ELECTRONICS WORLD

+ WIRELESS WORLD

FEBRUARY 1993 £1.95

Denmark DKr. 70.00
Germany DM 15.00
Greece Dra.760
Holland DFl. 14
Italy L. 7300
IR £3.30
Spain Pts. 780
Singapore S$ 12.60
USA $6.70

SOR DISTRIBUTION

A REED BUSINESS PUBLICATION

PC ENGINEERING

Autoroute to layout bargin?

HYPOTHESIS

Black holes in the electron

ANALOGUE DESIGN

Non linear electronics

NEW SERIES

Analogue troubleshooting

HISTORY

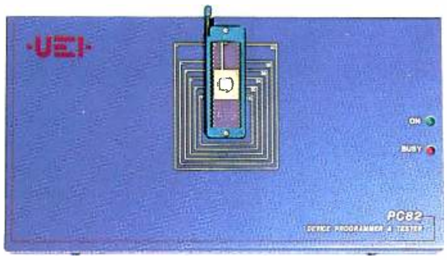
A fishy tale of early electricity

RF DESIGN

Self calibrating noise source

9 770959 833004 02

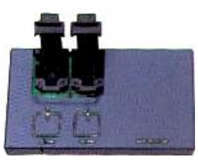
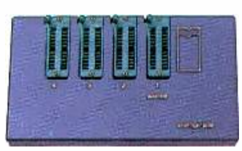
TOTAL PROGRAMMING SOLUTIONS FROM CITADEL



PC82 UNIVERSAL PROGRAMMER £449.00



- Universal programmer – the complete designers kit.
- Over 1,500 devices – call for list on FREE disk.
- EPROM, EEPROM, Flash, BPROM, GAL, PAL, MPU etc.
- Serial EEPROM, EPLD, MACH, MAX, MAPL, CMOS EPAL.
- Device testing – 74XX, 40XX, 45XX, DRAM, SRAM.
- PAL vector test.
- Clear menu driven software
- Text mode only, suits any video card.
- 40 pin Zero insertion force socket.
- Device testing – 74XX, 40XX, 45XX, DRAM, SRAM.
- Small half card to install in PC may be left in place.
- Secure round cable and locking D connectors.
- Proven reliability – over 100,000 units sold.
- Programmer pod size – 260×140×38mm.

ADAPTERS FOR THE PC82 From £85.00

- Extend programming facility for special devices.
- Allows alternative socket types eg PLCC.
- Multi-gang adapters for fast programming of EPROMS, GAL, PAL and popular CPU types.

FEATURES ALL PROGRAMMERS

For the IBM PC, install the interface card and programming socket, load the menu-driven software and you have a complete design system at your fingertips. The programmers will run on any compatible IBM machines such as XT, AT, '286, '386 or '486. Whether it be an Amstrad or Compaq the system will work. All features are software-driven and supplied on 5¼" disks, these may be copied onto your hard disk using the DOS copy command. All control of the programmer, programme voltages etc are menu-driven by selecting manufacture, type number, and selection of a suitable speed algorithm. Blank check, read & modify, verify, programme, auto programme, security blow etc.
FREE SOFTWARE UPDATES as new devices become available.

FILE CONVERSION FACILITIES

- HEX to BIN File conversions for Intel, Motorola and Tektronics.
- 2 way/4 way Bin file splitter for 16/32 bit data.
- Dump file to Console, modify and re-programme.

E2000 BULK FAST ERASER £199·00

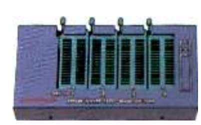
- Same advanced UV source as the M1 but 4 lamps.
- Very large capacity 64×32 pin chips or one double Eurocard.
- All other features as M1.
- Low profile steel case finished in powder coat.
- Size 365×240×65mm high.

M1 FAST ERASER £99·00

- Advanced UV source.
- Typical erase time three minutes.
- LED display of set time and countdown.
- End of time indicated by beep and display.
- Large capacity 13×28 pin devices.
- Sturdy construction, plated steel & aluminium
- Small footprint only 65×225×100mm high.

PC86 HANDY POCKET DEVICE TESTER £99·00

- Tests and identifies virtually all TTL & CMOS.
- Test many DRAM and SRAM memory chips.
- LCD display of type number and results.
- Battery operated (PP3) and completely self-contained.
- Zero insertion force test socket.
- Dimensions 90×140×30mm.


PC84-1 to -8 ROM PROGRAMMERS From £139·00

- Low cost EPROM programmer – devices up to 1Mb CMOS and NMOS.
- One to eight gang versions.
- To program 2716 to 271000.
- 32 pin Zero insertion force sockets.

ORDER INFORMATION

Please include £7 for carriage by overnight courier (£20 for exports) and VAT on all UK orders. ACCESS, VISA or CWO. Official orders welcome from Government bodies and local authorities.

For further information and your **FREE PC82** Simulation and device disk

PHONE SAMANTHA NOW ON:
081 951 1848
081 951 1849

FREE DEMO DISK

CP Citadel

CITADEL PRODUCTS LTD
DEPT WW
50 HIGH STREET, EDGWARE
MIDDLESEX HA8 7EP

CONTENTS

FEATURES


Cover: Dave Bell

REGULARS

In next month's issue: The thought of working with DSP frightens many people. We present a design for a simple PC add-on card which allows experiments with TMS320C10 code.
MARCH ISSUE IS ON SALE FEBRUARY 25

EDITOR
Frank Ogden
081-652 3128

DEPUTY EDITOR
Jonathan Campbell
081-652 8638

CONSULTANT
Derek Rowe

DESIGN & PRODUCTION
Alan Kerr

EDITORIAL ADMINISTRATION
Lorraine Spindler
081-652 3614

SALES MANAGER
Patrick Irwin
081-652 3732

SALES EXECUTIVES
Pat Bunce
081-652 8339

ADVERTISING PRODUCTION
Shirley Lawrence
081-652 8659

PUBLISHER
Robert Marcus

EDITORIAL FACSIMILE
081-652 8956

CLASSIFIED FACSIMILE
081-652 8931

SUBSCRIPTION HOTLINE
0622721666
Quote ref INJ

SUBSCRIPTION QUERIES
0444 445566

NEWSTRADE ENQUIRIES
Darelle Whitehead
071 261 5451

REED BUSINESS PUBLISHING

Obscene call charges?

It is time for the Government to come clean over its plans for introducing true competition into the UK telephone market.

The Government's wish to protect the lucrative international telephone businesses of BT and Mercury Communications is denying most domestic subscribers the chance of buying their telephone service from someone other than British Telecom.

The proposition is simple. Overseas traffic is lucrative. From a technical point of view it has never been easier to go into business as an international carrier. It requires little more than a modest satellite link and a switching centre to hook into the UK's existing trunk network. The centre intercepts 010 numbers and routes them automatically through Intelsat. The phone system in the receiving country does the rest. The equipment required fits comfortably into the average suburban house. A condition of granting the operators' licence would be that the new carriers make substantial and much needed investment in UK local telephone networks. The profit from international traffic should fund competition for the wire that comes through your front door.

There are already signs that US operators are prepared to invest in local telephone networks through their interest in UK cable television companies. But without international licences the biggest US telephone operators are discouraged from investing billions of dollars in Britain.

On paper the UK may have the most liberal telecommunications market in Europe but the benefits to private subscribers have been limited to cosmetic niceties.

Pictures on phonecards and award-winning television adverts may give the consumer a warm feeling towards BT. But most of us have not seen reduced telephone bills or improved the service as a result of direct competition. For most BT is the only choice. Two years after the White Paper supposedly opened the UK market to anyone with the money to invest, BT's virtual monopoly over Britain's 24m telephone lines is still secure.

One of the largest telephone operators in the US has waited a year for the Government to give the go ahead for its plans to invest hundreds of millions of pounds in a British domestic network. The problem is it wants to carry its own international calls.

This application is being viewed as a test of the Government's commitment to competition by many potential investors.

Government seems reluctant to risk the wrath of BT and Mercury which retain duopoly control of international telephone traffic. This seems perverse given the Government's loudly stated determination to break that same duopoly for all other UK telephone services.

Only a cynic would suggest that the Government is concerned over the effect on BT's share price before its has the chance to off-load its remaining 22% holding this year. Any threat to international call revenues, which account for 14% of BT's business and an even larger share of its profits, would alarm the City, a body not without its quota of cynics.

It must be remembered that no other country is even considering foreign ownership of its international telephone carriers and the Government is wise to tread carefully. But seeking reciprocal agreements in the US may not be realistic and could lead to serious delay.

One thing is certain. Real service improvements for the domestic subscriber will not happen without effective competition to BT. New domestic services cannot be funded without the high profit revenues from international traffic.

Surely it is not beyond the wit of President Heseltine at the DTI to come up with a compromise which offers the carrot of international business with the condition of substantial investment in UK telephone networks.

British Telecom has enjoyed the good life for years. It is about time that real competition provides benefits for all of Britain's 24 million telephone users.

Richard Wilson.
Richard is Communications Editor of Electronics Weekly.

Electronics World + Wireless World is published monthly By post, current issue £2.25, back issues (if available) £2.50. Orders, payments and general correspondence to **L333, Electronics World + Wireless World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.** Telex:892984 REED BP G Cheques should be made payable to Reed Business Publishing Group.
Newstrade: IPC Marketforce, 071 261-6745.
Subscriptions: Quadrant Subscription Services, Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 0444 441212. Please notify a change of address. Subscription rates 1 year (normal rate) £30 UK and £35 outside UK.
USA: $116.00 airmail. Reed Business Publishing (USA), Subscriptions office, 205 E. 42nd Street, NY 10117.
Overseas advertising agents: France and Belgium: Pierre Mussard, 18-20 Place de la Madeleine,Paris 75008. United States of America: Ray Barnes, Reed Business Publishing Ltd, 205 E. 42nd Street, NY 10117.Telephone (212) 867-2080. Telex 23827.
USA mailing agents: Mercury Airfreight International Ltd Inc, 10(b) Englehard Ave, Avenel NJ 07001. 2nd class postage paid at Rahway NJ Postmaster. Send address changes to above.
Printed by BPCC Magazines (Carlisle) Ltd, Newtown Trading Estate, Carlisle, Cumbria, CA2 7NR
Typeset by Marlin Graphics 2-4 Powerscroft Road, Sidcup, Kent DA14 5DT

Better deal needed from memory cards

Public acceptance of memory card technology will stay low until a universal filing system transparent to the end user is agreed, according to a report from manufacturer Fujitsu.

The report says that "compatibility between cards still needs to be addressed as the card software and with it the formatting and filing system can cause problems when using different manufacturers' machines."

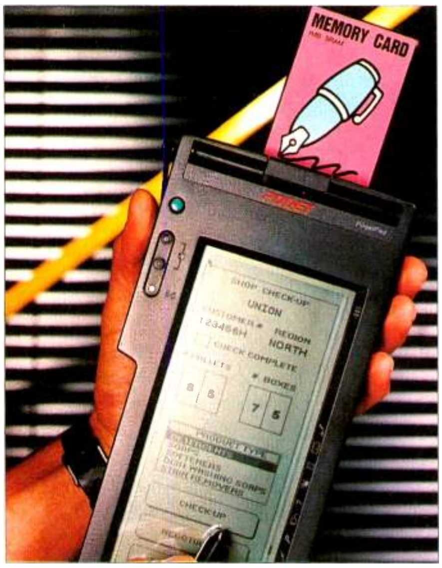
Japan is the largest market for the cards. According to research by SRI International, in 1991 the total Japanese market was 1.1 million cards which is expected to grow to 64 million by 1995.

Rom cards are estimated to have 68% of the market which it is predicted will slip to less than 30% by 1995. These are used for storing software for use with card only machines.

The second largest group is for sram cards with 17%. This sector is growing fast and is expected to have the largest share at 35% by 1995.

But the big expansion will be seen in Flash cards - from 3% in 1991 to nearly 22% in 1995.

The Fujitsu report said: "For the Japanese model to be repeated across the world, it is essential that the industry and the end user is made aware of the advantages of this memory media."



Memory card being used in a palmtop machine

The growth should be boosted by the development of a wide range of non-memory cards including units for modem, lan, and ISDN applications.

Fujitsu moans that while makers of PCs, laptops, and palmtops are designing PCMCIA sockets in their products, these are normally an optional extra and not built-in as standard.

A wide range of new card products are expected in the autumn including dram and sram cards which can be used like floppy disks for storing data which can easily be read and overwritten.

Court forces delay in Am486 chip

There will be a six month delay in the introduction of AMD's *Am486* microprocessors following a federal court decision last year that a copyright licence between AMD and Intel does not extend to microcode in Intel microprocessors.

But Jerry Sanders, AMD's chair, put on a brave face. He said: "While we are bitterly disappointed at the ruling, it will have no unanticipated impact on AMD. As a prudent company, we had a contingency plan. Development of an independently derived microcode for the Am486 family has been under way for some time."

His view on the ruling though was clear when he added: "No verdict or ruling can change the underlying truth. In 1976 I negotiated in good faith and AMD paid a substantial sum for the rights that AMD is now being denied. There is no acceptable alternative for us than to continue to fight for justice."

Walker gets honourary degree

Electroacoustics and hi-fi specialist Peter Walker has received an honourary Doctor of Science degree from Keele University.

Walker started his own business at 19 years old which became known for the Quad range of amplifier and loudspeaker designs. In 1954 he produced the world's first full-range electroacoustic loudspeaker.

He received an OBE for his contribution to the audio industry in 1990

RF transistor develops 600W

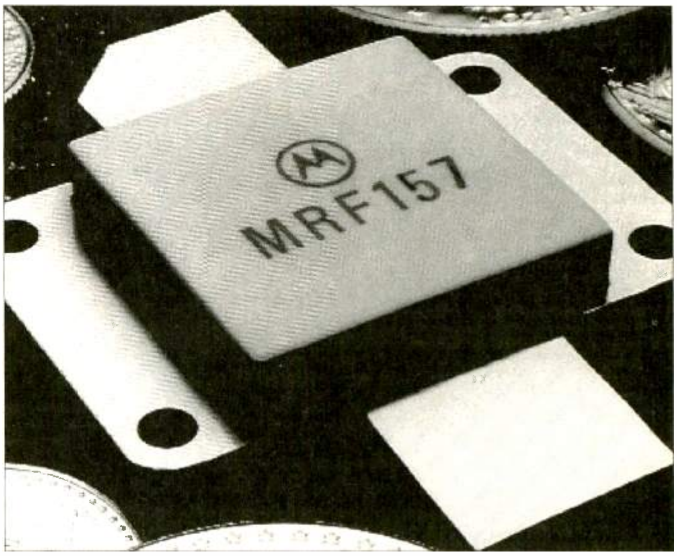
Motorola has produced a continuous duty 600W RF power transistor operating up to 80MHz.

The *MRF157* device has been designed with silicon nitride passivation, source ballasting and integral gate resistors.

Supply voltage is 50V and typical characteristics include a gain of more than 20dB at 30MHz, drain efficiency of 45%, and a third order IMD at rated output power of -25dB. Other specifications include V_{ds} and V_{dg} of 125V, V_{gs} of ±20V, and a continuous drain current of 60A.

The package is designed for conduction cooling. If a copper heatsink is not used, Motorola recommends a copper head spreader between the device mounting surfaces and the main heatsink. Samples and small quantities are available from stock at about $500 each. Production quantities have a three to four month lead time.

Applications for the device include SSB transmitters, amplifiers used with magnetic resonance imaging equipment, sputtering equipment, and amplifiers operating at up to 80MHz.



Japan banks on memory at world chip show

Once again Japanese memory technology looks set to dominate this February's IEEE International Solid State Circuits Conference in San Francisco.

This year is the 40th anniversary of the conference which has gained the reputation of being the main forum for highlighting practical semiconductor developments. Only papers based on working silicon are accepted for presentation at the conference.

Among the highlights are papers on 256Mbit drams from Hitachi and NEC, and a fast 256Kbit bicmos sram also from Hitachi.

The NEC dram uses a multi-divided array structure and has an access time of 30ns. It is made using 0.25μm cmos technology with a finely divided 1/1024 array access activation architecture.

The same cmos technology is used for Hitachi's dram which has an access time of 70ns. Standby current is 26μA at 1.5V using sub-threshold current limiting and sub-array replacement to repair wordline-to-bitline shorts.

Hitachi's new static ram has an access time of just 1.5ns and comprises two 128K-bit ram blocks configurable from 2K by 64-bit to 32K by 4-bit from eight modules. It uses 0.5μm technology.

Despite Japan's high standing in the memory arena, as usual the USA is the most predominant with more than 60 of the less than 110 papers being presented. Japan has less than half the US number, the rest being made up with a smattering from Europe, Canada, and the rest of the world.

One of the US' most exciting developments appears in a paper from Michigan University on a 160,000 transistor GaAs microprocessor. This 200MHz 32-bit risc chip uses a 2V 1μm GaAs DCFL process and dissipates 24W.

The growth in high volume radio phone systems has driven the development of new radio architectures which largely eliminate conventional IF stages and the consequent trimming adjustments. They use quadrature local oscillator signals running at signal frequency feeding a four-quadrant transistor multiplier tree. Typical of this is a device from the USA. It features a 2.5GHz silicon bipolar image-reject front end from National Semiconductor using 0.8μm bicmos technology. A Spanish paper from Telettra Espana in the same session describes a 0.7 to 3GHz GaAs QPSK/QAM direct modulator.

The Fraunhöfer Institute for Applied Solid-State Physics in Frieburg, Germany, is presenting a paper on an 18 to 34GHz dynamic frequency divider based on 0.2μm AlGaAs/GaAs/AlGaAs quantum well transistors. It consists of a two-ring oscillator configuration with NiCr thin-film resistors, MIM capacitors, and two-layer wiring.

In the image sensors and displays section, a joint paper from GTC and NEC gives details of a polysilicon TFT defect-tolerant scanner. The circuit is claimed to be immune to open and short defects without circuit repair. It has been developed for active-matrix liquid crystal displays.

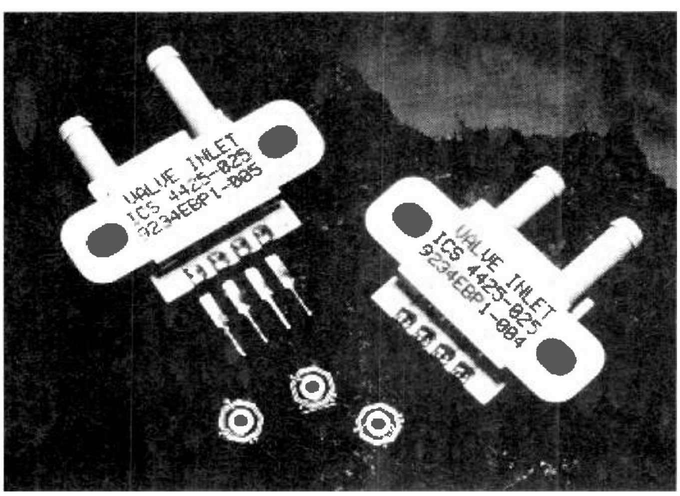
Silicon flow valve uses IC technology

A light weight silicon microvalve looks set to help drug dispensing and ventilator and respirator control in hospitals.

The device is made by IC Sensors and can proportionally control gases and fluids.

Henry Schuster, managing director of IC Sensors' Eurosensor division, said: "It is not just open and shut. It can be used as a proportional controller. This lends itself to medical dispensing for say a drug in a patient or automatic dispensers in hospitals."

It weighs just 0.3g and is designed to replace larger solenoid valves weighing upwards of 15g.



Solid state flow valve mounts directly onto PCB

Made using micro-machining technology, each valve consists of a centrally bossed silicon diaphragm mated to an etched silicon valve body. A thin metal film is deposited on the diaphragm to form the bimetallic actuator.

By adjusting the electrical power dissipated within the resistors implanted in the diaphragm - and thus the temperature of the actuator - the thermal expansion difference between silicon and metal results in the controlled displacement of the central boss away from the valve seat.

Schuster said: "There are people who don't want a mechanical or electromagnetic device for switching gases or air or whatever. They want a device in which nothing moves. There are no plungers or inductances. It is purely a piece of silicon that opens or closes an orifice."

The devices cost £65 each, but this comes down to £28 for orders more than 5000.

Other medical applications include controlling the pressure on patients lungs when in a ventilator. It can also be used for in-throat respirators to gently open and close the air flow.

High flying award

Avionics graduates and undergraduates are eligible for a new award for innovation and design skills sponsored by Racal Instruments and Star UK, the European aeronautics training and research organisation.

Students will be asked to submit their final year projects and the winner will get a trophy and £1000 at a presentation in California. There will also be awards and diplomas for runners up.

To enter, a 300 word synopsis should be submitted by the end of February, accompanied by pictures and diagrams as necessary.

Entries are invited from anywhere in the world apart from the USA and Canada which may have their own award in the future.

For more details contact Paul Eastaugh on 0734-669969.

Solid state gyros from piezo spin-off

Mechanical gyroscopes based on the principle of rapidly spinning top have served for many years as sensors in inertial navigation equipment on board aircraft and ships. These naturally require precise machining. If gyros could be produced at consumer prices there are many applications which would readily use them. For instance low cost inertial navigation for cars and light aircraft, stabiliser systems, aids for blind people.

Optical gyros record angular velocity by measuring the relative phase of standing waves of light set up in a ring of optical fibre. There are no moving parts but this technique remains expensive. However, a new class of gyroscope based on piezoelectric vibration promises a combination of price and performance for consumer applications. The Japanese company Murata has developed a viable gyro system which sells for just £40 in high volume. It demonstrated the thumb-sized device acting as a stabiliser on a model radio-controlled motorcycle at last November's Electronica show. The gyro allowed the model to remain upright at impossibly slow speeds.

The vibrating piezoelectric gyro is a true angular velocity sensor. It makes use of the Coriolis effect, a force which develops at right angles to the direction of moving object subjected to a rotation. This is the same force which determines the direction of water down a plug hole, and that standing into wind in the northern hemisphere tells you with certainly that you have the centre of depression to your right.

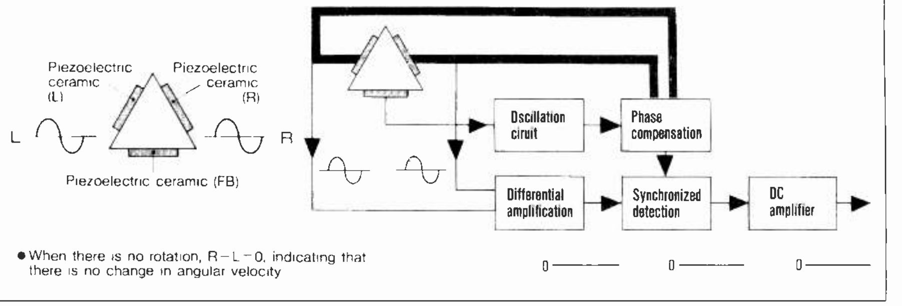
Piezoelectric gyroscopes are essentially simple structures. A number of electrodes fitted radially to a typically cylindrical or Toblerone shaped bar of piezoelectric ceramic material are made part of an oscillator circuit working at the resonant frequency of the piezo structure. The electrical signals developed across the transducer facets exhibit a fixed phase relationship with each other unless disturbed by some external force. When the bar is subjected to rotation, the Coriolis force comes into play causing the phase relationships to change. The difference relates directly to the amplitude of rotational velocity.

Practical structures and circuits tend to use three, equally spaced electrode pairs fixed to the piezo bar with one electrode of each pair connected to ground. The signal electrode from each of two pairs feeds a limiting differential amplifier while the signal electrode from the remaining pair excites the bar using amplified feedback derived from an additive amplifier connected across the inputs of the differential pair.

The measurement circuit compares output from the differential amplifier with the drive signal applied to the bar. Phase variation relates directly to turning forces applied to the bar as the Coriolis force modifies the vibrational pattern of the ceramic crystal.

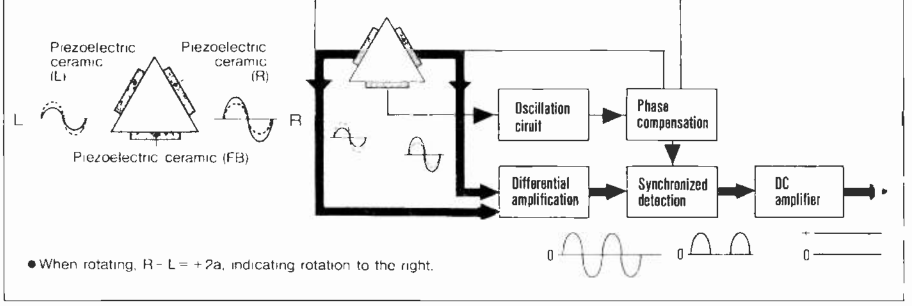
Typical sensitivity for Murata's *Gyrostar* is about 20mV/degree/second with a linearity of 0.1% up to the maximum rotational rate of 90°sec^{-1}. **Frank Ogden**

Moving in a straight line (no rotation)

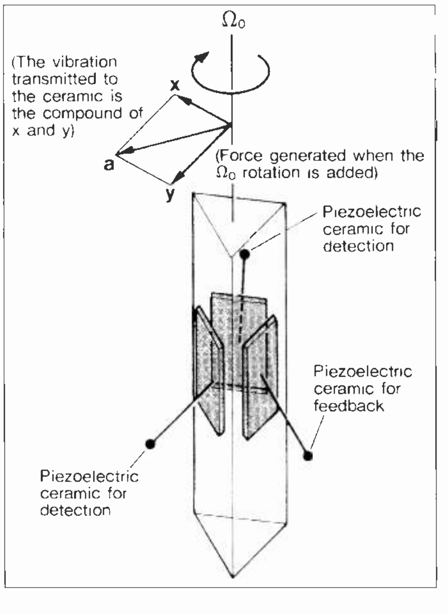


• When there is no rotation, R − L = 0, indicating that there is no change in angular velocity

Rotating



• When rotating, R − L = +2a, indicating rotation to the right.



IEE and Engineering Council fall out over unity

The Engineering Council and the IEE are at loggerheads over the Fairclough initiative for a new single body for the engineering profession.

Despite giving a cautious welcome to the proposals, the two bodies disagree over the way it should operate.

The Engineering Council believes that the institutions should be subordinate to the new body rather than having a relationship based on a partnership as suggested in the proposal. It statement said: "The new body must necessarily be above, not on a par with, the institutions."

However, the IEE believes the tasks of judging applicants and awarding discipline specific titles for qualifications, performance and conduct should be the role of the institutions as should the process of accreditation.

And the IEE made clear in a statement that "Registration should be limited to engineers who are members of appropriate institutions."

The Engineering Council though considers it essential that membership of the new body should include outside members. Otherwise it believes the new body's council would become "the creature of the institutions and would sideline the interests of industry, education, and the desire of those who are on the Council's register to have some form of representation."

While the IEE appears to approve of the idea of a partnership, the statement from the Engineering Council says: "Such a body would need to have direct control of its subordinate organisation and this therefore will necessarily exclude concepts of equal partnership."

RESEARCH NOTES

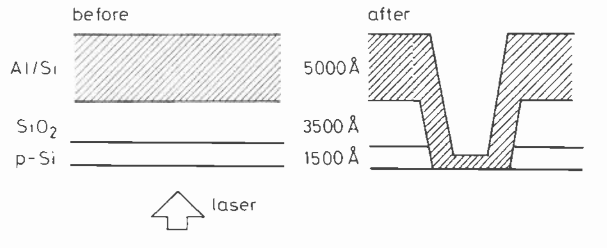
Laser mends LCD displays

A team at the GEC-Marconi Hirst Research Centre at Wembley has developed an ingenious laser technique for repairing manufacturing defects in the drive circuitry integrated onto the glass substrate of advanced LCD displays.

In their latest paper (*Electronics Letters* Vol 28, No 24) the GEC-Marconi team points out that as displays get larger, the chances of process-induced defects also become greater with a corresponding reduction in manufacturing yield. So any method repairing defects is likely to become more important as time goes on.

The idea of devices that can be repaired is not in itself new, but there are considerable problems when the operation involves any more than burning out shorts and unwanted links – especially where doped polysilicon is used for interconnects and where the device involves liquid crystals on a glass substrate.

GEC-Marconi has not only developed ways of cutting unwanted connections on the micron scale, it has also demonstrated its ability to join open-circuit links, even in fully assembled displays filled with liquid crystals.



Films before and after welding.
(Picture courtesy PV Kolinsky, SM Fluxman, RA King, RM Wood, CS Whitehouse and AJ Lowe, Electronics Letters, November 1992, Vol 28, No 24.)

To implement this technique, the display has to have redundant or spare circuitry on the substrate. Normally this is non-functional and adds little or nothing to costs. But if an active circuit element proves faulty on test, the system will allow a manufacturer to cut out the faulty part and micro-weld in the spare circuitry. The unit should then behave to its full design specification

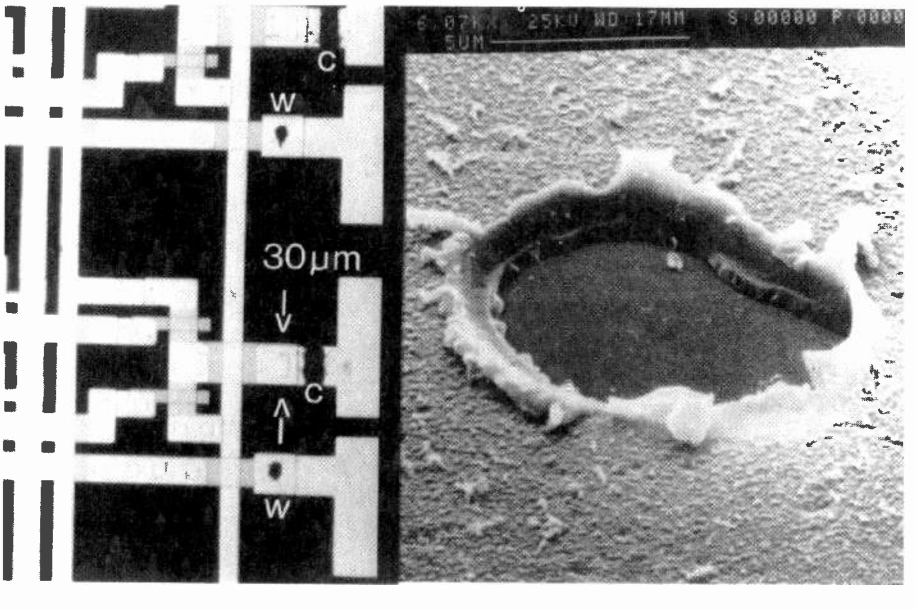
Cutting links on the micro-scale presents few problems: a laser can easily be focused on the link to blast away unwanted metal. But welding together open-circuits is much more difficult, especially where the intended joint is not between two metal parts, but between metal and polysilicon.

The GEC-Marconi team has achieved all these objectives using a Nd:yag infra-red laser directed by means of a bench microscope. A beam-splitting device and a separate low-power visible-light laser to align the system is included, and using this arrangement, the cutting/welding beam can be aligned to within 2µm of its intended target.

Results have been impressive – especially with welded joints – all of which have proved reliable, even when carrying currents above their normal operational values. The figures show what happens when the laser punches metal through the insulating layer. The electrical connection is believed to take place along the wall of the hole.

As well as repairing faults on test substrates, the new technique has been successfully tested on fully fabricated displays containing liquid crystals. More laser power is necessary to achieve a successful weld, but apart from a few transient bubbles in the liquid crystal, results are identical. Faulty displays – with up to 65% of the display area blank – have been restored to full working order.

The GEC-Marconi team says that the technique lends itself well to automation and is likely to lead to a vast improvement in manufacturing yield.



Photomicrograph of two (part) stages of LCD column driver welds (W) and cuts (C) with the SEM of a successful weld showing breakthrough.

SMALL SELECTION ONLY LISTED – EXPORT TRADE AND QUANTITY DISCOUNTS – RING US FOR YOUR REQUIREMENTS WHICH MAY BE IN STOCK

Marconi TF2008 – AM-FM signal generator – Also sweeper – 10Kc/s – 510Mc/s – from £350 tested to £500 as new with manual – probe kit in wooden carrying box.
HP Frequency comb generator type 8406A – £400.
HP Sampling Voltmeter (Broadband) type 3406A – £200.
HP Vector Voltmeter type 8405A – £400 to £600 – old or new colour.
HP Synthesiser/signal generator type 8672A – 2 to 18GHz £4000.
HP Oscillographic recorder type 7404A – 4 track – £350.
HP Plotter type 9872B – 4 pen – £300.
HP Sweep Oscillators type 8690 A & B + plug-ins from 10Mc/s to 18GHz also 18-40GHz. P.O.R.
HP Network Analyser type 8407A + 8412A + 8601A – 100Kc/s – 110Mc/s – £500–£1000.
HP Down Converter type 11710B – .01-11Mc/s – £450.
HP Pulse Modulator type 11720A – 2-18GHz – £1000.
HP Modulator type 8403A – £100-£200.
HP Pin Modulators for above-many different frequencies – £150.
HP Counter type 5342A – 18GHz – LED readout – £1500.
HP Signal Generator type 8640B – Opt001 + 003 – .5-512Mc/s AM/FM – £1000.
HP Amplifier type 8447A – .1-400Mc/s £200 – HP8447F .1-1300Mc/s £400.
HP Frequency Counter type 5340A – 18GHz £1000 – rear output £800.
HP 8410 – A – B – C Network Analyser 110Mc/s to 12GHz or 18GHz – plus most other units and displays used in this set-up – 8411A – 8412 – 8413 – 8414 – 8418 – 8740 – 8741 – 8742 – 8743 – 8746 – 8650. From £1000.
HP Signal Generator type 8660C – .1-2600Mc/s. AM/FM – £3000. 1300Mc/s £2000.
HP Signal Generator type 8656A – 0.1-990Mc/s. AM/FM – £2000.
HP 8699B Sweep PI – 0.1-4GHz £750 – HP8690B Mainframe £250.
Racal/Dana 9301A-9302 RF Millivoltmeter – 1.5-2GHz – £250-£400.
Racal/Dana Counters 9915M – 9916 – 9917 – 9921 – £150 to £450. Fitted FX standards.
Racal/Dana Modulation Meter type 9009 – 8Mc/s – 1.5GHz – £250.
Racal – SG Brown Comprehensive Headset Tester (with artificial head) Z1A200/1 – £350.
Marconi AF Power Meter type 893B – £200.
Marconi RCL Bridge type TF2700 – £150.
Marconi/Saunders Signal Sources type – 6058B – 6070A – 6055B – 6059A – 6057B – 6056 – £250-£350. 400Mc/s to 18GHz.
Marconi TF1245 Circuit magnification meter + 1246 & 1247 Oscillators – £100-£300.
Marconi microwave 6600A sweep osc., mainframe with 6650 PI – 18-26.5GHz or 665° PI – 26.5-40GHz – £1000 or PI only £600.
Marconi distortion meter type TF2331 – £150, TF2331A – £200.
Microwave Systems MOS/3600 Microwave frequency stabilizer – 1GHz to 40GHz £1k.
Tektronix Plug-ins 7A13 – 7A14 – 7A18 – 7A24 – 7A26 – 7A11 – 7M11 – 7S11 – 7D10 – 7S12 – S1 – S2 – S6 – S52 – PG506 – SC504 – SG502 – SG503 – SG504 – DC503 – DC508 – DD501 – WR501 – DM501A – FG501A – TG501 – PG502 – DC505A – FG504 – P.O.R.
Ailtech Stoddart receiver type 17/27A – .01-32Mc/s – £2500.
Ailtech Stoddart receiver type 37/57 – 30-1000Mc/s – £2500.
Ailtech Stoddart receiver type NM65T – 1 to 10GHz – £1500.
Gould J3B Test oscillator + manual – £200.
Infra-red Binoculars in fibre-glass carrying case – tested – £100. Infra-red AFV sights £100.
ACL Field Intensity meter receiver type SR – 209 – 6. Plugs-ins from 5Mc/s to 4GHz – P.O.R.
Tektronix 491 spectrum analyser – 1.5GHz-40GHz – as new – £1000 or 10Mc/s 40GHz.
Tektronix Mainframes – 7603 – 7623A – 7633 – 7704A – 7844 – 7904 – TM501 – TM503 – TM506 – 7904 – 7834 – 7104.
Knott Polyskanner WM1001 + WM5001 + WM3002 + WM4001 – £500.
Ailtech 136 Precision test RX + 13505 head 2 – 4GHz – £350.
SE Lab Eight Four – FM 4 Channel recorder – £200.
Ailtech 757 Spectrum Analyser – 001 22GHz – Digital Storage + Readout – £3000.
Dranetz 606 Power line disturbance analyser – £250.
Precision Aneroid barometers – 900-1050Mb – mechanical digit readout with electronic indicator – battery powered. Housed in polished wood carrying box – tested – £100-£200-£250. 1, 2 or 3.
HP141T SPECTRUM ANALYSERS – ALL NEW COLOURS TESTED WITH OPERATING MANUAL
HP141T+8552A or B IF-8553B RF – 1kHz–110Mc/s-A IF – £1300 or B IF – £1400.
HP141T+8552A or B IF-8554B RF – 100kHz–1250Mc/s-A IF – £1400 or B IF – £1500.
HP141T+8552A or B IF-8555A RF – 10Mc/s–18GHz-A IF – £2400 or B IF – £2500.
HP141T+8552A or B IF-8556A RF – 20Hz–300kHz-A IF-A IF – £1200 or B IF – £1300.
HP8443A tracking generator/counter – 100kHz–110Mc/s – £500.
HP8445B tracking pre-selector DC–18GHz – £750.
HP ANZ UNITS AVAILABLE SEPARATELY – NEW COLOURS – TESTED.
HP141T mainframe – £550 – 8552A IF – £450 – 8552B IF – £550 – 8553B RF – 1kHz–110Mc/s – £550 – 8554B-RF – 100kHz–1250Mc/s – £650 – 8555A-RF – 10Mc/s–18GHz – £1550.
HP 3580A LF-spectrum analyser – 5kHz to 50kHz – LED readout – digital storage – £1600 with instruction manual – internal rechargeable battery.
Tektronix 7D20 plug-in 2-channel programmable digitizer – 70 Mc/s – for 7000 mainframes – £500 – manual – £50.
Datron 1065 Auto Cal digital multimeter with instruction manual – £500.
Racal MA 259 FX standard. Output 100kc/s–1Mc/s–5Mc/s – internal NiCad battery – £150.
Aerial array on metal plate 9"×9" containing 4 aerials plus Narda detector – .100–11GHz. Using N type and SMA plugs & sockets – ex eqpt – £100.
EIP 451 microwave pulse counter 18GHz – £1000.
Marconi RF Power Amplifier TF2175 – 1.5Mc/s to 520Mc/s with book – £100.
Marconi 6155A Signal Source – 1 to 2 GHz – LED readout – £600.
Schlumberger 2741 Programmable Microwave Counter – 10Hz to 7.1GHz – £750.
Schlumberger 2720 Programmable Universal Counter 0 to 1250Mc/s – £600.
HP 2225CR Thinkjet Printer – £100.
TEK 576 Calibration Fixture – 067-0597-99 – £250.
HP 8006A Word Generator – £150.
HP 1645A Data Error Analyser – £150.
Texscan Rotary Attenuators – BNC/SMA 0-10-60-100DBS – £50-£150.
HP 809C Slotted Line Carriages – various frequencies to 18GHZ – £100 to £300.
HP 532-536-537 Frequency Meters – various frequencies – £150-£250.
Barr & Stroud variable filter EF3 0.1Hz–100kc/s + high pass + low pass – £150.
S.E. Lab SM215 Mk11 transfer standard voltmeter – 1000 volts.
Ailtech Stoddart P7 programmer – £200.
H.P. 6941B multiprogrammer extender. £100.
Fluke Y2000 RTD selector + Fluke 1120A IEEE-488-translator + Fluke 2180 RTD digital thermometer + 9 probes. £350 all three items.
H.P. 6181 DC current source. £150.
H.P. 59501A – HP-IB isolated D/A/power supply programmer.
H.P. 3438A digital multimeter.
H.P. 6177C DC current source. £150.
H.P. 6207B DC power supply.
H.P. 741B AC/DC differential voltmeter standard (old colour) £100.
H.P. 6209B DC power unit.
Fluke 80 high voltage divider.
Fluke 431C high voltage DC supply.
Tektronix M2 gated delay calibration fixture. 067-0712-00.
Tektronix precision DC divider calibration fixture. 067-0503-00.
Tektronix overdrive recovery calibration fixture. 067-0608-00.
Avo VCM163 valve tester+book £300.
H.P. 5011T logic trouble shooting kit. £150.
Marconi TF2163S attenuator – 1GHz. £200.
PPM 8000 programmable scanner.
Fluke 730A DC transfer standard.
B&K 4815 calibrator head.
B&K 4812 calibrator head.
Farnell power unit H60/50 – £400 tested.
H.P. FX doubler 938A or 940A – £300.
Racal/Dana 9300 RMS voltmeter – £250.
H.P. sweeper plug-ins – 86240A – 2–8.4GHz – 86260A – 12.4–18GHz – 86260AH03 – 10–15GHz – 86290B – 2–18.6GHz. 86245A 5.9–12.4GHz.
Telequipment CT71 curve tracer – £200.
H.P. 461A amplifier – 1kc–150Mc/s – old colour – £100.
H.P. 8750A storage normalizer.
Tektronix oscilloscopes type 2215A – 60Mc/s – c/w book & probe – £400.
Tektronix monitor type 604 – £100.
Marconi TF2330 or TF2330A wave analysers – £100–£150.
HP5006A Signature Analyser £250 + book.
HP10783A numeric display. £150.
HP 3763A error detector. £250.
Racal/Dana signal generator 9082 – 1.5–520Mc/s – £800.
Racal/Dana signal generator 9082H – 1.5–520Mc/s – £900.
Claude Lyons Compuline – line condition monitor – in case – LMP1+LCM1 £500.
Efratom Atomic FX standard FRT – FRK – 1–1–5–10Mc/s. £3K tested.
Racal 4D recorder – £350 – £450 in carrying bag as new.
HP8350A sweep oscillator mainframe + HP11869A RF PI adaptor – £1500.
Alltech – precision automatic noise figure indicator type 75 – £250.
Adret FX synthesizer 2230A – 1Mc/s. £250.
Tektronix – 7S12–7S14–7T11–7S11–S1–S52–S53.
Rotek 610 AC/DC calibrator. £2K + book.
Marconi TF2512 RF power meter – 10 or 30 watts – 50 ohms – £80.
Marconi multiplex tester type 2830.
Marconi digital simulator type 2828A.
Marconi channel access switch type 2831.
Marconi automatic distortion meter type TF2337A – £150.
Marconi mod meters type TF2304 – £250.
HP 5240A counter – 10Hz to 12.4GHz – £400.
HP 3763A error detector.
HP 8016A word generator.
HP 489A micro-wave amp – 1–2GHz.
HP 8565A spectrum analyser – .01–22GHz – £4k.
HP 5065A rubidium vapour FX standard – £5k.
Fluke 893A differential meters – £100 ea.
Systron Donner counter type 6054B – 20Mc/s–24GHz – LED readout – £1k.
Takeda Riken TR4120 tracking scope + TR1604P digital memory.
EG&G Parc model 4001 indicator + 4203 signal averager PI.
Systron Donner 6120 counter/timer A+B+C inputs – 18GHz – £1k.
Racal/Dana 9083 signal source – two tone – £250.
Systron Donner signal generator 1702 – synthesized to 1GHz – AM/FM.
Systron Donner microwave counter 6057 – 18GHz – Nixey tube – £600.
Racal/Dana synthesized signal generator 9081 – 520Mc/s – AM–FM. £600.
Farnell SSG520 synthesized signal generator – 520Mc/s – £500.
Farnell TTS520 test set – £500 – both £900.
Tektronix plug-ins – AM503 – PG501 – PG508 – PS503A.
Tektronix TM515 mainframe + TM5006 mainframe.
Cole power line monitor T1085 – £250.
Claude Lyons LCM1P line condition monitor – £250.
Rhodes & Schwarz power signal generator SLRD-280 – 2750Mc/s. £250–£600.
Rhodes & Schwarz vector analyser – ZPV+E1+E3 tuners – .3–2000Mc/s.
Bell & Howell TMA3000 tape motion analyser – £250.
Ball Efratom PTB-100 rubidium standard mounted in Tek PI..
Ball Efratom rubidium standard PT2568-FRKL.
Trend Data tester type 100 – £150.
Farnell electronic load type RB1030-35.
Fairchild interference analyser model EMC-25 – 14kc/s–1GHz.
Fluke 1720A instrument controller+keyboard.
Marconi 2442 – microwave counter – 26.5GHz – £1500.
Racal/Dana counters – 9904 – 9905 – 9906 – 9915 – 9916 – 9917 – 9921 – 50Mc/s – 3GHz – £100–£450 – all fitted with FX standards.
B&K 7003 tape recorder – £300.
B&K 2425 voltmeter – £150.
B&K 4921+4149 outdoor microphone.
Wiltron sweeper mainframe 610D – £500.
HP3200B VHF oscillator – 10–500Mc/s – £200.
HP3747A selective level measuring set.
HP3586A selective level meter.
HP5345A electronic counter.
HP4815A RF vector impedance meter c/w probe. £500–£600.
Marconi TF2092 noise receiver. A, B or C plus filters.
Marconi TF2091 noise generator. A, B or C plus filters.
Tektronix oscilloscope 485 – 350Mc/s – £500.
HP180TR, HP182T mainframes £300–£500.
Bell & Howell CSM2000B recorders.
HP5345A automatic frequency convertor – .015–4GHz.
Fluke 8506A thermal RMS digital multimeter.
HP3581A wave analyser.
Philips panoramic receiver type PM7800 – 1 to 20GHz.
Marconi 6700A sweep oscillator+6730A – 1 to 2GHz.
Wiltron scaler network analyser 560+3 heads. £1k.
R&S signal generator SMS – 0.4–1040Mc/s – £1500.
HP8558B spectrum ANZ PI – .1–1500Mc/s – o/c – £1000. N/C – £1500 – To fit HP180 series mainframe available – £100 to £500.
HP8505A network ANZ + 8503A S parameter test set + 8501A normalizer – £4k.
HP8505A network ANZ + 8502A test set – £3k.
Racal/Dana 9087 signal generator – 1300Mc/s – £2k.
Racal/Dana VLF frequency standard equipment. Tracor receiver type 900A + difference meter type 527E + rubidium standard type 9475 – £2750.
Marconi 6960–6960A power meters with 6910 heads – 10Mc/s – 20GHz or 6912 – 30kHz–4.2GHz – £800–£1000.
HP8444A–HP8444A opt 59 tracking generator £1k–£2k.
B&K dual recorder type 2308.
HP8755A scaler ANZ with heads £1k.
Tektronix 475 – 200Mc/s oscilloscopes – £350 less attachments to £500 c/w manual, probes etc.
HP signal generators type 626 – 628 – frequency 10GHz–21GHz.
HP 432A–435A or B–436A – power meters+powerheads – 10Mc/s–40GHz – £200–£280.
HP3730B down convertor – £200.
Bradley oscilloscope calibrator type 192 – £600.
Spectrascope SD330A LF realtime ANZ – 20Hz–50kHz – LED readout – tested – £500.
HP8620A or 8620C sweep generators – £250 to £1k with IEEE.
Barr & Stroud variable filter EF3 0.1Hz–100kc/s+high pass+low pass – £150.
Tektronix 7L12 analyser – .1Mc/s–1.8GHz – £1500 – **7L14 ANZ** – £2k.
Marconi TF2370 spectrum ANZ – 110Mc/s – £1200–£2k.
Marconi TF2370 spectrum ANZ+TK2373 FX extender 1250Mc/s+trk gen – £2.5k–£3k.
Racal receivers – RA17L–RA1217–RA1218–RA1772–RA1792 – P.O.R.
Systron Donner microwave counter 6057 – 18GHz – nixey tube – £600.
HP8614A signal gen 800Mc/s–2.4GHz old colour £200. new colour £400.
HP8616A signal gen 1.8GHz–4.5GHz old colour £200, new colour £400.

ITEMS BOUGHT FROM HM GOVERNMENT BEING SURPLUS. PRICE IS EX WORKS. S.A.E. FOR ENQUIRIES. PHONE FOR APPOINTMENT OR FOR DEMONSTRATION OF ANY ITEMS. AVAILABILITY OR PRICE CHANGE. VAT AND CARR., EXTRA. ITEMS MARKED TESTED HAVE 30-DAY WARRANTY. WANTED: TEST EQPT – VALVES – PLUGS & SOCKETS – SYNCROS – TRANSMITTING & RECEIVING EQPT. ETC.

Johns Radio, Whitehall Works, 84 Whitehall Road East, Birkenshaw, Bradford BD11 2ER. Tel. No. (0274) 684007. Fax 651160.

CIRCLE NO. 107 ON REPLY CARD

Feeding time at the black hole

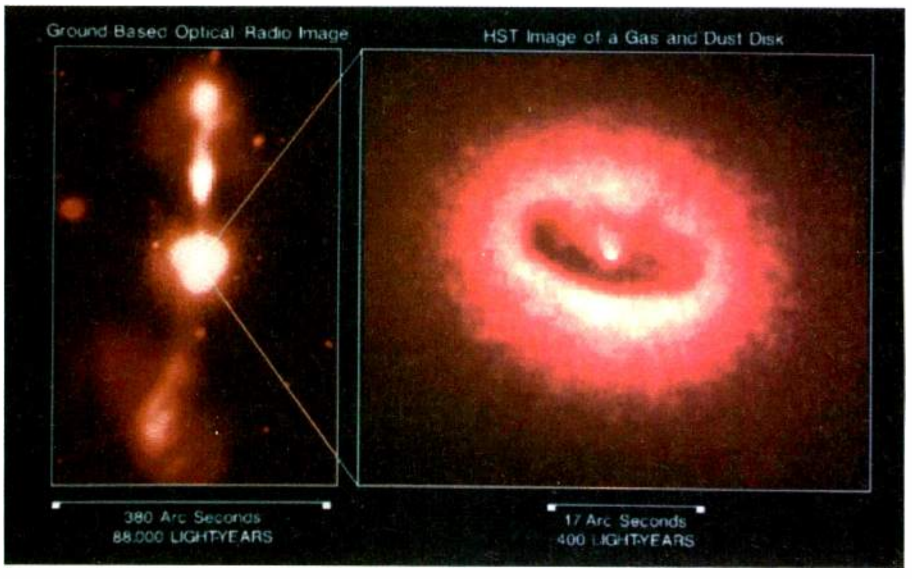
In spite of the bad press that surrounded the Hubble space telescope and its design flaws, lots of good science is going on up there in orbit.

Investigators using the wide field/planetary camera have recently reported the best views yet of the disc of material that is being pulled into the jaws of a suspected black hole. A black hole is a still-theoretical object which forms after a massive star collapses. The matter becomes so densely compacted that its powerful gravitational pull traps all matter that comes near to it. Not even light can escape, which explains why no-one has ever seen a black hole.

The disc in the picture, presumed to be the feedstuff of a black hole, is at the core of a galaxy in the Virgo Cluster 45 million light years from Earth. According to Dr Walter Jaffe of the Leiden Observatory in the Netherlands, one of the investigators, the nucleus of this system is probably the home of a black hole with a mass 10 million times that of our Sun. The system, described as an "active galaxy", emits especially strong radiation which provides evidence that it harbours a powerful energy source.

The photos show a comparison between the results from the Hubble and the best ground based optical or radio images, indicating that even a defective mirror in space can be better than a good one on the ground. This latest picture provides the first clear image of gas being sucked in an orderly way down to the very edge of a black hole.

After the Space Shuttle servicing mission for the Hubble Telescope scheduled for later this year, the researchers hope to use spectroscopy to study the motion of the gas within a few dozen light years of the black hole. This might allow them to prove the existence of the black hole by measuring its mass accurately.



The NGC 4261 elliptical galaxy (left) is one of the 12 brightest galaxies in the Virgo Cluster, located 45 million years away. Photographed in visible light (white), the galaxy appears as a fuzzy cluster of hundreds of billions of stars. The orange radio image shows a pair of opposed jets that emanate from the nucleus and span a distance of 88,000 light years.
The right hand picture shows the Hubble telescope's image of the core of NGC 4261. A giant disc of cold gas and dust fuels a possible black hole at the galaxy's centre. The disc is estimated to be 300 light years across and represents a cold outer region that extends inwards to an ultra hot accretion disc within a few hundred million miles of the suspected black hole. Matter is fed into the black hole by the disc, where it is compressed by gravity and heated. Hot gas squirts out from the vicinity of the black hole, creating the radio jets. These are aligned perpendicular to the disc and provide strong circumstantial evidence for the existence of a black hole 'central engine' in the galaxy.

More power to monolithic millimetrics

Semiconductor development is mainly a process of steady improvement, punctuated occasionally by radical new technologies. But continuing progress in certain key areas, while rarely headline-grabbing, is currently spawning impressive new performance specifications.

Take for example the recent announcement (*Electronics Letters* Vol 28 No 23) of a monolithic millimetre-wave IC capable of 14.2dB power gain at 47GHz. That in itself is impressive, but this four-stage device, developed at Comsat Laboratories and Hercules Defense Electronics Systems Inc in the US, is a power chip with a linear output of 165mW. Its developers claim the chip has the highest power gain and complexity of any single MMIC at U-band frequencies.

Designed using the Touchstone microwave circuit analysis program, the 5mm chip incorporates integrated RC components, ensuring unconditional stability down to a few MHz.

Fabrication involves growing layers by molecular beam epitaxy (MBE) and then isolating components using optical lithography and direct-write electron beams. Evaluation of the chip's performance involved the development of a special input/output coupling system using a ridged waveguide transition with less that 0.25dB insertion loss over the frequency range 40-48GHz.

The authors of the paper say the already impressive power output can be increased further by using several of these devices in conjunction with low-loss off-chip power combiner/dividers.

Navigation by polarised light

Polarisation is a familiar enough concept to those who design and install RF antenna systems. But Lawrence Wolff, a computer scientist at Johns Hopkins University in Baltimore, is on the verge of developing a polarisation-based navigation system

All electromagnetic radiation can be polarised or made to vibrate in a preferred plane. Light, like radio energy, can also become polarised when its waves are generated or filtered, so as to assume a definite angular orientation. Normally we humans can not tell whether light is polarised or not – though legend has it that the ancient Vikings had the ability to navigate at sea by detecting the polarisation of light from the sky.

Today those variations in polarisation are mainly exploited by photographers who use special filters to make the sky look a deeper shade of blue or to eliminate reflections from glass or water. They work because when randomly polarised light is refracted or reflected it becomes markedly polarised, and so can be attenuated by a filter with opposite polarisation.

Wolff realised that this normally-invisible information could be decoded and used to advantage by computer vision systems. He reasoned that if polarisation information can help bees and fish – and arguably Vikings – to navigate, then the same information could help an artificial vision system to make sense of confusing or ambiguous data from a video camera. Video cameras, like human eyes, are normally polarisation-insensitive.

Robert Smith

Polarised spec–ulation: Lawrence Wolff, assistant professor of computer science at the Johns Hopkins University School of Engineering hopes his vision system will stop unmanned space vehicles tumbling into craters.

Wolff's research is backed by the Defense Advanced Research Projects Agency (Darpa) and covers a patent application for a polarisation-sensitive camera sensor. He sees a potential application of the principle in development of a vision system for Darpa's unmanned ground vehicle programme. "The system would enable such a vehicle to navigate terrain, avoiding such pitfalls as going off cliffs, driving into lakes or running over people. It could also help prevent robots used in science and industry from running into glass doors or other transparent objects."

Ultimately, it is thought that polarised vision systems might be used to navigate space rovers on planets that have no magnetic field.

Laboratory results show that, as well as preventing vehicles falling into lakes, the vision system can enable computers to distinguish between visually similar materials that have different polarisation characteristics. Metals can easily be distinguished from non-metals and even substances with varying electrical conductivities.

Wolff's camera represents a new class of image sensor in which there is no longer the need to rotate polarising filters mechanically in front of a lens. The system makes use of liquid crystals to steer or rotate the plane of polarisation of the incoming light so that it can subsequently be analysed by a fixed polarisation filter. Four-dimensional computer vision, it seems, is just around the corner.

Flower power?

Animals, including ourselves, operate essentially by electricity. Action potentials – pulses of up to 70mV – indicate that a message has flashed along one of the neurons that make up the nervous system. But though electrical transmission of biological messages is universal throughout the animal world, few scientists have ever suggested that plants might be wired up in a similar way. Now, strong evidence for this comes now in a paper (*Nature* Vol 360 No 6399) published by a team from the Universities of East Anglia and Leeds and the Horticulture and Food Research Institute of New Zealand.

Botanists know that plants have a crude sort of communications system that allows one part - usually the growing tip - to send a message to an other part telling it to respond to gravity or light etc. The transmitter in this case is a chemical that diffuses from one area of the structure to another. But there is one intriguing plant reflex that has remained a mystery because no-one has ever discovered a chemical agent that operates it..

Imagine a small tomato seedling quietly minding its own business, when along comes a gang of hungry caterpillars, munching away at the top leaf. The assault does not go unnoticed and a message is sent to other leaves telling them to manufacture a nasty-tasting chemical: when the caterpillars move on to pastures new they end up with severe indigestion. Simple negative feedback! It's also a form of self-defence that occurs quite widely in the plant kingdom.

