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AUSTRALIA'S TOP ELECTRONICS JOURNAL

The Australian Electronics Monthly

excitement electronics

Modems, Networks & Data Communications

A TRULY EFFECTIVE MAINS HASH FILTER PROJECT

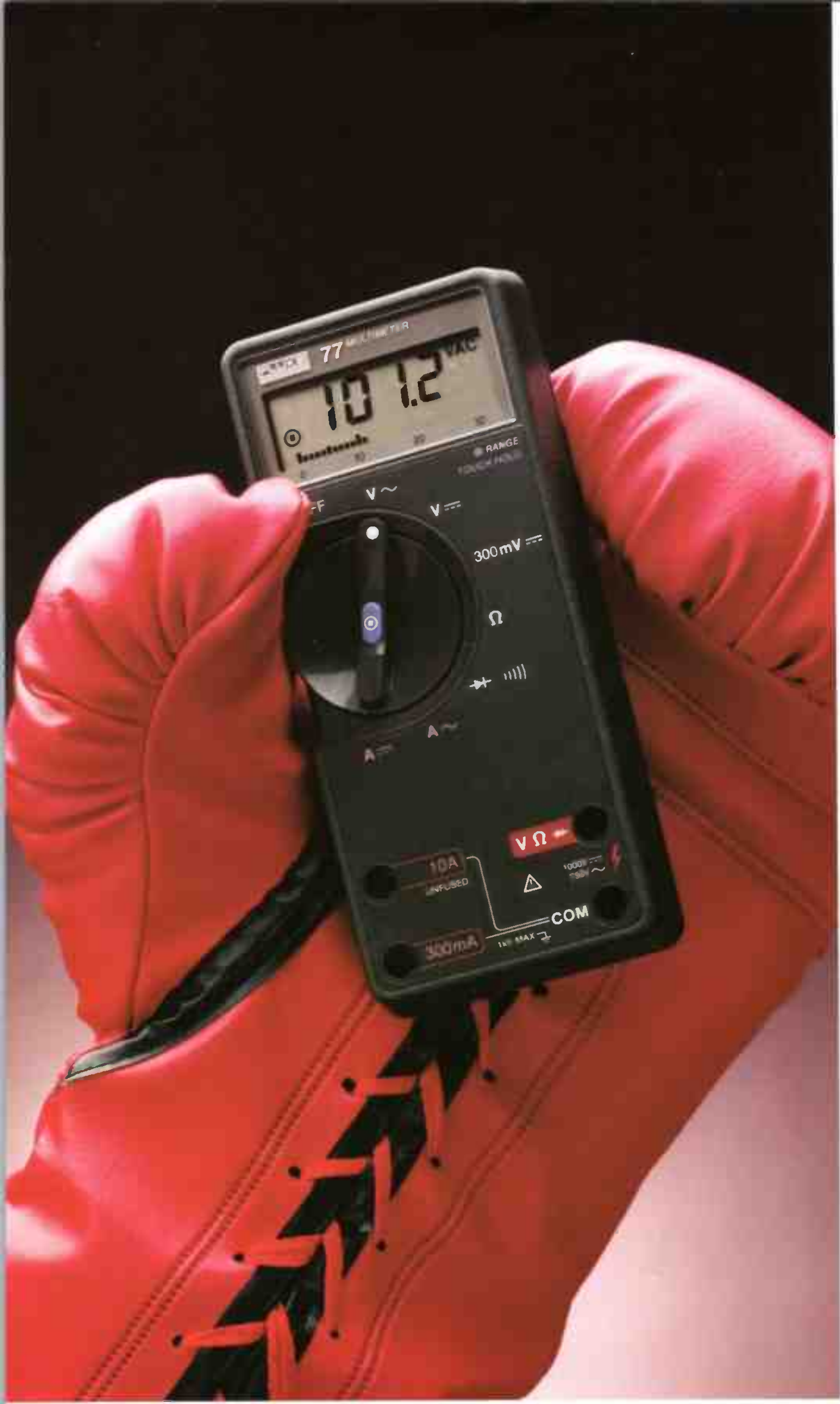
JVC 'vidi-fi' VCR reviewed

Ionospheric radio propagation

RF power meter/ monitor project

Brawl over digital audio tape standards

Super modem project



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The Australian Electronics Monthly

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THERE HAS BEEN CONSIDERABLE DISCUSSION within the hi-fi world over the past year about the 'sound' of compact disc versus the vinyl disc, with particular emphasis on the 'shortcomings' of the compact disc. There are those that will not admit that CDs have any shortcomings, just as there are those who claim that vinyl has more 'life'. It would be nice if matters were so clear cut.

When boiled down, the criticisms levelled at compact disc (*digitally* recorded, mastered, mixed then pressed) focus on two principal points — 'shyness' in the bass, and mid-range 'harshness' when compared to the vinyl pressing of the same performance. There are now plenty of examples available where one can A-B a CD and a vinyl disc of the same performance, both pressed from the same master (presumably!, if the labels are right). The question has been raised as to whether there's some fundamental deficiency in the digital compact disc recording/manufacturing/reproducing chain or that some 'enhancement' is being added to the vinyl pressings in order to prolong the sales life of vinyl.

Frankly, we think that can be dismissed with most 'conspiracy' theories. But, from our experience, there's some substance in the claims. An excellent example we have come across is the Dire Straits *Brothers In Arms* album, available on both vinyl and compact disc. The CD is quite clearly the inferior sound-wise, except for the expected vinyl disc surface noise. Is it the CD digital-to-analogue reproduction electronics system? In trying a number of CD players, this was clearly ruled out — bass shyness and mid-range harshness always showed through.

Examples favourable to the compact disc also exist, but seemingly few and far between. The Sutherland/Pavarotti operatic highlights album exemplifies this. There's a telling example here. Recorded in Kings Hall, London, on the CD you can hear the rumblings of the London tube trains that run beneath the hall, but not on the vinyl disc. (Sounds remarkably like turntable rumble — not possible on a CD!). In the other aspects, this CD is superior to the vinyl disc.

Do many engineers who mix the vinyl pressings take more care than those who do the CDs? Are CDs produced with the 'mass market' — CD portables, "ghetto blasters", car players, etc — predominantly in mind, ignoring the hi-fi listener?

Clearly, the capabilities of the digital medium can deliver truly exciting results, but it seems the software publishers may, in large measure, have adopted Nellie Melba's ill-famed attitude of ". . . give 'em muck". Are we expected to believe the virtues of CD as extolled, or as we hear it?

Roger

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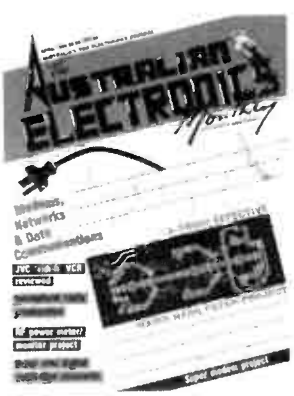

COVER

The Mains Filter project is this month's cover feature, showing part of the pc board overlay. Design by Angelica Koop; production, Marni Raprager.

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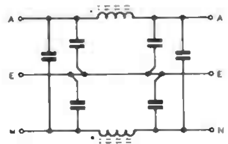

Does your computer suffer 'random reset', your radio radiate rude 'raspberrys', your hi-fi catch you with clicks and crackles? Mains-conducted "hash" is mostly the culprit and this project provides an effective cure in the majority of cases.

AEM2600 Peak RF Power Meter/Monitor
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Don't tie up that expensive SWR/power meter. This handy, low-cost project can be used as an in-line power monitor or general RF power meter around the shack. Featuring a 10-LED bargraph display, it can be used to monitor powers from QRP to QRO.

AEM4610 Super modem — Part 1
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*Looking for a **smart** modem at an affordable price? This project is fully software-driven, can be used with any computer having a serial (RS232) port and communications software, features auto-dial auto-answer and auto-hangup. It has CCITT V.21/V.23 plus Bell capability and incorporates an expansion bus for useful add-ons.*

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A 9-element Yagi for the Two Metre Band
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Following up their 70 cm UHF Yagi, Dick Smith Electronics present a Yagi to cover the popular 144-148 MHz band.

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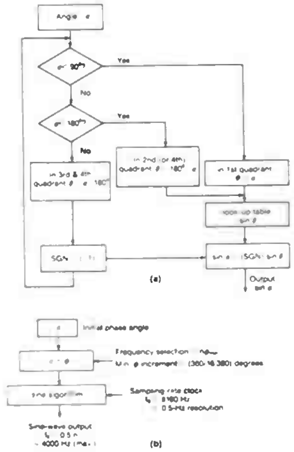

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A Digital Signal Processing (DSP) chip can implement all the required functions for a high speed modem. The application of Texas Instrument's TMS320 DSP to the task is examined in this special feature.

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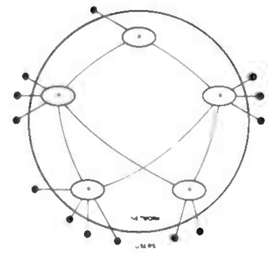
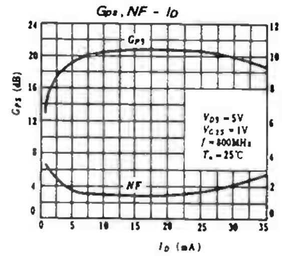


If you want to find out what the "data communications revolution" is all about, but don't know where to start — start here! Our feature covers the basics of the technology, the techniques and the relevant standards.

NEXT MONTH!



BUILD A 430 MHz/477 MHz GaAsFET MASTHEAD PREAMP
There's no substitute for 'good ears' on UHF. This masthead preamp employs a low-noise 3SK121 GaAsFET to improve the signal-to-noise ratio where you need it most — right at the antenna. Carrier-sensed transmit thru-line switching is employed and the unit operates from a 12 Vdc supply.

BUILD THE SUPER MODEM
Part 2 of the project gets into the actual construction. Yes folks, here it comes — faster than a speeding ASCII bit, more powerful than a block move, able to leap tall downloads with one command — *super* modem!

DABBLING IN THE DIAL-UP DATA JUNGLE
Once you have a modem, you'll wonder what you ever did without it. Our feature next month, following on from this month's introduction to the subject, gives an insight to the services, information and activities you can dial-up with your computer and a modem.

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

Putting vacant 'phone lines to good use

While the telephone in your home or office is not being used, the 'vacant' 'phone line could be put to use as a remote burglar or fire alarm monitor or by gas and electricity utility companies for reading your meters. So says UK company Racal-Milgo, who will trial a system just such as this in Britain this year.

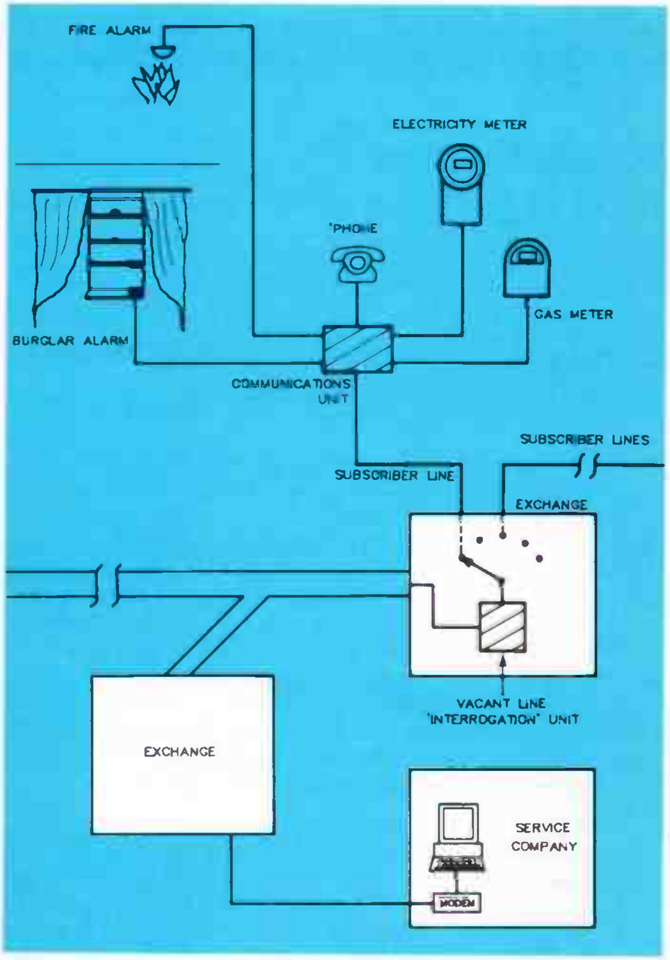
Dubbed the "Bitstream" system, it employs an electronic communications device linked to the ordinary telephone line on your premises which accepts inputs from devices that can read gas or electricity meters or, when linked to appropriate sensors, relays warnings from burglar or fire alarms that may be installed.

The outputs can be 'interrogated' by a unit at the exchange which communicates with 'phone-linked computers of the gas and electricity authorities or service centres responsible for equipment in the particular properties they service.

According to Racal, Bitstream was the product of 18 months intensive development effort. Racal will provide British Telecom with three pilot systems so that trials can start this June and be completed some time next year. The company says it could take another year to 'fine tune' the system.

Some 20 million telephone lines are in use in Britain alone and Racal believes Bitstream could enjoy a mammoth market and be in universal use by the end of the century. Racal is also currently bidding to develop a similar system to meet the needs of the West German national telecommunications authority.

Although this is 1986, not 1984, George Orwell knew what he was talking about! (—Ed.)



Japan takes lead in electronic biosensors

Application of electronics in biology was stumped for a long time for the lack of effective biological-electronic transducers. However, since Isao Karube and a group of workers developed a 'biosensor' for detecting hydrogen peroxide in food in 1974, advancement came pretty rapidly.

Biosensors comprise a 'biological receptor', which could be enzymes, antibodies or microbes immobilised in a membrane, and an electronic transducer. The biosensor reacts with the chemical it is designed to detect converting this chemical activity into a measurable electrical signal.

Karube's group went on to make many kinds of enzyme sensors following their initial success. Now, the electronics giants of Japan are pouring substantial research money into the development of biosensors. They believe the devices could revolutionise health care. Biosensors are capable of quickly and accurately detecting minute quantities of substances in blood.

Some seven or eight Japanese companies are actively selling biosensors, while between 30 and 40 are engaged in developing them. Fuji Electric sells a glucose biosensor which is popular with sake (rice wine) brewers who use it during fermentation. Apparently, it can detect the concentration of glucose in a 20 *microlitre* sample within a minute. This rapidity of response means the sensors can be incorporated into the production process for on-line analysis.

Work is now being done on integrating several sensors onto a single chip. It is expected that, in the future, arrays of disposable 'biochip' sensors could, by detecting different parameters, report body condition, results being read by a microcomputer. Medicos, paramedics or patients could 'phone-in results via modem for remote diagnosis by an expert computer system in hospitals.

NEC has succeeded in integrating sensors for urea, glucose and potassium onto one chip which has a working life of 30 days. Over the next few years, NEC plan to develop a large range of multi-function biosensors for measuring many other substances, including cholesterol.

RF radiation safety standard

Difficulties encountered in setting a safety standard on RF radiation for Australia are highlighted in a paper recently published by the CSIRO's division of Applied Physics.

The paper, entitled *The Australian Safety Standard for RF Radiation — A Curate's Egg*, by Dr D.L. Holloway, outlines the events leading up to the decision to set an Australian standard, he says.

He says that, like the legendary curate's egg, the recently published Australian standard is good in parts. In other parts it is faulty. However, it is an improvement on the American ANSI standard which had been used here by default up to the present time.

Dr Holloway says that as the good features in the Australian standard are departures from the U.S. ANSI standard there is a danger of their being removed in some future revision on the pretext of compliance with standards in use overseas.

The community should be on guard against this and every attempt should be made to encourage radiation workers or their representatives to participate in all revisions of the standard.

"Is it over-optimistic to hope that instead of taking this retrograde step, the Standards Association, through its representation on international bodies, will be able to convince other countries that they should adopt the good features of the Australian standard?"

International brawl over new digital audio tape standards

Dennis Lingane

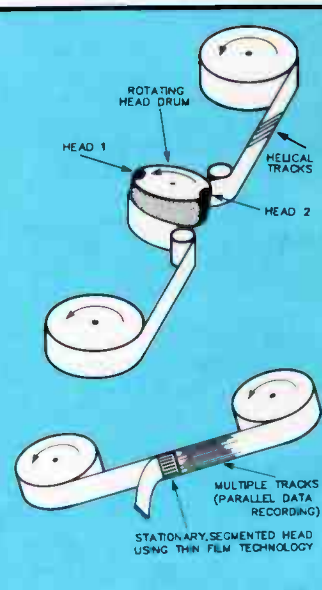
When it's released, digital audio tape technology will give the consumer a record/replay system with performance to rival compact disc. But 'differences' of opinion among the companies concerned in the decision on standards has led to two standards being proposed, opening a Pandora's box of confusion for the public if they're both released.

CONTROVERSY over the soon to be released digital audio cassette tape standards has simmered behind the scenes for the past year. The new digital audio tape, known as "DAT" makes existing audio cassette recorders obsolete, for the new DAT technology will offer superior performance and recording times. The 20-year-old compact audio cassette suffers from the limitations of analogue recording technology with far less dynamic range and poorer signal-to-noise ratio compared to digital techniques, and a handicap in having a maximum playing time per side of only 45 minutes. A DAT-cassette will hold up to two hours of stereo sound with performance to match the booming compact disc.

The controversy revolves around five issues:

- The international committee which decides on the standards has settled not on one format, but two. The formats are known as "R-DAT" and "S-DAT" (see accompanying panel), the R standing for rotating head type, the S standing for the stationary head type.
- The software industry, which stands to make a substantial fortune from pre-recorded software sales, has won a battle to ensure you won't be able to record from a compact disc to a DAT without going through the analogue decoding-encoding process (i.e: you won't be able to do a direct digital dub).
- The industry has successfully lobbied for the two systems not to be made public because it may confuse consumers and rob the industry of sales of CD players.
- Europe's leading tape manufacturer, BASF, has led a campaign to try and stop the industry launching *either* system because it says that both are not good enough. BASF's spokesman, Bill Andriessen, says that the common-or-garden audio cassette will defeat these new contenders if they are released because they offer nothing new.
- Other industry pundits predict that if the delayed launch is too long the 8 mm video system's PCM audio could become the new digital standard by default.

THE TWO DAT SYSTEMS PROPOSED



Two DAT systems have been proposed. They differ principally in the manner in which the tape is scanned by the head(s).

The R-DAT system employs a rapidly rotating head drum with two heads which lay down helical tracks, rather like the system employed in video recorders.

In the S-DAT system, the tape moves past a stationary head which lays down 22 parallel tracks from a segmented, thin film head.

Both techniques enable data to be recorded at a rate of more than two megabits per second which is what gives DAT the performance capability to match the compact disc.

As you are no doubt aware by now, the R-DAT and S-DAT systems are not compatible. It is known that Philips and Sony prefer R-DAT, whereas others, notably Sharp, prefer S-DAT. The cassettes for each system are of different sizes and appearance, but both are smaller than the conventional compact audio cassette.

Software lobby

We will *not* be able to record sound digitally from a CD with either of the new digital audio tape cassette systems. The Digital Audio Committee in its standardisation has conceded to lobbying from the software industry to choose a system of digital home recording that is incompatible with CD.

While CD has a 44.1 kHz/16-bit sampling system, the digital audio tape committee has opted for 48 kHz/16-bit recording and playback system. But to cater for the software industry they will also have a 44.1 kHz playback-only system. This will enable software producers to make play-only cassettes from the same digital master tapes they make the compact discs. The tape decks will be built so as to automatically sense whether it's a pre-recorded cassette or one that can be recorded onto. The idea is to stop piracy. We of course will be still able to record the CD in analogue. In fact, the cassette decks will have two inputs, one for pure digital and the other for analogue. You *will* be able to record the CD via the analogue decoding, so it's only a gesture against piracy really.

The software industry says that it's bad enough that they have to live with analogue media piracy, but given a digital recording system there would be no quality loss when recording off a CD onto tape and the pirates would have a ball.

Split over standards

According to Herman de Haan, the Philips member of the Digital Audio Cassette committee that has standardised the two digital tape systems, the electronics industry will ulti-

BASF's Bill Andriessen — wants a flip-over cassette for the new digital audio tape

mately settle on the Rotary Digital Audio Tape (R-DAT) cassette as an industry standard.

The rotary recording system is similar to a video recorder using a drum that spins with two heads that helically scan the tape. The stationary head system, employing a flat film segmented head that stripes around 20 tracks onto a tape at the same time, involves new head technology that not all manufacturers are ready for. So the rotary head will be the industry standard it is believed.

"Our job was to settle on an industry standard," says Mr de Haan. "We were given two systems to work on so we made the standards for both. Now it's down to the industry chiefs to decide which they will launch.

"It's unlikely they will launch with two cassettes. It would be ridiculous.

"We at Philips expect them to opt for the rotary system for several reasons. Firstly, because the majority of manufacturers are now in agreement the rotary system is the best. Until recently, the committee was split 50/50. Now it's swung to the rotary and only 10 per cent of the manufacturers are still keen on the stationary head system."

Asked whether Bill Andriessen of BASF, who feels that both systems are not suitable because they do not offer the consumer anything new, stood a chance of convincing the committee to opt for a flip-over rotary-type cassette, Mr de Haan said: "Not a chance. The committee has decided the standards and that is the end of it.

"The committee has been disbanded and the cassette moulds are all made so they are compatible between manufacturers, so it is too late. It is now down to the political heads to make their decision which tape will be the world standard. But it will be one of the two, and most likely the rotary system."

The reasons the industry is expected to opt for R-DAT is because it offers longer playing time (two hours against 40 minutes on the fixed head system), uses a smaller cassette, is cheaper in its use of tape, and needs to employ only 128 RAM chips in the electronics instead of 256 as needed by the S-DAT system."

Also, there are only four manufacturers (Philips, JVC, Sharp and Sony) that can make the complex stationary heads that use the thin film technology.

Asked why the industry didn't opt for a flip-over rotary that would give four hours of recording, he said that the committee felt that two hours was enough, and anyway, the tape only takes 28 seconds to rewind from the end to the beginning.

The new digital tape system is expected to be introduced in 1987 (although, as this goes to press, an announcement on which system will finally be decided on was expected within weeks). It wasn't shown by any manufacturers at the Japan Audio Fair in Tokyo recently because the industry was worried that it would have caused confusion on the market and damaged the sale of CD players.

Other sources reported that the DAT Standards Committee arrranged a seminar and demonstration at a nearby hotel, but all but one of the firms with DAT equipment to show dropped out. Only the Sony R-DAT recorder was shown. It is to be smaller than most portable tape recorders. Because the circuitry is not yet integrated onto chips, it needed a bank of ancillary equipment. When Sony demonstrated it, the sound soon started to crackle and break up. Sony engineers then swiftly switched off the machine and covered it with a blanket.

Rivalry from 8 mm

If the industry waits too long it could miss out and PCM sound on 8 mm video could become the new standard because it offers 18 hours of music on an 8-bit digital (pulse-code modulated) system.

It is ideal for cars because the 18 hours is stored in six tracks of three hours each and so a driver can hop from track to track as his mood dictates. An 8-bit system would be sufficient for a car where a too-wide dynamic range is a problem rather than a benefit because one can't hear the low, quiet passages because of road noise.

Will DAT flop?

But while the industry may be looking with excitement to the new digital tape era, BASF's colorful tape expert Bill Andriessen, who sits on the Digital Tape Committee, says they are both poor.

"This is a typical example of what creation by committee produces. The committee's brief from world-wide manufacturers was to decide on one standard cassette for the digital age. Not only has the committee not done that, but it has chosen two cassettes, neither of which is suitable for the future.

"There is no doubt that in the future we should have a new tape medium for the digital age. But if it is to replace the popular and dominant compact cassette it must offer something new. Neither of the two cassettes settled on is ideal, and I predict they will both be rejected by the consumer.

"Then we will have to start all over again."

Mr Andriessen blames the complex face-saving politics of the various Japanese companies for the decision to standardise two cassettes. He said one group of manufacturers wanted the S-DAT and another the R-DAT. Because they couldn't agree they settled on the two. But Andriessen predicts that neither will survive if they are both launched and the public will stick with the compact cassette.

"Neither system offers the consumer any extra benefits other than digital recording and most wouldn't bother with the marginal gain in sound quality over the compact cassette," he said.

"These days, using a high quality compact cassette and Dolby C it is virtually impossible to pick between the sound quality of compact disc and the tape," he claims. —to p.101 ▶

Swag of new 8 mm video products released by Sony

Sony, just seven months after launching the first 8 mm video product on the Australian market, released another swag of V8 products in mid-February: a portable camera that can be used in one hand, two VCRs (one with digital PCM audio included), a tiny portable recorder and a PCM audio processor.

Sony's new top-line 8 mm VCR is the EV-S700. It features PCM ('pulse code modulation') stereo sound with a claimed 88 dB dynamic range and the capability of recording up to 18 hours of PCM stereo sound in the long-play (LP) mode.

Other features include up to three hours of recording and playback on long-play video mode, a three-week/six-event programmable (audio & video) timer and a full-function wireless remote control. Sony are dubbing this product "DAV", for 'digital audio-video'.

Their economy 8 mm VCR, the EV-A300, comes with standard FM audio and a three-week/four-event programmable timer. This model also comes with a full-function wire-less remote control. A PCM digital audio processor for recording and playback is available as an add-on, the PCM-EV10.

Both VCRs also feature clean still pictures, frame-by-frame advance and step slow functions. Additionally, the EV-S700 also includes a double-speed fast playback function. The flying erase head feature is available on both machines. Suggested retail prices are $1899 for the EV-S700 and $1149 for the EV-A300.

Apparently, the PCM audio employs both analogue and digital compansion to achieve the claimed 88 dB dynamic range. The actual analogue-to-digital conversion is 8-bit, with an extra two bits employed apparently to provide some digital compansion on peaks. This, together with a limited amount of analogue compansion, provides performance equivalent to a 13-bit digital system, Sony sources say.

Six separate stereo tracks can be recorded on tape in full PCM audio mode. They can be accessed serially, which gives a total of 18 hours playback (in CP), or you can jump track-to-track. No 'item search' facility is available however, to enable quick finding of a particular item on the tape. With audio facilities and performance such as this in a video recorder, the line dividing audio and video becomes increasingly blurred.

The latest camera in Sony's 8 mm video range is the CCD-M8 'Handycam'. This unit weighs just 1 kg, can be operated with one hand and has been specifically designed for the first-time video camera owner. It is a record-only unit. When finished, the tape can be placed in any 8 mm VCR for immediate playback.

The M8 employs a completely solid state charge-coupled device (CCD) image sensor, as with Sony's earlier V8 models. Sound is recorded on the tape along with the video, using an FM subcarrier (see "The New 8 mm Video Tape Technology", AEM, Jan. '86, p. 28).

A full range of accessories can be purchased for use with the Handycam in the 'PAK-88' format, which includes a portable deck-type VCR, the EV-C8, which Sony claims is the world's smallest. Suggested retail price for the CCD-M8 is $1899, and for the PAK-88, $2999.

Perth's success show

The 1985 Perth Electronics Show, held early last August, was a proven success and remains unchallenged as the largest and most important consumer electronics and homeware exhibition in Australia, the organisers say.

Organisation is already underway for the 1986 Perth Electronics Show which will be held again at the Claremont Showgrounds in Perth from July 31st to August 3rd next year, with an exclusive trade-only day on July 30th. Already the show organisers predict that exhibition space will be 20 per cent up on 1985 and say there has been considerable interest from potential new exhibitors.

"The success of the 1985 Perth Electronics Show has prompted numerous enquiries," says Chris Gulland, who has been show manager for the past six years. According to Gulland, the 1985 exhibition was the most successful Perth Electronics Show on record.

"A total of 220 major companies were represented on 93 stands in a show area of 12 000 sqm. Visitors to the Show topped 85 000," he said.

A number of successful innovations were introduced in 1985 which will continue in 1986. A full day was set aside for trade-only visitors and included product knowledge and marketing seminars. Reduced airfare and accommodation packages for interstate and overseas visitors were also launched.

"The 1986 Perth Electronics Show will not only be bigger and more comprehensive, the trade sessions will become an important event on the industry calendar," said Gulland.

"We plan a full day again for trade and media only and seminars will cover a much wider range of topics."

The Perth Electronics Show is now an exciting success story. According to Gulland, it is an important venue for new product launches. Manufacturers fly in state-of-the-art equipment from around the world for Show previews. The event attracts countless senior business visitors from overseas and interstate, retailers from across Australia, national media and key Australasian representatives from the manufacturing industry.

A comprehensive brochure on the 1986 Perth Electronics Show is now available including exhibitor information, floor plans and Show events. Write to **Perth Electronics Show, PO Box 745, West Perth, 6005 WA. (09) 382 3122.**

New tricks for Beta and VHS

With the new 8 mm video format launched and running well, the video Shogun are now updating their technology for the half inch VHS and Beta formats. Not all the technology that made V8 so successful technically will be usable in the older formats, though.

Achilles heel of V8 is the high cost of the metal tape cassettes essential to this new format. Even though the metal powder tape is cheaper than the metal evaporated, the quantity for a three-hour ½" VC is a major expense that will keep metal out of the big VC for some time to come. Improvements in quality will be less spectacular for old formats.

The Beta group recently announced "Super Beta", which is claimed to improve the picture resolution by a gain of 10%. Sony has already released their new Super Beta machine, the SL-HF950ES with a suggested retail price of $1899. This is made possible by shifting the luminance band up to give a wider band for video frequencies in the VCR so the whole chrominance and luminance spectrum is improved. The great problem with format upgrades is that compatibility with older VCRs is in question.

Gary Wilson, Sony's technical guru, has assured me that Super Beta is fully cross-compatible with old Beta, but the extra 10% cannot be expected on old units. Also, it is a requirement of Super Beta that the latest HG (high grade) VC be used, but not metal.

JVC and National, the VHS leaders, have hastened to release news of their update "HQ" (high quality) which is on the way, due for release mid-year. They both point to the release of the new "white clip" level outlined in the review of JVC's new vidi-fi VCR elsewhere in this issue.

National points to the inclusion of this update in their NV280A VCR released last July. Both say they will not promote HQ until all the HQ features are in current models. National saying, to do so would be "premature ... misleading to the consumer; ... real benefit in increased picture quality, whilst maintaining ... compatibility *with current and future models of all VHS brands*". The italics are mine as it shows that the many VHS producers are as usual keeping standards intact; probably using common ICs. This has been a great VHS strength in the past.

There are four enhancements that go to make HQ: (1) White clip raised 20% giving crisper, sharper images; (2) Detail enhancement by HF signal processing with pre-emphasis; (3) Luminance Vertical Processor, doubling luminance signals from adjacent lines while noise factor only rises 1.4 to improve S/N ratio; (4) Chrominance Vertical Processor, using the same method of signal doubling with noise only twice, for reduced colour noise.

This all sounds jolly good until the last note on the National technical data, which says:

"*From the viewpoint of compatibility with conventional VHS models, . . . items 3, 4 have been adopted for use in the LP (long play) mode only. They are not applicable to the SP (standard play) mode.*"

I have sought clarification, which is coming from the designers in Japan.

Malcolm Goldfinch

The midi grows more popular

Australian beer drinkers know what a middy is but Australian consumers are only just discovering the hi-fi midi.

According to the Consumer Electronics Suppliers Association (CESA), Australians have traditionally thought that 'bigger is better' when it comes to hi-fi. But growing sales in midi-size, or shelf-size, sound systems indicates that the Australian market, like those overseas, is beginning to appreciate the benefits of the more compact hi-fi systems.

Sales of midi-size hi-fi systems has grown from virtually nothing a few years ago to almost 20 per cent of the Australian market, according to CESA. All the major manufacturers have released midi systems in the past few years.

Some industry pundits say the generally midi size of compact disc players, the boomer product in recent years, will accelerate the trend.

CESA says midi systems don't dominate the furniture, and fit well into modern smaller-size rooms.

Another trend, says CESA, is to 'home entertainment centres', which reap the maximum benefit from TV, video and hi-fi systems, following the integrated sight and sound concept introduced in recent years, and midi sound systems suit this concept too, CESA claims.

'Theatre sound' from your TV or VCR

That big sound you experience in the cinema can be obtained from your TV or video recorder, according to Melbourne-based GFS Electronic Imports, by using an add-on device made by the MFJ Enterprises of the USA.

The MFJ-1500 takes either a mono or stereo input and provides variable time delay and reverberation to 're-create' that "big theatre" sound.

The unit provides processed and unprocessed outputs which can be fed into a stereo amp. If you don't want to, or can't, use your stereo, the MFJ-1500 has an in-built two watt amplifier. A single speaker is connected to the MFJ-1500 and placed behind the listening position to provide the ambience of a large theatre.

The MFJ-1500 measures 254 × 50 × 150 mm and operates from 12 Vdc or 240 Vac. Contact **Greg Whiter, GFS Electronic Imports, 17 McKeon Rd, Mitcham 3132 Vic. (03) 873 3777.**

Sanyo launches VHS VCRs

Sanyo has announced the release of a range of VHS format video cassette recorders. Mr Mat Matsunaga of Sanyo Australia said the move to add the VHS format to its range of video products came as a result of continuing requests from dealers who were responding to "consumer demand for Sanyo VHS recorders".

"Sanyo has been producing VHS-format VCRs under the Fisher brand for some time. It is a logical step in our development as one of the world's major producers of electronic products to expand into VHS," said Mr Matsunaga. "The VHS recorders will complement our range of Beta recorders. We will also be releasing new Beta format recorders through 1986. Later this year, Sanyo will also launch an 8 mm video," he said.

The three VHS models, VHR-1100, VHR-1300 and VHR-1500 all feature the HQ (high quality) technology designed to produce sharper, clearer images.

In the HQ circuitry, the white clip has been increased from 160% to 190%, while a "detail enhancer" provides increased contrast, definition and clarity as well as reducing signal loss, says Sanyo. Further details from **Wally Fabiszewski, Sanyo Australia, 14 Mars Road, Lane Cove 2066 NSW. (02) 428 0822.**

Now it's the home sound studio!

With the advent of compact disc players, sound reproduction has come almost as close to the quality of the original programme as possible. The next challenge, many audio enthusiasts say, is to be able to create one's own music, in a similar way to that of professional studios.

Being able to dub in other voices or instruments with a pre-recorded piece, or with one's own composition, achieving a mix of different sounds and coming up with a truly original creation, are features that more and more audio buffs are beginning to discover.

Home recording is rapidly emerging as the next 'boom' area in the audio industry, some pundits say.

In response to this trend, the Japanese firm Shiino Corporation has created the Vesta Fire MR-10 Portable Studio, distributed in Australia by Rank Electronics Pty Ltd. This mini studio package is a 10-channel mixer/4-track recorder that allows you to create and record your own music, employing professional recording procedures such as overdubbing, punch in/out, and sound mixing.

A dbx Type II noise reduction system ensures clean, quiet recordings with plenty of headroom to avoid distortion, the makers say. The MR-10 is also equipped with stereo phono inputs, allowing one to add voices and/or instruments to already mixed-down music.

The Vesta Fire MR-10 Portable Studio sells for around $699.00 from selected audio specialist dealers throughout Australia.

For further information, contact **Andrew Horman, Rank Electronics Pty Ltd, 16 Suakin St, Pymble 2073 NSW. (02) 449 5666.**

Giant step for Nakamichi

Nakamichi Corporation took a giant step towards becoming a full-line home audio electronics manufacturer by introducing the PA-7 and PA-5 'STASIS' power amplifiers, CA-5 control amplifier, and ST-7 AM/FM stereo tuner.

The PA-7, PA-5, ST-7, and CA-5 exemplify the twin electronics lines Nakamichi launched with the OMS-7 and OMS-5 CD players last October. Both series are designed to produce identical sound, the main difference between them being the added convenience features found in Series-7 components.

For the first time, Nakamichi say, the true audiophile can avail himself of the conveniences provided by mass-market electronics with the sound quality heretofore possible only with extremely expensive esoteric equipment.

The PA-7 (rated at 200 watts/channel) and PA-5 (100 watts/channel) feature a STASIS topology which does not employ global feedback to reduce distortion. Both amplifiers are claimed to be inherently stable with any speaker and are said to have uniform output impedance for optimum sound quality.

The CA-5 Control Amplifier is designed for the "purist" and features those controls essential for music reproduction: level, balance, and input selection. The phone stage accommodates both moving-coil and moving-magnet pickups with selectable input impedance for the former and selectable capacitive loading for the latter. In addition to phono, CD, tuner, and aux inputs, the CA-5 is designed to accommodate two tape decks and has an extra set of outputs for driving a second power amp. A special circuit controls power to an entire Nakamichi home electronics system via an optional System Power Control Strip (SPC-1).

The ST-7 AM/FM Stereo Tuner was designed by the renowned Larry Schotz and features the latest "Schotz Noise Reduction" circuit to improve effective stereo sensitivity. With Schotz NR, 50 dB quieting in stereo is achieved at 28 dBf (European/Australian models: 31 dBf) — 9 dB less than possible with conventional designs without resorting to "psuedo-stereo" reproduction, say Nakamichi.

Both 75 and 300 ohm inputs are provided; left and right outputs are independently adjustable to match sound level to that of other components.

Further details from **Convoy International, 400 Botany Rd, Alexandria 2015 NSW (02) 698 7300.**

Double auto-reverse cassette deck

Onkyo's TA-RW99 double auto-reverse cassette deck has features intended to give up to six hours of uninterrupted replay from C90 tapes.

One feature is a quick reverse function that detects the end of the tape with an infrared sensor, reducing the between-sides gap to less than one second.

Both cassette holders of the TA-RW99 are equipped with the quick auto-reverse function, thus allowing you to make continuous both-sides recordings with no lengthy interruption between cassette sides. A high-speed dubbing function allows copying a C60 cassette in 30 minutes.

Being two auto-reverse decks in one, the TA-RW99 can continuously play both sides of either one cassette (in either holder) or two cassettes. When two cassettes are loaded, the continuous replay mode alternately plays both sides of each cassette for any length of time — a useful function for providing background music at parties and other get-togethers.

The TA-RW99 also has a direct song access feature, allowing you to locate up to 30 specific selections on the tape quickly and easily. It comes in matt black, and is priced around $869.00 from selected hi-fi specialist stores throughout Australia. Further information from **Margot Bowles, Regent Audio, 16 Suakin St, Pymble 2073 NSW. (02) 449 5666.**

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Cat. No.	Outside Diam. mm	Inside Diam. mm	Length mm
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DS111	2.29	.64	12
DS112	1.93	.91	12
DS113	2.49	1.14	12
DS114	3.18	1.80	12
DS115	1.52	.64	19
DS116	2.49	1.14	19
DS117	2.29	.64	19

Here's the professional desoldering station that has everthing except a fixed place. The low maintenance, self-contained vacuum/air pump in this compact unit now lets the station travel to the job.

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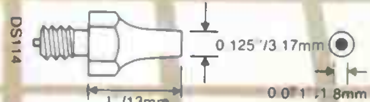

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The JVC HR-D565EA hi-fi VCR with infra-red remote control.

Hail the 'vidi-fi' !

JVC's HR-D565EA reviewed

Robert Fitzell AAAC   Malcolm Goldfinch

Just when you thought it was safe to separate the video and the hi-fi gear, along comes "video hi-fi". JVC's new VHS video cassette recorder incorporates new HQ ('high quality') video circuitry and hi-fi helical scan FM stereo audio. Malcolm put the video through its paces and Bob compared the hi-fi audio against compact disc – both with interesting results.

ONE CANNOT HELP feeling a little numb after trying to keep pace with the deluge of 'breakthroughs' coming from the video industry. The video owner, and the few prospective video owners left, probably feel much the same. CCD cameras, 8 mm video, PCM hi-fi on 8 mm video, we have covered fully in recent issues, often in advance of the announcements of these products in Australia.

The lastest vidi-fi VCR (see box), is part of the new wave of updating in the established formats of Beta and VHS. (See Story "Video Updates" in Consumer Electronics News this issue). The new technology that makes V8 possible is now being incorporated in their formats. Whereas metal tape, either coated or vacuum deposited, is a vital part of the V8 format and responsible for the very high prices of V8 videocassettes (VC), the half inch VHS/Beta cassette uses too much tape to make metal tape in these a feasible cost proposition for most home video users. New HG tape coatings of ferrite and cocktail mixes of rare metals are making great strides in improving the possible recording bandwidths. The new V8 format is not being allowed to run unchallenged.

Hyper headspeed hi-fi

Tape recorder buffs have long known the value of tape-to-head speed; 15 ips/380 mm/s is the pro standard; eating up quarter inch tape at an alarming rate. Consider now the moving Beta vidi-fi head, with a speed past the tape of 585 mm/s, and for VHS 485 mm/s, both at the PAL scan, standard speed. It is no surprise that the latest vidi-fi machines are claiming a performance in audio to surpass pro reel machines and rival the CD. The fact that a four hour VHS high-grade VC, costing $15-20, can be used to record for eight hours in long-play, on two discrete tracks of audio, at a head speed for 485 mm/s, is to say thė least mind boggling to conventional audio tape engineers.

The end result of my first tests on a vidi-fi machine in 1984 were startling. On audio, it gave 20 Hz-22 kHz flat, harmonic distortion less than 0.22 dB, wow and flutter less than 0.011 dB, and a dynamic headroom of 92.9 dB. All these tests, made over a year ago on a JVC HR-D725EA, exceed the manufacturers' claims! I used an ordinary high grade TDK tape for

REVIEW ITEM:	Video Cassette Recorder
MANUFACTURER:	JVC
MODEL	HR-D565EA
FORMAT:	Front Loading
PRICE:	Not Known
SUMMARY:	On the tail of the CD players

Beta and VHS 'vidi-fi' (video hi-fi) systems

Because the Beta VCR format has a low helical scan head-to-tape speed compared to VHS (18.7 m/s as against 23.39 m/s) it could not follow VHS's half-speed long play, offering more than double the Beta recording time in the big NTSC markets. This is probably the main reason why Beta lost its lead to VHS as the world's dominant video format. Three years ago a better sound system for Betamax manufacturers became a survival priority.

The original Sony hi-fi system, developed in conjunction with Nakamichi Laboratories, for Beta format using the same drum-scan heads used for video and audio, was entirely within the NTSC TV standard. They saw a window in the Beta-NTSC spectrum that allowed an FM multiplex hi-fi audio recording along with the video signal at a head speed of 585 cm/s. This system is very similar to the V8 format FM head sound option described in AEM January '86, p30. The fact that VHS format had no such window was hailed by the Beta camp as the end of VHS.

Like the video-disc, the arrival of Beta hi-fi on the Australian market seemed to be on an indefinite hold after the Australian demonstrations to media (using NTSC hardware). A year later the news came it would not work on PAL TV systems. Simultaneously, the VHS hi-fi system, using separate heads with azimuth shift, overlay audio recording was announced. The Beta camp soon followed with their version. The overlay recording is compatible with PAL or NTSC TV standards. At present, this appears to be the worldwide accepted method of 'vidi-fi' recording on half inch video tape.

Two audio heads are added to the video-scan drum and the azimuth is varied from the video heads by 30 deg. (Figure 1). Special hi-fi video cassettes are now being sold for best results, but ordinary high quality VCs seem to take vidi-fi depth recordings quite well.

Although this azimuth variation for the audio/video dichotomy would appear to be settled and absolute, the complete separation of audio and video, when extreme signals are coincident, is achieved by what JVC has named Depth Multiplex (D-MPX). Beta vidi-fi employs a very similar system.

The stereo audio is recorded first, by the two audio heads with special gaps to take the signal deep down in the magnetic emulsion on the tape base. The frequency modulated signals between 1 MHz and 2 MHz provide their own bias and have a deep penetration characteristic.

Secondly, the video heads with finer gaps and different azimuth angles lay down the luminance and down-converted chrominance signals, at frequencies of 2.5 MHz to the top recording limit of about 4 MHz. Such a combination of circumstances favours shallow recording on the tape emulsion surface and the audio signals are barely disturbed (see Figure 2). Playback is a reversal of this process. It is very effective. In the vidi-fi units tested, I failed to detect any video-audio crossmodulation on a sensitive Sony TV monitor, nor could I hear any video crosstalk from my sensitive B&W VM 1 (video monitor) speakers.

Malcolm Goldfinch

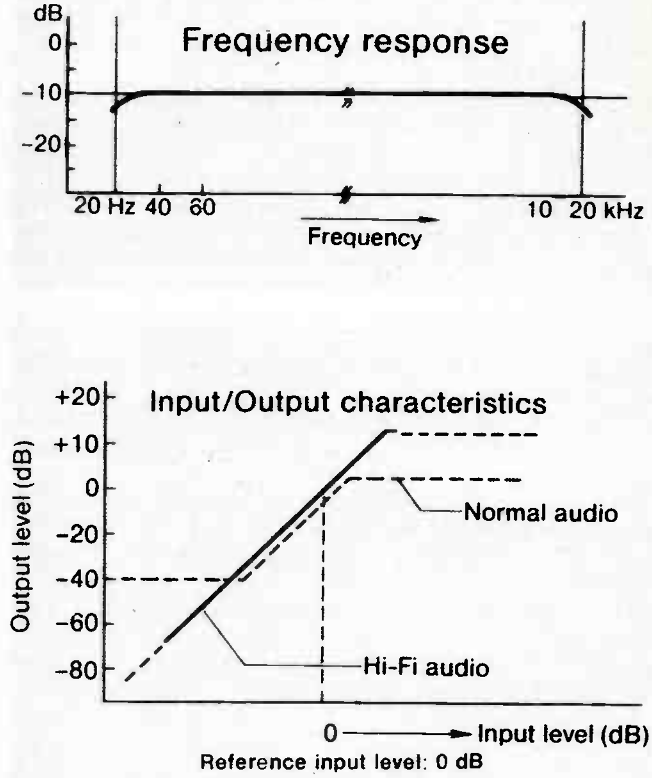


Figure 1. JVC's illustration of input/output characteristics and frequency response.

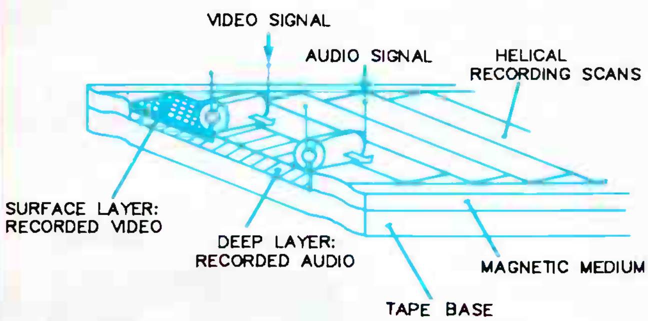
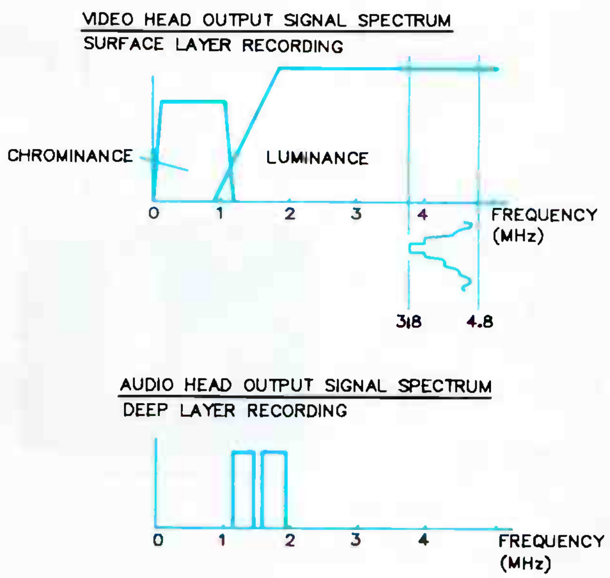


Figure 2. Above: 'Depth recording' of the audio, with the video signal overlaying it. Below: How the video and audio frequency spectrums are made up. The two audio channels are frequency modulated on separate carriers between 1 MHz and 2 MHz.



the tests before special hi-fi tape arrived. This model is still top of the JVC pile and now very expensive, but nowhere near the cost of studio type reel recorders in half inch, which it exceeds in quality and playing time many times over. Also, the hyper headspeed seems to make expensive noise reduction systems, with their inevitable distortions or phase shift, quite redundant.

So far, conventional audio "experts" seem to behave as though helical scan audio does not exist. Like the video consumer, they don't quite know what to do with vidi-fi. Most of us have a place for music listening and another for TV. Where do you put a vidi-fi? (no prizes for rude suggestions!)

What is now becoming obvious from these performance figures is the similarity of quality between vidi-fi and CD audio. In many ways they complement each other. CD is a fabulous sound source and vidi-fi an impeccable recording medium of similar quality (made for each other?).

Before the copyright people bring out their bogeymen, let me quote from Homer, or was it Diogenes in his echo chamber, "*What consenting CDs and vidi-fis do with each other in the privacy of their homes let no man or woman try and sunder!*"

When Anthony Toop of JVC offered me a chance to try the latest vidi-fi with new technology I not only jumped at the chance to try their latest video, but talked to our Editor, Roger Harrison, about an audio match, with CD supplying sound and JVC's HR-D565EA (rrp $1299) at the batting end. As umpire, Robert Fitzell would use his instrumental wizardry to keep score. Read all about this test match further on but firstly, we have a video machine, so, on to the new picture quality features.

White clip video 'trick'

This is an improvement on the headroom of the white clip which is required to take the best advantage of the bandwidth which is possible for a half inch VCR to record. With improved technology and bandwidth, the white clip can be reduced with a corresponding improvement in definition.

The video signal is a high frequency luminance signal that gives the image shape. A chrominance signal gives colour. The new JVC video circuit raises the allowable white clip level of the pre-emphasized luminance signal by 20% to avoid signal loss when the luminance rises. As claimed, the picture I observed does have sharper edges and greater clarity overall; particularly with full sharpness. This is a control to 'sharpen' or 'soften' the picture like a photographer can do with photo printing paper. It is just one part of the overall video 'HQ' (high quality) update taking place during 1986 in both Beta and VHS formats.

What does this really mean in hands-on values? There is one very harsh test I use to examine the quality of a VCR; I copy from a copy of a copy. The Tape I use is TDK Extra High Grade as a reference on all tests. The benchmark VCR is a Canon VT-10, with a Sony Profeel stereo TV monitor and stereo tuner amp, with B&W ZMF VM1 monitor speakers. These are the constants, the VCR under test is the variable. I play a standard tape I have recorded onto the test or use a TV test pattern. Then I copy the copy until the result is unacceptable.

