Radio Data clock
Easy IR remote control
RS232 port expander
15 channel audio equaliser
Learn S-parameters

Circuit ideas:
Add more hard drives
Single-pot Wien
Current reversing charger
and more...
Hewlett Packard
8642A – high performance R/F synthesiser
(0-1.105GHz) £4750
3315A – synthesiser (200Hz-81MHz) £2400

436A power meter and sensor (various)
from £750
437B power meter and sensor (various) from £1100

Hewlett Packard
Wandel & Goltermann
SPECIAL OFFER
PCN-4 PCM Channel measurement set
(various options available) from £5500

Marconi 6310 – programmable sweep generator
(2 to 20GHz) – new £3250

Marconi 6311 Prog’ble sig. gen. (10mHz to 20GHz) £4000
Marconi 6313 Prog’ble sig. gen. (10mHz to 26.5GHz) £6250

Hewlett Packard
5342A – microwave frequency counter
(500MHz-1GHz) opt 1 & 3 £700
5370B – universal time interval counter £1500
Hewlett Packard 8662A synth. sig. gen. (10kHz to 1200MHz) £8250

Hewlett Packard 33244A synth. function/sweep gen. (21MHz) £2500

OSCILLOSCOPIES
Gould 4998 160MHz 4 channel DSO £15000
Hewlett Packard 54601A £6900
Hewlett Packard 54620A 100MHz - 2 channel £7100
Hewlett Packard 54630A 200MHz - 2 channel £9500
Hewlett Packard 54650A 500MHz - 4 channel £10500
Tectronix 465A 100MHz - DSO £11000
Tectronix 465B 150MHz - DSO £13000
Tectronix 465H 200MHz - DSO £15000
Anritsu MS9710B 100MHz - Dual channel £3250
Anritsu MS9711B 200MHz - Dual channel £3500
Anritsu MS9712B 500MHz - Dual channel £3950
Anritsu MS9713B 1GHz - Dual channel £4350
Anritsu MS9714B 2GHz - Dual channel £4750
Anritsu MS9715B 4GHz - Dual channel £5150
Anritsu MS9716B 6GHz - Dual channel £5550
Anritsu MS9717B 8GHz - Dual channel £6050
Anritsu MS9718B 10GHz - Dual channel £6550

MISCELLANEOUS
Eaton 2075-2A – Noise Gain Analyzer £At £250
Fluke 5100A/B/B (200MHz) – Calibration Units (various available) from £900
Fluke 2805A – Digital Multimeter £300
Hewlett Packard 33210A Distortion measurement set £1200
Hewlett Packard 4434A – 422 Power meters £4500
Hewlett Packard 7762D Dual-Dimensional Couplers £350
Hewlett Packard 3488A – Sweep/Control unit £450
Hewlett Packard 3475A multi meter 6 1/2 digi £950
Hewlett Packard 37614A – Digital Transmission Analyzer £150
Hewlett Packard 37615A – Jitter Generator & Receiver £1250
Hewlett Packard 37616A – 2GHz Frequency counter £950
Hewlett Packard 6822A – Analog System PSV (20-30A) £750
Hewlett Packard 6822B – Digital PSV system £1250
Hewlett Packard 6822C – Quad Output Power Supply £2000
Hewlett Packard 6622A – System Power Supply 800W £350
Hewlett Packard 8118A Pulse-Function Generator (1Hz-20MHz) £1250
Hewlett Packard 8119A - 10MHz Pulse Generator £825
Hewlett Packard 8120A – 25MHz Square Waveform £1350
Hewlett Packard 8121A – Sweep Waveform Generator £1150
Hewlett Packard 8053A DMM-1008A Vector Voltmeter (100k-1GHz) £2500
Hewlett Packard 8053A – DMM-1008A Vector Voltmeter £2500
Hewlett Packard 86568S – Synthesised signal generator £1450
Hewlett Packard 1654B – Syn. sig. gen. (0-1.105GHz) £1150
Hewlett Packard 86620 – Syn. sig. gen. (10kHz-250MHz) £3350
Hewlett Packard 5501B – Modulation Analyzer £2750
Hewlett Packard 8803A – B and E Distortion Analyzer £1950
Hewlett Packard 88070A Noise Figure Meter £1950
Hewlett Packard 1660A – B + Logic Analyzer Mainframes £2000
Hewlett Packard 16501A & C – Logic Analyzer System Expander Frame from £2200
Hewlett Packard 16501A & B – Logic Analyzer System £2000
Hewlett Packard 8650B - 20GHz Frequency Counter £1950
Hewlett Packard 89524A – 2GHz Frequency Analyzer £1750
Hewlett Packard 89525A – 4GHz Frequency Analyzer £1750
Hewlett Packard 89526A – 8GHz Frequency Analyzer £1750
Hewlett Packard 89527 – 16GHz Frequency Analyzer £1750

SPECTRUM ANALYSERS
Anritsu AC 5011 £1950
Advantest R3210 Spec. An. (9kHz-3.6GHz) £8800
Agilent PSA-LSA – 2.5GHz £1800
Anritsu MS 2680A – 960MHz - 8.1GHz £7500
Anritsu MS 2690A – 2GHz - 1700MHz £1450
Anritsu MS 615B 1000 – 2GHz – as new £1750
Anritsu MS 610A 1000 – 2GHz – as new £1500
Advantest TKN540-1100 £1950
Hewlett Packard 8594A – Dual channel dynamic signal analyser £2000
Suyzu – 100MHz £850
Hewlett Packard 8595A - 1.3GHz – Network Analyzer £1950
Hewlett Packard 8575A/8757A Saturator Network Analyzer from £10000
Hewlett Packard 8535A Maintains 8559A Spec. An. (0.1 to 21GHz) £2350
Hewlett Packard 8517 Mainframe x 8559A Spec. An. (0.1 to 21GHz) £2700
Hewlett Packard 8580B Spectral Analyzer (10Hz-1GHz) £2125
Hewlett Packard 8567A – Network Analyzer £3250
Hewlett Packard 8567B – Network Analyzer £3750
Hewlett Packard 8567C – Network Analyzer £4250
Hewlett Packard 8567D – Network Analyzer £4750
Hewlett Packard 8567E – Network Analyzer £5250
Hewlett Packard 8567F – Network Analyzer £5750
Hewlett Packard 8567G – Network Analyzer £6250
Hewlett Packard 8567H – Network Analyzer £6750
Hewlett Packard 8567J – Network Analyzer £7250
Hewlett Packard 3566A Dynamic signal analyser £3950
Hewlett Packard 8594B – Dynamic signal analyser £3950
Hewlett Packard 8515A Spectrum/Network Analyzer (10Hz-500MHz) £3250
HVA 27500 - 30GHz Portable £1950
Meguro – MSA-491 – 300MHz – Spec. Analyzer £2700
Meguro – MSA-492 – 1GHz – Spec. Analyzer £4000
Wandel & Gottliebmann TSI-1 system analyser (9kHz-1000Mhz) £9000
Without 0409 – 1-2000MHz R/F Analyzer £1950

All equipment is used - with 30 days guarantee and 90 days in some cases. Add carriage and VAT to all goods.
Tel: 02476 650 702
Fax: 02476 650 773

COVENTRY

Radio Communications Test Sets

Marconi 2955 £2000
Marconi 2955B £4500
Marconi 2956B £4750
Marconi 2945A £5000
Anritsu MS5555A £1200
Hewlett Packard 8922B (GSM) £6950
Hewlett Packard 8922M (GSM) £8500
Schlumberger Stabilock 4013 £3395
Schlumberger Stabilock 4040 £1500
Racial 6111 (GSM) £1750
Racial 6115 (GSM) £3995
Rhode & Schwarz CM104 (94Mhz) £5950

NEW PHONE CODE FOR COVENTRY 02476

Tel: 02476 650 702
Fax: 02476 650 773

Racal 6115 (GSM) £3995
Rhode & Schwarz CM104 (94Mhz) £5950

Fax 02476 650 773
913 COMMENT  
Due diligence and culpable incompetence

914 NEWS  
- Copper telephone lines  
- 4G mobile phones  
- MOS gate materials  
- Surrey's microsatellite launch  
- Fuel cells for mobile phones  
- Cash for obsolescence problem  
- Wristwatch distress beacon  
- 3G phones need 100k MIPS

922 REMOTE CONTROL  
THE EASY WAY
If you want to add remote control to your next design, there's no need to start from the ground up. Les Johnson shows how easy it is to produce your own infrared decoder that responds to a wide range of low-cost commercial remote-control hand-sets.

926 PICBASIC PRO
Find out how you write sophisticated programs for the PIC microcontroller without having to learn assembler.

928 S-PARAMETERS  
MADE SIMPLE
Les Green believes that RF designers who are not familiar with S-
parameters are missing out on a wealth of information. Here he sets out to unravel their mysteries.

935 15-CHANNEL  
GRAPHIC EQUALISER
For a graphic equaliser to be useful in a hi-fi environment, it has to have a large number of channels. Michael Slifkin and Leonid Shigir's design has 15.

943 FOUR-WAY RS232  
ROUTER
Instruments with RS232 interfaces are abundant, but the average PC only has one spare COM port so experiments involving a number of instruments are tedious. Frank Thompson's switch box expands one RS232 port to four.

946 VERSATILE STIMULUS  
FOR DIGITAL TEST
Digital word generator — software notes. Essential reading if you're interested in Colin Attenborough's digital tester published last month.

949 NEW PRODUCTS
New product outlines, edited by Richard Wilson

960 LF RADIO DATA CLOCK
Roger Thomas argues that his Radio Data receiver is easier to implement than earlier designs, yet it doesn't compromise on performance. Use the decoder in stand-alone mode, or for reading Radio Data into your PC using optional software from the author.

970 CIRCUIT IDEAS
- High-fidelity filter for data retrieval  
- Single-gang pot. tunes Wien Bridge  
- Simple reversing battery charger  
- Add four hard drives to your PC

977 BEGINNERS' CORNER:  
NEGATIVE RESISTANCE OSCILLATOR
One of the simplest radio-frequency oscillators relies on negative resistance. Ian Hickman dissects it, and shows you exactly how it works, and how well it performs.

982 WEB DIRECTIONS
Useful web addresses for the electronics designer.

986 LETTERS
Filters and linearity, Comme une bombe, Slew rate matters, E numbers and resistors.

January issue on sale 7 December
Sinking fast with poor tech support? Expensive maintenance fees? Costly upgrades? Old fashioned software?

Realise your potential & break free with EDS!

Introducing EDS Advance the new modular electronics design system that includes simulation, schematic, PCB, autorouting and CADCAM modules as standard.

Our powerful integrated development environment brings powerful management to your projects and now features 3D style PCB footprints, Viper rip up and retry autorouter, shape based design rule checking, full copper pour support with unlimited automatic zones and split power planes, cross probing between schematic/pcb/netlist, netlist navigator, wizards to automate key features, DTP quality feature rich schematics, 2000 look and feel, and a wide range of import/export options.

If you are struggling with your existing system and feel its time for a change, why not give us a call and we will send you our free information pack. Or visit our web site and download a free trial copy of EDS.

Try before you Buy at www.quickroute.co.uk

CIRCLE NO. 104 ON REPLY CARD
Due diligence and culpable incompetence

At the close of the latest newsletter from the Bletchley Park Trust – the organisation that's doing a marvellous job conserving and developing our World War II code-breaking centre – is the tag line, "The Bletchley Park website is now a secure site."

It’s doubly appropriate too, not merely because the security of its highly confidential activities was maintained a secret until recent times. Today the website – at www.bletchleypark.org.uk – accepts credit card orders for the many books and video tapes its sells on cryptographic subjects and its customers expect their transactions to be handled with total security.

No doubt they are, but how does the customer know? Equally importantly, how does the organisation offering electronic commerce services know? On the basis of recent happenings, they don't and this is the scandal.

Undertakings that handle the money of others have a duty of care and trust. And this duty applies regardless of the channels by which the money passes. Firms inviting customers to do business with them electronically are expected to exercise due diligence to ensure that the mechanisms they provide are fit for purpose. But what do we find?

- A man logging on to Powergen’s website to pay his bill came across unencrypted credit card details, home address and payment records for himself and 7000 other customers.
- The online bank Egg was subject to a serious attempted fraud that required little technical skill.
- A miscreant accessed the customer files of supermarket giant Safeway and sent an amusing but highly damaging e-mail to its entire customer base.
- Woolworths had to shut down its online store after customers' details and another user spotted credit card numbers.
- On Barclays Bank site, any customers' details could be viewed – even after they had logged out. This was the third blunder in two weeks.
- The Halifax Building Society was forced to delay the opening of its on-line bank, Intelligent Finance, because of security concerns.
- A survey commissioned for Internet shopping site Zoom.co.uk revealed that one in four UK Internet users who buy good online were still concerned about security – that's 25 per cent of those disposed towards electronic shopping; by implication 100 per cent of the rest of the population wouldn't trust it.

Although lamentable, this last episode was the only event to confer any real credit. Woolworths paid customers compensation after the event. Powergen first denied insecurity, then accused its customer of being a hacker, while Barclays failed to apologise immediately to the customer who exposed its security flaws. None of this inspires confidence.

Excuses of 'one-off incidents' hold little water either. When confidential data can be accessed as simply as hitting the browser's back key (Barclays) or deleting the trailing section of a URL, it's patently clear that no 'due diligence' has been exercised in bug-testing these systems.

In the frantic rush to be first-to-market, traditional testing has been forsaken. Ironically, in the same week as Powergen had its 'one-off incident', security consultancy NTA Monitor revealed that 80 per cent of companies did not test the security of their sites.

With the number of Europeans banking on the Internet set to triple in the next three years – according to a report published by investment bank JP Morgan – and other exponents of e-commerce will have to do better. Both the Consumers' Association and the National Association of Bank Customers have stated that Internet banks must take responsibility for fraud and draw up clear policies for handling security breaches.

Currently, policies vary and in some cases, customers themselves are liable for losses incurred. Only the Halifax has proactively stated that it would guarantee any losses incurred to customers who did not act with criminal gain in mind.

This comes at a time when unless they improve their security procedures, online banking operations are likely to become a major target for organised crime. Indeed, according to security testing firm NTI Monitor, eastern European criminals may already be targeting operations in the UK.

Two software designers from Kazakhstan recently demanded $200,000 in exchange for the database of financial tycoon Michael Bloomberg. And a number of other high-profile frauds involving electronic banking have been traced to countries of the former Soviet Union.

Legal remedies are far less effective than prevention and as Winn Schwartau, CEO of Security Experts and founder of Infowar.com, observes, "We want to prevent breaches, not study them later. Fear of police prosecution doesn't stop the enlightened criminal when he knows full well that the odds of being caught are almost zero."

And legal remedies lose effectiveness when incidents cross international borders and in any case, computer fraud, unlike murder or robbery, is still not universally recognised as crime. Laws to fight it are typically found only in industrialised nations that depend on computers.

This will not stop new shopping and banking sites from opening online but to secure their customers' confidence they will have to demonstrate far higher standards of security. To continue as at present would be culpable incompetence.
Fourth generation mobile phones already under consideration

Fourth generation mobile phone technology is already under consideration despite the fact they will not be a commercial reality for at least ten years. Ericsson is one company already starting work because as vice president of research, Hakan Eriksson, points out the technology has so far followed a ten year cycle of development.

According to Eriksson, data rates of up to 100Mbit/s could be possible from 4G systems depending on where you are sited in relation to a basestation.

"If you're close you have a high bit rate, it could maybe come up in the order of 20 to 100Mbit/s," said Eriksson. "If you're far out you could maybe have what we have today with W-CDMA at 384kbit/s. It would be the largest span in possible bit rates."

New materials studied for nanometre MOS gates

Silicon dioxide will fail to satisfy the needs of CMOS in the next few years, as somewhere between 2 and 1nm it is too thin and leaks current.

New materials are needed and some of these come from the hidden depths of the chemistry set.

Lucent's Bell Labs is looking at zirconium and silicon doped alumimates. Used with a TiN gate, these materials can withstand standard, i.e. high-temperature, CMOS processing.

With an equivalent oxide thickness (EOT) of 1.2nm, Lucent achieves leakage below 50mA/cm2.

EOT is used to compare gate insulators. It is the thickness of SiO2 needed to get the same transistor transconductance as the insulator being compared.

The University of Texas has been looking at ZrO2 and zirconium silicate – Zr2Si1O6.3. At equivalent thicknesses of 0.89 and 0.96nm respectively, it is getting leakages of 20 and 23mA/cm². The university used a TiN barrier between insulator and polysilicon gate to prevent destructive interaction during 950°C anneal.

The same university also showed that HfO2 can be used with n-type polysilicon gates with no barrier layer, achieving a leakage of 0.23mA/cm2 at 1.04nm EOT. Further work has produced working P and NMOS devices with an EOT of 0.8nm. These use a TaN gate and the combination is said to show promise for 70nm (compared with today's 1.3µm) processes.

Together with other US universities, Texas is also working on molybdenum as a gate metal for hard-to-make ZrO2 PMOS devices. Samsung has taken a look at Al2O3 and may have found a way to make use of it as a gate insulator. It is said to have leakage three orders of magnitude better than SiO2.

Over in Japan, Toshiba has shown that Ta2O5 is suitable for use in sub-50nm damascene metal gate MOSFETS and has been doing fundamental research into materials including ZrO2.

Finally, a German team has really plundered the dark recesses of the periodic table and come up with praseodymium oxide. At an EOT of 1.4nm it has measured leakage currents of 5 x 10-9A/cm2. This is around 104 better than HfO2 and ZrO2 films. The team claims that breakdown voltage for such a gate would be 6V, corresponding to an incredible field strength of 43MV/cm.

Melanie Reynolds
Antex have a great track record of offering high quality soldering irons at a low price. So race off with a ‘fixed temperature’ iron or take the ‘In Handle’ temperature controlled model for a burn.

Both offer total safety with a choice of a PVC or burn-proof silicone lead, and every model has been manufactured in the UK and meets CE conformity.

And with Antex you get loads of extras from a wide variety of long life bits to state-of-the art soldering stations.

So visit our web site or your electronics retailer and take one for a test drive.

YOU CAN NOW BUY ANTEX EQUIPMENT ON-LINE
ALL SOLDERING IRONS PURCHASED ON-LINE BEFORE CHRISTMAS WILL RECEIVE A FREE DESOLDER PUMP

www.antex.co.uk

b² Spice 2000
Analogue and digital circuit design for the PC

Packed with new features:
• Uses the latest xspice engine for guaranteed accurate mixed mode simulation
• Parameterised ac sweep • Monte carlo analyses • Parameterised transient sweep
• New xspice simulations • New noise and distortion analyses • Improved features for processing plot families as units • New menu items to show local maxima, minima, and zero crossings and much more

Accurate results that can be relied on

ONLY £199 ex VAT
*(UPGRADE FOR EXISTING USERS)*
FREE 30 DAY TRIAL

RD Research, Research House, Norwich Road, Eastgate, Norwich NR7 0JA
Tel: 01603 673331 Email: rd.research@pusten.co.uk www.locking.co.uk/spice

*Please add £5.00 postage and packing * applies to users of B. Spice & B. Logic. All trademarks acknowledged.
Surrey launches new microsatellite

Surrey Satellite Technology has successfully fired one of its microsatellites into space. This one, Tiungsat-1, was launched on board a Dnepr launch vehicle from the Baikonur Cosmodrome in Kazakhstan. The launch on board Dnepr is significant in that it is the second commercial use of the demilitarized SS18 intercontinental ballistic missile. The first was for the launch of Surrey’s Usosat-12 minisatellite in April 1999 when Surrey was the sole payload for the Dnepr rocket.

Tiungsat-1 was built for Malaysian firm Astronautic Technology, and was activated on its first transit over Malaysia seven hours after launch from a ground station installed by Surrey in Kuala Lumpur. The 50kg Tiungsat-1 microsatellite will provide 80m resolution multispectral Earth imaging, 1.2km meteorological Earth imaging, digital store-and-forward communications and a cosmic-ray energy deposition experiment.

Among the benefits that Tiungsat-1 will provide for Malaysia is information on Earth resources, land use and environmental haze pollution and weather patterns, including hurricane warnings.

This is Surrey’s third launch this year, making a total of 19 satellites in 19 years.

LEDs under consideration for traffic control

Light-emitting diode technology is being considered for use in traffic-control applications by the Intelligent Transport Systems industry.

UK suppliers, users and evaluators discussed the possibilities for the technology at a recent meeting of the Intelligent Transport Society (UK) Enforcement Interest Group. Although LED technology offers advantages, there are problems to be overcome before it can be deployed.

“Optical units utilising LED technology offer the potential for reduced energy consumption and reduced maintenance costs,” said Trevor Ellis, the Group’s chairman, “but new approaches to monitoring LED failures have to be developed for legal and safety reasons.”

Meanwhile, the M25 Controlled Motorway Scheme is to be extended following the award of a four year contract by the Highways Agency to consulting group Mouchel.

The contract will see automatic control of the motorway extended from 22km to a 30km stretch.

Work will include development of a system that includes second-generation camera enforcement equipment and new controlled motorway indicators.

Obsolescence problem gets Government cash

The government is putting up money to tackle component obsolescence - the problem increasingly hitting makers of long-life electronic equipment.

“Electronic component obsolescence is now one of the biggest threats to the future of many sectors of industry,” said Sir Richard Evans, chairman of BAE Systems.

"Unless we start managing obsolescence from the beginning of a new production cycle to the end of equipment life, military and commercial aerospace, nuclear, medical, transportation, petrochemical and other areas will face critical problems as essential electronic components disappear from the market.”

Sir Richard was speaking at the opening of the National Obsolescence Centre (NOC), jointly funded by the DTI and the Defence Evaluation & Research Agency (DERA).

DERA already maintains a database of components for third party organisations.

It constantly checks component production status with manufacturers. It also notifies users if a component becomes obsolete or is approaching obsolescence, in other words, the manufacturer has said it would stop production.

Currently DERA only offers the service to military customers and prime contractors. With the introduction of NOC, this service will be opened up to commercial clients.

“Users will lodge lists of components with NOC,” said Mike Housley, DERA director of NOC. “We will update the status of the components on a regular basis, probably once a week.”

The service will be Web-based with customers having secure access to status information.

NOC, using DERA engineering resources, will also be offering to find alternatives for obsolete components.

Also involved in NOC is the Component Obsolescence Group (COG), an industry body made up of component users and producers that aims to provide information to members through regular meetings.

Steve Bush, Electronics Weekly

See www.nocweb.org and www.cog.org.uk.

NOC can also be reached on 0208 285 7721, contact Ted Smith.

Wristwatch transmits distress calls for 48 hours

Swiss watchmaker Breitling is selling a wristwatch equipped with a transmitter to broadcast on the international distress frequency in an aeronautical emergency.

Called the Breitling Emergency, it is intended to enable downed pilots to be located on land or at sea. When activated by unscrewing a protective cap and pulling out an antenna, the Emergency broadcasts at 121.5MHz. The signal lasts for 48 hours and could be picked up 160km away by a search aircraft flying at 6000m, said the company.

Initially, the watch will be available for sale only to licensed pilots and a fine is payable for misuse. Price is $3500 in titanium or $48,000 in gold and diamonds.

UPDATE
Long live copper

Anyone could be forgiven for thinking that the radio spectrum and optical fibre are the only transmission mediums worth using for transmitting communications traffic given the amount of buzz they currently generate. But while these technologies may be talk of the town in the telecoms world, generating huge amounts of comment and column inches, it would do us well not to forget that the majority of people still rely on that old faithful technology – the trusty copper wire.

"While you read an awful lot about wireless technology and other forms of access, copper is far from dead," says Charles Louisson, access applications marketing director at Lucent Technologies Microelectronics Group. "With the unbundling of local loops happening in most of the European countries there is going to be tremendous competition [to gain access to the copper networks]."

Indeed the United Kingdom is a classic example of this with companies clamouring to fit their equipment in the exchanges while BT seemingly clings avidly onto its exclusive access to them. There must be money to be made here considering the huge row which the process of opening up the networks to competition has created.

Companies want to be able to use the copper network to provide high speed ADSL (asymmetric digital subscriber loop) services in competition to BT, but there is still money to be made using the copper network in its current incarnation.

"Everybody talks about DSL and broadband services and while these are definitely coming," comments Louisson, "in the near term consumer equipment manufacturers are looking for something that can be used in any home, ideally anywhere in the world so they can build just one flavour of their product. PSTN modem is really what offers that to them."

Louisson says there has been a tremendous surge in enthusiasm over the last couple of years for fitting modems into equipment. Part of this surge can be put down to the rise of interactive digital TV.

"We believe the TV is becoming an alternative method, at least in some sectors of the market, for Internet access," states Louisson. "So much of the media today contains links to Internet sources we believe it will become the pervasive way of accessing the Internet."

Which means good news for the traditional dial up modem for the Internet connection part, which in turn is good news for companies like Lucent and Conexant who supply the silicon.

This is especially true as new standards like V.92 emerge which are intended to close the performance gap between modems on standard copper wire and ADSL. Making the best of what is already there seems the way to go because the fact is that despite all the talk there are going to be some areas that ADSL simply will not reach for economic reasons.

"I don't think it's the case you'll see copper diminish in any way. I think you'll see an increase in other types of technology but copper is still going to be around it," says Nick Burd, director of DSL products for Conexant’s Personal Computer Division. "The fact that copper is in the ground already is a fairly compelling reason for its re-use in as many forms as you can possibly find."

Copper cables are here to stay and it seems there is still plenty of life left in the old technology.

Modem rates at a glance

- **Dial-ups over telephone lines**
  - V.90 - 33.6kbit/s from user
  - V.92 - 48kbit/s from user
  - 56k - 56kbit/s from user

- **Data compression**
  - V44 & V42 - boost dial-up speed by 50 per cent and more

- **ADSL modems over telephone lines**
  - G.lite - 384kbit/s from user & 1.5Mbit/s to user
  - DMT full rate - 384kbit/s from user & up to 8Mbit/s to user

- **Cable modems over coaxial cable TV networks**
  - DOCSIS standard-compliant - 10Mbit/s from user & 36Mbit/s to user.
Flexible polymer substrates carry circuits

A t IDEM, the International Electron Devices Meeting, in December, a team from Pennsylvania State University will describe organic circuits made on flexible polymer substrates. Penn State's active material is pentacene, a material also used by Bell Labs to create organic devices.

Along with nickel for gate electrodes and palladium for the source and drain, the pentacene is deposited on 75µm thick polyethylene naphthalate.

The maximum temperature used during device processing is 110°C. Manufacturing at lower temperatures on plastic material could reduce the cost of making devices.

Multiple circuits have been fabricated including inverters, ring oscillators, frequency dividers, differential amplifiers and various test structures. A ring oscillator has a propagation delay of less than 40µs per stage.

Electron mobility is said to be 1cm2/Vs, while the transistor's on-off ratio is greater than 107.

These specs are equal to that of organic devices on rigid substrates, the researchers claim.

Meanwhile Cambridge is the source of two papers in the organic electronics and displays session at IDEM.

While ink-jet printing has been applied to polymer displays, Cambridge University has used the technique to print transistors.

One of the major achievements is accurately aligning the gate with the drain and source after the gate insulation has been laid down.

Using a piezoelectric ink-jet print head from Seiko Epson, the team managed to print a channel 5µm in length (the distance between the drain and source). Reducing the amount of photolithography will significantly cut the cost of manufacturing devices.

Finally, Cambridge Display Technology (CDT) will give an overview of the state of the art in polymer light-emitting diodes and a full colour active matric display will be shown.

