Competition winner: receiving pulsed ultrasonics

ELECTRONICS WORLD

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Bar codes demystified

Code-hopping remote control

Opto audio link

Superhet techniques

Audio filter using DSP

Is Linux for you?

Circuit ideas:

- Analogue interface for LPT
- Stable go/no-go indicator
- Audio opto isolator
- Emergency light
- PWM motor controller

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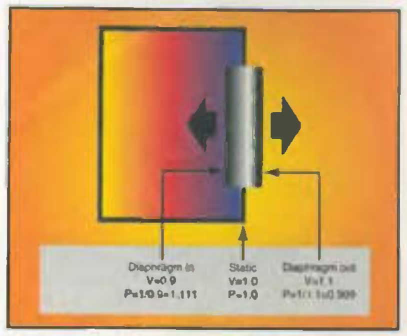
Illustration: Hashim Akib



Motional feedback based on the position of the speaker cone has its drawbacks. Wouldn't it make sense to derive feedback from the cabinet? John Watkinson tackles the issue on page 698.

If you use CAD regularly and you're plagued by frequent system crashes, Linux may be the answer to your problems. Take a look at Rod Cooper's review on page 666.

The "ultimate wireless Lego robot" – according to Motorola at least. This and more top news stories, starting on page 652.

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It's official – work isn't fun any more

Staff are spending ever more 'working' time surfing Web pages that have nothing to do with work—and nearly half waste over three hours a week of their employers' time in this way.

But if you thought sex was the most popular subject that they 'research' in company time, you'd be utterly wrong. So what's the key attraction? Why, finding a better job!

That's the verdict of a recent survey by Vault.com, which found that nearly 40 per cent of personal Internet use at work was related to looking for a better position. It speaks volumes of course and points to the dissatisfaction that many employees feel today.

According to one survey, some 85 per cent of the American workforce is disenchanted with their job or career and figures are most likely similar in other industrialised countries.

In a recent *US News & World Report* survey, people were asked how happy they were with their lives. The three areas where people were overwhelmingly dissatisfied were jobs, finances, and leisure time. For most people finances are inextricably linked with a job, while discontentment with the job influences one's leisure time.

Many people feel underpaid and overworked, often finding themselves dwelling over work issues when they're supposed to be relaxing. So the source of most dissatisfaction is the job.

That's bad news because unhappy, stressed-out employees do not make productive workers. According to Linda Rosenstock, director of the National Institute of Occupational Safety and Health, people who are stressed at work cost companies more money, suffering more heart disease, increased injury risk and other kinds of medical problems.

The causes are all too familiar – heavy workload; long hours; no decision-making power; poor social environment; conflicting or uncertain job expectations; job insecurity; or lack of growth opportunities.

Specific reasons are not hard to find; a MORI poll conducted for telecomms vendor Mitel cites aggravation on the way to and from work as the most annoying aspect of the job (41 per cent of employees), closely followed by workplace politics (37 per cent) and constant interruptions (33 per cent).

No fewer than 42 per cent would seriously consider changing jobs to avoid these distractions. Over a quarter would accept a salary cut just to have the freedom of working in peace.

With so much evidence of dissatisfaction with workplace conditions, one might imagine that employers in the electronics, communications and IT industries would take the problem seriously now.

Of course, this disharmony may be entirely intentional – part of the grand plan. That's because people reportedly work harder when they're feeling rotten.

Studies by psychologists from the University of Alberta reveal that cheerful folk waste time maintaining their happy moods, while their fed-up workmates just get on with the job.

Four groups of people were observed building circuit boards on a production line. While the cheerless characters worked no faster, they made half as many mistakes as their more jovial colleagues. Drawing on long-established distraction theories, the explanation is that disenchanted people lose themselves in work to take their minds off their miseries.

Working yourself to distraction is hardly the solution, though. Tom Welsh, the self-styled premier authority on new solutions for career satisfaction and owner of the delightfully named website www.workhappy.com, declares that unfulfilled workers are probably in the wrong profession, pursuing unsuitable careers that make their lives miserable.

Working longer hours is not the answer either. Already 44 per cent of Americans call themselves workaholics, well over 100 million, working an average of 47 hours a week. Within Europe it's British workers who work the longest hours.

In the electronics industry the problem is particularly subtle and deep. One report tells of a software engineer who was "too busy" to drive some distance to Workaholics Anonymous meetings for help with his addiction. In desperation he set up an Internet chapter of the organisation and now airs his grievances on line with the other workaholics who attend these digital meetings.

According to Tom 'Work Happy' Welch, the solution lies in discovering who you really are, identifying what you want out of your job and your life, and learning how to achieve it. You can love your work, gain control over your future, earn more money, and live a happier, healthier life. All it takes is a little planning and some focused action.

That may be, but employers could do their bit as well, instilling pride in work well done, also keeping employees informed and acknowledging the value of their individual contribution.

Since time immemorial managers who express personal interest in their employees have always managed to get more output. But even this lesson seems to have been forgotten. Perhaps they are "too busy" as well. ■

Andrew Emmerson

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Microchip combines PIC microcontroller with DSP

At last Microchip, makers of the popular PICmicro range of microcontrollers, has revealed details of its forthcoming dsPIC DSP-microcontroller combination.

PIC with DSP – performance

The chip
- 30Mip/s
- 94 instructions
- 11 addressing modes
- up to 4 Mbytes x 24 flash
- up to 32K x 16 ram

DSP engine
- 16-bit by 16-bit multiplier
- 40-bit adder
- two 40-bit saturating accumulators
- 40-bit bi-directional barrel shifter

Peripherals
- fault-tolerant oscillator
- up to 8 capture and 8 compare functions
- dedicated motor control/power conversion
- PWM
- Quadrature Encoder Interface
- Interfaces for
- RS-485, UART, I^2C, SPI, AC97, CAN, I^2S
- up to five 16-bit timers
- watchdog timer
- up to 80 I/O bi-directional ports
- 10-bit high-speed simultaneous sampling a-to-d converters
- 12-bit A/D converters.

It will be a single-instruction stream non-pipelined modified Harvard machine with a 16-bit data RISC core and 16-bit DSP engine.

The instruction set architecture has been designed, 'to be highly efficient for C compilers and RTOSs,' said Microchip. Towards this vectored exception processing supporting eight user-prioritised, fixed latency, interrupts and seven traps, is included.

Applications foreseen include motor control, Internet-connected appliances, automotive products, power supply management and speech recognition.

Microchip claims dsPIC will be supported by its own tools, application specific libraries and third-party tools. Devices are planned in packages with from 28 to 100 pins and will operate from 2.5 to 5.5V with a variety of power saving modes.

The company's 0.5μm flash process will be used. Beta sampling is planned for the fourth quarter of 2001 with volume production in 2002.

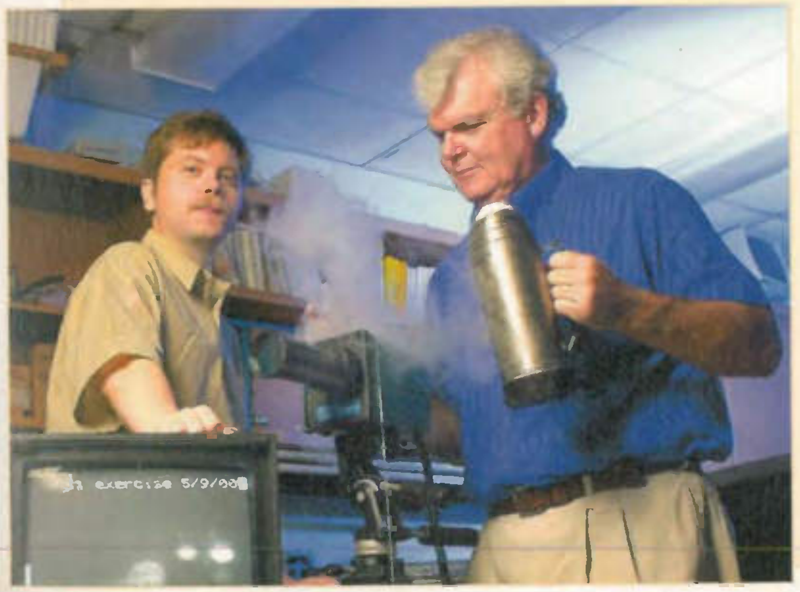
Electronic ink display inventor teams with Philips

E Ink, inventor of a display technology that relies on the electrostatic attraction of tiny coloured particles in a liquid, has revealed yet another prototype. This time it is with Philips Components.

The announcement comes only four months after E Ink agreed to develop and commercialise active-matrix electronic ink displays. The prototypes use a 13cm sheet of E Ink's electronic ink with Philips' active matrix backplanes and drivers.

The modules can display monochrome and grey-scale images with a resolution of 80dpi. The partners intend to be selling high-resolution electronic ink displays for smart hand-held devices in 2003.

Unlike LCDs, E Ink's displays do not need polarisers and have a high contrast ratio and a wide viewing angle. The company already has ties with IBM (*Electronics World*, July 2001), and has shown a simple coloured prototype.



Snake sensors detect changes down to 0.001°C

Poisonous snakes could be the inspiration behind a new generation of infra-red imagers if the University of Texas has anything to do with it.

Crotalines, better known as pit vipers, have unusual 'pit organs' that the snakes use to locate warm-blooded prey.

The nerve-rich depression is located in front of the snake's eye and harbours heat-sensors so sensitive the snake can detect a mouse several metres away.

Researchers say the viper's sensing system responds to temperature changes "much less than one-thousandth of a degree centigrade".

Man-made sensors with a similar sensitivity apparently need cooling to –200°C.

The picture shows researcher Dmitriy Protsenko (left), and Professor John Pearce collecting images using a thermographic camera as part of the research programme.

Fuel cells deliver up to 3kW and run on any hydrocarbon fuel

Fuel cells developed by German firm NovArs look set to go into pilot production.

NovArs' US technology backer Manhatten Scientifics aims to start pilot production of fuel cells aimed at portable electronics such as power tools, home generators and lap-top computers.

The cells are based on a proton exchange membrane (PEM), which can extract hydrogen from almost any hydrocarbon fuel.

Power outputs range from 2W to 3kW, the firm said. Energy density is around 115W/l, several times higher than lead acid batteries.

Manhatten has contracts to produce fuel cells for motorbike manufacturer Aprilia, vacuum cleaner maker Electrolux and the US Army.

The firm is discussing building a small production line with several companies, it said, which could be based in the US, Europe or Japan.

Light-emitting plastics a step closer to production

Cambridge Display Technology (CDT) has signed a deal with Tokki to co-develop production equipment for light-emitting polymer (LEP) displays.

CDT LEPs are one of the two technologies vying for space in the plastic semiconductor displays market, which has yet to develop. Many predict that plastic displays will dominate the front of mobile phones and personal organisers in the next few years. Organic light-emitting diodes, or OLEDs, from Kodak and its licensees are the other technology – which seems to be slightly ahead in the race to market at the moment.

The CDT-Tokki agreement covers the next generation of Tokki's volume manufacturing physical vapour-deposition (PVD) and encapsulation technology.

Development work will include looking for encapsulation techniques to reduce cost and improve display life.

CDT has purchased a 355mm Tokki PVD machine to be installed at its pilot development line, currently under construction in Godmanchester near Cambridge. This facility is expected to come on line in early 2002.

Nissei Sangyo will be Tokki's exclusive distributor for equipment developed in the deal.

LEP displays took another step towards production recently when Osram Opto Semiconductors (Osram OS) brought forward production plans for LEP displays.

It was due to start manufacture in 2002, but in a statement said it, "expects to bring a commercial LEP display manufacturing plant in Penang, Malaysia on stream during 2001."

According to Osram OS, which is a joint venture between Osram (51 per cent) and Infineon, it already has an LEP pilot line in San Jose.

Its licence allows Osram to manufacture and sell LEP displays up to 1/4 VGA pixel format with rights to license higher information content in the future.

The right to manufacture lighting devices is also permitted by the licence.

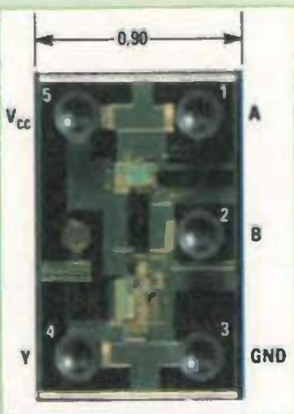
Osram said it will initially develop OEM LEP products for mobile, cellular and automotive applications.

New package options for smaller circuit boards

Texas Instruments has developed a family of packages for simple logic chips which can cut circuit board footprints by 70 per cent, compared with its previous packaging.

Called NanoStar, the 5- and 8-pin packages are aimed at single and dual logic gates, often used in products such as mobile phones, laptops, MP3 players and other hand-held equipment.

Until now TI has used the 5-pin SC-70 package for single gate logic. NanoStar has a footprint of 1.4 by 0.9mm, or 1.26mm^2, which means it uses 70 per cent less board space than SC-70. Its height is 0.5mm.



Connection to the PCB is via eutectic solder balls – the mixture of metals in the balls melt and solidify at the same temperature. Thermal properties are improved compared with the SC-70 packages, TI said.

SM power inductors for small PSUs

Surface-mount power inductors aimed at shielding in lap-top computers and other handheld equipment and mobile products have been introduced by US firm Coilcraft. The inductors have a footprint of 3.7 by 3.7mm, and a height of just 2.6mm. Components in the 1008PS series have inductances ranging from 1 to 1000μH and saturation currents up to 3A. A designer's kit is available from order.coilcraft.com.

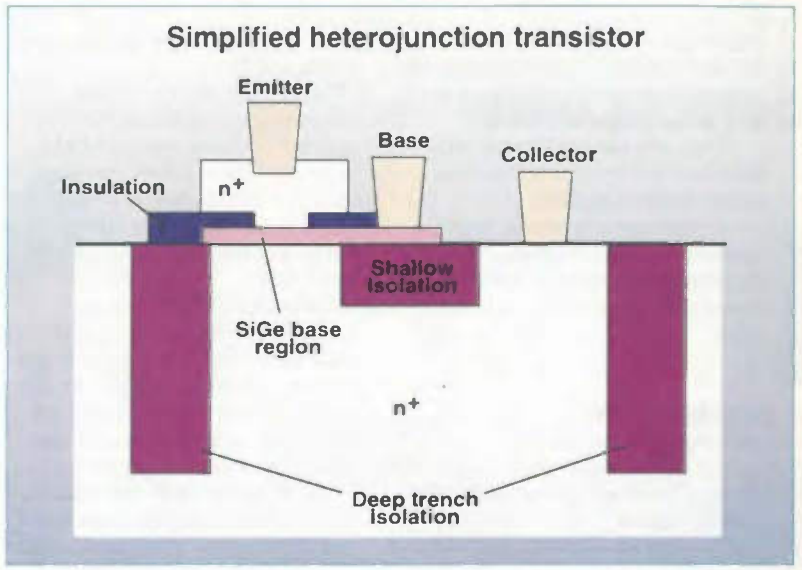
Bipolar transistor achieves 210GHz

IBM Microelectronics has developed a silicon germanium heterojunction bipolar transistor (HBT) running at 210GHz.

The move marks a big step forward, which could extend silicon's reach to the 40Gbit/s communications market and beyond.

IBM exceeded 200GHz by taking its 0.18μm SiGe process, which runs at up to 130GHz, and reducing the vertical thickness of the transistor's base.

With a cut-off frequency (f_T) of 210GHz, IBM's transistor is not only 75 per cent faster than its own previous devices, it is significantly faster than any other published SiGe transistor. Hitachi, for example, last year detailed a 0.2μm SiGe HBT with an f_T of 76GHz.



This simplified HBT shows its vertical structure. Deep trench isolation protects individual transistors, while a shallow trench separates the base-emitter junction from the collector connection.

Other materials, such as indium phosphide, are being touted for high speed comms applications due to higher performance, but they are more expensive to manufacture. IBM claims its HBT, compared to a similar speed InP device, uses 20 per cent less current – around 1mA.

What's interesting is that IBM's process differs little from other companies' devices. HBTs are built on a 0.18μm BiCMOS process with an emitter area of 0.2x1μm.

The major difference comes with the thickness of the base region. Although grown epitaxially like most HBTs, the base has an undisclosed thickness. This reduces the transit time of electrons across the base, which directly affects the cut-off frequency.

Furthermore the amount of germanium in the base is graded, from almost none at the base-emitter junction to between 20 to 30 per cent at the base-collector junction. This brings into question the device's claim to be an HBT at all.

"There is a small percentage of germanium at the base-emitter junction, so there is a heterojunction effect, seen in an increase of the current gain," said Seshandri Subbanna, senior engineering manager for analogue and mixed signal at IBM. "The main heterojunction is at the collector-base junction."

Subanna's engineers expect to have manufactured simple circuits based on the HBTs by the end of the year.

● In a separate announcement, IBM said it will add 'strained silicon' to its CMOS manufacturing within two years, a process it claims will increase switching speeds by 35 per cent.

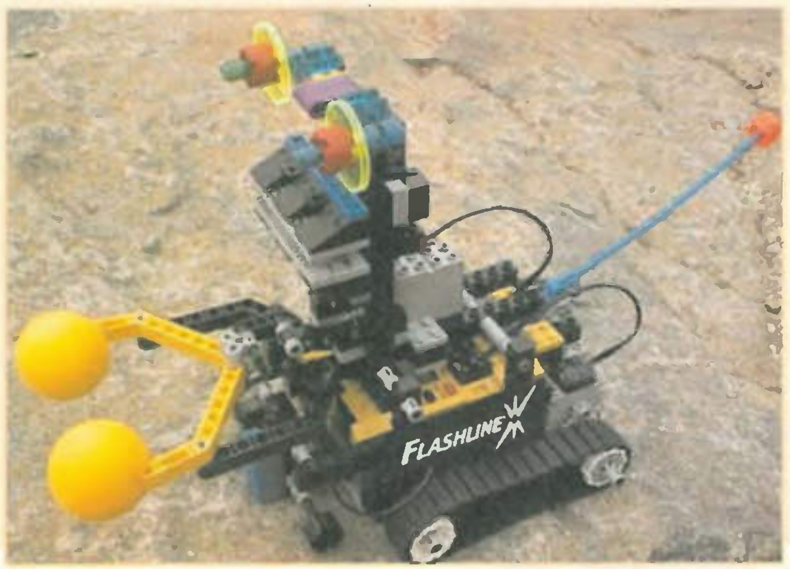
"The limiting factor for switching speeds is the mobility of electrons and holes," said Helmut Schettler from IBM. Strained silicon increases electron mobility by 70 per cent, he said.

Strained silicon is made by growing a silicon layer on top of a lattice with a slightly larger inter-atom spacing. This is often a 75/25 silicon/germanium layer giving a one per cent expansion.

If the top layer of silicon is fairly thin, as it is in a fet's channel, then the silicon retains the spacing of the substrate and is said to be strained.

Even a one per cent larger lattice increases degeneracy of the silicon's conduction band, trapping electrons and reducing the scattering of free electrons in the lattice. This increases mobility.

IBM has completed some test structures using strained silicon and expects to have it in production by 2003. "It's a question of getting a reliable process," Schettler said.



Java makes robot clap

The JavaOne Developers Conference in San Francisco saw the emergence of the "Ultimate Wireless Lego Robot", or so Motorola claimed.

Together with Flashline, Motorola assembled the robot to demonstrate their wireless data technology.

Users remotely sent commands from a Motorola i50sx phone through the Internet to the robot, which will dance, clap its hands, wag its tail, and move around in response.

Both the handset and the application use Java J2ME, one of the smaller versions of Java aimed at portable applications. The Internet connection is 'always-on' and the software is bolted together from re-usable modules.

First products using Indium phosphide semis available next year

Indium phosphide, one of the new breed of high-performance compound semiconductors, is set to appear next year in a commercial product.

TRW, with partner Hitachi, will introduce InP devices into mobile phone handsets in 2002.

InP is an exotic material, until recently confined to laboratories, but its phenomenal speed is tempting manufacturers to bring it into the open.

InP applications – according to TRW

- mobile phone handset power amplifiers
- digital and microwave ICs for satellite payloads
- 40 and 80Gbit/s optical network components
- integrated fibre-optic receivers
- Ku-band to above-V-band LNAs, VCOs and PAs
- components for 'last mile' broadband access
- 60GHz wireless picocells
- 94GHz wireless links.

"TRW's baseline InP HEMT [high electron mobility transistor] process with 65 per cent indium in the channel yields devices with an f_t of 300GHz and an f_{max} of 450GHz. InP HEMTs exhibit higher gain than GaAs HEMTs, as well as a lower noise figure and better PAE [power-added efficiency]," claimed the company in a paper last year.

And TRW has made an InP static frequency divider that operates at least 80.1GHz – way over the head of silicon. In fact, it could have been faster but TRW's test gear ran out of steam.

Direct integration of optical components is another possibility with InP. Devices such as LEDs, lasers, and photodiodes operating in the 1.3-1.55 µm (optical fibre) region may be made alongside HEMTs and HBTs (heterojunction bipolar transistors).

These speed, efficiency and versatility advantages have been more than offset by cost, yield, and reliability problems, as well as lack of high quality large-diameter InP substrates – which are fragile and brittle when you can get them.

According to TRW, InP shares many of these problems with GaAs and the company introduced a high-volume commercial GaAs HBT process in 1993 when others thought it was years away.

Its InP process is modelled on a 1µm descendent of its original GaAs process. Steps transferred include substrate supply (75mm now, 100mm in development), epitaxy (molecular beam), yield and backside processes.

It claims process yields equivalent to those of GaAs HBT processes on its space-qualified 75mm InP process. The 100mm process will be for commercial and space applications.

Reliability is high, says the company, with MTTF (mean-time-to-failure) values of 10^7 to 10^9 hours for devices at 125°C ambient.

Mini mouse is world's smallest

This is the smallest manual input device in the world, claims its maker InControl Systems.

Called Piccolo Point, this is a force sensitive mini-joystick – shown in the picture combined with push-buttons to make a mouse.

It is aimed at wireless and hand-held products and is under 4mm thick with a 14 by 18.5mm footprint – including connector – and with a predicted life of ten million operations.

The company also offers a custom microcontroller that emulates a serial or PS/2 mouse and works with standard mouse drivers, or the user can exploit unused resources in an existing microcontroller to support pointing.

Piccolo Point is available from Diamond Electronics.

Diagonal routeing promises faster chips with lower power consumption

A consortium of companies has set up an initiative to promote diagonal routeing inside ICs, a technique that could increase speeds, cut power drain and improve yield.

Called the X Architecture, the technique rotates the fourth and fifth metal layers through 45°. Standard chips are arranged with metal layers in the so-called Manhattan layout, alternately running horizontally and vertically.

While using diagonal lines is hardly new, the idea of devoting two whole layers to 45° lines is a bold move.

This simple change to the orientation of two metal layers could reduce the length of any single interconnect by up to 30 per cent.

An entire cross-section of the industry from EDA firm Simplex, through a number of mask and equipment makers, to semiconductor manufacturers STMicroelectronics and Toshiba are promoting the move.

In fact Toshiba and Simplex claim to have been working on a production system for over two years.

"As we developed the technology that enables the X Architecture, we worked closely with our partner Toshiba over several years to prove the manufacturability of this new architecture," said Aki Fujimura, president and CEO of Simplex.

On typical chip designs, the firms reckon the total interconnect length is cut by 20 per cent. Consequently performance increases by 10 per cent and power dissipation drops by a fifth.

Perhaps even more significant is the claim that the process could increase the number of dies per wafer by 30 per cent.

"In today's era of five-plus metal-layer designs, the advantages of using diagonal lines are tremendous in terms of chip performance, as well as area," said Dr Kenji Yoshida, v-p of engineering at Japan's Semiconductor Technology Academic Research Center.

Using metal layers four and five means that existing library cells and intellectual property blocks are unaffected as they use lower metal layers.

Bar codes demystified

Roger Thomas gives a brief history of bar codes and the organisations that issue bar-code numbers. He details the most common bar-code format used in retailing, and provides information on how to decode the stripes using a low-cost bar-code wand, PIC microcontroller and software.

There are many different bar-coding schemes in operation, but for retail products the EAN-13 system is used. Products that are only sold in one store – i.e. own label goods – or require weighing and labelling in-store are not part of this scheme.

An EAN-13 bar code allows for unique product identification using thirteen numbers. Bar codes found on food and household products do not include the price or product description. This information is obtained from the computer system that the scanning equipment is connected to.

Bar-code numbering

In the UK, the organisation that allocates company prefix numbers is called e-centre. This is the trading name of the Association for Standards and Practices in Electronic Trade – EAN UK Ltd. It was launched on 7 October 1998 with the merger of the Article Number Association and the Electronic Commerce Association.

Article Number Association, or ANA, was the UK authority for company prefix numbers and established in 1976. The Electronic Commerce Association was formed in 1987, originally as the EDI Association, but in 1996 it broadened its activities to incorporate electronic commerce.

ANA was a founder member of the European Article Numbering, or EAN, Association formed in February 1977 with its headquarters based in Brussels. The name was changed in 1992 to EAN International to indicate that its activities are no longer confined to Europe.

EAN International is represented in 99 countries by local offices. It was founded to create a compatible bar-coding system based on the North American bar-coding system known as Universal Product Code, or UPC.

UPC format

The UPC coded bar code was adopted by the North American retail industry in 1973. American Uniform Code Council (UCC) administers the allocation of UPC numbers.

A UPC number is a twelve digit number with the first digit being a number-system character. The following table shows what each system number represents.

0	UPC retail number
1	reserved
2	items that need to weighed In-store
3	drugs and health related products
4	used for in-store labelling
5	coupons
6	UPC retail number
7	UPC retail number
8	reserved
9	reserved

After this number, there follows a five-digit company number – allocated by UCC – and a five-digit product number, assigned by the company. This provides 100000 companies the ability to number 100000 products for each system number.

The last digit is a check digit. At present, UPC numbers 1, 8, 9 have not been allocated giving scope for additional 300000 company-prefix numbers.

EAN format

EAN-13 is a thirteen number group structured in a similar way to UPC number. However there is no system number. This is replaced by a country prefix. Following the country prefix, there is a unique company prefix, product number and a check digit. This check digit ensures that the bar code has been correctly scanned.

The country prefix is the first two or three digits of the bar-code number.

For the UK, the country prefix is 50, Fig. 1. If a bar code starts with 50, this does not necessarily mean that the UK is the country of origin for the product though.

Unlike UPC, the EAN scheme has the company prefix and product numbers of variable length. Varying the length of the company prefix makes for a more efficient use of the numbers. If a company only needs to number 100 products then they are provided with a longer company prefix than a company needing to number 10000 products.

Each nine-digit company-prefix number can be used to create up to 1000 different product numbers. Eight digit prefix numbers can be used to create up to 10000 numbers and seven digit prefix numbers can be used to create up to 100000 numbers. The company allocates the individual product numbers – not the organisation that allocated the company prefix.

Coupon code

Two prefixes have been reserved for use on EAN coded redemption coupons. Prefix 98 is used for a coupon that might cross national boundaries and prefix 99 is reserved for national coupons.

For example 99 YYYY NNN VVV C comprises YYYY, which is the coupon issuer number, NNN the coupon reference number, VVV the redemption value and C is the check digit.

The redemption value range of the coupon is from 1p (VVV = 001) to £9.98 (VVV = 998); the decimal point is fixed. For values greater than £9.98 the code 999 is used and the redemption value entered at the checkout. Coupons that offer free goods are encoded by VVV=000. Coupon numbers may be re-issued after 36 months has lapsed.

ISBN book codes

The International Standard Book Number (ISBN) is a unique ten-digit number allocated to every book by its publisher. The ISBN system was in use before the EAN-13 numbering system was adopted.

An ISBN code consists of four parts. The first part indicates the language or country of origin and can be a one, two or three digit number. For example, a 0 or 1 number indicates the book is written in the English language. The number 2 is for books in the French language, 3 for books in the German language, 4 for books published in Japanese. The second part indicates the publisher and the third part the book number allocated by the publisher. The size of each field is not fixed and the last digit is the check digit.

ISBN codes are represented in the EAN/UCC-13 coding scheme by adding a 978 prefix. The final digit is the EAN/UCC calculated check digit and not the original ISBN check digit.

Check digits in the ISBN system use a different algorithm. It is possible that the original ISBN book number – and possibly the associated ISBN bar code – will also be printed near the EAN/UCC-13 bar code. If the original ISBN number is printed, the different fields can be separated by hyphens.

Fig. 1. List of European country-prefix codes.

Austria	90 and 91
Belgium and Luxembourg	54
Denmark	57
Finland	64
France	30 to 37
Germany	400 to 440
Greece	520
Ireland	539
Italy	80 to 83
Netherlands	87
Norway	70
Portugal	560
Spain	84
Sweden	73
Switzerland	76
United Kingdom	50

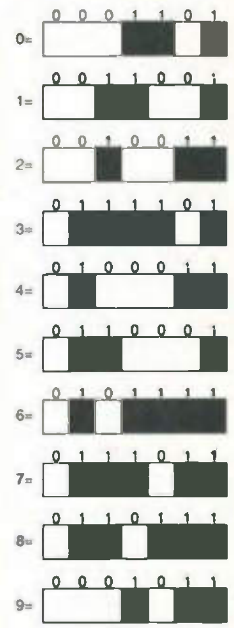


Fig. 2. Bar code 'Table A', top, and the same table converted to a number, below.

[0]	0001101 = 13
[1]	0011001 = 25
[2]	0010011 = 19
[3]	0111101 = 61
[4]	0100011 = 35
[5]	0110001 = 49
[6]	0101111 = 47
[7]	0111011 = 59
[8]	0110111 = 55
[9]	0001011 = 11

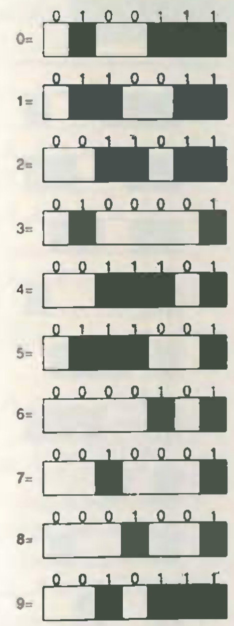


Fig. 3. Bar code 'Table B', top, and its related numbers, below.

[0]	0100111 = 39
[1]	0110011 = 51
[2]	0011011 = 27
[3]	0100001 = 33
[4]	0011101 = 29
[5]	0111001 = 57
[6]	0000101 = 5
[7]	0010001 = 17
[8]	0001001 = 9
[9]	0010111 = 23

Fig. 4. Encoding of the first number of the bar code.

0	AAAAAA
1	AABABB
2	AABBAB
3	AABBBA
4	ABAABB
5	ABBAAB
6	ABBBAA
7	ABABAB
8	ABABBA
9	ABBABA

Next to the bar code there may also be an additional five-number bar code. If this bar code is the book's price, then it will begin with a 0 for the price in pounds and 5 for the price in US dollars. A code of 90000 indicates that the book has no suggested retail price. Any other number beginning with 9 is used internally by the publishers.

The 978 number scheme is also used to identify computer CD-ROM software used for education or reference – including catalogues on CD. Music CDs or games CDs are not included in the 978 numbering scheme and use a normal EAN/UCC-13 number.

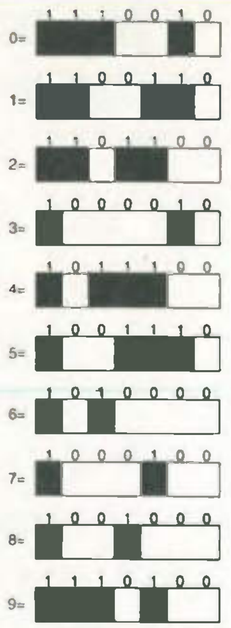


Fig. 5. Bar code 'Table C', top, and decoded numbers, below.

[0]	1110010 = 114
[1]	1100110 = 102
[2]	1101100 = 108
[3]	1000010 = 66
[4]	1011100 = 92
[5]	1001110 = 78
[6]	1010000 = 80
[7]	1000100 = 68
[8]	1001000 = 72
[9]	1110100 = 116

ISSN periodical codes

A system used to identify serial publications, such as newspapers and magazines, is called the International Standard Serial Numbering, or ISSN, scheme. An ISSN number is coded in the EAN/UCC-13 scheme with a 977 prefix. These EAN/UCC-13 bar codes can also have a separate two digit extension code.

For daily publications the number is 977 SSSSSSS PD C WW. Here, 977 is the ISSN prefix number and SSSSSSS the ISSN number. Letter P indicates change of price. It is increased in value by one each time the price rises. The 'D' indicates the day of the week – week starts Monday – while C is the EAN/UCC check digit. Finally, WW is the week number represented by a separate two digit symbol.

For weekly publications the number is 977 SSSSSSS PP C WW. In this case, 977 is the ISSN prefix number and SSSSSSS the ISSN number. The 'PP' indicates change of price, rising by one for each price increase. Letter C represents the EAN/UCC check digit while WW represnts the week number as a separate two digit symbol.

For monthly publications this additional two-digit bar code indicates the month.

UPC in Europe

Products identified with UPC bar codes have been scanned without any problem in Europe. The twelve-digit UPC number can be processed by preceding the number with 0 to make it EAN-13 compatible.

However, the reverse has not always been true in that some European suppliers have had to obtain UPC numbers if their product was to be sold in North America. The problem is not with the scanner equipment but incompatibility due to many American retail computer database systems not being able to handle the extra digit, or the variable length product and company number.

UPC future

The Uniform Code Council organisation is expected to use all of its company prefix numbers by the year 2005. Consequently the UCC has established the 1 January 2005 for all retailers to accept the EAN-13 code, as well as the UPC code, at the point of sale terminals.

This date was agreed in May 1997 at a joint meeting between the UCC and EAN International. UCC acquired country prefixes 10, 11, 12 and 13 from EAN International. After the 1 January 2005, thirteen digit EAN-13 numbers will, for the first time, be allocated by the UCC.

There is no ambiguity between the EAN and UCC numbers. The existing twelve-digit UPC number is not being replaced by EAN-13, but adopting the EAN-13 format allows for expansion and a global numbering system.

UK bar codes

If you look at a typical EAN-13 bar code number, the 5 (first number of the UK 50 country prefix) is shown on the left before the guide bars. The first country prefix number is not directly incorporated as bar stripes but is encoded by the choice of which characters are taken from **Fig. 2** or **Fig. 3** for a given position. These are often referred to as Table A and Table B.

For example, UK bar code use the sequence 'ABBAAB' to signify the number 5, **Fig.** 4. The first number to be coded (0) is taken from Fig. 2. The second and third numbers use Fig. **3**, and so on. Similarly the table sequence 'ABBABA' is used to denote the number 9 – used for magazines and books.

Only twelve numbers are actually encoded in the bar-code stripes. The last six numbers are taken from **Fig. 5** (i.e. Table **C**). Definitions in this table are the reverse of those in Fig. 3.

Each number definition is unique so there are no duplicate patterns.

Bar-code forms

EAN/UCC-13 uses proportional coding with four different widths. When printed, this is more space efficient than coding the number in binary. There are no inter-character gaps – spaces are part of each number definition.