When I started testing videos this way six years ago, a copy of a copy was really too poor. Gradually, this third generation copy has improved with better machines, including my

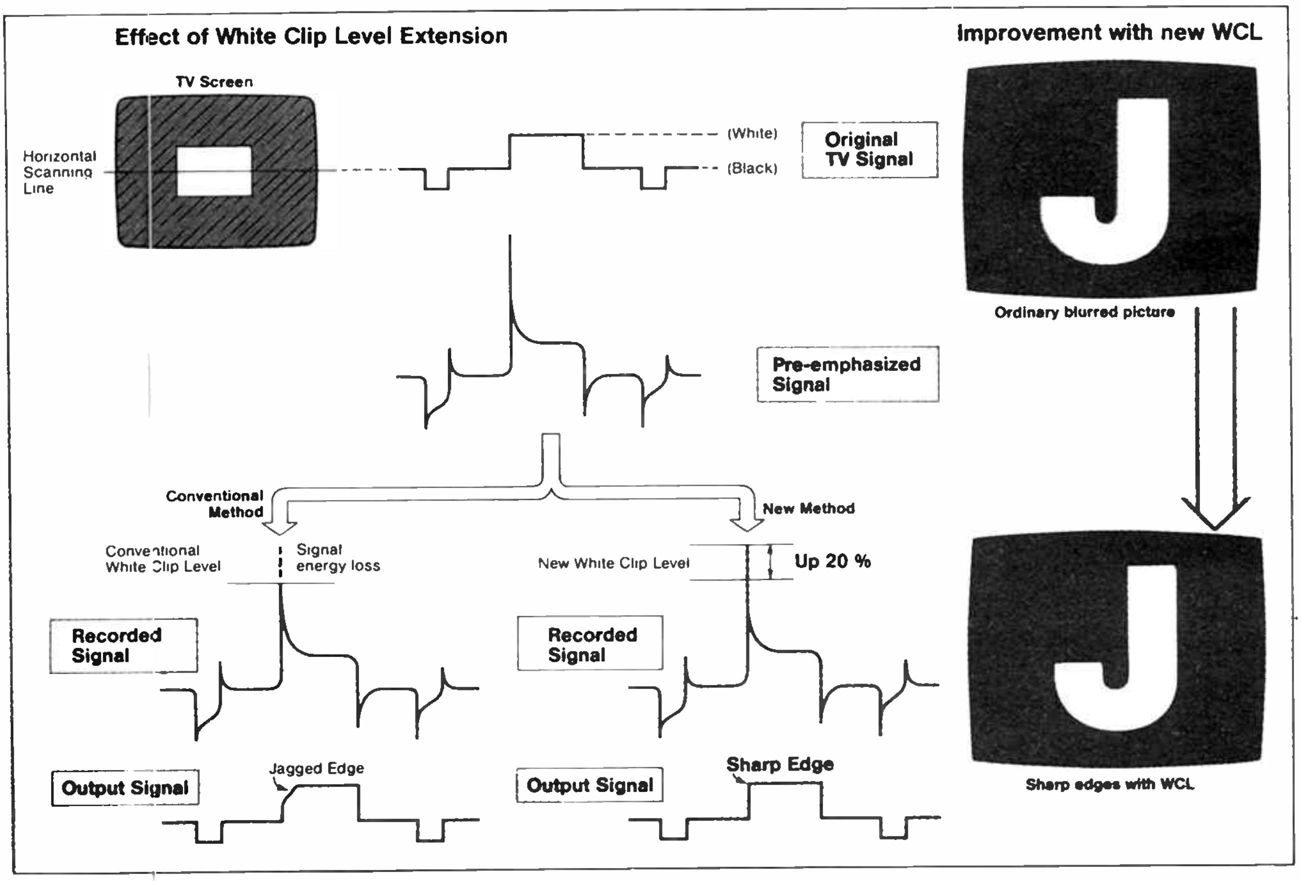


Figure 3. How the 'white clip' technique works.

benchmark VCR, so third generations are passable.

This copying quality is of great interest to home video users who want to edit and sound dub a second generation master, so they are able to make third generation copies of sufficient quality to publish their videograph in quantity using home video equipment. In the past, I have always found this third copy of doubtful quality. Also, it clearly reveals the relative quality of the VCR under test.

In testing the JVC HR-D565EA, the record-only run showed it to make a good third copy. In the play-only run the third copy was exceptionally good and I tried a fourth copy. To my surprise it was quite acceptable; better than many third copy results from older VCRs! For the hell of it I tried a fifth. This was not good and lost chroma in spots from the home video original but was quite passable from a TV test pattern original. In VHS, the edge track audio always copies well for several dubs. The hi-fi audio would be excellent for many generations of copying.

The reason for the superior video copying quality was undoubtedly coupled to JVC's 20% white clip circuit and the picture sharpness control on full "sharp". When the Canon was used as a replay unit results were good, but using the JVC HR-D565EA for replaying every copy, the results were exceptional. The reason for this is that the white clip and sharpness control only works on replay, not on record mode.

Unusual features

There is nothing very different about many features, appearance, layout or controls on the HR-D565EA. The date setting I like as it is a new, simple system on a flap which hinges down on the front to give a large numeric keyboard that also has days from 1-7. A programme bar and left and right move arrows completes the time setting controls. The Cancel, Clock Adjust, Dimmer, Reset, Clock Counter Reset buttons are on the flap to the left. They are clearly marked and easy to read, particularly if the VCR is low down in a stack.

Setting a programme is a breeze. It is like a PC. Just press Program and big fluoro letters where the time and date were now show "P:" for programme "1", the first unused programme of four. Cursor dashes flash below the date display. Key in, for the day, say 25th. 25 comes up, the month cursor flashes. Key in 12th, the display vanishes and the Start/Stop display is up with the cursor flashing below Start. Key 1800 and the cursor goes to Stop, key in 2030 and the cursor is at TV PR. Key channel 9 to complete the set. If you know what you want to put in the prompts allow the set in several seconds without having to remember procedure; a great leap forwad in the "Lost Ark" jungle of VCR control.

But I suspect many are like me and make mistakes while setting. This is where the JVC HR-D565EA really scores. No more back to the beginnings, just press the Back or Next key and you can re-do any error. Also, you may recall any setting and change any part; press Program and it shows each timer setting. It is all like a wordprocessor. Clocksetting is just as easy using the day overlays on the numerics. The clock and channel settings stay in operation for days without mains power.

By contrast, the function controls on the face above the flap are very finicky. To operate them you need a bit of 747 flight deck skill. In a 70 × 60 mm space there is: audio limiter on-off; manual controls beside tracking level indicators may be used (these indicators are selectable); OFF/ON; hi-fi track; picture sharpness pot; tape memory on-off; source select: (tuner, aux, simulcast); headphone level pot; audio monitor select [Normal, Mix (both), hi-fi (helical scan)]; audio monitor for hi-fi (Ch. 1, stereo (both), Ch. 2); tracking pot; Timer button (tuner/timer in control); and instant record button for limited time. It is quite easy once you have done it all several times!

If you like control from an armchair the remote does most functions but not the settings just described.

You can audio-dub the linear track but not the hi-fi tracks; connect a video camera; record or replay bi-lingual soundtracks; search and stop tape on elapsed time. The usual video-in-out BNC jacks are missing. In their place is the new industry standard A/V socket which I found a disaster as far as the male connector is concerned. I pride myself as a master of plug pushing and pulling, but the completely new 21-pin A/V connector with nibs in perfect alignment refused to enter even with drastic pressure. The whole plug came apart into its components and was only accepted after the female nibs had been deflowered with a fine screwdriver and the sharp edges of the male prongs rounded after removing the shield. The operations took half an hour with the use of micro lenses. This connector must be improved. At the other end of a metre of cables there are the two usual BNC connectors for video in/out. The audio connector is a standard DIN 5-pin male and it all worked well.

Subjective impressions

The sound from the ABC and other simulcasts is often derived from impeccable source material. The Brits particularly lead the world with their Covent Garden Ballet and opera tapes. Both video and sound are superb and I had the good fortune to catch a sample of Romeo and Juliet, and Samson and Delilah with the JVC HR-D565EA.

To replay, I took the mountain to Mahommet by moving the JVC HR-D565EA from the TV-video lab upstairs and patching it into my Nakamichi 730 tuner/amp coupled to two B&W DM6 monitors in front and two DM4s phased-in behind the listening point. For video, I used a Sony portable close to the listening point on a VCR cable. My ears are old and I subscribe to Neville Williams' dictum of hearing loss due to age, but I invited keen young ears as well. The consensus was sound of extraordinary, in fact studio monitor, quality. I just found it so enjoyable because I was hearing tones and instruments I thought gone forever, except from my Nakamichi OMS-5 CD player into the same system. The Samson and Delilah recording was an equal tour de force with Sidney Nolan's dreamtime sets and costumes matching the drama of San Saens' music. As a constant ballet and opera goer I found it right up with the real experience. We live in an amazing world.

When Bob Fitzell returned the JVC HR-D565EA he had made a vidi-fi test recording of some of The Empire Strikes back from a Channel 10 stereo broadcast; not a hi-fi simulcast. I did not expect too much from TV sound, but the quality of this stereo just laid me back. With the full 90 watts RMS per side of hi-fi ranged in front, and the DM4 rear (ambience) speakers I had lazerblasters singeing the back of my head! If you go for a stereo-tv, make it part of the hi-fi system. I found it an audio-visual thrill close to cinerama, and all in my own home.

Top movies are now starting to be released in this new vidi-fi medium for VHS and Beta formats. Take one home and you can have James Bond or Darth Vader invading your home in super, wallpaper-peeling, surround-sound! Now let's hear from Bob how the test match went with compact disc audio.

The VCR as a tape deck

Some years ago it was common to hear complaint that tape recorders might be a lot of fun and convenience but really weren't on if you wanted quality audio. Sure you could have ▶

almost endless party tapes and could pirate your favourite songs from the radio, but the hiss (remember that?), what about the hiss, and the compressed dynamic range, and what about the wow and flutter!? Party tapes OK, but you really wouldn't want to hear a piano or an oboe sounding as if they were played on the 8.12 lurching into Central Station.

What a long way tape recorders have come. Along with Mr Dolby and a great deal of design effort in tape drive mechanics we have all come to expect even quite ordinary cassette tape recorders to provide recordings that rival the original in overall sound quality. Many authorities now use small portable cassette tape recorders to obtain community noise data that they previously would have argued could only be safely obtained using a Nagra or similar recorder costing perhaps ten or twenty times as much.

Unfortunately for the tape recorder gurus the digital disc has again put the tape recorder under pressure, not for the reasons of wow and flutter where the older recorders most often foundered , but back in the magnetic domains of tape noise and dynamic range. One of the most striking qualitites of the digital disc is the astonishing silence between tracks, the total absence of background and surface noise, and the overall dynamic range achievable. It is, for example, usually easy to pick which tracks on a disc have been taken from an alalogue master and which have been digitally recorded, so distinct is the absence of noise on the digital recordings. The digital disc is, in terms of signal-to-noise and dynamic range at least, head and shoulders above our tape recorders and turntables.

Many product developments begin as hybrids and in some ways our latest review item is one of these. Along with the burgeoning market in home video has come a demand for better audio quality. After all, who wants to watch 'Amadeus' at home if you can't enjoy Wolfgang's cackle in full fidelity, or perhaps 'Witness' for which pedestrian standard audio would destroy much of the atmosphere of the film. One of the new wave of video recorders to enter the market is the 'hi-fi' stereo VHS video cassette recorder, model HR-D565EA, from JVC. The main difference between the recorder and its predecessors is, apart perhaps from some subtleties of control, the 'hi-fi' part — a deep layer recording underlying the recorded video signal — offering a high fidelity stereo alternative to the standard longitudinal audio recording track running along the edge of a standard video cassette tape. The JVC provides both hi-fi and standard audio tracks, so if you have a library of video tapes the machine will still replay them with exactly the same audio quality that you previously had.

This JVC machine conforms to the hi-fi VHS standard, so that commercial tapes showing the hi-fi symbol on the front can be replayed with high quality audio performance using the machine. Whilst these tapes do not appear to be all that numerous at present, it can be expected that they will increase. For now, it is likely that an owner will need opportunities such as a recording of say a simulcast or from a live recording in conjunction with a video camera to get the benefits of the video hi-fi potential.

As an audio recorder this VCR, entirely apart from its video capabilities, offers quite exciting possibilities. With response of 20 Hz to 20 kHz, and wow and flutter of less than 0.005 per cent WRMS, these specifications are above those of even the best of cassette recorders and nudging at compact disc quality. If the specs are true then it potentially offers a new standard of performance for those who continue to doubt the trueness of digital players and wish they could stick to wholly analogue devices, as well as a way out for those who are perfectly happy with digital disc sound but are frustrated that the rest of their system is again starting to sound substandard.

The facilities

As a video recorder it is possible to record video signal and simultaneous high fidelity stereo audio over the same magnetic tape, the video track superimposed over the top of the audio track. Simultaneous audio can be recorded on the longitudinal audio track running along the edge of the standard video tape, or if you are wanting to be at all creative, you can dub announcements and messages on the longitudinal track later.

Mixed simultaneous recording of audio using a microphone is available on both the audio tracks. However, later dubbing of the hi-fi track cannot be done without wiping both the video and hi-fi audio recording. The record level of the hi-fi track can be manually adjusted on the JVC or automatic level adjustment can be selected using an audio limit switch. Manual control or record level is not available for the standard audio track. Hi-fi record level control is quite good, using slide faders with a linear LED style level meter graduated in decibels with colour indication of overload.

Programming and setup selection uses quite small switches located behind a hinged face panel, and I really found them just a little too small for easy use. Some care is required in the adjustment of some of the video controls since they affect the audio tuning also and it is possible to introduce some interference if a recording is made without any checking of the overall video record status. We also found some interference occurred when replaying standard video tapes with the audio select left on (mix), although this was eliminated when normal audio only was selected.

A monitoring headphone socket is provided on the front panel of the recorder with a headphone level control located behind the hinged fascia panel. The tape transport can be monitored using a selectable digital tape counter. Compared with the rather rapid count advance of standard audio cassette players the count on the JVC is rather slow and does not seem to offer very good resolution. The counter does however, function as a rewind memory which is very handy when recording and later rewinding to the start point or if you are wanting to repeat a large tape section. Without this feature one could go rather mad with a three hour tape length. The counter may be reset at any time to update the rewind stop point.

Main operational controls are keypad micro-switches on the front panel that require more positive pressure than do similar style keys on audio cassette recorders. Monitoring of operational status is quite good with the major settings being displayed on an illuminated panel on the front of the recorder. All of the major controls including programming can be operated using the infrared remote control unit which, if anything, is easier to manipulate than the main panel controls.

Hi-fi audio connection to the recorder is via standard stereo RCA input and output sockets on the rear. Output from the recorder is fed to tape or auxiliary input sockets of an amplifier in exactly the same was as any other recorder, whilst input to the machine is also the same as for a standard cassetter recorder. Some care is required in setting up the recorder to ensure that hi-fi track recording will occur. However, this would become relatively standard procedure once familiar with the machine and few adjustments would ever be made once set up.

Operation

I found operating the JVC video recorder annoying in many ways. Standard cassette recorders are now so good in their functional features that we have all come to take for granted the ease with which most of them operate. With most cassette recorders the basic controls such as pause, play etc are both positive and almost instantaneous. Even if there is any doubt in your mind you can usually visually check that the tape is advancing and that things are happening properly with little difficultry.

Not so with the video recorder. I found that frequently I had not got the tape going when I thought I had and since you can't see the tape there is no way to be sure that the system is operating without checking the display. I am sure the manufacturer would argue that the display symbols give instant display of the status, and I am sure that they do. For example it is possible to turn the record level display meter off and find yourself running blind. I simply found it less 'user friendly' than a cassette tape recorder.

A major part of this difficulty in becoming familiar with the machine is due to the very real delays in anything happening after any key is pressed. Starting of tape transport seems to be associated with such huffing and whirring and clicking that I am not at all confident that rapid cueing could ever be achieved. Whilst this may not seem important to some, I for one do not like hearing clicks and bangs between tracks just because the machine is so slow to start that it leads to an overall mentality to be sure that the start of the track will not be missed. (This is an unfortunate drawback of the VHS tape transport mechanism Ed.)

I also found the tap count to be so slow that it would be of little use for accurate cueing. This will probably be of little real concern to most since the count is still sufficiently good to locate tracks on the tape, you just may miss the start or begin somewhere in the previous track. For overall tape record the count will be vital since searching through a three or four hour tape can be more than frustrating. Fast forward and rewind are also not what we are used to with the cassette player, although this may in fact be deceptive since we are dealing with tapes of three and four hours of playing time.

Performance

Clumsy operation apart, the laboratory measurement of audio performance of this recorder show real potential, once the tape is off and running. Two aspects are, however, of real concern.

Figure 4 shows the record monitor frequency response, or the frequency response of the electronics. As we should expect, the response is essentially flat from 20 Hz to 20 kHz, with a 0.25 dB roll-off at about 18 kHz. One annoying aspect of the recorder audio performance is audible crackle just after tape replay commences. This sounds exactly like the crackle heard when a television is turned on. While I do not feel the problem is major, some improved RF suppression in the electronic circuitry may be well worth design investment. This unwanted noise can be seen in the recorder replay frequency response trace, Figure 5 as a spike at low frequencies. This gives the false impression that low frequency performance is uncontrolled, whereas in fact the noise is quite broadband and causes a pulse that the all-pass level recorder cannot remove. Figure 5 is the record/play response at 0 dB — quite stunning at 20 Hz to 20 kHz +/- 1 dB! The BEST of cassette recorders can nearly get there using Dolby C and metal tape, while most would run out of steam at about 10 kHz for the same roll-off.

Signal-to-noise ratio (Figure 6) is also quite outstanding at

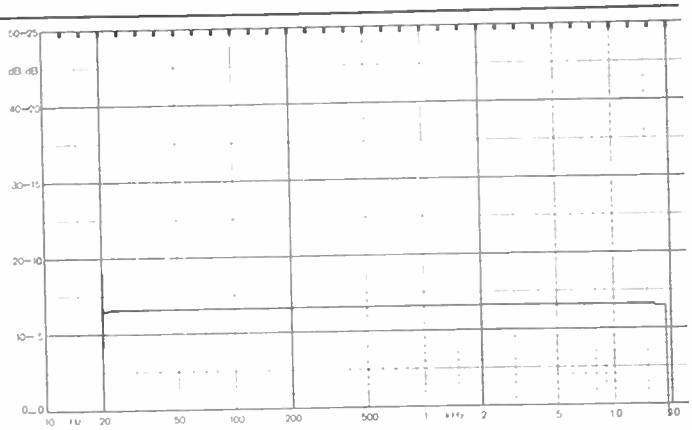


Figure 4. Audio record monitor frequency response.

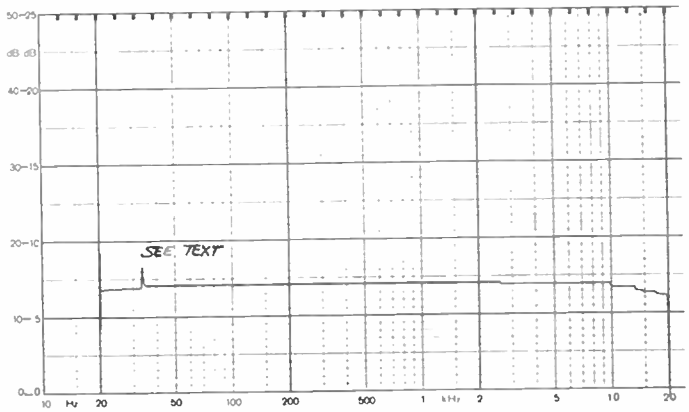


Figure 5. Hi-fi audio replay frequency response. Quite a stunning result, but see the text about that low frequency 'glitch'.

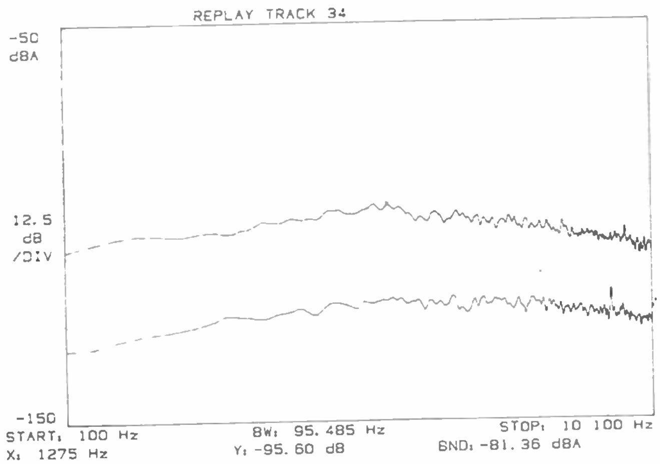


Figure 6. Signal-to-noise ratio, hi-fi audio — outstanding at around 96 dB at 1 kHz.

over 81 dB(A), and 96 dB at 1 kHz. This also is about 5 dB better than the top cassette players, although still 20 dB behind the CD players. Nonetheless, it is very difficult to make genuine use of a dynamic range of even 80 dB very often. The record monitor signal-to-noise was only of the same order, which suggests the limit may be the circuitry and not the tape.

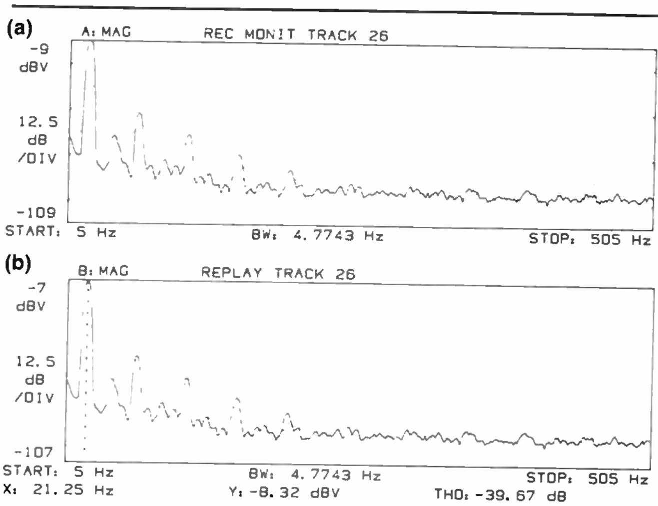


Figure 7 (a), (b). Replay distortion of the electronics.

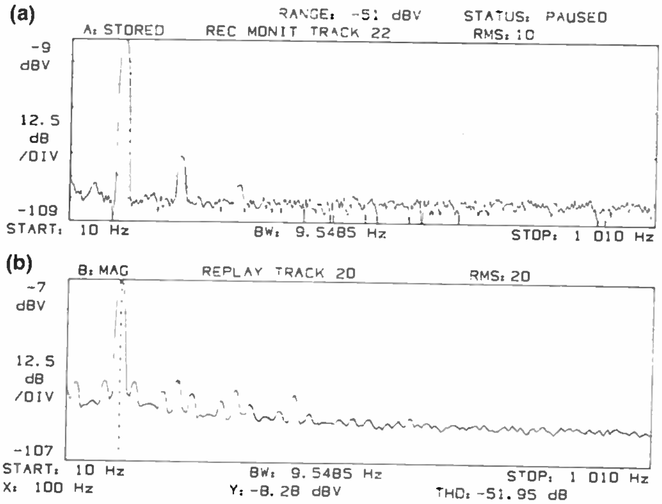


Figure 8 (a), (b). Distortion at 100 Hz for the electronics (top) and tape replay (bottom).

The second performance anomaly is far more alarming and one for which we have no real explanation at present. We found very serious broadband distortion to be caused when higher frequency tones were recorded and replayed. Surprisingly, this was not audible during subjective listening tests of music, and this suggests either the sustained high level pure tones were able to send the amplifiers into oscillation or that the record level head-room is not linear across the frequency bandwidth and we were causing overload. In either case, the recorder is not functioning correctly.

We were unable to investigate this apparent problem in any further depth in the time we had, or to have discussed it with the recorder importers, prior to writing this article. However, we hope to do so and to comment further on it later. In the meantime, there must exist some doubt about the high frequency headroom of the recorder. The problems apparent at higher frequencies became obvious during our distortion testing. The results of these tests are given in Table 1, although we have also included the analyser traces here since the broadband noise problem does become apparent. You should note that all traces have a linear frequency scale.

Figures 7A and 7B show the electronics and replay distortion at 21.5 Hz and 0 dB which can be seen is entirely due to circuit limitation. The source material is the Denon CD

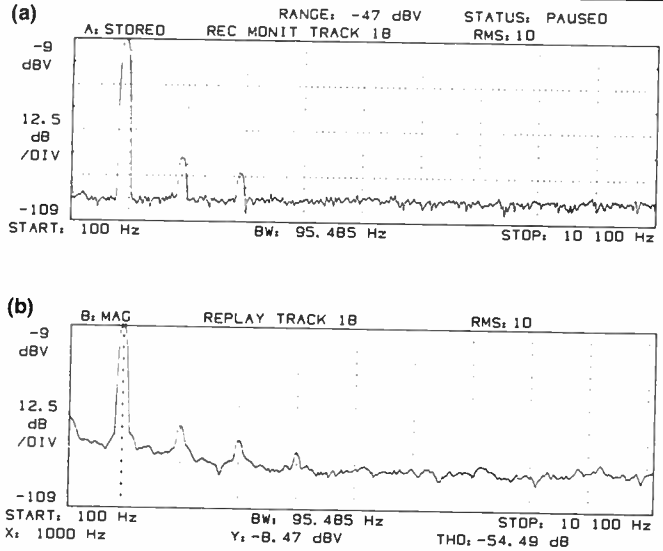


Figure 9 (a), (b). Distortion at 1kHz for the electronics (a) and tape replay (b).

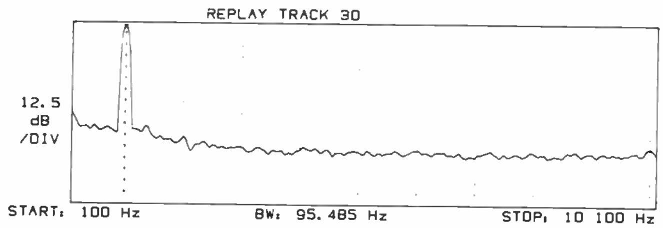


Figure 10. Distortion at -24 dB source level is masked by the noise.

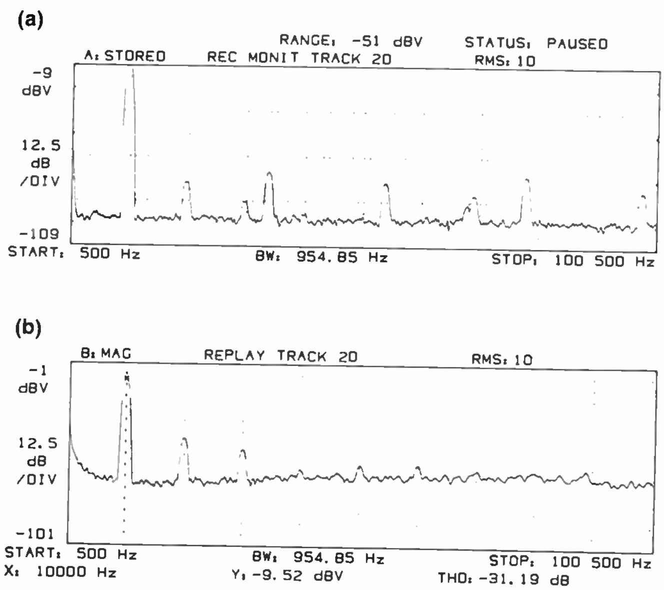


Figure 11 (a), (b). Showing the ultra high frequency difference products.

TABLE 1: Performance results summary

	Electronics	Replay
Frequency Response, OdB:	20 Hz-20kHz, +/-01 dB	20 Hz-20 kHz +/-1 dB
Signal to Noise:	n/a	81 dB(A)
Total Harmonic Distortion:		
21.5Hz, OdB	-39.7 dB	-39.7 db
100 Hz, OdB	-64.6 dB	-52.0 db
1 kHz, OdB	-65.0 dB	-54.5 dB
10 kHz, OdB	-64.0 dB	-31.2 dB
20 kHz, OdB	-65.2 dB	-27.8 dB

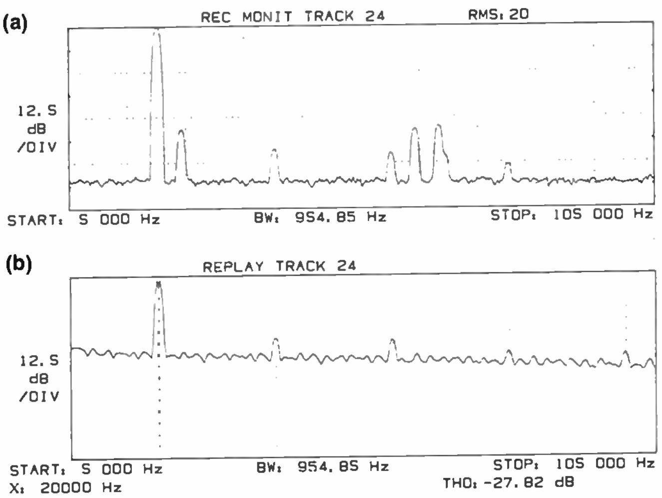


Figure 12 (a), (b). Distortion increases at the top end of the audio band.

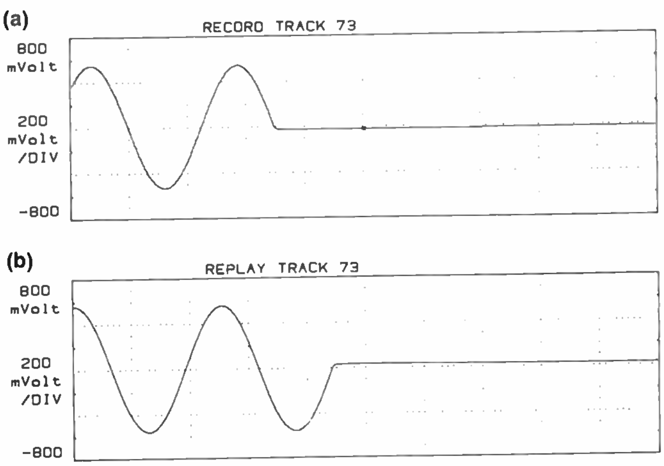


Figure 13 (a), (b). The 1 kHz toneburst test proved very impressive. Note the phase shift.

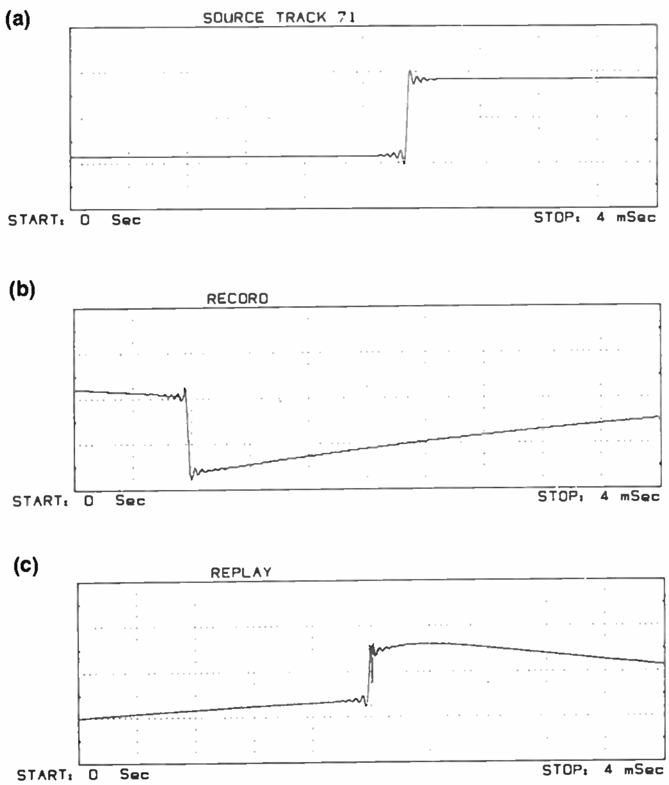


Figure 14 (a), (b), (c). Source, record monitor and tape replay results with a 100 Hz square wave.

test disc 38C39-7147 through a Nakamichi OMS-5 player. Distortion at -39.7 dB is very impressive. Figures 8A and 8B for 100 Hz show distortion on tape replay to be well above the electronics, both in harmonic terms and in broadband noise. At 1 kHz (Figures 9A and 9B) the same applies, although if anything performance is improved here. At −24 dB source level (Figure 10) noise has become so dominant that distortion on replay is not seen at all.

At 10 kHz a different picture is starting to emerge. The source monitor record (Figure 11A) is showing the ultra high frequency difference frequency products found in testing of the OMS-7 CD player, as well as harmonic distortion due to the JVC recorder electronics. On tape replay, perhaps as expected, all of the difference frequencies are gone (this must set a few minds thinking) while distortion has increased substantially, together with considerably more broadband noise (squelch, as my ears tell me). Table 1 will show just how much the distortion has increased. Distortion and noise at 20 kHz continued to increase as Figures 12A and 12B show.

Performance with a 1 kHz toneburst is very impressive (Figures 13A and 13B) and for the electronics buffs you will be interested to see that replay response is phase-shifted.

More challenging is a 100 Hz square wave for which the electronics did not appear nearly as impressive as we would have expected. Figures 14A, 14B and 14C give the source, record monitor and replay analysis for a 100 Hz square wave at -10 dB. With some amplitude error, the source is CD accuracy, the record monitor disappointingly distorted and the ▶

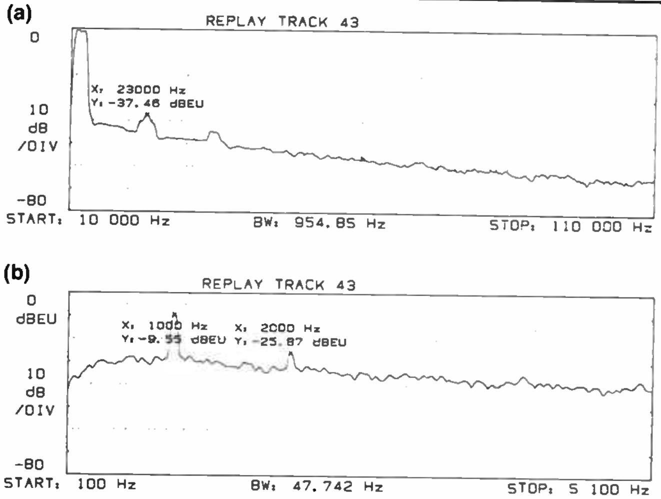


Figure 15 (a), (b). Intermodulation distortion products with 11 kHz and 12 kHz mixed 1:1. A wide bandwidth trace is shown above, narrow bandwidth below.

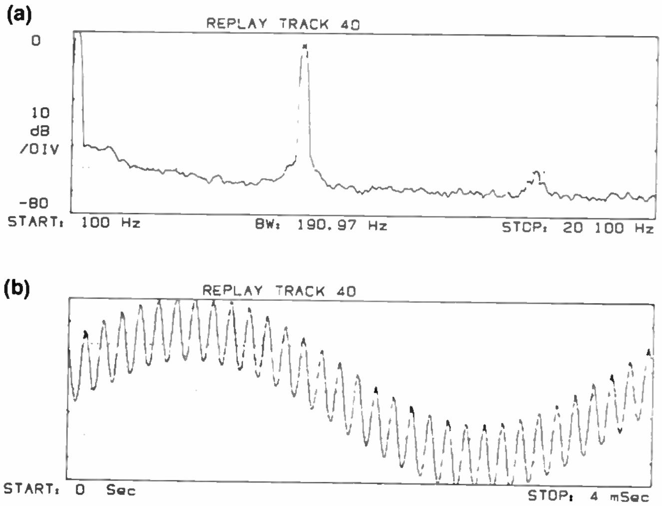


Figure 16 (a), (b). Intermodulation products (a) from 250 Hz mixed with 8020 Hz, 4:1 amplitude ratio. Input signal shown in (b).

tape replay only marginally more so. For these traces you should ingnore phase since there is no phase relationship between each trace.

Intermodulation products are given in Figures 15A and 15B for 11 kHz + 12 kHz at 1:1 amplitude ratio. We have used two analyser bandwidths to show that difference frequency products exist at integrals of 1 kHz (i.e. 12 kHz minus 11 kHz) as well as summation frequencies of 23 kHz +/- 1 kHz, 34 kHz and 35 kHz, and thereafter, noise. Our last distortion traces, Figures 16A and 16B, show intermodulation products with 250 Hz and 8020 Hz at an amplitude ratio of 4:1. Similar product frequencies can be seen in the traces although in this case we have shown the waveform as well.

Our final performance test was impulse response (Figure 17) which shows recorder replay performance with a logarithmic frequency trace. Each trace indicates two millisecond time advance from the rear to the front of the diagram. The major elements seen are transient response deficiencies at 9 kHz and 575 Hz, whilst elsewhere the response is remarkably smooth.

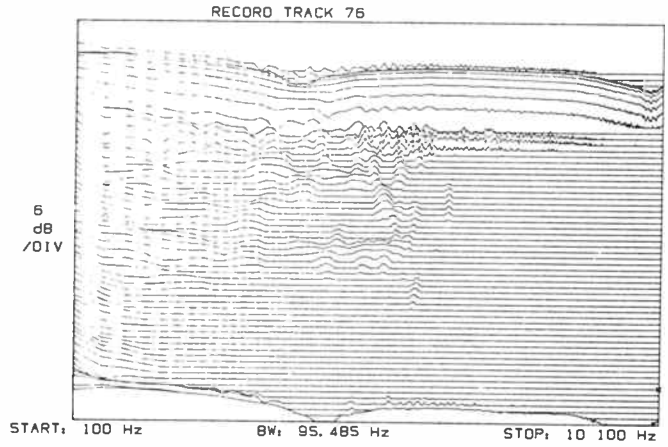


Figure 17. Hi-fi audio response with an impulse source. The frequency scale here is logarithmic. This shows up transient response deficiencies at 575 Hz and 9 kHz.

An Overview

Subjectively, I did find the audio quality of this hi-fi VHS recorder to be very good. Without any apparent extra trills (i.e: Dolby etc) the machine has achieved performance quality potentially exceeding the best of current generation cassette tape recorders.

Given good loudspeakers and a high powered amp, the JVC is able to mix it for sound quality with the CD players. Whilst the CD does have the odd 20 dB up its sleeve in laboratory performance, it is very difficult to make use of that performance without risk of hearing damage, neighbourhood complaint or inhumane treatment to loudspeakers. I found that for most recordings off a CD source there was little deterioration in overall subjective response, no background noise problem, good dynamic range, and everything else that the specifications suggest. The nagging doubt concerning audio performance is in respect of higher frequency headroom for which I will reserve my opinion. I did not feel that audio quality suffered for most source material, but driven hard the recorder must lose quality.

Functionally, I feel it is a dog compared with most cassette recorders. Remember though, that these types of problems are only transient ones and once you have become used to the player this will probably not irk you greatly. Applications also for immediate audio use are restricted to your own recordings, since the machine is a video recorder and not an audio one. This has spin-offs since the cost per playing hour of video tapes is very much less than standard cassettes, but unless your friends have similar equipment you can forget taking your favourite tape to a party. Also, whilst three to four hours of high fidelity playing does sound initially attractive I would have some doubts that this is really all that useful now that FM radio is becoming common throughout much of Australia.

If there was a portable one though, with a good video camera or microphone and some improvement to high frequency headroom — now there is something to work on!

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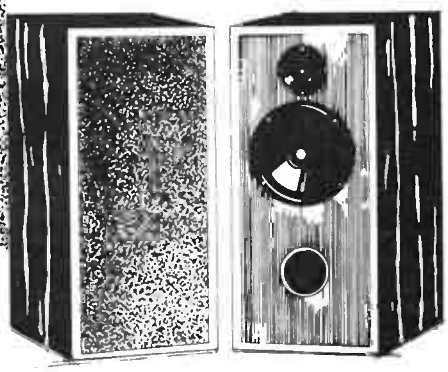

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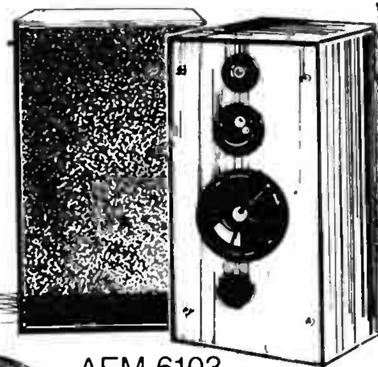

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These two hot selling high performance kit speakers are now being demonstrated at the locations mentioned beneath. Hear for yourself how these speakers outperform well known fully imported speakers costing 2-3 times more.

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Scan Audio, who is behind VIFA in Australia, has organized Australia-built x-overs, and professionally manufactured flat-pack cabinets to perform with David Tilbrook's specification. All you need is a simple toolbox, wood glue, soldering iron and some hours of your spare time – and you are the owner of a pair of Digital Monitors worth $1500 or $2500 respectively.

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FOOTSCRAY AUDIO, 142 Hopkins Street, Footscray.
STEVE BENNETT HI-FI, 105 Shannon Avenue, Geelong West.
BELAND ELECTRONICS, 294 Charman Rd., Cheltenham.
TAS: WILLS HI-FI, 11 The Quadrant, Launceston.
QUANTUM SOUND CENTRE, 194 Liverpool Street, Hobart.
HI-FI HOUSE, 32 Rooke St., Devonport.
NSW: HEMPEL SOUND, 455 Penshurst Street, Roseville East.
HI-FI HOUSE, Cnr. Crown & Corrimal Streets, Wollongong.
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JAYCAR, 188 Pacific Highway, Gore Hill.
JAYCAR, 117 York Street, Sydney.
JAYCAR, 121 Forest Road, Hurstville.
NEWCASTLE HI-FI, 642 Hunter Street, Newcastle West.
BYRON BAY SOUND CENTRE, 58 Johnson St., Byron Bay.
QLD: HANDO'S HI-FI, 70 High Street, Toowong.
QUEENSLAND STEREO VISUAL, 28 Taigum Shop Centre, Taigum.
JAYCAR, 144 Logan Road, Buranda.
WA: ALBERTS HI-FI, 177 High Street, Fremantle.
ALBERTS HI-FI, 396 Murray Street, Perth.
ALBERTS HI-FI, 642 Albany Highway, Victoria Park.
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EAGLE ELECTRONICS, 55 Unley Road, Unley.
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All Electronic Components in Melbourne stock the Fairchild-made FT3055 in the TO-220 flatpack. These sport a Vcb of 100 volts and maximum collector current of 10 amps. And they cost just 70 cents. The advantage of the flatpack is that it requires just one mounting hole and the device may be pc board mounted.

Available from **All Electronic Components, 118-122 Lonsdale St, Melbourne 3000 Vic. (03) 662 3606.**

Fibre optics for the experimenter

If you thought fibre optics was for the well-heeled or found only in engineering labs with big budgets, then take a look in the 1986 Tandy catalogue or the opto-electronics rack in your nearest Tandy store.

Browsing around a local Tandy store recently, we stumbled across their "Optical fibre, Tx/Rx Pair". This comprises a three metre length of fibre optic cable and an emitter/detector set, complete with Applications notes. Catalogue numbers are, respectively, 276-228 and 276-225. They cost $9.95 each.

Some interesting and innovative projects could come out of that lot.

Jaycar gets toll-free 'Telemail' order line

Sydney-based kit and component supplier, Jaycar, has installed a 'Telemail' 008 toll-free order line for out-of-town customers.

If you live outside Sydney or Brisbane, and regularly order your requirements by mail, now you can take advantage of the speed and reliability of using the blower for the cost of a local call only.

You can "pledge your plastic" for your orders, and Jaycar accepts American Express, Bankcard, Mastercard and Visa. The magic number to ring, is **008 022 888.**

Dick Smith's April catalogue . . .

Will appear in the month of May, lashed together with your copy of *Australian Electronics Monthly!* Sources within the organisation say the catalogue has been held over one month so they can shoehorn all their ". . . exciting new product lines into the '86 catalogue, including a great range of new 'high tech' kits for the hobbyist."

Let us all hope it's worth the wait. Just as a week is a long time in politics, a month is a long time in publishing!

PROJECT BUYERS GUIDE

Your 'Hash Harrier' feature project, the AEM5505, will get rid of, or at least reduce, mains-borne problems like 'random reset' in personal computers, clicks and buzzes in the hi-fi and cracks and crashes in radio receivers.

The FE-1570-7501 toroids used in our prototype are made by the US company Arnold, kindly supplied by Magnetic Core & Alloy Distributors Pty Ltd, of Templestowe, Victoria. They are available retail through all Electronic Components, 118-122 Lonsdale St, Melbourne 3000 Vic. (03) 662 3606. The T-157-26 toroid made by Amidon of the US is an equivalent type, but not currently available. The T-184-26 is a stock type and may be substituted. Amidon toroids are imported and distributed by R.J. & U.S. Imports of Sydney and available retail through Geoff Wood Electronics of Rozelle in Sydney, Electronic Components of Fyshwick in Canberra, Truscott Electronics of Croydon in Melbourne and Willis Trading Company in Perth. The 9 mm × 194 mm ferrite aerial rod is commonly available. DSE stock it as cat. no. L-1401.

The Varistors specified (V250LA15A or V250LA20A) are made by GEC and are also available through All Electronic Components. Dick Smith Electronics stocks them too, cat. no. R-1802. G.S.I. "Transorb" devices may be used in this application also. They are distributed by Promark in Sydney and Melbourne.

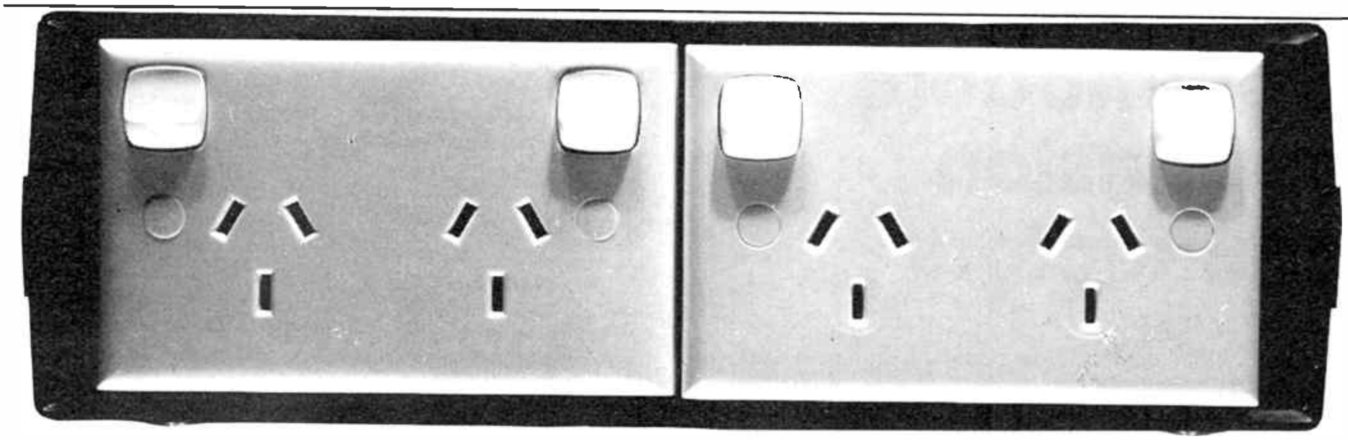
Capacitors specified for this project are 630 V polycarbonate types. Such capacitors are made by Phillips, Siemens, Thomson-CSF and Roederstein. They are distributed by, repectively, Philips, Siemens, Promark and Mayer Krieg. You may find suitable types stocked by All Electronic Components in Melbourne, Geoff Wood Electronics and Sheridan Electronics in Sydney.

The 260 × 190 × 80 mm all-plastic instrument case specified for the Harsh Harrier comes from Jaycar, cat. no. HB-5910. The SAA-approved fuseholder is stocked by Jaycar, cat. no. SZ-2025.

Constructors of the AEM2600 Peak RF Power Meter/Monitor should find little difficulty in obtaining parts as all commonly-available devices and components have been specified. The 10-LED bargraph display used in our prototype came from Jaycar, cat. no. ZD-1700.

Printed circuit boards for our projects will, as usual, be available directly from our offices, or over the counter from All Electronic Components in Melbourne, Eagle Electronics and Protronics in Adelaide and Geoff Wood Electronics in Sydney.

The Star Project, Dick Smith's nine element 144 MHz Yagi, will be available through their stores and dealers, cat. no. K6297. It costs $89.



The 'Hash Harrier' — a truly effective mains filter

Warwick Holmes and Jonathon Scott

Does your computer suffer from 'random reset', your radio radiate rude raspberrys, your hi-fi catch you with clicks and crackles? Mainsborne 'spikes' and 'hash' are the likely culprits. This project can provide a most effective cure in the majority of cases and at an economical price.

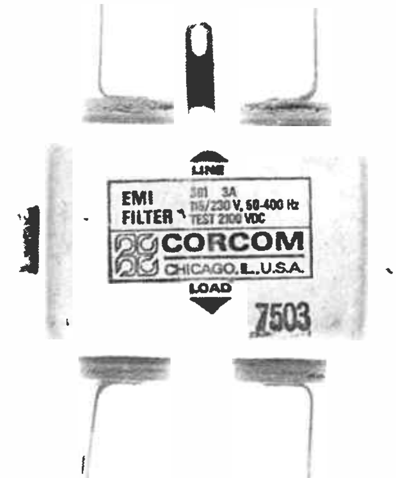
THERE ARE MANY "line filters" of one sort or another widely available from electronics retailers. The fact that they are not all equally worth what you pay for them should come as no surprise. This article discusses what they are intended to achieve, what is inside them, and some of the problems in devising an effective, economical unit for home construction. The design presented may be employed with a personal computer (and its peripherals), hi-fi or other audio equipment, and sensitive radio receivers. But first, let us look at what is 'inside' a line filter and the job they're intended to do.

A small 'tin can' line filter can be obtained for a few dollars. These things have a few capacitors and coils inside a case a bit larger than a matchbox with 'input and output' terminal lugs, or maybe some wires protruding. A box with a few power points, a mains flex and maybe a fuse or circuit breaker, sells for anything from under a hundred dollars to several hundred dollars. One popular brand contains, in addition to the hardware visible from the outside, two of the abovementioned small metal cans, a voltage 'spike' suppression devices and sells for well over $200. More elaborate ones contain a transformer and sell for many hundreds or a thousand or two dollars.

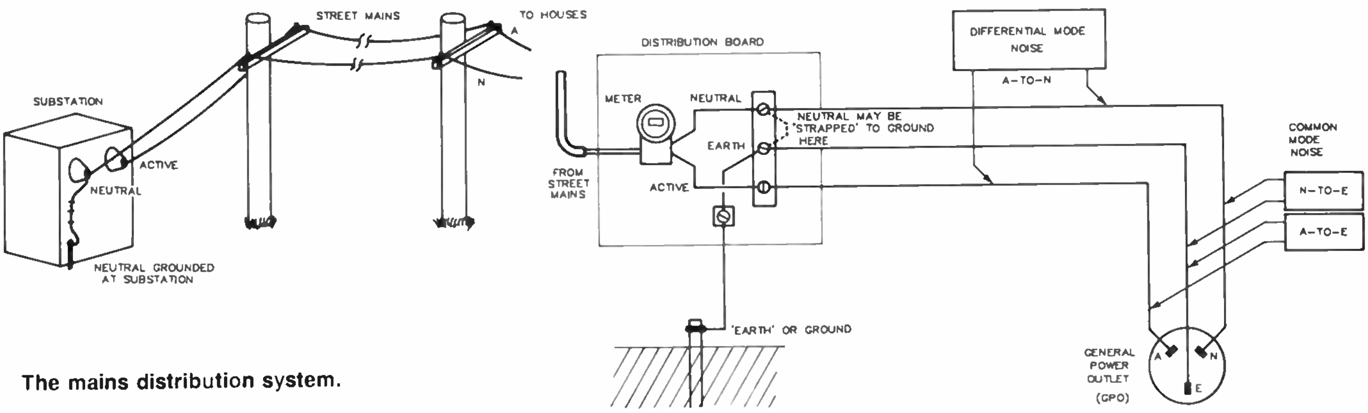
All such units share a common aim. They seek to prevent 'spikes', 'hash' and other electrical nasties from reaching your delicate, sensitive equipment. Unfortunately, they do not all do an equally efficient job on the different types of interference; neither, as we said above, is it a clear case of "you get what you pay for".

Indeed, as one might expect, there are degrees of protection available. Some filters will stop bigger nasties from passing than others. Also, some equipment (in particular, some computers) are more susceptible than others. We have been offered thousand dollar filters that two men lift, and ten dollar filters you can pocket. We have seen computers hiccough when their own printers were turned off, and seen standard HP computers operate faultlessly through electrical storms that anihillated half the gear in the same laboratory — from portable telephones to mainframes — *permanently*.