But how does leaf A communicate with leaf B, telling it to retaliate? Dr David Wildon and his colleagues had a hunch that this communication might not be chemical but electrical, as in animals. Because of its unorthodoxy, they had to go to extraordinary lengths to make their case.

They wired up a tomato seedling with electrodes and wounded the leaf seed. Some 30s later they observed a pronounced electrical peak that was shown to travel along structures called plasmodesmata - tiny channels with properties remarkably like the gap junctions of human nerve cells.

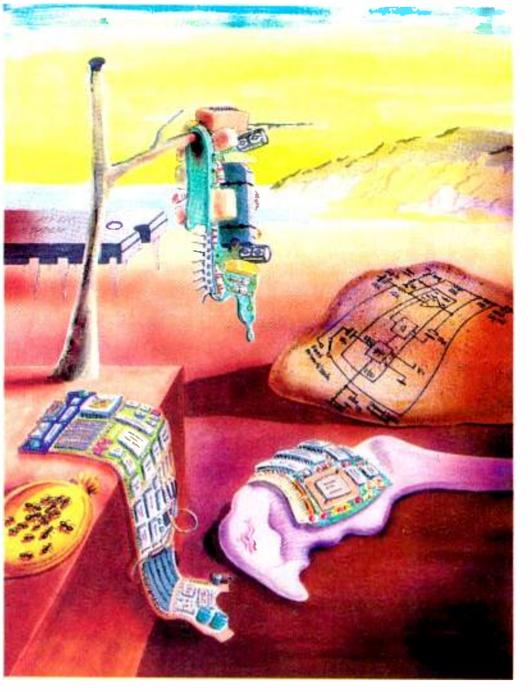
To prove the voltage spikes were not merely some incidental effect, the scientists chilled part of the plant's leaf stem to prevent the transmission of any coincident chemical signals. There was virtually no difference, suggesting strongly that the prime means of communication was indeed electrical.

So what does this all mean? To begin with, the finding does lend some slight credibility to occasional reports of plants being used as transducers to predict earthquakes or other traumatic events. Plants might just possibly respond to premonitary movements that humans can not detect directly.

But more relevant to most of us is the risk of someone setting up a society for the prevention of cruelty to plants. Taking a leaf from the animal welfare organisations, they might well home in on the innocent gardener pruning a much loved rose. If you're at all worried, Dr Wildon has some helpful advice from his research: use a sharp pair of secateurs. It appears that a clean cut to a leaf doesn't elicit the same electrical response as a leaf under attack by caterpillars.

Research Notes is written by John Wilson of the BBC World Service

The twisted world of non-linear electronics



It is not such a big step to go from light bulbs into chaos. **Dan Ayers** *takes a look at both positive and negative aspects of non-linear components and circuit techniques.*

Turn on an incandescent filament light bulb. Doubling the voltage across a bulb certainly does not double the current since a hot filament has a markedly higher resistance than a cold one. The common light bulb looks to the supply rather like a constant current source. This non-linear behaviour is found throughout electronics and is sometimes a curse, sometimes a boon.

A low current bulb may be used to stabilise an *RC* sine wave oscillator. Ideally, a Wien bridge oscillator requires an amplifier with a gain of exactly three, which in the basic circuit of **Fig. 1a** is determined by $1+R_b/R_a$.

In practice, small errors are unavoidable so the gain is chosen to guarantee oscillation and a non-linear element is introduced to gently keep the sine wave from drifting up to its clipping limit[1]. A low-current bulb serves this purpose cheaply, **Fig. 1b**, but devices that need less current are preferable.

In effect, the bulb acts as a voltage-dependent resistor: as voltage across it increases, so does its resistance. An alternative VDR, **Fig. 1c**, rectifies and smooths a sample of the oscillator signal. The resulting voltage controls the drain-to-source conduction of a fet in turn controlling the amplifier's gain.

The non linearity is the semiconductor junction often perplexes circuit designers. Obviously there is a great difference between a diode's forward and reverse-biased resistance but in non-linear circuit design, the relationship between the diode's forward voltage and current is much more interesting. Incrementing forward voltage in linear steps increases current flow exponentially over a usefully wide region.

Figure 1 shows a diode network for stabilising a Wien oscillator. Unlike most stabilising methods which take several cycles to react, diode control is instantaneous, but this brings the penalty of introducing distortion. In many low-distortion designs, a positive-coefficient thermistor acts in the same way as the light bulb of Fig. 1b while, in other designs, an NTC thermistor replaces feedback path R_b.

Waveform synthesis

Tuned-feedback sine-wave generators like the Wien bridge oscillator may suffer from capacitor leakage and matching problems, especially at low frequencies. They can also produce an annoying bounce when their frequency is changed.

Simple square or triangle waveforms can be filtered to remove harmonics but this filtering creates a profusion of design problems. There is however another way of subtracting harmonics without filtering. It involves non-linear techniques and although it follows the same principle as digital synthesis from a sine wave lookup table, it is less complicated in practice.

The output from simple triangle wave oscillator may be passed through an exponent circuit to produce a passable sinewave. Waveform accuracy largely depends on how closely the 'bending' circuitry approximates the sinusoidal shape. Since the process is not a function of frequency, it doesn't exhibit bounce or other amplitude related problems. This technique is found in several function-generator chips, including the *8038* and *XR2206*.

There are basically two wave shaping methods, one using inherently non-linear components, **Fig. 2**, and the other relying on approximating the wave by a series of straight lines, **Fig. 3**. Both have numerous applications.

Frequency plots for instrumentation are usually shown as decades or octaves rather than on a linear scale. In the case of a network analyser, this requires a sweep oscillator with a ten or two-fold increase in frequency for a unit increase in control voltage.

Conditioning a linear control input via a buffered diode provides a suitable non-linear characteristic through the diode's exponential *V/I* relationship. A better option is to use the V_{be} to I_c exponential relationship of a standard junction transistor. Temperature errors can be reduced by a long-tail pair and temperature-

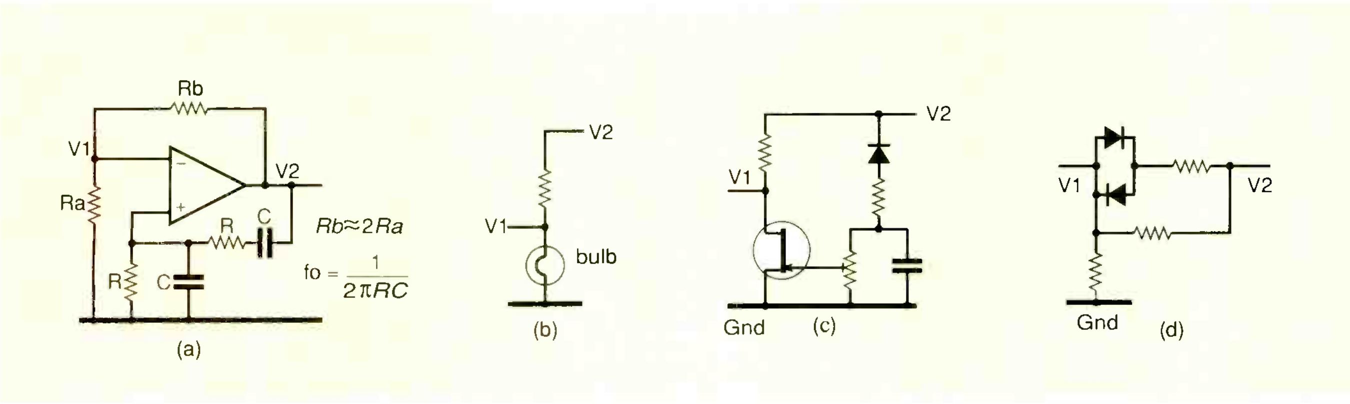


Fig. 1. In basic Wien bridge oscillator, (a), amplitude can be stabilised by replacing Ra, Rb with non-linear networks. Low current lamp acts as a VDR, (b), and a fet as a voltage-controlled attenuator, (c). In (d), diodes provide non-linear feedback.

dependent resistor, R_T of **Fig. 4**.

Early analogue music synthesisers relied on combinations of voltage-controlled modules. Since music is almost entirely based on octaves, the modules needed exponential converters to modify the linear control voltage supplied from keyboards or sequencers. Convenience dictated that the converters were exponential current sources or sinks for current-controlled oscillators or filters.

In audio, the ear's non-linear response renders linear peak-level meters very difficult to interpret. Levels need to be indicated on decibel scales so that sound pressure change ratios can be evaluated in terms of equivalent change ratios in subjective loudness.

On a decibel scale, the relationship between the signal level and the scale's indication is logarithmic. Log converters can be formed by inserting a subcircuit with exponential characteristics in the feedback path of an op-amp, **Fig. 5**. Generally, the inverse of the logarithm function is obtainable by simply inserting the log converter in the feedback path of a further op-amp, **Fig. 6**. Remember that you cannot apply negative voltages to the two-quadrant log converter.

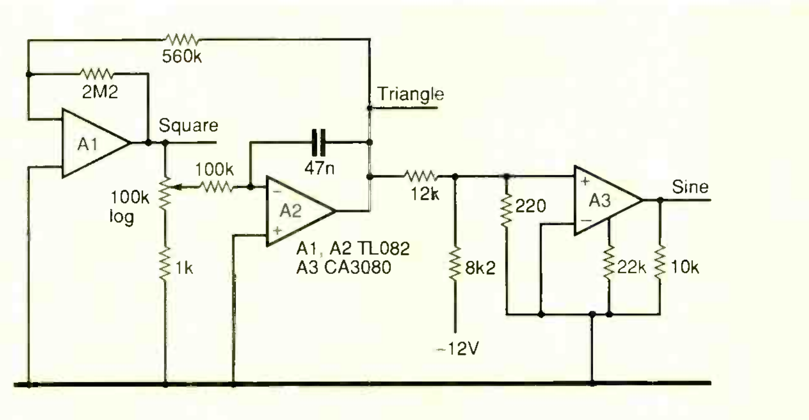


Fig. 2. Function generator synthesizes sine wave from triangle using transconductance amplifier A3 biased into non-linear region. Tweaking resistors around IC3 can give better than 2% purity.

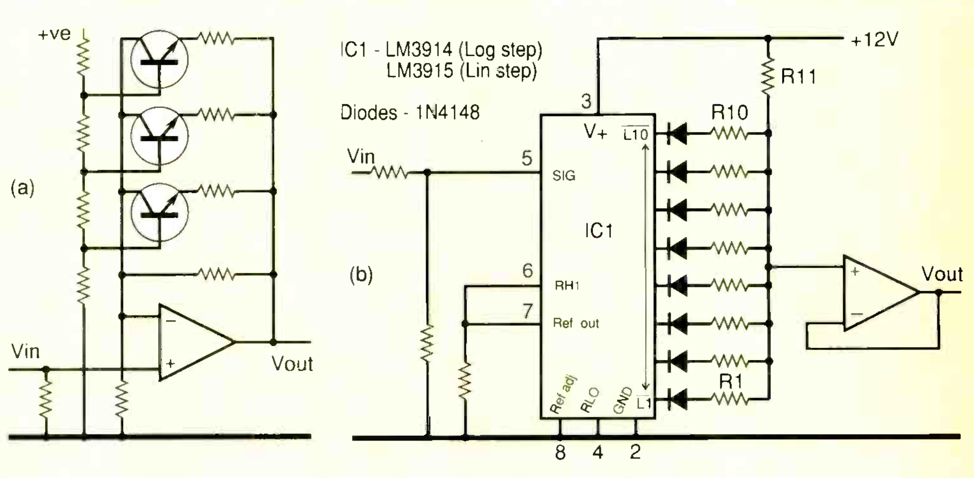


Fig. 3. Piecewise approximation to a non-linear function. In (a) transistors successively turn on as input voltage increases. Base resistors determine break points, emitter resistors determine slope. Bargraph chip, (b), gives 10 breakpoints. It must be used in bar mode. Resistor ratios determine slope.

Testing for non-linearity

Linearity of DC-coupled systems is analysed by plotting output voltage or current against input by various means. With AC circuits, the usual approach is to drive an amplifier with a pure sine wave and look for distortion on the output having notched out the drive signal fundamental component. This leaves distortion products plus noise.

A linear circuit might preserve a sine wave's shape, but it might also modify its phase or amplitude (dynamic range modifiers are described later). Close examination is possible by analysing the original sine wave via a notch filter. Any non-linearity adds frequency components at multiples of the fundamental input frequency – i.e. harmonics.

Bipolar transistor audio power amplifiers suffer mainly from third-harmonic components originating at crossover and odd harmonics due to clipping. Valve amplifiers, with their 'soft' overload characteristics, tend to produce predominantly low-order odd and even harmonics due to their different non-linear characteristics. This makes an overdriven valve audio amplifier sound subjectively 'warmer' than its bipolar counterpart.

Field-effect transistors feature non-linearity characteristics close to their valve counterparts. Under certain conditions they provide a mathematical squaring function[2] that causes a notable form of harmonic distortion. Feeding the circuit of **Fig. 7** with a sine wave frequency of f results in an output frequency of $2f$ since

$$\sin^2 x = \frac{1}{2}(1 - \cos^2 x)$$

This square law can also be used to multiply the value of two voltages together

$$xy = \frac{(x+y)^2 - (x-y)^2}{4}$$

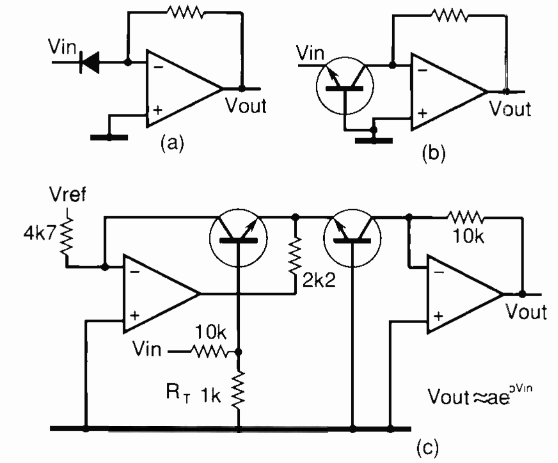
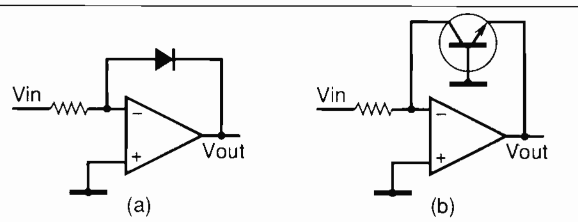


Fig. 4. Exponential converters: a simple diode provides the function in (a) or a single transistor as in (b). Circuit (c) is the practical version featuring temperature compensation. The transistors should be thermally coupled.



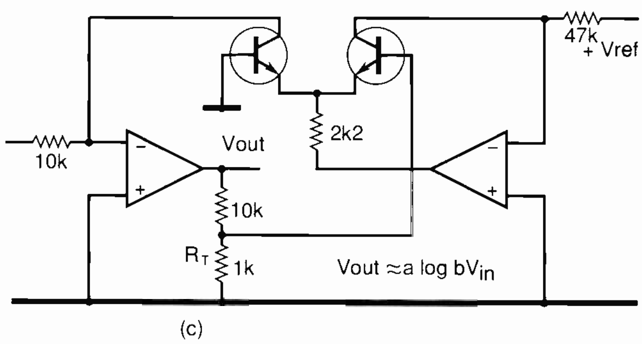


Fig. 5. Logarithmic converters. A diode in feedback path (a) or transistor (b) gives inverse of exponential function. Circuit (c) is a practical version. Note similarity to Fig. 3a.

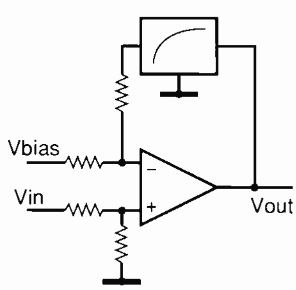
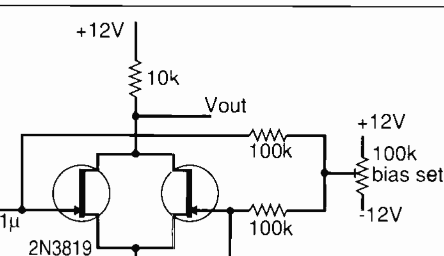


Fig. 6. Placing non-linear network in feedback of op-amp provides inverse of network function. Adjust resistors and bias for required gain and offset, take care to avoid instability.



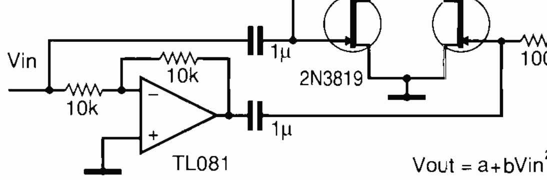
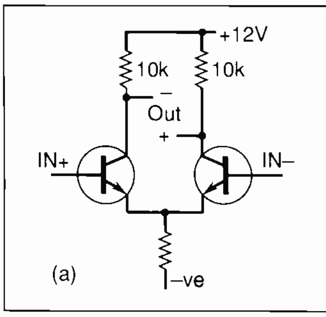
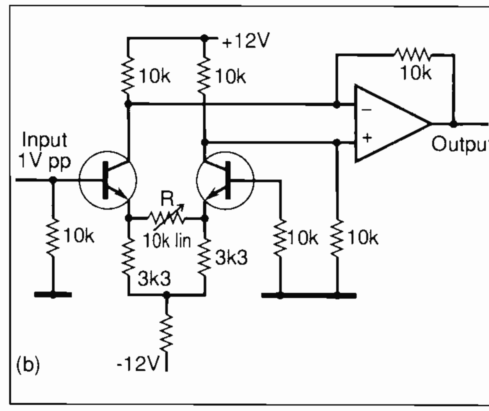


Fig. 7. Practical circuit for using square-law response of fets. Substitution of bipolar transistors demonstrates differing curves.





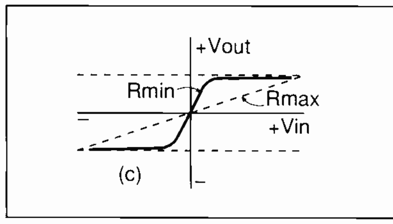


Fig. 8. Basic long-tail pair configuration (a) has non-linear characteristics for large signals. Practical circuit (b) allows control over non-linear response, from linear (R minimum) to tanh (R maximum).

Basic long-tail differential pairs, **Fig. 8a**, behave non-linearly for large signals[3]. For an input varying from below about –50mV to +50mV, output changes rapidly between two fixed output voltages, following a tan*h* transfer function[4].

Fig. 8b stretches the crossover region and varying the link between emitter currents via the potentiometer allows a range of functions from linear to tan*h*. This practical circuit was developed to simulate valve amplifier soft clipping for a guitar effects pedal. Altering the bias voltages and substituting fets may provide an even closer imitation. The *CA3080* of Fig. 2 performs in the same manner.

Gain of the long-tail pair is controlled by the tail current[3] so the circuit acts as a current-controlled amplifier. If tail current is derived from the input signal in some way, a whole range of non-linear functions become available.

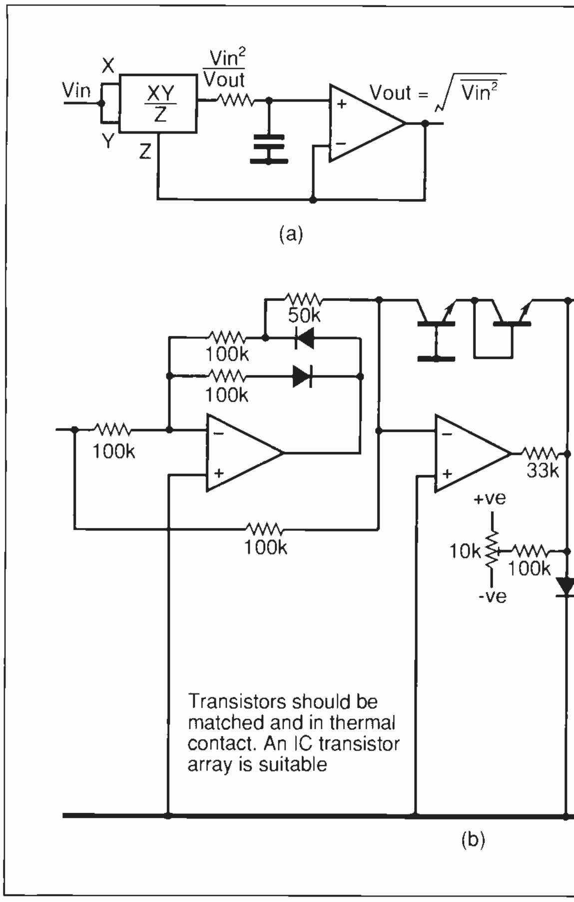


Fig. 9. RMS converter block diagram,(a), and practical converter using precision rectifier and log and analogue units for multiply/divide (b), based on a circuit from reference 1.

Intermodulation

Feeding a non-linear circuit with a signal containing two sine waves at frequencies f_1 and f_2 results in an output including not only the two input frequencies but also a proportion of their sum and difference. This type of distortion is most undesirable for audio engineers as the extra frequencies present are not harmonically related to the input and therefore subjectively most noticeable and unpleasant.

In such circuits, the instantaneous level of one signal effectively modulates the other, hence the name intermodulation distortion. The ear's cochlea has a similar non-linear response and distorts in the same way, particularly with loud sounds[5]. Interestingly, the ear has a curious non-linear effect known as the restored fundamental. If two signals of 800 and 1000Hz are played, the listener also hears a 200Hz tone - a frequency that would have harmonics at 800 and 1000Hz.

In audio, the benefits of intermodulation are limited to special effects. For the radio engineer however it is indispensable. If one of the signals is a constant RF wave and the other music, the result is a modulated RF signal as used for radio communication[6].

Multiplier chips like the *LM1496* are full of long-tail pairs and carry out modulation in a more controlled way. When used for modulating a signal, or demodulating it by the same principle, such multipliers are known as mixers to the RF engineer; when shifting the frequency of a modulated signal, they are also known as converters. Audio engineers may be more familiar with the name ring modulator.

RMS measurement

The RMS signal level corresponds to average power dissipated when a signal is feeds a resistive load. It is obtained by applying a squaring function to the signal then taking the mean of this positive, varying level and then applying a square-root function to the DC result. By juggling a little algebra, it is possible to produce the same result with a reduction in circuit complexity and associated error, **Fig. 9**. Purpose-built chips provide the function but the discrete version can still offer a more economical alternative provided that you pay attention to transistor matching and thermal coupling.

If a section of the *V/I* curve of a device 'doubles back' on itself, i.e. as voltage increases, current decreases, the device is said to exhibit negative resistance, more correctly called negative differential conductance[7]. This characteristic allows several electronic building blocks to be constructed with a surprisingly low component count, **Fig. 10**.

Tunnel diodes and Gunn devices are two-terminal components exhibiting negative resistance. Suitably biased and connected they will amplify or oscillate up to microwave frequencies. For frequencies from DC to a few megahertz, negative resistance can be synthesized with conventional semiconductors.

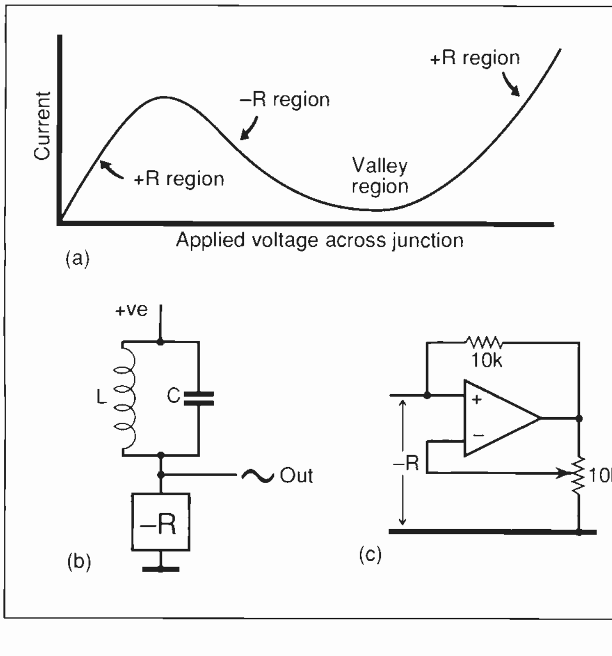


Fig. 10. Curve (a) shows typical negative resistance. In (b) negative resistance compensates for losses in tuned circuit producing oscillation while (c) shows possible synthesis using op-amp. Configuration (d) a so-called lambda circuit, uses complementary fets for floating negative resistance.

Companding systems

In audio systems, it is often desirable to modify the dynamic range of the material, i.e. the difference between the softest and loudest sounds. On magnetic tape for example, the dynamic range normally available is much narrower than that of the ear.

To maintain a reasonable signal-to-noise ratio, it is possible to compress the signal on recording and expand it again on playback. Since the range of numbers between 0 and 1000 compresses to a range of 0 to 3 logarithmically, it is not surprising that audio compression and expanding – companding – involves similar non-linearity.

The common system for altering the dynamic range of a signal makes use of three basic elements – a voltage-controlled amplifier[8], a level tracker to extract the existing dynamic information of the signal, and circuits to change the resulting information into a control voltage used by the amplifier to impose the new characteristic onto the original signal.

Except for crude speech-quality systems, where simple fet attenuators suffice, it is rarely necessary to use discrete transistor circuitry

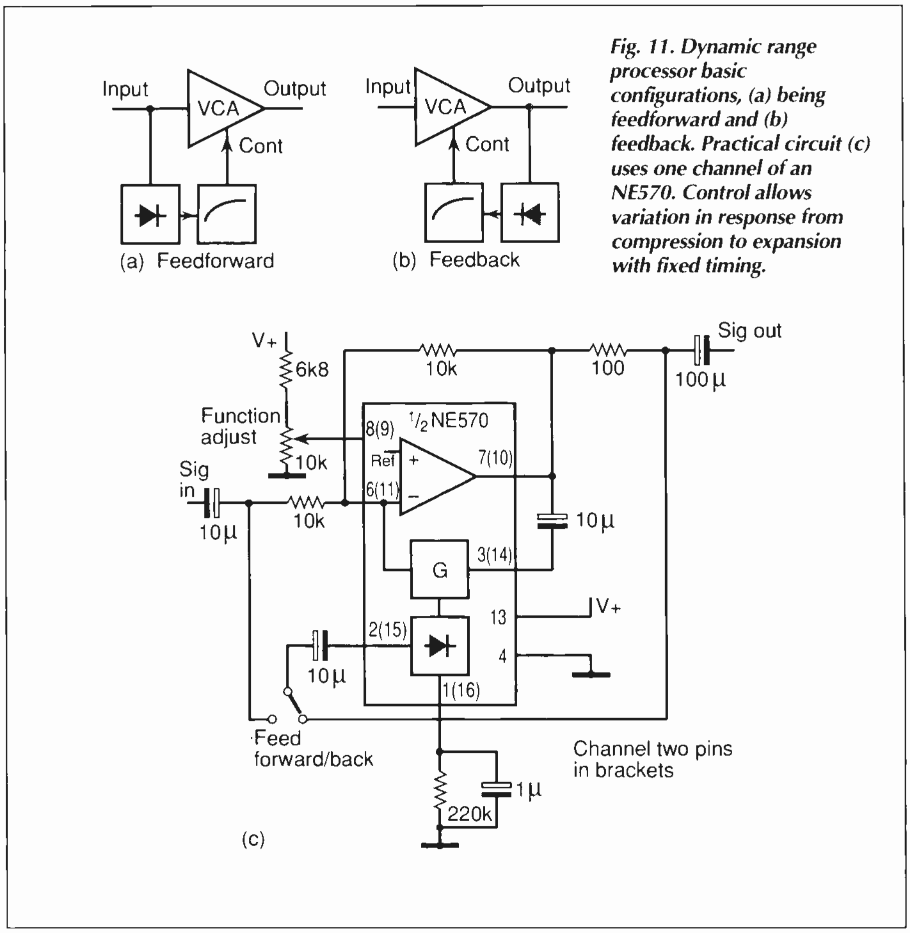


Fig. 11. Dynamic range processor basic configurations, (a) being feedforward and (b) feedback. Practical circuit (c) uses one channel of an NE570. Control allows variation in response from compression to expansion with fixed timing.

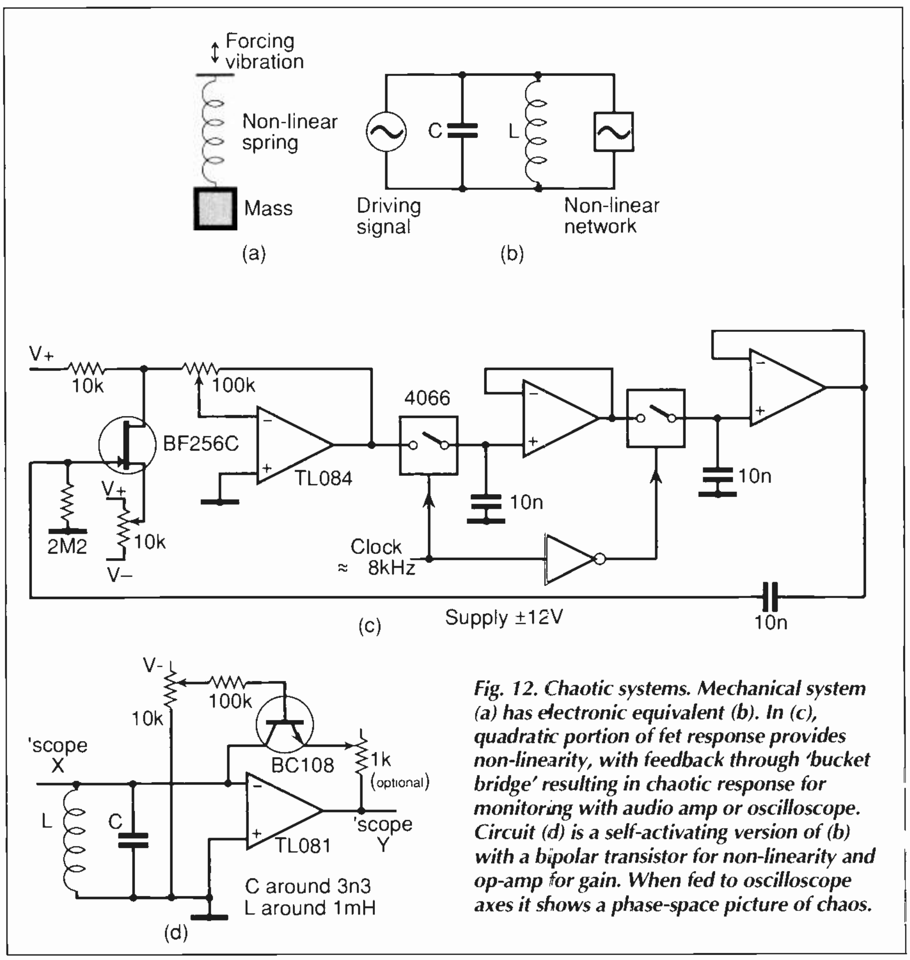


Fig. 12. Chaotic systems. Mechanical system (a) has electronic equivalent (b). In (c), quadratic portion of fet response provides non-linearity, with feedback through 'bucket bridge' resulting in chaotic response for monitoring with audio amp or oscilloscope. Circuit (d) is a self-activating version of (b) with a bipolar transistor for non-linearity and op-amp for gain. When fed to oscilloscope axes it shows a phase-space picture of chaos.

for the voltage-controlled amplifier. Integrated circuits such as the cheap, low-fidelity *CA3080* operational-transconductance amplifier or the studio-quality *dbx 2150A* VCA have considerably simplified circuit design. VCAs are a form of multiplier working in two quadrants only.

The level-tracking element is basically a rectifier with smoothing. It can be rudimentary, in the form of a diode and capacitor, or it can feature precision rectification and variable time constant smoothing for attack and decay to allow for different programme material. Depending on the response preferred, the level can be tracked at the input of the VCA (feedforward) or the output (feedback).

Voltage corresponding to the average signal level is then fed to the VCA via a non-linear network. The circuitry that extracts the and processes the signal level is commonly known as the side chain, as opposed to the signal path through the VCA. A device containing all the active components for a two-channel compressor or expander is the *NE570*, Fig. 11. On its own, it is just about suitable for hi-fi applications; an external high-quality op-amp can be added to improve noise performance[9].

Those who would believe that analogue electronics is dead should listen to the difference that analogue companding can make to digital audio sampling.

Chaotic dynamics

Recent developments in chaos theory have inspired a fresh look at non-linear dynamic systems. A physical example of such a system is a mass on a spring with a non-linear elasticity, **Fig. 12a**.

When the system is driven by sinusoidal vibrations, the mass might oscillate periodically in slightly distorted fashion at a rate related to the frequency of the driving force. If the drive frequency is changed a little however, the oscillation might stay at the same frequency, move to a different related frequency or become irregular and aperiodic.

The sequence of motion the mass moves into is known as an attractor. When the mass moves continually in an irregular manner, it has found one of the so-called strange attractors of chaos. The qualitative change from one attractor to another is known as a bifurcation and the distance between bifurcations is predictable[10].

Complexity of the behaviour of a chaotic seems to imply that inexplicable forces are at work but it is easy to demonstrate that a simple system can behave chaotically. Take a logistic equation sometimes used to model population growth,

$$x_{t+1} = kx_t(1-x_t)$$

At a given time, x_t, population is a function of that of a previous instant, x_{t-1}. Assuming that x_0 is initially 0.1 and k is one, x_t tends to zero. When k is two, x_t tends to 0.5 and when k is three, x_t eventually alternates between two values. When k is five, x_t tends to infinity. Within limits, when k is four the value of x_t

seems to vary randomly and a simple quadratic has produced chaotic behaviour. Making a small change to the initial conditions soon leads to a radically different sequence of values, showing the 'butterfly effect' of sensitive dependence on initial conditions found in all chaotic systems[11].

Chaotic circuits

In electronics, a non-linear circuit with feedback can easily produce chaotic behaviour. **Figure 12c** is an approximation of a logistic system. To get an idea of the nature of a chaotic system, it is possible to monitor most systems in phase space by connecting the horizontal and vertical amplifiers of an oscilloscope to different parts of the system.

Going back to the physical system of a mass on a non-uniform spring, a direct analogy is a tuned circuit with non-linear reactances. A non-linear reactance can be synthesized quite easily with standard components[12], but the simplest arrangement I have found for creating chaotic signals uses an op-amp to maintain the oscillation of a tuned circuit.

Because of the non-liner feedback arrangement, the oscillation produced by this circuit is chaotic as often as it is periodic, **Fig. 12d**. The inductor shown should be a few millihenries. I found that 100 turns on a ferrite rod was adequate but it played havoc with Radio 4.

Chaotic behaviour possibly lies behind many previously unexplained and partially explained phenomena – particularly where aperiodic signals such as $1/f$ noise are found. In the light of chaos theory, analysis may also offer insight into the behaviour of negative resistance oscillators – from those using Gunn diodes to unijunction relaxation circuits with their probabilistic switching points.

No component is perfect. Resistors have thermistor characteristics, diodes act as varistors... you name it. As a result, no practical circuit is entirely linear. If a circuit features amplification and feedback, chaos will be lurking round the corner. ■

References

1. Clayton, G. B., *Operational Amplifiers*, Butterworth. ISBN 0-408-00370-7, 1979.
2. Collins, T. H., *Analog Electronics Handbook*, Prentice Hall. ISBN 0-13-033119-8.
3. Lidgey, J., *The Tail of the Long-Tail Pair*, *E&WW* Sept/Oct 1985.
4. Calvert, J. M., and McCausland M.A.H., *Electronics*, J.Wiley & Sons. ISBN 0471-99640-8, 1978.
5. Kinsler, Frey, Coppens and Sanders. *Fundamentals of Acoustics*, J.Wiley & Sons, ISBN 0471-02933-5, 1982.
6. Schwartz, M., *Information Transmission, Modulation and Noise*. McGraw-Hill. ISBN 0-07-055782-9, 1981.
7. Brophy, J. J., *Basic Electronics for Scientists*, McGraw-Hill, ISBN 0-07-008133-6, 1983.
8. Hawksford, M., *Voltage-Controlled Amplifier Systems*, *E&WW* April 1982.
9. Rothman, J., '*Audio compressor*' *The Modern Electronics Manual* Part 4, Chapter 12.4. Wimbourne Publishing. (Note also 'High Quality Noise Gate', 'Audio Limiter', 'Stereo Aural Exciter', same author and source).
10. Various, *Non-Linear Dynamics*, *Encyclopedia of Physical Science & Technology* Vol.9, Academic Press, ISBN 0-12-226909-8.
11. Beard, N., *The Science of Chaos*, *E&WW* June 1991.
12. Lesurf, J., *Chaos in Electronics*, *E&WW* June 1992.

PC ENGINEERING

RELIABLE PERFORMANCE and a neat autorouter

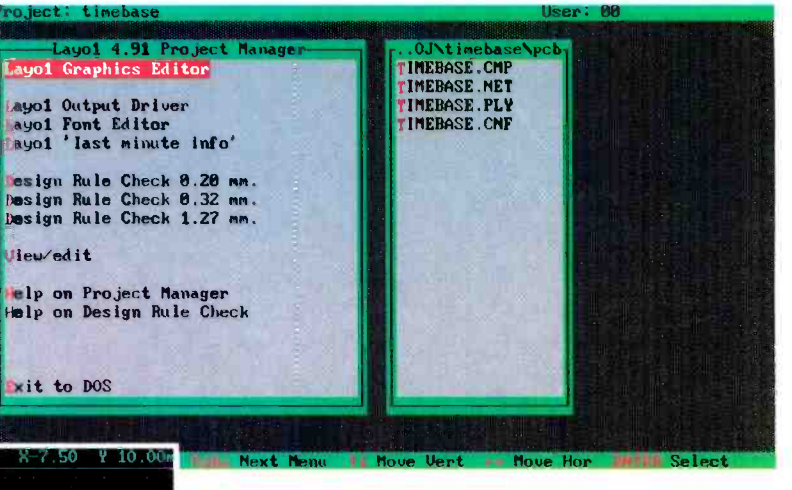
Selecting a PCB layout package is a daunting task: there are so many to choose from. Layo1 may not stick out from the crowd, but at its price, Martin Cummings finds it a reliable bet.

Layol is an entry-level PCB draughting package that will handle surface mounting and autorouting for just under £100. Dutch author Peter Baas originally designed it to take schematic data prepared on other packages, such as *Orcad*, so the software works well with several schematic capture tools or is happy to be used as a stand alone.

Only PCB layout was available for review – but a complementary schematic capture program should now be available – and like many cad packages, it is available in more expensive versions offering almost the same features but able to deal with circuits of differing complexity.

In practice, *Layol* is a collection of programs co-ordinated by a menu system called the project manager. As well as selecting the program to run, the project manager co-ordinates data files and holds configurations for different users. So several custom environments such as grid sizes, printer driver and screen colours can be saved. It is even possible to change the working language – as long as you want to work in Dutch.

The text editor, similar to *Wordstar* or *Sidekick*, is reasonable, and can be used to add menu items and batch commands to the project manager screens. Up to ten different menu screens can be created, and other packages such as a schematic capture program can be integrated into the menu structure. The editor can also be used to create and view net lists, component schedules and error files.

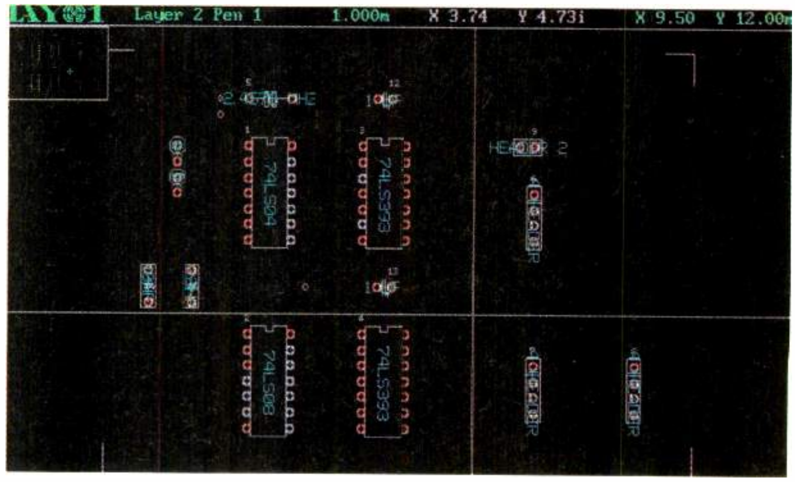


The Project Manager menu system coordinates operation.

Groups of layers can be defines and named.

But most work is carried out under board editing, using an uncluttered screen with just one line at the top reserved for useful information. Co-ordinates are simultaneously displayed in metric and imperial units, but in different colours to avoid confusion, along with the current layer, pen number and command mode.

Most commands can be selected by mouse from drop down menus or, in most cases, pressing initial letter keys. Unfortunately not all commands are available to the mouse and a significant number need a key press – often function keys, and sometimes from the main keyboard. There seems little logic to where certain commands will be found. Once learnt and memorised commands are no problem: but until then, the learning curve is steep, and a memory jogging card to fit over the relevant keys would have been a big help.

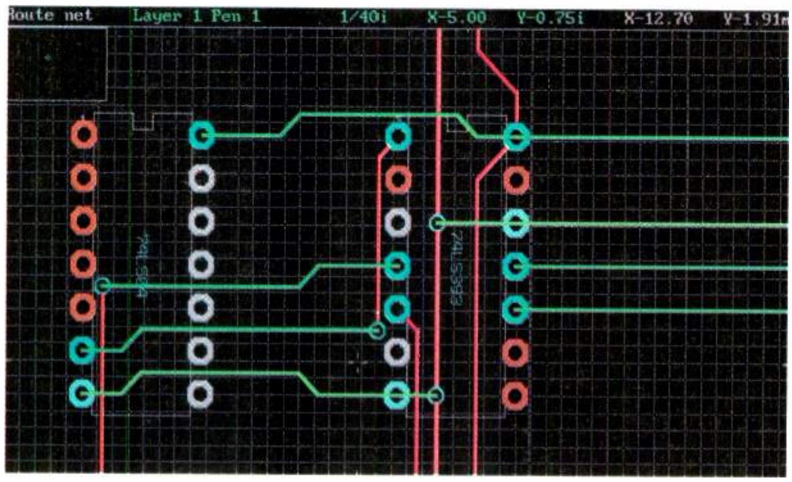


A miniature version of the complete PCB helps with orientation.

Moving around the screen

Three cursor styles are available, all of which include a set of unusual edge of screen cross hairs, giving the look of a flight simulator. The cursor can be moved any distance off screen and it is actually quite easy to lose. At first, retrieval seemed to be only possible by carefully studying the XY co-ordinates and working out how far and in which direction to move the mouse – frustrating as this happens surprisingly often. But a quick phone call to Pentagram revealed the well kept secret that there is a simple key press command to restore the cursor to the centre of the screen – the F key (for find?).

Snap and visible grids can be adjusted from 1in down to 1/1280in – the finest resolution of the program – and automatic pan, if enabled, moves to the next screen as the edge of the drawing is approached. Nine zoom levels allow screen redraw around the current cursor position and also provide a method of manual panning.



EPad colours indicate net status.

One useful aid to orientation is the miniature version of the complete PCB which can be displayed in the top left hand corner of the screen. As well as the outline, all pads are shown together with current cursor position – so when zoomed in you can still keep your orientation on the overall design. The miniature also helps on those occasions when the cursor disappears off board, though as the replica is in the top left corner it is only useful if the cursor is lost below and to the right.

Of the 19 layers, eight are for tracks and the rest have predefined purposes. For example one layer is for through hole pads, two are for surface mount pads and one is for via holes. Layers can be displayed in any combination, and can be grouped for display and given a name for later reference. The layer display menu is a matrix of layers and groups: just tick the layers needed in each group and edit the name. Selection made here also determines the layers on the dot matrix printout.

Libraries

After specifying board dimensions, drill sizes and up to seven different pens – each pen defined with a width between 0.1-5mm – the first step is to create a component list. The list can either be created by picking components from the libraries and placing them on the board or by typing in an ascii file. Nine component libraries contain around 400 shapes which for layout alone, is a more than adequate supply. All the regular components are here along with plenty of surface mount devices and some of the more unusual shapes such as slider potentiometers, heatsinks and bridge rectifiers are. A useful print out of all components providing a graphical index to the libraries can be found in the reference manual.

System requirements

IBM compatible XT upwards
640K memory
MS-dos 3.xx or higher
Hard disk
Mouse, three buttons preferred
EGA graphics
Suitable output device
Epson or HP compatible printer

Key features

Maximum board size 650mm square
16 layers
Nine component shape libraries
Design rule checker
Configurable autorouterBuilt-in text editor
Step and repeat facility
Macro capability

As usual, components not provided can be created using the component editor and stored in a user library. *Layo1* seems to put an almost excessive emphasis on pad design and up to 128 pad types can be to hand at any one time. The pad editor gives access to an almost infinite set of possibilities, allowing pads to be pulled and pushed from all sides to create some grotesque shapes and sizes as well as the more traditional circles, rectangles or octagons.

Components are selected from the library by name and once selected become a shape connected to the cursor ready to place. Parts rotation is conveniently achieved by clicking two mouse buttons simultaneously, and the program is reasonably successful in moving components in real time with the cursor. A useful feature is that the position of the component can be frozen while the cursor is moving. Once the cursor has been stationary for a certain time, the component moves to catch up with it. It's a technique that takes a little getting used to but it works well and, for the experienced user, speeds up placement and adjustments.

As each shape is placed the user is prompted to enter a component type, such as *74LS04*, and an identifier, such as *U1*. The screen can display just the outline

Start up and documentation

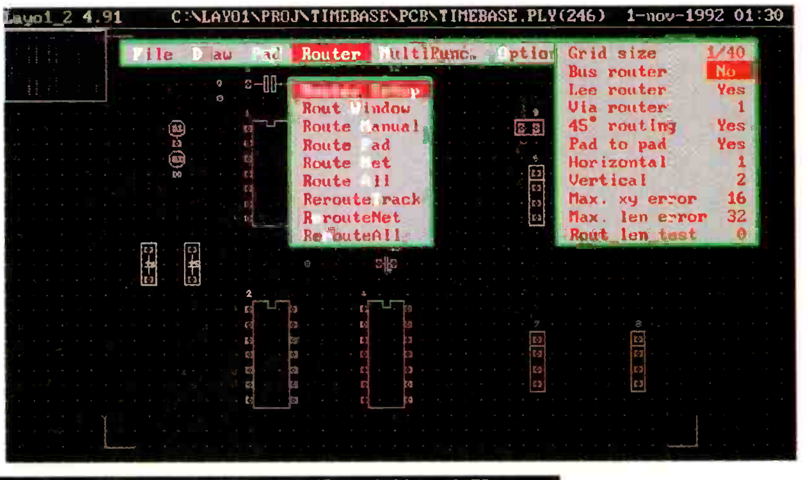
Installation is quick with surprisingly few questions to answer, followed by the option to change the selected video board. Several formats are supported up to 1024 x 768 pixels. Files are supplied compressed, but the two disks, when installed, fill only a relatively modest 1.5Mbytes of hard disk. A well structured directory set is automatically created, separating programs, component libraries and project files.

The spiral bound manuals immediately endear themselves to a user by staying open on the desk at any page. Everything is green, the logo on the packaging, the menu screens and even the disks. Presumably the green is supposed to look like the solder resist of PCBs.

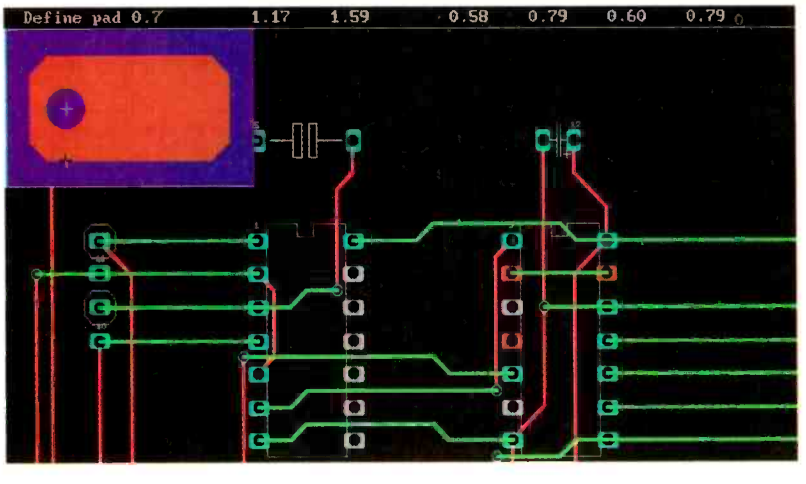
In essence the user manual is a tutorial guiding the novice user through the creation of a board. While that is useful, several issues are glossed over and features are revealed in a curious order. For example, advice on basic screen manipulation such as panning and zooming is hidden in the text rather than being highlighted at the beginning.

At the end of the tutorial you are left with the feeling that there must be a lot more to the program (and it is true that a lot more exists) if only you knew how to operate it.

But all these gripes are superficial problems, only of consequence to the beginner, and a little patience, perseverance, and bed time reading of the manuals, will help the user become familiar with what is undoubtedly a competent layout package.



Layo1's autorouter performs well and is more flexible than many of its competitors.



Pad design offers almost infinite possibilities.

or add either the types or identifiers for all components. A key press toggles through three options. Pin numbers can also be displayed, though they are so small that they are only visible on a high zoom factor.

Text can be added, rotated and scaled, and though only one font is supplied alternatives can be selected and others can be created with the supplied font editor. Desk top publishing in copper has yet to catch on, so the most likely application is to create and have available some special symbols – perhaps targets or alignment marks.

If *Layol* is used stand alone, connections are entered by pointing and clicking on the appropriate pads and a netlist is automatically compiled. The pads change colour to indicate no connection; connection but not yet routed; or routed connection, and once entered, connections can be displayed as a rat's nest. Separate keys call up the rat's nest for a selected pad, a selected component or the complete design.

Manual routing is trivially easy, select the width, draw the tracks and add vias when required. Horizontal and vertical movements are all logged by the program which plots the appropriate colour and layer. Any connections are allowed, but later on it is possible to run a check against the netlist. Producing buses or similarly repetitive circuitry is a piece of cake using the copy repeat function. Copy the track once, tell *Layol* how many more are needed and they are repeated with the same offset as used for the first copy. Such a repeat function is not unusual, but this one is refreshingly easy to use.

Complete blocks of circuitry can be picked up, moved around and copied. Again, this is useful for assisting with repetitive circuitry or, by repeating the whole design better use can be made of artwork or raw materials at the manufacturing stage. For the downright lazy, yet more automation is possible through macros that, in the now familiar fashion, record key presses and replay them at a single key request.

Autorouting

Layout software starting at just under £100 often includes an autorouter, but this one performs better than most and is more configurable than others its price bracket. Encouragingly the autorouter is an integral part of the package and not a bolt-on extra.

Before autorouting several parameters must be set first: which two layers to use? whether to allow vias? and whether to use a 1/20in or 1/40in grid. The finer grid gives more flexibility but is slower, uses more memory, and so can only route about 20 square inches at a time. Larger areas have to be routed section by section. There are also some more obscure variable that need to be selected, such as the permitted length errors which influence the routing strategies.

Speed is difficult to assess because host machine and board complexity can vary so much. But *Layol* seems comparable with similar packages and is certainly fast enough for it to be of little consequence. Simple designs can complete in under a minute, though autorouting more complex boards will give the operator time for a coffee.

A design rule checker scans the layout for the necessary clearances – minimum allowable clearance is specified when the checker is invoked – and output from the checker is an ascii file giving, in readable form, a list of clearance violations, the nature of the problem, net number involved and co-ordinates of the offence.

Outputting prints

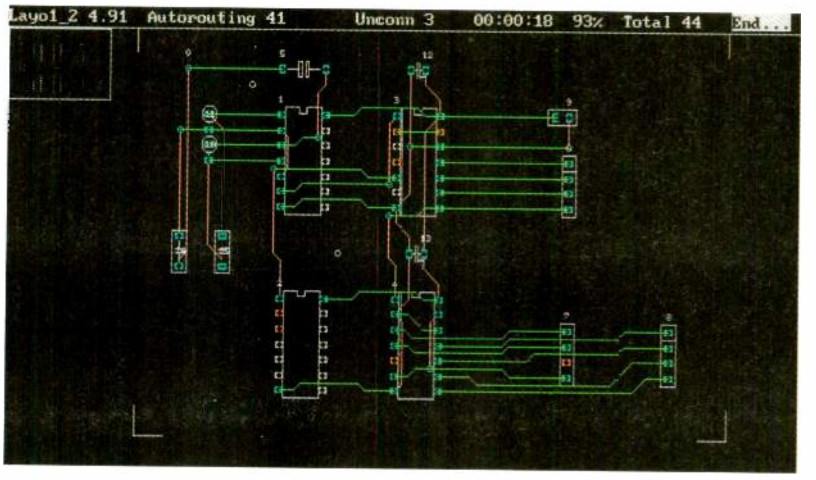
Printer drivers allow check prints to be produced. At the moment only Epson dot matrix and Hewlett Packard laser devices are supported, though compatibility and emulations mean this will satisfy most needs. Pen plotters are not supported.

Size of the check print can be scaled, but the scale factor influences both X and Y axes, so independent compensation for small scale errors in the output device is not possible.

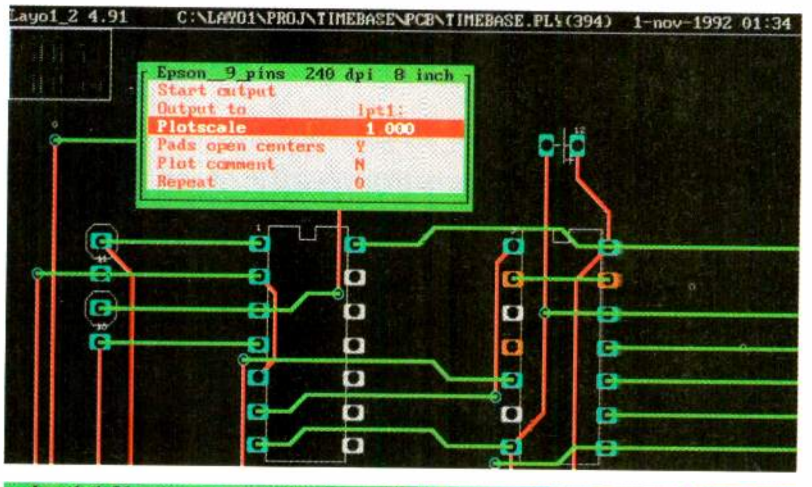
Printer output will probably limited to checking, or a prototype at best.

Final output is generated by a fairly elaborate post processor that includes drivers for HPGL, postscript and Gerber devices and Excellon drilling equipment. The post processor and photoplotter drivers can be copied and sent to a plotting bureau or board manufacturer and normal licensing arrangements are relaxed to make it easier to obtain final output even if the equipment for producing it is elsewhere or belongs to another organisation. Screens allow configuration of the layer combinations and up to 20 configurations can be defined. For example the top copper layer could require pads and vias, surface mount pads, and the upper track layer. Output can be mirrored, rotated and scaled.

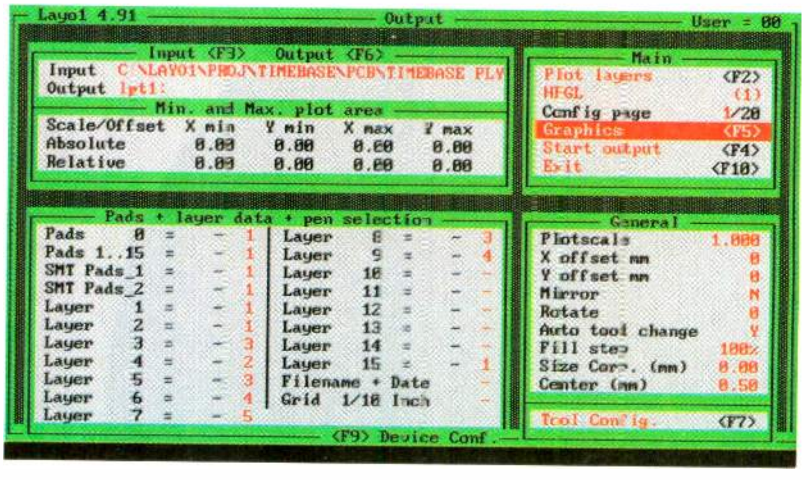
One unusual facility of *Layo1*'s post processor is that is provides a preview capability for a layout package. We expect most word processors to be able show graphically on screen what (hopefully) will come out on the printer. *Layo1*'s post processor takes just a few seconds to generate graphics on screen, giving confidence that the correct layers have been selected and, just like the word processor, saving wasted output by illustrating user errors before they are cast in ink.



A simple task for the autorouter completed in 18s.



Check prints can only be scaled with one factor for both X and Y axes.



Up to 20 configurations of layer combinations can be defined for output.

Reliable and competent

Selecting a PCB layout package these days is a daunting task, merely because there are so many to choose from and it is difficult to see what marks this one out from similar offerings.

As a stand alone draughting aid, *Layo1* is a reliable and competent tool and has clearly been in existence long enough to become a mature product.