In addition to the bar-coded twelve numbers, there are two guide characters and a centre character. These guide bars may be extended below the rest of the bar code.

To increase scanning reliability, not all the possible character permutations are used. The maximum black or space width is four and there are always two sets of bars and two sets of spaces per number. Overall, there is virtually an equal number of bars to spaces per bar-code number.

Bar-code definitions on the left side of the centre guide bar all start with a space and end with a bar. With bar codes on the right the converse is true starting with a bar and ending with a space. A blank area – referred to as the 'quiet zone' – must appear before and after the bar code. Bar-code scanners use this zone to determine the exact beginning and end of the bar code.

Bar-code wand

Quality bar-code wands are often manufactured with a metal barrel; cheaper wands tend to be made of plastic. These wands look like a large pen. At one end there will be a small lens and at the other end a lead.

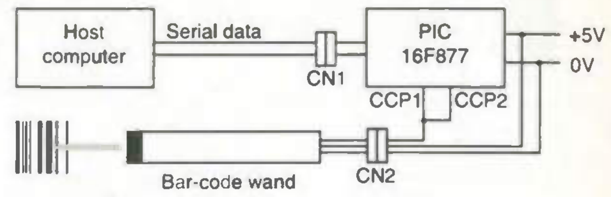
The wand must be able to distinguish between the bar-code bars and the gap between the bars. To do this, most hand-held wands use several red light emitting diodes that are used to illuminate the bar code with visible red light and a photocell light detector in the centre of these leds. The light detector converts the reflected optical signal into a digital signal that is then fed to the microcontroller.

The printed bar should absorb the light, while the background reflects the light back to the wand detector, the detector responds to this intensity change. A return signal above a certain threshold will produce a logic 0 and below this threshold will produce a logic 1. Consequently as the wand is moved across the bar code the background produces a logic '0' and a bar is logic '1'.

Place the wand to the left of the bar code in the blank area just before the bar code. The wand is held like a pen and a straight line is lightly drawn across the entire bar code. If it does not scan the first time then do not press down harder the second time as this makes no difference.

Initially it may take a few attempts to scan a bar code before the correct position and speed are found.

Fig. 6. Block diagram of bar-code reader, together with the complete circuit, apart from the power supply and wand.

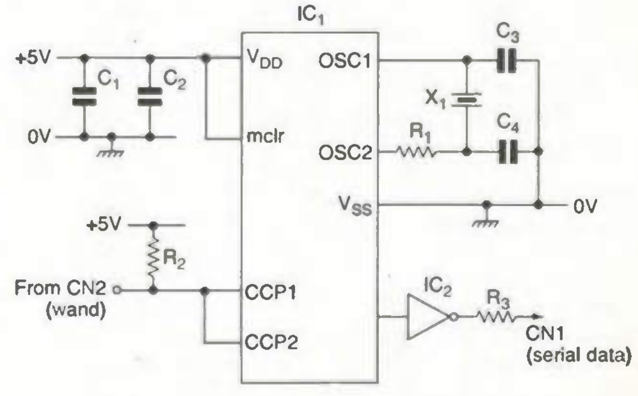


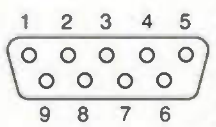
Component list for bar-code decoder

IC_1	PIC 16F877
IC_2	74LS14
C_1	10μF
C_2	1nF
$C_{3,4}$	15pF
$R_{1,3}$	470Ω
R_2	1kΩ
X_1	20MHz crystal
CN_1	serial connection
CN_2	wand connection

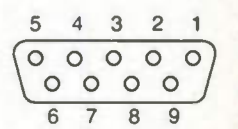
Power wiring list.

+5V	PIC pin 1
+5V	PIC pin 11
+5V	PIC pin 32
+5V	wand pin 9
+5V	74LS14 pin 14
0V	PIC pin 12
0V	PIC pin 31
0V	wand pin 7
0V	74LS14 pin 7





Connector CN1 – a 9-pin 'D' type – feeds serial data from the PIC to the host computer, with serial data on pin 2, and ground on pin 5.



Feeding serial data from the wand to the pic, 9-pin 'D' socket CN2 has ground on pin 7, the wand signal on pin 2 and +5V on pin 9.

Wedge

Having scanned a bar code for data capture, the information needs to be input into application program. This data transfer is often achieved using a keyboard 'wedge'.

There are two versions of the wedge – hardware and software. With the hardware wedge, the keyboard from the PC is plugged into the wedge, as is the bar-code scanner. The wedge is then plugged into the PC keyboard port. Whenever a bar code is scanned the wedge sends this data to the PC as if the bar-code number was entered using the keyboard.

A software wedge is used with a lap-top computer or portable terminal where there is no external keyboard port. The bar-code scanner is connected to the serial or usb port. Software reads the data from the bar-code scanner; converts and sends this information to the keyboard buffer. The bar-code data then appears in the application program as if it was entered using the keyboard.

Any program that expects bar-code numbers to be entered manually via the keyboard can be used with a suitable wedge without any need for the program to be modified.

Wand connections

An external five-volt power supply will be required to power the wand and PIC circuit. A wand requires about 40mA continuous current.

Bar-code colours

Bar codes do not have to be printed in black on white but this is usually the easiest – and safest – print option. Red, yellow, and white are suitable background colours as they will reflect the scanner light. Blue, green, dark brown and violet can be used for the printed bar as they appear black under the red scanner light.

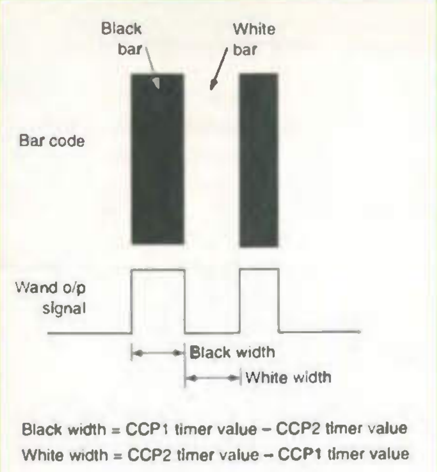


Fig. 7. Using capture register and timer values to calculate bar widths.

Bar-code trivia

In 1967 the Association of American Railroad selected a bar-code identification system to keep track of the rolling stock. The first test of the system was in 1961.

Each carriage was given a four-digit number to identify which railroad owned it and a six-digit identity number. These bar-code stripes were placed on the side of the rolling stock using reflective material.

This was the first attempt at an industrial application of bar-code technology, previous systems have all been associated with retailing. It took until the mid 1970's before the majority of the rolling stock had these bar codes. However for cost and other reasons the system was abandoned in the late 1970s.

Also in 1967, RCA installed one of the first retail scanning systems at a store in Cincinnati. A set of concentric circular bars and spaces of varying widths represented the product number. These bar codes were not pre-printed on the product but these labels were put on each item by the store. Retail industry recognised the advantages of this technology to speed up the check-out process and for inventory control but this could only be achieved with industry wide standards.

In 1970 the US Supermarket Ad Hoc Committee was formed and the result was the Universal Grocery Products Identification Code. Three years later the UPC (Uniform Product Code) numbering system using linear bar-code symbols was adopted.

On 26th June 1974 at a super-market in Troy, Ohio the first retail product with a UPC bar code was scanned using one of the first bar-code scanners installed. The scanner was manufactured by National Cash Register Company – now known as NCR – and the product was a packet of Wrigley's chewing gum.

For those that do not have a 16F877 programmer I can supply a programmed PIC for £20, this includes the Windows 95/98 software.

PIC and MPLAB are registered trademarks of Microchip Technology Incorporated, USA.

Windows 95/98 is a registered trademark of the Microsoft Corporation.

Usually, only three wand connections are required. The connections are power, i.e. +5V, and ground, and signal output. These connectors are usually a 9-pin 'D', but other connectors are possible. Most bar-code wands have an open-collector data output, in which case a pull-up resistor, R_2, is required.

Wand output connects directly to the 16F877 PIC, which converts the TTL signal from the wand into bar-code widths. These different bar-code widths are converted by the PIC software into a series of numbers and transmitted via a ttl buffer to the serial port of the computer, Fig. 6.

Timing-bar widths

Using the microcontroller's 16-bit timer, namely timer 1, the bar-code width can be calculated. Timer 1 is in counter mode and is free running. The 20MHz clock is internally divided by four and the prescaler is also set to divide by four, therefore the clock to the timer is running at 1.25MHz.

The bar-code wand output, Fig. 6, connects to both capture pins on the PIC16F877. Register CCP1 is triggered on the black to white transitions (logic 1→0) and CCP2 is triggered on a white to black transition (logic 0→1).

Whenever there is a rising or falling edge generated by the bar-code wand output then timer 1 value is read.

Timer 1 is not reset when its value is read, when it reaches its maximum value of $FFFF_{16}$ it starts counting up from zero. This does not pose any problems if the two timer readings are either side of this timer event as the width calculation is done using unsigned 16-bit integer arithmetic.

Calculating bar widths

The program waits until the bar-code wand detector output goes low and the start of the quiet zone is assumed. PIC programming times the width of the first black bar (guide bar). This value is used as the initial reference value for black bars (width=1).

Next the width of the first white bar – i.e. the gap between guide bars – is measured. This will be used as the initial reference value for white bars (width=1). The second black guide bar is timed and the average taken of both black guide bar values by adding both results and dividing by 2.

Software will 'time out' after approximately 20ms of inactivity after the start of scan. If this happens, a suitable error message is appended to the numbers already scanned in.

Black and white width values are calculated independently of each other. The width value is used as the basis of comparisons for all following width timing calculations. In theory, the black and white width values should be the same but having them separate reduces any problems caused by variation in the quality of bar-code printing.

If the timer width of a subsequent single width is less than the reference value then the reference width becomes this new value. Whatever number is encoded in the stripes there will always be the two middle single width guide bars for reference. If the width=2 reference value is different from a scanned bar, then this new value is divided by 2 and made the new single-width reference value. This ensures that if the speed at which the wand is moving across the bar code changes, then the subsequent measurements will still be accurate. There will be some variation in scanning speed as a constant speed across the whole bar code is very unlikely.

If the bar width time value is less then 150% of the appropriate reference value then bar width is one. If the timed bar is between 150% and 250% of the reference value then bar width is two. If the bar width is between 250% and 350% of the reference value then bar width is set to three. If the bar width is greater than 350% of the reference value then bar width is four.

Bar width into binary

The various bar-code widths are measured and converted into a binary sequence according to the bar width. This sequence should begin with '101', which represents black, white, black single width guide bar and is checked by the software. If it is missing then an error message is sent to the PC and the rest of the scan is ignored as the software does not have a valid reference value.

Likewise, the software checks that the middle guide bars are also present. If they are not, then the error message is sent. These guide bars are not part of the bar-code number and are subsequently ignored by the software.

Converting bar binary into numbers

As already established, each bar-code number is uniquely defined using, in effect, a seven-bit binary definition. Each bar-code number binary definition is converted into a number.

The scanned bar code starts off as a binary number and is also converted to its equivalent number. The appropriate table is searched, looking for a numeric match for each number. For example, if the first bar-code

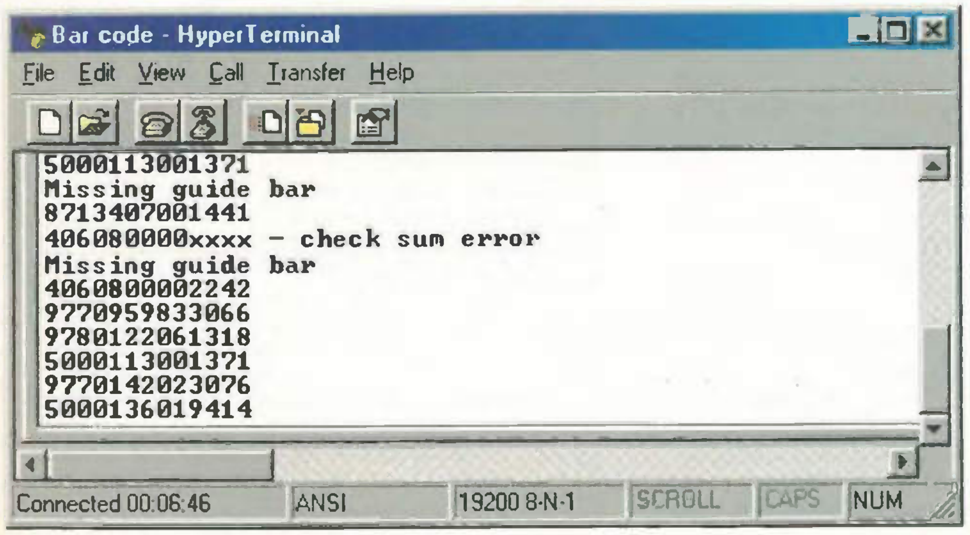


Fig. 8. HyperTerminal, which is part of Windows 95/98, can be used to display numbers received through the RS232 port. Among the bar codes displayed here is a German code (40) found on a soft drinks plastic bottle

Calculating the check digit

Here is an illustration of how the simple formulas needed for calculating the EAN/UPC check digit are used.

Example: calculate the check digit (C) for the EAN/UCC-13 number:

501234576421C

Starting on the left side of the number add together all alternate even numbers:

0+2+4+7+4+1=18

Multiply the result by three:

18x3=54

Add together the remaining odd numbers:

5+1+3+5+6+2=22

Add both results together:

54+22=76

The check digit is the smallest decimal number which, when added to the previous result, produces a number divisible by 10

76+C=80
C=80−76
C=4

The full number is 5012345764214

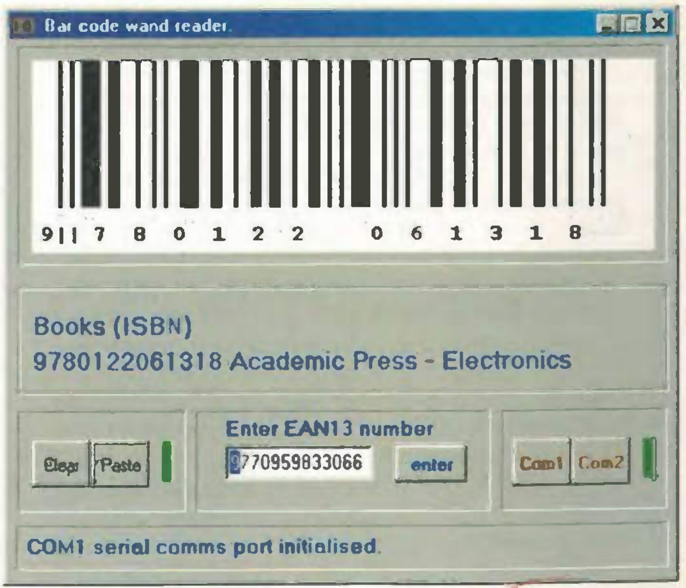
PC software

I have produced Windows 95/98/ME software that has the ability to check that a EAN/UCC-13 bar-code number is valid. It also determines which country allocated the bar code from the country prefix number. Bar-code numbers can be typed in from the keyboard, as well as being scanned.

The software can also generate EAN/UCC-13 bar codes. The resulting bit maps can be copied to the clipboard and pasted into another application.

The software includes a simple text-based user defined database. If the bar-code number matches a bar code within the database then text information contained in the database is displayed. This helps demonstrate how bar codes can be used for inventory or asset tracking systems.

If you are interested in this software, please write to me, Roger Thomas, at 24 Slave Hill, Haddenham, Aylesbury, Buckinghamshire HP17 8AZ. I can also supply a pre-programmed PIC 16F877 for £20. This price includes the Windows software.



Windows software, available from the author, shown here checking a scanned magazine bar code in the database.

sequence number is 13 – which it will be for a UK bar code – then a match is found in table A, Fig. 2, and '0' is returned. If there is no match then an 'x' is sent indicating a scanning error.

Depending on whether table A or B provided the first six numbers this also determines the first number, which is the country prefix. Consequently all numbers have to be stored so that the first number can be decoded from Fig. 4 and transmitted first.

If one of the first six numbers has not scanned properly then the first number cannot be derived and an 'X' is sent as the first number.

Once the bar code is converted into a thirteen-digit number, it needs to be verified to see if it has been scanned correctly. This is done by removing the last digit – the check digit – and using all the remaining numbers to generate a check number. If the scanned number includes an 'x' then the scanned bar-code number will automatically fail.

The algorithm to create this check digit is the same one that was originally used. Both UPC and EAN-13 use the same formula. This calculated number is compared with the scanned check digit. If they are the same then this verifies the bar code has been scanned correctly; if not the bar code is rejected and a 'check-sum error' message sent to the computer.

Using List 1, programmed into a PIC, data is transmitted from the microcontroller at 19200 baud, 8-bit data and no parity. Although the microcontroller has a built-in serial port, it is necessary to invert the data using a 74LS14 buffer. This inversion would normally happen when using a serial interface driver but as data is flowing one way a serial interface driver is not needed.

Terminal software

As the output from the PIC microcontroller is the bar-code number or error messages in plain text (ASCII) then the Hilgraeve HyperTerminal software – supplied with Windows – can be used to view this information, Fig. 8. Set the HyperTerminal properties as 'direct to com'. Set the Port Setting as follows 19200 bits per second, 8 data bits, no parity, 1 stop bit, and no flow control. ■

List 1. PIC object code for reading bar codes and conveying the number via RS232 to a PC. When programmed into a flash PIC16F877, this hexadecimal code allows the decoding of a EAN/UCC-13 bar code and sends the bar-code number to the PC. This PIC code is intended for personal use only, any commercial use requires written agreement from the author.

Microchip MPLAB assembler software saves the PIC object code in INHX8M format. All numbers are in hexadecimal and each line starts with 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.

Using a text editor, such as Windows Notepad, enter the hex data and save the data in a file with a hex extension (for example barcode.hex).

If the PIC programmer is being used in conjunction with the Microchip MPLA8 software then select the import (import to memory) option from the file menu. Find the appropriate directory and select the barcode.hex file. To view the hex code that will be programmed into the PIC16F877, select from the Windows menu the 'Program Memory' option.

