. There are many extraordinary things about this chip. For instance: there is no internal micro-code which means there is no delay between your application program in high level Forth, with no speed penalty.

The Novix 4000 has many of the qualities of the Transputor or the RISC-type processors, but even more incredible is its ability to jump to subroutines and back in one cycle!

The board is supplied with an on-board EPROM programmer, programmable (0 to 8 MHz) processor clock and on fire-up, loads its running system from EPROM to fast RAM. It can be plugged into an IBM slot, or used with a serial link with any computer or stand-alone with its own video and keyboard controller.

PRICE: \$699.00

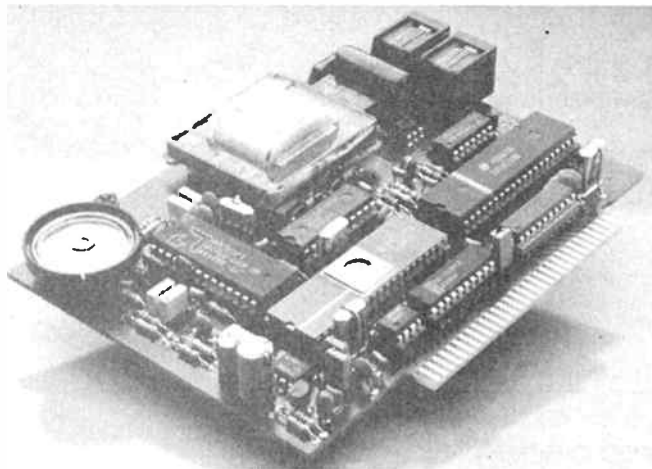
This is not a games machine but an experiment with the future.

MAESTRO DISTRIBUTORS

Calool St, South Kincumber 2256 NSW

Telephone: (043)68 2277, 68 2278

DEALER ENQUIRIES WELCOME



A "Nice" small in-modem

An Australian manufacturer has launched what is claimed to be the world's smallest 1200 baud internal modem for the IBM PC. The Nice inside modem from the Nice Computer Company of Australia Pty Ltd is less than half-card size and plugs straight in to any IBM PC, XT, AT or compatibles. The modem is even small enough to fit into portables.

The modem will operate at 1200 baud and 300 baud full duplex under both the Bell and CCITT standards as well as providing CCITT V.23 operation at 1200/75 baud for Viatel. The modem has an extended Hayes AT-compatible command set and will even hold one commonly used telephone number to avoid having to type it each time.

It is possible to configure the modem as any one of the IBM "COM" ports one to four, and it also provides auto-dial, auto-answer and auto-disconnect. The modem will originate or answer at any speed and employs true baud rate scanning to match its operation to the remote modem.

The new Nice modem will be marketed Australia-wide as well as in export markets and has a recommended retail price in Australia of \$849. A less expensive version without 1200 baud full duplex capability costs \$599 and can be upgraded later if required. Both modems are supplied with communications and Videotex software.

For further information on this modem, as well as the rest of their extensive range, contact: The Nice Computer Company of Australia Pty Ltd, Suite 3, 41

Rawson Street, Epping 2121 NSW. (02)869 8777.

The BIT Blitzer 123E Modem

The BIT Blitzer 123E from Banksia Information Technology of Hong Kong, is an automatic, intelligent, 300, 1200 and 1200/75 bps full duplex, asynchronous and synchronous external modem, which meets the CCITT V.21, V.22 and V.23 standards as well as the Bell 103/212A standards.

The Blitzer 123E is automatic and intelligent as it implements the full Hayes "AT" command set, including 19 "S" registers, so that PC communications packages can make use of all their features.

The modem features baud rate conversion for those computers unable to handle the 1200/75 split rate, as well as call progress monitoring, loopback for remote diagnostics, ten activity and status monitoring indicators (LEDs), very low power consumption and an internal speaker with command protocol controlled volume settings.

There are no switches or user alterable jumpers to be set, all

modem setup and configuration options are permanently held in non-volatile memory and can be altered via the command protocol.

The Australian distributor for the Blitzer 123E is: Mike Boorne Electronics Pty Ltd, Suite 3, 61A Hill Street, Roseville 2069 NSW. (02)46 3014. The unit is retailed through Dick Smith stores.

Locally designed personal computer security system

If you're worried about security of your computers, then you should see Finch Computer Services of Victoria who has designed and manufactures a device known as the "Compuloc Security Board" which prevents unauthorised access to personal computers.

The Compuloc is a small board that plugs into a vacant slot on your PC or compatible computer and offers varying levels of access to information stored on the hard disk or floppy disks.

The Compuloc offers three levels of access to the computer. Level 1 is for the system operator and allows four passwords to be installed with system operator status. This status allows full access to both the hard disk and the floppy disks.

Level 2 status is the level normally granted to operators. The Compuloc supports more than 180 operators at level 2, all of whom have access to the hard disk only. The computer will not boot from a floppy disk, so operators can be forced into a special menu program which then restricts access to certain files on the drive.

Level 3 status allows access to the floppy drives only and may be useful for allowing the computer to be used for recreational purposes etc.

In operation, the computer will allow three attempts at entering a correct password after being turned on or reset. After three unsuccessful attempts, the keyboard will lock and a siren sound will be emitted by the internal loudspeaker in the computer. The siren can only be stopped by turning power to the computer off and then re-booting. If the correct password is entered, the machine will operate as normal

except for the restrictions placed by the different levels of access.

Unauthorised removal of the Compuloc board from the computer without having first run a de-installation program, will disable the hard disk until it is re-formatted. Therefore, if the computer is stolen, the data on the hard disk is secure.

For further information, contact: Finch Computer Services, 50 Hamilton Road, Bayswater 3153 Vic. (03)729 6301.

High performance modem module from Texas

Texas Instruments has announced the release of a high performance, multi-standard modem module. Known as the MOD3110, it complies with CCITT V.22bis, V.22, V.21 and V.23 standards as well as the Bell 212A, 103 and 202 standards. The module also includes the modulator/demodulator and controller functions for automatic call and answer protocols with either the V.25bis or the Hayes "AT" command set.

Owing to the highly integrated features of the MOD3110, an OEM can easily and quickly design a complete modem with minimal software and hardware effort. The module incorporates the necessary interfaces for either a PC-based or stand-alone mounting and is well suited to a variety of applications such as personal and professional computers, workstations, point of sale and Videotex terminals.

The MOD3110 is offered in a 50 mm x 79 mm, 50-pin dual-inline module package. For evaluation purposes, TI offers an evaluation kit which contains a demonstration board and an EPROM module. Together, these components emulate the complete modem solution using an RS232 interface and a simple line driver to the telephone line interface, TI say.

TI also provide a complete PC add-on board which allows fast evaluation of the modem performance and the industry standard Hayes AT command set, for any 8- or 16-bit IBM PC or compatible.

Further information may be obtained from: Texas Instruments Australia Pty Ltd, Semi Conductor Group, 6-10 Talavera Road, North Ryde 2113 NSW. (02)887 1122.

A disk drive double-up for your CPC6128

Rod Nugent

So you've had your CPC6128 for a while, eh? Tired of flipping your disks to get at that file you need on the other side? Maybe you're tired of running out of disk space and crashing that laboriously assembled program. No more! Here's how to install a double-sided disk drive BOAC-style (with a minimum of fuss).

HANDS UP all those 6128 owners who hate turning over their disk because that all important file is on the OTHER side. Or you run out of disk space at that vital moment and crash your program. Or can't fit their spleinig checker dictionary on-disk with the wordprocessor!

There is a solution to these and the other woes that beset 6128 owners because of the small disk capacity of the drive supplied with the machine. Get a bigger drive! For around \$160.00 you can fit a 360K drive INTO your 6128. That's less than half the cost of the add-on 5¼" drives AND its portable!

If you own one of the Giltronic or other 5¼" drives, don't turn off yet because there are a couple of goodies in this for you too. There is a FAST format program and auto log-in for the double sided disks available. You can kiss goodbye to DISCKIT+ and SETB40.

The modifications are fairly straightforward, requiring no extensive technical knowledge, just a steady hand. You don't even touch a soldering iron!

Here's a list of what you need:

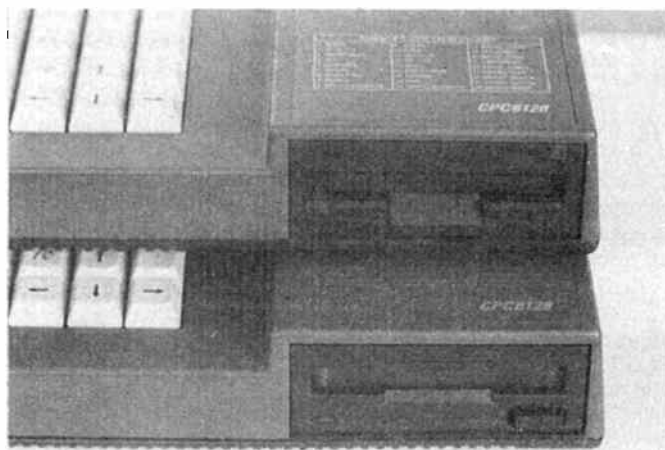
- 1) Your CPC6128;
- 2) A Hitachi 3" DSDD drive;
- 3) A 34-way card edge connector;
- 4) A disk drive power connector (e.g: Radio Spares #471-424)
- 5) Wire cutters, pliers, Philips head screwdriver and a file.

Handy, but not necessary, is a bench grinder and a 'DREMEL' or similar engraving tool.

"Where do I get all that?" you ask? The edge connector is a common item at most component retailers. My power connector came from Radio Spares. You get five for around ten dollars. The drive comes from England, from a company called "MATMOS." It cost me 49.00 pounds, including return air-freight and took only three weeks from posting my order until the postie delivered it. Top service, what! With the 26% duty, your drive should cost around \$140.00, depending on the prevailing exchange rate. MATMOS' address is at the end of this article.

Into the fray

Well here's how, folks. Finish all pending work on your computer. It should only be out of action for a day. But first, put all your files onto Side 1 of your disks. The new drive won't let you put the disk in upside down so you won't be able to access Side 2 once it's fitted. You could disassemble the drive and



Before and after – the top machine is the upgraded 6128. Note how far down to grind the top lip of the front panel.

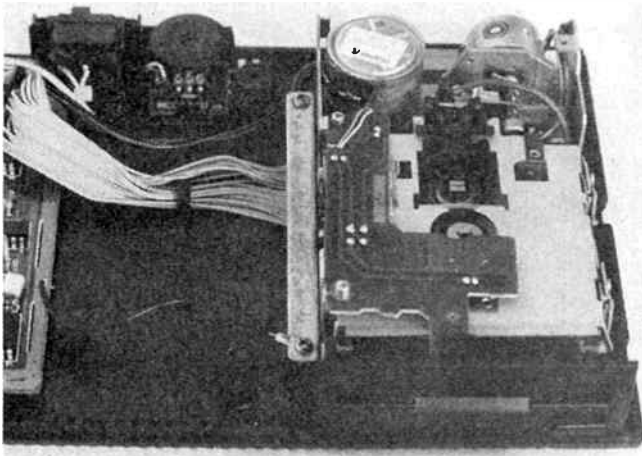
remove the tab that prevents you from flipping the disk, but it's not worth the trouble.

Clear a large, clean work area where you won't be interrupted. Turn the 6128 over and remove all the gold-coloured self-tapping screws from underneath. Turn it over again into the working position and remove the two black machine screws from the right side of the case. Lift the top cover over to the left and lay it face down beside the bottom. Be careful of the keyboard connector cable.

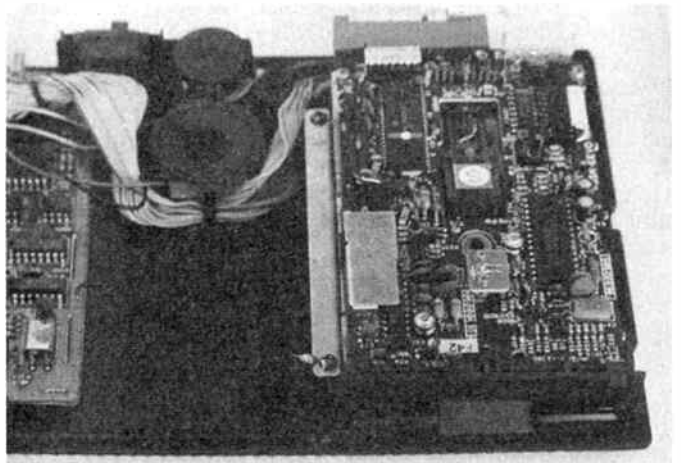
Remove the two gold screws holding down the mounting bracket on the left side of the drive. Lift the drive up, turn it over and disconnect the ribbon cable connector and power connector from the rear of the drive. These are very tight and may need a little coaxing. The power connector has a retainer that must be pushed out to release it. Remove the two machine screws holding the bracket onto the left side of the drive. Keep these and the bracket. Put the drive aside, you're finished with it.

It will be rather obvious that the Hitachi drive is a monster compared to the Matsushita that was in there. You have a little cutting and shutting to do to fit it in, but it will fit, and quite nicely.

Leaving the dummy disk in the drive, remove the front panel. You must remove the bottom 3 mm lip and the top 5



Original drive before removal. Note how the flat cable goes UNDER the original drive.



The new drive in place. Note that the flat cable now goes BEHIND the new drive. Also note the new speaker position.

mm or so, down to the TOP of the LED, of the front panel. I did this on a bench grinder, first laying a strip of tape across the front as a guide and grinding all but the last bit off, finishing with a fine file.