There is a very considerable problem in deciding just how much protection you are best to spend money on. For the home computer user, nothing at all often seems most economical. It always does, *until you lose that vital file*. When did you last backup those vital disks? How much could you lose in one go, if the directory is damaged on a disk? We're not insurance salesman, but line filters are insurance for your data.



A typical small 'metal can' type filter.



The mains distribution system.

In the audio field, a great series of *crackles* on that special tape can be more than an annoyance. Crackles, buzzes and intermittent hash can effectively ruin any attempt to copy weak shortwave signals.

With a computer, generally you know how sensitive it is. Mostly, a 'crash' due to a line 'glitch' only loses you what is in the memory — from a few minutes to a few hours work. If this happens as often as once a week, you have a very sensitive computer or you live in an 'electrically bad' neighbourhood and you are likely to need a good line filter, badly. If it happens once a year, you may choose to put up with the occasional loss of data and accept the (very small) risk that the whole disk may be lost.

Hence, the factors you need to weighup are: 1) How sensitive your equipment is; 2) How nasty is the environment in which it must work; 3) How important your volatile and online (computer) data, or audio tapes are. The first and second are usually summed by experience in the form of how much trouble you have had, if you have been operating without protection for a while. The last reflects itself in just how much you will pay to offset the risk of a freak incident, such as a thunderstorm, affecting your equipment.

Throughout the rest of this article we'll refer mainly to problems with a home or personal computer as an example, principally because that's what led to us investigating and designing this project in the first place. However, similar principles apply to mains filters used with any other electronic equipment plagued with, or sensitive to, mains-borne interference.

Some electrical background

Main's borne signals that can cause havoc have two salient properties. The first is their duration. Short-term, non-repetitive signals are usually called 'spikes', fast transients, or sometimes 'glitches'. Short-term repetitive signals are often referred to as 'hash'. The last is often associated with motors where 'hash' is commutation noise. Slow variations may be called 'surges' or 'brownouts', depending on whether they are increases or decreases. (A brownout is not quite a blackout, you see). They may just be slow, transient undervoltages or overvoltages.

The second property of a spurious signal is more subtle. It may be either a **common-mode** or a **differential-mode** signal.

The mains power is delivered between 'active' and 'neutral', but there is this thing called 'earth' as well. Ideally, neutral is the same as earth, and earth is just a safety measure. Unfortunately, this is rarely the case. The earth connection is usually made to neutral at the local substation, and in some installations at the house fuse box as well. This means that it goes via a lot of soil, rock, wire and whatever else. There is inductance and resistance there, and you will generally measure voltage as well, because of the devious paths that the electrons take through the world while Mrs Smith's toaster is fusing itself, your stove is chewing 25 amps or old Mr Winthrop's new electric Flymo lawnmower is hovercrafting into the swimming pool.

The long and the short of it is that your equipment has three connections — what it sees as earth, active and neutral. There is the added complication that you do not actually know for sure which is active and which is neutral, especially if grandad wired the extension or you have an old double adapter that reverses the connections.

A **differential-mode** signal is a signal present between **active and neutral.** The mains voltage you actually want to use is one of these. (This fact will be important later.) A **common-mode** signal is one which **appears between both active and neutral together, and earth.**

Some examples will make this distinction clear. When there is an atmospheric discharge it likely reaches both active and neutral together, because they travel together. Hitting earth, it will likely do so without hitting active and neutral since earth travels apart from them. So a lightning-type disturbance is typically common-mode as it affects active and neutral equally, but does not affect the earth line to a similar degree. (It is also likely to be pretty fast in its appearance, but it may also have a long duration, thus producing a spurious signal with a very wide frequency content.)

When the compressor in a refrigerator shuts off, the magnetic energy stored in the motor coils collapses, generating a substantial voltage. This is why switches in inductive circuits arc, and what capacitors across switch and relay contacts are all about. Recall that the arcing is what wears out car points, despite their protection capacitor. The energy in the 'fridge motor tries to keep the current flowing against the switch's abrupt action. The current was in the process of flowing between active and neutral to push the compressor, and so it is between the active and neutral lines that the disturbance is induced — a differential-mode signal. (It is also ▶

LEVEL

We expect that constructors of an

INTERMEDIATE

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

a fast transient because the energy from the collapsing magnetic field in the motor coils is soon dissipated.)

You may think that because your computer (or other equipment) derives its energy from current flow between the active and neutral lines, that it should ignore the earth. Regrettably, stray capacitance between the earth and the other lines may induce currents in the earth line which will affect the earth voltage level. (Not applicable to computers far from planet Earth.)

What should a line filter do?

An "ideal" line filter will stop all differential-mode signal frequencies above 50 Hz, *all* common-mode signals irrespective of frequency, and will 'clip' (truncate) all voltage transients to the rated peak level of the mains (340 V for nominal 240 Vac mains). There is, of course, no such thing as an "ideal" line filter. Some do not even make any attempt at clipping transients at all. It is how close a filter gets to the ideal aims that distinguishes it from its peers.

A line filter cannot handle brownouts or blackouts. Some more expensive ones can deal with minor brownouts such as might be the case far from a substation, but these often go by a fancier name than line filter (such as "line conditioner"). They achieve their brownout compensation by switching transformer taps or some similar, but more clever, electronic lurk.

Full blackout-immune power is the domain of continuous or "uninterruptible" power supplies. These operate by using the incoming power to charge batteries, and then building the mains voltage back up from the batteries when mains power is lost. However, better line filters do handle surges. This distinction is simply a product of the fact that it is easier to build a gadget that can shed excess energy than it is to build one that can produce energy when it is lacking!

TO FILTER A LINE

1) The simplest circuit

The most basic way of going about it is well known. In fact, you may find a circuit printed on the outside of some of the little metal cans filters. A typical circuit is reproduced in Figure 1.

In each arm, one for the active and one for the neutral, there is a three-element filter network. This is called a 'pi' network, for the resemblance of the topology to the Greek letter. A pi-network is used rather than a T-network (similar naming strategy — T has two bits horizontal and one vertical) because capacitors are cheaper than inductors. The T-network would require two expensive bits and one cheap one. There are other reasons why pi or T networks might be better but the cost angle probably dominates, we feel.

Some can filters contain two pi networks in each arm, which combine to give a five-element arrangement.

Filters such as shown in Figure 1 have a frequency response which rolls off above a chosen frequency. An ideal line filter would roll off above 50 Hz. For the response to start falling just above 50 Hz, the inductors and the capacitors would need to be fairly large values. This is where the trouble begins. Capacitors of mains rating and the necessary value get physically very big and expensive. Inductors of any value above a few tens of microhenries need to have a core of some sort, which means iron or a derivative, such as ferrite. A filter such as that in Figure 1, designed to roll off in the low kilohertz region, would have to be carried into the room by two beefy men and would not be cheap. Each inductor would require kilograms of metal in the core in order not to saturate!

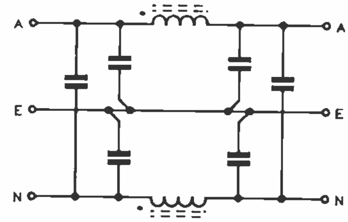


Figure 1: Circuit of a typical small 'metal can' type line filter. Notice that the two inductances forming the centre elements of each 'pi-network' are wound on the same former.

In order that they be small and cheap, a roll off starting in the tens of kilohertz is accepted and a "clever" trick is used. The two inductors in the twin-pi filter are wound on the same core. They are wound and phased in such a way that the magnetic field set up due to the neutral line current is in opposition to that set up by the active line current, which is of course the same magnitude. Thus, the field each winding generates cancels that of the other and even a small core will not saturate. The dots on the windings in Figure 1 signify this phasing arrangement. A toroid must be used, in order that the mutual coupling be close to one, while the windings are kept physically separate.

This idea is great in that there is then a decent inductance available in a small space. However, recall that we noted that the mains itself is a differential-mode signal. This winding arrangement neatly cancels the magnetic fields resulting from the mains signal, *and also for all other differential-mode signals*. Some of the nasties are differential, so they get straight through. Oops. The inductances cancel each other out wonderfully for differential-mode signals, preventing the mains saturating the core, no matter how much current your computer draws or how many turns are wound on the core. Trouble is, the same cancellation occurs for the unwanted signals too. *This filter configuration, then, is next to flatly useless for differential-mode nasties*, (up to where the load causes serious phase changes), although it has the acceptable value, size and cost of components!

Before elaborating on filter design, it will be best to examine the problem of filter circuits some more.

2) The simplest circuit in place

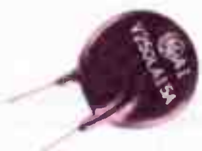
The little metal can with the above circuit does not exist alone in the world. In fact, if it is in a line filter box, is has a mains cord from its input, the power source, and another to the load — your computer. (Fact: in a one metre piece of mains flex, the A and N wires each represent an inductance of about five microhenries. Not only that, but as they travel together in the sheath, they look like a transformer, just like the toroidal one in the filter, except with bad mutual coupling and no iron core!) Furthermore, the computer presents a load impedance, and the mains a source impedance. These are virtually unpredictable in value in the real world.

The effectiveness of a circuit as a filter depends very much on the load and source impedance that it sees. We will not digress here into what a computer looks like as a load, nor what the power point looks like as a source impedance. (Both vary distinctly with frequency, type of interference, and the load may vary with time within a cycle!) The point to note is that it is not possible to say just how well a filter will filter until you know the load on the end of it. Problems can arise in the common-mode situation if the equipment is well isolated from the earth for dc, but strongly coupled by capacitance. In this case, as the experienced electronics readers will note, there is not necessarily any resistive impedance seen at all from either active or neutral to earth. Thus the common-mode advantage of such a circuit can be disrupted, or even reversed, by the reactive components ringing with the spike energy!

Inductors sufficient for good filtering are either very large, heavy and expensive, or they come in counter-wound pairs which cancel out spurious differential-mode signals and are marginally adequate in value. Capacitors of reasonable cost and availability are also small in value. Actual effectiveness will depend upon the computer (load) and the mains supply (source impedance), both of which are unpredictable.

3) Surge and spike clipping

Spurious signals of excessive magnitude need to be rejected. This function is not normally incorporated into the tin can filters, nor a lot of the fully-housed models, either. Fortunately, there is a component manufactured especially for the job. It is called a *Varistor*, and it looks like a beefy, bidirectional zener diode, electrically speaking. Normally looking like an open circuit, it draws current rapidly if the applied voltage exceeds its rating, preventing a spike rising further in voltage. These beasties, usually GEC-made, are not hard to find on retailers' shelves. The ones we got looked like red disk capacitors, and cost a few dollars each.



A commonly available Varistor — the GEC V250LA15A.

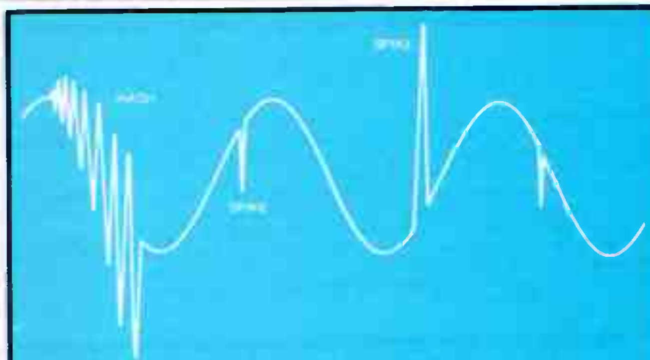
Varistors will get rid of a very large amount of energy for a brief period. They are rated at amps or tens of amps, depending on the one you buy, but of course cannot get rid of many watts. This is acceptable, as surges are usually quite brief. In addition, they do not normally get hot, as they do not conduct much in the absence of spikes.

Varistors will respond quickly, but only clip signals which exceed the normal peak line voltage value, normally seen on the line. Thus, if a spike occurs during the peak of the mains cycle, it will get clipped off, but if it comes near a zero crossing, the spike can be up to the full value of the mains (340 volts for a nominal 250 Vac supply) and not upset the Varistor at all. (This fact will be used in our design to advantage!)

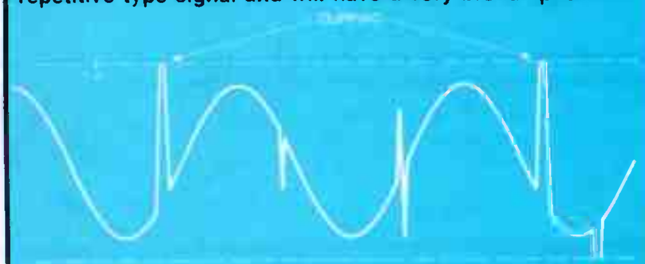
4) Isolation transformer circuits

A transformer very effectively removes common-mode signals, provided its windings are wound in such a way as to eliminate any significant capacitance that might otherwise conduct signals across the magnetic link. In addition, it naturally incorporates large coils and a core which is not saturating at its rated power handling level. Further, the core is usually made up of plates, or 'laminations', to avoid eddy curent losses. The laminations are of a thickness suitable for eliminating 50 Hz loss, and generally no more, for cost reasons. The same laminations become lossy at higher frequencies. This is beneficial if you are actually trying to dissipate higher frequency signals, as in a line filter.

Carefully designed isolating transformers are expensive. We suspect strongly that a major difference between susceptible computers and immune ones is the quality of the transformer in the power supply. It is sensible, of course, to make this (necessary) component the isolating transformer. The transformers inside computers will eliminate much of the electrical interference that falls in the kilohertz to tens of kilohertz region. They fall down on the job at a frequency which is determined by the interwinding capacitance; above the critical frequency the signals, particularly common-mode signals, 'leap' across the transformer primary and secondary windings. The simple line filters are intended to work with such transformers. They tackle, among other things, the higher frequency, common-mode signals.



Typical appearance of mains-borne spurious signals. 'Spikes' are generally non-repetitive or one-off events, but can sometimes appear at regular intervals. Spikes are generally high speed and of short duration, and hence have a considerable high frequency contents. 'Hash' is a repetitive type signal and will have a very broad spectrum.



The peak level of a spike can be 'clipped' using a Varistor, which conducts heavily when the voltage across it exceeds its rating.

The unwanted 'nasties' are attenuated by filtering, reducing their amplitude and frequency content.

Regrettably, where the computer itself contains a very ineffetive isolation arrangement, the line filter may need to do more of the protecting. In fact, if you encounter an extreme case of susceptibility to line interference where even a good line filter (or worse, ours) cannot deal with it, you may benefit from adding a simple isolating (240/240 V transformer; this will join with the filter to produce a very good overall filtering function indeed. We have a computer whose printer can glitch it about every second time it is switched off. Our line filter can improve this situation to about once in eight, but it cannot eliminate the problem because of the ferocity of the printer interference.

5) A practical and sneaky circuit . . .

This brings us back to the problem of designing an effective line filter. Clearly, it needs to use reasonable components. Very big inductors and capacitors are out. It must provide the best filtering function in common-mode that is possible with what components are reasonably available. It should do something to attenuate the higher frequency differential-mode signals, rather than passing them straight through with the mains power. It needs to provide spike clipping, as we ▶

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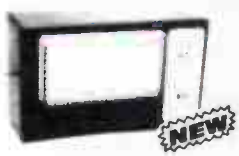

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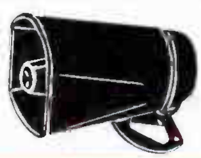

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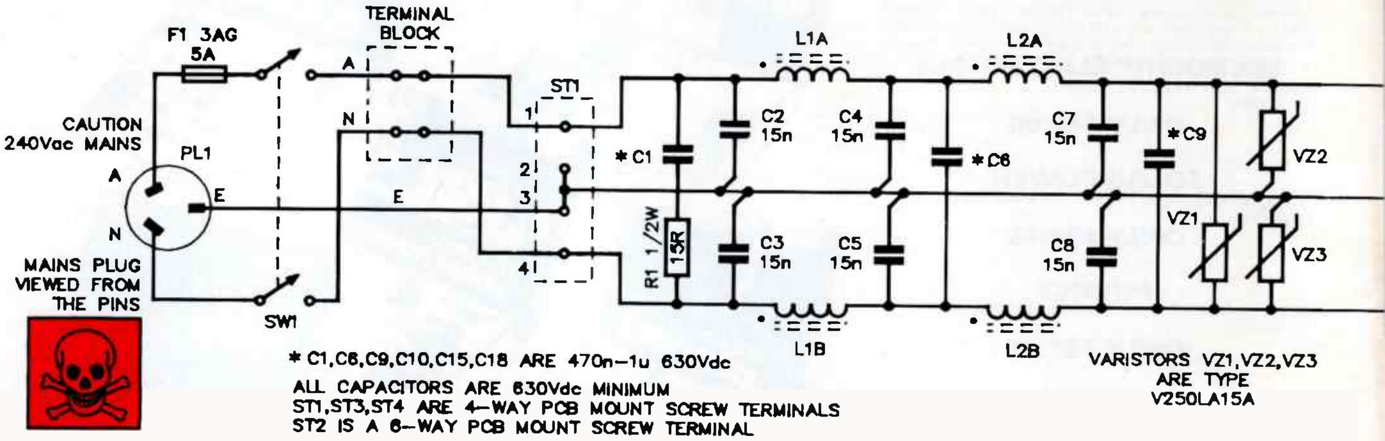
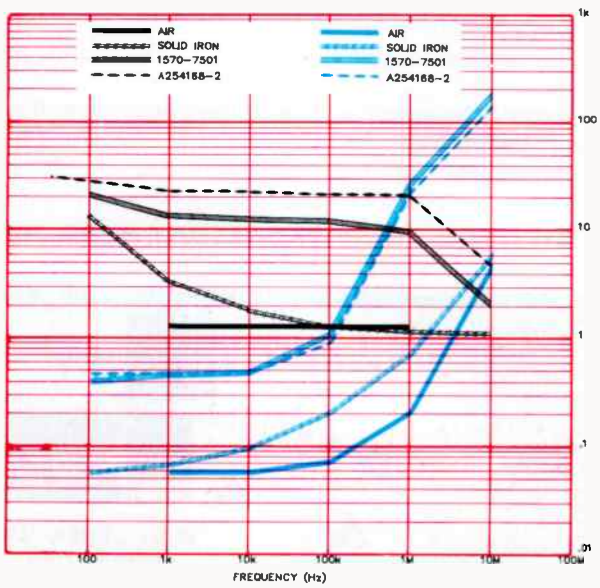


have noted that this is not so difficult. An isolating transformer is only necessary where the problem dictates its use. It's a waste if your computer has a good one inside already. Instead of this, it should be designed to work well with an isolating transformer which can be added, if needed, later.

The circuit employed in our project pretty well meets all these requirements.

A word should be said about the coil cores, as these have been carefully selected. The core material does not necessarily have to produce large inductance coils, nor have good high frequency performance. As the frequency gets above the 100 kHz to 1 MHz region, less inductance is required and core loss is actually desirable since we are trying to get rid of signals in that range! The core loss appears as an equivalent resistance in series with the coil. We tried a number of core types for the L1/L2 stage, including iron powder toroids, molybdenum permalloy ('mumetal') toroids and a short length of water pipe! Several toroid cores are recommended. The US-made Arnold types FE1570 7501 (iron powder) and A254168-2 (moly permalloy), kindly supplied by Magnetic Core and Alloy Distributors of Melbourne, have high permeability at low frequencies, giving large inductance, and very high loss indeed at the higher frequencies. A graph of performance of some L1/L2 coils with various core materials is shown here. The moly permalloy core is slightly superior to the iron powder core, but costs considerably more. Amidon toroids, also US-made, from R. J. & U. S. Imports of Sydney, have one type that is closely equivalent to the Arnold FE1570-7501, which is the T-157-26, but it is apparently not a stock item. The T-184-26, a slightly larger unit, may be substituted with similar results.

Measured curves for inductance (black) and loss resistance (blue) versus frequency for a variety of core materials.



The core cross-sectional area should be around 1 sq. cm. The iron pipe core was around 0.7 sq. cm, which accounts for its slightly lower inductance, limited by what we thought a practical length and thickness of pipe might be.

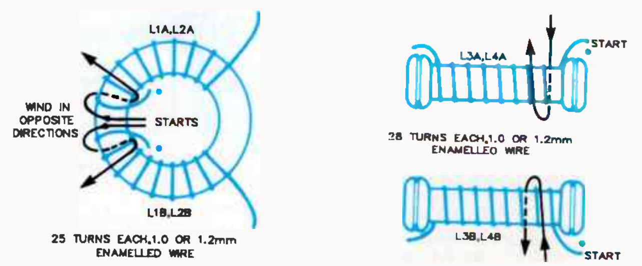
There is a lot of leeway on the inductance values. With the L1/L2 coils wound on FE1570-7501 toroids, we got 80 uH. The L3/L4 coils were wound on short lengths of 9 mm diameter ferrite 'antenna' rod, each being 48 uH with the turns specified.

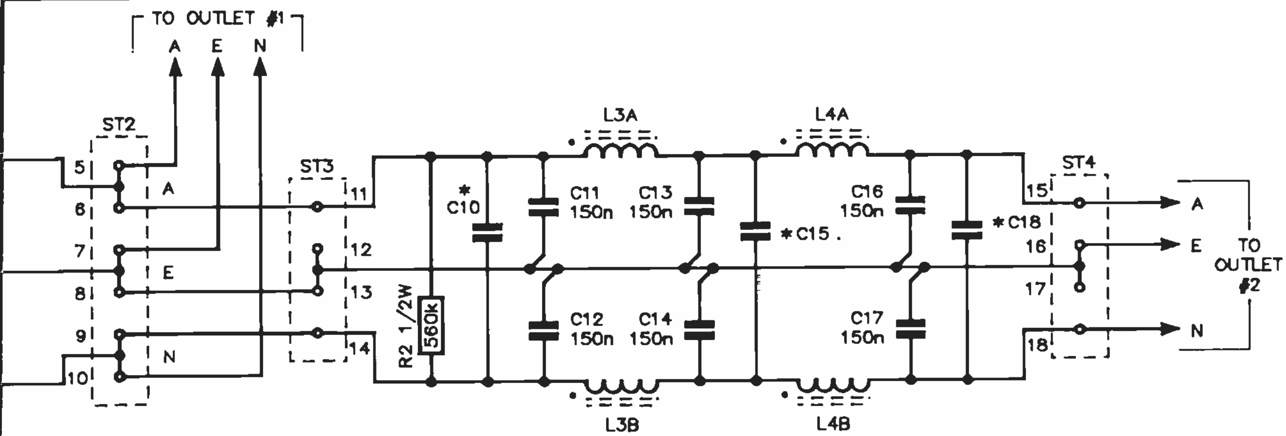
Construction

A single printed circuit board holds all the filter components. The two major filter sections are separated and the board can be cut lengthways between them, if so desired, for mounting the filter in a different housing to the prototype shown here. Actually, the unit in the photographs was built by the AEM lab. lads, the original being housed in a diecast box with two pc boards mounted one above the other. Choice of housing is up to you, unless you purchase the project as a complete kit. The 'electronics' could be wired-in to an appliance if you wish; it's as good at filtering hash getting out of an appliance as it is at stopping hash getting in.

Two dual power outlet sockets are provided. No. 1 provides a point of attachment for less hash-sensitive equipment (printers, plotters, power amps etc), while No. 2 provides an

How the coils are wound.





outlet with two stages of filtering for the more sensitive items (computer, monitor, preamp, tuner etc). Note that, while a pair of dual switched power sockets are used on the outputs, we have included a line switch on the input. The utility of this, if not immediately obvious, will be readily apparent once you've had a unit in use for a while.

For convenience, printed circuit mounting screw terminals are used to make connections to and from the circuitry on the pc board, The terminal block to which the mains input leads are terminated is simply bolted to the pc board in a convenient position as can be seen from the board overlay and internal photograph.

There is some choice of capacitor values, you will note from the parts list. The actual value is not too critical, but stick to the range specified for best results. Polycarbonate capacitors rated at 630 Vdc (250 Vac) are specified. These have a 'self-healing' dielectric in the event of dielectric 'punchthrough' caused by a high voltage transient which other capacitor types cannot safely withstand. Disc ceramic capcitors of 1000 Vdc rating could be employed for the lower values specified (15n and 150n), but are not recommended. Polycarbonate capacitors are available through a number of distributors and several retailers — see "Project Buyers Guide" in the Retail Roundup column in this issue.

Start by winding the coils. The accompanying diagram gives the details. The solenoid coils (L3/L4) are the easiest. The 200 mm length of ferrite rod is parted into four pieces, much as you part-off glass tubing. A shallow mark or nick is made with a small triangular file in the side of the rod where you desire to part it, to a depth of less than 1 mm. The rod is then broken by pressing the rod firmly but gently against the benchtop in the direction that propogates the crack started with the file. The four solenoids each takes 28 turns. Grommets are slipped on the end after completing the windings. These serve to protect the wire and to prevent the rod falling out of the coil as the wire naturally springs away from it a little. Scrape clean and tin the ends of each solenoid coil. There is no need to attempt any insulation of the rod and wire as the whole winding is at the same potential and the ferrite an enamel coating on the wire are sufficently insulating otherwise.

Winding the toroids requires some care. The two windings must be phased correctly, must be separated from each other on the core, *and must have **exactly** the same number of turns.* Failure to ensure this point will ensure the filter does not work! If the number of turns differs, the core may saturate due to the imbalance of magnetic fields from the windings.

The toroids specified have an insulating coating of enamel ▶

CIRCUIT DESCRIPTION

Referring to the circuit diagrams, three significant sections can be seen. These will be called the first filter section, the surge clipper section and the second filter section. Apart from these are sundries like the power switch and indicator, and the fuse holder, etc.

The first filter section consists of a twin-pi LC filter. The toroidal cores carry matched pairs of coils, so phased as to have the magnetic field due to the neutral current cancelling that from the active. This prevents the large and relatively slowly changing current of the normal ac mains saturating the core. Because of this (necessary) effect, the parallel capacitors, which combine with the differentially perceived inductances to filter differential signals, are rather large — 1 uF in our prototype. The capacitors to earth are considerably smaller, since the toroidal inductances are not cancelling with respect to common mode signals, and thus have much greater filtering effect. R1 reduces switch-on surge through C1.

Following the first filter section is the first outlet. Placed directly on the line to the outlet are three Varistors. These clip peaks that exceed some 350 volts (the peak value of the 240 volt mains). The Varistors are placed between the filter sections because, in this location they can clip any spikes generated by appliances connected to the first outlet which might otherwise reach the second outlet, *and* because they see the impedance of the first filter stage in series with any spike source external to the whole line filter, which reduces the peak current that they may have to draw in any fault situation. (Note that major fault situations, such as line surges or lightning strikes will originate from the supply side of the first filter stage.)

There are three Varistors, in order to be able to deal with both common-mode and differential-mode overloads and spikes. The peak voltage between any two connections is limited to the same 350 volt level.

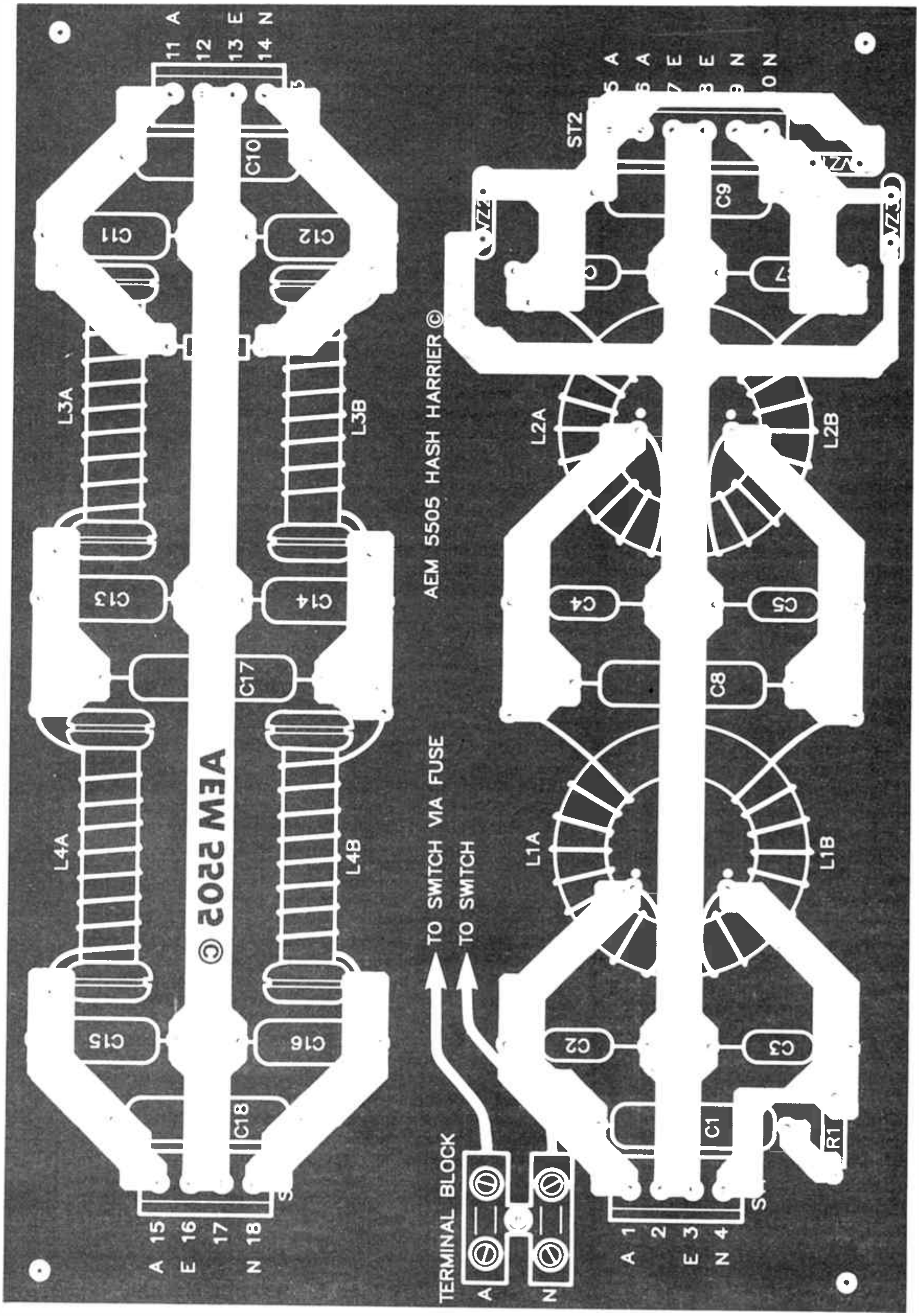
The second filter stage has the same topology as the first, but uses plain solenoids rather than toroids. This strategy confers one advantage, and pays one penalty. The advantage is that the inductance is not compromised for differential signals as is the case with the saturation-cancelling strategy represented by the toroids The penalty is that the supply current will saturate the solenoid cores. This will reduce their effectiveness as the current approaches its peak value. (In many switchmode supplies this only occurs within five volts or so of voltage peak). However, at the peak, the Varistor's protective capability is at maximum, and hence these two mechanisms tend to cover the whole cycle working together.

Because it is considered more likely that differential interference signals will be generated by appliances at the first outlet, the differential related capacitors are again larger than the common mode ones in this filter. (Much of the common mode signal will have been attenuated in the first stage, which strongly favours blocking this type of signal). R2 discharges any stored charge in the caps.

The fuse is selected to protect the unit from overheating. The gauge of winding wire used makes four amps acceptable. The whole device is "nominally" rated at 2 Amps continuous.

paint and there is no need to insulated the windings from the core material itself. If, for some reason, you use uninsulated toroids, then it would be wise to wrap them with two layers of electrician's tape. Uncoated cores have limited insulation breakdown capabilities and the corners may score the wire's enamel insulation with the likelihood of a short circuit occurring between the opposite windings, directly across the mains.

About 20-25 turns will fit on the toroids without overcrowding, the actual number is not critical, *provided each winding is identical.* Of course, the more turns you have the more inductance results and the better they are from a filtering viewpoint. Once the coils are wound, a drop of hot-met glue on each end will hold the windings in place, but mounting them on the pc board achieves the same end so this measure is not all that essential.



AEM5505 PARTS LIST

Semiconductors

VZ1, 2, 3	V250LA15A or V250LA15A GEC Metal oxide Varistors

Resistors

R1	15R, ½ W 5%
R2	560k, ½ W 5%

Capacitors

C1	470n-1u/630 Vdc polycarb.*
C2-C5	15n/630 Vdc polycarb.*
C6	470n-1u/630 Vdc polycarb.*
C7, C8	15n/630 Vdc polycarb.*
C9, C10	470n-1u/630 Vdc polycarb.*
C11-C14	150n/630 Vdc polycarb.*
C15	470n-1u/630 Vdc polycarb.*
C16, C17	150n/630 Vdc polycarb.*
C18	470n-1u/630 Vdc polycarb.*

*see text.

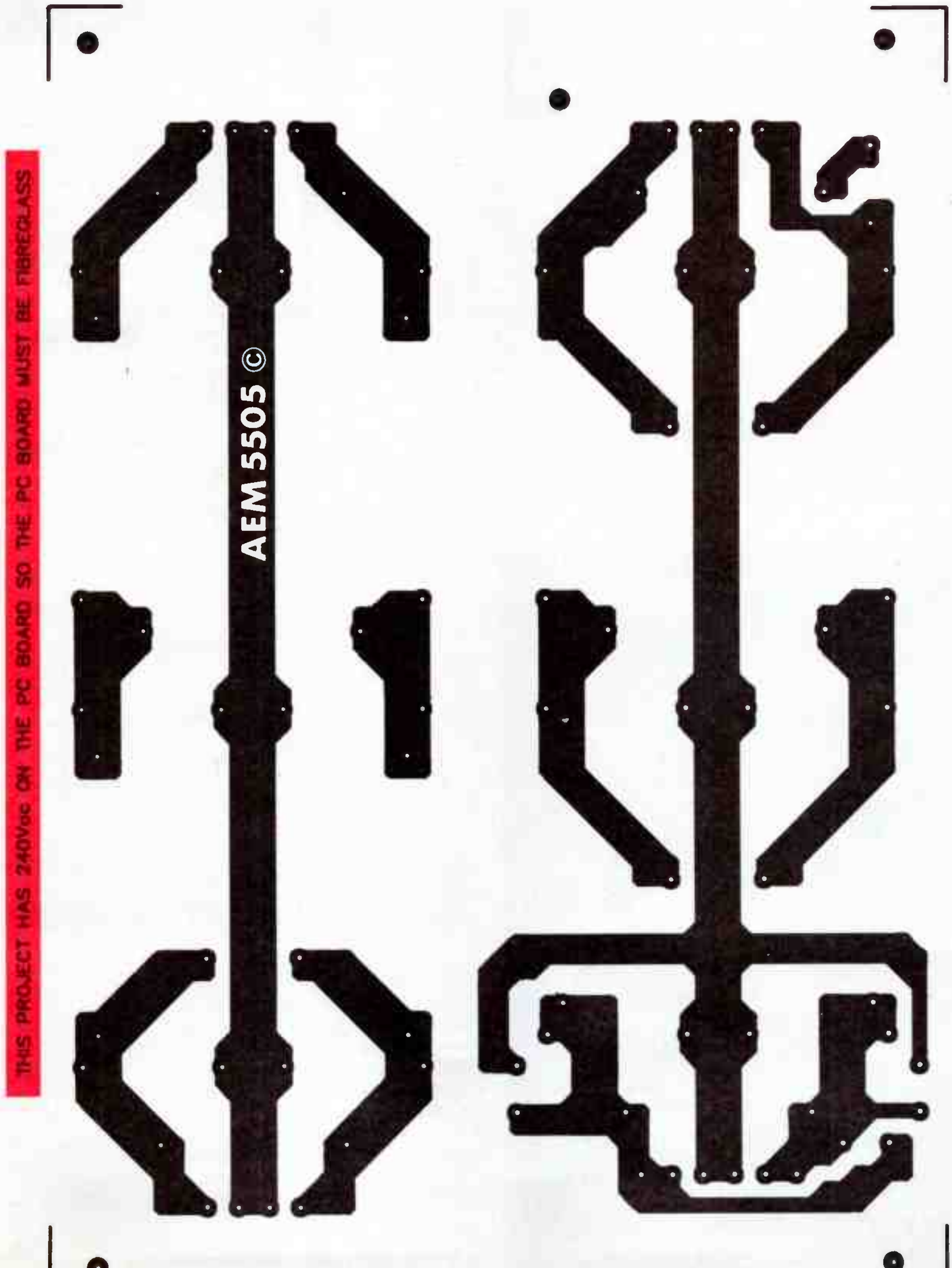
Miscellaneous

AEM5505 pc board; two toroidal cores e.g: Arnold FE1570-7501 or A254 1682 605.8, or Amidon T-157-26 or T-184-26; ferrite 'antenna' rod 9 mm diameter and about 200 mm long; one 6-way and three 4-way pc-mount screw terminals; illuminated DPDT mains switch (e.g: DSE cat. no. S-1506 or Jaycar cat. no. SK-0982); SAA approved 3AG fuseholder (e.g: Jaycar cat. no. SZ-2025 or Tandy cat. no. 270-9602); 3AG fuse, 5 A; Instrument case 260 x 190 x 80 mm (e.g: DSE cat. no. H-2507, Jaycar cat. no. HB-5910); 10 metres of 1.0 mm or 1.2 mm enamelled copper wire; five metres of three-core 10 A mains flex; 3-pin mains plug; two dual, switched power points; mains cable clamp grommet; five 6BA bolts; one 6BA nut; four 4BA bolts and nuts; two-way terminal block; heatshrink tubing; Scotchcal panel label.

Expected cost: $45-$52
(electronics only)
$75-$95 complete
(depending on hardware)

Now you can start on the mechanical bits. Details for cutting and drilling the front and rear panels of the case specified are given in drawings at the end of the article. If you use any other housing, you'll have to work out the details for yourself. The unassembled pc board may be used as a template for locating mounting hole positions. The box specified has 'lands' in suitable positions and the board is secured with short PK screws.

With the mechanicals out of the way, the pc board may be assembled. There's no strict order of assembly, but you may find it easier to mount the coils first, then the screw terminals, followed by the capacitors, Varistors and two resistors. Mount the mains input terminal block last. *Check everything thoroughly* when it's completed. The board may be screwed in place in the case bottom and the major components assembled to the front and rear panel. The wiring diagram is



Full-size artwork for the pc board.

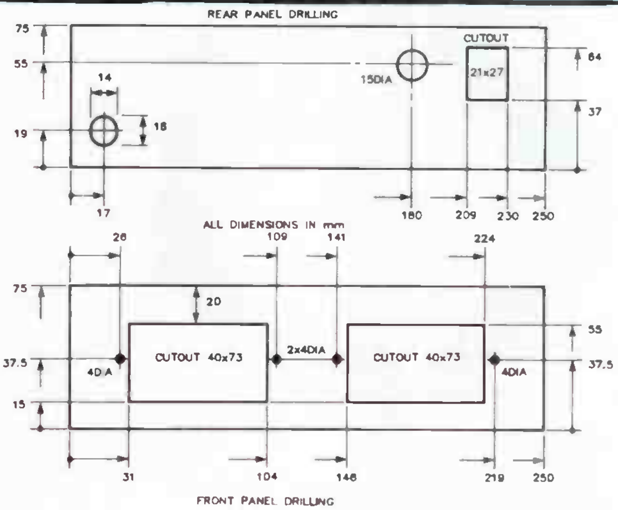
PROOF OF THE PUDDING

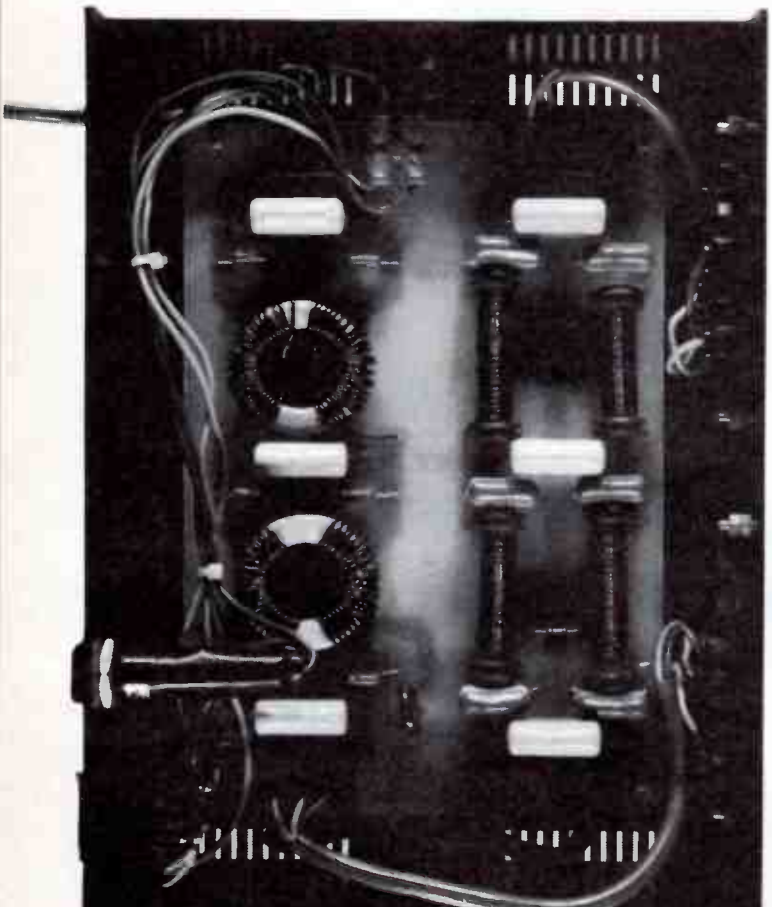
Apart from trying it under different circumstances with computers and peripherals, with pleasing results, it was decided to try out the project on a well-known mains-borne 'nasty' which could be made to occur at will.

We have a gas stove at home which features an electric 'spark' lighter. This gizmo generates a substantial voltage when triggered, and couples a particularly tenacious spike into the house mains. Every time it's used, my Series 5000/6000 Series hi-fi system delivers a sharp, loud 'crack!' from the speakers. Try as I might, short of powering it all from batteries, I could not get rid of this spike.

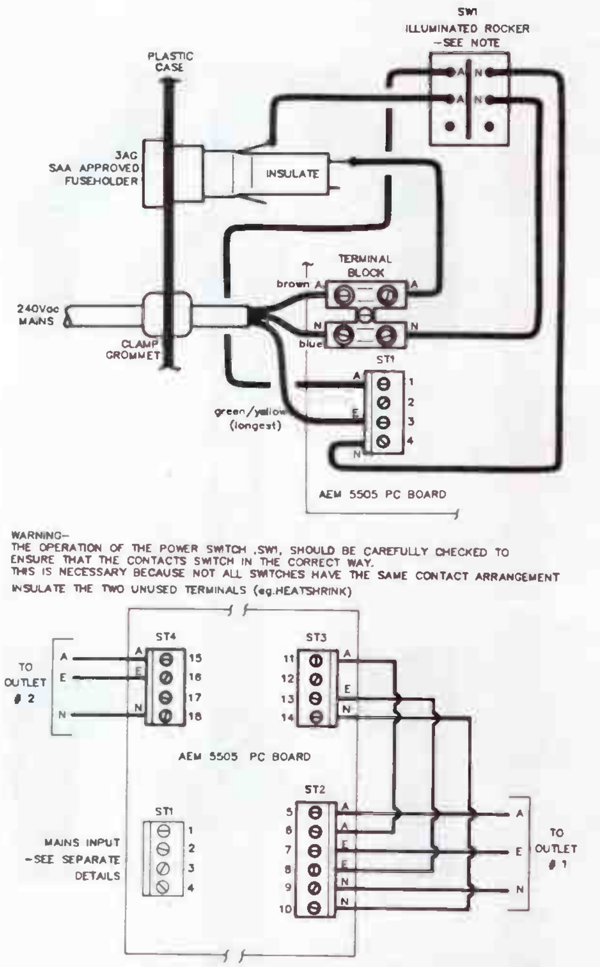
With the hi-fi system powered via this project, the mains-borne spike was effectively eliminated. A little directly-radiated signal from the spark is evident, but substantially attenuated.

David Tilbrook





SEE 'RETAIL ROUNDUP' FOR A GUIDE TO KIT SUPLIERS WHO MAY STOCK THIS PROJECT



Wiring diagram. Take great care with active (A) and neutral (N) wiring. The earth wire on the incoming mains lead should be longer than the two active and neutral leads for safety should mechanical strain break the other two.

given at the end of the article. *Leave the mains input power cord till last.* The interwiring is completed with wires stripped from mains flex. The outlet sockets are wired to the on-board screw terminals with short lengths of mains flex as can be seen from the internal photograph. Maintain the conventional mains cable colour-coding: Active — brown or red, Neutral — blue or black, Earth — green or green with yellow stripe. Cover the exposed fuse and switch terminals with heatshrink tubing for safety's sake.

After a thorough check, assemble the case, insert a 5 A fuse in the fuseholder and you're ready to 'harry that hash h-away'!

◀Internal view of the completed unit.

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SAVE $20

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A 'pigeon pair' for the RF signal generator Q-1312 opposite. Square/sine wave output with wide 20Hz - 200kHz frequency range. Highly accurate: +/- 3% - 2Hz. High/low unbalanced output control (-2000dB) with a fine adjuster. 20Hz - 20kHz sine wave output: 5V rms maximum at 1% or less distortion. 20Hz, 10V (p-p maximum) square wave output: 0.5us rise time. Synch: +/-3% of oscillator frequency per V rms.
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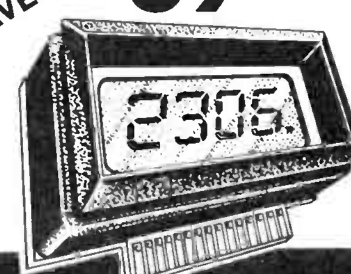

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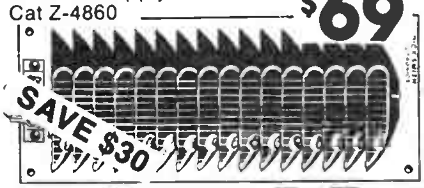

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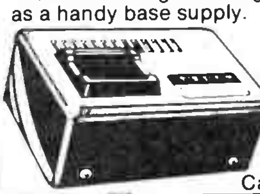

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Ceramic 50 Volt .01uF	R-2321	.15	.12
Capacitor Pack-Polyester	R-7040	$9.95	$7.95
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Cap Tant 35V .1MFD	R-4700	.65	.50
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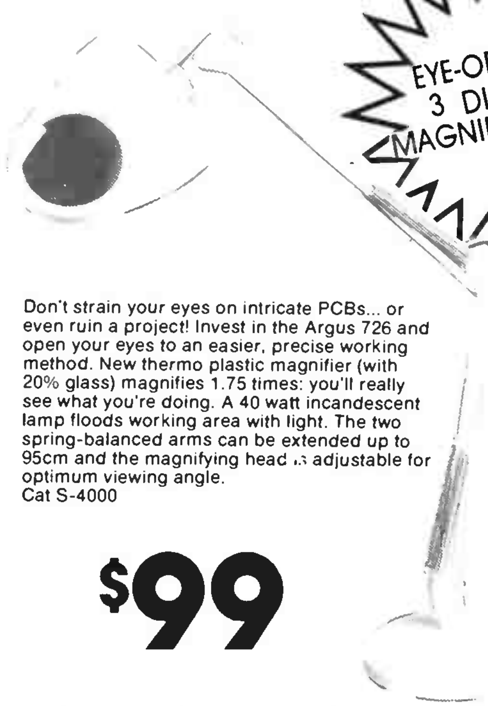

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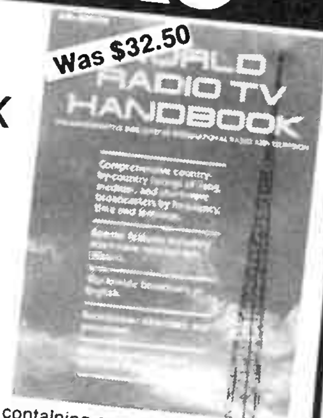

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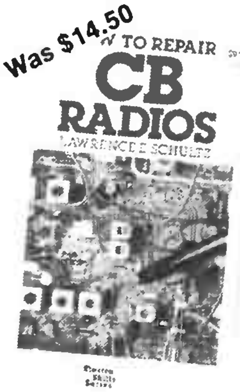

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See page 44 for address details

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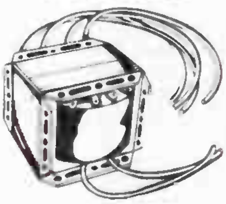
0-25 V at 3.33 A rms (blue-grey).
0-15V at 200mA rms (green - violet).
0-15V at 200mA rms (black - white).
Standard wiring tolerance: +/- 5%.
Cat M-1600

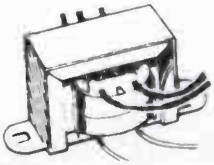
$49 SAVE $10



M-0150

Primary: 240V, 50Hz.
Secondary voltage: 2x47V, 2x15V.
Secondary current: (47V)3A ea, (15V) 0.5A, (total 300VA).
Terminations: Flying leads.
Cat M-0150

SAVE $10 **$39.95**



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Primary: 240V, 50Hz.
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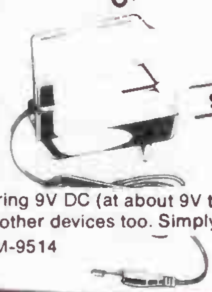
9V DC/200mA



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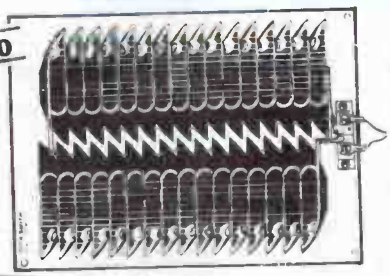
MINI SOLAR PANEL

SAVE $50



Compact electricity generator for hikers, RV owners, yachties... anyone who needs to power appliances or recharge batteries. Measures only 6⅜" x 8 ⅗" x 3/16" and weighs a mere 13oz. So it's small enough to pack a ruck sack, etc. Produces an impressive 16V/180mA output for a range of applications: add a rechargeable battery and its capabilities are greatly extended. A must for your camping trip!
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See page 44 for address details

B.153C/RE

PRE 'CATALOGUE RELEASE'

CABLES & WIRES

Cable, Mini Spi Twin Lo Volt W-2010 Was .25 **Now .20**
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Cable, SC4 for Shield W-2038 Was $1.30 **Now $1.05**
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Cable, SC1 shielded single W-2030 Was .35 **Now .25**
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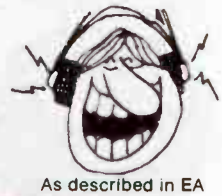

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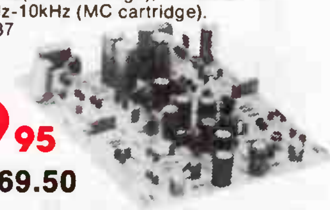

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Cat D-2835

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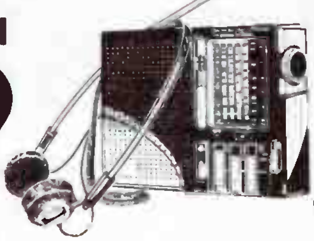

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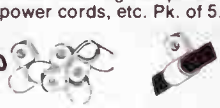

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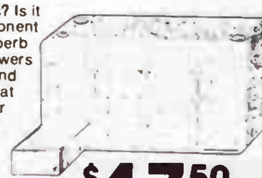

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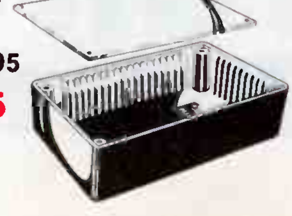

BARGAINS

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AT RED HOT PRICES...