Fuel cells promising for mobile phones

Motorola Labs has taken another step towards a working fuel cell for mobile phones with the demonstration of a prototype micro fuel pump.

The pump uses multi-layer ceramic technology for processing and delivering fuel and air to the fuel cell membrane-electrode assembly (MEA). This fuel delivery system can, said Motorola, be built into a miniature fuel cell.

Direct methanol fuel cells are proposed as alternatives to rechargeable batteries in mobile phones with the user inserting a small fuel cartridge into the phone instead of charging it.

"Eventually, these fuel cells could enable what people just dream of today - a lightweight energy source that would safety power a cellular phone for a month," said Jerry Hallmark, manager of Motorola Labs' Energy Technology Group.

Front-end design tools run under Linux

Synopsys has rolled out a complete set of its front-end design tools running on the Linux operating system. Products include the firm's flagship synthesis tools such as Design Compiler, along with static verification, test pattern generation and tools for FPGA design.

The move will push other EDA firms to port products, the firm says. "You can expect a flood of Linux announcements after this," said Karen Bartleson, director of interoperability at Synopsys.

"People like the price/performance benefits along with lower cost hardware. Linux is a very stable OS and this is important to EDA." For example, many tools can run overnight in large chip designs, requiring computers that do not crash.

Missing from the Linux line-up are the firm's physical synthesis and layout tools, and Epic analysis tools.
ABRITARY WAVEFORM GENERATOR-
STORAGE OSCILLOSCOPE-
SPECTRUM ANALYZER-
MULTIMETER-
TRANSIENT RECORDER-

- The HS801: the first 100 Mega samples per second measuring instrument that consists of a MOST (Multimeter, Oscilloscope, Spectrum analyzer and Transient recorder) and an AWG (arbitrary waveform generator). This new MOST portable and compact measuring instrument can solve almost every measurement problem. With the integrated AWG you can generate every signal you want.

- The versatile software has a user-defined toolbar with which over 50 instrument settings quick and easy can be accessed. An intelligent auto setup allows the inexperienced user to perform measurements immediately. Through the use of a setting file, the user has the possibility to save an instrument setup and recall it at a later moment. The setup time of the instrument is hereby reduced to a minimum.

- When a quick indication of the input signal is required, a simple click on the auto setup button will immediately give a good overview of the signal. The auto setup function ensures a proper setup of the time base, the trigger levels and the input sensitivities.

- The sophisticated cursor read outs have 21 possible read outs. Besides the usual read outs, like voltage and time, also quantities like rise time and frequency are displayed.

- Measured signals and instrument settings can be saved on disk. This enables the creation of a library of measured signals. Text balloons can be added to a signal, for special comments. The (colour) print outs can be supplied with three common text lines (e.g. company info) en three lines with measurement specific information.

- The HS801 has an 8 bit resolution and a maximum sampling speed of 100 MHz. The input range is 0.1 volt full scale to 80 volt full scale. The record length is 32K/64K samples. The AWG has a 10 bit resolution and a sample speed of 25 MHz. The HS801 is connected to the parallel printer port of a computer.

- The minimum system requirement is a PC with a 486 processor and 8 Mbyte RAM available. The software runs in Windows 3.xx / 95 / 98 or Windows NT and DOS 3.3 or higher.

- TiePie engineering (UK), 28 Stephenson Road, Industrial Estate, St. Ives, Cambridgeshire, PE17 4WJ, UK
  Tel: 01480-460028; Fax: 01480-460340
- TiePie engineering (NL), Koperslagersstraat 37, 8601 VL SNEEK
  The Netherlands
  Tel: +31 515 415 416; Fax +31 515 418 819
- Web: http://www.tiepie.nl
Remote control the easy way

If you want to add remote control to your next design, there's no need to start from the ground up. Les Johnson shows how easy it is to produce your own infrared decoder that responds to a wide range of low-cost commercial remote-control hand-sets. And if you thought that you would never get to grips with programming a microcontroller, there may be something here for you too...

Infrared remote-control decoding is considered something of a black art. However, this article will show you that it is quite straightforward in principle, and how easy it is to implement it on a PIC microcontroller.

Infrared remote control has been around for so long now that we tend to take it for granted. Yet, it is a marvel of modern technology that allows a whole variety of devices to be activated with the touch of a button.

Remote control handsets are produced in such abundance now that they can be bought for a few pounds, which makes them viable items for experimentation.

There are dedicated chips available that will decode the signals from a particular handset. However, with the flexibility and cost effectiveness of the PIC range of microcontrollers, you can develop a decoding subroutine for inserting into your own programs, or for use as a stand-alone infrared to RS232 converter.

Manufacturers' infrared protocols
Regrettably, remotes do not come in a single flavour. Each manufacturer uses a different set of protocols. The three main ones are RC80, which is used by Panasonic, RC5, which was designed by Philips and has become one of the more popular types, and then there's the Sony protocol. Called SIRC, Sony's protocol is hugely popular. Conveniently, it is also one of the easiest to decode. As a result, I will focus on this alternative and endeavour to illustrate how to decode the signals from a Sony remote control handset using the ever-popular PIC16F84 microcontroller.

Infrared-to-TTL converter
In a bid to eliminate ambient light sources - both natural and man made - from interfering with the data stream transmitted by the handset, modulated light is used. This modulation is centred around different frequencies depending on the manufacturer. It varies from 32kHz to 40kHz. In the case of Sony handsets, the modulation is centred at 40kHz.

What you need first is a device that can receive the modulated infrared light and convert it into a TTL signal that the PIC can handle. There's a number of these devices available, each having a specific centre frequency that they're more sensitive too.

For this explanation, I chose the IS1U60 from Sharp. It has a centre frequency of 38kHz, which is close enough to 40kHz so as not to matter.

Figure 1, shows the internal block diagram of one of these devices. Although the receiver/demodulator looks simple, it is a lot more than just a re-packaged infrared photodiode. It filters and amplifies it and demodulates the infrared signal. Then it provides a nice clean TTL output by means of a final comparator stage.

The demodulator chip also has built-in automatic gain control, or AGC, which helps stop overloading; if the handset is held too close. Using one of these devices is a great deal cheaper - and easier - than building your own discrete version.

Table 1. Sony's SIRC protocol defines the type of equipment in the device code sent from the handset.

<table>
<thead>
<tr>
<th>Command</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Television receiver</td>
</tr>
<tr>
<td>2</td>
<td>VCR 1</td>
</tr>
<tr>
<td>3</td>
<td>VCR 2</td>
</tr>
<tr>
<td>4</td>
<td>Laser-disc player</td>
</tr>
<tr>
<td>5</td>
<td>Surround sound unit</td>
</tr>
<tr>
<td>6</td>
<td>Cassette deck/tuner</td>
</tr>
<tr>
<td>7</td>
<td>CD player</td>
</tr>
<tr>
<td>8</td>
<td>Equaliser</td>
</tr>
</tbody>
</table>
Most infrared sensors have an active-low output. This means that the decoder—in this case the PIC controller—is presented with a logic 0 when an infrared signal is detected. With no signal present, a maximum current of 4.8mA is consumed, 2.8mA being typical. In addition, the recommended voltage is 4.7V to 5.3V.

Sony's infrared control protocol
SIRC—an acronym for 'serial infrared control'—uses a form of pulse-width modulation (PWM) to build up a 12-bit serial data stream, known as a packet. This is the most common protocol, but 15-bit and 20-bit versions are also available.

A pulse with a duration of 2.4ms is sent first as a header. This allows the internal AGC to adjust. It also allows the receiver to check if a valid packet is being received. A logic 1 bit is represented by a pulse duration of 1.2ms, while a logic 0 bit has a duration of 0.6ms. A delay of 0.6ms is inserted between every pulse. The string of pulses builds up the 12-bit packet. This packet incorporates a 5-bit device code. This code has 2^5, i.e. 32, different permutations and is used to represent a TV, video, hi-fi, etc., Table 1. There's also a 7-bit button code, which represents the actual button pressed on the remote, Table 2.

Each packet is transmitted starting with the most-significant bit, or MB. First the device code is sent, then the button code, Fig. 2.

After the packet is sent, a delay is implemented, which brings the whole transmitted signal to a length of 45ms. This is repeated for as long as a button is pressed.

Assembler versus BASIC
Knowing the principles behind infrared communications is one thing. Actually writing software based on the information is another.

For many, programming microcontrollers tends to conjure up the nightmare of writing programs in assembly language. But things have moved on. There are many high level language implementations for use with the PIC, such as C, Pascal, and BASIC. My personal preference is BASIC, or rather PicBASIC Pro.

In general, BASIC has received a lot of bad press since its conception in the middle part of the seventies. It is considered clumsy and inflexible, yet nothing could be further from the truth. Thanks to microEngineering lab's PicBASIC and PicBASIC Pro compilers, and Leading Edge Technologies' PicBASIC compiler range, this language has been brought into the 21st century.

Thanks also, in part, to BASIC's shallow learning curve, software designs that used to take weeks can now be realised in a just few hours.

So as to not seem too biased towards either language, I will present the software for this article in both assembler and PicBASIC Pro. This will allow you to make your own mind up.

I will also endeavour to illustrate the pros and cons (no pun intended) of both languages by not using optimised assembler routines. This means that both the BASIC and the assembler versions will follow the same structuring, which will enable a fairer appraisal of them.

It is not my intention to teach you how to program a PIC micro, so, throughout this article, it is assumed that you already have some knowledge of either assembler or PicBASIC Pro. I will also assume that you have a means of programming the PIC16F84.

For more information concerning the PicBASIC range of compilers, as well as an assortment of programmers, visit Crownhill Associates' dedicated web site at www.picbasic.co.uk. For information concerning assembler programming, visit Microchip's web site at www.microchip.com.

Decoding circuitry
Figure 3 is intended to help explain the principles behind infrared decoding. This PIC-based circuit incorporates two light-emitting diodes, one green, the other, red. The software is arranged so that pressing the channel-up button on a TV remote lights the green LED while channel-down will illuminate the red one.

As well as illuminating the LEDs, two bytes are transmitted serially, via asynchronous RS232, from Port A.3 through a 1kΩ current limiting resistor, R2. The serial data contains the device code as well as the button code and is transmitted at inverted 9600 baud (N-8-1).

You could attach this device to the PC's serial input for remotely influencing some software running on the PC for example. Or you could attach it to a BASIC Stamp for use in robotics applications.

The circuit layout is not too critical and could easily be built on stripboard. However, decoupling capacitor C5 should be placed as close to the IR sensor as possible, and C2 should also be located close to the PIC.

![Fig. 2. When you press a button on the Sony hand set, a 12-bit data packet is transmitted, comprising 5 bits that represent the equipment type and a further 7 bits representing the command requested.](image-url)

![Fig. 3. With this demonstration circuit and the right software in the PIC, you can turn the LEDs on remotely using a Sony handset. With a little imagination and a few software alterations though, this becomes a versatile yet very low cost wireless remote control circuit.](image-url)
**CONTROL ELECTRONICS**

**Listing 1. Determining a port's direction in assembly language.**

Bsf STATUS, 5 ;Point to TRIS reg
Movlw 'b00000100' ;Set PortA, as IN
Movwf PortA ;Configure the Port
Bcf STATUS, 5 ;Back to Page 0

**Listing 2. Assembler subroutine for pulse measurement.**

; Measure duration of high-to-low pulse on PortA, 2
; And leave the result in P.VAL.
; An illness resolution is achieved with a 4MHz crystal
Pulsin Clrwdt ;Walk the dog
Clrf Cntr ;Clear variables used.
Clrf P.Val ;prior to subroutine
Trans Btfss PortA, 2 ;Wait for 1 to 0 transit
Goto Edge ;Edge found!
Incfz P.Val ;Else inc. P.VAL until >255
Goto Trans
Incfz CTrs ;Loop until 255
Goto Trans
Return

Edge Clrf P.Val ;1 to 0 transit occurred
Ege_lp Clrwdt ;Wait the dog
Nop ;Timing loop
Nop
Nop
Nop
Incfz P.Val ;Inc. P.VAL until >255
Goto Edge LP
Return

**Listing 3. Assembler, 12-bit packet construction.**

;Receive a signal from a Sony remote control.
;If no header then IR_DEV, IR_BUT will hold 255
IRIN Clrwdt ;Walk the dog
Call Pulsin ;Measure the header
;Verify good header, if not valid then exit
;** If PVAL <200 then return with IR_DEV=255 **
Movlw 200
Subwf P.VAL, W
Btfsc STATUS, C
Goto Next1
Movlw 255
Movwf IR_DEV
Return
;** If PVAL > 250 then return with IR_DEV=255 **
Next1 Movlw 250
Subwf P.VAL, W
Btfsc STATUS, C
Goto PK_Strt
Movlw 255
Movwf IR_DEV
Return

;Build up packet by pulling in all 12-bits
PK_Strt Movlw 12
Btfsc STATUS, C
Goto One
Btfsc P.VAL, w
Goto S_again

S_again Call Pulsin ;Get the bit duration
Movlw 80 ;If >80 then it’s a 1
Subwf P.VAL, w
Btfsc STATUS, C
Goto One
Bcf Packet+1, 4 ;Clear the bit
Goto Cont

One Bcf Packet+1, 4 ;Set the bit
Rrf Packet+1, F ;Rotate bit into place
Rrf Packet,F
Decfsz Bitcnt ;Are 12-bits done yet?
Goto S_again ;No! then loop again

---

**Getting down to the coding**

The actual infrared decoding software is presented in the form of a subroutine, named IRIN, to make it easy to incorporate it into your own programs. The subroutine and subsequent main program loop may be split into several software tasks. These are outlined over the page.

**Task 1.** Configure Port A as both inputs and outputs.

**Task 2.** Devise a method of measuring the high to low pulse length received from the active low IR sensor.

**Task 3.** Implement task 2 to detect the header and bit pulses and then construct the 12-bit packet.

**Task 4.** Split the packet into two separate bytes containing the 7-bit button and 5-bit device codes.

**Task 5.** Devise a method of transmitting inverted serial RS232 data.

**Task 6.** Construct a main program loop that calls the decoder subroutine and illuminates the correct LED, as well as using task 5 for transmitting both, the device and button codes, serially.

**Implementing Task 1**

Our first coding task, that of configuring the port's direction, is the easiest. Assembler code for this is shown in Listing 1. This code configures bits 0, 1 and 3 of Port A as outputs, for attaching the LEDs and the serial output. Bit-2 is made an input for the attachment of the infrared sensor.

The same thing written in PicBASIC Pro is,

```
TRISA = $00000100
```

Note, that it is not necessary to do this in PicBASIC. The commands that deal with external influences automatically set the required pins as inputs or outputs.

**Task 2**

A means of measuring the pulse durations that signify a header, as well as the separate ones and zeros that go to make up the packet, is needed. An assembler version of a routine to do this is shown in Listing 2.

The high-to-low pulse duration is measured at bit 2 of Port A and the 8-bit value is returned in the variable P.VAL. Because we’re using an 8-bit (0-255) variable, it’s impossible to return a value of 2400 for a pulse length of 2400 microseconds. Therefore, the routine has a resolution of around 1μs when used in conjunction with a 4MHz crystal.

An 1μs resolution was chosen as opposed to 10μs, because not all remote handsets stick stringently to the recommended pulse widths. Therefore, a header pulse could be more than 2.5ms in length, which would push it beyond a byte’s storage capacity, i.e. greater than 255.

Values returned in P.VAL for a given pulse length are,

- Header pulse 2400μs returns 220
- One-bit pulse 1200μs returns 110
- Zero-bit pulse 600μs returns 55

To do the same task in PicBASIC Pro, requires just one command,

```
Pulsin PortA, 2, 0, 8 or 16-bit Variable)
```

When used in association with a 4MHz crystal, the compiler’s PULSIN command has a resolution of 10μs. Also, if a 16-bit variable is used to hold the result then a duration of 0-65535μs may be measured, where as, if an 8-bit variable is used this is reduced to 0-255μs.

You can use this property to your advantage by detecting the 2400μs header pulse with a 16-bit variable, and the individual 600μs or 1200μs bit pulses with an 8-bit variable. This eliminates any problems arising from a header pulse that is longer than 2.5ms. The values returned from the PULSIN command are as follows,

- Header pulse 2400μs returns 240
- One-bit pulse 1200μs returns 120
- Zero-bit pulse 600μs returns 60

The middle parameter of the PULSIN command, 0 or 1, determines whether a high-to-low or low-to-high pulse is to be measured. Where a zero is concerned, a high-to-low type is measured.
Task 3
Now the subroutine IRIN. In this routine, bit information received from the IR sensor is gathered, and the 12-bit packet is constructed from it.

Listing 3 is the assembler version of this. The first thing the routine does is try to detect a 2.4ms header pulse using the PULSIN subroutine, Task 1.

The result, held in P.VAL, is examined to see whether it’s between the values of 200 and 250. If it does not lie between these values, then the subroutine is abandoned with IR_DEV and IR_BUT holding a value of 255, which signifies an invalid header.

If a valid header is detected, then a loop of 12 is set up. Within this loop, the individual bits are measured using the subroutine, PULSIN. Depending on the result returned in P.VAL, the individual bits of the 16-bit variable PACKET are set or cleared. This is achieved by splitting the difference between a one-bit (110), and a zero-bit (55).

If the result is greater than or equal to 80 then it must be a one-bit that’s been received. If it’s less than 80 then it must be a zero-bit. The PicBASIC Pro version of the same routine is shown in Listing 4. This has exactly the same function as the assembler version, but because of the different values returned from the PULSIN command, the comparisons for a header and bit pulses are slightly different.

Resulting 12-bit packets for both types of routine are held in the variable PACKET ready for splitting into separate codes.

Task 4
For the resulting 12-bit packet to be of any practical use, it must be split into the 5-bit device code and the 7-bit button code. This is achieved by a series of rotations then masking.

The assembler version of this is shown in Listing 5. Within the variable PACKET, the button code is located, starting at bit-0. This is extracted by ANDing PACKET with 127, or 01111111 in binary, and the result is placed into IR_BUT.

To extract the device code, seven right rotations are performed, which effectively moves the button code out of the way and places the device code starting at bit-0 of PACKET. Again, this is extracted by ANDing, but this time with 31, or 00011111, and placed into IR_DEV.

The PicBASIC Pro’s version of the same routine takes only two lines of code,

' Split the 7-bit button code and 5-bit device code
IR_But=Packet & 00000000
IR_Dev=Packet & 01111111
'Mask the 7 BUTTON bits
'Move down and mask, the 5 DEVICE bits

Task 5
Our finished decoder could simply bring the eight Port B pins high for a given button pressed on the handset. A more desirable result would be to transmit both the button and the device codes serially. Therefore, our fifth task is a subroutine that does just that.

Listing 6 shows the assembler version of an asynchronous RS232 transmitter operating at inverted 9600 baud from bit 3 of Port A. The byte to transmit is first loaded into the W register then a call is made to Sout.

As it stands, the bit rate is set at 9600. To change it, alter the value placed into DLCTR, the higher the value, the lower the baud rate. For instance, a value of 44 will lower it to 4800 baud, while 88 will produce 1200 baud.

To do the same task in PicBASIC Pro, again takes only one command.

Serout Porta.3, 96000. [ Variable ]

Continued on page 985...
You no longer need to be a nerd to write your own professional microcontroller applications. PICBasic Pro is a viable alternative to assembly language regardless of whether your PIC-based application is part of high-end professional system or a kitchen table prototype.

The idea that Basic is a beginners language is a myth, as many PICBasic Pro developers will testify. See for yourself in Les Johnson's new book,'Experimenting with the PICBASIC Pro Compiler' – a free chapter from which you should have found on the cover of this issue*

The work comprises over 150 pages detailing:

- Display controller experiments
- Keypad interfacing
- Serial eeproms
- A-to-D & D-to-A conversion
- Remote control
- Temperature measurement
- Robotics
- Audio control devices
- Programming techniques

The full PICBASIC Pro instruction set and PDF format manual are available for download form www.picbasic.co.uk.

Order PICBasic Pro on line, and save money on bundled packages.

What is PicBasic?
The PicBasic Pro Compiler is the easiest way for you to program the fast and powerful Microchip Technology PICmicro microcontrollers. PicBasic Pro converts your BASIC programs into files that can be programmed directly into a PICmicro MCU.

The Compiler features: Basic Stamp II commands, direct and library routine access to pins on PORTA, C, D, E, as well as PORTB, arrays, real IF...THEN...ELSE and interrupt processing in BASIC.

The PicBasic Pro Compiler gives you direct access to all of the PICmicro registers – I/O ports, a-to-d converters, hardware serial ports, etc. – easily and in Basic. It automatically takes care of the page boundaries and RAM banks. It even includes built-in commands to control intelligent LCD modules.
Instruction set compatibility
The PicBasic Pro Compiler instruction set is upward compatible with the BASIC Stamp II and Pro uses BS2 syntax. Programs can be compiled and programmed directly into a PICmicro, eliminating the need for a BASIC Stamp module.
These programs execute much faster and are generally smaller than their Stamp equivalents. They may also be protected so no one can copy your code.
The PicBasic Pro Compiler is a DOS command line application (it also works in Windows) and runs on PC compatibles. It can create programs for the PIC12C67x, PIC12CE67x, PIC14C000, PIC16C55x, 6xx, 7xx, 84, 92x, PIC16CE62x, PIC16F62x, 8x, 87x, PIC17Cxxx and PIC18Cxxx microcontrollers. It also works with most PICmicro programmers, including Crownhill's EPIC Plus Pocket PICmicro Programmer. A printed manual and sample programs are included to get you started.

Simulation options
The PicBasic Pro Compiler can also be used inside Microchip's MPLAB IDE. This allows programs to be edited and simulated within Windows. More information is on the MPLAB page.
Version 2.3 of the PicBasic Pro Compiler adds support for the 16-bit core PIC18Cxxx microcontrollers. If you are a current PicBasic Pro owner and would like the latest version, please see the upgrade page on the web site for upgrade information.

Compiler features
True compiler action provides faster program execution and longer programs than BASIC interpreters
• Direct and library routine access to any pin or register
• Automatic page boundary handling past 2K
• Bit, byte and word arrays
• Real If...Then...Else...Endif
• Hierarchical expression handling
• Interrupts in BASIC and assembler
• BASIC Stamp I and II library
• Built-in LCD support
• Oscillator support from 3.58MHz to 40MHz
• I2C instructions to access more external devices including serial EEPROMs
• In-line assembler and Call support
• MPLAB / MPASM / ICE compatibility
• Use in DOS or Windows
• Supports PIC12C67x, 12CE67x, 14C000, 16C55x, 6xx, 7xx, 84, 92x, 16CE62x, 16F62x, 8x, 87x, 17Cxxx and 18Cxxx microcontrollers
• Compatible with most PICmicro
• If you want maximum compatibility with the BASIC Stamp I, or you would like to save a little money, or you just don't need all the extra features in PicBasic Pro, please take a look at our standard PicBasic Compiler.

There is a special offer for current PicBasic Compiler owners to 'cross-grade' to the PicBasic Pro Compiler. Please see the upgrade page at www.picbasic.co.uk for more information.

To order the book, send £24.95 plus £5.50 for shipping (overseas readers £8.50) to Crownhill Associates Limited, 32, Broad Street, Ely, Cambs, CB7 4AH. Tel: 01353 666709, fax: 01353 666710, e-mail sales@crownhill.co.uk

For more information, visit,
www.picbasic.co.uk
and,
www.crownhill.co.uk
Les Green believes that RF designers who are not familiar with S-parameters are missing out on a wealth of information. Here he sets out to explain them in relatively simple terms.

S-parameters are not particularly complicated to use or to understand, but like any mathematical or engineering subject, if you don’t have someone to ask about them, you can be difficult to pick up from books and articles alone.

So why do you need to know about S-parameters? Well, if you have never been specifically taught about S-parameters, then you are missing out on lots of articles related to RF engineering. Given that S-parameters originated in 1920, there is a lot of technical information in existence that makes use of them, and this is currently inaccessible to you.

Part of the problem with learning from application notes and articles is that they often have mistakes in them. If you don’t understand S-parameters, it is impossible to differentiate between a good, accurate article and an article containing basic errors.

I would estimate that it takes at least ten times longer to understand the small subject area when some of the sources of your information are wrong. One purpose of this article is to help you to spot errors in papers, books and application notes within this subject area.

At the same time, the article will give you the basic knowledge that you need. Armed with this knowledge, you may be able to go back to these other sources with renewed zest.

What is an S-parameter?
S-parameter is a contraction of ‘scattering parameter’. In English, the word ‘scatter’ has as one of its definitions, ‘separate and drive off in different directions’. The word ‘parameter’ means a constant for a particular system, which will vary from one system to another.

For example, a rubber ball will have a certain ‘bounceiness’. This bounce-factor would be a parameter for the ball and you might want to select one with a very high bounce-factor.

Thus, so far we have that S-parameters are constants for a particular component that relate to its tendency to pass, reflect or amplify a signal. Clearly, the subject we are talking about is closely related to transmission lines, amplifiers, signal generators and attenuators.

S-parameters only apply to the sinusoidal response at a particular frequency, or over a range of frequencies. This is known as the frequency domain, where domain means a region of thought or activity.

In general, it is difficult to calculate what the exact response of a system will be in the time domain (pulse response) when you only know the frequency domain response.

I’ll start with a very simple system, in very simple terms. A load has a complex impedance $Z_L$, which in general changes with frequency. You could measure this impedance with some sort of meter and plot a graph of how the impedance changes with frequency. Other people could now use this data to see how the load would perform in their system.

If the system that the load is to be connected to is a transmission line then things change. You would now have to characterise the load according to frequency and the length of the transmission line. This is not very convenient.

It is preferable to characterise the load in terms of its relationship to the transmission
line. In this way only one set of measurements is necessary. Such a system has been worked out and consists of quoting the reflection coefficient of a load. If the load is measured at the end of a length of lossless transmission line then the magnitude of the measured reflection coefficient will be the same, regardless of the length of the line.

A transmission line is considered to have a forward travelling wave going down the line towards the load. At the load some fraction of this incident signal is reflected, according to the reflection coefficient of the load. This reflected signal then heads back up the line towards the sending end, Fig. 1.

As you move along the transmission line, away from the load, the incident and reflected signals change in phase by opposite amounts. This is because the signals are travelling in opposite directions. On the phasor diagram, therefore, the incident and reflected voltage phasors rotate in opposite directions.

It is easy to see then, that at some points on a long line the two phasors will be pointing in the same direction. At some other specific points the phasors will be pointing in opposite directions.

The reflection coefficient is represented by a capital Greek letter gamma, \( \Gamma \), where it is understood that \( \Gamma \) is a complex number. If you want just the magnitude of the reflection coefficient then you either write \(|\Gamma|\), or use the symbol \( \rho \), which is the Greek letter rho.

If you have an incident voltage \( V_i \) and a reflection coefficient of \( \Gamma \), then the reflected voltage is simply given by

\[
V_r = V_i \times \Gamma
\]

This is the definition of the reflection coefficient in fact. When the incident and reflected phasors point in the same direction, you get a maximum signal whose amplitude is,

\[
V \times (1 + |\Gamma|)
\]

When the phasors point in opposite direction a minimum signal occurs whose amplitude is,

\[
V \times (1 - |\Gamma|)
\]

What has been described here is a standing-wave pattern on the transmission line. If you were to get a high-impedance RF voltmeter and put your probes onto the transmission line at various points as you moved away from the load, you would find where the RMS signal was large and others where it was small. The signal would vary continuously between these maximum and minimum signal points.

The standing wave of voltage would have a ratio of maximum to minimum values of:

\[
\frac{V}{V_i} = \frac{(1 + |\Gamma|)}{(1 - |\Gamma|)}\]

This ratio is simply known as the voltage standing wave ratio, VSWR.