You must also remove the eject button – a good pull will do the trick, and grind 1.5 mm off the bottom edge. This is about the thickness of the bottom edge moulding of the button. How neat you are with the grinder and file will determine how your finished unit looks, so tread lightly. Don't refit the front panel at this stage.

Next up is the 6128. Cover the main circuit board with an anti-static bag or foil and tape it down to keep dust and plastic out. On the inside of the drive well, on each side, are several small plastic supports about 2 mm high. These supported the old drive, but the new one sits on the floor, so clip these off with cutters and file the area smooth. File 2 mm off the pillars that the left side mounting bracket was screwed to.

On the inside front lip of the bottom casing is a small ledge. This supported the front of the old drive. This ledge must be ground down to the floor level of the casing. The DREMEL is just the ticket here. Only grind down the inside of the ledge, not the entire front lip of the casing. The inside face of the front lip must be flat after you finish, so the drive can sit right up flush with the front.

On the top casing there is a little ridge, about 1 mm high, running across the inside of the drive well. File this off flush with the casing edge. Slot the two screw holes on the right side of the top casing down about 2 mm.

Trial fit the drive into the well. You may find that the small capacitors on the printed circuit board just touch the top casing. You could try replacing them with some smaller ones, but I just removed a little plastic from inside the top casing. The casing is quite thick at this point. When it is all done the drive should slide freely back and forth in the assembled casing.

Reassemble the drive, fit the left side bracket and screw it into the case. It should be a good fit, but there is not much room to spare. Be sure there are no stress points in the casing. It should fit together perfectly without any screws in. File the drive front panel or your casing until it fits properly. You may need to adjust the slots in the right side to align with the drive screw holes.

That completes the mechanical work. The connections are

next on the agenda, followed by details of the BIOS alterations and formatting software.

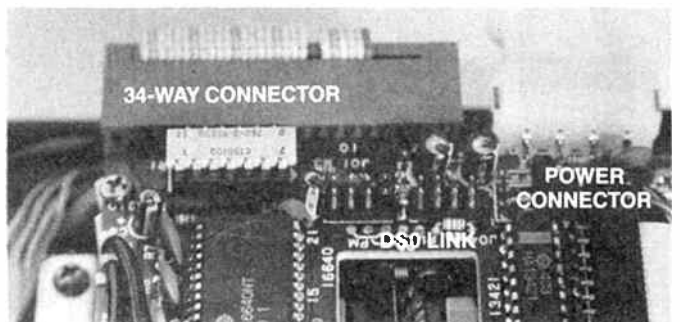
As I mentioned above, the original drive connection is a 26-way ribbon cable. Connecting a 26-way cable to a 34-way connector may seem a bit daunting, but it's quite simple really. Amstrad don't use the redundant signal leads of the standard 34-way connector.

Cut off the ribbon cable as close as possible to the 26-way connector. The red trace is wire 1 and they count across to wire 26. Split the ribbon at wire 6. You need 6 wires, including wire 1, in one lot and 20 in the other. Wires 1 – 6 correspond to wires 7 – 12 of the 34-way connector and wires 7 – 26 correspond to wires 15 – 34 of the 34-way connector.

Fit the split cable into the 34-way connector, holding it in place with the crimp plate. Check carefully before you crimp the connector, you may not get a second chance. If you crimp the connector on upside-down or try to use the strain relief, you won't have enough cable. The cable must hang down from the connector and pin 2 should be on the top right, looking at the connector from the front. This is the point most likely to cause problems, so BE CAREFUL.

Cut off the 4-pin power connector. Fit one of the female pins of the new power connector to each wire, crimping firmly with pliers or a crimp tool. You will have to notch out the bottom of the power connector so the wires come down

Close-up of the split cable in the 34-way connector. The connector numbers from RIGHT to LEFT here, with even numbers on the TOP side. The far right wire is number 1. Note the position of the DSO link, 4th from the left in the jumper block.



instead of out the rear of the connector. The RED wire is +12 V and goes in position 1 of the connector. The two BLACK wires go in positions 2 and 3, with the ORANGE wire, +5 V, into position 4. Plug it all together and tidy the wiring.

The new drive is now finished. Check the jumpers on the drive to make sure it is fitted with the DS0 link. Looking from the front, this is the jumper on the right of the jumper block and this tells it to be drive "A". The only thing to do now is shift your speaker. Unclip it and pull out the wiring. Relocate it to the left of the drive, in front of the volume control. I stuck mine down with double-sided tape. It is a bit softer now, but is still quite audible.

Reassemble the machine, checking again for pinched wires and pressure points. Fire it up and do a CAT in BASIC to check the drive works OK. If it doesn't go (not likely) check your wiring and re-crimp the edge connector.

Boot CP/M 3 and verify the disk with DISCKIT3. You may find, as I did, some errors on the last two tracks. These are caused by a little misalignment between drives and doesn't affect disks formatted with this drive. It will only cause problems when reading very full disks from other machines.

Accessing the other side

Access is only available from within CP/M 3. I will use some technical jargon here, but you don't need to know the ins and

```

;ERASE.MLS V1.0 FOR THE AMSTRAD CPC612B. 10/6/87 R NUGENT
;
;THIS ESI CLEARS THE SCREEN OF THE CPC612B.
;
;COMMON: BDOS CPM+ SYSTEM INTERFACE.
;
;ASM: ^ERASE
; CALL ERASE
;
;ERASE SUBR
;
BDOS EXT PROG ;DEFINE EXTERNALS
;
14 0000 E5 ^ERASE PUSH HL
15 0001 D5 ^ERASE PUSH DE
16 0002 C5 ^ERASE PUSH BC
17 0003 0E09 LD C,9 ;BDOS PRINT STRING
18 0005 110F00 LD DE,CLEARSTR ;ADDRESS OF CLEARING S
TRING
19 000B CD0100 CALL BDOS ;DO FUNCTION
20 000B C1 POP BC
21 000C D1 POP DE
22 000D E1 POP HL
23 000E C9 RET
24 000F 1B451B4B CLEARSTR DB 'E',27,'H',27,'S'
END

Start End Req
Code 0000:0000 0000:0014 0000:0014
Data 0000:0000 0000:0000 0000:0000
    
```

outs of it all to use the system. The other side is accessed by altering the Disk Parameter Block for that drive. Giltronic do this by temporarily altering the BIOS (your .EMS file), with the SETB40 program, to enable selection of the double-sided format. I took a different approach, which is much more versatile and will work for drive "A" and "B".