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

If you don't relish the thought of typing this in, e-mail j.lowe@cumulusmedia.co.uk using the subject heading 'bar codes'.

```
:100000006628423461347234203463346F3464348B
:100010006534203472346534613464346534723448
:100020002034703472346F346734723461346D3418
:1000300020347734723469347434743465346E34F3
:10004000203462347934203452346F346734653468
:1000500072342034543468346F346D346134733402
:100060000A340D3420342D3420346334683465343C
:1000700063346B342034733475346D342034653418
:10008000723472346F3472340A340D344D3469343E
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:100110002C08A1001508A0070318A10A1B08A002BB
:10012000031CA1032008AB002108AC00B00131087A
:100130000319C0283208A0003308A100FF30A20034
:10014000000030A002031DA2010030A102031DA20184
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:100390003A08023C031DD9292B08A0002C08A10013
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:1003B000B5003108643C0318DE29B10108003C088F
:1003C000A0000230A1005A25BC003C083B07BC003D
:1003D000B10A3108043C031DF6293C08053C031D05
:1003E000F3293E14F4293E10BC01672A31080B3C66
:1003F000031DFE29E2222E08C100672A3108123CA3
:10040000031D062AE2222E08C200672A3108193C81
:10041000031D0E2AE2222E08C300672A3108203C61
:10042000031D162AE2222E08C400672A3108273C41
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:1005100006254208AE0006254308AE00062544081D
:10052000AE0006254508AE0006254608AE000625A5
:100530004708AE0006254808AE0006254908AE006B
:1005400006254A08AE0006254B08AE0006254C08D5
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Is Linux for you?

If you design via CAD running under Windows, the chances are you've been frustrated by operating system crashes. Relatively speaking, Linux is very low cost, and according to Rod Cooper's experiences, it's well worth finding out how your favourite applications will run under it.

The fact that well-respected companies like IBM, Compaq and Dell now offer Linux as standard on their computers, and that large software companies like Oracle and Corel are producing applications for Linux means that this OS has to be taken seriously.

Linux is certainly worthy of attention by anyone using the PC professionally as a tool to do his/her job. One purpose of this review is to demonstrate to engineers not only that can you perform CAD, but also all the other tasks that might be incidental to an engineer's job, such as report writing, spreadsheets, databases etc.

The review does not attempt to describe how to run Linux – neither does it explain how Linux came about. You get all this information on the internet or from a Linux hand-book.

Linux is a product of the Internet, and indeed it would have been impossible for it to reach such a stage of prominence without it. If you have no Internet access you will be at a disadvantage. Alternatively though, there is general Linux literature on the market, and a few Linux magazines are now available.

Background to Linux

When I briefly looked at Linux a few years ago it was a tough, command-line operating system with a well-deserved reputation for being difficult to install. It offered all the disadvantages of DOS with very few redeeming features. The thing that has changed Linux out of all recognition and boosted its popularity is the relatively recent addition of Windows-like GUIs.

Whereas Microsoft is busy trying to camouflage the DOS origins of Windows 9x, users of Linux are actually encouraged to step outside the GUI and use the command line and generally get involved in the nuts-and-bolts of the Linux system. However, if you want to, you can remain to a large extent inside the cocoon of the Windows-like GUI and ignore this side of things.

Reasons behind a swing to Linux

Although Linux is inexpensive compared to Windows, this alone is not sufficient reason to change over to it. The effort needed in the learning curve, and the time taken to convert machines over to Linux, and the cross-platform compatibility question, should make you examine your reasons for swapping to Linux most carefully. There are possibly many more reasons than those I have listed here, but I can see six main reasons why anyone should want to ditch Windows either partly or wholly, and contemplate taking up Linux. These six are as follows;

1. Reliability. One of the problems with Windows is that every release has been 'hyped'. The promise has been constantly held out to solve the existing problems in the newest, latest version, but purchasers have been left with a vague feeling of disappointment with every successive issue.

What purchasers actually got was lots of extra features, which tended to obscure the reality – that the basics, in particular the lack of reliability and security had not been attended to sufficiently.

A respected writer in a well-known IT publication commented recently that most of the crashes in Windows were caused by the operators themselves. This is probably quite correct. He then on to say that he only crashed Windows once a month. This speaks volumes. If an expert crashes once a month, what chance have the rest of us got?

Some of these inherent faults have been addressed in Windows 2000 – but not all. Potential users may be put off by the cost of Windows 2000 and the incompatibility with current Windows 9x software. It also demands more PC resources, and it takes a lot of disk space. Not surprisingly, this has resulted in a less than complete take-up.

Microsoft's advertising suggests that Windows 2000 is now 50 times more reliable than Windows 9x, but how does this compare to Linux?

Bloor Research set up two servers, one running NT and the other Linux, and ran them under the same conditions for a year. Linux was stopped once, due to hard disk failure. NT crashed 26 times due to memory problems, a further 8 times due to file management and yet a further 33 times due to other problems. Most Windows users will be familiar with what these "other problems" were.

Windows 2000 of course uses the NT kernel. This begs an obvious question...

2. Politics. The political-legal rumpus between the USA's Dept of Justice and Microsoft has left a bad odour in its wake, and the wrangling is still not over. Linux is to all intents and purposes free.

3. Immunity from viruses. If you have been the victim of a virus attack via Windows, things are never quite the same again, especially if it was you who exposed your company and colleagues to such things as the Love Bug disaster.

It is easy to become a little paranoid about the virus menace. Linux has escaped lightly, but this is not, as some detractors have stated, due to the lack of Linux users. Indeed, Linux is used by very many internet servers so it cannot be that! These detractors speak in ignorance. The fact is that Linux is inherently virus-resistant.

4. Low cost. Linux itself – or GNU Linux to give it its correct title – is essentially free. It is released under the 'General Public License' by the GNU foundation. A copy is also included in the handbooks provided with the various distributions. Among other things, the license attempts to guarantee that Linux cannot be easily hijacked by proprietorial companies, so it is likely to endure.

The word "free" in this context is more a right to freely receive, modify and distribute the software than freedom from price. You can charge for this service if you want. A more accurate description for Linux would be "nearly free". Although you can download a version of Linux from the internet for nothing more than the cost of the call, assembling a version as good as the commercial versions is a mammoth task and definitely not for a beginner.

5. Ability to modify. Linux is not only nominally free, but includes the source code. This applies to many applications also, and means that, if you want to make modifications for a special usage, you can. The scope this offers developers is immense and is in sharp contrast to the world of Windows, where Microsoft and the third party application companies keep their source code a closely guarded secret and charge for any development assistance.

6. Fewer chores. I personally don't like backing up frequently, or defragmenting the hard drive. Defragmenting a HDD may seem to some to be a relatively unimportant chore which only needs to be done once in a while, but as drives have got larger and software bloated out to match, it has become an ever more time-consuming process.

However, there are some PC activities in Windows that demand frequent defragmenting so you just can't get away from it. Writing CDs with a CD-burner is one example. Here, it is advisable to defragment before writing to an audio CD in order to get a clean recording, especially if you want to avoid the dreaded buffer under-run. The important thing to note here that Linux fragments very slowly, being essentially self-defragmenting, so needs very little attention in this respect.

Potential snags to Linux

I should emphasise before you read this section that pointing out some of the snags of Linux is not an attempt at deni-

Running Windows applications under Linux

Using a virtual machine to run Windows is an old idea but it works well. It was used in IBM's OS2 Warp operating system. A copy of Windows 3.1 – called naturally enough Win-OS2 – was included with OS2 to cater for those who wanted to continue to use their existing Windows 3x applications, but who also wanted to use the superior OS2.

With OS2, a virtual DOS machine was created by OS2 on which Windows 3.1 ran. This version of Windows included the W32s extension for running 32bit applications.

There were considerable benefits to doing things this way. IBM claimed that OS2 could run Windows applications better than Windows itself – and it did. Stability was improved, and there was some crash protection.

There are commercial products that do the same trick for Linux and offer the same benefits. The two most well-known are VMWare and Win4Lin.

To use a virtual machine – or VM – you need a copy of Windows to install after you have installed the VM. The installation of a Linux VM and then Windows is very time-consuming and needs to be done carefully.

I found that installing VMware in particular is not user-friendly. If you plan on using it I recommend a few months' practice with Linux first. VMware can handle Windows 9x, NT and 2000 and costs $299.

Win4Lin is tailored for Windows 95 and 98 and costs $49.

Using an emulator

The doppelganger approach has the potential to be the best system of all. But unfortunately it is not fully developed yet.

The idea behind Wine is that if an alternative Linux-based set of APIs – or Application Protocol Interfaces – was presented to a Windows application instead of the regular Microsoft APIs, then it could be fooled into accepting Linux as Windows.

As far as an application is concerned, an API making a call on Linux is just as good as an API making a similar call on Windows. This is a variation on the old saying that a nod is as good as wink to a blind horse.

For this technique to work, a full set of Linux APIs is required. Here is the snag; the developers have only done around 90% of the equivalent Windows APIs. If an application needs one of the missing APIs, it is not possible to run it successfully. Although I would not recommend the current Wine for complete beginners, it only needs a basic grasp or Linux to have a go at it.

Wine is truly the key to the future popularity of Linux. It solves the dilemma under discussion completely. And because it's a non-commercial program, it's free.

Mandrake Linux 7

Produced by the French company MandrakeSoft,

Mandrake is a well-regarded distribution.

Despite being on just one CD, this version was a complete fully-functional Linux system with a large number of applications and utilities. Mandrake Linux is one of the versions you can get for £2.50 from The Linux Emporium, and as such is ideal for trying out a Linux system without committing yourself to buying the full distribution.

Version 7.0 is well worth consideration if you have a machine with 32 MB and RAM and do not want to upgrade with more RAM. It is a compact and useful Linux package.

Version 7.2 – the current version – is much enlarged, occupying seven CDs. It exhibits many small but regular incremental advances typical of Linux development – in contrast to Windows.

For the beginner the main advantage of version 7.2 is provision of the large pool of applications. You will not have to supplement your installation by chasing all over the Internet for what you want - it's right there for you to pick. And if you want to try out voice operation then the availability of ViaVoice and StarOffice will certainly be of interest.

The cascading menu system works in just the same way as Windows although the contents may have unfamiliar names.

grating Linux, merely to present it in a 'warts and all' style so that a newcomer can come to an informed decision.

Linux nomenclature. Part of the problem of converting over to Linux is the jargon. Initially you will feel as though you are in a foreign land and cannot speak or understand the language. The impact of this should not be under-estimated, but it not an insuperable problem by any means.

No-one should consider themselves locked in to the Windows system just because the jargon in Linux is different.

The Linux community seems to revel in its own particular brand of jargon. Why, for example, does a program for zipping files have to be called 'tar'. Why not 'LinuxZip'* which most people could understand? Does an installing program have to be called DrakX instead of LinuxInstall or Linstall?

The recursive acronym is popular. GNU stands for Gnu's Not Unix for example. The play on words and hidden reference is also often used. 'Bash' is not some useful program for terminating wayward applications, but a popular command shell – the equivalent of command.com in DOS – standing for Bourne Again Shell, after the Bourne shell in UNIX.

Similarly, you will be initially perplexed to be involved in such things as 'globbing', 'mounting' and of course 'unmounting'.

The jargon is so obtuse and there is so much of it, that it is not a bad idea to get hold of a Linux glossary and keep it at hand during the initial learning process.

Understandably, Linux *aficionados* tend to be fiercely defensive of the system they helped create so nothing is likely to change in this area - you just have to go along with it.

Hardware incompatibility. Linux will run on PCs with the 386-type architecture, so almost any PC based on Intel or its clones can accommodate it. I tested it on an AMD-based PCs and it ran well. I say almost any because some recent distributions of Linux, such as Mandrake and SuSe, are optimised for the Pentium processor.

It is still possible to run a version of these on an 'old' 486 but you need to be aware of the likely snags.

Although there is no significant problem with CPUs, there is a problem with certain peripherals because not many manufacturers write drivers for Linux. Windows has by far the largest number of drivers attributed to it.

Some manufacturers even appear to be stubbornly ignoring Linux, but this situation is changing. For example, Lexmark has just issued a colour printer driver for Linux – the first manufacturer to do so.

Nevertheless, there are long lists of drivers in Linux for printers, monitors, video cards etc and a good distribution of Linux will install without undue difficulty on a modern machine with plug-and-play peripherals, but there are areas where care is still needed.

There is likely to be little or no difficulty with keyboards, mice, CD-ROMS, hard drives and the like. A Linux distribution such as SuSe will detect most plug-and-play devices, and the latest versions offer USB support. But ISA cards have to be manually configured.

You are unlikely to be completely blocked unless you have elderly devices or a new peripheral. For example, I came unstuck with my relatively new Samsung SF 4300, which is a scanner, colour printer and fax all in one. No driver here – not even on the remote horizon. Interestingly, there is no driver from Samsung for Windows 2000 either!

The big exception to the general rule is the area of modems, which is a veritable mine field. The reason for this is that unfortunately many modem manufacturers have succumbed to the Wintel monopoly and produced so-called Winmodems – sometimes called soft modems. These have very few components on the pcb, and rely on Windows software and to a some extent use the PC's hardware instead of their own in order to function.

If you have a motherboard with a built-in modem, it is almost certain to be of this type. The advantage is one of cost – a Winmodem is comparatively cheap to manufacture because it is, in effect, only half a modem. The big snag is that the Winmodem takes a slice of the PCs resources when operating.

SuSE Linux

SuSE Linux has won several awards for the high quality of its distribution. It also has much more printed documentation than its rivals, in the form of manuals, installation guide etc.

There are two versions, Personal at £25.99 and Professional at £44.99. The Pro version comes on six CDs and includes a huge amount of software covering almost everything you would want to do with a PC.

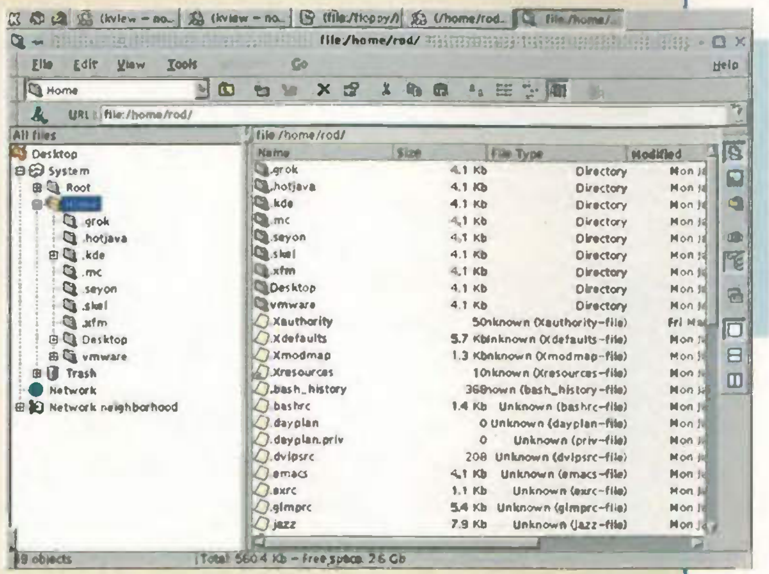
It will consume around 8 GB of hard disk space if you install it all. This is more software than most people will ever need, but some programs overlap, and some are mutually exclusive, so installing it all is unwise even if you have a big enough hard disk.

A DVD is included in the pack as an alternative installation medium, SuSE being the first Linux distribution to use this format. A floppy boot disk is also included, which is most useful if you find you can't boot from the CD-rom.

The Pro version includes software tools for developers and servers, video-conferencing, Java 2. Of course, by providing such a vast array, there will be many programs that you won't be interested in, but on the other hand there is bound to be something for everyone.

The Personal edition comes on just two CDs. Both Personal and Pro include the excellent StarOffice suite. SuSE Linux has an easy installation system, extensive documentation and a very large collection of Linux applications in its CDs. However, having a huge number of applications would be no good for the newcomer if he could not sort them all out, and it is here that SuSE excels with its install/uninstall and indexing system. The RAM requirements for running the graphical installer YAST2 may seem high, but even entry-level PCs now come with more than is needed, so this is no longer such an issue.

The overall impression is that SuSE Linux is a well-presented, thoroughly designed and workable OS, and has the best selection of Linux applications.



SuSE's equivalent to Windows Explorer. The directory tree should be familiar in style if not in content. Some of the files in the Home directory are displayed on the right hand side. Note that the panel bar has been rolled up to one side to increase usable screen area.

At present, Linux cannot work with them. All this may change, since steps are being taken to remedy this situation. It is a good idea to firstly to visit the web site www.linmodems.org to get the latest information and then proceed with the link to http://www.o2.net/~gromitkc/html, where, fortunately for beginners, there is a list of modems that do and do not work with Linux. Be warned this is a very long list.

I would not delay adopting Linux as an OS just because you have a software modem and need to replace it. In the overall context, replacing the modem is a small price to pay for adopting Linux. Just remind yourself about Linux's freedom from virus attack, for example, and the low cost, and the reliability.

If you decide to replace your modem, it is best to check with the sellers that it will indeed work with Linux, and that you can get a refund if it does not.

Difficult to use. There is no doubt that Linux used to be a computer buff's operating system. It was created by – and for the use of – those with a special interest in this field. I doubt if the rest of us mortals who use the computer for the mundane tasks like CAD, CAM and so on were originally taken into consideration. The legacy of all this is that Linux is not a system that is as easy to use or as intuitive as Windows. But in the long term, I do not think this should not bother most PC-users who have already mastered Windows.

As an instance of this, when installing new software, there is no friendly 'Installshield' system. Each application in Linux seems to have its own method, and this can range from difficult to ghastly.

To take an example, Acrobat Reader is available for both Windows and Linux. In Windows, you insert the CD, start Explorer, access the file, start it with a double click, you read the agreement, and it needs just a couple of mouse clicks to install it into the chosen directory, clean and simple.

In Linux, you need to log in as root, mount the CD-ROM, start File Manager, access the file linux-ar-405.tar.gz and transfer it by drag-and-drop to a temporary folder on the hard disk, access the command line and hence the temporary folder, then type the gobbledygook "tar zxf linux-ar-405.tar.giz" at the command line. You then type "cd ILINUXR.install" and press enter. Then type "./INSTALL" and press enter to start installation. Read the agreement, choose the directory, and you are finished.

Incompatibilities within Linux. There is broad compatibility between the various Linux kernels, and between the different distributions, but there are occasions when this is not true. Linux is under continual development so there are various kernels in circulation at any one time.

It is possible to up-date them, and this can be compared to up-dating Windows with a service pack. Kernels with an odd number tend to be versions under development and the even numbered ones like 2.2.14 are the ones to aim for.

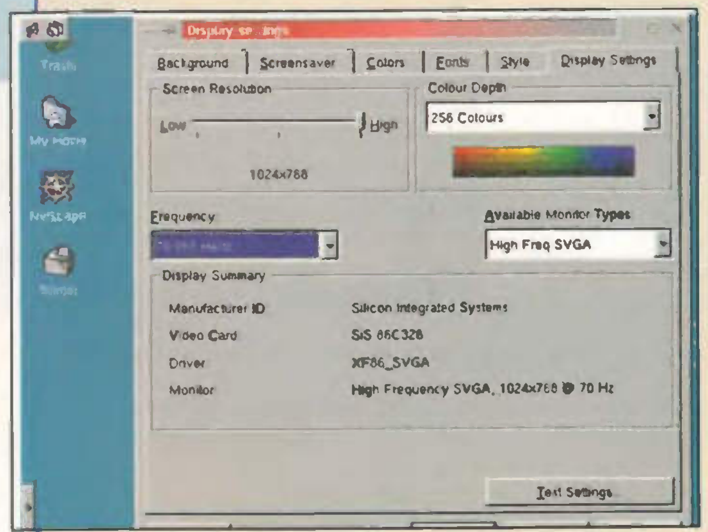
In the short time I spent doing this review, I came across two incompatibilities. In one, a device driver, would not work because it demanded a kernel version earlier than the one I had. The second was with a program that would not work with the distribution I was using with at the time, which happened to be Mandrake Linux 7.0. It would, however, work with the others.

Occasionally, one program will not work without the presence of another one. These situations are called interdependencies and are frequently encountered.

Corel Linux version 1.2

Corel Linux is easier to install and slightly more Windows-like than its rivals, and for these reasons is popular with newcomers to Linux.

Early releases of Corel-Linux came in for some criticism from reviewers because there were a few bugs and some errors of judgement about the interface. I am happy to say that these appear to have been put right in the second edition of Corel-Linux.



The OS installed smoothly and ran well on both test machines.

It must be pointed out that Corel-Linux is a lean distribution compared to SuSE and Mandrake. A typical Corel installation takes up about 600MByte, mainly because there are nowhere near as many applications provided with this distribution which consists of just one CD. Compare this with the six or seven CDs of SUSE and Mandrake. On the other hand, Corel Linux does not cost as much as these two.

This does not mean to say Corel have skimped on the basic implications needed for smooth running of your system There are still plenty of utilities and even a few games.

Although the two other Linux distributions mentioned in this article have GUIs that look uncannily like the Windows desktop layout at first glance, Corel has gone step further to make Linux just a little more Windows-like.

One thing acting in Corel's favour is the porting of its well-known and acclaimed Windows programs like Corel PhotoPaint, WordPerfect and CorelDraw over to Linux. This is a big advantage to those who already use these programs, because they can slip from Windows to Linux almost effortlessly.

Incidentally, Corel's PhotoPaint is of offered free.

Setting up the resolution and refresh rate for large monitors for CAD can sometimes be tricky, but this window from Corel Linux shows how clear and simple it is with Corel Linux.

Usually, a distribution will have sorted these out for you on installation and there is no problem. But sooner or later you will come across this snag. Finding and then installing the required program or file is not easy for the beginner.

Added to this little difficulty is the program that will not work until you delete another program already in the system. I had this trouble with Wine – the Windows emulator. The version from Codeweavers that I wanted to use would not co-exist with the version that came with the distribution and required it to be deleted manually before it would even attempt installation. A Windows application would most likely have up-graded automatically in this situation.

Another trend is that some programs are being described as 'Gnome compliant' for use with the Gnome desktop or 'KDE compliant' for use with KDE, implying a split within Linux into two camps. How far this trend will go is uncertain, and only time will tell.

Too much choice?

One would not normally think of a surfeit of choice as a snag but as an advantage. In fact, the breadth of choice in Linux is often cited as something beneficial by those who promote Linux – shades of 'it's not a bug; it's a feature'!

To give just one example, having two very similar desktop GUIs like KDE and Gnome for Linux, instead of one highly-developed one, seems such a waste of effort to the outside observer. They do, it is true, have a few different features and operate in slightly different ways, but this is re-inventing the wheel with a vengeance. There were good reasons for this split effort, and you can discover them if you dig about on the Web.

The excess of choice puts the beginner in a quandary. Which one should he or she go for? Learning how one desktop operates is fair enough – learning how two or three work seems like excessive effort to a Windows refugee. To include two or more desktops when you install Linux and invite users to alternate between them in order to use different features seems slightly crazy to anyone but a Linux fanatic – but this is exactly what some distributions do.

Other snags

There are only a few other snags in Linux. For example, you may find no undelete feature. If you use the delete command it's gone for good.

If you are in 'root' and this file this happens to a system file, then you really are in a fix. It would probably mean re-installing your OS.

However, this is only true at the time of writing. Things are developing so quickly in Linux that you may find it has been added by the time you read this. Other new features are also appearing rapidly, so if you require a particular feature, then you had better check the distribution you are interested in first.

Although the KDE and Gnome desktops are well designed, they do not yet have the spread of features that Windows has. For example, I missed the Windows Troubleshooters.

In Linux, there there is plenty of advice on trouble-shooting, but I found few graphical tools to help to implement it. Linuxers tend to revert to the command-line.

Books on Linux

As for books on Linux, there are hundreds, but locating them is not at all easy. I checked the computer book section at my local WH Smiths for example and although they had dozens of Windows books, there was not a single one on Linux.

PC World fared a little better with just one small shelf devoted to Linux. My local book store (Ottakars) did surprisingly well with a couple of dozen Linux books.

If you want real choice combined with short reviews from people who have read the books already though, Amazon.com is hard to beat.

If you are already a Windows user, you might look at Penfold's "Linux for Windows Users" but this is only a slim volume. If you like a graphical approach, and want a more substantial book then look at Bellomo's "Linux" from IDG. Although this is Red-Hat based and therefore Gnome-oriented, much of it is applicable to other systems.

Summing up

Linux at present is not quite as intuitive, user-friendly or as GUI-oriented as Windows, but is not far behind and is making rapid progress.

I would hesitate to recommend it to all members of the PC-owning public as a complete replacement for Windows just yet. Those of you who use your PC mainly as a games machine will be wasting your time; but those who use it to surf the Net will benefit from its security; engineers will benefit from its stability, scalability, flexibility – and everyone will benefit from Linux being nearly-free.

If you are fully conversant with the PC and Windows and appreciate what Linux has to offer, and are prepared to re-learn a certain amount, I think the advantages far outweigh the disadvantages.

If you are serious about finding an alternative to Windows, there is no significant reason to procrastinate on adopting Linux. Whether you can swap over partially or in full is to some extent dependent on what you do with your PC.

Windows may not disappear, but it would be most unlikely not to wane in the face of the Linux onslaught. This is not just because Linux is free and Windows expensive, but because you can in fact run Windows applications on Linux, effectively making Windows redundant.

There are various ways you can recycle your present collection of Windows applications in a Linux system using a virtual machine or a Windows emulator like Wine.

The best way to find out is through experimentation. Try using a caddy system for your hard drives and have a separate drive with Linux installed on it. An alternative is dual booting, but this can be confusing. ■

Useful web addresses

http://www.linux.com http://www.linux.org	Two websites giving general and comprehensive information about Linux.
http://www.linuxemporium.co.uk	A good UK source of cheap and sometimes free Linux programs.
http://www.winehq.com http://www.codeweavers.com	Two sources of information about the Wine project
http://www.freshmeat.net	A source of Linux applications with a searchable database.

Code-hopping remote control

Pei An has developed a highly secure wireless remote-control system based on Microchip's Keeloq code-hopping chips. One control receiver can recognise up to four transmitters, each with four push-buttons.

Remote control via RF is widely used in applications such as remote key entry system, alarm systems, gate and garage door openers and burglar detection systems.

Conventional remote control systems offer limited security due to two shortcomings: a) the combination of the code they transmit is fixed and. b) the number of possible code combinations is relatively small. Using code grabbing and scanning techniques, an unauthorised person can easily override the security measures.

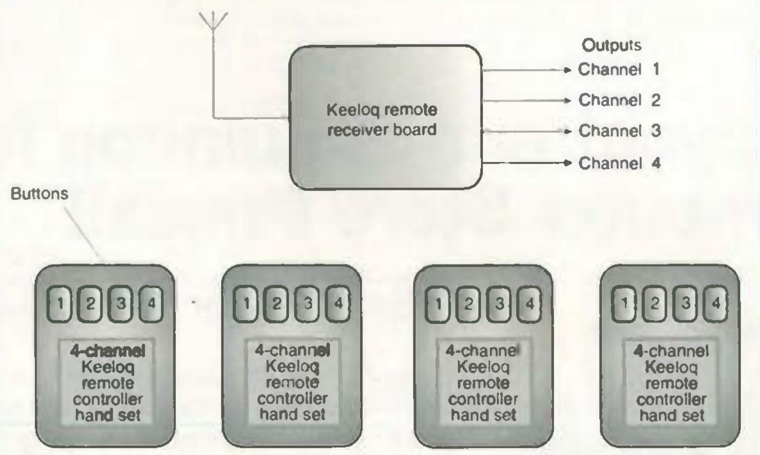


Fig. 1. The Keeloq radio-link remote controller contains up to four remote-control hand sets and one receiver.

Microchip's Keeloq hopping code system has two outstanding features. The first one is that a 66-bit transmission code is used. There are 7.3×10^{19} combinations. This makes code scanning impossible to apply. Scanning at a rate of 8 times per second, it would take 2.3×10^{11} years to break the code.

The second feature is that during its working life, the receiver will probably never respond to the same code twice. If the remote control is used eight times a day, 22 years will pass before the receiver responds to the same code again. This renders a code grabber useless.

The present design uses a hopping-code encoder and decoder pair, namely the HCS301 and HCS512. In a system, up to four transmitters can be acknowledged by one receiver. For transmitting and receiving data, a UHF FM radio link from Radiometrix is used.

The system has a communication distance of 150 metres over open ground and 50 metres in building. Figure 1 illustrates the Keeloq remote control system.

Hopping encoder

The HCS301, Fig. 2, has four inputs, labelled S0 to S3. Output PWM provides pulse width modulation and the –LED line connects to the cathode of a LED. When the HCS301 is activated, the LED illuminates. Pin functions are given in Table 1.

Once there is a change in status in S0 to S3 from logic 0 to 1, the HCS301 produces a 32-bit hopping code – i.e. encrypted data – generated by an encryption algorithm. It combines this with a 28-bit serial number, a 4-button press code and 2 status bits to create a 66-bit data stream. The last 34 bits can be either unencrypted or encrypted depending on user's setup. The serial data stream appears at the PWM pin, Fig. 3.

An 12-by-16-bit EEPROM inside the HCS301 holds an encryption key, device serial number, synchronisation counter and a configuration word. They are used by the encoder to create the 66-bit serial data.

Contents of the EEPROM are programmed by a Keeloq programmer. The contents are read-protected.

Programmer software, which runs on a PC, asks users to input a 64-bit manufacturer's code and a 28-bit serial number. The two codes are then processed by a key-generation algorithm to create the 64-bit encoder key.

Table 1

Pin functions of HCS301 encoder.

Pin	Pin name	Description
1	S0	Switch input 0
2	S1	Switch input 1
3	S2	Switch input 2
4	S3	Switch input 3
5	VSS	Ground
6	PWM	Pulse-width modulation (PWM) output pin or data pin for programming mode
7	–LED	Cathode connection for directly driving –LED during transmission
8	VDD	Positive supply voltage (3.5V to 13V)

The encoder key and the serial number are programmed into the EEPROM, in Fig. 4.

Changes in the transmitted code for each transmission are based on a 16-bit synchronisation counter. The value in the counter is updated each time a button is pressed.

When the logic status of S0 to S3 lines change from 0 to 1, the encoder carries out an operation as shown in Fig. 5. The encoder key and synchronisation counter are processed by a Keeloq encryption algorithm to generate the 32-bit hopping code (encrypted data). Because of the complexity of the code-encryption algorithm, a change in one bit of the synchronisation value will result in a large change in the hopping code.

The data stream can be transmitted out in four speeds. Using a basic pulse width of 400μs, representing the slow speed, a code transmission period is 108ms and the data transmission rate is 833bit/s. If the basic pulse width is 100μs – the fastest speed – a complete code transmission takes 27ms.

Flow of the encoder's operation is shown in Fig. 6.

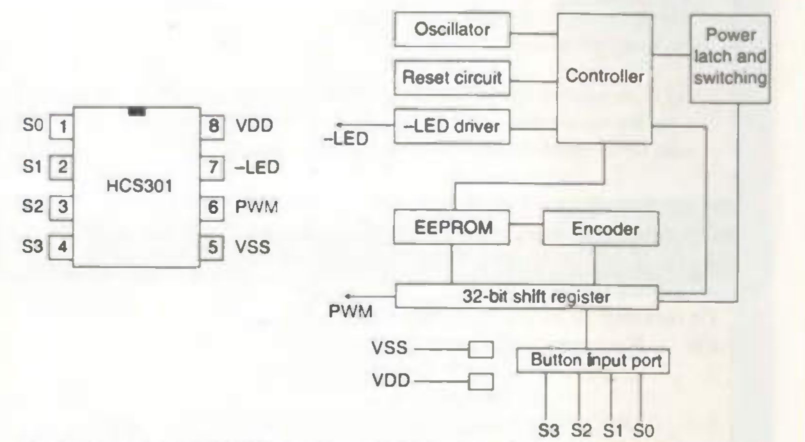


Fig. 2. Pin-out of HCS301 four-channel Keeloq encoder and its internal functional modules.

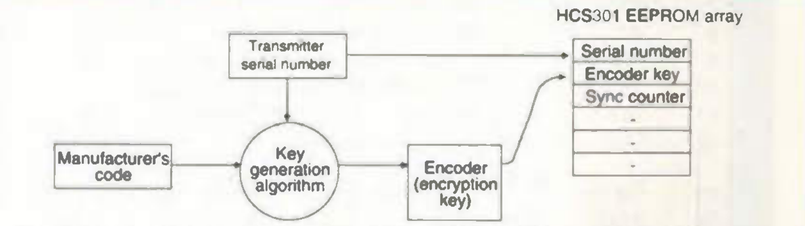


Fig. 4. During encoder programming, a transmitter serial number and a manufacturer's code are processed by a key generation engine to generate an encoder key. This key, together with other data, is stored in the on-board EEPROM of the encoder.

Decoder details

The Microchip HCS512, Fig. 7, is a code-hopping decoder that is compatible with the HCS301 encoder. Table 2 shows its pin functions.

Before a transmitter can be used with a receiver, it must 'learn' the receiver. During learning, the serial

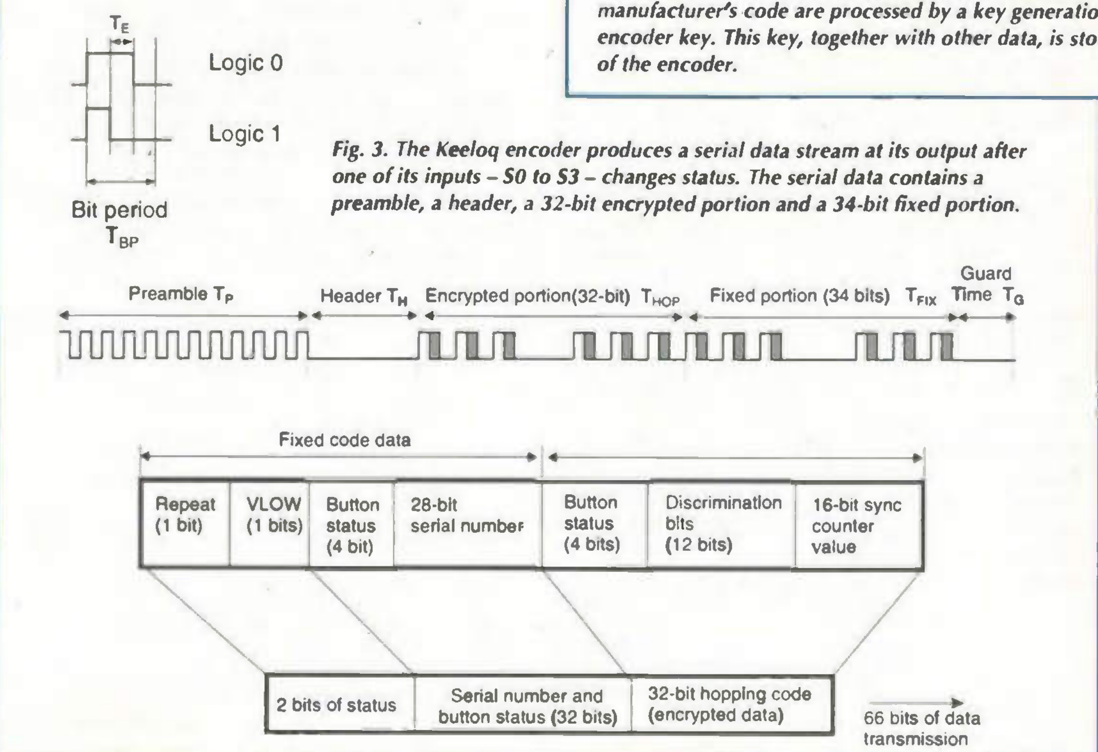


Fig. 3. The Keeloq encoder produces a serial data stream at its output after one of its inputs – S0 to S3 – changes status. The serial data contains a preamble, a header, a 32-bit encrypted portion and a 34-bit fixed portion.

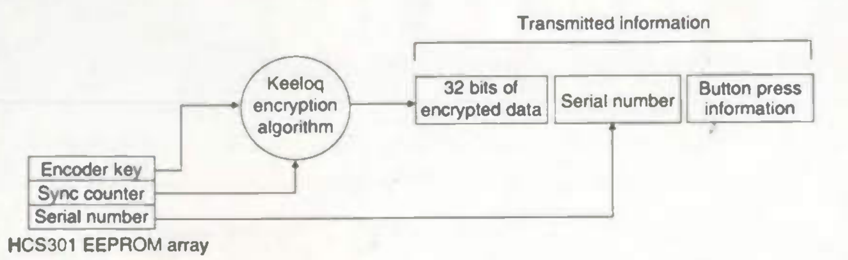


Fig. 5. In normal operation mode, the encoder key and the counter are processed by a Keeloq encryption engine to produce 32-bit encrypted data. These 32 bits, together with serial number and other information, form the 66 bits waiting for transmission.

Table 2

Pin functions of the HCS512 decoder.

Pin	Pin name	Description
1	-LRNIN	Learn input, to initialise learning. 10kΩ pull-up required
2	LRNOUT	Learn output to indicate learning in progress
3	NC	
4	-MCLR	Master clear
5	Ground	Ground
6	S0	Switch input 0. Source 20mA and drain 25mA
7	S1	Switch input 1, Source 20mA and drain 25mA
8	S2	Switch input 2, Source 20mA and drain 25mA
9	S3	Switch input 3, Source 20mA and drain 25mA
10	Vlow	Transmitter battery low indication output
11	SLEEP	Connected to RFIN to allow wake-up from sleep
12	CLK	Clock in programming mode and in synchronous mode
13	DATA	Data in programming mode and in synchronous mode
14	VDD	Positive supply voltage (3.5V to 13V)
15	OSCout	Oscillator out
16	OSCin	Oscillator in (4MHz). R=10kΩ and C=10pF
17	NC	
18	RFIN	Serial data input from receiver

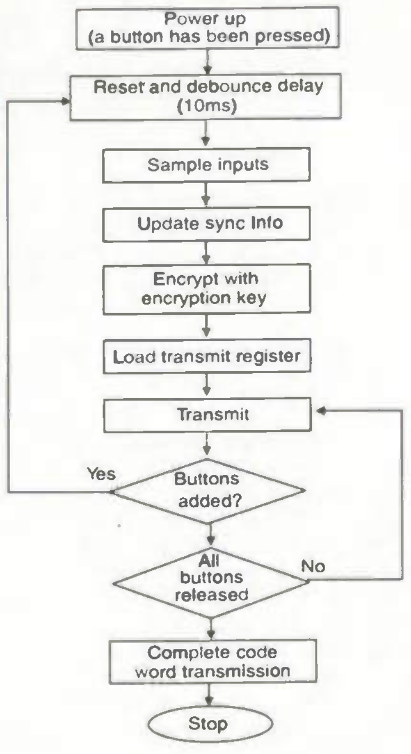


Fig. 6. Flowchart of the operation of the encoder.

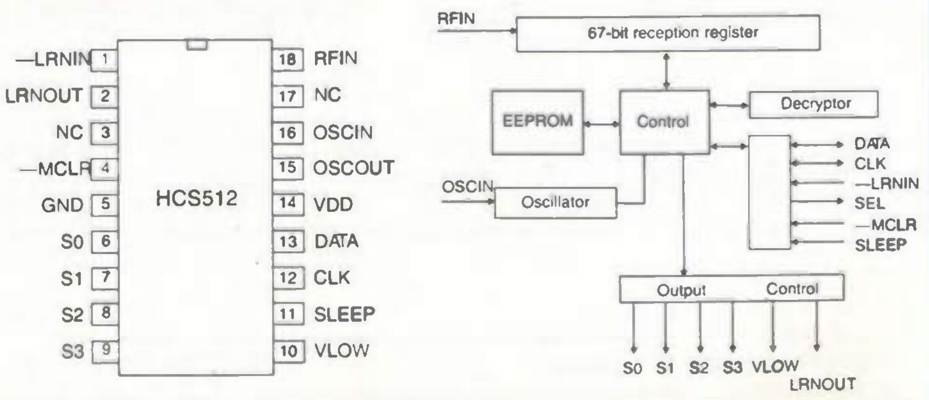
number, synchronisation counter and encoder key of the transmitter are stored in the EEPROM of the decoder. Up to four transmitters can be 'taught' by one receiver decoder.

If a decoder receives a message whose format is valid, the serial number is checked. If it is from a transmitter that has already been 'taught', the message is decrypted and the decrypted synchronisation counter is checked against what is stored for that transmitter. If the counter value is verified, the button status is loaded and status appears at S0 to S3, Fig. 8.

The decoder features a complex synchronisation technique to add security. If the stored counter value for a transmitter and the counter value that was just decrypted are within 16 of each other, the counter is stored and the command is executed.

If the counter value was not within 16, but is within 16 000, the synchronisation value is stored in a temporary location, and the system waits for another

Fig. 7. Pin-out of HCS512 4-channel Keeloq decoder and its internal function blocks.



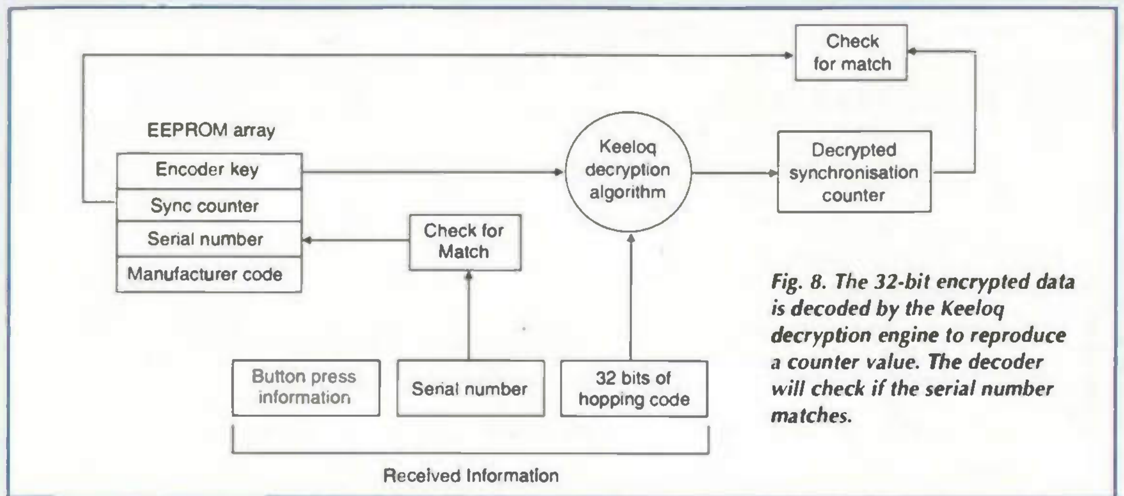


Fig. 8. The 32-bit encrypted data is decoded by the Keeloq decryption engine to reproduce a counter value. The decoder will check if the serial number matches.

transmission. When the next valid transmission is received, it checks the new value with the one in the temporary storage. If the two values are sequential, a new synchronisation starts up.

If the counter value was outside 16 000, the transmitter will not work and must be re-taught.

Flowchart of the decoder's operation is shown in Fig. 9.

Wireless Tx/Rx pair

Radiometrix' TX2 and RX2 UHF transmitter[2] and receiver are used for the wireless link, Fig. 10. The TX2 is a two-stage SAW-controlled FM UHF transmitter and RX2 is a double-conversion FM superhet UHF receiver. Both the TX2 and RX2 have two frequency versions: 418MHz for UK use and 433.92MHz for European use. They are type-approved to ETS300-200 and EMC conformant to ETS300-683.

Because the modules are type-approved, provided that they are used in the manufacturer's specified conditions with an appropriate antenna, the final products do not need further approval by radio authorities.

The transmitter/receiver combination is designed to transmit digital data up to 14kbit/s (A version) over a distance of 300 metres over open ground. The digital signal emanating from transmitter to receiver should have a mark-to-space ratio ranging from 20% to 80% averaged over 30ms (A version).

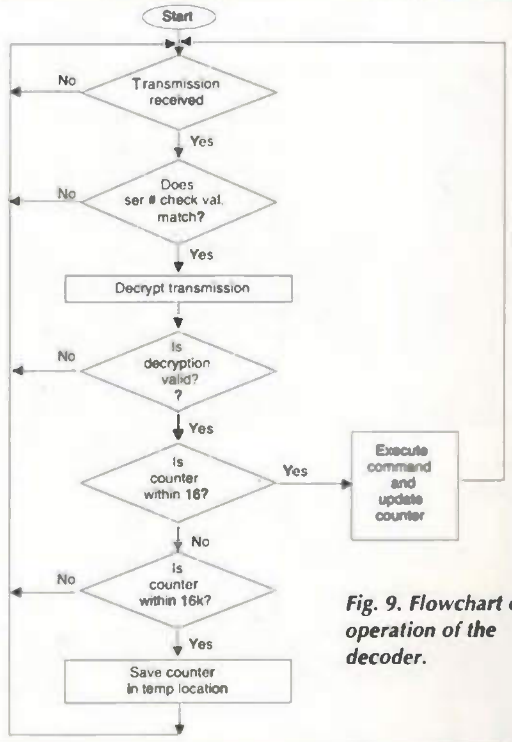


Fig. 9. Flowchart of the operation of the decoder.

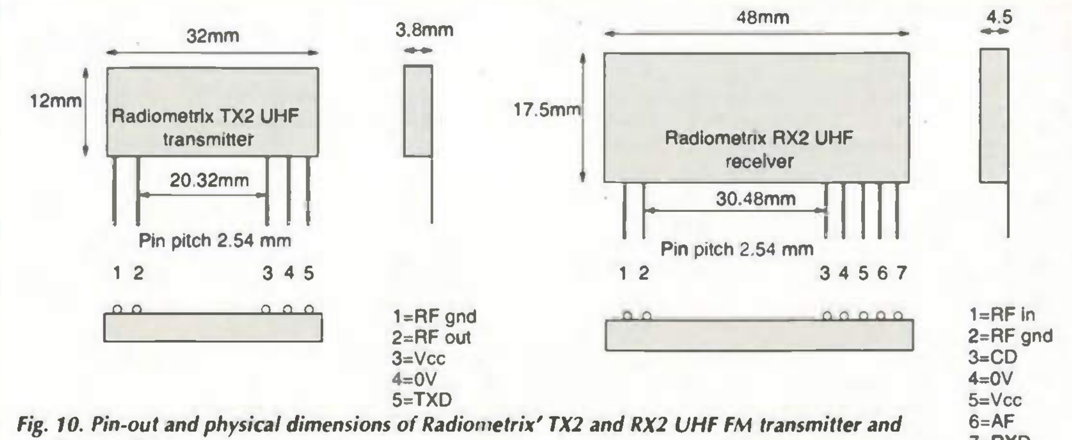
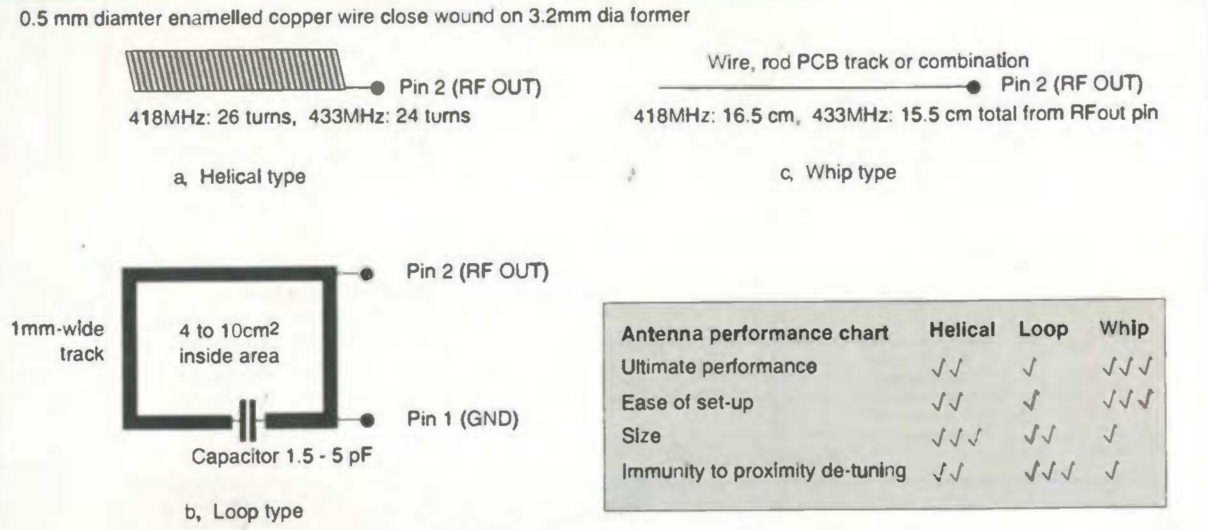


Fig. 10. Pin-out and physical dimensions of Radiometrix' TX2 and RX2 UHF FM transmitter and receiver modules.



Antenna performance chart	Helical	Loop	Whip
Ultimate performance	√√	√	√√√
Ease of set-up	√√	√	√√√
Size	√√√	√√	√
Immunity to proximity de-tuning	√√	√√√	√

Fig. 11. Three variants of antenna for the TX2 and RX2 modules.

The time between a data transition is from 0.07ms to 15ms (A version). If an equal mark and space square wave is transmitted from the transmitter to the receiver, the frequency of the signal should be within 6Hz to 7kHz (A version).

The antenna of the transmitter can have three versions: the helical type, the loop type and the whip type, **Fig. 11**. The helical option is the smallest. It needs to be optimised for the exact wavelength in use.

The loop antenna consists of a loop of PCB track, which is tuned by a variable capacitor. The whip-type antenna is a wire, rod, PCB track or combinations. How the three types of antenna are constructed and a comparison of their performances are given in the diagram.

Circuit of transmitter

Figure 12 is the circuit diagram of the transmitter. Four press-to-make switches are connected to S0 to S1 of the HCS301.

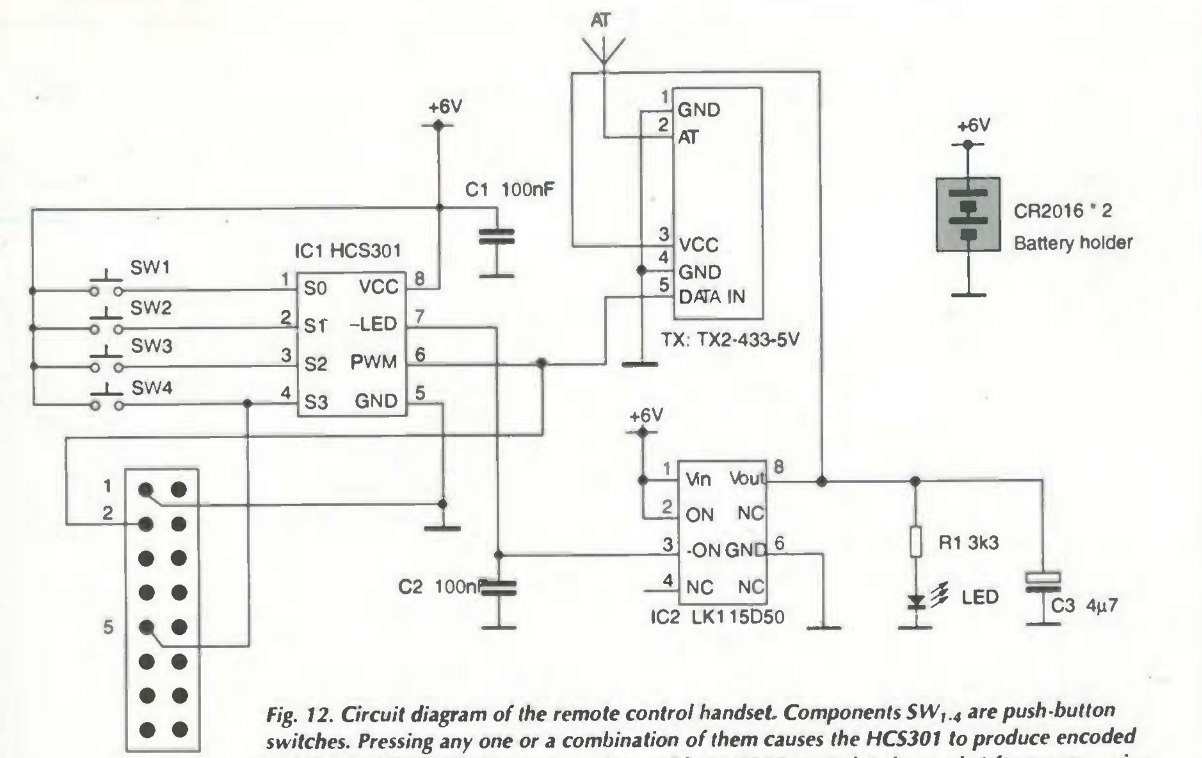


Fig. 12. Circuit diagram of the remote control handset. Components SW_{1-4} are push-button switches. Pressing any one or a combination of them causes the HCS301 to produce encoded serial data. LK115D50 is a +5V regulator with ON/OFF control. J_1 is a socket for programming the encoder in-circuit.

Output –LED connects to the ON/OFF pin of a +5V LK115D50 regulator. During a code transmission, the –LED pin goes low, enabling the regulator to output +5V DC to the TX2 transmitter module.

Two CR2016 3V button cells are used to power up the system. The LK115D50 has a dropout voltage of 0.17V with a sleep mode current of 0.01μA and an operating current of 280μA.

A 16-way DIL pin header is used to connect to a Keeloq programmer via a ribbon cable. The antenna in the design is a whip-type.

The complete circuit can be constructed on a single-sided pcb and housed in a slim box with four buttons, **Fig. 13**.

Receiver circuitry

The circuit of the receiver is shown in **Fig. 14**. Six LEDs indicate the logic statuses of S0 to S3, learning mode and low voltage on the transmitter. Switch SW_1 is used to set the encoder to enter learning mode. The MCP809 supervisory IC generates a reset signal for the HCS512.

A low-power, low-dropout +5V voltage regulator, namely a TC55RP5002, is used to produce the +5V supply. Connector TP_1 is a 16-way DIL header for connecting the receiver to a Keeloq programmer via a ribbon cable.

In the prototype, the antenna for the receiver is a whip-type. The complete circuit can be constructed on a single-sided pcb, Fig. 13.

Programming the encoder/decoder

For my design, I used the programmer supplied with the Keeloq evaluation kit. This kit is designed to give the user the opportunity to evaluate the Keeloq code-hopping technique quickly and easily without having to make a large capital investment.

All the hardware and software necessary to implement a fully functional remote control system is contained in the evaluation kit. This kit also demonstrates all of the operating modes of the HCS301 and HCS501 and other chips.

Windows-based software included can be used to program encoders and decoders. The software requires you to input some information. Encoder key, configuration information and other user selectable information are automatically programmed into the encoder's and decoder's EEPROM.

The programmer can be used for programming the HCS chips in-circuit. During programming, the current encoder boards and decoder boards should be connected to the programmer via a ribbon cable, **Fig. 15**. Note that the power supply to the decoder board should be disconnected before programming. For the transmitter, there is no need to remove batteries before programming.

Using the system

A full system consists of a receiver and four remote-control key fobs. The HCS301 encoder and HCS512 decoder must be programmed first by the Keeloq programmer. Note that during encoder programming, a slow data rate is selected. Before a remote control system can fully operate, all key fobs must be 'taught' by the receiver one by one.

If a remote control is recognised by the receiver, the 'Learn' LED flashes. The output status of S0 to S3 does not change.

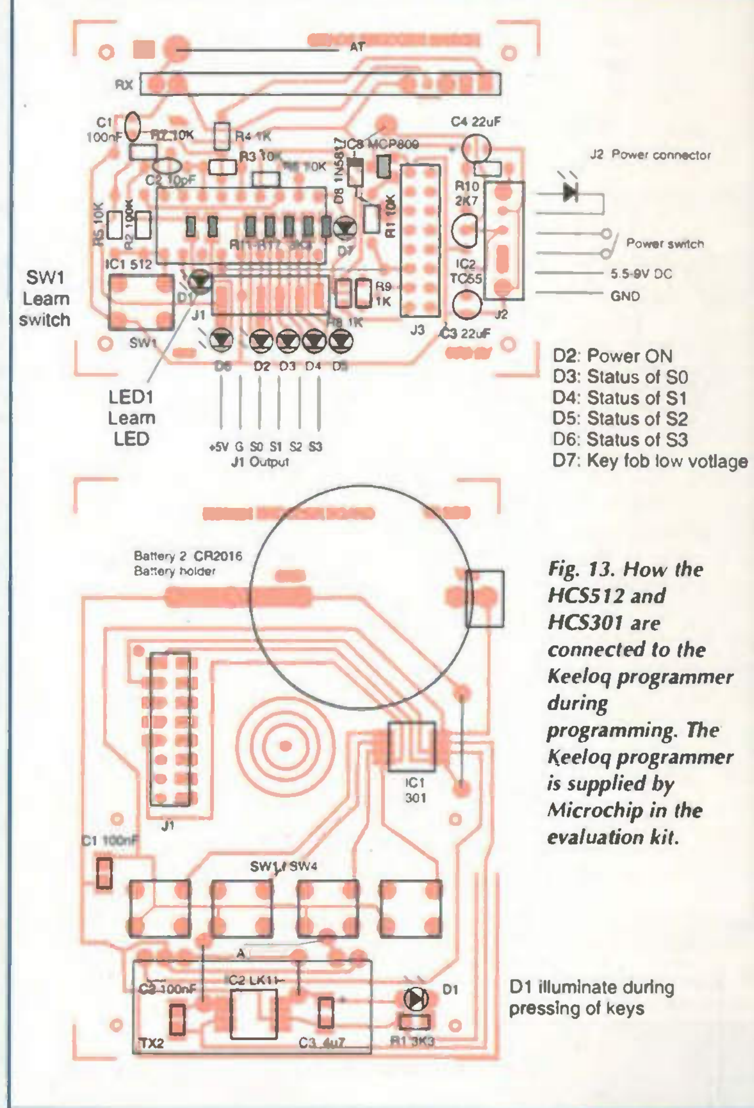


Fig. 13. How the HCS512 and HCS301 are connected to the Keeloq programmer during programming. The Keeloq programmer is supplied by Microchip in the evaluation kit.

Technical support

A designer's kit is available from the author. The kit includes PCBs and components. Please direct your enquiry to Dr Pei An by e-mail: pan@intec-group.co.uk or send a stamped s.a.e. to 'Keeloq', Electronics World, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8BZ.

During learning, the 'Learn' process, the switch on the receiver is pressed first. The 'Learn' LED should illuminate. Next press any button on the remote-control key fob. The 'Learn' LED turns off.

Now press any button on the key fob again. The 'Learn' LED flashes for four seconds or so then turns off. This indicates that this particular key fob is properly 'taught'. If a button is pressed again, the status of S0 to S3 will change.

If the 'Learn' switch is pressed and held for more than eight seconds the receiver clears all the records in its memory. In this case, the 'Learn' LED illuminates and after eight seconds, it turns off. All remote control key fobs must be 'taught' again.

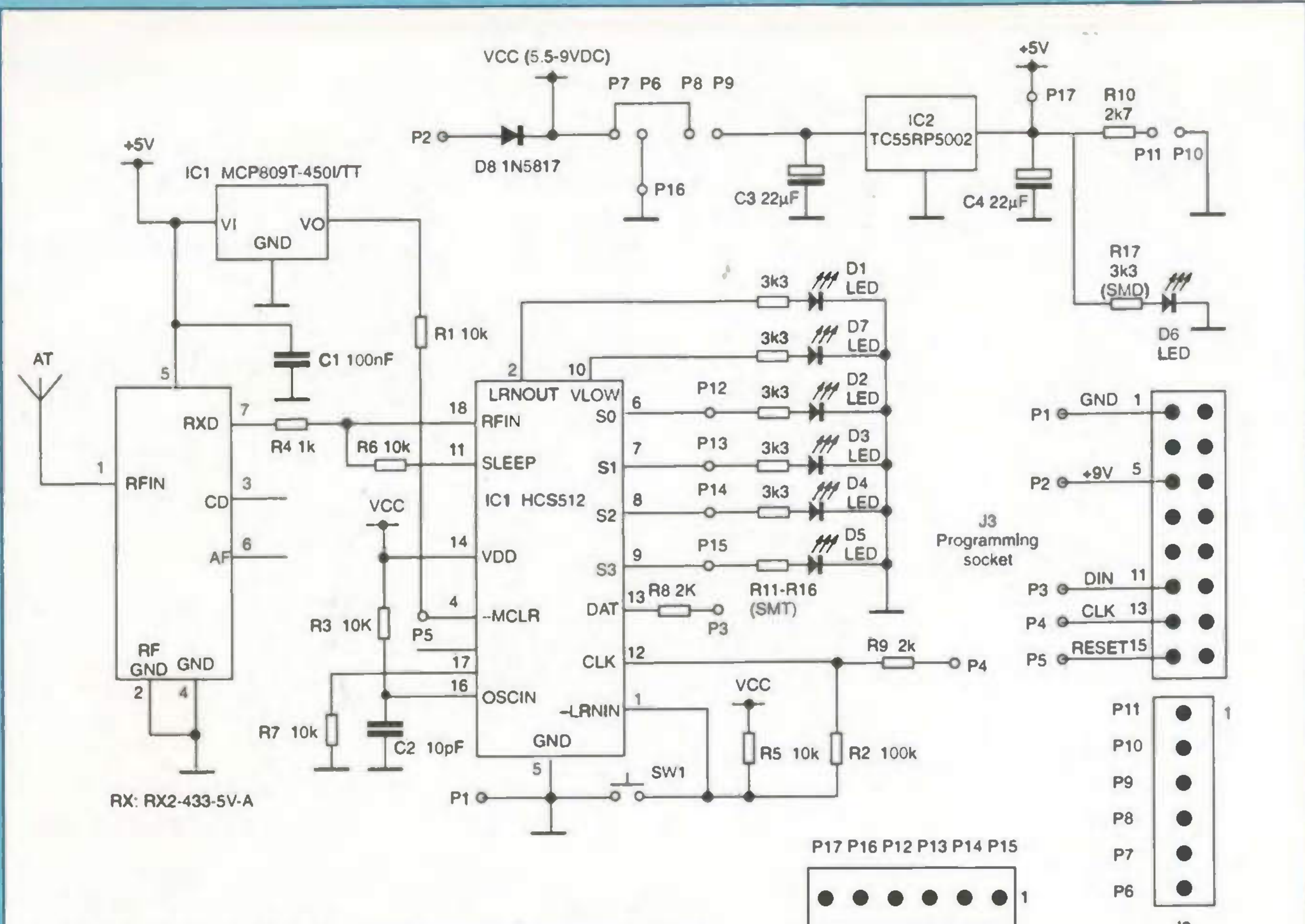


Fig. 14. Circuit diagram of the receiver. Key press status is output from J_1. Socket J_3 is for in-circuit programming of the decoder.

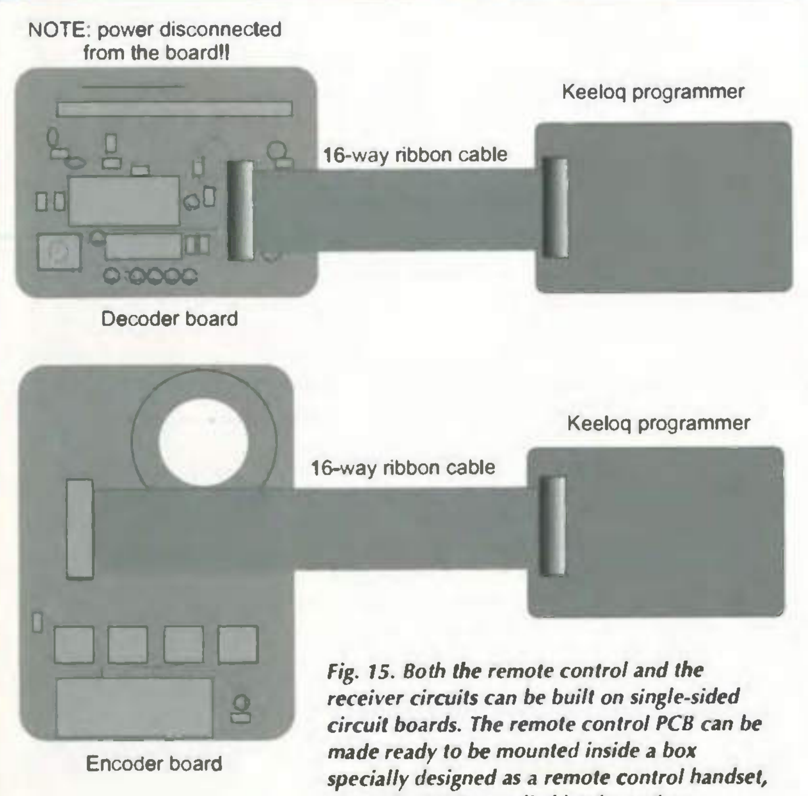


Fig. 15. Both the remote control and the receiver circuits can be built on single-sided circuit boards. The remote control PCB can be made ready to be mounted inside a box specially designed as a remote control handset, as are the PCBs supplied by the author.

Expanding the system

Outputs from the HCS512 can drain 25mA and source 20mA and the voltage level is 0 to 5V. They can drive light loads such as relays or LEDs.

Using relays, power transistors, CMOS, smart PROFET, OptoCMOS or optically isolated solid-state relays, heavier loads or high voltage loads can be controlled. ■

Acknowledgement

I would like to thank Mr Kangeyan from Radiometrix Ltd for his help on this design.

References

1. Secure data products handbook, Microchip, 1998, www.microchip.com
2. Data sheets for TX2 and RX2 which are available from Radiometrix Ltd, 44(0)208 428 1220. Web site: www.radiometrix.co.uk

Letters to the editor

Letters to "Electronics World" Cumulus Business Media, Anne Boleyn House, 9-13 Ewell Road, Cheam Road, Surrey SM3 8BZ
e-mail j.lowe@cumulusmedia.co.uk using subject heading 'Letters'.

Phono preamp for the CD era

I am happy that there has been such interest in my circuit. I am somewhat surprised though given that it is 2001 and digital audio technology has overshadowed analogue audio.

Referring to the August issue, the letters from Mr Hall and Mr Tutt were greatly appreciated. There seems to be an unfortunate decline in civility in public discourse. It should be possible to be critical without being offensive. While it is disappointing to receive criticisms of one's work such as Mr Self offered, it would discourage me only if the criticisms reflected real design problems.

The phono preamplifier had already been in constant use in my system for almost one year when the article was published so I felt pretty confident that it was reliable as well as subjectively pleasing.

Mr Walt Jung gives a good example of how to craft a critical response without engendering offence. He also is absolutely correct. I erred when I stated that the design is entirely JFET.

I am astounded that I made this error since I taught this very topic before the article was written and had specifically presented the course textbook material from page 690 and figure 13.30 of 'Microelectronic Circuits' by Muhammed H. Rashid. There, it clearly indicates that one-half of the diff-amp gain comes from the left-hand side of the differential amplifier through the current mirror. A similar explanation can be found in many treatises on op amp design, some of which I had also read prior to the design of this preamp.

However, my error in explaining how the circuit operates in no way affects actual circuit operation. I, like Walt, have no problem with signals passing through BJTs in properly designed circuits. There is, however, almost a cult following for all-JFET or all-MOSFET circuitry and it had been my intent to have no signal pass through a BJT. This can be accomplished, by the way, in several different ways while retaining the folded-cascode single-stage op-amp topology. I have played around successfully with such modifications on breadboard. I did not pursue them because they did not significantly improve the objective performance of the circuit.

In the same issue, I do not know how Mr Schick could conclude from my reply to Mr Self that I did not understand AN-346. My reply was based not only on my understanding of AN-346, but also of AN-104, aptly entitled "Noise Specs Confusing," which specifically addresses noise in a phono preamp. It uses the model for the Shure V15, Type III cartridge that is similar, although not identical, to my V15xMR.

Furthermore, William Chater in his article "A Mostly MOS Preamp," (*The Audio Amateur*, 1/90) lists the important noise sources that would have either the Type III or xMR cartridge resistance, itself, as the greatest single contributor to broadband noise. It was that article that prompted my statement that the cartridge was the biggest contributor to noise, a statement that apparently prompted this whole, largely unimportant flurry of comments and counter-comments.

However, it should be allowed by anyone discussing this subject that the input transistors, the cartridge resistance, or the 47kΩ resistor can be the biggest contributor. This depends upon whether or not one wants to factor in weighting curves based on hearing characteristics, cartridges with greater or lesser inductance and or resistance, particular BJT or FET input devices, etc. It also depends on whether one is talking about spot noise or broadband noise, and if broadband noise the specific band.

In any event, the title of my master's thesis was "A Method for the Determination of the High-Frequency Noise Spectrum of a Radio-Frequency Plasma." I probably do not need a tutorial on the subject of noise from either Mr Self or Mr Schick.

Perhaps my statement about PSpice inspired Mr Schick's comments. I was trying to be modest. I own five books on PSpice and have used it extensively for the last five years. There is nothing magical about PSpice; it does the same sort of circuit and network analysis that the human would do if the human could readily solve the often-unwieldy equations. While PSpice does occasionally fail to converge on a solution, I have found this to be unusual.

Also, I have never seen PSpice do anything "strange or unusual." In the case of the noise analysis that I did using PSpice, it showed the same increasing contribution of the 47kΩ resistor with frequency due to increasing reactance of the cartridge inductance that the analysis in AN-104 showed and to which Mr. Self alluded.

While the program failed to predict the low-amplitude, high-frequency oscillation in the real second stage, a second look at PSpice simulation results showed a "peaking" in the response at that frequency. The very same value of capacitance that tamed the actual oscillation is the one that PSpice simulation showed to be required to eliminate the peaking.

Although I designed three successful power amplifiers bereft of access to PSpice, I would no longer go directly

EAS – customer friendly?

Electronic Articles Surveillance (EAS) systems are being used in an increasing number of shops, department stores and libraries.

However, there has been very little discussion about the question of whether exposure to electromagnetic fields from this equipment might pose a health risk – particularly for vulnerable groups such as children and expectant mothers.

According to shops that use EAS, the manufacturers carry out measurements of the electromagnetic fields generated by their equipment – under laboratory conditions in which background sources of electromagnetic fields are eliminated – but the data is not shared with the companies that buy and install the equipment. Under these circumstances, one wonders whether the right balance is always reached between the security benefits of EAS technology and the need to limit people's exposure to electromagnetic fields in public areas.

Are some EAS systems more customer-friendly than others? What different technologies are involved and what is the strength of the electromagnetic fields emitted by these devices once they are actually installed?

Can any readers shed light on the subject or perhaps suggest which organisations or university research departments might have the answers?

Name and address supplied

Global warming?

Regarding the solar cell story on page 496 of the July 2001 issue, on Earth, the solar power incidence per square metre is seldom much more than 1kW. Per square centimetre, this amounts to 100mW.

I'm amazed that one square centimetre of this new solar cell will deliver 10 watts at a temperature of 1000°C from this. Presumably, this cell needs to be placed closer to the sun, or under a focussing device, to achieve such figures.

Michael Edinger
Via e-mail

from paper design to breadboard. With PSpice as a design evaluation tool, I destroyed not a single component in bringing the phono preamp design to operation, quite different from the parts mortality experience in the evolution of my amp designs. I am very impressed with this simulation program. If a powerful tool is available, it is foolish not to utilise it.

Let me stress again that electrical engineering design work is a compromise at every step. In this design, I emphasised low noise within the constraint of the single-stage op amp topology. This emphasis unavoidably affected other aspects of the design negatively, but still represented a reasonable approach. Such emphasis on noise was engendered by the (undue) emphasis placed upon it by those who preceded me.

My final comment re-addresses the remark made by Mr Self in the May issue, concerning headroom. If by headroom Mr Self means the input level at which the output begins to clip (overload), then his apparent assertion that single-stage designs have an inherent headroom advantage is incorrect.

If the second stage in a two-stage design has enough gain at 20kHz to compensate for the attenuation of the inter-stage low-pass filter, then the headroom for either approach is the same over the entire audio band. This assumes that both designs have the same stage topology, 1kHz gain, power supply voltage, and RIAA tracking characteristic.

This is not mere conjecture. I have a revised design that increases the impedance of the first-stage feedback network. This, in turn, allows a re-partitioning of the gain between the two stages. Clipping in the revised version occurs just below 10V RMS from 20Hz to 20kHz, about as well as one can do in a single-ended design with a bipolar 15V power supply. It is ultimately the power supply voltage that determines headroom in any design.

The two-stage design, by the way, is much more likely to accurately track the RIAA curve than is the single-stage design. That is one reason why many designers, including myself, favour the two-stage approach.

Readers who have questions about this or other of my designs should feel free to contact me at nthagard@eng.fsu.edu.

Norman Thagard, M.D.
Bernard F. Sliger Eminent Scholar Chair
Florida State University

Water-powered watches

About ten years ago, I remember there being a short craze on water powered watches. I'm not sure what principle these worked on. I guess that certain electrodes pick up free electrons but I would like to know for certain.

Any information you could give me about this technology would be much appreciated. Perhaps someone remembers what company made the watches, and how to get in touch with them.

Greville J Kirk
Via e-mail

Input filter distortion

It was with interest that I read Dave Kimber's intuitive suggestions for low-pass filter appreciation in letters on page 637 of the August 2001 issue.

However, I too despair, for now I do not know how I am supposed to have implied that a filter-less audio source exists. In referring to power amplifiers I merely stated – 'No filter, no distortion.'

Fortunately *EW* has come to everyone's aid by publishing an amplifier design incorporating input components that cannot cause audible degradation either by slew rate limiting, or by distorting the leading edges of waveforms. See page 578 of the same issue.

With good source equipment, a good signal, good loudspeakers and good ears, a stereo version of David White's mosfet amplifier could be left-right auditioned while one channel is fitted with 10kΩ for R_1, and 220pF for C_2 – the values originally proposed.

Apply a re-balanced mono feed and use just one loudspeaker to check for channel differences in definition, sibilants and transients; i.e. reproduced realism.

Both power amplifiers will of course retain their excellent 0.01% continuous sine wave distortion specifications, as measured by equipment that does not give a reading until long after the asymmetrical leading edge error has occurred. (See the red curve computer simulation with my last letter on page 553.)

But the output of the 10kΩ+220pF filtered channel will be additionally distorted by avoidable and on-going signal induced multiplicities of those same transitory errors.

I wonder therefore if any reader might volunteer to relieve everyone's despair by reporting some good old fashioned armchair auditioning. No one will then need to make assumptions, nor 'guess' whether signal distortion is introduced by a filter that acts at inaudible frequencies – 85kHz in this amplifier.

Graham Maynard
Newtonabbey
Northern Ireland

Earth leakage issues

In response to Chris Miller's letter in the July 2001 edition, entitled "Tracking down earth leakage," many items of electrical/electronic equipment do incorporate suppression systems that leak to earth – typically through suppression capacitors connected between L & E and N & E.

The earth leakage is limited by equipment safety standards, typically to 3mA. Obviously, a number of such devices used on a group of circuits protected by a 30mA RCD will cause the RCD to trip.

Certain standards do allow higher values of leakage currents, BSEN60950 for example. However, special considerations for the protective earthing of the circuit feeding to this equipment may be required, in accordance with BS7671 (IEE Wiring Regulations, 16th Edition).

BS7671 requires the installation designer to consider the use of a circuit, and make allowance for normal conditions. For standard UK socket outlet circuits, those intended to supply equipment outdoors require RCD protection.

I understand that some designers consider that, for example, an extension lead could be used to supply equipment outdoors from any downstairs socket, therefore all downstairs sockets in a house should be protected by RCD: clearly, where final circuits are grouped from the same RCD, as in many split consumer units, nuisance tripping will occur from time-to-time. This is obviously a case where the intended use of the circuits has not been fully considered.

RCD protection is not always required by BS7671 for final socket-outlet circuits within a domestic dwelling.

In many cases, it may be better to provide specific RCD-protected sockets for outdoor use rather than compromise the usefulness of the installation as a whole.

Alternatively, but more costly, is to add more 30mA RCDs. It is not generally recommended that settings above 30mA are used, where RCD protection is provided for domestic final circuits. Obviously, this does not to detract from the fact that RCDs must be used where manufacturers stipulate their use.

Graham Kenyon
Via e-mail

Buck-boost regulator

Regarding my circuit idea, 'Buck-boost regulator', on page 628 of the August 2001 issue, the two tantalum capacitors are printed as "47" which could be misinterpreted. My submission did quote 4µ7 (4.7µF). Also the 35V rating did not appear, which has equal significance.

Henry Maidment
Salisbury
Wiltshire

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Henry Maidment
Salisbury
Wiltshire

Designing with DSP

Design your own DSP audio filter

In this fourth and final article on implementing and programming real-time digital-signal-processing systems Patrick Gaydecki describes how to produce a real-time audio filter based on the simple hardware discussed in the June issue.

For those of you who haven't seen my previous articles, I have been using the DSP56002 to help explain how to design using DSP chips in general.

In this final article dealing with designing and programming DSP systems, I will be discussing how to configure the DSP56002. In particular, I will show how to initialise the phase-locked loop, the bus-control register – which controls memory access timing – the synchronous serial interface (SSI) for a-to-d and d-to-a converter communications and the serial communications interface (SCI) for communicating with a PC.

I will also look at how the simple system designed in the second article can be programmed to respond to interrupts, and how you can write software for real-time filtering of audio signals.

As discussed earlier, the DSP56002 has a register-based architecture, in common with most other processors of this type. Thus, to enable certain functions or configure the various sub-systems to operate in a particular way, appropriate words (bit patterns) must be loaded into the associated control registers.

All of the control registers are mapped into 'x-data' memory space, residing between locations X:$FFDE and X:$FFFF.

Design your own digital filter with no knowledge of maths?

Dr Gaydecki has developed a Windows-based application that allows you to design an audio-band filter on your PC and download it to the evaluation DSP system described in the second article in the series. If we get enough interest, we will look into the viability of producing PCBs and making the software available. E-mail j.lowe@cumulusmedia.co.uk with the subject heading 'Interested in DSP'.

Configuring the phase-locked loop

In the design covered in the second article, a control pin termed PINIT was tied low. This means that after reset, the PLL is disabled and the DSP56002 operates at the externally applied clock frequency. Hence if the clock frequency is 10MHz, the device operates at 5 MIPS, since each instruction requires two clock cycles.

In order to take advantage of a higher MIPS rate, it is necessary to multiply the applied clock frequency; this is done by activating the internal PLL.

The PLL control register (PCTL) is a 24-bit register located at address X:$FFFD. The bits are arranged as in **Table 1**.

Bits MF0-MF11 are loaded with a bit pattern that determines the multiplication factor (MF) applied to the clock frequency. A value of 0 specifies an MF of 1, a value of 1 gives an MF of 2, a value of 2 gives an MF of 3 and so on up to FFF_{16}, which gives an MF of 4096. In Motorola parlance, the hexadecimal number FFF_{16} would be written as $FFF.

Similarly, bits DF0-DF3 determine the division factor (DF). A value of 0 specifies a DF of 2^0, a value of 1 gives a DF of 2^1 and so on up to F_{16}, which yields a DF of 2^{15}.

The XTLD bit controls the on-chip oscillator output, XTAL. If the internal oscillator is not used, as in the design in question, the bit should be set, disabling the XTAL output. This minimises RF noise.

The PSTP bit determines whether or not the PLL and the on-chip oscillator operate when the DSP56002 is in a STOP processing state – i.e. suspended. This is normally cleared.

The PEN bit enables or disables the PLL. During reset, the logic level present on the PINIT pin is loaded into the PEN bit. After reset, the PINIT pin is ignored. Hence in this system, which is typical, the PLL is initially deactivated, and must be activated by setting PEN to 1.

Bits COD0-COD1 enable or disable the CKOUT pin, which is synchronised to the internal clock when the PLL is enabled. It is recommended that if this pin is not used, as in this case, it should be disabled by setting both bits to 1.

The value held in the CSRC bit determines whether the clock signal for the core is taken from the output of the voltage-controlled oscillator, in which case it is logic 1, or the divider within the PLL, which is represented by logic 0. Here it is set to 0.

The value held in the CKOS bit determines the source of the clock signal for the CKOUT pin. When CKOS is logic 1, the clock source is the output of the voltage-controlled oscillator. If CKOS is logic 0, the clock source is the divider within the PLL. In this case, it it again set to 0.

As an example, if the externally applied clock frequency is 10MHz and you want an internal clock of 60MHz, i.e. an MF of 6 and a DF of 1, the bit pattern in **Table 2** needs to be set.

In hexadecimal, the value in the table is 1D0005. The instruction:

