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Planar resistor design

Wireless 32-channel voltmeter

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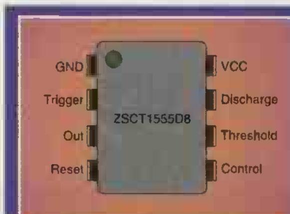

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Analysts rush in...

No group of people made themselves look more foolish in 2000 than the financial analysts. At the beginning of the year they valued high-tech companies so extravagantly that organisations like ARM and Bookham were propelled into the FTSE 100 of the UK's most valuable companies.

By the end of the year, these values had been decimated. Yet the companies involved were doing very nicely, thank you, in executing their business plans. It wasn't the businesses that had changed – it was the analysts' views of them. The analysts were fools in Q1 or fools in Q4 – they can take their pick.

To an extent, the hysterical nature of the analysts can be blamed on the attitude of their employers – stockbrokers, investment banks and the like – who require them to produce recommendations which 'churn' stock i.e. which make people want to buy or sell stock, so that the employers can make a commission on the deal.

On the other hand there's also the inexperience - and sometimes even the stupidity – of the people involved. As one ceo puts it: "As long as 23 year-old analysts spit out bad stuff, there's a problem with market perceptions - if they only realised the explosion happening in electronics!"

Some analysts are confused because they are employed to study the industrial world in sectors, and assume that the trends in a sector apply to every company within it, whereas different companies within a sector can operate in different markets, and perform in accordance with different industrial and technological cycles.

So it could be that the '23 year-olds' look at bad figures from Intel, Apple, Dell and Microsoft and think: 'High-tech's a bummer,' when what they should be concluding is: 'The PC business is a bummer'.

But the PC business should not be seen as an indicator of the state of the electronics industry. The commoditisation of the PC, with fewer people willing to upgrade regularly, while mainstream PC prices are dropping in line with Moore's Law, spells the end of the PC's role as the main driver of growth for the electronics industry.

"People seem to be surprised that Intel, which is tied to the PC industry, puts out these warnings about reduced growth", says Malcolm Penn, chairman of Future Horizons, "but it's obviously going to grow slower than the rest of the industry. The PC industry is growing at half the rate of the semiconductor industry".

Dataquest not only predicts slowing growth in the value of semiconductors going into PCs, but forecasts an actual decline in the market for semiconductors for PCs starting in 2002.

In 2000, for the first time since the 1980s, the main chip types which go into PCs – CPUs and DRAMs – grew by less than the industry average

By contrast, chips for applications such as mobile phones, digital consumer,car multimedia, storage, smart card and networking are growing so fast that they will represent 40 per cent of the chip market in 2004.

So the PC industry's problems should not be taken as symptomatic of the state of the electronics industry as a whole. The only thing that can save the Intel PC business model of constant upgrading via more powerful processors, extra DRAM and more elaborate software, is the rapid deployment of inexpensive xDSL and cable modem installations giving the opportunity for more services to be offered to users.

However, despite EU regulations opening up all European markets to local loop unbundling in 2001, Dataquest is pessimistic about domestic adoption of DSL and cable modems, estimating that, in 2005, only 8 per cent of Internet PC connections will be broadband through xDSL or cable modems

Instead, mass market broadband connectivity may come to the mass market via the TV using low-cost, or free, 'Internet Appliances' bundled with attractive entertainment, new services and interactivity.

Such appliances could prove to be the deathknell of the PC's aspirations to be the central device in a connected world. ■

David Manners

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£7m funding for independent research into mobile phone hazards

The UK's biggest ever investigation into the possible health effects of mobile phone use will see the Government and industry ploughing £7m into an independent research programme.

Industry will provide 50 per cent of the funding for the independent programme over the next three years.

There is still no proven scientific link between mobile phone use and potential health problems but the amount of research being done around the world is growing.

Speaking at the 'Mobile phones – is there a health risk?' conference last week was Dr Sheila Johnston, neuroscience consultant to the UK mobile phone industry. "There is a lot of research but the problem is a lot of people don't understand it. The gap right now is in human research," said Johnston who believes this is where the latest programme will be concentrated.

"There is no question that microwave radiation can be hazardous to human health," said James Lin, professor of Bioengineering at the University of Illinois. "The question is how hazardous is it?"

Concerns about negative results from the investigation being quashed, as happened with the BSE mad cow saga, were dismissed by Michael Repacholi of the World Health Organisation. He believes the lessons have been learnt: "The UK Government is BSE sensitive which may even cause an over reaction in the EMF (radiation) situation."

Leaflets setting out advice on the use of mobile phones will also now be included with every new phone as recommended by the independent Stewart report in May.

The advice includes keeping calls short, especially for those under 16, not using a phone while driving, and considering the SAR (specific absorption rate) value of phones when choosing a model. However, the standard method of measuring SAR is not expected to be set until the middle of next year.

Melanie Reynolds

UK-based mobile phone start-up warns rivals that it's "not just another wannabe"

UK-based start-up Sendo is set to take on the big mobile phone manufacturers in the European market by targeting the network operators.

"The operator is the key purchaser, the key decision maker, in what gets to market," said Hugh Brogan, CEO. "The operators are looking to retain customers, they're looking to differentiate themselves."

Brogan believes the company is ideally placed to meet this need by offering unique physical designs and customised software. Its manufacturing technique also means it can ship products within 48 to 72 hours.

A basic electronics module is manufactured in China and shipped to the Netherlands. On receipt of a customer order the module is programmed and the casing is fitted to completely enclose the module.

The first product, announced in Italy last week, is "technologically advanced" according to Brogan: "We want to show we're not just another wannabe."

The company is aiming to sell a "few million" phones in the first year and said sales of less than 500 000 would be enough to break even. In the UK, the first products should be offered through Virgin Mobile.

Sendo was founded in August 1999 with an initial $10m of funding from Hong Kong telecoms company CCT. Since then CCT has invested a further $25m and owns 35 per cent of the company. Brogan said its present plans did not require further investors but if it "bagged a big deal" then more cash will be needed.

Sendo is aiming to sell a "few million" phones in the first year and said sales of less than 500 000 would be enough to break even.

Bluetooth gets a five-fold boost

TDK Systems has announced a Bluetooth product that operates at a distance up to five times greater than required by the specification.

The mobile communications specialist's Bluetooth PC Card can connect to another Bluetooth device up to 50m away while the specification requires operation at 10m. TDK said this performance is achieved by using new ceramic antenna and input technology.

The card is expected to ship in the first quarter of next year.

The company is also developing a next generation Bluetooth /10/100 Ethernet PC card to combine fixed LAN connection and wireless Bluetooth in one PC card slot.

It has been working in partnership with UK-based Cambridge Silicon Radio.

A reprieve for Moore's law?

Researchers from Purdue University in the US have developed a transistor they claim could keep Moore's Law running until 2025.

A simulation tool showed that the double-gate transistor works as well as a conventional device down to a tenth of the channel length. A gate would function easily down to 10nm. "If we could learn how to manufacture a device like this we could extend Moore's Law to the year 2025," said Professor Mark Lundstrom from purdue.