System disk sectors start numbering at 41h, normal data

```

;FORMATDS.MLS FOR THE AMSTRAD CPC612B.
;05/07/87 R. NUGENT.
;
;THIS PROGRAM FORMATS DOUBLE SIDED DRIVES EITHER FITTED
;INTERNALLY OR THE EXTERNAL 5 1/4 INCH TYPES.
;
;REQUIRES: FMTDISK FORMATTING ESI
; ^ERASE SCREEN CLEAR ESI
;
;COMM BDOS.USERF ;COMMON DATA
;
12 0005 BDOS EQU 5 ;BDOS CALL LOCATION
13 0009 PRINTSTR EQU 9 ;PRINT STRING FUNCTION
14 0001 CONIN EQU 1 ;CONSOLE IN FUNCTION
15 0002 CONOUT EQU 2 ;CONSOLE OUTPUT FUNCTION
16 000D CR EQU 0DH ;RETURN
17 000A LF EQU 0AH ;LINE FEED
18 FD10 USERF EQU 0FD10H ;USERF FUNCTION
;
20 0100 0E0C LD C,12 ;GET VERSION
21 0102 CD0500 CALL BDOS
22 0105 7D A,L
23 0106 11F201 LD DE,VERFAIL
24 0109 FE31 CP JH
25 0108 C2ED01 JP NZ,FAILMSG
26 010E CD3203 INTRO ^ERASE ;INTRO MSG
27 0111 0E09 LD C,PRINTSTR
28 0113 111E02 LD DE,INTROSTR ;PRINT INTRO
29 0116 CD0500 CALL BDOS
30 0119 0E09 SELECT1 LD C,PRINTSTR
31 0118 115102 LD DE,SELECTTAB ;PRINT SELECT MESSAGE
32 011E CD0500 CALL BDOS
33 0121 0E01 LD C,CONIN
34 0123 CD0500 CALL BDOS ;GET RESPONSE
35 0126 FE03 CP OSH ;IS IT 'C
36 0128 CA0000 JP Z,0000H
37 012B E6DF AND ODFH ;MASK IT FOR CAPITALS
38 012D FE41 CP 'A'
39 012F 2B09 JR Z,CONFIRM
40 0131 FE42 CP 'B'
41 0133 2B05 JR Z,CONFIRM
42 0135 CD3203 ^ERASE
43 0138 1BDF LD SELECT1
44 013A 323103 CONFIRM ( DRIVE ),A ;SAVE DRIVE
45 013D CD3203 CONFIRM1 ^ERASE
46 0140 0E09 LD C,PRINTSTR
47 0142 117302 LD DE,CONFHMSTR ;PRINT CONFIRMATION MS
G
48 0145 CD0500 CALL BDOS
49 0148 0E02 LD C,CONOUT
50 014A 3A3103 A,( DRIVE );PRINT DRIVE DESIGNATI
ON
51 014D 5F LD E,A
52 014E CD0500 CALL BDOS
53 0151 0E01 LD C,CONIN
54 0153 CD0500 CALL BDOS ;GET RESPONSE
55 0156 FE03 CP OSH ;IS IT 'C
56 0158 CA0000 JP Z,0000H
57 015B E6DF AND ODFH ;MASK FOR CAPITALS
58 015D FE59 CP 'Y'
59 015F 2B07 JR Z,STARTFMT
60 0161 FE4E CP 'N'
61 0163 CA0E01 JP Z,INTRO
62 0166 1BDS JR CONFIRM1
63 0168 CD3203 STARTFMT ^ERASE
64 016B 0E09 LD C,PRINTSTR
65 016D 119702 LD DE,PRESSSTR ;PRESS KEY MESSAGE
66 0170 CD0500 CALL BDOS
67 0173 3A3103 LD A,( DRIVE );DRIVE LETTER
68 0176 5F LD E,A
69 0177 0E02 LD C,CONOUT ;PRINT DRIVE LETTER
70 0179 CD0500 CALL BDOS
;
71 017C 0E09 LD C,PRINTSTR
72 017E 11A0F2 LD DE,ABORTSTR ;EXIT MESSAGE
73 0181 CD0500 CALL BDOS
74 0184 0E01 LD C,CONIN ;GET RESPONSE
75 0186 CD0500 CALL BDOS
76 0189 E6DF AND ODFH ;MASK FOR CAPITALS
77 018B FE46 CP 'F'
78 018D C20E01 JP NZ,INTRO
79 0190 3A3103 LD A,( DRIVE );SELECT XDPB
80 0193 FE41 CP 'A'
81 0195 DE00 LD C,0 ;SELECT 'A'
82 0197 DD2164FF LD IX,OFF64H ;XDPB A
83 019B 2B05 JR Z,DDSELFMT ;FORMAT THE DISK
84 019D 00 INC C ;SELECT 'B'
85 019E DD217FFF LD IX,OFF7FH ;XDPB B
86 01A2 3E03 DDSELFMT LD A,3 ;SELECT FORMAT 3 360K DS
87 01A4 C5 DDSELFMT PUSH BC ;SAVE DRIVE NUMBER
88 01A5 CD10FD ^ERASE USERF
89 01A8 9500 DW 95H
90 01AA C1 POP BC ;RECOVER DRIVE NUMBER
91 01AB 3E31 LD A,'1' ;ERROR 1
92 01AD D2DD01 JP NC,EXECFAIL ;ERROR FAIL
93 01B0 79 LD A,C
94 01B1 32BC01 LD ( :1G0 ),A
95 01B4 3E65 LD A,0ESH ;FILLER
96 01B6 32BD01 LD ( :2G0 ),A
97 01B9 CD460300 GO ^FMTDISK O 0ESH
ES
98 01BE 3E32 LD A,'2' ;ERROR 2
99 01C0 D2DD01 JP NC,EXECFAIL
100 01C3 CD3203 ^ERASE
101 01C6 0E09 LD C,PRINTSTR
102 01C8 11DD02 LD DE,FINFRMT ;FORMAT COMPLETE
103 01CB CD0500 CALL BDOS
104 01CE 0E01 LD C,CONIN
105 01D0 CD0500 CALL BDOS ;GET RESPONSE
106 01D3 E6DF AND ODFH ;CAPITALS
107 01D5 FE59 CP 'Y'
108 01D7 C20000 JP NZ,0
109 01DA C36B01 JP STARTFMT
110 01DD F5 EXECFAIL PUSH AF
111 01DE 0E09 LD C,PRINTSTR
112 01E0 111503 LD DE,FAIL
113 01E3 CD0500 CALL BDOS
114 01E6 F1 POP AF
115 01E7 0E02 LD C,CONOUT
116 01E9 5F LD E,A
117 01EA C30500 JP BDOS
118 01ED 0E09 FAILMSG LD C,PRINTSTR
119 01EF C30500 JP BDOS
;DATA SPACE AND MESSAGES
121 01F2 57524F4E VERSFAIL DB 'WRONG VERSION OF CP/M - EXITING T
O SYSTEM',CR,LF,'$'
122 021E 464F524D INTROSTR DB 'FORMATDS - FOR THE AMSTRAD CPC612
B - VERSION 1',CR,LF,LF,'$'
123 0251 466F726D SELECTTAB DB 'Format disk in DRIVE <A> or <B>?
',CR,LF,'$'
124 0273 436F6E66 CONFHMSTR DB 'Confirm format <Y> or <N> on DRIV
E ',CR,LF,'$'
125 0297 496E7365 PRESSSTR DB 'Insert disk into DRIVE ',CR,LF,'$'
126 02AF 2C207072 ABORTSTR DB 'press <F> to FORMAT any other k
ey to abort ',CR,LF,'$'
127 02DD 07464F52 FINFRMT DB '07H,FORMAT COMPLETE - Another <Y>
or any other key to end ',CR,LF,'$'
128 0315 0DDA0A07 FAIL DB 'CR,LF,LF,07H,EXECUTION FAIL - ERR
OR ',CR,LF,'$'
129 0331 00 DRIVE DB 0
END

Start End Req
Code 0000:0100 0000:041F 0000:031F
Data 0000:0100 0000:0100 0000:0000
    
```

```

:FMTDISK.MLS V1.0 FOR THE AMSTRAD OPC6128 *6/5/87 R.NUGENT
:
: THIS ESI TAKES TWO PARAMETERS, DRIVE AND FILLER, SINGLE-BYTE VALUES.
: IT REFERENCES THE XDPB FOR THAT DRIVE AND FORMATS THE DISC IN THAT DRIVE
: USING THE FILLER BYTE GIVEN. DRIVE IS EITHER 1 OR 0 FILLER IS A HEX VALUE.
: USUALLY OESH
:
: COMMON: USERF THE BIOS USERF FUNCTION AT FD10H
:
: ASM: CALL FMTDISK
:       DB DRIVE
:       DB FILLER
:
: FMTDISK SUBR 5B 5B
:
: USERF EXT PROG ;DEFINE EXTERNAL DATA
:
: 1B 00BF DDFORMAT EQU 00BFH ;DEFINE EQUATES
:
: START OF CODE
21 0000 E1 FMTDISK POP HL ;RECOVER RETURN ADDR
22 0001 E5 PUSH HL ;PUT IT BACK FOR IY
23 0002 FDE1 POP IY ;POINT TO PARAMS
24 0004 110200 LD DE,2 ;UPDATE RETURN ADDR
25 0007 19 ADD HL,DE
26 0008 E5 PUSH HL ;RETURN ADDRESS
:
: START OF ROUTINE
28 0009 FD7E00 XDPBS LD A,(IY+ 0) ;GET DRIVE NUMBER
29 000C FE00 CP 0 ;IS IT DRIVE A
30 000E DD2164FF LD IX,OFF64H ;POINT TO XDPB A
31 0012 CA1900 JP 2,FORMAT1 ;JUMP TO FORMAT1 IF A
32 0015 DD217FFF LD IX,OFF7FH ;OTHERWISE XDPB B
33 0019 DD4612 FORMAT1 LD B,(IX+ 18) ;TRACKS/SIDE
34 001C DD7E11 LD A,(IX+ 17) ;SIDENESS
35 001F FE00 CP 0 ;IS IT SSIDE
36 0021 1600 LD D,0 ;SET LOGICAL TRACK COUNT
37 0023 2B13 JR 2,TABLEGEN ;IF SSIDE THE COUNT IN
B IS OK
38 0025 CB20 SLA B ;OTHERWISE DOUBLE THE COUNT
39 0027 328700 LD D,(SIDENESS).A ;STORE SIDENESS OF
XDPB
40 002A DD361101 LD (IX+ 17),1 ;SET FLIP SIDES FOR RO
UTINE
41 002E DD7E1A LD A,(IX+ 26) ;GET FREEZE FLAG
42 0031 328B00 LD (FREEZE).A ;STORE FREEZE OF XDPB
43 0034 DD361AFF LD (IX+ 26),OFFH ;FREEZE THE XDPB
44 0038 C5 TABLEGEN PUSH BC ;SAVE COUNT
45 0039 D5 PUSH DE ;SAVE LOGICAL TRACK
46 003A AF XOR A ;CLEAR A
47 0038 DDBE11 CP (IX+ 17) ;COMPARE WITH SIDENESS
48 003E OE00 C,0 ;IF SSIDE THEN ALWAYS HEAD 0
49 0040 2B07 JR 2,TRACKTBL ;IF SSIDE THEN GENERATE
FORMAT TABLE
50 0042 CB42 BIT 0,D ;TEST FOR ODD OR EVEN TRACK
51 0044 2B01 JR 2,PHYSTRK ;IF EVEN THEN HEAD 0
52 0046 C0 INC C ;OTHERWISE HEAD 1
53 0047 CB2A PHYSTRK SRA D ;HALVE D TO GET PHYSICAL TRACK
NUMBER
54 0049 DD5E14 TRACKTBL LD E,(IX+ 20) ;FIRST SECTOR NUMBER
55 004C 21B900 LD HL,FRMTBUFF ;SET POINTER FOR BUFFE
R
56 004F DD7E16 LD A,(IX+ 22) ;SECTOR SIZE
57 0052 DD4613 LD B,(IX+ 19) ;SECTORS/TK
:
: GENERATE THE HEADER TABLE
59 0055 72 STARTTBL LD (HL),D ;TRACK
60 0056 23 INC HL ;NEXT LOC
61 0057 71 LD (HL),C ;HEAD
62 0058 23 INC HL ;NEXT LOC
63 0059 73 LD (HL),E ;SECTOR NUMBER
64 005A 23 INC HL ;NEXT LOC
65 005B 77 LD (HL),A ;SECTOR SIZE
66 005C 23 INC HL ;NEXT LOC
67 005D 1C INC E ;NEXT SECTOR NUMBER
68 005E 10F5 DJNZ STARTTBL ;BACK FOR NEXT SECTOR
:
: START THE FORMAT
70 0060 D1 POP DE ;RECOVER LOGICAL TRACK NUMBER
71 0061 D5 PUSH DE ;PUT IT BACK AGAIN
72 0062 FD5E01 LD E,(IY+ 1) ;GET FILLER BYTE
73 0065 21B900 LD HL,FRMTBUFF ;POINT TO BUFFER
74 0068 FD4E00 LD C,(IY+ 0) ;GET DRIVE NUMBER
75 006B 0601 LD B,1 ;BANK 1
76 006D CD0100 CALL USERF ;FORMAT THE TRACK
77 0070 8F00 DDFORMAT
78 0072 D1 POP DE ;RECOVER THE LOGICAL COUNT
79 0073 C1 POP BC ;RECOVER THE TRACK COUNT
80 0074 3004 JR NC,FAILED ;IF FORMAT FAILED THEN E
XIT
81 0076 14 INC D ;OTHERWISE NEXT LOGICAL TRACK
82 0077 10BF DJNZ TABLEGEN ;BACK FOR TOTAL NUMBER OF
LOGICAL TRACKS
83 0079 37 SCF ;SET CARRY TO SHOW SUCCESS
84 007A 3A8B00 FAILED LD A,(FREEZE) ;GET ORIGINAL FREEZE
BACK
85 007D DD771A LD (IX+ 26).A ;PUT IT BACK
86 0080 3A8700 LD A,(SIDENESS) ;GET ORIGINAL SIDEN
ESS
87 0083 DD7711 LD (IX+ 17).A ;PUT THAT BACK ALSO
88 0086 C9 RET ;THATS ALL FOLKS
:
: DEFINE DATA AREAS
90 0087 00 SIDENESS DB 0
91 0088 00 FREEZE DB 0
92 0089 00000000 FRMTBUFF DS 80
END
:
Code Start End Reg
0000:0000 0000:00D9 0000:00D9
Data 0000:0000 0000:0000 0000:0000

```

disks start at C1h. I used a new sector numbering scheme, starting at 81h, to distinguish the double-sided disks. The BIOS is permanently patched to auto-select all three formats. The BIOS routine DD_SEL.FORMAT is also altered so that the new format selection, by loading reg A with 3, can be made from a user program through the USERF function. I would

like to propose this system as a standard for double-sided drive systems for the CPC6128. With a little time and modification it should also work on the 8256.

What all this means is that you don't have to do anything to use the double-sided disks, it is all taken care of automatically once they have been formatted. Owners of Giltronic and similar drives can use the patched BIOS and the formatting program for their drive. This gets rid of the confusion when you load a single-sided data disk into a drive set up as double-sided or vice versa. You will notice that it takes slightly longer to "log in" the double-sided disks. This is because the directory now has 128 entries instead of 64 and the BIOS must scan and hash twice the usual number of entries. You will also notice that the new drive is NOISY. It uses a stepper motor whereas the original used a worm-drive to step tracks.

Access from AMSDOS

I know of no way to access the other side easily from AMSDOS. I have done very little experimentation in BASIC and am open to ideas on that subject. I dare say an RSX could solve the problem.

It is this problem that brings to light - THE HITCH!. You cannot boot CP/M from a double-sided disk, even if it is formatted as a system disk. This is because the boot program uses the CP/M 2.2 ROM-BIOS to do the boot and this BIOS cannot access the other side, as far as I know. It is possible to alter the disk layout to make the disks bootable, by reading across one side and then across the other, but this slows response time considerably, requiring a track change every 4.5 Kbytes instead of every 9 Kbytes.

This problem is minor however, considering CP/M 3 doesn't need a system disk for each warm boot. Once the system is up, all disks can be data disks, with no loss of performance.

The software

The changes to the BIOS are fairly complicated and not easily explained in print. It takes some time with SID to make all the changes and it's not a job for novices or those who are not familiar with SID. I have not detailed the changes because they are not much use without the formatting program and you will have to buy that from me anyway! When you buy that, I will modify your BIOS.

One of the changes defeats some of the error reporting of the BIOS. This is not a situation I am happy about, but it seems to be unavoidable. It stems from a peculiarity of the uPD765 floppy disk controller (FDC) chip. This uses the write-protect signal during seek operations as a detection signal for double-sided media. The Hitachi drive does not return this "TS" signal and generates a "Seek Fail" error in the BIOS. The seek is performed OK, but the FDC chip returns a "Not Ready" error because it thinks the disk only has one side. In practice a real seek failure seldom happens on healthy disks, touch wood.

The formatting program, FORMATDS, is a no-frills formatter for double-sided data disks only. No-frills also means FAST. It will format a double-sided disk in less time than DISCKIT3 formats a single-sided disk. It was written for this article and is being upgraded to enable formatting, reading and writing of foreign formats on the 6128. A sort of PC-Alien for the 6128.

FORMATDS was written in assembler, using a product relatively new in Australia, MOPI (Macro Oriented Program Interpreter). This is available from pTIZAN Computer Ser-

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SUPERCOM

SuperCom is a product of Operating Systems Research Pty. Ltd and is produced and supported in Australia.

Winner of the coveted Australian Software of the Year Award, this is the ideal program for those who have an IBM PC or compatible and use or want a 'smart' modem, or even a 'dumb' auto-dial modem.

Just the thing you need to team with your PC/clone and the Supermodem!

Just look at these great features and facilities!

Incorporating the best of Crosstalk, Gateway, and Carbon Copy, Supercom is, as its name implies, a unique 'super program' when it comes to communications. Straight communications, file transfer, Viatel and a sophisticated remote facility are just some of the features of the package.

The authors have integrated all the facilities into the one package. As a result, the user is presented with one easy-to-learn user interface, rather than being asked to battle with a series of programs for each purpose.

THE RIGHT PACKAGE FOR BOTH CORPORATE AND EXPERT USER

Supercom is designed for both the occasional, non-technical user and the experienced operator. An initial 'beginner' mode (which may be disabled) allows the non-expert to establish communications from a simple menu with only one keystroke.

Autodialling is provided for both 'smart' and many older 'dumb' modems (via DTR dialing). Full automatic setup of speed and modem type is provided from this initial menu.

Once in 'expert' mode, the user is presented with a menu of functions which may be selected via the menu or directly from the command line, via short mnemonic titles.

A SUPERIOR TERMINAL EMULATOR IS INCLUDED

Very complete terminal emulation facilities are provided. Terminals which may be selected directly from the menu include:

- ADM3A
- ADM5A
- ADM31
- Televideo 910, 912, 925, 950
- IBM 3101
- Hazeltine 1500
- Esprit series

plus many more -- over 40 in total.

Learning is enhanced with extensive context-sensitive help. The status line quickly reflects the user's selections.

But for those still not satisfied, the built-in emulation editor allows the experienced user to alter and create further emulations.

ALL MAJOR FILE TRANSFER PROTOCOLS SUPPORTED

Supercom supports both SYMODEM and MODEM 7 batch transfer protocols for error free file transfer.

'PHOTOSTAT' FACILITY RUNS POPULAR IBM PC SOFTWARE REMOTELY

For those needing to use IBM programs remotely, the Supercom 'Photostat' facility is essential. Unlike the normal DOS mode provided with other comms packages, 'Photostat' provides access to the screen, essential for many popular PC programs, including Lotus, Open Access, Enable and WordStar.

Competing software offering this feature alone, sells for much more than the complete Supercom package.

AUTODIALLING AND REDIALLING - BEAT THOSE BULLETIN BOARD BLUES

Supercom will dial a number of predetermined numbers in rotation. All your favourite bulletin boards are dialled until you get onto one.

Supercom allows the user to build a dialling directory so that services can be quickly called up by name.