Documentation is professionally presented, with plenty of screen dumps, and though not as extensive as some, it is adequate to bring an engineer or draughter up to speed. The libraries of shapes are adequate, and the user interface, while not the easiest to grab hold of, once learnt, is as easy as any other to work with.

Of course, cad really shows its strengths when schematic capture and layout are both automated and though the package will work happily with several schematic capture products, imminent addition of schematic capture to the product range will provide a more integrated tool set. The addition will also improve the value for money, as it looks as if the extra software will be bundled in free of charge.

So a good range of features, including multilayer and surface mount support, a respectable autorouter and adequate libraries mean that *Layo1* can hold its own against the competition – particularly at the lower end of the market. It will not disappoint those who invest in it. ■

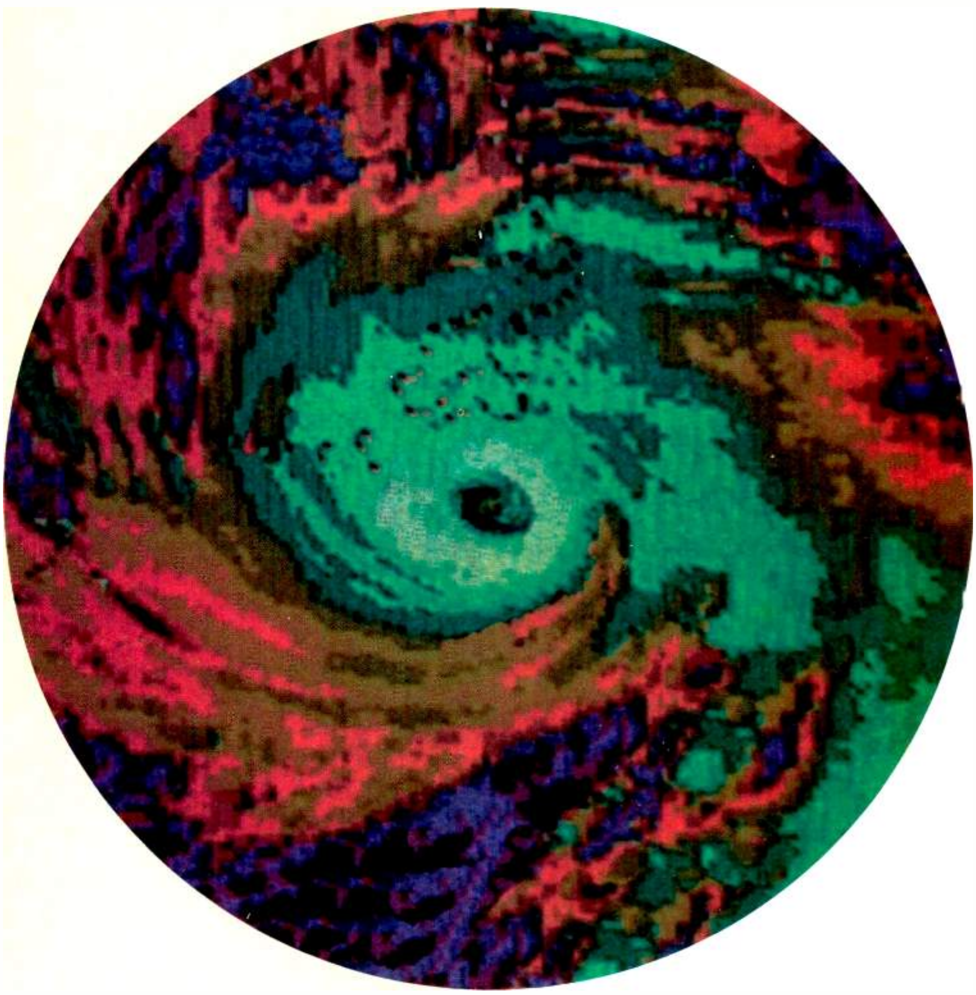
Supplier details

Evaluation copy 1000 data lines £25; Level 1 4000 data lines £99; Level 2 10,000 data lines £279; Level 3 20,000 data lines £535; Level 4 65,000 data lines £999.

Pentagram Electronic Designs, 6 Pasture Close, Clayton, Bradford, West Yorkshire BD14 6LY. Tel: 0274 882609 Fax:0274 882295

Gravity and electric force link up in black hole?

Is it just coincidence that the ratio of gravitational to electric force of the electron is so numerically close to Planck's time? D Di Mario presents an electron with a black hole nucleus which could shed new light on the link between gravity and electricity.



Working from three basic constants, gravitation, G, speed of light c and Planck's constant h, we can find what is probably the ultimate quantisation of time, sometimes referred to as Planck's time.

$$t = \left(\pi h G / c^5\right)^{\frac{1}{2}} = 2.395x10^{-43}\,\text{sec}$$

2.395×10^{-43} differs by only 0.2% from the ratio of the gravitational to the electric force of the electron:

$$Fg / Fe = Gm^2 4\pi\varepsilon_0 / e^2 = 2.4x10^{-43}$$

m and e are the mass and charge of the electron. Of course the other difference is that t is a time while F_g/F_e is a dimensionless number. One hypothesis which could explain such a coincidence is that the electron contains at its centre, a black hole having the Planck's dimensions of time t, radius $r= tc$ and mass $M= rc^2/\pi G$.

t is so short that the very small black hole is either being created or annihilated. Its existence is time dependent but its measureable effect – a never ending variation into nothing, due to the time dilation factor – would be seen by an outside observer as the effect of a time independent entity, appearing to have all the characteristics of a charge.

A black hole would explain the dimension difference between the two equations . If the black hole were stationary (non-rotating) the two equations would have the same numerical result; rotation will cause a decrease, by a different amount, of the measureable mass and charge of the electron. Rotational speed U_e could be calculated, by relating, as an hypothesis, the fine structure constant α to the rotational parameter U_e/c:

$$Ue / c = (1 - \alpha / 2)^{\frac{1}{2}}$$

Besides mass and charge, the vacuum permittivity ε is also influenced by the rotational parameter to a similar extent. Other secondary quantities will feel the effect of rotation only marginally and can be safely ignored with the advantage of having only basic equations to deal with, although small numerical inaccuracies will be inevitable.

In certain instances, as a good approximation, we could take a non-rotating black hole giving, for example, ε_0 with a difference of only 0.3% from the real value. To determine ε_0 we call R the F_g/F_e ratio and make it numerically equal to the equation, giving t – the case if no rotation is involved. Eventually we have ε_0 in function of the three basic constants only:

$$\varepsilon_0 \approx R^{\frac{1}{4}} / (2\pi)^{\frac{1}{2}}$$

The presence of a black hole as part of an electron is also supported by the Kerr-Newman equation which must be verified when dealing with black holes. By combining the equations so far seen we may devise a relation between mass and charge of the electron which seems to obey such condition:

$$Gm^2 \approx \pi\varepsilon_0^3 e^2$$

The approximation gives an error of 1% and is due to the fact that, also in this case, no rotation is taken into account. A black hole nucleus allows calculation of the electron mass without using the ambiguous electron radius:

$$m \approx \left(h^3 / \pi G c^3\right)^{\frac{1}{4}} / (2/\alpha - 1)^{\frac{1}{2}}$$

The discrepancy is contained within 0.08% – mainly due to the variation of volume brought about by rotation – and the equation has a part in the calculation of the proton/electron mass ration m_p/m. First find the term D as the ratio between the mass resulting from the above equation and the actual electron mass. Ignoring a secondary term which relates variation of volume with a corresponding variation in charge gives the following relation with an error of 0.04-0.09%. The spread depends upon the exact quantities used to calculate D:

$$m_p / m \approx (D-1)^{\frac{1}{8}} (2/\alpha - 1)^{\frac{3}{2}} (1 - \alpha/2)^{\frac{3}{8}}$$

As a consequence, the proton mass can be calculated with comparable precision. The difference between electron and proton is caused by the different rotational speed U_p of the black hole corresponding to a rotational parameter $U_p/c=(\alpha/2)^{0.5}$. It may appear strange but calculations show that U_e and U_p produce the same charge value.

When all secondary effects are taken into account, the precision of data obtained will be in line with that already known, though the equations should be seen as support for the black hole electron rather than a way to calculate known data with more precision.

Nevertheless one last equation connects the most important constants in an exact relationship, from where it is possible to calculate the gravitational constant with an accuracy at least an order of magnitude better than the current available value:

$$G = c^5 \alpha^2 (2-\alpha)^2 \left(e / 4\pi^2\right)^4 / \pi^h$$

$4\pi^2$ has the dimension of a reference charge and the time dimension reflects the initial difference between the first two equations.

One way to check validity is to see if, in the coming years, the experimental values measured with higher precision tend to the value found with the above equation. This is indeed what has been happening for the past 12 years.

In a letter to *EW&W* (Dec. 1980) the relation appeared for the first time; since then all new experimental data seem to converge consistently towards the value obtained with the last equation.

Probably there is still a long way to go before we see a comprehensive theory on electrogravity or some of its applications. On the other hand, even with the limitations of this approach, the concept of a black hole electron could be a good start. ■

NEURAL NETWORKS fight crime and disease

Artificial neural networks can offer powerful processing systems. But they must be used in the right way. Tom Ivall reports.

Are we expecting too much of the artificial neural network (ANN) in trying to make it solve whole problems rather than just bits of problems within larger, possibly hybrid, systems? According to Jim Austin, of York University, in a comment made at the IEE's latest colloquium on the subject *Neural networks for image processing applications*, this could well be the case.

He pointed out that real machine vision systems in industry were built up from multiple technologies – undoubtedly ringing a faint bell with listeners old enough to remember the hybrid (analogue-digital) computers being manufactured a few decades ago.

But in answer to Austin's criticism, the colloquium produced one application which not only had multiple ANNs performing different functions but intended to incorporate them into a conventional digital computer system. On the same day that the Home Office announced the latest annual rise in crime figures from 11 to 15 million offences it also revealed, at the IEE meeting, how it hopes to use ANNs to save effort in crime detection through fingerprint analysis.

Automated fingerprint classification

Jacqueline Bowen, of the Home Office's Police National Computer Organisation, is investigating multiple ANNs as alternative algorithms for automating the classification of fingerprints in national records.

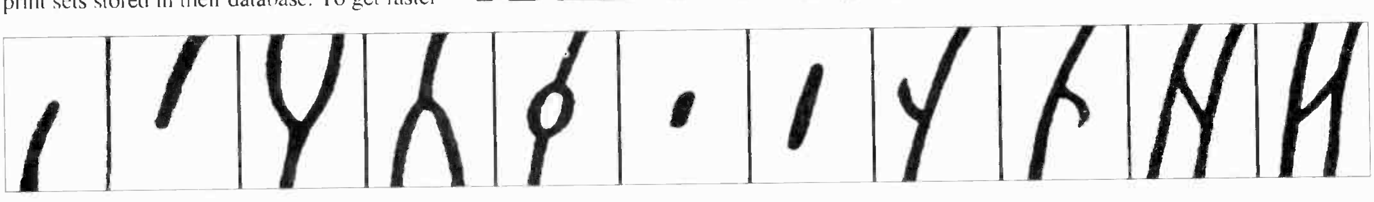
In practice police try to match scene-of-crime fingerprints to the millions of fingerprint sets stored in their database. To get faster and more accurate matching, the database is partitioned into several characteristic fingerprint types, the main types identified by pattern names like arches, whorls and loops.

But the initial classification of recorded fingerprints into these broad categories normally has to be done by a human expert – a time-consuming and labour-intensive task. So there is a good case for automating the process.

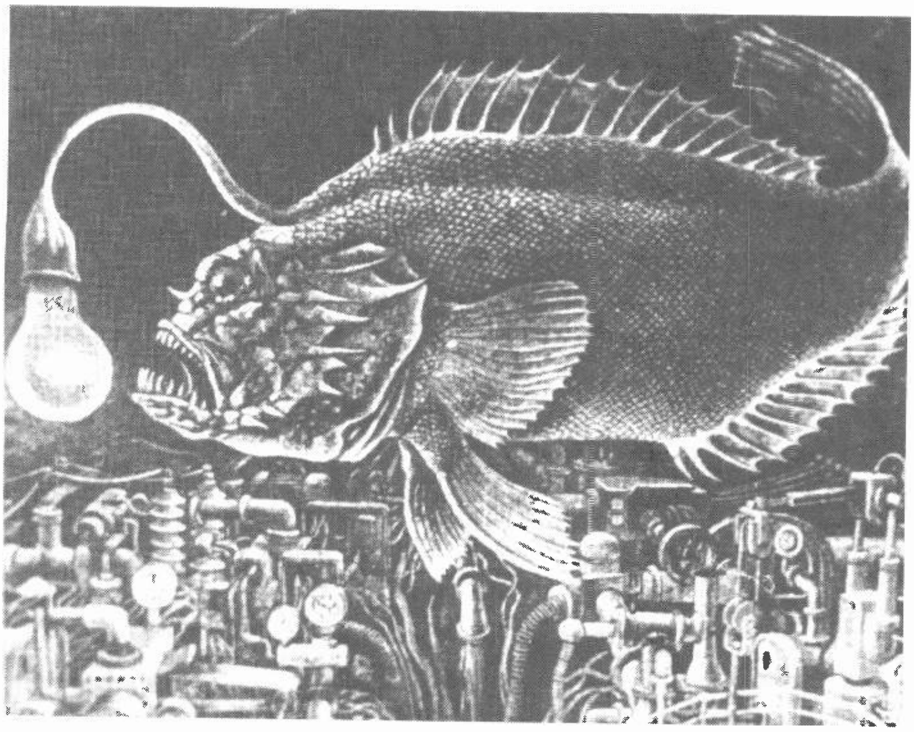
Bowen is trying ANNs because they can be trained to classify patterns. Furthermore they can generalise, by making plausible classifications of patterns that were not actually presented in the training process. When trained properly, according to Bowen, ANNs can perform up to 6% better than conventional rule-based systems. The ANNs are not yet in VLSI hardware form but are currently implemented

Cont ▶ 173

The whorl, is an example of one of eight main pattern types used to classify recorded fingerprints held in a database. The other main types are the arch, tented arch, loop (to left and right), twinned loops (to left and right), and composite. Illus.(A)



Irregularities in individual ridges of fingerprints; in combination these make each fingerprint unique. (As noted by anthropologist Francis Galton, cousin of Charles Darwin, in the late 19th century.)



Leonid N Kryzhanovsky shows how unravelling the mysteries of the electric fish prepared the ground for development of the battery

The fishy tale of early electricity

Great discoveries and inventions are often made at the boundary between seemingly unrelated fields. One of the most striking examples is the struggle of ideas touching on physiology and electricity in the 18th century.

The story begins in 1745 with the advent of the Leyden jar, a glass-dielectric capacitor, allowing accumulation and storage of relatively large quantities of electricity. Dutch physicist Petrus van Musschenbroek (1692-1761) found that discharging a Leyden jar through his body produced a sensation similar to a stroke given by the torpedo fish found in the Mediterranean. This led him to suggest the electrical action of the torpedo and since then the term *electric fish* has come into general use.[1]

Curiously, the german physician Engelbrecht Kämpfer (1651-1716) had likened the effect of the torpedo to lightning[2] although the electrical nature of lightning was not experimentally demonstrated until 1752. Dutch scientist Willem Jacob van's Gravesande (1688-1742) had also suggested the electrical action of the torpedo, but without experimental support.

Some other fish possess the same property as the torpedo. In 1751, French naturalist Michel Adanson (1727-1806) suggested the electrical action of a South American sheatfish. Experiments with electric fish were also performed by the French scientist Pierre Bayen (1725-1798), but they passed unobserved.[3]

Musschenbroek's important observation was that touching the torpedo with a sealing-wax rod produced no effect; touching the fish with a metal rod resulted in a shock – the shock felt both in water and in the air (when the fish is withdrawn from the water for a short time). But Musschenbroek gives no answer to the question he poses of whether the torpedo's electricity differs from "artificial" (frictional) electricity.[4] This question was to acquire paramount importance in connection with work by Luigi Galvani (1737-1797) professor of anatomy at the University of Bologna and of obstetrics at the institute of Sciences of the Bologna Academy.

John Walsh (1725?-1795) a fellow of the Royal Society of London took the next step in the torpedo fish mystery with experiments performed in La Rochelle and on the Isle of Re in the Bay of Biscay. In a 1772 letter to Benjamin Franklin (1706-1790) Walsh wrote to the inventor of the lightning conductor:

> "He who predicted and showed that electricity wings the formidable bolt of the atmosphere, will hear with attention, that in the deep it speeds an humbler bolt, silent and invisible: He, who analysed the electrified Phial, will hear with pleasure that its laws prevail in animate Phials: He, who by reason became an electrician, will hear with reverence of an instinctive electrician, gifted in his birth with a wonderful apparatus, and with the skill to use it."[5]

Walsh confirmed the observation made by Edward Bancroft (d1821) a medical officer and born naturalist, that strokes of an electric fish are felt only if it is touched at two points, one at its back and the other at its bowl. It was Walsh who identified the torpedo's double electric organs whose picture had been given in a 1678 publication by the Italian physician Stefano Lorenzini.

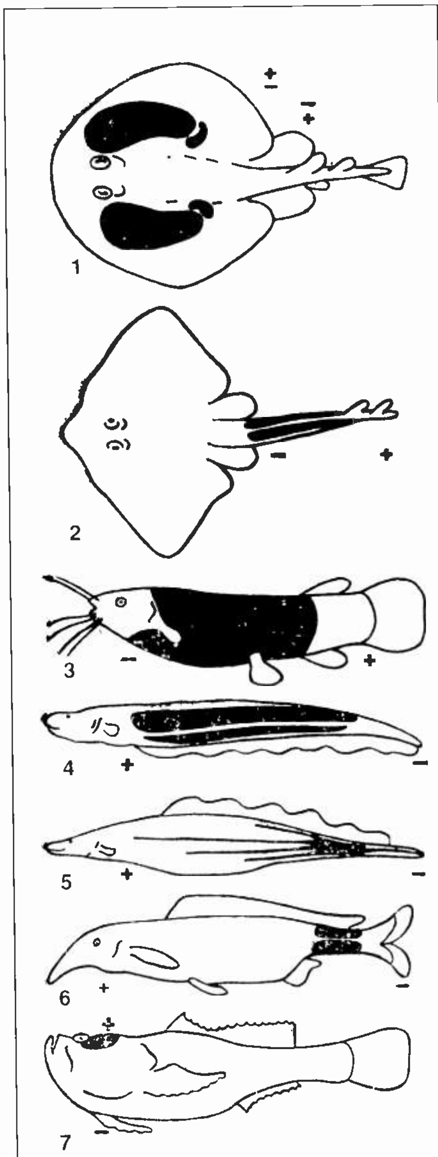
Fish electric organs consist of stacks of plates made up of modified muscular, nervous and ferrous cells – processes in electric fishes may be simulated by switched-capacitor circuits using mos transistors.[6] The organs will be used for defence, attack, intraspecific signalling and spatial orientation, with electrical discharges produced by a series of salvos. In the *Torpedo occidentalis*, the impulse discharge power amounts to 6kW.

Walsh continued his research in a similar way to the earlier Leyden jar experiments, directing the torpedo's electrical discharges through four people joined in a circuit.

Although the shocks in Walsh's experiments were relatively weak, they were still felt by all four. Again reflecting the earlier Leyden jar tests, Walsh then discharged the torpedo through a long wire held by two persons placed on insulators, one holding the wire in one hand and touching the torpedo with a free hand from below and the other person, from above. Both experienced shocks. Replacing the wire by glass or sealing-wax resulted in null effect, results which all bore witness to the electrical action of the torpedo.

When the fish was momentarily withdrawn from water, the shocks were felt to be about four times stronger.

In experiments with the torpedo, Walsh did not obtain an electric spark, nor did he observe the attraction of a pith ball. But even at that stage of research, he was convinced of the electrical action of the fish. He wrote:



Electric fish (painted spots show the location of electric organs):
Torpedo occidentalis, 2 Raja clavata, 3 Malapterurus electricus, 4 Electrophorus electricus, 5 Gymnarchus niloticus, 6 Gnathonemus petersii, 7 Astroscopus guttatus.

"As artificial electricity had thrown light on the natural operation of the Torpedo, this might in turn, if well considered, throw light on artificial electricity, particularly in those respects in which they now seemed to differ."[7]

Henry Cavendish (1731-1810) was persuaded by Walsh's experiments to conduct pioneering research on electric net works[8], work which enabled Cavendish to disprove some objections to Walsh's conclusions. For example, answering the question of how it was possible to verify that the torpedo generates electricity if sea water is a good conductor, Cavendish explained that it was a matter of divided circuits. The resistivity of the human body is approximately equal to that of salted water so that part of the torpedo's electricity will pass through you and you will feel a shock even in water, concludes Cavendish. In discussing this issue, he uses the concept of lines of current established not until the 19th century.

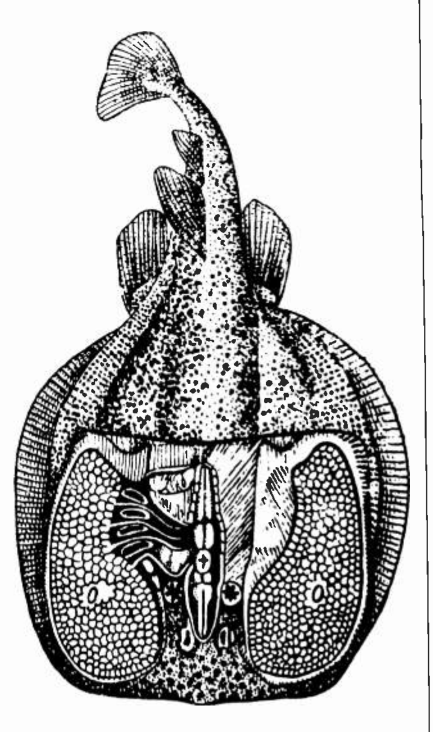
This is how Cavendish countered the observation that the torpedo does not produce sparks nor does it attract light bodies. He says we must distinguish between the quantity of electricity and the voltage (Cavendish uses the term intensity of electrification). The sensation of an electric shock, he says, depends on both the quantity of electricity passed through a body and the voltage – relatively low in the torpedo.

Cavendish made a battery of 49 Leyden jars connected in parallel and charged it from an electrostatic generator to such a small degree that sparks accompanying a discharge could be seen only under a microscope. Nevertheless, the battery produced a shock as sensible as that given by the torpedo. Developing these ideas, Walsh found that simultaneously touching one of the poles of the torpedo's electric organ and a point between them resulted in a shock half as strong as that produced on touching both poles.

John Hunter FRS (born 1728) was also concerned with electric fishes, in particular the electric eel. In his 1775 paper, he coins the term animal electricity[9] – a notion that was to become vital to the development of science.

Walsh, the "father of animal electricity" as Hunter called him, also wanted to investigate the electric eel found in South America. But being Member of Parliament, he could not leave England for any length of time.

According to modern findings, the potential difference between the ends of the electric organ of the eel *Electrophorus electricus* may attain 1.2kV. The eel can produce short impulses with a power of 500V by 2A = 1000 W, enough to stun a human and allegedly kill a horse. The electric eel is usually over 1m in length (eels up to 2.5m long have been reported) and its electric organs of the fish are in its tail portion which makes up about 4/5 of the whole length. The plus and minus poles are in the rear- and fore-part, respectively, and the strongest stroke results when the head and tail of the fish simultaneously touch the most distant points of the body of a victim.



Torpedo with dissected electric organs (marked "o").

Not without difficulties, live electric eels were delivered to Walsh, and in August 1776 he produced an electric spark in the gap between foil conductors pasted onto the glass (the fish was in air, the experiment in water not succeeding).[10]

Electrical evidence

There was one more piece of evidence attesting to electrical operation of some fish.

The effect on a magnetic needle of discharge of a Leyden jar and lightning had been recognised long before the famous work of Hans Christian Oersted (1777-1851)[11]. Similarly, G W Schilling observed the effect of the electric eel on a compass needle, the effect showing itself when the needle was in water near the eel or outside the tank, as reported by him in 1769.[12]

These are the studies on electric fish that paved the way for Galvani's experiments in animal electricity, experiments that eventually changed our way of life.[13]

When in 1780 (or somewhat earlier) Galvani proceeded to his electrophysiological experiments on frogs, some scientists considered "animal electricity" to be inherent only in electric fish. Now we know that electrical processes occur in every living organism *at cell level*. But, macroscopically, those scientists turned out to be rights.

Like other physiologists of his time, Galvani started from some "animal essences" similar to but not identical with the "electrical fluid".[14] It was convenient to explain various phenomena, including psychological ones, on the basis of mysterious essences and fluids.

But the studies of Walsh, Cavendish and others showed that the electricity of the torpedo and other electric fishes did not differ from artificial electricity while featuring a relatively low voltage.

Still, such theoretical errors did not prevent Galvani from performing experiments inscribed for ever in the annals of science.

Galvani's experiments

Galvani's experiments were carried out using a spinal cord, crural nerves and stripped hind legs jointly articulated from a recently dead frog. By touching the spinal cord with a conductor connected to an electrostatic generator, he observed jerking of the stripped legs (the electrical excitation of nerves and muscles had been known for a long time).

After repeating and extending the experiments, Galvani and his assistants arrived at an unexpected result: the muscles contracted even though the set up was merely touched with an earthed conductor (eg a lancet held in the hand) while a nearby electrostatic generator (not connected) produced sparks. It was probably Galvani's wife who noticed the necessity of a spark in this experiment.[15]

A hundred plus years later, R Ritter used to advantage a frog's leg nerve and muscle as the "radio wave detector" in his repetition of Hertz's indoor experiments with a maximum "transmission range" of 38m (limited by the size of the basement of Berlin Physical Institute.[16]

The researchers supposed that the same effect ought to be obtained with atmospheric discharges. In fact, they suspended their preparation in the open air and atmospherics resulted in muscular contractions – the preparation acting as a "lightning marker".

But the most interesting finding was still to be made by Galvani's team. Twitches were observed even in the absence of atmospheric discharges. The set up was suspended on an iron grille using a copper hook stuck into the spinal cord, and by pressing the hook to the grille, Galvani invariably observed strong convulsions. He concluded that the success of the experiment was due to the dissimilarity of the metals in contact (iron and copper in the given case).

He obtained the same effect indoors without any atmospherics.

In his historical experiment successfully performed in October 1786, Galvani completed a muscle-iron wire-copper hook-nerve circuit.

In a subsequent series of experiments, he used various combinations of metals to observe convulsions of different strengths. In the autumn of 1786, the phenomenon of galvanism was discovered: the production of a current in a circuit comprised of two dissimilar metals closed through an electrolyte.

Galvanism is accounted for by the contact potential difference (PD) between a metal and an electrolyte and the response of the animal preparation to the electric current due to a difference in PD, between dissimilar metals.

But Galvani interpreted his discovery in another way. In his 1791 publication, he "explained" the twitches of frog legs by the discharge of a "nerveo-electrical fluid", allegedly accumulated in the muscle, which he likened to a Leyden jar.

Physicists had strong reasons to question such an explanation. Firstly, there had been the evidence linking the electricity of fishes with artificial electricity. Secondly, the analogy between the muscle and the Leyden jar was undermined by Galvani's own experiments. He noticed that violent convulsions were only observed when the "galvanic circuit" (to use a later term) contained two dissimilar metals. The Leyden jar can be discharged equally well through any conducting circuit.

Birth of the battery

Alessandro Volta (1745-1827) recognised the importance of galvanism. Adhering for some time to Galvani's view, at first he believed the frog's muscle to be a source of electricity. But in 1793, he definitely refuted Galvani's interpretation and rightly concluded that the frog's muscle is merely a sensitive indicator of the electric current due to the presence of dissimilar metals in contact in an electrolyte (a second-kind conductor, to use Volta's term).

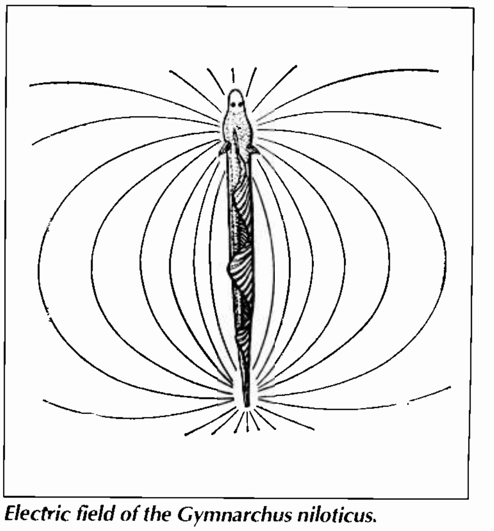
Even so, the Galvanists did not concede defeat, and in 1794 and 1797, they announced experiments employing only nerve-muscle preparations (without metals) and showed that twitches could be produced merely by touching nerves to muscles. More than that, Galvani the anatomist found that the electrical discharge is generated in the torpedo fish in structures similar to ordinary nerves and muscles.[17]

But Volta the physicist was no longer misled, and by that time was on his way to creation of the world's first DC supply, later to become known as the voltaic pile.

The whole story is a perfect example of the truth expressed by Sir Oliver Lodge (1851-1940):

"You may, by ill-luck, start with erroneous ideas, and may be aiming after something impossible to attain; but, if you keep your senses open by the way, the things you will unexpectedly hit upon turn out far more interesting and really valuable than the chimera in quest of which you started."[18] ■

The author is with the Popov Central Museum of Communications, St. Petersburg.



Electric field of the Gymnarchus niloticus.

References

1. J Sigaud de la Fond, "Precis historique et experimental des phenomenes electriques", Paris, 1781. p.637; G Albrecht, *Geschichte der Electricitat*, Vienna, 1895, p.96
2. J Walsh, Of the Electric Property of the Torpedo, *Phil. Trans.*, 1774, Vol.63, Pt.2, pp.461-480, quoted p.473.
3. M Gliozzi, "Storia della Fisica", Turin, 1965. I used a Russian translation (Moscow, 1970, pp.190-191).
4. P van Musschenbroek, "Cours de physique experimentale", transl. *J Sigaud de la Fond*, Paris, Vol.1, pp.392-393.
5. Walsh (ref.2), pp.476-477.6. H Marguerre. Fische als Hochspannungsquellen, *Elektronik*,1990, No.17, pp.47-48.
7. Walsh (ref.2), p.468.
8. H Cavendish, An Account of some Attempts to imitate the Effects of the Torpedo by Electricity, *Phil. Trans.*, 1776, Vol.66, pp.196-225; J Heilbron, "Electricity in the 17th and 18th Centuries", Berkeley, Calif., 1979, p.487.
9. J Hunter, An Account of the Gymnotus electricus, *Phil. Trans.*, 1775, Vol.65, Pt.2, pp.395-407.
10. Sigaud (ref.1), p.645.
11. B Franklin, "Experiments: A New Edition of Franklin's Experiments and Observations on Electricity", ed. IB Cohen, Cambridge, Mass., 1941 pp.242-243.
12. G W Schilling, Sur les phenomenes de l'Anguille Tremblante, Transl. from the German, Nouveaux Memoires de l'Academie Royale des Sciences et Belles-Lettres, 1770 (Berlin, 1772), pp.68-74, cited in R Chipman, The Earliest Electromagnetic Instruments, Contributions from the Museum of History and Technology: Paper 38 (United States National Museum Bulleting 240), Washington, D.C., 1964, p.123.
13. H Lipson, "The Great Experiments in Physics", Edinburgh, 1968. I used a Russian translation (Moscow, 1972, p.117).
14. Gliozzi (ref.3), p.191.
15. E du Bois-Reymond, "Untersuchungen uber thierische Elektricitat", Vol.1, Berlin, 1848, p.39
16. R Ritter, Bemerkung zu den Hertz 'schen Versuchen uber Strahlen electrischer Kraft, *Annalen der Physik und Chemie*, 1890, Vol.40, pp.53-54.
17. T Brown, Galmani, DSB, Vol.5, pp.267-269; *J Heilbron, Volta, DSB*, Vol.14, pp.69-82.
18. Cited in P Rowlands, "Oliver Lodge and the Liverpool Physical Society," Liverpool, 1990, p.9.

LETTERS

Blumlein mystery

At a discussion on the life and work of AD Blumlein held by the Institution of Electrical Engineers last October, a member of the audience asked for an update on the "official" biography which Francis Thomson has been promising for the last 20 years.

He noted that the 50th anniversary of Blumlein's death, in June 1992, passed without any sign of the biography and that as a result the public remains almost wholly ignorant of Blumlein's work. When *The Times* reported the fly past over the anniversary memorial service near the crash site, it did not even mention Blumlein by name.

The questioner also asked what progress has been made in ensuring that the mass of biographical material which Thomson has collected, much of it from public appeals, is secured for posterity now that he seems unlikely ever to finish the job undertaken.

For the benefit of those not present at the IEE meeting I can offer an update.

In 1991 Thomson once again started asking magazines and journals to publish appeals for more biographical material. Those editors who knew that Thomson had started collecting original papers in 1972 (or earlier) treated his fresh call with suspicion. Others, for instance, *Television*, the journal of the Royal Television Society, and *Nature* published the fresh appeals. Later (23 January, 1992) *Nature* took the unprecedented step of publishing a note warning readers that it had "since come to light that Mr Thomson is unable to produce evidence of work on such a book, that he has declined to make the material already collected available to others and that readers would be ill-advised to accede to his request for biographical material".

In the meantime (May 1991), knowing that third party honest broker attempts at negotiating access to the archives and guaranteeing their long term security had failed, I formally requested that the IEE investigate Thomson's behaviour. I drew attention to his use of IEE membership when publishing further appeals for material. I made very clear that my motive, in asking the IEE to investigate the behaviour of one of its members, was to safeguard the material collected.

It took the IEE over a year, and many nags from me, to come to a decision (in late June 1992). The IEE's decision was to take no action. The reasons given were marked "Confidential" and the IEE has refused my requests to lift this restriction.

However the IEE has stated, without seal of confidence, that "the investigating panel received assurances from Mr Thomson that the archival material he has collected will be safeguarded and (the panel) has no reason to doubt this assurance".

Because I had previously raised the question of the Blumlein archive with the Royal Society, I asked the Royal Society if it had any news to tell us. Although my first letter and enclosures went mysteriously astray, I did finally hear from the Royal Society's librarian, Sheila Edwards, by happy coincidence on the very morning of the IEE seminar (October 26).

"I am happy to confirm that I have been in correspondence with Mr Thomson," wrote Edwards, "and that the Officers of the Society have agreed to accept Mr Thomson's generous offer to donate his collection of Blumlein papers to the Society". So when will this be, and when will bona fide researchers be able to read through the Blumlein archives in the Royal Society's library?

The good news is that the Blumlein archives, when available, will be subject to the Royal Society's normal rules. This is that the papers are kept secret until 40 years after the death of the subject. As Blumlein died more than 50 years ago, this means that the Blumlein papers will be available as soon as the Royal Society has them.

So when will that be? Here, I fear, is the bad news.

Edwards admits that the Royal Society is "still negotiating with Mr Thomson". How will the Royal Society let people know when the papers arrive? An announcement may be made in the Society's own Journal, but no decision has been taken yet. Should I phone and enquire for the benefit of those who do not see the Society's journal, in three months perhaps? "It is likely to be take longer than three months". Well how long? "There is no time-scale yet".

In the absence of any more constructive suggestions from the Royal Society, I could only suggest that those who are concerned should phone the Royal Society and ask for themselves.

This suggestion did not, however, appeal to the IEE. The Institution's assistant secretary, Philips Secker, later warned the IEE meeting that to make such approaches would be "counter productive" because "negotiations are at a delicate stage".

Without further explanation, which has not been offered, it is hard to reconcile this warning with the IEE's assurance that it had received assurances from Thomson which the IEE "had no reason to doubt".

Barry Fox
Hampstead
London

Old light

Research Notes in the December issue of *EW + WW* shows again that there is nothing new under the sun.

I refer to the article "Lights that make the radio fade", where some Canadian researchers claim to have discovered the interaction of fluorescent lights with electromagnetic waves.

This problem has been common knowledge within the electronic security industry for many years, where microwave doppler sensors are used to detect the presence of an intruder moving within a building. These devices are effectively a simple short-range radar system, looking for a return signal, whose frequency is modified by the doppler effect from a moving target.

Fluorescent lights are a serious source of false alarms, as they produce a strong return signal with doppler information at twice the mains frequency. The signal processing of these sensors generally includes some kind of notch filtering or similar to provide a reasonable level of immunity.

TRF Hankins
Senior Principal Engineer
R & D Department
Racal-Guardall Midlothian

Quarter light

With regards to the article "Lights that make the radio fade" (*EW + WW* December 1992), I was not surprised to read that the Communications Research Centre In Ottawa had found that fluorescent lamps acted as modulating reflectors at UHF.

In a paper that I read at ICAP '87 I mentioned a similar phenomenon that the BBC found when an excited-gas-type navigation hazard lamp was installed near a high-power UHF television antenna on a mast. In this case the minor lobes of the vertical radiation pattern of the antenna were modulated to such an extent that viewers close to the transmitting station saw hum-bars on their pictures. The immediate, if not permanent, cure was to cover the lamp with wire netting.

Could the peak in intensity found by the Canadians at 2GHz been due to the quarter-wave spacing between the lamp and its reflector at that frequency?

Dick Manton
Purley
Surrey

Microphone challenge

We are glad that readers have risen to the challenge set by our extreme microphone preamp design published in October (Letters, *EW + WW*, December 1992).

Herder's design is essentially the "superbal" configuration of Fletcher and Law of which readers were reminded in Circuit Ideas, (*EW + WW*, February 1992). Like our design the superbal CMRR is also dependent on a matched pair of resistors. Our reason for not using the superbal is that the common-mode cancelling amplifier, IC2, appears in the main signal path. The op amp's frequency response and distortion, if not its noise, will affect the output. In our design this is not the case, so a lower specification and, hence, lower power op amp can be used. In addition, to properly balance the inputs the resistors round IC2 should also be matched. The output decoupling becomes unnecessary if the output is referenced to the artificial earth applied to IC2.

The issues raised by Meunier need clarification. The recordings made with our design have been considered as of very high quality and meet the needs of the professional radio journalist and radio producer. They have been broadcast on local and national radio. This would not have happened if the microphones were being adversely affected by the circuit or made to sound muffled. We assured ourselves that the response of the M58 mentioned in the article is not affected by the load. There is almost no difference between the frequency response plots made with various loads down to a near short circuit (courtesy of Beyer Dynamic).

However, there are certain microphones, such as the AKG D202, which are essentially two microphones in one. The D202 has a bass and a treble element with a crossover to combine the outputs. The load presented by our design does affect the sound of a D202 giving a bass lift which many find more pleasant. This effect is not perceptible with microphones with a more conventional construction, such as the Beyer M58 or hypercardoid Beyer M201. The self-induced current damping effect in a microphone is insignificant since, unlike a loudspeaker, the transduction efficiency is very, very low, both from acoustic to electrical energy and vice versa. Perturbing microphone responses is not really an issue in practical recording since there are no dynamic microphones nor rooms in which recordings are made that have a flat response. The real issue is whether the recordings sound crisp and clear, and they do.

Meunier's suggestion of introducing a parallel load resistor will always make the signal to noise ratio worse. The attenuation of the signal will be more than the reduction in thermal noise. Assuming a noiseless amplifier the SNR will degrade by

$$\sqrt{\frac{R_s + R_l}{R_l}}$$

if a load resistor is placed in parallel with the source. For an arbitrarily complex network between the signal source and the amplifier, adding a dissipative component can only worsen SNR, never improve it. If only this were not true!

Adrian Pickering** and **Max Hadley
University of Southampton

Making links

Antiquaries will know that Andrew Ainger in his letter "Keeping an ear to the ground" (*EW + WW*, December 1992) describes a system conceived by Steinheil, Bavarla, in 1838. Among pioneers of Steinheil's system was Trowbridge, USA, who, around 1875, proposed the system for transatlantic signalling. In the UK, Preece developed a practical system before the turn of the century with a range of about 6km

However, Steinheil's system was allowed to die following demonstrations of Marconi's system, but was resuscitated during the WW1 with the name earth current signalling when it was found to be inherently suited to maintaining contact between support positions and the trenches.

As the name implies, signalling was originally attributed simply to earth currents but, before 1900, Preece suggested that current loops linking the earthing electrodes (earth probes) created a magnetic field, and at a distance, signalling was primarily by mutual inductance; this was demonstrated by Stanley in 1915. However, Maxwell's equations show that electromagnetic waves were also involved and these may well have contributed to the overall effect. Earth probe antennas were employed with Hertzian wave systems before 1914; the Beveridge, or travelling wave antenna is perhaps best known.

A more recent application is the Sanguine type antennas used with strategic extremely-long-wave (45Hz) transmitters, but the distance separating the earthing electrodes is 160km.

Probes spaced about 100m apart, make a highly efficient, yet inconspicuous, long and very-long wave antenna; I have used this type of antenna, with filters and a battery powered oscilloscope, to study electromagnetic phenomena. However, with waves several thousand kilometers long it is difficult to differentiate signals arriving via em waves from electromagnetic induction.

My father operated earth current signalling equipment during WW1 and from information he gave me, I made a device based on a buzzer and valve amplifier in 1935 which let me communicate with a school friend who lived a mile or so away.

More than half a century later, after a career as an agriculturist, my interest was rekindled and during experiments with a tuned system, I was able to maintain reliable communication at 10km, though this was by no means the limit. Carrier frequency was less than 10kHz so as to comply with DTI regulations.

George Pickworth
Kettering
Northants

Power for the people

I am an undergraduate at City University and working in a group advising a company, Intermediate Technology (a charity involved in helping under-developed countries help themselves), on a project to improve power distribution to remote villagers in Nepal. Power distribution relies on the villagers acquiring vehicle batteries and shuttling them between recharging points and their homes.

Due to the distances involved and the weight of the batteries the villagers tend to leave it to the last minute before recharging. This is leading to seriously reduced battery lives and the villagers having to somehow get more batteries which they cannot easily afford.

We are working on methods of reducing the distances the villagers have to haul the batteries, efficient recharging methods, and discharge limiting the batteries. This involves looking into power distribution networks, inverters, basic recharging circuits, and very basic discharge limiters to be attached to the batteries.

I would be grateful for any viable solutions which have to be cheap and use components, skills and equipment that are available in Nepal.

Peter Wivell
Ashford
Middlesex

Working assumptions

Recent suggestions of ways to revive the economy have included large scale building projects and lower taxes on cars. Meanwhile the media and communications industries remain silent. It is not as if there haven't been job losses and cut backs in these sectors - all major computer, electronics, and communications companies have made staff redundant. What we are seeing is the unopposed erosion of our invisible infrastructure.

Construction, transport, power supply, and heavy manufacturing industries have all lobbied for support for their sectors of the economy, sectors that we have always thought of as the infrastructure. Managers recognise the effects on their businesses of housing shortages for staff, train delays, power cuts, and traffic jams, and call for improvements to made to the infrastructure.

Yet the fact that their marketing departments could not get their message to the customer due to the ineffectiveness of the media has never been an issue. This flaw in the invisible part of the infrastructure has brought our consumer driven-economy to a halt. Products have been designed for mass appeal at the expense of usefulness to overcome the deficiencies of the mass media.

There is no lobby for the invisible

Safe radiation

Anthony Hopwood's article: "Natural radiation focused by power lines: New evidence" (*EW + WW*, November 1992), contrasts sharply with the recent publication by the Health and Safety Executive: "The tolerability of risk from nuclear power stations" (HMSO - 1992) which states:

"Ionising radiation and radioactive materials can readily be detected and measured, even in small quantities, by sensitive instruments. The annual dose to people in this country from radioactivity in the ground, radioactivity in our bodies from birth or acquired since, and cosmic rays is about 1mSv, with about a third coming from each of these sources. This value is an average, The dose to individuals may differ from the average by a factor of between 2 and 3, either higher or lower".

The effect postulated by Hopwood is thus within the range of natural variation and does not provide any reason to depart from Sir Richard Doll's conclusion in his report "Electromagnetic fields and the risk of cancer" (National Radiological Protection Board- 1992) that: "The epidemiological findings that have been reviewed provide no firm evidence of a carcinogenic hazard... that might be associated with residence near major sources of electricity supply".

DE Jeffers
The National Grid Company
Guildford Surre

Quantum folly

The focusing of natural radiation by power lines (*EW + WW*, November 1992) appears to be entirely consistent with the view that processes of computation have their origins in electromagnetic phenomena most accurately explained in terms of the quantum theory of physics.

The directional differentiation effect near power lines suggests the influence of phase quadrature and therefore that accurate analytical models for investigational purposes could be constructed using the methods of projective geometry and electronic holography applied to artificial neural networks.

The direct links between quantum physics and computation now being firmly established imply the dawn of a new era in all branches of medicine. That so many of the teaching hospitals in London should be closed or amalgamated on supposedly commercial grounds seems to be yet another folly of the present government. Their combined expertise will soon be needed.

Brian Clement
Crickhowell Powys

Peer pressure?

The findings and theory in Anthony Hopwood's article "Natural radiation focused by power lines: New evidence" (*EW + WW*, November 1992) were presented at the public inquiry into NGC's proposal to put up new overhead lines from Teesside to York. We felt that we could not press the arguments very far in view of the absence of direct relevance to 400kV lines carrying about 5GW, although it is reasonable to argue that the cosmic ray concentration effect below such lines would be much greater than below 33kV lines studied by Hopwood. However, there is little doubt in my mind that this is an important and significant effect which may well contribute to the effects of overhead lines on health.

As I see it, this explanation has a very similar status to the free radical cage escape mechanism which occurs in the presence of EMF and which gives rise to the same kind of chemistry in biological cells as high energy radiation. I have to say, however, that there is in my view more convincing experimental correlation in the latter case. In the end it will probably be shown that the two mechanisms are complementary and hence synergistic.

I must congratulate your journal on having been in the forefront in publicising the effects of EMF. I am sure I don't need to tell you that there is enormous vested interest on the part of industry to suppress the results which are now appearing from all parts of the world. You will be happy to hear that when NGC's lawyers attempted to dismiss reports in *EW + WW* as being of low scientific status on the grounds that the articles were not "peer reviewed", I was able to point out that neither are some articles in *Science* and *Nature*! The inspectors have substantial appendices consisting of papers from *EW + WW* to read before they come to their conclusions at the termination of the inquiry.

Professor G Scott
Newby Cleveland

infrastructure, some funding from the EEC, but no political clout.

Only after our consumer driven economy has been completely destroyed will leaders who are less restricted by political dogma and less dependent on philosophical '*isms* to maintain their powerbase have any place.

It will be then that the media, computer and information technology industries will have a voice equal to that of the car and construction industries, with journalists, advertisers and broadcasters being able to lobby for a more effective infrastructure to support their efforts.

Peter Kruger
Royston
Herts

Russian plea

We are in the process of producing a monograph containing photographs and biographies of specialists in radio engineering and electronics who had been working in Petrograd up to 1918, including those who have for one reason or another emigrated.

We are sorry to say that during the last 70 years the branch of historical science studying the development of domestic radio engineering and electronics has lost a lot of information about our compatriots.

We would like to hear from anyone who knew anything about the lives and destinies of Russian specialists, scientists, or military engineers in different companies and countries.

Of particular interest would be information on Semyon Moiseevich Izenshtein, Leon Moiseevich Izenshtein, Ilja Emmanuilovich Muromtsev, Jackov Moiseevich Ivaz, Nickolay Petrovich Gorjachev, Boleslav Kazimirovich Zelenovsky, Dmitry Semyonovich Troitsky, Georgy Alexandrovich Zolotovsky, Lev Petrovich Muravyov, Mitrophan Nickolaevich Kritsky, Vladimir Nickolaevich Teich, Dmitry Maximilianovich Sockoltsev, Dmitry Nickolaevich Artemyev, Iosif Davydovich Tyckotsiner, Grigory N Ogloblevsky, and others.

I Yu Krivtsov and EV Soboleva
National Committee on History & Philosophy of Science & Techniques
St Petersburg
Russia

Lipschutz errors

With regards to the letters from Lipschutz and Perrott (*EW + WW*, September 1992), remember GEE was never designed as a bombing aid. It came from a 1937 proposal by RJ Dippy for an aircraft landing system but was not proceeded with because of the pressure of work on radar. (Watson-Watt, "Three steps to victory", 1957).

It was not until the RAF's inability to navigate at night became obvious in 1940 that serious work started. Dippy said at the time that he thought it would not have a better range than 100 miles at the 30MHz it was using, but it would let bombers find their home bases accurately.

Important because the RAF was losing more aircraft to accidents caused by getting lost and running out of fuel, or hitting high ground looking for their airfield, than the Germans were shooting down.

Also, it was used off the south-western approaches for U-boat hunting where it was out of range of jammers.

The article by Darrington in the May 1992 issue on Lipschutz'z ideas for automatic plotting was interesting. But I doubt that they would have worked in practice.

The idea of automatic plotting is not new. HA Affel took out a US patent in 1926 for such a device, although not specifically designed for aircraft. He proposed four radio beacons at the corners of a square around the area of interest, and differential ranges (obtained by phase-comparison) to be plotted by an X-Y plotter. Although the theory was fine, the practicalities were elusive and it never came to fruition.

This is what might also have defeated Lipschutz had his ideas been taken up. It seems he may not have been an experienced navigator when he designed his plotter, and it is a pity this was ignored in the article.

Merely sensing the null of an incoming radio signal is useless unless all you want is to fly directly to the transmitter. Even then, it will only work if there is no wind and no drift, otherwise the aircraft will simply fly round in circles.

If the null was sensed correctly relative to the fore-and-aft axis of the aircraft, the next step would be to translate it into a bearing related to true north, otherwise it cannot be plotted on any map or chart. But magnetic compasses of the day (1939) were unstabilised, subject to all sorts of errors, and were quite difficult to read when they were swinging wildly. And the reading still had to be corrected for deviation (a few degrees) and variation (over the UK about 12degW in 1939) both of which were continuously varying.

Navigators would not have welcomed spending the entire flight manually cranking in these corrections as well as the actual magnetic heading of the aircraft.

Even if all this could be done, the net major problem would be plotting the bearing. Unfortunately, the assumption that a simple reciprocal can be plotted is untrue - there is the matter of convergence. This comes about because lines of longitude are not parallel and bearings are measured relative to them.

These problems would have occurred no matter how accurately the null was sensed, but that could not be very accurate. The major problem getting an accurate MF bearing, particularly at night, was that an ordinary loop is just as sensitive to horizontally polarised skywave as it is to vertically polarised ground wave. Errors skywave causes are large but often steady over several minutes. Averaging by lamps or other methods will not smooth them out.

If Lipschutz proposed Adcock type aerials to get over this he must have been unaware of the mechanics of these aerials on an aircraft. A deflection away from the vertical of only a few degrees is quite enough to re-introduce enough horizontal polarisation to bring back skywave problems, and if they were made short and stiff enough not to deflect in the airstream did he propose to tell the pilots never to bank, climb or dive?

There are many other points that could be made, but it all goes to prove that ideas are cheap, it is the hard slog of actually making them work that matters. Perhaps those civil servants and assessors of 1939 were not quite as stupid as Darrington makes them out to be!

WF Blanchard
Dorking
Surrey

Course notes

As a retired RAF Engineering Officer I followed with interest your article "Pursuing a lost course" (*EW + WW*, May, 1992) and the ensuing correspondence.

Sir Edward Fennessey totally ignored the fact (Letters, July) that the air war not only took place over the Northern part of Germany or Europe, but also in the Middle East - Cyrenaica, Crete, Malta, and North Africa, as well as Italy and Yugoslavia, where effective radio aids were mostly unreliable. This applied to both the bomber and fighter force. Had Heinz Lipschutz's invention not been rejected, it is possible that it would have been available to the RAF and allied air forces who would then have been totally independent of all ground aids world-wide.

It is difficult to understand why the invention was rejected without some evaluation, considering its importance if proven a valid proposition - from an engineering and operational point of view. The fact that Captain Lipschutz was willing to offer his help in any trials should surely have been accepted. The rejection and failure to carry out an evaluation was most shortsighted, to put it mildly.

When my squadron, No 274 (Hurricane) desert air force, was tasked to support our ground troops in the battle for Crete it meant a sortie of at least 500 miles from our base at Gerawla, a few miles East of Mersa Matruh, to Crete and return. The squadron faced air battles over the island and was obviously unable to land and refuel. Navigational aids were primitive and our pilots found great difficulty in finding Crete and returning to base.

Lipschutz's inertial navigational system would have been a godsend.

Had this invention been fully proved for operational use, then not only would INS have been available to the allied air forces in Europe and the Middle East, but eventually it could have been supplied by Britain to the US air force in its battle against Japan.

Proven in war it would have been a money spinner for this country, for not only could we have sold it to the air forces of the world but also to civil aviation, thereby guaranteeing many, many jobs for a skilled engineering force.

Barry Wilkinson
Barry
South Wales

Human problems

True as some of your November editorial may be, it is surely the primary purpose of formal education to prepare each generation of students for the problems - including the human problems - they will meet in their working lives.

In the next half century or so the vast economic effects of global population growth will certainly have to be faced by the developed nations.

Unwelcome as it may be to those currently studying advanced MMIC technology, a fundamental knowledge of human nature is also necessary. This can most easily be acquired by some awareness of the humanities and at least a modicum of managerial ability.

It is the lack of the latter which seems to have been an endemic British disease after WW2 I doubt if academics who have never faced the problem of finding the next pay packet for their employees are the best surgeons to remove this canker.

A considerable part of the British defence - and electronics - industry was built up on the iniquitous cost-plus system which completely inhibited the creation of competent responsible management. It wasn't necessary since the government - and thus the taxpayer - always paid for all the mistakes and errors of judgement.

We thus have nearly two generations who were kept cozily employed by this system which was abandoned very early across the Atlantic. One only has to gaze at the moronic yuppies travelling round the M25 at above the legal speed, and at the same time using their cellular phones, to question their managerial ability - or if their journeys are necessary at all. Certainly a misapplication of electronics.

Your remarks about German widgets are perhaps more aptly applied to those emanating from the Far East. Having worked in various countries in which German competition was evident, I have experienced high technical ability matched with managerial efficiency. Perhaps this is the result of a highly disciplined population and rigid realistic economic control. Germany's economic power certainly does not derive from the production of widgets.

In conclusion let us encourage entrepreneurs in the 21st century, whether they have studied the sciences, arts, or neither.

Tourism may still be a valuable national economic asset in the future to attract the millions in the Pacific Rim. Are there not opportunities in many disciplines, all of which have some electronic content, in mass transportation, medical science, environmental protection, waste disposal, mass catering, food distribution, affordable family holiday accommodation, and so on?

Just as the Japanese after WW2 studied the Western mentality and produced technology to satisfy a pent-up demand for entertainment and automotive products, so we should now be considering if and how we could satisfy the future purchasing power and habits of millions in parts of the world other than Europe.

It is necessary to look far beyond Maastrict, Brussels will never produce entrepreneurs. It will strangle them before birth.

M Le M Manson
Squadron Leader RAF (retired)
Acilia
Italy

Importance of history

I think you are wrong about art history courses (*EW + WW*, November 1992). All citizens should have some general knowledge of history, not just the history of battles and politics but also of technology, art, design, and music. This knowledge can only diffuse down from the people who are experts in each area. If you remove the experts and semi-experts, the average person will become increasingly ignorant.

The chief reason these courses run, however, is that there is a demand for them from potential students. The subjects are naturally interesting and rewarding to study.

The problem with courses on worthy subjects such as electronics or chemical engineering is that they are not popular - most people see technology as difficult, boring, or downright wicked. If there was a big demand for engineering courses, the money would naturally follow.

So long as they are scraping the bottom of the barrel to try to keep up their student numbers, the course standards, the financing, and the motivation of the lecturers will all be poor.

The problem lies further back, perhaps in the schools, perhaps in TV programming, perhaps in the prevalence of magazines with "Power lines cause cancer" all over the cover.

Don Cox
Middlesborough
Cleveland

No future

Your observations regarding the standing of science and engineering in this country are depressingly true (Comment, *EW + WW*, October 1992). The decline in the UK economy is a direct result of this standing.

You only have to look at the jobs pages in the electronic press to see how low the status of science and engineering has dropped. At £20,000 for senior engineer level posts with countless years of experience and a list of required qualifications a mile long, why bother? Plumbers can diddle more than that on cash jobs.

My son is six years old and I can see an engineer in him now. But not if I get my way. It's going to be the medical or law profession for him. Engineering is an enjoyment for me, but struggling to pay the mortgage and running old cars is part and parcel of it. Not for him it won't be!

Derek E Coleman
Wales

...Temps perdu

The French long wave station *France Inter* is somewhat unusual as it also transmits talking and music as well as the second pulses. I have no information on this station, but I know the frequency is 163.84kHz.

I will soon be 70 years old and would love to build a clock using this French transmission. Do any of your readers know of any addresses to which I could write for information circuits or anything at all to do with time code transmissions in general. I wrote to the French Embassy some time ago but have had no reply.

RMW Quaile
Caythorpe
Lincolnshire

■

DESIGN BRIEF

LTPs and active double balanced mixers

The long-tailed pair has proved a seminal influence in analogue circuit design, ever since it first appeared. Ian Hickman explores the LTP's flexibility.