You can therefore specify the load in terms of the VSWR it will give on a transmission line, rather than its reflection coefficient. However, you will note that giving the reflection coefficient magnitude and phase imparts more detail about the load than merely giving the VSWR. The VSWR does not contain the phase information.

Having worked through this introductory material, you should now be in a position to meet the first S-parameter. For a simple load, the reflection coefficient is exactly equal to the parameter \( S_{11} \). In fact whenever you see an S-parameter where the two subscripts are the same, you know that you are looking at a reflection coefficient when all the other ports are perfectly terminated in the characteristic impedance of the system, \( Z_0 \).

I have written that very carefully and in full. People often use the term 'matched' very loosely and this causes confusion. If you want the maximum power transfer you use a conjugate match. If you want minimum reflected signal you use a \( Z_0 \) match.

There are also other conditions of network terminations that can be referred to as matching which are 'obvious' from the context, provided you are already an expert in the field of course! In this article I will explicitly refer to \( Z_0 \)-matching and conjugate matching as appropriate.

### Complex numbers made simple - part 1

In electrical engineering, we are used to dealing with sinusoidal AC signals. Everyone in the business knows about resistance and reactance. This is the most elementary presentation of impedance; there is a resistive part that dissipates power and there is a reactive part that doesn't.

The reactive part comes in two types; there is inductive reactance, which increases with frequency, and there is capacitive reactance, which decreases with frequency.

In mathematical terms,

\[ X_l = \frac{1}{2\pi f \times L} \]

and,

\[ X_c = \frac{1}{2\pi f \times C} \]

In a series combination of a resistor and an inductor, you can't just add the resistance and the reactance together because the current in the inductor is 90° out of phase with the voltage across it. The total impedance is evaluated by the use of a phasor diagram.

In mathematical terms, you can use a simple notation and say that for a series \( LR \) circuit,

\[ Z = R + j \times X_l \]

Here \( i' \) represents the 90° phase shift.

For inductance, \( +j \) is used. For capacitance, \( -j \) is used because the phase shift in a capacitor is opposite to that in an inductor.

Since \( j \) represents 90° phase shift, \( pj \) is 180° phase shift, which means it is now heading back in the opposite direction. Thus \( pj \) is equal to \( -1 \) and you have the mathematical idea that,

\[ j = \sqrt{-1} \]

At school, you may have used \( i \) instead of \( j \), electrical engineers prefer \( j \), as \( i \) is reserved for current.

Remember: this mathematical method only applies to sinusoidal signals.
Two-port nets
The two-port network is the most common type of device you will encounter. It simply means that there are two entry points to the device. A load would be an example of a one-port device and an in-line attenuator would be an example of a two-port device.

Figure 2 is a simple diagram of this two-port network. It has two sets of terminals, labelled port 1 and port 2. You might expect them to be labelled as 'input' and 'output' and there are two specific reasons why this is not done.

In the first place, a device such as an attenuator or a filter may have no preferred direction; in this case the use of the terms input and output would be arbitrary.

In the second place, there may be multiple i/o ports and the signals will in general be passing in both directions simultaneously. Hub? If you remember the transmission line case, there were forward and reverse travelling signals in the same conductor at the same time.

In general you want to look at the system in terms of simultaneous forward and reverse travelling signals. The maths has to sort out which is the dominant direction at any time.

Hopefully the haze is beginning to clear and some of the things you have read about are starting to make sense. If you see $S_{33}$ you know that you are dealing with a network that has at least three ports. If all the other ports are $Z_R$ matched then the reflection coefficient seen at port 3 will be simply $S_{33}$. That isn’t very hard is it?

Two ports, four S-parameters
There are four S-parameters for a two-port network. There are the two input reflection coefficient terms and there are transfer terms in each direction. When an incident voltage arrives at a port, some is reflected and some continues.

In a lossless device such as a connector, the amount that is transmitted is necessarily less than that which arrived, since some power has been reflected. In an active network such as an amplifier, it is critically important that there is more gain in one direction than in the other. Both of these situations are handled by the mathematics embedded in the S-parameter equations.

In these equations, incident voltages are heading into the network. In other words, both ports are considered as inputs. The reflected voltages are heading away from the ports,

\[ V_{ref1} = S_{11}V_{inc1} + S_{12}V_{inc2} \]
\[ V_{ref2} = S_{21}V_{inc1} + S_{22}V_{inc2} \]

Interpreting these equations, the signal coming out of port 1 is the (complex) sum of the reflected part of the signal going in at port 1 and the signal transmitted from port 2. Thus $S_{12}$ is the transmission factor from port 2 to port 1.

The subscript notation looks backwards in this case, but is necessary in order to make the parameters fit conveniently into a matrix.

Note that S-parameters are complex numbers in general. But they may reduce to ordinary numbers at low frequencies, due to the phase shift becoming essentially zero.

It is instructive to start off with a simple signal flow graph showing a generator connected to a load. The result is an equation for the incident voltage on the load. Of course the
actual voltage on the load is the incident voltage plus the reflected voltage. Mathematically,

\[ V_L = V_i \times (1 + \Gamma) \]

However, you can regard this term as a calibration factor for the load. Whenever the load gets a certain incident voltage, its response will be the same. What we are more concerned about is the mismatch error given by the term,

\[ \frac{1}{1 - \Gamma} \]

This will vary according to the generator reflection coeffi-


### Simple transmission lines

The characteristic impedance of a transmission line is \( Z_0 \); for a lossless line it is a pure resistance. Throughout this article, the transmission line is considered to be lossless.

When you first apply a signal to a long piece of transmission line, regardless of the load at the end of that line, the line appears to have a resistance of value \( Z_0 \). This has been called the surge impedance of the line.

Once the applied signal reaches the load, a reflected signal will be generated if the load is anything other than a pure resistance of value \( Z_0 \). If there is no reflection then the line is perfectly \( Z_0 \)-matched.

The incident voltage is defined as the signal that would be at the load, if the load were a resistor equal to \( Z_0 \). The actual voltage at the load is defined as the (complex) sum of the incident and reflected voltages. The reflected voltage is therefore the (complex) difference between the actual voltage on the load and the voltage that would be on a \( Z_0 \) load.

A load of \( Z_L \) in a \( Z_0 \) system driven by \( V_C \) gives a voltage of,

\[ V_0 \times Z_L \]

With a \( Z_0 \) load, it is simply \( V_C \times 2 \). The difference between these two is the reflected voltage,

\[ V_0 \left( \frac{Z_L - Z_0}{Z_L + Z_0} \right) = V_0 \left( \frac{2Z_L - Z_0}{2Z_L + Z_0} \right) \]

The reflection coefficient is the reflected voltage divided by the incident voltage giving,

\[ \Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \]

### Simple dimensional analysis

You may have been taught dimensional analysis at school. You take something like force and analyse it in terms of the fundamental quantities ‘mass’, ‘length’ and ‘time’ using square brackets. Thus,

\[ \text{[force]} = \text{[mass]} \times \text{[acceleration]} \]

\[ \text{[mass]} \times \text{[length]} \times \text{[time]}^{-2} \]

You are then told that in an equation, the dimensions of terms that are added or subtracted must always be the same.

In electrical engineering we actually need an electrical unit as well, and it is conventional to use current as the electrical dimension. However, taking ohms, volts, henrys, and so on down to their fundamental units is a waste of time.

To simplify the rule, you can say that in any equation, when terms are added, subtracted or equalled the units must be the same.

To further clarify this, let me say that if you are adding something to a voltage term, that thing must be a voltage and not a current, a frequency, a power or anything other than a voltage. This provides a very rapid ‘sanity check’ on an equation, either being manipulated by you or being published in an article.

With a bit of practice you will spot common terms such as \( \text{Ohm} \), which you know as a time constant, and therefore has the dimensions of time. If you had to reduce the capacitance and resistance individually to \( \text{[mass]} \times \text{[length]} \times \text{[time]}^{-1} \) form then you would get bored very quickly!

### Quick test 2

1) What is the VSWR of an ideal 40Ω resistor in a 50Ω transmission system?
2) A load has a reflection coefficient of 0.345\angle 36° at 15.9MHz. What is the VSWR?
3) What is the magnitude of the reflection coefficient of an ideal 50Ω resistor in series with an ideal 100nH inductor? Assume that the frequency is 10MHz and that the transmission system is 50Ω.

### Quick test 3

Spot any dimensional errors in these equations, assuming the standard symbols for voltage, current, resistance, power, inductance, capacitance and impedance. In ordinary use, the terms would have subscripts or suffixes to show where they had come from. Here I have reduced the equations to a more basic form,

1) \( V = IR + I^2R \)
2) \( CR = \frac{L}{4R} \)
3) \( P = IV + I^2R + \frac{V^2}{R} \)
4) \( Z = 3R + j2\pi fL - j2\pi fC \)
cient and the load reflection coefficient. Note that the equations naturally produce results based on reflection coefficient rather than VSWR. Also, the VSWR of the load tells you the VSWR on the line. The VSWR of the generator has no effect on the VSWR on the line.

If given the VSWR, you have to be able to convert to reflection coefficient without difficulty. Do realise, though, that you now have no phase information on the reflection coefficient.

As soon as the phase information on one of the reflection coefficients is lost, you can no longer calculate the mismatch error exactly. All you know is that the value lies between the limits of,

\[
\frac{1}{1+\Gamma_G^2} \Gamma_G \quad \text{and} \quad \frac{1}{1-\Gamma_G^2} \Gamma_G
\]

This is then known as the 'mismatch uncertainty'.

Of course you are desperately clinging on, waiting for S-parameters to be mentioned again. Well I have been using reflection coefficients for the generator and the load because this is usual practice. You could call those \( S_{11} \) if you wanted. The key thing was to develop the use of the signal flow graph. Now that is done, you can actually work out more complex systems.

### Simple signal flow graph

There is a graphical representation of linear equations which is very useful when dealing with S-parameters.

![Simple signal flow graph](image)

This signal flow graph is for a load connected to a generator through a lossless cable. The number in the middle of the arrows is the (complex) gain for that path. The blobs with the same colour represent the same point in space. The signal flow graph is separating out the forward and reverse travelling waves, which makes it much easier to see where they are going.

Note that there are two paths from the load to the generator. This represents only one physical wire. We are not talking about one signal going down the centre of a coaxial cable and the other going through the outer sheath. Both the signals travel down the same piece of wire, but in opposite directions.

The rules of the signal flow graph are very simple:
- Only go in the direction of the arrows.
- The voltages add where the arrow heads meet.
- The (complex) gain of a path is written on the arrow.
- An arrow going out from a blob (node) does not affect the voltage at that point.

You can now analyse the circuit. The voltage on the bottom blob of the load is \( V_i \times G \). This signal travels back to the generator without loss (the path has a gain of 1 on the diagram) and gets reflected by passing up to the top blob on the generator.

Coming into the top blob on the generator we therefore have,

\[ V_G + V_i \times \Gamma_G \]

Of course this is equal to the voltage \( V_i \) that was originally used as a label on the top blob of the load. The top blob of the generator is connected to the top blob of the load via a path with a gain of one. Hence the two voltages must be equal. Now we have,

\[ V_G + V_i \times \Gamma_G = V_i \]

\[ \therefore V_G = V_i \times (1 - \Gamma_G \Gamma_G) \]

\[ \therefore V_i = \frac{V_G}{1 - \Gamma_G \Gamma_G} \]

I hope you will agree that the maths was not too bad. Although the reflection coefficients are complex numbers, this does not make them any more difficult to handle than ordinary mathematical symbols.

### Inserting a two-port network

For simplicity in the signal flow graph below, all paths with unity gain are shown in red.

![Inserting a two-port network](image)

Assume a voltage at the top left corner of the network of \( V_A \), so that,

\[ V_A \times S_{21} + V_i \times \Gamma_G \times S_{22} = V_i \]

which is the loop on the right of the network,

\[ \therefore V_A = V_i \times \frac{1 - \Gamma_G S_{22} \times S_{22}}{S_{21}} \]

We also have on the left-hand side of the network that,

\[ V_0 + V_i \times S_{11} \Gamma_G + V_i \times \Gamma_G \times S_{11} S_{12} = V_A \]

Replacing \( V_A \) and rearranging gives:

\[ V_i = \frac{V_G}{1 - S_{11} \Gamma_G - S_{22} \Gamma_G \times (S_{11} S_{12} - S_{12} S_{11})} \]

### Quick test 4

1. What two-port device is represented by the wideband S-parameters,
   \[ |S_{11}| = |S_{22}| = 0.2, \quad |S_{12}| = 10, \quad |S_{21}| = 0.03? \]

2. What two-port device is represented by the wideband S-parameters,
   \[ |S_{11}| = |S_{22}| < 0.01, \quad |S_{12}| = S_{21} = 0.17 \]

3. Using S-parameters for the attenuator in the appropriate previous question, show how the mismatch uncertainty is reduced by the use of the attenuator in a system where,
   \[ |S_{12}| = |\Gamma_G| = 0.3 \]

4. Repeat 3, but give both ends of the attenuator a VSWR of 1.5 (when the other ends are \( Z_0 \)-matched.)
More complex systems

The next system to be considered has a two-port network between the generator and the load. Note that there is no need to specify this as a passive attenuator, an amplifier or a filter at this stage. The S-parameters of the network specify what the network does without further qualification.

The calculation is not too difficult and gives some rather important points. The thing to do now is to learn to read the result and work out what it all means.

Firstly, look at the terms on the underside of the equation for \( V_r \). All the terms are multiplied by reflection coefficients which should ideally be zero. In that case,

\[
V_r = S_{21} \times V_G
\]

It is now clear that if \( |S_{21}| \) is greater than unity, you have an attenuator with port 1 as the input. If \( |S_{21}| \) less than unity, then you have an attenuator. Parameter \( S_{21} \) is therefore the ideal voltage gain of the network. This is \( 20 \log_{10} |S_{21}| \) when expressed in decibels.

For a linear passive attenuator, \( S_{21} = S_{12} \); this is a property called reciprocity. It applies to linear devices such as resistors, capacitors and inductors, and to any network composed of them.

For an amplifier, it is conventional to specify the input as port 1. Thus you always look for the forward voltage gain of the device in terms of \( S_{21} \), with a suitably small value of the reverse voltage gain \( S_{12} \).

You will have heard of the idea of using an attenuator to improve mismatch uncertainty. The principle is very simple. The mismatch occurs by a signal bouncing off the load then bouncing off the generator and returning to the load.

If an attenuator is inserted between the load and the generator, the desired signal is reduced by the attenuation factor of the attenuator; let's suppose this is a factor of \( \times 5 \). The signal bouncing of the load has to go through the attenuator, bounce off the generator then go back through the attenuator.

As a result, this multiply-reflected signal is attenuated by a factor of \( \times 25 \). The mismatch uncertainty is greatly improved by this, as you will see from the test questions.

For this to work, the attenuator has to have a much lower reflection coefficient than the worst of the load and source reflection coefficients. This fact is often neglected. You do see foolish examples given where the attenuator reflection coefficient is so bad the overall result would actually be worse! If you complete the quick tests then you will never be caught out by this sort of gross error.

If you have worked through this article and done the tests, you should be in a much better position to understand the books and literature in this subject. Note that almost all texts work in terms of power, not voltage.

Watch out for normalisation though. Rather than use actual voltages, texts often divide by the square root of the characteristic impedance, so that the incident wave squared gives power.

The other 'trick' is to use a characteristic impedance of \( 1 \Omega \). Both these habits can be spotted by using the dimensional analysis skills mentioned in that panel.

Answers

**Quick test 1**
1) \( Z = 50 + j20.73 \Omega \)
2) 54.13 \( \Omega \)
3) 22.52°
4) \( Z = 50 - j20.73 \Omega \)

**Quick test 2**
1) 1.25
2) Frequency irrelevant. Phase of \( \Gamma \) irrelevant.
VSWR = 2.053.
3) \( X_l = 6.283 \Omega \)
\[
\Gamma = \frac{50 + j6.283 - 50}{50 + j6.283 + 50} = 0.0627
\]

**Quick test 3**
1) Left hand side and \( I.R \) are voltage, but \( P.R \) is power.
2) Time constants both sides. Fine.
3) All power. Fine.
4) The capacitive term is wrong.

**Quick test 4**
1) This is an amplifier with a voltage gain of around 10 and input and output VSWRs of around 1.5.
2) This is a \( \times 10 \) (20dB) attenuator with input and output VSWRs of 1.02.
3) For a comparison look just at the denominator (underneath part) of the expression for \( V_r \) and take both reflection coefficients as positive, 
\[
1 + \rho_1 \rho_0 = 1 + 0.09 = 1.09
\]
Do the same with the attenuated system,
\[
1 + 0.01 \times 0.3 + 0.01 \times 0.3 + [0.01 \times 0.01 + 0.1 \times 0.1]0.3 \times 0.3
\]
\[
= (1 + 0.003 + 0.003 + [0.0001 + 0.01] \times 0.09)
\]
\[
= 1.0069 \quad (\text{much better})
\]
4) \( |S_{11}| = |S_{22}| = 0.2 \)
\[
1 + 0.06 + 0.06 + [0.04 + 0.01] \times 0.09 = 1.125
\]
You will notice that the mismatch uncertainty can be worse when the attenuator reflection coefficient is lousy. In this case the attenuator reflection coefficient is slightly better than both the source and load reflection coefficients and yet the result is still worse.
Develop and test complete micro-controller designs without building a physical prototype. PROTEUS VSM simulates the CPU and any additional electronics used in your designs. And it does so in real time.

- CPU models for PIC and 8051 and series micro-controllers available now. 68HC11 coming soon. More CPU models under development. See website for latest info.
- Interactive device models include LCD displays, RS232 terminal, universal keypad plus a range of switches, buttons, pots, LEDs, 7 segment displays and much more.
- Extensive debugging facilities including register and memory contents, breakpoints and single step modes.
- Source level debugging supported for selected development tools.
- Integrated 'make' utility - compile and simulate with one keystroke.
- Over 4000 standard SPICE models included. Fully compatible with manufacturers' SPICE models.
- DLL interfaces provided for application specific models.
- Based on SPICE3F5 mixed mode circuit simulator.
- CPU and interactive device models are sold separately - build up your VSM system in affordable stages.
- ARES Lite PCB Layout also available.

*E g. PROTEUS VSM can simulate an 8051 clocked at 12MHz on a 300MHz Pentium II

Write, phone or fax for your free demo CD - or email info@labcenter.co.uk.
Tel: 01756 753440. Fax: 01756 752857. 53-55 Main St, Grassington. BD23 5AA.
For a graphic equaliser to be useful in a hi-fi environment, it has to have a large number of channels, argue Michael Slifkin and Leonid Shigris. This complete design uses OP27 op-amps for their precision, low noise and speed.

Graphic equalisers found in recording and broadcasting studios are used to shape the sound. They are not necessarily there to compensate for any deficiency in the frequency response of the audio equipment or studio.

That they should be of interest to the man in the street is somewhat surprising, but there has been a tendency in recent years to equip music centres and radios – often quite cheap ones – with so-called graphic equalisers.

The term graphic equaliser clearly arises from the layout of the instrument, which involves a series of parallel slide potentiometers arranged side by side so that the positions of the slider knobs gives a graph-like plot of amplitude versus frequency.

Commercial equalisers are very expensive instruments. They usually have 31 channels spaced a third of an octave apart and covering a frequency

Prof. Slifkin is with the Jerusalem College of Technology and can be contacted at slifkin@optics.jct.ac.il

Leonid is a former student of the College.

Fig. 1. Outline of the graphic equaliser topology showing four active band-pass filters.
Fig. 2. Full circuit of one stereo channel of the 15-band equaliser. The OP27 was chosen for its low noise, high speed and precision.

**Graphic equaliser specifications**

- Input signal: 1V
- Input resistance: 15kΩ
- Internal resistance: 200Ω
- Audio frequency: 30Hz to 25kHz
- Signal-to-noise ratio: 90dB
- Gain: -12dB to +12dB.

The equaliser has 15 channel centre frequencies: 49, 75, 116, 179, 275, 423, 650Hz, 1, 1.53, 2.36, 3.63, 5.58, 8.57, 13.18 and 20kHz.
range from around 20Hz to 16 or 20kHz.

Modern equalisers are digital. They allow for pre-programmed settings. There are one or two less well specified equalisers, supposedly for the professional market, that are only 15 channels with the centre frequency every \( \frac{3}{5} \) octave.

There's also a variety of stand-alone equalisers made for car radios and the like that are 10 or 7-channel devices. These are advertised as giving lift to the bass sound. You can even buy a software program, for use with RealPlayer and similar programs on the computer, which gives a representation of a graphic equaliser on the screen. This enables you to shape the sound from your computer using the mouse.

A popular equaliser for the PC uses 10 channels. See for example, http://cgi2.prognet.com/pluszone/tutorial60/equaliser.html

However, the manufacturer's claim that this equaliser operates up to 65kHz should be treated with some reserve. The three-channel graphic equaliser in some cheap audio equipment can only be a gimmick. It is difficult to see how they are that much better than the traditional bass and treble tone controls.

The drawback of cheap equipment with small speakers is usually that the bass response is too low but that can be corrected by boosting the bass and/or cutting the treble. Five-channel equalisers are provided on some quite expensive radios/tape recorders.

Normally, the audio frequency is taken to cover the range from around 20Hz to 20000Hz. Not many people will be able to hear the whole of that range though. The upper frequency limit that a human being can resolve falls with increasing age. The effect of adjustments at such high frequencies would be quite unnoticeable. It is unlikely that the average Clapham omnibus rider would have the ear to be able to adjust a 31-channel equaliser.

A quite non-scientific survey among friends and acquaintances with audio equipment equipped with equalisers found that the majority never bother with controls at all after the first few hours – or sometimes even minutes – of ownership.

It is however clear – and one only needs to read the correspondence column of this journal – that there are people who feel very passionately about audio quality. To these people, no doubt a design for a relatively inexpensive but effective graphic equaliser

---

**Performance curves**

While these are not ideal curves, as there is clearly some interaction between channels, we nevertheless believe that they are sufficiently good to warrant using the equaliser for audio shaping or compensation.

These curves represent very extreme conditions. In practice, you would not expect to set up major variations in gain in adjacent channels, but rather there would be a relatively smooth transition between channels.

---

**Fig. A. Response of the 49Hz channel.**

**Fig. B. Response of the equaliser with the 275 and 650Hz channels set to +12dB and the 432Hz channel set to -12dB.**

**Fig. C. Response with all three previous channels set to +12dB and is a measure of the ripple of the equaliser. A ripple of about 2dB is more than acceptable. In general the ear is not sensitive to changes in sound amplitude less than 3dB.**
would be of interest. In addition people with impaired hearing might find some form of audio shaping of value.

To be honest with you, the real impetus for this project was the appearance in a local dealer in surplus electronic equipment of a large number of 10kΩ, four-inch linear slide potentiometers, boxed, unused and at a knock-down price.

Tone controls consist of a high-pass and low-pass filter with amplification and attenuation. Nowadays, you can get TDA1524A tone-control IC that requires only a few additional passive components to operate. However, graphic equalisers require a number of band-pass filters. The ideal filter response would be rectangular. This is unfortunately far from obtainable.

Whereas passive filters require both inductance and capacitance, active filters need only capacitance. An active filter is one using one or more operational amplifiers. Op-amps are necessary to obtain both gain and attenuation and to avoid using inductors.

Narrow band-pass filters are needed to make a useful graphic equaliser. The important factors are the bandwidth, generally the frequency difference between the 3dB points, the flatness of the filter response and the slope of the sides of the response.

A graphic equaliser's design is no more nor less than the design of a narrow band filter and there's a wide range of configuration options available for such filters. At one time, Wireless World, as this journal was then called, published a pack comprising about 16 cards in a transparent envelope, each card giving details of a different active filter circuit. For many readers — including one of the writers — this was probably the best instruction they ever received in filter technology.

We designed our filters from the information given in an excellent book by Williams¹, finally opting for a Butterworth type filter. According to Williams, Butterworth filters should be used wherever possible because of their favourable characteristics. They have the flattest top of any active filter but the slope is not as good as others and the phase shift through the filter is somewhat poorer.

We used a two-pole filter — one with two capacitors — to give us a steeper slope than a single-pole filter. The centre frequency of the filter, f₅, is defined in terms of the high and low 3dB attenuation frequencies f₁ and f₅ as f₅=√(f₁f₅).

We did a computer simulation of a three and five-channel graphic equalisers.
er using Butterworth second-order filters. We found that such devices were very poor in that adjustment in one channel had a marked effect in adjacent channels. This made it quite difficult to get a prearranged response.

As a result of this simulation, it was clear that using fairly simple filters required a larger number of narrower channels if each channel was not to have an effect at frequencies well outside the nominal channel. We decided to build an equaliser with as near to professional specifications as was feasible on a limited budget.

There are professional instruments on the market using 15 channels and we felt that that would suffice. We opted for the specifications mentioned in the separate panel.

Circuitry

Figure 1 shows the basic idea. We used the OP27 operational amplifier. This is a low-noise, high-speed precision device, making it very suitable for this application. A data sheet for this amplifier can be downloaded from: http://www.ti.com/sc/docs/products/analog/op27.html

The actual design was based on formulae given in Williams work and is too complex to discuss here. However, certain factors have to be determined. These include the filter selectivity factor, Q, defined as the ratio of f0 to f0-f1. The selection of 15 channels over the frequency range gives a Q factor of 2.31 per channel with the minimum frequency of 40Hz and a maximum frequency of 25kHz. The multiplication factor between the adjacent centre frequencies is found from the expression

\[ K = \frac{25k}{40} \]

and is approximately

1.53.

Figure 1 shows the basic Butterworth two-pole configuration.

Setting up

Figure 2 shows the complete circuit. In each filter section, a 10kΩ slide potentiometer adjusts the feedback to give gain or attenuation. The preset potentiometer in each slide potentiometer’s wiper should be adjusted so that the gain is 1 when the slide potentiometer is in its centre position.

We made up two complete equalisers in one enclosure to use with stereo equipment. According to our ears, the equaliser works well.

Measurements made with a signal generator confirmed that the different channels individually behaved more or less as designed, although the centre frequencies were not as accurate as we had supposed. It should be pointed out that we used standard value components, the nearest in value to those predicted by the equations, which would certainly give rise to some inaccuracy.

Reference

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' - blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

For many years there have been rumours about a biography of Alan Blumlein, yet none has been forthcoming. This is the world's first study of a man whose achievements should rank among those of the greatest Britain has produced. This book provides detailed knowledge of every one of his patents and the process behind them, while giving an in-depth study of the life and times of this quite extraordinary man.

Contents

Earliest days
Telegraphy and telephony
The audio patents
Television
EMI and the Television Commission
The high-definition television period
From television to radar
The story of radar development
H2S - The coming of centimetric radar
The loss of Halifax V9977
Legacy
To Goodrich Castle and beyond
Four-way RS232 router

In software terms, the two standard RS232 COM ports on the PC are readily accessible. Also, there's a considerable number of instruments that are equipped with compatible serial port.

Usually though, at best only one COM port on the PC is free so only one instrument can be interfaced. In most cases, a mouse occupies one COM port and a modem the other. In the case of a lap-top computer the situation may be worse. There may simply not be enough physical space for a second port connector.

Companies such as Thurby Thandar1 and Amplicon2 do offer multi-RS232 port expansion systems, but these are relatively expensive. The following proposed circuit, which we refer to as an RS232 switch box, provides a cost effective alternative. It allows four instrument with RS232 ports to be connected to a single serial port on a PC or compatible.