SCRIPT FACILITY FOR UNATTENDED INFORMATION GATHERING

For users needing information from Viatel or other services on a regular or time-dependent way, Supercom incorporates a Script facility. Once set up, the program will dial up, log on, get and store information, and log off again. It will do this at a specific time, or every so many hours. Perfect for getting financial or other information, automatically.



COMPLETE VIATEL COMPATIBILITY

Supercom supports Viatel, even on low cost modems that do not support split baud rates. Capture mode can be switched on and off with just one keystroke.

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Full support for HAYES compatible modems is provided, with user-installable strings to take advantage of special modem features. Includes support for the extended HAYES command set as used in 2400bps modem (V22 bis).

SUPERCOM RUNS ON ALL THE LATEST PCs

Supercom works on all IBM PCs and compatibles running colour graphics (CGA), Enhanced Graphics (EGA) and monochrome (including Hercules). Disk formats including both 5 1/4 inch and the newer 3 1/2 inch formats. Recent machines confirmed for Supercom include:

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- Toshiba T1100 Plus
- Compaq 386

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Oct. 1987 — Australian Electronics Monthly — 85

The "ideal" comms package

WELCOME to the first birthday of Dial Up! It seems hard to realise that this column is one year old with this issue. Several days ago, I was congratulating the Editor on the magazine's second birthday, when we both suddenly realised that the column was about to celebrate its first. Both of us had figured that "DIAL UP" would only be viable for about six months.

It seems fairly normal for birthday celebrations of columns to indulge in a little crystal ball gazing for future trends and to also indulge in some nostalgia. I don't intend to do either! I would just like to thank all of you who have made this column a success. In particular, I would like to thank all of you who have taken the time to write to the column and ask questions, air views and suggest changes. I would welcome more letters, especially from newcomers to comms who would like some particular topic covered in this column. EVERY letter sent to this column will be answered. If you don't see an answer to your problem within two months of writing, then phone the magazine and arrange to send another copy – the original probably is lost.

Comms packages

In last month's column, I promised to discuss what I would consider to be the "ideal" comms package. Let's get to work.

Firstly, a comms package must have pull-down menus and a pull-down help screen that has its prompt on the screen ALL THE TIME. It's very easy to forget which command invokes the HELP section, particularly if you don't use a comms package as often as I do. The pull-down menus are an absolute necessity, as they enable similar functions to be grouped in the one area (e.g. the dialling directory, the comms parameters – baud rate, start/stop bits, parity, comms port etc). A change to any function can then usually be accomplished by as few as four key-strokes.

Secondly, it MUST have a fairly extensive dialling directory, capable of storing all the necessary parameters for the dialling of a particular phone number or BBS. The dialling directory MUST ALSO be capable of EASY revision, as numbers often change and second lines are often installed for a popular service.

Thirdly, it must be capable of terminal emulation. At the very least, it must support ANSI, VT-52 and VT-100, and IBM 3101. This is important for those persons wishing to take advantage of remote editing features. For example, if your comms program does not support terminal emulation, then you can't edit a file on remote VAX, because the function keys on your keyboard (used for editing commands) will not send the correct sequences to the remote computer. VT220/240 emulation is also becoming a desirable feature and could be classed as an optional extra.

Fourthly, the comms package should allow your own system to be set up to handle an incoming call. This is known as "HOST MODE" and is usually a fairly heavily scaled down version of what a BBS does. It should allow for limited file transfer/editing and should allow password access to various levels of the package and operating system.

Fifthly, the package should either provide a limited editing process, or, more preferably, it should allow you to access your favourite editor without exiting from the package.

Sixth, it should provide extensive file transfer capabilities. As an absolute minimum, it should support XMODEM, YMODEM, KERMIT, ASCII, TELINK and at least one operative sliding window file transfer protocol, such as SuperKermit, WXModem or Sealink. These should be available for both uploads and downloads.

Finally, those little things that help make life easy – a chat mode to allow you to carry out a typographical conversation with a remote user, colour support for a colour monitor, script files (AND NOT ABSTRUSE ONES EITHER) to fully automate a comms session, a translate table to catch and "overhaul" incoming characters that might do nasty things to your screen or hard disc, a log file to record a comms session to disc (for subsequent leisurely perusal), a screen capture file for that vital bit of information that suddenly pops up during a scrolling screen of info and the ability to recall and view both of the last two features from within the comms package.

This may seem like a rather tall order for a comms package to provide, but there are at least FOUR public domain (or shareware) programs, that more than fit the bill on 95% of the above features. No, I'm not going to give the game away now, you'll just have to read the next few columns to find out. Of course, the more bells and whistles that are added to a package, the more memory it consumes. If memory is a premium, then some of the simpler packages may be more appropriate. Incidentally, if any of you come across (or have) a favourite comms package that I don't mention, drop me a line and I'll attempt to include it in a future column. I should mention, however, that I run an IBM/PC clone and an Apple 2+ clone, so these are the only computers on which I can evaluate a package. (I don't even use the Apple clone much any more – it's a bit slow compared to a 10 MHz AT clone).

PC-Talk

This was one of the first public domain (in fact it's classed as "Freeware") programs to become available for comms on the IBM PC. This program, despite its vintage, is far more useful than some of its progenitors. It only supports Xmodem and ASCII file transfers (adequate for 90% of file transfers). One can only set the foreground/background colour and the modem MUST be on when the package is booted. Likewise,

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the choice of comms parameters is limited to two settings – 300 or 1200 baud. This is adequate for most modem transfers, but certainly limits direct transfers between two PCs.

PC-Talk does have a dialling directory and a set-up screen which can be invoked as “pseudo pull-down” window; it only allows fairly primitive option changes. This package is what I would consider to be the absolute minimum (yes, there are plenty below this level). I successfully transferred several files from my local BBS using this package. Here, I must record a word of thanks to my local BBS sysop John (The Premier) Caine (Fidonet number 711/405). He must be heartily sick of my constant plaguing him both on-line and via his busy phone. John also sells computer systems (no, it's not a free plug) under the brand name – you guessed it – PREMIER.

Telix

Telix (version 2.12), is one of the four P.D./Shareware programs that fulfills 95% of the above criteria. I now prefer it to Procomm, because of its additional file transfer protocols. Telix allows for the Sealink sliding window protocol in both the download and upload paths, as well as the more usual protocols, ASCII, Kermit, Modem7, Telink and Ymodem (both normal and batch varieties).

Telix operates with pull-down menu windows and most of the commands are identical to those of Procomm. The documentation is provided with the ARC file and runs to about 60 pages. It's all fairly high quality and the index is excellent. One of Telix's best features is the inclusion of several examples of script files. These are set up for all the best known BBSs and are easily modified to accommodate your own parameters. I have included my own example below as a guide to those who wish to access OPUS- and FIDO-type bulletin boards. The comments should be self-explanatory.

```

set ansi=on

ifonline start
dial "1" . replace with right number
ifoffline failed

timeout 180 failed

start:
waitfor "FIRST name:" . replace firstname, lastname,
send "RDY;HILL;y:PASSWORD:" . and password with your info
stop

failed:
set ansi=off
message "No-one's Home - try again later"

```

Figure 1. Sample OPUS script file

Comment lines are commenced with a period. If a period occurs on a line, then any information remaining on that line will be regarded as a comment. In the copy of Telix that I downloaded, the line with the label “start:” was omitted. Check to make sure that your script file is the same as mine,

with the exception of the name and password. Incidentally, the lines that “set ansi=on” and “set ansi=off” are designed to enable/disable ANSI graphics characters for an IBM PC. If your computer or terminal does not support ANSI graphics, do not include either of these lines.

```

ifonline start
dial "2" . replace with right number
ifoffline failed

timeout 2 start . send Spaces until acknowledged

start:
send " ~ "
waitany

timeout 180 failed

waitfor "FIRST name:" . replace firstname, lastname,
send "RDY;HILL;y:PASSWORD:" . and password with your info
stop

failed:
message "Logon failed"

```

Figure 2. Sample Fido script file.

One of the most valuable features of these script files is the ability to test for “ifonline” and “ifoffline.” This tells Telix whether or not the script file is being executed from a dialling directory (i.e: the modem is offline), or whether you have already dialled the service and you just wish to send the appropriate log-on string. I have not found any other comms program that provides these features, including commercial varieties.

Telix is extremely easy to configure – I particularly like the manner in which the colour of all the menus may be varied. When you wish to change the colours, Telix comes up with a list of all the available options, and has two windows which show the effect of the new colours. I consider this method slightly better than that of Procomm and infinitely superior to Cross-Talk, which only provides very limited colour combinations anyway.

Telix is slightly less versatile than some other comms programs. In that it doesn't provide for more than two comms ports. I don't find this a problem, because I only use the two, but several acquaintances of mine with serial plotters, mouses, printers etc, find it a pain. Telix provides for all the common bit transfer rates up to 19.2kB (incidentally, an issue of Byte shows how to get 19.2kB out of an IBM – see reference 1).

In the next issue, I will discuss two very good, but vastly different P.D. comms packages and several duds. Remember, please tell me if there is any topic (or comms package) that you would like to see covered. ♀

REFERENCES:

1. Byte, February 1987, pp 338 and 339 (BIX section).

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*100 kHz to 30 MHz optional extra.

High stability frequency control.

The reference oscillator which determines the frequency stability and readout accuracy of the R-5000 is accurate to + or - 10 ppm within a temperature range of - 10 to + 50 degrees Celsius.

10 Hz step dual digital VFOs.

Built in dual VFOs operate independently of each other, and allow split frequency and split mode operation. The frequency steps are basically 10 Hz, giving that "True VFO" feel when tuning. The frequency steps are changed to 1 KHz in AM mode, and 5 kHz in FM mode.

Provision is made for the connection of both high and low impedance antenna systems.

Superb Interference Reduction.

Selectivity is enhanced by the use of dual crystal IF filters for SSB, and further features include IF shift and tunable notch filters. The IF filter selection system is fully flexible, in the same manner as the TS-440S transceiver, and offers automatic selection by mode, or manual selection according to the operator's requirements.

A dual mode noise blanker system deals effectively with both impulse noise as well as the "woodpecker".

Keyboard Frequency Selection

Frequencies can be entered using direct keyboard control, and a frequency lock switch prevents accidental frequency changes from occurring.

100 Memory Channels Capability

100 memories are provided, which store frequency, mode, and which antenna has been selected. Memory information can be scrolled to review contents of any memory channel.

Memory Scan and Programmable Band Scan.

Further memory facilities include memory scanning with programmable memory lockout, and programmable band scanning with centre stop for accurate on-channel tuning.

Plus a full list of other desirable features:

- Dual 24 hour clocks with timer
- Optional VS-1 voice synthesiser for frequency announcement
- Optional control by personal computer using the IF-232C interface
- Lithium battery backup of memory contents
- Built in AC power supply and option to use the receiver on 13.8 volt DC supplies
- High quality internal loudspeaker
- AGC time constant switchable fast/slow
- Switchable RF input attenuator (0 to 30 dB in 10 dB steps).

To summarise: the R-5000 from KENWOOD offers the operator a top performance communications receiver of the very highest quality, with all the features and functions which the discriminating user could demand.

With the R-5000, KENWOOD gives the dedicated listener a receiver which will match the performance of the very best transceivers available today.

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Return of the low-cost amateur transceiver



Some great news for the budget-minded radio amateur is the introduction of a new range of low cost, mono-band HF transceivers by well known retailer, Emtronics. Manufactured by Tokyo Hy-Power of Japan, the new range is sure to appeal in a market presently dominated by equipment which is financially out of reach for many enthusiasts.

The range includes five models covering the 80 metre band, 40 metre band, 20 metre band, 15 metre band and 10 metre band. Each model will cover a 500 kHz segment of the respective band with the exception of the 10 metre model, which covers the entire band from 28 MHz to 29.999 MHz.

The transceivers use a PLL synthesised VFO offering extremely good stability and all models have a four digit LED frequency display reading down to 100 Hz.

Operation is possible on SSB and CW with the sideband used depending on the band of operation. The 80 and 40 metre band models provide lower sideband whilst the remaining models all operate on upper sideband.

There are no memories, multiple VFOs, speech processors or infra-red remote controls (you think I'm joking don't you!) to add cost, just a simple to use, straightforward transceiver. Semi-break-in CW operation is included, as is a CW sidetone monitor.

A number of options are available for the transceivers, including a narrow CW filter and a noise blanker. All models are equipped with receiver incremental tuning (RIT) and there is even a button to lock the VFO on frequency to avoid accidental frequency changes whilst operating mobile or portable. Microphone and dc power lead

are included as standard.

The power output of all models is 20 W CW and 20 W PEP on SSB. All the models are designed to be powered by an external 13.8 V supply.

Performance specifications indicate a receive sensitivity of 0.4 uV for 10 dB S+N/N and stability of better than plus or minus 150 Hz from turn on for the first 60 minutes, then 100 Hz per 30 minutes thereafter. The receiver is a single conversion superhet using a 9 MHz IF and selectivity is claimed as -6 dB at plus and minus 1.1 kHz and -60 dB at plus and minus 3.0 kHz.

Measuring 180 mm wide by 60 mm high and 250 mm deep, the transceivers weigh approximately 2.6 kg. Emtronics expect to have stock of all models by the latter part of October and the retail price is expected to be around \$599. A normal 12 month warranty will be offered on all models.

For further information on the exciting range of HF mono-band transceivers, contact Emtronics at their head office in Sydney on (02)211 0988 or their branches in Victoria, (03)670 8551 or Queensland (07)394 2555.