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HI EFFICIENCY POWER HEATSINK.

Thick base, radial fin dseign. Dissipates huge amounts of heat; Thermal resistance to ambient -1 degree/watt (at 2 ft/sec forced air flow); temperature rise above ambient with no forced air flow 60 degrees at 30W heat dissipation level.
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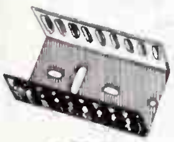

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Manufactured to exacting tolerances to ensure snug fit and optimum heat transfer on TO-5 cases. Massive body allows rapid heat dissipation.
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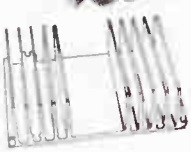

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20V/500mA SOLAR PANEL

We all know that the Sun is more than a means of tanning our bodies. It's a constant source of power to generate electricity capable of operating a variety of appliances. AND it's one of the most cost efficient means possible. With a solar panel you can harness the Sun's — in the bush, camping, on picnics — or even more serious applications in isolated areas. Completely weather and shock proof; measures just 266 x 240 x 5mm and weighs less than 0.5kg! Easy to install; complete with instructions.
Cat Z-4844

WOW!

Was $259

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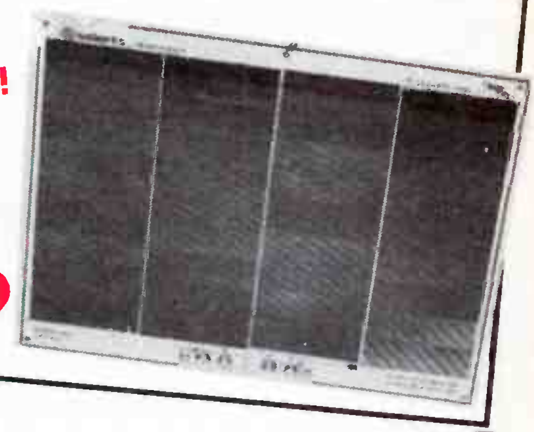
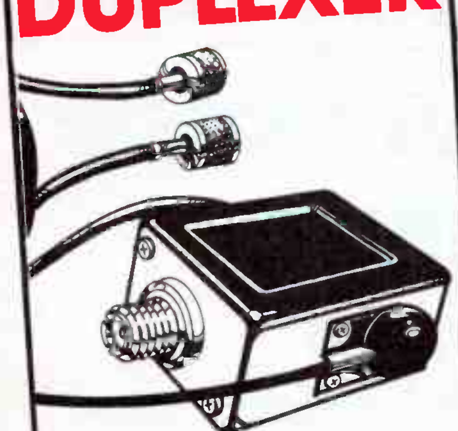


DUPLEXER



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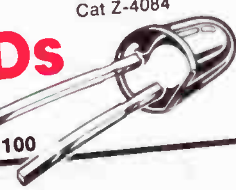

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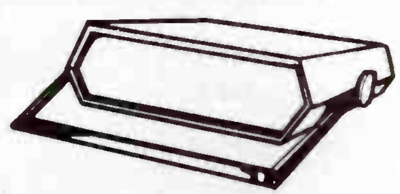

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BARGAIN SAVE OVER 40%

DICK SMITH ELECTRONICS
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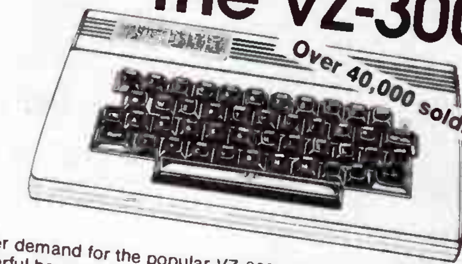
COMPUTERS

For every need & budget... as close as your nearest DSE store!

Yes!! A real computer for under $100... The VZ-300



Sheer demand for the popular VZ-300 means we can offer this powerful home micro at such an unbelievable price! It's not a toy but a real computer offering full 18K RAM (expandable to 64K), 45-key keyboard PLUS colour, sound and graphics capabilities. The whole family will enjoy using it because of the brillant array of software: personal finance, educational and games. If price has barred you in the past from joining the computer revolution, NOW there's no stopping you.
Cat X-7300

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The Cat Personal Colour Computer

DSE's popular CAT gives you more 'byte' from the proverbial Apple! Not only does it offer more memory (compare CAT's 32K ROM to Apple's 16K), it's Apple compatible — so you can run most Apple II series software. All that, and the CAT costs considerably less! CAT's impressive 64K RAM offers the serious home programmer a workable memory capacity and then some. The well layed out 81-key keyboard features numeric pad and 8 function keys capable of 24 software/programmable functions. On-screen colour (and sound) bring all your programs alive: brilliant 560 x 192 pixel grahics AND full 80-column text display. Includes inbuilt cassette, joystick and Centronics-type printer ports; Bus expansion interface, RS-232C serial adapter and more! The CAT is excellent value which will make any home programmer 'purr' with delight.
Cat X-7500

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Talk to a DSE Expert about our updated range of software.

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SYSTEM ONE
Cat X-8000
Now with 256K

$1395

DICK SMITH ELECTRONICS

See page 44 for address details

B.153F/RB

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FOR SALE: Commodore 64 software. Pogo Joe, Moon Patrol, Gyruss, Raid Over Moscow, Pooyan. $20 each or $65 for the lot. Cheque to Darryn Stokes, 3 Buckley Drive, Coonamble 2829 NSW.

SHORTWAVE LISTENERS: Join Australia's friendly 'Southern Cross DX Club', GPO Box 1487, Adelaide 5001 SA. Shortwave, mediumwave, utility and amateur information monthly. Enquiries welcomed.

WANTED: NORTHSTAR ADVANTAGES, any condition hard disk or floppy. Phone Robert Armstrong (049) 59 2400.

WANTED BY INVALID PENSIONER: ZX81 printer or add-ons, any condition. Must be complete, low priced. Please write: D. Shepherd, 4 North St, Nerang 4211 Qld. (07) 58 2543. Any parts accepted, working condition or not.

WANTED: RECEIVERS. Science Fair "Globe Patrol" and deleted "SW Radio Kit" (no. 28.110), DX-160, FRG-7, Drake R7, Icom, Trio, Kenwood, Racal, JRC receivers and handbooks, also old WRTV H'books. Tony (042) 29 2573.

WELLER CROSSWORD COMPETITION NO. 8

SEND IN YOUR ENTRY BY LAST MAIL APRIL 28

Our eighth Crossword is again pretty easy, so why not try the Cryptic Clues first. Don't forget the first prize of the Weller WTCPN goes to the nearest correct entry, so even if you miss one or two answers send in an entry as every one else may have missed some too. Our Crosswords are prepared using 'Crossword Magic' supplied by and available from Edsoft Pty Ltd, 20 Blackburn Rd, Blackburn Victoria.

The winner of Weller Crossword No. 6 (January) was Bryce Ames of Whyalla Stuart S.A.

Answers to Crossword No. 7 (March) are on p. 101.

We will accept entries postmarked no later than April 29

CooperTools

THE PRIZE

A transformer-powered soldering station complete with a low voltage, temperature-controlled soldering pencil. The special Weller 'closed loop' method of controlling maximum tip temperature is employed, thereby protecting temperature sensitive components, while the grounded tip and non-inductive heater protects voltage and current sensitive components. The soldering pencil features stainless steel heater construction, a non-burning silicon rubber cord and a large selection of iron plated tips in sizes from .8 mm diameter to 6 mm diameter with a choice of tip temperature of 315°C/600°F, 370°C/700°F and 430°C/800°F. The transformer case features impact-resistant noryl for durability and protection against accidental damage, a quick connect/disconnect plug for the soldering iron, extra large wiping sponge, tip tray to store extra tips, plus an improved off/on switch with a long-life neon indicator light, a non-heat sinking soldering pencil holder, and a 2 m flexible 3 wire cord.

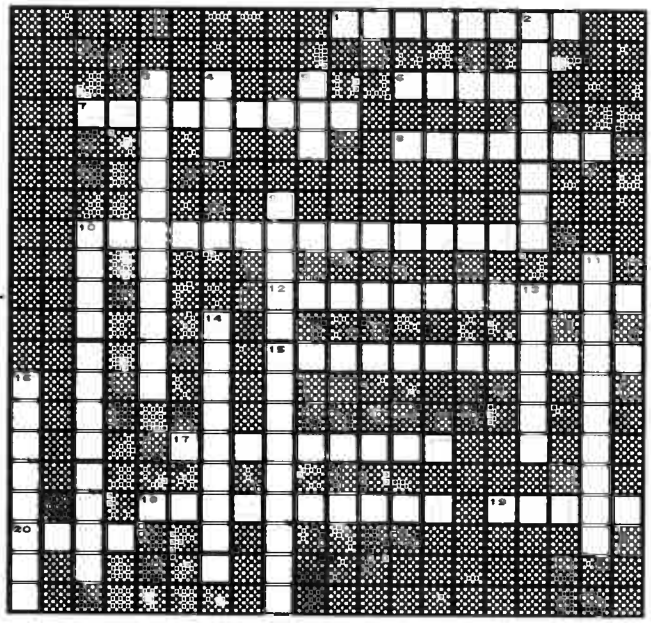
Cryptic Clues

ACROSS

1. Every glider should have one
6. The point is on the screen
7. Irish office divider
8. Fast reader
10. Sound link (2)
12. Rarely the same result (2)
15. Free-for-all in the park (2)
17. Chiselled on the work surface
18. Collection of computerists (2)
19. Empty your mind
20. With the cigars

DOWN

2. Measuring the days
3. On the farm once they fed horses now they given them diesel (2)
4. Bitch's first half
5. Firewood
9. Midget processing unit
10. The Opera House is a notable example
11. Outside the main body
13. Singular of main theme from 'Cats'
14. Cranial Tattoo
16. Akin to heavy pencil



Regular Clues

ACROSS

1. A control device with handle
6. Picture element on CRT
7. To divide a segment into smaller units
8. An instrument which automatically interrogates processes, signals etc
10. Can link computer to computer via telephone (2)
12. A set of digits such that each successive digit is equally likely to any of n digits to the base n of the number 2 (2)
15. Free access to programs
17. A frequently used routine whereby the difference between similar items is measured.
18. Club (2)
19. Erase or reset
20. A place of access to a system

DOWN

2. Computer circuit that keeps track of the months
3. Method of moving paper using pins (2)
4. Binary digit (abbrv).
5. To list or register
9. The control or processing portion of a small computer
10. Organisational structure of a small computer
11. Any communication device of a computer
13. Media or equipment used to hold information in electrical or magnetic form
14. Device for transferring data to floppy disk or tape
16. Light sensitive device used with CRT for selecting portion of display

SEND IN YOUR ENTRY BY LAST MAIL APRIL 28

The competition is open to all persons normally resident in Australia or New Zealand, with the exception of members of the staff of Australian Electronics Monthly, the printers, Offset Alpine, and/or associated companies.
The winning entry will be drawn by the Editor, whose decision is final; no correspondence will be entered into regarding the decision.
Winners will be notified by telegram the day the result is declared and the winner's name and contest results published in the next possible issue of the magazine.

Cut out or photocopy the entry form, complete it and send to:

"Weller Crossword"
Australian Electronics Monthly
PO Box 289,
Wahroonga NSW 2076

In case two or more entrants correctly complete the crossword, we'll have to judge who's best at waxing lyrically, in 30 words or less, over: ***"Why I think the Weller WTCPN is the soldering station for me".***

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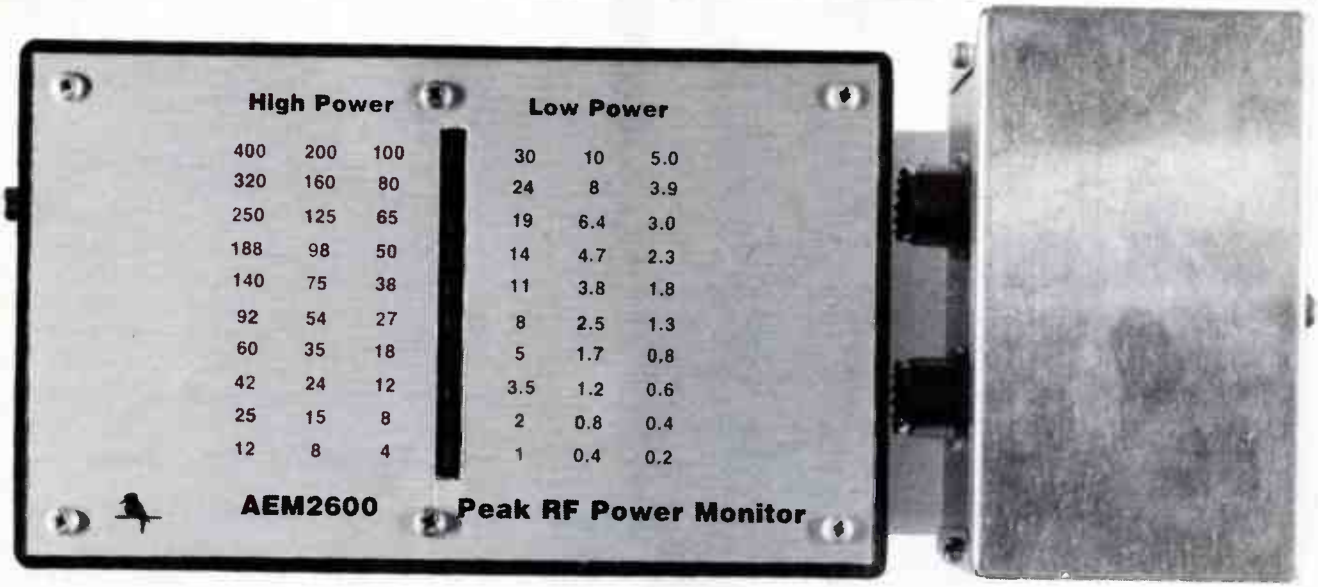
Name . . . .

Address . . . .

. . . . **Postcode** . . . .



The completed project — 'RF head' with the coax sockets at right, and the 'display unit', left. The front panel of the display unit was dressed up with a Scotchcal label with a powerscale.

A peak RF power meter/monitor

Roger Harrison VK2ZTB

This project features low cost, simple construction and a handy LED bargraph display. The display section is housed separately to the RF-sensing section, which is convenient and permits the installation of separate RF-sensing sections for each rig or antenna.

JUST ABOUT every amateur radio and CB 'shack' I have ever visited sported at least one RF power/SWR meter of some sort or another. Frequently, I noticed, they were used as more or less permanently installed in-line RF 'monitors'. This is ostensibly a 'good thing' as it gives a visual indication that the transmitter/feedline/antenna system is behaving as it should. However, there are two drawbacks to this. Firstly, it ties up the instrument so that, when you want to measure the RF power or SWR on another rig or antenna, you've got to go through the hassle of disconnecting it and coupling it into the other feedline. If you've lashed out and bought a versatile, good quality instrument, then having it permanently in-line unnecessarily ties up an expensive item of test gear. Secondly, in the situation where you may have a number of rigs and/or antenna systems, with multiple feedlines, individual monitoring or measuring cannot be readily achieved with a lone instrument. Some operators I notice, own a number of RF power/SWR meters in order to circumvent this hassle.

With only one display unit and a number or RF-sensing/monitoring units, you can have individual monitoring of a number of rigs or antenna systems. This project can provide such a facility at minimal cost. You can 'release' your expensive shack RF power/SWR meter for the applications suited to it, rather than tying it up as an expensive monitor.

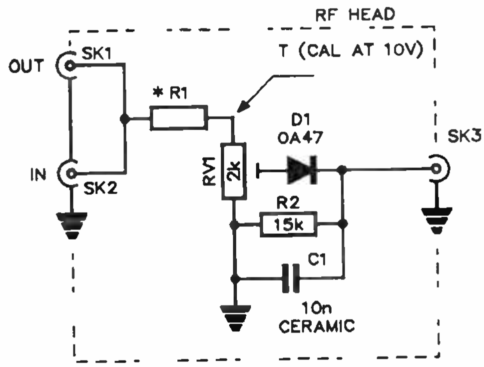
Aspects of the design

The circuit appeared under *Practicalities* in the February 1986 issue of the magazine, and was adapted from a project described by David Beard WA4QGA in the August1983 issue of CQ. Basically, it employs a peak rectifier to measure the peak RF voltage across the 50 ohm antenna feedline.

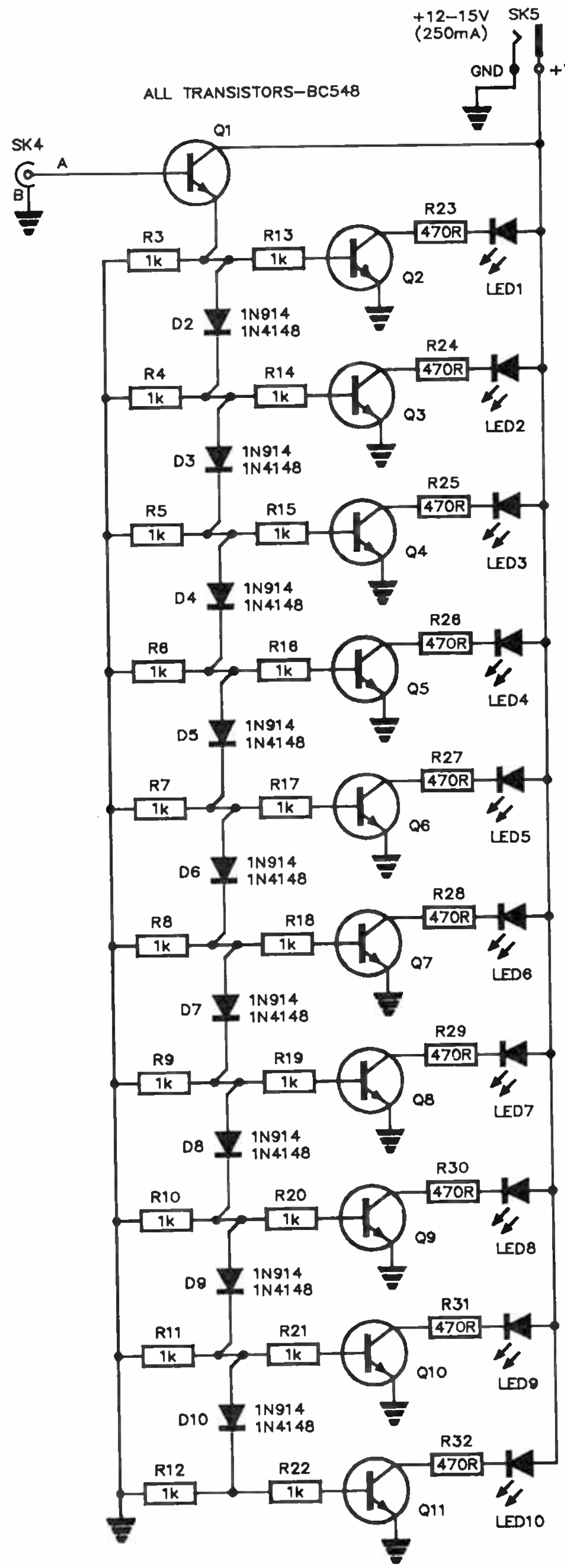
The LED bargraph-style display provides a distinctive indication, particularly with dynamically varying transmissions such as Morse and single sideband. While a sensitive (say, 100 microamp) moving coil panel meter could be used in lieu of the bargraph and its drive electronics, the latter works out slightly cheaper in cost and provides an indication which more accurately follows the rapidly fluctuating excursions of CW and SSB transmissions. In addition, the LED display can be seen under widely varying lighting conditions.

The RF-sensing section employs a simple peak rectifier tapped directly across the feedline to derive a dc output to drive the display section. It is housed in an 'RF head' that can be inserted in the coax feedline to the antenna. You can make up a number of these, one for each rig/antenna system if you need to. Each can be configured to sense a different full-scale peak RF output to suit differing rig powers.

As it is necessary to individually calibrate each RF head unit I decided to follow the KISS methodology here ('keep it simple, Sam'). A resistor and trimpot tapped across the 50 ohm feedline system is employed, as can be seen from the circuit diagram. By using the appropriate value of R1, you



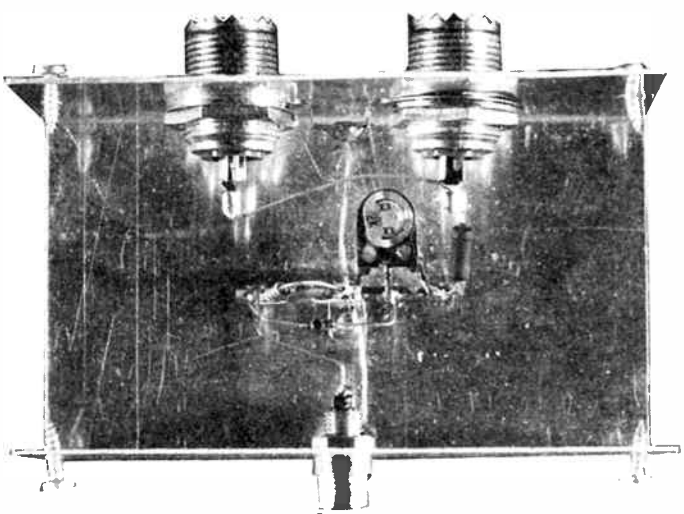
* SEE TEXT–TABLE 1



CIRCUIT OPERATION

This circuit employs an old LED display technique that is simple to implement without requiring a special driver IC. A simple peak rectifier tapped directly across the antenna feedline derives a dc output to drive the 'totem pole' display. The halfwave peak rectifier (D1 and surrounding components) is housed in a thru-line 'RF head' inserted somewhere in the coax to the antenna. With about a volt or so output from D1, Q1 will turn on, forward biasing the the base of Q2 which will turn on, lighting LED1. As the rectifier output rises with increasing RF power delivered to the line, each 1N914 diode, commencing wtih D2, turns on in turn, turning on the next transistor in the totem pole (Q3-Q11). Each LED thus turns on at a discrete power level, providing a bargraph display.

Input to the peak RF rectifier is via a voltage divider, RV1 providing a means of calibration. The value of resistor R1 will determine the peak RF indicated by LED10 ('full scale'). Table 1 gives full-scale power levels for a variety of useful powers with suitable values of R1.



Inside view of the RF head.

LEVEL

We expect that hobbyists who are

BEGINNERS

in electronics construction should be able to successfully complete this project.

can set the full-scale peak RF power indicated by the 'top' LED in the display. The values are arranged such that 10 V peak on the point marked 'T' in the circuit represents the full-scale peak RF value. RV1 is then adjusted so that the top LED lights with 10 V peak applied here.

Table 1 lists the required values for R1 for a variety of convenient full-scale peak power ranges. Note that close-tolerance, 1% or 2%, resistors are specified. If you can't get the E48 values specified (20k, 2k and 910R), they can be made from combinations of E12 values. For 20k, use 18k with either a 2k2 or 1k8 in series. For 2k, use 1k8 and either a 220R or 180R in series. For 910R, use 820R + 82R in series, 820R and 100R in series, or 680R + 220R in series.

So that costs were kept to a minimum, the RF head is housed in a small, cheap aluminium box and the display in a common 'jiffy' box. The project may be powered from any external dc supply that can deliver between 12 and 15 Vdc at up to 250 mA. Alternatively, there is enough room in the display jiffy box to mount a small, low cost mains transformer (such as PL18/5VA), bridge rectifier and filter capacitor.

As an alternative, the RF-sensing and display circuitry could be readily mounted within a homebrew transmitter/transceiver, or an antenna tuner, for front panel RF output monitoring.

Construction

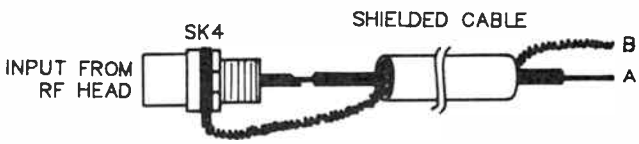
Here, too, I've followed the KISS methodology. The display electronics is mounted on a pc board. This has been laid out to accommodate either 10 individual LEDs or a commonly available 10-LED bargraph array. The latter is shown in the picture of the final prototype. It came from Jaycar, cat. no. ZD-1700. The display pc board mounts to the front panel of the jiffy box with 14 mm tapped, insulated standoffs such that the display just protudes through the panel cutout.

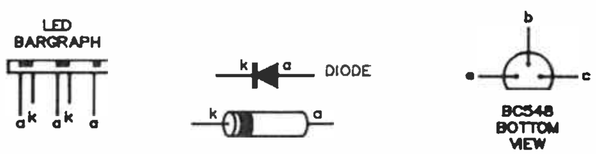
An RCA connector, linked to the pc board via a short length of shielded cable, provides for connection to the RF head.

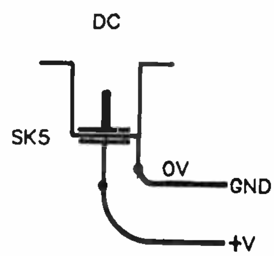
The RF head components mount to the lid of a small (104 × 60 × 46 mm) aluminium box. Two SO239 panel-mount coax sockets mount on one side, the RCA connector output on the opposite side. The small components mount to a 5-lug tagstrip on the 'top' side, as can be seen from the internal picture.

Best place to start is with the mechanical operations. The drawings here show all the necessary dimensions. Mark out the boxes and panels with a soft lead pencil first. Centre punch all hole centres before drilling.

The cutout for the LED bargraph on the display unit front panel may be made either with a 'nibbling' tool or by drilling a series of 4.8 mm (3/16") holes and flat-filing the edges. When you've got the front panel cutting and drilling finished, ensure all the 'dags' are removed so you can attach the Scotchcal label. This is more easily done if you wet both the







AEM2600 PARTS LIST

Semiconductors

D1	OA47
D2-D10	1N914, 1N4148
LED1-LED10	10-LED bargraph, or 10 × LEDs
Q1-Q11	BC548, BC108

Resistors all ¼W, 5% unless noted

R1	see Table 1
R2	15k
R3-R22	1k
R23-R32	470R
RV1	2k trimpot

Capacitors

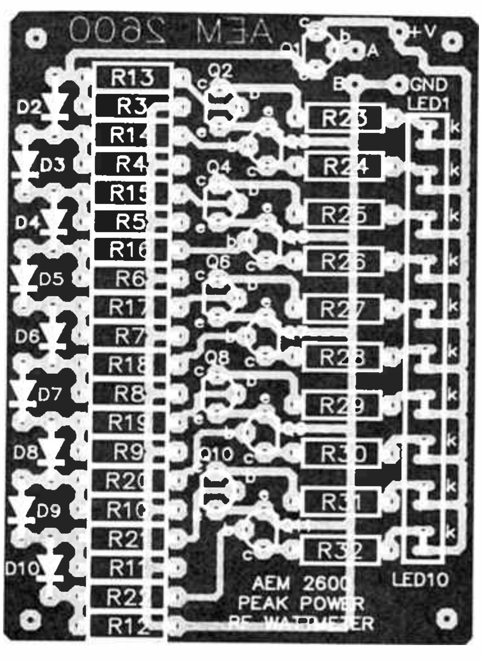
C1	10n ceramic

Miscellaneous

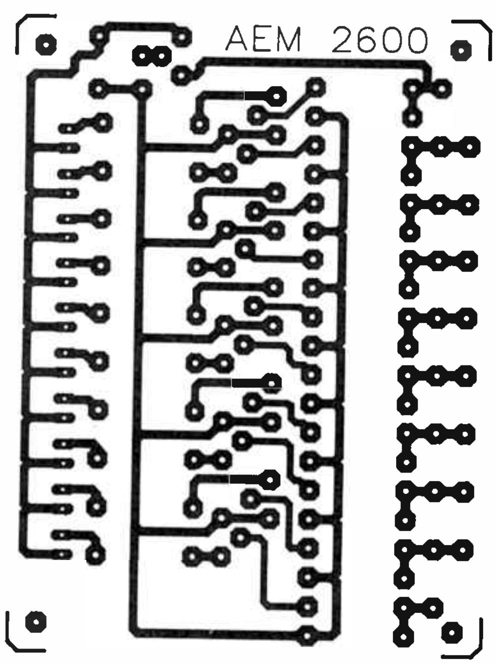
PL1, PL2	RCA line plugs
PL3	2.5 mm dc power plug
SK1, SK2	SO239 chassis-mount coax sockets
SK3, SK4	RCA sockets
SK5	2.5 mm dc power socket

AEM2600 pc board; 5-lug tagstrip; jiffy box 158 × 50 × 95 mm; small aluminium box 104 × 60 × 46 mm; two 14 mm insulated standoffs with screws; required length of shielded cable; short length of tinned copper wire; 6BA bolt and nut; Scotchal front panel label.

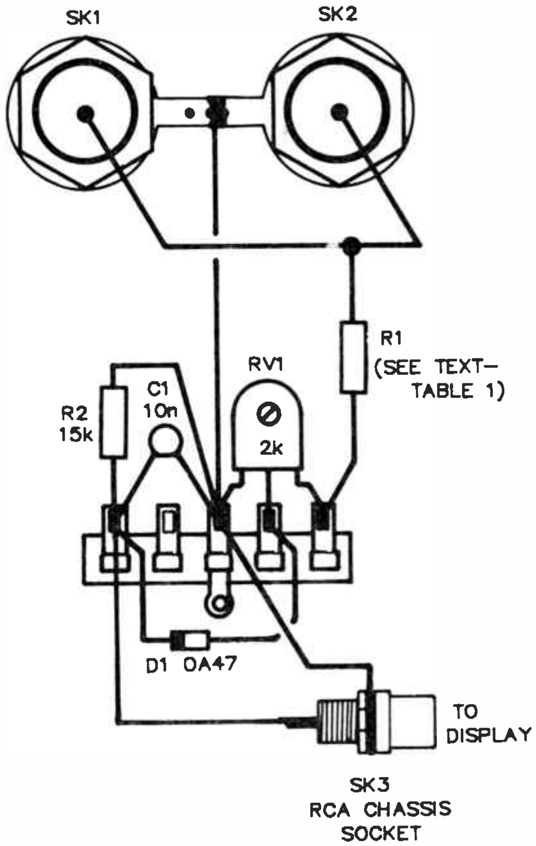
Expected cost: $28-$35



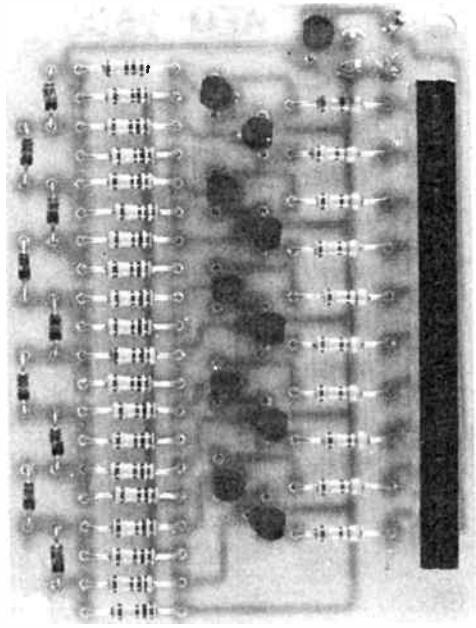
Display unit, pc board overlay and wiring diagram.



Full-size artwork for the pc board.



RF head wiring diagram.



View of the complete board assembly.

TABLE 1. Selecting R1

Peak RF pwr	400	200	100	30	20	5
Value of R1 (all 1% or 2%)	20k*	15k*	10k	5k7	2k	910R

*1W, all others ½W.

TABLE 2. Calibration

LED	Voltage at 'T'
10	10.00
9	8.90
8	7.88
7	6.80
6	6.04
5	5.06
4	4.12
3	3.44
2	2.71
1	1.97

label and panel first. This allows you to slide it accurately into place. Otherwise, you only get one chance to get it right. Smooth it on with a sponge, working from the middle out, ensuring you get rid of any bubbles. Once it's in place, use a sharp 'hobby knife' or scalpel to cut out the holes for the various screws and the LED display.

Now you can tackle the electronics. The RF head assembly is quite straightforward. Construction is shown in the accompanying wiring diagram. Note that, if you prefer, a short length of coax may be used to link the two SO239 coax sockets. See that you get the OA47 diode the right way round. If you intend to use this project on the bands above 28 MHz, the leads on C1 should be kept to a minimum. In fact, a 500 pF disc ceramic would be better substituted here.

The display is also quite straightforward. Assemble the pc board first. The only thing to watch here is that you get the semiconductors in the right way round. For the off-board connections (input and power supply), I used pc stakes for convenience, but they're not essential. These two connections need leads about 120 mm or so long. Note that, with the dc power connector, the *general* convention has the *centre pin* as the *positive* lead. If you use a plugpack to power this project, ensure the polarity of the connector before powering-up.

The RF head, or each RF head if you have a multiplicity of them, connects to the display unit via a shielded cable of the required length with RCA plugs on each end.

Now, before powering-up, visually check everything, particularly the orientation of all semiconductors.

Power-up and calibration

Connect the RF head to the display unit. Set RV1 to about mid-range. Apply power to the display unit. No LEDs should light up. If they do, you've got a fault. If all appears well, take a resistor of around 4k7 to 10k and bridge it between 'A' (base of Q1) and the supply positive. All the LEDs should light. Check the orientation of the diodes and transistors if there are any problems with this test.

If, or when, it's working correctly, you can commence to calibrate it. The calibration can be carried out with a multimeter and a variable dc supply. Alternatively, you can use an audio oscillator or other ac source capable of delivering at least 20 V peak-to-peak, and an oscilloscope.

The basic procedure is very *simple*. Apply 10 Vdc, or 10 Vac peak, between ground and point 'T' at the RF head. Then adjust RV1 until the 'top' LED (LED10) just lights. Note that there's a little latitude as the brightness will vary over a small range with slight variation in the setting of RV1. Set it to what you consider to be a satisfactory point. Really, you need do no more than that. ▶

JAYCAR TELEMAIL 008 022 888 TOLL FREE

FOSTER HORN TWEETER

We used to stock this tweeter, but reluctantly stopped when Plessey stopped importing Foster. Now there's new importers and we have them back in stock again. This tweeter is brilliant. It is very bright with great crisp sound. Frequency response 5kHz - 40kHz, system power 100 watts rms. SPL 96dB/w @ 1 metre
Cat. CT-2016

ONLY $29.50

FOSTER DOME TWEETER

We couldn't complete this years catalogue without having a Foster dome tweeter. It is the DO25N25 model. System handling 150 watts rms. Resonance frequency 1.2kHz. Frequency response 3kHz - 30kHz. SPL 91dB/w @ 1 metre
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ONLY $31.00

FOSTER 4" WIDERANGE
C100K03

This ever popular widerange/midrange is now available again. Ideal where high quality is needed, but where space is at a premium. Nominal power 3W max power 10W, resonance frequency 80Hz, frequency response 80 - 17kHz.
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If you are after a top quality midrange, this is it. Bright, crisp, clear midrange, and it certainly looks the part. Suits system power up to 150W rms. Frequency response 1.2kHz - 8kHz SPL 92dB/W @ 1 metre. Resonant frequency 520Hz
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VIFA 10" 3-WAY SPEAKER KITS

TWEETER D19TD Cat. CT-2019
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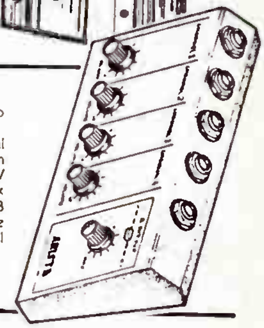
4 CHANNEL MIC MIXER

Its size and simplicity makes this mixer very portable and easy to operate. It will accept up to 4 low impedance microphones ★ 4 low impedance microphones 600 ohms input ★ Individual gain control for each mic ★ Master volume control ★ Power on LED ★ Inputs/outputs 6.5mm mono sockets ★ DC operated 9V battery ★ Input impedance 600 ohm ★ Output impedance 1.5k ohms ★ S/N ratio 55dB ★ Frequency response 20 - 20kHz ±2dB ★ Weight 320 grams ★ Dimensions 148 x 46 x 86mm ★ Torque variable range 1-22dB ★ Input sensitivity 1mV ★ Output level 90mV (at input 5mV) ★ THD 0.01%
Cat. AM-4205

ONLY $45.50



NATIONAL INSPECTION LIGHT

This quality National made unit enables you to place a spot of light in the most awkward places. Ideal for servicemen and kit assemblers. Needs 2 AA batteries.
Cat. TH-1835

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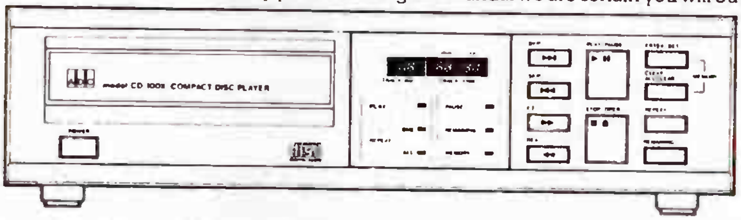
NOT ALL COMPACT DISC PLAYERS ARE THE SAME! NEW

It is becoming increasingly apparent that not all CD players are the same. You get no guarantee of superb sound quality by paying around $1,500. You may get a model that bristles with programming facilities but is in fact no better than a model costing ⅓ as much.
With this is in mind, Jaycar has concluded an exhaustive technical evaluation of models suitable for inclusion in the 1986 Jaycar Catalogue. We feel that the choice of the **ADC Model CD-100X** player will be welcomed by the technical reader of this magazine.

SPECIAL OFFER - We welcome technical scrutiny of this magnificent CD player. To prove this, we can supply a detailed 40 page technical service manual on the ADC CD-100X. This manual (one of the best we've seen out of Japan) covers theory of player operation, circuit operations, test procedures, test print and waveform illustrations, block diagrams, IC description and schematic diagrams and much, much more!
If you wish to review this manual before you buy send $10 (inc. P&P) for a copy. After reading this manual we are certain you will buy. (When you buy the CD-100X we will take $10 off the purchase).

BRIEF TECHNICAL SPECS.

Frequency Response	5 - 20kHz ±0.5dB
T.H.D.	0.004%
Dynamic Range	95dB
Channel Separation	90dB @ 1kHz
Optical Pickup	3 beam laser
D/A Conversion	16 bit linear
Filter	Seventh order passive filter
Error Correction	CIRC dual error system



ONLY $549 plus p&p
Cat. AC-0400

FEATURES: • Motor driven horizontal loading (front load) • 3 beam laser (not 2) • Metal chassis for rigidity • Astigmatic beam focus • 16 memory track programming.
The price for this magnificent unit?

NEW GENERATION CORDLESS TELEPHONE

Microprocessor controlled - 200 metres range and absolute security

Quite simply the finest cordless phone we have used. Telecom approved.

FEATURES
• Operating range up to 750 feet (250m) • Security code system with 16,384 combinations • Last number re-dial • Call function at base unit to alert handset • Power on/off switch and standby/talk switch on handset • Reset button for hanging up and recalling dialling tone • Pulse dialling with audible tone feedback at the touch of a key • LED Indicator on handset for low battery indication • Built-in overcharge protection for handset unit • Handset switched automatically from "Talk" to "Standby" mode when placed on base unit • Hearing aid compatible
Cat. YT-7065

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CALCULATORS
MODEL SC122

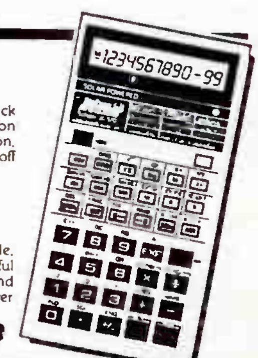
Solar powered, smart slimline desk top model with small black sachet. LCD, 12 digit, standard 4 functions, automatic punctuation display, independent 4 key memory and grand total calculation, %, √, +, −, and digit shift item, round down and round off selectable. Size: 23(H) x 102(W) x 167(L)mm
Cat. QC-7132

ONLY $34.95

MODEL SC570

Scientific calculator, popular school model, hand held style, complete with black sachet. 10 + 2 digits, LCD, 68 useful functions, 15 levels of parantheses, decimal, binary, octal and hexadecimal conversion, random number generator, auto power off, uses 2 G13 type batteries
Size: 85(H) x 71(W) x 134(L)mm
Cat. QC-7118

ONLY $32.50



GIANT SIZE IC TEST CLIPS

137mm IC clip RED ____________ Cat. HM-3046
137mm IC clip BLACK ____________ Cat. HM-3047

BOTH UNITS $2.50 each
10 or more units $2.30 each

COMPUTER CABLE

12 conductor computer interface cable. Colour coded with Mylar shielding. 12 x 7/0.16mm
Cat. WB-1580

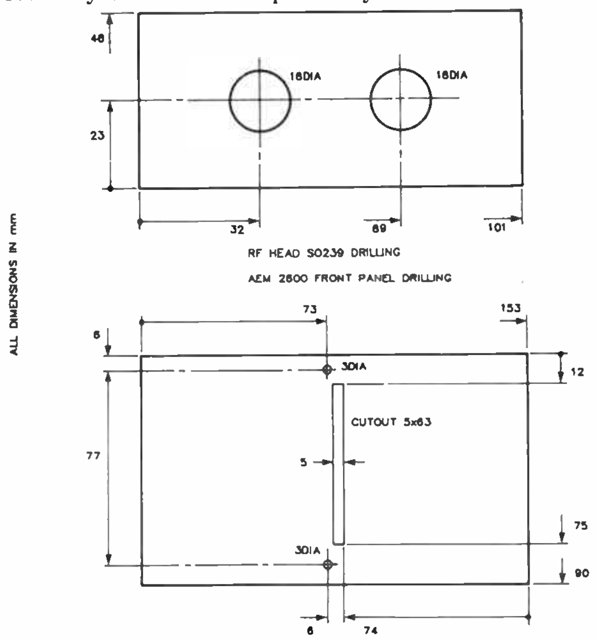
$2.20 per metre
$175 per 100m reel

Table 2 gives a guide to the voltage points at 'T' at which each LED will turn on. Note that, owing to variation in components, individual units will vary somewhat. Hence, the power levels shown on the Scotchcal front panel are only approximate within about ±5%. As this is not a true measuring instrument as such, but more of an indicator/monitor, that sort of accuracy is quite acceptable.(Note that Table 1 in the *Practicalities* article, p.80 Feb. '86 AEM, were scaled from the original circuit. The inevitable component non-linearities account for the differences here).

Installation suggestions

The RF head is 'inserted' at a convenient point in the coax feedline system. If the feedpoint of your antenna is fixed and accessible, it's best to insert it as close as you can get to the feedpoint. For end-supported dipoles, just install it at a convenient point. If you use an antenna tuner in the shack, install the RF head between the rig and the tuner.

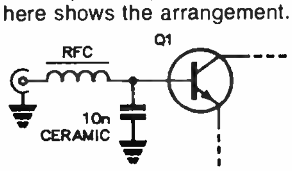
Where you might have multiple feedlines to monitor, with RF heads inserted in each (or as many as you wish to monitor), the output of each could be brought out to a multi-way RCA socket panel and the display unit 'patched in' to the appropriate one as required.



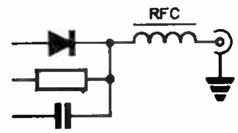
Drilling details for the boxes.

ELIMINATING POTENTIAL RFI PROBLEMS

At the higher power levels, you may possibly expererience RFI problems through radiated RF coupling into the display unit either from the RF head or the cable running from it to the display unit. Such problems will likely cause the display to indicate full output, long before full-scale power is reached, by rectification in the base-emitter junction of Q1. The judicious placement of RF chokes and a bypass can eliminate the problem. As a first measure mount an RF choke right at the input socket of the display unit, plus a 10n disc ceramic bypass mounted on the copper side of the pc board, from the base of Q1 to ground (with the shortest leads possible). The circuit here shows the arrangement.



As further protection another RF choke can be added to the RF head, mounted between the RCA socket and the junction of D1/R2/C1 on the tag-strip, as per the circuit here:



The value of the RF choke will depend on the band, or bands, the unit will be used on. A choke of 1 mH to 2.5 mH is suggested for the bands 7 MHz and below. Above that, a choke around 470 uH (plus or minus a standard value) is recommended. For the 10 metre and six metre bands, a value around 100 uh (plus or minus a standard value or so) could be used.

High Power			Low Power		
400	200	100	30	10	5.0
320	160	80	24	8	3.9
250	125	65	19	6.4	3.0
188	98	50	14	4.7	2.3
140	75	38	11	3.8	1.8
92	54	27	8	2.5	1.3
60	35	18	5	1.7	0.8
42	24	12	3.5	1.2	0.6
25	15	8	2	0.8	0.4
12	8	4	1	0.4	0.2

AEM2600 Peak RF Power Monitor

Full-size artwork for the front panel.

Microbee updates with "Premium Series" models

Never a company to stand still, Microbee Systems Ltd has released upgraded versions of their standard models, dubbed the "Premium Series". All the options on the current 'Standard' models are built-in to the Premiums, including colour video and Viatel/videotex communications capability.

New features on the Premiums include greatly enhanced high resolution graphics capability, an additional four keys for cursor control and a volume setting control for the internal speaker.

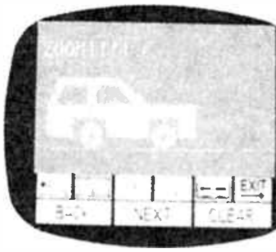
The new hi-res graphics capability will probably be the feature most-welcomed by Microbee owners/enthusiasts and new customers alike. The Premiums can display a full screen of 131 072 pixels, all individually programmable. (Wow! — weather FAX pictures on-screen via the AEM3500 Listening Post).

The main circuit board of the Premiums is a complete redesign, with improved colour video and keyboard scanning circuitry. Processor screen accessing is now fully synchronous and transparent, says Microbee, giving a clearer and more stable display free of the glitches apparent on the older Standard models.

Microbee also say that keyboard scanning is now much more reliable and disk models feature the ability to assign extended functions to the numeric keys.

Price of the Premiums is $100 above the Standard series in each of the three configurations (which are: 32K PC85, 64K Computer-in-a-book and 128K Small Business System). Microbee Systems is also offering owners of existing 'Bees the opportunity to upgrade to the Premium Series at what they say is "... an attractively low price". This maintains the company's policy of continued upwards compatibility.

Further details are available in a well-produced and informative brochure available from Microbee System's Technology



Centres and authorised dealers, or from **Microbee Systems Ltd, PO Box 105 North Ryde 2113 NSW. (02) 887 3723.**

Computers watching computers

A new system designed to speed up the servicing of computers in the field has been launched by Voicecall Communications Pty Ltd. Called Computerwatch, the system is said to minimise computer downtime by accelerating the response rate to service calls of computer field personnel.

The Computerwatch system is available in Sydney, Melbourne, Canberra, Brisbane, Adelaide, Perth and the Gold Coast.

Each State or Territory has an independent network but they are all fully linked to each other via Austpac.

The software for the system has been designed by CMS, the research and development division of Voicecall headed by Nati Stoliar, managing director and Dr Richard Freyer, head of research.

Computer companies employing only a small number of field engineers will benefit in the following manner, the company says: Their field engineering centre will be provided with a 24 hour fully integrated and computerised telephone answering service on a unique telephone number supplied by Voicecall via the Telecom network. This number will be answered in the name of the company and calls will be logged into the Voicecall computer.

Details of the service required will be taken by an operator, who will then advise that a field engineer will contact them shortly.

As the call is terminated the request is transmitted to the field engineer on his National Panasonic alphanumeric pager which can accept up to 400 characters per message to a total of 1200 characters or 20 messages, whichever is the less, and can store them in its memory.

The message is then viewed by scrolling the liquid crystal readout of the pager, just like a pocket telex. A hard copy readout can also be obtained by plugging the pager into a standard office printer using a special interface unit.

Larger computer companies employing a greater number of field engineers will be able to respond to calls using the Voicecall Computerwatch system in an additonal way.

The Voicecall network computer can be interfaced to any other computer using a standard protocol RS232, so the Computerwatch system for despatching information can be carried out direct from the customer company's own computer to the transmission network.

As an alternative, Voicecall can provide direct access to the customer's computer on a 24 hour basis by dial-up or land line. Using the fully linked network between States through Austpac, Voicecall can provide client companies which operate nationwide, the facility to utilize Computerwatch for despatch purposes.

The Computerwatch system is already in use by Wang Computers, Fujitsu Australia, Burroughs and other computer companies for their field engineering support. For further information, contact **Herman Lux, Voicecall Communications Ltd (02) 211 3688.**

New Nokia modem features 1200 bps duplex

Sydney firm EEL Communications has released the Nokia DS 3565 featuring V22b call mode operation, which offers automatic answering and disconnection as standard.

Its advanced design uses microprocessor and LSI technology for small size and low power consumption. The mechanical design allows the modem to fit perfectly under most telephone sets.

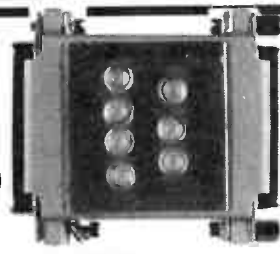
The DS 3565 is intended for synchronous and asynchronous data transmission in the full duplex mode over a switched network or over two-wire leased lines. ▶

AEM4600 DUAL SPEED MODEM

Geoff can't put this kit together fast enough. The queue started to form the moment the magazine came out.

Features both 300/300 baud full duplex and 1200/75 baud half duplex operation so it's ideal for Viatel. All functions are selected with quality C&K toggle switches with four LEDs to indicate correct functioning. Interfacing is standard RS232 using a minimum of signal lines for "universal" interfacing.

Geoff's kit comes complete with punched front panel (looks like a bought one!) and is just **$159.00**



$38.70

CAS6 RS232 MINI TESTER

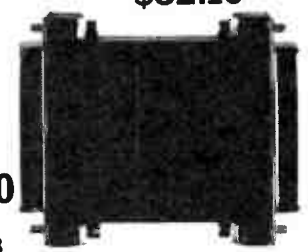
- Male to female connections
- All pin wired straight through
- Dual colour LED indicates activity and direction on 7 lines
- No batteries or power required

T D - Transmit Data
R D - Receive Data
R T S - Request to Send
C T S - Clear to Send
D S R - Data Set Ready
C D - Carrier Detect
D T R - Data Terminal Ready

CASI RS232 SURGE PROTECTOR

- Avoids costly damage from large voltage peaks caused by lightning or other power problems
- Uses metal oxide varistors (M O V) to suppress any voltage above 26V on pins 2 3 & 7
- Will handle up to 1 Joule & 250A peak current

$32.10

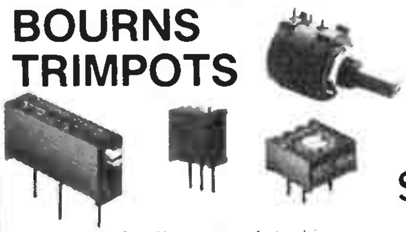


$19.90

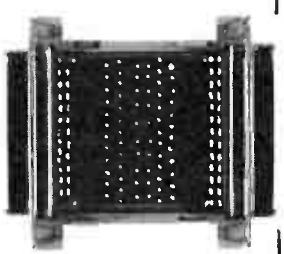
CAS8 MALE TO MALE GENDER CHANGER
CAS9 FEMALE TO FEMALE GENDER CHANGER

- Saves modifying or replacing non-mating RS232 cables by changing from male to female to male
- All 25 pins wired straight through

NOW STOCKING BOURNS TRIMPOTS



Continuing Geoff's policy of stocking only the highest quality components we have now added a range of Bourns trim pots. The PC board mounted types are available in three styles and many values are available ex-stock. Call us for full details, pricing etc.