The RS232 switch box

This design is based on the MAX238 from Maxim3. Since the circuit is specifically made to transfer data from TTL voltage levels to the RS232 voltage levels, it proved relatively simple to fabricate a fully-compatible multiplexing system.

The mother board, Fig. 1, accepts signals from the computer. It routes RS232 through to one of four daughter boards depending on which interface has been enabled via a signal from the printer port.

Instruments with RS232 interfacing are abundant, but because the average PC only has one spare COM port, experiments involving a number of instruments are tedious. With Frank Thompson's RS232 switch box, the LPT port selects one of four routes for RS232 communications under software control, essentially expanding one COM port to four.
Fig. 1. RS232 switch box 'mother board'. The MAX232 is there so that the circuit communicates with the PC using true RS232 levels. Each of the four connectors shown carries one daughter board, as in Fig. 2.

Data DB0 (2)
PC's printer port

Data DB2 (4)

Data DB3 (3)

GND (8, 9)

PC's RS232 port
and data strings were displayed on the screen.

No problems were encountered with the two-wire RS232 cable of the CD75 conductivity instrument.

In summary
Within the speed limitations of any serial port, I found that the RS232 switch box is an extremely useful circuit for interfacing many laboratory experiments to a PC. Importantly, it has also proved to be student proof!

Although four ports are available on the existing switch box, it can be expanded to use all eight data lines on the printer port.

Also, if some form of data-line expansion were then to be used, the number of RS232 ports could be increased even further. The main limiting factor may then be the accumulated time involved with the PC serving all the ports in succession.

More information
1. Thurlby Thandar – www.ttinst.co.uk
2. Amplicon – amplicon.co.uk
5. Instrotech – www.instrotech.com

Listing 1. Qbasic routing for finding the the PC printer port’s base address.
DEF SEG = 0 ‘access page ZERO vectors
CLS
PRINT “Number of Centronics ports: “, (PEEK(&H111) AND (128 + 64))/64
A = PEEK(&H408) + 256 * PEEK(&H409) ‘find base vector
A$ = HEX$(A)
‘print out number of ports and base address of LPT1
PRINT “Address of LPT1 : “; PEEK(&H408) + 256 * PEEK(&H409)
PRINT LPT1 in Hex is ‘; A$
PRINT “Address of LPT2 : “; PEEK(&H40A) + 256 * PEEK(&H40B)
PRINT “Address of LPT3 : “; PEEK(&H40C) + 256 * PEEK(&H40D)
PRINT ‘Press any key to return to program
END

Listing 2. Qbasic for taking readings from two instruments using the RS232 switch box.
’******Test Switch BOX******************************
’******start with readings from Mettler Balance PM 460
Count = 1 ‘count readings
DO
OUT 956, 0 ‘open port 1 on SWITCH BOX
OPEN “COM1:2400,E,7,1,CS,DS,LF” FOR RANDOM AS #1 specify RS232
PRINT #1, “S” ‘computer sends message to balance
INPUT #1, M$ ‘mass string returned from balance
PRINT M$ ‘write mass string on screen
CLOSE #1
’****** change RS232 to obtain conductivity readings
’****** readings from CD 75 meter
OUT 956, 1 ‘open port 2 on SWITCH BOX
OPEN “COM1:9600,N,8,1,CS,DS,CD” FOR RANDOM AS #2
INPUT #2, RESULTS$ :
PRINT RESULTS$
CLOSE #2
Count = Count + 1
LOOP UNTIL Count > 10 ‘take 10 readings
END

Fig. 2. One of the switch box’s four daughter boards. The 241 schmitt buffer ensures signal integrity and the MAX238 provides proper RS232 levels for communication with whatever is connected.
Versatile stimulus for
digital test


In last month’s issue, my article ‘Versatile stimulus for Digital Test’ described a PLD-based system capable of producing a preprogrammed stream of digital words. This instrument interfaces to a PC and is intended as a stimulus to digital testing.

Two pieces of software are needed for the tester. One is the firmware for the PLD. The other provides the PC-based GUI that allows the tester to be elegantly and conveniently programmed and monitored.

Both pieces of software were provided on the free CD mounted on the cover of the November issue. The following is a more detailed explanation of the software provided for those of you unfamiliar with some of the procedures involved.

Interested in just getting it working?
If you have no Visual Basic, no Visual C, and no PLD programming software, then the ‘Install’ directory is the only one that will interest you. You’ll need to send an SAE marked ‘DT PLD’ to Electronics World’s editorial offices to obtain a programmed PLD though.

The ‘Install’ directory contains three files; double-click the ‘setup’ application to install the word generator’s software. The software can be uninstalled using Start/Settings/Control Panel/Add/Remove programs.

For advanced users...
The ‘VB source code’ directory will be useful to those of you familiar with Visual Basic 6. As usual, double-clicking on the Visual Basic Project File will start Visual Basic and allow you to poke holes in my code.

The file WfmGenDLL.dll is the dynamic link library, or DLL, containing functions called by Visual Basic; this allows control of the printer port to which the hardware is connected. The file 'count.wfm' is an example waveform file.

The files in the ‘WfmGenDLL’ directory are needed to modify the DLL for your own purposes. You’ll need Visual C++6, of course. Double-click the ‘.dsw’ file to start Visual C++6 with the project loaded. The file WfmGenDLL.cpp contains most of the code that I wrote.

Functions made available to the Visual Basic program have names of the form,

WFMGENDLL_API return_type fname(parameter1, parameter2, …).

These exported functions must be listed in the file ‘WfmGenDLL.h’ – a point that I missed in the main article. These ‘.h’ and ‘.cpp’ files are the only ones that the programmer must modify; all other files are generated automatically when you choose a DLL in the Visual C++ wizard. See last month’s article for details.

The ‘Release’ directory inside ‘WfmGenDLL’ contains the resulting DLL. When you select ‘generate mapfile’, the map file...
turns up here too. There’s more on this in last month’s article.

PLD software details

‘WrdGnPLD’ contains files associated with the design of the PLD. It will only be of use to you if you have Lattice’s PLD software.

Double-clicking the ‘wrdgen.syn’ file starts up the Lattice software with the project loaded. The directory ‘wrdgen’ inside ‘WrdGnPLD’ contains the results of the graphical layout process described in the main article. Significantly, it contains the .jed file which is fed to a blank PLD to program it.

If you install the ‘WrdGnPLD’ directory somewhere deep in a nest of directories, remember to avoid having a path to which DOS would take exception – keep the directory names short and avoid spaces.

‘Sim’ contains files that show you how a design may be simulated using Lattice’s software. The file ‘counter.syn’ is the one to double-click to start the software with the counter design loaded. The same restrictions about directory names apply here.

Double-click the ‘.abv’ file to edit it, to run the simulation, single-click the ‘.abv’ file, and double-click ‘Equation Simulation waveform’. You can then add signals to the display using Edit/Show from the menu bar.

Remember that the generator needs Windows 95 or 98. Relying on the design as it does on the simple C code,

```c
__out p (PORT, VALUE); 
```

to change the state of printer port lines, it can’t be used with Windows NT or Windows 2000.

A tip

Since writing the original article, I’ve found that there’s a more elegant way to achieve something mentioned there.

When I told you how to set up the DLL calling convention by using ‘Project/Settings in Visual C++’, I said that the calling convention had to be set up separately for the Debug and Release versions of the program – if you need to use them both. There’s a better way.

In Project/Settings, above the left-hand pane, there’s a drop-down box, with options ‘Win32 debug’, ‘Win32 release’, and – and this is the important bit – ‘All configurations’. This last option will do what it says, saving you the trouble of entering the settings separately for each type of build.

Colin has put a considerable amount of time and effort into producing and debugging this design. You are free to use and modify the software for your own personal interests, but if you want to make commercial gain from the design – in full or in part – you must first obtain a licence from Colin.
Test Equipment Price Blitz!

While Stocks last:

**PHILIPS PM3217 Oscilloscopes**
DC-50MHz Dual beam, Dual Timebase (incl Delay).
Incl NEW probes and Cover...
an Un-Beatable £125

**LAST FEW Available:**

**MARCONI 2019A Signal Generators**
80kHz to 1040MHz AM-FM...Synthesised...3x LCD readouts.
STILL ONLY £395

---

**OSCILLOSCOPE CLEAROUT**

- **TEK 212 Portascope (120v Charge)**
  One Only . . . One damaged probe otherwise OK . . .
  Hence Only £75
- **UNUSED Wayne Kerr**
  DTA20 DC-20MHz
  Twin Trace. Nice basic
  Easy to use scope
  NOW ONLY £195
- **UNUSED Wayne Kerr**
  DTV40-DC-40MHz
  4 Trace Twin Timebase
  Ex-Demo
  Only Only at £225
- **Gould OS300 DC-20MHz**
  Twin Trace Nice Basic Easy to use Scopes
  Now Only £125
- **Gould OS3500 + 3010DVM**
  Twin Trace DC-60MHz
  One Only at £195
- **TEK 922R DC-20MHz**
  Twin Trace Horiz mount
  One Only at £125
- **TEK 2205 DC-20MHz**
  Twin Trace . . . Modern Design
  One Only at £175

- **TEK 465, 465B, 465M**
  DC-100MHz Twin Trace Twin Timebase
  All The Same Price
  Only £275
- **IWATSU SS-5711**
  DC-100MHz Timebase
  4 Trace Twin Timebase
  One Only £325
- **TEK 475 DC-200MHz**
  Twin Trace Twin Timebase
  Now Only £325
- **TEK 2445 DC-150MHz**
  4 Trace Twin Timebase
  On Screen Readout and Cursors
  Now Only £475
- **TEK 2445A DC-150MHz**
  4 Trace Twin Timebase
  On Screen Readout, Cursors and Menu
  Now Only £575
- **TEK 7623A+ 7A13, 7A18A, 7B53A**
  Modular, Storage, 4 trace
  On Screen Readouts etc
  Now Only £475
  As above but in 7623B
  Mainframe
  Now Only £550

---

**TEST EQUIPMENT CLEAROUT**

- **HP 8569B opt H02**
  Spectrum Analyser
  10MHz-22GHz
  Storage, readouts etc
  One Only at £2,995
- **MARCONI 6311**
  Microwave Sig Gen
  10MHz - 20GHz
  One Only at £2,250
- **MARCONI 6313**
  Microwave Sig Gen
  10MHz - 26.5GHz
  One Only at £2,495
- **EIP 575 Source Locking Microwave Counter**
  12 digit LED . . .
  10Hz - 18GHz
  One Only £975
- **RACAL DANA 1991**
  Universal Nano Counters
  Now Only £95
- **BALLENTINE 6127B**
  Programmable Scope Calibrator
  One Only at £795
- **CONSULTRONICS AUTO-TIMS**
  Automatic Date Line Analyser
  Cased, Mint
  Two Only at £395
- **PHOENIX 5500A**
  Telecomms Analyser
  (not RF)
  Two Only at £295
- **FARNELL SCG UNUSED**
  Synthesised Clock Generators . . .
  15MHz - 50MHz
  Now Only £75
- **SIEMENS D2008 Level Meter**
  200kHz to 18.8MHz
  One Only at £150
- **ROHDE AND SCHWARZ SMLH**
  Signal Generator 10kHz - 40MHz AM-FM
  One Only at £125
- **B&K 2112 AF**
  Spectrometer £175
  B&K 1614 BandPass Filter
  Set £125
  B&K 4911 Motion Analyser
  £125
- **HIGH POWER 50ohm attenuators**
  2x 10db @ 100W
  BNC connectors
  Reduced to Clear Only £10
- **FLUKE 80-40k High Voltage Probes**
  For DVMs . . . to 40kV . . .
  Cased. As New
  Now Only £35
- **TRAVELLING Wave Tubes . . . NEW**
  2.8 - 3.1GHz . . .
  10mW - 2kW
  Two Only at £425

---

**ANCHOR SUPPLIES LTD**

All prices are plus VAT and Delivery

The Cattle Market, Nottingham NG2 3GY, UK
Tel: +44 (0) 115 986 4902 Fax: +44 (0) 115 986 4667

Also at Ripley, Derbys (01773) 570137 and Coalville, Leicestershire (01530) 811800

Visit our web site: www.anchorsupplies.com email: electronics@anchorsupplies.com

CIRCLE NO. 112 ON REPLY CARD
Low-profile 100W PFC supply
Bulgin Power Source has introduced a 100W open-frame power supply that incorporates power factor correction (PFC) circuitry complying with the requirements of IEC1000-3-2.

Featuring a maximum height of 26mm, the low profile BPSVP03 switch-mode PSU is suitable for applications in telecommunications, networking and computer equipment. The supply has a universal input of 90-264V AC and can be specified with single outputs of 5, 12, 15 or 24V. Using a 175kHz fixed frequency forward circuit topology, it achieves a typical efficiency of 85 per cent.

Bulgin
Tel: 01522 500511

Embedded audio design
Gennum is launching a single-chip embedded audio codec solution for multiplexing/demultiplexing digital audio streams into, and out of, digital video signals. The GS9023 embedded audio codec supports the multiplexing and demultiplexing of 20 or 24-bit synchronous audio data with a 48kHz sample rate. It incorporates sufficient processing power to multiplex/demultiplex up to four digital-audio channels. In addition, it integrates with popular AES/EBU digital audio receiver and transmitters to simplify system design. Cascadable architecture allows for the multiplexing and demultiplexing of up to 16 audio channels with no external glue logic. The device supports video standards with rates from 143Mbit/s to 540Mbit/s and when in multiplex mode, also supports the generation and insertion of EDH information according to SMPTE RP165.

Gennum
Tel: 01252 747001

Bluetooth chipset
Infineon Technologies has begun sampling its first Bluetooth chip set. The BlueMoon I set includes integrated baseband, link manager and host controller interface chips. There's a separate RF transceiver comprising two ICs—a baseband controller and an RF transceiver. The baseband IC, which comes in either a low profile, fine-pitch BG28 or TQFP100, incorporates a link controller and PCM interface. There is UART support for both software and hardware handshaking and integrated program ROM. The RF transceiver includes in the receive path an IF-filter on chip. The BiCMOS device is available in small outline TSSOP38 package.

Infineon
Tel: 01344 396313

PCI graphics controller
Based on Intel’s 430 TX chipset and supporting low-power Pentium MMX CPU with 166MHz or 266MHz clock, the Profive CPU-T6VEF board from Datasound Laboratories has a VESA compatible PanelLink interface which allows the connection of flat-panel displays within a distance of up to 5m without EMI problems, claims the company. The CPU solders directly onto the board, reducing susceptibility to vibration problems. Beside the ISA-bus and PCI-bus connectors, which belong to the PCI104-Plus

Low-power M16C 16-bit micro
Mitsubishi Electric has added to its M16C series of 16-bit microcontrollers with a low power device, the M16C120, which is a 5Mips device, is available in mask and flash ROM versions, providing 32kbytes of ROM and 1024bytes of RAM or 4kbytes of ROM and 2048bytes of RAM respectively. The device features a 91 basic instruction set and 43 I/O ports including eight LED drive output ports and eight key on wake-up input ports. There is also an eight channel, 10-bit a-to-d converter and six 15-bit timers. The MCU is fully compatible with M16C160. The small outline devices are 10mm square and come in 56-pin QFPP and 52-pin SDIPs. The device also provides enhanced memory to memory operation and bit manipulation instructions. On chip features include a one line watchdog timer and two fast UARTs.

Mitsubishi Electric
Tel: 01707 278900
standard, the Profive CPU-T6VEF board has a full featured PCI graphic controller with 2Mbyte SDRAM. Analogue CRT monitors are supported as well as flat panel displays. A 10/100bit PCI Ethernet controller with an adapter board and an 8Mbyte flash-disk has been added on-board.

DSL
Tel: 01462 675530

8-bit flash micro
Hitachi’s latest low-power flash micro, the H8/3664F, is based on the H8/300H CPU core and features a range of peripherals not typical in 8-bit micros, says the firm. These include on-chip communications capability, 16-bit timer and on-chip watchdog timer with built-in oscillator. The H8/3664F is suitable for upgrading applications currently using an 8-bit micro to 16 bits without a significant cost penalty, says the maker.
Hitachi
Tel: 01628 585163

Hall-effect switch ICs
The A3361 and A3362 from Allegro Microsystems are two-wire Hall-effect sensor ICs that switch in response to a changing magnetic field. They are for automotive and industrial applications. A dynamic-offset cancellation technique, based on chopper stabilisation, reduces the residual offset voltage normally caused by device overmoulding, temperature dependencies and thermal stress. The A3361 output current goes low in the presence of a south pole of sufficient strength. The A3362 output current goes high. Each includes on-chip voltage regulator, Hall-voltage generator, small-signal amplifier, chopper stabilisation circuitry, Schmitt trigger and a constant-current open-collector output. An on-board regulator permits operation with unregulated supplies at voltages from 3.5 to 24V. Noise radiation is limited controlling output current slew rate. Three package styles are available: miniature low-profile surface-mount package; miniature SOT-89 or TO-243AA transistor-style package for surface-mount applications; and three-lead miniature single-in-line package for through-hole mounting. Operating range is –40 to +85°C.
Allegro Microsystems
Tel: 01932 253355

Framing device
Vitesse has introduced the VSC9142, an OC-48c packet and ATM over SONET framing device that integrates the physical layer functions of serial clock, data recovery, clock generation, multiplication, multiplexing and demultiplexing between serial and parallel data paths to process and map packet and ATM cells into an OC-48c data stream. It is for data networking equipment such as core and edge routers, ATM switches and multi-service (ATM, IP and Ethernet) switches requiring Sonet-quality links between two nodes. The device uses 0.18µm CMOS technology and dissipates 2.5W. The user can extract or insert specific bytes, status information or the entire SONET transport overhead bytes for supporting operations, administration and maintenance. Performance counters and monitoring functions are integrated in the device. The serial physical layer front end complies with SONET Bellcore GR-253 jitter requirements and provides a power-down mode.
Vitesse
Tel: 01634 683393

Solid-state relay
Clare is producing four-pin solid state relays to replace electromechanical and reed relays in security systems. The CPC1008N and CPC1016N, with an on-resistance of 8 and 16Ω respectively, are 100V rated and have 1500V input to output isolation. These devices are immune to magnetic field
Too good for words

The New Ranger XL Series
Ranger 2 for Windows £170
NEW Ranger 2XL £500
NEW Ranger XL from £950
FREE Website Download Demo

Advanced Systems & Technology for PCB Manufacturers
Old Burton Lane Works, Burton, Petersfield, Hants. UK GU31 5SJ
Tel: (044) 01730 260062 Fax: (044) 01730 267273

CIRCLE NO.113 ON REPLY CARD

MARCONI 2019A
AM/FM synthesised signal generator 80kHz-1040kHz
NOW ONLY £400

MARCONI 932C AF Power Meter, Serial Measurement
Used £170

MARCONI 903B - No Swt

MARCONI 2610 True RMS Voltmeter AutoRange 30nV-

Gould 2610 True RMS Voltmeter AutoRange 30nV-

AVO 546W in Ever Ready Case, with leads etc £150

Marshall G2601, 260MHz Counter - £150

RACAL 2000 LCD Clamp Meter 0-100A £60

CLASSIC AMMETER DA 116 DIGITAL 3.5 DIGIT
COMPLETE WITH BATTERIES AND LEADS
ONLY £30

SOLARTRON 7045S BENCH TYPE DIGITAL MULTIMETER 0.1% 1.5GHz
ONLY £30

STEWARD OF READING
110 WYKEHAM ROAD, READING, BERKS RG6 1PL
Telephone: (0118) 9269341 Fax: (0118) 9351696

CIRCLE NO.114 ON REPLY CARD

December 2000 ELECTRONICS WORLD

STEWART OF READING
110 WYKEHAM ROAD, READING, BERKS RG6 1PL
Telephone: (0118) 9269341 Fax: (0118) 9351696

Callers welcome 9am-5pm Monday to Friday (other times by arrangement)
interference and compatible with surface mount manufacturing techniques. They need a minimum input control current of 2mA.

Clare
Tel: 00 32 12 672002

Fan-motor driver IC
A fan motor driver IC from Rohm Electronics combines SOP8 packaging with integrated application-specific functionality. The BA6428F is a single-phase, full wave fan motor driver IC for use in desktop computers, office equipment and peripherals. Built-in motor protection functionality includes a lock detector, automatic restart function and output terminal that provides an alarm when the motor is locked. An integral thermal shutdown facility protects the IC and the motor from overheating. Operating from a typical supply voltage of 5V, it has a maximum power dissipation of 687mW.

Rohm Electronics
Tel: 01908 282666

Audio subsystem
Wolfson Microelectronics has released the WM8722 audio subsystem for digital TV applications. It combines the audio processing requirements of a digital TV system on one chip, letting the user control input and output audio source selection, routing and signal level. It has two stereo analogue outputs, one at line level and one that includes an analogue volume control. This lets the user vary the output to a TV while maintaining a constant volume on the other output. The on-chip tone generator can be routed to the line or variable outputs. There are two analogue inputs to accommodate switching and level control of two mono or a single stereo source. The device supports data input word lengths from 16 to 24-bit and sampling rates up to 96kHz. The chip consists of a serial interface port, digital interpolation filter, multi-bit sigma-delta modulator and stereo d-to-a converter in a 20-pin SSOP. The three or two-wire serial MPU compatible control port provides access to all features including tone generation, digital de-emphasis for CD replay, on-chip mute, attenuation and phase reversal. The programmable audio data input port supports various glueless interfaces to DSPs, audio decoders and S/PDIF, AES and EBU receivers.

Wolfson
Tel: 01316 679386

Chip-on-glass LCD modules
Chip-on-glass LCD modules for custom graphics applications are available from Anders Electronics. Using STN or FSTN technology, the products

The Distributor with 20,000 hard-to-find lines
EX STOCK!!!

Semiconductors
We have one of the largest ranges of discrete parts in the UK, both new and obsolete types and, if we do not have it in stock, we can usually source it for you.

Call or fax for our latest Semiconductor stock list.

Computer products
We carry in stock everything to make a Personal Computer.

CPUs – Memory – Motherboards – Cards – Scanners – Modems – Sound Cards – Speakers – All types of Drives – Cases – PSUs – Monitors etc

Components & equipment
Call or fax for our latest Semiconductor stock list.


See our web site. Non-trade customers, send £9.80 to the sales office for a complete suite of catalogues.

SS1 Semiconductor Supplies International Ltd

Dawson House, 128 - 130 Carshalton Road, Sutton, Surrey, England, UK. SM4 4TW
020-8643 1128 (Sales and Technical Queries)
Fax: 020-8643 3637 (For International use +4420)
e-mail: sales@ss1-lk.com Web: ss1-lk.com

PCI digital I/O boards
Diamond Point has introduced the Quatech PCI digital I/O data acquisition board with Daqsuite 3.0 software. The PXB-3210/PCI provides 64 isolated digital I/O channels, which protect against external voltages up to 5kV DC and eliminate ground loops. Inputs can accommodate voltages from 0 to 24V with a 2.4kΩ input resistor. The digital input common junction can be configured as common ground or common power, enabling either current source or current sink inputs. The 32 digital outputs are configured as common ground and provided with a 500mA sink current. It has a dual interrupt trigger that provides an internal interrupt signal on each digital input channel. Also available is the PXB-818R/PCI board, which provides eight optoisolated digital inputs for collecting data in noisy environments and eight relay actuator outputs. It is expandable to 32 inputs and 32 outputs accessed via a D-37 female connector.

Diamond Point
Tel: 01634 722390

LANLINE-UK
Professional PCB Layout for Windows at Computer Store Prices!

Easy-PC For Windows 4.0

now reads Ultiboard designs/libraries*

Suddenly, a professional level PCB layout product is available at a realistic price. Just check the specification and see what excellent value you get with Easy-PC For Windows. Then test before you buy with a demo version - you will be simply amazed with Easy-PC For Windows.

True Windows 32 bit product
Integrated Schematics and Layout as standard
Windows drag & drop throughout
Multiple documents open within display
Technology files for fast start-up
Tiled display - Cascade, Vertical, Horizontal
Multi-level Undo/Redo
Integrated standard AutoPloace
Optional shape based AutoRouter
Full Copper Pour
Solder powerplanes
Unlimited signal/powerplane layers
Unlimited non-electrical/dec layers
Keep outline in areas for routing
R/H mouse menu support
Pan across design to cursor position
Cross probing between Schematics and PCB
Full forward & backward annotation Schematics/PCB
Modalless driven operation, no menu selection required

Over 7,000 users must be right!

Consistently, one of Europe's most popular
PCB Layout products for Windows.
95% of Easy-PC has won praise from users for the wealth of features within each new release.
Many of these new features are normally only found in the world's most expensive PCB Layout software packages.

Now try Easy-PC For Windows for yourself!

Number One Systems
Call +44 1684 773662 or Fax +44 1684 773664
E-mail info@numberone.com
call us for a demonstration copy or download from www.numberone.com

Number One Systems, Oak Lane, Bredon, Tewkesbury, Glos, GL20 7LR, UK

LANGREX SUPPLIES LTD

PHONE 020 8664 1166
FAX 020 8664 3056

DISTRIBUTORS OF TUBES AND SEMICONDUCTORS AND I.C.S.
1 MAYO ROAD • CROYDON • SURREY CR0 2QP
24 HOUR EXPRESS MAIL ORDER SERVICE ON STOCK ITEMS

e-mail: langrex@aol.com

CIRCLE NO.175 ON REPLY CARD

FREQUENCY SHIFTER
FOR HOWL REDUCTION

- For public address and sound reinforcement.
- Provides more gain and greater stability.
- 5Hz Fixed Shift Board with mains supply.
- Broadcast Monitor Receiver 150kHz-300kHz.
- Advanced Active Aerial 4kHz-30MHz.
- Stereo Variable Emphasis Limiter 3.
- PPM10 In-vision PPM and chart recorder.
- Twin PPM rack and Box Units.
- PPM5 hybrid, PPM9 microprocessor and
PPM8 IEC/DIN -50v/+60v drives and movements.

SURREY ELECTRONICS LTD
The Forge, Lucks Green, Cranleigh GU6 7BG
Telephone: 01483 275997 Fax: 01483 276477

CIRCLE NO.116 ON REPLY CARD
NEW PRODUCTS

Please quote Electronics World when seeking further information

are made by Nan-Ya and can interface mechanically with a motherboard via an FPC tail that can be either soldered directly to the PCB or mated with a ZIF connector. With resolutions up to 128 by 64 pixels as a single chip, the modules have glass thickness options of 1.1, 0.7 and 0.55mm and a minimum pixel gap of 0.01mm. They can be supplied with backlight colours including white or blue LED.

Anders
Tel: 0207 388 7171

Power racks

XP's HPR2 2U rack system accepts up to three HPR400-H 400W modules, delivering from 400 to 1200W. It has AC and DC fail and redundancy. The modular power rack is configured for n+1 redundancy, hot swap operation. The HPR3 3U system accommodates up to five HPR400-V 400W modules, providing 400W to 2kW. Units have fuse or breaker output distribution, system alarm module with LVD option and operating range of -40 to +70°C. Efficiency is typically 85 per cent. The HPR4 takes up to three HPR2k8 2.8kW modules, providing a power density system to 8.4kW. Input breakers are standard, and a float-battery control for battery charging is included. Modules deliver 50A at 48-54V DC or 100A at 24-27V DC at efficiency levels of 91 per cent. All versions have DC output voltage adjustment and come with a diode O-ring. Applications include mobile basestations or industrial users requiring critical load redundancy.