The great Novice debate continues

The current debate on extended privileges for

Novice radio operators took another turn recently with a letter from the Victorian Division of the Wireless Institute of Australia to the Federal "Future of Amateur Radio Committee" and the Department of Transport and Communications, detailing the results of their recent survey of Victorian amateurs on the questions raised.

The Victorian Division of the WIA conducted a survey of Victorian amateurs during August, inviting both members and non members of the Institute to participate.

Some 547 survey forms were completed and returned and as a result of the responses received, the Victorian division has made a number of recommendations.

These recommendations include the granting of VHF/UHF privileges to Novice licence holders as well as the introduction of a "no code" class of Novice licence permitting access to VHF and UHF frequencies only.

The Victorian Division does not recommend the granting of "data" privileges to Novice licencees and is against the introduction of a class of licence below that of the current Novice level.

The Division considers a "common band" to be highly desirable and supports the investigation of the standard of the current Novice examination with a view to restoring the level to that appropriate as an entry level standard should it be shown that the level of the examination has risen significantly in recent years.

They support the granting of parts of six metres, two metres and 70 cm to Novice licenseees with the following suggested frequencies:

Two metres - 145.000 MHz to 145.050 MHz for CW and SSB only, 145.050 MHz to 145.150 MHz for FM only.

Six metres - 52.100 MHz to 52.150 MHz for SSB and CW only, no FM permitted.

Seventy centimetres - 438 MHz to 440 MHz FM only and 433 MHz to 435 MHz FM only, thereby including the 70 cm repeater network.

Melbourne-Canberra packet radio link

On Thursday 20th August, Melbourne amateur radio operators linked their computers through a series of dedicated VHF packet radio repeaters to the National Capital, Canberra.

The combined technical expertise and dedication of the Melbourne and Albury/Wadonga packet radio groups finally made the link possible with the completion and installation of VK3RPN at Wadonga.

Data signals from Melbourne are lifted over the Great Dividing Range by VK3RPL, situated high in the Divide where it looks to the north over the Strathbogie Ranges and along the Goulburn Valley to VK3RPW at Shepparton. The signals then follow the general direction of the eastern section of the Midland Highway, passing north of Benalla and Wangaratta, arriving at VK3RPN ready to travel interstate to NSW.

The toughest part of the data highway is the job of VK3RPN, the long haul north-east over Albury to VK2WG-1, east of Wagga. VK2WG-1 is tasked with ensuring the packet signals avoid the massive Kosciusko National Park and thus have a clear path to Canberra.

The time taken for data signals to travel between the cities will depend on the level of traffic on the data highway. An average time for the return trip will generally be in the order of 10 seconds.

These days, most home computers can be used for packet operation without difficulty. For many, a simple and inexpensive modem, software and a radio are all that is required.

For Victorian amateurs wishing to obtain more information on this fast growing aspect of amateur radio, contact: VK3QQ (QTHR) or (03)434 3810 or write to: The President, VK3AVE, Melbourne Packet Radio Group, PO Box 299, St. Albans, Vic.

For amateurs in other states who would like to know more about packet radio, you could contact one of the national societies such as the Australian Amateur Packet Radio Association (AAPRA) by sending a stamped, self-addressed envelope to: The Secretary, AAPRA, 59 Westbrook Avenue, Wahroonga 2076, NSW.

Get amongst the DX fun on six and two metres this summer!

Roger Harrison VK2ZTB

The VHF amateur bands – 50-54 MHz (6m) and 144-148 MHz (2m) literally “come alive” during the summer months each year owing to a propagation phenomena arising in the ionosphere which permits contacts over ranges of hundreds to thousands of kilometres (‘DX’). Here are some pointers to getting amongst the fun.

THERE ARE THOSE amateurs, confirmed VHF enthusiasts, who propound that the most fun you can have on the air is chasing DX during “the season”. Generally this is taken to mean mid-summer – December-January, but it actually extends from October through to February, and occasionally March.

The ‘fun’ comes from the largely unpredictable nature of the phenomenon – one minute you’re talking to a VK6 some 1800 km away, the next you’re talking to a VK4 only 800 km away – and the signals are typically described as “rock crushers”. Six metres is the popular band for this sort of DX, but 2m also gets into the act at times. And it’s brought to you courtesy of the ionosphere and its popular product called “sporadic-E”. Another summertime phenomenon VHF enthusiasts exploit for long-distance contacts occurs in the lower atmosphere, dependent on regional weather effects. But that’s properly the subject of another article!

Sporadic what?

If you acquired your licence in the time-honoured way, then I can assume you know of our old friend the ionosphere. The lowest reflective layer, lying in the height range between 90 and 120 km, is the E layer.

At certain times, very dense ‘clouds’ of ionisation will form in the E layer, the vast majority forming in a narrow height range between 95 and 105 km. They are relatively thin, being typically less than 1 km thick. They can appear and disappear in the space of minutes, or last for many hours. The clouds can remain stable over a geographic position or drift, at velocities up to 300 km/h, over considerable distances. They seem to appear nighttime, daytime – anytime. Hence the name, sporadic E, or Es (“ee-ess”) for short.

Sporadic E has been observed for over 50 years by amateurs, scientific researchers and communicators. For some it’s a curse, for others, a boon. Much low band TV interference during the summer months is caused by sporadic E. It’s also responsible for the popularity of the six and two metre bands during the summer months.

Get to know your Es

Perspicacious readers will have already noticed that, despite the name, sporadic E is not quite as sporadic or random as its name suggests. True enough, it can occur at any time, but it has a tendency to occur more often at some times than others. Summer, for example. Getting to know the quirks and characteristics of Es can considerably enhance your chances of

catching more of the DX and getting amongst the fun.

Firstly, ionospheric speaking, the Earth has each hemisphere divided into three regions – the ‘low’ latitudes (the equatorial region), the ‘high’ latitudes (the polar regions) and the bits in between called the ‘mid’ latitudes (pretty well where most of Australia is located). The ionosphere has broad variations and differing characteristics in each of these regions. As Australia is largely situated in the mid latitudes, I will concentrate on the characteristics of mid-latitude sporadic E.

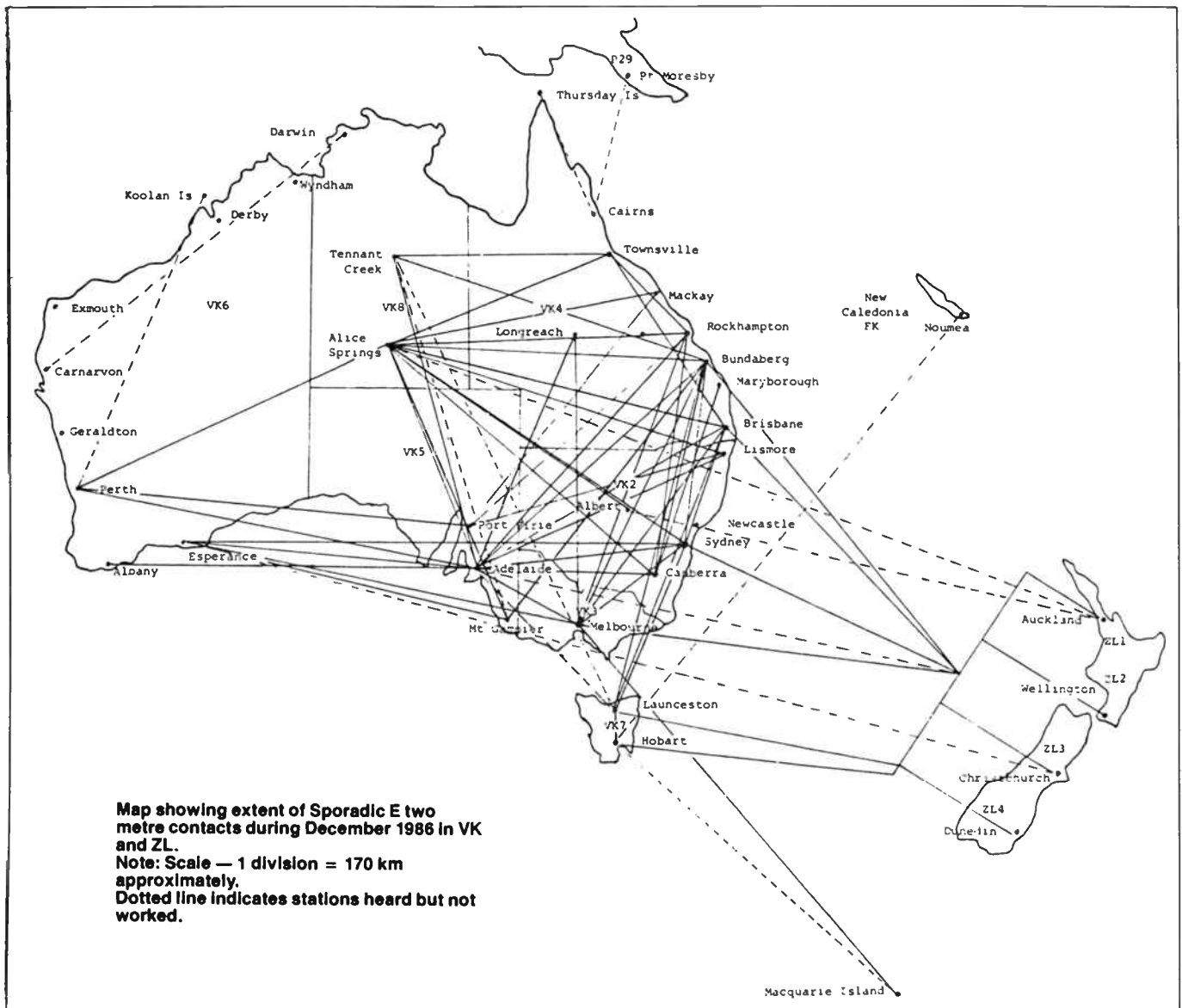
You have already learned that there’s lots of Es about during the summer months. That’s when most VHF enthusiasts take advantage of it. But it seems to be a well-kept secret that there’s also a distinctive, but lesser, peak during the winter months.

Sporadic E also exhibits a diurnal (daily) variation in occurrence. Mid-summer Es generally peaks about three hours before and again six hours after local noon. How well organised can you be! You can work a little DX before a late breakfast, do your own thing during the day and come home to work yet more DX in the early evening. Mid-winter Es obligingly peaks around 1800-2100 local time when you should be warm and cosy inside your shack.

The occurrence rate of Es falls during magnetic storms but there’s a silver lining in every (missing) cloud – intense Es activity often persists for three to four days following large magnetic storms. Keep an eye/ear on the ionospheric/geomagnetic forecasts put out by the Ionospheric Prediction Service (IPS Radio & Space Services). Magnetic storm warnings are issued and they also give progress reports on storms in progress. The NSW Division WIA Sunday morning broadcasts on VK2WI include weekly ionospheric reports from IPS, or you can get information from the IPS recorded message service anytime (24 hours a day) on (02)269 8614 which is updated at regular intervals.

Researchers classify Es into three types – weak, strong and intense. Strong Es will propagate six metre signals well, while intense Es permits 144 MHz propagation. Intense Es is generally short-lived and follows considerable strong Es activity.

High sporadic E activity tends to be clustered in two or three days so that, when you first notice a bit of DX activity on six metres, you can be fairly confident it will last for another day or two. Likewise, no Es activity tends to last for two or three days. The peaks of Es activity get later in the day the more intense it gets. That is, intense Es usually occurs late in the day, typically between 1800 and 2400 hours local time.



Propagation via sporadic E

Since the Es clouds lie at around 100 km height, a little terrestrial geometry will tell you that the maximum distance for single-hop propagation is around 2200 km for a zero radiation angle. But, because the real world is imperfect, maximum distances achieved are usually around 1800-2000 km. Typical single-hop distances are 800-1400 km. This is not to say, though, that contacts over distances of 2100-2500 km cannot be made. A combination of Es clouds lying above 100 km plus a little atmospheric refraction will combine to extend the propagation distance. Witness the regular contacts between New Zealand and the east Australian seaboard. Distances covered are around 2100-2500 km. Multiple-hop propagation does occur, but is relatively infrequent. Contacts over distances of 2800-4000 km via Es are not unknown.

As I said earlier, sporadic E clouds are usually quite dense and comparatively thin. Thus, to radio waves, the clouds appear as virtual mirrors. Signals propagated by Es are typically very strong and single-hop communications over widely differing skip distances is observed. As the clouds can cover a considerable geographic area, they will conform to the curvature of the Earth. Thus, from the underside, large clouds will look like a concave shaving mirror and signals 'illuminating' a large area of the cloud will be focussed at the termination of the path. This greatly increases the signal strength and results in two stations in adjacent suburbs experiencing

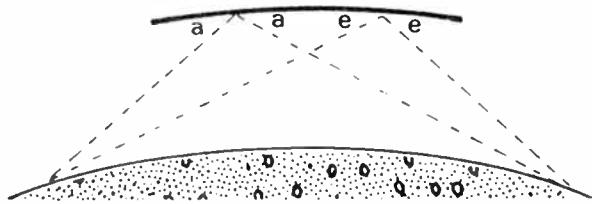
greatly different propagation conditions — one gets a DX station at "20 over 9", while the other can't hear a thing!

While Es-propagated signals are generally very strong, they also experience very deep fades. It is the focussing effect and the fact that the clouds drift that causes the fading, moving the focus point as the cloud moves.