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- trimming tools

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Readers outside Europe, please add £2.50 to your order.

Specifications

Switch position 1

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

Switch position 2

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

Switch position 'Ref'

Probe tip grounded via 9MΩ, scope i/p grounded

UK is set to participate in European MEDEA+ research plan

Britain is to join MEDEA+, the Europe-wide research programme which starts in January, extending the existing scheme by eight years.

A spokesperson from the Department for Trade and Industry said: "The UK will formally join MEDEA+ this January, and it's our intention to fund suitable projects."

European companies such as Philips and STMicroelectronics have benefited significantly over the last decade from MEDEA and its predecessors.

Of the 9400 man-years of research in the original MEDEA programme, only 16 came from UK firms.

While companies based in the UK were eligible, no applications for funding were made, the DTI said. This was probably due to restrictive Eureka rules.

In addition, the DTI cited limited demand for MEDEA in the UK: "The UK has a substantial semiconductor manufacturing industry, but most of the large companies are inward investors who do R&D in their own countries."

As inward investors change their attitude and opt to carry out research in the UK, they may choose to apply for funding.

"We are in negotiation with a number of companies including large ones," the DTI said.

The Government will also encourage small and medium sized firms to enter the programme, which will be worth a total of ¤4bn over the next eight years.

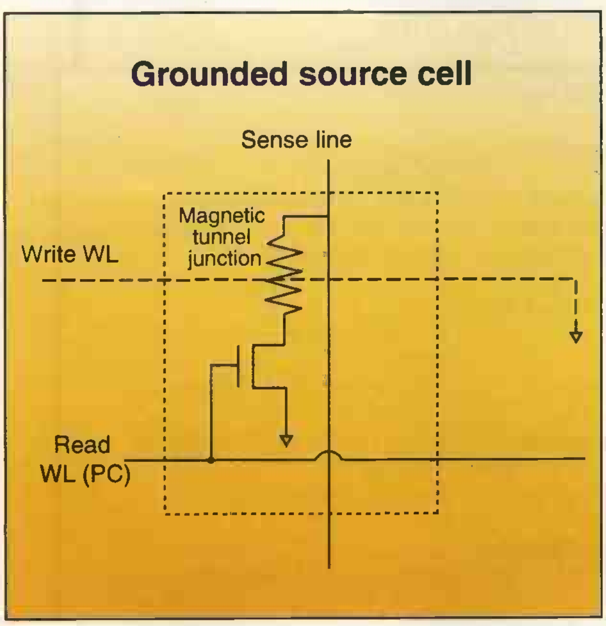
Richard Ball

Magnetic memory comes closer to reality as IBM and Infineon agree collaboration

Magnetic memory has taken a step closer with a joint development agreement between IBM and Infineon.

The two firms are to take MRAM research and develop it for production. IBM will combine its well-developed MRAM technology with Infineon's ability to manufacture high density memory.

Commercially available products – both embedded memory and stand-alone chips – are expected by 2004. MRAM, with the desirable traits of being fast, small, having a non-destructive read, being non-volatile and easy to integrate, sounds like the ideal technology.



IBM has offered glimpses of its MRAM technology over the past year at various technical conferences. At ISSCC earlier this year the firm detailed its core technology.

IBM is using a magnetic tunnelling junction (MTJ) to store data. Two electrodes of magnetic material, such as nickel/iron or cobalt/iron, sandwich a thin aluminium-oxide tunnelling layer.

Information is stored as magnetic polarisation – not as a charge. When the two magnetic electrodes have the same polarisation, there is more chance of electrons tunnelling through the aluminium oxide layer, so its resistance is reduced by 20 to 30%.

By changing the magnetic polarisation of one layer, resistance is increased. This resistance is sensed using a FET.

"For 15 years or so people have been trying to use magneto-resistive materials," Roy Scheuerlein, a researcher at IBM, said earlier this year. But previous MRAMs used serially-linked MR blocks which reduced sensitivity.

"The MTJ, and the way we use it in the cell, is dramatically better," said Scheuerlein. "The power required to read is 10^5 times better than GMR [used in hard disk drives]." Resistance of the cell is around 2.5kΩ compared with about 10Ω for a GMR head.

"We can build this on standard CMOS. It looks somewhat like a DRAM cell," Scheuerlein said.

Which is where Infineon comes in to the picture. It will apply its expertise in building large memory arrays – as it does with DRAM today.

IBM has already produced a 1Kbit test chip made using a standard 0.25µm CMOS. It claims to have achieved 10ns access time from address input to data output. Using higher performance sense amplifiers, IBM has brought this down to 3ns. At the cell level, writing bits takes a time of less than 2.5ns.

However, MRAM is not the perfect memory. It is not as small as DRAM, but is a lot smaller than SRAM, It's not as fast as SRAM, but is quicker than both DRAM and flash.

IBM and Infineon are sure to come up against some significant hurdles in moving to production. MRAM's non-volatility may well be the attribute that forces it through to volume production.

PCB buyers hit by material shortfalls

Material shortages are causing serious problems for electronic equipment manufacturers, according to analysts Purcon-iPro. The shortages, combined with rising prices and lengthening lead times means that buyers of PCBs face a shortage. Purcon-iPro said there are all the signs that it is currently a sellers market.

Government announces dramatic shake-up plans for comms regulation

The Government has announced in a White Paper the biggest shake-up of communications and broadcast regulation for a decade.

A single regulator for the entire industry will be created including the current responsibilities of Oftel to be called the Office of Communications (Ofcom).

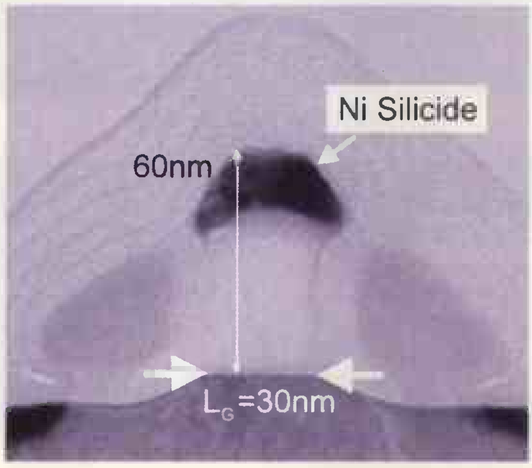
The White Paper also holds out the prospect of Government cash being used to accelerate the introduction of broadband technology like ADSL. It suggests there may be a case to require higher bandwidth services to be made universally available in an attack on the slow pace of change in unbundling the local telephone network.

"We will promote the availability of widespread access to higher bandwidth services and we will look for ways to build on the public investment that is already being made in broadband and consider whether public support is needed to help research and develop new high-speed networks," said the White Paper.

In a joint statement Culture Media and Sport Secretary Chris Smith and Trade and Industry Secretary Stephen Byers said: "Our goal is to make the UK the safest and most reliable place to use the new communications services."

Transistor has a gate just three atoms thick

Intel researchers have made transistors with gate lengths of 30nm and using a gate dielectric just three atomic layers thick. The firm expects to be using these devices in as little as five years.