$26.40

CAS4 RS232 MINI PATCH BOX

- Interface RS232 devices
- With male and female 25 pin inputs
- 25 leads with tinned end supplied
- Complete with instructions

CAS11 RS232C NULL MODEM ADAPTOR

- Male to female connections
- Pins 2 and 3 reversed
- All 25 pins connected

$19.90

TRUE RMS

EDM1346

• 4½ digits • 8 functions Vdc, Vac, Adc, Aac, Ohms, Audible Continuity, Diode test, Data Hold • 0.05% basic accuracy

ONLY $225.00 *ex tax ($258.75 inc tax)*

DC Voltage

Range	• 200mV 2V 20V 200V 1000V
Resolution	• 10uV 100uV 1mV 10mV 100mV
Accuracy	• 200mV 1000V (0.05% rdg + 3dgt)

AC Voltage (True RMS, AC coupled 10% to 100% of range)

Range	• 200mV 2V 20V 200V 750V
Resolution	• 10uV 100uV 1mV 10mV 100mV
Accuracy	• 200mV 200V
	@45Hz 1KHz (0.5% rdg + 20dgt)
	@1KHz 2KHz (1.2% rdg + 30dgt)
	@2KHz 5KHz (5.0% rdg + 40dgt)
	200V @2KHz 5KHz not specified
	750V @45Hz 1KHz (1.0% rdg + 20dgt)

DC Current

Range	• 2mA 20mA 200mA 2A 10A
Resolution	• 100nA 1uA 10uA 100uA 1mA
Accuracy	• 2mA 200mA (0.3% rdg + 3dgt)
	2A 10A (0.75% rdg + 3dgt)

AC Current (True RMS, AC coupled 10% to 100% of range)

Range	• 2mA 20mA 200mA 2A 10A
Resolution	• 100nA 1uA 10uA 100uA 1mA
Accuracy	• 2mA @45Hz 400Hz (2.5% rdg + 20dgt)
	20mA 200mA
	@45Hz 400Hz (0.75% rdg + 20dgt)
	@400Hz 1KHz (0.75% rdg + 30dgt)
	2A 10A
	@45Hz 500Hz (1.2% rdg + 20dgt)

Resistance

Range	• 200Ω 2KΩ 20KΩ 200KΩ 2MΩ 20MΩ
Resolution	• 0.01Ω 0.1Ω 1Ω 10Ω 100Ω 1KΩ
Accuracy	• 200Ω (0.2% rdg + 5dgt + 0.04Ω)
	2KΩ 200KΩ (0.1% rdg + 3dgt)
	2MΩ (0.15% rdg + 3dgt)
	20MΩ (0.5% rdg + 3dgt)

LORLIN QUALITY WAFER SWITCHES

If you're finding it hard to get the wafer switch you want for a particular project give Geoff a call. He can build to your order from the high quality Lorlin RA range - and up to 6 banks. The following configurations are available:

Poles	1	2	3	3	6	4	2
Positions	12	6	3	5	2	4	9

Contacts have a 5A rating with only 10 milliohm resistance. Diameter is 25.4mm.

8.30 to 5 Monday to Friday. 8.30 to 12 Sat
Mail Orders add $3.00 to cover postal charges
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All prices INCLUDE sales tax.
Tax exemption certificates accepted if line value exceeds $10.00

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$10.00 minimum

specialising in electronic components for the professional and hobbyist.

Over a switched network, the modem provides automatic answering as well as automatic disconnection. The telephone connection can be used alternately for speech and data transmission.

The DS 3565 works in two of the five modes specified in CCITT Recommendation V22; Mode 1 for synchronous data at 1200 bps, and Mode 2 for asynchronous start-stop data at 1200 bps + 1% to -2.5% and Bell 212. The DS 3565 can be used together with any modem complying with V22 A, B or C or Bell 212, EEL claim.

The DS 3565 is mainly intended for use at the subscriber site for duplex 2-wire communication over the switched network with a dial-in computer centre. Considerable savings can be achieved by using this simplified modem for the main traffic subscriber end and using normal modems with channel selection for the computer end, EEL say.

Manual or automatic operation is simply selected with the front panel membrane type switches. The automatic answer function according to CCITT Recommendation V25 connects the modem to the line after an incoming call has been received. The disconnect facility automatically releases the connection after loss of carrier.

Two parallel terminal interfaces are provided. In addition to the normal CCITT V28/ISO 2110 25-pin connector the modem also includes a simplified 7-pin interface with 5 V CMOS circuits. Both interfaces comply with CCITT V24 and include provision for power feeding from the terminal using +12 V or +5 V.

All control switches and LED indicators are located on the front panel, enabling easy selection of the functions and test mode. Operation instructions are provided on a card accessible from the front of the modem.

Further details from **EEL Communications, Electrical Equipment Limited, 33 Bellona Avenue, Regents Park 2143 NSW. (02) 645 2777.**

More speed for Avtek Multimodem

Avtek Electronics has done it again with the release of a high speed (1200/1200 baud) enhancement for their popular Multimodem II. The Multimodem already supports all the usual standards (300/300, 1200/75 and 75/1200 baud rates) and the new high speed option is available as a built-in hardware addition, providing the highest speed currently available for data transfer on public telephone lines.

The price of the all-standard (V21, V22, V23) Multimodem will come as something of a shock to people used to seeing prices of $1200 — $1500 being asked for modems providing the V22 standard alone. The price, with V21, V22 and V23 standards at the flick of a switch, is $699 including sales tax, and Avtek expect to be selling a lot of modems.

According to Phil Gleeson of Avtek, we are likely to see a lot more of the high speed (V22) standard coming into use in the next few months. The 1200/1200 standard is "the only way to fly" according to Phil. In the United States it's very popular, and looks like taking over entirely in the long run.

The Multimodem is unique Gleeson claims, in providing a built-in expansion bus. The design has allowed the option of the advanced V22 circuitry to be a quick and easy addition, with no major redesign. It also means that existing owners of Multimodem IIs can quickly and economically upgrade. "We don't build obsolescence into our modems," says Phil.

For further information, contact: **Avtek Electronics on (02) 427 6688**

Modems, networks and data communications

by Jon McCormack

By now, most of us are aware of the "computer revolution" which has taken place over the last few years. But the micro-chip is only part of a bigger revolution which is underway now as you read this – "information technology". Man is now storing, transmitting and receiving huge amounts of data, and it's not just computer programs. Electronic mail, music, pictures – anything. This article looks at some specific areas of "information transfer" – modems and networks.

THERE ARE TWO GENERAL WAYS computer data can be transferred — by serial or parallel methods. Parallel methods transfer more than one bit at a time — usually eight or 16 bits. This type of transfer is suited to short distances, since to transfer eight bits in parallel requires at least nine wires.

Transmission by serial methods involves transferring each individual bit one at a time. This means each 8-bit byte is broken into eight separate 1s or 0s and each of these is transmitted. As you would expect, serial transmission requires less wires and is usually reliable on low bandwidth transmission lines. However, serial transmission is usually slower than parallel.

The most common type of serial interface is RS232. It is also one of the biggest problem-causes in computer interfacing. There is a "standard" RS232, but you should never expect any RS232 interface to be standard. The "standard" was set by the AEIA (American Electronics Industries Association), quite some years ago now and was meant for the communication of terminals (data terminal equipment, DTE) and modems (data communications equipment, DCE). The RS232 connector has 25 pins — quite a few considering you only need two for communication.

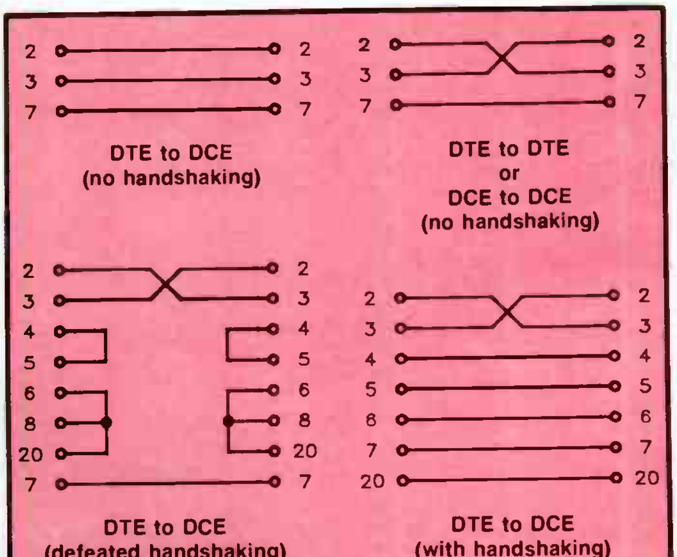


Figure 1. Common RS232 connections.

A lot of those 25 pins are not used these days and as such, some manufacturers decided to put those spare pins to non-standard use and that's where the problems began. The simplest RS232 connections require three wires for two-way communications. I don't propose to go into any greater depth about RS232. Suffice to study Figure 1 for the most common RS232 connections. (Or see *The ins and outs of RS232*, AEM, Nov. and Dec. 1985).

Data formats

With RS232, data is transferred by changing the voltage on the line. A "0" is represented by a voltage between +3 and +12 volts (called the "space" condition), a "1" is represented by a voltage between –3 and –12 volts (called the "mark" condition). Again, this is not true of all computers. For example, the Microbee does not supply negative voltages for the mark condition.

Since RS232 does not provide clocking signals, each byte of data transferred must have its own synchronising system. Normally, the line sits at the 1 (mark) state. In order for the receiving machine to know when a character transmission is starting the line jumps from the 1 state to the 0 (space) state. This condition signals that the data follows this bit. Similarly a "stop" bit or bits is sent at the end of each character transmission (always a 1).

Figure 2 shows what data transmissions look like. The actual number of data bits can vary from five to eight for

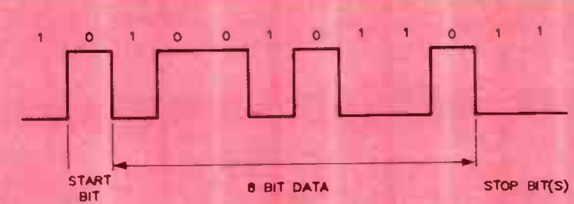


Figure 2. In an asynchronous transmission, each byte of data is a complete message in itself. A single 0 represents the start of the data (called the START bit). The data (usually 7 or 8 bits) then follows. Sometimes a parity bit (not shown) follows the data, then one or two STOP bits (ones).

This sequence of bits has described the data 1010010110, which is 96 in hexadecimal or 150 decimal.

This modem, model DS 3565 by Nokia, recently released by EEL Communications of Sydney, fits perfectly under most telephone sets and features 1200 baud full duplex transmission to the CCITT V.22b call mode standard as well as Bell 212. It automatically disconnects after loss of carrier. Two parallel terminal interfaces are provided.

different methods. However, it's usually 7 or 8. The number of stop bits is one or two. Sometimes a *parity bit* is sent (especially with 7-bit data) for error checking. The parity bit is sent right after the last data bit, just before the stop bit(s). There are two types of parity — odd and even. With odd parity, if the number of 1s in the data bits is odd then the parity bit is 0, if not it's 1. Even parity is the opposite.

Well, you might have guessed that there are a lot of combinations you can have — different computers use different types; most terminals allow changing of stop bits, parity etc.

Baud rates

The most important thing about connecting two RS232 pieces of equipment together is making sure they're both operating at the right speed. The measure of the speed of a line is called the "baud rate" and is the maximum number of changes per second that can occur in the line. If the speed is 300 baud and you have seven data bits and one stop bit (no parity), then the maximum speed that you can transfer is the baud rate in bits per second divided by the number of bits per character:
300/(1 start bit + 7 data bits + 1 stop bit)
= 300/9
= 33 characters per second.

If you had eight data bits, even parity and two stop bits on the same line, then the maximum speed that you can transfer is 300/(1 start + 8 data + 1 parity + 2 stop) = 25 characters per second.

Common baud rates are 110, 300, 1200, 2400, 4800 and 9600. Higher rates such as 19 200 or 38 400 are possible.

Modems

MOdulators-DEModulators have been with us for a while now. Modems take the computer's digital signal (e.g: an RS232 signal) and convert it to an analogue signal suitable for longer range transmission than RS232 can provide. Generally, modems are used to transfer data over the public telephone, or private leased lines. Before we look at modems, let's look at the principles by which they operate.

The use of telephones for communications is a technology older than that of present day computers, and thus use of the telephone system for transmission has meant an adaptation of the two systems. Telephone systems carry low grade voice signals and have a poor bandwidth (about 300-3000 Hz). Because of this, standard 'phone lines cannot transmit data at a very fast rate; that's why most modems operate at 300 or 1200 baud.

How is the data actually transmitted? First, the computer's digital signal is converted to an analogue one, i.e: a sine wave. The modem transmits a continuous sine wave at a preset frequency, called a "carrier". This carrier is transmitted whether or not data is transmitted. The carrier is *modulated* in response to the incoming digital signal. For the mathematically inclined, this carrier can be represented by the formula:

$$a_c = A_c \sin(2\pi f_c t + \Theta_c)$$

where:

a_c is the instantaneous value of the carrier voltage at time t.
A_c is the maximum amplitude of the carrier voltage at any time.
f_c is the carrier frequency.
Θ_c is the phase.

Now any one of these characteristics (i.e: amplitude, frequency or phase) can be altered to indicate a digital 0 or 1.

Amplitude modulation (AM)

The amplitude, or level, of the carrier (A_c in the above formula) is modulated according to the digital input [see figure 3(a)]. In a simple form, the value of A_c can be 0, or some constant K, giving a wave shape as in Figure 3(b). In more complex situations, several levels of amplitude modulation are possible; four levels [Figure 3(c)] will allow twice as much information to be sent in the same elapsed time. Amplitude modulation is *not* often used by itself due to transmission power problems and sensitivity to distortion.

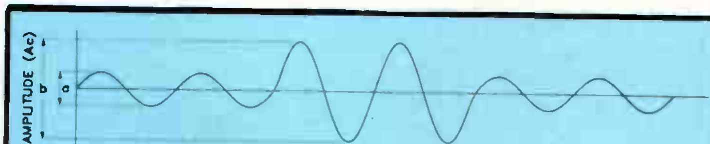


Figure 3(a). A sine wave with amplitude modulation. The two levels of amplitude (a and b) represent the binary 0 and 1. The frequency remains constant.

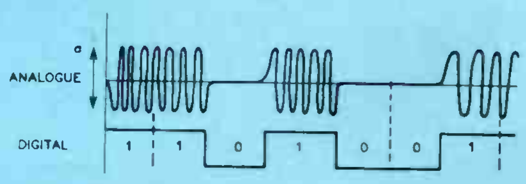


Figure 3(b). The simplest type of amplitude modulation (AM). Here the amplitude is either 0 (represents binary 0) or "a" (represents binary 1). The corresponding digital waveform which modulates the wave is also shown.

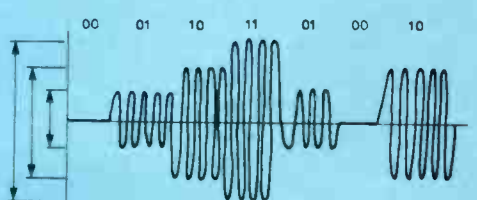


Figure 3(c). This shows more complex AM — here, four levels of amplitude are used, each level represents two bits. This allows twice as much data to be transmitted than with only two levels.

Frequency modulation (FM)

The value of f_c is modulated according to the input. Figure 4(a) shows the waveshape due to frequency modulation. A technique known as *frequency shift keying* (FSK) is the most common method used in modems. The carrier frequency is modulated up or down depending on the input. Multi-level modulation is also possible [Figure 4(b)]. FM is usually used up to baud rates of about 1800 and is less affected by noise on the transmission line than AM.

Phase modulation (PM)

The phase of the carrier (π_c) is varied [Figure 5(a)]. This is called *phase shift keying (PSK)*. As the figure shows, a phase change of +180° is the same as a −180° phase change, and thus the maximum range the phase can be varied is +/− 180°. Differential phase shift keying (DPSK — what else!) assigns a 0 to 0°-to-180° phase shift, at other times a 1 is assumed. Phase modulation allows up to around eight different phases [Figure 5(c)] allowing a lot more data to be sent over a given bandwidth than AM or FM.

As stated earlier, most modems (300 and 1200 baud types) use FSK techniques. Higher speed modems use phase modulation and frequency modulation. Currently, 2400 baud is the fastest modem you can use on the public switched network (called the 'phone by normal people). However, as technology advances (as the saying goes) we should see 4800 and 9600 baud modems in common use in the near future, that use multiple modulation techniques to achieve these speeds. Just imagine dialling-up your favourite remote CP/M system at 9600 baud!

Data transmission arrangement

There are three ways in which the transmission of data occurs:

(i) **simplex:** data is transmitted in one direction only, e.g: public address system; environment sampling system.

(ii) **half duplex (HDX):** data travels in both directions but only one way at a time. i.e: **A** may send to **B** and **B** may send to **A**, but *both cannot send at the same time.*

(iii) **full duplex (FDX):** data can be transmitted in both directions simultaneously.

Full duplex is the most common method of communication.

A modem's transfer of data is called an *asynchronous transmission*. This means that each character is sent individually. Because of this, each character has its own synchronising system. This mode of transmission is suited to irregular input, such as that from a keyboard. The actual data is proceeded by some *start bits* and some *stop bits*. This is illustrated in Figure 2. Normally there is one start bit and one or two start bits.

Standards

Yes, as in everything in computing, there are standards for data transmission via modems. Most of these "standards" are set by the International Telegraph and Telephone Consultative Committee (CCITT). The accompanying table shows some of the relevant ones.

The transmission line

The most common use of modems is for connection to the 'phone line. The maximum transmission rate of a line is called its "transmission capacity". This can be calculated by Shannons' Law:

$$C = W \log_2 (1 + S/N)$$

where:

C is the transmission capacity of the line, in bits per second.
W is the bandwidth.
S/N is the ration of signal power (S) to noise power (N) — the signal to noise ratio.

A voice-grade line with a 100-to-1 signal-to-noise ratio (note that this is not 100 dB) and a bandwidth of 2600 Hz yields a maximum rate of 17 311 baud. This is a theoretical value and in practice the maximum value is much lower. This value is not the speed of your modem either, as full duplex modems transfer twice as fast as their speed suggests.

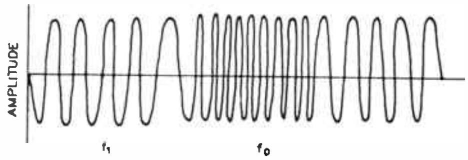


Figure 4(a). Frequency modulation (FM) involves changing the frequency of the sine wave according to binary input. Here, f_0 represents binary 0 and f_1 represents binary 1. FM, or FSK is the most common method used for slow-to-medium speed modems. It is also used in small home computers for reading and writing data onto a cassette. (You can't connect your cassette interface to the 'phone, however!)

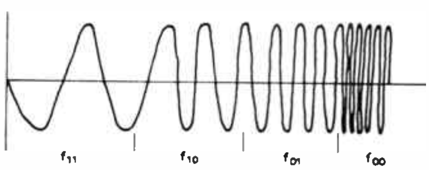


Figure 4(b). Multi-level modulation. Here there are four different frequencies which represent the binary 00 01 10 and 11. Four times as much information can be transferred in the same time as the two-level FM shown in 4(a). Practical frequencies for modem use might be:

f_{11} = 1300 Hz
f_{10} = 1600 Hz
f_{01} = 1900 Hz
f_{00} = 2200 Hz

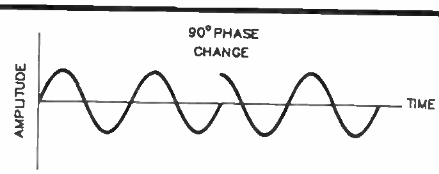


Figure 5(a). Phase modulation (PM, or PSK) is used in the higher speed modems. The diagram shows a phase change of 90°. This can be used to signify a '1'. At all other times a '0' is assumed. Note that with PM, the frequency and amplitude remain constant.

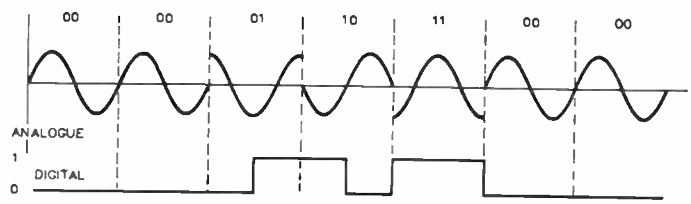


Figure 5(b). This shows "dibit" ('dye-bit' — meaning two bits) modulation — two bits of information per change on the line. In the example here there are four different phase cycles possible and each one indicates a particular combination of two bits. The corresponding digital input to modulate the resultant wave is also shown — strictly speaking this is not a good way to show the digital input, because before a phase change is made two bits must be received to decide which of the four phase changes is required.

RELEVANT STANDARDS

INTERFACE BETWEEN THE MODEM AND DATA-PROCESSING MACHINE

CCIT Recommendation

V.24 Definition of interchange circuits between modems and data terminal equipment.
V.25 Automatic calling and/or answering equipment and disabling of echo suppressors.

MODEM STANDARDS FOR USE ON THE SWITCHED TELEPHONE NETWORK

CCITT Recommendation

V.21 300 baud modem, full duplex.

Originate device:	logic 0 = 1180 Hz	logic 1 = 980 Hz
Answer device:	logic 0 = 1850 Hz	logic 1 = 1650 Hz

Answer tone frequency: 2100 Hz

V.23 600/1200 baud modem, half duplex.

Mode 1 = 600 baud:

Transmit:	logic 0 = 1700 Hz	logic 1 = 1300 Hz

Mode 2 = 1200 baud:

Transmit:	logic 0 = 2100 Hz	logic 1 = 1300 Hz

Provision for 75 baud backchannel:

	logic 0 = 450 Hz	logic 1 = 390 Hz

V.26b 2400/1200 baud modem, full duplex.
V.30 Parallel data transmission modems.
V.22 Standardisation of data-signal rates.
V.25 Automatic calling and/or answering equipment and disabling echo suppressors.

The CCITT standards apply to Australia and most European countries. However, in America the standards are "Bell" (from Bell Labs, now called AT&T, owners of the USA 'phone network).

Bell

103/113/108 300 baud half or full duplex modems
Originate device:
logic 0 = 1070 Hz logic 1 = 1270 Hz
Answer device:
logic 0 = 2025 Hz logic 1 = 2225 Hz

202 1200/600 half duplex, 75 baud backchannel
Transmit:
logic 0 = 2200 Hz logic 1 = 1200 Hz

201 2400 baud, 4-phase

212 1200 baud modem

208 4800 baud, 8-phase PM modems

Which type of modem?

After that swag of theory you're now wondering how it all relates to real world modems, and what sort of modem should you buy. It depends on what you want to access.

In Australia, most public access systems you can phone up required 300 baud V.21 modems (this includes most remote CP/M and bulletin board systems). Some now (or soon will) offer 1200/75 modem. If you want to talk to the folks overseas in the US of A you'll need a Bell-compatible modem as well, or a modem capable of Bell operation.

The fastest modem you can readily buy runs at 2400 baud, full duplex. Compared to 300 baud that's fast. Few public access systems in Australia have modems running this fast. However, in the United States 2400 baud is becoming quite common. As an example, local manufacturer, NetComm, makes and sells a 2400 baud modem that also has 1200/1200 and 300 baud. On top of this it has auto-dial, auto-answer, auto-hangup and auto-speed selection. Not bad for a box that fits under a standard phone!

The modem you buy will most probably depend on your budget. Most lie between about $150 and $3500, depending on speeds and features. Bear in mind that 300 baud is on the way out, 1200/1200 and 2400/2400 baud modems are the way of the future.

Networks

Most people have heard the word "network", few realise how general the term really is. A network in the computer sense is an arrangement of intersecting data lines. Connected to these lines are computer devices. The purpose of these lines is to allow several computers to communicate to each other and more complex networks allow several machines to share files and/or resources such as disks, printers or terminals. Points where the data lines intersect are called "nodes" — one (sometimes more) computer(s) or peripherals can be connected to each node. The network software/hardware allows transfer of data from one node to another. If the two nodes are not connected directly together then the data is transferred via other nodes (called "routing"). ▶

Avtek's popular "Multimodem" has been enhanced several times since it came on the market a few years ago. The latest model features operation on CCITT standards V.21 (300 baud full duplex), V.23 (1200/75 baud, including Viatel) and V.22 (1200 baud full duplex). The Bell modes can also be selected. Locally manufactured, it has the unique facility of an internal expansion bus for later add-ons. It costs $699 fully optioned.

You may wonder why you can't just connect all the nodes together so each node is connected to every other node, thus allowing data to be transferred directly from any node to any other. There is no reason why you can't. However, if each of your nodes are in, for example, Melbourne, Sydney, Perth and Darwin, the cost of connecting each city (node) to every other would be very expensive, and probably not worth it anyway.

The path a message may take depends on factors such as line load and state of the line (i.e: if it's working or not). Efficient routing algorithms have been the subject of much research by computer scientists, who are always looking for ways to make transfers more efficient. The network allows one node (computer) to talk to many different computers, not necessarily all at the same time (see Figure 6). The most common example of a network is the phone system — the public switched network [Figure 6(b)]. One computer can connect to many different computers, simply by dialling up the desired node. There are many other networks; I'll briefly explain them as a complex study of networks is a book in itself.

Telecom-provided networks

As Telecom are responsible for landline communications in Australia, they offer a number of data transfer and communications facilities and networks.

A network known as "packet switching" requires that data from each node is sent in quantised "packets" (see Figure 7). The packet switching nodes are computers, not circuit switching exchanges as in the normal telephone system. All messages must be in a special format, which usually includes both source and destination address. When a message reaches a node, it is stored in memory then sent to either another node or to a user.

The path a packet takes to travel from A to B may vary each time it is sent, depending on line loading or failures. Telecom has its own packet switched network — "Austpac" which was introduced in 1982 and operates on a nationwide level with links to international packet switched networks. On Austpac, each packet contains the data, call control information (such as destination) and error control information. Packets may contain up to 1K of data. Charging is dependent mainly on the amount of data sent, not on distance, i.e: it costs the same to send 1K of data from Melbourne to Sydney as from Melbourne to Perth. You can access Austpac via Telecom installed nodes or by dialing a node via the telephone system. The phone system itself is not part of Austpac.

Telecom also provides the *Datel* service which is more suitable for sending large amounts of information between fixed locations as a permanent connection must be made.

Viatel is another service offered by Telecom, but is not strictly speaking a network. Viatel allows registered users with the proper modem (1200/75 V.23) and terminal (or computer with terminal emulator) to access the Viatel computer. The user can then do things such as find out stock exchange information, weather, do banking from home, order equipment, send a telex anywhere in Australia, etc.

Figure 6(a).

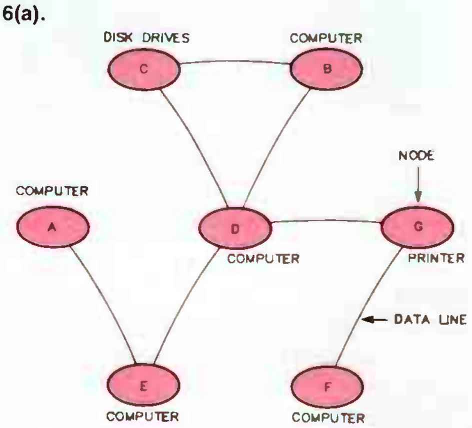
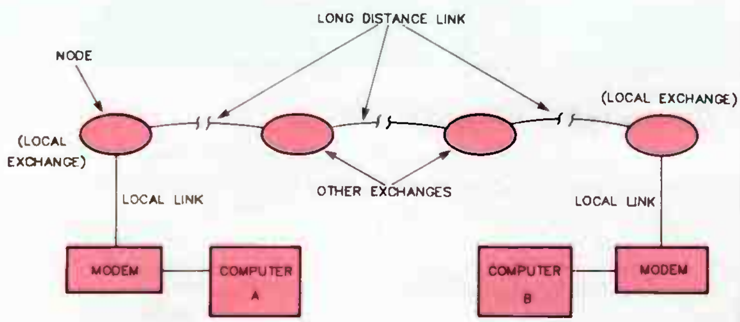


Figure 6(b).



In Figure 6(a) we see a representation of a computer 'network'. Each of the oval shapes represent nodes: connected to each node may be a computer or peripheral device such as a printer. The lines that link each node are called "data lines". It is important to realise that the distance between two nodes may be as little as a metre or as great as the distance from Sydney to Perth. Since not all nodes are connected together, if for example Node A wishes to send a message to Node F, the networking software must work out the most efficient route to send the message. This is not just the shortest distance. The message may travel via nodes E, D and G to reach F.

In Figure 6(b) we see the public switched network (telephone system). Here, each node is the local exchange. In order to reach another 'phone, which may be interstate or even overseas, several exchanges connected via long distance links must be used — routing is at work again here.

Viatel is dialled-up on the phone from anywhere in Australia and you are only charged the cost of a local call. Viatel is in effect a giant *electronic magazine*, with a number of organisations (called "Service Providers or SPs) having pages in the magazine. Sometimes you are charged to look at SP's pages, but usually it's no more than about two or three cents per page. One of the most exciting facilities about Viatel is it's *electronic mail*. For five cents you can send a letter to any registered user, anywhere in Australia — rates are distance independent.

Every user has a special number called the Viatel number, which is like a person's address. For example, my number is 359263270. If someone wants to send a letter to me they must know my number. However, 9-digit numbers are a bit hard to remember so Viatel provides an alphabetical list of registered users which you can look at to find a person's number. While Viatel is very simple, without the features of most RCPMs etc., it does have huge amounts of information and Australia-wide coverage which really makes it quite powerful.

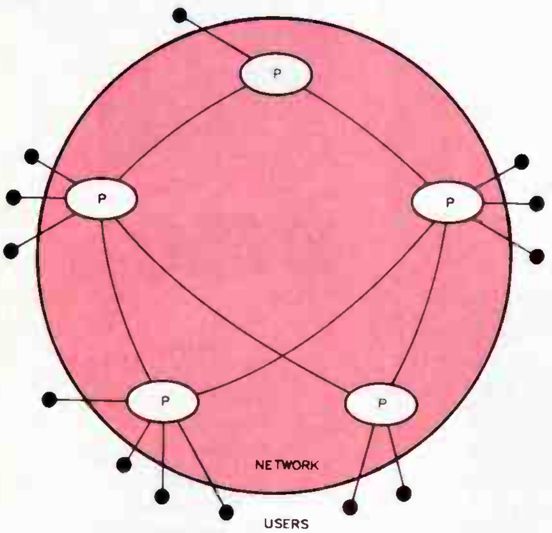


Figure 7. Here is a packet switching network. The packet switching nodes are computers, not circuit switching exchanges as in the public switched network. All messages must be in a special format including some form of destination address. When a message reaches a node it is stored in memory then forwarded either to a user or to another node. The route a message takes may vary according to line loading or line failure.

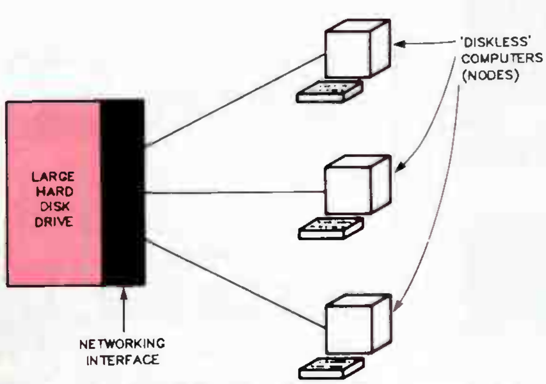


Figure 8. A networked file server incorporates a high speed local area network (LAN) to allow several diskless computers to share one large disk. The performance of file-served machines as opposed to disk machines is similar, but costs are less if many machines are served by one large disk.

Local area networks

Another common type of network is the "Local Area Network" or LAN for short. LANs are used to connect computers separated by a small distance, such as the same building. LANs usually operate at very high speeds, up to 10 million bits per second is common. Data is usually transferred via coaxial cable or optical fibres as these media have a very high bandwidth. Because of the speed more complex operations are possible rather than just "electronic mail" or file transfer.

"Network File Servers" used on LANs allow several diskless computers to use one large disk (see Figure 8) at speeds similar to those with in-built hard disk drives. LANs are popular for use with personal computers and minicomputers. Most network software allows such things as file and node access protection, priority message transfer etc. One of the most popular minicomputer LANs is "Ethernet", mostly used on UNIX machines, but becoming available for PCs. Ethernet allows transfers at a speed of 10 Mbits/sec and accepts a wide variety of communications standards. Many LANs (sometimes pseudo LANs) are available for IBM PC-type computers, most of these are of limited use as they have no standards for connecting to other computers as they rely heavily on PC compatability and thus are not as general as, say, Ethernet.

Network software is a highly specialised area with a great deal of research work still underway to provide better and faster communication between computers. One Australian piece of software, "ACSnet" (Australian Computer Science Network), allows a large degree of transmission media independence (i.e: it does not care if two nodes are connected by coax or telephone, nor at what speed they transfer data).

ACSnet software was developed at Sydney University and is distributed by the Computer Science department there. ACSnet has replaced the UNIX program UUCP in Australia ▶

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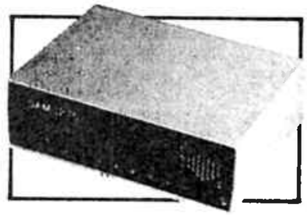

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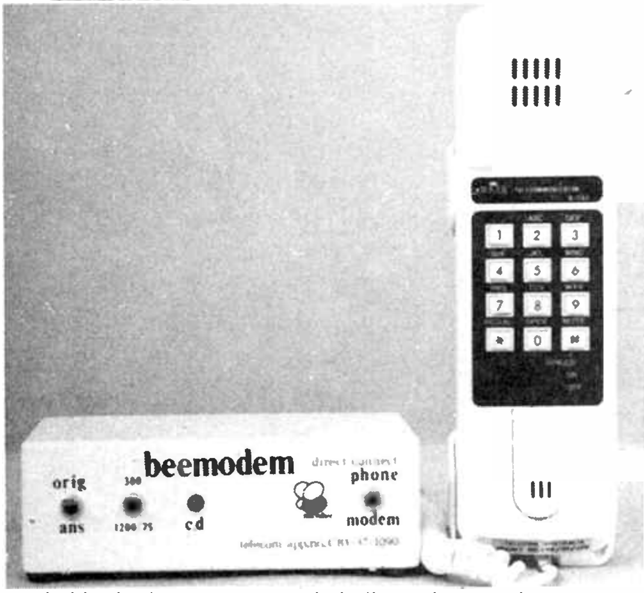


Probably the lowest-cost ready-built modem on the market (at $189.50) is Microbee Systems' "Beemodem". Though made specifically for the locally-produced Microbee, it can be used with any computer having an RS232 port and terminal software. It features both 300 baud (V.21) and 1200/75 baud (V.23/Viatel) operation and comes with the 'phone handset.

as it is more secure than UUCP but still allows all the network niceties such as electronic mail and file transfer. The Sydney-based RUNX public access system allows users to use ACSnet and many other public dial-up systems are considering its installation.

In addition to normal communications many networks provide special connections to other networks or computer systems. These are called "gateways". Gateways open a channel to other networks or computers. Depending on the situation, facilities available may be more limited than those available on the host network. To connect to some computers, the user may (directly or indirectly) have to access several gateways. Gateways therefore are a type of network in themselves.

Conclusions

We've covered a lot of ground yet only touched the surface of the world of information technology. Future trends show much more networking between all sorts of computers. There may be a day not too far away when the disk drive you use on your PC is located hundreds or thousands of miles away — with performance the same as if in-built.

The trends are to all-digital transmission, optical fibre technology and satellite transmissions. As systems performance becomes faster we will see more complex things than just "electronic mail" — pictures, books, music, films etc., can all be turned into 1s and 0s.

One day a person will be able to access virtually all the recorded information in existence — far more than any individual can comprehend in one lifetime. These concepts are very frightening if their use and accessibility is not carefully considered — we need to be the masters of information technology, not its victims.

Well, enough of the "1984" stuff, if you want to find out more about IT, I can recommend *Data Communications, Networks and Distributed Processing* by Ulyess D. Black — Reston Publishing (Prentice Hall) Co. The book is much more technical than this article but still explains the basic concepts and is easy to understand. Telecom also provide many booklets on their data communication services, available from your local Telecom business office.

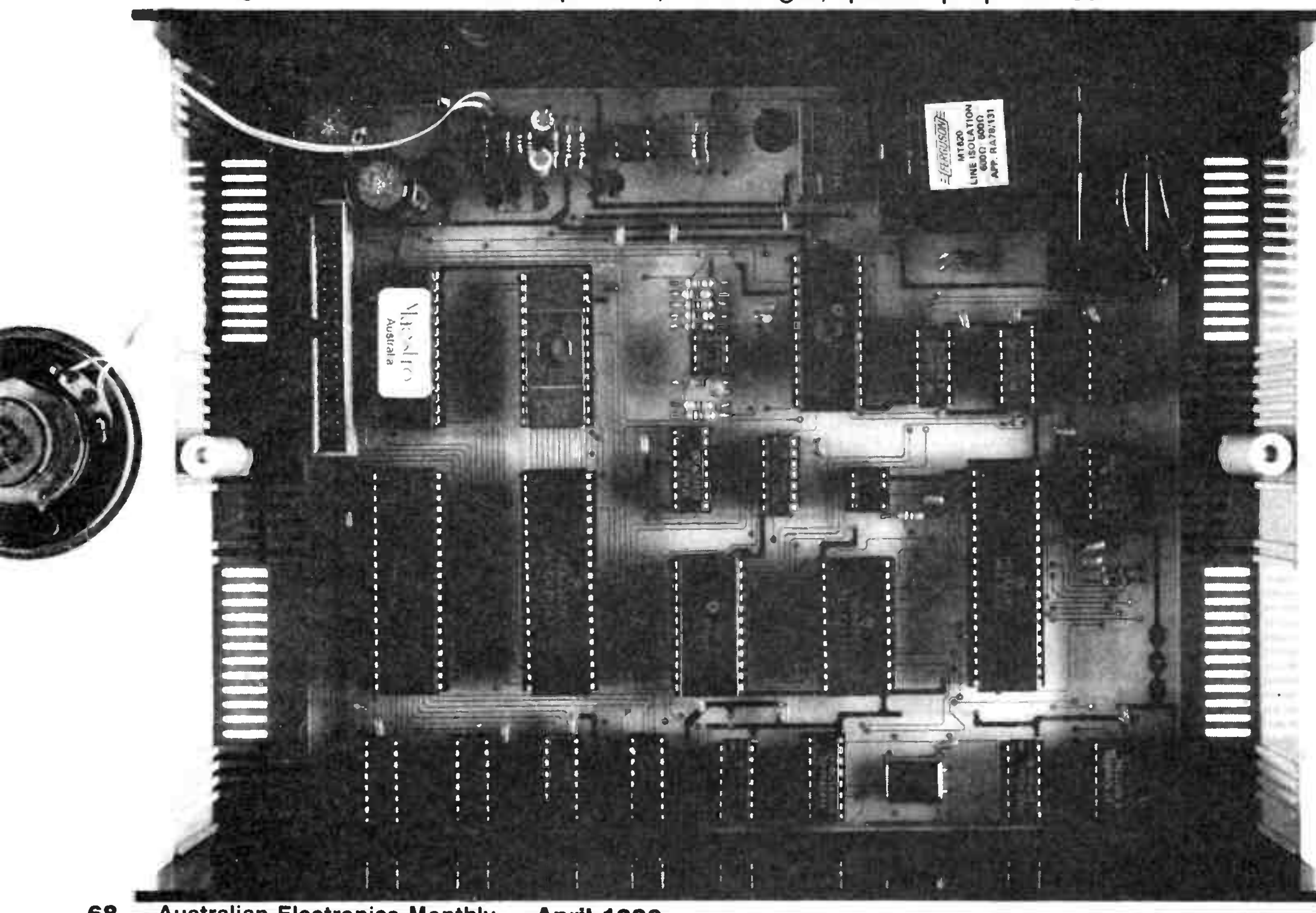
aem project 4610

A software-driven *super* modem project

Chris and Dan Darling – design
Roy Hill – articles

Part 1

If you drew up a "wish list" of everything you wanted in a modem, you'd likely draw up the specification for this project. Firstly, and most importantly, it can be used with *any computer* that has an RS232 serial interface and suitable communications or terminal software. It features the capability to operate on all of the CCITT V.21 (300 baud) and V.23 (1200/600/75 baud) signalling standards plus the Bell 103 (300 baud) and 202 (1200/75/5 baud) standards. In addition, it has auto-dial/auto-answer features and tone-dialling capabilities. All functions are selected from a menu, operation being controlled by its own internal microcomputer system. And it doesn't cost 'an arm and leg' for a kit or contain expensive, hard-to-get, special purpose ICs.



IF YOU CANVASSED many computer users, who'd had experience with a modem, about the characteristics of their 'ideal' unit, you'd hear them saying such things as — "... faster than a speeding ASCII bit, more powerful than a block move, able to leap tall downloads in a single ..." — you know that we mean. Simple, low cost, switch-operated modems are fine as "starters" units, but constant dialling, operating the 'phone/modem' line switch, hanging up and going through it all again, tends to pall after a while. 'Smart' direct-connect modems with all their functions totally software driven, where you are able to select operating mode and dial a number that may be stored on your computer's disk for example, appeared on the commercial market some years ago. The convenience and flexibility of this arrangement is immediately clear and is a trend that has accelerated rapidly. Their price, however, is *fearsome*, principally because they are aimed at a strictly "commercial" market and secondly, as they are imported, unfavourable exchange rates and import duty force up the final price to the customer here.

For the many not so well-heeled who need an efficient solution to a data communications need — schools and hobbyists particularly — the project presented here should fulfil the majority of requirements for a 'smart' direct-connect modem.

Features

Of principal interest is the set of signalling modes the modem supports. They are as follows:

a) CCITT V.21 300 baud, full duplex.
b) CCITT V.23 600 baud, half duplex, 75 baud back channel.*
c) CCITT V.23 600 baud as above, but with soft turn off.
d) CCITT V.23 1200 baud, half duplex, 75 baud back channel.*
e) CCITT V.23 1200 baud as above, but with amplitude equaliser.
f) CCITT V.23 1200 baud as (d), and with soft turn off.*
g) CCITT V.23 1200 baud as (f), but with amplitude equaliser.
h) Bell 103, 300 baud full duplex.*
i) Bell 202, 1200 baud half duplex with 5 baud back channel.
j) Bell 202, 1200 baud as above, but with amplitude equaliser.
k) Bell 202 1200 baud, half duplex, 75 baud back channel.
l) Bell 202 1200 baud, as above, but with amplitude equaliser.

Additional features include:

- Complies with Telecom requirements
- Fully software driven; no other controls
- Software in EPROM gives ability to upgrade later
- Auto-dail capability
- Auto-answer capability
- Auto-hangup capability
- Tone-dialling capability
- Bit rate conversion in either direction
- Line monitoring speaker
- Expansion bus to accommodate future add-ons
- 8K RAM buffer (with optional battery-backup)

Background

Brothers Chris and Dan Darling own and operate a business called "Maestro," which they started some five years ago. Maestro is located on the Central Coast of NSW, just north of Sydney. Initially, they did preliminary electronic design and programming under contract, along with electronic organ servicing (these days, the beasts are all microprocessor controlled and contain substantial digital circuitry). Their aim was to get into computer-oriented work.

They saw a need for locally-produced modems when Telecom's Viatel videotex service was launched as the prices of imported modems appeared prohibitive for many potential users. Chris and Dan set about to design a modem and accompanying software package for Apple II owners. Known as the "Apple II In-modem" (as it's a plug-in unit), the final product was launched last year as a ready-built direct-connect unit complete with videotex software, retailed through George Parry's *Micro-Education*. It is a highly successful product. Following the success of this unit, they will release a new Maestro Apple modem shortly, and are looking towards the export market.

The modem design presented here commenced as a unit designed to address the IBM PC and compatibles market which Chris and Dan perceived required a smart modem as IBM users, in their experience, tend to demand more than Apple users. They set down a broad specification and commenced some design research which resulted in a 'lash-up' prototype substantially as per the block diagram shown here. It became obvious, though, that it would suit any computer with an RS232 interface. Having got that far, it became apparent that adding an expansion bus to permit add-ons, especially V.22 1200/1200 baud capability, was a natural progression for the tendency in the market at present is for users to buy two separate modems, one with V.21/V.23 capability and a separate V.22 modem.

An essential part of the design philosophy was to employ readily available, second-sourced ICs and other components throughout to obviate problems with component supply in the first place and servicing difficulties at a later date with installed units.

At the stage where they had the majority of features worked out and a substantial working prototype, Chris and Dan approached the magazine suggesting it would make an interesting and popular project. We could but agree. In addition, we saw an opportunity to promote Australian electronic entrepreneurial endeavour. So, local technical writer Roy Hill was commissioned to write the necessary articles and documentation.

As Maestro has the stocking and assembly facilities, they are able to offer both kits and built-up units via mail order. Kits will be priced below $300, built-up units (Telecom approved) priced below $400. This offers a substantial saving over imported units. Additionally, Maestro also has available a 'Viatel Communications Package' in either Apple or IBM format on 5.25" disk at under $20 for a limited period.

Roger Harrison

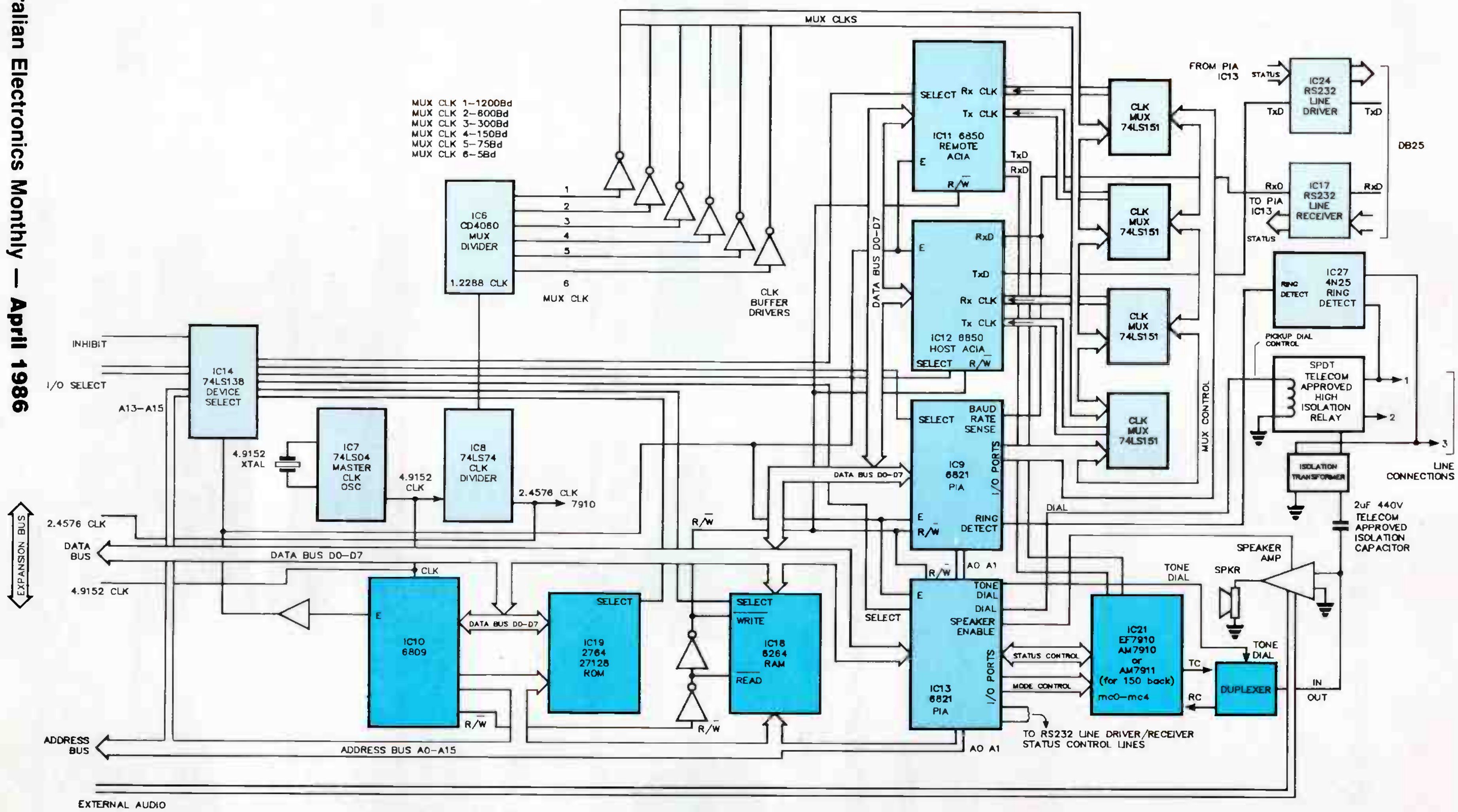
The Circuit Overview will explain salient points of the various features. The expansion bus provides for later hardware add-ons, while the EPROM permits later software enhancements — the two going hand-in-hand. Add-ons planned as future projects in the magazine include:

- V.22 (CCITT) 1200 baud full duplex operation
- A *reliable* EPROM programmer
- Real time clock
- ASCII-to-speech converter

◀ **Here's a photograph of the prototype. A double-sided, plated-through hole board with solder mask is used and the whole unit mounts neatly in a readily available, low-cost, sturdy plastic instrument case. The expansion bus connector can be seen at the rear left hand side of the board. The layout is quite 'open', making assembly a relatively easy task. Note the use of IC sockets throughout.**

* *Note: A 150 baud back channel is available as an optional selection with these modes.*

Overall block diagram of the *Super* Modem.



System software

The software to drive the system is written in 6809 assembly language and is contained in the EPROM. The software only takes up a small amount of the space inside this EPROM (currently a 2764 — 8K x 8), leaving plenty of room for the future addition of software drivers for the proposed expansion boards. On receiving a select signal from the host computer via its RS232 port, the modem sends a menu selection to the screen. This menu selection looks like:

```
  ---------------------------------------
  !    ****        MENU          ****  !
  ---------------------------------------
  !      RECEIVE       !      TRANSMIT !
  ---------------------------------------
A !       1200         !      BRC    75 !
B !       1200         !             75 !
C !  BRC           75  !      1200      !
D !                75  !      1200      !
  ---------------------------------------
E !       300          !    ORIGINATE   !
F !       300          !     ANSWER     !
  ---------------------------------------
  !          CURRENT    STATUS          !
  ---------------------------------------
A !       1200         !      BRC     75!
  ---------------------------------------
```

Let's take a look at some aspects of the menu. BRC refers to Bit Rate Conversion — a means of converting low bit rates to high bit rates and vice versa. This allows for conversion of 1200 to 75/75 to 1200 in either direction and also supports baud Bell 5-150 bit rate conversions from 1200 bps (baud). This is essential with some computers (e.g: the Commodore 64).

The appropriate transmission/reception rates are selected by pressing the corresponding alphabetic key. The selection chosen (or the default selection when first fired up) is displayed in the CURRENT STATUS window. Further options are available through the use of CONTROL keys and the menu may be extended when further options e.g: 1200 baud V.22 full duplex become available. A detailed discussion of these codes and their corresponding selections will be covered later in this project. However, regardless of the codes or their corresponding selctions, all I/O is handled through the 6809.

The main use of the 8K CMOS RAM chip is to provide buffer space for incoming/outgoing data. The buffer is a fully re-circulating type. It is not necessary to empty the buffer completely before it starts filling again. The 6809 keeps track of the current location of the buffer pointer and simply overwrites old transmitted/received data with fresh data. The buffer is capable of being battery-backed and circuitry is provided on the board for this purpose. An external NiCad battery (i.e: external to the board, but inside the case) will have to be supplied by you.

If the modem is disconnected from the computer, but still has the power applied, it is still possible to receive incoming data. A message stored inside the EPROM warns the sender that the modem is not connected and that only 8K of RAM is available for the reception of data. Any transmissions received whilst the modem is disconnected can be examined when the modem is reconnected to the computer.