Before semiconductors, a double triode was about as close as anyone could get to a monolithic matched pair. In a sensitive, high input impedance valve voltmeter, designed accurately to measure DC levels, drift was a major problem. The HT circuit could be stabilised easily enough, but heater supplies were more expensive to tackle. A double triode allowed any change in anode current for a given grid voltage in one half of the valve, due to heater voltage/cathode temperature change, to be cancelled for the main part by a similar change in the other half.

One of the earliest applications of the long-tailed pair LTP was at DC, in valve voltmeters, **Fig. 1a**. But when transistors came on the scene, the LTP really came into its own. Early versions employed selected discrete transistors, packaged in a common heatsink to avoid temperature differences. Later, single can devices like the *2N2060* came on the scene, offering even lower drift in DC coupled circuits.

The LTP is useful in a host of AC applications as well, **Fig. 1b** showing just one. It also has many uses at RF[1]. **Figure 1c** shows how the basic LTP can be used as an RF modulator. When LTPs are piled up together, things really start to get interesting. **Figure 2a** shows a seven transistor "tree", which forms the basis of many modulator/demodulator/mixer circuits. The baseband-to-RF conversion conductance is set by the value of *R*, the total resistance between the emitters of the lower LTP. Each of the two outputs is double balanced in its own right, containing neither carrier nor baseband components – at least, if the circuit is ideally symmetrical.

The circuit produces a double sideband suppressed carrier output and, used in conjunction with a suitable sideband filter, forms a simple SSB exciter. While it could be built using discretes, an IC implementation provides close matching of all the components, and the provision of separate constant current transistor tails for the lower LTP enables the conversion conductance to be set with a single resistor, **Fig. 2b**. The larger this resistor, the lower the conversion conductance, but the more linear the circuit operation becomes.

By contrast, the upper LTPs are operated without any such emitter degeneration. Their job is to switch the current smartly at their emitters to one or other collector cir-

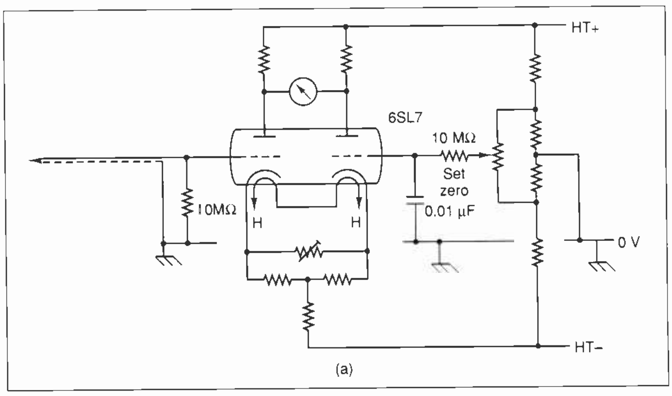
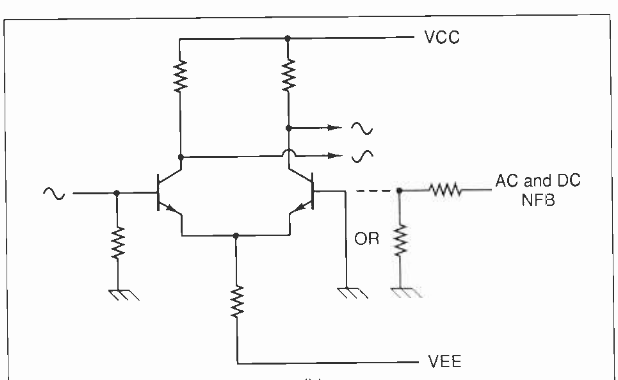


Fig. 1a). A double triode provided an almost drift-free high input impedance voltmeter, greatly reducing the effect of mains voltage variations since the temperature of the two cathodes was equally affected. b) The LTP is also useful in ac applications, eg this "phase splitter", such as might be used in a push-pull amplifier. c) The LTP can also be used as an RF modulator, but the output at each collector is "unbalanced", ie contains components at both the carrier and at the baseband (modulating) frequency. If the two outputs are combined in a push-pull tank circuit, it is single balanced (containing no baseband component), but the carrier is still present ie, the output is AM.



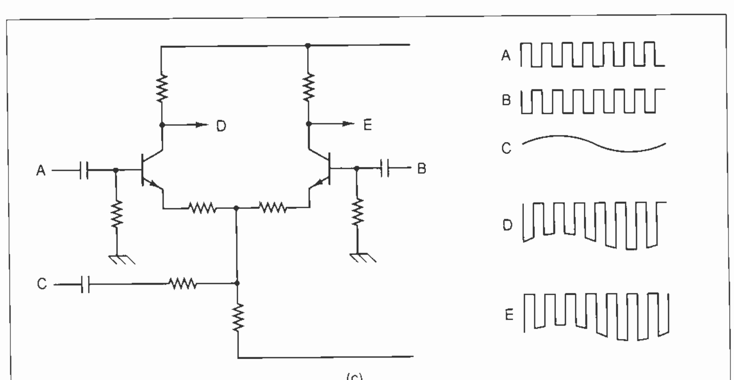
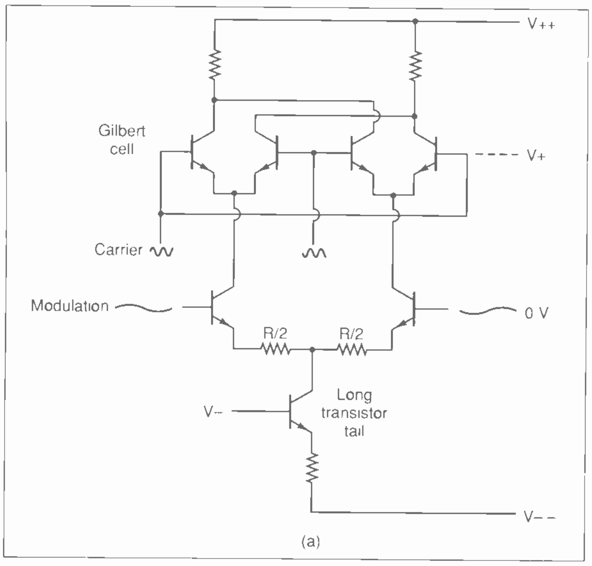
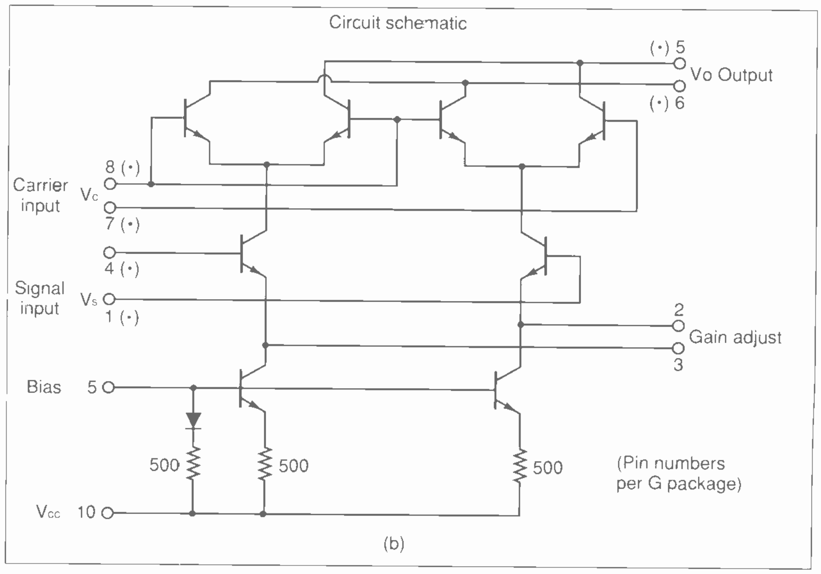
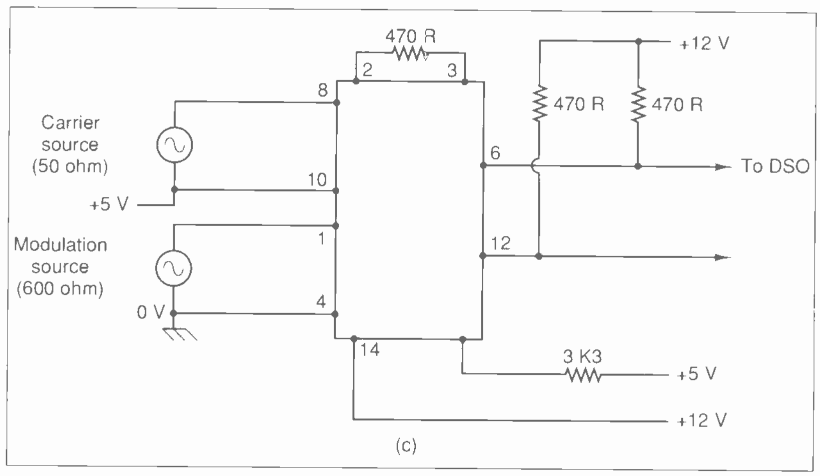


Fig. 2a) The basic seven transistor tree double balanced modulator.
b) An IC version is available from many manufacturers under type numbers such as LM1496, LM1596. Note: pin numbers refer to the round G package.
c) Simple test circuit using 1496. Note: pin numbers refer to the DIL P package.







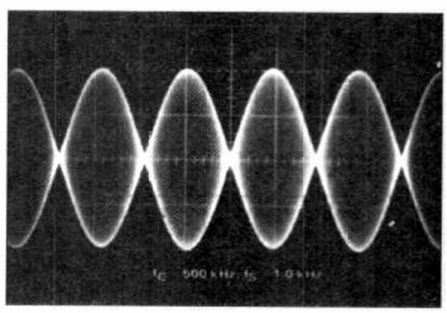
cuit with as little delay as possible. To this end, the amplitude of the carrier is made large compared with the 100mV or so needed to switch the upper LTPs; alternatively, a squarewave carrier can be employed.

An *MC1496* was connected into the circuit of Fig. 2c, ready for some practical measurements, but first we should look at some of the illustrations in the data sheet. **Figure 3a** shows the DSB output of an *MC1496*, the (suppressed) carrier frequency being 500kHz and the modulating frequency 1kHz. Spectrum, **Fig. 3b**, shows the carrier to be almost completely suppressed, the device providing a typical suppression of 65dB at 0.5MHz and 50dB at 10MHz carrier frequency respectively. Carrier suppression is optimised by applying a null adjustment to the bases of the lower LTP, to cancel out any standing V_{be} offset. If such an offset is deliberately introduced, then a standing carrier component will be present in the output. This permits the production of (full carrier) AM (amplitude modulation), **Fig. 3c**, which shows very nearly 100% modulation. The spectrum is shown in **Fig. 3d**.

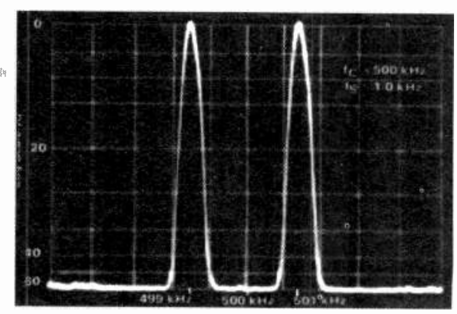
Amplitude modulation is used for broadcasting on the long, medium and short wavebands and is simply recovered from the incoming signal with a diode detector. The detector charges up a capacitor to the peak of the RF waveform, whilst a resistor in parallel with the capacitor enables the voltage to leak away again.

The RC time constant used is long compared to the period of the RF, but short compared to that of the highest baseband frequency, enabling the detector output[2] to follow the peaks of the RF

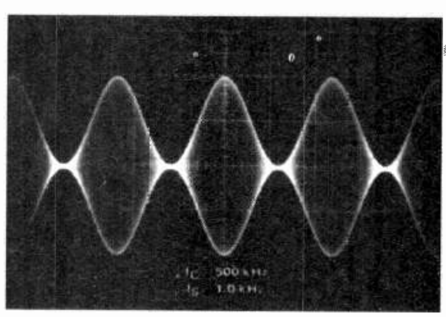
Fig. 3



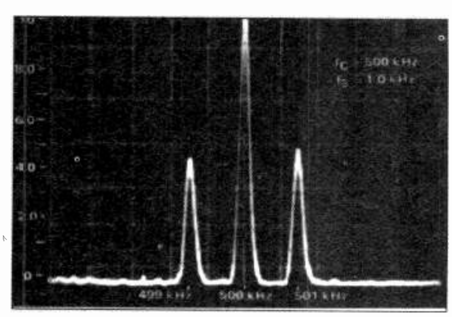
a) Double sideband suppressed carrier output of the MC1496.



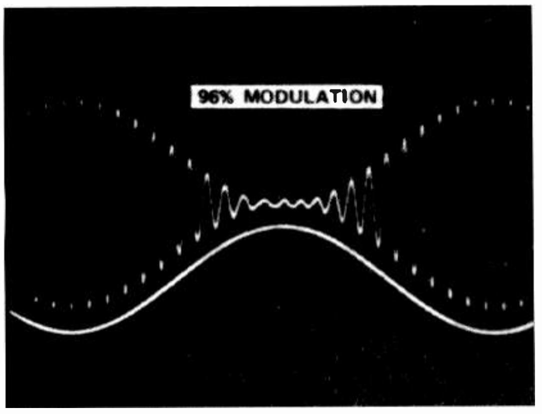
b) Spectrum of a), RF = 0.5MHz, baseband modulation 1kHz.



c) 100% modulation AM, also with RF = 0.5MHz, baseband modulation 1kHz.



d) Spectrum of c).



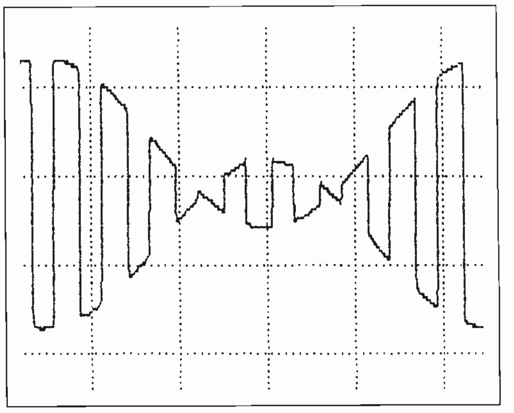


Fig. 4a (left) AM with modulation index of 96%. The waveform is continuous with no sudden phase changes. b (right) AM with modulation index of 130%, instantaneous 180° phase flips are visible twice per cycle.

down into the troughs of the modulation. Due to the large disparity between the baseband and RF frequencies, the individual cycles of the latter are not visible in Fig. 3c, but in fact the carrier is continuous, and the waveform exhibits no phase changes.

This is illustrated in **Fig. 4a**, where, for clarity, a much lower RF has been used; the modulation depth is 96% and the baseband waveform is shown as well for comparison. (The RF waveform here looks sinusoidal rather than square because I have cheated slightly. The waveform shown was actually produced by an *MC1495* which is a four quadrant multiplier, rather than by an *MC1496* with its cell of four switching transistors. An active double balanced modulator like the *MC1496* would of course usually be used with a tuned tank circuit rather than with resistive loads as in Fig. 2c, providing a sinusoidal output).

In contrast, if the AM modulation index is allowed to exceed 100%, then there are sudden 180° phase changes apparent in the RF waveform – see **Fig. 4b** which was produced using the circuit of Fig. 2c. A diode detector is only sensitive to the amplitude of the peaks, not to their phase, and so the recovered baseband audio would be a grossly distorted version of a sinewave.

An interesting case arises when the modulating frequency is the same as the RF carrier frequency, F_C. The double balanced modulator or mixer then acts as a phase sensitive detector, producing the sum and difference of the modulating and carrier frequencies. As these are in this case identical, the results are 2_{F_C} and 0Hz, ie the second harmonic and a dc term. The value of the latter term can be anything from a peak positive value, through zero, to the same peak value but negative, depending upon the relative phasing of the inputs at the carrier and modulation ports of the mixer.

Figure 5a shows a circuit where the two inputs are in phase, which results in a peak positive output at one output port of the mixer and peak negative at the other. If, moreover, a large signal is used so as to overdrive the modulation port, the second harmonic output becomes small, one output remaining "stuck high" and the other "stuck low".

The exceptions to this are the two instants each cycle where the input waveform passes through zero, at which points all transistors must be conducting equally. This results in narrow spikes, **Fig. 5b**, which are rich in harmonics (the slightly rounded shape of alternate half cycles is due to the single ended drive to the modulation port). This circuit can thus be used as a frequency multiplier: for example, using a 5MHz input from a standard frequency source; the outputs could be combined in a tuned push-pull tank circuit so as to extract any desired harmonic of 10MHz.

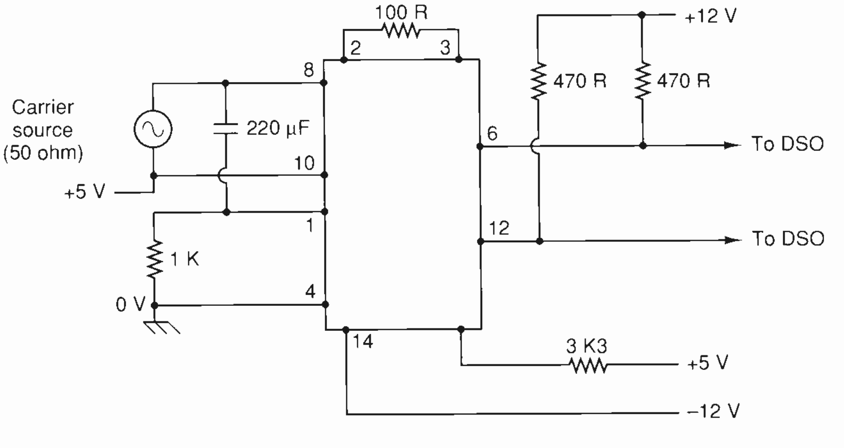
With further overdriving of the modulation port, or by using a clipped sinewave drive, the spikes become very narrow, enabling very high order harmonic generation to be achieved simply. ■

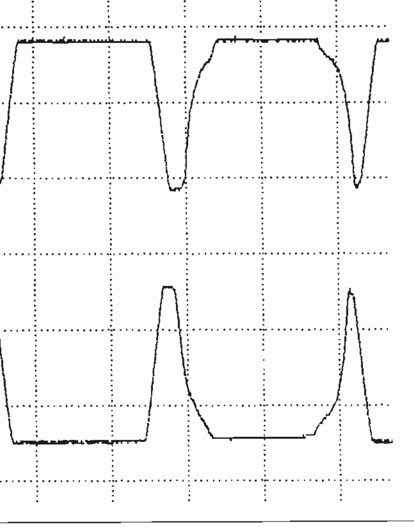
References

1. Design Brief *EW + WW* p168 Feb. 1992
2. Design Brief *EW + WW* p976 Nov. 1991

Acknowledgments
Figures 2b, 3 and 4a are reproduced by courtesy of Motorola.

Fig. 5a) Circuit used for harmonic generation. b) Waveforms at the outputs of circuit shown in a).





UNDERSTANDING diodes and their PROBLEMS

Even the simplest active devices may exhibit baffling behavioural problems. No diode is perfect, and their imperfections are fascinating – even two-terminal devices are quite complex.

Serialised from the book Troubleshooting Analog Circuits by Robert Pease.

All diodes start conducting current exponentially at low levels, nA and up, and an ideal diode may have an exponential characteristic, with a slope ΔV/ΔI of:

$$g = (38.6\text{mS/mA}) \times I_F$$

where mS = milliSiemens = millimhos, and I_F = forward current.

Indeed transistors do have this slope of 38.6mS/mA at their emitters, at room temperature, corresponding to 60mV/decade of current. But the slopes of the exponential curves of different real (two-terminal) diodes vary considerably. Some, like a *1N645*, have a slope as good as 70 or 75mV per decade. Others like *1N914*s have a slope as poor as 113mV/decade; or have intermediate values such as 90mV/decade.

But the data sheets *never* tell you about this. To tell the truth, I didn't even recognize the fact myself when I wrote the first version of this, as published in *EDN*. I assumed the slopes started out from 60mV/decade and then worsened – shifted over to 120mV/decade at higher current levels. But I was wrong – and nobody ever contradicted me.

Figure 1 shows just a few of the different curves you may get when you buy a diode. None of these slopes is characterised or guaranteed. Changing supplier will also have an effect, so each supplier should carefully checked for a particular application.

As the current level continues to increase, the conductance per milliampere deteriorates due to series resistance and high-level injection and other non-linear factors. So, at a large forward current, a diode's forward voltage, V_F, will be considerably larger than predicted by simple theory, and larger than desired. Of course, some rectifiers, depending on their ratings, can handle large currents, from amperes to kiloamperes. But the V_F of all diodes, no matter what their ratings, err from the theoretical at high current levels.

Schottky diodes can now have smaller V_F than ordinary PN diodes. But even germanium diodes and rectifiers still have their following because their low V_F are similar to the Schottky's: some new germanium Schottky diodes are supposed to have even lower V_F.

High-speed and ultra-high-speed (sometimes also called high-efficiency) silicon rectifiers are also available, designed

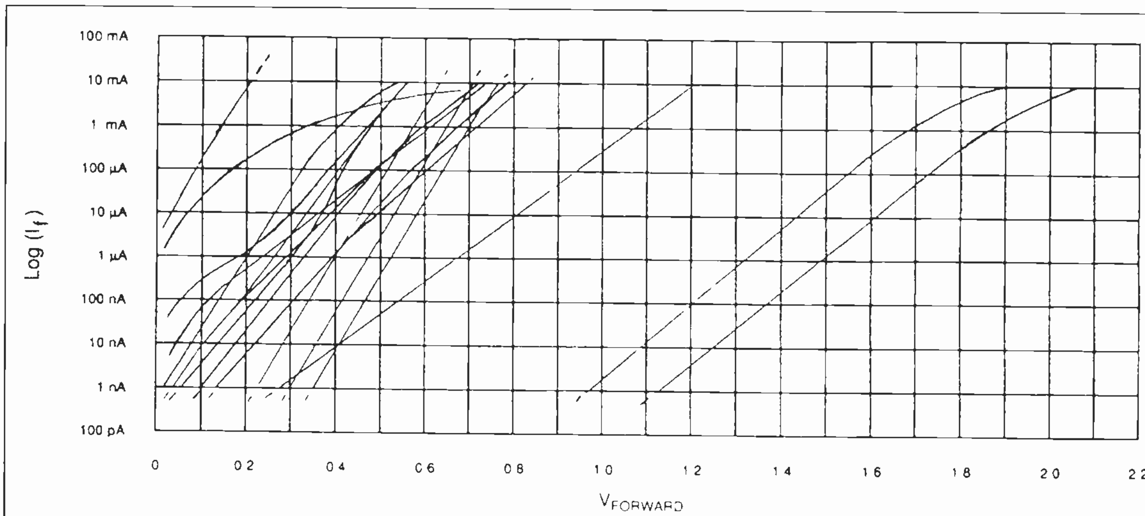


Fig. 1. The diode made up of a transistor's emitter has high conductance over a wide range of currents. All the other diodes have inferior conductances... and they are just about all different. The two right hand curves are forward biased leds. The exponential looking one on the left is for a germanium device.

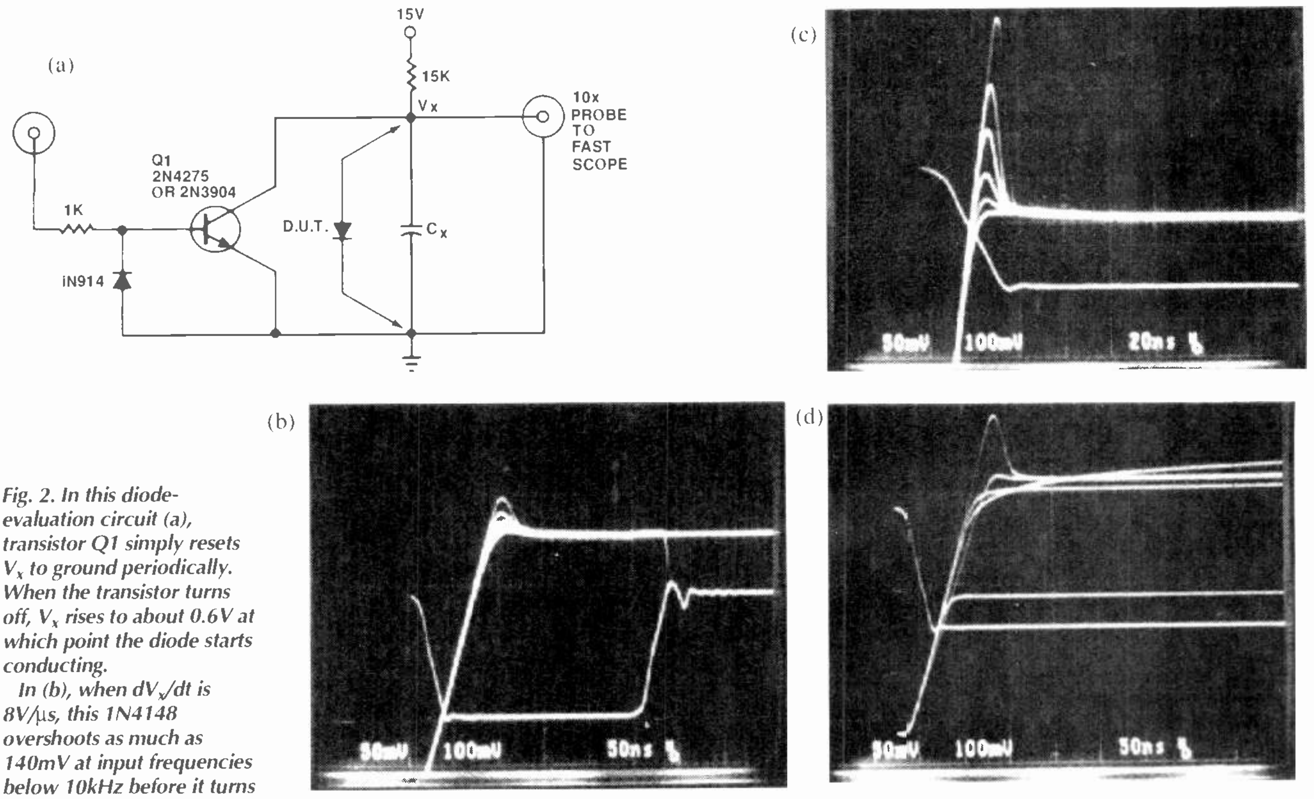


Fig. 2. In this diode-evaluation circuit (a), transistor Q1 simply resets V_x to ground periodically. When the transistor turns off, V_x rises to about 0.6V at which point the diode starts conducting.

In (b), when dV_x/dt is 8V/µs, this 1N4148 overshoots as much as 140mV at input frequencies below 10kHz before it turns on. At higher frequencies – 120, 240, 480, 960, and 1920kHz – as repetition rate increases, overshoot shrinks and disappears. Maximum overshoot occurs when $f_{in} < 7$kHz.

In (c), when dV_x/dt increases to 20V/µs, this same 1N4148 overshoots as much as 450mV at 7kHz but only 90mV at 480kHz and negligible amounts at frequencies above 2MHz.

In (d), various diode types have different turn-on characteristics. The superimposed, 120kHz waveforms are all invariant with frequency except for the bad 1N4148.

for fast switching-regulators and other high frequency applications. They don't have quite as low V_F as Schottky diodes and are not quite as fast. But high reverse-voltage ratings are available and so they are useful for certain switch-mode circuit topologies that impress large flyback voltages on diodes.

Reverse-bias problems

But it is reverse-biasing various diodes that leads to really wild dissimilarities.

For example, the guaranteed reverse-current specification, I_{rev} for many types of diodes is 25nA max at 25°C. Yet measuring them reveals that many have merely 50 or 100pA of leakage.

The popular *1N914* and its close cousin, the *1N4148*, actually *do* have about 10-15nA of leakage at room temperature because of their gold doping. So although these diodes are inexpensive and popular, it is wrong to use them in low-leakage circuits since they are much leakier than other diodes with the same leakage specs.

So why do some low-leakage diodes have the same mediocre 25nA leakage spec as the *1N914*?

Diode manufacturers set the test and price at the level most people want to pay because automatic test equipment can test at the 25nA level – but no lower – without slowing down: characterising and testing a diode for 100pA or better means paying extra for the slow-speed testing. Of course, high-conductance diodes such as Schottkys, germaniums, and large rectifiers have much larger reverse leakage currents than do signal diodes, but that is not normally a problem.

For a very-low leakage diode, use a transistor's collector-base junction instead of a discrete diode[1]. The popular *2N930* or *2N3707* have low leakage, typically. Some *2N3904*s do, too, but some of these are gold-doped and are leakier.

The plastic-packaged parts are at least as good as the TO-18 hermetic ones, and it is easy to find "diodes" having less than 1pA leakage even at 7V, or 10pA at 50V. The low leakage is not guaranteed, but it is usually quite consistent, though the c-b diode generally doesn't turn on or off very quickly.

Other sources of ultra-low-leakage diodes are the *2N4117A* and the *PN4117A*, *18A*, and *19A*. These devices are jfets with very small junctions, so leakages well below 0.1pA are standard with 1.0pA max, guaranteed – not bad for a £0.40 part. The capacitances are small, too.

Speed Demons

When a diode is carrying current, how long does it take to turn the current off? Slow diodes can take hundreds of microseconds. For example, the collector-base junction of a *2N930* can take 30µs to recover from 10mA to less than 1mA, and even longer to the nA level. This is largely due to the recombination time of the carriers stored in the collector region of the transistor.

Other diodes, especially gold-doped ones, turn off *much* faster – down into the nanosecond region. Schottky diodes are even faster, a lot faster than 1ns. But this may still be in parallel with a PN junction turning off slowly at a light current level. If a Schottky turns off from 4mA in less than 1ns, there may still be a few µA that do not turn off for a µs: so if using a Schottky as a precision clamp that will turn off very quickly, as in a settling detector[2], don't be surprised if there is a long tail.

Switching regulators need diodes, high-current rectifiers and transistors to turn off quickly. If the rep rate is high, the current large and the diode turns off slowly, it can fail due to overheating.

Do not try a *1N4002* at 20 or 40kHz as it will work very badly, if at all. Sometimes, if only a moderate amount of current is needed at high speed, several *1N914*s can be used in

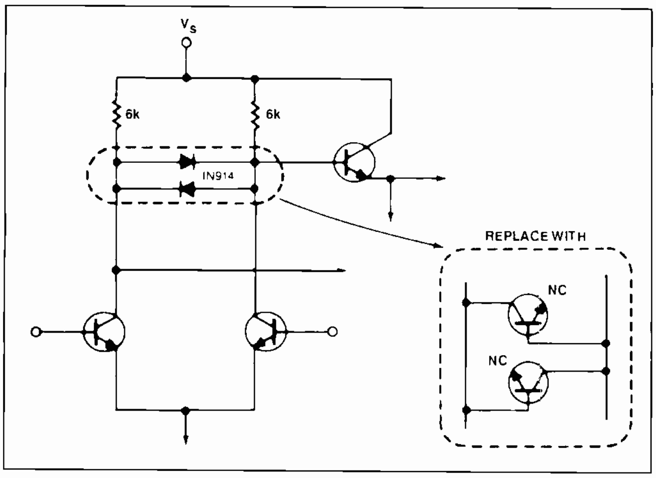


Fig. 3. Even though the diodes in the first stage of this op amp are forward or reverse biassed by only a millivolt, the impedance of these diodes is much lower than the output impedance of the first stage or the input impedance of the second stage at high temperatures. Thus, the op-amp's gain drops disastrously.

parallel – an emergency solution that can work well. But long-term reliability is suspect. The best approach is to engineer the right amount of speed for a circuit. High-speed, fast recovery, and ultra fast diodes are available.

The Schottky rectifiers are even faster, but not available at high voltage breakdowns. Anyone designing switching regulators at these speeds should really know what they are doing – or at least wear safety-goggles.

Turn off – turn on

Logic diodes like the *1N914* are popular because they turn off quickly – in just a few nanoseconds – much faster than low-leakage diodes. What is not well known is that these faster diodes not only turn off fast, they usually turn on fast too.

For example, feeding a current of mA towards the anode of a *1N914* in parallel with a 40pF capacitance (20pF of stray capacitance plus a scope probe or something similar), usually causes the *1N914* to turn on in less than 1ns. Thus, the V_F has only a few millivolts of overshoot.

But with some diodes, even *1N914*s or *1N4148*s from some manufacturers, the forward voltage may continue to ramp up past the expected DC level for 10 to 20ns before the diode turns on. The overshoot of 50 to 200mV is quite surprising (**Fig. 2**). Even more astonishing, the V_F overshoot may worsen at low repetition rates, but can disappear at high repetition rates (**Fig. 2b-d**).

I spent several hours once discovering this particular peculiarity when a frequency-to-voltage converter suddenly developed a puzzling non-linearity. The trickiest part of the problem with the circuit's diodes was that diodes from an earlier batch had not exhibited any slow-turn-on behaviour. Further, some in a batch of 100 from one manufacturer were as bad as the diodes in Figs. 2b and 2c. Other parts in that batch and other manufacturers' parts had substantially no overshoot.

When confronted, the manufacturers at first tried to deny any differences. But eventually they admitted that they had changed some diffusions to "improve" the product. One engineer's "improvement" is another's ruination so always be alert for production changes that may cause problems. Changing the diffusions, process or masks may have a major effect on a circuit.

Many circuits require a diode that can turn on and catch, or clamp, a voltage moving much faster than 20V/µs. For consistency in a circuit with fast pulse detectors (for example), qualify and approve only manufacturers whose diodes turn on consistently. As with any other unspecified characteristic, be sure to protect against "bad" parts by first evaluating and testing, then specifying the performance required.

Also, to see fast turn-on of a diode circuit with low overshoot, keep the inductance of the layout small. It only takes a few inches of wire for the circuit's inductance to make even a good fast rectifier look bad, with bad overshoot.

One "diode" that does turn on and off quickly is a diode-connected transistor. A typical *2N3904* emitter diode can turn on or off in 100ps with negligible overshoot and less than 1pA of leakage at 1V, or less than 10pA at 4V. (This diode does, of course, have the base tied to the collector.) But it can only withstand 5 or 6V of reverse voltage, and most emitter-base junctions start to break down at 6 or 8V. Still, these diode-connected transistors make nice, fast, low-leakage diodes. Their capacitance is somewhat more than the 1pF of the *1N914*.

Strange diode effects

Leds kept in the dark make an impressive, low-leakage diode because of the high band-gap voltage of their materials. They can exhibit less than 0.1pA of leakage when forward biased by 100mV or reverse biassed by 1V. Of course, a diode does not have to be reverse-biased to give a leakage problem.

In one hybrid op-amp I was designing, I specified that the diodes be connected in the normal parallel-opposing connection across the input of the second stage to avoid severe overdrive (**Fig. 3**). But in operation the op-amp's voltage gain fell fall badly at 125°C because the diodes were *1N914*s, and their leakage currents were increasing from 10nA at room temperature to about 8µA at the high temperature. Remember that the conductance of a diode at zero voltage is approximately (20 to 30mS/mA) x $I_{leakage}$. That means each of the two diodes really measured only 6kΩ, and because the impedance at each input was only 6kΩ, the op-amp's gain fell by a factor of four, even though the diodes may have only been forward or reverse biased by a millivolt. Substituting transistor collector-base junctions for the diodes put the gain back up where it belonged: you cannot safely assume the impedance of a diode at zero bias is high if the junction's saturation current is large.

For example, at 25°C a typical *1N914* will leak 200 to 400pA even with only 1mV across it, so a *1N914* can prove unsuitable as a clamp or protection diode – even at room temperature – despite having virtually no voltage biased across it, in even simple applications such as a clamp across the inputs of a fet-input op amp.

Zener, zener, zener...

Just about all diodes will break down if too much reverse voltage is applied, but zener diodes are *designed* to break down in a predictable and well-behaved way. The most common problem with a zener is to starve it: pass too little current and it may get too

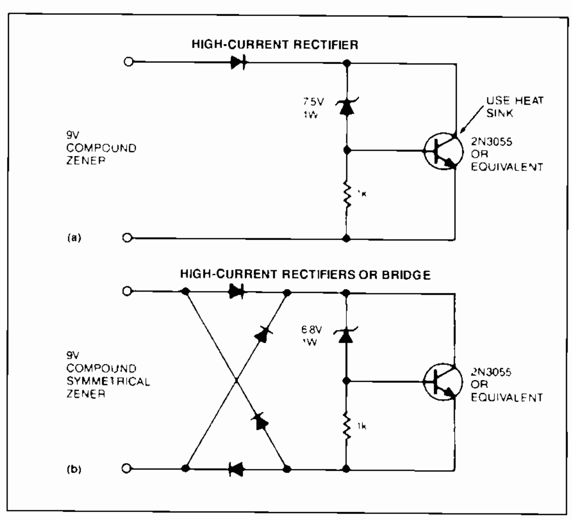


Fig. 4. The power rating of this compound zener (a) is that of the power transistor. The second compound zener, (b), is almost the same as (a) but acts as a symmetrical, matched, double-ended compound zener.

noisy. Many have a clean and crisp knee at a small reverse-bias current, but this sharp knee is not guaranteed below the rated knee current.

Some zeners will not perform well no matter how carefully they are applied. In contrast to high-voltage zeners, low-voltage (3.3 to 4.7V) devices are poor performers and have poor noise and impedance specs and bad temperature coefficients – even if they are fed a lot of current to get above the knee, which is very soft.

The reason is that, at voltages above 6V, zeners are really avalanche-mode devices and employ a mechanism quite different from (and superior to) the low-voltage ones, the real zener diodes. At low-voltage levels, band-gap references such as the *LM336* and *LM385* are popular, because their performance is good compared with low-voltage zeners.

Zener references with low temperature coefficients, such as the *1N825*, are only guaranteed to have low temperature coefficients when operated at their rated current – eg 7.5mA. Adjusting the bias current up or down, can sometimes tweak the temperature coefficient, but some devices are not happy if operated away from their specified bias.

Also, do not try to test an *1N825* to see what its "forward-conduction voltage" is because in the "forward" direction, the device's temperature-compensating diode may break down at 70 or 80V, damaging the device's junction, degrading performance and stability, and increasing its noise.

The *LM329* is popular as a 6.9V reference because its *TC* is invariant of operating current, as it can run from any current from 1 to 10mA. The *LM399* is even more popular because of its built-in heater that holds the junction at +85°C. Consequently it can hold $^1/_2$ or 1ppm per °C. The *LM329* and LM399 types also have good long-term stability, such as 5 or 10ppm per 1000h, typically.

The buried zeners in the *LM129/-LM199/LM169* series also have better stability than most discrete references (*1N825* or similar) when the references are turned on and off – and before you subject a zener to a surge of current, check its derating curves for current *vs* time, which are similar to the rectifiers' curves. These curves will show why you cannot put an ampere into a 10V, 1W zener for very long.

In fact, most rectifiers are rated to be operated strictly within their voltage ratings: exceed that reverse voltage rating, break them down, and their reliability will be degraded. To evade unreliability, redesign the circuit to avoid over-voltage, or add in an *R-C*-diode damper to soak up the energy; or find a controlled-avalanche rectifier.

The rectifiers are rated to survive (safely and reliably) repetitive excursions into breakdown when their rated breakdown voltages are exceeded. Manufacturers of the devices can also give you a good indication of how to keep out of trouble.

If only a zener will do to conduct a surge of current, take a look at the specially designed surge-rated zener devices – also called transient-voltage suppressors – from General Semiconductor Industries Inc (Tempe, AZ). Their 1W devices, such as the *1N5629* through *1N5665A*, can handle a surge of current better than most 10W or 50W zeners.

If a really high-current zener is needed, a power transistor can help (**Fig. 4**).

Zapping

A diode tends to fail by becoming a short circuit when overpowered – and zeners cannot absorb as much power as might be expected from short pulses. But can IC designers take advantage of this situation? The answer is yes!

The V_{OS} of an op amp usually depends on the ratio of its first-stage load resistors. IC designers can connect several zeners across various small fractions of the load resistor. When they measure the V_{OS}, they can decide which zener to short out – or zap – with a 5ms, 0.3-1.8A pulse. The zener quickly turns into a low-impedance (≈1Ω short), so that part of the resistive network shorts out, and the V_{OS} is improved.

In its *LM108*, National Semiconductor first used zener zapping, although Precision Monolithics (Santa Clara, CA) wrote about zener zapping first and used it extensively later on. Although the technique is useful, make sure nobody discharges a large electrostatic charge into any of the pins that are connected to the zener zaps. Zeners really do make a cute lightning flash in the dark when they are zapped, but be careful not to hit them too hard if you don't want them to zap and short out.

Zener zaps are also becoming popular in digital ICs under the name of "vertical fuses" or, more correctly, "anti-fuses". If an IC designer uses platinum silicide instead of aluminum metallisation for internal connections, the diode resists zapping.

Opto-isolators

An opto-isolator, also called a photo-coupler or opto-coupler, usually consists of an infrared led and a sensitive phototransistor to detect the led's radiation. Working with the cheaper *4N28* means it may be necessary to add circuitry to achieve moderate speeds. For example, tailoring the biases per **Fig. 5**, will push the response of a *4N28* up toward 50kHz; otherwise the devices can not even make 4kHz reliably. The trick is decreasing the phototransistor's turn-off time by using a resistor from pin 4 to pin 6.

I've evaluated many different makes and lots of *4N28*s and have found widely-divergent responses. For example, the overall current gain at 8mA can vary from 15 to 104%, even though the spec is simply 10% min.

Further, the transfer efficiency from the led to the photodiode varies over a range wider than 10:1, and the β of the transistor varies from 300 to 3000. As a result, the transistor's speed of response, which is of course related to β and f_{3dB} would vary over a 10:1 range. If a circuit does not allow for gain and frequency response varying so wildly, expect trouble.

For example, two circuits, one an opto-isolated switching regulator[3] and the other a detector for 4-20mA currents[4], have enough degeneration so that any *4N28* will work.

Data sheets for optoelectronic components often don't have a clear V_f curve or list any realistic typical values, often listing only the worst-case values. So it may not be realised that the V_F of a led in an opto-isolator is a couple hundred millivolts smaller than that of discrete red or infrared leds.

Conversely, the V_F of high-intensity, or high-efficiency, red leds tends to be 150mV larger than that of ordinary red leds.

Solar cells

Extraneous, unwanted light impinging on the PN junction of a semiconductor is only

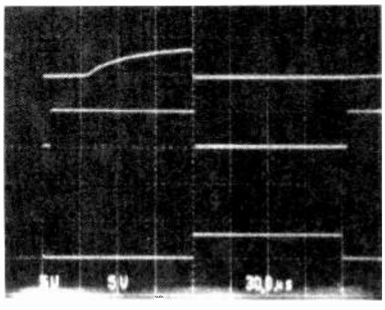
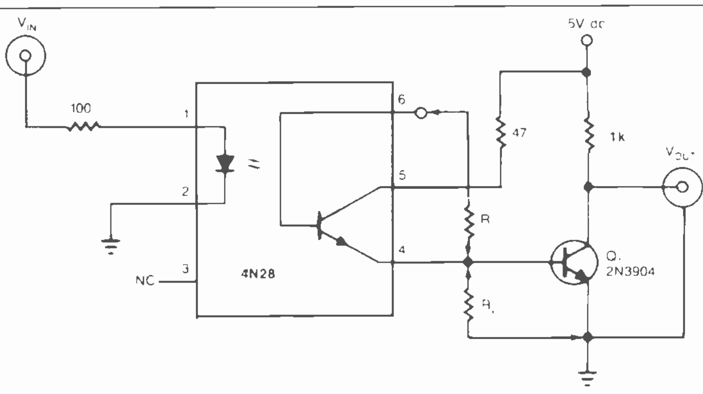


Fig. 5. Adding R1 and R2 to the inexpensive 4N28 optoisolator lets it handle faster signals with less delay – 5µs vs 60µs. The scope photo's bottom trace is an input waveform, the top trace is the circuit's output without R1 and R2, and the centre trace is the output with R1=2MΩ and R2=1kΩ.



How can diodes fail?

If a diode is expected to turn on and off, but instead does something unexpected, that unexpected behaviour may not be *a failure*, but it could certainly cause trouble.

You can kill a diode by applying excessive reverse voltage without limiting the current or by feeding it excessive forward current. When a diode fails, it tends to short out, becoming a small blob of muddy silicon rather than an open circuit. I did once see a batch of *1N4148*s that acted like thermostats and went open-circuit at 7°C, but such cases are rare these days. One of the best ways to kill a diode is to ask it to change up too big a capacitor during circuit turn-on. Most rectifiers have maximum ratings for how much current they can pass, on a repetitive and on a non-recurring basis. I have always been favourably impressed by the big Motorola (Phoenix, AZ) books with all the curves of safe areas for forward current as a function of pulse time and repetition rate. The curves take a little understanding, but after a while they are fairly handy tools.

Manufacturers can play other tricks than just changing processes. Fortunately reverse-marked diodes are pretty rare these days. But I once built a precision test box that worked right away and gave exactly the right readings – until I picked it up to look at some waveforms. Then the leakage test shifted way off zero.

After some study, I narrowed the problem down to an *FD300* diode, whose body is a clear glass DO-35 package covered with black paint. This particular diode's paint had been scratched a little, so when I picked up the test box, the light shone under the fixture and onto the diode.

To minimise such problems I recommend the following strategies:

- Have each manufacturer's components specifically qualified for critical applications. This is usually a full-time job for a components engineer, with help and advice from the design engineer and consultation with manufacturing engineers;
- Establish a good relationship with each manufacturer;
- Require that manufacturers notify when, or preferably before, they make changes in their products;
- Keep an alternative source qualified and running in production whenever possible.

one of many tricky problems encountered when designing and operating precision amplifiers – especially high impedance amplifiers. Just like a diode's PN junction, a transistor's collector-base junction makes a good photodiode, but a transistor's plastic or epoxy or metal package normally does a very good job of blocking out the light.

When light falls onto the PN junction of any diode, the light's energy is converted to electricity and the diode forward biases itself. If a load is connected across the diode's terminals, useful amounts of voltage and current can be drawn from it. A number of large-area diodes could be stacked in series and used for recharging a battery – the most unreliable part of this system is the battery. Even if they are not abused, batteries do not like to be discharged a large number of cycles, and will eventually refuse to take a charge.

But the most critical problem with solar cells is their packaging. Most semiconductors do not have to sit out in the sun and the rain as solar cells do, and it is hard to make a reliable package when low cost is – as it is for solar cells – a major requirement.

In addition to packaging, another major trouble area with solar cells is their temperature coefficients. Just like every other diode, the V_F of a solar cell tends to decrease at 2mV/°C of temperature rise. Therefore, as more sunlight shines on the solar cell, it puts out more current, but its voltage could eventually drop below the battery's voltage, whereupon charging stops.

Using a reflector to get even more light onto the cell contributes to this temperature-coefficient problem. Cooling helps, but the attendant complications rapidly overpower the original advantage of solar cells' simplicity. ■

References

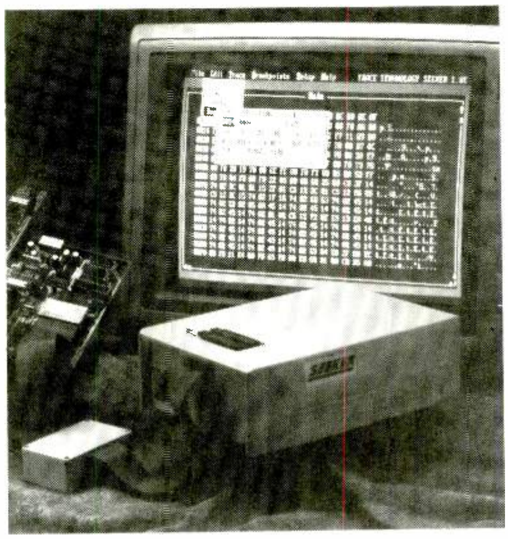
1. Pease, Robert A. "Bounding, clamping techniques improve on performance," *EDN*, November 10, 1983, p. 277.
2. Pease, Bob, and Ed Maddox. "The Subtleties of Settling Time", *The New Lightning Empiricist*, Teledyne Philbrick, Dedham MA, June 1971.
3. Pease, Robert A., "Feedback provides regulator isolation," *EDN*, November 24,1983, p. 195.
4. Pease, Robert A., "Simple circuit detects loss of 4-20mA signal," *Instruments & Control Systems*, March 1982, p. 85.
5. *Eveready Ni-Cad Battery Handbook*, Eveready, Battery Products Div, 39 Old Ridgebury Rd, Danbury, CT.
6. *Battery Application Manual*, Gates Energy Products, Box 861, Gainesville, FL 32602. (Note: A sealed lead-acid and NiCd battery manual.)
7. Perez, Richard, *The Complete Battery Book*, Tab Books, Blue Ridge Summit, PA, 1985.
8. Small, Charles H, "Backup batteries," *EDN*, October 30,1986, p. 123.
9. Linden, David, Editor-in-Chief, *The Handbook of Batteries and Fuel Cells*, McGraw-Hill Book Co., New York, NY, 1984. (Note: The battery industry's bible.)
10. Independent Battery Manufacturers Association, *SLIG System Buyer's Guide*, 100 Larchwood Dr,Largo, FL33540. Note: Don't be put off by the title; this book is the best for lead-acid batteries.)

UNIVERSAL EMULATION

Seeker is a universal, low-cost Emulation System, which provides sophisticated breakpoint and tracing facilities for most 8 Bit Processors.

Support is provided in one single package by combining configurable hardware with powerful software. No additional personality modules are required.

Furthermore, by utilising high technology Gate Arrays, Seeker is easily re-configured for use with the specified microprocessors.



The following features make Seeker one of the most powerful debugging tools available.

- 4 Complex Breakpoints
- Disassembler for all Supported Microprocessors
- Single Stepping
- Trace Buffer
- Symbolic Debug
- High Speed Target Microprocessor File Download
- Menu Driven Host PC Software
- Mouse Interface

Supported Microprocessors are:

- Z80, 64180/Z180
- 6800 and Derivatives
- 8031 and Derivatives
- Z8 Family

Seeker - For Effective Universal Emulation

DESIGNED AND MANUFACTURED IN THE UK

TRACE TECHNOLOGY LTD
Unit 4, Shuttleworth Road, Elms Industrial Estate, Bedford MK41 OEP
Tel: (0234) 266455

CIRCLE NO. 123 ON REPLY CARD

Field Electric Ltd. Tel: 081-953 6009. 3 Shenley Rd, Borehamwood, Herts. WD6 1AA. 081-953 6009; Fax: 081-207 6375

3.5" floppy disk drive Chinon BBC compatible, new **£35** c/p £4.00.
3.5" floppy disk drive NEC IBM compatible. Full height unit. **£39.95** new & boxed, 1.6Mb, c/p £3.00.
Switch mode power supplies 240V AC input 5V DC 40amp **£29**; 12V DC 10amp **£46**; 5V DC 40amp –12V DC 4amp +15V DC 11amp **£48**.
Western Digital 3.5" hard disk drive new 40Mb RLL ST506 **£85** c/p £6.00.
NEC new & boxed 5.25" floppy disk drive model FD1055-311 BBC compat. ½ height **£48** c/p £6.00.
Plantronics (Auralite) type headsets very lightweight new BT approved ideal for comms: **£15.95** c/p £3.00.
Farnell fan-cooled PSU 240V AC input +12V DC 4amp –12V DC 1amp +5V DC 10A –5V DC 5amp **£16** c/p £7.00.
Ali flight case for computers 510×480×175 **£45** c/p £10.
Auto data switch 401. Up to 4 PC to 1 modem or printer. New & boxed **£46** c/p £5.50.
Auto data switch 801. Up to 8 PC to 1 modem or printer. New & boxed **£56** c/p £5.50.
Wyse compatible terminals by Falco c/with keyboards. Swivel & tilt monitor **£135.**
Wyse 50 terminal new & boxed c/with keyboard. Swivel & tilt monitor (115vac) **£200.**
Monitor Mover. Rotates 360°. Hold up to 25kgs. Weight space for keyboard. Clamps to desk **£39** c/p £8.75.
16 bit serial card with 8 serial outlets, inc leads **£100** c/p £5.00
286-10 AT motherboards complete with bios (various types) Intel processor chip no RAM (DIL) 8 slots. Size 220x330. Sold with no guarantee £19.95 c/p 6.50

Farnell stabilised B30/20 power supply 0–30V 20A linear **£295**.
Farnell DT12/5 12MHz o'scope **£175**.
Farnell D30/4 power supply **£250**.
Hewlett Packard 3490A multimeter **£275**.
Hewlett Packard 180C o'scope m/frame c/with 1804A 4chn. vert. amp 50MHz 1821A time base delay gen. **£375**.
Hewlett Packard 221A square wave gen. 1Hz/10MHz **£55**.
Hewlett Packard 3400A RMS voltmeter **£250**.
Hewlett Packard 7015A X-Y recorder **£225**.
AVO universal bridge B150 **£125**.
Black Star Jupiter 500 function gen. new & boxed **£105**.
Thandar TG105 5Hz-5MHz pulse gen. new & boxed **£115**.
Wavetec waveform gen. 159 **£250**.
Trend data distortion gen. **£165**.
Schlumberger 4900 RF-AF measuring unit **£290**.
Tektronix 7623A o'scope m/frame **£395**.
Tektronix 454 o'scope **£325**.
Tektronix 191 constant amplitude sig. gen. **£150**.
Dolch Atlas 9600 logic analyser c/with software **P.O.A.**
Datel tester 10A. Data link tester (modems etc) **£175**.
Schlumberger 4000 precision signal gen. **£350**.
Wandel Goltermann, measuring set for group delay & attenuation: receiver LDE-2 £350.
All above prices +17½% VAT. Please ring for c/p rates.

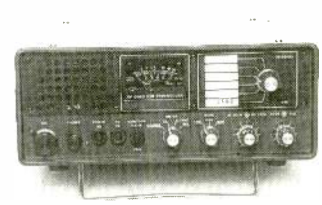
VISA Access

We would like the opportunity to tender for surplus equipment
Official orders credit card telephone orders accepted with Access, Amex, Diners, Visa cards. Overseas enquiries welcome c/p rates U.K. mainland only. Please ring for c/p rates not shown. All prices inc. V.A.T. unless stated. Stock list available.

CIRCLE NO. 124 ON REPLY CARD

HF BASE STATIONS & MOBILES

- 2-30MHz
- 20 channels
- synthesised
- 100 watts RF o/p
- cost efficient



- 6 channel (crystal)
- 2-18MHz
- robust construction
- 100W RF
- remote controller option

SMC can offer a complete range of HF and VHF communications equipment including towers, trailor mounted towers, antennas, cables, repeaters, mobiles, interconnect, etc. The company has over 30 years experience installing, supplying and OPERATING communications equipment.
For all your requirements contact:

SMC

SOUTH MIDLANDS COMMUNICATIONS LIMITED
S M House, School Close, Chandlers Ford Ind Est, Eastleigh, Hampshire, SO5 3BY
Tel: (0703) 255111 Fax: (0703) 263507

CIRCLE NO. 125 ON REPLY CARD

PROGRAMMABLE POWER SUPPLIES

MX2020

MX 9000

MIC-4070D

SC 130

Buy top quality instruments direct from **Electronics World + Wireless World** and avoid disappointment. If you are not satisfied, return the goods and we will refund the purchase price*.

*Goods must be returned within seven days of receipt; must be returned in their original packing; must not be tampered with in any way, and must be returned in the condition in which they were received.

FUNCTION GENERATOR

The **MX2020** 0.02Hz – 2MHz sweep function generator with LED digital display offers a broad range of features. Output waveforms include sine, square, triangle, skewed sine, pulse and TTL. Lin and log sweeps are standard as is symmetry, DC offset and switchable output impedance from 50Ω to 600Ω. The digital display provides readout of the generators' frequency or can operate as separate 10MHz frequency counter. £199.00 plus VAT (£233.83).

LCR METER

The **MIC-4070D** LCD digital LCR meter provides capacitance, inductance, resistance and dissipation measurement. Capacitance ranges are from 0.1pF to 20,000μF plus dissipation. Inductance ranges from 0.1μH to 200H plus a digital readout of dissipation. Resistance ranges from 1mΩ to 20MΩ. Housed in a rugged ABS case with integral stand it is supplied complete with battery and probes at £85.00 plus VAT (£99.88)

FOUR INSTRUMENTS IN ONE

The **MX9000** combines four instruments to suit a broad range of applications in both education and industrial markets including development work stations where space is at a premium.

The instruments include:

1. A triple output power supply with LCD display offering 0-50V 0.5A, 15V 1A, 5V 2A with full overcurrent protection;
2. An 8-digit LED display 1Hz - 100MHz frequency counter with gating rates of 0.1Hz, 1Hz, 10Hz and 100Hz providing resolution to 0.1Hz plus attenuation inputs and data hold;
3. A 0.02Hz to 2MHz full featured sweep/function generator producing sine, square, triangle, skewed sine, pulse and a TTL output and linear or logarithmic sweep. Outputs of 50Ω and 600Ω impedance are standard features;
4. An auto/manual $3^1/_2$ digit LCD multimeter reading DCV, DCA, ACV, ACA, resistance, and relative measurement with data hold functions.

The MX9000 represents exceptionally good value at only £399.00 plus VAT (£468.83).