Clock speeds will reach 10GHz operating from a sub-1V supply. Moreover the transistor's design is compatible with current IC techniques.

"Many experts thought it would be impossible to build CMOS transistors this small because of electrical leakage problems. Our research has proven that these smaller transistors behave in the same way as today's devices and shows there are no fundamental barriers to putting them into high volume in the future," said Intel's Dr Gerald Marcyk.

The company reckons Moore's Law has at least ten years of life. "As our researchers venture into uncharted areas beyond the previously expected limits of silicon scaling, they find Moore's Law still intact," said Intel v-p Dr Sunlin Chou.

£128m for science fund

Photonics and communications technology research at universities will be benefit from an injection of Government cash into scientific research.

A total of 28 research projects at universities across the country will get a share of £128m, which will be managed jointly by the Department of Trade and Industry and the Wellcome Trust.

Inevitably biochemistry, DNA and medical research dominate the project list but there is also room for some projects related to microelectronics, photonics and multimedia.

Semiconductor analyst predicts downturn in 2001

The semiconductor industry will turn down next year, according to IC Insights, the Arizona semiconductor industry analyst.

"Over the past 30 years, the IC industry has encountered six boom-bust cycles," said the analyst's report, "the downturn portion of an IC industry cycle is usually triggered by global economic recession, IC industry overcapacity, or IC inventory corrections. In 2001, IC Insights believes that the IC industry will be affected by all three 'triggers'."

For this year, the company is predicting 35 per cent growth for the semiconductor industry and 79 per cent growth in the semiconductor production equipment industry.

In the UK, Malcolm Penn, chairman of analysts Future Horizons, attributed the Q4 downturn to over-expectations by PC makers leading to inventory sell-offs. "The PC industry is growing at half the rate of the semiconductor industry," said Penn, "people seem to be surprised that Intel, which is tied to the PC industry, puts out these warnings about reduced growth. But it's obviously going to grow slower than the rest of the industry."

Dataquest not only predicts slowing growth in the value of semiconductors going into PCs, but forecasts an actual decline in the market for semiconductors for PCs starting in 2002.

IC Insights reckons semiconductor production capacity will grow 24 per cent this year but less than 10 per cent next year. It reckons the 'inventory burn' – the selling off of semiconductors surplus to requirements – will continue until mid-2001.

"Worldwide GDP is forecast to slow from 4.8 per cent growth in 2000 to 3.5 per cent or less in 2001," says IC Insights, "although not a worldwide recession, the reduction in growth will negatively impact electronic system sales in 2001."

The result of that is over-stocking of components which, says the company, usually results in pricing weaknesses which are expected to persist throughout the first half of 2001.

The report ends optimistically: "After modest growth in 2001 and 2002, IC Insights expects the IC market to increase 20 per cent or more beginning in 2003." ■

David Manners

Wireless

32-channel voltmeter

You can read up 32 analogue voltages accurately via four individual remote a-to-d converter modules using Pei An and Ping Hua Xie's wireless data logger system. The central control station links to a PC via its COM port and each channel is read with 12-bit resolution.

This system allows a computer to measure up to 32 voltages remotely via a 433MHz radio link. It consists of a central station connected to the RS232 port of a computer and up to four wireless remote data loggers having different addresses.

Each logger has eight analogue input channels with an analogue-to-digital conversion accuracy of 12 bit. The measuring range is 0 to 2.5V.

Within buildings, the radio can operate at up to 30m, or 120m over open ground, **Fig. 1**.

Main elements of the system

The central station connects to a PC's RS232 port. Its function is to receive commands from the computer, to broadcast the message to remote data loggers, to receive data sent back by remote loggers and finally to send the data back to the computer.

A Microchip PIC16F84 is at the heart of the central station. An RS232 transceiver and a Radiometrix radio packet controller take care of the wireless interfacing, **Fig. 2a)**.

Each remote data logger is a stand-alone device located within the radio range of the central station. Up to four loggers can be used, each with a unique address of 0, 1, 2 or 3.

A PIC16F84 controls the logger. An eight-channel MAX147 a-to-d converter is used for measuring analogue voltages. This converter has 12-bit resolution. Further radio packet controllers handle the wireless data transfer, Fig. **2b**).

How it works

At power-up, the central station reads data from its RS232 interface to see if the computer has sent a command. At this stage, its radio transmitter is switched off.

To read eight analogue voltages from a particular remote data logger, the computer first sends a stream of commands to the central station. These commands incorporate an address byte specifying which remote logger will receive them. Then the central station broadcasts the message. Next, the central station listens to a reply from the addressed data logger.

Immediately after power-up, all the remote data loggers are in listening mode, waiting for a valid radio-frequency signal. Once the message broadcast by the central station is received by the RPC, the PIC on the data logger checks whether the current data logger is addressed by comparing the received address with its own.

If the logger is not addressed, it just goes back to listening mode. If the logger is addressed, the PIC reads data from the eight-channel a-to-d converter. It then writes data to