The auto-dial feature of the modem will try to ring a number five times before giving up. The modem dials the number, and if it is engaged, waits 20 seconds and then tries again. After five unsuccessful attempts the modem disconnects from the line ('hang-up'). As mentioned previously, an on-board speaker allows audible monitoring of the dialling process. For monitoring exchanges which do not have fast switching mechanisms, hitting the space bar during the entering of a number will insert a delay (pre-determined by the firmware) into the dialling sequence to allow the exchange to catch up. More details on the software will be given in a following article.

Circuit overview

The heart of the circuit is a Motorola MC6809 high performance 8-bit microprocessor (IC10). This unit was chosen to provide the versatility of operation that a project of this nature requires. The memory map for the microprocessor is quite simple — an 8K CMOS RAM chip (IC18) occupies the very bottom of memory (locations 0 — 2048 decimal, 0 — $800 hexadecimal) and an EPROM (IC19) occupies the very top of the memory map from locations 49 152 — 65 535 decimal, $C000 — $FFFF hexadecimal. The EPROM supplied is in 8K type 2764 and it splits this area in two identical halves. That is, the contents of the top 8K of memory is echoed in the bottom 8K. A jumper location on the board will later enable the selection of a 16K EPROM, to occupy the whole of this space. This will enable future projects to be accommodated, without requiring extensive hardware modifications to the board.

The modem part of the project employes the popular AMD/Thomson 7910 World Modem chip (IC21). Four 74LS151 multiplexers drive two MC6580 ACIAs (asynchoronous communications interface adaptors — ICs 11 & 12). Two of the multiplexers control the transmit mode on the 6850 and two control the receive mode. Separating the receive/transmit units in this manner allows split bit rates to be easily accommodated.

The system clock is a standard crystal controlled oscillator running at 4.9152 MHz. This frequency is divided twice, by a 74LS74 (IC8) and this divided frequency is used to drive the 4060 (IC6) divider. This divider provides all the necessary frequencies to produce the required bit rates mentioned in the introduction.

Two MC6821 PIAs (peripheral interface adaptors ICs 9 & 13) provide the control lines necessary to activate the various features of the modem and a 74LS138 3-to-8-line decoder (IC14) is used to provide chip select logic. A spare line of this decoder is reserved for future expansion boards.

Power-on-reset is handled by a 555 timer in the one-shot mode.

Serial transmission/reception to and from the computer is handled using 1488/1489 line drivers/receivers (ICs 24 & 17).

Isolation of the line is provided by means of T1, a 3.5 kV isolation transformer, and a 4N25 opto-isolator. Amplification of the incoming signal is handled by IC20, an LM301. An on-board speaker provides for monitoring the line. In order for the user not to be driven insane by the continual wailing of the carrier signal, the speaker is automatically switched off two seconds after the carrier is detected.

The whole project may be powered by a plug pack or other external power supply delivering a nominal 16 Vac at 1.5A.

MODEM OF THE FUTURE

Digital signal processor chip is ideal for high speed modem

By substituting software for logic hardware, a single-chip microcomputer geared to signal processing can perform all the functions of advanced modems for ordinary phone lines at low cost.

DIGITAL signal processing (DSP) encompasses a wide variety of applications ranging from high speed modems to spectrum analysers. The chips are usually used in real-time, computation-intensive operations. They require techniques such as parallel on-chip hardware, special input/output (I/O) connections and a reduced-instruction-set-computer (RISC) instruction set. This level of computational power opens markets and applications that were not previously cost-effective. These include speech analysis, synthesis and recognition; high-speed modems; digital filtering; spectrum analysis; telecommunications; and image processing.

Using a single-chip signal processor as the basic building block, a low-cost, high-speed modem can be implemented to operate over unconditioned lines via the commercial switched telephone network. Economical performance is made possible because of the resultant modem's ability not only to adaptively equalize dial-up lines for high-speed transmission, but also to achieve superior bit-error rates.

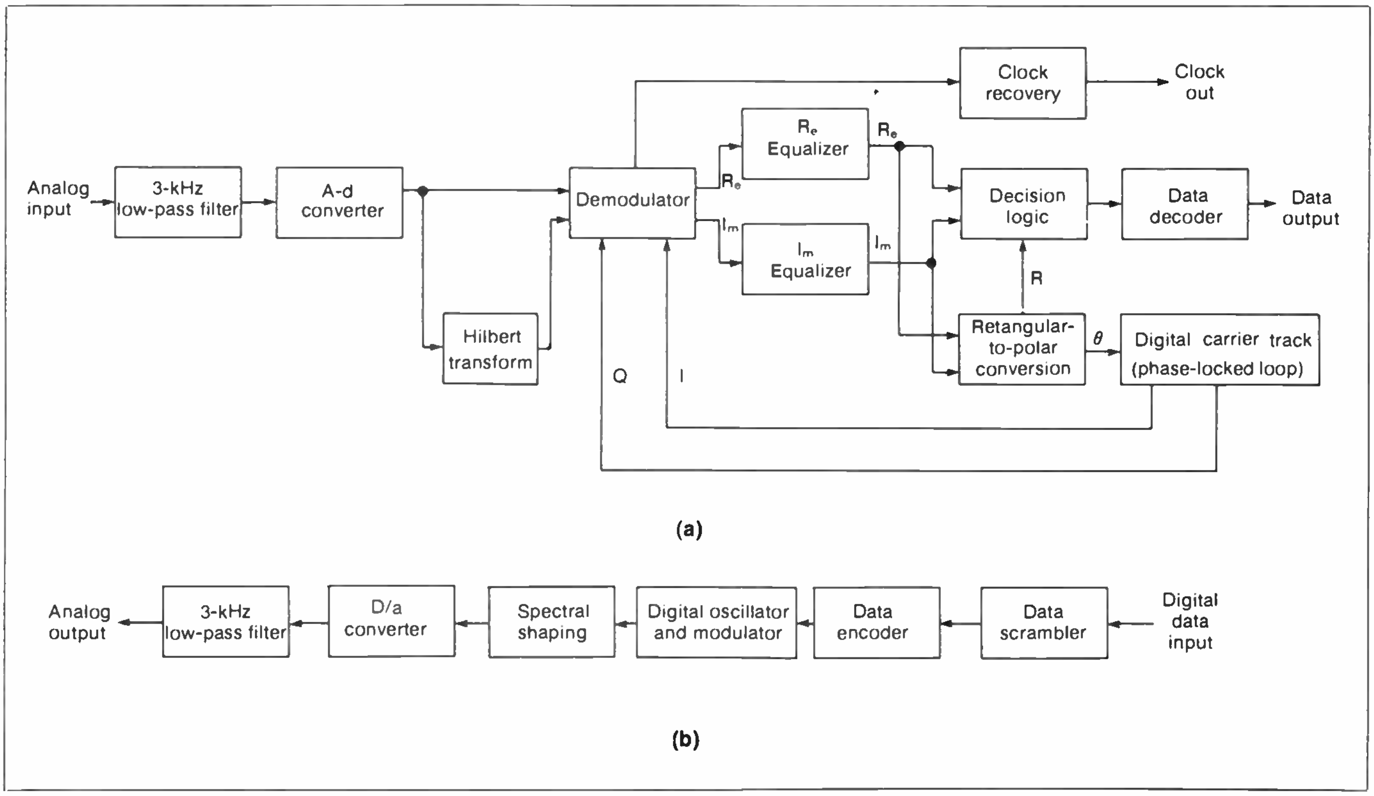


Figure 1. This generalized high speed modem, for both transmission (a) and reception (b), can be adapted to a variety of modulation formats with a wide range of speed options by merely changing the stored program in the TMS320 microcomputer's ROM.

This engineering feature is presented using information compiled from material kindly supplied by Texas Instruments Australia Pty Ltd, to whom we are indebted for permission to reproduce the diagrams and photographs.

Adaptive modem on a chip

The Texas Instruments TMS320 one-chip microcomputer can be programmed to produce either a phase- or a frequency-modulated synchronous signal and to demodulate (detect) such signals. Also, the carrier frequency and bit rate can be selected to be compatible with almost any available high-speed or low-speed modem.

A versatile, high-speed modem structure, as illustrated in Figure 1, permits the implementation of several modulation formats with various speed options from common hardware (the 320) controlled by a stored program. (The hardware for an external clock and other functions are not shown.) For example, a 320's subroutine-module feature allows calling a frequency-synthesizer routine by different modulator programs. In addition, a basic filter algorithm can be changed simply by altering functions from memory. Also, since the modem is not needed until a communications link is established, the 320 can provide auto-dial and tone dialling dual-tone multifrequency (DTMF), signals.

The digital input bit stream for transmission is often first 'scrambled' for securing the data and then applied to a digitally implemented phase shift-keyed (PSK) oscillator and modulator algorithm whose output goes to a bandpass filter that shapes (and limits) the spectrum of the transmitted signal. An external 12-bit digital-to-analogue converter, followed by a 3 kHz low-pass filter provides an analogue-signal output suitable for a 'phone line.

Received signals from a 'phone line are first filtered by a 3 kHz low-pass filter. Usually, an external hardware automatic gain control (AGC) loop is used, but a digital loop can be implemented if the analogue-to-digital (A-D) converter that follows the 3 kHz filter has sufficient dynamic range. the A-D output is applied to a 'Hilbert demodulator' algorithm (implemented as finite-impulse-response filter, as explained later). Decision logic determines which of the allowed, or expected, phases is closest to the received version and sends out corresponding data to a descrambler (if needed) to recover the bit pattern originally transmitted.

A baud-sync-recovery phase-locked loop monitors the bit train state transitions, using them as a reference for establishing baud synchronism, as well as the bit-sync clock and other major clock signals from a common external oscillator source.

All the other associated modem functions can be easily controlled by a host processor. For these ancillary communications functions, such as full-duplex operation, echo suppression, automatic equalization and error correction, two or more 320 signal processors can be combined, operating in parallel or in a 'pipelined' fashion.

Making a sine generator

The 320 digitally implements a sinusoidal generator that can synthesize sine waves with frequencies of 0.5 Hz to abut 4 kHz in 0.5-Hz steps with just a modest amount of memory and computation time.

A look-up table supplies the value of the sine for a given angle. To generate a sinewave frequency, the angle, α, must be continuously incremented.

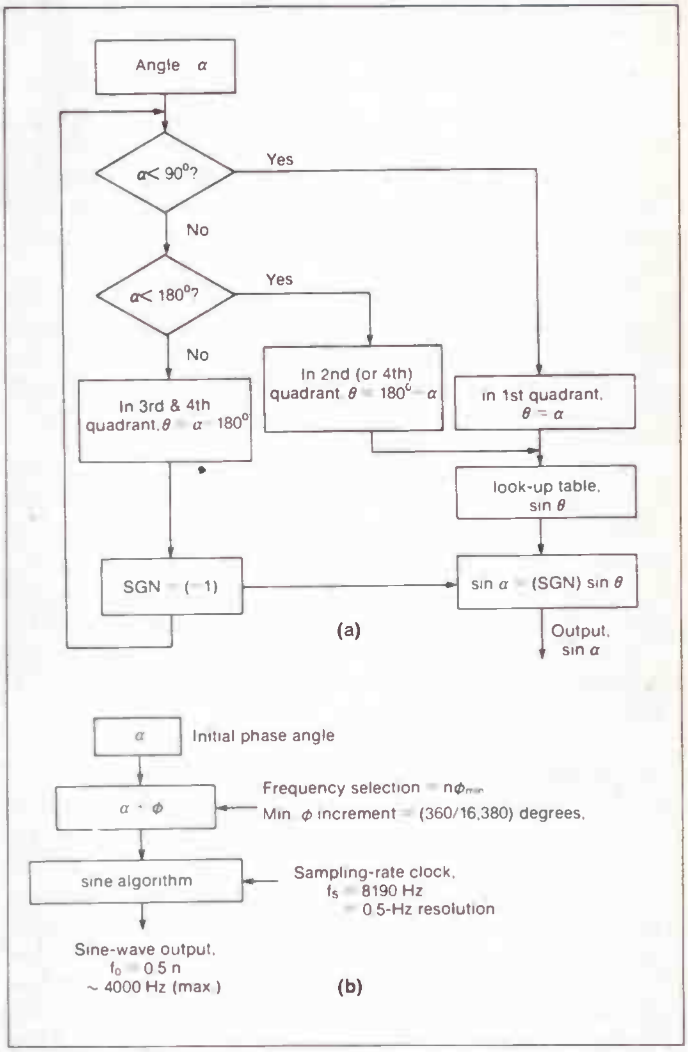


Figure 2. The sine of any angle, α, can be determined with just a 0°-to-90° look-up table and this algorithm, (a). If $(\pi/2)-\alpha$ is taken as the angle, the cosine of α is determined. Advancing α or $(\pi/2)-\alpha$ in successive incremental amounts, ϕ, generates respectively a sine or a cosine wave (b). The algorithm therefore functions as a frequency synthesizer whose frequency output can be determined by the size of ϕ and the clock rate of the algorithm.

The look-up table output represents a digital sinewave function that oscillates at a frequency depending on the rate, f_s, at which the output process — called sampling — is carried out.

In this overall process, called frequency synthesis, α is incremented by an equal integral amount, ϕ, every time a sample (or look-up) is taken. The incremental angle represents a phase advance, and the number of such advances per four-quadrant sinewave cycle with a 12-bit resolution look-up table is $4(2^{12}-1)$, or 16 380 steps. Thus, for a sampling frequency of, say, 8.19 kHz, the frequency resolution of the frequency synthesizer is 8190/16 380, or 0.5 Hz. Keeping the sampling frequency constant, an initial angle must be incremented by ▶

a ϕ of 2400 steps (52.7473°) at every sampling time to generate a 1200Hz sine wave (Figure 2b).

Shift-keying the frequency

We can generate a frequency-shift keyed (FSK) output by changing the value of ϕ in Figure 2 by small increments, $\Delta\phi$, added at every sample. The corresponding frequency changes are then used to identify different parts of a data stream. Multiple values can be used for a multi-FSK system.

By changing the value of ϕ and adding that to just the *first* sample of an identifiable data part, the *phase only* of that part is shifted (the frequency remaining unaltered), and a phase shift keyed (PSK) signal is generated. As with frequency-shift keying multiple ϕ values may be used for a multi-PSK system.

Modifications of the frequency synthesis algorithm can produce a host of functions other than FSK and PSK for a modem, including dual-tone multifrequencies for automatic dialling, linear frequency modulation, amplitude modulation, and pulsed (tone-burst) signal generation. In addition, like an analogue voltage-controlled oscillator, this 320-implemented frequency synthesizer can be used as a VCO to implement a digital phase-locked loop.

A phase-locked loop in digital form

Modem receivers use phase-locked loops for carrier tracking and coherent demodulation of an incoming complex signal, α_r (Figure 3). The 320 can be programmed to perform the phase-locked function digitally. An FSK signal generator (as previously described) serves as the VCO, and phase detection consists simply of taking the difference between the VCO's digital output and the received carrier signal, which at this point is assumed also to be in digital form. After processing through a digital loop filter, $\Delta\alpha$ becomes $\Delta\phi$ for the FSK — or in this case for the VCO — algorithm. The output of the VCO represents the input signal's carrier frequency, highly filtered of noise and data, but still following any slow variations of the input carrier's frequency or phase. In effect, α_o is the carrier "extracted" from the input, α_r.

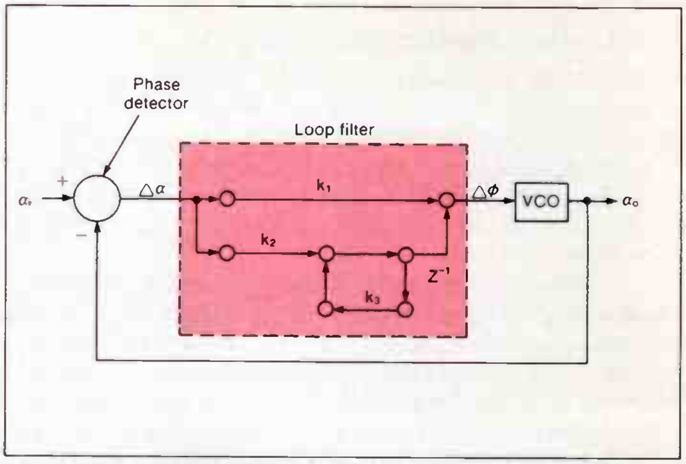


Figure 3. An important element in many modems is a phase-lock loop. As it can for all the other modem elements, the 320 signal-processor microcomputer can provide this function completely digitally. Note the voltage controlled oscillator, loop filter, and phase detector components — each are just 320 firmware.

The loop filter, a second-order configuration, consists of a proportional element defined by a gain multiplier, k_1, and an integrating element defined by coefficient k_2 and k_3. Operating at a 5 MHz clock rate, a 13-instruction sequence that implements the phase detector and filter takes just 2.6 μs. When these functions are combined with the digital VCO algorithm, they form the complete digital phase-locked loop program, which executes in less than 20 μs per data sample.

Demodulation

To demodulate a PSK carrier, the extracted carrier is split into in-phase (I) and quadrature (Q) components, by a 'Hilbert' transform (see Figure 2a again). These I and Q signals can then become carrier references for mixing with either a so-called 'Costa' loop[2] or a Hilbert transform[3] method of providing a quadrature signal.

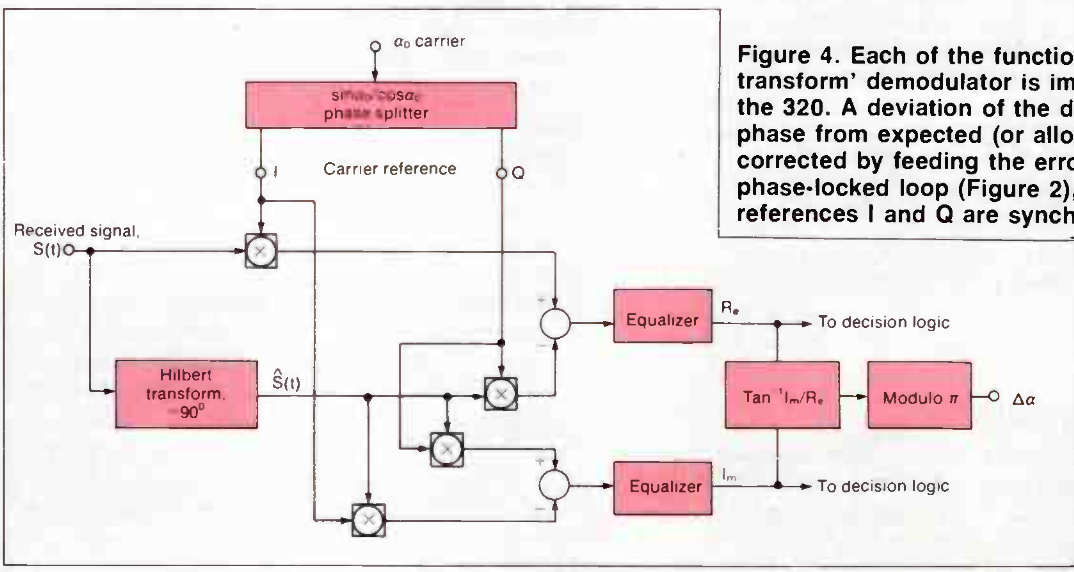


Figure 4. Each of the functions in this 'Hilbert-transform' demodulator is implemented digitally in the 320. A deviation of the demodulated signal's phase from expected (or allowed) phase states is corrected by feeding the error signal $\Delta\alpha$ back to the phase-locked loop (Figure 2), to which carrier references I and Q are synchronised.

The Hilbert transform (Figure 4) is the more general method, since it can handle any multilevel phaseshifted signal simply by changing the reference 'template.' Also, although difficult to implement in analogue form, a Hilbert transform is a relatively simple function for a digital system. The transform primarily adds a 90° phase shift to all Fourier components of a complex time-domain signal. (The transform, and also the equalizer, are implemented with a finite-impulse-response filter, which is discussed later).

Digital filters and equalizers

The two basic types of digital filters commonly used — the infinite-impulse-response (IIR) and the finite-impulse-response (FIR) filter — can both be implemented easily with the 320. However, the IIR filter tends to display poor phase characteristics, which is highly undesirable in digital communications. Accordingly, the FIR structure is more commonly used in modems to implement low pass, high pass, bandpass, band rejection, equalizer, and Hilbert transform networks.

An n-point FIR configuration, as shown in Figure 5, can be made to behave like any one of these network types, and it will exhibit linear phase characteristics and sharp frequency transitions.

When this FIR digital filter is used to compensate for varying differential phase delays and amplitude errors that may be introduced by a long communication channel, it is called an adaptive equalizer (Figure 6).

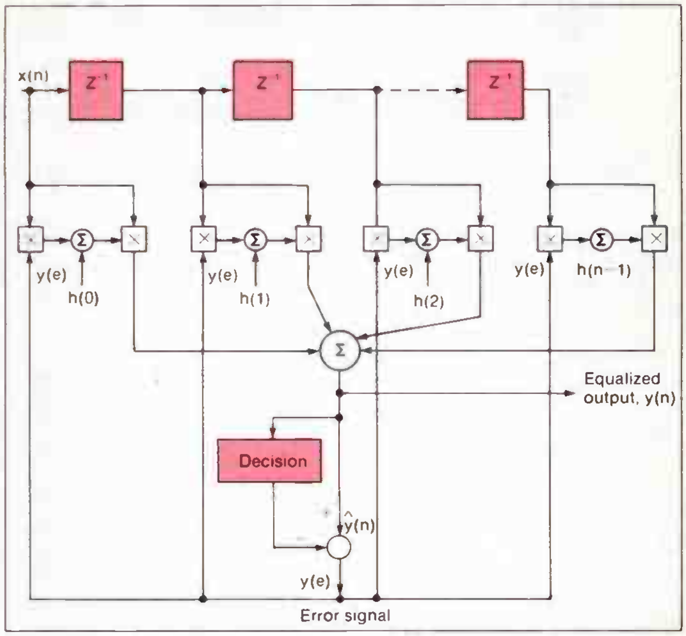


Figure 6. The FIR filter can even be made to adjust automatically to varying communications channel conditions, a process called 'adaptive equalization.'

A fundamental assumption with adaptive filters is that the channel characteristics change slowly with respect to the signalling rate. Accordingly, program functions minimize the error between the expected and the received signal over several baud intervals.

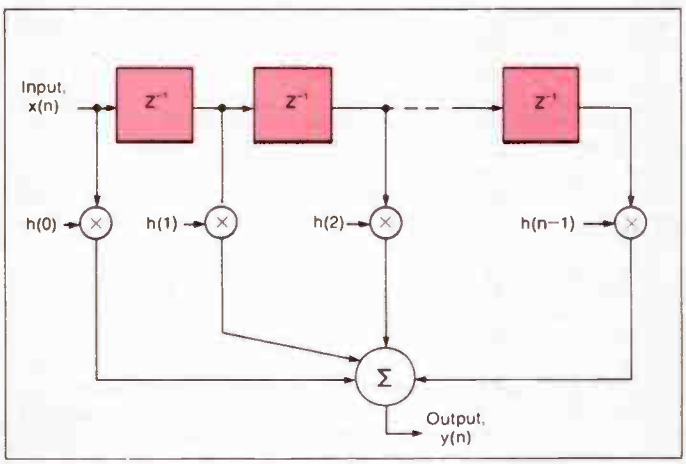


Figure 5. This finite-impulse-response (FIR) n-point filter configuration can be programmed to provide the characteristics of almost any type of filter a modem might need.

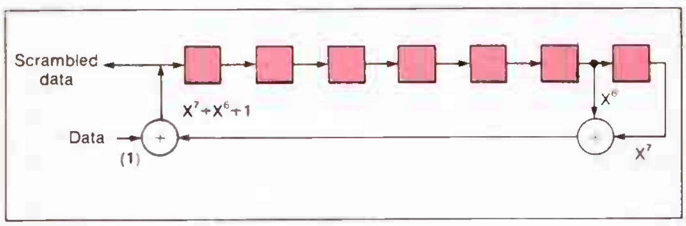


Figure 7. A pseudorandom word generator implemented with the 320's software, which is the equivalent of this hardware shift register circuit, can encrypt digital data before it enters the modem and decrypt it at the receiver modem's output.

Scrambler modems

In addition to the basic modem functions, the 320 can also provide data scrambling. A data scrambler consists of a psuedorandom sequence generator whose output is used to ' randomize' the data bit stream and to prevent certain data sequences from appearing. A descrambler employs a similar sequence generator. Synchronized to the scrambled transmitted data stream, the descrambler puts out a signal that is then combined with the received stream to accurately recover the original bit stream.

The CCITT V.27 scrambler (shown in simplified form in Figure 7) generates a pseudorandom code with hardware shift registers. However, the 320 carries out the function in a different way with 17 software instructions which are executed in 3.8 μs. This approach stores the sequence in RAM and uses a tap mask to implement the equivalent shift-register function.

References

1. R. Rabiner and B. Gold, *Theory and Applications of Digital Signal Processing*, Prentice-Hall, 1975
2. Floyd M. Gardner, *Phaselock Techniques*, John Wiley & Sons, 1979.
3. A. V. Oppenheim and R. W Schafer, *Digital Signal Processing*, Prentice-Hall, 1975.
4. Harry Y-F Lam, *Analog and Digital Design and Realization*, Prentice-Hall, 1979.

▶

TMS320

Digital Signal Processor Family

Digital Signal Processing (DSP) is concerned with the representation of signals (and the information that they contain) by sequences of numbers, and the transformation of processing of such signal representations by numerical computation procedures.

Since the late 1950s, scientists and engineers in research labs have been touting the virtues of digital signal processing, but practical considerations have prevented widespread application. Now, with the availability of integrated circuits, such as Texas Instruments' TMS320, digital signal processing is leaving the laboratory and entering the world of application. The reasons for this are numerous and compelling. Perhaps the most important reason is that extremely sophisticated signal processing functions can be implemented using digital techniques. Indeed, many of the important DSP techniques are difficult or impossible to implement using analogue (continuous-time) methods. It is almost equally important that VLSI technology is best suited to the implementation of digital systems, which are inherently more reliable, more compact, and less sensitive to environmental conditions and component aging than analogue systems. Another advantage of the discrete-time approach is the possibility of time sharing a single processing unit among a number of different signal processing functions. This is particularly efficient and cost effective in large systems having many input and output channels. Indeed, until recently, digital processing was only cost effective where it could be applied in large systems. Now, however, with VLSI techniques, low-cost processors such as the TMS32010 are available and a wealth of opportunities exist for the application of DSP techniques.

The potential applications will be found in any area where signals arise as representations of information. In many cases, the signals represent information about the state of some physical system (including human beings). Often, the objective in processing the signal is to prepare the signal for digital transmission to a remote location or for digital storage of the information for later reference. On the other hand, the signal may be processed to remove distortions introduced by transducers, the signal generation environment, or by a transmission system. Still another important class of applications arises when information is automatically extracted from the signal so as to control another system or to infer something about the properties of the system which generated the signal. Some of the more important areas where the above types of processing are of interest include speech communication, geophysical exploration, instrumentation for chemical analysis, image processing for television, audio recording and reproduction, biomedical instrumentation, acoustical noise measurements, sonar, radar, automatic testing of systems, and comsumer electronics.

The requirements of DSP call for a 'Harvard architecture' that permits parallel information fetching from program and data memories. An instruction's execution cycle overlaps the fetch cycle of the next instruction in a pipelined manner. A modified Harvard architecture in the TMS320 DSP chip (Figure 8) allows crossovers between program and data memories to provide program branches based on data values from instructions and data values from constants in program segments. Therefore, even though the hardware is divided into two basic segments for handling data and program information separately, the segments are bridged in operation.

While many general purpose microprocessors devote minimal space to the arithmetic logic unit (ALU), in DSP, ALUs occupy almost a third of the chip's space. Memory is the other major consumer of chip area. In the TMS320, for example, four basic arithmetic units — the multiplier, the barrel shifter (a shift register than can perform one to 15 shifts in one quarter-cycle), the ALU and the accumulator — occupy 30 per cent of the silicon. The multiplier computes the product of two 16-bit inputs in one 200 nsec. cycle. Likewise, the barrel shifter can shift an operand from one to 15 positions on its way to the ALU, producing a shift and add in a single cycle.

On-chip memory size plays a major role in many signal-processing applications.

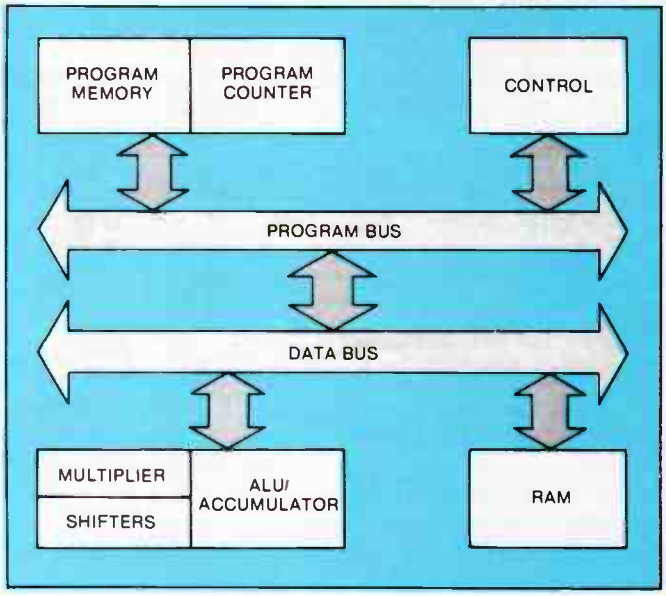


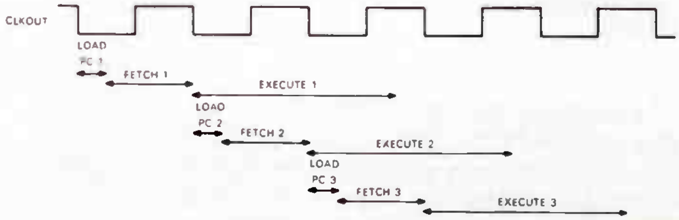
Figure 8. The TMS320 digital signal-processing (DSP) chip is based on a modified Harvard architecture that supports separate program and data memory spaces for parallel processing, eliminating the need for a separate ROM. This "bridge" permits crossovers between program and data memories.

Harvard architecture

The TMS320 utilizes a modified Harvard architecture in which program memory and data memory lie in two separate spaces. This permits a full overlap of instruction fetch and execution. Program memory can lie both on-chip (in the form of the 1536 x 16-word ROM) and off-chip. The maximum amount of program memory that can be directly addressed is 4K x 16-bit words. Instructions in off-chip program memory are executed at full speed. Fast memories with access times of under 100 ns are required.

Data memory is the 144 x 16-bit on-chip data RAM. Instruction operands are fetched from this RAM; no instruction operands can be directly fetched from off-chip. However, data can be written into the data RAM from a peripheral by using the IN instruction or read from program memory by using the TBLR (table read) instruction. The OUT instruction will write a word from the data RAM to a peripheral, while a TBLW instruction will write a data RAM word to program memory (presumably, off-chip).

The diagram here outlines the overlap of the instruction prefetch and execution. On the falling edge of CLKOUT, the program counter (PC) is loaded with the instruction (load PC2) to be prefetched while the current instruction (execute 1) is decoded and is started to be executed. The next instruction is then fetched (fetch 2) while the current instruction continues to execute (execute 1). Even as another prefetch occurs (fetch 3), both the current instruction (execute 2) and the previous instruction are still executing. This is possible of a highly pipelined internal operation.



HARVARD ARCHITECTURE

	MEMORY				CYCLE TIME						PACKAGE					I/O		INSTRUCTIONS	TECHNOLOGY
	ON-CHIP		OFF-CHIP		nanoseconds						DIP	PGA	PLCC			Serial	Parallel		
	RAM	ROM	PROG	DATA		200	160	125	100		40	68	44	68					
32010	144	1536	4096			/	/				/		/				8x16	60	NMOS
32011	144	1536				/					/		/			2	8x16	60	NMOS
320C10	144	1536	4096			/	/				/		/				8x16	60	CMOS
											(no. of pins)								
32020	544		64K	64K		/	/					/		/		1	16x16	109	NMOS
320C25	544		64K	64K				/	/			/		/		2	16x16	133	CMOS

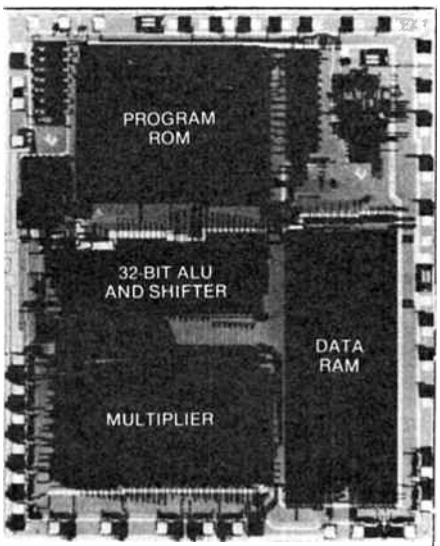


Figure 9. The TMS320 DSP employs a "memory-intensive architecture." It includes a 16-by-16-bit parallel multiplier that multiplies two 16-bit inputs in one 200 nsec cycle, a barrel shifter that can move an operand from one to 15 positions in one cycle and a 32-bit arithmetic logic unit (ALU).

New packet radio terminal node controller kit

Lockhart Technology in Canada recently announced the availability of their new revised VADCG TNC 'PLUS' terminal node controller (TNC) for use in amateur packet radio communications. The TNC+ is based on the reliable VADCG TNC, produced in 1979, and includes some of the standard features such as 8085 CPU, 8273 HDLC and 8250 UART. It has remained at the same physical size to allow retrofit of existing Mk1 TNC units.

Some of the new features are 64 kbytes of 2764/6264 ROM/RAM configurations, allowing optional downline loading of TNC software, and provision of battery backup of CMOS RAM, which enables storage of user dependent terminal control parameters.

The TNC also provides circuitry for an on-board switch-mode power supply enabling operation from a 12 V supply.

There is provision for use of an 8255 PIA for hardware function setting. It can act as a second terminal port, along with the standard DB-25 connectors, providing RS232/V.24 signalling to both terminal and modem ports.

The TNC+ pcb and documentation is available for CDN$50 plus CDN$5 p&p, the full parts kit is CDN$180 plus CDN$5 p&p. For the optional on-board 12 V supply parts, add CDN$20. (A complete TNC kit order adds up to CDN$260). Send money order to **Lockhart Technology, 9531 Odlin Road, Richmond. B.C. Canada. V6X 1E1.**

The Sydney Amateur Digital Communications Group provides the software support for the VADCG TNC+, including the SADCG Master/Monitor software which provides a menu driven system for both Vancouver V2 and AX25 protocols in 2764 EPROMs.

In conjunction with the VADCG TNC+, the SADCG provides a '7910 Radio Modem pc board. The modem uses the AMD7910 'world modem' chip providing various Bell and CCITT AFSK modem frequencies. It interfaces to the TNC via a DB25 connector. The approximate total building cost of the modem is $80. The SADCG 7910 radio modem pcb and documentation is available for $20 plus $2 postage from the **SADCG, PO Box 231, French's Forest 2086 NSW.**

The SADCG is a non-profit, volunteer organisation involved in promoting development of Amateur Packet Radio systems.

(A note to radio clubs: the TNC+ is suitable as a Digital Repeater in conjunction with the SADCG D.R. software package, which allows both AX25 and Vancouver V2 frames to operate independently from the one unit, which gives both users the full capabilities of both protocols, plus provide networking and many other facilities).

Digital antenna system

You can match an antenna over the range 3.5 MHz to 30 MHz using Icom's new AH-2 digitally-controlled antenna tuning unit. The tuner has been designed for mobile applications where broadband antenna matching has traditionally been a problem.

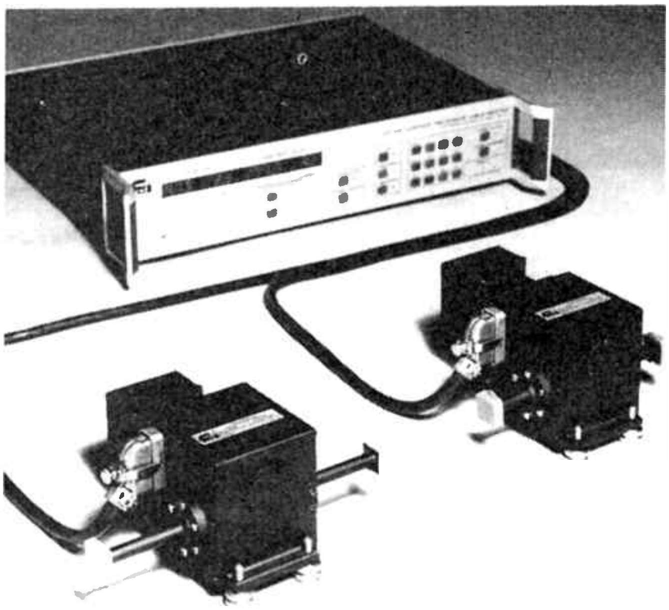
The unit consists of a control unit that resides beside the radio (usually the IC-735 multimode HF transceiver) and a tuning unit that mounts close to the whip antenna supplied.

You select the desired frequency and pushes the TUNE button on the control unit. An on-board CPU selects the most favourable LC combination for the given length of whip antenna and the frequency. Worst case tuning time is 20 seconds but typically is about 4-5 seconds says Icom.

Maximum input power is 120 watts. Unlike normal tuners that require full output power during the tune up period, the AH-2 derives the frequency information direct from the transceiver during use. Then, just 300 mW is used for a very short time to check the tune L/C mix selected by the CPU. An in-built memory system allows up to eight preselected frequencies to be stored. This allows a tune up time of one second or less on these frequencies.

The tuning unit assembly is constructed in a tightly sealed plastic case to provide dust and water proofing. Mobile antenna mounting is made very easy by use of a clever bracket that utilises the towing hook found below most vehicles.

Details from **Icom (Australia) Pty Ltd, 7 Duke Street, Windsor 3181 Vic. (03) 51 2284.**



Microwave attenuators

Flann Microwave Instruments offer an extensive range of broadband, high precision, programmable microwave attenuators and phase changers complemented by a new microprocessor-based series of control processors. These instruments in combination provide a highly accurate, repeatable and reliable measurement facility suitable for microwave ATE and system applications, Flann say.

The series of programmable rotary vane waveguide attenuators, covering the 4-140 GHz frequency band, provide an attenuation range from 0 to 60 dB with 1% or 0.1 dB accuracy, whichever is the greater. The resettability factor is better than 0.1 dB at 60 dB and improves considerably throughout the lower attenuation ranges, claims Flann. e.g.: 0.01 dB resettability between 0 and 20 dB. Each attenuator can be set incrementally to any 0.1 dB within the full attenuation range.

All the programmable phase changers are based on the conventional broad band rotary vane design and models are available for each waveguide bandwidth within the 4-140 GHz frequency range. Each instrument offers 360° continuous phase change, excellent repeatability and low SWR.

The new control processors are designed for computer control (remote) via the GPIB and/or manual control (local) via a front panel. Remote operation uses ASCII with an 18 character control set, all codes being acceptable but only the control set being acted upon.

Further information from **Flann Instruments Limited, Dunmere Road, Bodmin, Cornwall PL31 2QL England.**

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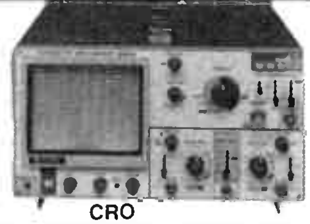
- GW-GOS-3310: 10MHZ, 1CH, 75mm CRT, COMPACT TRIGGERING CRO



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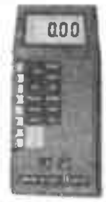

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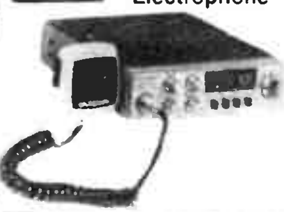

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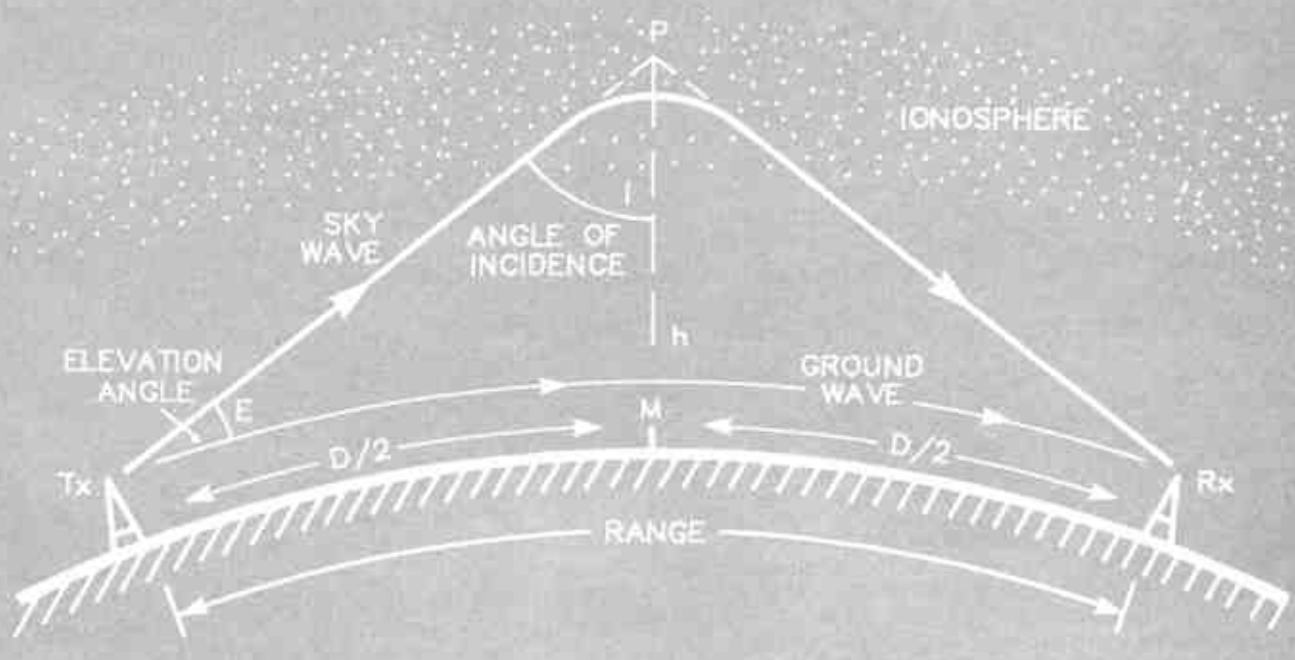
Radio Communicators guide to the ionosphere

Part 5
Leo McNamara and Roger Harrison

Radio propagation



NOW THAT we have some idea of what it is that supports or permits HF radio propagation, we can move on to radio propagation itself. In this chapter we shall discuss a few things which determine whether or not a radio wave will actually propagate on a given circuit, and how well it will do. We shall start with a simple geometrical model of propagation.

Some simple ideas

Figure 5.1 illustrates some of the ideas which we will need to discuss. Radio waves emitted by the transmitter **T** at an elevation angle **E** travel a distance **D/2** before striking the ionosphere at the point **P** and being reflected back towards the ground, hitting it at the receiver **R**. In reality, the ray is not *reflected* at P, but is continuously *refracted* or bent towards the ground as it passes through the ionosphere. However, for many purposes we can ignore this complexity and consider the ray to be reflected at **P**. The ionosphere at the point of reflection, **P**, is at a height **h** above the midpoint, M, of the circuit. The path of the waves, **T-P-R** is called a *raypath*. The angle I between the raypath **TP** and the vertical **PM** is called the *angle of incidence* of the ray at the ionosphere. The distance along the ground between T and R is called the ground *range*, which we have denoted by **D.**

Figure 5.1 also illustrates the difference between the ground *wave* and the sky *wave*. We are concerned in this article mainly with the sky wave, since it is the sky wave which goes up to the ionosphere and back, facilitating HF communications over long distances. However for short distances, the ground wave is also useful and rather easier to use. Figure 5.2 illustrates the range covered by the ground wave for a typical circuit. It can be seen that the ground range decreases as the frequency increases. At 3 MHz the ground range is about 110 km. For lower frequencies, such as those used in the MF broadcast band, the ground range is somewhat greater. At 10 MHz, in the middle of the HF band, the ground wave will be useful out to about 60 km. The ground range increases as the electrical conductivity of the ground increases, and is greater over the sea than over land.

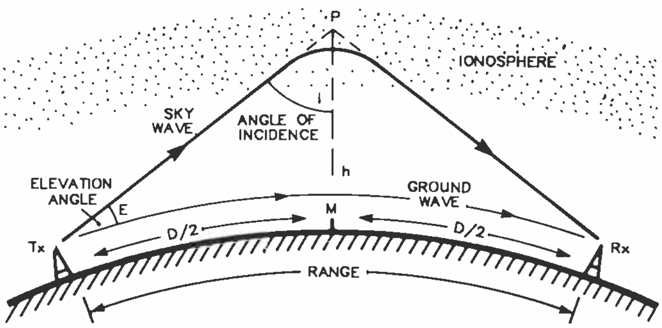


Figure 5.1. A greatly simplified, but still very useful, view of the paths taken by radio wave travelling between a transmitter (Tx) and receiver (Rx). The ground wave hugs the ground and will dissipate before reaching the receiver if the range of the circuit is too long. The sky wave, or ionospheric wave, is reflected from the ionosphere at a point P down towards the receiver. The angle between the ground and the path (known as a raypath) followed by the wave as it leaves the transmitter is called the elevation angle. The angle between the vertical at the point of reflection (P) and the raypath is called the angle of incidence. Note that the wave never actually reaches the point P — the wave is returned to the ground by a process of continual refraction (bending) within the ionosphere, rather than by a process of simple reflection. However, we get sufficiently accurate results if we think in terms of simple reflection.

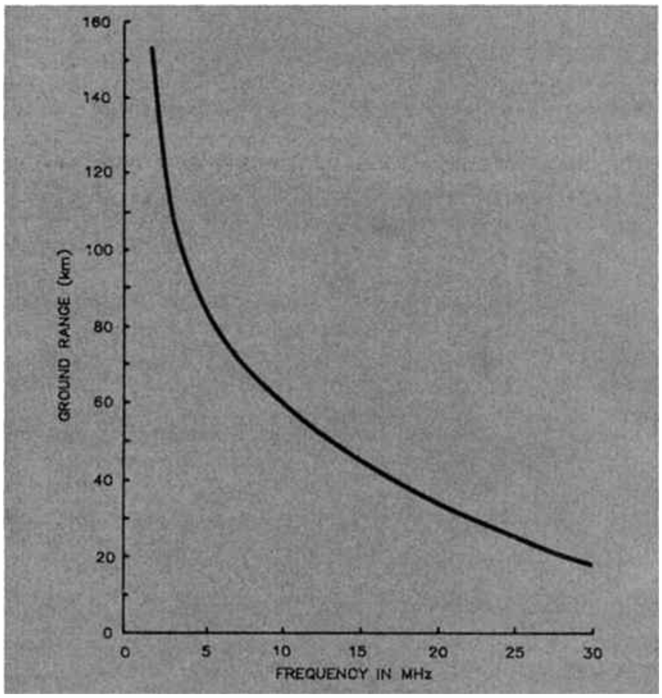


Figure 5.2. The approximate range over which the ground wave may be used, as a function of frequency, for dry land.

In practice, there are always at least two raypaths for a sky wave travelling between a given transmitter and receiver. Figure 5.3 illustrates what happens to rays of the same wave frequency leaving a transmitter at different elevation angles. For low elevation angles (ray 2), the signals hit the ground at a point closer to the transmitter, that is at a shorter ground range, until the ground range is reduced to some particular value Z km (ray 3). Any further increases in the elevation angle cause the ground range of *increase* again (rays 4 and 5).

We can deduce several things from Figure 5.3. Firstly, there will in general be *two* raypaths between a given pair of transmitters and receivers. [Two more raypaths will rear their ugly heads in the next section.] For example, raypaths 1 and 5 connect the same two points on the earth, as do raypaths 2 and 4. For any particular circuit, the two rays are called the *high ray* (rays 4 or 5) and the *low ray* (rays 1 or 2), corresponding to high and low angles of elevation. Under many circumstances, the high ray (also called the Pedersen ray) will be heavily attenuated and we will be left with only the low ray. The raypath 3 is unique because the corresponding high and low raypaths coincide exactly.

Polarization

We shall come across the idea of polarization many times in this series, so it is worth getting some idea of what it is all about before we proceed any further. Like many of the subjects covered here, we could write a book about polarization, but we will not. All we really need for the present purposes is a few very basic ideas.

Polarization of radio waves is best described by analogy, in view of the fact that we cannot "see" the radio waves themselves. Consider what happens to a long rope fixed at one end when it is flicked at the other end. If we flick the loose end up and down in a vertical plane, the rope will move up and down all along its length. All movement of the rope will be in a vertical plane — there will be no sideways motion. We can describe this movement of the rope as being *vertically polarized.* If we flick the rope from side to side, keeping our hand in a fixed horizontal plane, the motion of the

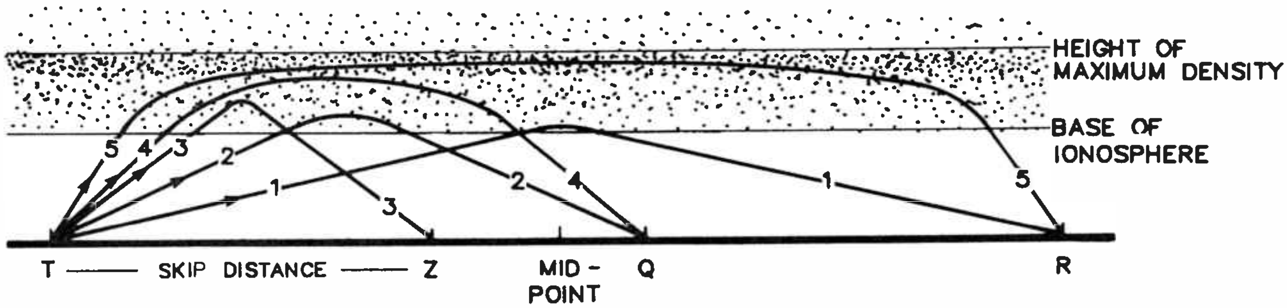


Figure 5.3. Sample raypaths for a given ionosphere and fixed frequency as the elevation angle at the transmitter T is increased. It is found that increasing the elevation angle results in the reflected ray reaching the ground at a point which moves closer and closer to the transmitter (from R to Q to Z), until a point Z is reached after which increasing the elevation angle leads to *increasing* ranges. The rays 4 and 5 are called the "high" rays, and have the same ground ranges as the "low" rays 1 and 2, respectively. The high and low raypaths coincide for the point Z and for the raypath 3. It is not possible for a sky wave to reach any point closer than Z to the transmitter, since changing the elevation angle from that corresponding to raypath 3 leads to an increased ground range, regardless of whether the elevation angle is increased or decreased. The distance TZ is known as the skip distance for the circuit (at the given hour, month, level of solar activity and frequency).

rope will be confined to a horizontal plane and is described as *horizontally polarized*. The third thing we can do is to move our hand in a circular motion. All parts of the rope will then move in a circle and the motion of any point on the rope is therefore *circularly polarized*. When the motion is constrained to a single plane, such as with vertically and horizontally polarized motion, the motion is said to be *plane polarized*.