Tel: 01189 845515

24V dc-to-dc converter

Synqor has introduced a 24V input dc-to-dc converter. The quarter-brick sized model can operate without a baseplate or heatsink. It supports a 2:1 input voltage from 18 to 36V, with nine versions from 1.5 to 15V output, and can deliver up to 25A or 100W. The module uses synchronous rectification and has full-load efficiencies up to 87 per cent for a 3.3V output unit. Footprint is 3.7 by 5.8cm, height 1cm and weight 34g. Control and protection features include on-off control, remote sense, voltage trim, short circuit, output overvoltage and thermal shutdown. Applications include wireless basestations, process control and industrial.

Tel: 01753 860276

Optical transceiver

Cypress has introduced an integrated 2.5Gb/s STM-16 and OC-48 transceiver for optical networking systems. The CY7B9532V is packaged in a 120-pin TQFP and uses 1.3W of power. For STM-16 and OC-48 optical terminator, SDH and Sonet router and add-drop mux subsystems, it integrates an STM-16 and OC-48 transmitter, receiver, clock data recovery circuit and serdes (serialiser/deserialiser) in one chip. The on-chip transmit FIFO allows for a flexible data clocking rate. Support for the LVPECL interface provides connectivity to network mappers and framers while support for the HSTL parallel interface drives low-Z transmission lines and eliminates the need for resistors in short connections.

Cypress Semiconductor
Tel: 01707 376700

Copper pair qualifier

The ALT2000 is a tool for physical qualification, monitoring or maintenance of copper-pair subscriber loops. It has an alphanumeric keypad and independent function keys to control the test process. An LCD shows the results. Automatic measurements check the quality of service being provided, and the instrument can store and recall test results to let a technician provide certifiable results in printed form. These tests can be performed in baseband and high band, dealing with spot requirements and DSL frequencies. Frequency bands are programmable, including the automatic extrapolation of
WATCH SLIDES ON TV MAKE VIDEOS OF YOUR SLIDES DIGITISE YOUR SLIDES (using a video capture card)

"Liesging dials" automatic slide viewer with built in high quality colour TV camera. It has a composite video output to a phono plug (SCART & BNC adaptors are available). They are in very good condition with few signs of use. For further details see www.drdaq.co.uk...£91.91+vat = £108.00

Board cameras all with 512x562 pixels 8.5mm 1/2 inch sensor and composite video output. All need to be housed in your own enclosure and have fragile exposed surface mount parts. They all require a power supply of between 10 and 12v DC 150mA.

47MM size 6/30x2/7mm with 6 infra red LEDs (gives the same illumination as a small torch but is not visible to the human eye) £37.00 + vat = £43.48
30MP size 32x32x14mm spy camera with a fixed focus pin hole lens for hiding behind a very small hole...£38.00 + vat = £41.13

43MAC size 39x36x27mm camera for 'C' mount lens these give a much sharper image than with the smaller lenses...£32.00 + vat = £37.60

Economy C mount lenses all fixed focus & fixed iris

VSL1120F 12mm F1.6 12x15 degrees viewing angle...£15.97 + vat = £18.76
VSL4052F 4mm F1 22 63x67 degrees viewing angle £17.65 + vat = £20.74
VSL6020F 6mm F1 22 42x32 degrees viewing angle £19.05 + vat = £22.38
VSL8020F 8mm F1 22 32x24 degrees viewing angle...£19.90 + vat = £23.38

Better quality C Mount lenses

VSL1814F 16mm F1.6 30x24 degrees viewing angle...£26.43 + vat = £31.06
VSL813M 8mm F1.3 with iris 56x42 degrees viewing angle...£77.45 + vat = £91.00

1205 surface mount resistors 12 values 10 ohm to 1M ohm 100 of 1 value £1.00 + vat 1000 of 1 value £5.00 + vat

866 battery pack originally intended to be used with an orbit mobile telephone it contains 10 1.6Ah sub C batteries (42x22x32 size usually used in cordless screwdrivers etc.) the pack is new and unused and can be broken open quite easily...£7.46 + vat = £8.77

Please add 1.66 + vat = £1.95 postage & packing per order

JPG ELECTRONICS
276-278 Chatsworth Road, Chesterfield, S40 2BH.
Tel 01246 211202 Fax 01246 550959 Mastercard/Visa/Switch
Callers welcome 9:30 a.m. to 5:30 p.m. Monday to Saturday

The science lab in a PC

The DrDAQ is a low cost data logger from Pico Technology. It is supplied ready to use with all cables, software and example science experiments.

DrDAQ represents a breakthrough in data logging. Simply plug DrDAQ into any Windows PC, run the supplied software and you are ready to collect and display data. DrDAQ draws its power from the parallel port, so no batteries or power supplies are required.

Tel: 01480 396395, Fax: 01480 396296, E:mail: post@picotech.com, Web: www.drdaq.com

CIRCLE NO.117 ON REPLY CARD  CIRCLE NO.118 ON REPLY CARD
ADSL maximum expected data rate. Using its capability to perform as a return-loss meter, it can measure the level of echo signal caused from impedance mismatching on the line. It can perform attenuation measurements using an insertion loss function. This can be done in-service using live signal data.

Trend Communications
Tel: 01628 524977

**NEW PRODUCTS**

Please quote Electronics World when seeking further information

Sector antennas cover 3.6GHz

European Antennas has designed two slim panel sector antennas covering 3.4 to 3.6GHz, vertically and horizontally polarised. The SA16-60-35V/579 and SA16-60-35H1584 measure 474 by 88 by 9.5mm and weigh 1.15kg including mounting brackets suitable for a 50mm pole. They are housed in a machined aluminium chassis that can withstand harsh environments from -30 to +60°C. They have 16dBi gain, 60° sector coverage and 10° elevation HPBW combined with a fixed electrical down-tilt of 2° for cellular coverage. They comply with ETSI specifications for copolar and cross-polar radiation patterns.

European Antennas
Tel: 01638 731888

24-bit, 40kHz

Burr-Brown's ADS1252 is a delta-sigma a-to-d converter for industrial process control, medical analysis systems and test and measurement applications. Resolution is 24 bits and data rate 40kHz. It consists of a fourth-order delta-sigma modulator, digital filter, control logic and two-wire synchronous serial interface for connection to microcontrollers and digital signal processors. The device operates from a nominal 5V supply and consumes less than 50mW. Specifications include 0.0015 per cent linearity error and 2.8ppm rms noise – effective resolution of 18 bits up to 40kHz. It is packaged in a surface mount SO-8.

Burr Brown
Tel: 01923 233837

160MHz op-amps

From Micrel Semiconductor, the MIC911 and MIC914 operational amplifiers require 1.25mA supply current and achieve 105 and 160MHz gain-bandwidth, respectively. The MIC911 is heavily compensated to make it easier to use; the MIC914 is uncompensated, yet

BOOK TO BUY

Low-Power CMOS VLSI Circuit Design

A comprehensive look at the rapidly growing field of low-power VLSI design

Return to Jackie Lowe, Room L514, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Please supply the following title:

Low-Power CMOS VLSI Circuit Design

Total

Name

Address

Postcode

Telephone

Method of payment (please circle)

Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Information

Credit card no.

Card expiry date

Signed

Low-power VLSI circuit design is a dynamic research area driven by the growing reliance on battery-powered portable computing and wireless communications products. In addition, it has become critical to the continued progress of high-performance and reliable microelectronic systems. This self-contained volume clearly introduces each topic, incorporates dozens of illustrations, and concludes chapters with summaries and references. VLSI circuit and CAD engineers as well as researchers in universities and industry will find ample information on tools and techniques for design and optimisation of low-power electronic systems.

Topics include:

- Fundamentals of power dissipation in microelectronic devices
- Estimation of power dissipation due to switching, short circuit, subthreshold leakage, and diode leakage currents
- Design and test of low-voltage CMOS circuits
- Power-conscious logic and high-level synthesis
- Low-power static RAM architecture
- Energy recovery techniques
- Software power estimation and optimisation

UK Price: £54.50  Europe £55.50  ROW £57.50

** Price includes delivery and package **
Feel like you're in the wrong job?

Come to totaljobs.com and try out our free Career Health Check. You'll also find thousands of jobs, with new vacancies added every day. And you can post your CV on site, apply for jobs online, even have us e-mail you when suitable jobs come along. So don't be sheepish, visit totaljobs.com

totaljobs.com
totally change your life
Valve Radio and Audio Repair Handbook

* A practical manual for collectors, owners, dealers and service engineers * Essential information for all radio and audio enthusiasts * Valve technology is a hot topic

This book is not only an essential read for every professional working with antique radio and gramophone equipment, but also dealers, collectors and valve technology enthusiasts. The book is divided into two parts: 1: Practical Handbook of Valve Radio Repair, full coverage of valve amplifiers will add to its appeal to all audio enthusiasts who appreciate the sound quality of valve equipment.

Contents: INCLUDES: Electricity and magnetism; Voltage, current, resistance and Ohm's Law; Real life resistors; Condensers; Tuning; Valves; Principles of transmission and reception; Practical receiver design; Mains valves and power supplies; Special features of superhet; Battery and mains battery portable receivers; Automobile receivers; Frequency modulation; Tools for servicing radio receivers; Safety precautions; Fault finding; Repairing power supply stages; Finding faults on output stages; Faults on detector/AVC/AF amplifier stages; Finding faults on IF amplifiers; Faults on frequency-changer circuits; Repairing American 'midget' receivers; Repairing faults on automobile radios; Repairing battery operated receivers; Repairing FM and AM/AM receivers; Public address and high fidelity amplifiers.

UK Price: £22.50 Europe £25.00 ROW £27.00

** Price includes delivery and package **

Return to Jackie Lowe, Room L333, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Please supply the following title:

**Valve Radio and Audio Repair Handbook**

<table>
<thead>
<tr>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postcode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telephone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method of payment (please circle)</th>
</tr>
</thead>
</table>

Access/Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Information

<table>
<thead>
<tr>
<th>Credit card no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card expiry date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

unity-gain stable. Supply voltages are ±2.5 and ±9V. Input offset voltage is 1mV typical, signal voltage gain 80dB, PSRR 88dB and CMRR 112dB. The devices come in SOT23-3 packaging. Applications include portable instruments, medical equipment, video and imaging. Micrel Semiconductor

Tel: 0207 823 3224

Output router

Clare Instruments has launched the G9000 Route Master output routing device for applying tests to multiple testing points. For operation with G-series microprocessor controlled test instruments, it lets test applications be applied to up to 12 external earth points and four flash or insulation resistance test points, plus a single load test connection. With 16 channels available, customer variations can be accommodated. It is fully automated via direct control from the G series test station. An LED mimic display indicates test status during the test cycle.

Clare Instruments
Tel: 01903 502551

Multi-control unit

Rittal has improved the SNMP enclosure monitoring and access device on its computer multi-control unit. The latest units are available with 512kbyte flash memory to allow for software upgrades with the addition of extension card driver programs. It was designed as a one unit per enclosure device, for applications such as pure temperature monitoring. But the addition of I²C bus extension cards allows the monitoring of up to 20 enclosures from one unit. Access control of up to five enclosures may be controlled via one unit. It is no longer reliant on an Ethernet connection being present, with an ISDN extension card providing dial-up facilities and SMS messaging. It can be attached directly to sensors via a plug-and-play unit occupying the same 1U rack space at the rear of the rack, still allowing airflow up through the centre.

Rittal
Tel: 01709 704000

Bridge rectifiers

International Rectifier has introduced the DF 1A single-phase, full-wave bridge rectifiers for industrial and consumer electronic devices. Applications include power supplies and battery chargers for cellular phones, notebook computers and other portable and rechargeable devices. They follow standard pinouts and are compatible with PCB assembly and soldering techniques. Soldering can be done below 245°C to reduce solder oxidation without losing meniscus and fillation. The rectifiers are also suitable for 250 to 260°C soldering for 8 to 10s. Stable operation is from −55 to +150°C. The package has an electrically insulated, UL-approved case. The junction-to-case thermal resistance is 60°C/W. Maximum repetitive peak reverse voltage range is 50 to 1000V. They are made with glass-passivated die and encapsulated in a four-pin through-hole (D-70) or a surface-mount (D-71) dual in-line package. The through-hole devices are shipped in tubes, while surface-mount devices are supplied in tape-and-reel.
Self on Audio
by Douglas Self

The cream of 20 years of *Electronics World* articles – focusing on recent material.

A unique collection of design insights and projects – essential for all audio designers, amateur and professional alike.

Scientific electronics based on empirical data

Douglas Self has been writing for *Electronics World* and *Wireless World* over the past 20 years, offering cutting-edge insights into scientific methods of electronics design. This book is a collection of the essential *Electronics World* articles, covering twenty years of amplifier technology but with a very strong bias towards more recent material. The articles include self-build projects as well as design ideas and guidance for the professional audio designer. The result is a unique collection of design insights and projects - essential for all audio designers, whether amateur or professional.

Contents: Introduction; PRE-AMPLIFIERS: An advanced preamplifier MRPI; High-performance preamp MRP4; Precision preamp MRP10; Moving-coil head amp; Preamp '96 I; Preamp '96 II; 'Overload Matters' (RIAA overload); Balanced line inputs and outputs, part 1; Balanced line inputs and outputs, part 2; Power amplifiers: FETs less linear than BJTs; Distortion in power amplifiers 1-8; Distortion residuals; Trimodal part 1, 2; Load-invariant power amp INVAR.DOC; Common-emitter amps; Two-stage amplifiers; SPEAKERS: Excess speaker currents; Class distinction (amp classification); Relay control; Power partition diagrams; Audio power analysis.

Douglas Self has dedicated himself to demystifying amplifier design and establishing empirical design techniques based on electronic design principles and experimental data. His rigorous and thoroughly practical approach has established him as a leading authority on amplifier design.

This book will appeal to audio electronics enthusiasts, professional amplifier designers and anyone involved with power amplifiers. Paperback, 416 pages.

**UK Price:** £26.50  **Europe** £27.50  **ROW** £28.50

Please supply the following title:

**SELF AUDIO**

Total

Name
Address

Postcode
Telephone

Method of payment (please circle)

Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Information

Credit card no

Card expiry date

Signed
We’ve published Radio Data decoders before, but Roger Thomas argues that his receiver is easier to implement yet doesn’t compromise on performance.

Using the decoder in stand-alone mode, you can read Radio Data time on the unit’s seven-segment display, or you can interface the unit to a PC for greater flexibility using software from the author.

The BBC uses three synchronised long wave transmitters on 198 kHz (1515m) to provide national coverage of Radio 4. These transmitter sites are located at Burghead (50kW) north Scotland, Westerglen (50kW) in south Scotland, with the main transmitter located at Droitwich in central England (500kW).

Stability of the long wave transmitter carrier is very accurate and can be used as a frequency reference. The transmitted carrier frequency is maintained to an accuracy of 1 part in 10^13.

What may not be so well known is that these long wave transmissions also carry a data signal. Digital data is transmitted by directly modulating the 198kHz carrier and provides for 16 different data channels. One data channel is used to transmit an accurate time code.

The radio audio signal and data signal are independent of each other and quality of the programme audio is not affected by the data transmission. The programme audio is used to amplitude modulate the carrier wave, whereas the data signal is transmitted by phase modulation of the carrier wave. This is not a recent innovation as the first trials of the radio data system took place in 1979.

In the December 1993 issue of *Electronics World* a GEC-Plessey design appeared in an article called ‘Low-cost 198kHz radio data receiver’. The circuit design seemed to me at the time to be rather complex and did not provide a complete decoding solution.

In this earlier design, the data receiver used an SL6659 FM radio IC requiring a high-Q quadrature coil that had to be wound by hand. Demodulated audio output from the SL6659 was fed to an operational amplifier circuit.

These four operational amplifiers were wired as a filter, amplifier, integrator and comparator circuit to convert the demodulated audio into a data square wave. The circuit did not decode this data and suggested the use of a microprocessor to achieve this.

As you will see, the radio-data circuit of this design is very simple. It requires only three transistors and no coils to wind. This simplicity is due to the transmitted data not being demodulated to a base band signal for subsequent decoding. Instead, it is decoded directly by the PIC 16F877 microcontroller software.

Software in the PIC, as presented later in the article, decodes the time packet for displaying on seven-segment leds. This four-digit numeric display is driven directly by the PIC.

Using the optional software, the Radio Data stream can be sent to a PC via its serial port for post processing and display. A programmed PIC 16F877 is available from the author, as is the Windows 95/98 software for monitoring the channels and displaying the time.

Data modulation

Data modulation of the 198kHz carrier uses bi-phase encoding where a data bit ‘1’ is signified by 20 milliseconds of phase advance of the carrier followed by 20 milliseconds of phase retard, Fig. 2. Conversely a data bit ‘0’ is signified by 20 milliseconds of phase retard of the carrier followed by 20 milliseconds of phase advance. The phase deviation of the 198kHz carrier is ±22.5° and this phase shift changes over several milliseconds rather than as an abrupt phase change.

Bi-phase modulation avoids any net phase shift of the carrier when averaged over a period of one second or more. Thus the frequency stability of the carrier remains and its use an accurate frequency reference is not compromised.

Radio data

Data is sent in 50-bit synchronous packets as a synchronous transmission so there are no inter-packet gaps. Each 50-bit data packet contains a 1-bit prefix code which is always transmitted as a ‘1’, 4 bits of channel identification, 32 bits of data, and 13 bits for error detection.
Transmission data rate is 25 bits per second, thus each 50 bit data packet takes two seconds to transmit. Therefore there are potentially thirty self-contained packets of data that can be transmitted each minute. These packets are numbered 0 to 29 for reference, with the data carried in each packet allocated to any one of 16 different data channels. Apart from the time packet, information destined for any other channel can be transmitted in any order. Several packets of data sent sequentially and allocated to the same channel is allowed.

Cyclic-redundancy check
The 36 bits of data transmitted has an additional 13-bit cyclic redundancy check, or CRC, data block.
The prefix code bit is not included in the CRC calculations. This CRC data check determines whether the data packet has been correctly received and has no transmission errors. If the data is not synchronised or bits are missing then the CRC check will fail.
Probability of a data packet with errors passing this check is low because the ratio of CRC check bits to data bits is high. There is a small mathematical chance that a corrupt packet will pass the CRC check, but for all practical purposes this can be ignored.
Software does not attempt to try to correct a failed packet because there is a possibility that the 50 bits of data are in fact parts of two consecutive packets. CRC failure may be due to incorrect synchronisation rather than received bit errors.
To determine if the 50-bit packet of data has been correctly received, the CRC for the received 36 message bits is calculated with the aid of a look-up table. Calculating the CRC is achieved by using modulo-two addition – i.e. Boolean exclusive OR – for each '1' bit in the received 32-bit message. The appropriate value for each permutation is returned from the look-up table. This table comprises a CRC matrix derived from the 13-bit generator polynomial used in the original coding.
Once the 13-bit CRC is calculated in software, it is then compared with the received 13-bit CRC. If the two match, then you can be confident that the packet is error free.
An alternative method is to divide all 50 bits, including the CRC bits, by the generator polynomial. If there are no errors, the answer should be all zeros. This is very much a hardware solution using a division register to serially clock in the bit data. Using a look-up table in software is easier to implement.
The only weakness is when receiving data comprising of all zeros. This will pass the CRC check. Such a situation may occur when initially tuning the data receiver. However this will never occur when receiving data. The time packet – which has an application code of ‘0000’ – will invariably have at least a single ‘1’ in the day of week (for Monday), year start day and week number. All other packets will always have a ‘1’ somewhere in the application code and data.

Time data formats
Channel 0 is allocated to the time data and this information is always transmitted in packet 29. This packet is the last packet in the minute sequence so that the boundary between packet 29 and the next packet is the minute edge, Fig. 3.
The time code transmits its time information in UTC, which is short for Co-ordinated Universal Time* and represents the difference between UTC and UK local time. This time offset is rather generous as it allows a local time offset of up to ±15½ hours from UTC.
Software in the PIC can display either UTC or local time by using the time zone switch. The PC software displays both times simultaneously. This is useful for radio amateurs and short wave listeners as times are usually quoted in UTC.
Unlike the Rugby MSF transmissions, the BBC Radio 4 time packet does not include the month or year. Nevertheless, the date can be calculated by working out the number of days in the year from the week number and day of the week. The software process converting this to a date is rather tortuous.
Note that the day of the week and week number is aligned with UTC time not local time. Including the start day of the year – on 1 January – and leap year flag would enable a calendar to be constructed from the time packet, Figs 4, 5.

Time filler code
The first bit after the application code is the ‘T’ bit. In the time packet, this bit indicates whether the packet is carrying time data or if the time packet is being used as a ‘filler’, in which case the ‘T’ bit set to 1.
Filler data bits are arranged in an alternating binary sequence, as you can see in Fig. 6. This code is transmitted wherever there are no other data packets that need to be transmitted. As the radio data is a synchronous, and to maintain carrier frequency stability, data has to be transmitted at all times.

Radio circuit details
Ferrite antenna coil and variable capacitor form a tuned circuit adjusted to be resonant on the BBC Radio 4 frequency of 198kHz. The 2N3819 JFET transistor has a high input impedance. Here it forms a buffer circuit to prevent the rest

* Universel Temps Coordonné – Ed.
of the circuit from loading the antenna circuit.

Connected to the drain of the 2N3819 is a 198kHz crystal. This crystal forms a passive narrow filter. Ideally only the carrier frequency with its phase modulation – a bandwidth of only 50Hz – should be passed to the PIC microcontroller.

Series resistor \( R_2 \) reduces the sharp peak frequency response of the crystal. This prevents the crystal from oscillating and the 198kHz data radio circuit turning into a 198kHz oscillator circuit. Usually the data radio circuit is dominated by this crystal which, with its HC-31U can, measures 22mm by 18mm.

This crystal filter is needed as computer power supplies can create radio interference. Such power supplies are usually switch-mode types and switch at a similar frequency range to the data transmission. Computer monitors can also generate interference. The prototype circuit boards, before being wired into a suitable enclosure, worked reliably when situated within a metre of a PC tower and next to the computer monitor.

After the crystal filter there’s a two-transistor circuit that amplifies the radio data signal to that approaching tll level. The signal feeds a 74LS14 buffer located on the PIC circuit board. This buffer has a Schmitt trigger input to ensure that a constant tll output signal is fed to the PIC microcontroller. There is signal level variation due to the audio modulation.

**Ferrite antenna**

My prototype used a LW/MW ferrite rod antenna supplied by Maplin Electronics under the order code LB12N. Using a pre-wound antenna coil gives a reliable circuit that can be easily replicated by others. It also simplifies the construction of the radio.

It is feasible to use a ferrite antenna assembly from a defunct radio that covers long wave. But make sure that the long/medium wave coil switching and tuning capacitor connection is fully understood before dis-assembly.

If you opt for the Maplin ferrite antenna then remove the medium-wave coil, leaving the long wave coil, which has a scramble winding with thicker wire.

The antenna coil connects to a variable tuner capacitor of around 140pF. This tuning capacitor was also from Maplin, order code FT78K. One end of the coil is soldered to the AM antenna pin and the other end soldered to AM ground, i.e. the centre pin. The oscillator connection on the tuner capacitor is not used.

The ferrite coil and variable capacitor should be connected to the Radio Data receiver via screened cable. This allows you to find the antenna’s best position independently of the orientation of the data receiver.

**Displaying the data**

A 4-digit, 7-segment LED displays the time information from the PIC microcontroller. The time format is decoded by the microcontroller software from the time packet.

**Fig. 4. Radio Data’s time packet summary.**

- **P** prefix always transmitted as ‘1’.
- **A** application code.
- **T** time or filter code flag.
- **Y** leap year indicator.
- **S** start day of year (1 January).
- **W** week number.
- **D** day of the week.
- **M** minute.
- **L** local offset from UTC.
- **C** cyclic redundancy check.

Sequentially, the packet looks like this:

```
PAAAATYSSSSWWWDDHIIIHM MMDDDDHHMMYYYY
```

**Fig. 5. Detailed time code packet description**

- **P** prefix transmitted as ‘1’ [1 bit]
- **A** application code [4 bits]
  - 0000 time packet
  - 0001 data packet
  - ... 1111 data packet
- **T** 0 = time data [1 bit]
- **Y** leap year [2 bits]
  - 00 this year is a leap year
  - 01 last year was a leap year
  - 10 leap year in two or more years
  - 11 next year is a leap year
- **S** start day of year (1 January) [3 bits]
  - 000 not used
  - 001 Monday
  - 010 Tuesday
  - 011 Wednesday
  - 100 Thursday
  - 101 Friday
  - 110 Saturday
  - 111 Sunday
- **W** week [6 bits]
  - ...53
- **D** day of the week [3 bits]
  - 000 not used
  - 001 Monday
  - 010 Tuesday
  - 011 Wednesday
  - 100 Thursday
  - 101 Friday
  - 110 Saturday
  - 111 Sunday
- **H** hour [5 bits]
  - 0...23
- **M** minute [6 bits]
  - 0...59
- **L** local offset (hours) [6 bits]
  - mbs sign ± [1 bit]
  - 1...14 hours difference (4 bits)
  - isb = 1/2 hour (1 bit)
- **C** cyclic redundancy check [13 bits]

**Is Radio Data more than just a precise clock?**

Apart from transmitting time data, the only other known application for Radio Data is the Radio Teleswitching system used by the Electricity Association on behalf of the electricity supply companies.

Radio Teleswitching uses time coded data transmitted for remotely switching night time storage and water heaters installed in the home. It is also used to set the tariff rates on the electricity meters for off-peak electricity usage. Other applications being suggested are regional flood warning systems.

The restricted number of 32 data bits per packet – excluding prefix, application code and CRC bits – precludes any application that requires transmitting free form text as each packet can only contain between 4 and 7 characters, depending on the coding.

Despite this restriction, a format where particular bits represent data – like the time packet – could be transmitted. This could include stock-market data, radio-propagation information, or motorway-traffic information.

When the system was first suggested, one proposal was for the coded data transmission of weather and shipping forecasts, but this was never implemented.
It is necessary to multiplex the display as the microcontroller cannot source the current for all four digits simultaneously. Also there are not enough I/O pins for each segment to be connected directly to the PIC. Each led digit is on in turn for 12ms, Fig. 7.

All the segments for each digit are wired together and connected to port D. Each digit is switched, i.e. multiplexed, by the appropriate n-p-n transistor connected to port B1-4, assuming a common-cathode type display.

Each transistor switches the segments in the digit to zero volts to light that particular segment. Any low cost n-p-n transistor should be suitable, provided its maximum collector current capability is adequate.

As current for each led segment is sourced from the PIC port pin, current limiting resistors R(10-17) are needed. The PIC can source a maximum current of 200mA and each individual port pin can source a maximum of 25mA. The following formula can be used to determine a suitable value for this resistor,

\[ R = \frac{V_s - V_f}{I_{seg}} \]

where \( V_s \) is the supply voltage, \( V_f \) is the segment forward voltage and \( I_{seg} \) is the required current through the led segment. As each segment line has this current limiting resistor it is not necessary to incorporate another in the transistor's collector.

Maximum current flow occurs when displaying the numeral eight and decimal point is lit, as the display is multiplexed only one digit is on at any one time. As the display only shows the time, the eight will only occur as the last digit. The first digit is either blank, or displaying the numerals one or two, so the average current consumed by the led display is much less than the maximum, Figs 7, 8, 9.

**Time switch**

Time zone switching is used to select between local time and UTC time, and to reset the PIC software if required. The display will show either UTC or UK local time, as appropriate.

As the data is held in memory, the time can be re-calculated and displayed when this time button is pressed. If the time display is in UTC, the time led will be lit. Local time is the default.

When local time is selected, the PIC software automatically displays any time changes between UTC and British Summer Time (BST). Consequently there is no need for buttons to set the time manually.