FG SERIES FUNCTION GENERATORS

The **FG500 series** sweep/function generators provide two powerful instruments in one package, a 6MHz or 13MHz sweep/function generator and an intelligent 100MHz frequency counter. The microprocessor based instruments offer sophisticated facilities yet remain extremely competitively priced. A menu driven display allows easy set up and operation. A 16 character by 2-line LCD display provides clear and unambiguous readout of generator output and frequency measurement.

FG-506: 2Hz to 6MHz sweep/function with 100MHz counter £325.00 plus VAT (£381.88)

FG-513: 2Hz to 13MHz sweep/function with 100MHz counter £482.00 plus VAT (£566.35)

Credit card orders accepted by phone 081 652 3614

Please send me the following instruments...

....

....

I enclose a cheque/postal order/eurocheque to the value of £..................made payable to Reed Business Publishing Ltd or Please debit my Access/Visa/American Express/Diners Club with £......................Card Number..

Card expiry date.......................... Signature................................Date..........................

Name...Address..

....

...................................Postcode.................................Phone..............................

Return to: Lorraine Spindler, Rm L333, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Please allow 21 days for delivery.

EWWO/93

M & B RADIO (LEEDS)

THE NORTH'S LEADING USED TEST/EQUIPMENT DEALER

OSCILLOSCOPES

- **TEKTRONIX 2445A** 150MHZ FOUR TRACE ... £1500
- **TEKTRONIX 475** 200MHZ OSCILLOSCOPES WITH PROBES/ MANUAL ... £400
- **TEKTRONIX 465B** 100 MHZ WITH DIGITAL MULTIMETER (AS NEW) ... £475
- **TEKTRONIX 465B** 100MHZ DUAL TRACE ... £375
- **TEKTRONIX 465** 100MHZ DUAL TRACE ... £300
- **TEKTRONIX 466** 100MHZ STORAGE WITH DVM OPTION ... £450
- **KIKUSUI COS6100** 100MHZ 5 CHANNEL ... £550
- **IWATSU SS6122** 100MHZ 4 TRACE + CURSORS ... £900
- **TEKTRONIX 5103/5B10N T.B.** 2=5A20N DIFFERENTIAL PLUGINS ... £195
- **PHILIPS PM3217 50MHZ** DUAL TRACE WITH PROBES/MANUAL £375
- **PHILIPS 3200** 15MHZ MAINS/BATT PORTABLE ... £90
- **TEKTRONIX T935A** 35MHZ DUAL TRACE PORTABLE ... £175
- **BALLANTINE 1002B** 15MHZ DUAL TRACE BATT PORTABLE ... £195
- **TELEQUIPMENT D32** DUAL TRACE BATT PORTABLE ... £135
- **HITACHI V650F** 60MHZ 3 TRACE ... £275
- **HITACHI V222** 20MHZ DUAL TRACE ... £225
- **GOULD OS3600** 100MHZ DUAL TRACE WITH DVM OPT ... £275
- **GOULD OS4000** 10MHZ DUAL TRACE DIGITAL STORAGE SCOPE ... £195
- **GOULD OS250B** 15MHZ DUAL TRACE COMPLETE WITH PROBE/ MANUAL ... £125
- **GOULD OS1420** 20MHZ DIGITAL STORAGE OSCILLOSCOPE ... £325
- **FARNELL DTC12** 12MHZ DUAL TRACE/COMPONENT TESTER ... £195
- **FARNELL DT12-5** 12MHZ DUAL TRACE ... £150
- **TELEQUIPMENT D67A** 35MHZ DUAL BEAM ... £195
- **TELEQUIPMENT DM64** 20MHZ STORAGE OSCILLOSCOPE ... £135
- **HP 1727A** 275MHZ STORAGE OSCILLOSCOPE ... £450

SIGNAL GENERATORS

- **MARCONI 2019A** 1040MHZ AM/FM ... £1950
- **MARCONI 2018** 520MHZ AM/FM ... £850
- **MARCONI 2017** 10KHZ TO 1024MHZ ... £2250
- **HP 8640B** 1024MHZ COMPLETE WITH OPT 001/002/003 ... £1550
- **WAVETEK 2520** 200KHZ TO 2.7GHZ SYNTHESIZED ... £1950
- **MARCONI 2015/2171** SYNCHRONIZER 10MHZ TO 520MHZ AM/FM/ CW SIGNAL GENERATOR (as new condition) ... £325
- **MARCONI 2016A** 10KHZ TO 120KHZ (RF TRIP) ... £195
- **MARCONI 2016** 10KHZ TO 120MHZ AM/FM ... £145
- **FARNELL SSG2000** 10KHZ TO 2GHZ SYNTHESIZED ... £2250
- **FARNELL SSG1000** 10KHZ TO 1GHZ SYNTHESIZED ... £1500
- **FARNELL SSG520** 520MHZ SYNTHESIZED ... £500
- **FARNELL SSG520 + TTS520** MOBILE RADIO TEST STATION (PAIR) ... £900
- **ADRET 740A** 10KHZ TO 2.7GHZ SYNTHESIZED GENERATOR ... £1950
- **ADRET 20230A** 1MHZ SYNTHESIZED SOURCE ... £195
- **POLRAD 1106ET** 1.8 TO 4.6GHZ COMPLETE WITH MODULATOR ... £550
- **WAVETEK 193** 20MHZ SWEEP FUNCTION GENERATOR ... £295
- **FARNELL ESG520** 520MHZ SYNTHESIZED PORTABLE GENERATOR ... £295
- **PHILIPS 5324** 100KHZ TO 110MHZ AM/FM/SWEEP ... £200
- **EATON 3552B** BROADBAND RF AMPLIFIER ... £1000
- **KALAMUS** WIDEBAND RF POWER AMPLIFIER .5 TO 1000MHZ ... £750
- **FARNELL LA520** RF AMPLIFIER 1.5 TO 520MHZ ... £175
- **FARNELL LFM2** SINE SQUARE WAVE OSCILLATOR ... £85
- **FARNELL LFM4** OSCILLATOR ... £200
- **FARNELL TM8** TRUE RMS SAMPLING RF MILLIVOLTMETER 1GHZ £350
- **RACAL DANA 9301A** TRUE RMS VOLTMETER ... £450
- **HP 3400A** TRUE RMS VOLTMETER ... £145
- **HP 3403C** TRUE RMS VOLTMETER ... £150
- **RACAL DANA 1998** FREQUENCY COUNTER ... £750
- **RACAL 9921** 3GHZ FREQUENCY COUNTER ... £375
- **RACAL 9841** 3GHZ FREQUENCY COUNTER ... £225
- **MARCONI 2432A** 560MHZ FREQUENCY COUNTER ... £200
- **NARDA 3020A** BI DIRECTIONAL COUPLER 50 TO 1GHZ ... £250
- **NARDA 3001-30** DIRECTIONAL COUPLER 460 TO 960 MHZ ... £85
- **NARDA 3022** BI DIRECTIONAL COUPLER 1 TO 4GHZ ... £250
- **NARDA 769/6** 150W 6DB HIGH POWER ATT (NEW) ... £100
- **BIRD TENULINE 8343** 100W 6DB ATT ... £100
- **BIRD TERMALINE 8201** 50 OHM 500W ... £100
- **HP 9133** COMPUTER 150 TOUCH SCREEN/PRINTER ... £500
- **RACAL DANA 1002** THERMAL PRINTER ... £150
- **HP 3455A** HIGH STABILITY VOLTMETER GPIB ... £1200
- **HP 3478A** LCD DIGITAL MULTIMETER ... £400
- **HP 3468D** DIGITAL MULTIMETER 51/2 DIGIT ... £400
- **HP 5306** GPIB MULTIMETER/COUNTER ... £225
- **HP 8750A** STORAGE NORMALIZER ... £400
- **HP 53482A** 225MHZ FREQUENCY COUNTER ... £195
- **HP 461A** AMPLIFIER 1KHZ 150MHZ ... £100
- **HP 6294** PSU 0 TO 60 VOLTS 1 AMP ... £85
- **HP 3556A** POSPHOMETER ... £50
- **HP 4271B** 1MHZ DIGITAL LCR METER ... £950
- **TEKTRONIX 521A** PAL VECTORSCOPE ... £1000
- **TEKTRONIX 1481R** WAVEFORM MONITOR ... £500
- **TEKTRONIX 141A** PAL TEST SIGNAL GENERATOR ... £750
- **RACAL DANA 5002** WIDEBAND LEVELL METER ... £750
- **RACAL DANA 9303** TRUE RMS RF LEVELL METER ... £750

SPECTRUM ANALYSERS

- **TEKTRONIX 496P** 1.8GHZ PROGRAMMABLE ... £3500
- **H/P 8558B** 1.5GHZ 182T MAIN FRAME ... £1800
- **H/P 141T 8552B IF 8554B** 1250MHZ + 8553B 110MHZ COMPLETE AUDIO TO RF SYSTEM ... £2250
- **H/P 8555B** 18GHZ PLUGIN (NEW BOXED) ... £2350
- **ROHDE/SCHWARZ ZAM 52** 20GHZ SCALAR NETWORK ANALYSER ... £2850
- **ANRITSU MS3401A** 10KHZ TO 30MHZ NETWORK ANALYSER £2000
- **WAYNE KERR RA200/ADS1/ALM2** FREQUENCY RESPONSE ANALYSER (AS new) ... £650
- **H/P 3580A** 5HZ TO 50KHZ SPECTRUM ANALYSER (new) ... £2000
- **H/P 8566B** 22GHZ SPECTRUM ANALYSER ... £17000

TEST EQUIPMENT

- **MARCONI 2955** COMMUNICATIONS TEST SET ... £3000
- **MARCONI 2950** MOBILE RADIO TEST SET ... £250
- **DYMAR 2085** AF POWER METER ... £225
- **MARCONI TF2331** DISTORTION FACTOR METER ... £295
- **HP 651B** TEST OSCILLATOR ... £200
- **HP 333A** DISTORTION METER ... £225
- **MARCONI 2305** MODULATION METER ... £2000
- **EFRATOM FRT** ATOMIC FREQUENCY STANDARD ... £2500
- **FLUKE 540B** THERMAL TRANSFER STANDARD ... £850
- **BRADLEY 232** AC CALIBRATION SOURCE ... £1000
- **BRADLEY 156** OSCILLOSCOPE CALIBRATOR ... £200
- **WAYNE KERR 44C** AUDIO MEASURING SET ... £150
- **HP 745A** AC CALIBRATOR ... £750
- **HP 8405A** VECTOR VOLTMETER + ACCESSORIES ... £1000
- **FLUKE 103A** FREQUENCY COMPARATOR ... £500
- **BICCTEST T431M** CABLE TEST SET ... £250
- **COSSOR 437** CABLE LOGGER ... £250
- **HP 435B** POWER METER 8482+30DB ATT (as new) ... £975
- **HP 435A** POWER METER 8482H HEAD ... £650
- **MARCONI 6960** RF POWER METER 6912 HEAD 30KHZ TO 4.2GHZ 6920 HEAD 10MHZ TO 20GHZ ... £1000
- **HP 394A** VARIABLE ATTENUATOR 1GHZ TO 2GHZ ... £125
- **POWERSENSE** LINE ANALYSER ... £450
- **LEADER LCT910A** CRT TESTER/REJUVENATOR ... £195
- **AMBER 4400A** MULTIPURPOSE AUDIO TEST SET ... £550
- **FERROGRAPH RTS2/ATU1** TAPE RECORDER TEST SET ... £300
- **RACAL DANA 6000** MICROPROCESSING DVM ... £350
- **RACAL DANA 9000** MICROPROCESSING TIMER COUNTER 510MHZ ... £295
- **PHILIPS PM2434** DC MICROVOLTMETER ... £75
- **RACAL DANA 488** IEEE STD 488 BUS ANALYSER ... £250
- **SINADDER 3** METER ... £145

BULK PURCHASE SPECIALS

- **HP 180** 50MHZ OSCILLOSCOPES TESTED ... £145
- **MARCONI 1101** RC OSCILLATOR 20CS TO 20KCS ... £45
- **AVO 8 MULTIMETERS CASE + BATTERY LEADS** ... £25
- **UNAOHM EP594** TV FIELD STRENGTH METER 48 TO 860MHZ ... £55
- **ADCOLA 777** DESOLDERING STATION ... £150
- **FLUKE 8000A** HIGH GRADE DIGITAL MULTIMETER ... £100

RADIO EQUIPMENT

- **RACAL RA1792** HF RECEIVERS ... £1800
- **RACAL RA2309B + RA2295** 90 TO 400MHZ ... £950
- **EDDYSTONE 770U** 150 TO 500MHZ ... £185
- **EDDYSTONE 990S** 250 TO 850MHZ ... £195
- **PHILIPS** 88MHZ TO 108MHZ BROADCAST TX ... £4000

ALL PRICES PLUS VAT AND CARRIAGE

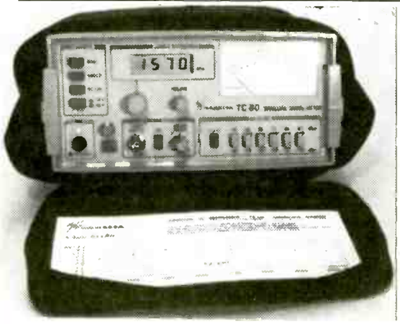
86 Bishopsgate Street, Leeds LS1 4BB

Tel: (0532) 435649 Fax: (0532) 426881

CIRCLE NO. 126 ON REPLY CARD

SADELTA SIGNAL STRENGTH METERS FROM B.K. ELECTRONICS

The new Sadelta Signal Strength Meter, the TC-80, has been designed to facilitate the dish alignment of satellite TV systems. Signal levels can be accurately measured on the TC-80, allowing the evaluation of signal conditions for satisfactory operation and picture quality. The TC-80 has a clear LCD direct frequency readout, coupled to a multiturn tuning control enabling precise channel identification. The TC-80 also incorporates three unique features: video composite, audio outputs, ramp and RF signal outputs, which enable an oscilloscope to be used as spectrum analyzer.



TC-80 IN ITS STURDY CARRY CASE

TC-80, USING A LCD TV AS A MONITOR

- ★ 4 digit LCD freq. display
- ★ Freq. range 950 to 1750MHz
- ★ Sweep mode sweeps entire freq. band for rapid satellite location
- ★ Tone select switch for audible tone proportional to signal strength
- ★ Measurement from 40 to 100dBuV
- ★ Audio demodulation with internal loudspeaker
- ★ Video demodulation
- ★ Rear SCART connector for A/V connection
- ★ Oscilloscope/spectrum analyzer output
- ★ Sound tuning 5 to 8MHz
- ★ LNC PSU 14V or 18V
- ★ LNC current measurement
- ★ Internal rechargeable battery with charger

PRICE: £490.00 + £85.75 V.A.T. FREE DELIVERY

U.K. POST PAID, export enquiries welcome. Visa/Access or cheque with order, payable B. K. Electronics. Official Orders welcome from Govt. Depts., colleges, P.L.C.s etc. Large (A5) S.A.E. for technical leaflets of complete range. Credit card orders are accepted by 'phone, fax or post.

BARCLAYCARD VISA

B. K. ELECTRONICS

UNITS 1 & 5 COMET WAY, SOUTHEND-ON-SEA ESSEX SS2 6TR

Tel.: 0702 - 527572 Fax.: 0702 - 420243

CIRCLE NO. 127 ON REPLY CARD

HALCYON ELECTRONICS

Test equipment, video monitors, amateur radio gear, printers, power supplies, communications, disk drives, multimeters, oscilloscopes, scientific instruments, connectors, component bridges, frequency counters, signal generators, computers.

- BBC-B & MASTER COMPUTERS From £90
- ANTIQUE TEST EQUIPMENT POA
- TEK 465B 100MHZ DUAL TRACE DEL T/B £475
- HP 1740A 100MHZ DUAL TRACE DEL T/B £450
- KENWOOD/TRIO CS2070 70MHZ 4 Trace £395
- HP 1722A 275MHZ DUAL TRACE, ETC POA
- HAMEG HZ65 COMPONENT TESTER £29
- TEKTRONIX 520 521A PAL V/SCOPES From £475
- TELEQUIPMENT D67A 25MHZ, 2T, DEL T/B £215
- H.P. 1700A 35MHZ DUAL TRACE £249
- TEK 453 50MHz DUAL TRACE DEL T/B £249
- SCOPEX 4D25 25MHZ DUAL TRACE £169
- BECKMAN 9020 20MHZ DUAL TRACE £249
- DATA PRECISION 6000 WITH 611 PLUG-IN AND 681 DISK DRIVE UNIT £995
- HAMEG 203-5 20MHZ, 2 TRACE, COMP TESTER £249
- HITACHI VC 6015 10MHZ DIGITAL STORAGE £345
- H.P. 1340A X-Y DISPLAYS £99
- LEADER LBO-9C ALIGNMENT SCOPE £195
- TEK 5L4N 100KHZ SPECT ANAL WITH 5110 M/F, 2x 5A18N, 5B10N TIME BASE £750
- TELEQUIPMENT D75, 50MHZ 2 TRACE DEL T/B £225
- TEKTRONIX 7403N, DF1, 7D01 LOGIC ANAL £495
- TEK 545/585 SERIES PLUG-INS From £10
- WANDEL/GOLTERMANN SPM-2 LEVEL METER £169
- WANDEL/GOLTERMANN SPM-3 LEVEL METER £189
- WANDEL/GOLTERMANN PS-3 SIGNAL GEN £169
- MARCONI TF2304 AM/FM MOD METER PRTBLE £249
- RACAL 9059 F/CTR 560MHZ MAINS/BATT £145
- 19" RACKS, 20U, 31" DEEP £125
- HP 3490A DMM AC/DC/V OHMS 6-DIGIT £125
- XFORMERS SEC 30-0-30V 20A, UNIV PRI'S C-Core £20
- CONSTANT VOLTAGE TRANSF'S 150VA-2KVA POA
- MARCONI TF2331 DIST'N FACTOR METER £175
- MARCONI TF2300 FM/AM MODULATION METER £195
- TEKTRONIX 834 PROG DATACOMMS TESTER £395
- BELL & HOWELL 658 16mm SOUND PROJECTOR £95
- BERTAN 205A-05A 0-5KV 5mA £59
- BRANDENBURG 470 0-2.5KV 5mA £29
- H.P. 6521A 0-1KV 200mA £95
- FERRANTI 26 LASER PSU 600v-1.6KV 15mA £39
- KINGSHILL CF9162 TWIN 0-150v 200mA £49
- FARNELL E350 0-350v 100mA, 2x 6.3V £49 to £69
- DEFIBRILATOR 50-400 JOULES BATT/MAINS £49
- FARNELL FG1 FUNC GEN .2-2.2MHZ £129
- COMMUNICATIONS RECEIVERS, VARIOUS POA
- 200W U.V. SOURCE WITH TIMER £65
- PERISCOPES MILITARY No. 43 Mk.3 £19
- LCR MARCONI TF1313A 0.1% £95
- LCR MARCONI TF2701 IN SITU £125
- LCR MARCONI TF868B £69
- LCR COMPONENT COMPARATOR AVO CZ457/S £75
- WAYNE KERR B321 LOW IND. BRIDGE £39
- HP1901A -05A -08A -17A 25MHZ PULSE GEN £125
- SCR578N GIBSON GIRL EMERGENCY XMITTER £75
- LEVELL TM6B MICRO V-METER 450MHZ £95
- LEVELL TM3B MICRO V-METER 3MHZ £85
- TU8B/TU9B TUNER UNITS BRAND NEW £29/£39
- OERTLING V20 SINGLE PAN BALANCES 200GM £95
- ANALYTICAL BALANCES WITH WEIGHTS 250GM £69
- UDI 2026 SONAR SCANNER, SURFACE UNIT £895
- UPA CAVIDERM CD6 P.T.H. TESTER £750
- MARCONI MARINE KESTREL 3 £49
- DECADE R/C/V BOXES FROM £15
- KAYE DEE, PNEUMO UV EXP UNIT 390×260mm £175
- VACUUM PUMPS TYP 100 MBAR (28L/MIN) £95
- CALIBRATION STANDARDS C/V/L/R POA
- COSSOR CRM533A VHF NAV/COM RF SIG GEN / COSSOR CRM511 ILS/VOR AUDIO SIG GEN £750
- TOPAZ 91007-11 7.5KVA 120/240–120/240 ISOL £175
- KINGSHILL NS1540 15V 40A PSU CASED, AS NEW £195
- HP 626A, 628A SIG GENS, LAST FEW £35 ea

LIST AVAILABLE, BUT 1000's OF UNLISTED BARGAINS FOR CALLERS ALL PRICES EXC. OF P&P AND VAT

QUALITY ELECTRONIC EQUIPMENT ALWAYS WANTED

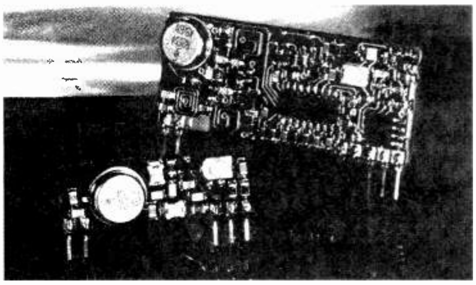
423, KINGSTON ROAD, WIMBLEDON CHASE, LONDON SW20 8JR

SHOP HOURS 9-5.30 MON-SAT. TEL 081-542 6383.

CIRCLE NO. 128 ON REPLY CARD

LOW POWER RADIO LINKS

There is considerable interest in low power radio telemetry and related applications following recent UK deregulation. The DTI no longer requires licensing for certain types of low power radio link provided that the equipment meets an approved specification and is used in accordance with the regulations. Wireless data links have never been easier says Ian Hickman.



Low cost telemetry: these type approved modules use SAW filters for oscillator stabilisation at 418MHz. Although the RF output power from the smaller transmitter module is measured in microwatts, the sensitive double conversion receiver provides a theoretical path transmission distance of over 20km.

Here is a typical application: design a personal alarm for the elderly or infirm enabling the wearer to summon help at need, from any where in the house or garden.

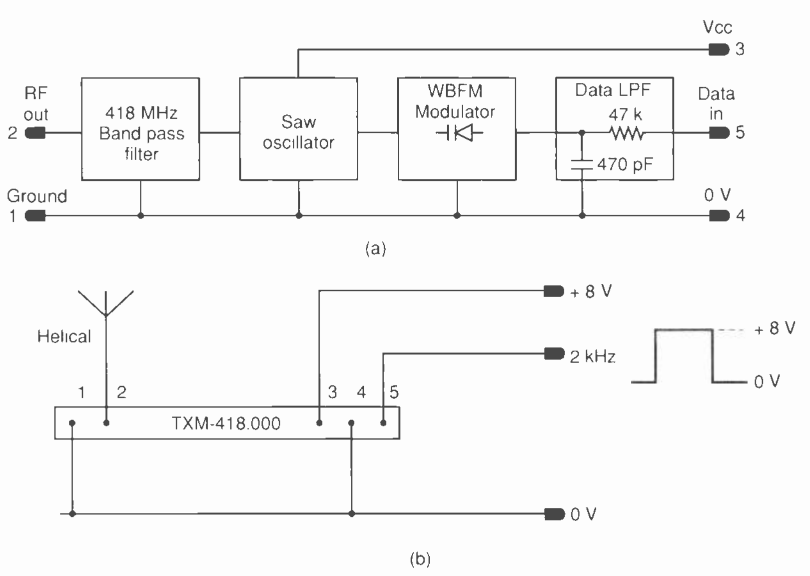
Until recently, such a device could not be built without submitting the whole unit for type approval under the relevant MPT specification. New regulations now permit this type of system to be built and sold without type approval provided that the RF part uses type approved radio modules.

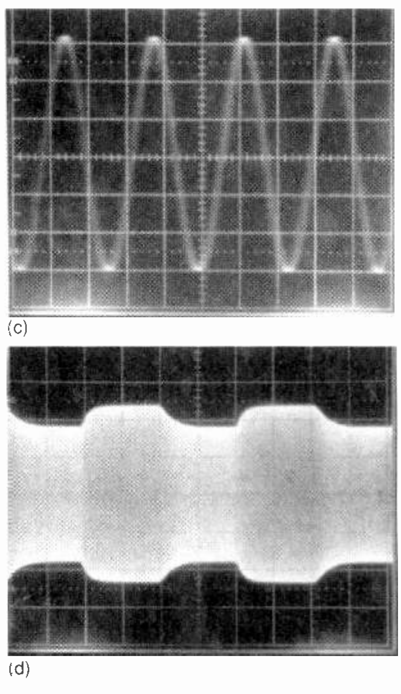
Available from a number of manufacturers, many modules are designed with a specific end use – such as security systems – in mind. The modules which constitute the subject of this article are totally uncommitted. This means that the purposes to which they can be put are limited only by the user's ingenuity, the mode of operation being determined by the nature of the peripheral circuitry with which he surrounds them. The modules in question operate in the band 417.90 – 418.10MHz and are type approved to MPT1340: *general telemetry, telecommand and alarms*, which specifies a maximum ERP of -6dBm, i.e. 250μW. Please bear in mind however that they must be used in accordance within the terms of their type approval (see box *Transmitting the letter of the law*).

Module characteristics

The *TXM-UHF* transmitter module is a sur-

Fig. 1 a) Block diagram of the TX-UHF transmitter module. b) Connections in recommended test circuit. c) The output of the transmitter module following 20dB of attenuation, 10mV/division vertical, 1ns/div horizontal, 12V supply, no modulation. d) As c except 9V supply, 100μs/div horizontal, 2.4kHz squarewave modulation applied.





face acoustic wave oscillator, varactor modulator and RF output filter. I constructed a test jig for the module by mounting the hybrid device on an odd piece of strip-board as a means of connecting power, modulation, etc. Of course, anyone who contemplates constructing a UHF circuit on strip-board needs his head examining, but in this case all the hot circuitry is on the module, with only dc and low frequency inputs supplied via the strip-board. The RF output was connected to a couple of inches of 50Ω coax, the other end of which was terminated in a BNC plug.

The rated output of the unit at 12V is –3dBm ERP, which would correspond to 159mV rms into a 50Ω load. The trace in **Fig. 1** looks like a very nice sinewave; it must be said that at 418MHz, the 'scope would show even a squarewave as pretty well sinusoidal. Figure 1 also shows the RF output again, but this time at 100μs/div, 9V supply, with a 0 to 8V cmos 2.4kHz squarewave modulation input which was also used to trigger the 'scope. The modulation is supposed to be only FM produced by a varactor diode. However there is noticeable incidental AM, doubtless due to the higher Q of the varactor at the higher reverse bias level of 8V. 2.4kHz squarewave modulation corresponds to revs (reversals, i.e. a continuous 101010 pattern) at 4.8kbits/s, the incidental AM making the baseband lowpass filtering of the modulation clearly visible. This is incorporated in order to limit the transmitter's OBW (occupied bandwidth)

Transmitting the letter of the law

The Low Power Devices Information Sheet BR114, from the Radiocommunications Division of the DTI, dated May 1989 and listed in annexe 1 shows a number of types of low power devices for telemetry, etc that were exempted from licensing by the end user, though of course the manufacturer was still required to obtain type approval for the device to the appropriate MPT specification before offering it for sale.

Telemetry is defined as the use of telecommunication for automatically indicating or recording measurements at a distance from the measuring equipment Related applications include:

telecommand, the use of telecommunication for the transmission of signals to initiate, modify or terminate functions of equipment at a distance;

teleapproach, the use of telecommunication for the purpose of gaining information as to the presence of any moving object;

radio alarm, an alarm system which uses radio signals to generate or indicate an alarm condition, or to set or unset the system;

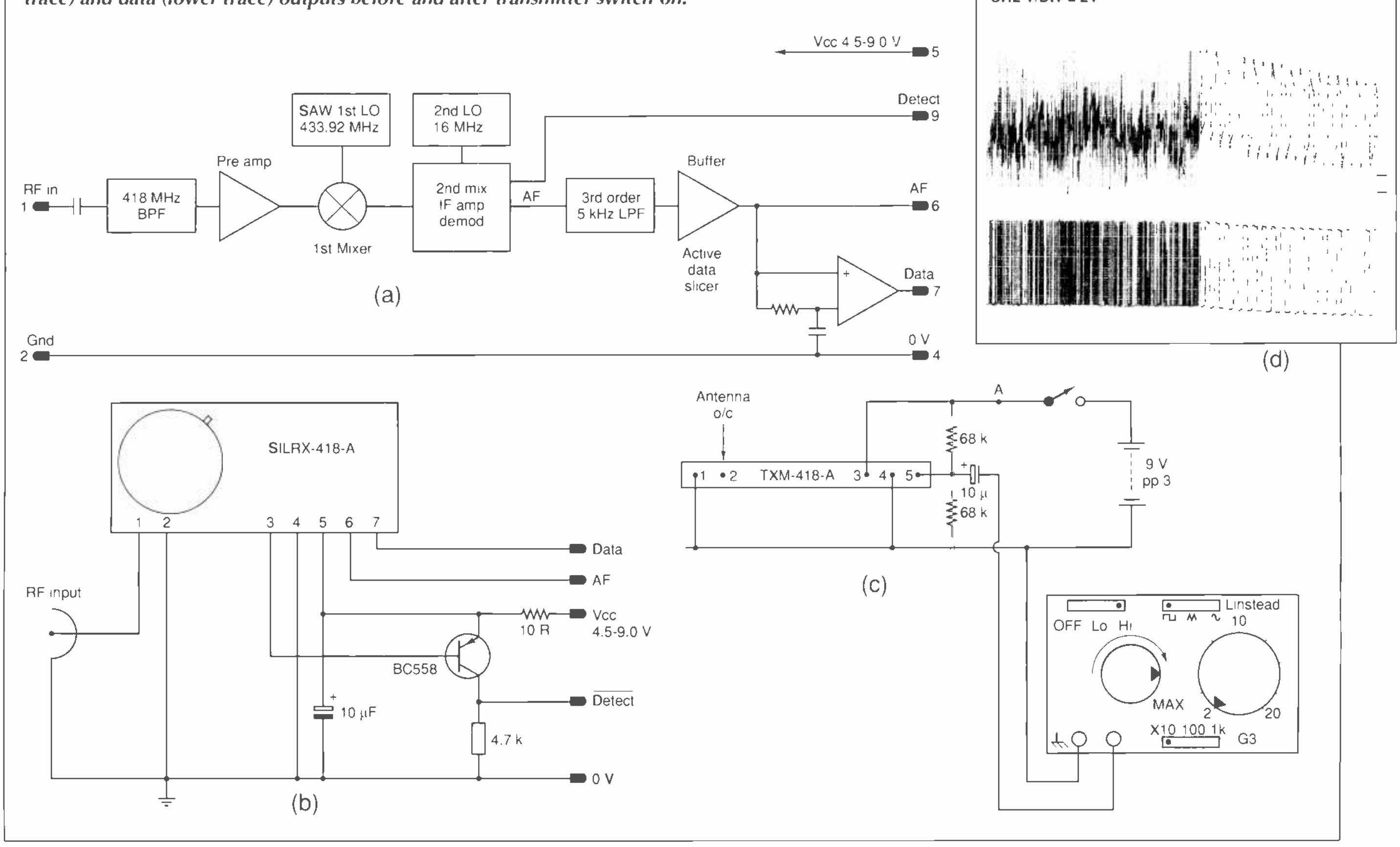
radio microphone, a microphone which uses a radio link to convey speech or music to a remote receiver;

other uses including induction systems for the hard of hearing in cinemas and other public places, metal detectors, model control, access and anti-theft devices and passive transponder systems.

BR114 also specified (in annexe 2) a further list of low power devices that were not exempt from licensing. This was coupled with a note to the effect that the DTI intends to exempt some of these at a future date, and in the meantime would issue licences free of charge, and even supply manufacturers of type approved equipment with blank licences for them to issue as required! BR114 has been superseded by RA114, dated July 1991, from the re-organised Radiocommunications Agency, and alarms in general (those covered by MPT Specifications 1265, 1344, 1360, 1361 and 1374) have been transferred to Annexe 1, the exempt category. This is reproduced here as Table 1 and it can be seen that the allocations therein span the spectrum from VLF (e.g. 0 – 185kHz, induction communications systems) through HF, VHF and UHF to centimetric wavelengths (e.g. various allocations between 2.445 and 33.4GHz, low power microwave devices).

The annexe 2 items, not exempt from licensing, are shown in Table 2. Some of the frequency allocations are the same as, or adjacent to annexe 1 allocations, the difference being that in general the licensed devices are permitted a higher ERP.

Fig. 2 a) The SILRX-418-A Receiver block diagram. b) Basic receiver test circuit (see text). c) The transmitter circuit used with b. d) The receiver audio (upper trace) and data (lower trace) outputs before and after transmitter switch-on.



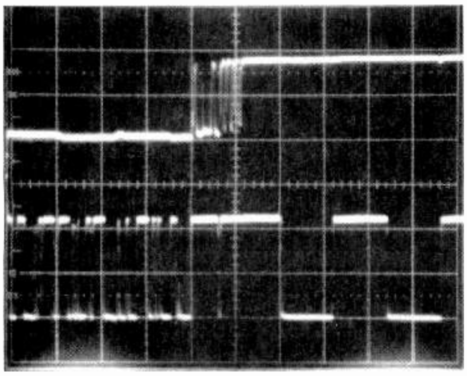


Fig. 3 Receiver data settling time test, upper trace (5V/div) TX supply switch-on; lower trace (2V/div) RX data output (TX modulated at 200Hz), 2ms/div horizontal.

by suppressing the higher order FM sidebands.

With a TX dc supply of 9V and the modulation input strapped to 0V, the frequency was 417.96MHz and, strapped to +9V, 418.01MHz. This is well within the maker's initial frequency accuracy specification.

The close-in spectrum of the transmitter when transmitting 30Hz squarewave modulation at ±25kHz deviation indicates an OBW of less than 120kHz at the –50dB level. The far out spectrum shows all harmonics to be more than 50dB down, thanks to the transmitter's output bandpass filter.

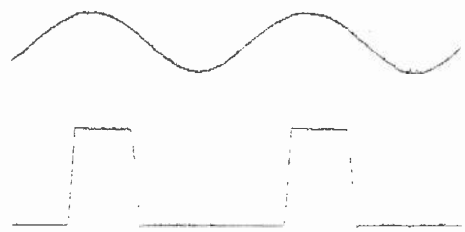
The *SILRX-418-A* receiver is a double superhet design, the block diagram being as in **Fig. 2.** The receiver was mounted upon another scrap of strip-board ready for testing in conjunction with the transmitter. The circuit was as shown, except that a *BC214* was used instead of the *BC558* and its 47kΩ collector load was replaced by an 820Ω resistor in series with an LED.

The transmitter was set up as in Fig. 2, with 20Hz squarewave modulation from a battery powered audio function generator. As the output of the latter was centred about ground, a blocking capacitor and bias chain was employed to keep the modulation swing at pin 5 of the transmitter module within the range 0 to 8V. In view of the minimal separation – the receiver was within a metre of the transmitter on the lab bench – no antennas were used. Figure 2d shows the receiver audio output (upper trace) and the data output (lower trace). The transmitter was switched on half way through the trace, the audio and data outputs up to that point being just noise and clipped noise respectively. Following switch-on, the audio output is a 20Hz squarewave exhibiting considerable sag, due to partial differentiation by the inadequate modulation coupling time constant. There is also an initial transient dc level shift, as the 10μF blocking capacitor charges up. The data output is a cleanly sliced version of the audio, with the initial transient also suppressed.

In applications such as telecommand, while the transmitter only needs to be powered to send a command, the receiver must usually be ready to receive at any time (the rare exceptions being systems where commands need only be sent at pre-determined times). If the receiver is battery operated, a pulsed squelch system with a duty cycle of about 1% on-time in the absence of signals saves power. If the presence of a signal is detected (a matter of two or three milliseconds from switch-on), the DETECT signal may be used to extend the on-time to receive a command.

Figure 3, taken with a data modulation of 200Hz, shows the switch-on of the transmitter's +9V supply, exhibiting over two milliseconds of switch bounce, while the lower trace shows the receiver's recovered data output. The first negative-going edge about two milliseconds after the end of the TX switch bounce looks a bit suspect, but thereafter things are fine so clearly the data settling time is well within the maker's figure of 10ms (although that is quoted with a 5V receiver dc

(a)



(b)

Fig. 4 a) The TXM-UHF and SILRX-418-A can handle linear signals, with some distortion; 1kHz full amplitude sinewave modulation applied to TX module (lower trace) and as recovered by the receiver (upper trace).
b) At a reduced modulation level (upper trace) the distortion of the received signal is negligible, although the effect of a reduced level into the data slicer is evident (lower trace).

Table 1. Exempt devices.

Use	Frequency	Maximum ERP	Specification
Induction communications systems	0-185 kHz and 240-315 kHz	See specification-transmitter output is 10 watts maximum	MPT 1337
Metal detectors	0 148 5 kHz	See SI no. 1848/1940	N/A+
Access and anti-theft devices and passive transponder systems	2-32 MHz	See specification	MPT 1339
Telemetry, telecommand and alarms			
General telemetry and telecommand	26 27 MHz	1 mW	MPT 1346
Short range alarms for the elderly and infirm	27/34 MHz	0 5 mW	MPT 1338
General telemetry and telecommand (narrow band)	173.2 to 173.35 MHz	1 mW*	MPT 1328
General telemetry and telecommand (wide band)	173 2 to 173 35 MHz	1 mW*	MPT 1330
Short range fixed or in-building alarms	173.225 MHz	1 mW	MPT 1344
General telemetry, telecommand and alarms	417.90 to 418 10 MHz	250 μW	MPT 1340
Industrial/commercial telemetry and telecommand	458.5 to 458.8 MHz	500 mW	MPT 1329
Alarms			
Car theft paging alarms	47.4 MHz	100 mW	MPT 1374
Radio alarms (marine alarms) for ships	161.275 MHz	10 mW	MPT 1265
Mobile alarms	173.1875 MHz	10 mW	MPT 1360

Low Power Radio/May T1

Use	Frequency	Maximum ERP	Specification
Fixed alarms – above 1 mW and up to 10 mW	173.225 MHz	10 mW	MPT 1344
Fixed alarms	458.8250 MHz	100 mW	MPT 1361
Transportable and mobile alarms	458.8375 MHz	100 mW	MPT 1361
Car theft Paging alarms	458.9000 MHz	100 mW	MPT 1361
Model control			
General models	26.96 to 27.28 MHz	100 mW	N/A+
Air models	34.995 to 35.225 MHz	100 mW	N/A+
Surface models	40.665 to 40.955 MHz	100 mW	N/A+
Other			
General purpose low power devices	49.82 to 49.98 MHz	10 mW	MPT 1336
Radio microphones and radio hearing aids	173.35 to 175.02 MHz	5 mW (narrow band) 2 mW (wide band)	MPT 1345
Low power microwave devices	2.445-2.455 GHz 10.577-10.597 GHz 10.675-10.699 GHz 24.150-24.250 GHz 24.250-24.350 GHz 31.80-33.40 GHz	100 mW 1 W 1 W 2 W 2 W 5 W	MPT 1349

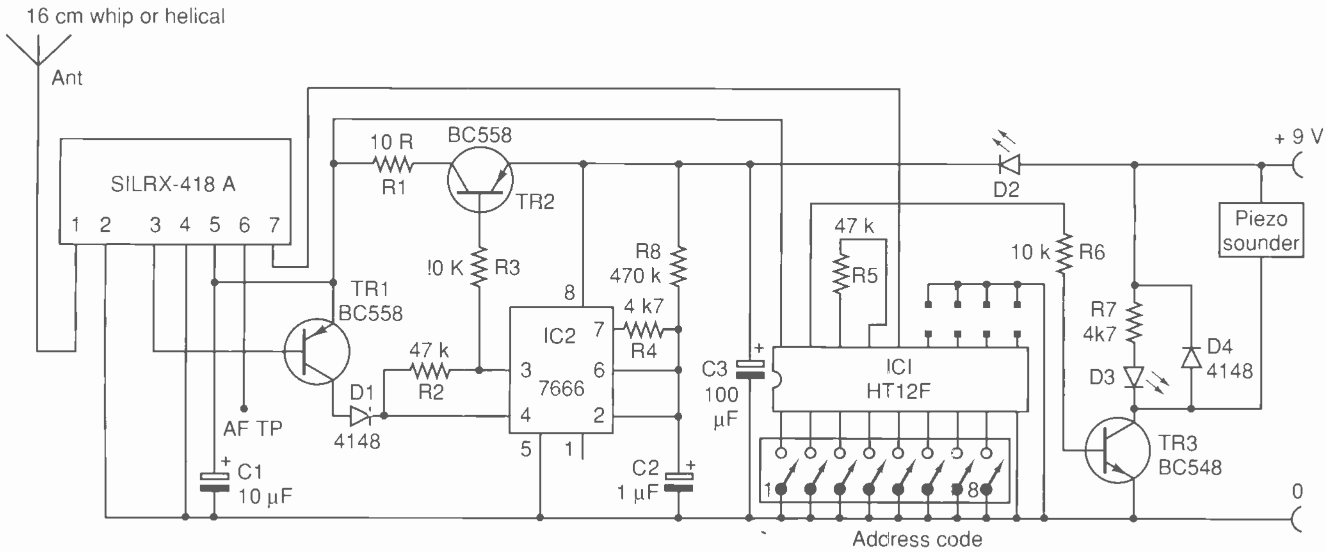
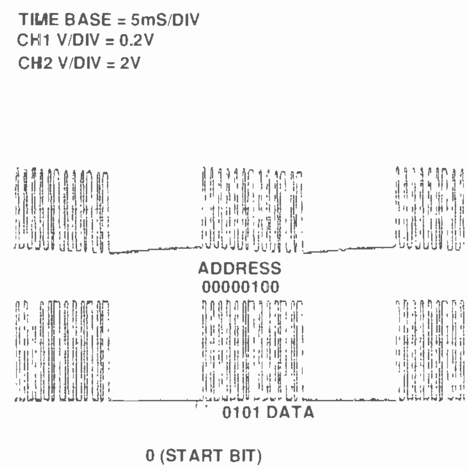


Fig. 5 a) SILRX-418-A receiver audio output (upper trace) and data output (lower trace) when receiving repeated 12 bit sequences of 0000 0100 0101. b) SILRX-418-A Pager application circuit treating all twelve bits as addresses, giving 4096 different possibilities.

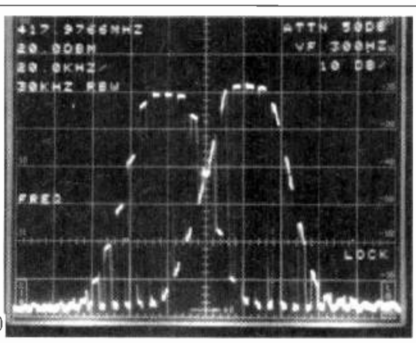


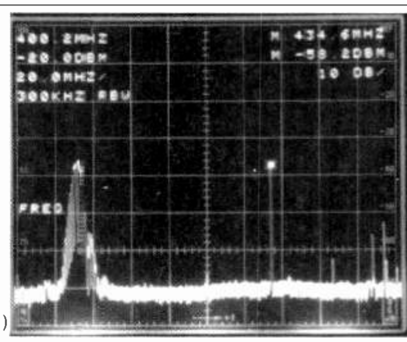
supply against the 9V used here).

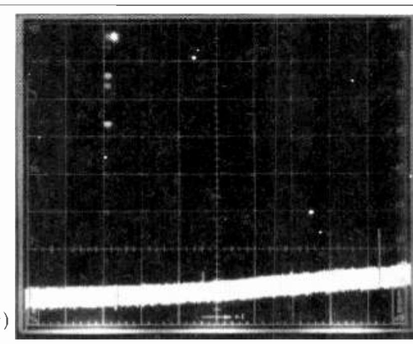
To test system linearity using the signal from the receiver's AF output terminal, the TX was modulated with an 7.5V pk-pk sinewave, **Fig. 4a**, lower trace, and the RX audio captured – upper trace – for comparison. The result looks just a little bit secondish, the positive peaks too rounded and the negative too peaky, but clearly the link would be capable of transmitting analogue data.

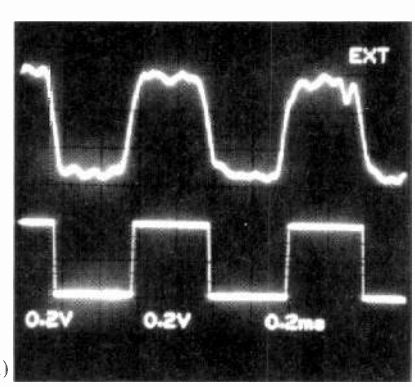
Figure 4b shows the recovered audio (upper trace) when the modulating sinewave was reduced to 3V pk-pk and clearly the distortion is very low indeed – at the sacrifice of some 8dB path loss capability. On the other hand, with the reduced deviation and consequently reduced input to the data recovery circuit, the slicer is finding it rather hard work (data output, lower trace).

However, with a reduction in path loss capability of just 6dB relative to binary modulation, it would be perfectly possible to operate the link with four levels rather than just the two of plus or minus 25kHz deviation, preferably with some linearisation in the modulator to give equally spaced levels at the receiver.


(a)


(b)


(c)



(d)

a) Close-in spectrum of the TXM-UHF transmitter module modulated with a 30Hz squarewave with ±25kHz deviation, showing an OBW of 120kHz at the –50dB level.
b) 0 - 1800MHz spectrum, showing 2nd and 3rd harmonics more than 60dB down and 4th harmonic over 50dB down relative to the 418MHz output (which is indicated by the marker just below top of screen reference level).
c) Spectrum of 433MHz 1st LO radiation of the matching SILRX-418-A receiver module (at marker) and of a super-regenerative receiver operating at about 330MHz (where there is no U.K. frequency allocation). Note that even for equal signal levels, the total interference power radiated from the super-regenerative receiver would be much greater since it produces lines spread over a considerable bandwidth. In fact, the antenna used on the spectrum analyser is about 6dB down at 330MHz relative to 433MHz, so the single spectral line of LO radiation from the superhet receiver is at a lower level than the peak of the broad band of radiation from the super-regenerative receiver. (Low level signals at RHS are Band IV TV signals)
d) The output of the SILRX-418-A receiver with a 1kHz squarewave modulated input signal of ±25kHz deviation at a level of –113dBm, i.e. 0.5μV. Upper trace; audio output, 0.2V/div, 500μs/div: lower trace;recovered data output, 2V/div indicating the remarkable sensitivity of the double superhet design. $P_{transmit}/P_{receive}$ = 107dB nom. or 5 x 1010. $P_t/P_r = (2.44 \times \pi \times d/l)2$, giving a theoretical path loss capability between isotropic antennas of 21km. The SILRX-418-A receiver module mounted on a piece of strip-board, front left next to 'scope, and the matching TXM-UHF similarly mounted, front right next to modulation source.

Two bits per symbol could therefore be transmitted, doubling the maximum bit rate throughput.

With the proliferation of unlicensed transmission systems it might seem that mutual interference would make them unusable. The more so since many of the bands are too narrow to allow channelling. A number of factors prevent this from being a real problem in practice, at least for the present.

Firstly, the ERP is purposely limited to a fairly low level. Thus while the modules featured here might give a range of several kilometres under exceptional circumstances – with elevated antennas on a large flat plain without trees or other obstructions – the manufacturer quotes reliable maximum range over open ground (with antennas mounted at a height of only 1.5m) of 200m, while excessively obstructed paths (with buildings etc) and/or antennas less efficient than 1/4 wave whips may in extreme cases reduce the reliable operating range down to some 30m.

Secondly, the devices are designed (for the most part) for intermittent operation, e.g. in telecommand applications. Even a telemetry application will not normally broadcast continuously, but send batches of readings at predefined intervals or on telecommand.

Thirdly, even though a receiver may pick up a transmission not intended for it, these devices are commonly operated with an address code as a header to each transmission, and a receiver can thus ignore a transmission not labelled with its own particular address code.

The first two points reduce the possibility of a wanted transmission being jammed by an unwanted, and the third minimizes the possibility of inappropriate response to the reception of an unwanted signal.

Coding

While NRZ (non-return to zero) data, typified by the reversals illustrated in Figs 2 and 3, could be used, a popular and commonly employed mode of signalling used with low power radio modules uses both 0 and 1 logic levels for each data bit, making the code (like Manchester code) self clocking. A typical example is the Motorola range of cmos devices *MC14026* (encoder) and *MC14027/028* (decoders). These 16 pin devices have nine pins dedicated to setting address and/or data bits. Each pin can be connected to ground (low), to V_{dd} (high) or can be left open circuit. Thus data is trinary, permitting in principle the transmission of 3^9 = 19683 different codes. The MC14027 interprets the first five trinary bits as address giving 3^5 = 243 different addresses, the remaining four bits being interpreted as data. For the four data bits, an open is interpreted as a logic 1, so only 2^4 = 16 different data messages are available. The *MC14028* interprets all nine pins as addresses, but with the same limitation on address pin 9 as the data pins on the *MC14027*: consequently 2×3^8 = 13122 different addresses are available, but only a single data bit (received or not received), indicated by the VT (valid transmission) flag. With either receiver, two consecutive valid addresses followed by identical data must be received before the new data is latched and the VT flag set.

Dil switches with a choice of three ways per pole are rather rare and so another popular scheme, typified by the 18 pin dil plastic devices by Holtek, type number *HT12E* (12-bit encoder) and *HT12D* (8-bit address and 4-bit data decoder) uses address/data pins with binary selection.

■

Table 2. Non-exempt devices.

Use	Frequency	Maximum ERP	Specification	Application form
Audio frequency induction loop deaf aid systems' (higher power non-carrier systems)	0-16 kHz	See specification – transmitter output is above 10 watts	MPT 1370 (in draft)	RA77
Telemetry and telecommand				
Medical and biological telemetry	300 kHz to 30 MHz	See specification	W6802/MPT 1356 (in draft)	RA77
Telemetry systems for data buoys	35 MHz	250 mW	MPT 1264	RA61
General telemetry and telecommand (narrow band) – above 1 mW and up to 10 mW	173.20 to 173.35 MHz	10 mW	MPT 1328	RA77
General telemetry and telecommand (wide band) – above 1 mW and up to 10 mW	173.20 to 173.35 MHz	10 mW	MPT 1330	RA77
Medical and biological telemetry (narrow band and wide band)	173.7 to 174.0 MHz	10 mW	MPT 1309/ MPT 1312	RA77
Medical and biological telemetry	458.9625 to 459.1000 MHz	500 mW	MPT 1363 (in draft)	RA77
Teleapproach				
Teleapproach (perimeter intruder detection systems)	40 MHz or 49 MHz	See specification	MPT 1364 (in draft)	RA77
Teleapproach anti-theft devices	888/889 MHz (and 0 to 180 kHz)	See specification	MPT 1353 (MPT 1337)	RA50

PROFESSIONAL READER SERVICES OFFER: EVALUATION MODULES AT HALF PRICE

Readers wishing to experiment with the low power radio modules mentioned in this article can obtain a TXM-418-A/SILRX-418-A transmitter/receiver pair for £23 +VAT (£27.03 inclusive), half the normal component price. This offer also includes a set of data sheets together with inclusive postage and packing. Please note that this offer price applies to the UK only.
Other EC readers may obtain the modules at the inclusive price of £38.

To order the modules, use the special order form located between pages 144/145. Cheques should be made payable to Radiometrix Ltd. The company's address is printed on the order form. This offer is strictly limited to two pairs of modules per reader at the offer price. All enquiries relating to this offer should be made to Radiometrix Ltd. Phone 081-813 8223.

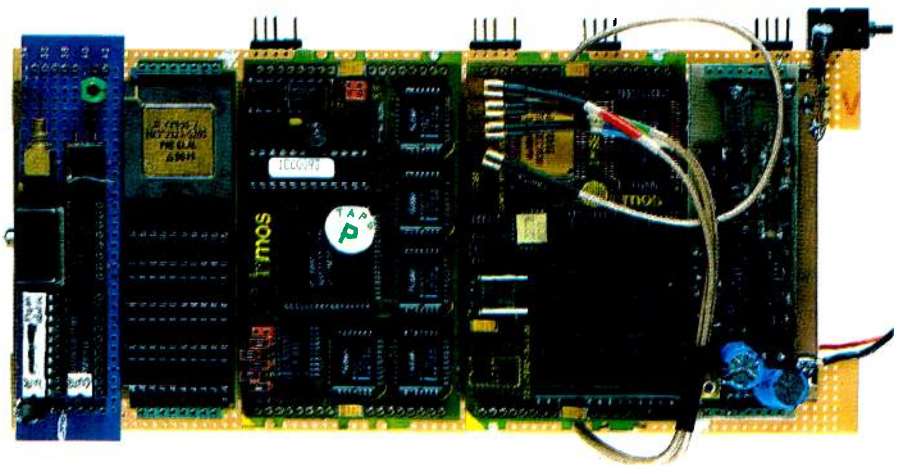
Holtek encoder/decoder ICs may be obtained from Fischer Computers (UK) Ltd, 43/44 New Street, Walsall, West Midlands WS1 3DF. Phone 0922-30619.
Enquiries relating to low power radio systems in general may be addressed to

The Low Power Radio Association, The Old Vicarage, Haley Hill, Halifax, HX3 6DR, 0422 359161 ('phone) 355604 (FAX)

GPS

3: The GPS message on the hardware platform

The data content of the GPS message is both complex and subtle... Complex because it carries corrections ranging from relative movement to relativity, yet subtle because it was originally designed to be decoded without help from powerful microcomputers. ***Philip Mattos*** *examines the connection between system software and hardware.*



The GPS message conveys the information needed by the receiver to operate the system. It is made up of two distinct parts: that which relates to the satellite transmitting the data, and that which relates to the overall system.

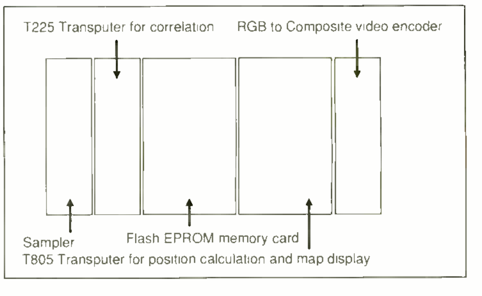
The former is known as the *ephemeris*, although it includes more than just orbit parameters, and the latter is known as the *almanac*.

The message frame from the satellite consists of five subframes, each of length 300 bits. This corresponds to a data rate of 50 baud for six seconds. The first three subframes contain the ephemeris information, satellite clock information, and the status of the satellite. These repeat every frame, ie every 30s. Subframes 4 and 5 contain the system pages, and continue to cycle for 12.5 minutes before repeating, with each one having a page identity to indicate its contents.

Inside the subframe, the data is coded very tightly in binary, because in the early seventies when the system was designed, memory was very expensive.

Each subframe consists of ten 30-bit words, with a preamble in the front of the first, and a 6-bit checksum or parity field at the end leaving 24 useful bits of data. Some fields have to be assembled from different areas of the message, and all are fixed point binary, with the scale factors given in the specification. The early design era of the format shows here too remembering that the 8-bit micro was not born until about 1974, the 16-bit until 1978. Some values are scaled in semicircles, to avoid multiplication operations in the receiver, and the orbit radius is given as a square root because the processor in the receiver of that era would have had difficulty with this calculation. All the GPS calculations have to be done in at least 48-bit floating point, usually 64-bits.

All the data from the satellite is transmitted in the form of coefficients for the orbit or clock description equations given in the specification. The user must plug in the exact time into these equations to calculate the position of the satellite.



Key diagram to the main processing circuit board photograph. The hardware is built in module format to make maximum use of pre-existing parts. The sampler and RGB encoder are new for GPS. The T225, flash memory card and main/graphics processor are all standard off the shelf products.
Radio circuitry is considered in detail in a later article.

The almanac contains the orbit data and clock data and satellite health, to less accuracy than the ephemeris but with a semi-infinite validity. The curve fit used to generate the data relates to the whole orbit, and the trends of the orbit, rather than just a four hour segment.

The almanac is used by the receiver to

choose which satellites are currently available in the sky. These are then acquired, and the more accurate ephemerides downloaded for positioning.

In addition, the almanac contains information to model the ionosphere, and to calculate the difference between GPS time and UTC... and even a 22-byte message in ascii.

Once the ephemeris message from the satellite has been loaded, the continuing information needed from it is timing. By monitoring the propagation delay of each satellite against its internal clock, the receiver can track very accurately the relative delays of the four satellites in use. These are known as the pseudo ranges, once converted to metres using the speed of light. The term "pseudo" is used because they are not true ranges, firstly because they are relative, secondly because they need correcting for the errors in the satellite clocks, and thirdly because they need correction from the speed of light, due to ionospheric, tropospheric and relativistic effects. These corrections are covered later.

The accuracy of tracking the satellites can be illustrated by looking at the speed of light.... 300,000,000 metres per second. Thus one microsecond, the length of a code chip on the commercial signal, is worth 300 metres in range measurement, and due to geometrical magnification, up to a mile in horizontal position. Thus the signal must be tracked to an accuracy of 10 nanoseconds, to give 3 metres in range and 20 metres in position, if the receiver is not to become a dominant error source for the system.

Satellite position calculations

Before the user position can be calculated from the pseudo ranges, the satellites' positions at that instant must be calculated. This is a two-stage process, because the position when the signal was transmitted is needed, not its position on reception, and the correction between the two cannot be made unless both user position and satellite position is known. Thus a first approximation is made using the current estimate of user position, yielding an approximate expected propagation delay. This value is subtracted from the time of reception, and a new position for the satellite is found. In other words, iteration.