In HF applications, antennas are also described as being polarized. The most common antennas used in HF communications are the vertical monopole (the whip antenna is one of these) and the horizontal dipole. Consider first the vertical monopole, as in Figure 5.4. In general, radiation leaves a length of wire acting as an antenna in a direction at right angles to the antenna, with the electric field of the wave vibrating (just like the rope) in a direction at right angles to the direction of travel. In the case of the vertical monopole, the electric field vibrates in a vertical plane and the energy radiated by the antenna is vertically polarized. The antenna is also described as being vertically polarized, because it transmits vertically polarized radiation. In a similar fashion, a horizontal antenna is said to be horizontally polarized.

What happens if we transmit on a vertically polarized antenna and receive on a horizontally polarized one? Think what would happen to our rope if we were flicking it in a horizontal plane and put two vertical posts astride it. The posts would stop the rope from moving side to side, which is the only motion which we have given it, and the part of the rope between the posts and the anchor point will end up with no motion at all. In other words, there will be no energy transmitted from our hand to the anchored end of the rope.

Similarly, if we cross our antennas, there can be no transfer of energy between them, unless the plane of polarization of the wave changes during the passage of the wave through the ionosphere. We end up drawing the same conclusions if we think in terms of what the electric field is doing. The important point in this case is that an electric field will induce a voltage in a conductor only if the conductor is *not* at right angles to the direction of the field.

This is the reverse situation to the antenna transmitting energy with the electric field parallel to the direction of the antenna. Polarized sun-glasses give the same effect. Try looking with one eye through two pairs of sunglasses when they are held at right angles to each other. If the glasses are well made, everything will appear very dark because very little light is being transmitted through the two lenses. The first lens polarizes its transmitted light in one direction and the second lens refuses to pass light polarized in that direction. This is illustrated in Figure 5.5.

Only in the case of perfectly polarized antennas will no radiation be received. In general, as with the usually imperfect sunglasses, there will be some radiation which will get through. In the rope experiment, increasing the slit width to several times the diameter of the rope will allow a *range*

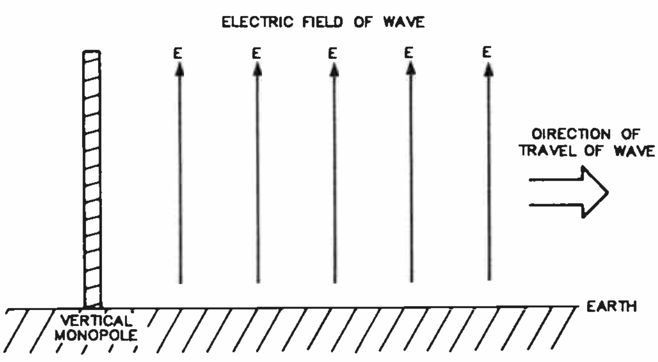


Figure 5.4. Sketch of the electric field vector E of a radio wave emitted by a vertical monopole. The energy of the wave travels at right angles to the direction of E. The strength of the electric field oscillates in amplitude at a frequency equal to the wave frequency. Since a radio wave is also an electromagnetic wave, it will also have an oscillating magnetic field which would be perpendicular to both the direction of the electric field and the direction of wave propagation.

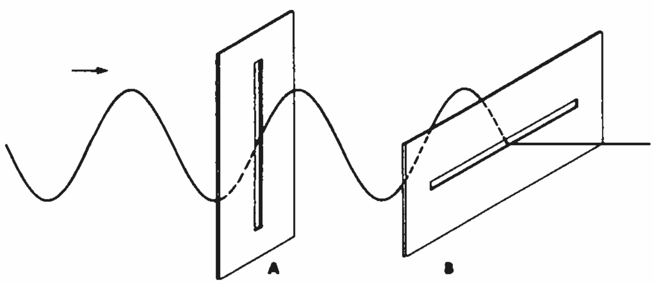


Figure 5.5. Passage of a plane-polarized wave through two slits held at right angles to each other. The plane-polarized wave passes untroubled through the first slit, which is vertical and matches the plane of polarization of the incoming wave. However, the wave cannot pass through the horizontal slit because this slit will accept only waves which oscillate in the horizontal direction, whereas the wave oscillates only in the vertical direction. ▶

of polarizations to pass through the slit, rather than just the one parallel to the slit.

When a plane polarized radio wave hits the ionosphere, it splits into two *characteristic waves* which propagate independently through the ionosphere. These waves are known as the *ordinary* and *extraordinary* waves and are *elliptically* polarized. To get some feeling for what an elliptically polarized wave is, we can imagine ourselves travelling along with the wave, looking straight ahead. The electric field can be thought of as a stick at right angles to the direction of travel (called a *vector* in the trade), which rotates and changes its length as the wave progresses. It can rotate in either a clockwise or anti-clockwise direction corresponding to either the ordinary or extraordinary wave, depending on the orientation of the raypath relative to the direction of the Earth's magnetic field. If the stick keeps the same length as the wave progresses, we have the special case of *circular polarization.*

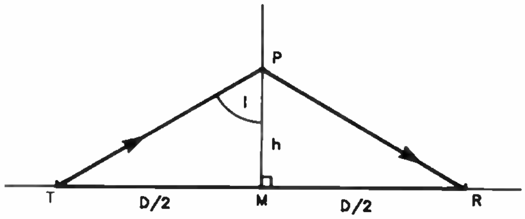


Figure 5.6. Simple geometry used to relate oblique propagation on a circuit to the properties of the ionosphere at the midpoint of the path. A flat earth and a flat ionosphere are assumed. Signals from the transmitter T strike the ionosphere at P and at an incidence angle I, before being returned to the ground at R, a ground range D from the transmitter. The maximum frequency that will be supported on the circuit TR will depend on the critical frequency of the ionosphere at P, and inversely on the cosine of the angle of incidence.

The maximum usable frequency (MUF)

One of the most important quantities in HF communications is the *maximum usable frequency* or MUF, which is the maximum frequency that will be supported by the ionosphere for a given circuit. The MUF depends on just two things — the critical frequency, **FC**, of the ionosphere at the reflection point, **P**, and the geometry of the circuit.

To a good approximation, the MUF is given by the formula

$$\text{MUF} = \text{FC} / \cos \text{I} \quad \ldots\ldots 5.1$$

where cos is the cosine function we met in Part 4. Referring to Figure 5.6, and using Pythagoras's Theorem, cos I is given by:

$$\cos \text{I} = \text{PM/PT} = \text{h} / [\text{h}^2 + (\text{D}/2)^2]^{1/2} \quad \ldots\ldots 5.2$$

We can satisfy ourselves that this formula is probably correct by considering some special cases. Note that the "½" tells us to take the square root of what is inside the square brackets.

If the radio waves go straight up and down, and R coincides with T, we have D = 0 and cos I = 1, corresponding to I = 0. Again, if the radio wave travels nearly horizontally, they will travel a large distance and D will become much greater than h. In this case, cos I becomes very small and I approaches 90 degrees. Thus we can see that the formula works for the special cases.

Since cos I can vary from 0 to 1, equation 5.1 indicates that the MUF is equal to the critical frequency of the ionosphere for vertical incidence (I = 0, cos I = 1) and much greater than FC for very large angles of incidence, which correspond to small elevation angles and large ground ranges. In practice, the world is round and the curvature of the surface prevents the angle of incidence from getting too close to 90 degrees. This is illustrated in Figure 5.7.

If the critical frequency is fixed, a higher MUF may be obtained by reflecting the signals from a *lower* layer. This is because a lower layer means a smaller value of cos I and thus a larger value of 1/cos I. It is a little tortuous to follow this path of turning things upside down, so we will introduce another name from geometry, the *secant*. The secant, or "sec" for short, of an angle is just the inverse of its cosine, that is sec I = 1/cos I. Thus we can write equation 5.1 in the somewhat easier form:

$$\text{MUF} = \text{FC} \times \sec \text{I} \quad \ldots\ldots 5.3$$

The factor sec I is usually called the *obliquity factor* for the circuit, because it relates the ionosphere at the reflection or midpoint of the circuit to what happens on the *oblique* circuit. Figure 5.8 illustrates how the obliquity factor varies with circuit length for reflection from the E layer (h = 100 km) and F layer (h = 300 km). As we have already seen, the obliquity factor is equal to one for very short circuits (D = 0). Note that Figure 5.8 actually shows the "corrected" obliquity factor, k sec I, where k is a correction factor which takes

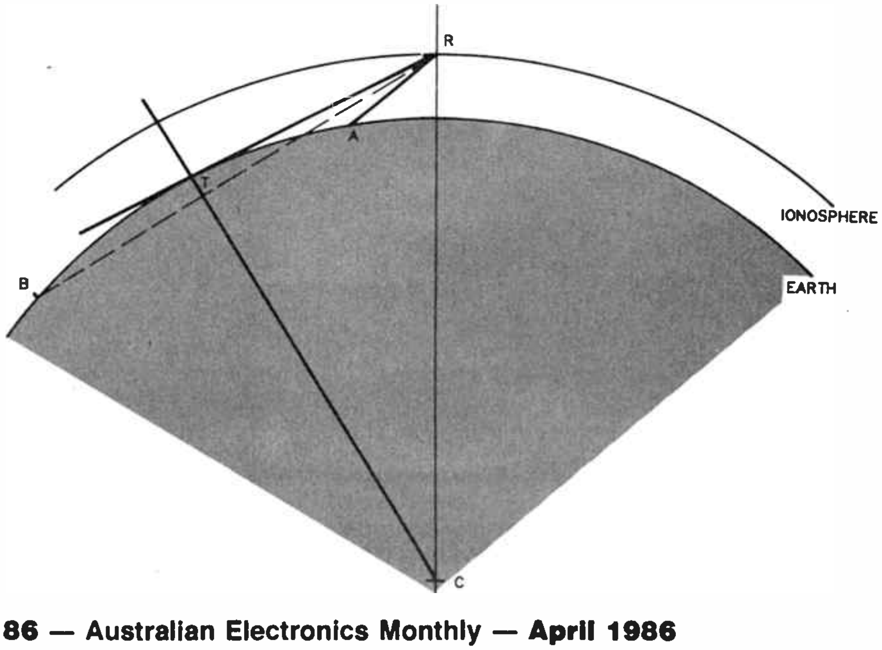


Figure 5.7. There is an upper limit to the frequency which the ionosphere will reflect, which is set by the curvature of the earth and the height of the reflecting layer. Moving a transmitter from A to T, where the ray TR is tangential to the earth at T (corresponding to a zero elevation angle) will increase the angle of incidence and obliquity factor, and thus the MUF. However, moving even further across from the point R to the point B leads to a *decrease* in the angle of incidence, and to the physically impossible situation of the ray BR travelling underground. Thus T is as far as one can get away from R, and the angle TRC is the maximum value possible for the angle of incidence. For F-layer reflections, this maximum angle is above 73 degrees, while the maximum range is about 3800 km.

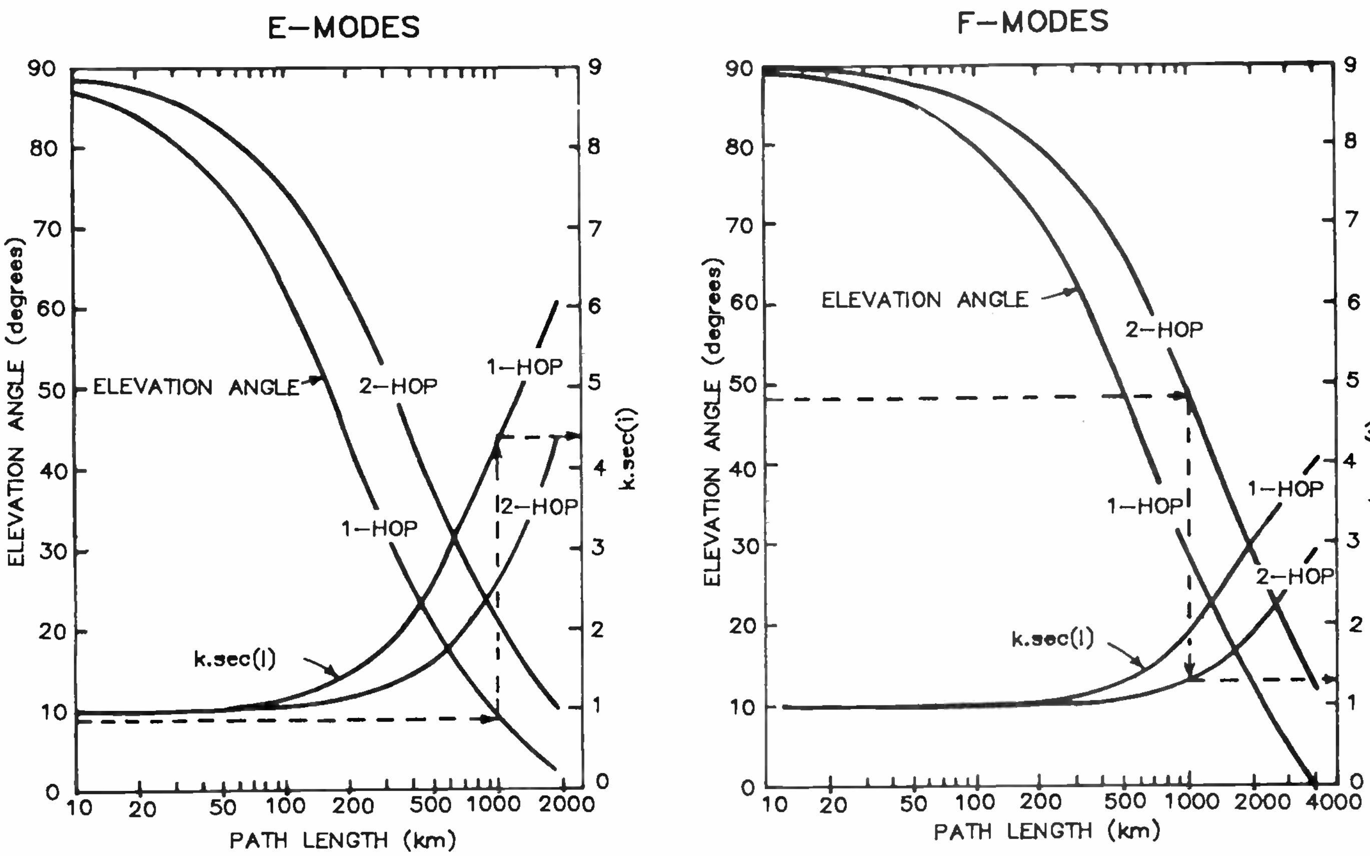


Figure 5.8. The "corrected" obliquity factor, k sec I, and elevation angle as a function of circuit length for signals reflected from (a) the E layer, assumed to be at an altitude of 100 km and (b) the F layer, assuming that reflection takes place at 300 km. The two sets of curves correspond to one-hop and two-hop propagation modes. In the latter, the signals hit the ionosphere twice, and the ground in between the two ionospheric reflections. These diagrams can be used to estimate the elevation angles for a circuit of given length, and thence to help in the choice of appropriate antennas, as well as estimating the obliquity factor for the circuit. The obliquity factors are greater for E-layer reflection than for F-layer reflection.

account of the fact that the Earth and ionosphere are both curved. The value of k is about 1.1 under most conditions.

The obliquity factor decreases as the altitude of the reflection level increases. Thus it is greater for E-layer reflections than for F-layer reflections. For the F layer, which is so thick that we must consider the effects of the different altitudes within it, signals reflected from low in the layer have higher obliquity factors than signals reflected from higher up.

Equation 5.3 may be used to calculate the MUF for reflection at a given altitude in the F layer, provided the critical frequency FC (= foF2 in this case) is replaced by the *plasma frequency*, FN, which is related to the electron density at the given altitude by Equation 3.3:

$$FN = 9 \times 10^{-3} N^{1/2}$$

Thus if we wish to consider what happens to a ray at a frequency lower than the MUF for the layer itself, we can work with the equation:

$$MUF(h) = FN(h) \times \sec I(h),$$

where the "h" tells us that we are considering what happens if reflection occurs at the height h. Reflection can occur at the height h provided the operating frequency is less than the product of the plasma frequency and obliquity factor at that height.

In general, the higher the frequency the higher it must penetrate into the ionosphere to find a plasma frequency high enough to reflect it. However, penetrating further into the ionosphere is not a good thing from the point of view of the obliquity factor, which decreases as the height of the reflection level increases, and acts in opposition to the effect of increasing plasma frequency.

Figure 5.8 also shows the elevation angles corresponding to circuits of different lengths. For example, if the circuit length is 1000 km and reflection is to be by the E layer, the elevation angle of the signals would have to be nine degrees. We can also use this figure to work out where our signals would land if our transmitting antenna put most of its radio energy out at a particular elevation angle. For example, if a ray leaves the transmitting antenna at an angle of 28 degrees, and is reflected by the F layer at 300 km, it would travel 3000 km.

Figure 5.8 can be used to great effect in choosing the correct antenna for a circuit. HF communications will not be effective unless the antennas are chosen to match the path taken by the radio waves (see "choosing the correct antenna" later).

The skip zone

For propagation to be possible on a particular circuit, the operating frequency, P, must be less than or equal to the MUF for the circuit. Now, the MUF is defined as:

$$MUF = Q \times FC$$

where Q is the obliquity factor and FC is the critical frequency of the reflecting layer. Thus it is necessary that:

$$P \leqslant Q \times FC,$$

from which we can deduce that the obliquity factor, Q, must ▶

be greater than or equal to the quotient P/FC. (NOTE: The symbols < and > stand for less than, or greater than. When used in conjunction with an equal sign, meaning for example, less than or equal to, they appear as ⩽ and ⩾.)

Suppose the operating frequency P is 20 MHz and the critical frequency FC is 10 MHz. It is then necessary that $Q \geqslant 20/10$, or $Q \geqslant 2$. Figure 5.8 tells us that for a one-hop F-layer propagation mode, $Q \geqslant 2$ requires that the path length be greater than or equal to 1000 km (approximately). In other words, if we are using 20 MHz and the critical frequency of the ionosphere is 10 MHz, we can communicate with positions 1000 km or more away from us, but we *cannot* communicate with any position closer than 1000 km to us, if we stick to using the sky wave. The 1000 km zone around us is called the *skip* zone. Communication within the skip zone is still possible using the ground wave, but this peters out after about 50 - 100 km.

When the operating frequency is less than the critical frequency, there is no skip zone. The mathematically minded reader will note that under these conditions, it is necessary that $Q \geqslant N$, where $N \leqslant 1$, but $Q > 1$ always because the secant of any angle is always greater than one. Another way of thinking of the situation is that, by definition, the ionosphere will reflect all waves at frequencies less than the critical frequency when these are incident *vertically* on the ionosphere, and oblique propagation *enhances* the ability of the ionosphere to reflect a signal with a given frequency.

The skip zone for a given transmitter will depend on the operating frequency (increasing as the frequency increases) and on the critical frequency of the reflecting layer. The latter dependence means that the skip zone will have all the variations normally associated with the critical frequency — diurnal, seasonal and solar cycle.

Figure 5.9 illustrates the skip zone for different operating frequencies for a transmitter situated at Alice Springs in Australia. Any location within a contour marked as "f" MHz (where f = 12, 13, 15, 20, 25 etc) cannot be contacted via an F-region skywave using the frequency f. For example, if the operating frequency is 25 MHz, most of Australia lies in the skip zone.

It is important to note that if the receiver is on the edge of the skip zone, the operating frequency must be the maximum usable frequency (MUF) for that particular circuit. Because energy arrives at a receiver on the edge of the skip zone by both the high and low rays, which coincide exactly at the MUF, the strength of the signal will be greater than at frequencies less than the MUF. One advantage of working at the MUF, and thus on the edge of the skip zone, is this enhancement of the signal strength. However, as we shall see in a later article, working near the edge of the skip zone does have its problems.

The skip zone is usually a pest when it exists, but it can sometimes be put to good effect if secure communications are required. If we do not want someone to hear our transmissions, we are sometimes able to ensure that he is within our skip zone.

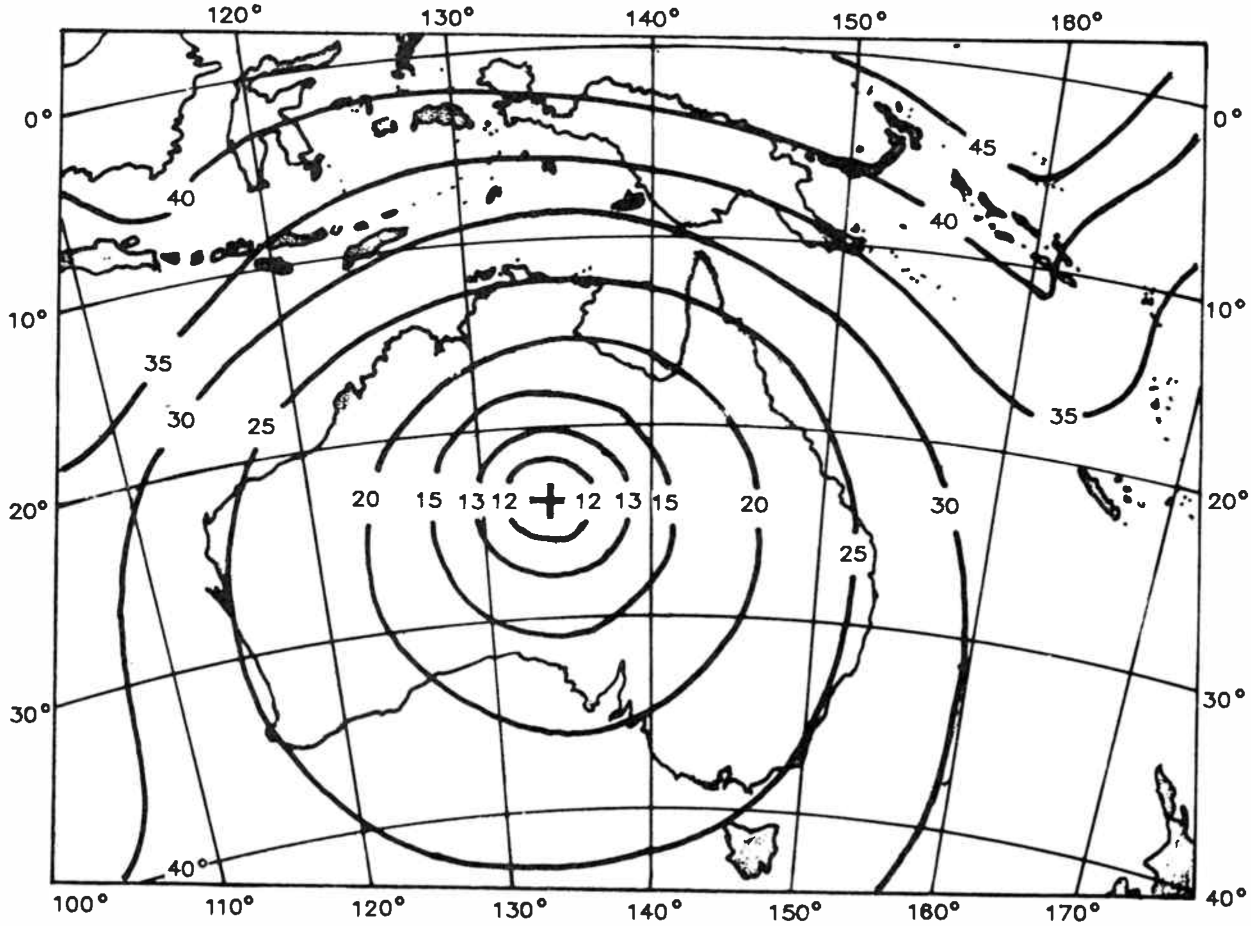


Figure 5.9. The skip zone for different frequency transmissions from a site in Alice Springs, Central Australia. Within any contour labelled "f", communication with a receiver inside the contour is not possible for frequencies greater than f MHz. For example, most of Australia lies within the 25 MHz skip zone. This means that a person in Alice Springs working on 25 MHz could not communicate with anyone in Australia apart from Tasmania, which lies outside the 25 MHz contour (near 42 degrees south). Note that the skip zone varies as the ionosphere varies. This particular diagram corresponds to 05 UT, March, high solar activity. The value of foF2 at Alice Springs was 11 MHz.

Propagation modes

A propagation mode is the path that a radio wave takes when travelling or propagating from the transmitter to the receiver. These paths are many and varied and when a radio wave leaves a transmitting antenna, it will choose its own propagation mode, which may not be the one we would have preferred it to take. Some propagation modes are better to use than others and we should always be aware of the modes that our signals are probably taking, even if we cannot force the signals to travel via the best mode or mode of our choice.

Propagation may be one-hop (one single reflection from the ionosphere), two-hop (two reflections from the ionosphere, with a reflection from the ground in between), and so on, and may be via any one or several of the layers of the ionosphere. If we ignore reflections from the D and F1 layers, which are not usually important at HF, we need to consider only reflections from the E layer, a sporadic-E layer and the F2 layer. Since we are ignoring the F1 layer, we shall talk about the F layer, rather than the F2 layer. Recall that at night only the F2 layer exists and is simply called the layer.

Figure 5.10 shows some of the propagation modes which are possible using just the three layers. Luckily, some modes ▶

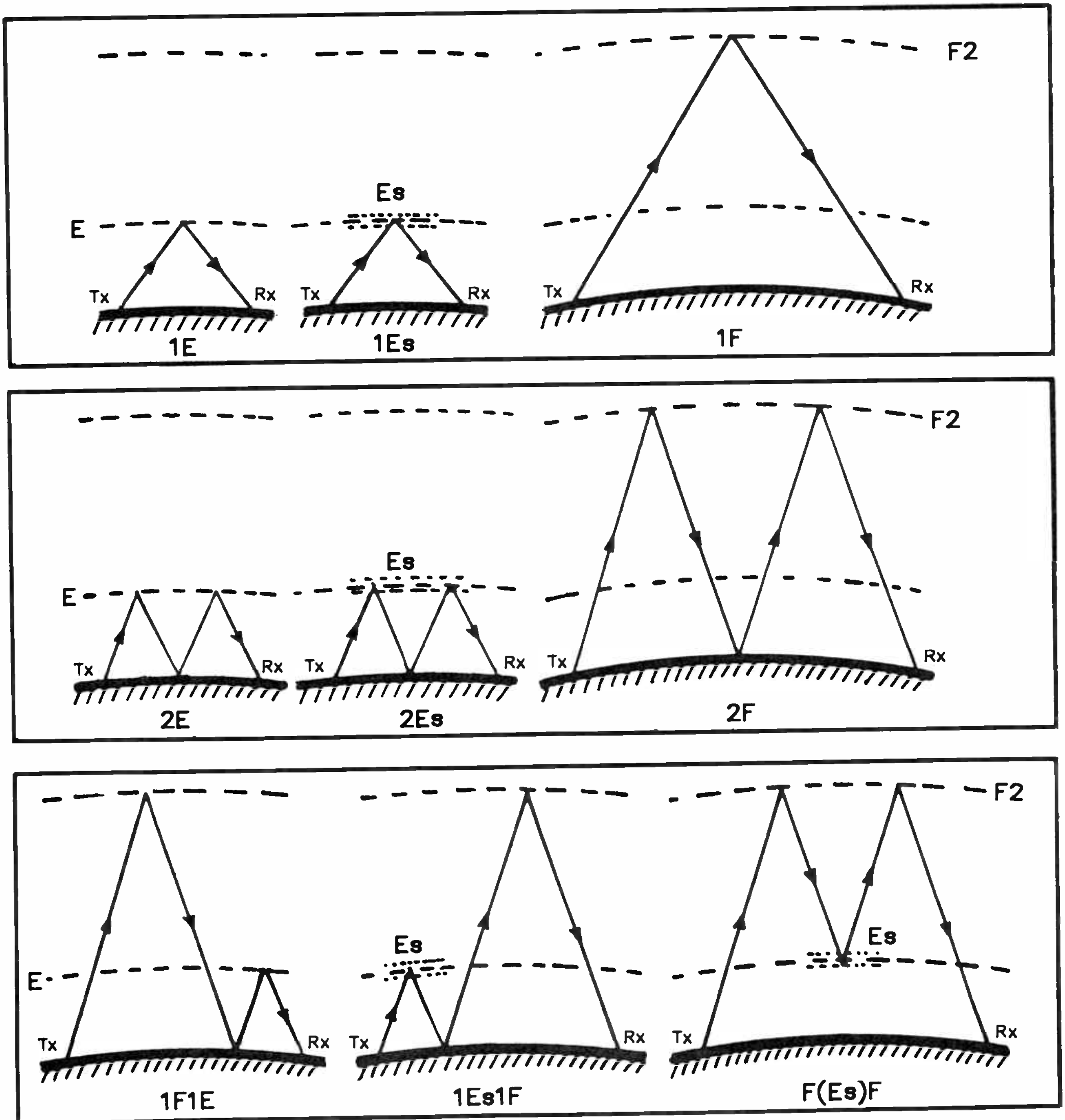


Figure 5.10. Propagation modes which are possible for signals reflected from the Es, E or F2 layers. The top panel illustrates one-hop modes (1E, 1Es and 1F) which involve only one reflection from one ionospheric layer. The middle panel illustrates two-hop modes. The lower panel illustrates so-called "combination modes" which involve reflections from both an E layer (E or Es) and the F2 layer. Note that we have ignored modes involving reflections from the F1 layer, which are not important under most conditions.

lead to more attenuation of the signal than others and in practice we do not have to worry about them all. As a general rule, the higher the order of the mode, or the more hops it has, the lower its signal strength will be because every reflection of the signal at either the ground or ionosphere results in loss of energy. For example, the 2-hop F-layer, or 2F, mode must be reflected from the ground once, and from the F layer once more than the 1F mode, suffering losses at each reflection. Consequently the losses on a 1F mode will always be less than those on a 2F or higher order (3F, 4F, ...) F-layer mode. Typical ground reflection losses for long hops (low elevation angles) are 3 dB for a poorly conducting ground and 0.5 dB for reflection from the sea.

Lower order propagation modes are also characterized by higher MUFs than those supported by higher order modes. For example, the MUF for a one-hop F mode (1F MUF) is greater than the MUF for a two-hop F mode (2F MUF) on the same circuit. This is because the obliquity factor for the 1F MUF corresponds to the full length of the circuit and is thus greater than for the 2F MUF, which corresponds to a hop length equal to *half* the full length of the circuit.

The E layer is a much worse reflector than the F layer, and two reflections from it are normally enough to reduce the signal strength below the level of detectability, that is, it sinks below the noise level. Sporadic-E layers, on the other hand, are often very good reflectors of radio wave energy and can be very useful, although they can also sometimes be a bit of a menace.

Multipath interference

On any given circuit, it is usually preferable to have the signal propagate by only one propagation mode. If the signal arrives by two different modes, with approximately equal signal strengths, they can interfere with each other in what is known as *multipath interference*. This is because the signals usually have different travel times, the distances covered over the two propagation paths being slightly different. To see why having two signals is a bad thing, consider what happens to Morse code when the signals arrive by two different paths. This is illustrated in Figure 5.11, which shows what happens in the extreme (and unlikely) case in which the second signal is delayed by exactly a pulse length. When we should have

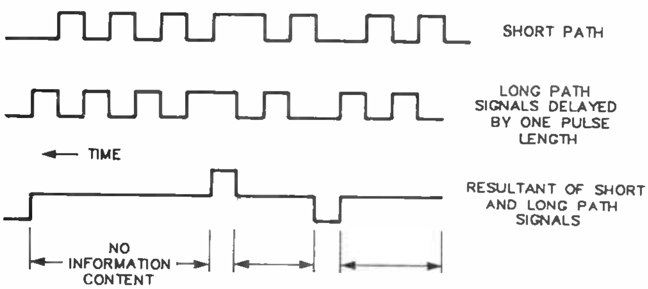


Figure 5.11. Pulse-coded signals (such as morse code) arriving at a receiver by two different propagation modes whose path differences is such that signals travelling over the longer path arrive exactly one pulse length later than those travelling via the shorter path. The resultant signal, illustrated in the lowest of the three sketches, is formed by adding the signals which arrive at the same time. It can be seen that the resultant signal often bears no relation to the transmitted signal, because pulses from the long path reach the receiver when a null is arriving from the short path. This is a particularly severe example of multipath interference. Pulse lengths are usually chosen to be much longer than the propagation modes, and multipath interference is then not so severe. However, if high data rates are required, necessitating short pulse lengths, multipath interference becomes very important and must be taken into account.

had no signal if we are going to make sense out of what we are receiving as signal 1, the signal coming via the second propagation mode has a pulse arriving. The result of the two signals adding together in our receiver is thus a continuous signal, with no breaks to indicate spaces between the pulses. All information content of the signal is therefore lost.

There are two ways to avoid multipath interference. The simplest is to choose a frequency that is too high to propagate by any mode other than the lowest order mode. Recall, for example, that the 1F MUF is always greater than the 2F MUF. The second way, which is not so simple, is to choose an antenna which favours one propagation mode. This is just one good reason for choosing an appropriate antenna for a given circuit.

Interference can also occur between the high ray and low ray on any circuit, if they have equal amplitudes. However there is no multipath interference at the MUF, since the signals propagating by the high and low rays follow exactly the same path and take exactly the same time to travel to the receiver. We shall return to this point in a later article.

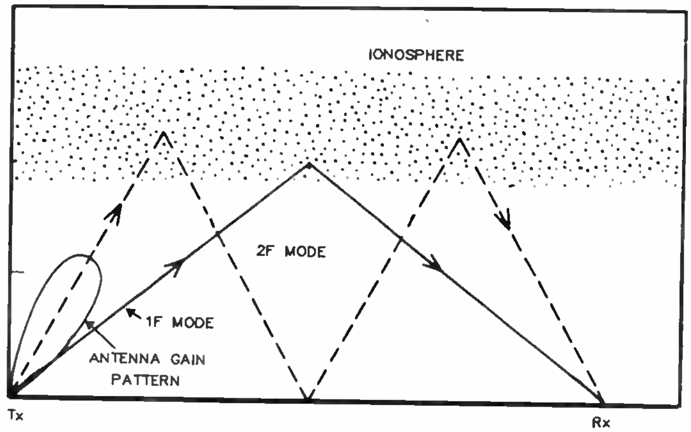


Figure 5.12. The antennas should always be chosen to match the length of the circuit. In this diagram, the transmitting antenna is ideally suited to the 1000 km circuit, but it is no use for a 300 km circuit (or shorter) because virtually no energy goes off at the steep angles required for the short distances.

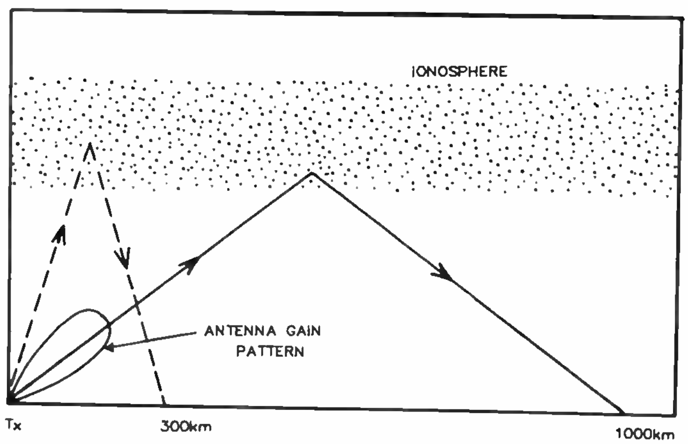


Figure 5.13. The antennas should always be matched to the required propagation modes. In this example, most of the transmitted energy would travel via the 2F mode, so there is no point in choosing a frequency that is supported by the 1F mode, but not by the 2F mode. The failure of the antenna to excite the IF mode could, however, be an advantage because of the decreased probability of multi-mode (multipath) interference.

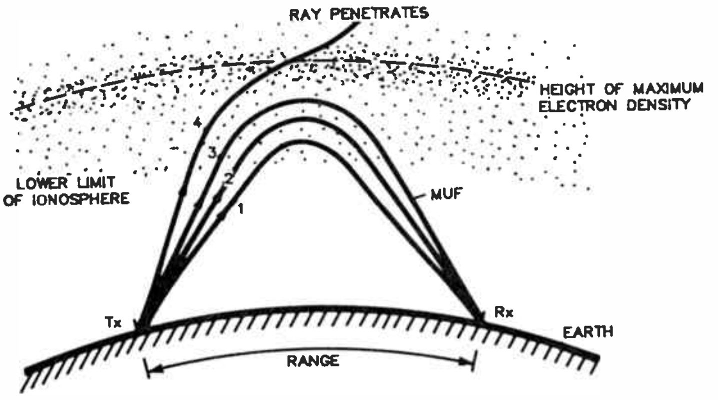


Figure 5.14. Raypaths for increasing frequencies on a fixed circuit. The higher frequency rays (2 and 3) penetrate further into the ionosphere than the low frequency rays (ray 1) and leave the transmitting antenna at correspondingly higher elevation angles. Rays at frequencies higher than the MUF reach altitudes where the obliquity factor is too low for reflection to occur. They therefore penetrate the ionosphere.

Choosing the correct antenna

Basically, there is just one reason for choosing the correct antenna — so that the signals propagate over the path that we want them to, both in terms of arriving at the receiver at all, and then to do so by the best possible propagation mode. The choice of antennas is very much a "horses for courses" selection. One antenna may be ideal for one situation, but almost hopeless for another.

Before choosing an antenna, we must first work out the geometry of our circuit, especially the elevation angles, which are normally the same at the transmitter and receiver. We can do this using Figure 5.8, reading off the elevation angles for each possible propagation mode. As a working rule, for low frequencies (up to about 10 MHz) we should assume E-layer propagation during the day, with F-layer propagation at higher frequencies. Only one-hop and two-hop modes need be considered*.

Once we have deduced the elevation angles for the 1F and 2F modes, say, we can select an antenna which first of all has a radiation pattern with a maximum at the appropriate elevation angle. For example, for a 1000 km circuit, the elevation angles for the two modes are 28 degrees and 48 degrees, so we would need to choose an antenna which radiates the bulk of its energy somewhere around 45 degrees. An antenna which puts most of its energy out at an angle of 10 degrees, for example, would be absolutely useless on this circuit — most of the energy would end up at a range of 2000 km. In this case it would hit the ionosphere over the receiver, which is clearly not what is intended.

Figure 5.12 illustrates the gain pattern for an antenna which would be quite suitable for a 1000 km circuit, but which would be quite inefficient for a short circuit (including a vertical incidence one). Antennas must be chosen to match the intended circuit length. They must also be matched to the intended propagation mode, as illustrated in Figure 5.13. In this case most of the energy would travel via the 2F mode, so there is no point in working at a frequency which is supported by the 1F mode but is too high for the 2F mode.

Figures 5.12 and 5.13 also illustrate the fact that, for the same operating frequency, signals on short circuits need to penetrate more deeply (higher) into the ionosphere before they can be reflected. At vertical incidence, a signal at a frequency equal to foF2 would need to penetrate right through to hmF2, the height of maximum electron density. However on an oblique circuit, the same signal would be reflected at a lower lever — the longer the circuit becomes, the lower the level of reflection, because the increasing obliquity factor means that a lower plasma frequency is adequate to reflect the signals.

If the obliquity factor is kept more or less fixed by considering a fixed circuit, and the operating frequency is increased, the increasing frequencies would need to penetrate higher into the ionosphere for reflection to occur. This means that for a given circuit, the higher frequencies will leave the transmitting antenna at the higher elevation angles and follow higher raypaths to the receiver.

This is illustrated in Figure 5.14. Note that signals at the MUF on an oblique circuit do not reach hmF2. Any attempt to use a higher frequency than the MUF, by trying to have the signals reflected from a higher altitude, is defeated by the fact that the obliquity factor decreases as the altitude increases. Such frequencies would therefore not be reflected, but would penetrate the ionosphere.

Table 5.1 is a good guide to the choice of an antenna appropriate to a particular circuit. For distances under about 1000 km, a horizontal dipole antenna would be a good choice. A vertical monopole, or a whip antenna, would be a poor choice because most of the energy radiated from a vertical ▶

Path length km	Required radiation (elevation) angles	Suitable simple antennas
0-200	60°-90°	Horizontal dipole: broadside to required azimuth, 0.25 wavelength (λ) above ground.
200-500	40°-70°	Horizontal dipole: broadside to required azimuth, 0.3λ above ground.
500-1000	25°-50° 10°-20°	0.25λ vertical monopole or horizontal dipole: broadside to required azimuth, 0 5λ above ground.
1000-2000	10°-30° and low angles	Vertical monopole: up to 0.3λ long with ground screen.
2000-3000	5°-15° and 20-30°	Vertical monopole: up to 0.3λ long.
>3000	low angles	Vertical monopole: up to 0.6λ long with ground screen.

TABLE 5.1. Examples of simple antennas which can be used on circuits of given lengths and elevation angles. The propagation modes are assumed to be single hop modes.

* When life starts to get too serious, this rough and ready approach is not good enough and the experts should be called in.

monopole leaves the antenna at low elevation angles. Vertical monopoles are most suitable for long circuits. For very short circuits, the best antenna is a half-wave horizontal dipole erected high above the ground. This antenna sends most of its energy straight up, or nearly so, where the ionosphere will reflect it back down to within an area centred on the transmitter.

Choosing an antenna that will support only one of the possible propagation modes on a given circuit can be quite a difficult job and requires more complicated and expensive antennas than are normally available.

Absorption

Every radio wave reflected from the ionosphere is partially absorbed as it passes through the D region, both on the way up to the reflection point in the E, F1 or F2 layers, and on the way back. It is therefore essential that we know something about absorption.

Absorption is easily explained on what is called the microscopic level, which means that we look at what individual atoms are doing. When an electron absorbs energy from a radio wave, it vibrates or oscillates to and fro at a frequency equal to that of the radio wave. The energy of the radio wave is thus transformed into kinetic energy, or energy of motion. The oscillating electron re-radiates this energy in the form of radio waves (this is how a radio wave is transmitted from an antenna) so the energy of the radio wave is passed forward from one electron to the next.

If, however, an oscillating electron collides with a heavy neutral atom, it will give up its energy to the atom. The atom does not then vibrate at the radio wave frequency, because it is not a charged particle, but uses its increased energy to travel a little faster. The energy which the electron took from the radio wave is thus lost as far as the radio wave is concerned and we say that part of the wave's energy has been absorbed or that the signal has been attenuated.

Because it is the neutral atoms which are the villains of the piece, snatching radio wave energy from the light-weight electrons, we can deduce that absorption will be strongest where there are the most neutral atoms. This is at lower altitudes in the atmosphere, so the parts of the ionosphere giving rise to most absorption of radio signals are the D region and, to a lesser extent, the lower part of the E region.

To a first approximation, the absorption of a radio signal follows the same variations as the electron density in the D region. This is particularly the case for signals reflected obliquely from the F layer, which is our main area of interest here. For signals reflected vertically from the E region, extra absorption occurs near the level at which the signal is reflected, and this is related more to the way the electron density varies with height in the E region than to the underlying D region. The extra absorption is known as *deviative absorption* because it occurs when the ray is deviated by the ionosphere — in fact the ray is deviated completely around so that it retraces its upward path. In other words, the ray is reflected. The absorption suffered by the signal as it passes through the D region is called *non-deviative absorption*, because the ray passes essentially undeviated through the D region. It is the non-deviative absorption which follows the variations of the D region and which is important for HF communications via the F region.

Non-deviative absorption builds up after sunrise, is greatest at noon, drops rapidly after sunset, and is almost zero at midnight. It is greater in summer than in winter, in general, and is greater at higher levels of solar activity. These variations are illustrated in Figures 5.15 and 5.16. The absorption varies inversely with the square of the frequency — for example, if the frequency is decreased by a factor of two, the non-deviative absorption will *increase* by a factor of four. This is why higher frequencies are normally preferred to lower frequencies.

An interesting feature of absorption in Winter at mid latitudes is the occurrence on some days of very high values of absorption. These days are called *winter anomaly* days because of the anomalously or unusually high values of absorption, which can reach the levels normally encountered only in the Summer. Fortunately, the Winter anomaly can be overcome by the use of higher frequencies for communications since the critical frequency of the F2 layer (foF2) is higher in winter than summer. This is the mid-latitude seasonal anomaly described in Part 4.

The absorption of a wave depends on the sense of its polarization. For example, an extraordinary wave is more heavily absorbed than an ordinary wave. This can be explained quite nicely on the microscopic level. The electrons in the ionosphere cannot move across the field lines of the Earth's magnetic field, but instead circle or gyrate around them. The rotating electric field of a circularly polarized wave can act to either speed the electrons up, or slow them down, depending on the direction of rotation of the electric field. The *ordinary wave* is the one whose electric field *slows the electrons down*, while the *extraordinary* wave gives them extra energy and *speeds them up*.

The more energy the electrons get from the wave, the larger the radius of the circle which they travel in, and the larger the chance of their striking a neutral atom and losing all of their energy. Consequently the extraordinary wave is more heavily abosrbed than the ordinary wave. When the wave frequency of the extraordinary wave is equal to the gyrofrequency (the frequency at which an electron gyrates around a field line — see Part 4), *all* the energy of the wave is transferred to the neutral atoms and the wave is completely absorbed. This does not happen with the ordinary wave.

The lowest usable frequency

We have seen earlier that the highest, or maximum, usable frequency depends on the critical frequency of the ionosphere at the reflection point and on the geometry of the circuit, which determines the obliquity factor. There is also a *lowest usable frequency* for a given circuit at a given time, which depends on:

(1) The efficiency of the antennas.
(2) The transmitter power.
(3) How much absorption the signal suffers.

At low frequencies, the optimum size of an antenna can get prohibitively large. For example, at 2 MHz, a halfwave dipole is 75 m long. It is therefore common practice to use smaller, less efficient, antennas which lead to less energy actually being radiated for a given transmitter power than is possible for an ideal antenna. This inefficiency can be overcome to some extent by increasing the transmitter power to get the received signal up to the required signal strength. Since the efficiency of a given antenna decreases with frequency, a point will be reached as the frequency is decreased when the signal arriving at the receiver cannot be detected above the background noise level. This frequency is called the *lowest usable frequency* or LUF.

The LUF is also heavily affected by the ionosphere, in particular by the amount of absorption that a signal suffers as it traverses the D region. We have seen that absorption depends inversely on the square of the frequency, so that as the frequency goes down, the absorption increases and the signal at the receiver gets correspondingly weaker. The effect on propagation is obviously very similar to that of an inefficient antenna, both acting to decrease the signal strength as the frequency decreases. The LUF on any circuit is set by the two phenomena acting together.

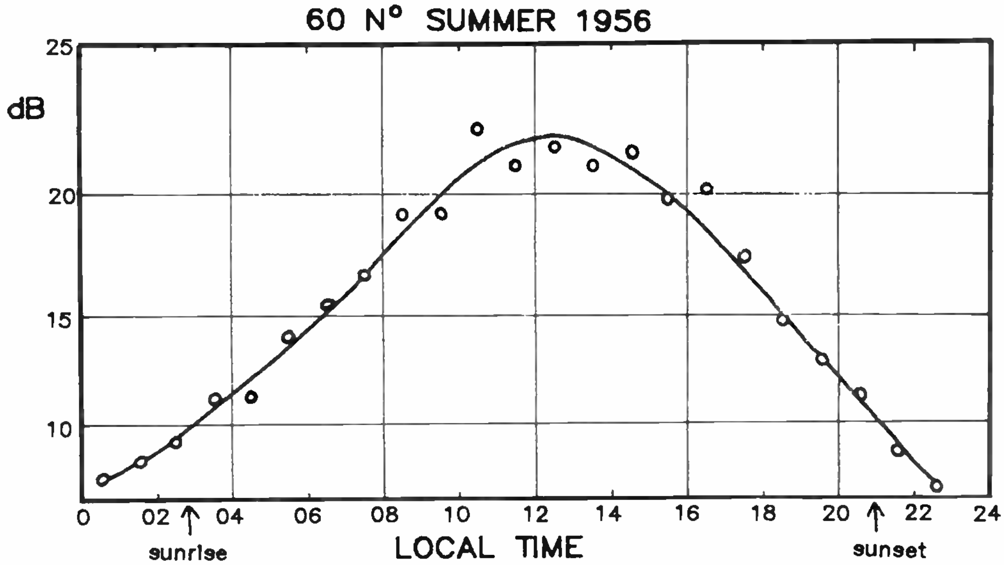


Figure 5.15. The diurnal variation of absorption due to the D layer at a station 60 degrees N, in summer at high solar activity. The absorption peaks at noon and drops off to zero during the very short night.

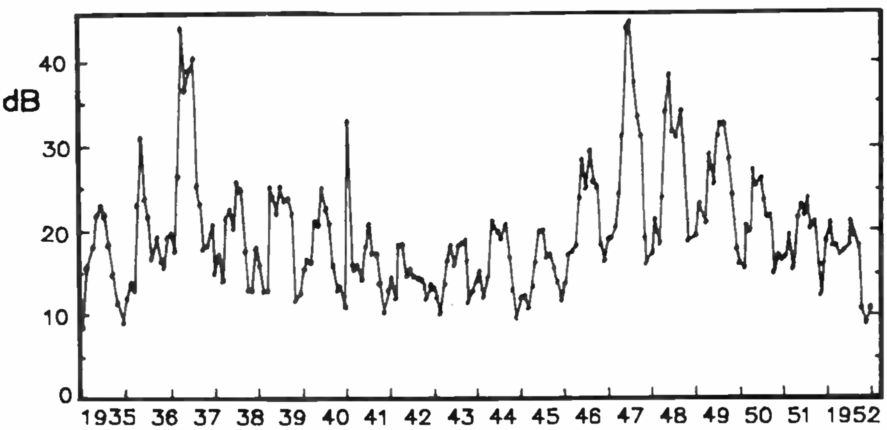


Figure 5.16. The variation of absorption of a vertically incident radio wave at 4 MHz, for Slough (near London, UK), from 1935 to 1952. The absorption shows an annual variation, generally being greater in mid-year (summer) than at the end of the year (winter). It also shows a solar cycle variation, being greatest in years of high solar activity, such as 1937 and 1947. The January 1941 results show a winter anomaly period during which the absorption exceeded even the normal summer levels.

Because the LUF on a circuit depends significantly on the amount of absorption that a signal suffers, it will vary in much the same way as absorption itself varies. In other words, the LUF on a given circuit will be highest during the day, during the summer, and at solar maximum. At night, when the absorption is very small, the LUF decreases to very low values and is controlled only by the inefficiency of the antennas, provided the transmitter power is sufficient to give an adequate signal-to-noise level at the receiver.

Variability of the MUF

We saw in Part 4 that the ionosphere varies significantly from one day to the next, and that this variability is described in practice by the statistical terms lower decile, median and upper decile. Because of this variability, the MUF defined by equation 5.3 will also vary from day to day and must be described in statistical terms. In practice, the term MUF is used in two senses:

(1) As the maximum usable frequency corresponding to a given critical frequency and circuit (equation 4.3).

(2) As the monthly median value of the maximum usable frequency on a given circuit at a given hour for a given month.

The term is used in the latter sense when talking about *predicted* values of the maximum usable frequency. When predictions of the MUF are made for a particular month on a given circuit, the frequencies specified are normally the expected median values of the individual MUFs for the month. Recall that the median value is the value which is greater than *half* of the individual values. If we were to use the predicted MUF at a particular hour for communications on the corresponding circuit, we would expect to get through on that frequency on 50% of the days of the month.

Although HF communication has its failings, we can certainly do better than a 50% success rate for communicating on a given circuit. If we use a frequency which is lower than the predicted median MUF (and our predictions have no errors!), there will be more than half the days on which our working frequency is below the actual daily value of the MUF. Some communicators work on a frequency which is 15% less than (or 85% of) the predicted MUF, with a view to achieving substantially higher success rates than 50%. However it is more logical to use a frequency which is equal to the lower decile value of the individual MUFs. We would then expect to get through on that frequency on 90% of the days of the month (at a particular hour), without having to guess how often communications at a frequency equal to 85% of the MUF would be successful.