Experienced VHF DXers often talk about "backscatter". On such occasions, the signal is reflected by the Es cloud, virtually without loss, to some distant point. Upon striking the ground, the signal will be scattered in all directions and that portion scattered back along the general direction of the original path is propagated via the Es cloud again. It may well be heard by other stations that may be located laterally some distance from the originating station, but all stations will be beaming in the same general direction.

Backscatter signals are weaker than normally experienced and generally suffer more fading. It is not unusual to work a station 1000 km away by single hop and be joined by a third station on backscatter who is some hundreds of kilometres away and at right angles to your beam heading and beaming in the same direction. For example, it's not unusual for Victorian stations to be working station as in Queensland and South Australia — the latter on backscatter who can't be worked direct at the same time.

Backscatter usually appears when an "opening" is well developed, when the Es clouds are at their densest or



The 'focussing effect'. A large Es cloud is actually concave and acts like a shaving mirror, focussing the rays where they come down following reflection. Only two possible rays are shown for the sake of clarity.

approaching it; that is, it's a good precursor to developing intense Es. Hence, backscatter is a good indicator of a rising maximum usable frequency (MUF).

Just like the 'ordinary' ionosphere Es has a maximum usable frequency. When the skip is near the maximum and you can't hear closer stations in the same direction, you're near the MUF (or there aren't any stations closer!). When the signals get really strong and the skip shortens, the MUF is rising. When the skip shortens to about 750 km or less, go to two metres and look for stations around 2000 km away in the same direction. Such events are usually short lived, though 6m may stay open for hours.

It's quite possible to work quite short skip on 6m via Es, but few stations have antennas with a lobe at the required high radiation angle. Years ago, when I lived in Melbourne, I used a 3/4-wave groundplane which sports two main radiation lobes – one low and one high. I could work Albury, Broken Hill, Hamilton and Adelaide while the locals couldn't hear them. If you think DX is getting the maximum distance then take your blinkers off! What's more, I only ran a few watts. You don't necessarily need the kilowatts or repeaters to have fun on six metres!

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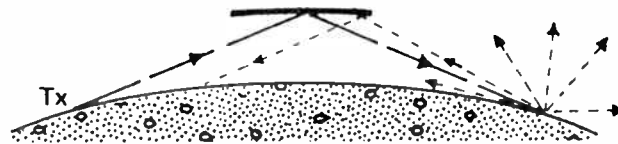


Name:

Address: Postcode:

Distances greater than 2000 km can be covered via Es propagation, as mentioned earlier. Double-hop propagation is possible but requires either a cloud covering an extensive geographical area or several clouds strategically placed along the path. As Es clouds seem to form in "arrays" over a considerable area and all drift in the same direction, this is highly likely how much multi-hop propagation occurs.

In addition, recent research has shown that, with strong Es, horizontal clouds are extremely rare, they are almost always tilted; not much, usually just a few degrees. Thus, multi-hop propagation may also occur via reflection from two strategically placed clouds having tilts that face each other, two reflections occurring without intermediate ground reflection. Don't expect such happenings to be frequent or long-lived, however. Local research suggests that the largest tilts are observed around dawn and dusk.



Backscatter. Reflected signals are scattered in all directions from the distant reflection point. That part scattered back along the direction of the original path may be heard on occasions if the Es cloud is dense enough.

Catching the openings

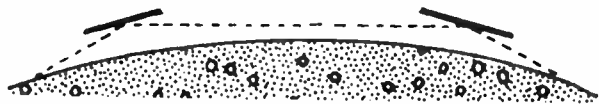
To make the most of sporadic E DX, you need to arm yourself with aids (no, no – not AIDS!). Some means of listening to a wide range of frequencies across the VHF band, from at least 28 MHz upwards, is useful for tracking the formation of Es and the likely MUF. A VHF scanner is ideal. An old, small screen monochrome TV set has served many an experienced DXer well.

You'll need some sort of wideband listening antenna, preferably with an omnidirectional radiation pattern. Discone-type antennas are ideal for this. In fact, we described one in our first issue – project AEM3010, The Scantenna, July 1985 – the hub parts for which are available from Ashpoint Industries, 38-44 Birmingham St, Alexandria 2015 NSW. Ready-made 'skeleton' discone types are also available from firms such as Emtronics, Dick Smith Electronics and Tandy. While these antennas are vertically polarised, loss from cross-polarisation is reduced by propagation.

If you're restricted to listening on the amateur bands, then a groundplane or small two- or three-element beam is useful – something with a fairly broad beamwidth so you can catch signals that may come from over a wide area. Your 'Big Bertha' 10-element Yagi can restrict your opportunities. First find the (DX) skirmish – using the general coverage antenna – then bring in the cavalry!

Compile a list of amateur band beacons and other VHF 'marker' signals in suitable geographic areas so that you can identify the general geographic area of a band 'opening'. But remember the focussing effect. Just because you can hear the VK5 6m beacon doesn't mean you're necessarily going to work Adelaide stations! TV station sound and vision carriers can be good marker signals, but remember they've a roughly 20 dB power advantage on amateur signals. A weak, fading Channel 0 sound carrier indicates a path is opening, but you may have to wait until the signal 'firms up' before making contacts on 6m.

A regularly updated list of beacons is published in the monthly column "VHF-UHF – An Expanding World" conducted by Eric VK5LP in the WIA's journal, "Amateur Radio". You'll also find beacon and TV station information listed in the Australian Radio Amateur Callbook published by the WIA.



Multi-hop propagation without intermediate ground reflection may occur from widely separated clouds tilted to face each other along the path. Strong Es clouds are always tilted, according to recent research.

Operating techniques

Observe the usual operating courtesies during openings. To look for the presence of an opening, or a developing opening, tune across your selected marker signals – starting from the lowest frequencies, paying special attention to those stations around 2000 km away, or a little further. (A handy distance chart is published in the Callbook). These are likely to be the first heard. Aimless 'frequency hopping' or band tuning might turn up something, but it's an inefficient technique.

The 28 MHz band can be especially valuable, particularly during low sunspot years. Look for interstate VK signals and/or stations from New Zealand and New Guinea if your location is right (not over 2500 km away).

On hearing some likely signals, watch the progress of a possible opening. If the signals rise in strength and you start to hear stations at shorter and shorter skip distances, start monitoring higher frequency signals in the same general area(s). If, or as, they appear, go up to 6m and start tuning around. Nothing heard? – try the calling frequencies (52.010 MHz – CW, 52.050 MHz – SSB). Short calls, with a longer listening time, repeated at frequent intervals, are better than long drawn-out CQs. Remember – if everybody listens and nobody calls, all miss out on the opening! If a colleague across town is on the air, have a brief chat from time to time and compare notes – but always leave a few seconds break between overs to let the DX break in.

During an opening, don't forget to use your aids to look further afield or for further developments. See if you can chart the progress of the MUF. Take special note of the skip distance. Keep a map handy for getting a rough idea and ask each station you work for their location. Plot it on the map (dress makers' pins are great for this if you mount your map on a piece of softboard). If you notice the skip distance shortening, use your listening aids to find stations at higher frequencies around 2000 km away, as mentioned earlier. With Es, the MUF cutoff is characteristically abrupt – it has been observed to cutoff in 100 kHz or so.

If you use a small beam, either as the main station antenna or as part of your listening aids, swing it through the four compass quadrants and tune around from time to time. You could get a pleasant surprise. To get an insight into the character of Es openings, read the band activity reports in the VHF/UHF columns in past issues of Amateur Radio, Amateur Radio Action and Break-In (the NZ Amateur Radio Transmitters Society journal).

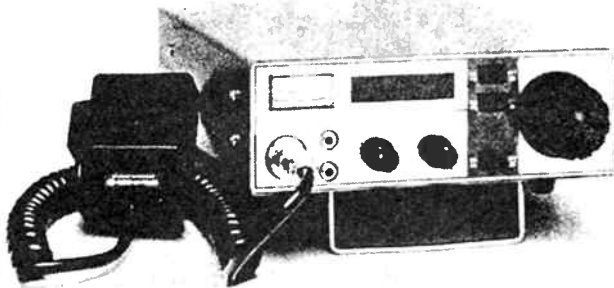
It's wise to keep a log, if not for QSL purposes, then for keeping notes. The notes may be as brief or as detailed as you see fit (but detailed is better). It's a good memory aid when going back over events and you learn from that. It's good for comparing notes with others and it's a good source of information to the various columnists mentioned above – provided you send them something! Those published reports have often been an important source of historical propagation data – both factual and subjective.

Whenever you're in the shack, always turn on the gear – especially if you've got a scanner or other suitable listening aid. Tune around and give the occasional call – remember that Es can occur at any time. Many a surprise DX contact has been had on an apparently 'dead' band.

Have fun this season! 🐣

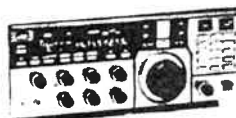
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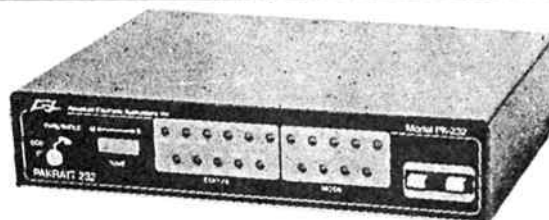
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Ph: (03) 87 8881 or 870 0330
FAX: (03) 870 0871

QUEENSLAND:
418 Logan Road, Brisbane Corner
Qld. 4120.
Ph: (07) 354 2888
FAX: (07) 354 4318

One for the knob-twiddlers!

National Panasonic has added a 'new dimension', to home video recorders, they say – a large knob on the right hand side of their new NV-G25A VCR that allows you to select the functions you require by simply spinning the knob.

While two-speed videos are not new to National's range, this model offers a combination of features not previously found. In addition to the Dial Search, the NV-G25A offers the Digital Scanner barcode programming device, Double Super Fine Slow, programmable remote control, VHS search system, lap time counter to the second, HQ (high quality) picture, title search and one calendar month 8-programme timer all cased in an 82 mm high chassis.

The Dial Search feature allows the home enthusiast to dub or edit more easily. A rotary dial, previously found only on industrial models, controls review, reverse playback, still, slow (1/30, 1/10, 1/5), normal playback, double speed playback and cueing. As a consequence, operation is speeded up considerably with edit points being located almost immediately, National say.

In LP mode, the G25A can record or playback for eight hours, and in addition to the revolutionary Digital Scanner barcode device for time-shift recording, a 42-function infrared remote control unit makes it a highly versatile machine that is easy to use, National claim. See your nearest National dealer.

High performance dome tweeter

Australian Loudspeaker Manufacturers Pty Ltd, a Perth-based company specialising in high quality loudspeaker design and manufacture, has announced the release of a new high performance 26 mm dome tweeter.

The model D26al features an aluminium dome manufactured by a new process in which pressure is applied during forming, imparting a high gloss surface completely eliminating "orange peel" surface imperfections which can cause failures in conventional metal domes.

Only a single resonance at 23 kHz is evident in transient

decay analysis and this, coupled with the exceptionally linear frequency response, ensures transparent and detailed sound quality, say ALM.

A crossover frequency as low as 2 kHz may be used (with adequate network slope), making the unit ideal for 2-way systems as well as 3- and 4-way systems. A large magnet system with machined gap surfaces and a high temperature voice coil enable high sensitivity and exceptional maximum sound pressure levels.

Each unit undergoes full measurement and listening tests before leaving the factory and a graph of the frequency response is supplied with each D26al.

For further information, contact: Australian Loudspeaker Manufacturers Pty Ltd, Factory 4, 173 Bank Street, East Victoria Park 6101 WA. (09)361 6132.

Yamaha dominates hi-fi awards

Yamaha has dominated the 1986/87 annual hi-fi awards presented by Audio-Video International of the USA with its components being selected as "top brand" in six of the eight categories.

The top 10 brands are selected on a points basis incorporating specifications, design innovation, craftsmanship and a cost/performance ratio. The results, according to Yamaha, establish the Yamaha brand as one of the world's most respected brands in home audio equipment; fittingly, in the company's 100th year.

Results are calculated by a combination of input from audio critics, audio writers and audio dealers, forming the world's best-read and most accepted product analysis, we are told.

Yamaha this year was voted as having the top integrated amplifier, top tuner, top receiver



(tuner-amp.), top power amplifier, top preamplifier and top sound processor. The company's components were not exactly disgraced in the two remaining categories either, being voted third out of 53 compact disc players and fourth out of 32 brands of tape decks reviewed.

What you might call "scooping the pool". Congratulations Yamaha.

JVC Celebrate 60 years

The Victor Company of Japan Limited, known as JVC, celebrated 60 years in business on 13th September, 1987. Founded in 1927, JVC have led the electronics industry through astounding progress in technology, beginning with Japan's first television set in the 1930's.

Perhaps the best known invention from JVC is the Video Home System (VHS) which, in only 11 years, has sold in excess of 130 million units worldwide. JVC has long been an industry leader in this field, with developments including the first portable VCR and the GR-C9EA 'VideoMovie', claimed to be the world's smallest and lightest VHS camcorder.

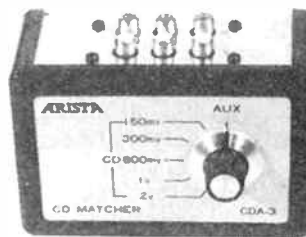
With the advances being made in today's technology, it is difficult to see further improvements being made, but JVC claim to be already at the forefront of development with products such as Digital Audio Tape (DAT) and the Super-VHS (SVHS) system.