The size of error which would result if this were left out is easily calculated. The satellite orbits at about 5km/s, and the average propagation delay is around 70ms. Thus the satellite position would be out by about 350m without the correction. There is no need to iterate further, as the time error due to the 350m is about 200ns, as the satellite motion is only a shallow angle to/from the user. In 200ns the satellite flies less than a metre, which is again at a shallow angle, so the resulting pseudo range error around 0.2 metres... of relevance only to surveying receivers.

Another interesting correction to be made is that all our calculations were done using Earth centred Earth fixed (ECEF) coordinates. This means that our coordinate frame is rotating with the earth. Thus if the four satellite positions are for four different times, due to the four different transmission delays, then the positions are all relative to different frames. All must be translated into the ECEF frame in use at time of reception.

While equations could be derived that allowed for this, the signals would not travel in straight lines in that hypothetical frame of reference so the post correction method is preferable.

The basic calculations used a modified Keplerian description of the orbits. This is given in the GPS spec and consists of an eccentric orbit, with semi-major axis and eccentricity given. There is also the angle around the orbit where the apogee can be found; where the orbit plane crosses the equator; its inclination angle and where around its orbit the satellite was/will be at the reference time of the data.

Most of the parameters consist of a static term, and first and second derivatives.

In addition to the Keplerian parameters, there are second order corrections given. These are the Sin(2wt) and Cos(2wt) terms, and relate to radius, along track, and across track corrections.

All the parameters are plugged into the equations with the exact time of transmission, and, almost, out pops the result. The "almost" is because one equation (eccentric anomaly) can only be solved by iteration, but a simple Newton-Raphson approach converges very rapidly.

The reason for the plethora of data is that the orbit is complex. It takes account of the accuracy required, the various gravitational densities of parts of the earth, the earth's magnetic field, the effect of the moon (both directly and via sea and land tides on earth) and even solar wind on the space craft. All these perturb the orbit. These perturbations are monitored by tracking stations on ground, using GPS in reverse (multiple receivers, one transmitter) to produce an accurate curve fit predicting the orbit for the next few hours.

User position calculation

Once the satellite positions are known, a start can be made on calculating the user position. There are four unknowns: the position in the X,Y,Z axes, and the offset of the user clock, T. There are also four equations, each being a simple Pythagoras calculation of range between the user and the satellites.

$$Ri = \sqrt{(X - Xi)^2 + (Y - Yi)^2 + (Z - Zi)^2}$$

for i=1 to 4 where Xi, Yi, Zi is the position of the ith satellite.

This would be the intersection of three spheres, and only three satellites would be needed, so note that we do not know the actual range Ri, but the difference in range between one satellite and all the others. This is, mathematically, the intersection of three hyperboloids, and, while it is soluble, it is very messy.

The usual method is to let the user position be (X+dX) etc, and multiply it out. Then ignoring second order terms (eg dX.dY), the equation linearises to:

$$|A|[dx\ dy\ dz\ c dt] = 0$$

where $|A|$ is the cosine matrix of angles from the user to each satellite, c is the speed of light, and t is the user clock error.

This is solved to produce a correction to each axis, and is then repeated from that new position until the corrections are so small that the calculation is deemed complete.

The algorithm converges very rapidly. One example with an initial error of a million metres converges to 17km in one step, to 3.5m in the next, and better a micron in the third... clearly dwarfed by other errors.

Corrections

There are four corrections made to the measured pseudoranges. They are covered below in order of magnitude.

Satellite clock. The satellites carry Caesium standards as main clock, dropping back to a Rubidium standard, and then finally an ovened crystal. Despite running from an atomic standard, drift must occur. This is constrained to be less than a millisecond, the epoch of the

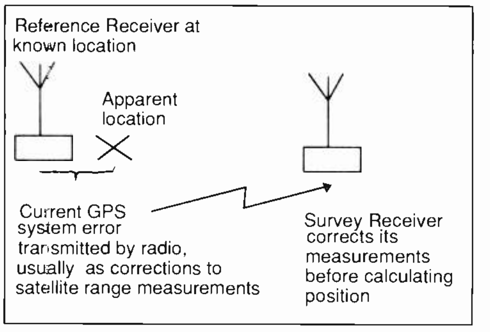


Fig. 1. Ionospheric and selective availability errors can be removed by using two receivers. The one at a known location measures the system errors, and passes the corrections by a radio link to the second, or alternatively both record their data for correction in post processing. The corrections are measured at the pseudorange level, rather than the lat-long level, as this allows a free choice of satellites in the mobile receiver.

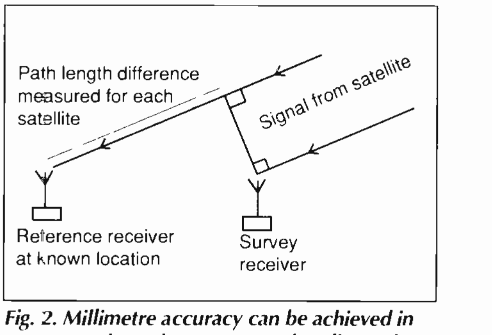


Fig. 2. Millimetre accuracy can be achieved in survey receivers that measure a baseline rather than an absolute position. By measuring the carrier phase difference between the two sites, millimetre accuracy is achieved subject to ambiguity in the number of integer carrier cycles between the two antenna.

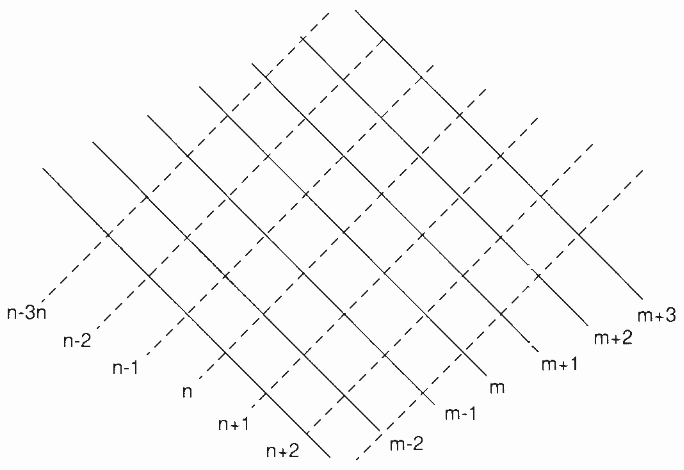


Fig. 3. The ambiguity means there is a grid (actually 3-D, and the receiver could be at any of the intersections. The size of the overall search volume depends on the code-tracking accuracy of the receivers. The mesh-step of the grid is the wavelength of the signal, about 20 centimetres.

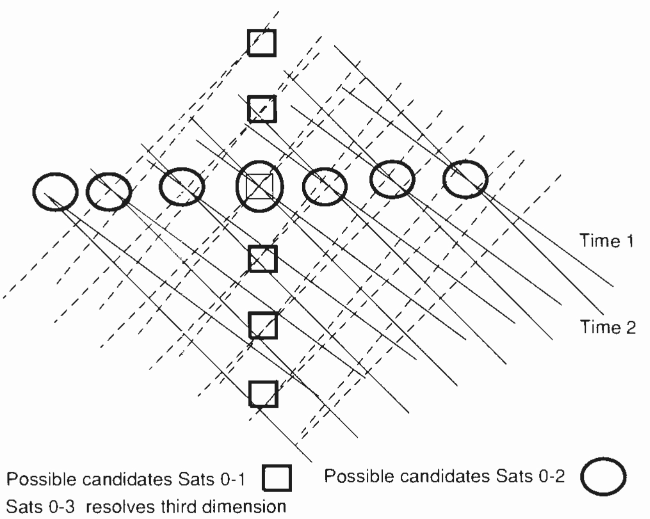


Fig. 4. As the satellites move along their orbits, the mesh-axes rotate independently, yielding a small number of points on each line as possibles. Only one point meets this requirement for all the satellites. This takes up to an hour, and serious post-processing, on most GPS sets, but a few recent ones can do it in around 10 minutes, real-time. The time duration is not dependent on the processor, rather on the need for the satellites to move along the orbits.

spreading code but after several years in orbit, the clock is many microseconds out.

The data transmitted from the satellite gives the error at the reference time, the rate of drift, and the curvature, or second derivative. This last is currently set to zero... it only becomes necessary when a satellite has fallen back to its crystal clock.

The receiver calculates the error at the current instant, and makes the appropriate correction to the measured pseudorange by multiplying the time correction by the speed of light.

Ionospheric. The ionosphere distorts the measurements by delaying the passage of the signal. The delay is variable, depending on the electron density in the ionosphere, and the angle that the signal passes through it. The characteristics of the ionosphere change with time of day, due to exposure to the solar wind, but also with the seasons, and the 11 year sunspot cycle.

Because the delay is proportional to the square of the frequency, it is possible to eliminate it by making measurements on two frequencies. For this reason, GPS satellites also transmit on 1226MHz, known as L2, but the commercial signal is not available on this frequency. The commercial user must make corrections using a mathematical model.

A default set of parameters are supplied in the specification, but these are updated by those sent with the almanac pages. There are eight parameters that describe two features, the vertical delay, and its variation with time.

The ionospheric error leads to about 60m of position error, reduced to about 30m by the use of this model, which is known as the Klobuchar model after its inventor.

Note that the error is almost zero at 0200 – 0300 local time as the ionosphere is then stable after yesterday's sun and not yet affected by today's. It is also reduced by avoiding low angle satellites.

Tropospheric. While the ionosphere is around 350km above the earth, the lowest layers of the atmosphere, known as the troposphere also have an effect. This is because the increasing density of the atmosphere nearer the earth causes refraction, bending the radio waves and increasing the actual path length, and also because air and water vapour reduce the speed of light below its free space value.

There are no transmitted corrections for this. The receiver relies on a set of three models, for 0-1km, 1-9km and above 9km altitudes, which are published in the specification. The magnitude of the correction is about two metres.

Relativistic. There are two sets of relativistic corrections. The first results because the satellite clock seems to speed up as it is travelling fast relative the user. This is quite independent of Doppler effect, or direction of travel. This is corrected by the satellite, in that it runs its clocks $4.45E^{-10}$ slow or 4.55mHz on the 10.23MHz standard. This may seem trivial, but the acceptable tolerance on the atomic standards is $1E^{-11}$ so without this correction, it would appear 44 times out of short term specification. The long term spec is fifty times tighter!

This covers the situation for a circular orbit. However the receiver must make the remaining corrections for the elipticity of the orbit.

The second type of correction is well disputed, the subject of conference papers, but not used in receivers yet. Because the radio waves are passing through a gravity gradient, one might expect their speed to change. Also, because the ECEF coordinate frame is rotating, and the satellites are at some 20,000 kilometres greater radius, there is a considerable velocity difference that some say has a relativistic effect.

However, remember that all measurements made on the satellites are relative to each other. Thus any error that occurs on all satellites equally automatically cancels. Also, any correction not handled in the spec is not handled in the monitoring stations, so in general will result in a slightly incorrect orbit prediction that compensates for the error.

Selective availability

Selective availability is the deliberate distortion of the system by the US Department of Defense. They feel this is necessary to prevent the enemy using the full accuracy of the system for weapons directed against the USA.

Originally it was expected that the civil system with one microsecond code bits would be far less accurate than the military one at 100ns, and the military system could always be denied to the enemy.

However over the twenty year development of the system, receivers became so sophisticated that they could track the carrier wave (see below) at 600ps per cycle, leapfrogging this barrier.

Selective availability works by dithering the clocks of the satellites in a random manner. It is adjusted to give horizontal errors of up to 100m 95 percent of the time, 300m the remaining 5 percent, with vertical error about 50 per cent worse. It can also be operated by transmitting distorted orbit information.

The military receivers can remove these distortions by decrypting coded parameters in the navigation message. The decryption keys are dynamic, and change frequently, and must be distributed to any user who needs this accuracy, for instance in time of war.

Differential GPS

Almost all the errors of the GPS system can be removed by using two sets of equipment, one at a fixed location, the other at points to be surveyed. The first set can then correct for all the errors seen, even errors in the maps in use, and by transmitting these corrections to the second set, enable it operate "perfectly".

The errors that remain are the tracking noise in the two receivers, clearly not common to the two sites, and the secondary effect of any other error that results from the distance between them.

The two sets must use the same group of satellites. Given that, the simplest solution is to transmit a lat-long-height set of corrections and this is fine for a small separation. Its advantage is that it only needs a single monitor site.

Next level is to transmit pseudo range corrections. This is valid up to about a thousand kilometres, and still uses a single monitor.

The final and most advanced level is to separate the corrections into orbit corrections and satellite clock corrections (and ionosphere corrections).

This last, known as Wide Area Differential GPS (WADGPS), is at an experimental stage, and depends on a fixed network of monitor stations that can effectively triangulate the satellites. The corrections are then broadcast on a geostationary satellite such as the Inmarsat series.

These types of differential GPS all yield positions accurate to around 5m, in real time, even in motion.

To go further, either long term integration, or carrier phase methods are needed.

Carrier phase positioning

The ultimate accuracy from GPS is achieved by using the output of the carrier phase tracker in differential mode. As with conventional differential GPS, the orbit and ionospheric errors, and selective availability are all cancelled by using the two receivers. The wavelength of the carrier wave is about 20cm, so a phase locked loop which can track it to 5° is achieving a spatial resolution of about a centimetre.

The problem is (see **Figs. 3** and **4**) that we do not know which particular cycle of the carrier we are tracking, as the code tracker is usually only accurate to a few metres. This is known as cycle ambiguity. It is resolved by considering all the possibilities, which may be 10m of range, ie 50 cycles, on each of four satellites, ie three differences, making 125,000 possibilities, and finding which are most precise solutions. As the satellites move, the residual errors on each change on all but one, the correct one, so that after about ten minutes, one can be certain of the correct choice.

Until very recently this work could not be done in real time, so the tracking data from both monitor and local receivers was logged, and the true position/separation calculated by post processing.

Recently, with the very accurate narrow separation correlator code tracker from Novatel in Canada, researchers at the University of Calgary have been able to reduce the ambiguity considerably, so that the work can be done in real time. This receiver is so precise that its code tracker is accurate to six centimetres rms without using carrier phase, which ought to give direct solution to the ambiguity equations. However, nature is not kind... the ionosphere delays the code, but advances the carrier by the same amount, so code solutions do not translate directly to carrier solutions.

Another manufacturer, Ashtech (San Jose, Calif), claims one centimetre plus one millimetre per kilometre of separation between the two receivers.

System hardware

This article is based on the design and construction of a complete automotive GPS system, from antenna to map display. The board shown in the photograph takes the signal from the radio, samples it, feeds the samples to the computer. This processor performs all the GPS tasks to generate the position, and also the map handling tasks such as reading the map data from the flash eprom card and controlling the framestore that generates the RGB video signals. The final stage combines the four (including sync) video wires onto a single PAL or NTSC composite video coax for the TV monitor.

The 7.7 x 3.5in board is a passive backplane supporting modules 3.5 x 1.1in wide. Each module has a standard 16-pin organisation, with the 3.5 dimension being chosen to allow use on a PC/XT add-in card.

Seven module widths are used here, being a single width module for the sampler, the 16-bit correlation processor, and for the RGB to composite encoder, with two double width modules for the flash eprom card and the main CPU with video store.

Signal Path. The circuitry of the sampler module is shown in **Fig. 5**. The input from the radio is DC-blocked by a large value capacitor to allow the use of radios with a DC offset. The coax, which may have considerable length if the radio is remotely sited, is then terminated in a suitable resistor to prevent reflections. One stage of a *74HCU04* hex-inverter is used to amplify the signal after the cable loss. This is done by using a high value resistor from output to input to bias the inverter to its linear transfer region. It then exhibits very high gain, and generates cmos logic levels at the output if overdriven. A second inverter stage without the feedback sharpens up the edges. This produces a logic level signal corresponding to positive and negative half cycles of the radio noise output. The information content is contained in the timing of the transitions.

The signal is then fed to the input of a *74HC164* shift register, clocked at 2.046 MHz, twice the GPS code chipping rate. When the shift register is full, its contents are latched into the *C011* link adapter, which transmits it up a two wire serial link to the transputer memory.

Clock generation. A 10.23MHz oscillator is constructed using two unbuffered *74HCU04* inverter stages. Note the difference from the conventional single inverter TTL oscillator using a series resonant crystal: this design allows the use of a parallel resonant crystal. This arrangement can accept microprocessor controlled varactor diode tuning in a version for professional use. A third inverter is used to buffer the oscillator output, so that varying loads do not affect the frequency.

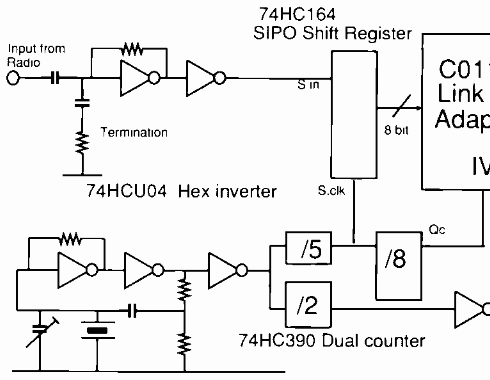


Fig. 5. Sampler circuit diagram. The sampler captures the radio output signal, packs the samples into bytes, and sends the bytes up the serial link into the transputer memory.

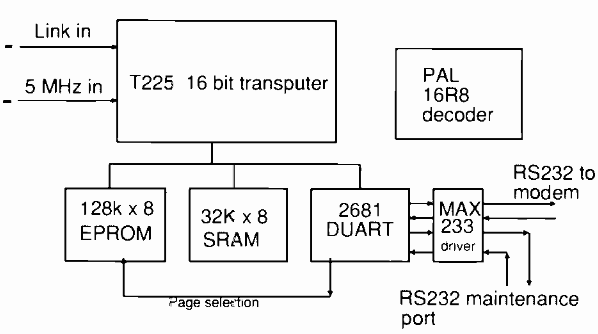


Fig. 6. 16-bit correlation processor. The T225 handles the radio samples in realtime blocks of one millisecond, performing correlation and code tracking to relieve the main CPU of this drudgery.

The oscillator drives a *74HC390* dual decade counter.

The first counter is configured as divide by 2 and divide by 5 counters in parallel, generating 2.046 MHz for the sampler clock, and 5.115 MHz as a frequency reference to the computer. The second decade counter is configured to divide by 8, and is fed from the 2.046MHz signal. This generates 256KHz to send packed bytes of samples to the transputer.

Control. The above completes the circuitry for embedded systems as in a car. To allow the sampler to be used in a system where the transputer boots its code from, and sends its screen information to, a PC, the sampler must be stopped while booting up. This is achieved with a flip-flop that is cleared by the reset signal, and clocked by the first byte of data sent to the link adapter. The QV, or data available signal is used, as the data bits themselves could power up in either state. The flip-flop output holds the sampler clock counter in the reset state until a byte is sent by the program.

The eight output data-bits are available for any control uses in the system. In the map dis-

The Transputer

The Inmos transputer was launched in 1985, some seven years after the company was founded with British government funding. The concept was to provide a computing component that could be interconnected with additional transputers to give the required processing power. The concept has similarities with adding transistors in an amplifier to give the required level of gain. The enabling transputer feature is the serial link, which allows direct connection between processors, or from processor to peripheral, without any hardware glue logic, and without any software to slow down the communications or hog the CPU.

Less visible, but just as essential is the hardware scheduler that allows several jobs to share the CPU without any software overhead. Jobs usually relinquish the CPU voluntarily, by performing some i/o transfer that must await an acknowledgement. If they do not, however, they will be put to the back of the queue after about one millisecond. This sounds short, but is on average about 10,000 instructions.

The transputer architecture was designed to allow compilers to operate efficiently. It is called a risc machine by many, but also has many high level instructions, and while most RISC machines have many registers, the transputer has only three. These are stack organised, to minimise opcode length by removing addressing. The small number was chosen after much simulation on real programs as the best compromise between the inefficiencies of creating temporary registers in memory, and the inefficiencies of storing away unnecessary registers on context switches.

The correlation transputer is the 16-bit *T225*. It has a CPU with a 50ns (20MHz) instruction cycle, four serial links, 4KBytes of 50ns static ram, and system services all on chip. There is an external memory interface that can mix 8 and 16-bit memory on the same bus, and of course the hardware scheduler that allows parallel programming and operation of independent or interacting jobs.

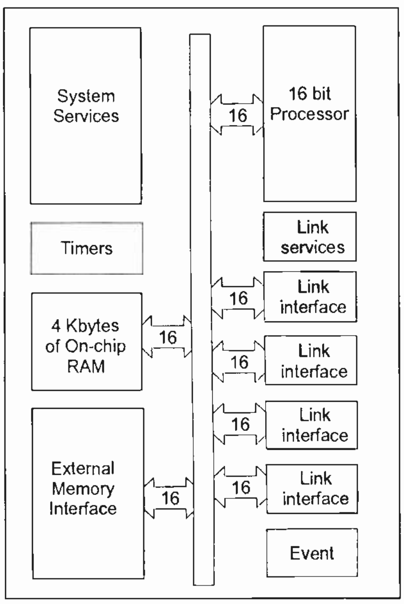
The main compute engine is the 32-bit *T805*. Note the structural similarity between the two... the only differences are the data-bus width, the addition of a 64/80 bit floating point unit (FPU) and a much more flexible external memory interface. In fact, with the exception of the instructions that execute in the FPU, and some image handling instructions, the same instructions execute on both machines. The image handling instructions were omitted from the 16-bit machine as it is unlikely that a video frame store would be attached to a 16-bit machine.

The memory interface on the *T805* is programmable to set the cycle timing and strobe phasing to suit almost any type of memory, and it also generates the control signals and refresh addresses for dynamic ram. This allows the connection of low cost dram, as well as video ram in the car map-display application.

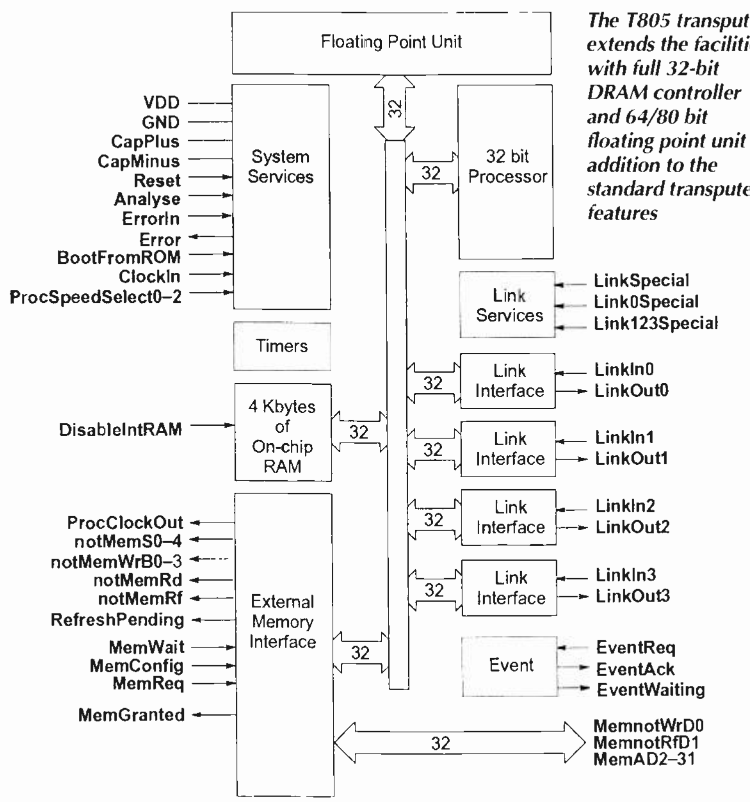
In the GPS environment, we use the links to connect the radio. This allows the 2Mbit/s signal to pass directly into transputer memory while the processor is still working, uninterrupted, on the previous block of data.

In a marine version, there was only one transputer, but a second link was used to drive the keyboard and screen, allowing the provision of up to three control consoles, for example chart table, steering position and flying bridge.

In the car version, two transputers are used, so the link between them is just the two wires, and ROM is only provided on one. The other is booted over the link.



The T225 transputer is CPU, memory, comms and services on the same chip, running at up to 30 MHz.



The T805 transputer extends the facilities with full 32-bit DRAM controller and 64/80 bit floating point unit in addition to the standard transputer features

play version, they are used to strobe the user input buttons around the screen. In the panic button version, they are used to drive the 16 character text display.

The 16-bit correlation processor. The 16-bit processor has two tasks... to boot the system, and to perform the dull repetitive task of correlation that reduces the bandwidth of the GPS signal by a thousand times from 1MHz to 1kHz, pulling it out of the noise in the process. The software for this will be covered later but, at startup, it is a highly intensive task, best done in the 32-bit CPU. Once locked onto a satellite, it is repetitive and can be done in hardware or software. In this design, the 32-bit processor delegates it to the 16-bit slave.

The 16-bit Inmos *T225* transputer has no floating point unit. It has the vital BITCOUNT instruction that fortuitously allows the software processing of spread-spectrum single bit coded signals. But the real reason for its inclusion, rather than a 32-bit alternative, is its ability to work with byte-wide eprom and sram.

Two-wire serial links running at 20Mbit/s electrical rate handle input from the sampler and communication with the main processor. The circuit is shown in **Fig. 6**. There is a dual UART on the bus, which also provides the page register for the 128k x 8 eprom, too large to be addressed by the 16-bit CPU directly.

The 32k x 8 static ram retains battery backed information such as almanac and initial position between power-ups, while the PAL chip performs address decoding.

Not shown in the circuit is a battery-backup control chip and lithium battery. The control chip hides in the address space of the ram, and ensures it is not accessed when the power is out of spec, and switches between main and backup voltage as appropriate.

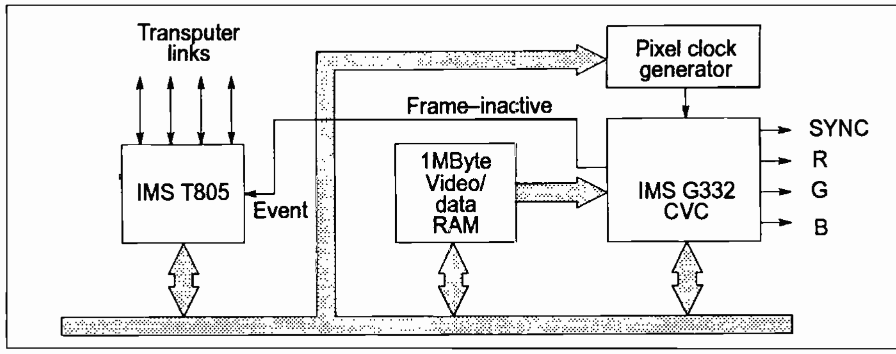


Fig. 7. Main processor, graphics engine.

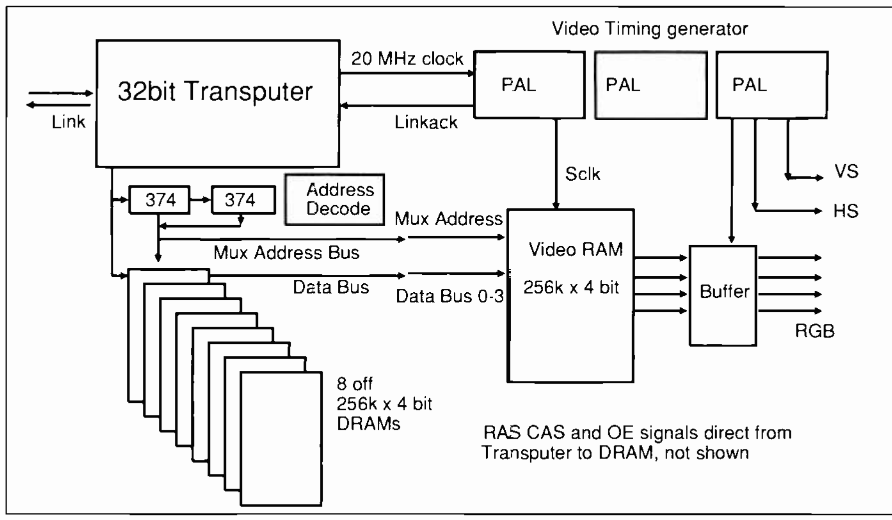


Fig. 8 . Main CPU and graphics engine with framestore, production design. The T805 performs the GPS mathematics calculations using its FPU, but has plenty of capacity spare to draw the maps and tracks on the screen. The picture is continuously read from the memory to the screen by the G332 colour video controller in the demo, but in the production version, three programmable logic arrays are used as the programmability and resolution of the G332 are not required.

The main processor and framestore

The main processor is a *T805* transputer, a 32-bit CPU with an on-chip floating point unit.

In the demonstration unit, this module is an Inmos *B437* transputer module, available off the shelf. It contains the *T805*, a *G332* graphics chip, and 1Mbyte of video memory, which can be used for program, data and video-store as required. A block diagram is shown in **Fig. 7**, though this module provides far more video performance than required... it will drive 110MHz video systems: the PAL/NTSC compatible in-car monitor needs around 10MHz.

Thus a much lower cost video system has been developed, using three pal chips as counters to generate sync and blanking signals, and to signal the transputer's link engine when a new raster line must be copied into the video ram internal shift registers. Thus without processor involvement, and without the problems of bus arbitration, video refresh is achieved. It does not have the flexibility of the programmable *G332* solution, and cannot refresh the video ram serial port on-the-fly during a raster line, but it allows the main memory to be provided in low cost dram, with just a single or dual video ram chip (**Fig. 8**).

Note that the transputer has an internal dram controller which provides timing and generates refresh. The only external chips required are those which separate the address/data bus, and multiplex the address for the dram. These tasks can be done in the same chips.

Output from the video system is RGB and sync on four separate coax connectors. These may be taken directly to a computer style monitor, or suitably coded for TV monitors.

The map data store

The map data store would normally be in an exchangeable plug-in memory card. However in order to remain compatible with the plug-in-module style of the design, an Inmos *B418* flash eprom module has been used. This provides 256KByte of memory accessible down the transputer serial links.

The handling of map data is covered in a future article on GPS applications. Suffice to say here that the Ordnance Survey 250,000 scale maps, in vector form, may be pre-processed to obtain a complete 50km x 50km square into this amount of memory, complete with the names of every village, the outline of the built up land in the village, even of woods and forest. The processor can then display this to any desired scale from 10km across the screen to 50km.

In the demonstration version, I connect system to PC and load in data for the area required. In a production version, the user would remove the memory card and plug in another.

The RGB to composite video encoder

To use a low-cost volume product for the display, the video output is converted to television standards before passing to the monitor.

This is done with a Sony *CXA1145* chip designed for the purpose. It needs only DC blocking capacitors, a colour burst crystal, a chrominance filter and a luminance delay line added to complete the circuit, and was again built on the module format. A pin selects between PAL and NTSC on the encoder chip, but ideally one would also change the filter and delay line to match.

The final output is a single coax carrying the luminance signal at baseband, with the line and frame sync signals coded conventionally as "blacker than black" levels. Colour is encoded as a colour burst before the video on each line, then quadrature signals on the colour sub-carrier at 3.58 or 4.43MHz.

Philip Mattos is a consultant engineer working for Inmos, SGS-Thomson

Next month: radio hardware

HEAT TURNED UP ON SUPERCONDUCTOR APPLICATIONS

Power transmission cables with no losses has come a step closer with development of new superconducting materials. Andy Wright reports.

A UK-based research team is on the brink of a breakthrough in developing friendlier superconducting materials with higher transition temperatures. The team's discovery of a new ceramic material that becomes superconducting up to 92K is a significant step forward in the search that has been continuing apace since the Nobel-Prize-winning discoveries of 1986. The new material looks to be a promising candidate for a new generation of cables for power transmission.

Researchers from GEC and BICC, working at the Hirst Research Centre near London, reported the breakthrough earlier this year – a series of materials based on cadmium, lead and copper oxides promising superiority over known high-temperature superconductors in key areas of high-current applications.

Like most scientific work, the development actually comes after a long period of hard work – in this case two years' painstaking analysis, during which more than 15,000 material compositions were synthesised and characterised using a robot .

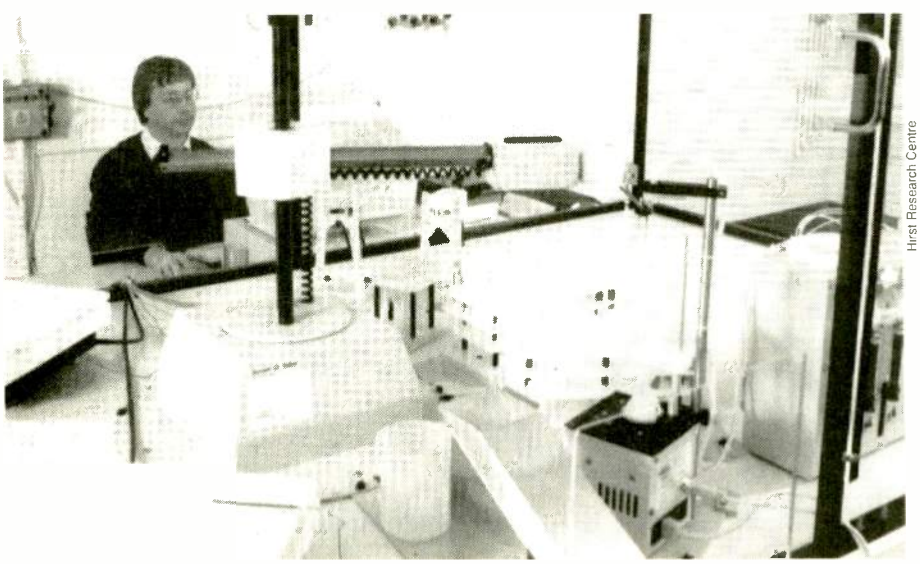
The breakthrough was helped by knowing where to look, based on the structures of known high temperature semiconducting materials.

The basic features are comparatively simple. Alternating layers of copper and oxygen atoms form conducting slabs, separated by insulating slabs formed of metal and oxygen ions. The conducting slabs are doped to produce charge carriers, with superconductivity arising when pairs of these carriers can move freely through the material without being scattered by the lattice. Because the interaction between carriers within the conducting layers is stronger than coupling between these layers, the pairs are effectively confined to their conducting slab. As a result, superconductors of this design are strongly anisotropic and electrical and magnetic properties are radically different parallel and perpendicular to the layer structure – though anisotropy can be adjusted by altering the properties of the insulating slabs.

Unfortunately, ceramics with this strongly anisotropic structure have important drawbacks for practical high-current applications such as transmission lines. One major problem is flux creep – the temperature-dependent wandering of lines of magnetic flux – severely limiting the superconducting critical current in high magnetic fields.

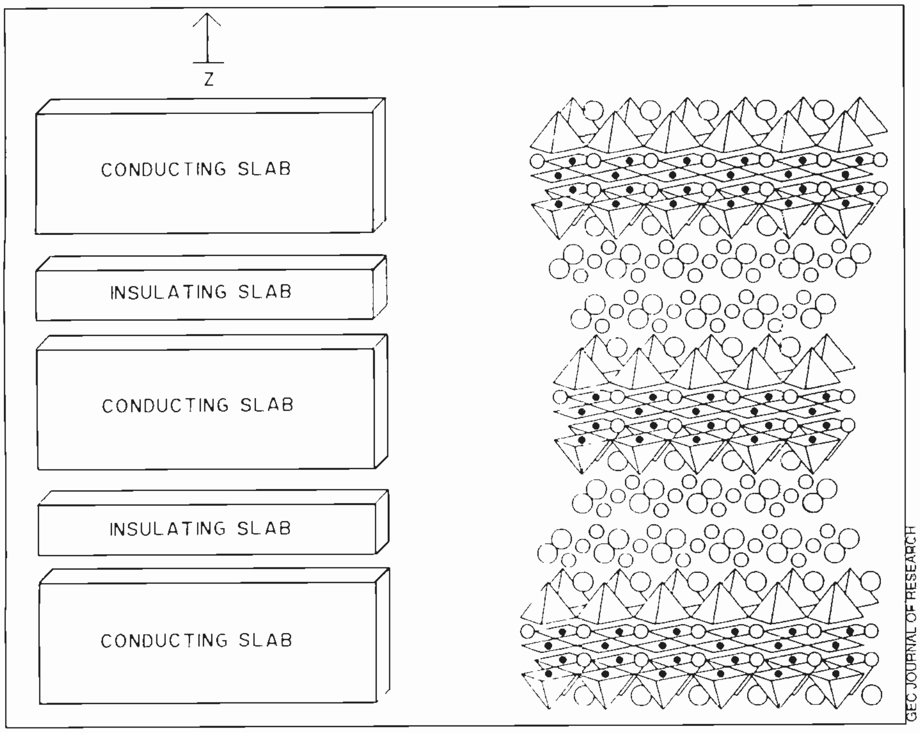
Well-known materials such as the YBCO 123 phase ($YBa_2Cu_3O_{7-\delta}$) show strong magnetic flux pinning at liquid nitrogen temperatures. But making use of this desirable property is difficult. Advanced material processing techniques must be used to form bulk polycrystalline conductors by aligning crystal grains biaxially, in a process known as texturing. A further challenge is to control the oxygen content and to prevent the superconducting phase deteriorating in the atmosphere.

Another well-known family of high temperature superconducting materials, known by the acronym BSCCO (Bi-Sr-Ca-Cu-O), overcomes some of YBCO's problems, but does not perform well in high external magnetic fields or at high temperatures. Even small magnetic fields applied perpendicular to the copper-oxygen layers reduce its current-carrying capacity. Nevertheless, a great deal of effort has been put into developing manufac-



Hirst Research Centre

Hirst researchers use a robot to generate samples of high temperature superconductors from liquid solutions.



The sequence of conducting and insulating slabs in high-temperature superconducting materials. The crystal structure shown is that of $Tl_2Ta_2Ca_2Cu_3O_{10}$, but a comparable interleaving of layers applies for the new (Pb, Cd)-1212 superconductor.

turing processes, such as the BSCCO-Ag tape process (filling a silver tube with BSCCO powder, drawing the material into wire, then applying a series of rolling and heat treatments). Significant progress has been made towards producing long superconducting tapes, but daunting challenges still remain.

Lead cuprates

Better electronic and magnetic properties are found with another family of materials containing thallium. Main problem with these is that thallium oxides are both volatile and highly toxic, and a key objective for the Hirst Research team was to look for thallium-free alternatives.

Promising candidates appeared to be lead cuprates, following the discovery of superconductivity in $Pb_2Sr_2(Y_{1-x}Ca_x)Cu_3O_{8-\delta}$ in 1988. Again, for developing practical superconducting cables, materials science considerations have been crucial. Much research has been focused on the (Pb, Cu)-1212 phase, as this is readily synthesised by conventional powder methods in an oxidising atmosphere. But its superconducting phase is complicated to synthesise, requiring preparation under high oxygen pressures followed by quenching to room temperature.

The art of creating new superconductors lies in considering which of the many possible substitutions will lead to stable – and superconducting – crystal arrangements.

Progress is made partly by intelligent guess-work and partly by trial-and-error – hence the use of a robot to speed up and automate the tedious process. To enable the Hirst Research Centre to investigate permutations of six different elements, its robot is capable of providing 80 different samples per day.

As for intelligent guess-work, the most encouraging path lay in substituting cadmium for copper in the lead-containing dopant layers. Where copper prefers a perovskite structural environment, cadmium prefers the same rock salt type structure as lead, resulting in a more orderly arrangement of oxygen atoms.

The theory is that the presence of copper within the lead-containing dopant layer leads to a random oxygen atom arrangement, trapping holes inside the layer and preventing them moving into copper-oxygen layers.

Another factor is the fixed valence state of cadmium, which along with the element's structural preferences, helps to stabilise the oxygen content.

Confidence in this Cu-replacement approach was boosted by the fact that other researchers had already claimed success in creating bulk superconductors by replacing copper with calcium or strontium in the doped layer. Here again though, sample preparation involved an over-pressure of oxygen.

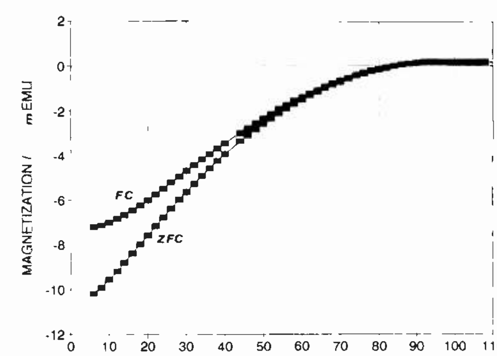
Sample preparation

In pursuit of the goal of producing superconductors readily in bulk, the Hirst team adopted a simplified approach to preparing their samples. Briefly, the process involves mixing solutions containing metal complexes with EDTA (ethylene diamine tetra acetate is a dis-olve-all chelating agent), then evaporating off the water and decomposing the EDTA complexes by heating to 500°C in air. The resulting mixture of oxides and carbonates is ground and calcined at various elevated temperatures in the expectation of creating pure 1212 phases.

The purest phase of PCSYCCO, as identified by X-ray diffraction techniques, is obtained by dividing the samples finely and firing at between 750°C and 850°C. Powder X-rays indicate a tetragonal unit cell with a slightly shorter *a*-axis and slightly larger *c*-axis than the (Pb, Cu)-1212 phase, implying that cadmium ions fit well into the structure.

Samples show clear signs of superconductivity at 92K by the onset of diamagnetism, and by electrical resistance measurements.

The relatively weak diamagnetism is equivalent to only a few percent of a perfect superconductor in the bulk sample, though this is partly explained by small grain size. Measurements show a distinct paramagnetic-to-diamagnetic phase change at 92K, though the electrical resistivity starts to drop at around 90K, but only reaching zero around 45K. The effect is thought to be a problem caused by the sintering process with lead-containing cuprates. Work is continuing to eliminate such shortcomings, for example by sintering the material under oxygen. Solving the problem

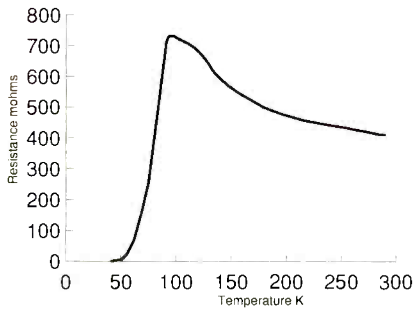


Variation of magnetisation with temperature of $(Pb_{0.5}Cd_{0.5})Sr_2(Y_{0.7}Ca_{0.3})Cu_2O_{7-\delta}$. Both field-cooled and zero-field-cooled values were recorded.

Collaborative effort

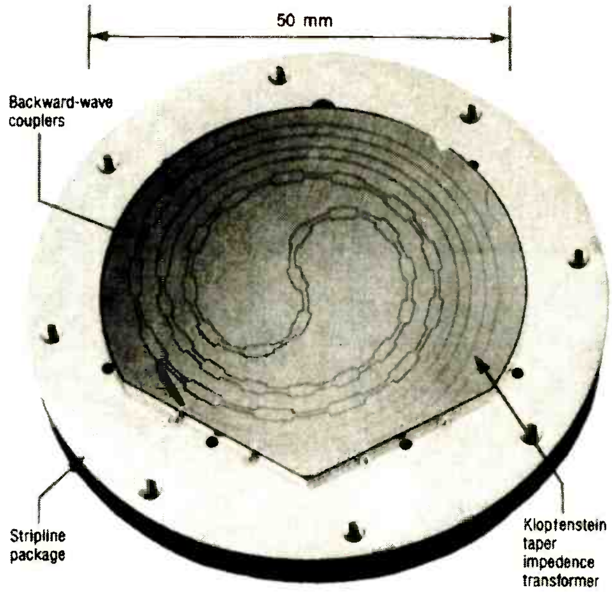
Driving-force for research into high temperature superconductivity is obvious. The European Community estimates that resistive dissipation between power station and consumer is costing member states around ecu2.5 billion every year. That is a bill that would be dramatically reduced if traditional cables were replaced by superconductors operating at liquid nitrogen temperatures.

So there is plenty of motivation for the recently-reported work – a collaboration between GEC Alsthom, BICC, ABB, Alcatel Cable, Pirelli Cavi and Siemens under the EC Brite/Euram materials and technology programme. The same companies are also studying techno-economic aspects of superconductor applications.



Variation of electrical resistance with temperature of PCSYCCO.

Operating at 77K, this experimental chirp expander made with YBCO superconducting film is just a fraction of the size required by a conventional resonant cavity design. The superconducting microstrip allows an order of operating Q not normally associated with the technique



could lead to even-higher superconducting transition temperatures than those already obtained.

Meanwhile, the new superconducting material is being transferred to other collaborators in the EC Brite/Euram project, who will develop the processes required to turn the scientific discovery into practical superconducting cables. It may be a decade or so before this bears fruit, and as participants in the EC Joule project, the collaborators are also looking hard at economic feasibility. But positive results will not only be good news for power transmission, but also for future developments with the far-reaching possibility of no-loss energy storage. ■

Acknowledgements

This article was prepared with the help of D M Jacobson, M R Harrison and R Ghiggino at the Hirst Research Centre.

References

1. Beales T P, Dineen C, Freeman W G, Hall S R, Harrison M R, Jacobson D M & Zammattio S J. Superconductivity at 92K in the (Pb, Cd)-1212 phase $(Pb_{0.5}Cd_{0.5})Sr_2(Y_{0.7}Ca_{0.3})Cu_2O_{7-d}$, Superconducting Science & Technology 5 pp.47-49 (1992).
2. Tilley D R, & Tilley J. Superfluidity and Superconductivity, IOP Publishing 1990.
3. Harrison M R, Chemical and Structural Aspects of High Temperature Superconductors, GEC Journal of Research, Vol 8, No 2, pp.74-82 (1990).

Amplifier clip detector

Driving any power amplifier into clip soon proves fatal to loudspeaker drive-units. But the exact threshold of clip depends on output loading and mains voltage. Music signals are asymmetric, so bi-lateral detection is essential. The circuit provides true indication of clip irrespective of these variables by sensing the abrupt rise in feedback as the amplifier moves into clip.

The *SSM 2017* true differential amplifier (IC_1) reads the error voltage across the bases of the amplifier's differential input stage. R_1 and R_2 stand-off the amplifier's sensitive input nodes so stability is not affected by stray capacitance to ground. C_1 optionally prevents IC_1 responding falsely to VHF non-linearity.

In the linear mode, drive to IC_1 is close to 0V, rising sharply as the amplifier is over-driven. Unselected *2017*s have appreciable DC offset, so IC_1's output is AC coupled (C_2, R_4), then fed to window comparator IC_2, which responds symmetrically to impulses greater than ±20mV, lighting the clip led after integration (C_3, C_4). PR_1 adjusts IC_1's gain in the region of x20 to x100. It is set on test such that the led's illumination corresponds to a given THD: or a threshold between, say, 0.1 and –0.6dB below clip. The monitor output feeds a scope or analyser for diagnostics.

Ben Duncan
Ben Duncan Research
Tattershall
Lincoln

Current-to-frequency converter

As an alternative approach to the voltage-to-frequency converter circuit in which one resistor charges and discharges the capacitor, proposed by Trofimenkov *et al* in IEEE Trans. Inst. Meas., Sept. 1986, this circuit behaves also as a current-to frequency converter in which pulse width/period ratio is a function of the input current.

When the output voltage of the *555* timer in **Fig. 1** is high, *C* charges through the operational transconductance amplifier, in which a slight voltage imbalance at its input causes all its bias current I_B to flow in its load. This means that *C* is charged by the constant bias current. At the two-thirds V_{cc} point across the capacitor, the output voltage goes low and *C* starts to discharge through *R*. At one third V_{cc} on the capacitor, the output voltage again goes towards the supply and the cycle repeats. Since the input port of an OTA is a diode in series with a resistor, a voltage at the input will have the same effect as a current, so that voltage control is also possible. This circuit has been tested using a *CA3080* OTA and a *555*.

Muhammad Taher Abuelma'Atti
Dhahran
Saudi Arabia

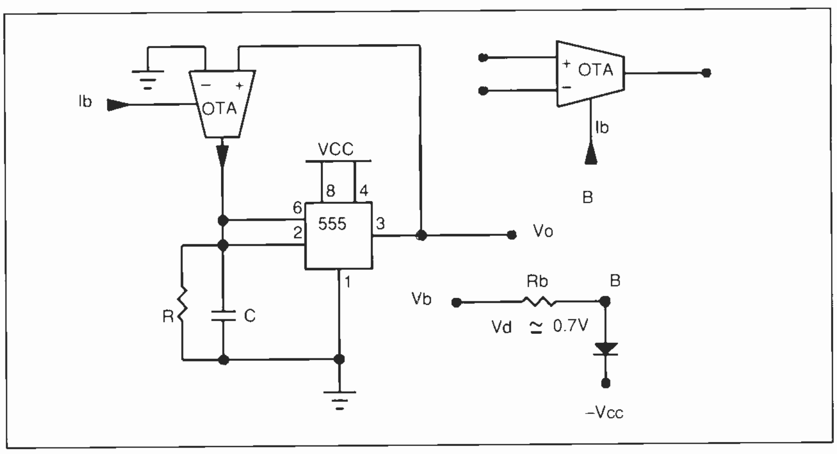
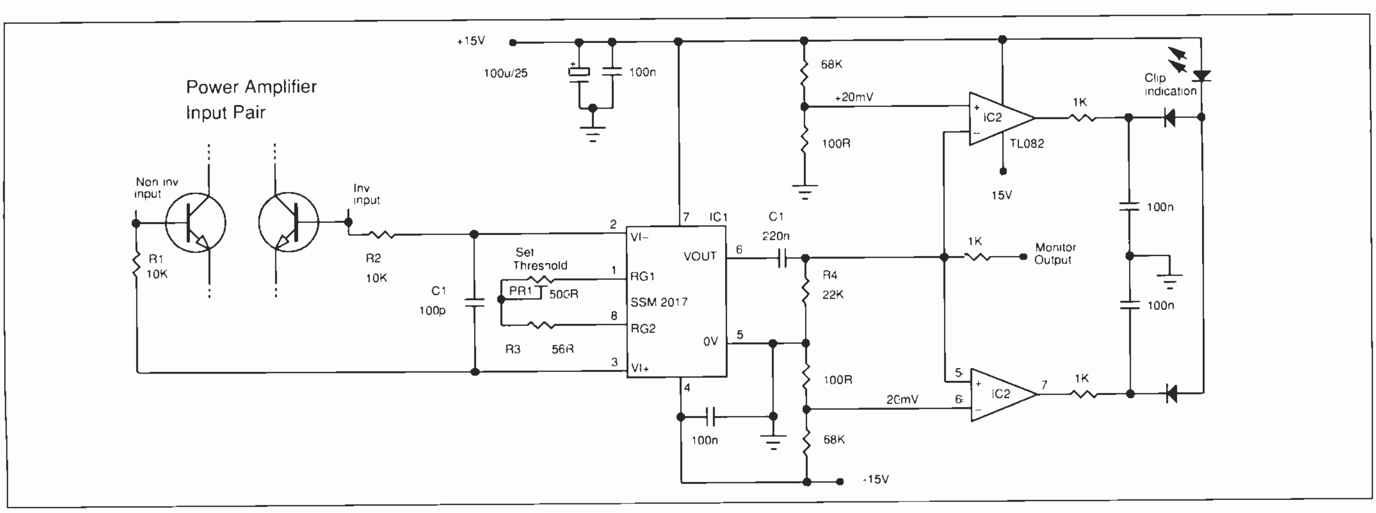


Fig. 1. Current-voltage converter, also workable using voltage control.



Schmitt-trigger VCO

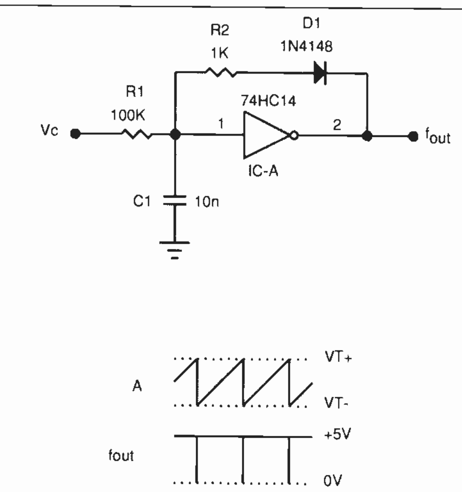
One section of a *74HC14* hex. schmitt inverter makes a useful voltage-controlled oscillator.

When power is applied to the circuit of **Fig. 1**, point A is at 0V and the inverter output is high. Capacitor C_1 charges through R_1 towards the input control voltage V_c but, when it reaches the upper trigger level of the Schmitt V_T+, the inverter output goes low and discharges the capacitor through R_2 and D_1.

As a result, the voltage at point A drops, the cycle repeating when it reaches the lower threshold V_T. At the output, a narrow, negative-going pulse appears, coincident with the "flyback" at point A.

Pulse width is dependent on the discharge current set by the value of R_2 and the frequency on V_c, C_1 and the hysteresis of the buffer.

Yongping Xia
Torrance
California USA



V_c (v)	f_{out} kHz
3.5	1.28
4.0	1.85
4.5	2.42
5.0	2.99
5.5	3.51
6.0	4.08
6.5	4.65
7.0	5.13
7.5	5.62
8.0	6.09
8.5	6.66
9.0	7.14
9.5	7.69
10	8.06
11	9.26
12	10.1

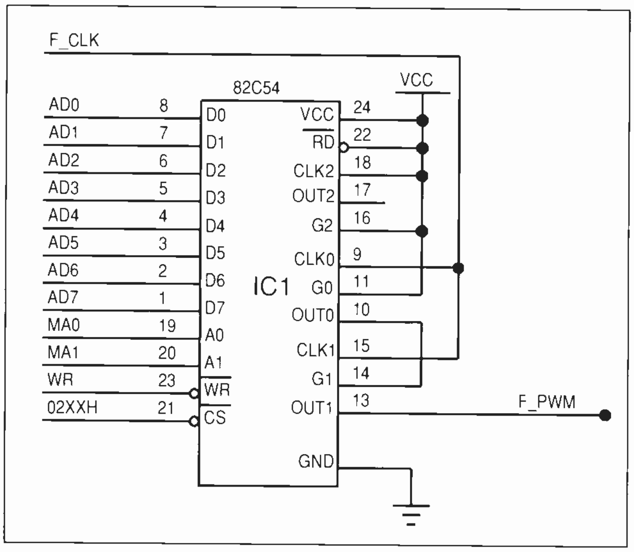
Simple voltage-controlled oscillator using one element of a hex. schmitt trigger inverter 74HC14. Frequency change against control voltage is reasonably linear, but absolute frequency will vary fairly widely from that shown in the table, since it depends on schmitt hysteresis, which is not held to close tolerance.

Programmable PWM

Intel's *8254* programmable interval timer contains three programmable counters, which may be made to perform the functions of programmable one-shot (mode 1) and square-wave (mode 3) generators, among others, by inputs to the D0-7 pins. In the application shown, the device is used as a programmable pulse-width modulator.

Two of the timers are used: timer 0 is programmed in mode 3 and timer 1 in mode 1, so that the output frequency is $f_{pwm} = f_{clk}/(2^n)$, in which n is the number programmed into the counter.

Pulse-width modulator, programmable in frequency and duty cycle, using two of the 8254's three counter/timers.




```
timer_cntr          equ 0203h       ;timer/counter 8254
timer_0             equ 0200h       ;timer0
timer_1             equ 0201h       ;timer1
timer_2             equ 0202h       ;timer2
rseg at 30h
t0_value            dsw 1           ;timer0 count value
t1_value            dsw 1           ;timer1 count value
t2_value            dsw 1           ;timer2 count value
mode_set            dsb 1           ;timer mode set
cseg at 2080h

init:
1db mode_set,#00110110b  ;timer_0 as mode 3
stb mode_set,timer_cntr
1db mode_set,#01110010b  ;timer_1 as mode 1
stb mode_set,timer cntr
1d t0_value,#512         ;512=2^^9 if you decide N=9
stb t0_value,timer_0     ;i.e. the range of duty cycle
stb t0_value+1,timer_0   ;of PWM is from 0 to 511
1d t1_value,#100         ;if you want duty cycle = 100
stb t1_value,timer_1
stb t1_value+1,timer_1
halt:                    br halt
```

Duty-cycle range is from 0 to (2^n-1) so that if, for example, output frequency is to be 15625Hz and duty cycle range is (2^9-1) or 511, the clock frequency is 8MHz.
The listing given here will do the job.

Shwang-Shi, Bai
Chun-Shan Institute of Science and Technology
Taiwan

Linear swept VCO

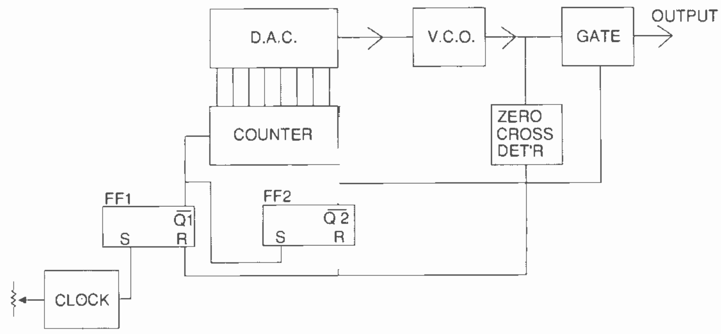
A criticism levelled at conventional audio sweep generators is that no matter how pure the sine-wave from the VCO may be under static (non swept) conditions, the picture changes when the VCO is swept.