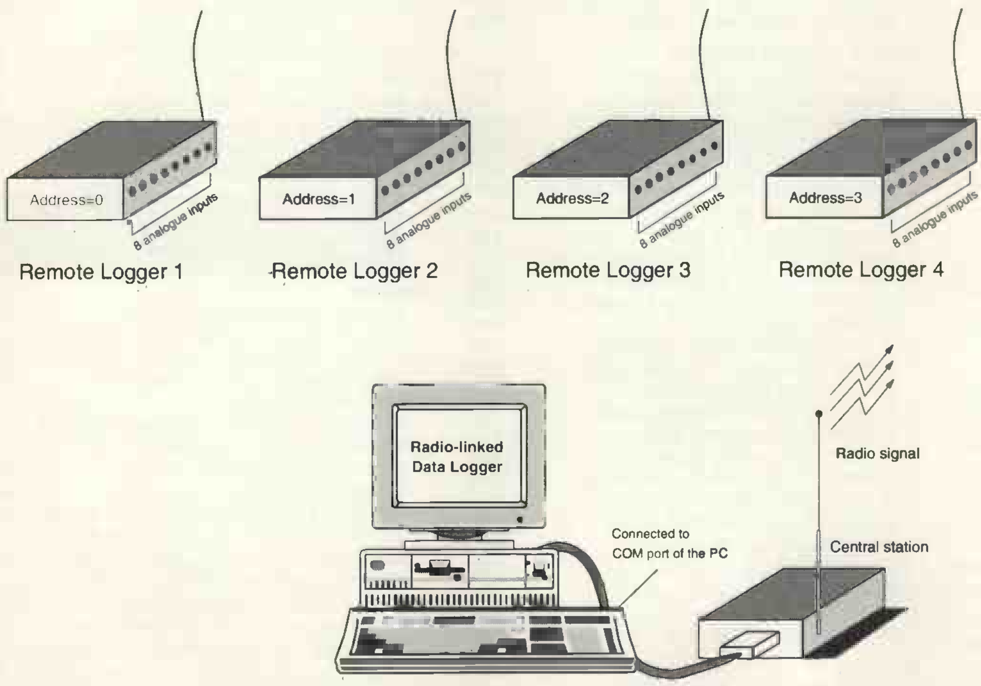
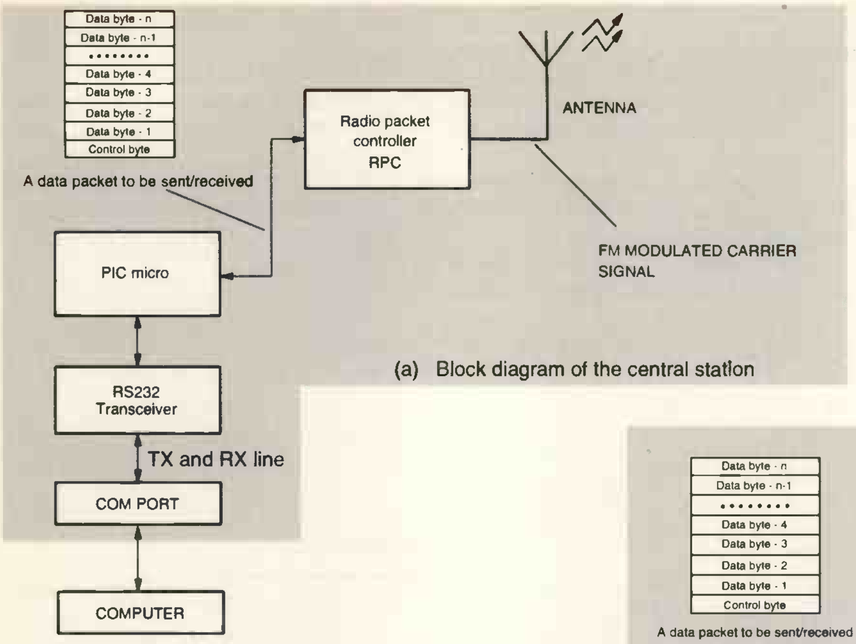
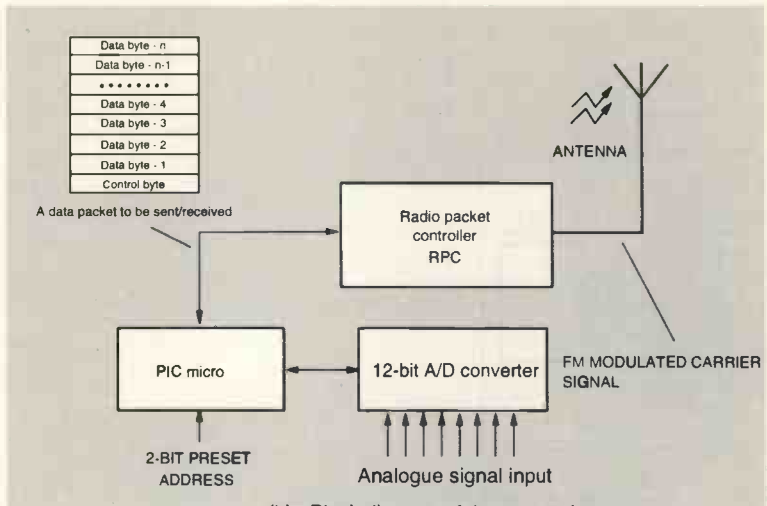


Fig. 1. Wireless remote data acquisition system comprising a central station and up to four remote data loggers. Each data logger has eight 12-bit analogue inputs. The central station connects to the RS232 port of a computer. In total, the computer can read 32 voltages remotely. Communication distance is 30 metres in building, 120 metres over open ground.



(a) Block diagram of the central station



(b) Block diagram of the remote logger

Fig. 2. Block diagram of the central station and remote data logger.

the RPC, which broadcasts the data.

After the central station receives data from the addressed logger, it sends data to the computer via the RS232 port. Inside the computer, the information can be stored in a file for future retrieval, or it may be displayed on the screen. This completes a data read cycle.

Radio packet controller

The RPC is a SAW-controlled FM transmitter and superhet receiver. It is designed to comply with ETSi 300-220 regulations.

There are two version of the RPC. One works at 418MHz for UK use and the other at 433MHz for European use. Their respective part numbers are RPC-418-A and RPC-433-A.

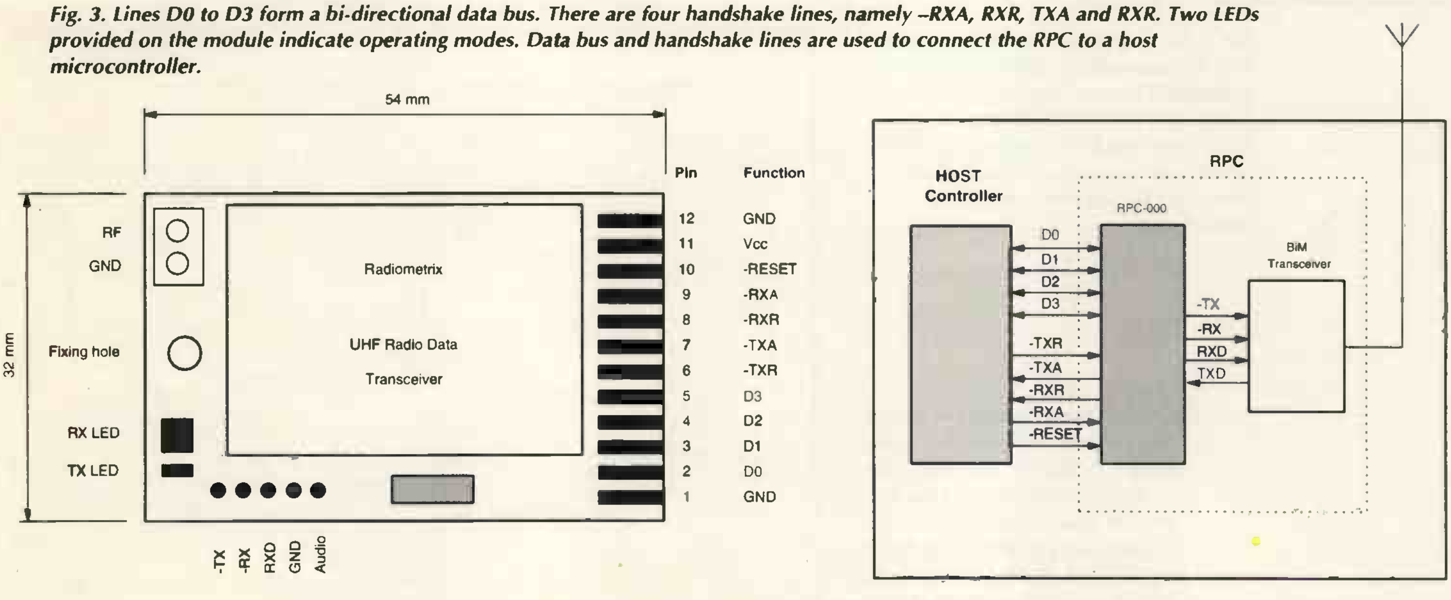
These RPCs are self-contained plug-in devices that require a whip type antenna, a 5V power supply and a byte-wide I/O port on a host micro-controller. Logic levels on the i/o port are 5V CMOS compatible.