Port RA0 is polled every 50ms and has the time selection switch connected to it. Although the switch could have been wire to generate an interrupt, it would probably have needed hardware de-bouncing. The associated time led requires an appropriate current limiting resistor, \( R_t \).

If you decide not to use the led display then the time selection switch and led serves no useful function and need not be connected. However the 120k\( \Omega \) pull-up resistor on port RA0 still needs to be connected.

**Implementing the design**

It is possible to implement the Radio Data circuit on strip board. This is not usually recommended due to the capacitance between the copper tracks. But at the frequencies involved here, this is not a problem. Keep all component leads and connections short though.

The design needs a regulated 5V power supply. Type and size of the enclosure will primarily depend on whether the led display is used and if there is an integral power supply. There's no need to add the display if you are only interested interfacing the radio data decoder to a PC.

It is advisable to build the data radio and PIC circuit on separate boards. If you do this, the radio section can be housed in its own small metal box.

Use screened cable for the link between the radio and the PIC. The controller's circuit and the multiplexed display can generate radio frequency interference and should be housed in another metal box with the external ferrite antenna connected via screened cable.

The PIC 16F877 needs to run at 20MHz using a crystal. When running the PIC in high-speed mode, a series resistor is recommended to prevent over-driving of the crystal.

On the prototype, the PIC circuit board seemed to be susceptible to mechanical knocks that could cause the PIC microcontroller to stop. This failure mode was evident on the display as the multiplexer would stop functioning and only one digit would be lit.

I traced the cause to the 20MHz PIC crystal. The solution was to earth the crystal case by wrapping a bare wire over the case and soldering each end of this wire to 0V. Fortunately the crystal had been laid flat on the strip board, which allowed the above wiring to be done without difficulty.

**PIC calibration**

To decode the radio data signal, the output from the TTL buffer is connected to both the capture inputs of the PIC microcontroller. After reset, the PIC software needs to calibrate itself. As the signal has to be sampled in real time, this
requires a PIC clock speed of 20MHz. A PIC running at 10MHz is not fast enough.

During calibration, the PIC microcontroller displays a 'CAL-'. When the calibration process is finished, the software starts to decode packets. The display shows the number of packets received without error until the first time packet is decoded. This count should increase every two seconds.

The software uses both capture and compare port inputs in capture mode, on the PIC’s pins 16 and 17. Timer 1 is 16 bits and runs at maximum speed in capture mode since it is used to time the pulse width. By using the elapsed time between the rising edge of CCP1 and falling edge of the waveform on CCP2, the pulse width is determined, Fig. 10.

Sampled over 20 seconds, successive timer calculation gives the average pulse width. If the waveform duty cycle ratio is not exactly 50:50 then this will not affect subsequent calculations – within reasonable limits of course.

The figure calculated in this way averages out any effects that the phase modulation has on the pulse width. Essentially the result should be exactly 198kHz. Thus the software can verify that the radio is tuned to the BBC transmission.

If the PIC software detects a carrier signal but it is not exactly 198kHz then a suitable 'Err' message will be displayed on the led display. On a PC, the message 'not 198kHz signal' is displayed.

**Zero crossing**

Having worked out what timer values constitute a transmitted '1' or '0', the software now needs to synchronise with the radio data stream. This is done by looking for the zero-crossing point by timing the pulse width and analysing the results.

The software looks for the maximum rate of change. This requires the PIC software to maintain many timer counts including minimum, maximum and several moving averages. The software requires several hundred readings to determine where this change occurs.

You can see from Fig. 11 that the maximum rate of change occurs half way through the waveform, due to the bi-phase encoding. Once the maximum change has been found then the zero crossing time can be determined.

Once the zero-crossing point has been calculated, the processing requirement falls and the software can now start to decode the digital data and send binary data to the PC.

The PIC uses the incoming data stream as a clock so that synchronisation is maintained. By sampling the waveform looking for changes in phase direction around the zero crossing point, transmitted source binary data can be determined.

---

**Fig. 10. The PIC software calculates the width of the TTL waveform by measuring the time elapsed between edges CP1 and CP2.**

---

**Fig. 11. Determining the zero crossing point requires a lot of processing power since the PIC has to calculate in real-time where the maximum rate of change occurs in a sine wave.**

---

This sampling needs to be done over a few milliseconds.

Having previously determined the median value of the pulse width – equivalent to the carrier having no phase modulation – subsequent pulse width measurements reference this value. The effect of the phase-shift modulation is to increase or decrease the relative waveform pulse width. This relative width change is small, Fig 12.

**PC-to-PIC data link**

Using the optional software, the PIC transmits the decoded binary data serially to the PC in ASCII form. Binary data is transmitted from the PIC's serial communications port via one of the 74LS14 buffers, the reason for this inverting buffer is that it replaces a RS232 interface chip which in operation would invert the data. The series resistor is there to limit the current flow in case of a wiring or hardware fault.

Serial data from the PIC to the PC is transmitted at 38400 baud using 8 data bits, one stop bit and no parity. But the actual underlying transmission data rate is only 25 baud. As the data rate from the radio data receiver is so low there is no need for any communication handshaking. Windows 95/98

---

**Fig. 12. Pulse width calculations – converting the 198kHz radio frequency to a pulse width.**

Firstly, with no modulation,

\[
\text{Pulse width} \times \text{phase shift} = 5.05 \times 22.5 \times 360 = 0.32 \mu s \text{ phase shift}
\]

With a $\pm 22.5^\circ$ phase shift,

\[
= 5.05 - 0.32 = 4.73 \mu s
\]

and the application software buffers the incoming serial data so it is extremely unlikely that any data will be missed.

The serial connection cable can be built using screened cable, Fig. 14. Length of the cable is restricted to approximately 1.5 metres. This allows the data radio to be situated some distance from the PC.

**PIC time decode**

There is no unique header that would allow the PIC software to recognise the start of a data packet. This would have added

Continued over page
The conventional story of Thomas Edison reads more like myth than history: With only three months of formal education, a hardworking young man overcomes the odds and becomes one of the greatest inventors in history. But the portrait that emerges from Edison: A Life of Invention reveals a man of genius and astonishing foresight whose career was actually a product of his fast-changing era. In this peerless biography, Paul Israel exposes for the first time the man behind the inventions, expertly situating his subject within a thoroughly realized portrait of a burgeoning country on the brink of massive change. Informed by Israel's unprecedented access to workshop diaries, notebooks, letters, and more than five million pages of archives, this definitive biography brings fresh insights to a singularly influential and triumphant career in science.
CONTROL & INSTRUMENTATION

Fig.14. 9 pin 'D' female serial connection. Viewed from the solder side, pin 2 receives data from the PIC while pin 5 is ground.

![Diagram](image)

to the data overhead and with the low data rate available this would be unacceptable.

Instead, the software decoder relies on the fact that only a correctly received packet that is properly synchronised will pass the CRC check.

To establish synchronisation, the PIC software looks for the '1' code - i.e. a prefix bit. Once this is found, the following 49 bits are loaded and the CRC test is applied.

If the packet fails the CRC test then the software will continue to attempt to re-synchronise with the transmission. This is achieved by first searching through the stored data looking for another binary '1'. Then the following bits are moved along (bit shuffle) and the requisite number of bits are read in

to restore the number of bits in memory to 50. Finally, the CRC test is applied again.

The process is repeated until a packet of 50 bits passes the CRC test. If for some reason the CRC test subsequently fails on a packet of data then the synchronisation process defined earlier will take place again.

Once the 50-bit packet in memory passes the CRC check and the application code is '0000' you can be confident that time data packet 29 has been found. Any packets with a different application code are discarded.

If the PIC software fails to receive a time packet at the appropriate time then the internal PIC clock software updates the display. A decimal point appears, indicating that this has happened.

The internal software clock is accurate enough to maintain the correct time for many hours should the radio data fail for some reason.

Setting up the radio

It is possible to set the radio up by experimentation. First, the antenna coil former has to be adjusted for maximum signal strength. Once a suitable spot on the ferrite is found the tun-

**Technical support**

A programmed PIC 16F877 and the Windows 95/98 PC software is available from the author at £20.00 fully inclusive. Write to Roger Thomas at 24 Slave Hill, Haddenham, Aylesbury, Bucks HP17 8AZ. E-mail jackie.lowe@rbi.co.uk for a copy of the hexadecimal listing as text.

**Components**

- \( L_1 \) 2.2kΩ [data radio]
- \( R_{2,4,6} \) 4.7kΩ [data radio]
- \( R_{3,5,7} \) 180kΩ [data radio]
- \( R_{7} \) 120kΩ (time zone select) [PIC circuit]
- \( R_{8,9} \) 470Ω [PIC circuit]
- \( R_{10-17} \) [LED display]
- \( L_{D1,2,3,4} \) 7 segment LED display [LED display]
- \( L_{D5} \) led (time zone select) [LED display]
- \( T_{1} \) 2N3819 JFET [data radio]
- \( T_{2,3} \) BC549C NPN [data radio]
- \( T_{4,5,6,7} \) NPN transistor see text [LED display]
- \( S_{1} \) mom. push to make [LED display]
- \( I_{C1} \) 74LS14 (buffer) [PIC circuit]
- \( I_{C2} \) PIC 16F877-20 [PIC circuit]
- \( X_{1} \) 198kHz crystal [data radio]
- \( X_{2} \) 20MHz crystal [PIC circuit]

* Maplin Electronics.
† Programmed PIC 16F877 available from author.
‡ 198kHz crystal was from AEL Crystals Ltd, Module D Airtech, 2 Jenner Rd, Fleming Way, Crawley, West Sussex RH10 2GA.
ing capacitor is used to peak the response. The orientation of the ferrite with regard to the Radio 4 transmitter will also influence the signal strength.

During this set up process it may be necessary to reset the PIC software so that it can re-calibrate itself. A software reset can be generated at any time by holding down the time zone select switch for approximately 5 seconds. This calibration process sets up all the following measurements and comparisons. If the tuning is subsequently changed then the software may reject packets that would otherwise be acceptable.

The data radio’s ferrite antenna should be kept some distance from the data radio and PC to prevent radiated noise being picked up by the antenna. It is notoriously difficult to predict where the best relative position of the data radio, antenna and PC should be as the PC and monitor can generate radio interference.

CRC errors
Most failed CRC packets received can be traced to electrical interference caused by switching on or off of household appliances. This either causes a glitch on the electricity supply or a burst of radio interference. Local lightning can cause reception errors.

With long wave there is little fading of the signal so errors due to adverse radio propagation are rare. I have left the prototype switched on all day without receiving any errors.

PC software
The PC software is beyond the scope of this article, but it is available separately, as detailed in the panel entitled ‘Technical support’. It checks the binary data received from the data radio using the same CRC method as used within the PIC software, Fig. 15. This ensures the integrity of the communications link between the radio and PC.

Initially, data from the PIC is not synchronised and can start at any point within a data packet. This may give rise to several CRC or prefix errors until the PC software is synchronised to the transmission. Once the PC software is synchronised it may then take up to a minute before the time data packet is received.

Once 50 bits have been received from the PIC, the first bit – the prefix bit – is checked. It should be a binary ‘1’. If not then all the bits are moved along (bit shuffle) until a ‘1’ is found in the first bit position.

Next, the appropriate number of bits is read from the serial port buffer to make up a packet. This block of data is then passed to the CRC test routine. All packets of data correctly received are displayed as a binary pattern in application code order.

The software can automatically update the PC’s internal clock when the sync button is pressed (local time). Note that the computer’s time display must be set for 24 hour time display. If not then this can be changed using the regional settings menu.

Radio data activity
During certain times of the day, the filler code is seen more often than other data occupying all the available blocks between time packets. At other times, many channel 2 and 14 data packets are transmitted. At night there are more filler codes, but the same kind of data pattern seen during the day is repeated.

It is probable that channels 2 and 14 are the Tele-switching data as the system needs information sent constantly, not just at off-peak times.

Figure 16 is part of the data taken in the evening using the PC Windows software. Software can save the received data as a binary bit pattern to a text file.

Several channels do not have any data activity. Presumably, these have not been allocated. It is a pity that this resource is not being fully used as the radio signal has reliable national coverage.

Clearly the data transmission capability is not being fully utilised otherwise there would not be any need for the number of filler codes to be transmitted.

Note that the PIC software provided in this article is intended for personal use only. Any commercial use is prohibited without the author's explicit written consent.

Further reading
Please send me _____ copies of The LP is Back!

Name ____________________________

Address ____________________________________________
_____________________________________________________

Fax number ___________________ Post code ____________

Daytime phone number ____________________________

I enclose a cheque for £ ________

Or debit my Visa ____ Master Card ____ (tick one)

Card number _______ _______ _______ _______

Expiry date _____ / _____

Card-holder’s signature: ____________________________

Love vinyl?

If you treasure your vinyl collection, this book is for you. Featuring articles from the pages of the US magazine Audio Amateur and other sources, it contains absolutely everything the serious LP music collector needs to get the most out of both vintage records and the highest quality new pressings.

Articles feature:

• Cleaning discs
• How to build a cleaning machine
• Calibrating and maintaining your tonearm and cartridge
• Equipment that will improve the quality of long-play record listening

Collected from the high point of this old-new again technology, 'The LP is Back!' brings a wealth of information to help you keep your existing equipment in top form and help you understand and appreciate the best in new products available from cartridges to turntables. Published 1999, 160 pp., 8in by 10 1/2in, softbound.

Fully inclusive prices:

UK £11.49
Europe £11.99
ROW £13.98

How to order:

Post the coupon to:
The LP is back, Electronics World, The Quadrant, Sutton, Surrey SM2 5AS, or fax 0208 652 8111,
or e-mail jackie Lowe@rbi.co.uk

Please make cheques payable to Reed Business Information
Radio Code hex listing for the PIC controller

This PIC hex code when programmed into the flash PIC T6F877 allows the decoding and display of the time packet, however this version does not send data to the PC. When the radio circuit is connected to the programmed PIC the led display will always show the correct time and automatically adjust between changes in BST and UTC. If the time zone switch is incorporated then either BST (local) or UTC time can be displayed.

Microchip's assembler software saves the PIC object code in INHX8M format. All numbers are in hexadecimal and each line contains a colon. After the colon each line starts with the number of data bytes followed by the address and the PIC object code, the last byte is the line checksum.

Use a text editor, such as Windows' Notepad, to enter the data as listed. Once the code is typed in then save the data in a file with a hex extension (for example radio.hex).

When programming the flash PIC ensure that the PIC configuration fuse options are set to the following - oscillator mode is set to HS (high speed crystal), watching timer is off and power up timer is enabled.

If the PIC programmer is being used in conjunction with the Microchip MPLAB software then select import (import memory) option from the file menu. Find the appropriate directory and select the radio.hex file.

To view the hex code which will be programmed into the PIC select from the Windows menu the Program Memory option.
Fact: most circuit ideas sent to *Electronics World* get published

The best circuit ideas are ones that save time or money, or stimulate the thought process. This includes the odd solution looking for a problem - provided it has a degree of ingenuity.

Your submissions are judged mainly on their originality and usefulness. Interesting modifications to existing circuits are strong contenders too - provided you clearly acknowledge the circuit you have modified. Never send us anything that you believe has been published before though.

Don't forget to say why you think your idea is worthy.

Clear hand-written notes on paper are a minimum requirement: disks with separate drawing and text files in a popular form are best - but please label the disk clearly.

---

High-fidelity filter for data retrieval

Measurement transducers are usually interfaced with data logging equipment by using a filter to remove unwanted high-frequency noise and prevent aliasing. Although complex filters using conventional analogue or switched-capacitor methods are available, single-pole passive filters are often preferred because of their simplicity and low cost.

Many designers do not realise that transducers often have severe bandwidth limitations and that limiting the frequency response imposes a significant phase lag on the signal. The phase non-linearity can prevent correlation of complex signals.

The circuit shown restores the phase and amplitude of test data stored in digital form. It does so by multiplying the stored distorted signal by the inverse transfer function.

Single-pole filtering of signal \( V \) produces a signal \( V_0 \), where \( V = \frac{V}{1+sCR} \).

Therefore \( V_0 = V(1+sCR) \). So to restore the signal \( V \) to \( V_0 \), it must be multiplied by the function \( F \), where, \( F = 1+sCR \). This is achieved by the circuit shown, restoring both the amplitude and the phase of the signal.

To test the system, I measured the transfer function of an RC section with \( R \) at 10kΩ, \( C \) at 4.7μF. The response was -3dB, with 45° phase lag, at 3.4Hz. As corrected by the circuit, the response showed an amplitude variation of +0.2dB maximum out to 18Hz, and a phase lag of 1.5° at 3.4Hz, 10° at 12Hz.

Components \( R_1C_1 \) and \( C_2 \) were added to remove high-frequency noise from a d-to-a converter's output. Such noise is minimised by using a high sample rate and high resolution converter, to avoid any large changes between sample values.

*Ian Shepherd*
Oxfordshire

---

*Diagram*:

- **Circuit for restoring the amplitude and phase of low-pass filtered data.**
  - Capacitor \( C \) is a non-polar electrolytic selected for ±1% tolerance.

(D49)
Single gang potentiometer tunes Wien Bridge

A Wien-type network can be modified to give smooth change of the zero-phase-shift frequency \( f_0 \) at constant attenuation by varying a single resistance.

In the diagram \( C_1, C_2, R_1, R_2 \) form the basic Wien bridge reactive arms. It is convenient to make \( C_1=C_2, R_1=R_2 \), giving,

\[
F_0 = \frac{1}{\sqrt{2\pi RC}}
\]

Added resistances \( A, B \) enable tuning to be adjusted by \( P \). When \( P=0 \), resistor \( R_2 \) is connected to \( R_1 \) and the network reverts essentially to its basic form. Resistors \( A \) and \( B \) both now come in series with the nominally infinite amplifier input impedance and so have no effect.

When \( P \) is finite, \( F_0 \) falls. The new, reduced frequency is the basic \( F_0 \) divided by \( \sqrt{1+M} \) where \( M \) is the ratio of the equivalent resistance of \( A, B, P \) to \( R_2 \).

Normally the circuit attenuation would change as \( P \) was varied but for one special tapping point on \( A, B \) the attenuation is constant. With equal \( C_1 \) and \( R_2 \) in the basic network, this tapping is when \( B=2A \); the attenuation factor is then constant at 3.

To avoid loading the network, the amplifier must be a FET-input type, preferably with a low input capacitance. To set up, first make \( P=0 \) and adjust \( R_2/R_4 \) for weak oscillation. Leaving \( R_2/R_4 \) as set, adjust \( P \) to maximum resistance and adjust \( A/B \) for weak oscillation. These settings should hold good for all values of \( P \), but if the input capacitance of the amplifier causes a dip at some point make a slight readjustment of \( R_2/R_4 \).

The values indicated give a tuning range of approximately 500-6000Hz. This represents about the practical limit of frequency sweep.

To avoid the effects of cramping at the high end, add a fine tuning resistance of a few kilo-ohms in series with \( P \). Any smaller amount of frequency sweep can be set by appropriate choice of \( A, B \) and \( P \). This makes the arrangement useful for fine-tuning conventional Wien bridge oscillators.

The arrangement is also usable for some other types of RC oscillator. It is even more useful in selective amplifiers where consistent performance can be obtained over a range of frequency.

George Short
Brighton
East Sussex
E25

Simple reversing battery charger

These simple circuits charge primary cells using the periodic current-reversal method. In the left-hand circuit, the 555 oscillates at 50Hz.

When the output, pin 3, goes high, the forward pulse current passes through the cell, charging it. When the output goes low pin 3 is pulled to ground and a reverse current pulse flows from the battery discharging it, thus giving a periodic current reversal cycle.

The cell may discharge through the 555 if the supply is switched off. The right-hand circuit overcomes this. It is similar to an earlier circuit on page 322, of Electronics World April 1998 issue, but it takes advantage of an inherent 'reverse transistor' mechanism to provide a PCR cycle.

When pin 3 goes high, the base emitter junction of \( T_2 \) is forward-biased and a forward current flows from collector to emitter, charging the cell. When pin 3 goes low, the collector is pulled to ground and thus the base-collector is forward-biased and the transistor works in the inverted mode. Thus a reverse current pulse flows from emitter to collector discharging the cell, giving a PCR cycle. In the absence of the supply, the base-emitter is reverse-biased preventing discharge.

These circuits were designed for zinc chloride cells. For alkaline cells, increase current by reducing \( R_2 \) and alter the duty cycle by changing \( R_3 \) and \( R_4 \). The type of transistor used is important.

A locally-made SL100 was used as it performed better than the usual 2N2219.

Dantes John
Kerala
India
E32

Simple reversing chargers, left, and a modified version that won't discharge the battery if the power supply to the 555 is turned off. If you implement this circuit, be aware that primary cells can explode or leak under certain circumstances so take necessary precautions. Don't use recharged cells in valuable equipment that could be damaged by leakage.
Adding four hard drives to your PC

Most people are accustomed to thinking that PCs accept at most two hard-disk drives. However, Linux users can use all four IDE (Integrated Drive Electronics) ports, enabling a maximum of eight autotune IDE hard disks.

The port addresses are as shown in Table 1, where the CS3FX

<table>
<thead>
<tr>
<th>Port</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>0x0</td>
</tr>
<tr>
<td>B0</td>
<td>0x1</td>
</tr>
<tr>
<td>C0</td>
<td>0x2</td>
</tr>
<tr>
<td>D0</td>
<td>0x3</td>
</tr>
</tbody>
</table>

for ports 3, 4 are undocumented – at least in available manuals. As is obvious from this data, inter-changing A3 and A4 converts a primary or secondary port into a tertiary or quaternary port. Any

Continued on page 974...

Routine for detecting hard-disk drives.

Program id; uses dos; (@Turbo IDE identification. @Jonah Faber 1999*)

var i,sel,drv; byte; status,clear: shortint; IDE,x,y,z,u: word; data:interger;

const ma_select=$A0; sl_select=$B0;
day; array[0..6] of string[3]=('Sun', 'Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat');

procedure wait(count:word); var R: registers; begin
    with R do AX:=$8301; intr($15,R); clear:=0;
    with R do begin AX:=$8300; BX:=ofs(clear);
        CX:= count; DX:=0; ES:=seg(clear) end;
    intr($15,R) end;

procedure delay(count:word (* in units of 65.6 msec *) ); begin
    wait(count); repeat status:=port[IDE+7] until (clear<0) or (status=0) end; (* This enables I/O redirection. Turbo Pascal’s own delay() no *)

begin getdate(x,y,z,u);
write($13#$10, 'Hard Drive Detection on ', day[u], ', ', y, ', ', z, ', ', x div 10, y mod 10, ', ');
foreach drv from 0 to 7 do
begin
    if odd(drv) then sel:=sl_select else sel:=ma_select;
    case (drv and 6) of
        0: IDE1:=IDF0; 2: IDE1:=IDF10; 4: IDE1:=IDF18; 6: IDE1:=IDF16;
    end;
    port[IDE1]:=sel; status:=port[IDE+7];
    if status<0 then begin
        port[IDE+6]:=sel; port[IDE+206]:=4; delay(1);
        if status<0 then begin (* sometimes expects command after reset *)
            begin port[IDE1]:=sel; port[IDE+206]:=2;
                port[IDE+7]:=0; delay(1)
            end;
        end;
    end;
    if status<>0 then begin
        (*The crux of this code is just *)
        (* assume that drive is reset *)
        port[IDE1]:=sel; port[IDE+206]:=2;
        (* IDE[6]:=A0 (B0 if slv) *)
        port[IDE+7]:=SEC;
        (* IDE[206]:=2; IDE[7]:=EC *)
        delay(20);
        (* wait half a second *)
        write('hd'+chr(97+drv)+':');
        (* read 256 words from IDE[0] *)
        if (status and 1)=1 then writeln('command not supported (cdrom?)')
        else if (port[IDE+7] and 8)<>8 then writeln('????')
        else for I:=0 to 255 do
        begin
            data:=portW[IDE]; case i of
                0: if data<>0 then write('ATAPI ');
                1, 3, 36, 37: write(data,'/');
                6, 63: write('write(date,'/');
                $15: write(data div 2, ' KB cache ');
                $1B..$2E: if datastrpos then write(chr(hi(data)),chr(lo(data)));
                $50: if data=0 then write('ATA-',data,'');
                $52: if odd(data) then write('SMART');
                $30: write(' '); SFF: writeln;
            end;
        end;
    end;
end;

Hard Drive Detection on Mon 10-4-99 10:33...

hda: 872/16/36 96kB cache H3256-A3 872/16/36
hdb: ???
hdc: command not supported (cdrom?)
hdh: ???
National Instruments sponsors Circuit Ideas

National Instruments is awarding over £3500 worth of equipment for the best circuit ideas.

Once every two months throughout 2000, National Instruments is awarding an NI4050 digital multimeter worth over £500 each for the best circuit idea published over each two-month period. At the end of the 12 months, National is awarding a LabVIEW package worth over £700 to the best circuit idea of the year.

About National Instruments

National Instruments offers hundreds of software and hardware products for data acquisition and control, data analysis, and presentation. By utilising industry-standard computers, our virtual instrument products empower users in a wide variety of industries to easily automate their test, measurement, and industrial processes at a fraction of the cost of traditional approaches.

Software

Our company is best known for our innovative software products. The National Instruments charter is to offer a software solution for every application, ranging from very simple to very sophisticated. We also span the needs of users, from advanced research to development, production, and service. Our flagship LabVIEW product, with its revolutionary, patented graphical programming technology, continues to be an industry leader. Additional software products, such as LabWindows/CVI, ComponentWorks, Measure and VirtualBench, are chosen by users who prefer C programming, Visual Basic, Excel spreadsheets, and no programming at all, respectively.

Hardware

Our software products are complemented by our broad selection of hardware to connect computers to real-world signals and devices. We manufacture data acquisition hardware for portable, notebook, desktop, and industrial computers. These products, when combined with our software, can directly replace a wide variety of traditional instruments at a fraction of the cost. In 1996 we expanded our high-performance E Series product line in PCI, ISA and PCMCIA form factors, shipped our first VXI data acquisition products, and added remote (long-distance) capabilities to our SCXI signal conditioning and data acquisition product line.

Our virtual instrumentation vision keeps us at the forefront of computer and instrumentation technology. National Instruments staff works actively with industry to promote international technological standards such as IEEE 488, PCMCIA, PCI, VXI plug&play, Windows 95/NT, and the Internet. More importantly, we integrate these technologies into innovative new products for our users.

NI4050

The NI 4050 is a full-feature digital multimeter (DMM) for hand-held and notebook computers with a Type II PC Card (PCMCIA) slot. The NI 4050 features accurate 5-1/2-digit DC voltage, true-rms AC voltage, and resistance (ohms) measurements. Its size, weight, and low power consumption make it ideal for portable measurements and data logging with hand-held and notebook computers.

- DC Measurements: 20mV to 250V DC; 20mA to 10A
- AC Measurements: 20mV rms to 250V rms; 20mA rms to 10A rms;
- True rms, 20Hz to 25kHz
- Up to 60 readings/s
- UL Listed
- 5-1/2 Digit Multimeter for PCMCIA

LabVIEW

LabVIEW is a highly productive graphical programming environment that combines easy-to-use graphical development with the flexibility of a powerful programming language. It offers an intuitive environment, tightly integrated with measurement hardware, for engineers and scientists to quickly produce solutions for data acquisition, data analysis, and data presentation.