JVC has also announced the release of a Super-VHS VideoMovie camera which, at a little over one kilogram, is claimed to offer performance surpassing that of current one-inch TV news cameras!

Hagemeyer (Australasia) B.V., marketers of JVC products in Australia, will be celebrating JVC's 60th birthday with their most impressive line up of pro-

ducts ever, according to Mr. Edwin Koemans, the Managing Director.

Seem's like JVC won't be resting on their laurels and we can expect them to launch a few more innovations over the next 40 years to their centenary.



CD matcher from Arista

Arista Electronics has increased their range of audio accessories with the introduction of the CDA-3 compact disc matching unit.

Many amplifiers are equipped with only one auxilliary input, so as the home entertainment centre expands with the addition of a compact disc player and/or VCR, the inconvenience of having only one auxilliary input arises.

The CDA-3 will allow connection of both units to the amplifier and allow switching between either unit. The other advantage of the CDA-3 is its signal matching capability.

The majority of compact disc players have an output of between 1.6 V and 2 V, whereas the input voltage of the average auxilliary input is around 750 millivolts. The CDA-3 will optimise the balance between input and output by allowing you to select between several different input voltages.

For further information and the name of your nearest stockist, contact: Arista Electronics Pty Ltd, 57 Vore Street, Silverwater 2141 NSW. (02)648 3488.

The times are a-changing

Roger Harrison

The ninth annual Perth Electronics Show, held over 29th July to 2nd August, this year reflected an industry embattled. Some of the major companies who had mounted substantial displays in past years were missing and many displays were decidedly "this is retail get-that-sale" oriented. The volume and range of new releases from all fronts were not in evidence, but the determination of the "stayers" was pretty clear. 1988 will be a telling year, for the Show itself and the industry as well.

THE OPENING FUNCTION, held at the adjacent Claremont Football Club, gave the first inkling of decline – there were spare seats where last year there was a crush. Touring the show later it was immediately apparent some industry identities of the past years were not there: Philips, Mitsubishi and Sharp, in particular. In addition, fewer pavilions in the Perth's Claremont Showgrounds were occupied, although show organisation chairman, Bob Rogers, claimed the total space booked this year was only down 250 square metres on 1986. Last year's plan to shift the venue to the Burswood Island function centre, adjacent the casino, was abandoned quite early in the planning.

Some major "players" in past years, like Sony, Sanyo and National, reduced the size of their stands this year. But Yamaha, JVC and NEC put in more effort, with large, flamboyant, attention-grabbing displays. Talking with executives from these companies later in the show, it's apparent these companies are out to make the best of the rationalisation happening in the market at present.

The smaller marketers of previous shows were this year replaced by local retailers who appeared to simply recreate their showrooms – complete with price ticketing and department store point-of-sale promotions. Tacky.

In the two main pavilions, the Show organisers had rearranged the stand and aisle areas, the aisles criss-crossing the pavilions in a diamond pattern. It was an effective move that broke up the long aisles of past years' floorplans and forced the crowds to circulate among the stands. I got the distinct impression the aisles were wider than in years past.

Showing off

JVC mounted a large, flamboyantly decorated stand strategically placed in the centre area immediately in front of the entrance/exit of one of the major pavilions. It featured a large triangular stage where a troupe of dancing girls stopped the crowds at regular intervals with a series of stunning routines performed to a backdrop of video screens showing "clips" of

JVC
INVEST IN QUALITY



JVC discovers "sex sells". Their stand featured a regular show with dancing girls performing a series of well choreographed routines against a backdrop of video product clips. It brought the crowds to a standstill every time.

products dynamically presented in the style of rock videos, accompanied by flashing lights and a prolific smoke machine. Around the corner, Playboy's Playmate of the Year, Felicity Collins, drew attention to the swag of JVC technology she received in prizes. Or, maybe she just drew attention.

Meanwhile, at the other end of the same pavilion, Yamaha's stand, similarly strategically located opposite an entrance/exit, went in for taste in contrast to JVC's raunch. Their attention-getter was a piano-flute duo who gave refined recitals of popular classics and re-arranged pop songs. Their stand was arranged in four spacious sectors around a central hub. The first sector had the live music, clockwise from there came their entertainment equipment – portables, music centres etc. Then the hi-fi – dominated by a single display of their Centennial Edition equipment, about which more later. The ▶



And the crowds flocked in. NEC mounted a flamboyant display of their broad product range, dominating surrounding exhibitors at one entrance/exit to one of the main pavilions.

The 1987 Perth Electronics Show

last section was devoted to the award winning surround sound processor, the DSP-1 which was previewed at last year's show.

A new entrant to the show this year, and to the consumer electronics market in Australia, was the giant Korean manufacturer, Samsung Electronic Corporation. They are currently in the throes of setting up an importing and distribution chain in Australia, under the umbrella of a company called Samsung Electronics Aust. P/L, based in Sydney. Their stand was back-to-back with JVC and dominated the nearby Akai and Pioneer stands.

Samsung's product range includes TV sets, video cassette recorders and players, portable sound systems ("ghetto blasters"), microwave ovens and consumer whitegoods. Company spokesman, Mr J. I. Sohn, said Samsung "... wants to bring quality products at moderate cost to the Australian consumer". It was Samsung who developed the 4 mm video recorder that took the video world by surprise at this year's Las Vegas Consumer Electronics Show.

What's new in consumer electronics?

This is the fifth successive Perth Electronics Show I have attended. In past years, many exhibitors took the trouble to show off products not due for release for six months or more, and one got the opportunity to preview next year's new products. In past years, one was almost overwhelmed by it; not so this year. The majority of new product was simply updates on older models.

I expected to see previews of digital audio tape (DAT) equipment and CD-Video, at least. With all the controversy (misplaced) raging over DAT-vs-CD, I had expected to see some fairly "high key" displays and hear some demonstrations, but I was disappointed.

I was disappointed with the compact disc supporters, too. I saw prototype CD-video machines on display in 1985 (from Philips) and thought this would be the year CD-video would be previewed prior to a 1988 release. Nope. Not one to be seen. CD-video is expected to be the technology that consolidates the position of compact disc with consumers. It offers something which DAT cannot, and is expected to generate the mass sales necessary to drive down the already falling price of compact discs.

JVC had a sample DAT deck on view, and Alpine had a car DAT deck, but neither were working displays and no demonstrations were given to the press.

However, JVC previewed their new "Super" VHS recorder technology. This separates the colour (chrominance) and brightness (luminance) components of the video signal and records them on the tape using depth modulation. Tracks are laid down diagonally across the tape in the conventional manner, but adjacent tracks are laid down by different heads with a 20 degree azimuth offset from one another to avoid interference.

The technique permits optimisation of the video components in the recording process and delivers a resolution of 400 lines across the screen, compared to around 220 lines currently. This gives much better definition in pictures with fine detail, as the demonstration we saw dramatically showed. The catch is, you need a high definition monitor or TV to go with it! While a distinct improvement, it still falls short of broadcast and video disc quality. It might be marketed as a stop gap between current technology and the introduction of high definition television (HDTV) — once the various parties come to an agreement on standards. Nobody's holding their breath on that last one. Talking it over with some industry executives press commentators at the show, it is expected HDTV will be for direct-broadcast satellites, and not for terrestrial broadcasting.

We probably won't see S (for super) VHS in Australia for a year or more as the demonstration equipment we saw was NTSC standard, which is the video standard for Japan and the US, while ours is PAL. JVC's spokesman would not venture when a PAL version might be available.

Three years ago, in the midst of the computer boom, computer companies and products vied with audio and video for dominance over the show. Last year, computers and computer product took something of a back seat, but not so this year. Amstrad, Commodore and Microbee put on strong, well-organised displays in strategic positions in one of the two main pavilions, while local companies occupied stands dotted around the rest of the show.

There were few new products of promise. Yamaha devoted one-quarter of their stand to a hi-fi system, mentioned earlier, designed by a team of engineers given virtual carte blanche. Its part of a range issued to mark Yamaha's 100th anniversary. Dubbed the Limited Centennial Edition Series, and all hand-made, it comprises a digital control preamp (CX10000) which borrows technology from their CDs and DSP-1 sound field synthesiser. Cost? \$15 000.

The accompanying MX-10000 power amp delivers 250 watts per channel in Class A operation, said by many a golden-eared audiophile to be the purest class of amplification. It weighs 43 kgs and costs but \$12 000. The matching CDX-10000 compact disc player has numerous technical features in the electronics, to outshine the limited competition, as well as special constructional features. A digital output terminal allows direct connection to the CX-10000 preamp. All for a mere \$5000. The NSX-10000 three-way speakers were developed using computer aided design for the drivers to obtain low coloration. The specially shaped box of 12-laminate birch is based on Yamaha's experience in piano construction. The crossover network is spot-welded, rather than soldered, to improve signal transmission, Yamaha claim.

Add \$22,000 for the speakers and you get a superlative hi-fi sound system for less than \$55,000! Forego the new BMW this year.

NEC entered the audiophile market this year with a small range of integrated amplifiers and components. Cornerstone of the range is the A910 100 watt stereo amp which features an infrared remote control and inputs for VCR along with tuner, CD and turntable. They had four CD players on-show, the CD-903 leading the range.

While on the subject of speakers, Mike Henriksen of Scan Audio from Melbourne went to some lengths to display and demonstrate his company's Dali, Vifa, Scan-Speak and Jamo speaker ranges. I heard a stunning demonstration of the new Dali 40 speakers, admittedly in non-ideal surroundings. These feature the bandpass bass system currently the buzz among speaker designers and hi-fi enthusiasts the world over. Pardon the pun, but I think we'll be hearing more of these Dalis.

The Sydney-based "audio boutique" distributor, Convoy International, has replaced their Nakamichi product range with a range of new amplifier components from Adcom. These echo the "minimalist" approach of NAD equipment and are devoid of flashing lights and digital displays beloved of the Japanese manufacturers. The product seems well engineered and should find a niche for itself in the market.

Video proved a disappointing field this year. Frankly, there was nothing really new or exciting. While NEC and National each showed a new "digital" hi-fi VCR, everything else was "more of the same we've seen before". 8 mm video is yet to make its mark, really, and the only new product of note here was a camcorder from Pentax. But I doubt they'll make a big song and dance about it.

Sony's only real contribution was a snazzy little automatic

8 mm tape editing suite. You can edit tapes from your 8 mm camcorder directly onto a Beta or VHS recorder. At \$550, it should appeal to the growing band of video home movie enthusiasts.

Car sound held its own this year, in contrast to most other areas. Alpine released a 12-disc boot-mounted CD changer, model 5950 which uses a fibre-optic cable to transmit the player's digital output to the control unit in the car obviating noise pickup along the way. Perth-based Arena distributors introduced car speakers from the US maker, MTX. Their Road Thunder speakers, available in three models ranging from a 200 mm two-system to a 250 mm three-way enclosure, are said to provide "gut thumping bass" and are primarily designed for "difficult" cars like hatchbacks, panel vans and station wagons.

Local electronics thrives

In contrast to the mainstream consumer sector, West Australia's electronics industry appears to be on the rise. They joined the PES for the first time last year in a pavilion of their own, dominated by Parry Corp's USAL submarine robot exhibit. This year, almost 20 exhibitors crowded into the pavilion, the entrance dominated by Altronics who should be familiar to most readers as a prominent retailer and mail order specialist. They also manufacture PA systems, a representative range of which were on display.

Jemal Products, a major local printed circuit manufacturer (who supplies many electronics retailers with project pc boards) showed their expertise not only in the pc board area, but in chassis bashing and production assembly. You'd be surprised at how many locally made products have been housed in a Jemal-made case.

An interesting product I spotted was "Boatguard", a boating theft and vandalism alarm system from local manufacturer Monitronix. The system is designed to protect boats moored at a marina. Protected boat have a multi-point alarm system installed with sensors hooked up to a small on-board transmitter. When the alarm is triggered, the on-board transmitter sends a coded signal to a remote land-based monitoring receiver located at a professional security monitoring company. Action can be taken immediately, and owner contact information, boat location etc are immediately available from the alarm system database. Safety monitoring can also be included - like bilge level, gas and fume detectors, etc. To the boat owner, cost of equipment and installation is around \$500 and the monitoring service costs less than \$100 a year, according to Monitronix.

In conclusion

Consumer spending on electronics is well down on previous years, and we saw the beginnings of the slide last year. Competition in the marketplace is fierce and some companies have clearly experienced falling market shares. Some have fallen victims to the battle; Philips being an obvious example, although their troubles were not entirely based in the consumer electronics area. Nevertheless, some optimism remains in the industry and it is expected that the expensive top-end, high-tech products will lead the way out of the current depression, according to some industry people. You can only sell just so many \$899 sound systems! Perhaps what I predicted following last year's show, that value for money and not price points alone will lead the way, will be fulfilled.

The tenth Perth Electronics Show should be interesting indeed! The organisers have a special opportunity here and should make the most of it. The PES is, after all, Australia's only surviving consumer electronics show, and to last a decade is a feat in itself!



The entrance to the West Australian Electronics Industry Association pavilion was dominated by Altronics' stand where they had portion of their substantial component line on display along with their PA and portable 240 V supply systems.