All the necessary rf circuitry is contained within the RPC, as are the low-level packet formatting and packet recovery functions required to inter-connect a number RPCs to a single radio-linked network.

Details of the RPC presented here are limited to those relevant to the design. More information can be found in the manufacturer's data sheet[1].

Figure 3a) shows the pin-out of the RPC while **3b)** illustrates how it is applied. This device has a four-bit bi-directional data bus – D0-D3 – and four handshake lines. Its pin-functions are:

Fig. 3. Lines D0 to D3 form a bi-directional data bus. There are four handshake lines, namely –RXA, RXR, TXA and RXR. Two LEDs provided on the module indicate operating modes. Data bus and handshake lines are used to connect the RPC to a host microcontroller.



(a) Radiometrix RPC pinout

(b) Typical application

Pin	Function
1	Ground
2	D0, bi-directional data bus. Input or output of RPC. +5V CMOS logic.
3	D1, bi-directional data bus. Input or output of RPC. +5V CMOS logic.
4	D2, bi-directional data bus. Input or output of RPC. +5V CMOS logic.
5	D3, bi-directional data bus. Input or output of RPC. +5V CMOS logic.
6	–TXR, host requests to transfer data into the RPC. Input to RPC. +5V CMOS logic.
7	–TXA, RPC acknowledges request to the host. Output from RPC. +5V CMOS logic.
8	–RXR, RPC requests to transfer data to host. Output from RPC. +5V CMOS logic.
9	–RXA, host acknowledge request to RPC. Input to RPC. +5V CMOS logic.
10	–RESET, HOST reset the RPC. Input to RPC. +5V CMOS logic.
11	V_{cc}, +5V supply.
12	Ground.

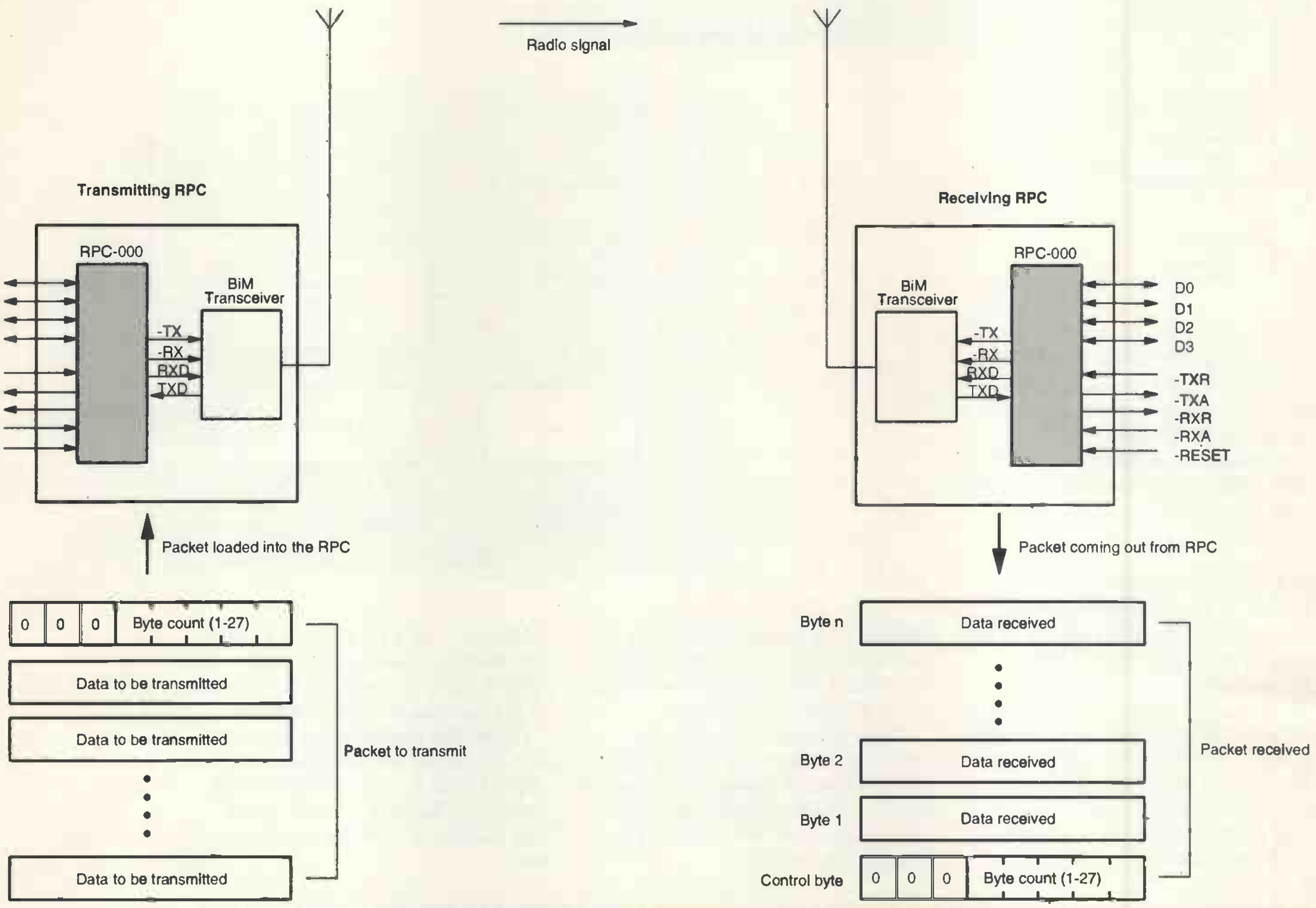


Fig. 4. Up to 27 bytes can be downloaded into the transmitting radio packet controller's buffers. These bytes can be transmitted to receiving RPCs and appear in the receiving RPC's buffers. The RPCs perform all necessary low-level data formatting for reliable radio digital transmission.

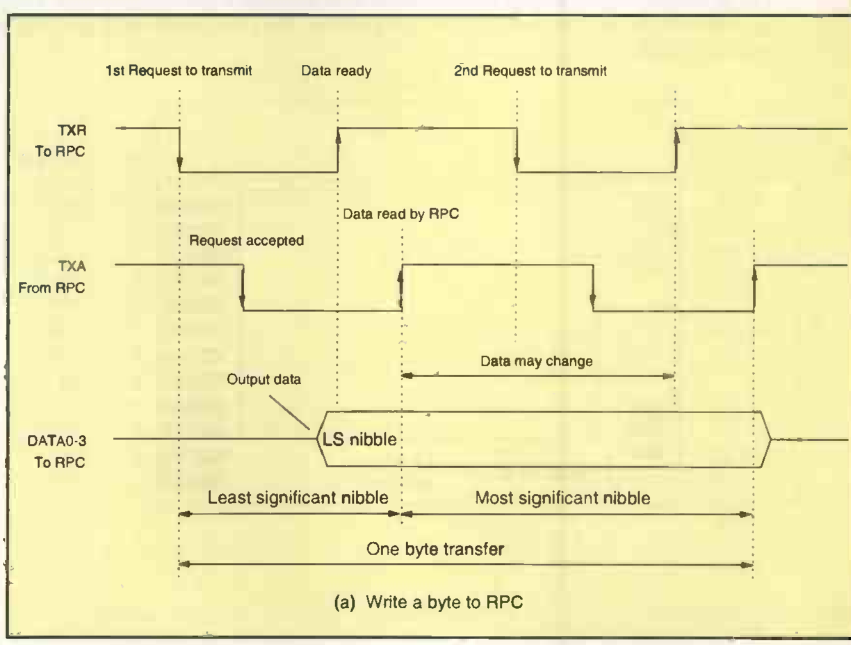


Fig. 5. Timing waveforms for writing data into the RPC's buffer and for reading data from it. The handshake between the host and the RPC secures data transfer between the host and the RPC. Note that a complete byte (8 bits) is transferred in two consecutive nibble (4 bits) transfers.