The frequency which is equal to the lower decile value of the 30 or 31 individual MUFs for the month is known as the *optimum working frequency* (OWF) or *frequency optimum travail* (FOT). The OWF or FOT is the internationally agreed standard for the "best" or "optimum" frequency to use at a given hour on a given circuit. Its use will result in successful communications, at least as far as the correct choice of frequency is concerned, on 90% or 27 days of the month.

A nine element yagi for the two metre band

Garry Crapp

Technical Products Department
Dick Smith Electronics

Here's a simple-to-build nine element Yagi kit featuring coverage across the entire 144-148 MHz amateur 'two metre' band. It delivers reasonable gain, requires no tuning and can be used for vertical or horizontal polarization.

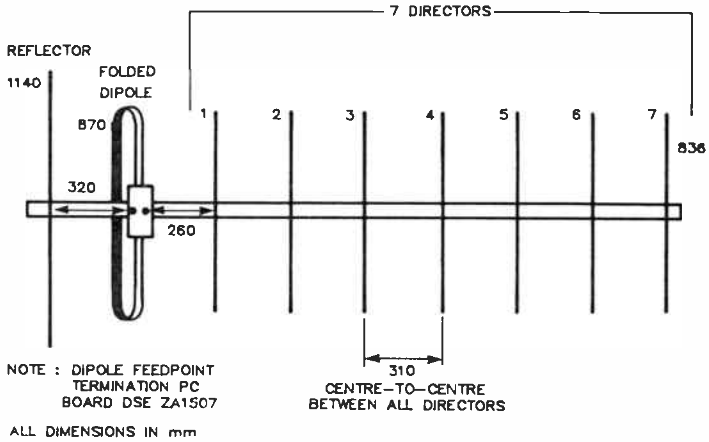


Figure 1. General mechanical and assembly details.

PROBABLY THE MOST POPULAR of the amateur bands above 50 MHz is the two metre band, 144-148 MHz. These days, activity covers virtually the entire band. Dedicated DXers running regular 'skeds' (contact schedules at set times) using CW and single sideband occupy the first half megahertz — and consistently work distances, day and night, that would be the envy of many 80 metre operators. A variety of beacons populate the next half megahertz. Satellites are found just below 146 MHz while FM operation predominates from 146 to 148 MHz with 'channelised' operation providing a host of simplex channels and repeaters located all over the country. There is also increasing 'non-voice' activity in this end of the band, with radioteletype (RTTY) and packet radio operation.

Getting amongst the myriad activities on this popular band is not as simple as getting hold of a rig and 'running-up a wire', as you can on the HF bands. Simple antennas, such as a groundplane, will get you on the air, but soon you'll feel the need for 'something a bit better'.

Considerations

Through a carefully thrashed-out 'gentlemen's agreement', the two metre band has been segmented to avoid clashes between the fundamentally different transmission modes and the activities that they suit. Operation down the 'bottom end' of the band employs horizontally polarised antennas from long established practice. In the 'top' 2 MHz, vertical polarisation is employed, for FM activity commenced principally as a mobile-to-mobile and mobile-to-base operation. Vertical whips are much easier to install on a vehicle! While that is still the major 'flavour' of FM activity, this end of the band is now often used for cross-town chatter.

For satellite operation, circular polarisation is employed for the signal may arrive from the 'bird' at any angle. Most often you'll find satellite proponents using two linearly polarised antennas arranged at right angles and connected so as to receive or transmit signals that may have any random polarisation.

The range any VHF/UHF station can reliably achieve without 'external' assistance from repeaters or propagation phenomena is entirely determined by what is called 'station system performance'. A station system comprises:

- the antenna
- the feedline
- the receiver, and
- the transmitter

The 'height of the antenna above average terrain' (termed the HAAT), also matters. Either you buy a home on top of the biggest hill for miles around, or put your antenna as high as you can (on top of the biggest tower you can afford)!

The performance of the receiver and transmitter is a matter of personal preference and depth of pocket, and as this is an antenna project, let's just stick to what can be done with the antenna and feedline.

To make the most of your location, no matter how 'good' the site, a beam antenna is necessary. By far the most popular beam antenna type employed on the amateur VHF and UHF bands is the *Yagi*, named after Hidetsu Yagi, one of the co-inventors. Its popularity derives from its ability to deliver the most gain for the least materials used, or 'best bang for the buck' as the Americans say.

The design of Yagi antennas is not simple, there being complex mathematical interrelations between the dimensions of the elements and their spacings etc to produce the desired results. In years gone by, there was a lot of 'cut-and-try'. Modern mathematical analysis and computer number-crunching has been able to make Yagi antenna design more of an engineering exercise.

Design details

The first major requirement of this antenna, like the K6305 70 cm Yagi described in the February 1986 issue of *Australian Electronics Monthly*, was simplicity of construction. To that end, a simple element spacing scheme was settled on, using directors all the same length and spacing. A mechanically manageable boom length had to be determined, consistent with achieving a beam with reasonable gain (i.e.: 10 dB or better). A boom length of about 2.5 metres was settled on, on which a nine element Yagi fitted well. The seven directors and single reflector are cut from 9 mm diameter aluminium tubing. The driven element is a folded dipole, fabricated from 10 × 3 mm aluminium strip. This comes pre-formed in the kit.

Figure 1 shows the overall mechanical details. The spacing between directors is 310 mm. All directors are 836 mm long; the reflector 1140 mm long. The end-to-end length of the prefabricated folded dipole is 870 mm.

The folded dipole feedpoint is terminated to a small pc board. 'Folding' the driven element raises its impedance to a manageable several hundred ohms. But, the feedpoint is balanced and because unbalanced 50 ohm coaxial cable is a readily available and commonly employed feedline on the VHF bands, a suitable matching scheme to provide the required impedance and balanced-to-unbalanced transformation is necessary. Here, a 'trombone' balun has been used for the task.

The general arrangement of the trombone balun is shown in Figure 2. Now you see where its name came from! The U-section is a half wavelength of 50 ohm coax, taking the velocity factor of the line into account (typically around 0.66 or so for common dielectric cables). The 50 ohm coax feedline is parallelled with one end and the inner conductors connect to the dipole feedpoint. The U-section provides a 4:1 impedance transformation as well as converting between the balanced and unbalanced condition. In the kit, the trombone U-section is cut from a length of coax supplied which is about 70-odd cm long.

The reflector and driven elements are attached to the 19 × 19 mm square section aluminium boom using a simple element-to-boom clamp made from a short piece of 25 mm wide aluminium U-channel. Figure 4 shows the general arrangement.

Performance

The antenna was designed to work across the whole band and exhibits a voltage standing wave ratio (VSWR) of 1.5:1 or better over 144-148 MHz. Gain achieved is around 12 dB with respect to a dipole ('dBd'), and the front-to-back ratio 17 dB. The measured 3 dB beamwidth (E-plane) is about 50 degrees. Table 1 summarises the details.

Assembly

Construction is quite straightforward. No measuring or drilling is required. First, identify the reflector — it's the longest length of aluminium tubing! You'll find the boom has the element positions marked. The position of the folded dipole driven element is easily identified, for two holes are drilled in the boom on the side where the pc board feedpoint termination mounts, and one hole is drilled on the opposite side of the pillar that supports the dipole.

Assembly should commence with the balun and feedpoint pc board. The balun should be cut from the length of RG58C/U supplied with the kit, as per Figure 3. Overall length is 720 mm. Cut back the outer sheath 15 mm from each end, unbraid the shield and form it into a 'tail'. Then bare the centre conductor for 5 mm at each end, removing the insulation with a razor or sharp hobby knife. At all times take care not to nick the wires. Now you can solder the balun to

This month's ★ Star Project ★ is from Dick Smith Electronics who will be marketing kits through their stores and dealers; cat no. K6297 $89. Mail order enquiries to PO Box 321, North Ryde 2113 NSW. (02) 888 3200.

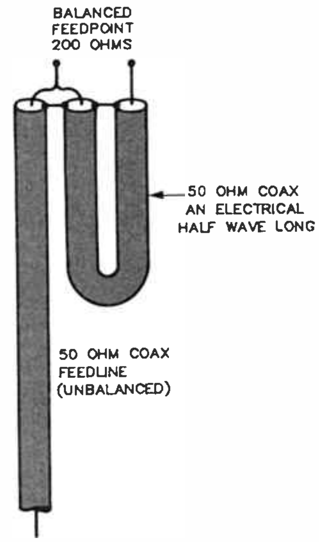


Figure 2. The 'trombone' balun.

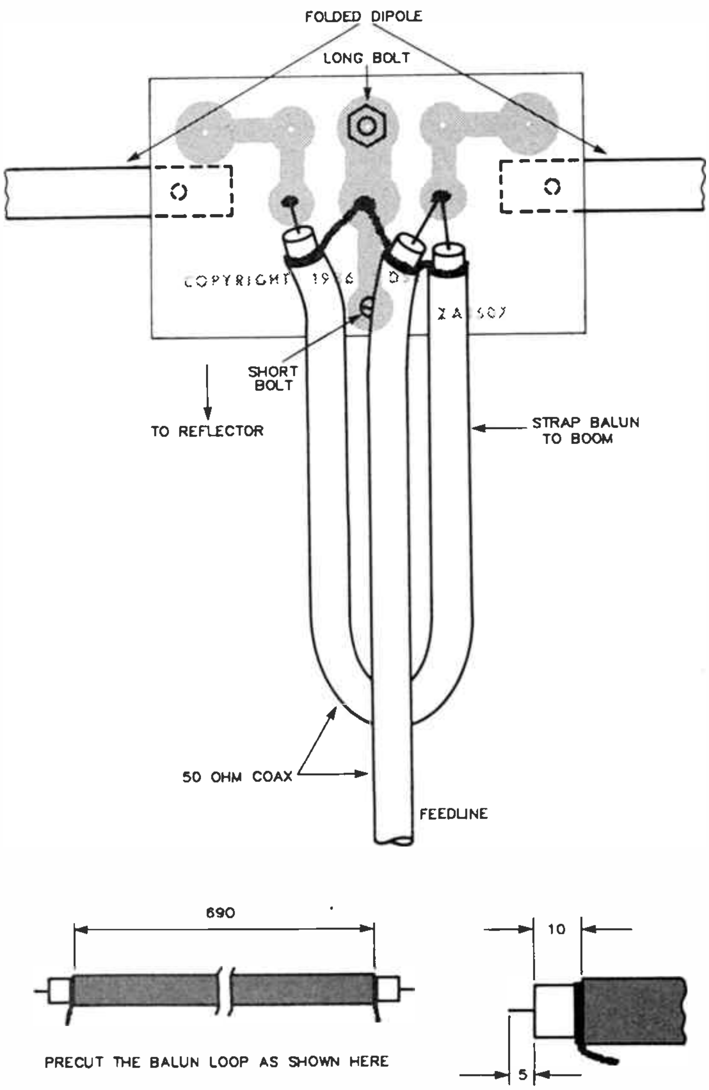


Figure 3. Balun/feedpoint assembly.

the pc board as detailed, starting with the braid tails, then following with the centre conductors. Take care not to melt the coax's insulation. Once that's done, put the assembly aside.

Now you can start assembling the directors and reflector to the boom. The element-to-boom clamp assembly is illustrated in Figure 4. It consists of a short piece of 25 mm wide aluminium U-channel, drilled through the sides of the U at the open end, through which the element passes, and drilled through the bottom so that a bolt and nut can clamp the element to the boom.

The element positions are all marked on the boom. Line up the directors and reflector over the marks and tighten the element clamp nut. Now you can assemble the driven element.

Holding the folded dipole in place, pass the long bolt through it, the 30 mm long standoff pillar and the boom so that the bolt protrudes right through the side where the pc board mounts. Slip the pc board (with attached balun) in place and secure it with washers and nut as indicated in the Figure 5 drawings. Now secure the pc board to the boom with the short bolt.

A 'flying lead' of 50 ohm coax has to be attached to the feedpoint, as per Figure 3, to run down to the main antenna feedline. This flying lead should be flexible cable and of sufficient length to allow rotation of the antenna without becoming fouled or strained. After attaching the flying lead, seal the terminations with a suitable sealing compound such as Selley's 'Silastic'. The folded dipole terminations may be protected from the ravages of the weather with clear lacquer.

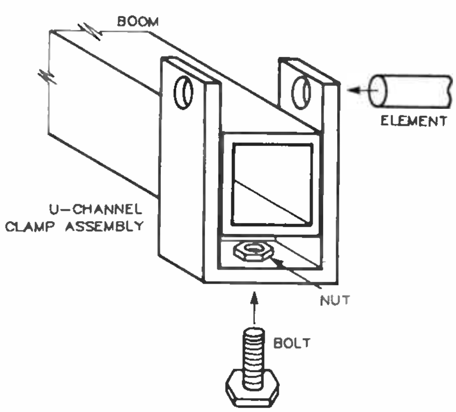


Figure 4. The element-to-boom clamp.

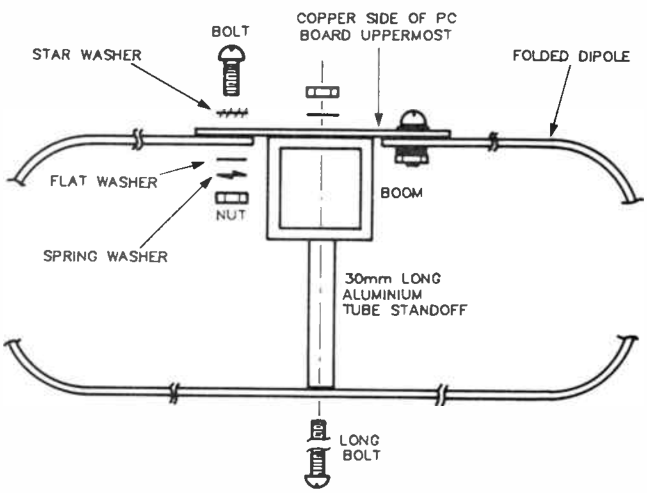


Figure 5. The folded dipole assembly.

Mounting and rotating it

This antenna has to be mounted to the antenna mast at the balance point of the boom, whether it's horizontally or vertically polarised. If a single one is employed in vertical polarisation, then a non-metallic mast must be used for a distance below the antenna of at least half the Yagi's boom length. For clamping the boom to the mast, a variety of clamps made for TV antenna application are available.

Suggested arrangements for mounting the antenna are given in Figure 6. Most light to medium duty rotators may be used for aiming this antenna.

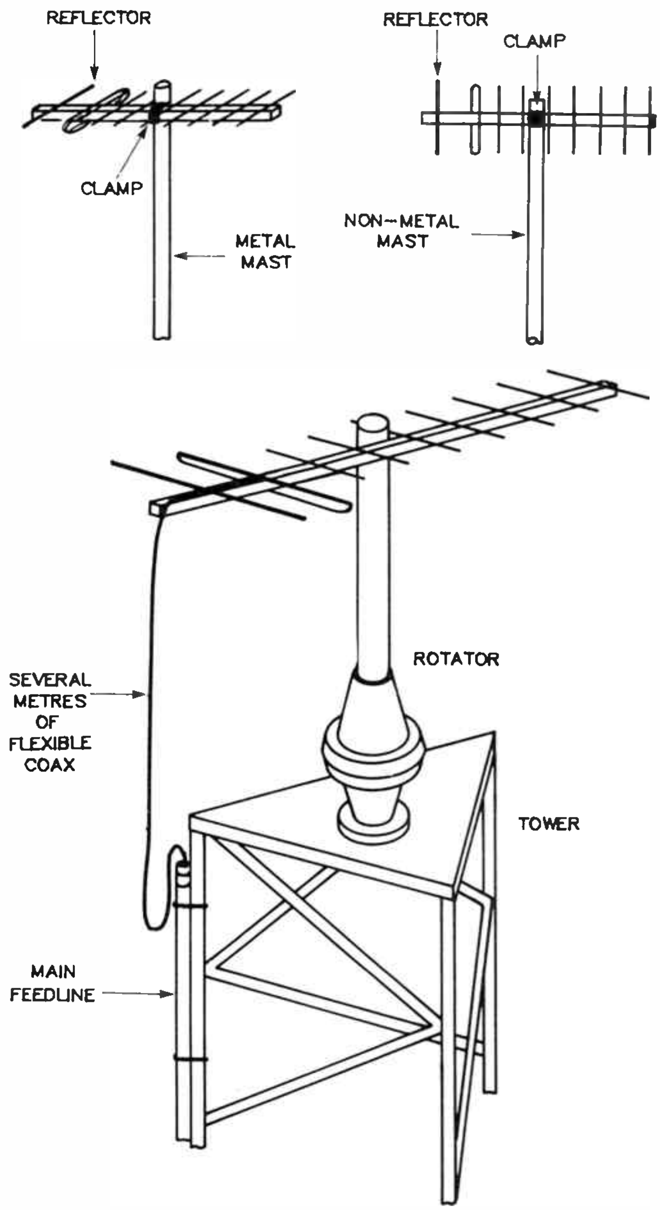


Figure 6. Suggestions for mounting and rotating the antenna.

Feedline considerations

Having settled on where and how high the antenna's to be mounted, consider the feedline. As you know, all feedlines exhibit loss. What point is there in putting up a gain antenna if you throw away the gain with loss in the feedline? Not only that, lossy feedlines affect receiver noise figures and

—to p.101 ▶

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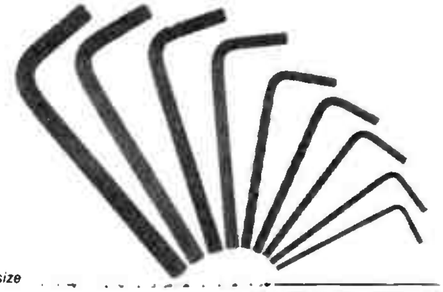

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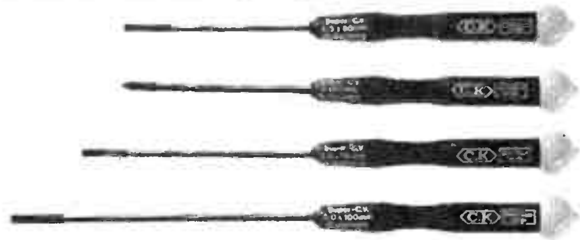

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Philips extend "zero defects" warranty to include all integrated circuits supplied worldwide

The "zero defects" warranty implemented in August 1985 by the Philips affiliate Signetics (Sunnyvale, California), is being extended to cover all integrated circuits produced worldwide by the Philips group of companies. Under the terms of the Warranty a customer who finds a single defect in a batch will be able to return the entire batch to Philips for re-screening or replacement. Philips are the first major integrated circuit suppliers in the world to set a Zero Defects standard, they say.

The warranty took effect from March 1st and will apply immediately to all standard-function ICs manufactured to that date. Customers will have a thirty day period in which they can report a faulty batch.

The zero defect warranty will also apply to application specific ICs (ASICS) but only with close customer cooperation.

"With this warranty we are telling our customers that our standard is not 500, not 200 nor 50 parts per million, but zero", said Bill McCormick, general manager of the Electronics Components division of Philips Australia.

"It is clear to us that the entire IC manufacturing industry must eventually offer the same warranty, and we are in a position to spearhead this movement," he said.

Philips began a major quality improvement program in 1981, starting in the components group, to eliminate defects by designing them out of their manufacturing and administrative operations. At that time, the IC industry's average outgoing electrical defect rate ran at about 10 000 parts per million.

The program caused a cultural renaissance within Philips making defect prevention — rather than detection — the only way to perform. Every member of the workforce was actively involved in this process. Each individual within the company was committed to quality improvement, Philips say.

By 1985 the impact of the program was such that the implementation of the zero defect warranty became a reality.

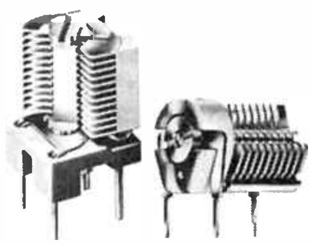
The program is now at the point where continued improvement depends increasingly on customer interaction and cooperation. The ongoing collection of field data — and subsequent analysis — and cooperation with major customers are essential to the company's ultimate goal of zero defects, according to Philips.

To stimulate industry-wide interest Philips will launch an international IC promotional campaign from mid-year. The campaign will centre on the use of a graphically-striking "0" symbol accompanies by the words "one standard, Zero Defects — from people committed to quality". A similar campaign has already been running in USA and international magazines under the Signetics name.

Bonzer trimmers

A range of bonzer trimmer capacitors from A. Tronser GmBH of West Germany is now stocked by Promark in Sydney and Melbourne. All are air dielectric types for pc board and panel-mounting applications.

Also available in the range are miniature solid dielectric tubular types for UHF and microwave applications. Maximum capacitance values range from



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Power problems

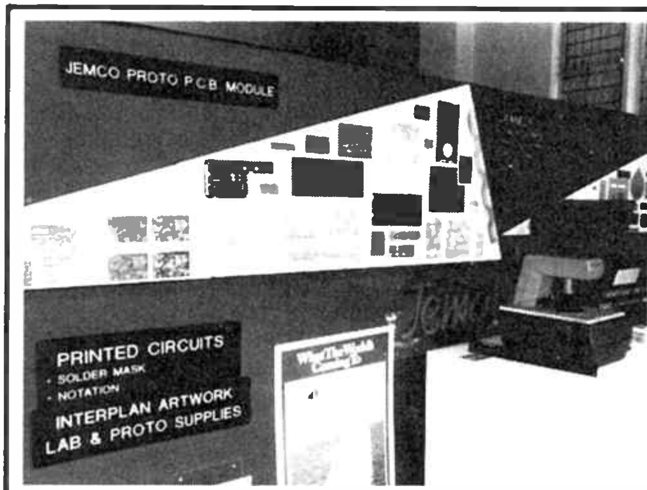
The problem of providing an interference free power supply for computers and micros has become a feature of today's electronic era. Many types of destructive interference reach sensitive equipment through the power supply mains.

Electromark has taken a special approach to the problem. For protection of equipment, software and data against damage or corruption from spikes, normal mode noise and common mode noise, they install a Tycor filter located between the power outlet and the computer.

Advantages claimed for the Tycor filters are: • Dedicated lines become unnecessary; • Reduction in downtime; • Decreased service costs; • Elimination of time consuming and costly reboots.

Tycor filters will remove decaying oscillatory transients and spikes as well as common mode noise, according to the makers. They also offer almost complete protection against massive impulses from lightning strike and other power line accidents, say Tycor.

For further information, specifications and prices, contact **Electromark Pty Ltd, 43 Anderson Road, Mortdale 2223 NSW. (02) 570 7287.**



JEMAL APPOINTS VICTORIAN REP.

Jemal Products of Perth has announced the appointment of All Electronic Components as the sole Victorian distributor of the huge range of goods and services offered by Jemal.

Manufacturers, designers, etc in Victoria will now be able to communicate directly with technical people for componentry, pc board and front panel work, assuring a most professional finish to any prototype and product run at modest cost, Jemal says.

Services available include sourcing, supply and assembly of components, manufacture of printed circuit boards, panels, chassis and racks. Plated-through hole PCB facilities and the latest membrane switch technology are also available. All services are "in-house" — customer's design security is assured — and all product is made in Australia.

Contact **All Electronic Components** to arrange a visit from their representative, or call at **118-122 Lonsdale St. Melbourne** and view the Jemal Display. **(03) 662 3506.**

— from page 96

aem star project

TABLE 1: SPECIFICATIONS AS MEASURED ON PROTOTYPE

Frequency range	144-148 MHz
VSWR	1.51:1 across band
Polarisation	vertical or horizontal
Gain	12 dBd
Front-to-back ratio	17 dB
3 dB beamwidth	50° (E-plane)
Feedline impedance	50 ohms

thus, sensitivity. Hence, the best quality low-loss coax you can afford is recommended. In addition, you should keep the line length as short as possible, consistent with getting the antenna as high as practicable.

Don't put the antenna mast 100 metres away from the rig's location if you can at all avoid it. Put it closer, even if it has to be lower, in order to keep those feedline losses down. If you have a substantial run of feedline between the antenna and the rig, you'll have to spend proportionally more on the feedline to keep the losses down.

The larger diameter cables have less loss than the common 6.5 mm cables (such as RG58). If you have to use any length of 6.5 mm cable, get a good low-loss type and use the shortest possible length — preferably less than 3m.

Andrews FHJ4 is a solid (i.e: not flexible) line with very low loss at 144 MHz and relatively high cost as a consequence. Special connectors are required and are not easily fitted. Consider FHJ4 as the 'Rolls Royce' of cables. Belden 9913 is a semi-flexible coax that comes highly recommended and standard "Type N" connectors can be fitted. If you have a run of less than 20 metres, then RG213 may be used as it's quite economical, but 9913 would be better.

— from page 9

International brawl over new digital audio tape standards

"So why should the consumer opt to spend money on new tape systems that have no advantage?"

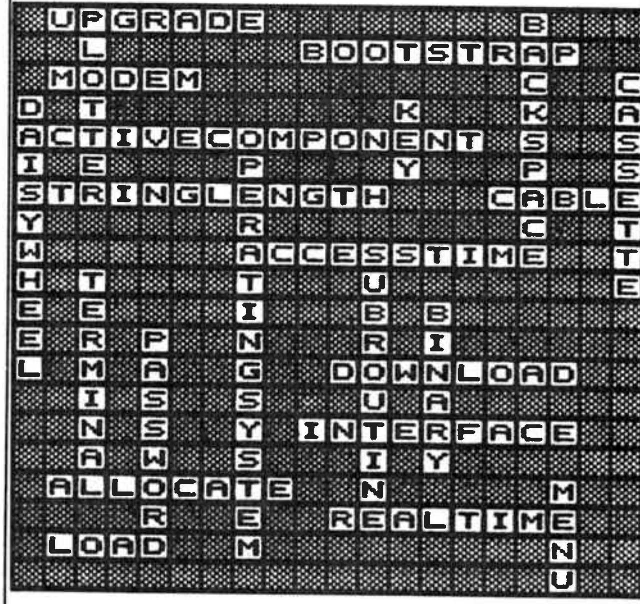
Andriessen said that S-DAT is about the size of the current compact cassette and has the same playing time. The R-DAT, using a rotational head drum like a video recorder, offers around two hours of recording on a cassette that is about half the size of the compact cassette. He obviously believes the R-DAT is a better system than the S-DAT because it is more economic in its use of tape. But the fault with this cassette is it doesn't flip over, he says.

What Andriessen wants the committe to do is opt for an R-DAT cassette that is slightly larger than the one currently proposed, which would flip over and give four or five hours of recording.

"If we don't have something new to offer we won't get the consumers to accept it," he said. "The trend is to time-shifting and current audio tape technology requires you to be at home when you want to record from a program from the radio, simply because the tape is too short with its 45 minutes per side to record anything of worth.

"What we need is a recording robot — a new tape system you can leave at home to record the program you want while you are out. It means a tape that is long enough to handle the programs you want."

ANSWERS TO WELLER CROSSWORD NO. 7.



Binary, Octal, Hex and all that jazz . . .

Theo Baitch

HOW OFTEN have we heard about these mysterious words, mumbled as part of their jargon by the computer experts, programmers and others involved with the mysticism which enrobes computers and all that goes with it? And how often have we read about them, trying to put a meaning to these expressions, which were obviously of such great significance to the computer hobbyists and "hackers"?

What they really mean

We normally express the numerals used in everyday use in the form of decimal numbers and using the decimal number system. There, it is possible to express any number as the sum of multiples of the number 10 (hence the name "decimal" system), raised to the appropriate power.

Since $10^0 = 1$ and $10^1 = 10$ and $10^2 = 100$ and so on, the *exponent* (that little number above the line) indicates in fact, the number of zeros after the 1. So for example, the number 1986 can be expressed as a sum in the following number:

$$
\begin{aligned}
1986 = \quad & 1 \times 1000 = 1 \times 10^3 \\
+ & 9 \times 100 = 9 \times 10^2 \\
+ & 8 \times 10 = 8 \times 10^1 \\
+ & 6 \times 1 = 6 \times 10^0
\end{aligned}
$$

$$1986 = 1{\times}10^3 + 9{\times}10^2 + 8{\times}10^1 + 6{\times}10^0$$

It is interesting to note that the group on the extreme right (the group incorporating the least significant number) counts units. Each count in the second group from the right equals the base (or *radix*) of the system which, in the decimal system, is 10.

Binary simply stands for *binary number*, or a number based on the "binary number system". This number system differs from the decimal number system in that it is based on the use of the number "2" as its base (or radix) and derives its name from there (bi = 2). This 2 takes the place of the 10 used in our familiar decimal number system.

Similarly, **octal** stands for *octal number*, or a number based on the "octal number system". This number system in turn differs from the decimal number system in that it is based on the use of the number "8" as its base (or radix) and also derives its name from there (octo = 8). This time, it is that 8 which takes the place of the 10 used in the decimal system.

Finally, **hex** stands for *hexadecimal number* (and not for witch or witchcraft . . .!) which is a number based on the "hexadecimal number system". In line with what has been said above, this number differs from the decimal system in that it is based on the use of the number "16" as its base (or radix) and similarly derives its name from there (hexa = 6; deci = 10). It is this 16 which takes the place of the 10 of the decimal system.

Why have such exotic number systems?

The need for these exotic number systems arose from the fact that electronic computers and other digital circuits can best operate when using simple "on" and "off" voltage impulses and are thus operating by using a "digital information transfer system".

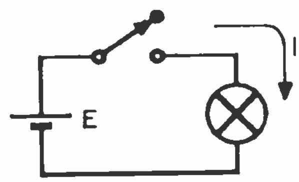
Digital systems are very reliable, simple to design and operate and are very immune to external interference, since they convey only two, very distinctly different, states or conditions. And since there are "two" of them, this leads us straight into the "binary system".

The binary system

In fact, a switch, which might be a mechanical device or its electronic equivalent (e.g: a transistor), is the simplest digital coding device. It has two conditions.

(i) an open or open-circuit condition; when the switch is open, the circuit is interrupted and thus there is no current flowing in the circuit.

(ii) a closed or closed-circuit condition; when the switch is closed, the circuit is also closed and current can thus flow through the circuit.



The above conditions are also frequently expressed as *logic conditions* or as *logic states*.

An **open switch**: when there is **no** current flowing in the circuit, or when there is no voltage appearing at a certain point in the circuit, is called the "Logic 0 (zero)" or *low* state.

A **closed switch**: when there **is** a current flowing in the circuit, or when there is a voltage appearing at a certain point in the circuit, is called the "Logic 1 (one)" or *high* state.

Since we have *two* states involved, we call this digital system the *binary system*, which can be most readily handled by electrical means, consisting of *zeros* and *ones*.

Those circuits which handle only the two voltages mentioned above (a "low" and a "high" voltage) are called *digital circuits*. While the two voltages involved are referred to as low and high voltages, they may take on many different values, provided that one of these voltages is relatively higher with respect to the other, such as, for example: + 5 V and 0 V, 0 V and -5.2 V, + 12 V and 0 V, etc.

The binary number system

As said earlier, the binary number system is based on the use of the number 2 as its base. The binary system is extremely popular in the field of computers and data processing, since the base 2 admirably suits the fact that electric circuits and switching devices can have only two states, as indicated above: either open, with no current flowing and no potential (that is 0) or alternatively, closed, with current flowing and with a potential (that is 1). The two characters 0 and 1 of the binary number system can therefore easily represent the bistable nature of electrical devices. These two numerical values 0 and 1 in the binary number system replace very conveniently the numerical values 0 to 9 of the conventional decimal number system.

A number is expressed in the binary number system in a similar fashion to the decimal system, except that the powers of 2 are used to head the columns (i.e: groups).

So, the column headed $2^0 = 1$ (or units column) will be on the extreme right, followed by $2^1 = 2$ and $2^2 = 4$ and $2^3 = 8$ and $2^4 = 16$ etc, progressively from right to left. This means that the extreme right-hand (or *least significant* column) will count units (0, 1). Each count in the second column equals the radix (or base), that is 2. Each count in the third column equals $2^2 = 4$. Similarly, each count in the fourth column equals $2^3 = 8$ and each count in the fifth column equals $2^4 \times 16$ etc.

This will allow us to show the equivalence of numbers expressed in the decimal system and in the binary system:

Decimal notation	2^3 = 8	2^2 = 4	2^1 = 2	2^0 = 1	binary notation
0	0	0	0	0	0000
1	0	0	0	1	0001
2	0	0	1	0	0010
3	0	0	1	1	0011
4	0	1	0	0	0100
5	0	1	0	1	0101
6	0	1	1	0	0110
7	0	1	1	1	0111
8	1	0	0	0	1000
9	1	0	0	1	1001

In expanding the above principle to larger numbers, we can see that the binary number system, while most suitable to be handled by computers and other digital systems, is nevertheless somewhat clumsier than the decimal system in the sense that rather more digits are required to represent the same number. So, for example:

Decimal		Binary
151_{10}	equals	10010111_2
105_{10}	equals	1101001_2
75_{10}	equals	1001011_2

The subscript used shows the base (or radix) of the particular number system.

The octal number system

Because the binary number system is difficult to easily use and recognise, two other number systems are also used. These are called the "octal" and "hexadecimal" number systems respectively.

The octal number system uses the eight numerals 0, 1, 2, 3, 4, 5, 6, 7. It should be noted that the base (radix), 8, is equal to $2^3 = 8$ and this system thus lends itself to digital data handling, too. In the same manner as in the decimal and binary systems, each digit position corresponds to a power of 8.

Binary numbers may be represented by octal numbers by separating the binary number into groups of three, starting from the right; such as, for example:

Binary: $010\ 101\ 011_2$
Octal: 2 5 3 = 253_8

and

Binary: $111\ 000\ 110\ 001_2$
Octal: 7 0 6 1 = 7061_8

The hexadecimal number system

The hexadecimal system uses 10 numerals and six symbols, sixteen in all. These 16 numerals are made up of the numbers 0 to 9 and the first six capital letters of the alphabet, that is A, B, C, D, E and F.

Hexadecimal digits can also be represented by binary notation. Each "hex" digit is equivalent to four consecutive binary digits or "bits" (**B**inary dig**its**) since $16 = 2^4$. This makes hex notation very useful for handling large binary numbers.

Hexadecimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

In the same manner as decimal, binary and the octal systems, each digit position corresponds to a power of 16.

In a somewhat similar manner as shown for octal numbers above, binary numbers may be represented by hexadecimal numbers by separating the binary number into groups of four (since four binary bits are required to represent the numbers from 0 to 15); starting from the right, for example:

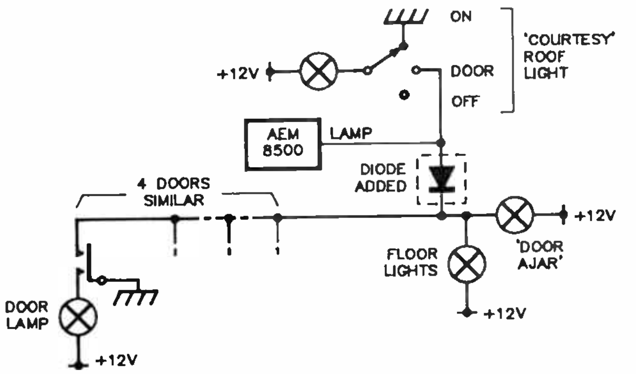
Binary: $1100\ 0111\ 1110_2$
Hexadecimal: C 7 E = $C7E_{16}$

and

Binary: $1110\ 0000\ 0011\ 1011_2$
Hexadecimal: E 0 3 B = $E03B_{16}$

(to be continued)

Small mod. for the AEM8500 Courtesy Light Extender



I recently built the AEM8500 Courtesy Light Extender and fitted it to my 1983 Sigma sedan. The car is fitted with several of the luxury features, including more interior lights than you can poke a stick at.

A problem soon became evident in that the driver was confronted with a 'door ajar' warning light until the extender time period elapsed. The circuit shown here is re-drawn from the vehicle electrical diagram and shows a small modification which overcomes this problem. The cost of this alteration is a massive 10¢ or thereabouts, for a diode suitable to carry the light's current.

This modification can be used in any vehicle which has a similar arrangement of lights and warning lamps, to extend the time of only the main roof light.

If the roof light fitting is of suitable construction, the printed circuit board may be mounted adjacent to the light in the ceiling of the car. This also provides easy mounting of the isolating diode.

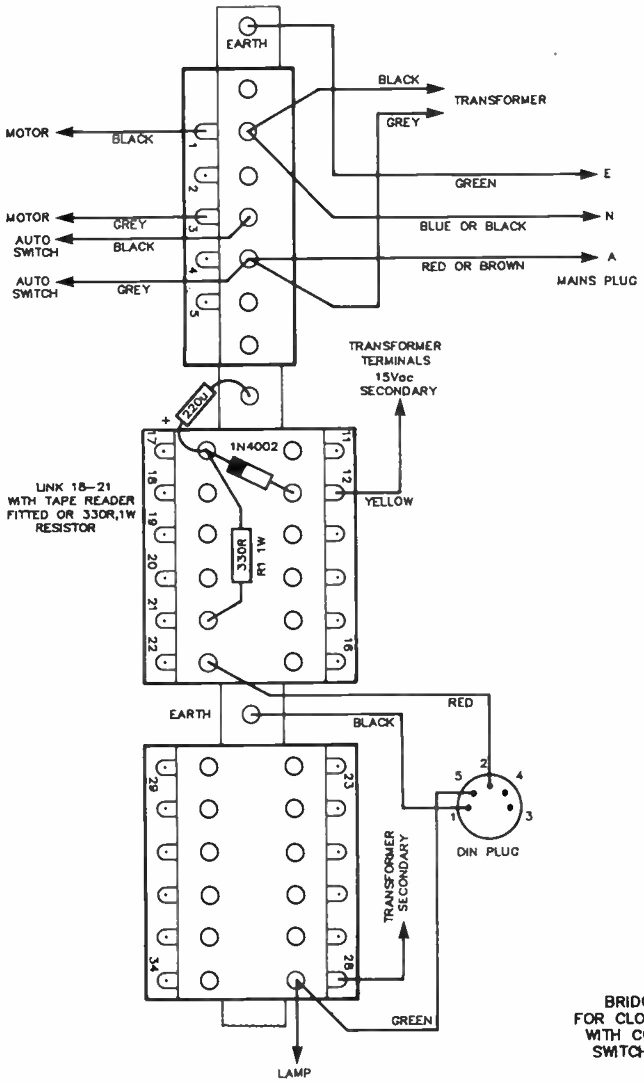
W.G. Neumann,
Yeerongpilly, QLD.

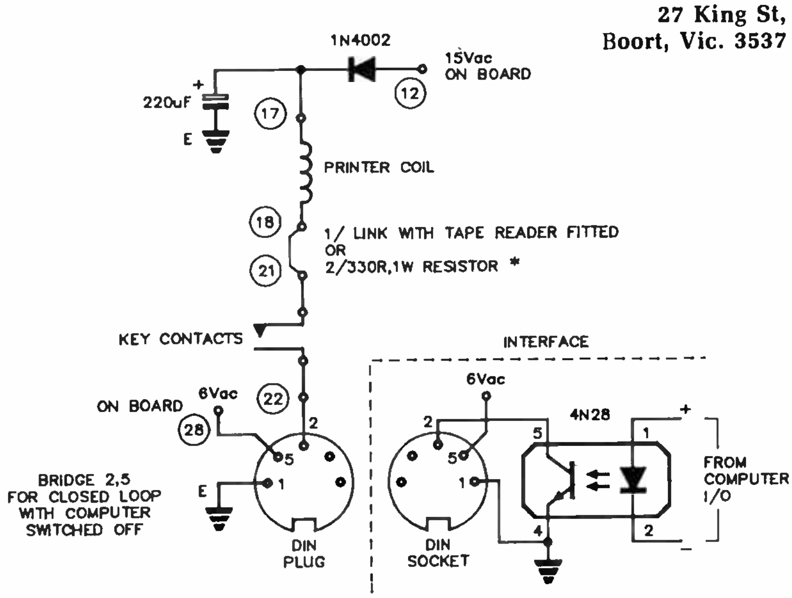
Simple Siemens TTY interface for the C64

Here's a much simpler, well-proven interface for driving a Siemens 100 teletype as a printer from the Commodore 64 than that shown on page 71 of the February '86 issue in the *Commodore Codex* column. Actually, it's suited to pretty well *any* computer with a suitable serial output.

The computer's serial output drives the optocoupler LED while the optocoupler's transistor output is used to drive the printer coil. The circuit shows the general arrangement, while the wiring diagram illustrates how it's actually done within the Siemens TTY. The circled numbers refer to the tiepoint numbers.

Frank Rees
27 King St,
Boort, Vic. 3537





* READER COILS OR 330R SETS CURRENT TO NOMINAL 30–40mA

Engineering education — for the top 3% only!

Dear Roger,

I read your February '86 editorial with concerned interest, which has prompted me to write. Your ideas and attitudes on the skilled training and tertiary qualifications of people entering the work force for the first time are no doubt from someone who has had many years of experience and is highly regarded in the electronics industry. However, I would like to present another point of view to your readers — that of a 1st year Science Student at Sydney University.

Firstly, you have questioned the "attractiveness" of engineering as a career and how Australia's performance in the training of engineers is "dismal". But it is not the attractiveness of engineering that is the problem. I will give an example to illustrate this:—

In 1984 the entry mark to Electrical Engineering at Sydney University was 363. This mark enabled students who were in approximately the top 20-30% to gain entry, with a quota of 100 into this faculty.

In 1985 the entry quota for Electrical Engineering at Sydney University was dropped to 80 and the entry mark raised to 398! Since this is the lowest possible to gain entry into the course, this represents something like the top 3% of all students in the State!

From the above figures, it can be seen that it is extremely difficult to gain entry into this faculty.

As I see it, the government is to blame for their cuts in education spending, while their wages continue to increase to enormously high levels. Perhaps if the politicians wages were cut by half or one third, then more of the taxpayers money could be spent on worthwhile ventures — one of these being education.

This matter is of personal concern to me, as I only succeeded in gaining 389 in the H.S.C. — 9 marks under the entry mark.

However, I have been an electronics hobbyist for six years and have worked many hours in my holidays in a reputable electronics store. There are a lot of other electronic hobbyists who must be content with another career!

I hope I have provided a point of view that is of interest to readers and which provokes some feedback.

Chris Smith
Epping, NSW

Your identification of entry quotas to university engineering courses as a contributing factor to Australia's dismal performance in turning out engineers is a very good point indeed, and one which seriously needs addressing by those concerned — the politicians, university boards, faculty heads, etc. The entry quotas set, in fact, do not reflect the level of demand for the skilled people a course will turn out, but the priorities of the individual institution, so far as I can see.

However, it seems clear you chose to attempt an Electrical Engineering course much earlier than HSC or even School Certificate level. That motivation, I warrant, came from your hobby. Am I right? We need to attack the problem at both ends — the motivation of young people and the policies which decide who will gain entry to engineering courses.

Roger Harrison

A future for amateurs

Dear Roger,

May I take this opportunity of offering my congratulations to you and Jim Linton VK3PC on your most appropriate article, "Amateur Radio — Future Direction" in the February issue of *Amateur Radio* (journal of the Wireless Institute of Australia).

I agree completely that steps must be instituted NOW to ensure the survival of our hobby. Steps must be taken to harvest those many areas mentioned in the article. Those steps must be very professional in their structure and execution. I don't think it is sufficient to rely on Amateurs to enrol members through friends, the odd advertisement in technical journals, etc. If the WIA has not formed a committee to consider this matter as yet, then steps should be taken to do so immediately.

I think your paper would be a very solid starting point for WIA action.

Pat Kavanagh VK2DMY
North Sydney NSW

At time of going to press, moves are afoot to establish just such a committee as you suggest.

Roger Harrison

Watch your language!

Dear Sir,

Can't resist the urge to write to you in regard to the title of your "Amiga" review (page 62, February '86 issue).

J. Nathan Cohen is obviously a good journo (bon = 'good' in French) buta he don'ta speeka de Italiano so good. Mama mia, she-a saya "Buono giorno" for l'Inglese "Good day".

If you start butchering Italian in this way we'll all end up with mass burnings of AEM in the streets of "Footiscray". (This latter is a joke dependent on familiarity with a particular TV advertisement seen only in the cultural capital of Oz).

With best wishes for the success of the magazine.

Ken Anderson,
Boisdale, Vic.

*The title to the Amiga computer review was a 'multicultural' pun from Mr Cohen. The asterisked footnote explanation of it (*Italian for "G'day") was the Editor's idea for carrying the joke further. Watsa matta you, anyway — can'ta take-a joke? (Please Mr Grassby, I'll apologise, but no lurex tie!).*

Compulsory reading

Dear Sir,

I enjoy reading AEM and have added it to my monthly compulsory reading list. I am particularly pleased to see that you try to cater for varying computer users. e.g: various software available for the Listening Post. Keep up the good work.

Brian Symons
Mackay, Qld

Roederstein MKT capacitors

Dear Sir,

Thank you for the advance information on your projects. It is pleasing to see reference to products our Company represents in your project 5504 (March issue).

Please correct one vital mistake in the notation on your AEM 5504 parts list.

Roederstein is represented and distributed by Mayer Krieg & Co in Adelaide, Melbourne, Sydney and Auckland and not by Promark.

Thank you, and keep up your high standard.

Peter Krieg
Manager (NSW)
Mayer Krieg & Co.

I'm aghast! Our apologies. There are, in fact, two missing lines which 'disappeared' when this note was sent for correction to a typographical error. We did manage to correctly attribute the distribution of Roederstein MKT capacitors to your firm in the **Project Buyers Guide** *in the February issue's "Retail Roundup" column, from which the note at the foot of the AEM5504 Electromyogram parts list was prepared.*

Roger Harrison

The Last Laugh

A NOTE on AWA-Thorn's January price list for software and hardware for the Amstrad home computer listed among the new releases a software package called "Halley's Comet". An asterisk beside it led to a footnote at the bottom of the page which read:

*"*Please note all stock of Halley's Comet software still available after April this year will need to be reserved until 2062 A.D."*

That's what we call **confidence** in your product!

More than a black hole

The press made a great to-do over results from Russia's Comet Halley probe in early March, with pictures of 'streamers' trailing from the head, details of the core, etc. What was more interesting however, were reports of a 'cometary ring'. We're all aware of planetary rings a la Saturn, and the more recently discovered black rings around Uranus, composed of some carbon compound (not unlike rubber, we're told). Well, it seems the Russian probe photographed something similar encircling Halley's Comet. Scientific sources have tentatively named it "Halley's Grommet!"

The fundamental laws

As at least all senior high school students are aware, indeed anybody who has studied the fundaments of science, there are a number of immutable laws which are the foundations of discipline.

In electronics, being in reality applied physics, there are three of these laws, in case you didn't know. Ponder on them awhile, for they provide food not just for the mind but the body, as well. Named for the great minds that elicited them, they are expressed mathematically as follows:

OHM'S LAW

$$R = \frac{E}{I}$$

KIRCHOFF'S LAW

$$I_{T} = I_{1} + I_{2} + \ldots I_{n}$$

COLE'S LAW

$$SA_{lad} = \frac{C_{ut}CAB^{j}}{BE_{ef}B^{e}RG_{r}}$$

SMD-RESISTORS

FOR PROFESSIONAL ELECTRONICS

BEYSCHLAG Metal Film Resistors »Harmonic Series«

Version	Temperature Coefficient	Tolerance
STANDARD	TC 100	5 % – 2 %
PROFESSIONAL	TC 50 – 25	1 % – 0,5 %
PRECISION	TC 25 – 15	0,25 % – 0,1 %
Style	**Rated Dissipation P70**	**Resistance Range**
MBA 0204 - BX	0,4 Watts	0,22 Ω – 10 MΩ
MBB 0207 - BX	0,6 Watts	0,22 Ω – 10 MΩ
MBE 0414 - BX	1 Watt	0,22 Ω – 22 MΩ

IEC Series

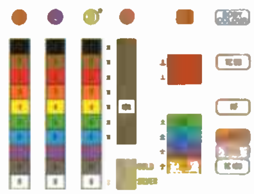
E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192
10	100	100		147	147		215	215		316	316		464	464	68	681	681
		101			149			218			320	47		470			690
	102	102	15	150	150	22	221	221		324	324		475	475		698	698
		104			152			223	33		328			481			706
	105	105		154	154		226	226		332	332		487	487		715	715
		106			156			229			336			493			723
	107	107		158	158		232	232		340	340		499	499		732	732
		109	16		160			234			344			505			741
11	110	110		162	162		237	237		348	348	51	511	511	75	750	750
		111			164	24		240			352			517			759
	113	113		165	165		243	243		357	357		523	523		768	768
		114			167			246	36		361			530			777
	115	115		169	169		249	249		365	365		536	536		787	787
		117			172			252			370			542			796
	118	118		174	174		255	255		374	374		549	549		806	806
12		120			176			258			379			556	82		816
	121	121		178	178		261	261		383	383	56	562	562		825	825
		123	18		180			264	39		388			569			835
	124	124		182	182		267	267		392	392		576	576		845	845
		126			184	27		271			397			583			856
	127	127		187	187		274	274		402	402		590	590		866	866
		129			189			277			407			597			876
13	130	130		191	191		280	280		412	412		604	604		887	887
		132			193			284			417			612			898
	133	133		196	196		287	287		422	422	62	619	619	91	909	909
		135			198			291			427			626			920
	137	137	20	200	200		294	294	43	432	432		634	634		931	931
		138			203			298			437			642			942
	140	140		205	205	30	301	301		442	442		649	649		953	953
		142			208			305			448			657			965
	143	143		210	210		309	309		453	453		665	665		976	976
		145			213			312			459			673			988

RANGE OF VALUES 0 OHM – 10 MOHMS TEMPERATURE COEFFICIENTS TC 15 – TC 100 TOLERANCES 0,1% – 5%

Colour coding for Beyschlag Mini-Melf – as is usual for resistors with leads – with 4 or 5 colour bands for resistance value and tolerance

* is not used for 4 band coding

EXAMPLE 37,4 KOHM ± 1% TC 50

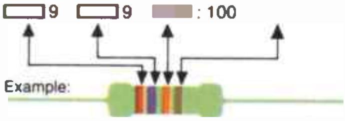


BEYSCHLAG GmbH P O Box 1220 D-2240 Heide
Telephone 481-950 Telex 28801 Telefax 481-95209

Metal Film Resistors »Harmonic Series« STANDARD	light green
Metal Film Resistors »Harmonic Series« PROFESSIONAL	light blue
Metal Film Resistors »Harmonic Series« PRECISION	light blue
Carbon Film Resistors STANDARD	ruby-red

Colour coding according to IEC Publication 62 and DIN 41 429

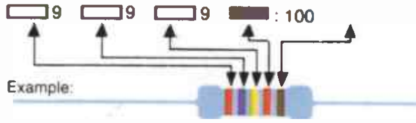
band 1	band 2	band 3	band 4
0	0	x 1	
1	1	x 10	
2	2	x 100	± 2 %
3	3	x 1 k	
4	4	x 10 k	
5	5	x 100 k	
6	6	x 1 M	
7	7		
8	8	: 10	± 5 %
9	9	: 100	



Example:

red - violet - orange - gold = 27 k Ω ± 5 % TC 100

band 1	band 2	band 3	band 4	band 5	colour dot
0	0	0	x 1		
1	1	1	x 10	± 1 %	
2	2	2	x 100	± 2 %	
3	3	3	x 1 k		TC 15
4	4	4	x 10 k		TC 25
5	5	5	x 100 k	± 0,5 %	
6	6	6	x 1 M	± 0,25 %	
7	7	7		± 0,1 %	
8	8	8	: 10		
9	9	9	: 100		



Example:

red - violet - yellow - red - brown = 27,4 k Ω ± 1 % TC 50

A cut out and keep Resistor colour coding chart from Crusader Electronics