The following scheme, which uses a combination of sweep and burst techniques, is a way of overcoming this.

In essence, a staircase ramp generated with a clock, an n-bit counter and an n-bit D-to-A[1]. The ramp is suitatbly scaled before being applied to the VCO[1,2]. The output from the VCO is gated off for one cycle while it slews at each step in the ramp.

A positive transition of the clock sets FF_1. On completion of the current cycle from the VCO the zero-crossing detector produces a positive edge which resets FF_1. The positive edge from FF_1 now clocks the counter and sets FF_2. Q_2 inhibits the output. The D-to-A output increments to the next staircase level. At the end of the next cycle (distorted as it slews) the zero-crossing detector resets FF_2. The ouput inhibit is removed and the circuit produces a burst which lasts until the next clock pulse where upon the above action repeats.

The ouput therefore consists of bursts of undistorted and complete sine-waves, the frequency of which increases with each step of the staircase. ■



DM Bridgen
Racal Radio Ltd
Reading

References
1 J, Wannamaker, Radio-Electronics, Feb 1991, pp 43-49+70.
2. D.M. Bridgen, EW+WW, Feb 1992, pp 102-105.

NEW PRODUCTS CLASSIFIED

ACTIVE

Asics

200MHz FPGAs. AT&T's ATT3000 series of field-programmable gate arrays now run at 200MHz – a performance attributed to the use of the company's 0.6μm silicided cmos process. Devices toggling at 230MHz are expected in production early in 1993. AT&T Microelectronics, 0344 865927.

Asic libraries. The Liberty series of physical layout libraries and compilers from Compass allows a designer to choose the foundry and cmos process for production. As well as working with the Compass Navigator system, the series supports a variety of design tools such as Mentor Graphics, GenRad and Zycad. The library includes gate array and standard cells, ram and multiplier compilers and the Compass Datapath compiler. Compass Design Automation, 0908 661729.

0.8μm gate arrays. Four new devices have joined Hitachi's *HG62G* gate array family. Gate counts now reach 54200, 51100 and 70500, with i/o of 264, 288 and 336. The fourth device is for smaller applications and contains 10000 gates with 136 i/o pads.The HG62G family offers sub-nanosecond operation (0.3ns for a 2-input power nand) and operates from 2.7V to 5.5V rails. Hitachi Europe Ltd, 0628 585000.

Discrete active devices

Fast-recovery mosfets. *ABB-IXYS HiPerFET* mosfets allow the use of the ABB-IXYS intrinsic diode in free-wheeling applications due to its fast reverse recovery, which is 60% faster than standard mosfets with no increase in on resistance. The one intrinsic diode eliminates the series schottky and parallel diodes. The range includes 75A/100V/0.02Ω up to 12A/1000V/1.05Ω types all with reverse recovery time of less than 250ns. Kudos Thame Ltd, 0734 351010.

Digital signal processor

Histogrammer. Harris's *HSP48410* is described as a histogrammer/accumulating buffer and is designed for extremely accurate histogram calculation and image contrast enhancement in machine vision systems, target recognition and medical imaging. It will evaluate contrast in images of up to 4096 by 4096 pixels and generate a histogram of input gray levels for manipulation or analysis, the data being used to modify or enhance the image. Harris Semiconductor (UK) Ltd, 0276 686886.

Linear integrated circuits

Video amplifier. Comlinear's *CLC411* is a 200MHz video op-amp intended for HDTV, composite video, line driving and D-to-A output buffering. Slew rate is 2300V/μs with a settling time to 0.1% of 15ns. To 30MHz, gain varies less than 0.05dB and diff. gain and phase are within 0.02% and 0.03% respectively. The device has fast, break-before-make enable and disable. Joseph Electronics Ltd, 021 643 6999.

Zero-drift op-amp. Linear claims its new *LTC1250* chopper-stabilised op-amp to be the lowest-noise device of its type available. From 0.1Hz to 10Hz, noise is 0.65μV pk-pk in the presence of a 4.2V output swing into 1kΩ. Sample-and-hold capacitors are on the chip. Particularly useful for bridge transducers, there is only 50nV/°C offset drift and maximum offset is 10μV. Linear Technology (UK) Ltd, 0276 677676.

Dual/quad op-amps. *LT1112/4* dual and quad op-amps from Micro Call are claimed to exhibit the lowest offset voltage of any such non-chopper stabilised amplifier available. Typical and maximum figures are 20μV and 70μV, both with a maximum drift of 0.5μV/°C. Input bias and offset currents are both 250pA. Noise performance of both devices between 0.1Hz and 10Hz is 0.32μVpk-pk and slew rate is 0.3V/μs. Micro Call Ltd, 0844 261939.

Triple video amplifier. Elantec's *EL4390* consists of three 60MHz current feedback amplifiers, each with a DC-restore amplifier activated by a common TTL/cmos-compatible control signal and each having a separate restore reference. Response is flat to within 0.1dB to 10MHz and slew rate is 900V/μs. Microelectronics Technology, 0844 278781.

Video distribution. A low-cost video distribution amplifier, the *EL2099* from Elantec, will drive up to six double terminated cables at a –3dB bandwidth of 60MHz and a gain of 2, giving ±11V into 25Ω and slewing at 900V/μs. Output current is 500mA and differential phase and gain are said to be low. Microelectronics Technology, 0844 278781.

FM pager receiver. Philips claims its *UAA2080* to be the most advanced single-chip direct-conversion FM receiver for pagers. When used with the *PCF5001T* decoder, the result is a two-chip wide-area beep-only pager or a high-performance display pager front end. The chip receives and demodulates FM NRZ FSK data, operating at up to 512MHz with a sensitivity of -124dBm for a bit-error rate of less than 3/100. Active and standby currents are 2.7mA and 3μA. Philips Semiconductors Ltd, 071 436 4144.

Complementary mosfet arrays. Complementary mosfet pairs in the same package from Zetex feature a 60V maximum drain/source voltage and a peak current rating of 3A. The *ZVC2016E* handles 280mA continuously and has a gate/source threshold of 3.5V at 1mA, with an on resistance of 5Ω at 10V and 500mA. Zetex plc, 061 627 4963.

Power mosfets. Hitachi's fourth generation of power mosfets the *DIV-L* series, are smaller in size and exhibits smaller conduction and switching losses. On resistance is now down to 18mΩ for a 60V device and fall time has been reduced by 30%. Reverse recovery time is typically 125ns. The range includes more than 20 types of n and p channel devices at 60V and lower breakdown. Hitachi Europe Ltd, 0628 585000.

Logic building blocks

Character display. Two ICs from Philips, the *PCA8510* and *PCA8516*, are designed to generate on-screen characters for television displays and camcorders, being the first to incorporate software half-tone colour control to enhance readability. They will show a full screen of up to 13 or 40 lines of 36 or 40, 12 by 18 characters, depending on the television standard. Philips Semiconductors Ltd, 071 436 4144.

Memory chips

4Mbit eproms. AMD has announced the *Am27C4096* and *Am27C400* devices, the former being organised as a 256K by 16bit type and the latter a rom-compatible cmos device user-configured as 512K by 8bit or 256K by 16bit eprom. Both are in 0.85μ cmos and possess an access time of 120ns. Advance Micro Devices UK Ltd, 0483 740440.

4Mbit word-wide drams. Hitachi's second generation of devices, the *HM514260A* 256K by 16-bit type and the *HM514280A* 256 by 18-bit unit are dynamic rams in 0.7μ cmos, with access times down to 70ns. The 60A

Please quote "Electronics World + Wireless World" when seeking further information

uses only 825mW when active, reducing to 1.1mW from 5V on standby. Hitachi Europe Ltd, 0628 585000.

Mixed-signal ICs

Electronic digital pot. From Dallas, the Dallastat *DS1668/1669* is a digital interface and non-volatile memory, forming an alternative to mechanical potentiometers. *DS1668* has a manual interface and the *1669* is configurable for two-button operation, both types being digitally controlled by means of the interface. The memory retains last setting when power is removed. Values are in three ranges up to 10kΩ, 50kΩ and 100kΩ. Joseph Electronics Ltd, 021 643 6999.

Distance sensor. The *GP2D02* distance sensor by Sharp contains an infra-red led, a position sensor and signal-processing to measure distances between 4cm and 30cm or 10cm-80cm, depending on the version. Output is in the form of an 8-bit code. Current consumption is 7ma or 4.5mA, dropping to 2μA in the absence of a reflective object. Sharp Electronics (Europe), 010 49 40 23 76-0.

Optical devices

Bright, blue leds. Sharp's *GL5BX43* silicon carbide light-emitting diode has a luminous intensity of 16mCd at 20mA, emitting at a wavelength of 470nm and a bandwidth of 70nm. Sharp points out that RGB displays using leds are now possible. Sharp Electronics (Europe), 010 49 40 23 76-0.

Power semiconductors

Switching regulator. Two 200kHz current-mode off-line switching regulators by Linear provide 1% regulation and stabilisation with no opto-coupler for feedback, power transmission and secondary sensing being done via the transformer. *LT1105* has a totem-pole output to drive an external fet, while *LT1103* has its own fet output, the former being designed for 50W-250W output and the latter for 10W-100W operation. Linear Technology (UK) Ltd, 0276 677676.

2kW linear amplifier. A 2000W linear amplifier by Apex, the *PA30*, produces up to 8kW pulse output and the 2kW continuous from zero to 40kHz. Output current is 50A continuous (100A pk) on rail-to-rail supplies of up to 200V. Power mosfet outputs avoid secondary breakdown and on-chip sensors provide thermal protection. The package measures 2.8 by 2.2 by 0.4in. Microelectronics Technology, 0844 278781.

Power mosfets. *APT10050JN* is an n-channel 1kV power mosfet from APT, rated at 520W dissipation and packaged in SOT-227. The single die is rated at 20A, with a drain/source on-state resistance of 0.5Ω, meeting 2.5kV RMS isolation. Microelectronics Technology, 0844 278781.

Regulators. Sharp's PQ series of voltage regulators drops only 0.5V from input to output, reducing power loss and therefore the need for large heat sinks. Output current is up to 2A; regulation is 0.2% for a 2000-fold load current increase and stabilisation gives a 0.4% output voltage change for a two-fold input change. Sharp Electronics (Europe), 010 49 40 23 76-0.

DIP power. Power+Logic is a new range of TI peripheral drivers in dip packages – the first to combine power transistors and cmos logic on the same substrate. *TPIC6259* is an 8-bit addressable latch; *TPIC6273* an octal D-type latch; and *TPIC6595* an 8-bit shift register, all working in the range -40°C to 125°C. Texas Instruments Ltd, 0234 223252.

PASSIVE

Passive components

Tantalum chip capacitors. Capacitors in Murata's *227* range measure 1.2mm in height and have a range of values from 0.1μF to 6.8μF in voltage ratings of 4-20V DC. Leakage current is less than 0.4μA at 25°C. Murata Electronics (UK) Ltd, 0252 811666.

Connectors and cabling

2mm IDC connectors. Cambion has the *2630* series of insulation-displacement sockets and headers in straight and right-angle form for termination of 1mm 28awg ribbon cable. Current capacity is 1A per line. These tuning-fork contact sockets with a barb to retain the cover come in 12 to 50-way versions and offer a contact resistance of 20mΩ and insulation resistance of 1GΩ. Interconnection Products Ltd, 0433 21555.

Tough microwave cable. Internally strengthened microwave cables from Gore are small in diameter, low in weight and flexible, but withstand 175lb/linear inch, which means they will take the weight of a forklift truck, should the occasion arise. The cables have Gore-Tex expanded PTFE dielectric, giving a temperature range from –200°C to 200°C. A range of connectors is available. W L Gore & Associates (UK) Ltd, 0382 561511.

Filters

Chip EMI filter. Murata's *NFM51/52R* EMI filters offer 100dB/decade damping and are intended for use with digital circuitry, eliminating noise from clock and video RGB circuits or that from DSP and image processing equipment. Four cut-offs are available: 50MHz, 100MHz, 200MHz and 500MHz, suppression at 5GHz still being about -40dB. Murata Electronics (UK) Ltd, 0252 811666.

EMC shielding. *Econoshield* is RFI Shielding's new material for the commercial sector where low compression force is needed – round doors, for example. Shielding is effective between 30MHz and 1GHz, providing around 30dB attenuation. The material consists of polyurethane foam covered by a layer of Monel wire, available in a variety of cross-sections, most being available with a pressure-sensitive adhesive backing. RFI Shielding Ltd, 0376 342626.

Hardware

Rectangular feedthrough C. Possibly the first mass-produced rectangular feedthrough capacitor is produced by Beck. It measures 4.9 by 4 x 2.7mm and was designed to fit over the rectangular 30A pin of a car component. Values of the ceramic capacitors is 1000pF at 100V DC. Beck Electronics Ltd, 0493 856282.

RF seals. Conductive, elastomeric materials for Anti-EMI sealing from Dunlop have been tested to US military spec. MIL-G-83528A. The new materials are based on silicone and fluorosilicone rubber with metallic or metal-coated fillers and reinforcements such as metallised fabric, which offers a 0.001Ω/cm resistivity. These materials will attenuate frequencies up to 18GHz by up to 100dB. Dunlop Precision Rubber, 0509 502151.

Infra-red pocket boxes. Hand-held boxes designed to hold IR circuitry for signalling or remote control by OKW are said to be the only ones available with IP65 sealing and battery compartments. They are made in polycarbonate and ABS in three sizes and a belt clip is an option, as is machining and silk screening to order. OKW Enclosures Ltd, 0489 583858.

Instrumentation

Measuring receiver. ITT's *VX600S* TV measuring receiver copes with satellite and FM ranges, meeting European standards for to monitor, video modulation and video/sound separation. As video and sound quality monitor, it reproduces on screen a zoomable picture, with the input signal and line trigger. It will also operate as a spectrum analyser. Feedback Instruments Ltd, 0892 653322.

Wider-range sig gen. Hewlett-Packard has expanded the frequency range of its *HP70340A* modular signal generator with the addition of a new module, the *HP70341A* 10MHz-1GHz unit. Modulation is 60dB log. AM, 10MHz peak FM deviation and pulse modulation with less than 10ns rise and fall times. Frequency resolution is 1kHz, or 1Hz as an option. Hewlett-Packard Ltd, 0344 362867.

Digital multimeter. Saje's *7130* bench multimeter is programmed via RS232 or, as an option, IEEE488, to measure alternating and direct voltage and current, frequency and power in VA. Mathematical facilities offered are percentage, compare, difference, maximum/minimum and relative, these being intended to ease production batch testing. Saje Electronics, 0223 425440.

TV signal-level meter. Leader's model 952 multi-channel television and satellite signal-level meter is programmed to cover VHF/UHF television and CATV as well as satellite channels. It can cover up to 128 channels simultaneously, with a bar-graph display automatically scaling to respond to both smallest and largest signals in a group. Both sound and vision carriers are displayed and the instrument stores in non-volatile memory four sets of eight channels, channels from any band being shown together. Thurlby-Thandar Ltd, 0480 412451.

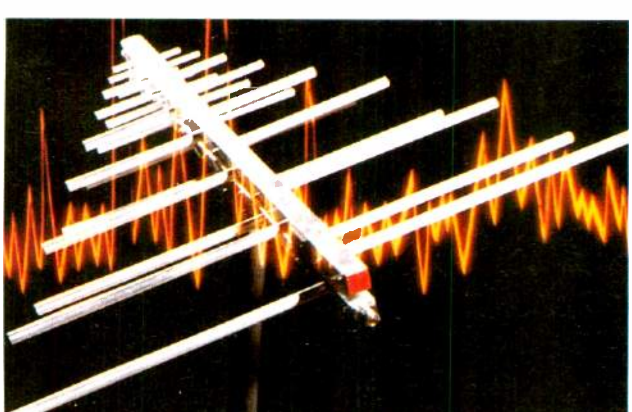
Literature

Sensor handbook. Piezoresistive silicon pressure sensors and transmitters, with application notes on signal conditioning and interfacing, are all described in a new handbook from Sensortechnics in Puchheim, Germany. Sensortechnics GmbH, 010 49 89-80 08 30.

Marerials

Ceramic HV capacitors. A range of capacitors from the Cera-Mite Corp. handle up to 13kV RMS at 60Hz, using a new ceramic material. Capacitance values are 400pF to 4700pF working at 10kV DC/4kV RMS at 60Hz to 40kV DC/13kV RMS at 60Hz. The material in the KT series confers improved reliability and stability, tighter tolerances and low dissipation. Acal Electronics Ltd, 0344 727272.

EMC components. Global introduce a range of EMC antennas and custom made chokes and filters. Antennas cover the 20MHz-1GHz frequency range in biconical and log. periodic form and are supported by most automated EMC software. Global Specialities, 0978 853920.



Power supplies

Programmable PSU. Thurlby-Thandar offer the *TSP3222*, a dual programmable power supply intended as both bench unit and as part of an ATE system. Outputs are both 0-32V, 0-2A, independent and isolated to 300V. Both operate in constant-I or constant-V mode with automatic crossover and switching of the display from current to voltage. A GPIB interface is fitted and a LabWindows device is an option. Feedback Instruments Ltd, 0892 653322.

Memory protection. Double-layer capacitors from Surtech are small and light alternatives to the batteries usually used for memory protection, offering a reduced backup time and reduced board space. The *AC300* or Ace Caps work in the -20°C to 70°C temperature range. Surtech Interconnection Ltd, 0256 51221.

Battery protection. TI has the *4MM* – a bimetallic protector for re-chargeable batteries. It guards against both thermal overload and short circuits, replacing the two devices normally used. Texas Instruments, 0234 223252.

Radio communications products

Linear amplifier. AML's new *APO1501640* 1.5-1.6GHz linear power amplifier provides a 10W output with a gain of 22dB, flat to within ±0.2dB. A feature is gate-current monitoring to achieve enhanced reliability. European Microwave Components, 0376 515200.

Telemetry RX module. *SILRX-418-A* is a sil-outline UHF radio telemetry receiver module made by Radiometrix. It is meant for use with the *TXM-418-A* transmitter module in low data-rate paging applications and is a PCB-mounted 418MHz receiver, needing only an antenna. The double-conversion FM superhet and data slicer driven by the AF output will drive a digital decoder for secure links. Maximum active-mode current is 15mA - 130μA when on standby. Quantelec Ltd, 0993 776488.

Radio data link. A range of UHF communications equipment by Wood & Douglas is intended for remote outdoor use. The SurTel data link provides simplex or semi-duplex communication over a 20km line-of-sight range, internal modems transferring data at 1200 and 2400 baud. The required supply is either 12V DC or mains and a standby circuit maintains only the oscillator in operation, thereby ensuring minimum frequency drift with a short power-up delay. Wood & Douglas, 0734 811444.

Multi-function measurements. Scopemaster from Thurlby-Thandar is a combined oscilloscope, counter-timer, data analyser and multimeter in one case, the whole costing £450. The dual-channel digital storage oscilloscope has a 20MHz bandwidth, sampling at 20Msample/s, with a repetitive mode to 2.5ns resolution. There are ten waveform stores and a printer output. All the separate instruments use the oscilloscope's 3in LC screen and the whole thing is battery-powered. Thurlby-Thandar Instruments, 0480 412451

Switches and relays

Low-noise relay. *CRX-12X* from BLP is a relay designed for the car industry, having a low level of acoustic noise (60dBA) so that intermittent windscreen wipers, for example, do not cause too much of a racket. It has silver alloy contacts and operate and release times of 6ms and 2ms respectively. BLP Components Ltd, 0638 665161.

Product labels. *Info-mark* and *Appliance-mark* by Donprint are label-printing devices, using on-screen design and 300dot/in printing on material capable of withstanding temperatures up to 380°C and a variety of cleaning materials including petrol,detergents and some fairly hostile chemicals. Donprint Label Systems Ltd, 0355 249191.

Please quote "Electronics World + Wireless World" when seeking further information

Miniature RF relay. A 12V miniature PCB-mounted RF coaxial relay marketed by Cirkit will switch up to 50W CW at 1GHz, with a maximum insertion loss of 0.3dB at 1.8GHz and an SWR of 1:1.3 at 1.8GHz. Line impedance is 50Ω and contact form is single-pole changeover. Cirkit Distribution Ltd, 0992 444111.

PCB connector. A surface-mounting, dual-row inverse connector from Methode has an off-the-board height of 7.1mm. It comes in two forms: one with vertical holes and the other with horizontal holes for inserting from either side, both having from two to forty positions on each row at 0.1in pitch. Contacts handle up to 3A. Methode Electronics Ltd, 0535 603282.

PCB switches. A new family of sub-miniature switches by Elma, the *Type 09*, are meant for PCB mounting or for through-panel use. Either toggle or push-button variants are made, the toggle type with two or three positions and the button type in latching or momentary contact form, with the option of illumination. Radiatron Components Ltd, 081-891 1221.

Transducers and sensors

Miniature gyro. Murata's *ENC-05s gyrostar* is a miniature version of the company's triangular piezoelectric vibratory instrument, which uses a prism to increase sensitivity by 100 times compared with a tuning-fork type. The triangular structure overcomes the vulnerability to vibration suffered by earlier designs. Bandwidth is 50Hz, the maximum angular velocity of ±90°/s producing a 72mV DC variation about the 2.5V reference. Murata Electronics (UK) Ltd, 0252 811666.

Position transducer. Rayelco miniature position transducers by Magnetek use the extension of a spring-loaded cable to drive the fixed sensor, the cable being capable of mounting in variable directions. Five models in the range cover 0-2in to 0-20in at ±0.15% of full scale maximum error, while withstanding 20g and 0-200°C. Powertronic International Ltd, 0438 759377.

COMPUTER

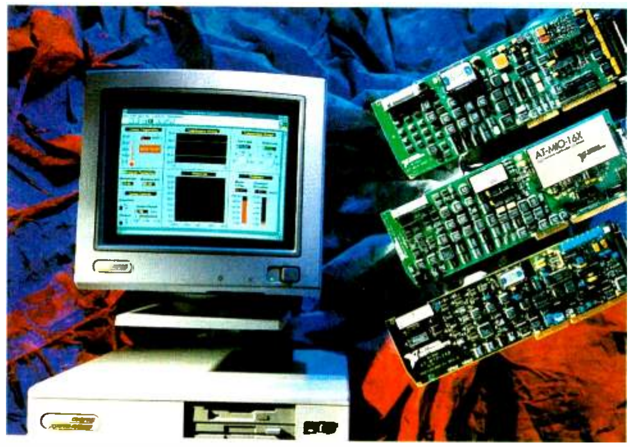
Computer board level products

Data acquisition. Two boards from Amplicon, the *C10-AD16jr/jr-AT*, are for use with PC XT/AT and compatibles and are 100% compatible with the *DAS16G* board. One is a half-length 140mm board taking 300mA from the computer and having 16 single-ended or eight diff. analogue inputs, the 3µs converter acquiring and transferring at up to 100kHz. The *jr-AT* is three times faster and is able to use the repeat input string for 286+ computers for data transfer at up to 330kHz. Amplicon Liveline Ltd, 0800 525 335.

16-bit GPIB controller. Amplicon's *INES-AT* IEEE 488.2 GPIB controller board performs all the IEEE talker, listener and controller functions to make an AT PC either the bus controller or appear as a listener. DMA transfer mode is automatic and transfer rate is 1Mbyte/s. A command interpreter supplied allows calls of the IEEE routines from any programming language and Windows 3 and above is supported by dynamic link libraries, languages included are most of the Basics, Pascal, Forth, Fortran and C in their various quick and turbo guises. Amplicon Liveline Ltd, 0800 525335.

STEbus processor board. Arcom's new *SCIM486SLC* is a high-performance embedded computer based on the Cyrix Cx486SLC processor. It is the first 486SLC to run on STEbus and is wholly contained on a 100 by 160mm Eurocard. The processor has a 32-bit internal data path and 1K of on-chip cache to allow risc-like single-cycle execution. A 16-bit hardware multiplier performs integer multiplication up to eight times faster than in a 386 to improve video performance by 100%. The unit runs at 25MHz and, with an SVGA adaptor fitted, is effectively a PC AT. Arcom Control Systems Ltd, 0223 411200.

Card memories. Triangle point out that the demand for card memories for notebooks has greatly reduced the price and that they are therefore worth considering for industrial use. The company offers the *TDS 20200*-based computer module and *TMB-200-03* or *TMB-55-03* card memory readers, which attach to a PC and appear as another disk drive to the computer, reading data in the same way as from a dos file. Triangle Digital Services Ltd, 081-539 0285.



Analogue, digital and timing i/o. Three multifunction boards from National for the PC offer analogue, digital and timing i/o data acquisition. *AT-MIO-64F-5* has 64 single-ended analogue inputs to 12 bits, eight TTL digital i/o lines, three counter timers and 16-bit DMA, all at 200kHz. AT-MIO-16X has similar facilities, with a 16-bit sampling ADC and AT-MIO-16D a 12-bit ADC. National also has the Lab-PC+, an improved version of the Lab-PC providing differential inputs a no increase in cost. National Instruments UK Ltd, 0800

Development and evaluation

PIC16CXX emulator. Running on PC 286 upwards, Microchip's Picmaster universal in-circuit emulator now handles the company's *PIC16CXX* range of microcontrollers, the industry's only 8-bit risc family. It will support different family members by means of a probe card change. Arizona Microchip Technology, 0628 850303.

Universal programmer. *BP-1200* from BP Microsystems Inc. is claimed to be the first programmer capable of programming and testing up to 240 pins in DIP, PLCC, LCC QFP, PGA, SOIC and TSOP packages. Attention has been paid to the reduction of ground bounce, so that the units cope with fast cmos PLDs and FPGAs. Direct Insight Ltd, 0455 558854.

Image compression. The JPEG image-compression board for PCs by C-Cube Microsystems is now available in Europe. It is an ISA half-card running at 10MHz and supporting grey scale, YUV (4:2:2 and 4:4:4), CMYK and 24-bit RGB. Data compression rate is more than 1Mbyte/s, allowing the unit to compress or decompress a 24-bit, 640 by 480 image in 0.7s on a 386SX. The still-image development kit includes schematics, PAL equations, .BMP-compatible link library source and full documentation. Kudos Thame Ltd, 0734 351010.

Eprom emulator. *Optorom* from Raisonance will emulate 8-bit eproms from the 27(C)16 to the 27(C)080 with no hardware upgrading, and handles eproms in 16 and 32-bit mode up to 4 by 4Mbit using an add-on board. Data can be down-loaded from the serial port of a PC at 115Kbaud in binary, Intel-hex, Tektronix and Motorola formats over a high-speed opto-isolated RS232 link. Logicom Communications Ltd, 081 756 1284.

Turbo C debugger. *ChipView-51* is Nohau's new C source-level turbo C debugger for the company's range of EMUL51-PC in-circuit emulators, compatible with the Borland turbo debugger. The unit provides up to 16K source lines using the standard trace board with a mix of detailed functions. Breakpoints can be to stop at the breakpoint, rather than at one op-code after it, as is usual. Over 150K of context-sensitive help is provided. Nohau UK Ltd, 0962 733140.

Computer peripherals

Paradise upgraded. Western Digital's improved software drivers for its Paradise accelerator card for Windows delivers performance gains of up to 77% over the previous version 1.0. Utilities include drivers for Lotus 3.1, Microstation 4.03 and VersaCad 6.0. Current Paradise users will be able to obtain the drivers free. Western Digital (UK) Ltd, 0372 742955.

Software

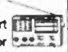
Mathematical modelling. *VisSim* from Adept Scientific is an interactive, intuitive maths modelling program, running under Windows, for work on animated simulation, real-time control and dynamic analysis. It require no knowledge of programming and is entirely graphic in presentation, including over 70 linear and non-linear function blocks to be "wired" together on screen to form graphical equations defining the process, at which point a mouse click runs the simulation. Adept Scientific Microsystems, 0462 480055.

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable) Ideal for all sorts of precision timer applications etc. **Now only £4.00 ref 4P151.** Good experimenters board.
FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R or £2 a metre.
12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R. Gives up to 15v

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual override facility. Complete with wallbrackets, bulb holders etc. Brand new and guaranteed. **Now only £19.00 ref 19P29**

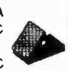
Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R
VIDEO SENDER UNIT Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R. Turn your camcorder into a cordless camera!
FM TRANSMITTER housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R. Good range device.
MINATURE RADIO TRANSCEIVERS A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases and earpieces. £30.00 ref 30P12R

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR.
12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £19 ref 19P14R. Ideal for listening all over the world.



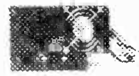
CAR STEREO AND FM RADIO Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. **£19.00ref 19P30**
LOW COST WALIKIE TALKIES Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R. Ideal for garden use or as an educational toy.

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.
NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R Pack of 10 AAA,s £4.00 ref 4P92R.
TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. New ed. £20.00 ref 20P32R.
GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R
FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R. 35mm square.
FM BUG Built and tested superior 9v operation £14.00 ref 14P3R
COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.
SINCLAIR C5 MOTORS 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22R. Limited stocks.
As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8R. 800 rpm.
ELECTRONIC SPEED CONTROL KIT for c5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R. Potentiometer control.
SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R. 2xC cell model £6.00.



ACORN DATA RECORDER ALF503 Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R
VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes **New low price £15.00 ref J15P4**
PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £20.00 REF 20P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.
12 TO 220V INVERTER KIT As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.
VERO EASI WIRE PROTOTYPING SYSTEM Ideal for designing projects on etc. Complete with tools, wire and reusable board. **New low bargain price only £2.00 ref B2P1**
25 WATT STEREO AMPLIFIERIC. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69R (Circuit dia included).
BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R
FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827R.
12V 19A TRANSFORMER Ex equipment £20 but OK.
ULTRASONIC ALARM SYSTEM. Once again in stock these units consist of a detector that plugs into a 13A socket in the area to protect. The receiver plugs into a 13A socket anywhere else on the same supply. Ideal for protecting garages, sheds etc. Complete system **now only £19 !!!**
POWER SUPPLIES Made for the Spectrum plus 3 give +5 @ 2A, +12 @700mA & -12 @ 50mA. £8 ref Q8P3
UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.
IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R.
RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170R.
QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R. Ideal for tea on the move!
LED PACK .50 red, 50 green, 50 yellow all 5mm £8.00 ref 8P52
IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel £5.00 ref 5P186R. 3 metre version £6.00 ref 6P50.
COPPER CLAD STRIP BOARD 17" x 4" of .1" pitch "vero" board. £4.00 a sheet ref 4P62R or 2 sheets for £7.00 ref 7P22R.
STRIP BOARD CUTTING TOOL £2.00 ref 2P352R.

WINDUP SOLAR POWERED RADIO! FM/AM radio takes rechargeable batteries. Complete with hand charger & solar panel 14P200R. Set of 2 AA nicads £2 ref L2P9
PC STYLE POWER SUPPLY Made by AZTEC 110v or 240v input. +5 @ 15A,+12 @ 5A,-12 @ .5A,-5 @ .3A. Fully cased with fan, on/off switch, IEC inlet and standard PC fly-leads. £15.00 ref F15P4



AMSTRAD MP3
UHF/VHF TV RECEIVER/CONVERTER
CONVERTS COLOUR MONITOR INTO A TV!
£9.00

TELEPHONE HANDSETS 10 brand new handsets with mic and speaker only £3.00 ref 3P146R
BENCH POWER SUPPLIES Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R
SPEAKER WIRE Brown twin core insulated cable 100 feet for £2.00 REF 2P79R
DISC DRIVES Customer returned units mixed capacities (up to 1.44M) We have not sorted these so you just get the next one on the shelf. Price is only £7.00 ref 7P1R (worth it even as a stripper)
MICROSCOPE 1200X MAGNIFICATION Brand new complete with shrimp hatchery, shrimps, prepared slides, light etc. £29.00 ref J29P4.
LIGHT ALARM SYSTEM Small cased alarms that monitor a narrow beam area for sudden changes in light level. Complete with siren that sounds for a preset time when unit is triggered. £7.00 ref J7P1
JOYBALLS Back in stock popular Commodore/Atari equiv (replace standard joystick) £5.00 ref J5P8

AMSTRAD 1640DD BASE UNITS
BRAND NEW AND CASED
TWO BUILT IN 5 1/4" DRIVES
MOTHER BOARD WITH 640K MEMORY
KEYBOARD, MOUSE & MANUAL
OUR PRICE JUST
£79!!!!

CAR BATTERY CHARGER Brand new units complete with panel meter and leads. 6 or 12v output £7.00 ref J7P2.
CUSTOMER RETURNED SPECTRUM +2 Complete but sold as seen so may need attention £25.00 ref J25P1 or 2 for £40.00 ref J40P4
CUSTOMER RETURNED SPECTRUM +3 Complete but sold as seen so may need attention £25.00 ref J25P2 or 2 for £40.00 ref J40P5
SCART TO D TYPE LEADS Standard Scart on one end, Hi density D type (standard VGA connector) on the other. Pack of ten leads only £7.00 ref 7P2R
OZONE FRIENDLY LATEX 250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R
VIEWDATA SYSTEMS Brand new units made by TANDATA complete with 1200/75 built in modem infra red remote controlled qwerty keyboard BT appproved Prestel compatible, Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R
COMMODORE 64 COMPENDIUM Pack consisting of a Commodore 64 computer, power supply, data recorder and software. All for £69 ref Q69P1.
PPC MODEM CARDS Made for the Amstrad PPC1640/1512 range these are plug in modules that operate at 2400 baud. No data. £15 ref Q15P5.
AMSTRAD LQ3500 PRINTER ASSEMBLIES Entire mechanical assemblies including print head, platen, cables, stepper motors etc etc. infact everything bar the electronics and case! Our price just £10 ref Q10P3.
AMSTRAD DMP4000 PRINTER ASSEMBLIES Entire printer assemblies including print head, platen, cables, stepper motors etc. Everything bar the electronics and case. Our price just £20 ref Q20P2.
TOROIDAL TRANSFORMER 146VA with tappings at 8v, 10v and 32v will give 50v at 3A or 32 at 4A etc. Centre tapped primary. £9 ref Q9P2. Fixing kit is £2 ref Q2P1.
AERIAL BRACKETS Wall plate 7.5" sq complete with rawl bolts, 10" stand off brackets with standard tube clamps. Will take up to 2" mask. Substantial bracket (would take body weight). £7 ref Q7P1.
TV SOUND RECEIVERS Popular units that with the addition of a speaker act as a tv sound receiver. Ideal as a stand alone unit or for connecting into HI FI!. £12 ref Q12P4

BULL ELECTRICAL
250 PORTLAND ROAD HOVE SUSSEX BN3 5QT TELEPHONE 0273 203500
MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.
PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY
FAX 0273 323077

CAMERAS Customer returned units. 3 for £10 ref L10P2.
STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200
TALKING CLOCK LCD display, alarm, battery operated. Clock will announce the time at the push of a button and when the alarm is due. The alarm is switchable from voice to a cock crowing!£14.00 ref 14P200.R

HANDHELD TONE DIALLERS Small units that are designed to hold over the mouth piece of a telephone to send MF dialling tones. Ideal for the remote control of answer machines. £5.00 ref 5P209R
AMAZING TALKING COINBOX! Fully programmable talking, lockable coinbox BT **approved**, **retail** price is £79 ours is just £29! ref J29P2.
ANSWER PHONES £15 Customer returned units with 2 faults one we tell you how to fix the other you do your self! £18 ref J18P2 or 4 for £60 ref J60P3 BT approved (retail price £79.95!! each)
COMMODORE 64 MICRODRIVE SYSTEM Complete cased brand new drives with cartridge and software 10 times faster than tape machines works with any Commodore 64 setup. The orginal price for these was £49.00 but we can offer them to you at only £25.00! Ref 25P1R
90 WATT MAINS MOTORS Ex equipment but ok. Good general pupose unit £9.00 ref F9P1
HI FI SPEAKER BARGAIN Originally made for TV sets they consist of a 4" 10 watt4R speaker and a 2" 140R tweeter. If you want two of each plus 2 of our crossovers you can have the lot for £5.00 ref F5P2
EMERGENCY LIGHTING SYSTEM Fully cased complete with 2 adjustable flood lights. All you need is a standard 6v lead acid battery. Our price is just £10 ref J10P29
AMSTRAD 464 COMPUTERS Customer returned units complete with a monitor for just £35! These units are sold as faulty and are not returnable.
WOLSEY DMAC DECODERS Made for installation in hotels etc as the main sat receiver no data but fully cased quality unit. £20 ref K20P1. Suitable psu £8 ref K8P3.
SWITCHED MODE PSU Fully cased unit 215mmx145mmx55mm giving +5, +12 and +20v well made case complete with mains lead. £8 fer K8P3.
REMOTE CONTROLS Brand new infra red CONTROLS originally made for controlling WOLSEY satellite receivers. £2 ea ref K2P1 or 20 for £19 ref K19P1.
TELEPHONES Modem 1 piece phones BT approved. Last no redial. £8 ref K8P1.
386 TOWER SYSTEMS Tower case 52cmx40cmx20cm. 2 fans, speaker, 275w psu, IEC I/L and O/L. 386 m/board with onboard disc controller, ethernet, display driver, parallel and serial ports. **There are several IC's missing from the m/board plus no data! £79 ref K79P1.**
DOS PACKS Complete set of PC discs with MS DOS 3.2, Locomotive basic, gemdesktop and gem paint. No manuals, 5 1/4" discs. £10 ref K10P2
CORDLESS TIE CLIP MICROPHONE transmits between 88-108MHZ FM. 5.2cm x 2cm, uses LR44 watch battery. Complete with wire aerial & battery. £16 ref K16P1.
CHASSIS MOUNT TRANSFORMERS 240v primary, 12v secondary 20VA £2 ref K2P2 240v primary, 16v secondary 10A (split winding). £10 ref L10P1
100 RED LED PACK (5MM) £5 REF K5P2
12V STEPPER MOTOR Ideal for models etc. 3" dia. £2 ref J2P14.
INFRA RED BEAM SWITCH 24v DC 5m range source & sensor housed in plastic case. £12 ref J12P1.
CAPACITOR BARGAIN PACK 100 CERAMICS £2 REF J2P2.
SPECTRUM JOYSTICKS TWO FOR £5 REF J5P2.

AMSTRAD PC CASE, POWER SUPPLY AND 1.44MEG FLOPPY DRIVE ALL THIS FOR £44 REF L44P1

BUMPER PACK NO 1 10 of our popular £1 packs for just £5 our choice of contents.
BUMPER PACK NO 2 25 of our popular £1 packs for just £12. Our choice of contents.
LCD 1 X 32 DISPLAY Bargain price of just £3 complete with loads of data for a similar display. £3 ref L3P1.
USEFUL POWER SUPPLIES. 18v 900mA dc output (regulated) fully cased with mains cable and DC out cable. £6 ref K6P1.
UNCASED PC POWER SUPPLIES. Standard PC psu without case, fan etc. Good for spare or low cost PC!. £4 ref L4P6.
RADAR DETECTORS. Detects X and K bands (ie speed traps). Not legal in the UK so only available if you intend to 'export'it. £59 ref J59P1.
100 WATT MOSFET PAIR. Same spec as 2SK343 and 2SJ413 (8A,140v, 100w) 1 N channel and 1 P channel. £3 a pair ref J3P9
LOW COST CAPS. 1,000 capacitors £3 (33uf,25v) ref J3P10.
VELCRO. 1 metre length 20mm wide, blue. £2 ref J2P16.
JUG KETTLE ELEMENTS. Good general purpose heating element just £3 ea ref £3P8 or 5 for £10 ref J10P3.
VERY BIG MOTOR. 200v induction 1.1kw 1410 rpm 10"x7" GEC 1" keyed shaft. Brand new. £95 ref J95P1.
BIG MOTOR. 220-240v 1425rpm 2.8A 5/8th" keyed shaft GEC 6.5" x 8" complete with mounting plate. £38 ref J38P1.
SMALL MOTOR. Electrolux 160 watt 3,000 rpm, 220-240v 5/8" shaft. precision built £18 ref J18P1
EPROMS 27C64 PACK OF 10 £7 REF M7P1.
EPROMS 27C256 PACK OF 10 £9 REF M9P1.
EPROMS 27C512 PACK OF 10 £10 REF M10P1.
MODEMS FOR £1.25? These modems are suitable for stripping only hence they are only 4 for £5 ref J5P3.
SOLAR POWERED WOODEN MODELS. Complete with solar panel, motor and full instructions. £9 ref J9P2. 3 diff £20 ref J20P3.
TV SOUND RECEIVER Fully cased, mains powered,that need a speaker for stand alone use or could be wired into hifi. £12 ref 12P22.
SOUND OPERATED LIGHT. Clap your hands and light comes on. Turns after preset delay. (4 AA's req'd). £2 ref J2P3.
FERGUSON SRB1 REMOTE CONTROLS. Brand new units ideal for a spare or have two remotes! £4 each.

IN SUSSEX? CALL IN AND SEE US!

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

CIRCLE NO. 137 ON REPLY CARD

Fuzzy logic de-fuzzed

It must puzzle people wanting to buy a washing machine to discover that it not only washes cleaner, but uses fuzzy logic to do it; fuzziness is not normally a characteristic of logic. Ross Bannatyne of Motorola in East Kilbride has written a note, *DC410*, to dispel the haze which still exists among engineers.

Bannatyne explains the principles behind the sudden popularity of fuzzy logic: that it is an intuitive method of describing complicated problems in terms such as "fairly hot" or "fast", with no need to be adept at programming; and that it is a powerful, non-linear and efficient way to map outputs to inputs using a small amount of code.

A classic control problem, for example, is the inverted pendulum in **Fig. 1**. To keep the pendulum upright, one has to apply a voltage to the trolley's motor to move it in the same direction as the pendulum, using the angle of the pendulum and the rate of change of that angle as inputs. Four second-order differential equations would normally be needed to solve the problem, which would need a 32-bit floating-point processor.

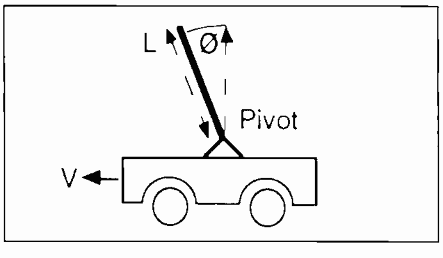


Fig. 1. Classic control problem of inverted pendulum and trolley. Fuzzy logic will do this with a low-cost processor instead of a 32-bit floating-point type.

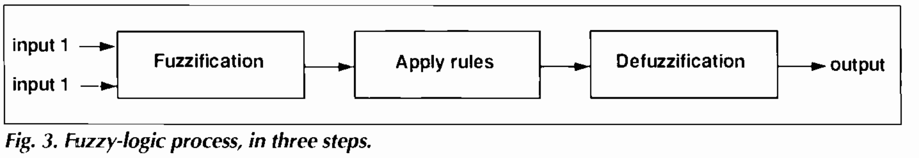


Fig. 3. Fuzzy-logic process, in three steps.

Fuzzy logic embedded software will do the job with a 2MHz *68HC11*. An even more compelling point is that the use of fuzzy logic can shorten development time by up to 90% in some cases and will certainly reduce the size of required memory – look-up memory does nor assume the importance it does in conventional techniques of input/output mapping.

The two diagrams in **Fig. 2** illustrate the way in which relatively imprecise descriptions can be made more precise than exact ones. In the left-hand diagram, "1" and "0" qualities describe whether one is old or middle-aged, so that one is either one or the other and an intersection of the areas would not give much more information except to indicate that one was on the borderline. On the other hand, the fuzzy descriptions show that a 48-year-old is 80% middle-aged and 20% old.

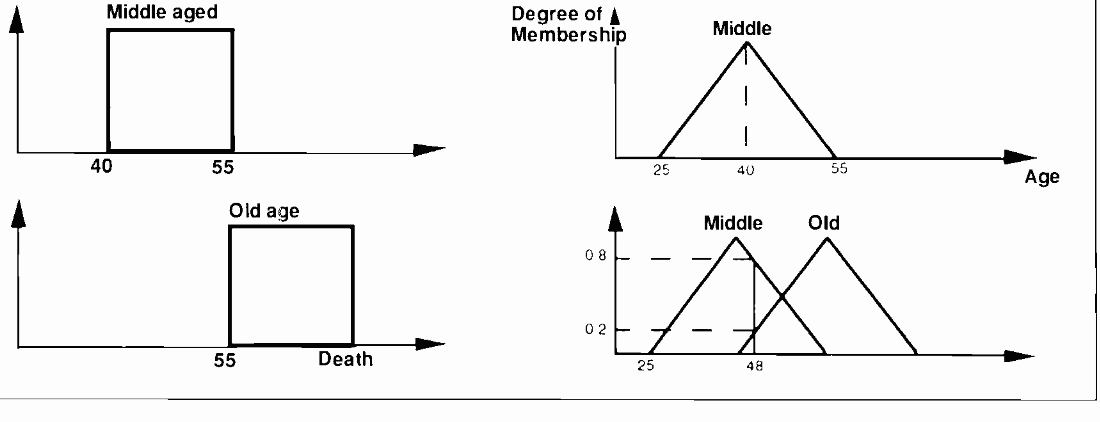
Figure 3 shows the fuzzy procedure in broad outline. The first block "fuzzifies" the input, converting input values to the amount to which they belong to one of the Fig. 2 sets allotted to describe them, or their degree of "membership". An "expert" knowledge defines the limits and degrees of membership; for example how hot is "hot" in a furnace or how fast is "fast" in an engine. The advantage here is that to get to the final solution one has simply to tune the degrees of membership.

In the second block, rules are applied, these rules being written in "fuzzy inference" language such as IF-AND-THEN. if, for example, it is "cold" outside AND it is "not very warm" inside, THEN turn the heating on.

Lastly comes de-fuzzification to give a definite output.

Motorola Ltd, *European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP.*

Fig. 2. Difference between bivalent sets and fuzzy sets. With fuzzy sets you can be more middle-aged than old, not on or the other.



DC-to-DC converter transistors

Note AN81 by Zetex describes use of the company's hi-rel range of E-line bipolar and mosfet transistors in DC-to-DC converters, providing up to about 10W for small equipment such as fluorescent tubes and flash guns.

With high current capability, these devices will easily function in a single-transistor converter such as the 8W fluorescent lamp inverter in **Fig. 1**. Such a load comes well inside the "awkward" category, since it needs a high voltage to strike, whereupon if promptly becomes a low-impedance load, taking up to about 3A for this size of lamp. Instead of an expensive T0220 kind of device, the Zetex E-line *ZTX652* will handle the variable load, supplying the current without needing a high $V_{CE(sat)}$.

Figure 2 is a minimal converter giving +12V and –5V for memory, interface and display circuits from a 5V supply. Two *ZTX449*s working at 25kHz have to supply up to 1.5A peak at $V_{CE(sat)}$ of 250mV to give decent efficiency from 5V.

Capacitors are another type of difficult load since, in a typical flashgun for example, the voltage across them varies from 0 to 400V during the charging cycle. A flyback converter to isolate the load from the switching circuit is one answer and Fig. 3 is an example, the higher peak switching current needed in a flyback converter over a forward converter putting the high current and low saturation voltage of these transistors to good use. A shutdown sensor avoids output C overcharging and increases battery life.

Zetex plc, Fields New Road, Chadderton, Oldham OL9 8NP. Tel: 061 627 5105.

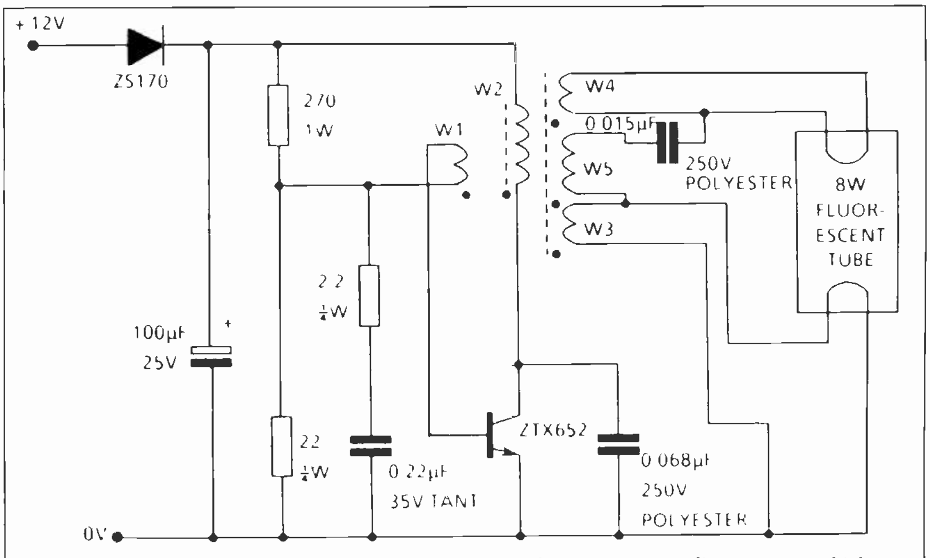


Fig. 1. Single-device 8W converter for a fluorescent tube, using Zetex E-line ZTX652, which passes high current at low saturation voltage.

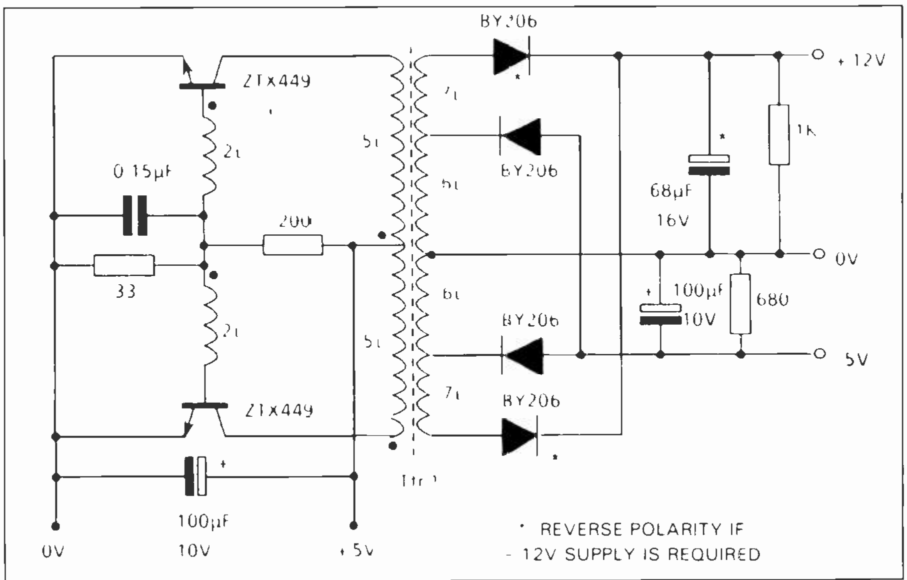


Fig. 2. 5W converter for memories and interfaces, powered by a 5V supply.

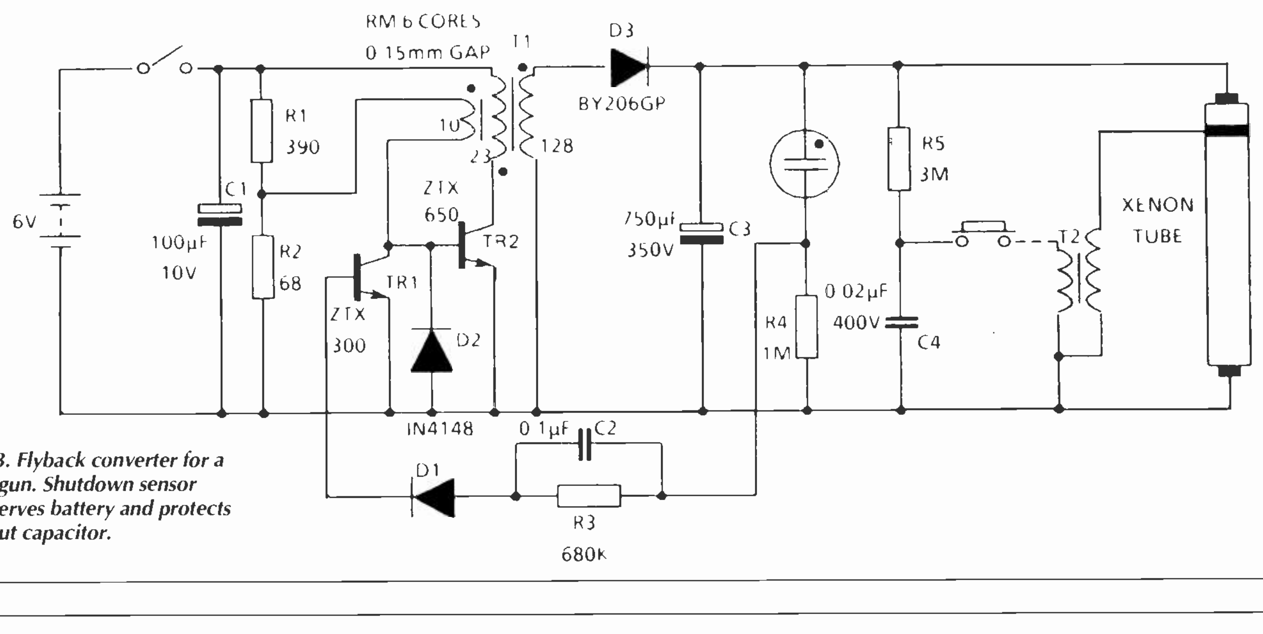


Fig. 3. Flyback converter for a flashgun. Shutdown sensor conserves battery and protects output capacitor.

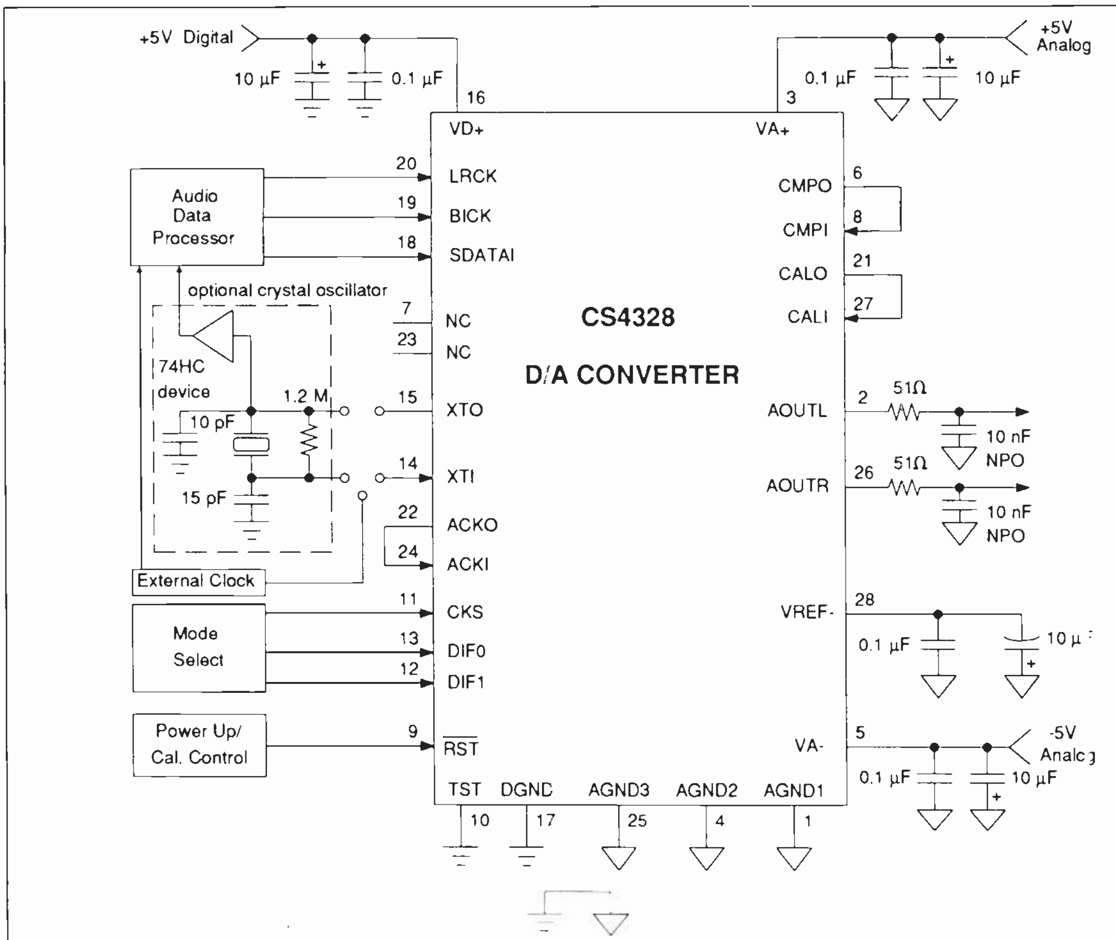


Fig.1. Connection diagram of Crystal's CS4328 D-to-A converter for stereo digital audio, which takes in data at 48kHz, 44.1kHz and 32kHz, producing line-level output.