The host can be a micro-controller or a computer. It needs to be able to write a data packet consisting of 1 to 27 bytes into the RPC's data buffers. The packet is then sent out by the transmitting RPC to other RPCs.

The exact data packet appears in the receive buffers of all RPCs within the radio range. Once data is written into its buffers, the RPC takes care of the radio data transmission to other RPCs without any further intervention **Fig. 4.**

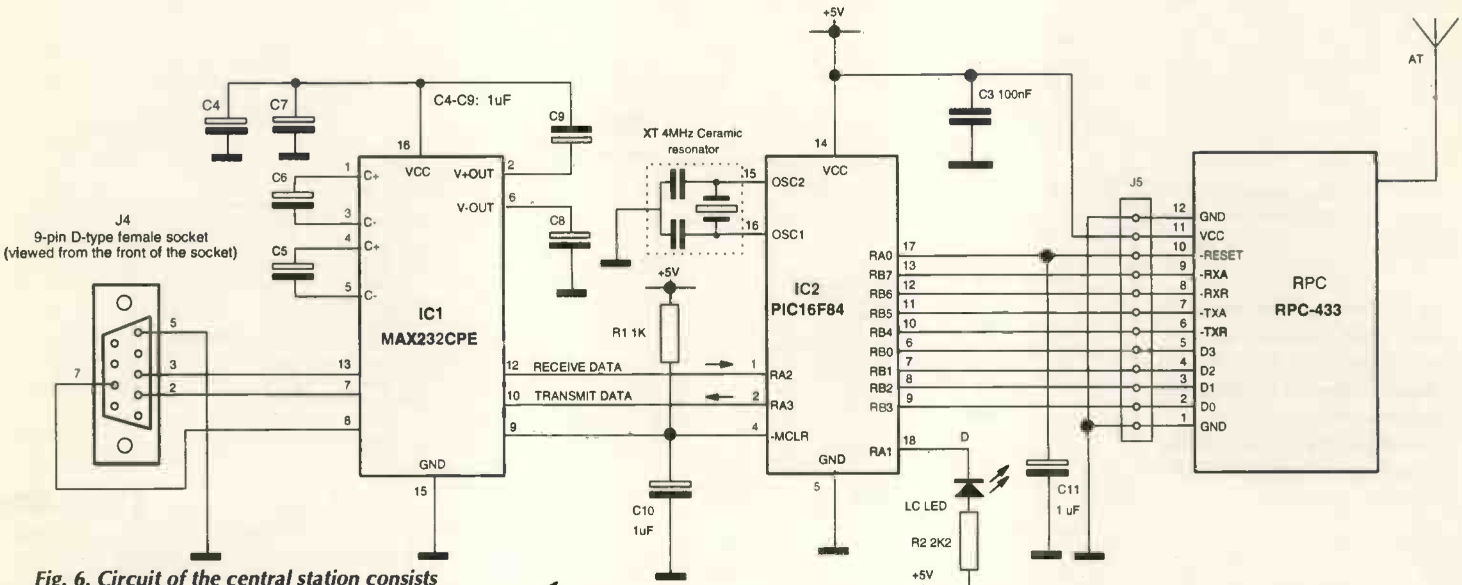
More details on how data are transferred between RPCs is given in the module's data sheet.

How the packet controller works

The packet controller has four operating modes: idle/sleep, host-RPC data transfer, radio-data transmission and radio-data receive.

In idle/sleep mode, the receiver is enabled continuously or intermittently, depending on the set-up, to search for valid message preambles. Programming the RPC to search intermittently minimises power consumption. In this mode, the RPC also monitors the TXR line. The host requests to send data using an active-low signal.

In the host-RPC data-transfer mode, if the host is to transfer data into the RPC, the TXR line is taken low by the host. If the RPC is to transfer data into the host, the RXR line is taken low by the RPC. In this mode, the radio receiver of the RPC is disabled.



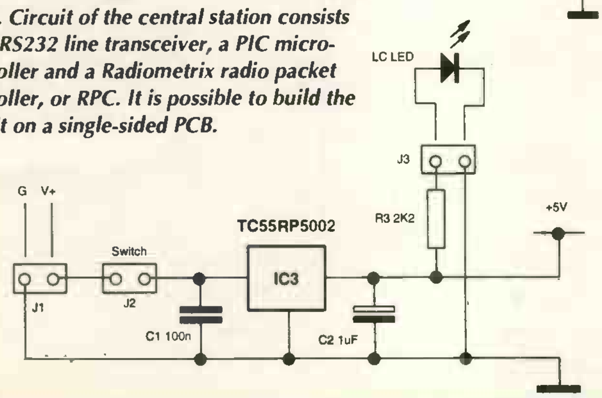


Fig. 6. Circuit of the central station consists of an RS232 line transceiver, a PIC micro-controller and a Radiometrix radio packet controller, or RPC. It is possible to build the circuit on a single-sided PCB.

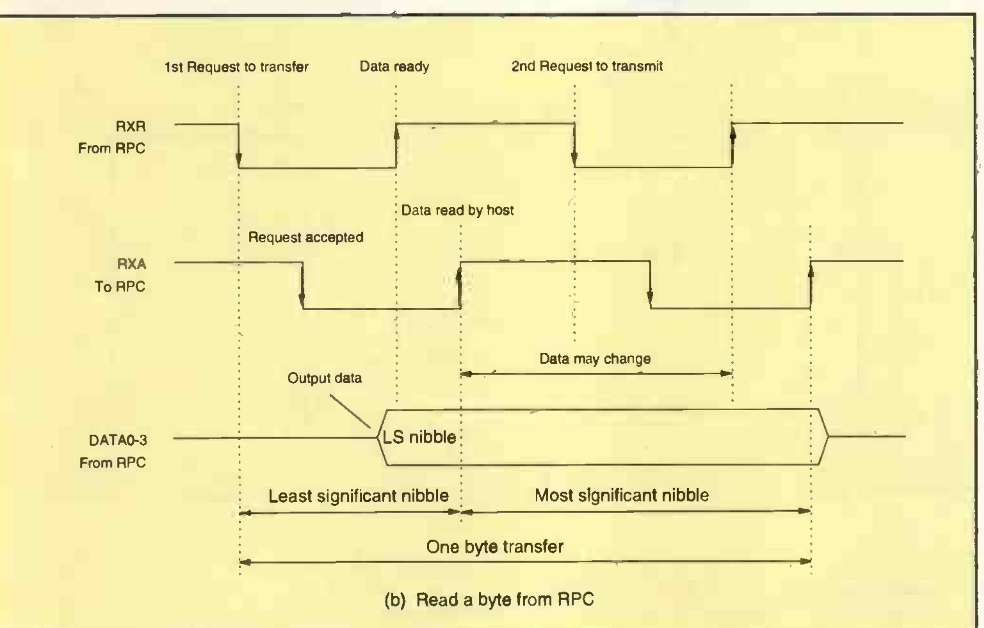
To transfer a full 27-byte packet between the RPC and the host takes less than a millisecond. Details of writing data into the RPC or reading data from it are described later.