```
MOVEP #$1D005,X:$FFFD
```

achieves the desired result of multiplying the internal clock frequency six times, yielding a processing speed of 30MIPS. For more details on the PLL, see reference 1.

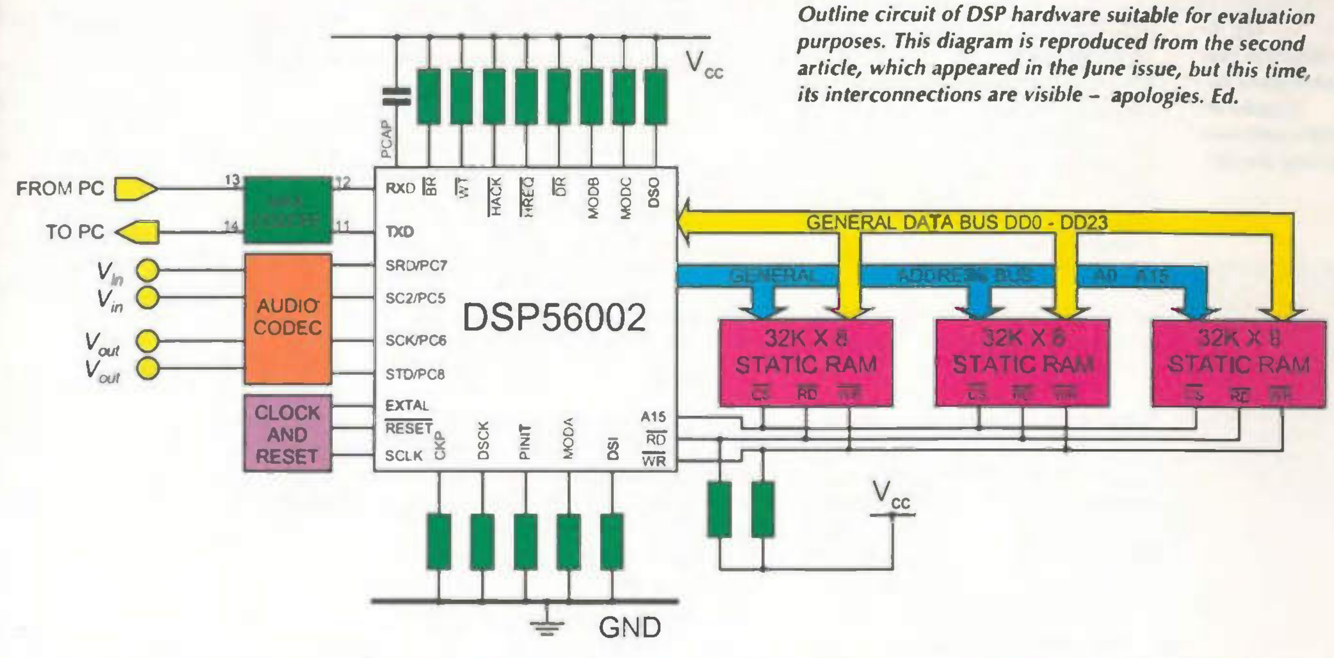
Access speed of the external memory bus

The DSP56002 can be configured to operate with memory chips of various speeds by inserting wait states during the access cycle of the external memory bus. If the $\overline{WT}$ pin is deasserted – i.e. tied to logic high, as in this case – then the number of wait states inserted is equal to the value held in the bus control register (BCR), located at X:$FFFE.

Since the system in question has been designed with high-speed RAM with an access time of 10ns in accordance with the full-speed access cycle, no wait states are necessary. Thus the command:

```
MOVEP #0,X:$FFFE
```

ensures the external memory bus is



Outline circuit of DSP hardware suitable for evaluation purposes. This diagram is reproduced from the second article, which appeared in the June issue, but this time, its interconnections are visible – apologies. Ed.

Table 1. Bit functions of the DSP chip's PLL control register.

Bits	Mnemonic	Description
0-11	MF0-MF11	Multiplication factor bits
12-15	DF0-DF3	Division factor bits
16	XTLD	XTLD disable bit
17	PSTP	Processing state bit
18	PEN	PLL enable bit
19-20	COD0-COD1	Clock output disable bits
21	CSRC	Chip clock source bit
22	CKOS	CKOU clock source bit
23		Reserved; write as zero.

Table 2. Bit pattern in the PCTL register to obtain a 60MHz internal clock from a 10MHz external clock.

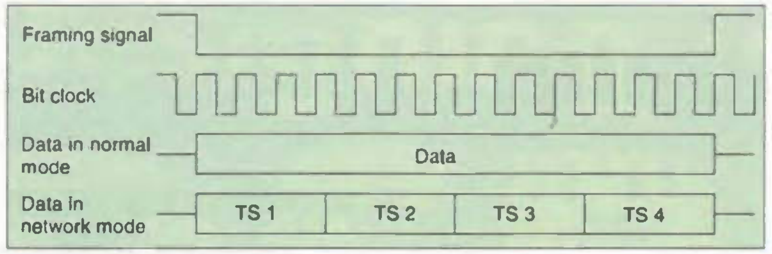
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Previous articles in this set...

April 2001 issue – overview of DSP technology.
June 2001 issue – interfacing a DSP with peripheral chips, features details of a simple, working DSP hardware system.
July 2001 issue – programming and software issues.

Dr Patrick Gaydecki is a Senior Lecturer with the Department of Instrumentation and Analytical Science at UMIST in Manchester.

Fig. 1. Synchronisation and data signals for transfer of information between a codec and the SSI.



operating at full speed. For more details on bus wait states, see reference 2.

Synchronous serial interface

As discussed in the second article, the a-to-d and d-to-a converters normally connect to the SSI of the DSP56002.

Two modes of communication are possible, namely 'normal' and 'network'. In normal mode, one datum word is sent by the a-to-d converter to the DSP per frame, or to the d-to-a converter from the DSP. This is the case for a single-channel system.

For a stereo or surround-sound system, multiple words are sent within a frame. Each word within a frame occupies what is termed a time slot. **Figure 1** shows the signals required for normal and network mode operation.

Assume for the time being that the a-to-d converter generates the framing and bit clock signals. These are fed both to the DSP56002 and the d-to-a converter. Again, this is typically the case. The DSP56002 is therefore said to be operating as a slave device.

It is important to bear in mind that, apart from the mode, data may be clocked into and out of the SSI using polled or interrupt-driven communication. For simplicity, I will consider a single-channel normal-mode system.

The SSI starts to read in the datum bits when it detects the leading edge of the framing signal. Each bit is read in synchrony with the bit clock.

Once a complete word has been read, bit 7 in the SSI status register (SSISR) is automatically set to 1. This is located at X:$FFEE. This bit can either be continually tested – i.e. polled – or it can be used to trigger an interrupt. Either way, once it is set the DSP core can read the datum word into a core register or memory and start processing it.

To use the SSI for a-to-d and d-to-a communication, it must first be enabled as a synchronous interface, since it has a dual function. It may also operate as a general-purpose I/O port. Thus, the appropriate bits must be set in the port C control register (PCC), located at X:$FFE1. In this case, the upper five bits must be set.

Next, it must be configured for a particular mode by loading the appropriate words into the SSI control registers A and B (CRA and CRB), located at X:$FFEC and X:$FFED respectively. The DSP56002 can be configured to accept data-converter word lengths of 8, 12, 16 or 24 bits. For normal-mode polled communication with 16-bit resolution in which the DSP56002 operates as a slave, bits are set as in **Table 3**. Hence,

$$CRA=0100000000000000_2=4000_{16}$$

and,

$$CRB=0011001000000000_2=3200_{16}$$

Listing 1 contains a code fragment that reads data in from the a-to-d converter and sends it straight out again to the d-to-a converter. Note how compact it is.

Using the SCI receive interrupt

The listing shows how the system can take data from the a-to-d converter and then send it to the d-to-a converter. But since no interrupts are enabled, it is locked in an endless loop until the processor is reset or the

Fig. 2. Software design interface for the Kemo KDF real-time digital filter system.

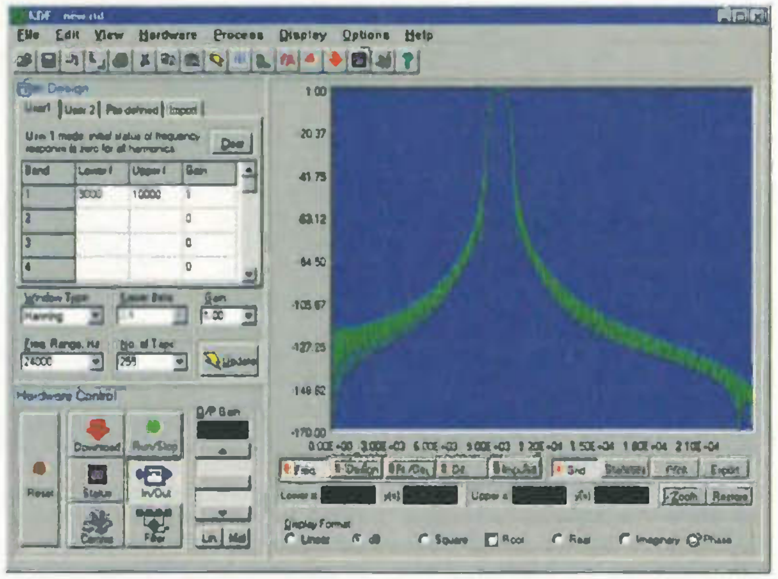


Table 3. With bits set as follows, the DSP56002 operates as a slave with normal-mode polled communication and 16-bit resolution.

CRA bits 0-7 (Pre-scale modulus): set to 0 (only used if DSP is master).
CRA bits 8-12 (DC): set to 0, since this is equal to the number of words per frame minus 1.
CRA bits 13-14 (WL0-WL1): set to 1 and 0, giving a word length of 16-bits.
CRA bit 15 (PSR): set to 0, as this is not needed in slave mode.

CRB bits 0-3: set to 0, as they are not used.
CRB bits 4-5: set to 0, as external frame and bit clocks are supplied by the ADC.
CRB bit 6: set to 0, as the MSB in/out is first and the LSB is last.
CRB bits 7-8: set to 0, as the WL bit clock is used for both TX/RX.
CRB bit 9: set to 1 for synchronous clock control.
CRB bit 10: set to 0 for continuous clock.
CRB bit 11: set to 0 for normal mode.
CRB bits 12-13: both set to 1 to enable RX and TX.
CRB bits 14-15: Not set here since interrupts are not required, i.e. polled-mode is used.

power removed.

By enabling the SCI receive interrupt, it is possible to communicate with the device through the serial port while it is running the program. You might want to do this if, for example, the program was performing some additional processing and you wanted to change the gain of the output data on the fly by sending commands through the SCI. Principles of SCI interrupts were outlined at the end of my third article.

In order to enable the SCI interrupt, you need to do three things. First, set up the SCI control register (SCR) to generate an interrupt if a character is received. Also make sure it is set up for a standard protocol (e.g. 8 data bits, 1 start and stop bits). The SCR is located at X:$FFF0.

Next, set the interrupt priority level in the interrupt priority register (IPR) located at X:$FFFF. And finally, unmask the interrupt using the mode register (MR).

Without getting bogged down in too much detail, the first three instructions in the code fragment in **Listing 2** accomplish these three tasks respectively. After this, you have the code to read and write a-to-d and d-to-a converter data as above.

If an SCI interrupt occurs, the program counter needs to know where to look for the interrupt service routine, so remember that you also need a

```
JSR mysub
```

instruction located at P:$14. Look back at the third article for more details on this. After the main code, we have a label that indicates the start of the interrupt service routine. This must end with an RTI instruction. Code for this is in listing 2.

Putting it all together – simple filtering

One of the most common applications of DSP devices is signal filtering. They are ideal for this, since digital filters really just involve a large number of multiplications, additions and shifts – operations they are very good at doing quickly.

Although the mathematics behind digital filters is beyond the scope of these articles, I can at least discuss the method by which these algorithms are implemented.

Real-time digital filters generally come in two flavours: finite-impulse response (FIR) and infinite-impulse response (IIR). Let's consider the first type. With FIR filters, the incoming signal points are multiplied by a set of numbers – called taps or coefficients – and added together to produce one new, filtered, value. This process is repeated each time a new signal point is acquired.

The number of coefficients in the filter kernel varies widely – anywhere between 3 and 1023 is common, depending on the filter required. For example, a simple five-point running mean filter would comprise five taps, each of value 0.2. This process is formally termed 'convolution'. Many textbooks have been dedicated to this subject – in particular, how to choose the values of the taps to generate a particular frequency response.

Listing 1. Simple a-to-d converter read and d-to-a converter write routine.

```
ORG P:$0
        MOVEP #$1F0,X:$FFE1        ; SSI mode
        MOVEP #$4000,X:$FFEC       ; Configure CRA and CRB for 16-bit
        MOVEP #$3200,X:$FFED       ; data, normal mode
LOOP1   JCLR #7,X:$FFEE,LOOP1      ; Wait for 16-bit word from ADC
        CLR A
        MOVE X:$FFEF,A1             ; Read data into A
        MOVE A1,X:$FFEF             ; Send to DAC
        JMP LOOP1
        END
```

Listing 2. Code fragment showing enabled SCI receive interrupt.

```
        MOVEP #$0B02,X:$FFF0       ; Set up SCI and enable receive interrupt
        MOVEP#$C000,X:$FFFF        ; Set interrupt priority level in IPR
        ANDI #$FC,MR               ; Unmask interrupts in the Mode Register (MR)
MOVEP #$1F0,X:$FFE1                ; SSI mode
        MOVEP #$4000,X:$FFEC       ; Configure CRA and CRB for 16-bit
        MOVEP #$3200,X:$FFED       ; data, normal mode
LOOP1   JCLR #7,X:$FFEE,LOOP1      ; Wait for 16-bit word from ADC
        CLR A
        MOVE X:$FFEF,A1            ; Read data into A
        MOVE A1,X:$FFEF            ; Send to DAC
        JMP LOOP1
MYSUB   MOVEP X:$FFF4,A2           ; Start of interrupt service routine. This reads
.                                  ; one character from the SCI
.
RTI                                ; Return from subroutine
        END
```

Listing 3. Complete algorithm for nine-point running mean filter in real time, incorporating full speed memory access and SCI interrupts. Code length does not change with increased filter length.