Stereo D-to-A converter

Crystal's *CS4328* is an audio stereo digital-to-analogue converter for digital audio which contains, in addition to the D-to-A function, an eight-times digital interpolation filter and a 64x oversampled delta-sigma modulator to control the reference voltage to an ultra-linear analogue low-pass filter, allowing adjustment of the sample rate between 1kHz and 50kHz simply by changing the clock frequency while maintaining a linear phase response.

Figure 1 shows a typical application circuit and **Fig. 2** the sequence of operations. Audio first sees the digital interpolation filter, which takes out images of the input signal at multiples of the sample frequency F_s of less than eight times. This leaves multiples of 8 x sample frequency and reduces filtering requirements, leaving the audio band intact, as in **Fig. 3**.

Then comes a sample-and-hold stage in which data points from the interpolator are held for eight clock cycles ($64xF_s$). The response is a sinx/x shape with zeros at 8 F_s multiples, suppressing the $8xF_s$ signals and getting rid of much of the energy surrounding them, as in **Fig. 4**. The result of all this as data at a rate of 64 F_s.

In a 48kHz sampling system, the delta-sigma modulator receives data at 3.072MHz and carries out fifth-order noise shaping, allowing 1-bit quantisation to support 18-bit processing by suppressing quantisation noise

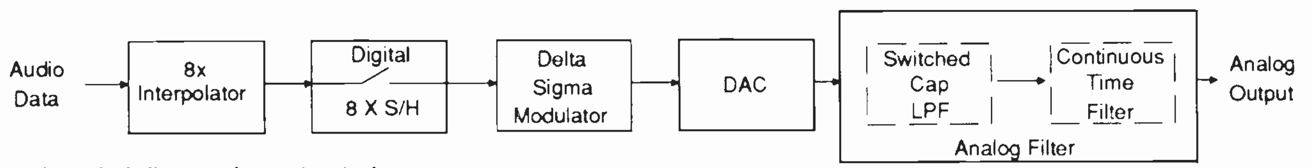


Fig.2. Block diagram of operations in the CS4328.

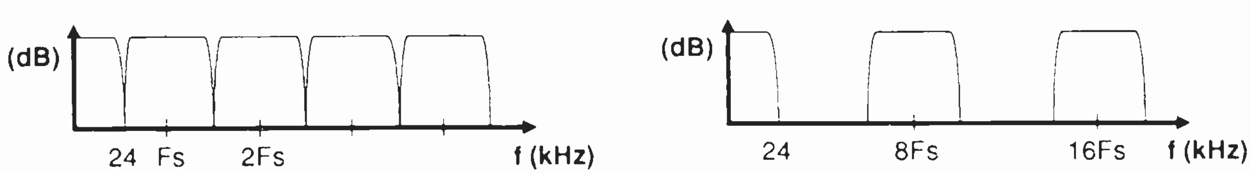


Fig.3. At the interpolation filter output, all images of the input at less than eight times Fs are removed, considerably easing filtering requirements.

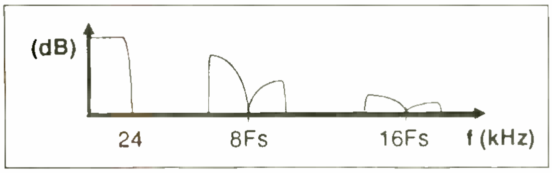


*Fig. 4. Interpolation filter zeros are at 8*Fs, taking out these frequencies and most of their energies.*

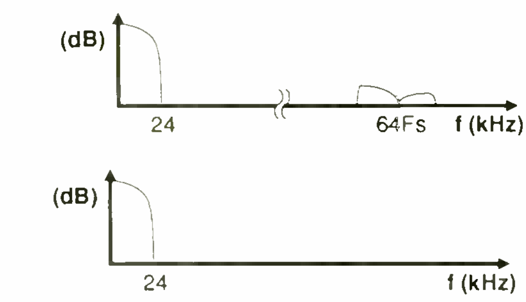


Fig. 5. After the switched-capacitor and continuous-time filters, this is the resulting spectrum.

in the relevant bandwidth.

A D-to-A now translates the 1-bit signal to a series of charge packets, the magnitude of each determined by sampling a reference to a switched capacitor where the polarity of each packet is controlled by the 1-bit signal. This system is insensitive to clock jitter.

Analogue filtering consists of a switched capacitor low-pass and a continuous-time type, **Fig. 5** showing the output of the S-M type and that of the second filter.

An evaluation board from Crystal carries the *CS4328* and a *CS8412* digital audio receiver, taking data from AES/EBU, S/PDIF and EIAJ-340 sources and also providing timing for the CS4328. **Figure 6** shows its block diagram.

Note *CS4328* by Crystal Semiconductor Corporation, which is available here from Sequoia, gives full details of the evaluation board, including PCB layouts.

Sequoia Technology Ltd, *Unit 5, Bennet Place, Bennet Road, Reading, Berkshire, RG2 0QX. Telephone 0734 311822.*

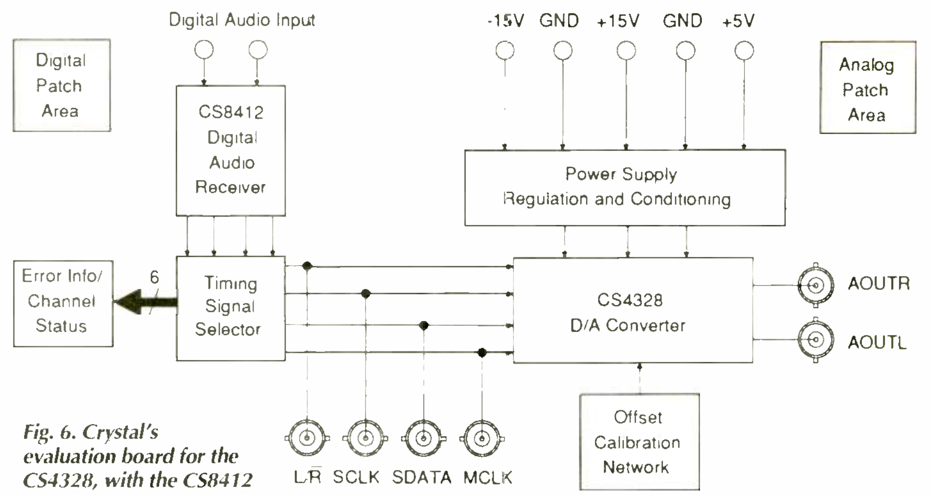


Fig. 6. Crystal's evaluation board for the CS4328, with the CS8412 digital receiver.

BOOKS TO BUY

Credit card orders accepted by phone 081 652 3614

Analog Electronics
Ian Hickman
Good all-round electronics designers are hard to find, according to the recruitment specialists. There are either bad all-rounders or good specialist (for example, microwave, power supply, microprocessors specialists). Many young designers have been lured away from the fundamentals of electronic design to more 'glamorous' digital work. yet there are many simple pieces of electronic equipment for which a purely analogue realisation is still cheaper, more reliable and more appropriate than a microprocessor-based solution. Analogue staff are in desperately short supply, and in many fields - telecommunications for example - analogue skills are very much in demand. Ian Hickman's latest book includes many examples from his large collection of circuits (built up over thirty years in commercial, professional and defence electronics), selected for their usefulness in a wide range of applications. Hardback 300pages.
Price £32-40

Circuit Designers Companion
Tim Williams
This compendium of practical wisdom concerning the real-world aspects of electronic circuit design will be invaluable for linear and digital designers alike. The subjects covered include grounding, printed circuit design and layout, linear ICs, logic circuits and their interfaces, power supplies. electromagnetic compatibility, safety and thermal management. How to design to production and to cost restraints is stressed throughout. The style is direct, lucid and non-academic, aimed at the practising designer who needs straightforward,easy-to-follow advice. Hardback 320pages.
Price £26-50

Electronic Alarm Circuits Manual
R M Marston
One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary. Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur. Paperback 144pages.
Price £13-95

Filter Handbook
Stephan Niewiadomski
A guide to electronic filter design and implementation, clearly written and without the enormous amount of mathematics usually found in books on this subject. Especially of interest for electronics engineers and technicians, students, enthusiasts and also radio amateurs. Hardback 208pages.
Price £26-50

Modern Electronic Test Equipment
Keith Brindley
Describes in a down-to-earth manner how the main categories of test equipment work, allowing the reader to compare available instruments, make an informed choice and then to use the equipment to the best advantage. Any engineer, technician, scientist, student or teacher who reads the book will have a better understanding of the equipment and get better service from his instruments. Paperback 224pages.
Price £15-95

Servicing Personal Computers
Michael Tooley
This book sets out the principles and practice of personal computer servicing in a handy reference manual. It contains a wealth of information, including a large number of circuit and block diagrams. Various software diagnostic routines have been included together with listings and, where appropriate, actual screen dumps. Numerous photographs show typical adjustments and alignment points. It is for anyone concerned with the maintenance of personal computer equipment or peripherals, whether professional service technician, student or enthusiast. Hardback 256pages.
Price £27-00

Newnes Radio and Electronics Engineer's Pocket Book
Keith Brindley
A compendium of facts, figures and formulae for the designer, student, service engineer and all those interested in radio and electronics. Paperback 328pages.
Price £10.95

Newnes Electronic Assembly Book
Keith Brindley. Hardback 304pages.
Price £11.95

Newnes Z80 Pocket Book
Chris Roberts
Aimed at practising electronic and software engineers and technicians involved with the design, manufacture, testing of maintenance of Z80 type microprocessors based equipment. It is also aimed at students following courses in microprocessor related subjects. Contents include packages, pinouts and specifications; processor operation and signal timing; internal architecture; the flags; instruction address modes; instruction set; interrupt response; programming techniques and support chips. Hardback 185pages.
Price £13-95

Newnes 68000 Pocket Book
Mike Tooley. Hardback 257pages.
Price £13-95

Newnes 8086 Pocket Book
Ian Sinclair. Hardback 342pages.
Price £11-95

Newnes Electrical Pocket Book
21st Edition
E A Parr. Paperback 526pages.
Price £13-95

Diode, Transistor and FET Circuits Manual
R M Marston
Specifically aimed at the practical design engineer, technician and experimenter but will also be of interest to the electronics student and the amateur. Subjects covered include basic diode circuits; Special diode circuits; Transistor principles; Transistor amplifier circuits; Transistor oscillators and astables; Transistor audio amplifiers; Transistor circuit miscellany; FET Principles; JFET circuits; MOSFET circuits; VMOS circuits; Unijunction transistor circuits. Over 340 carefully selected and outstandingly useful practical circuits, diagrams, graphs and tables. Paperback 240pages.
Price £13-95

Digital Audio and Compact Disc Technology
L Baert, L Theuissen and G Vergult
Essential reading for audio engineers, students and hi-fi enthusiasts. A clear and easy-to-follow introduction and includes a technical description of DAT (digital audio tape). Contents includes principles of digital signal processing, sampling, quantization, A/D conversion systems, codes for digital magnetic recording, principles of error correction, the compact disc, CD encoding, opto-electronics and the optical block, servo circuits in CD players, signal processing, digital audio recording systems, PCM, Video 8, R-DAT and S-DAT. Hardback 240pages.
Price £18-45

The Scanner Handbook:
A Complete Guide to the Use and Applications of Desktop Scanners
Stephen Beale and James Cavuoto
Desktop scanners are quickly becoming standard components in personal computer systems. With these electronic reading devices, you can incorporate photographs and illustrations into a desktop publishing program, convert printed documents into text files, and perform advance-capability facsimile transmission. The book is an informative guide to selecting, installing and using a scanner. Paperback 254pages.
Price £20-95

Open Systems:
The Basic Guide to OSI and its implementation
Peter Judge
A concise, clear guide to this complex area of computer standards, untrammelled by jargon and with appropriate analogies to simplify this difficult topic. This book is essential for users and suppliers and is required reading for all in the computer industry.
"It is the best introduction to the subject I have

Please send me the following books...

....

....

I enclose a cheque/postal order/eurocheque to the value of £...................made payable to Reed Business Publishing Ltd or Please debit my Access/Visa/American Express/Diners Club with £......................Card Number.. Card expiry date............................ Signature..................................Date.............................

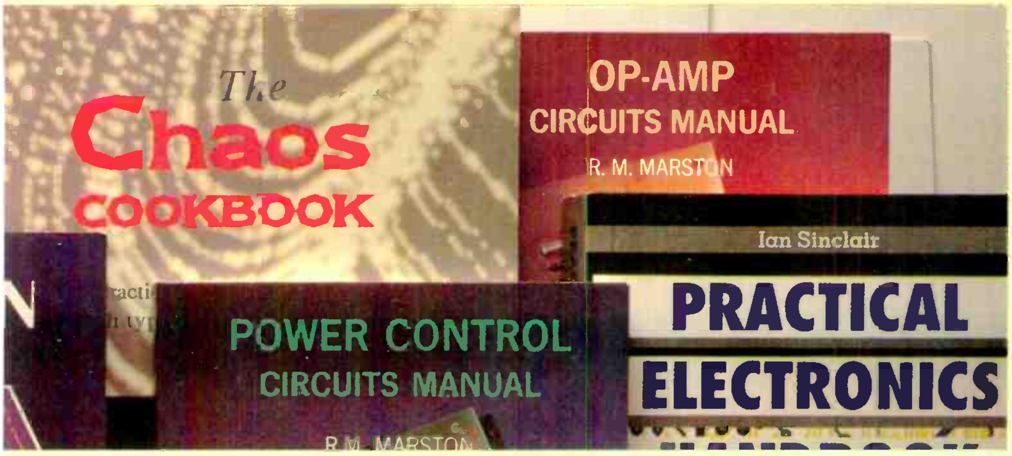
Name..Address..

....

....Postcode.....................................Phone...............................

Return to: Lorraine Spindler, Rm L333, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. PRICES INCLUDE POSTAGE AND PACKAGING. Please allow 21 days for delivery.

Credit card orders accepted by phone 081 652 3614



seen" - John Spackman, former Director, Computing and Information Services, British Telecom. Paperback 184pages.
Price £13-95

Audio IC Circuits Manual
R M Marston
Contents include: audio and pre-amp circuits, dual audio pre-amp circuits, audio power amplifier circuits, high-power audio circuits, LED bar-graph displays and CCD audio delay-line circuits. Paperback 176pages.
Price £13-95

Analog Circuit Design
Art, science and personalities
Edited by Jim Williams
Thirty well known contributors share some of their insights, knowledge, and perspectives on analogue design. Taken as a whole, these authors demonstrate that analogue design is less a set of techniques and methods to be rigorously followed than a way of thinking about things. This book isn't a text book, nor is it really a 'tutorial' in conventional sense of the term. Instead, its primary goal is to help the reader think in an analogue way. It is the latest title in the 'EDN series for Design Engineers'. Hardback 390pages.
Price £32-00

Troubleshooting Analog Circuits
Robert A Pease
Troubleshooting Analog Circuits is based on a series of articles that became one of EDN's most successful and well-read, and found an enthusiastic audience among electronic engineers and technicians.
Contents: Introduction; Troubleshooting linear circuits - the beginning; Choosing the right equipment; Getting down to the component level; Solving capacitor-based troubles; Preventing material and assembly problems; Solving active-component problems; Identifying transistor troubles; Operational amplifiers - the supreme activators; Quashing spurious oscillations; The analogue-digital boundary; Dealing with power components; Round-up of loose ends; Floobydust; Letters to Bob; Troubleshooting charts; Appendices. Hardback 220pages.
Price £21-45

Newnes Electric Circuits Pocket Book
Linear IC
Ray Marston
Newnes Electronic Circuits Pocket book is aimed directly at those engineers, technicians, students and competent experimenters who can build a design directly from a circuit diagram, and if necessary modify it to suit individual needs. Hardback 336pages.
Price £13-95

Microprocessor System Design
A Practical Introduction
Michael Spinks
An introduction to essential concepts and techniques underlying the design of useful electronic circuits, especially microprocessor boards and their peripherals.
No previous knowledge of electronics is assumed: new terms and ideas are explained as they arise, maths and jargon are kept to a minimum. After an introduction to the groundwork of electronic circuits - digital and analog components, op amps and PALS - the reader goes on to discover how microprocessors work and how they are used in bus-based systems. Michael spinks uses real industrial circuits as examples - including some with specialized applications - and includes a chapter on practical problems such as debugging, and a comprehensive glossary. Paperback 247 pages.
Price £21-95

Communication Services Via Satellite
G.E. Lewis
Satellite communication systems are capable of carrying not only all existing telecommunications services to reach previously inaccessible areas, but also new services which were not feasible before the advent of satellites. Satellite communications systems create a series of new technical problems, requiring new solutions, for the engineers involved in communications and television services equipment. Such engineers will find this book an invaluable guide to how the system signal is coded, modulated, demodulated and processed, and they will obtain a good understanding of the way in which the system functions. Several actual systems are described and a number of analyses and design rules are included. This book is aimed at systems design engineers involved in the commissioning, design and installation of communications and television services equipment. Service engineers and technicians will also find it valuable reading. Paperback 386 pages.
Price £27-00

The Chaos Cookbook
A Practical Programming Guide with type-in-and-go Listings
Joe Pritchard
It is rare for mathematics to capture popular imagination but chaos has done so. Chaos sets ultimate limits on what science can predict. It is mathematics theory about prediction, a model that describes the relationship between past and future, explaining how natural and man-made systems behave. Equations defining chaotic systems are often very simple but give rise to exceedingly complex and, if the behaviour is converted into a computer graphics display, beautiful results. The Chaos Cookbook examines chaos theory in a much more practical way than other books. Chaos is not just a way of generating computer graphics, or a mathematical curiosity. It has relevance to the real world and the easiest way to explore and visualize chaos is through the computer screen. The book uses the computer as a tool and provides programs to run that demonstrate the concepts, including type in and go listings, which even the initiated will appreciate as they are absent from other books. Paperback 366 pages.
Price £19-95

OP-AMP Circuits Manual
R. M. Marston
The operational amplifier (op-amp) is a direct-coupled high-gain differential amplifier that can readily be used as the basis of a variety of ac or dc amplifiers, instrumentation circuits, oscillators, tone generators and sensing circuits etc. It is one of the most popular and versatile 'building blocks' used in modern electronic circuit design and is available in three basic forms: the 'standard' (741, etc.) type, the 'Norton' (LM3900, etc.) type and the OTA (CA3080 and LM13600, etc.) types. This manual explains how each of these devices works and shows how to use them in practical applications. The manual presents a total of over 300 practical circuits, diagrams and tables, and is specifically aimed at the practical design engineer, technician and experimenter. Easy-to-read, down-to-earth, non-mathematical but a very comprehensive manual. Paperback 211 pages.
Price £13-95

Power Control Circuits Manual
R. M. Marston
Electronic power control circuits can be used to control (either manually or automatically) the brilliance of lamps, the speed of motors, the temperature of heating devices such as electric fires or radiators, or the loudness of audio signals, etc. This control can be achieved using electromechanical switches or relays, or electronic components such as transistors, SRCs, TRIACs, or power ICs, etc. This book takes an in-depth look at the whole subject of electronic power control, and presents the reader with a vast range of useful circuits and diagrams. Contents: Basic principles, Switch and relay circuits; CMOS switches/selectors; AC power control circuits; DC power control circuits; DC motor control circuits; Audio power control circuits; DC power supply circuits. Paperback 198 pages.
Price £13.95

Practical Electronics Handbook
Ian Sinclair
Ian Sinclair has completely update and revised this popular title. It still contains a carefully selected collection of standard circuits, rules-of-thumb, and design data for professional engineers, students and enthusiasts involved in radio and electronics, but is now over one hundred pages bigger. The book covers many areas not available elsewhere in such a handy volume, and this new edition now includes chapters on microprocessors and microprocessor systems, digital-analogue conversions, computer aids in electronics plus hardware components and practical work. Paperback 338 pages.
Price £15-95

Books published by Butterworth-Heinemann.

SPECIAL OFFER

Microprocessor Architectures and Systems
RISC, CISC & DSP
Steve Heath
A guide to microprocessor architectures explaining the differences, advantages and disadvantages, and design implications. With most semiconductor manufacturers supplying only one type of architecture, processors becoming more complex than mainframe computers, and design cycles shortening from two years to six months, it is vital for designers to choose the right processor. Steve Heath is processor technology specialist for Motorola.Hardback 300pages.

Normal Price £36-50 Now only £19.95 to EW + WW Readers

Self-calibrating noise source using silicon

Modern semiconductor noise sources for testing communications equipment need calibrating by the manufacturer. As a result, they are too expensive for many people. T H O'Dell describes a novel way around the calibration problem.

In the past it was possible to obtain temperature limited thermionic diodes suitable for use as self-calibrating noise sources in the HF and VHF bands.

Writing in 1982, Jessop[1] may well have been the last author to describe such a noise generator. He gave a detailed design, based on **Fig. 1**, involving a diode with a plain tungsten filament fed by a variable 0-6V supply. To provide the source impedance needed for HF and VHF receiver noise measurements, the diode passed its anode current into a 75Ω resistor R_s.

As **Fig. 2** shows, the thermally limited anode current, I_A, of such a diode varies with anode voltage, V_A. In such a thermally limited diode, there is a wide-band noise current superimposed on the anode current with a mean square value

$$\overline{i_n^2} = 2eI_AB \qquad (1)$$

where e is the electron charge, 1.6×10^{-19}C, and B is the system bandwidth in hertz. The noise generator of Fig. 1 is connected to the receiver input which is matched to R_s. As a result, noise power delivered to the receiver must be

$$P_n = \frac{\overline{i_n^2}R_s}{4} \qquad (2)$$

There is also the maximum available noise power generated by the source, R_s, because of its finite temperature, T. This is well known[2] to be kTB, where k is Boltzmann's constant, 1.38×10^{-23}J/K. Ideally, this unavoidable noise power from input termination R_s would be simply amplified by the power gain of the receiver, G, appearing at the output as kTBG. However, practical receivers are not ideal and produce more noise output power than this.

To indicate how closely the receiver approaches the ideal, the concept of noise factor, F, is introduced. Writing the noise power actually measured at the receiver output as,

$$P_{no} = kTBFG \qquad (3)$$

it is clear that an ideal receiver would have an F of unity. In practice a good HF or VHF receiver will have a noise factor of about two.

The information box "Measuring receiver noise" discusses how noise sources are used.

Semiconductor noise sources

The beauty of the thermionic diode noise generator was its self-calibrating nature. Its shot noise current was given fundamentally by equation one. Now however it has now fallen out of professional use, being replaced by far more reliable, and much wider bandwidth, solid state noise sources incorporating avalanche diodes[5]. These are quite expensive and must be calibrated. The manufacturer measures the absolute noise power output of the source and provides the information with the product, usually as an equivalent noise temperature or an excess noise ratio expressed in decibels.

Commercial solid-state noise sources are outside the budget of many. It would be nice if there was a modern solid state replacement with the same self-calibrating feature as the old thermionic diode. My proposal, shown in **Fig. 3**, is essentially a photodiode illuminated by a simple filament lamp. Comparing **Figs. 2** and **3**, it is clear that both devices share the same very high impedance characteristic, with the photodiode having the great advantage of working at a much lower voltage.

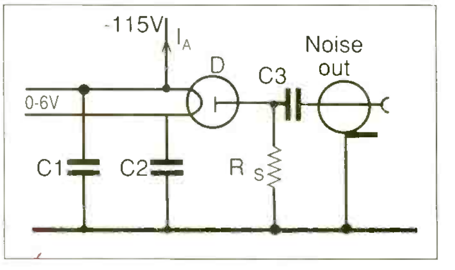


Fig. 1. Needing no calibration, thermionic diode noise sources were cheap relative to modern equivalents using avalanche diodes. R_s is 75 or 50Ω.

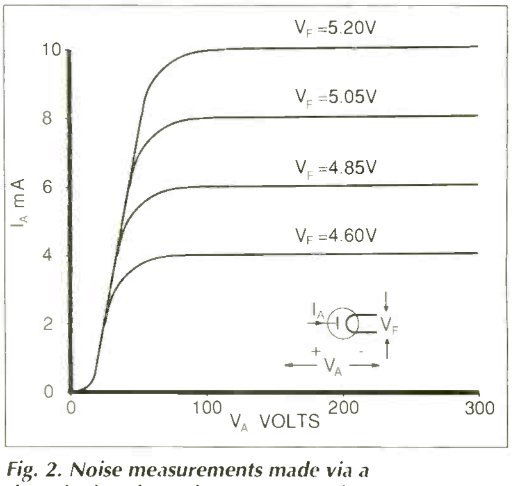


Fig. 2. Noise measurements made via a thermionic valve noise generator rely on increasing saturation anode current by increasing filament voltage. These curves are based on a CV172 diode generator.

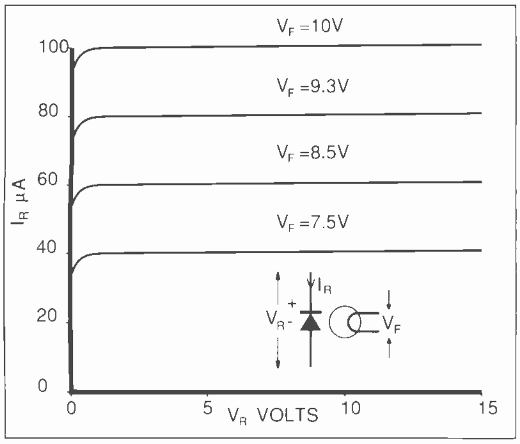


Fig. 3. Curves with similar characteristics to those of the thermionic diode, Fig. 2, are produced when a Hewlett Packard 5082-4220 photodiode is combined with a 12V, 0.5A filament lamp.

Both devices also share the same fundamental shot-noise component:

$$\overline{i_n^2} = 2eI_AB$$

for the thermionic diode and

$$\overline{i_n^2} = 2eI_RB$$

for the photodiode.

Unfortunately, for sensible levels of illumination, the photodiode can only provide reverse currents up to about 100μA. As the first equation in the panel shows, when R_s = 75Ω, anode current will need to be a few milliamps if noise factors as high as two or three are to be measured.

Figure 2 shows that a maximum anode current of 10mA would be ideal, which means that the photodiode falls short by a factor of 100 as a direct replacement for the thermionic diode. In all other respects however the photodiode looks well worth considering. Its power supply problems are trivial and its high frequency performance should be excellent.

High-speed diodes, like the Hewlett-Packard *5082-4220*, or the readily available *BPX65* can be relied upon to give a shot-noise current up to several hundred megahertz.

Making the impedance that the photodiode drives a hundred times bigger overcomes its shortfall in current capability. This calls for an impedance transformation of 100:1 between the photodiode and R_s, the output impedance of the noise generator. Of course an impedance transformation of 100:1 calls for a 10:1 transformer, and it is just not possible to realise this over a wide RF bandwidth. On the other hand, a narrow-band 10:1 transformer is a simple design problem.

Three possible ways of solving the design problem are shown in **Fig. 4**. In all three cases, a high-Q resonant circuit couples the photodiode, represented by the current generator, to the low impedance output socket. In **Fig. 4(a)** a resonant transformer is used, in **(b)** the impedance transformation is effected by making the tuning capacitor act as a potential divider, while in **(c)** a tapped inductor is used. In all three cases additional damping is provided by resistor **R** to make the output impedance of the noise generator 75 or 50Ω as required.

Although described as narrow-band, the impedance transformation will have a bandwidth much greater than the bandwidth of the apparatus being tested. A communications receiver usually has an overall bandwidth below 10kHz whereas the photodiode noise generator has a bandwidth of more than 100kHz.

Measuring receiver noise

Initially when using a thermionic diode noise generator the filament is cold and anode current is zero. The only noise output power should be P_{no}, given by equation three in the main text. Great care must be taken to isolate the receiver being measured from unwanted signals[3].

A relative indication of noise power can be obtained by simply measuring the RMS voltage across the receiver audio output. Of course the receiver must be working at such a low level input that its AVC has no effect, otherwise it will be non-linear and none of the simple linear theory being used here applies.

Diode filament voltage is then increased, causing anode current to rise, until noise output power from the receiver is just doubled. When this is done, GP_n must be equal to output noise power P_{no} given by equation three in the main text; receiver input noise power P_n is given by equation two.

Writing this equality down, substituting equation one and re-arranging provides the well known result for the noise factor[4],

$$F=20I_AR_S$$

when R_s is at room temperature, 290K, for which kT/e has the value 25mV.

Similarly, noise factor is measured using the photodiode source by connecting it to the receiver and first measuring noise power output with the lamp off. Supply voltage to the lamp is then increased until the noise output power is doubled. At this point the value of the photodiode current, I_R, is noted.

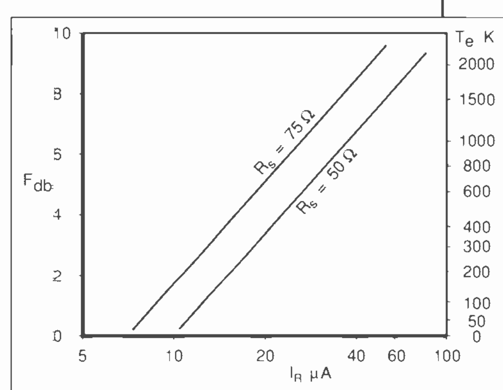
Following the same argument that led the previous equation, noise factor F is given by $2000I_RR_S$, where account is taken of the 100:1 impedance transformation.

Usually, the noise figure is quoted in decibels which is related to the noise factor by

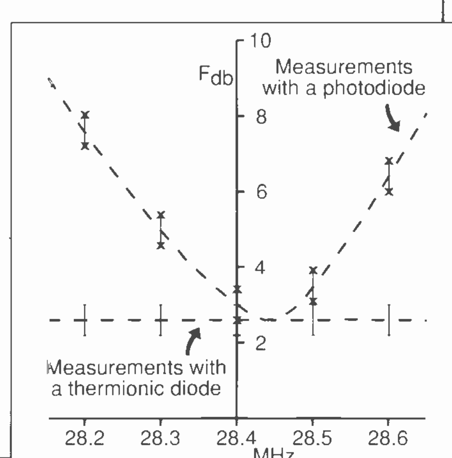
$$F_{dB} = 10\log_{10}(F)$$

Noise in decibels as a function of photodiode current for source resistance values of 75 and 50Ω, is shown in the first plot. Effective input noise temperature, T_e=290(F-1), is also scaled to the right. Since noise in modern communications systems can be very small indeed[2], expressing noise in this way is becoming more popular than the straightforward noise figure.

As this is a relatively narrow band noise-source it is vital that measurements are made as close to the centre of its operating bandwidth. In the second graph, you can see that this is easily checked by making a few measurements across the band.



Increasing photodiode reverse current increases noise predictably. Here, resulting noise is expressed both as decibels and as effective input noise temperature.



Comparing measurements made on a DX200 communications receiver reveals both the accuracy of the photodiode noise source and the need to use it as close as possible to the centre of its operating frequency. At 28.43MHz, both the thermionic and photodiode noise sources agree that the noise figure is 2.6dB.

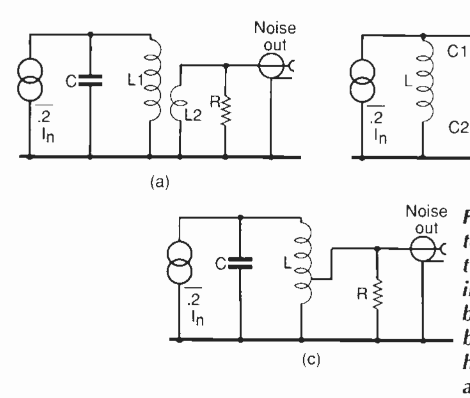


Fig. 4. Matching a photodiode noise source to a receiver's input needs an impedance transformation of 100:1, which is impossible to realise over a wide bandwidth. These three high-Q narrow-band circuits all solve the problem but (c) has the advantages of easy implementation and low component count.

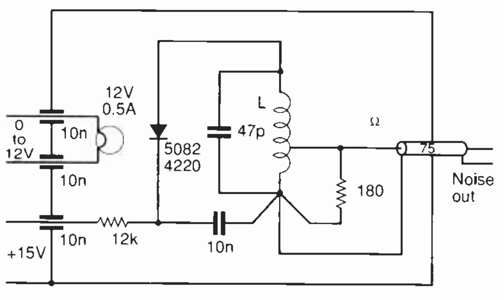


Fig. 5. Practical noise source for the 28MHz band. In common with most RF measurement equipment, this circuit needs careful construction but unlike avalanche-diode equivalents it avoids expensive calibration.

All three methods of impedance transformation shown require good RF voltage and impedance measurement facilities to verify the design. The tapped inductor of Fig. 4(c) is the least demanding however and also involves least components.

Applying the design

Figure 5 shows the circuit of a photodiode noise generator for use in the 28MHz band which has been built by applying the ideas discussed. **Figure 6** is a photograph of the actual hardware.

Inductor L is a low capacitance, high Q coil comprising 10 turns of 0.85mm (20SWG) copper wire, 15mm in diameter with its turns spaced 2.5mm apart. It is best made by winding about 15 turns, closely spaced, on to a 12.5mm diameter rod. This 15 turn winding is then allowed to expand by its own springiness and slipped off the rod. You will then find it possible to screw the coil into the holes of a small piece of 2.5mm pitch pin board, about 25mm by 50mm, so that it occupies two rows of holes in the board which are 15mm apart. Excess turns are then cut off, leaving the ten turns required, and the ends of the coil soldered to two pins. The single turn tap, shown in Fig. 5, is soldered to a third pin.

Although almost entirely air spaced the resulting coil, visible in **Fig. 6**, is rigid and mechanically stable. The 10:1 transformation ratio has been effected here geometrically and subsequent measurements with a high impedance voltmeter should verify that it is sufficiently accurate.

As seen in Fig. 6, the circuit is housed in a small diecast box and the power supplies to the photodiode and lamp enter via feed-through capacitors. It is important to use the grounded end of the inductor as the only ground point inside the box. To this single ground are returned the 47pF tuning capacitor, the 0.01μF photodiode decoupling and the 180Ω damping resistor. Grounding to the box itself is then made through the coaxial lead to the output socket. The negative side of the 15V supply is connected at a point near the +15V feed-through.

These grounding precautions are important, especially if you do not have access to a screened environment. Even if well away from the frequency chosen for measurement, interference may induce currents in the earthing system. These currents can give rise to spurious output from the noise generator if you fail to follow the single-point earth rule.

Additional loss required if the circuit is to present a 75Ω output impedance is provided by the 180Ω damping resistor. The actual value of this damping resistor can only be found by measuring the output impedance, which is best done by comparing it with a standard 75Ω termination at the resonant frequency. Of course the Q of the coil must be large enough to ensure that Q/C is greater than 7.5kΩ. As C is 47pF in this design, the Q at 28MHz must exceed 64, which is not at all demanding.

Fixed tuning is used in this design because it greatly simplifies construction and the problems of screening. No great disadvantage follows because the noise generator has a bandwidth greater than 100kHz. When working outside a screened room, it should be possible to find a quiet spot within this bandwidth for making noise factor measurements. ■

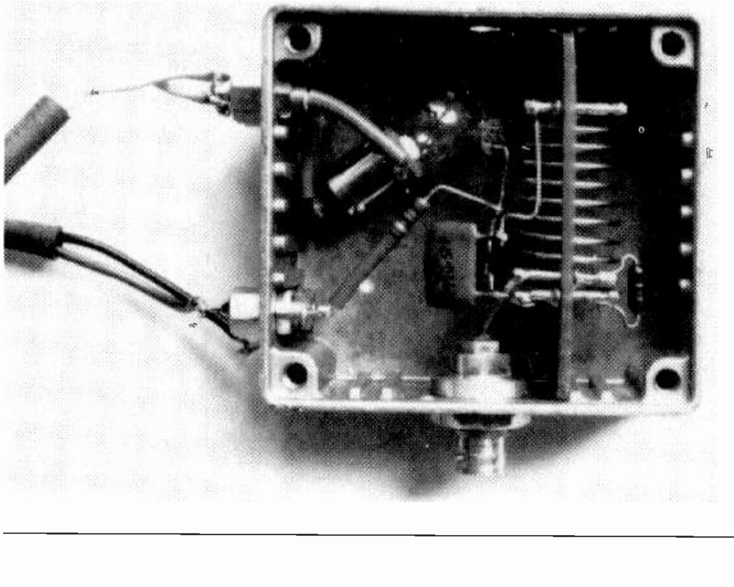


Fig. 6. This photograph of the author's prototype shows how connections are soldered to the lamp to avoid contact noise.

References

1. Jessop, GR, A reliable noise generator, *Radio Communication*, vol 58, pp. 674-6, August 1982.
2. Smith, KL, Noise, *Wireless World*, vol 81, pp. 107-10, 169-73, 235-7 and 326-30, March, April, May and July, 1975.
3. Noise figure measurement accuracy, Hewlett-Packard Application Note No 57-2, November 1988.
4. ARRL Handbook 1991, 68th. Edition, (Newington, CT, 1990) pp. 12-3.
5. Chambers, D.R., A noise source for noise figure measurement *Hewlett-Packard Journal*, vol. 34, No. 4, pp. 26-7, April 1983.

▶ *from 116*

in proprietary software on a PC, which provides a menu for operation and demonstration to police forces.

Combined networks

Best results have been obtained from a combination of three networks. Two of these are trained to recognise different data representations of a given fingerprint while the third is trained by a combination of the outputs of the first two to give an overall classification of the fingerprint image.

One representation is a digitised and encoded 20 x 20 array of the average directions (measured by angles) of the raised ridges which form a fingerprint. The other representation, called a vorticity map, encodes the curvature of ridges in the image and yields information on the location of features known as cores and deltas. Both are derived from 480 x 480 pixel images.

Each ANN has three interconnected layers of neurons: input (typically 280 neurons), hidden (20) and output (4), using the back error propagation training algorithm[1]. In training, the input layer is presented with a succession of ascii data representations encoded from different fingerprints, while the output layer is presented with the desired output classification data.

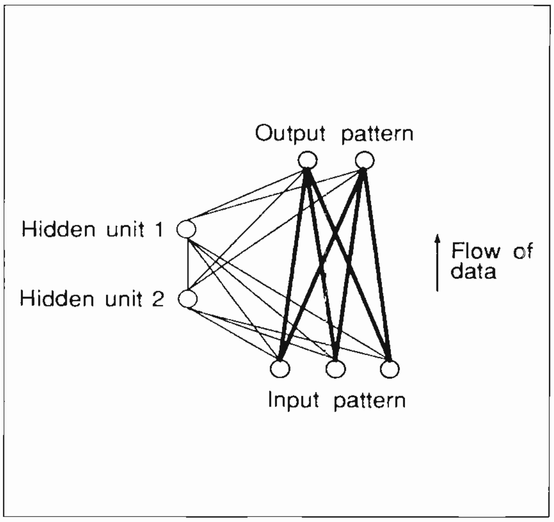
Actual outputs resulting from the input data are compared with the desired outputs and the errors are used repeatedly to adjust the internal weighting of the neurons (multiplication) until the error is as close to zero as possible for all the input fingerprints. Convergence is thus achieved, and the network has been trained to recognize any subsequent fingerprint which falls into the desired output pattern classification.

In tests the multiple ANNs have been trained on 118 different examples of each of four main fingerprint pattern types. These four types constitute 91.4% of the total database, the remainder being distributed among four further pattern types. Test results, given in detail by Bowen, show that over 93% of the fingerprints are classified correctly. Probably in practice the residue of images which cannot be processed automatically in this way will have to be classified manually by a fingerprint expert.

Medical imaging

Neural networks are also being used to recognise and classify biological patterns in medical imaging. The colloquium revealed two experimental approaches – though both with some way to go before they are likely to get anywhere near clinical practice.

Every year in Britain about 4500 women are diagnosed as having cancer of the cervix and about 2500 of them die of it. But if detected and treated at an early stage the disease can be cured, with a 95% success rate. This is where the NHS national screening programme comes in. Regular cervical smear tests detect any abnormal changes in the size, shape and colouring of cells taken from the surface of the cervix.



In the cascade-correlation neural network algorithm, hidden units are introduced one by one to obtain optimum network size for a given task. Neural network systems can achieve better than 90% correct recognition of finger prints and better than 95% detection of cervical cancer cells.

But the complex samples have to be inspected through microscopes by human experts. Each smear contains 200,000 cells and takes up to 10 minutes to inspect, so the task is onerous, fatiguing and slow.

Stephen McKenna of Dundee University's Microcentre reported on experiments using neural networks to distinguish between the monochrome images of individual normal and abnormal cells, each formed by 256 x 256 pixels. For this a set of 80 features is extracted from each image – coincidentally the same number of characteristics in an average fingerprint. The cell image is first converted into a two-dimensional frequency spectrum pattern, using the discrete Fourier transform, to give data compression among other things.

McKenna briefly mentioned work by a colleague, Ian Ricketts, who had used a multilayer perceptron with a single hidden layer of four neurons and training by back error propagation, as in the Home Office project. This classified 96.3% of 524 cell images correctly. But McKenna's paper was mainly devoted to experiments with a cascade-correlation ANN for the same application.

The idea is to avoid the difficulty with multi-layer networks of finding the best number of hidden layers and neurons. For a specific task this has to be done experimentally and is not at all straightforward.

Moreover the cascade-correlation ANN is about 20 times faster to train.

Cascade-correlation is what is called a constructive algorithm. You start with a single-layer ANN, train it, then add hidden neurons to it one by one, training as you go, until the network error becomes acceptably small. The added neurons come from a pool of candidates. All these are trained, and the most successful candidates are connected to the output layer while the others are discarded.

The best result achieved with this method, using four hidden neurons, was 95.8% of cervical cells classified correctly. Obviously, where health and life are at stake we need 100% correct classification. So is the ANN automatic inspection technique worth pursuing and can we ethically allow a trade-off between throughput and reliability? When deciding, we should note that even expert cytological workers can, and have, made mistakes in this field.

Computerised tomography

In the second medical imaging application, a combination of two ANNs is used to recognise the presence or absence of a condition called baso-spasm in the brain. This disorder is shown up by blood flowrates in the brain, observed from a series of cross-sectional images obtained by single-photon emission tomography.

Julian Mason, speaking for Warwick University and Walsgrave Hospital, Coventry, explained that the initial images represented 16 transverse "slices" 1cm thick through a patient's brain, constructed by computerised tomography. Arrays of pixels from these were converted into data and applied to two multilayer perceptrons with back error propagation.

The first ANN was trained on the individual slices and the second on the 16 outputs from the first, thus giving a result for each complete brain. He claimed that correct overall classification on patients was better than 95%.

Again the ANNs were simulated in software on a digital computer. To avoid the great expenditure of time needed to implement a massively parallel network on a serial machine, Mason and colleagues have been considering using commercial logic chips to achieve similar results. But simulated networks using the probabilistic logic node principle 2 have not yet performed satisfactorily. ■

Background
1. "An introduction to computing with neural nets" by Richard Lippman, IEEE ASSP Magazine, April 1987.
2. "Artificial neural networks" by Tom Ivall, *EW + WW*, March 1990.

CLASSIFIED

TEL 081 652 8339 **FAX 081 652 8931**

ARTICLES FOR SALE

VALVES AND C.R.T.s

(also Magnetrons, Klystrons, 4CX250/350)

Minimum order charge of £50 + VAT

One million valves in stock. Obsolete types a speciality! Fax or phone for quote.
Special prices for wholesale quantities.
Orders from government departments, overseas etc. most welcome.
Many other types in stock. Please enquire re any type not listed.

CATHODE RAY TUBES 400 different types in stock.
Please enquire if your requirements are not listed below.

						M28.13LG	£45.00
3JP1	POA	D10.230GM	£45.00	E723 (EEV)	POA	M31.182GV	£45.00
12CSP4	£35.00	D13.611GH	£59.00	F28-130LDS	POA	M31.184W	£55.00
1074H	£45.00	D13.630GH	£59.00	F31.12LD	£75.00	M31.190GR	£45.00
1396P	POA	D14.200GM	£75.00	LD708	£75.00	M31.191W	£55.00
8931 (W.H)	POA	D16.100GH97	£65.00	M7.120W	£19.50	M31.325GH	£35.00
CME822W	£7.00	DG7-5	£45.00	M14.100GM	£35.00	M38.100W	POA
CME1523W	£9.50	DG7-6	£45.00	M17.151GVR	£175.00	M40.120W	£59.00
CRE1400	£29.50	DG7-32	£55.00	M23.112GV	£45.00	MV6-5 (Mul)	£50.00
D9.110GH	£45.00	DG7-36	£55.00	M24.121GH	£55.00	SE5FP31	£45.00
CME1431W	POA	DH3-91	£50.00	M24.122WA	£55.00	VLS429AG	POA

4CX250B ITT, used but fully tested .... £20+VAT Discounts for 10 or more pcs
4CX350A Eimac, used but fully tested .... £50+VAT

VALVES Prices on application. Please enquire re any type not listed below.

A2426	EC158	M8162 Mul	Z803U	6F33
A2521	ECC81	M513B	Y644	6L6GC
C1149-1	ECC81 Spec Q	Magnetrons	1B35A	6SL7GT
C1166	ECC82	PC900	2K25	6SN7GT
CCS1	ECC82 Spec Q	PCC89	3B28	12BH7
CV TYPES: Many	ECC83	PD500	3J-160E	12E1
in stock. Not all	ECC83 Spec Q	PL509	4-65A	13E1
listed below.	ECC88	QQV03-10	4-125A Eimac	19AQ5
Please	ECC88 Spec Q	QQV03-10 Mul	4-400A	211
inquire.	EF39	QQV03-20A	4C28	805
CV488	EF73	QQV03-20A EEV	4CX250B	807
CV1881	EF91	QQV06-40A	4CX250BC	811A
CV2355	EF92	QQV06-40A Mul	4CX350A	813
CV4014	EF93	QY3-125	4CX1000A	4635
CV4024	EF95	QY4-250	4CX5000A	5763
CV6087	EL34	QV04-7	5B-254M	6336A
CV7160	EL38	R10	5B-255M	6973
CX1140	EL81	SU2150	5B-257M	8056
DA42	EL81 Mul	TT21	5B-258M	8122
DET22	EL84	S11E12	5U4G	*Sockets:*
DET23	EL5070	TD03-10E	6AK5W	B9A PCB
DF91	GY501	U19	6A56	B9A chassis
E80L	Klystrons	UBC41	6BH6	Octal chassis
E83F	KT61	UCL82	6BJ6	Many others
E88CC	KT81	UY85	6BM6	
E180F	KT88/6550	VL5631	6CH6	
E810F	M8136 Mul	Z759	6CJ6	

Testing to special quality – Military/CV, low microphony etc available on request

BILLINGTON EXPORT Ltd

Unit 1E. Gillmans Industrial Estate. Billingshurst. Sussex RH14 9EZ.
Callers by appointment only.
Telephone: 0403 784961 Fax: 0403 783519
Min. UK order £50 + VAT. Min. Export order £50 + Carriage.

PHILLIPS PM3217 Dual trace 50MHz Delay sweep £320
FARNELL DT12-5 12MHz Dual channel scope £120
FARNELL DT12-14 12MHz Dual channel scope £120
TEKTRONIX 2215 60MHz Dual channel scope £375
TEKTRONIX 475 200MHz Dual channel scope £425
TEKTRONIX 434 50MHz Dual channel scope £250
TELEQUIPMENT D755 50MHz Dual channel scope £180
TELEQUIPMENT D1010 10MHz Dual channel scope £95
TELEQUIPMENT D1010R 10MHz Dual channel scope £95
TELEQUIPMENT D1011R 10MHz Dual channel scope £95
TELEQUIPMENT D1016A 20MHz Dual channel scope £125
SCOPEX 4D10 10MHz Dual channel scope £95
SCOPEX 4D10A 10MHz Dual channel scope £95
SCOPEX 4D25 25MHz Dual channel scope £125
DM64 10MHz Dual channel scope £95
D67A 25MHz Dual channel scope £130
REDIFON 1kW Linear amplifier 1.5MHz–30MHz c/w aerial filter unit – mains power unit and drive unit GK203N £1250
MARCONI Universal Bridge TF2700 .... £120
MARCONI UHF Attenuator DC–1GHz TF2163S £150
MARCONI 2GHz Digital frequency meter 2435 .... £495
GOULD Signal generator J3B £120
KEMO 1.0Hz–100kHz Phasemeter Type DP1 (new) £120
FLUKE 845AB High impedance voltmeter – null detector (new) £500
SIEMENS Level meter 200Hz–620kHz Type D2155 c/w tracking osc. Type W3155 .... £1250
HP 3770B Telephone line analyzer £950

All our equipment is sold with a 30-day guarantee.
SAE for enquiries. Phone for appointment or for demo. of any item.
P&P included UK only. VAT excluded.
For more details please contact:
TELFORD ELECTRONICS, Old Officers Mess, Hoo Farm, Humbers Lane, Horton, Telford, Shropshire TF6 6DJ. Phone: 0952 605451. Fax: 0952 677978.

TURN YOUR SURPLUS TRANSISTORS, ICS ETC, INTO CASH
Immediate settlement.
We also welcome the opportunity to quote for complete factory clearance.
Contact:
COLES-HARDING & CO. 103 South Brink Wisbech, Cambs PE14 0RJ.
ESTABLISHED OVER 15 YEARS
Buyers of Surplus Inventory
Tel: 0945 584188 Fax: 0945 475216

GOLLEDGE
ELECTRONICS
CRYSTALS OSCILLATORS FILTERS
Comprehensive stocks of standard items. Over 650 stock lines. Specials made to order.
OEM support: design advice, prototype quantities, production schedules.
Personal and export orders welcome.
SAE for our latest product information sheets.
GOLLEDGE ELECTRONICS LTD
Merriott, Somerset, TA16 5NS
Tel: 0460 73718 Fax: 0460 76340

SPECIAL OFFER

SATELLITE RECEIVER New Ferguson BSB (Chassis only) **£10**
35cm DISH With LNB 11.7 to 12.7 GHz BSB/2D-MAC ... **£15**
HAND SET Remote Control for above Receiver **£1.50**
D2 MAC EPROM **£10**
PAL/ASTRA Upgrade Board **£20**

All prices exclude VAT & Carriage

Also Large Quantities of Electronic Components For Disposal

TELEPHONE 081 445 0749/445 2713
FAX 081-445 5702

R. HENSON LTD

21 Lodge Lane, North Finchley, London N12 8JG
(5 minutes from Tally Ho Corner)

COURSES

Cooke International

SUPPLIER OF QUALITY USED TEST INSTRUMENTS

ANALYSERS, BRIDGES, CALIBRATORS, VOLTMETERS, GENERATORS, OSCILLOSCOPES, POWER METERS, ETC.
ALWAYS AVAILABLE

ORIGINAL SERVICE MANUALS FOR SALE
COPY SERVICE ALSO AVAILABLE

EXPORT, TRADE AND U.K. ENQUIRIES WELCOME.
SEND S.A.E. FOR LISTS OF EQUIPMENT AND MANUALS.
ALL PRICES EXCLUDE VAT AND CARRIAGE
DISCOUNT FOR BULK ORDERS. *SHIPPING ARRANGED*

OPEN MONDAY–FRIDAY 9AM–5PM

ELECTRONIC TEST & MEASURING INSTRUMENTS

Unit Four, Fordingbridge Site, Main Road, Barnham, Bognor Regis, West Sussex, PO22 0EB
Tel: (+44) 0243 545111/2 Fax: (+44) 0243 542457

INDEX TO ADVERTISERS

OVERSEAS ADVERTISEMENT AGENTS
France and Belgium: Pierre Mussard, 18–20 Place de la Madeleine, Paris 75008.
United States of America: Jay Fenman, Reed Business Ltd., 205 East 42nd Street, New York, NY 10017 – Telephone (212) 867 2080 – Telex 23827.

Printed in Great Britain by BPCC Magazines (Carlisle) Ltd, and typeset by Marlin Graphics, Sidcup, Kent DA14 5DT, for the proprietors, Reed Business Publishing Ltd, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. © Reed Publishing Ltd 1992. *Electronics and Wireless World* can be obtained from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd, INDIA: A.H. Wheeler & Co, CANADA: The Wm Dawson Subscription Service Ltd; Gordon & Gotch Ltd, SOUTH AFRICA: Central News Agency Ltd; William Dawson & Sons (S.A.) Ltd· UNITED STATES: Worldwide Media Services Inc., 115 East 23rd Street, NEW YORK, N.Y. 10010. USA. *Electronics & Wireless World* $5.95 (74513).

Dataman's new S4 programmer costs £495
You could have one tomorrow on approval*

If you've been waiting for S4 we have some good news. It's available now. S4 is the 1992 successor to Dataman's S3 programmer, which was launched in 1987. The range goes back through S2, in 1982, to the original Softy created in 1978. Like its predecessors, Softy4 is a practical and versatile tool with emulation and product development features. S4 is portable, powerful and self-contained. Design and manufacture are State of the Art. S4 holds a huge library of EPROMS, EEPROMS, FLASH and One Time Programmables. Software upgrades to the Library are free for the life of the product, and may be installed from a PROM by pressing a key. *S4 makes other programmers seem oversized, slow and outdated.* S4 is now the preferred tool for engineers working on microsystem development.

Battery Powered

S4 has a rechargeable NICAD battery. On average, you can do a week's work without recharging. On a single charge, up to a thousand PROMS can be programmed – and charging is fast: it only takes an hour. Normal operation can continue during the charging process.

Continuous Memory

Continuous Memory means never losing your Data, Configuration or Device Library. You can pick up S4 and carry on where you left off, even after a year on the shelf. If the NICAD battery loses all of its charge, RAM contents are preserved by the LITHIUM backup battery.

Remote Control

S4 can be operated via it's RS232 Serial Port. The standard D25 socket connects to your computer. Using batch files or a terminal program, all functions are available from your PC keyboard and screen.

Free Terminal Program

You could use any communications software to talk to S4. But the Terminal Driver program, which we include free, is the best choice. It has Help Screens to explain S4's functions and it sends and receives at up to 115200 baud – that's twelve times as fast as 9600 baud. At this speed a 64 kilobyte file downloads in 9 seconds. There is a memory resident (TSR) option too, which uses only 6k of your precious memory, and lets you "hot key" a file to S4. Standard *upload* and *download* formats include: ASCII, BINARY, INTELHEX, MOTOROLA and TEKHEX.

S4 loads its Library of programmables from a PROM in its socket, like a computer loads data from disk. Software upgrades are available free. Download the latest Device Library from our Bulletin Board.

Microsystem Development

With S4 you can develop and debug microsystems using Memory Emulation. This is an extension of ROM emulation, used for prototype development, especially useful for single-chip "piggy back" micros. When you unpack your S4 you will find an Emulator Lead with a 24/28/32 pin DIL plug and a Write Lead with a microhook. Plug the EMULead in place of your ROM. Hook the Write-Lead to your microprocessor's write-line. Download your assembled code into S4. Press the EMULate key and your prototype runs the program. S4 can look like ROM or RAM, up to 512K bytes, to your target system. Access-time depends on S4's RAM. We are currently shipping 85ns parts.

CIRCLE NO. 101 ON REPLY CARD

Your microprocessor can *write* to S4 as well as *read*. If you put your *variables* and *stack* in S4's memory space, you can inspect and edit them. You can write a short monitor program to show your *internal registers*. S4's memory emulation is an inexpensive alternative to a full MDS and it works with any microprocessor. Many engineers prefer it because their prototype runs the same code that their product will run in the real world.

Dimensions & Options

S4 measures 18 x 11 x 4 cm and weighs 520 grams. 128k x 8 (1MB) of user memory is standard, but upgrading to 512k x 8 is as easy as plugging in a 4MB low-power static CMOS RAM. The stated price includes Charger, EMUlead, Write Lead, Library ROM, Terminal Driver Software with Utilities and carriage in U.K. but not VAT.

**Money-back Guarantee*

We want you to buy an S4 and use it for up to 30 days. If it doesn't meet with your complete approval you will get your money back, immediately, no questions asked.

Call us with your credit card details. Stock permitting, we are willing send goods on 30 days sale-or-return to established U.K. companies on sight of a legitimate order.

Customer Support

Dataman's customer list reads like Who's Who In Electronics. Dataman provides support, information interchange, utilities and latest software for S4, S3, Omni-Pro and SDE Editor-Assembler on our Bulletin Board which can be reached at any time, day or night.

DATAMAN tools for microengineering

Station Road MAIDEN NEWTON
Dorset DT2 0AE United Kingdom
Phone 0300-20719
Fax 0300-21012
Telex 418442
BBS 0300-21095
Modem 12/24/96 V32 HST N,8,1


BUYER'S GUIDE TO ELECTRONIC COMPONENTS 1993
Maplin
BSI
REGISTERED STOCKIST
BS 5750
Part 2 1987
Level B:
Quality Assurance
RS-2750
Order your copy of the New MAPLIN Catalogue on sale NOW!
Pick up a copy from any branch of WHSMITH or from our chain of shops for just £2.95 or post this coupon now to receive your copy for just £3.45 inc. p&p. If you live outside the U.K. send £5.50 or 14 IRC's for Airmail in Europe/surface mail outside Europe, or £10.65 or 27 IRC's for Airmail outside Europe.
I enclose £3.45/£5.50/£10.65 (delete as applicable).
Name
Address
Post Code
Send to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, England, SS6 8LR.
WW93
Over 700 product packed pages with hundreds of brand new products.
On sale now, only £2.95
Available from all branches of WHSMITH and Maplin shops nationwide. Hundreds of new products at super low prices!
CIRCLE NO. 102 ON REPLY CARD