By this time next year Sydney will have, in Darling Harbour, a major exhibition venue and a huge audience eager to sample its wonders - pretty well regardless of what's on, that'll just be the excuse to go. If the eastern states principals of the consumer electronics industry can get their act together and organise a committee and a show as successful and as powerful a drawcard - for the industry and public alike - as Perth has been for so many years, Perth will likely lose the show to Sydney. The words of Bob Dylan's now classic 60s song "The Times Are A-Changing" are as applicable here and now as ever they were. The industry will doubtless have an entirely different character 12 months hence, and I, for one, will be eager to see the changes. Roll on '88! 🐘

Amstradder

- from page 83

vices, in Canberra, ph. (062) 586823. This assembler, which is available for MS-DOS and CP/M systems, will assemble any microprocessor code in both manufacturers mnemonics and a new style of mnemonics, universal to all microprocessors. It has several unique and powerful features, including assembly time link/loading, external subroutine instructions and procedural instructions. It is a "heavy" change from M80 or DEVPAK but it makes for more structured programming. The package includes a library of external subroutines and the instruction sets for Z80, 8080 and 8086 processors and costs \$175.00 including tax.

I will upgrade your BIOS and supply FORMATDS for a paltry fifteen dollars. You send me a 3" or 5.25" standard Amstrad format disk with your .EMS file on it, a stamped, self addressed jiffy bag to return your goodies and a money order for fifteen dollars. I will modify your BIOS, supply FORMATDS, the MOPI source for FORMATDS and the subroutines used in it, SWEEP and NULU (possibly two of the best public domain utilities available), an update text file with any new info and then return your disk. This offer is for 6128's with C10CPM3.EMS as their original system file. This should be all 6128's, but who knows.

That's about it. If you know anyone who wants to buy a single-sided 3" drive, let me know! 🐘

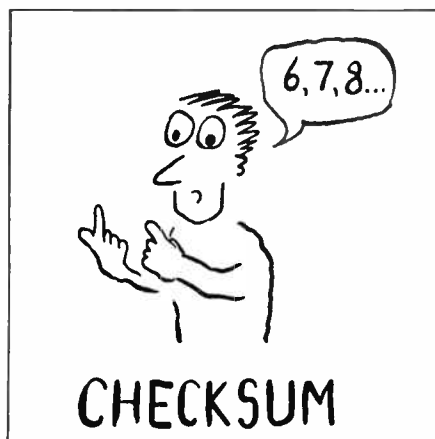
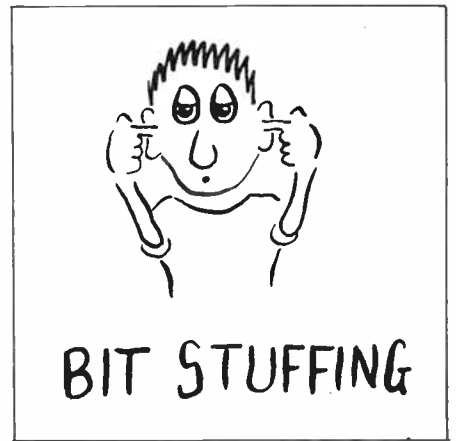
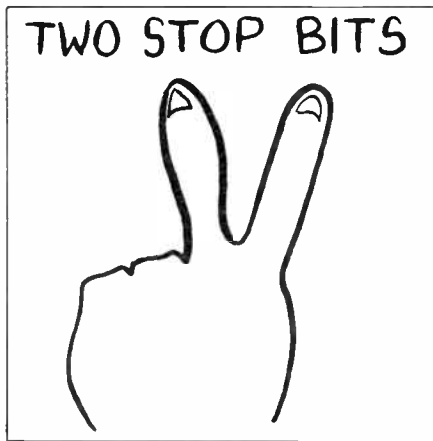
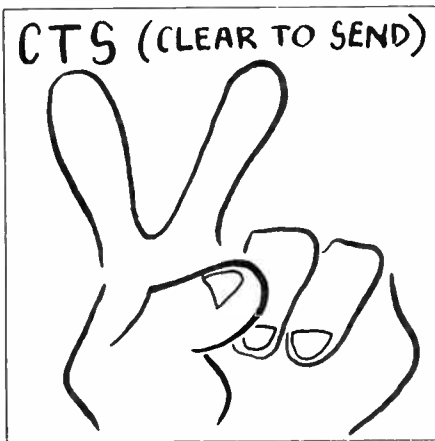
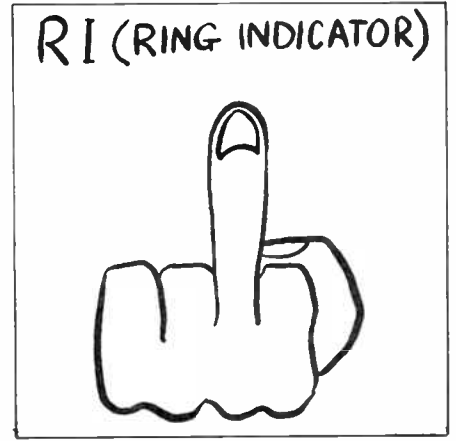
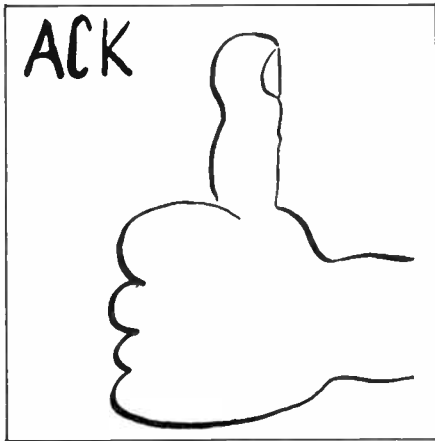
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The Last Laugh



COMPUTER communications developed a jargon all its own quite early in the development of computers and their peripheral equipment, when it was all lumped under the umbrella of "digital electronics". However, digital communications goes back a long way, recorded history giving us examples such as King Nebuchadnezzar's experience with the the finger writing on the wall, as told in the Old Testament. The Romans, of course, had digital mass communications — thumbs up or thumbs down for the defeated gladiators at the Colosseum. Yes, digital communications has a long, but perhaps not always honourable, history.

We thought we'd try out the concept of illustrating modern digital communications jargon with the ancient kind and approached our cartoonist, Greg Smith, who tackled the task with glee following an uproarious briefing. Regular readers will have seen some examples, specifically related to digital radio communications, in our "Guide to Digital Communications" featured in the June and July issues. Indeed, many readers asked for more! Fortunately, we can oblige, as that one session produced quite a few examples of modern digital communications jargon illustrated with the old symbology.

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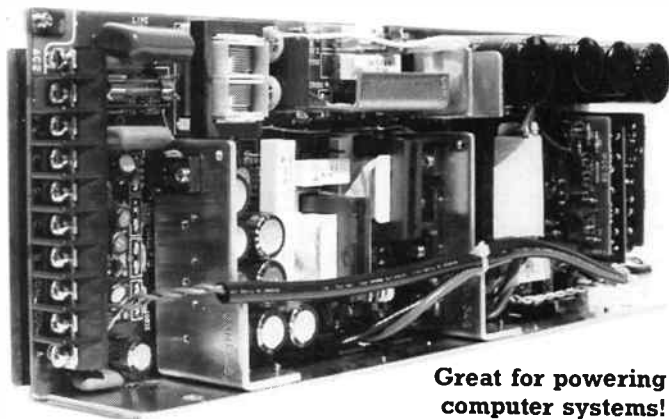
National
Matsushita Electric
National and Panasonic are the brandnames of Matsushita Electric

We've managed to secure LIMITED further stocks of these popular supplies. These are National brand MF Series high power, multiple output off-line (240/120 Vac) switchers made by Japanese electronics giant, Matsushita Electric.

Features

- Dual input (jumper selectable).
- Open frame construction.
- 150 watt (total output power)
- Up to 5 outputs.
- Designed to conform to UL114, 478, CSAC22.2 NO.143, NO.154, IEC380 (class 1), BS5850 (class 1), VDE0806 (class 1).
- 50 kHz operation.

Measures
350 x 135 x 65 mm



Great for powering
computer systems!

MODEL NO	OUTPUT A	OUTPUT B	OUTPUT C	OUTPUT D	OUTPUT E
ETU-5MF01	+5V 3 ~ 15A	+24V 0.4 ~ 1.5A	+12V 0.4 ~ 1.5A	-12V 0.4 ~ 1.5A	-5V 0 ~ 1A

NOTE. If any lower voltage is required on either B, C or D output(s), provision is made for a TO220 78-series regulator to be inserted on the PCB.

End of model sell-out!

The MF Series has been replaced by a new model and the distributors, A.J. Distributors Pty Ltd, have only a strictly limited number left — and they are all to be offered below cost!

Who said it? — you reap the benefit!

All units supplied with a circuit and data sheet.

Electrical Characteristics

PARAMETER	CONDITIONS	LIMITS
Input Voltage	Jumper selectable on the PCB	85 to 132 VAC 170 to 264 VAC 47 to 440 Hz 240 to 360 VDC
Input Line Regulation	Full input voltage range +5V output Other outputs 3 terminal regulator Non reg.	0.2% max 0.6% max 1.0% max
Load Regulation	Load change from 20 to 100% of rated output current at rated input voltage +5V output Other outputs 3 terminal regulator Non reg.	0.6% max 1.0% max 5.0%/A (typ)
Ripple and Noise	Peak to peak	1% +75 mV max
Over Current Protection	120% of rated output current (typ)	+5V output
Short Circuit Protection		Other outputs
Over Voltage Protection	+5V output	6.0 - 7.0V (typ)
Operating Temperature	Convection cooling	0 to 50°C no derating
Storage Temperature		-25 to 85°C
Weight		2.0 kg (4.4 lb)

A.J. Distributors has made this offer available exclusively to readers of Australian Electronics Monthly, the magazine is acting as a clearing house for orders.

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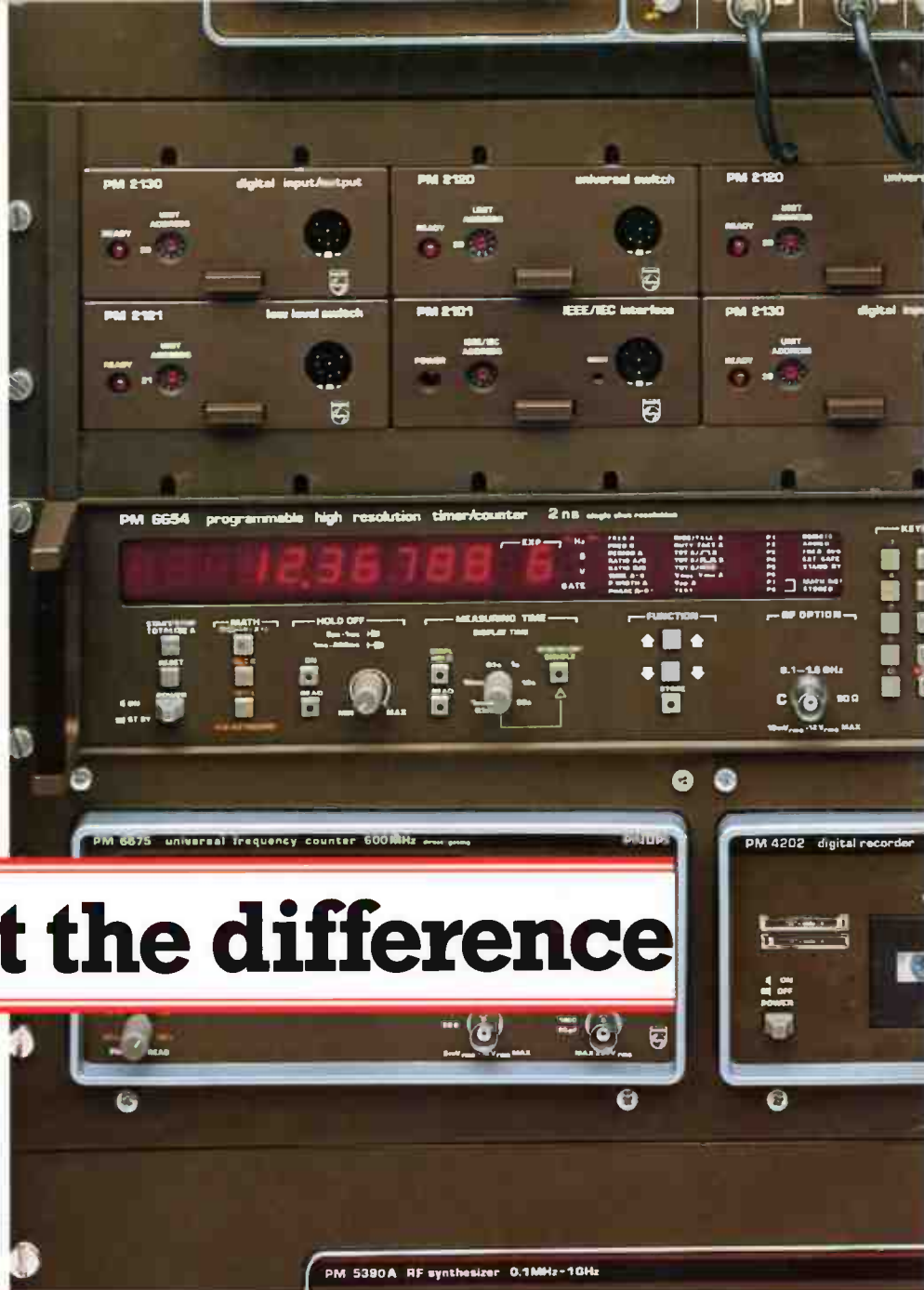
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