```
        MOVEP #$1D005,X:$FFFD      ; Set up PLL
        MOVEP #0,X:$FFFE           ; Set up address bus: no wait states
        MOVEP #$0B02,X:$FFF0       ; Set up SCI and enable receive interrupt
        MOVEP#$C000,X:$FFFF        ; Set interrupt priority level in IPR
        ANDI #$FC,MR               ; Unmask interrupts in the Mode Register (MR)
        MOVEP #$1F0,X:$FFE1        ; SSI mode
        MOVEP #$4000,X:$FFEC       ; Configure CRA and CRB for 16-bit
        MOVEP #$3200,X:$FFED       ; data, normal mode
        MOVE #0.1111,A0            ; Next 4 instructions load taps into memory
        MOVE #0,R0
        DO #9,FILL
        MOVE A0,Y:(R0)+
FILL
        MOVE #0,R0                 ; Next 4 instructions set up modulo addressing
        MOVE #0,R4
        MOVE #8,M0
        MOVE #8,M4
LOOP    JCLR #7,X:$FFEE,LOOP       ; Get ADC data
        MOVEP X:$FFEF,X0
        CLR A X0,X:(R0)+ Y:(R4)+,Y0        ; Next 4 instructions perform the
filtering
        REP #8
        MAC X0,Y0,A X:(R0)+,X0 Y:(R4)+,Y0
        MACR X0,Y0,A (R0)-
        MOVE A,X:$FFEF             ; Output the filtered data to the DAC
        JMP LOOP
        END
```

The convolution expression is given in mathematical terms as,

$$y[n] = \sum_{k=0}^{M-1} h[k]x[n-k]$$

where $x[n]$ represents the input signal, $y[n]$ represents the output signal, $h[k]$ represents the filter kernel and M is the number of taps.

Digital signal processors perform one multiplication, addition and shift in one instruction. Hence simple arithmetic shows that at 30 MIPS, an audio signal sampled at 44.1kHz could be filtered using a kernel comprising up to 680 taps. A filter with this many taps can be designed with a sharpness far beyond what is normally possible with analogue types.

To implement filters using the DSP56002, a special kind of addressing termed *modulo addressing* is used. There's more on this in my third article. Code shown in **Listing 3** implements a simple nine-point running mean filter. It also sets up the PLL, the external memory bus and the SCI interrupt, in the manner discussed above.

For more information on filtering using the DSP56002, see reference 3.

Commercial DSP Filters

There is a huge range of DSP products on the market, intended both for the professional engineer and the amateur enthusiast. One such system is supplied by Kemo Ltd, called the KDF, specifically aimed at audio bandwidths.

This product incorporates a Windows-based software system for designing the filter, and a DSP hardware module that executes the filter in real-time. No knowledge of mathematics is required. Once the user is happy with the design, it can be sent to the hardware from the same package with the click of a button.

Figure 2 shows the design interface. The nice thing about the system is that completely arbitrary filter shapes can be specified, either using its design facility or by importing ASCII text files representing the frequency response.

In summary

We hope that this series of articles on DSP systems design and programming has been a useful introduction to the subject. DSP is a truly enormous branch of learning, and one of the fastest growing and most important technologies of our time.

Although the learning curve is a little steep to start with, the rewards, in terms of intellectual satisfaction, are well worth the effort. Happy experimenting! ■

References

1. 'DSP56002 Digital Signal Processor User's Manual', Motorola Inc., document DSP56002UM/AD, 1993.
2. 'DSP56000 Digital Signal Processor Family Manual', Motorola Inc., document DSP56KFAMUM/AD, 1995.
3. El-Sharkawy, 'Digital Signal Processing Applications with Mototola's DSP56002 Processor', pub. Prentice-Hall Inc., NJ, USA, 1996.

NEWPRODUCTS

Please quote *Electronics World* when seeking further information

Ethernet and Internet connectivity demo kit

An Ethernet and Internet demonstration kit from Unique Memec includes a TCP/IP stack to enable embedded connectivity over industrial and appliance networks. The kit provides tools to explore and evaluate Microchip's various TCP/IP products. The heart of the Microchip Picdem Net kit is a demonstration board based on the 40-pin PIC16F877 flash microcontroller. TCP/ICP firmware is used for the network interface. After the initial setup of the IP and Ethernet address, performed via the RS232 port using a standard terminal program, engineers can choose to access the various functions of the board through a network or via the Internet. The board has Ethernet and RS232 interfaces. Engineers use a standard web browser, such as Netscape Navigator, to display inputs from the board (potentiometers and switches) and drive the LCD and control LEDs. Status indicators and user interface devices, including a 16 by 2 LCD indicator and LEDs, are provided. The PIC16F877 device acts as a web server with the ability to serve HTML web pages. The kit also includes Microchip's MPLab integrated development environment, user's guides, category five Ethernet cable, DB9 serial cable and universal power supply.

Unique Memec
Tel: 01296 397396
www.unique.memec.com

Band-three TX for digital/analogue TV

The NM and NW700 from Rohde & Schwarz are Band three transmitters for analogue and digital television. They use liquid cooling. The amplifiers have an integrated power supply, can be serviced during operation and are of modular design. The firm's real-time TV test receiver EFA comes in a 3HU chassis and can handle all terrestrial modulation for the US market. Operating in the VHF and UHF range, it demodulates digital (8VSB), analogue (M/NTSC) and US cable (ITU-R J83/B) signals. Digital formats are analysed in real time and demodulated to MPeg2 transport streams via SMPTE310 or ASI serial interfaces. The M/NTSC standard is demodulated to video and audio baseband.

Rohde & Schwarz
Tel: 0049 894129 11765
www.unique.memec.com

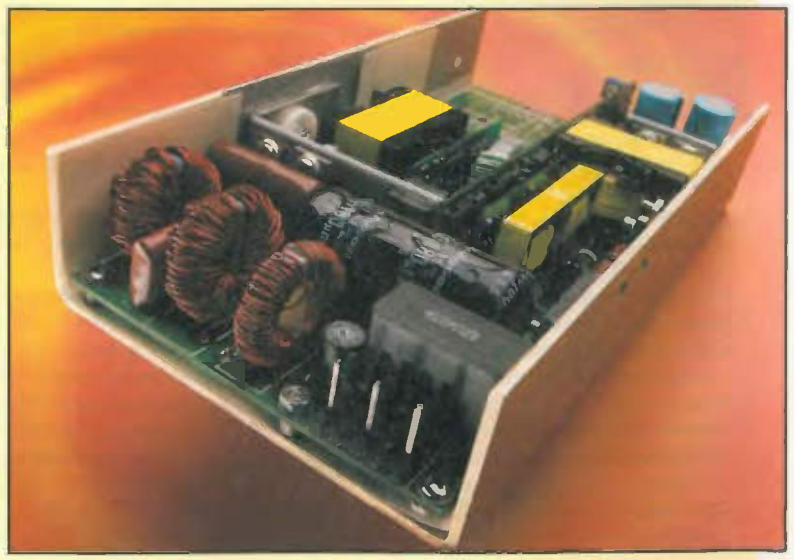
Processors for VoDSL gateways

Texas Instruments has announced DSL communications processors for home and office routers and voice over DSL gateways. The integrated silicon and software chip sets use the firm's programmable DSP-based DSL physical layer, Telogy Software VoDSL products and the same broadband access communications processor architecture as TI's recently announced VoIP gateway and Docsis-ready, voice-over cable modems. Providing integrated support for wireless and wired networking standards, the AR5D00, AR5V10 and AR5V20 help consumers network multiple PCs and Internet appliances, manage multiple Internet accounts and have access to entertainment and business services such as streaming video and audio, real-time video conferencing and virtual private network security. The AR5D00 is a chip set for home, Soho and SME routers. The AR5V10 chip set is for integrated access devices, residential gateways and Soho gateways to deliver up to four packetised voice lines and high-throughput data. The AR5V20 lets IADs and SME gateways support up to eight packetised voice channels. They support IEEE802.11, Wi-Fi, Bluetooth, Ethernet, IEEE1394, USB, Powerline and Home Phone Networking Alliance standards. All three support Linux turnkey communications processor software including a TCP/IP network stack with network management features or the VxWorks board support package.

Texas Instruments
Tel: 01604 663000
www.ti.com

Single-output 48V supply delivers 300W

Digital Power has announced the EPower 300T single output, 48V supply that gives 300W from a 17.3 by 9.7 by 3.0cm package. Power density is 0.61W/cm³ and it is for use in telecoms systems. Efficiency is up to 85 per cent, achieved by using synchronous rectifiers. In this topography, conventional diode rectifiers have been replaced by MOSFETs, which are turned on and off synchronously with the power converter. Each MOSFET behaves like a diode, letting it conduct in only one direction, but with lower forward voltage drop and rectification losses. The components for the two main outputs are along each side of the chassis to provide cooling without additional, separate heat sinks. This also improves lengthwise airflow. It incorporates conventional input power factor correction and EMI line filtering circuitry. The PFC circuit provides a 90 to 250V AC universal input, and the design uses surface mount components and tantalum capacitors.



Digital Power
Tel: 01722 413060
www.greshampower.com

Connector enables 5.0Gbit/s connection

Teradyne has announced a six-row version of its VHDM high-speed differential connector. It will support point-to-point backplane connections up to 5.0Gbit/s. Applications include Sonet OC-48, OC-192 and OC-768 systems, 10Gbit/s Ethernet, terabit routers, optical networking equipment, servers and data storage systems. The connector uses an orthogonal in-line grid rather than a staggered grid, allowing for traces up to 10mm wide and letting traces run through the connector without jogs.

Teradyne
Tel: 01344 426899
www.teradyne.com

Analogue output photocoupler

NEC Electronics' PS8601 eight-pin photocoupler provides a maximum supply voltage of 35V, response of 0.8µs and isolation voltage of 5kV rms. The single chip photocoupler contains a GaAlAs LED on the input side and a p-n photodiode and amplifier transistor on the output side. Applications

include interface circuits for instrumentation, control equipment, computer and peripheral manufacturing and electrical isolation of TV video terminals. Allowing voltage peaks up to 8kV, it has an operating temperature between –55 and +100°C. It is available in two packages – plastic DIP or as the PS8601L in a lead bending Gull-wing type for surface mount.

NEC
Tel: 01908 691133
www.euk.nec.co.uk

Gigabit Ethernet core for copper and fibre

LSI Logic has introduced a Gigabit Ethernet core for use in copper and fibre networks. The E1110 core is a 10/100/1000baseT Ethernet media access controller. It can support applications from 10 to 1000Mbit/s on one platform and suits embedded applications including switches, routers, servers and desktop computers. A programmable 10, 100 and 1000Mbit/s data rate option supports data transfer of Jumbo frames up to 10000bytes.

LSI Logic
Tel: 00 1 408 433 8000
www.lsilogic.com

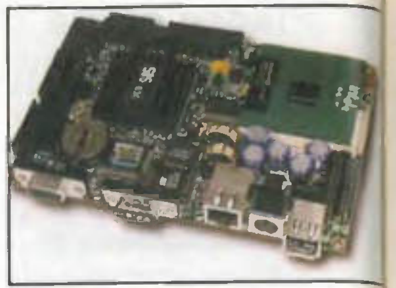
IR receiver resists the light

An infra-red receiver module with an internal automatic gain control to increase immunity against light disturbances caused by energy-saving lamps has been announced by Vishay Intertechnology. The Telefunken TSOP700 combines a photodetector and preamplifier in one package. It has a 455kHz carrier frequency and is for use in multimedia products and applications, including interactive TV, video conferencing systems, game controllers, interactive toys, wireless keyboards, wireless mice and remote controls. The receiver can handle up to 20kbit/s at a transmission distance of up to 20m. With an internal band filter, it is for PCM frequencies and provides TTL and CMOS compatibility. Power consumption is 10mW and it can operate from supply voltages from 2.7 to 5.5V. Rated for temperatures between –25 and +85°C, the device provides an output current of 5mA, with a demodulated output signal that can be directly decoded by a microprocessor. It measures 6 by 8.25 by 5.6mm. Receiver start-up time is 50µs and receiver data delay time 18µs.

Vishay
Tel: 00 1 610 644 1300
www.vishay.com

SBC for embedded multimedia

Diamond Point has launched the Inside Technology 786LCD/3.5 single board computer in 8.9cm format. Incorporating an integrated SiS 630 chip set with hardware accelerated MPeg-2 and DVD decoding to support high-end embedded multimedia applications, the board integrates Intel socket 370 Pentium III and Celeron processors and a 128-bit 2D and 3D hardware accelerated



graphics controller with up to 64Mbyte of shared video memory. The controller can drive flat panel plasma, TFT LCD and CRT displays at a resolution of 1920 by 1200 in 16 million colours. Optional graphics modules, including Panellink, LVDS, 50-pin LCDconnect and DVI TV-out including CRT2 and S-Video composite (Pal and NTSC) are available, with a Soundblaster Pro 16 compatible virtual AC-3 surround sound SPDIF 4Mbit/s IrDA infra-red communications module. For PC/104+ and ISA bus access, the board is powered by an onboard lithium battery. Connection for an external battery is also provided. A 10/100baseT Fast Ethernet port, two NS16C550 RS232 serial ports with 16byte Fifo buffer, bidirectional Centronics port offering ECP or EPP mode and five-channel USB port are provided.

Diamond Point
Tel: 01634 722390
www.dpie.com

Dual clock oscillator has six operational modes

National Semiconductor has announced an 8-bit Cop8flash microcontroller with multiple power save operating modes. With two on-chip oscillators and six operating modes, the device can monitor a system's environment, including temperature, humidity, voltage, current, pressure and power. This makes it suitable for analogue sensor applications in white goods, security systems, information appliances and mobile phones. It can also be used in personal access device touch screens and applications requiring power management, user interface, LCD brightness and contrast control, and battery charging. It consumes dynamic currents at 3.0V from 24µA to 3.3mA. The product has 32kbyte of on-chip flash and a six-channel, 10-bit a-to-d with an input filter path and multiplexer output. With its filter path, the device's integrated 10-bit successive approximation analogue-to-digital converter lets designers insert external circuitry, such as a low-pass filter, between the 16 input-channel analogue multiplexer's output and the direct a-to-d input.

National Semiconductor
Tel: 01870 2402171
www.national.com

Smartcard connector avoids PCB redesign

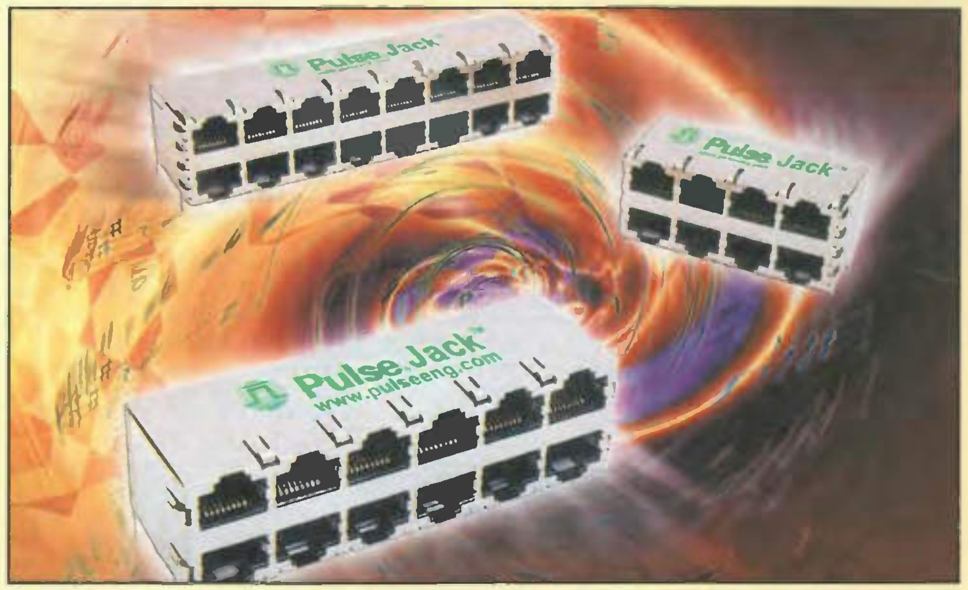
By encapsulating its L26 smartcard connector in a metal casing and adding a flexible printed circuit cable, FCI has introduced a panel mounted smartcard connector that lets OEMs upgrade equipment fascias without modifying PCB layouts. With its one piece construction, the Z00 connector comes with a choice of flexible printed circuit cables between 58 and 155mm long. Two connector bodies are available, handling card penetration depths of 25 and 35mm from card edge to panel surface. Card detection is via an integral normally closed, self-cleaning, wiping blade switch. Providing a choice of eight or 16 sliding contacts, the connector meets ISO7816 and Afnor LTE93421 standards. With the option of in-line capacitors, the flexible printed circuit cable complies with Europe Master Visa recommendations on signal integrity. The cable termination pitch can be either 1 or 1.25mm.

Digital Power
Tel: 01722 413060
www.greshampower.com

Multiport RJ-45 connectors

Pulse has announced the Pulsejack Harmonica family of multiport RJ-45 connectors with integrated magnetics. Developed with Tyco Electronics, the two-tier-stacked eight, 12 and 16-port connectors provide isolation and EMI suppression for 10/100baseT computer and telecoms networks. The two-by-four eight-port J2042H3A, two-by-six 12-port J2045H3B and two-by-eight 16-port J2039H3C connectors use the firm's Interlock base construction that reduces the stresses of human handling of subcomponents such as coils, leads and connecting wires.

Pulse
Tel: 01483 401700
www.pulseng.com



8-bit embedded applications get Ethernet reference

For embedded applications using 8-bit microcontrollers, a reference design from Triscend allows Ethernet connectivity. Based on the company's E5 configurable system-on-chip device, the design uses two chips. It combines an accelerated 80C51 microcontroller core, capable of delivering 10Mips, with embedded programmable logic, and uses the CS8900A Ethernet Mac phy from Cirrus Logic and the CMX-Micronet TCP/IP stack from CMX Systems.

Triscend
Tel: 01628 681565
www.triscend.com

Linear address range to 16Mbyte

Philips Semiconductors has announced the 87C51Mx2 microcontroller family including an 8-bit 80C51 supporting up to 16Mbyte of on-chip linear addressable memory for communications and consumer markets. The microcontrollers are based on the firm's 51Mx core, claimed to combine an increase in on-chip program and data memory with high-level C language performance. Binary object code compatibility is maintained, so engineers can reuse existing 80C51 codes. The architecture also retains 80C51 bus compatibility to allow reuse of peripherals and Asics. The 51Mx's 23-bit linear address supports up to 16Mbyte of on or off-chip program and data memory. The program counter is extended to 23-bit and the stack pointer to 16-bit. A 23-bit extended data pointer, with two 24-bit universal pointers using existing general purpose registers, creates a 16Mbyte linear address range for C compilers. The 87C51MC2 comes with 96kbyte of OTP memory and 3kbyte of RAM and the 87C51MB2 with 64kbyte of OTP and 2kbyte of RAM. Both operate with supply voltages from 2.7 to 5.5V and run at up to 24MHz (5V) with a typical instruction cycle time of 250ns.

Philips Semiconductor
Tel: 00 31 40 272 2091
www.semiconductor.philips.com

Audio d-to-a converter for CD players

Wolfson's stereo digital-analogue conversion technology is at the heart of two CD players from Rega Research. Sounds from the Rega Planet 2000 and Jupiter models depend on ICs based on the WM8716 multi-bit, 192kHz stereo d-to-a converter using a sigma-delta conversion technique to improve signal-noise performance and reduce clock jitter effects.

Wolfson
Tel: 0131 6679386
www.wolfson.com

Modular DSPs use FPGAs

Hunt Engineering has extended its Heron range of modular products for DSP with versions that use Xilinx FPGAs for DSP processing and flexible I/O. They let digital radio users remove an IF stage from their system by digitising directly at 100MHz and performing digital down conversion in the FPGA. When fitted to a Heron module carrier such as the HEPC8 PCI card, they can have their program downloaded from the PC over the serial bus. This lets users program and reprogram them as they would with the DSP elements of the system. There are three modules with FPGAs, each 10.16 by 6.35cm. The FPGA1 covers Virtex gate counts between 50k and 200k gates and the FPGA2 Virtex devices between 400k and one million gates. The IO1 combines a Spartan II FPGA with 200k gates with two channels of 105MS/s 12-bit A/D. Each input has a separately controllable programmable gain stage. The Spartan II FPGAs module allows the use of Xilinx Webpack development tools. The modules that use the Virtex

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and Virtex II FPGAs have more gate densities and features, but require the Foundation, Foundation ISE or Xilinx Simulink System Generator, which must be licensed from Xilinx. In the licensed software, Xilinx includes IP cores for DSP for configuring FFTs, digital data synthesis, correlators and filters.
Hunt Engineering
Tel: 01278 760188
www.hunteng.com

TFT LCD industrial panel PC

Advanced Modular Computers has launched the AMC-5030, a 38cm TFT LCD panel mount PC with a maximum resolution of 1024 by 768. Its aluminium front panel meets Nema 4 or IP65 standards. It can handle temperatures up to 50°C and non-condensing humidity levels up to 85 per cent. The model comes with a 90W power supply, three drive bays and the POS-566 socket seven card with processing speeds up to 100MHz. Onboard features include VGA with 2Mbyte EDO RAM, audio, 10/100Mbit/s Ethernet controller, digital I/O and one disk-on-chip socket. Dimensions are 395 by 277 by 141.2mm. A Dynapro resistive touch type screen is an option, bypassing requirements for a separate keyboard.
AM Computers
Tel: 01753 580660
www.amculc.com

PWM motor controller

Toshiba Electronics has introduced a PWM three-phase brushless motor controller IC with an external power FET module to produce a sinusoidal motor coil current waveform, so reducing electrical and acoustic noise. Using a dual modulation technique, the TB6539F/N can generate the sinewave output without the need for an additional external microcontroller. The device also has a built-in dead time function, which allows safe operation of the power FETs in push-pull configuration.
Toshiba Electronics
Tel: 00 49 211 5296254
www.toshiba-europe.com

Multilayer ceramic chip capacitors

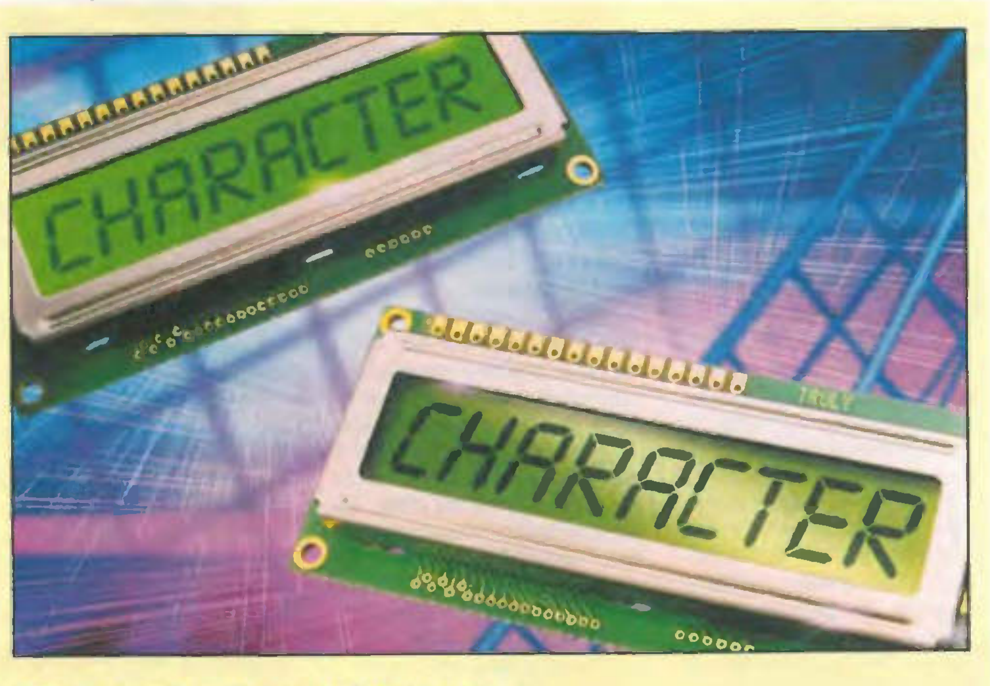
Multilayer ceramic chip capacitors have been announced by Vishay Intertechnology. The Vitramon VJ0612 capacitor will be used for high-frequency decoupling and bypass in laptop and desktop computers. Its VTOP housing lets designers place the capacitors underneath ICs. The VJ9743, VJ9742, VJ9741 and VJ9740 each measure 0.16 by 0.32cm, with maximum thickness options of 0.051, 0.066, 0.071 and 0.076cm, respectively. The chips can reduce AC noise in multi-chip modules. The VJ0612 has an inductance of 0.5nH.
Vishay
Tel: 00 1 610 644 1300
www.vishay.com

Serial EEPROM supporting ACR

A serial EEPROM from Unique Memec supports the advanced communications riser (ACR) special interest group specification. Microchip's 24LC09 EEPROM provides the enumeration memory for next-generation PC audio modem riser cards using a nonstandard address that lets the computer automatically detect and configure riser cards with standard plug-and-play capability. Each card provides intelligent modem, audio and network capabilities. The system bios of an ACR-compatible PC can communicate with the riser card, making it transparent to the computer's operating system.
Unique Memec
Tel:01296 397396
www.unique.memec.com

VCO has differential buffered output

Maxim Integrated Products has introduced the Max2753 2.4GHz monolithic VCO with differential output. It integrates



Single and dual-row LCD modules

Single and dual-row LCDs from Gothic Components display up to 32 characters and are available in various sizes, formats and colour options. The Truly 161 and 162 series includes TN and STN character display modules for designers creating equipment such as test and measurement instruments, pagers, personal audio, communication equipment and calculators. This range comprises four 16 character by one line displays, and nine of 16 character by two lines, with viewing areas from 64 to 99mm, and character sizes from 2.95 to 4.84mm. Displays are available in TN black character or STN blue character with options of colour polariser, colour backlighting, EL or LED. Polarisers come in grey, yellow-green or blue, or positive or negative, and backlights in blue, amber, yellow-green and white. Basic modules are available in transmissive, transflective or reflective.
Gothic Computers
Tel: 0118 978 7848
www.gothiccomputers.com

Please quote *Electronics World* when seeking further information

the oscillator, tank circuit and a matched output buffer in an eight-pin µMax package. The VCO is compatible with integrated transceiver ICs with a low IF architecture, which typically require an off-chip VCO and a differential interface to reduce spurious noise. Applications include cordless phones, HomeRF, Bluetooth and other proprietary radios operating in the 2.4GHz ISM band. Oscillator frequency tuning is factory adjusted to guaranteed limits from 2400 to 2500MHz with a +0.4 to +2.4V tuning voltage input range. The oscillator signal is buffered by a differential amplifier stage to provide –8dBm output power. This buffer stage also isolates the oscillator from load impedance variations. Oscillator phase noise is typically –130dBc/Hz at 4MHz offset. The VCO operates from a +2.7 to +5.5V supply. Internal regulation of the oscillator supply voltage eliminates the need for a dedicated external low dropout regulator. The VCO consumes 8.6mA of current. In shutdown mode, the current is reduced to 0.2µA. An evaluation kit is available.
Maxim
Tel: 0118 930 3388
www.maxim-ic.com

LCD driver-IC tester

Advantest's LCD driver test system is designed for the testing devices such as thin film transistor (TFT) drivers, and chips that integrate both a controller and a LCD driver. The T6371 can simultaneously test a maximum of either two TFT drivers or four chips that contain a controller and a LCD driver. It can also be used to perform voltage measurements of drivers with a maximum of 128 pins and capable of digital testing at up to 125MHz. For testing multiple-pin ICs, the unit can measure LCDs that have a maximum of 1,280 pins. The system also employs a per-pin comparator architecture, which enables the user to perform high-speed function testing. The system's testing station can simultaneously measure up to four such devices.
Advantest
Tel: 0049 8999 312129
www.advantest.de

Signal integrity tool suits optical PCBs

Ansoft has released version 3.7 of its PCB/MCM signal integrity tool for PCB needs in optical networks, memory interfaces and multi-gigabit transmission systems. The 3D extraction engine lets designers address problems such as power and ground bounce, simultaneous switching output noise and parasitic extraction (R, L, C, G) for any 3D structure on the PCB. It has interfaces that let it automatically read-in and characterise an entire PCB or MCM designed in Cadence's Allegro or Mentor Graphics' Boardstation. During the analysis, the designer can choose whether to analyse particular structures and nets in full 3D or a mixture of 2D and 3D. Any type of non-ideal power or ground plane (partial plane, split plane, random holed or meshed plane) can be analysed. It can also analyse single-chip, few chip or multi-chip (system-on-package) designs from Cadence's Advanced Package Designer. The software uses the partial element equivalent circuit method to produce a distributed 3D model. This method lets the tool create accurate models of high-speed traces such as differential pairs and source-synchronous data lines. The distributed nature of the model allows the effect of each individual interconnect structure – including the effect of the non-ideal ground planes – on the signal to be seen in Spice.
Ansoft
Tel: 020 8891 6106
www.ansoft.com

PCI-X & PCI analyser and exerciser

Acal Electronics has introduced the PBT-615 state analyser for PCI-X and PCI bus. Made by VMetro, it is a single-slot PCI card that contains a logic analyser and optional exerciser. The unit can capture and trigger on all bus activity in 32 and 64-bit PCI-X and PCI bus motherboards through a PCI expansion slot at speeds up to 100MHz. By equipping it with an optional piggyback module with a 500MHz timing analyser and a PCI-X anomaly trigger unit, it can automatically detect PCI-X protocol or timing violations. The analyser part provides non-intrusive and stand-alone operation as seen from the host computer to be analysed. This is possible because it is equipped with its own processor communications ports (RS232 and USB) and firmware in flash PROMs. The analyser can be operated from a PC running VMetro's graphical user interface, Busview for Windows, from a standard Ascii terminal, or using a terminal emulator on a PC or Unix workstation. The protocol-sensitive sampling of bus cycles for state analysis means the bus analysers know the bus protocol of the target bus to ensure that sampling takes place at the right moments. This gives a trace that includes many types of bus activity, such as arbitration, interrupts and cache cycles, and ensures that the bus is not sampled at unimportant times.
Acal Electronics
Tel: 01252 858585
www.acalelec.co.uk

Oscillator requires one resistor

The Linear Technology LTC1799 is a SOT23 packaged oscillator IC that generates any frequency from 1kHz to 30MHz. The frequency can be set within ±2.5 per cent by adding a 1 per cent resistor or ±1.6 per cent with a 0.1 per cent resistor. There is no need for a crystal, ceramic resonator, capacitor or external reference clock. Accuracy is maintained over all supply and temperature variations, drifting typically less than 0.004 per cent per °C and 0.05 per cent per volt. Maximum supply current at 5V for a 10MHz output is 2.4mA from –50 to +85°C. Applications include localised clocks, synchronisation of switching power supplies and driving switched capacitor filters.
Linear Technology
Tel: 01276 677676
www.linear-tech.com

Materials absorb microwaves

Two flexible, absorbent EMI materials have been introduced by Murata. The EA10 prevents abnormal oscillation in high frequency modules and

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suppresses interference between circuits. The EA20 has high-μ, high-loss characteristics for suppression over a wide band in digital products. Both microwave absorbers cover 0.1 to 20GHz and can be introduced at any stage in the sequence from design to delivery. The silicon-based materials are flexible and can be held in place with adhesive tape. Thicknesses available are from 0.2 to 2.7mm. The thickness depends on the frequency to be suppressed. Custom sizes can be supplied.
Murata
Tel: 01252 811666
www.murata.co.uk

Connector with 0.6mm pitch

Harwin's latest range of surface mount ultra-fine pitch connectors, called the MP6 connector series is a 0.6mm pitch board mounting connector provide stacking heights of 3mm, 4mm and 5mm between boards. They are available with up to 100 contact positions, polarised to prevent mis-mating and equipped with locating pegs for accurate PCB placement. Metal latching clips are available upon request if additional strain relief is required. The housings are manufactured from glass filled LCP and have a UL94V-0 flammability rating. The housing has a minimum insulation resistance of 100mΩ and dielectric withstanding voltage of 200V AC. Standard packaging is tape and reel

format on 330mm reels using embossed carrier tape with removable pick and place pads for automatic placement.
Harwin
Tel: 023 9237 0451
www.harwin.com

Full duplex OC-48 ATM OAM processor

Vitesse Semiconductor has announced the Monitor 4.8 manager for operations, administration and maintenance (OAM) network traffic at OC-48 data rates. This IC provides ATM layer functions for OAM and protection switching cell processing. Throughput is 4.8Gbit/s with 512k individual connection flows (256k full duplex flows) in VC, VP, VP/VC or VP/VC switch configurations. For use with the firm's Pacemaker 2.4, a traffic management and SAR device, the IC is for line card ATM cell and packet processing. When used with the firm's IQ2000 network processor, switch fabric components and framer-mapper devices, the family provides system designers with an end-to-end chip level product for next generation Internet infrastructure equipment. It is a silicon implementation of the ITU I.630 protection switching standard, and provides per connection activation and deactivation of OAM flows with performance and fault monitoring on all 256k connections independently. It interfaces with the outside world via four independent standard Utopia ports and a 32-bit 66MHz PCI interface for connection to a host CPU.
Vitesse Semiconductor
Tel: 001 310 937 1594
www.vitesse.com.

Supervisors monitor down to 300mV

Two dual voltage supervisor ICs for monitoring power supplies down to 300mV have been developed by Micrel Semiconductor. Available in the firm's Ittybitty SOT23-5 packaging, the MIC2774 and MIC2777 have a choice of preprogrammed voltage options and quiescent currents. One of the monitoring inputs is user-adjustable and the other is preprogrammed at the factory. Options accommodate standard logic supply voltages. Power supply current is 3.5A. The MIC2777 has active-high and active-low reset outputs; manual reset capability can be achieved by adding an external reset switch. The MIC2774 has a standard pin out with a dedicated manual reset input and a choice of active-high, active-low or open-drain active-low reset outputs. They are made on a BiCMOS process.
Micrel Semiconductor
Tel: 01635 524455
www.micrel.com.

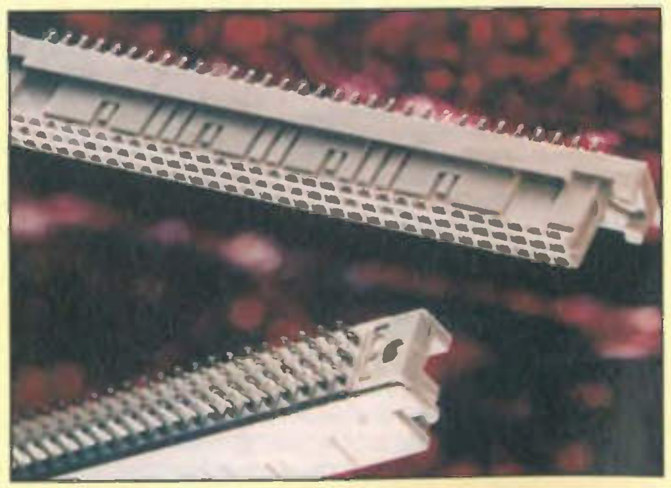
512kbit flash with random read

STMicroelectronics has announced a 512kbit flash memory device with sequential and random read operation, page mode programming, sector and bulk erase modes, and a 20MHz SPI-compatible serial bus.
Like its 1Mbit predecessor, the non-volatile field-programmable 512kbit (64k by 8 bit) M25P05 is targeted at applications for the storing of code and blocks of data in industrial, consumer and telecoms products, says the supplier. The flash chip contains two sectors of 256 pages each. Because one page is 128 bytes wide, the entire memory can be viewed as 512 pages or 65 536 bytes. The memory's page program instruction writes one to 128 bytes at a time. The memory can be erased at once using a bulk erase instruction. Alternatively, one sector at a time can be erased using a sector erase instruction. There is a 26ms full memory read operation at 2.7V; 3ms (typical) for 128-byte page programming; and 256kbyte

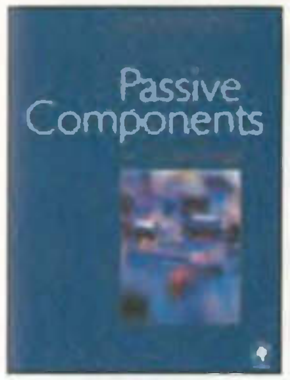
Press-fit connectors for D-sub and 2mm

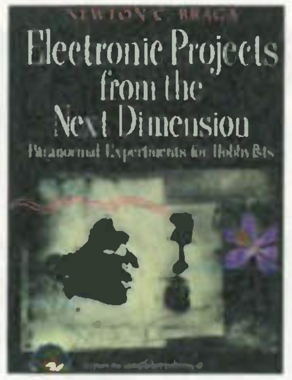
Northern Connectors offers press-fit connectors including the Harting DIN41612 and the Harbus 64 range. In addition, the distributor will provide press-fit products for both: D-Sub straight and right angle IDC board headers, hard metric 2mm connectors, and SCSI as well as BNC connectors.

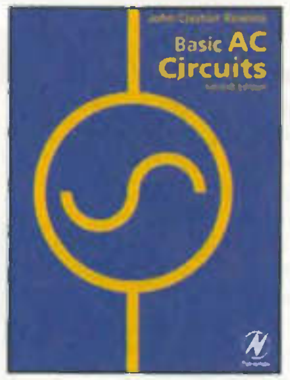
To achieve the packing densities required, back-panel PC boards are in the form of multilayer boards which use press-fit termination. The press-fit pins are inserted and adapt to the hole within the PC board. Electrical contact is made solely by pressure and cold welding of contact surfaces within the insertion zones.
Northern Connectors
Tel: 01744 815001
www.northern.connectors.com



BOOKS TO BUY







PASSIVE COMPONENTS FOR CIRCUIT DESIGN
Passive Components for Circuit Design is a unique introduction to this key area of analog electronics designed for technician engineers and anyone involved in circuit design. The coverage encompasses all component types capable of power amplification: resistors, capacitors, transformers, solenoids, motors and transducers. The behaviour of the components is explored along with the different types available and the principles of circuit design. Tolerances, stability, variation with temperature, reliability and manufacturing standards are all covered. Reading this book will improve your skills in component selection and analog circuit design. These are essential skills not only for the analog designer, but for all circuit designers, professional or amateur.
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Surface-mount DC-to-DC converters for 100A

Vicor has introduced a surface mount interface accessory, called SurfMate, which is designed for use with pin-compatible 2nd generation DC-to-DC converters and accessory modules. According to the supplier this will allow designers and assemblers to surface mount high-density DC-to-DC converters with current ratings up to 100A. It uses a pair of surface mounted headers that contain sockets to accept the input and output pins of the converter module. The header assembly is compatible with any thickness PCB, does not increase the module mounting height above the board, and is available for all three standard module sizes – Maxi, Mini, and Micro (full, half and quarter brick DC-to-DC converters). The interfaces are packaged in standard recyclable JEDEC trays for use with automated pick and place equipment and are compatible with standard reflow solder operations. After reflow, the modules are inserted into the sockets.
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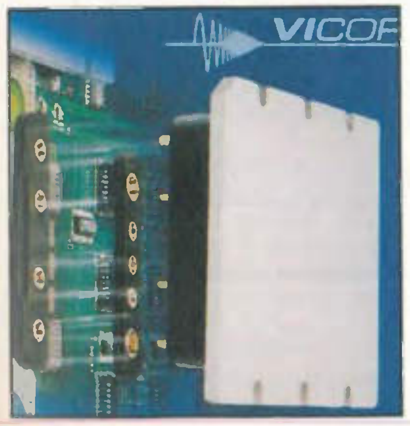

One-phase 'green' fan

The Green Motor fan range from Sunon has been awarded ISO14001. The range includes axial fans from 17 by 17 by 8mm frame size to 120 by 120 by 38mm, and microblowers from 35 by 35 by 4.8mm to 45 by 45 by 9mm. They use a one phase full-wave winding mechanism to reduce material waste, increase torque and reduce failure rate during production. The motor bobbin, which protects the coil, is produced from a high-temperature resistant, non-flammable and insulating engineering thermoplastic. This lets the fan motor be operated at an ambient temperature up to 90°C.