- Graphical programming development environment
- Rapid application development
- Seamless integration with DAQ, GPIB, RS-232, and VXI
- Full, open network connectivity
- Built-in display and file I/O

National Instruments - computer-based measurement and automation

National Instruments, 21 Kingfisher Court, Hambridge Road, Newbury, Berkshire RG14 5SJ. Tel (01635) 523545, Fax (01635) 524395

info.uk@ni.com www.ni.com
Ten year index: new update

Hard copies and floppy-disk databases both available

Whether as a PC database or as hard copy, SoftCopy can supply a complete index of Electronics World articles going back over the past nine years.

The computerised index of Electronics World magazine covers the nine years from 1988 to 1996, volumes 94 to 102 inclusive and is available now. It contains almost 2000 references to articles, circuit ideas and applications - including a synopsis for each.

The EW index data base is easy to use and very fast. It runs on any IBM or compatible PC with 512K ram and a hard disk.

The disk-based index price is still only £20 inclusive. Please specify whether you need 5.25in, 3.5in DD or 3.5in HD format. Existing users can obtain an upgrade for £15 by quoting their serial number with their order.

Photo copies of Electronics World articles from back issues are available at a flat rate of £3.50 per article, £1 per circuit idea, excluding postage.

Hard copy Electronics World index
Indexes on paper for volumes 100,101, and 102 are available at £2 each, excluding postage.
**Pandora's drums**

Unique and atmospheric music recorded in the early 1900s – the days before 78s.

Use this coupon to order your copy of Pandora's drums

Please send me CD(s) at £11.99 each including VAT plus £1.50 carriage per order UK, or £3.00 overseas for which I enclose:

- Cheque
- Credit card details
- Name
- Address

Phone number

Total amount £.........

Make cheques payable to Reed Business Information Group. Or, please debit my credit card.

Card type (Master/Visa)
Card No
Expiry date

Please mail this coupon to Electronics World, together with payment. Alternatively fax credit card details with order on 0181 552 8111. You can also telephone your order on 0181 552 3614, but only Mondays, Tuesdays or on Friday mornings. Address orders and all correspondence relating to this order to Pandora's drums, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

**£11.99 Available exclusively from Electronics World**

**Amazing music**

21 tracks – 72 minutes of recordings made between 1900 and 1929. These electronically derived reproductions are no worse than – and in many cases better than – reproductions of early 78rev/min recordings – some are stunning...

All tracks on this CD were recorded on DAT from cylinders produced in the early 1900s. Considering the age of the cylinders, and the recording techniques available at the time, these tracks are of remarkable quality, having been carefully replayed using modern electronic technology by historian Joe Pengelly.

<table>
<thead>
<tr>
<th>Track</th>
<th>Title</th>
<th>Artist(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Washington Post March</td>
<td>Band, 1909</td>
</tr>
<tr>
<td>2</td>
<td>Good Old Summertime</td>
<td>The American Quartet 1904</td>
</tr>
<tr>
<td>3</td>
<td>Marriage Bells, Bells &amp; xylophone duet</td>
<td>Burckhardt &amp; Daab with orchestra, 1913</td>
</tr>
<tr>
<td>4</td>
<td>The Volunteer Organist</td>
<td>Peter Dawson, 1913</td>
</tr>
<tr>
<td>5</td>
<td>Dialogue For Three, Flute</td>
<td>Oboe and Clarinet, 1913</td>
</tr>
<tr>
<td>6</td>
<td>The Toymaker's Dream</td>
<td>Foxtrot, vocal, B.A. Rolfe and his orchestra, 1929</td>
</tr>
<tr>
<td>7</td>
<td>As I Sat Upon My Dear Old Mother's Knee</td>
<td>Will Oakland, 1913</td>
</tr>
<tr>
<td>8</td>
<td>Light As A Feather</td>
<td>Bells solo, Charles Daab with orchestra, 1912</td>
</tr>
<tr>
<td>9</td>
<td>On Her Pic-Pic-Piccolo</td>
<td>Billy Williams, 1913</td>
</tr>
<tr>
<td>10</td>
<td>Polka Des English's</td>
<td>Artist unknown, 1900</td>
</tr>
<tr>
<td>11</td>
<td>Somebody's Coming To My House</td>
<td>Walter Van Brunt, 1913</td>
</tr>
<tr>
<td>12</td>
<td>Bonny Scotland Medley</td>
<td>Xylophone solo, Charles Daab with orchestra, 1914</td>
</tr>
<tr>
<td>13</td>
<td>Doin' the Raccoon</td>
<td>Billy Murray, 1929</td>
</tr>
<tr>
<td>14</td>
<td>Luce Mia!</td>
<td>Francesco Daddi, 1913</td>
</tr>
<tr>
<td>15</td>
<td>The Olio Minstrel, 2nd part</td>
<td>1913</td>
</tr>
<tr>
<td>16</td>
<td>Peg O' My Heart</td>
<td>Walter Van Brunt, 1913</td>
</tr>
<tr>
<td>17</td>
<td>Auf Dem Mississippii</td>
<td>Johann Strauss orchestra, 1913</td>
</tr>
<tr>
<td>18</td>
<td>I'm Looking For A Sweetheart And I Think You'll Do</td>
<td>Ada Jones, 1911</td>
</tr>
<tr>
<td>19</td>
<td>Intermezzo</td>
<td>Violin solo, Stroud Haxton, 1910</td>
</tr>
<tr>
<td>20</td>
<td>A Juanita</td>
<td>Abrego and Picazo, 1913</td>
</tr>
<tr>
<td>21</td>
<td>All Alone</td>
<td>Ada Jones, 1911</td>
</tr>
</tbody>
</table>

**Total playing time 72.09**

Published by Electronics World. All recordings reproduced by Joe Pengelly.
Unique reader offer:
x1, x10 switchable oscilloscope probes, only £21.74 a pair, fully inclusive*

*Additional pairs as part of the same order, only £19.24 each pair.

Please supply the following:

Probes

Name ____________________________
Address ____________________________
Postcode ____________________________ Telephone ____________________________

Method of payment (please circle)
Cheques should be made payable to Reed Business

Information
Access/Mastercard/Visa/Cheque/PO ____________________________

Credit card no ____________________________
Card expiry date ____________________________ Signed ____________________________

Please allow up to 28 days for delivery

Specifications

Switch position 1
Bandwidth DC to 10MHz
Input resistance 1MΩ — i.e. oscilloscope i/p
Input capacitance 40pF + oscilloscope capacitance
Working voltage 600V DC or pk-pk AC

Switch position 2
Bandwidth DC to 150MHz
Rise time 2.4ns
Input resistance 1MΩ
Input capacitance 12pF if oscilloscope i/p is 20pF
Compensation range 10-60pF
Working voltage 600V DC or pk-pk AC

Switch position ‘Ref’
Probe tip grounded via 9MΩ, scope i/p grounded

Seen on sale for £20 each, these high-quality oscilloscope probe sets comprise:

- two x1, x10 switchable probe bodies
- two insulating tips
- two IC tips and two sprung hooks
- trimming tools

There’s also two BNC adaptors for using the cables as 1.5m-long BNC-to-BNC links. Each probe has its own storage wallet.

To order your pair of probes, send the coupon together with £21.74 UK/Europe to Probe Offer, Electronics World Editorial, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Readers outside Europe, please add £2.50 to your order.
Negative-resistance oscillator

There is a host of different radio-frequency oscillator configurations — Hartley, Colpitts, Clapp, Butler, Franklyn, Pierce and Meissner to mention just a few. But one of the simplest — and one capable of very good performance — is the negative-resistance oscillator. Ian Hickman dissects it, and shows you in simple terms exactly how it works.

In the early days of wireless communications, the receiver was a crystal set or coherer, used in conjunction with a spark transmitter — basically a radio-frequency noise generator. This sufficed for signalling at the rate possible with Morse code.

Modern radio-frequency communications on the other hand would be impossible without high-quality RF oscillators. These produce a single frequency, like a monochromatic spectral line in optical terms, unlike the broad range of frequencies in white light, or in a spark.

There are many different oscillator configurations. Some work best with an LC network as their frequency determining element. These involve an inductor and capacitor ‘tank circuit’. Others lend themselves to having a quartz crystal as their frequency-determining element.

Whatever the type of oscillator, the frequency-determining part will have associated losses. These must be continually made up, to maintain a constant amplitude output signal.

Most ‘maintaining circuits’ can be considered, as in the case of the oscillators mentioned above, as an amplifier whose input is derived from the tank circuit, and whose output is fed back into it. Thus the amplifier works as a three-terminal device, with collector, base and emitter — or drain, gate, source; anode, grid, cathode, etc. — all connected to the tank circuit.

Negative-resistance oscillators

The losses in the tank circuit can be considered as a resistance, in parallel with a tuned circuit made with an ideal loss-free inductor and capacitor. If a resistance that is equal in value to the loss resistance but opposite in sign is connected in parallel, this ‘negative resistance’ exactly cancels out the loss resistance. Now, a steady oscillation can be maintained in the tank circuit.

One suitable negative-resistance device is the tunnel diode. It can be used to make amplifiers or oscillators up to microwave frequencies.

Unlike the transistor, the tunnel diode is strictly a two-terminal device. But a circuit can also be devised such as to use a transistor as a two-terminal negative resistance.

To see just how, it is necessary to investigate how a transistor works in just a little more detail than usual.

Alpha, beta, etc.

Figure 1 shows conventional current flowing into the emitter of a p-n-p transistor, and most of it coming out again at the collector. The ratio of collector current to the emitter current is denoted by $\alpha$. It is typically 0.99, and often even closer to unity.

The base current, $I_b$, is the small difference between the emitter and collector current. Greek letter $\beta$ denotes the ratio of the collector current to the base current.

$$\beta = \frac{\alpha}{1 - \alpha}$$

But note that $I_c = I_b + I_e$ is only true as far as an arithmetic sum is concerned.

Kirchhoff’s First Law states that the

In this series

As explained in a preliminary article in the May 2000 issue, this series is intended to help students — and anyone interested in getting to grips with RF design — gain a background in practical electronic circuitry and troubleshooting.

Originally, the series was developed in response to the government’s RF Engineering Education Initiative. Below is a list of the tutorials that have already appeared.

Due to the popularity of the articles so far, Ian is currently working on further tutorials, to be announced next month.

1. Timer circuit using the 555, June 2000 issue
2. Audio oscillator — Wien bridge based, July issue
3. $h_\text{fe}$ tester, August.
4. Radio-frequency oscillator, Colpitts type, September.
5. Audio frequency filter/oscillator — state variable based, October.
6. Capacitance meter, November.
7. Radio-frequency oscillator/receiver involving negative resistance, this issue.
a) Collector current takes time to get through, so at high frequencies it comes out lagging, b).

Fig. 1. Most of the emitter current comes out again at the collector, just a little at the base, a). Collector current takes time to get through, so at high frequencies it comes out lagging, b).

The algebraic sum of the currents at any node is zero, \(I_e + I_b + I_c = 0\). So in fact \(I_e = -(I_b + I_c)\). When analysing a circuit, I always have to think very hard about just which way this or that current is flowing.

The relationships above apply at DC (0Hz), and \(\beta\) is usually denoted nowadays by \(h_{FE}\). They also apply to small changes in current at low frequencies.

Such changes would be caused, for example, by small-signal sinewaves that result in variations of a few percent around the standing collector current. In this case, \(\beta\) is usually known as \(h_{FE}\).

In Fig. 1, vector diagram a) shows what is going on: the length of the emitter current vector is equal to the sum of the lengths of the other two, but in the opposite direction as shown, in order to satisfy Kirchhoff’s First Law.

But at much higher frequencies, things start to get a little more complicated. The current injected at the emitter has to travel through the base region before appearing at the collector.

In the case of a p-n-p transistor, as in Fig. 1, the current is carried by holes. These move rather slower than the electrons which carry the current in an n-p-n device. This is why \(r_t\) of transistors are almost invariably n-p-n types.

Anyway, the net result is that the collector current lags somewhat, as shown in vector diagram b) in Fig. 1. But \(I_e + I_b\) must still equal \(-I_c\), with the result that \(I_b\) must be as shown.

Current that flows the wrong way

Figure 1 shows what happens to the relative phases of the currents in the transistor’s three leads, as frequency rises. But that is only half the story. One needs to take into account the terminal voltages as well.

Figure 2 shows a transistor just like Fig. 1, but with a capacitor, \(C_t\), connected between its emitter and ground.

Imagine a small high-frequency sinewave connected to the transistor’s base terminal. Due to the high transconductance of a transistor, the emitter voltage will, to a first approximation, be the same as the base voltage. This voltage will appear across \(C_t\), causing a leading current of magnitude determined by the reactance of \(C_t\) at the frequency concerned.

Assume for the moment that \(R_e\) is a very high resistance, returned to a very high voltage – it is there just to provide the necessary standing emitter current to make the transistor work. This being a very high-value resistance, the voltage variations at the emitter will have negligible effect on the current through it. So it can be regarded as open circuit, from the a.c. point of view, as shown.

Figure 2a), then, shows \(V_e\) – approximately equal to \(V_t\) – and the resultant current through \(C_t\).

Clearly, and according to Kirchhoff again, \(I_{be}\) must equal \(-I\), since it is flowing away from the emitter, not into it. You probably see what I mean now about the necessity of keeping careful track of which way the currents are flowing.

So rotating the vector diagram of Fig. 2a), by 90° anticlockwise, and overlaying \(I_{be}\) on \(-I\), \(V_t\) will appear as shown in Fig. 2b).

Note that \(I_b\) is almost in the opposite phase to \(V_t\). Figure 2c) shows it resolved into two components – a capacitive component \(I_{bc}\), in quadrature with \(V_t\), and a resistive component \(I_{br}\). However, instead of the current \(I_{br}\) being in phase with \(V_t\), it is in antiphase.

When the base voltage rises, instead of current flowing into the base as it would into a resistance, it flows out at us, and flows into the base when the base voltage falls. In other words, looking into the base, one sees a negative resistance.

Putting negative resistance to work

Figure 3 shows a transistor with a capacitor from its emitter to ground, and its base connected to an LC tank circuit. Via this, the base is dc referenced to ground, while the \(R_e\) is 4.7kΩ. Here, \(R_{er}\) is returned to \(-15\text{V}\), as the transistor is an n-p-n type, that common or garden favourite in a TO92 plastic housing, the BC184.

The BC184 sample chosen proved quite typical, having an \(h_{FE}\) of 300 at 3mA – the operating current of circuit Fig. 3. Due to the way the circuit works, as a two terminal negative resistance oscillator, the collector plays no part in circuit action, and is simply decoupled to ground.

To monitor the circuit action, a tap was made on the inductor at three quarters of a turn up from ground. This tap was connected to the 50Ω input of a spectrum analyser via 50Ω coaxial cable. With \(C_t\) formed by a 1.8pF capacitor, the 5–65pF trimmer tuned the circuit over 85–180MHz.

Providing a good output over most of this range, the amplitude dropped off markedly towards the lower end, the circuit ceasing to oscillate at maximum capacitance of the trimmer.

Clearly, 1.8pF was sub-optimal, so it was increased to 3.9pF. The oscillator then tuned over the whole range of the trimmer, covering 64–167MHz. The maximum frequency is reduced, due to the larger \(I_{be}\) (see Fig. 2) adding additional stray capacitance across
the tank circuit. Output level to the spectrum analyser was +6dBm over most of the range, falling to +4dBm at 167MHz and 0dBm at 64MHz.

Figure 4 shows the +6dBm 100MHz output, with the second harmonic 36dB down, the third 48dB down, the fourth 57dB down and the fifth 70dB down.

Figure 5 shows the output at a much greater dispersion, just 5kHz per division. The shape of the response is little different from that of the analyser's internal filter, showing excellent spectral purity and short term stability.

In fact, the trace is identical to that produced by my Marconi 2022E synthesised signal generator, set to the same output frequency, although of course the latter did not exhibit the typical long term frequency drift of the Fig. 3 circuit.

Building the circuit
For a one-off experimental circuit like this, construction is best done on a scrap of copper-clad board, used as a ground plane. I wound the coil on the shank of a 5.4mm twist drill, for no better reason than that it happened to be lying on my bench.

Wind the four turns tightly together with no gaps between. Turn the two ends at right angles to the turns, parallel to the axis of the coil and snip to a couple of centimetres in length.

Now gently pull the ends apart enough to finish up with half a wire thickness spacing between the turns. Bend one end at right angles at 3mm from the last turn, and solder it to the ground plane, with the coil's axis vertical.

A yellow Mullard 5-65pF trimmer is convenient, with the two legs connected to the moving plates soldered to the ground-plane. Solder the tag from the fixed plates to the free end of the coil, a couple of millimetres above the top turn. Used like this, with a metal tipped plastic tuning tool, there will be no problem with 'hand capacity' altering the frequency when tuning.

Remaining components should be carefully arranged so that all wiring consists of component leads. The only wire you need is for the coil, and of course three supply leads.

Mount the 4.7kΩ resistor between two small capacitors, with leads snipped short, soldered to the ground plane and used as component anchoring points. Likewise, the transistor's base and collector leads are supported on the coil, and a 10nF capacitor respectively. Try to keep all leads very short.

Testing the circuit
If you are a student, you will probably be able to arrange access to a spectrum analyser in your college electronics lab.

You can use an oscilloscope with a bandwidth of 100MHz or more if you can't get hold of a spectrum analyser. In this case, do not bother with the tap on the coil. Simply place the tip of a x10 passive divider probe — with insulating sleeve spring hook — close to, but not actually connected to, the circuit.

On either instrument, the output can be monitored, though only the spectrum analyser will tell you the output level.

If you have no access to either type of instrument, a little ingenuity will suffice. Stand a portable transistor radio, with its telescopic aerial deployed, on the bench near the circuit.

With the radio tuned anywhere in Band II, tuning the oscillator through its range should, at some point, completely silence the background hiss. It may even silence the programme material, if the radio was tuned to a station. The odd 2cm of wire sticking up from the top turn should prove a more than adequate radiator.*

Alternatively, a portable TV can be pressed into service. With the set tuned to the bottom of Band IV-V,
tune the oscillator to somewhere near its maximum frequency, i.e. with the plates of the trimmer out of mesh. The ‘snow’ on the screen should be replaced by a blank white raster, as the TV picks up the oscillator’s third harmonic.

Tuning the negative-resistance oscillator down towards the bottom of its range, the TV should pick up other harmonics, the fourth, fifth and so on. With the oscillator set to its lowest frequency, tuning the TV up the band towards 860MHz should reveal yet other higher harmonics.

It is worthwhile keeping an eye out for a second-hand scanner, as this can be used for the purpose just described, but with a wider coverage than a tranny or TV. It won’t tell you as much as a spectrum analyser, but it won’t cost as much either, and will still tell you quite a lot.

A scanner can even tell you the frequency of an oscillator operating below the bottom of its tuning range. The frequency spacing between two adjacent harmonics equals the oscillator’s fundamental frequency.

For even better performance... Interestingly, my prototype circuit would oscillate with \( C_0 \) of zero, but only if the loading due to the tapping was removed. The range then covered was 80-185MHz, monitored with a few inches of wire as an antenna, on the end of the spectrum analyser lead. With the tap disconnected, the tank circuit runs at a higher \( Q \), i.e. higher dynamic resistance \( R_d \). Thus a higher value of negative resistance suffices to maintain oscillation.

This arrangement should lead to even better spectral purity, and the arrangement is in fact usable — although it might appear not to be — since there is no tap from which to draw an output. The trick is to make use of the collector, which in the circuit of Fig. 3 plays no part.

Instead of returning the collector direct to the well decoupled positive supply, it can be taken instead to the emitter of a another transistor. The base of this is decoupled to ground, making it a ‘grounded-base’ stage. An output is then taken from its collector.

The circuit now uses the ‘cascade’ connection. Due to the low input impedance of a grounded-base stage, the arrangement oscillates in just the same way as Fig. 3, and due to the absence of a tap, the tank circuit operates at the maximum possible \( Q \).

Output from the upper transistor will need filtering, so a further tank circuit or a low pass filter will be necessary.

Television magazine’s VCR Clinic column is a unique forum for practical servicing tips, with the UK’s leading service engineers and servicing writers contributing their observations and recommendations month by month. But try finding those faults reports for the Amstrad XY2123 that’s on your bench. Even with an index you will be chasing through a pile of magazines... until now. Peter Marlow’s VCR Fault Finding Guide is a distillation of the most used fault reports from 11 years of Television magazine. Arranged by make and model the information is extremely easy to access, and the book is a convenient size for the bench or to carry with you. This will undoubtedly become one of the service engineer’s most useful tools. Unlike other fault guides, this one is based on top quality information from leading authorities, and genuine repair case studies. This is real-life servicing information, not just a compilation of manufacturers’ manuals.

Approximately 2,000 reports on 193 models from 35 different manufacturers. Instant on-the-spot diagnosis and repair advice. Television magazine’s leading writers’ wit and wisdom available for the first time in book form

Return to Jackie Lowe, Room LS14, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Tailpiece
Here, the explanation of circuit operation has been given in terms of vector diagrams — those exceedingly useful means of clarifying what goes on in a circuit. But each vector represents a sinewave. In the case of the diagrams shown, all the vectors are of the same frequency.

My explanation that negative resistance is the cause of oscillation is fair and valid, as far as the start of oscillation is concerned. But initially, the value of negative resistance is lower than the dynamic resistance \( R_d \). So the amplitude of the oscillation will build up until non-linearities in the circuit prevent further increase.

The effective value of negative resistance thus rises, until it equals \( R_d \), and the amplitude stabilises at that level. At this level, vector diagrams are no longer valid, as the voltages and currents are no longer sinewaves. Vector diagrams cannot take harmonics into account.

Theoretical analysis of non-linear circuitry becomes very complicated, taking one into Liapunov functions and similar esoteric mathematical regions. But assuming linear parameters, the simple small-signal analysis presented gives a useful, if not complete, insight into the circuit operation.

How to pay

(VCR Fault Finding Guide) paperback

Please charge my credit/charge card

\[ \text{Credit Card No: } \quad \text{Expiry Date: } \]

Signature of Cardholder:

Cardholder’s statement address: (please use capitals)

Name:

Address:

Post Code:

Tel.

£22.50

980

ELECTRONICS WORLD December 2000
BOOK TO BUY

Completely updated, this comprehensive dictionary contains over 28,000 electronic terms, phrases, acronyms, and abbreviations from the ever-expanding worlds of consumer electronics, optics, microelectronics, computers, communications, and medical electronics. This dictionary is a valuable resource for professionals in the field, hobbyists, students, or anyone interested in electronics. - Poptronics

Included in this fully revised classic are well over 28,000 terms, phrases, acronyms, and abbreviations from the ever-expanding worlds of consumer electronics, optics, microelectronics, computers, communications, and medical electronics. From the basic elements of theory to the most cutting-edge circuit technology, this book explains it all in both words and pictures. For easy reference, the author has provided definitions for standard abbreviations and equations as well as tables of SI (International System of Units) units, measurements, and schematic symbols.

Modern Dictionary of Electronics is the bible of technology reference for readers around the world. Now fully updated by the original author, this essential, comprehensive reference book should be in the library of every engineer, technician, technical writer, hobbyist, and student.

Post your completed order form to:-
Jackie Lowe, Room L514, Quadrant House,
The Quadrant, Sutton, Surrey, SM2 5AS
Fax your completed order form to 020 8652 8111
UK Price: £42.50 Europe £45.00 ROW £47.50
Price includes delivery

How to pay
Modern Dictionary of Electronics

☐ I enclose a cheque/bank draft for £__________
(payable to Reed Business Information)

Please charge my credit/charge card
☐ Mastercard ☐ American Express ☐ Visa ☐ Diners Club

Credit Card No:__________ Expiry Date:__________

Signature of Cardholder______________________________

Cardholder's statement address: (please use capitals)
Name______________________________
Address______________________________

Post Code_______ Tel:______________
AQUILA VISION
http://www.aquila-vision.co.uk
Aquila Vision specialises in supplying and supporting Embedded Microprocessor Development products from PICs to DSPs. We also stock robotics boards, Linux and general interest CD-ROM’s.

CONCEPT ELECTRONICS
http://www.conceptkey.co.uk
Concept Keyboards are specialists in the design and manufacture of customer specified membrane panels and keyboards, and electronic design. Concept’s membrane manufacture is supported by a full electronic production facility to provide a complete turnkey keyboard and electronics service, fully accredited to ISO9001.

CONTROL SOLUTIONS
www.controlssolutions.co.uk
Data acquisition and control for beginners, hobbyists, and professionals. Perform mathematical and logical operations on data in real time. Email: info@controlssolutions.co.uk.

COKE INTERNATIONAL
http://www.cooke-int.com
E-mail: info@cooke-int.com
Stockists of Quality Used Electronic Test Instruments and Operating & Service Manuals.

CROWNHILL ASSOCIATES LTD
http://www.crownhill.co.uk
Crownhill supply low cost development tools for use with Micro-Controllers and Smart Cards. Products include Smart Card development tools, Smart cards, Micro Development tools and Bespoke Design Services.

DANIEL MBREARTY
http://www.dannmcbrearty.demon.co.uk/eng.html
Experienced engineer based in London, specialist in audio and control systems. Available for design, project engineering or general consultancy. Background of high-quality work.

DESIGNER SYSTEMS CO.
http://www.designersystems.co.uk
Electronic product design company with over a decade of experience promoting it’s own product range and designing and manufacturing innovative products for client companies/individuals.

FELLER UK
http://www.feller-at.com
Feller (UK) Ltd. manufacture Fully approved cordsets (Moulded mains plugs and connectors) and Power Supply Cables for all industrial Countries to National and International Standards

FLASH DESIGNS LTD
http://www.flash.co.uk
Flash supply low cost AVR ISP programmers (£39), MINI-ICE starter kits (from £69), Portable Easy-ICE emulators (from £199), ICE Adapters & 'C’ compilers for any ATMEL AVR, M6851, Dallas, Hitachi H8 microcontroller. Download FLASH NEWS now. Watch out for Special Offers'. ARE YOU developing code in a Flash?

Goot Products
http://www.kieagoot.co.uk
Ktea Trading Company is the sole agent for Goot products. We specialise in supplying the soldering and desoldering product range manufactured by Goot Japan for the UK market. Goot uses advanced production technology to manufacture high quality soldering iron products for industrial, professional and general purpose use.

HSPS LTD
http://dpspace.dial.pipex.com/hsp/
FILTER DESIGNER - Advanced analog and digital filter design software for the PC. - Standard and Professional versions. - Free download of Evaluation version.

LEVY/LATHAM GLOBAL
http://www.levylatham.com
U.S. Military Surplus meters, plug-ins, test sets, oscilloscopes, power supplies, signal generators, spectrum analyzers and radio components from Tektronix, Hewlett Packard, Sony, Philips and more.

LOW POWER RADIO
SOLUTIONS
http://www.lprs.co.uk
LPRS markets low power radio transmitters, receivers and transceiver modules manufactured by ourselves, Radiometrix, Circuit Designs, RTD and Micrel. Applications for telemetry, video and remote control.

ALCATEL COMPONENTS
http://www.components@alcatel.de

ASHWELL ELECTRONICS
http://www.ashwell-hq.com
Ashwell provide technical support for Apex Microtechnology op-amps and DOCCS; Aeroflex; EMP filtered connectors; M S Kennedy; Mitech obsolescence; NSC MiVero; Teledyne Relays and isocom ml/optocouplers.

ARCOM
http://www.arcomcontrols.com/ew/
A leading international supplier of communication and control technology to Industry, Arcom provides leading edge solutions through a comprehensive range of market leading products.

BROADCASTING COMMUNICATIONS SYSTEMS
www.broadcasting.co.uk
WINRADIO now brings you a complete choice in personnel computer controlled radio scanning and reception solutions ● Broadcast ● Media ● Monitoring ● Professional Amateur Radio communications.