Once a complete data packet is transferred into the RPC, it first manipulates data for proper radio transmission and then transmits the message. A full 27 bytes takes 13.8ms to transmit with a 5ms preamble.

Listen-before-transmit collision avoidance schemes are applied to prevent loss of data. The length of the preamble period can be also varied to increase the reliability of data reception.

On detection of a preamble, the receiving RPC carries out a number of actions in order to get the data packet correctly. Then the received packet is placed in data buffers.

To tell the host that a data packet has been received successfully, and is awaiting downloading, the RXR line is pulled low by the RPC. The data packet in the receiver RPC has the same contents as those in the transmitting RPC.



(b) Read a byte from RPC

Transfer between host and RPC

Figure 5a) shows how data bytes are written into the RPC. Firstly, the host pulls the TXR line low to tell the RPC that the host is about to send data. Then the host waits for the RPC to low its TXA line as an indication that the request is accepted by the RPC. Data are then placed on the four data lines – lower nibble of a byte first.

Now the host pulls the TXR line high to tell the RPC that a valid data is stable on the data bus. Next the host waits for the RPC to pull the TXA line high to indicate that the RPC has accepted the nibble.

This procedure is repeated to transfer the upper nibble of a byte. The writing procedure has to be repeated until the specified number of bytes are written into the RPC.

Figure **5b)** shows how data are transferred from the RPC into the host. In this case, the RPC firstly pulls down the RXR line. The Host responds to the request by pulling the RXA line low. Then the RPC places the lower nibble on the data lines and sets the RXR line high.

The host reads the data and makes the RXA line high. This completes one nibble read. The above procedure is repeated to transfer the upper nibble of a byte. The reading procedure has to be repeated until the specified number of bytes are read by the host.

Data format

Two types of data can be transferred between a host and an RPC. The first is data to be transmitted to other RPCs in the form of data packets. The second is data, i.e. commands, used to set up the RPC's

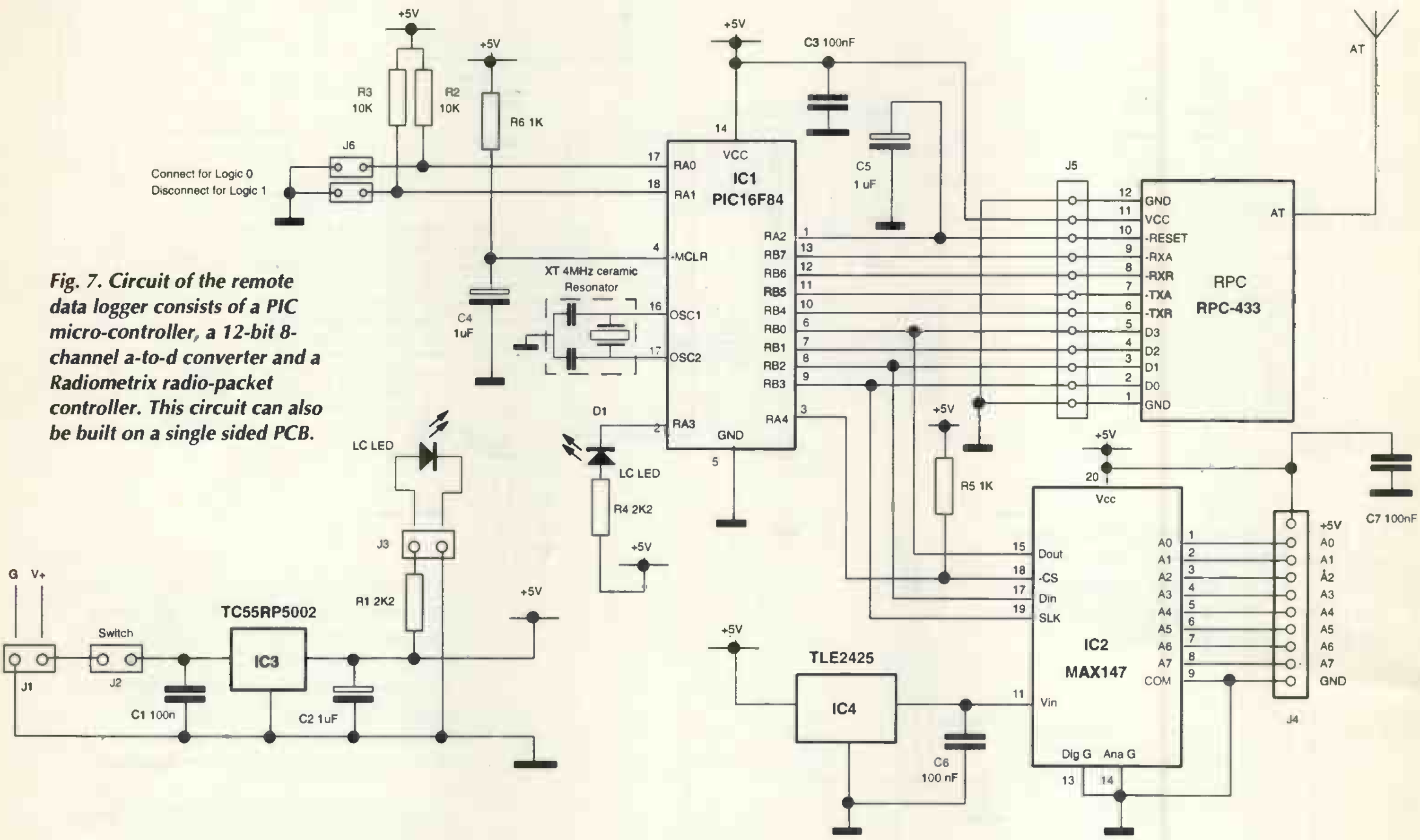


Fig. 7. Circuit of the remote data logger consists of a PIC micro-controller, a 12-bit 8-channel a-to-d converter and a Radiometrix radio-packet controller. This circuit can also be built on a single sided PCB.