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Tel: 0031 1461 54515
www.sunon.fr

Power switch IC supports USB wake-up

USB power switch ICs offering advanced configuration and power interface (ACPI) wake-up capabilities are available from Micrel Semiconductor. MIC2010 series devices include four dual-channel protected Mosfet switches optimised for universal serial bus (USB) wake-up capabilities supported by ACPI for desktop PCs. When the PC is active, these devices will guarantee 500mA continuous output current per channel as required by USB. When the PC is placed in the ACPI S3 sleep state, the outputs are switched to the 5V standby supply available in ATX style power supplies. In this state, the continuous output current is reduced to 100mA, or to a user-adjustable value. This reduction protects the smaller current capacity of the standby supply in case of short-circuit faults. When the PC is returned to the active SO state, the outputs are switched to the 5V main supply. The four devices include the MIC2010, MIC2012, MIC2070 and MIC2072. The MIC2010 offers adjustable auxiliary current limiting for more precise control, whereas the MIC2012 has preset current limits for the auxiliary mode. The MIC2070 and MIC2072 provide a circuit breaker function that latches the output(s) off when an over current condition is detected, reducing power consumption during a fault. ■
Micrel Semiconductor
Tel: 020 7823 3224
www.micrel.com

Modular compact PCI backplane

Schroff has introduced a modular CompactPCI backplane with a power supply interface for industrial and telecoms users. The various modules can be combined into a system whose flexibility allows the construction of prototypes and short-production-run models. The backplane consists of modular backplanes, power piggybacks and one or more power backplanes. The modular backplanes comply with revision 3.0 of the CompactPCI core specification. Models with three to eight slots are available in 3 or 6U formats. The five and seven-slot versions are bridgeable. All can be abutted without losing a slot width. The piggyback board, which is plugged directly into the rear of the backplane, is used for connecting each power supply. This board contains an ATX connector, various universal supply terminals for M4 eyelets (power bugs) and three drive connectors. The board both enables power to be fed to the backplane from various sources, and serves as a central node for power distribution in the system.
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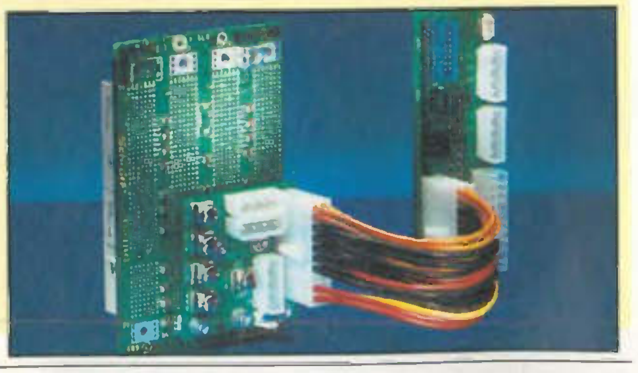


SPEAKERS' CORNER

A reader came up with the idea of reducing woofer distortion by using motional feedback derived from pressure changes inside the cabinet, as opposed to voice-coil position. "So why is no one using it?" he asks John Watkinson...

BASS PERFECTION?

Regular Speakers' Corner reader John Cole, from Devon, recently wrote in with a suggestion for improving bass response. John wondered why the idea wasn't used in practice. He wrote as follows:

"At 100Hz the wavelength is three metres, at 50Hz six, so to a reasonable approximation, a normal sized speaker is a point source that simply sucks and blows air. The material of the speaker has a constant volume, so where is the change of volume to accommodate that air? Clearly it's the change in volume of the air being compressed and rarefied in the box. That must be true even for a vented enclosure, as long as the vent and the driver are close together in wavelength terms. Inside the box there's essentially a single pressure, since again the space is small compared to a wavelength, and to a good approximation its change is proportional to the change in volume, being a fraction of atmospheric pressure.

The next step is obvious. Mount a pressure-sensitive microphone or – in these days when piezo-resistive devices are commonplace – a fast acting pressure sensor within the box and use feedback to constrain its output to follow the signal input at bass frequencies. Unlike motional feedback, that measures the coil position, this scheme uses a readily available linear transducer and doesn't require the cone to remain rigid as it strains against the internal pressure. Tell me please, why will it not work?"

I like questions like this because to answer properly requires a wide range of technologies to be considered. Let's start with the acoustics.

It is absolutely true that the average-sized speaker can be considered a point source that sucks and blows at low frequencies. The radiation is proportional to the volume velocity of the diaphragm.

However, the pressure in the box isn't, unless the box has infinite volume. **Figure 1** shows a finite box with a moving diaphragm. It assumed that the diaphragm is ideal, such that it moves an equal amount inwards and outwards due to a sinusoidal drive signal. However, this does not result in a sinusoidal pressure waveform in the box. Figure 1 shows why.

If it is assumed that the diaphragm displacement is 10 percent of the static volume of the box, then when the diaphragm moves in, the volume falls to 0.9 of the static volume, so that the pressure goes up to 1/0.9=1.1111 times static. However, when the diaphragm moves out, the volume increases to 1.1 times static, so the pressure falls to 1/1.1 = 0.909 times static.

Figure **1b)** shows that in the resultant pressure waveform, the positive peak would be 11 percent bigger than static whereas the negative peak would be 9 percent smaller than static. Figure **1c)** shows the pressure/volume relationship, which is not linear. If the loudspeaker were to be servoed such that the box pressure was sinusoidal, the radiation would not be sinusoidal and the result would be harmonic distortion.

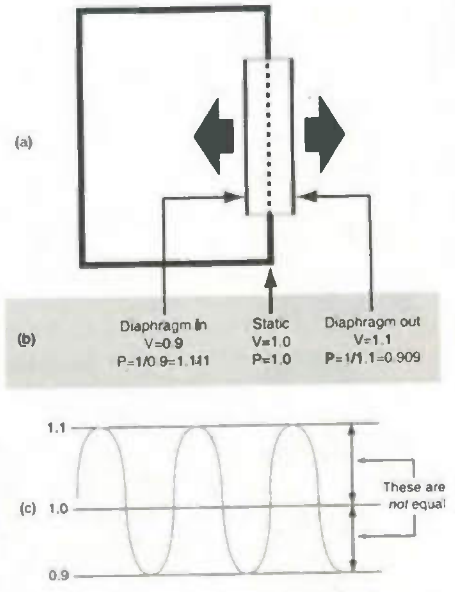


Fig. 1. Illustration a) represents diaphragms in a sealed box while b) indicates pressure resulting from 10% volume change. Drawing c) shows how the pressure waveform is distorted.

The assumptions made about this technique applying to reflex speakers are only true in the steady state condition, when the speaker has been emitting a sine wave for some time. In that case there will be a single pressure in the box which would be a sine wave distorted by the mechanism above.

However, there is more to sound reproduction than steady state. The time domain is more important. To take an analogy, a car that could do 150mile/h wouldn't be useful if it took two hours to reach that speed.

In the case of audio, sine waves don't carry any information because they have no bandwidth. Information in audio is carried in transients and it is important to reproduce them accurately. This requires linear-phase loudspeakers.

Reflex speakers simply cannot reproduce transients because the delays involved in establishing port resonances – and their subsequent decay – destroy phase linearity. In the light of modern active speaker technology, reflex speakers are inaccurate and obsolete.

Feedback won't fix it

The other point worth making in regard to this query is that it is all too easy to suggest 'fixing' a problem by putting feedback around something. In the same way that most speaker designers have a fixation with frequency response, it seems that most electronics engineers have a fixation with negative feedback as a universal solution. Unfortunately it's not that simple.

When considering a loudspeaker drive unit in a box, **Fig. 2** shows that it is a resonant system having a fundamental frequency within the audio band. The phase response below this resonance is 180° out from the phase response above.

The question then is do we want negative feedback above the resonant frequency which becomes positive feedback below, or *vice versa*? Of course neither of these approaches would work; they would be unstable. In order to use negative feedback around a loudspeaker, it is necessary to construct a compensating circuit that has the inverse phase characteristic to the drive unit and incorporate it in the feedback loop. Doing this is not a trivial matter.

The other problem with negative feedback is that it only works when there is some loop gain left. This means that the operating bandwidth and power output of negative feedback systems must be significantly less than the open loop characteristics.

A very precise donkey

Feedback may linearise and extend bandwidth at small amplitudes, but as amplitude increases, the system may just go open loop. You can't make a racehorse by putting feedback round a donkey. Instead you get a slower but very precise donkey.

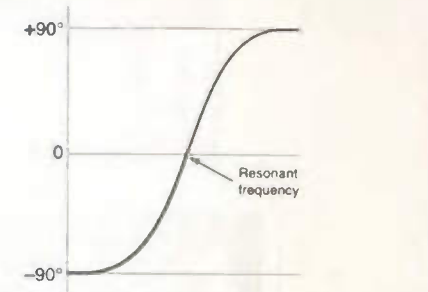


Fig. 2. Phase characteristic of woofer around resonance makes feedback difficult to stabilise.

These restrictions do not apply so much to feedforward because there is no requirement for loop gain – because there is no loop. In such a way we have arrived at another reason why Mr Cole's idea and other active technologies are seen so infrequently: the number of loudspeaker designers who can coherently explain the difference between feedback and feedforward is very small indeed.

You don't generally need those skills to take commoditised drive units from Taiwan and fit an MDF box around them. Worrying about phase linearity would cut into the time taken polishing the veneer. ■

Designing radio receivers II

Joe Carr discusses receiver design from the ground up. This second article looks at elements of the superheterodyne

In the first article of this set I looked at the various receiver architectures on the market, ending with the superheterodyne. This month I will be covering the various circuits within the superheterodyne receiver, starting a discussion of receiver performance parameters.

Front-end circuits

The principal task of the front-end and frequency-translator sections of the receiver in **Fig. 1** is to select the signal and convert it to the intermediate frequency. In many radio receivers though, there may be additional functions.

In some cases – but not all – an RF amplifier will be used ahead of the mixer. Typically, these amplifiers have a gain of 3 to 10dB, with 5 to 6dB being very common. The tuning for the RF amplifier is sometimes a broad band-pass fixed frequency filter that admits an entire band. In other cases, it is a narrow band, but variable frequency, tuned circuit.

Intermediate-frequency amplifier

The IF amplifier is responsible for providing most of the gain in the receiver, as well as the narrowest band-pass filtering. It is a high gain, often multi-staged, tuned-radio-frequency amplifier with a single frequency.

For example, one HF shortwave receiver block diagram lists 120dB of gain from antenna terminals to audio output. Of these, 85dB come from the 8.83MHz IF amplifier chain.

In the example of Fig. 1, the receiver is a single conversion design, so there is only one IF amplifier section.

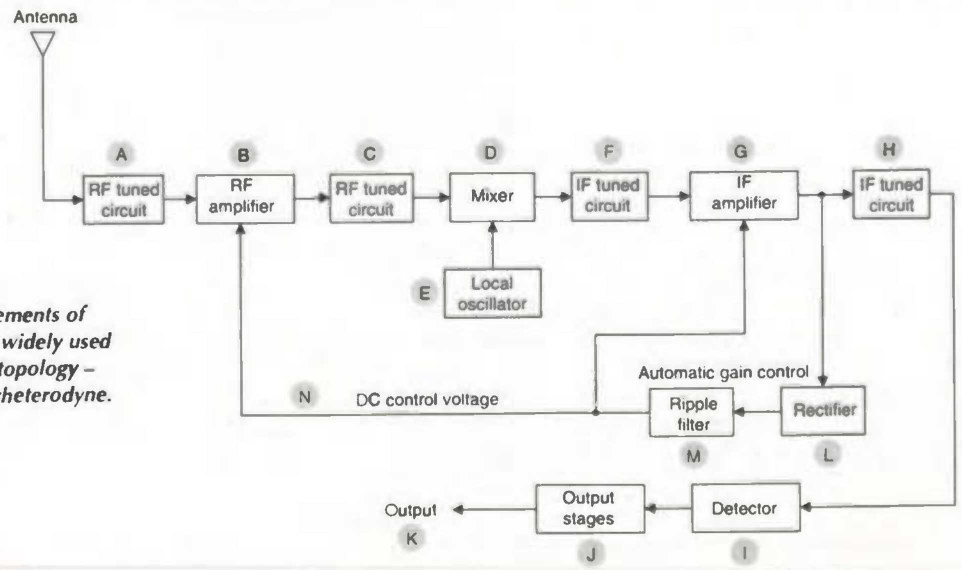


Fig. 1. Elements of the most widely used receiver topology – the superheterodyne.

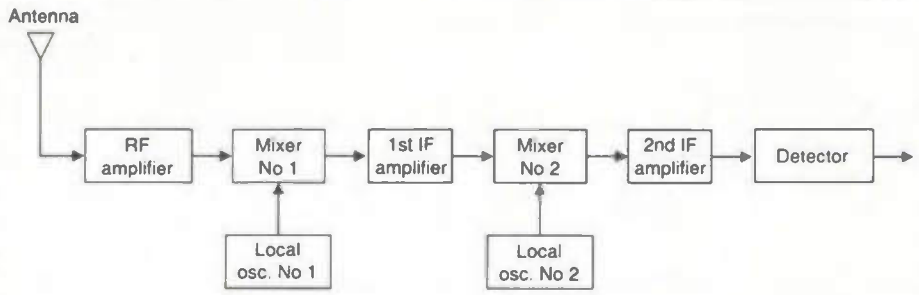


Fig. 2. Basic double-conversion receiver. It first converts the IF to a high intermediate frequency, and then down converts it to a lower intermediate frequency.

Detector stage

The detector demodulates the RF signal, and recovers whatever audio – or other information – is to be heard by the listener.

In a straight AM receiver, the detector will be an ordinary half-wave rectifier and ripple filter. In this case it is called an envelope detector.

In other detectors – notably double sideband suppressed carrier (DSBSC), single-sideband suppressed carrier (SSBSC or SSB), or continuous wave (CW or Morse telegraphy), a second local oscillator is heterodyned with the IF signal. This is usually called a beat frequency oscillator (BFO) and it operates near the intermediate frequency,

The resultant difference signal is the recovered audio. That type of detector is called a product detector. Many AM receivers today have a sophisticated synchronous detector, rather than the simple envelope detector.

Amplifying the audio signal

Audio amplifiers are used to finish the signal processing. They boost the output of the detector to a usable level to drive a loudspeaker or set of earphones.

Audio amplifiers are sometimes used to provide additional filtering. It is quite common to find narrow band filters to restrict audio bandwidth, or notch filters to eliminate interfering signals that make it through the IF amplifiers intact.

Double and triple-conversion receivers

Double and triple-conversion receivers are designed to take advantage of two aspects of radio design. The first is the fact that a high intermediate frequency will yield superior image performance, and the second is that it is easier to get high gain and bandwidth limiting filter characteristics at low frequencies.

Figure 2 shows a basic double-conversion receiver. It first converts the IF to a high intermediate frequency, and then down converts it to a lower IF.

The particular frequencies selected for the first and second IF depend on the application. In high-frequency shortwave receivers, the first IF will be in the order of 50MHz to gain the advantages of a high intermediate frequency – namely better image response. The second IF will be 10.7 MHz, 9MHz, 8.83MHz or 455kHz depending on the design.

In the VHF/UHF bands the high IF may be 10.7MHz, 50MHz or 70MHz, whereas the second IF will be 10.7MHz or 455kHz, depending on the design.

Direct-conversion receivers

The direct conversion receiver (DCR) is a sub-set of the superheterodyne in which the intermediate frequency is equal to the base-band frequencies. It converts radio signals directly to audio, rather than to an IF.

The local oscillator on the direct-conversion receiver is tuned to either the RF signal, or to a certain offset that depends on the tone that you wish to listen to in CW reception. The result is direct audio conversion in the DCR receiver.

Receiver performance factors

There are three basic areas of receiver performance that must be considered. Although interrelated, they are sufficiently different to merit individual consideration: noise, static attributes and dynamic attributes. I will look at all of these areas. But first let's look at the units of measure that we will use.

Input signal voltage. Input signal level, when specified as a voltage, is typically stated in either microvolts (μV) or nanovolts (nV). The volt is simply too large a unit for practical use on radio receivers. Signal input voltage – or sometimes power level – is often used as part of the sensitivity specification, or as a test condition for measuring certain other performance parameters.

There are two forms of signal voltage that are used for input voltage specification: source voltage V_{EMF} and potential difference V_{PD}, as illustrated in **Fig. 3**. The source voltage V_{EMF} is the open-terminal, i.e. no load, voltage of the signal generator or source. Potential difference, V_{PD}, is the voltage that appears across the receiver antenna terminals with the load connected. The load is the receiver antenna input impedance, R_{in}.

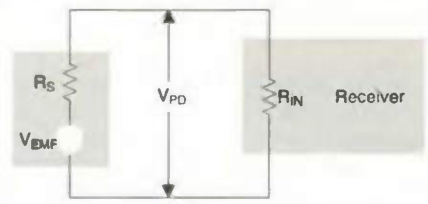


Fig. 3. Two forms of signal voltage are used for input voltage specification, namely source voltage V_{EMF} and potential difference V_{PD}.

When R_s=R_{in}, the preferred 'matched impedances' case in radio receiver systems, the value of V_{PD} is one-half V_{EMF}. This can be seen in Fig. 3 by noting that R_S and R_{in} form a voltage divider network driven by V_{EMF}, and with V_{PD} as the output. This is,

$$V_{PD} = \frac{V_{EMF} R_{IN}}{R_S} \quad (1)$$

It requires only a little algebra to convert signal levels from one unit of measure to another. See the end of the panel entitled 'Special units'. This job is sometimes necessary when a receiver manufacturer mixes methods in the same specifications sheet. In the case of dBm and dBμV, 0dBμV is 1μV V_{EMF}, or a V_{PD} of 0.5μV, applied across 50Ω, so the power dissipated is 5×10^{-15} watts, or –113dBm.

Noise considerations

A radio receiver must detect signals in the presence of noise. The signal-to-noise ratio, or SNR, is the key here because a signal must be above the noise level before it can be successfully detected and used.

Noise comes in a number of different guises, but for sake of this discussion we can divide them into two classes: sources external to the receiver and sources internal to the receiver.

There is little one can do about the external noise sources, for they consist of natural and man-made electromagnetic signals that fall within the pass-band of the receiver. **Figure 4a)** shows an approximation of the external noise situation from the middle of the AM broadcast band to the low end of the VHF region. A somewhat different view, which captures the severe noise situation seen by receivers, is shown in Fig. **4b)**.

One must select a receiver that can cope with external

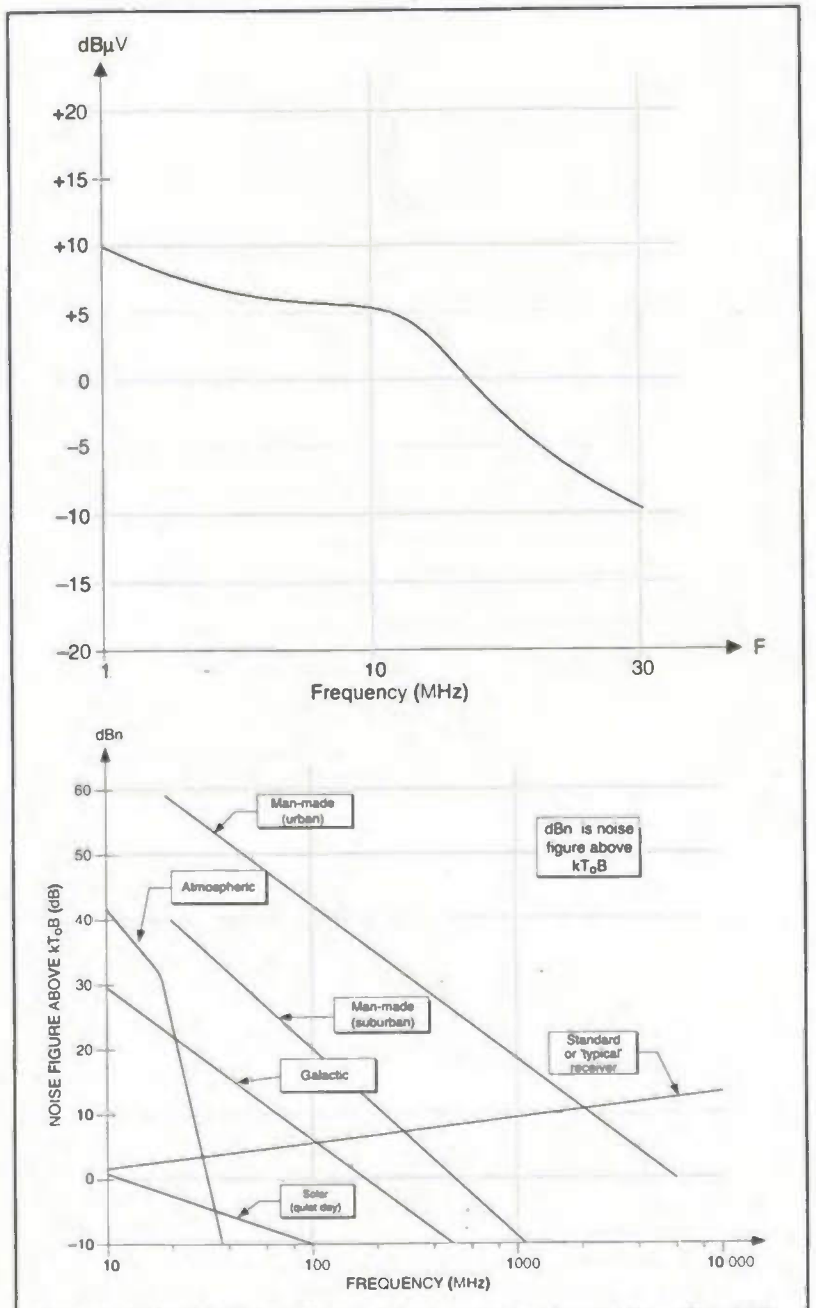


Fig. 4. In (a) is an approximation of the external noise situation from the middle of the AM broadcast band to the low end of the VHF region. A somewhat different view, which captures the severe noise situation seen by receivers, is shown in (b).

noise sources – especially if the noise sources are strong.

Some natural external noise sources are extraterrestrial. For example, if you aim a Yagi beam antenna at the eastern horizon prior to sunrise, a distinct rise of noise level occurs as the Sun slips above the horizon. This is especially so in the VHF region – the 150-152MHz band is used to measure solar flux.

The reverse occurs in the west at sunset, but it is less dramatic because atmospheric ionisation decays much slower than it is generated.

The receiver's internal noise sources are determined by the design of the receiver. Ideal receivers produce no noise of their own. Output from the ideal receiver would contain only the noise that was present at the input along with the radio signal. But real receiver circuits produce a certain level of internal noise of their own.

Even a simple fixed-value resistor is noisy. **Figure 5a)** shows the equivalent circuit for an ideal, noise free resistor, while Fig. 5b) shows a practical real-world resistor.

The noise in the real-world resistor is represented in Fig. 5b) by a noise voltage source, V_n, in series with the ideal, noise free resistance, R_i. At any temperature above absolute zero – i.e. 0K or about –273°C – electrons in any material are in constant random motion.

Because of the inherent randomness of that motion, however, there is no detectable current in any one direction. In other words, electron drift in any single direction is cancelled over even short time periods by equal drift in the opposite direction.

Electron motions are therefore statistically de-correlated. There is, however, a continuous series of random current pulses generated in the material, and those pulses are seen by the outside world as noise signals.

If a perfectly shielded 50Ω resistor is connected across the antenna input terminals of a radio receiver, the noise level at the receiver output will increase by a predictable amount over the short-circuit noise level. Noise signals of this type are called by several names: thermal agitation noise, thermal noise, or Johnson noise. This type of noise is also called 'white noise' because it has a very broadband – nearly Gaussian – spectral density.

The thermal noise spectrum is dominated by mid-frequencies – of 10^4 to 10^5Hz – and is essentially flat. The term 'white noise' is a metaphor developed from white light, which is composed of all visible colour frequencies. The expression for such noise is:

$$V_N = \sqrt{4KTBR} \qquad (4)$$

Here, V_N is the noise potential in volts, K is Boltzmann's constant (1.38×10^{-23} J/K) and T is the temperature in kelvins, normally set to 290 or 300K by convention. Also, R is the resistance in ohms and B is the bandwidth in hertz.

Table 1 and **Fig. 6** show noise values for a 50Ω resistor at various bandwidths out to 5kHz and 10kHz, respectively. Because different bandwidths are used for different reception modes, it is common practice to delete the bandwidth factor in equation 4 and write it in the form:

$$V_N = \sqrt{4KTR} \qquad V/\sqrt{Hz} \qquad (5)$$

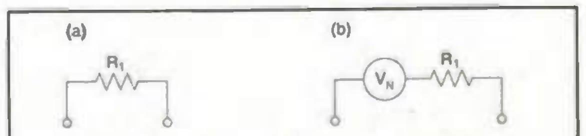


Fig. 5. Even a simple fixed-value resistor is noisy. The equivalent circuit for an ideal, noise free resistor is shown in (a), while (b) shows a practical real-world resistor.

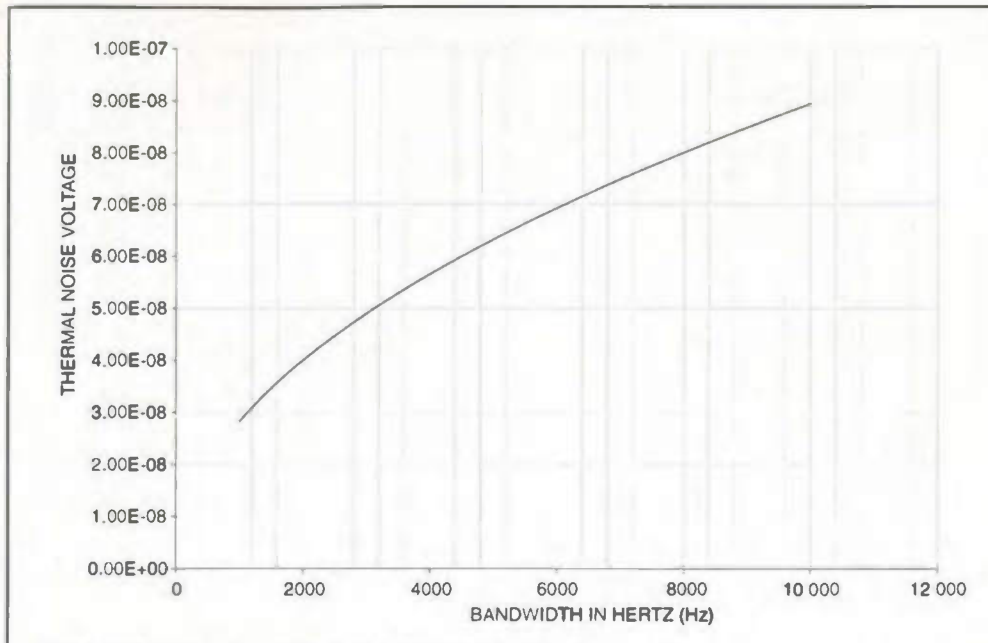


Fig. 6. Noise values for a 50Ω resistor at various frequencies.

Table 1. Noise values for a 50Ω resistor at various frequencies.

BW (Hz)	Noise voltage x E–08
500	1
1000	1.41
1500	1.73
2000	2
2500	2.24
3000	2.45
3500	2.65
4000	2.83
4500	3
5000	3.16
5500	3.32
6000	3.46
6500	3.61
7000	3.74
7500	3.87
8000	4
8500	4.12
9000	4.24
9500	4.36
10000	4.47

With equation 5, you can find the noise voltage for any particular bandwidth by taking its square root and multiplying it by the equation. This equation is essentially the solution of the previous equation normalised for a 1Hz bandwidth.

Signal-to-noise ratio

Receivers are evaluated for quality on the basis of signal-to-noise ratio, also known as S/N or 'SNR', and sometimes denoted S_n.

The goal of the designer is to enhance the SNR as much as possible. Ultimately, the minimum signal level detectable at the output of an amplifier or radio receiver is that level which appears just above the noise floor level. Therefore, the lower the system noise floor, the smaller the minimum allowable signal.

Noise factor, noise figure and noise temperature. The noise performance of a receiver or amplifier can be defined in three different, but related, ways: noise factor (F_n), noise figure (NF) and equivalent noise temperature (T_e); these properties are definable as a simple ratio, decibel ratio or Kelvin temperature, respectively.

Noise factor (F_n). For components such as resistors, the noise factor is the ratio of the noise produced by a real resistor to the simple thermal noise of an ideal resistor. The noise factor of a radio receiver – or any system – is the ratio of output noise power, P_{no}, to input noise power, P_{ni},

$$F_N = \left[\frac{P_{NO}}{P_{NI}}\right]_{T=290K} \qquad (6)$$

In order to make comparisons easier the noise factor is usually measured at the standard temperature T_o of 290K – standardised room temperature – although in some countries 299K or 300K are commonly used. The differences are negligible.

It is also possible to define noise factor F_N in terms of the output and input signal-to-noise ratios:

$$F_N = \frac{S_{NI}}{S_{NO}} \qquad (7)$$

Here, S_{NI} is the input signal-to-noise ratio and S_{NO} is the output signal-to-noise ratio.

Noise figure (*NF*). The noise figure is frequently used to measure the receiver's 'goodness,' i.e. its departure from 'idealness.' Thus, it is a figure of merit. The noise figure is the noise factor converted to decibel notation:

$$NF = 10\log(F_N) \qquad (8)$$

Here, *NF* is the noise figure in decibels, F_N is the noise factor and log refers to base-10 logarithm.

Noise temperature (T_e). The noise 'temperature' is a means for specifying noise in terms of an equivalent noise temperature. That is, the noise level that would be produced by a matching resistor – 50Ω for example – at that temperature, expressed in kelvins.

Evaluating the noise equations shows that the noise power is directly proportional to temperature in kelvins. It also shows that noise power collapses to zero at the temperature of absolute zero (0K).

Note that the equivalent noise temperature T_e is not the physical temperature of the amplifier, but rather a theoretical construct that is an equivalent temperature that produces that amount of noise power in a resistor. The noise temperature is related to the noise factor by:

$$T_e = (FN-1)T_o \qquad (9)$$

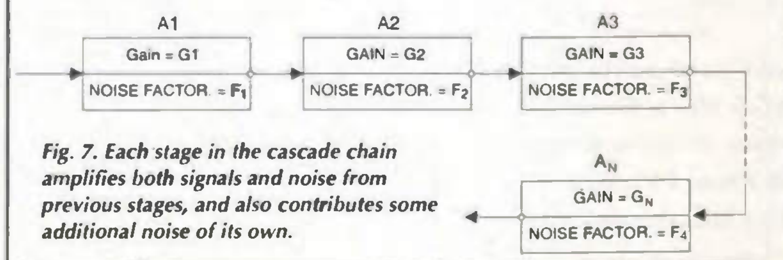


Fig. 7. Each stage in the cascade chain amplifies both signals and noise from previous stages, and also contributes some additional noise of its own.

and to noise figure by,

$$T_e = KT_o \log^{-1}\left[\frac{NF}{10}\right] - 1 \quad (10)$$

Noise temperature is often specified specified for receivers and amplifiers in combination with, or in lieu of the noise figure.

Noise in cascade amplifiers

A noise signal is seen by any amplifier following the noise source as a valid input signal.

Each stage in the cascade chain, Fig. 7, amplifies both signals and noise from previous stages, and also contributes some additional noise of its own. Thus, in a cascade amplifier the final stage sees an input signal that consists of the original signal and noise amplified by each successive stage plus the noise contributed by earlier stages.

The overall noise factor for a cascade amplifier can be calculated from Friis' noise equation,

$$F_N = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots + \frac{F_N - 1}{G_1 G_2 \ldots G_{N-1}} \quad (11)$$

Here, F_N is the overall noise factor of N stages in cascade, F_1 is the noise factor of stage 1, F_2 is the noise factor of stage 2, F_N is the noise factor of the nth stage, G_1 is the gain of stage 1, G_2 is the gain of stage 2 and G_{N-1} is the gain of stage (N–1).

As you can see from Friis' equation, the noise factor of the entire cascade chain is dominated by the noise contribution of the first stage or two. High-gain, multi-stage RF amplifiers typically use a low-noise amplifier, or LNA, circuit for the first stage or two in the cascade chain. Thus, you will find an LNA at the feed point of a satellite receiver's dish antenna, and possibly another one at the input of the receiver module itself. Other amplifiers in the chain might be more modest without harming system performance.

The matter of signal-to-noise ratio (S/N) is sometimes treated in different ways that each attempt to crank some reality into the process. The signal-plus-noise-to-noise ratio (S+N/N) is found quite often. As the ratios get higher, the S/N and S+N/N converge (only about 0.5dB difference at ratios as little as 10dB). Still another variant is the SINAD (signal-plus-noise-plus-distortion-to-noise) ratio.

The SINAD measurement takes into account most of the factors that can deteriorate reception. ■

The next article in this set will look at the receiver noise floor and the static measures of receiver importance, such as sensitivity and selectivity.

CIRCUITIDEAS

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 that 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.

Send your ideas to: Jackie Lowe, Cumulus Business Media, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8BZ

Stable go/no-go voltage indicator

The following circuit gives instant indication if a voltage is between two pre-set limit values or if it falls outside the limits. It has a temperature-stable internal voltage reference and so its accuracy is essentially determined by the stability of the external resistors R_1, R_2, R_3 and R_4.

At the core of the circuit is the TL4301, which behaves like a switch with an elevated trigger threshold. A simplified circuit below depicts the behaviour. When the trigger voltage is above 2.5V, the device is on. When the trigger voltage is below 2.5V, it is off.

In the basic circuit, the trigger voltage presented to pin 3, is determined by the ratio of R_1/R_3 and R_2/R_4.

When the measured voltage V is below the lower limit determined by the values of R_1, R_2, T_1 and the LED will be off. When voltage V is above the lower limit but smaller than the upper limit, T_1 will be on and the LED will light. The voltage is within the limit conditions. When V is above both limits, T_2 is also on and the LED is extinguished. Accuracy of the circuit is independent of supply voltage.

For go/no-go measurements on low impedance voltages – for example a check on power supply rail voltages, etc. – the LED can be powered from the voltage being measured. The only inaccuracy this will introduce is any drop in the voltage under test due to supplying the current for the LED. If the impedance is low and there is sufficient current available, this should be negligible.

The value of $R_1 \div R_2$ etc., can be calculated to set a particular threshold voltage by,

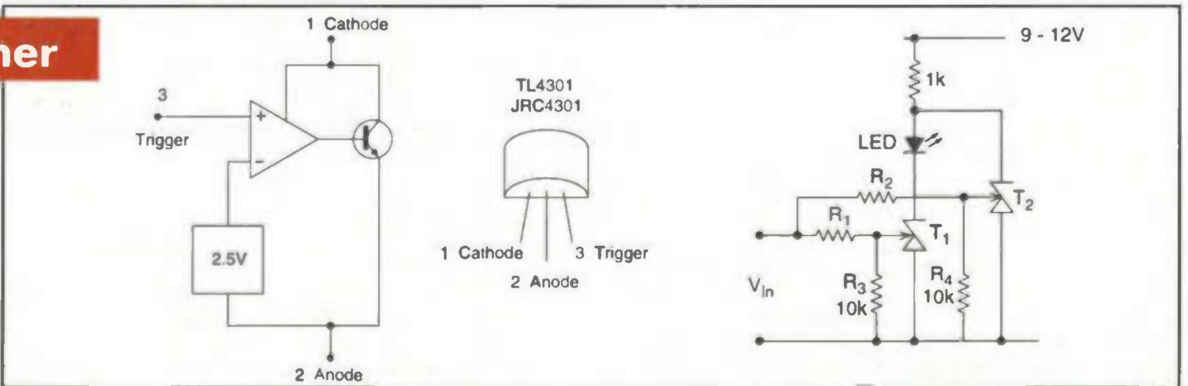
$$V_{lower\ limit} = \frac{2.5(R_1 + R_3)}{R_3}$$

$$V_{upper\ limit} = \frac{2.5(R_2 + R_4)}{R_4}$$

The table gives some useful values for common voltages.

John Rowe
Tai Po
Hong Kong
F35

£75 winner



$V_{lower\ limit}$	$V_{upper\ limit}$	R_1	R_2	R_3,R_4	Application
17V	19V	58k	66k	(all 10kΩ)	LNB H voltage
14.25	15.75	47k	53k		15V regulator
12.5	14	40k	46k		LNB V voltage
11.4	12.6	35k	40.6k		12V regulator
9.5	12	28k	38k		Scart pin 8 (4x3)
4.75	5.25	9k	11k		5V regulator
4.5	7.0	8k	18k		Scart pin 8 (16x9)

An optical audio isolator

A challenge recently arose to transfer audio across a high-voltage boundary without using transformers or capacitors, or RF of any kind. Initial tests with photovoltaic isolators, such as the PVI5100 indicated that audio transfer was just about possible, but signals heard on common low-impedance headphones were very weak and distorted. So I developed the active circuit shown in Fig. 1.

It makes use of a matched pair of MCT2E single-transistor opto-couplers, which have a current-transfer-ratio of approximately 100%. The output side is powered from a pair of 1.5V cells. On the input side, it is essential to bias the LEDs in the couplers with about 1V, provided by R_2, D_1, D_2 and R_3, D_3, D_4. These are fed from another pair of 1.5V cells.

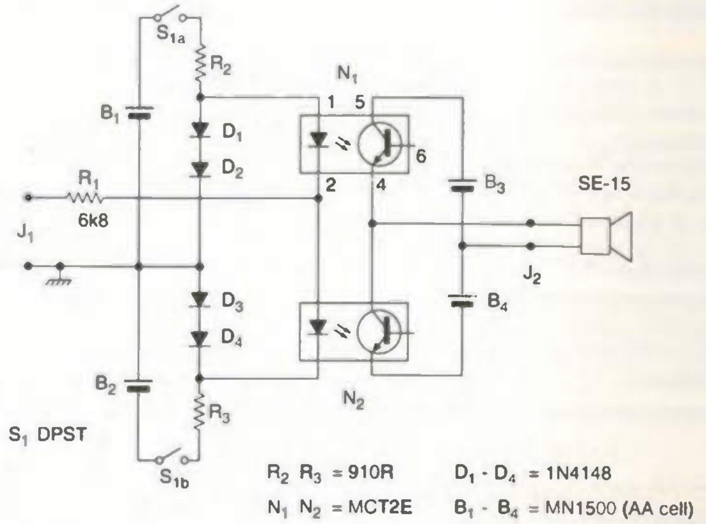
Resistors R_2 and R_3 are chosen so that a standing current of about 600pA flows through the output transistors, thus eliminating crossover distortion.

When a signal is applied via R_1, a linear transfer is obtained, and the frequency response extends from below 100Hz to above 10kHz. Note that the circuit is essentially current-driven, and R_1 may need to be altered to suit your hi-fi amplifier.

To power-down, it is necessary to disconnect the cells on the input side only, since the output ones then suffer less than 100nA transistor leakage current only.

For stereo, the batteries are shared between the two channels. In certain airliners, the audio to headphones is literally 'piped', but transfer through air was outside the scope of this wager!

C J D Catt
Cambridge
F46



Emergency light and alarm

This emergency light and alarm is powered by two AA Ni-Cd batteries and features four switchable options.

The circuit is permanently plugged into a mains socket and Ni-Cd batteries are trickle-charged. When a power outage occurs, the lamp automatically illuminates. Instead of illuminating a lamp, an alarm sounder can be chosen.

When power is restored, the lamp or the alarm is switched off. A switch provides a 'latch-up' function, in order to extend lamp or alarm operation even when power is restored.

Circuit operation is as follows. Mains voltage is reduced to about 12V DC at the 10µF capacitor's terminals, by means of the reactance of the 330nF 400V capacitor and the diode bridge. Thus avoids the use of a mains transformer.

Trickle-charging current for the battery is provided by the series 390Ω resistor, diode and the green LED that also monitors the presence of mains supply and correct battery charging.

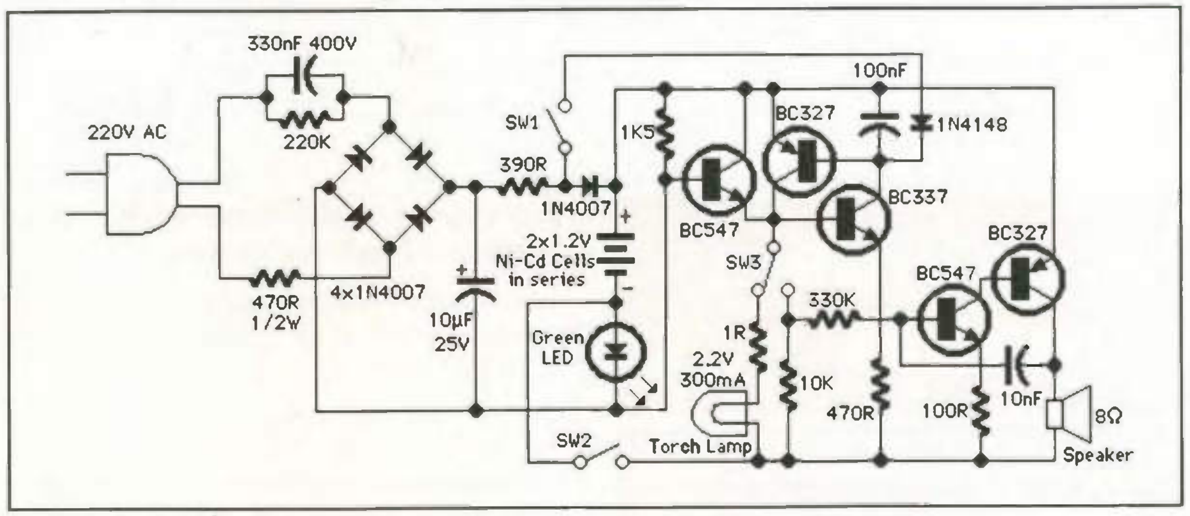
BC327 and BC337 transistors form a self-latching pair that start operating when a power outage occurs. In this case, BC547 biasing becomes positive, so this transistor turns on the self-latching pair.

If SW_3 is set as shown in the circuit diagram, the lamp illuminates via SW_2, which is normally closed; if set the other way, a square wave audio frequency generator formed by the rightmost couple of transistors and related components is activated, driving the loudspeaker.

If SW_1 is left open, when mains supply is restored the lamp or the alarm continue to operate. They can be disabled by opening the main on-off switch SW_2.

If SW_1 is closed, restoration of the mains supply terminates lamp or alarm operation, by applying a positive bias to the base of the p-n-p transistor.

Flavio Dellepiane
Genoa
Italy
F48



Slow diode as fast spike suppressor

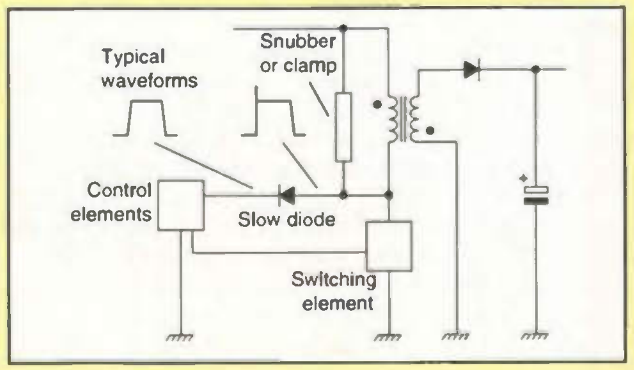
One of the most accommodating features of 'flyback' – also known as 'boost' – switch mode is that the primary-to-secondary flyback voltage is proportional to the turns ratio under any load condition. Voltage is therefore easily regulated by sensing the primary voltage.

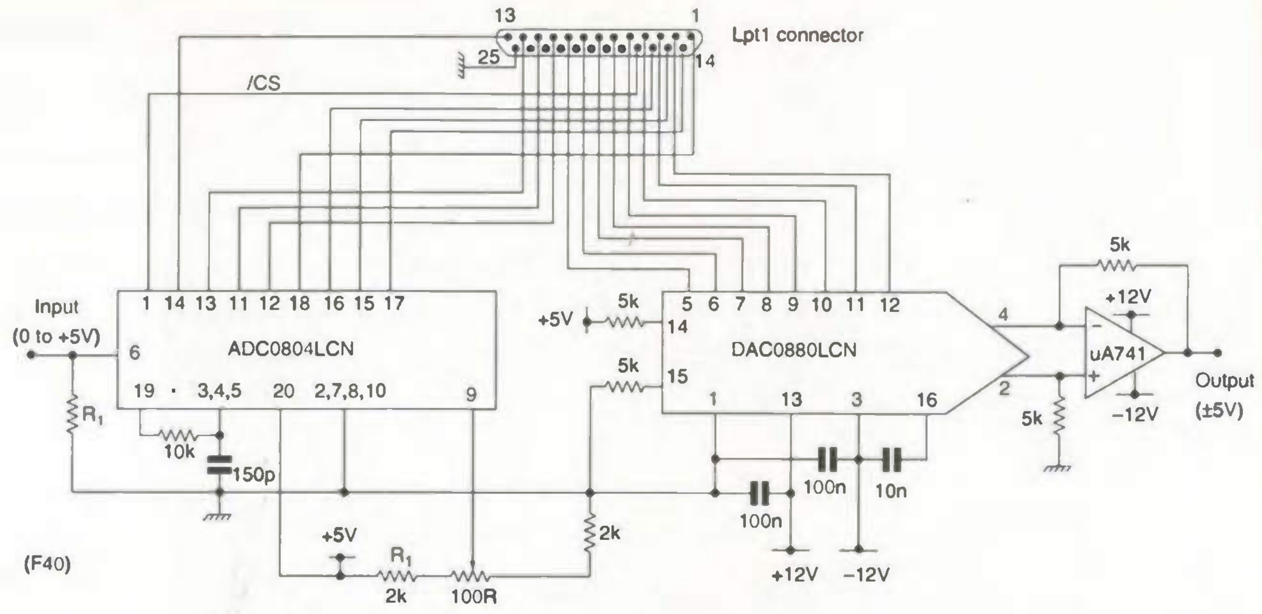
One upset though is that spikes rise to the clamp or snubber voltage due in the main to stray inductance. The solution is generally to sample after a slight delay to let things settle down. This works well, especially with dedicated management hardware, but is not ideal for minimalist design.

Disregarding the tenet, 'don't let slow diodes anywhere near switchers,' if the feedback is via a 1N4000 series or similar slow diode, spikes are blocked, in effect delaying sampling. A nominal resistance load is of course required but this is high and may by default be that of the input resistance of the control elements.

Maximum switching speed is not specified for such devices, but a slow diode can be relied on to be slow. Inhibiting of spikes and fast transients is pretty efficient. This 'wheeze' has been found to be reliable, accurate, repeatable and economical. Sometimes it pays to think laterally, and application is of course not limited to this example. One could envisage a cheaper – and perhaps more effective – alternative to, say, data line filters.

Andy Robertson
Girvan
Ayrshire
F51





Analogue interface circuit for a PC's parallel port

The bi-directional parallel interface, or LPT port, of an IBM PC compatible can be used for many applications.

One such application is to interface with the analogue world. This requires a-to-d and d-to-a converters, as shown. With this circuit, a PC can be used to sense an analogue voltage or output an analogue voltage each with 8-bit resolution. It uses an ADC0804LCN and a DAC0800LCN.

The D-to-A converter connects to the data lines of the port and is configured to give ±5V output with the use of operational amplifier 741. The a-to-d converter is configured to accept 0 to +5V input.

Offset voltage of the a-to-d converter can be adjusted by the 100Ω potentiometer. It is set in the middle for 0V offset. An a-to-d start of conversion cycle can be started by sending H→L→H at its pin 1, CS.

The circuit can be operated from the PC's power supply. However, –12V is not available directly from the PC's power supply, so a separate supply must be used.

Simple test programs written in QuickBasic are shown. Addresses of data, status and control ports of the LPT 1 are 378_{16}, 379_{16} and $37A_{16}$ respectively. A start-of-conversion cycle for the A-to-D converter is achieved by sending H→L→H to bit 3 of the control port. After the conversion, data is available at the control and status port.

Data bits 0 to 2 are available at the address $37A_{16}$, while data bits 3 to 7 are available at the address 379_{16}. Bit data is extracted using an AND operation. Bit 0 and 1 of the control port and bit 7 of the status port are inverted.

In the first program shown, the XOR operation is used to correct this inherent inversion. Data output of control and status port are combined to get the converted output. Converted output is then scaled to display it on the screen.

A listing for generating a sinusoidal analogue voltage is shown in the second listing. Any data sent at the data port of the LPT 1 is converted into analogue voltage between +5V and –5V. This simple circuit can be used for many applications.

M Tariq Iqbal
Rawalpindi
Pakistan
F40

QuickBasic program for recording and display a-to-d converter input.