BEDFORD OPTO TECHNOLOGY LTD
http://www.bot.co.uk
Optoelectronic products UK design development manufacture standard and

EQUINOX TECHNOLOGIES UK LTD
http://www.equinox-tech.com
Equinox Technologies UK Ltd., specialise in development tools for the embedded microcontroller market.

ECM SELECTION
http://www.ecmsel.co.uk
For the pick of the UK’s Top High-Tech Software and Hardware career opportunities - from fresh Grad/PhD to Senior Engineer/Manager - £22,000 - £70,000

ELECTRONICS PRINCIPLES FREE ONLINE
http://www.eptsoft.com
This popular electronics educational title now available to engineers, students and hobbyists absolutely free. A huge virtual textbook of electronics information, from DC to PIC’s.
To reserve your web site space contact Pat Bunce
Tel: 020 8652 8339 Fax: 020 8652 3981

MATTHEY MICROFILTERS
http://www.microfilters.net
30 years experience in the design and manufacture of high quality passive filters and delay lines. Used in Broadcast, Telecommunications, Medical, Multimedia, and Computer industries.

NEWNES - BOOKS FOR THE ELECTRONICS WORLD
http://www.newnespress.com
Over 300 books and information packages for those working with electronics and engineering technology. Visit our site for a free catalogue and downloads.

OMEGA RESEARCH LTD
http://www.omega-research.co.uk
“SMD prototyping adapters. Unique, flexible, low cost adapters to allow bench working with SMD devices. Range suits most devices down to 0.5mm pitch.”

QUILLER ELECTRONICS
http://www.quiller.com
100+ pages of detailed technical information on Schrack Relays, MEC Switches, Hirose Connections.

Put your web address in front of 21 000 electronics enthusiasts and experts.
Electronics World acknowledges your company’s need to promote its web site, which is why we are now dedicating pages in every issue to announce your WEB ADDRESS.
This gives other readers the opportunity to look up your company’s name, to find your web address and to browse the magazine page to find new sites.

We understand that cost is an important factor, as web sites are an added drain on budgets. But we are sure you will agree that the following rates make all the difference:

FOR 12 ISSUES:
Lineage only will cost £150 for a full year just £350 per month.
This includes your company’s name, web address and a 25-word description.
Lineage with colour screen shot costs £350 for a full year, which equates to just £29.17 per month.
This price includes the above mentioned information, plus a 3cm screen shot of your site, which we can produce if required.
To take up this offer or for more information ring:
Pat Bunce on 020 8652 8339 or fax on 020 8652 3981.
or e-mail: pat.bunce@rbi.co.uk

<table>
<thead>
<tr>
<th>Company name</th>
<th>Web address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
transistors. We also offer easily-fabricated aluminium enclosures for small production runs and prototypes.

STAFFORDSHIRE WIRELESS COMPANY
http://www.staffs-wireless.com
Wireless, communication, test equipment, bought and sold for very competitive prices visit our web site or telephone John on 01889 569029 or 0973 296461.

SUPRA AUDIO CABLES
http://www.supraaudio.com
STAFFORDSHIRE manufacturer production

TEST EQUIPMENT SOLUTIONS
http://www.TestEquipmentHQ.com
Specialists in the supply of quality refurbished Test Equipment.
Phone: +44 (0)1753 596000
Email: info@TestEquipmentHQ.com

TECHNICAL AND SCIENTIFIC SUPPLIES
http://www.technicalscientific.com
Suppliers of pre-1985 equipment and components.
- Test/Measurement equipment
- Valves and semiconductors
- Transducers and pressure gauges
- Scientific books and catalogues
- Manuals and data sheets

VANN DRAPER ELECTRONICS LTD
http://www.vanndraper.co.uk
Test equipment from Grundig, Kenwood, Hitachi, Fluke, Avo, Glassman. Advance in a comprehensive site including oscilloscopes, multimeters, power supplies, generators, counters, soldering, digital tv etc.

UK ELECTRICAL DIRECT
http://www.uked.com
For a comprehensive on-line directory, buyers guide and resource locator for the UK Electrical Industry look at this site. Many of the companies listed have links to their own web sites, making this a one-stop shop for a huge amount of information.

UK MAILING LIST GROUP
http://www.egroups.com/list/uktvrepar
Following on from the newsgroup discussion last month there is a UK Email group for TV technicians where you can send an Email to everyone in the group. There's just over 30 people in the group at present. For more details and how to register look at the group home page. Just a general comment though - you do have to be careful who you give your Email address to so that you can avoid 'spamming' - that is getting lots of unwanted Email about dubious Russian site (amongst others).

REED CONNECT
http://www.reedconnect.net/
Another free internet access site, this time from Reed Business Information.

To reserve your web site space contact Pat Bunce
Tel: 020 8652 8339 Fax: 020 8652 3981
PicBASIC Pro's various serial out commands have a lot more tricks up their sleeves. Not only do they allow different baud rates from 600 to 19200 - both inverted and non-inverted - but also output the results as 8 or 16-bit decimal, hexadecimal, binary or ASCII strings. This is ideal for interfacing to the many similarly controlled LCD modules on the market.

Task 6
Our final task is to write the main program loop which will call the decoder subroutine, serially transmit both codes, and illuminate the correct LED for a chosen button pressed on the handset.

An assembler version of this is shown in Listing 7. Within the loop, the returning values from IRIN are examined. If IR_DEV returns holding 255 then an invalid header was detected so the process is repeated.

If a valid header was detected, then both IR_DEV and IR_BUT are transmitted using the Sout subroutine. A check is then made of IR_DEV. If it's not holding a value of one, then it is a television remote handset, and again, the process is repeated.

If, however, the device code is for a television, IR_BUT is examined, if it holds a value of 16 (channel-up) then the green LED is turned on, and the red LED is turned on if it's holding 17 (channel-down).

The PicBASIC Pro version is shown in Listing 8. It has exactly the same function as previously described.

Using the subroutine, IRIN
Both versions of the IRIN subroutine may easily be incorporated into your own programs. A brief outline of the returned variables are,

CALL or GOSUB IRIN
IR_DEV returns holding the DEVICE code (0..31)
IR_BUT returns holding the BUTTON code (0..127)
Both IR_DEV and IR_BUT return holding 255 if a valid header was not received.

In summary
I hope that I've illustrated that to understand both infrared decoding and PIC microcontroller programming, you needn't be a rocket scientist.

Assembly language may never be fully replaced by high-level languages. If you don't mind its steep learning curve and unfriendly form, it still has an edge over higher-level languages if you want to squeeze the last drop of code space and programming speed out of a processor. Assembler is also available free of charge if you know where to look.

Listing 7. Assembler, Main code loop.

```
; ** THE MAIN PROGRAM LOOP STARTS HERE **
Again CLRdw :Walk the dog
Call IRIN :Get Ir signal from handset
Bcf PortA.0 :Turn off both LEDs
Bcf PortA.1
Moviw 255 ;If IR_DEV=255, look again
Subw IR_DEV,w
Bfss STATUS.z
Goto Again
;** Transmit DEVICE code then BUTTON code serially
; at inverted 9600 baud N-8-1 **
Moviw IR_DEV,w
Call Sout
Moviw IR_But,w
Call Sout
;** If IR_DEV=1 (TV device code), look Again **
Moviw 0
```

All the tools required for software development are downloadable from Microchip's web site. There's also a plethora of data sheets and application notes, downloadable from the same site.

Using a high-level language such as PicBASIC or PicBASIC Pro not only makes programming a more enjoyable experience. It also opens up new areas of electronics that were previously beyond the scope of all but the most advanced enthusiast. Among these are PIC, SPI serial eeprom, analogue-to-digital and digital-to-analogue interfacing.

The list is endless.

However, it's not just the enthusiasm that can benefit from PicBASIC. Because, both assembler and BASIC may be freely mixed within the same program, extremely powerful and flexible programs may be written.

Such programs can greatly decrease prototyping time, thus reducing the overall costs of a commercial product. After all, time is a precious commodity that should not be wasted.

Resources
Further information on infrared encoding and decoding, including a compatible Sony infrared transmitter project may be found in the book, "Experimenting with the PicBasic Pro compiler", written by yours truly. This is available via Crownhill Associates' dedicated PicBasic site at www.picbasic.co.uk.

Furthermore, all the components used in this project are also available from Crownhill at www.crownhill.co.uk - including the infrared sensor and a suitable remote handset, along with the free downloadable source code for both language versions of the infrared decoder.

Listing 8. PicBASIC Pro, Main body code.

```
*** MAIN PROGRAM LOOP STARTS HERE ***
Again: Low Green_LED;Low Red_LED
Gosub IRIN
If IR_DEV=255 then goto Again
If IR_DEV<>0 then goto Again
Serout PortA.3,N9600,[IR_DEV,IR_But]
Subw IR_DEV,w
Bfss STATUS.z
If IR_But=116 then High Green_LED
If IR_But=117 then High Red_LED
Pause 10
Goto Again
```

Extinquish both LEDs
Receive an IR signal
Check for valid header
If not a TV DEVICE code
then look again
Transmit the 2 bytes
If channel up, then green LED on
If channel down, then red LED on
Delay for 10ms (optional)
Do it forever
Without an engineering degree, a pile of money, or an infinite amount of time, the revised 289-page Interfacing with C is worth serious consideration by anyone interested in controlling equipment via the PC. Featuring extra chapters on Z transforms, audio processing and standard programming structures, the new Interfacing with C will be especially useful to students and engineers interested in ports, transducer interfacing, analogue-to-digital conversion, convolution, digital filters, Fourier transforms and Kalman filtering. Full of tried and tested interfacing routines.


Listings on disk – over 50k of C source code dedicated to interfacing. This 3.5in PC format disk includes all the listings mentioned in the book Interfacing with C. Note that this is an upgraded disk containing the original Interfacing with C routines rewritten for Turbo C++ Ver.3

Price £15, or £7.50 when purchased with the above book.

Especially useful for students, the original Interfacing with C, written for Microsoft C Version 5.1, is still available at the price of £7.50. Phone 0181 652 3614 for bulk purchase price.
Letters to "Electronics World"  Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Filters and linearity
In Letters in the August issue, Graham Maynard states that, "Together, 10kΩ-12pF form a low-pass filter that introduces 0.3% harmonic distortion at 2kHz" without explanation.

It defies understanding how a linear circuit can cause nonlinear distortion such as harmonic distortion. It might be possible that the rest of the circuit generates harmonic distortion through some interaction with the filter but under the circumstances described it is hard to see how this might occur.

If the harmonic distortion does increase by 0.3% due to the inclusion of the filter, it is likely to be due to sloppy design. The filter will introduce linear distortion. It will affect the frequency response, but this most definitely is not harmonic distortion.

It is also dubious as to whether the filter would produce any audible affect. Few people have much audio sensitivity beyond about 17kHz, and very little phase sensitivity over most of the audio band.

Further, it is ridiculous to fuss over trivial imperfections in power amplifier performance when loudspeakers and their environments are comparatively so deficient.

I warn anybody who might be inclined to listen to music that pushes their amplifiers close to their limits (slew rate or clipping) to enjoy it while it is their ears last.

With regard to Jo Atkins suggestion that, "Putting half an ohm between amplifier and speaker may suppress this mechanism," I am rather sceptical. Jo should consider that the speaker's voice coil impedance - the nominal Ω2, which in fact is usually anything but - is already between the amplifier and the back EMF from the speaker. A mere half ohm extra is unlikely to have the desired effect.

Phil Dennis
Dept of Plasma Physics
University of Sydney

Comme une bombe
With reference to the letter on page 799 of the October issue, if French radios started playing "comme une bombe", could they have had directly-heated output valves. These warm up faster than their indirectly-heated counterparts, commonly used in UK sets. The local oscillator of a superhet normally starts fairly abruptly once its cathode has warmed up. In most UK radios, however, the audio output pentode still hasn't warmed up yet!

At my school, the assembly hymn was sometimes accompanied on a veteran electronic organ. If the organist forgot to switch it on in advance, the music would begin "comme une bombe" at some time during the first verse!

Jeremy Jago
Nottingham

Slew rate matters?
I noted the recent exchanges on the subject of slew-rate limiting in audio amplifiers. As long ago as 1982 I built an amplifier using the new complementary MOSFETS from Hitachi, and some experimentation I settled on a circuit not dissimilar to the Hitachi application circuit.

Basically, this comprised an input p-n-p long-tailed pair driving the main voltage-gain n-p-n long-tailed pair, the latter loaded with a current mirror. This drove the gates of the MOSFETS as source-followers with just a preset resistor to set bias current.

The characteristics of the FETs were such that no temperature compensation or thermal coupling was necessary, so the scheme was very elegant. Harmonic distortion was good, rising to only 0.02% or thereabouts at any power - up to the 50W maximum - at 20kHz.

However, square-wave testing showed that the amplifier was slew-rate limited and that the limit would be reached if driven to full power at a frequency of about 50kHz. The origin of the slew-rate limit was the loop stabilisation capacitor - from collector to base of the voltage-gain side of the n-p-n pair - in conjunction with the finite driving current from the input stage.

Attempts at moving the frequency compensation to a different location, for example to the input stage, availed the slew-limit, but the harmonic distortion was worse. This was probably due to the fact that the MOSFETs presented a significantly non-linear capacitive load to the output of the voltage-gain stage, which was high impedance, and the stabilisation capacitor was providing some welcome local negative feedback. Thus moving the stabilisation component to a position where the resultant gain-shedding was of no benefit resulted in an overall drop in performance.

Returning to the original scheme, I could have elected to increase the currents in the circuit but this had a knock-on effect requiring the addition of heat-sinking and possibly a change to bigger transistors, all of which negated simplicity. Instead, I started to question the need for higher slew-rates.

Viewing the matter bluntly, in order to exceed the slew-rate several conditions would have to prevail. Firstly, I would have to be listening at a volume setting that would reach full power on programme peaks. Secondly, the program material would have to contain spectral information well in excess of the audible bandwidth, and thirdly the program channel would not have to be restricted in any way at high frequencies by the use of pre-emphasis and/or equalisation.

The first criterion is fair enough: we all like to bang head occasionally, but Led Zeppelin or Shostakovich (try the last ten minutes or so of 'Symphony no.4').

The second criterion is less easy to satisfy, as both FM and CD offer very fundamentally restricted in bandwidth. In the case of vinyl the situation is less clear, and maybe someone more knowledgeable than myself could comment on the reproduction bandwidth limits of the newer information-compressing digital formats.

The third criterion nearly always applies a further restriction. FM is pre-emphasised, CD is sometimes pre-emphasised and vinyl is subject to RIAA equalisation which strives to keep groove displacement in check at low frequencies and maintains an adequate degree of surface noise suppression at high frequencies, but only at the expense of severe tracking limitations imposed by stylus tip mass. This medium is thus seriously limited in its abilities to generate high slew-rates.

Traditional analogue tape recording is no better: if the record-head bias is set for lowest distortion - as is normally the case - much of the ability to record treble at high levels is lost due to partial erasure. Having gone through this argument, I was and am still happy with my amplifier, but I did introduce an input filter with a similar time-constant to the one described by J.N. Ellis but with a different purpose in mind.

My previous amplifier suffered from excessive sensitivity to mains-borne transients to a degree that was irritating, and unchecked RF transients can have enormous slew-rates. I was keen to have the facility to run the program source directly into the power amplifier when not using tone controls, and the input filter was one of a number of measures I used to suppress RF transients and has been entirely successful.

Incidentally, if anyone suspects that program material is causing slew-rate limited phenomena there is now a great deal of data-grabbing instrumentation available. It would make sense to attempt to capture some transients and measure their true slew-rates before jumping to conclusions.

John Wells
St Albans
Hertfordshire

E numbers and resistors
The sixties represent the beginning of my formative years in electronics. At the time, the now familiar E12 component value series was confined mainly to resistors, usually with 10 per cent tolerance.

For many years I took the idea of this series for granted, having realised that such components needed to be available in values that form an approximation to a geometric progression. However, more recently I was working out some values one day for a 10dB amplifier and I had a creeping feeling that something was wrong.

The middle value in the E12 series should surely be 3.162 - rounded off to 3.2 and not 3.3! Grasping the nearest calculator I discovered that all the values from 2.7 to 4.7 inclusive are too high and should be 2.6, 3.2, 3.8 and 4.6.

Since then, the series has been applied universally to capacitors and inductors - as well as "infilled" to form the E24 series as a result of the E96 series has been derived correctly, so things get even more absurd when designers adopt a cut-down sub-set from the E96 series that approximate in value to the original "wrong" E12 series!

To date no-one has given me a satisfactory explanation as to the origin of the E12 series values. Any offers?

John Wells
St Albans
Hertfordshire
ELECTRONICS WORLD December 2000

As an advertiser you can be certain that your sales message is going to be read by decision-making electronics professionals with the power to purchase your products.

The pre-paid rate for semi-display setting is £17 per single column centimetre (maximum 4cm). Box number £22 extra. All prices plus 17% VAT. All cheques, postal orders etc to be made payable to Reed Business Information. Advertisements together with remittance should be sent to Electronics World Classified, 12th Floor, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Fax: 0208 652 3981.
Tel: 0208 652 8339

FOR SALE

RF DESIGN SERVICES
All aspects of RF hardware development considered from concept to production.

WATERBEACH ELECTRONICS

www.ralver.dial.pipex.com

TEL: 01223 862550
FAX: 01223 440853

BARGAIN PARTS

For all your electronic parts, look no further.

WATERBEACH ELECTRONICS

TEL: 01223 862550
FAX: 01223 440853

ARTICLES WANTED

RF DESIGN SERVICES
All aspects of RF hardware development considered from concept to production.

WATERBEACH ELECTRONICS

www.ralver.dial.pipex.com

TEL: 01223 862550
FAX: 01223 440853

BARGAIN PARTS

For all your electronic parts, look no further.

WATERBEACH ELECTRONICS

TEL: 01223 862550
FAX: 01223 440853

TOP PRICES PAID

For all your valves, tubes, semi conductors and IC’s.

Langrex Supplies Limited
1 Mayo Road, Croydon, Surrey CR0 2QP
TEL: 020 8684 1166 FAX: 020 8684 3058

APPPOINTMENTS

UNIVERSITY COLLEGE LONDON
Department of Physiology

Technician Posts

Post 1 Electronics support & run a small electronics workshop. Post holder will be responsible for first line repair and maintenance of biomedical equipment. They will also have an interest in providing basic computer support to the department. Based at the Royal Free & Gower Street sites.

Post 2 Computing. Hourly paid term time only for a fixed term contract (1yr). Duties mainly at Gower Street. Successful applicant will be part of a small team supplying basic computer support such as networking, installation of software. The successful candidates will ideally have experience of providing support in both the teaching & research environment. Knowledge of Windows & UNIX an advantage. Applicants preferably hold relevant BTec National Certificate, City & Guilds or equivalent, training may be offered to individuals with lower qualifications. Salary on the Technical Staff Pay Scales Grade D or E (£13,317 to £18,433, 2000 pay award pending, plus £2,262 LW).
Closing date: 17th November 2000. For an application form/Job Description contact Audrey Rossiter on 0207-679-1351. Please state post number (1 or 2) when applying.

Working toward Equal Opportunity

éta BÉ

PRINTED CIRCUIT BOARDS - Quick Service. Design and Manufacture for Prototypes or Production. Agara Electronics, Unit 5, 508 Herbert Road, Bethnal Green, London E2 6DX. Tel: 0208 738991. E-mail: agara@argonet.co.uk

HiP744A storage scope with manual £300 inclusive. Many other scopes and items and test equipment and components available. Mayflower Electronics, 48 Brenda Road, Wancher, Somerset TA23 0RT. Tel: 01984 610835.

WIRELESS WORLD magazines for sale, 1976 to 1999, please telephone/fax S. Jacovides 020-7272 7139 or e-mail: jacovides@btinternet.com

FREE to collectors, two carphones, Motorola 4800X and NEC TRS-80-L 11A with handsets but no leads. Phone David Martin 01279 506121.

ELECTRONICS WORLD December 2000

989
Hioki’s New 8807/8808 Memory Recorder
These compact, light recorders have 2 or 4 analogue channels with isolated inputs, PC card slot, fax/modem communication function, versatile trigger functions and 3-way power. They are ideal for a variety of applications requiring long memory lengths and high transient speed capability.

Telonic Instruments Ltd
Tel: 0118 978 6911
Fax: 0118 979 2388

The New Instrupedia™, from National Instruments, is the latest version of the company’s free CD-ROM encyclopedia for instrumentation. Featuring an enhanced user interface and a new intuitive search engine, Instrupedia is updated with the entire National Instruments product catalogue and additional information useful to scientists and engineers when building PC-based test, measurement and automation applications.

Phone 01635 523545
Fax: 01635 524395
e-mail: info.uk@ni.com
web: www.ni.com/uk

Hioki’s New 8807/8808 Memory Recorder
These compact, light recorders have 2 or 4 analogue channels with isolated inputs, PC card slot, fax/modem communication function, versatile trigger functions and 3-way power. They are ideal for a variety of applications requiring long memory lengths and high transient speed capability.

Telonic Instruments Ltd
Tel: 0118 978 6911
Fax: 0118 979 2388

The New Instrupedia™, from National Instruments, is the latest version of the company’s free CD-ROM encyclopedia for instrumentation. Featuring an enhanced user interface and a new intuitive search engine, Instrupedia is updated with the entire National Instruments product catalogue and additional information useful to scientists and engineers when building PC-based test, measurement and automation applications.

Phone 01635 523545
Fax: 01635 524395
e-mail: info.uk@ni.com
web: www.ni.com/uk

How would you like to advertise in a marketplace where your products and services will be seen by the right people?
Then why not be seen in Electronics Weekly’s classified section, ARENA?
If you would like further information, contact Denise Stupart on:
020 8652 3034

ELECTRONICS WORLD is the longest established magazine in the industry, with a history of over 80 years.
The editorial is the most respected in the industry, presenting ideas to innovate and improve products.
For all your advertising needs
Call Pat 0208 652 8339
E-mail: Patbunce@rbi.co.uk
For more information about any of the products or services in this issue of ELECTRONICS WORLD, simply ring the relevant enquiry number. Enquiry numbers may be found at the bottom of each individual advertisement.

101 102 103 104 105 106 107 108 109 110 111
112 113 114 115 116 117 118 119 120 121 122
123 124 125 126 127 128 129 130 131 132 133
134 135 136 137 138 139 140 141 142 143 144
145 146 147 148 149 150
500 501 502 503 504
505 506 507 508 509 510 511 512 513 514 515
516 517 518 519 520 521 522 523 524 525 526
527 528 529 530 531 532 533 534 535 536 537
538 539 540 541 542 543 544 545 546 547 548
549 550 551 552 553 554 555 556 557 558 559
560 561 562 563 564 565 566 567 568 569 570
571 572 573 574 575 576 577 578 579 580 581
582 583 584 585 586 587 588 589 590 591 592
593 594 595 596 597 598 599 600

Name
Job title
Company Address
Telephone

DECEMBER 2000
Only tick here if you do not wish to receive direct marketing promotions from other companies.

Thank you

Subscribe today!
Guarantee your own personal copy each month
Save on a 2 year subscription

Subscribe today!
Guarantee your own personal copy each month
Save on a 2 year subscription
Please enter my subscription to ELECTRONICS WORLD. I enclose Cheque/Eurocheque to the value of £________ made payable to Reed Business Information.

Please charge my Mastercard/Visa/Amex account ________

With £________ Expiry Date __________

Signature __________________________

Name __________________________

Job Title __________________________

Address __________________________

Postcode __________________________

Tel: __________________________

Country __________________________

SUBSCRIPTION RATES

UK 1 year £36
UK 2 years £58
UK 3 years £72
Student rate (proof required) £21.30

Airmail
Europe 1 year £51
Europe 2 years £82
Europe 3 years £103
Rest of the world 1 year £61
Rest of the world 2 years £98
Rest of the world 3 years £123
Surface mail 1 year £41

Post to:
ELECTRONICS WORLD
P.O. Box 302
Haywards Heath,
West Sussex RH16 3DH UK.

CREDIT CARD HOTLINE
Tel: +44 01444 445566
Fax: +44 01444 445447
‘Electronics and Computing Principles V7’

Studying electronics or computing or just want to keep up-to-date in a easy and enjoyable way, then this is the software for you.

Personal user £99.95 + VAT.
Education/Industry £299.95 + VAT.
Includes unlimited multi-user site licence.

Including all the previous version six topics, many of which are revised and updated, from DC and AC theory, transistors, OpAmps, electrical, filters, digital techniques, microprocessors, programming the PIC microcontroller, where the architecture and full instruction set can be explored. More than a thousand interactive electronics, electrical, mathematics topics (just five shown above), now including computer science. V7 (developed in the UK) is a huge source of electronic and computing information.

Our software is used in colleges and universities at home and overseas to support electronics and computing courses from GCSE, A’Level, City & Guilds, BTEC to Degree level. It’s extremely easy to use, making it ideally suited to the novice just starting out, up to the qualified engineer who is looking to access hundreds of formula covering practically every aspect of electronics. Telephone for a full list.

ADDITIONAL TOPICS: Computer Science from how a CD-ROM works to calculating the placement of data on a hard disk drive, to file handling and data management systems, Component Testing, Physical Science, More Electronics, Self Assessment Questions, Electronics Lab software and a completely new Component and Equipment Dictionary. A 700 slide PowerPoint presentation is included on the CD-ROM.

PLUS: Changes to graphical presentation, function selection toolbar, number formatting and printing.

Cheques and P.O. made payable to eptsoft limited. UK and OVERSEAS POSTAGE ARE FREE.
Programs 8 and 16-bit EPROMs, EEPROMs, PEROMs, 5 and 12V FLASH, Boot-Block FLASH, PICs, 8751 Microcontrollers and more.

EPROM emulation as standard!
Rechargeable battery power for total portability.
All-in price includes emulation leads, AC charger, PC software, spare library ROM, user-friendly manual.
Supplied fully charged and ready to use.

Dataman 48LV

[Analysis]
- Plugs straight into your parallel port of PC or laptop.
- Programs and verifies at 2, 2.7, 3, 3.3 and 5 V.
- True no-adaptor programming right up to 48-pin DIL devices.
- Free universal 44-pin PLCC adaptor.
- Built-in world standard PSU – for go-anywhere programming.
- Package adaptors for TSOP, PSOP, QFP, SOIC and PLCC.
- Optional EPROM emulator.

Support

[Analysis]
- 3 year parts and labour guarantee.
- Windows/DOS software included.
- Free software updates via BBS/Internet.
- Free technical support for life.
- Next day delivery – always in stock.
- Dedicated UK supplier, established 1978.

Truth – Claim Verified

[Recommended Action]
Secure for own use without delay. Order via credit card hotline – phone today, use tomorrow. Alternatively, request more detailed information on these and other market-leading programming solutions.

Next day delivery – always in stock.
Dedicated UK supplier, established 1978.

Money-back 30-day Trial
Try the Dataman 48LV without obligation for 30 days. If you do not agree that these truly are the most powerful portable programmers you can buy, simply return your Dataman product within 30 days for a full refund.

DataMan Programmers Ltd, Station Road, Maiden Newton, Dorchester, Dorset, DT2 0AE, UK
Telephone +440 1300 320719 Fax +440 1300 321102
BBS +440 1300 321095 (24hr) Modem V.34/V.42B/V.32bis
Home page: http://www.dataman.com
FTP: ftp.dataman.com Email: sales@dataman.com

Orders received by 4am will normally be despatched same day.
Order today, get it tomorrow!

3 YEAR GUARANTEE