```
SCREEN 12
10 h = 0
CLS
FOR y = 0 TO 640
h = h + 1
OUT &H37A, 8
OUT &H37A, 0
OUT &H37A, 8
x1 = INP(&H37A)
x1 = (x1 AND 7) XOR 3
x2 = INP(&H379)
x2 = (x2 AND 248) XOR 128
x = x/+x2
v = x/25.5 - 5
PSET (h, 240 - 240 * v / 5)
NEXT y
GOTO 10
```

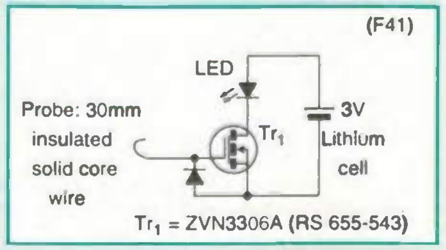
QuickBasic program for generating sinusoidal output.

```
10 FOR i = 0 TO 360
pi = 3.14
x = 127 * SIN(pi * i/180) + 128
OUT     &H378, CINT(X)
NEXT    i
GOTO    10
```

Mains voltage detector

This simple tester was developed to check for open circuit bulbs on Christmas tree lights. It is also useful for detecting live mains cables. By running the probe over an insulated cable the LED will illuminate when mains is present. If built on stripboard the gate/probe should be low capacitance to the surrounding copper. The battery can be permanently connected.

R A J Humphrey
Abingdon
Oxfordshire
F41



Simple circuit detects live wires.

12V DC motor controller outputs PWM

This pwm controller provides speed control from zero to maximum angular velocity for any motor up to 250W. It provides a smooth, progressive control, for drills, kiddie cars, golf trolleys, models, robots, etc.

Below 7kΩ of control potentiometer resistance, Tr_3 and Tr_4 conduct, turning the Tr_{1-2} constant current sink and IC_1 'on'. A small potential across C_3 causes Schmitt trigger IC_1 to oscillate with a very short 'on' period. Transistor Tr_5's base is thus toggled about its emitter potential, and its collector current is amplified by Darlington Tr_6 to drive two 25A output transistors.

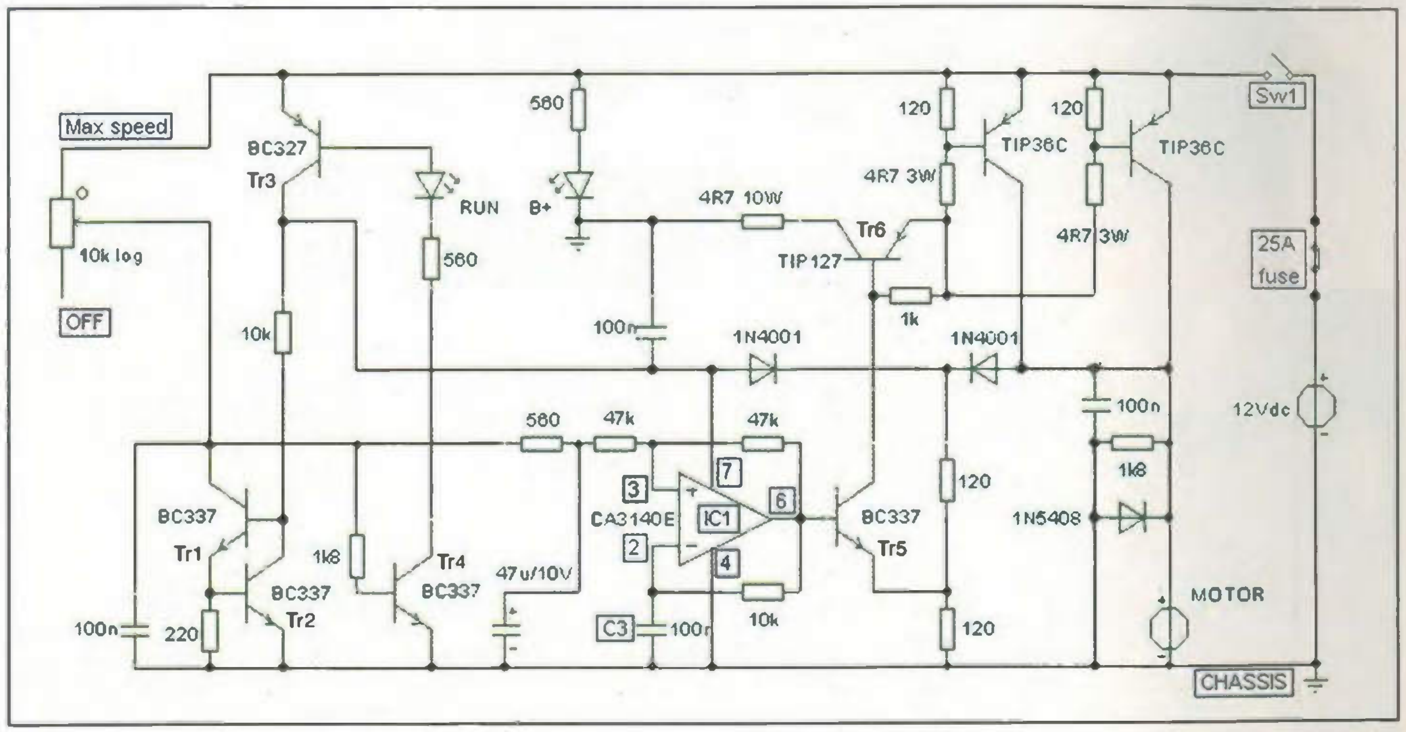
The control potentiometer track may be physically cut at 30° below maximum resistance to guarantee an electronically 'off' setting.

As the potentiometer resistance is further reduced, the voltage across C_3 and thus the IC_1 conduction period, increases. At minimum resistance, IC_1, and thus the output transistors, latch fully 'on'. An antilogarithmic potentiometer has produced very smooth and gradual clockwise power control, although ordinary 10kΩ log pots suit direct twist grip or pedal control.

All components fit in a 100 by 75 by 30mm alloy box; clip the power resistors and transistors to it. Fit additional output devices in parallel to increase power drive.

A 20:1 motor gearbox ratio with golf-trolley sized wheels should keep speed on the footpath legal. A 24Ah battery and 180W motor easily does the round on hilly golf courses.

Graham Maynard
Newtonabbey
Northern Ireland
F49



Minimal audio oscillators

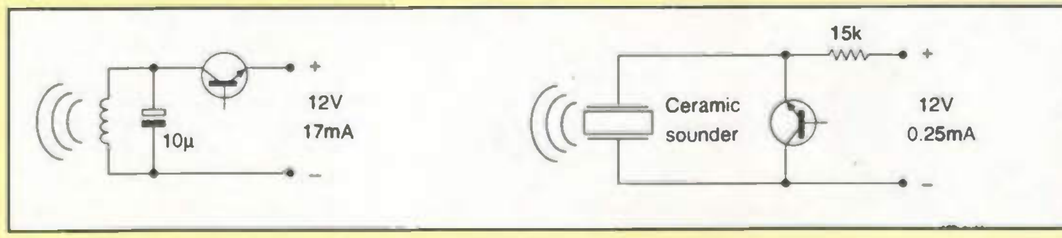
These two oscillators took inspiration from the circuit ideas in the August 2000 issue. One was a telephone earpiece oscillator by D.M. Bridgen and the other a ceramic oscillator by C. J. D Catto.

Using reverse-biased n-p-n transistors it is possible to design basic oscillators with just three components. The earpiece oscillator operates between 8 and 16V with a frequency of 1800Hz at 12V.

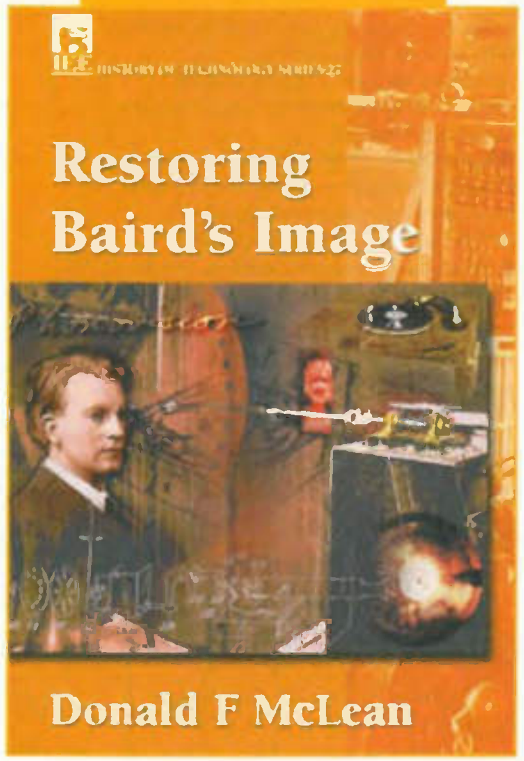
The ceramic oscillator exploits its intrinsic capacitance and operates between 9.5 and 20V with a frequency of 1000Hz. This latter oscillator draws very little power despite a sound level comparable to the earpiece oscillator.

You may try other n-p-n transistors, although I found that not all of them would oscillate. The base lead is normally left unconnected but it could be used to modulate the generated sound.

Dom Di Mario
Milan
Italy
F44



Simple sounders use parasitic effects in transistors.



Hugh Mobberley reviews Don McLean's recent book on the work of Baird.

Restoring Baird's image

November this year will mark the 65th anniversary of what is commonly regarded as the start of BBC Television in 1936. However, most of us are unaware that BBC Television started with regular scheduled broadcasting over four years before – in August 1932 – on the 30-line television system developed by John Logie Baird in the late 1920s.

Why is this so rarely mentioned? Part of it may be to do with the sheer complexity of television's development: the story has been over-simplified to maintain the general public's attention. Part of it may also be to do with Baird's reputation, which steadily declined into the 1960s. Most likely though, it has to do with the sheer scale of the technological development of high definition television overshadowing all the earlier pioneering work.

So says a new book by Donald McLean, 'Restoring Baird's image,' published by the Institution of Electrical Engineers. This book makes an authoritative case for changing our thinking on early television in Britain, from the work of Baird all the way to the start of the 1936 high-definition service.

The author's credentials come from his unique restoration of several contemporary videodisc recordings made of 30-line television. These discs, covering the years 1927 to 1935, provide new reference points for the pioneering achievements of Baird and the quality of television programming in those early days. No images from these discs have previously been seen, with the later recordings of BBC TV entirely unknown until the late-1990s.

Baird's early concept for a videodisc player and display. This would have been an alternative money-earner for Baird – if it had worked.

The author's work of restoring these discs forms the core of the book. Written in terms that a layman can easily follow, the story of the restoration reads like an archeological dig or a forensic analysis from a detective story. The book allows us to share with the author his genuine excitement in seeing, for the first time, video images of Baird's well-known 'Stookie Bill' ventriloquist's dummy from 1927, of the high-kicking Paramount Astoria Girls from 1933 and of the contralto, Betty Bolton.

Historical images from the dawn of television are one thing, but the book goes one major step further. Embedded in the distortion and revealed by computer-based signal analysis, are the telltale signs of the type of camera and equipment that Baird used and the reasons why the recordings were unsuccessful.

It would be a mistake to judge this book solely on the restoration of the early videodiscs. The double meaning of the book's title, 'Restoring Baird's Image' covers both the literal restoration of video recordings and the figurative restoration of not only the image and stature of Baird but also of the engineering achievements of the 30-line Baird era. What makes this book a fascinating read is its historical coverage of the first decade of television.

Written in a conversational style, the book opens up this complex period in television's early history. The book goes a long way to help the reader appreciate the significance of these recordings and the era in which they were made.

It starts by taking us on an objective introduction to television's early history, identifying mechanically scanned television as another valid form of imaging that is of far more use today than it has ever been. A chapter on the development of videodisc and videotape recording - a rare sight in any television history book - describes how the 30-line recordings happen to be made 25 years before videotape and nearly 50 years before the videodisc player.

The achievements in the 30-line TV broadcast period before 1936 are quite a revelation. After sixty years of believing that no video recording of 30-line BBC TV existed, several discs turned up around five years ago. These video recordings were made on domestic aluminium disc audio recorders from 'off-air' broadcasts.

Akin to finding the proverbial needle in a haystack, the author has identified one of the discs as being a television special - the world's first television revue – transmitted by the BBC on 21st April 1933. Together with the other recordings, the book convincingly presents the evidence that 30-line BBC TV was in no way amateur, but was as professional and professionally produced as the later 405-line service became.

The book closes with a critical eye turned to the historians and documentary makers who have modified the history of television over the years. What separates this book from others covering the same period is its uniqueness and originality – it has both a new story to tell and illustrates an old story in a new and entirely authoritative way. Support from the leading experts on Baird, Ray Herbert and on videotape recording Martin Salter, assures the book's historical accuracy.

There are some 150 figures in the book, including 60 previously unpublished historic photographs and over 120 30-line images – the largest collection in any one publication. This is a TV historian's delight providing a refreshing 'new look' history in both words and pictures. The book's well-kept secret is that the author has painstakingly cleaned up the historic photographs, removing crease marks, scratches, dust specks and mould.

A visit to the author's website at http://www.dfm.dircon.co.uk reveals many of the restored video clips from the videodiscs which it was not possible to include in his book.

The rarity of many of these pictures together with the high quality of restoration and reproduction makes this, for just the photographs alone, an attractive book to buy.

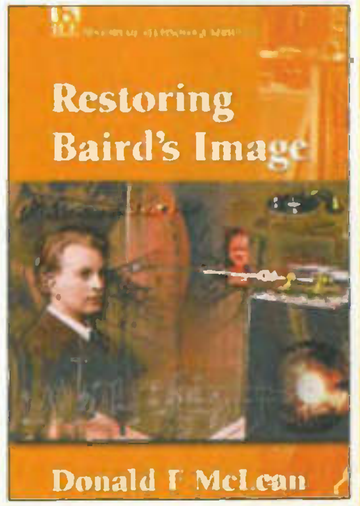
To quote from the Foreword, John Trenouth of the National Museum of Photography Film and Television, describes the author's work is "an outstanding example of industrial archaeology." ■

John Logie Baird

One of the book's hidden secrets: not content with restoring the early videodiscs, the author has also restored all the historical photographs in the book.

A copy of Restoring Baird's Image can be obtained by sending a cheque for UK Price £32.00 Europe £34.00 ROW £36.00 To Jackie Lowe, Cumulus Business Media, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey, SM3 8BZ.

Cheques should be made payable to Cumulus Business Media



Winners!

The third winning entry from our ZXF36L01 design competition, announced in the March 2001 issue. All three winners will be receiving a voucher, redeemable at Farnell Electronic Components. Winner David Flatt receives a voucher for £500, the runners up, Mike Button and S. Vijayan Pillai, will receive vouchers of £100 each.

Many thanks to all of you who entered. We hope to publish some of those entries in the near future. All entrants will receive a cheque covering the cost of the Zetex development system.

For more details on the ZXF36L01 filter/mixer, take a look at the March 2001 issue.

Receiving multi-band pulsed ultrasonics

When receiving ultrasonic signals, band limiting helps reduce noise problems. With a wideband receiver, multiple bands are normally used, ramping up the number of components needed. £100 Farnell voucher winners S. Vijayan Pillai and S. Subash have devised a method for reducing the number of components using the mixer and oscillator features of the ZXF36L01 at the front-end of an ultrasonic receiver.

In an ultrasonic system, where a pulsed transmission of narrow band signal is involved, band-limiting the received signal reduces noise problems. Normally, band limiting is achieved by splitting the band right from the hydrophone level. This involves more hardware and sensors.

Wide-band hydrophones with built-in amplifiers are available covering 2 to 80kHz. One example is a wide-band ultrasonic sonar system whose useful range extends from 2 to 80kHz.

In the scheme described here, a ZXF36L01 does the band sampling. As a result, only one sensor and one a-to-d conversion are necessary.

Output from this system is in band-serial, bit-parallel form. The expected signal has a minimum pulse duration of 5ms. Band processing in time is done for 2 to 85kHz, as shown in the **Table**.

Band sampling is done at every 0.5ms. The first 1.5ms is used for the lowest band and is separately processed. Since the converted band is limited to 19kHz, the sampling frequency of 64kHz is sufficient. A multi-channel processing scheme can be applied to the digital signal, **Fig. 1**.

Both mixer and band-pass filter can be realised using one ZXF36L01. An outline of the implementation is shown in **Fig. 2**.

For:

F_o=14kHz, R=10kΩ, C=1000pF

select R_f and R_i for a Q of 1.4. These components are

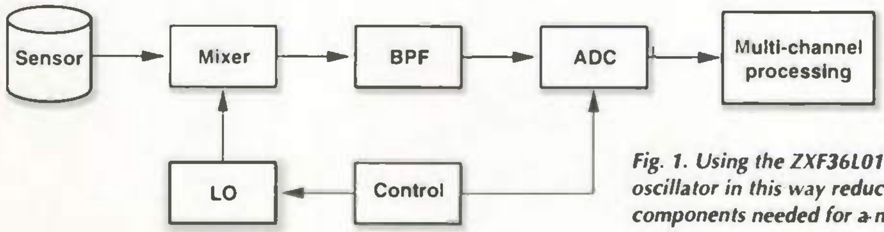


Fig. 1. Using the ZXF36L01 as a mixer and local oscillator in this way reduces the number of components needed for a multi-band sonar receiver.

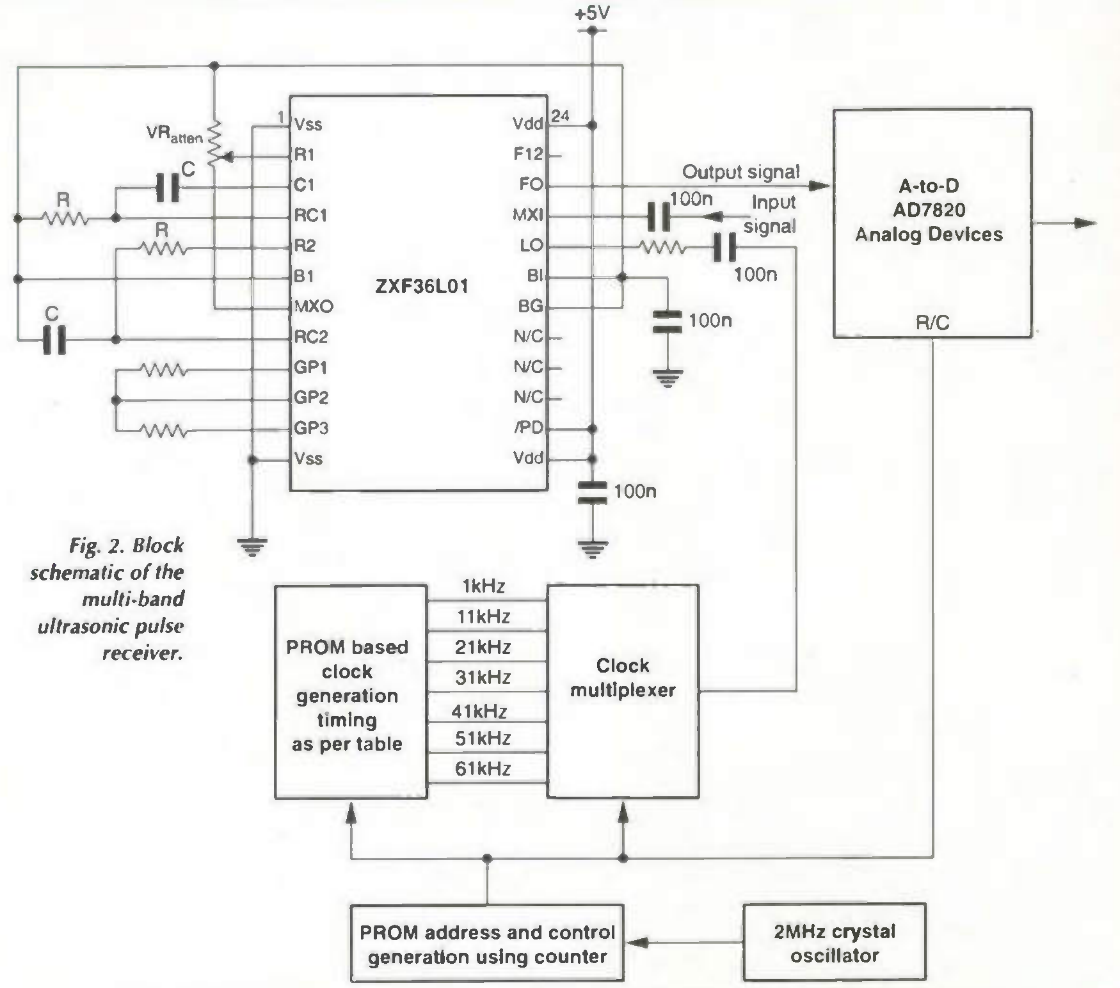
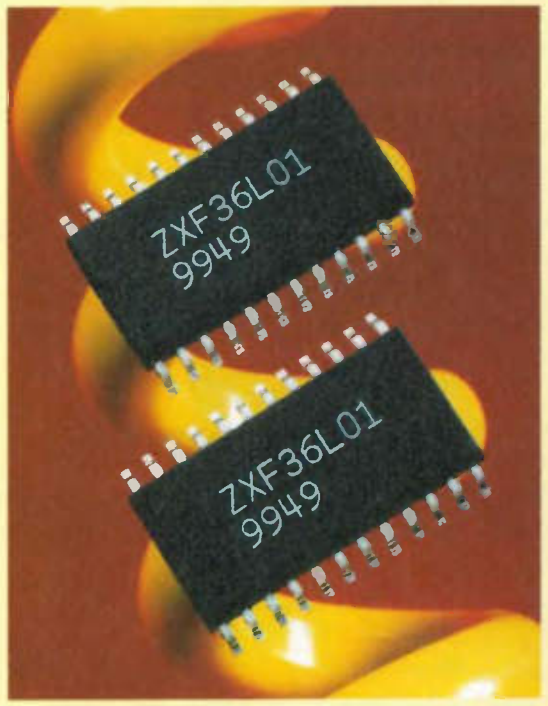


Fig. 2. Block schematic of the multi-band ultrasonic pulse receiver.

Launched this year, the ZXF36L01 is a versatile high-Q band-pass filter requiring a minimum of external components. In addition to the variable-Q analogue filter there is also a mixer block, making the device suitable for a wide range of applications.

A designer's kit is available from Farnell and you can find full data on the device on Zetex's web site http://www.zetex.com/pdf/ics/zxf36101.pdf.



COMPETITION

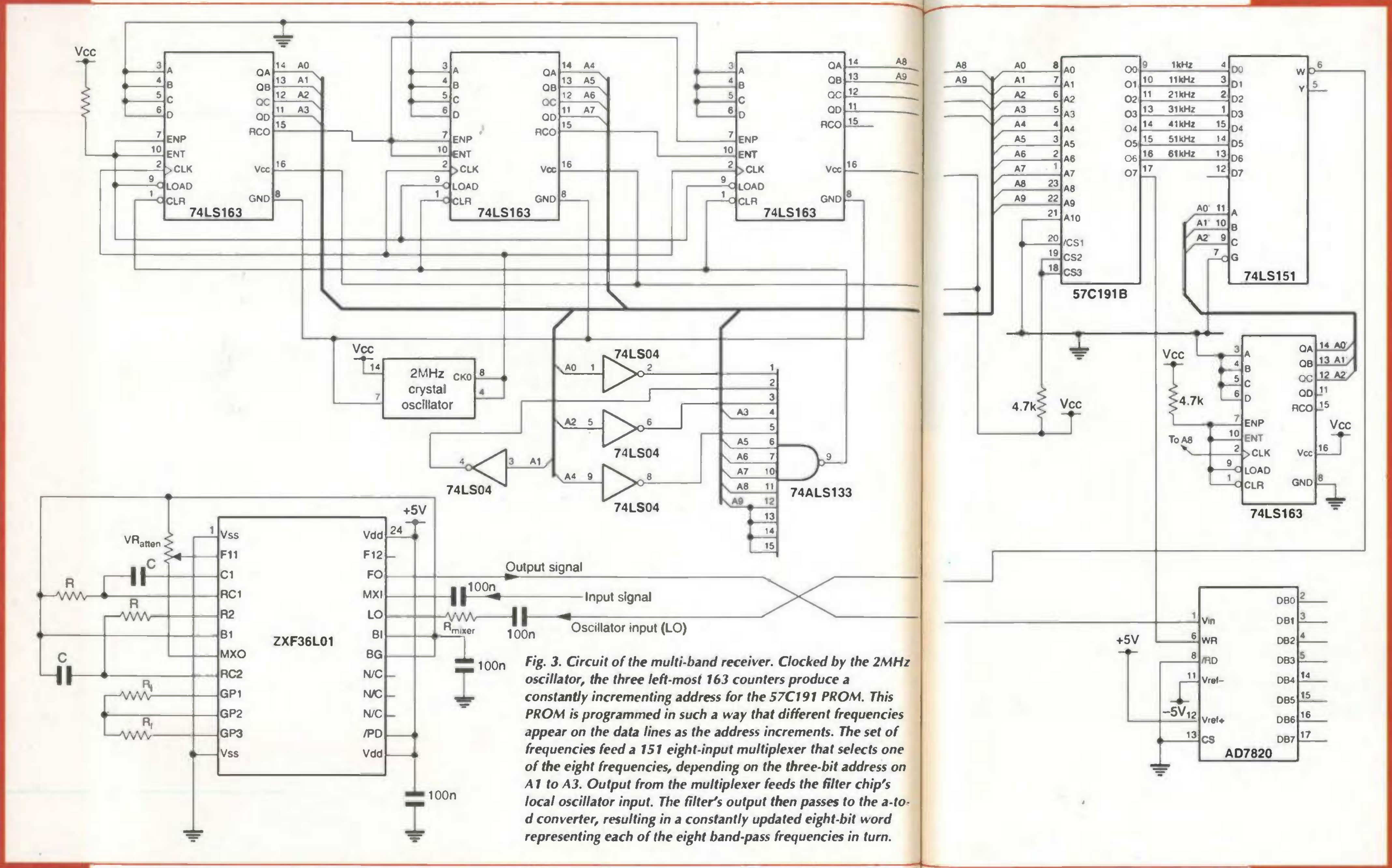


Fig. 3. Circuit of the multi-band receiver. Clocked by the 2MHz oscillator, the three left-most 163 counters produce a constantly incrementing address for the 57C191 PROM. This PROM is programmed in such a way that different frequencies appear on the data lines as the address increments. The set of frequencies feed a 151 eight-input multiplexer that selects one of the eight frequencies, depending on the three-bit address on A1 to A3. Output from the multiplexer feeds the filter chip's local oscillator input. The filter's output then passes to the a-to-d converter, resulting in a constantly updated eight-bit word representing each of the eight band-pass frequencies in turn.

shwon in **Fig.** 3. Since the local-oscillator clock is direct TTL output, use a value of 1kΩ for R_{mixer}.

Chose *R_attn* depending up on the signal input.

Table. Band processing in time for 2 to 80kHz.

Time (ms)	Band (kHz)	LO (kHz)	Band shifted to (kHz)	Filter	Filter Q_{eff}
0-0.5	2-10	X	2-10	X	X
0.5-1	10-20	1	9-19	14	1.4
1-1.5	20-30	11	9-19	14	2.5
1.5-2	30-40	21	9-19	14	3.5
2-2.5	40-50	31	9-19	14	4.5
2.5-3	50-60	41	9-19	14	5.5
3-3.5	60-70	51	9-19	14	6.5
3.5-4	70-80	61	9-19	14	7.5

PROM frequency synthesiser

The PROM is a WS57C191B. This is a standard 24pin DIP slim package manufactured by Waferscale Integration. Inc. It is used as a frequency synthesiser.

An address is fed to the PROM once per microsecond and the three interlinked 74163 counters are cleared at every 1000μs. They cycle from 0 to 1000, addressing 1000 unique locations in the PROM.

If, for example, 1kHz at pin 9 of the PROM is needed, logic zero is stored in the first

$$\frac{1000000}{2\times1000}=500$$

locations and then logic one to next 500 locations at the LSB (output O0) bit position of the PROM.

Similarly if 11kHz is needed at pin 10, store logic zero for the first,

$$\frac{1000000}{2\times11000}=45$$

locations, logic one in the next 46 locations, logic zero in the next 45 locations, logic one in the next 46 locations, and so on until 1000 locations are filled at the O1 output bit position of the PROM.

Other frequencies can be created at outputs O2 to O7 of the PROM in the same way. At the O7 bit position, the frequency to be generated is 64kHz, which is given as a sampling clock to the a-to-d converter. ■

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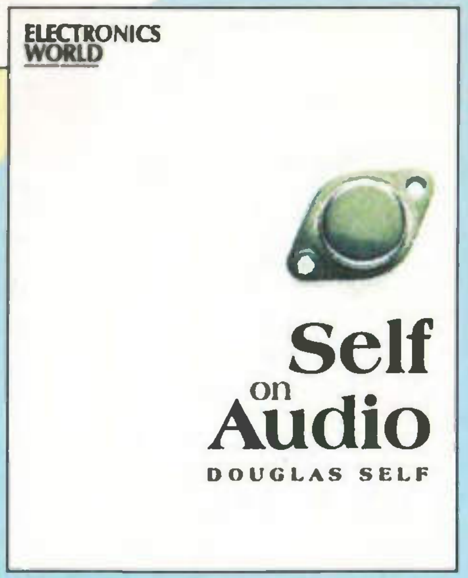

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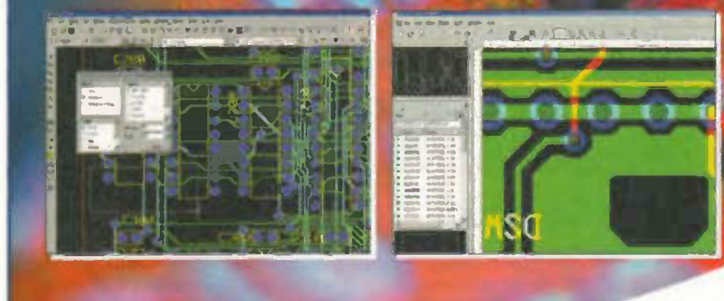

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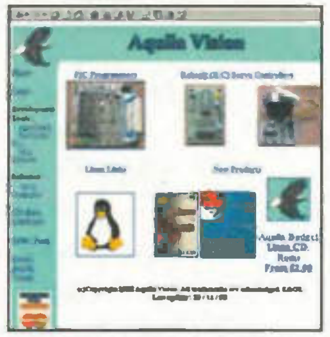

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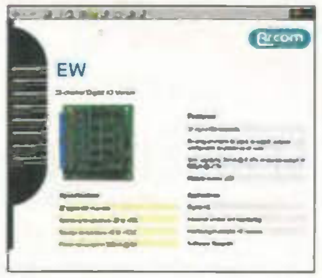

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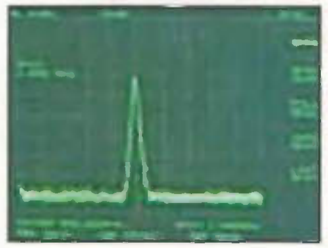

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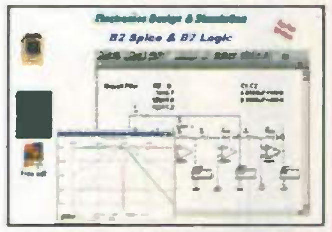

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Ian Hickman describes a simple opto-electronic link with enough bandwidth to carry speech. It was designed so that a group of students could make it up in a couple of hours. In its basic form, the link's working distance is limited, but it is easily modified for building-to-building use – or even further.

Beginners' corner

An optical speech link

This simple all analogue opto-electronic link conveys speech from a transmitter station, via a pulse modulated light beam, to a receiver, as in **Fig. 1**.

At the send end, the output of a microphone is amplified, and then applied to a pulse generator arranged as a modulator. The pulse train output of the modulator carries the speech signal as variations in mark/space (on-off) ratio. This mark/space modulated speech signal drives a light-emitting diode.

At the receive end, a photodiode detects the light pulses and produces a corresponding output – albeit tiny. This is amplified by an op-amp, connected as a transresistance amplifier. It is then further amplified by a second inverting op-amp stage.

Output from the second amplifier is applied to a low-pass filter. This filter acts as a demodulator, thus recovering the original speech signal.

For convenience, the output was monitored on an existing laboratory amplifier or 'squawk box' – one of those endlessly useful pieces of kit that's a must in any electronics laboratory.

The transmitter circuit

To feed the transmitter, **Fig. 2**, I used a very ordinary moving-coil microphone with an output resistance of 2000Ω. It was connected directly to the non-inverting input of an op-amp, one section of a TL084 quad op-amp.

A single op-amp would of course have sufficed. However, a quantity of quad op-amps had been made available for the students to experiment with under the RFEEI scheme, described in an earlier article.

With a 10MΩ feedback resistor, the voltage gain of the op-amp was 10 000 000÷2000=×5000, or 74dB. Open-loop gain of the TL08x series devices is typically ×200 000, and in any case not less then the ×25 000 minimum figure, so the actual gain is very close to the theoretical figure.

Besides amplifying the signal by the stated amount, of course, it also amplified the op-amp's input offset voltage by the same figure. As it happened, the op-amp used had a very small offset voltage, but the maker's maximum figure for the device is 15mV. Such a worst-case op-amp would not be usable in the circuit as shown, as its output would be 'stuck' hard at the level of one or other supply rail.

The speech signal output from the op-amp was applied, via 100kΩ resistor R_2, to the pulse generator/modulator. This modulator used one section of a CD40106 hex inverting Schmitt trigger.

Voltage at the inverter input, pin 1, rises as R_3 charges C_1 up, towards the supply voltage V_{cc}. When the voltage reaches the trigger's upper threshold, the output at pin 2 switches abruptly from V_{cc} to 0V (ground). Capacitor C_1 is then discharged via R_4 and D_1, until the voltage at pin 1 falls to the lower threshold. At this point, the output switches back to V_{cc}, the level of the supply at pin 14, and the action repeats.

The result is a pulse train at about 18kHz, with a mark/space ratio of about 2:1. This frequency is barely out of the audio range, but certainly beyond my hearing – and, I suspect, beyond that of most if not all of the students.

Fed via R_2, the speech signal voltage at the output of the op-amp

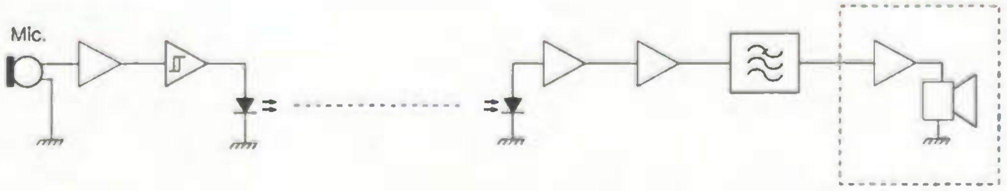

Fig. 1. Outline of an opto-electronic speech link. Speech from the microphone is amplified then modulated before being applied to the transmit LED on the left. Very small signals received via the photodiode feed a transresistance amplifier, which in turn feeds a second amplification stage before demodulation.

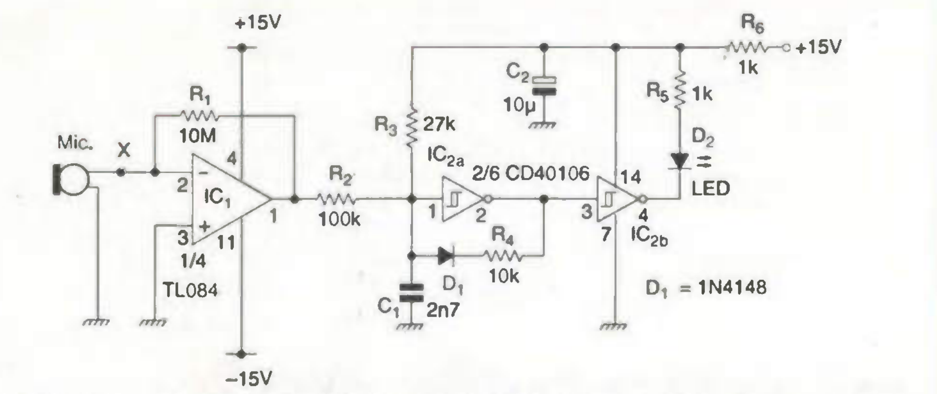

Fig. 2. Opto-link transmitter circuitry with, from left to right, the microphone and its amplifier, the modulator, and finally the transmitter LED together with its buffer/driver.

affects both the pulse-repetition frequency, or prf, and the mark-space ratio. When the voltage rises, the prf increases and the mark-space ratio decreases. When it falls, the prf decreases and the mark-space ratio increases. The change in frequency is immaterial, as far as operation of the link is concerned, the useful information being carried by the mark-space ratio.

The modulated pulse train is applied to another section of the CD40106. This device is used as a buffer to drive the light emitting diode D_2, the current being limited by series resistor R_5.

At the receiving end

At the receiver, **Fig. 3**, the photodiode D_3 is aligned with the transmitter's light emitting diode D_2, so as to detect the light pulses. These are amplified by op-amp IC_{3a}, connected as a transresistance amplifier. In this configuration, the photo-current generated by the diode is balanced by the current fed back to the inverting input via R_7.

Increasing the value of R_7 gives a greater output voltage for a given amount of light falling on the diode. There is a limit to how much R_7 can be increased though. The self capacitance of the photo-diode and the op-amp's input capacitance, together with R_7, form a low-pass filter. This filter action limits the circuit's frequency response.

Further gain is provided by IC_{3b}. This amounts to 40dB or ×100, defined by the ratio of R_9 to R_8. Output from IC_{3b} is applied to the simple first order low-pass filter formed by R_{10} and C_4, the cut-off frequency being about 5kHz. This largely smoothes out the 18kHz pulses, leaving a waveform whose instantaneous value reflects the current mark-space ratio, i.e. the original speech waveform. This signal was then applied to the lab. amplifier.

The ins and outs of 'system integration'

The students worked in two groups. One group built up the kit of Fig. 2, the other that of Fig. 3. The circuits were built up on experimenters' plug-board, with component leads bent over and plugged in wherever convenient.

I suggested that each circuit block be built up and got working in turn, rather than connecting up the whole circuit, and then trying to get it working. Thus in Fig. 2, the pulse generator of IC_{2a} was built first, then the IC_{2b} circuitry was added.

Next, the microphone and IC_1 were connected up, and the resultant offset at pin 1 measured. As this was only a volt or so, the circuit was deemed to work. Adding R_2 completed the transmitter section. Had the output offset been excessive, a capacitor of, say, 100nF, would need to be inserted at point X.

Similarly, at the receive end, IC_{3a} and the photo-diode were connected up, and operation checked by alternately shielding the diode from room lights, and flashing a torch at it. The IC_{3b} circuitry was then added, and then the low-pass filter.

Finally, with the lab. amplifier connected, the operation of the system overall was checked. Speaking into the microphone at one end of the link produced clear and distinct speech out of the lab. amplifier at the other; indeed, if the gain of the lab. amplifier was set too high, the system would 'sing round', as the microphone was able to 'hear itself' from the other end of the link.

An ordinary high-brightness RED diode was used for the transmitter. The photo-diode was a standard small silicon variety. With the aid of a simple lens, the range could be increased to the length of two laboratory benches.

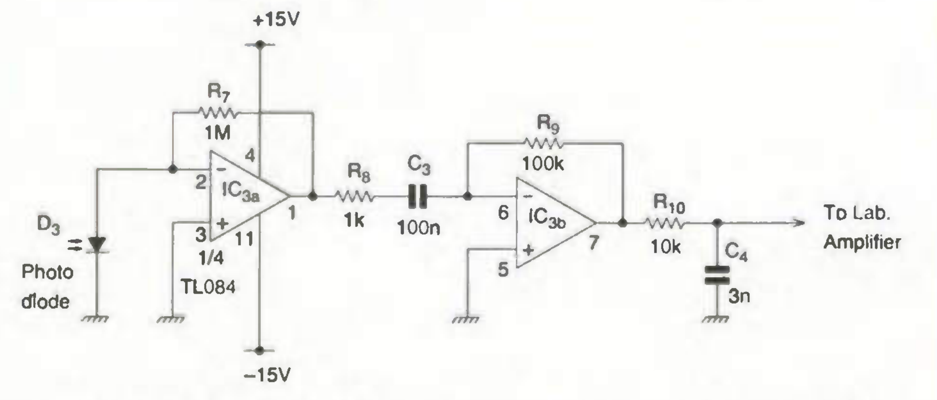

Fig. 3. Receiver circuitry for the optical speech link. The signal from an ordinary photodiode is amplifier in two stages. A simple low-pass filter provides demodulation, final output being the original speech signal. This signal is still at a low level so further amplification is needed before a loudspeaker can be driven.

Increasing the range

Various steps are available for increasing the range. The most obvious is to increase the drive to the LED, by reducing the value of R_5. This is possible, if the other unused inverters in the CD40106 are connected in parallel with IC_{2b}.

Brighter LEDs than that used are also now available. The other way of increasing range is to arrange that more of the light emitted by the LED falls on the active area of the photo-diode, as detailed below.

With a wireless communication system, the range is determined by the available 'effective radiated power' at the transmitter, and the sensitivity at the receiver. The effective radiated power at the transmitter can be increased, in the desired direction of communication and at the expense of other directions. This can be done using a transmitting antenna with directional gain.

Likewise, at the receiver, a further improvement can be achieved by using a directional antenna aligned with the transmitter.

At frequencies in the HF band, up to 30MHz, it is difficult to achieve a large improvement with directional antennas, as they would need to be very large. At VHF and UHF directional gains of 6 to 15dB are possible with Yagi antennas – more with antenna arrays.

At microwave frequencies, where dish antennas are used, gains of around 40dB can be employed. Even higher gains are possible at optical frequencies. The equivalent of a directional antenna here can be either a refractor (a lens), or a reflector.

Suitable high-quality optics are in fact available, for a very modest price, now that camcorders have rendered 8mm cine cameras obsolete. Somewhere lurking in a cupboard I have a Bolex cine camera with a two-lens turret (Kern-Paillard normal and telephoto). This took over from a Bell and Howell camera with a three-lens turret (Taylor Hobson normal, telephoto and wide angle, also lurking).

The telephoto lenses in particular, Yvar 1:2.8 and Serital 1:1.9, offer the possibility of spectacular signal gain, permitting building-to-building communication. The disadvantage is that alignment them becomes critical.

Such communication should be possible – even in daylight – thanks to the remarkable linearity of silicon photodiodes used in the photoconductive mode as in Fig. 3, rather than photovoltaic mode.

Simple ac coupling of the photo-diode amplifier output may be adequate to reject the constant background output due to daylight. When seeking maximum range though, a high value feedback resistor is involved so the background light may saturate the op-amp.

In this case, the scheme shown in **Fig. 4** can be used[1]. This scheme rejects the unwanted output. The auxiliary op-amp monitors the output, and feeds back a current cancelling out the large constant photo-diode current due to daylight, thus driving the average output voltage to zero.

The feedback is ineffective above a certain frequency – around 16Hz with the component values shown – and so the wanted pulse train carrying the desired intelligence is unaffected. ■

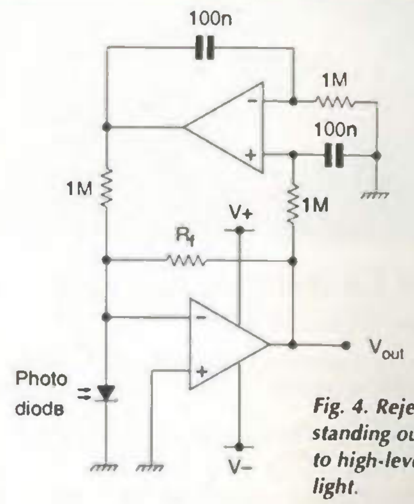

Fig. 4. Rejecting the standing output due to high-level ambient light.

Reference

1. Burr-Brown Application Bulletin AB-061.

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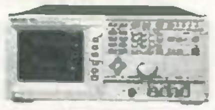

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