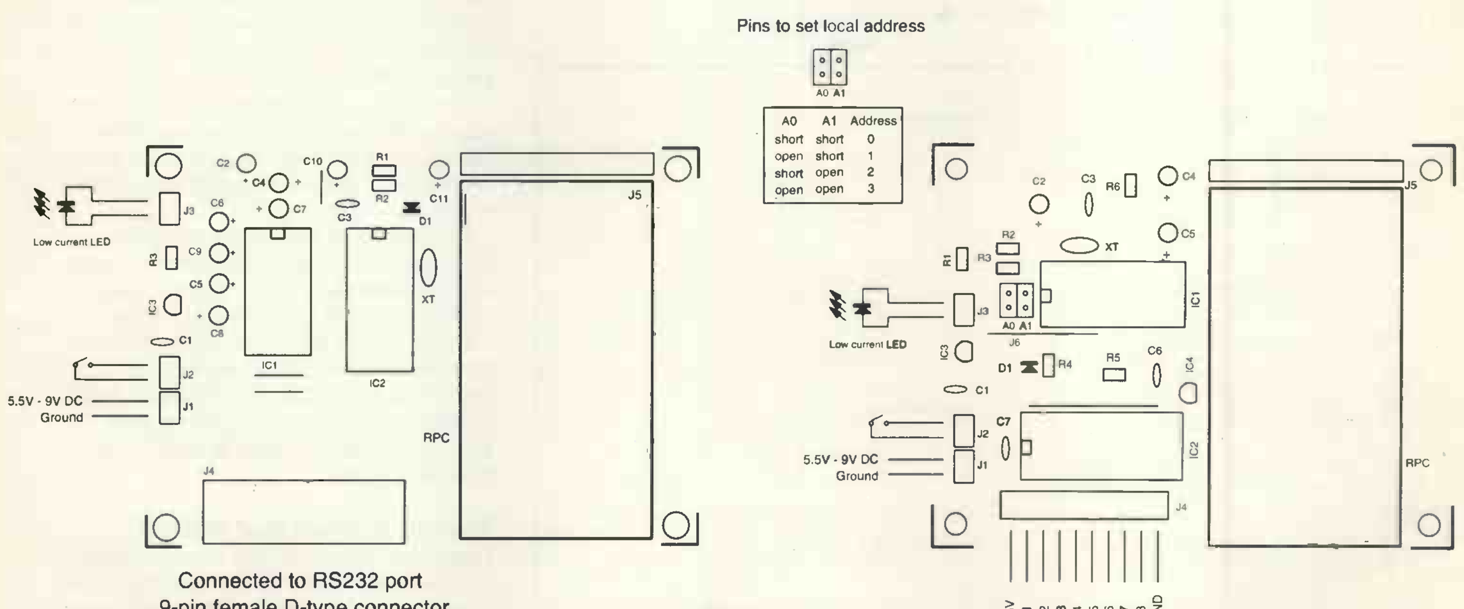


Fig. 8. Component layouts of the central station and the remote data logger as per the author's prototype and kits.

operating modes. These commands are to be written into RPC's memory.

There are 63 on-board memory locations within each RPC, 01_{16} to $3F_{16}$. The first 15 bytes contain parameters to control the RPC. The rest of the memory is free for user-defined data. Functions of the locations are detailed in the manufacturer's data sheet.

For a data packet, the first byte is always the control byte. Bit 7 of the byte is always 0. Bits 6 and 5 are the preamble control bits. For normal preamble, which is the case in this design, bits 6 and 5 are both zero. Bits 4 and 0 indicate the number of bytes in the present packet – including the control byte itself. The maximum number of data bytes is 28, including the control byte.

To read a byte from an RPC's memory location, the byte sent to the RPC by the host has bit 7 set to one and bit 6 to zero. Bits 5 to 0 define the address of a memory location. The RPC responds with two bytes, the first of which is a control byte itself – i.e. an echo. The second byte is the memory contents.

To write a byte to the RPC's memory, the host issues two bytes: a control byte and the byte to be written into the location. The control byte has bits 6 and 7 set to one. Bits 5 to 0 define the address of a memory location. The RPC does not give any response.

Circuit of the central controller

The central station consists of a MAX232CPE RS232 transceiver, a PIC16F84 and an RPC, **Fig. 6**. The station connects to a computer via an RS232 port.

Line PA2 of the PIC receives data from an RS232 port while PA3 transmits data to the RS232 port. Port B controls the RPC. Line PA1 connects to a low-current LED that gives a visual indication.

The power supply to the central station is a DC at 5.5V to 10V. A low-power TC55RP5002 regulator produces the +5V rail. Component layout and connections of the board are shown in **Fig 8a)**.

The communication protocol is rather simple. First, the computer sends a command byte 88_{16} to the central station. The byte is followed by a byte that specifies a remote logger address of 0, 1, 2 or 3.

After the PIC receives these two bytes from the computer, it writes a data packet into the RPC. The packet consists of a control byte 02_{16} and the address byte of 0 to 3. The RPC then broadcasts the data packet.

After the RPC completes the broadcasting, it goes into listening mode to catch the reply from the addressed remote logger.

PIC object code for the remote module

```
:020000001028C6
:1000200083166F308600033085008312003 08B000A
```

PIC object code for the central station.

```
:020000001028C6
:1000200083166F3086001430850083120030 8B00F9
```

Technical support

Designers' kits, PIC and VB4 source codes are available from the authors. The kit includes PCB boards, all components, programmed PIC and VB5 software. Please direct your enquiry to Dr Pei An, 11 Sandpiper Drive, Stockport, Manchester SK3 8UL.
Tel/fax/answer: +44 (0)161-477-9583.
E-mail: pan@intec-group.co.uk

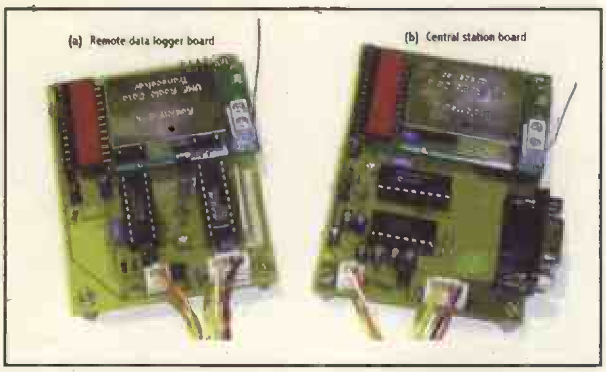
Visual Basic program list for running the remote data logger on a PC

```
Dim Rsport As Boolean
Dim Data(16) As Byte
Dim Filename, UsePort, UseNolog As String
Dim dummy As Double
Dim i As Integer
Dim TimeStart As Long
Dim Inputdata As String
Dim Overrun As Boolean
Dim Start_time As Long

Sub Delay(ByVal Intervel As Integer)
Dim start As Long
        start = Timer
        Do While Timer < start + Intervel
        Loop
End Sub

Private Sub Log_data()
If cmbPort.Text = "COM1" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 1
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 1
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If Rsport = True

ElseIf cmbPort.Text = "COM2" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 2
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 2
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True

ElseIf cmbPort.Text = "COM3" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 3
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 3
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True

ElseIf cmbPort.Text = "COM4" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 4
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 4
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True
End If
        UsePort = cmbPort.Text
        UseNolog = CmbNolog.Text
        Label1.Caption = "COM port:" + cmbPort + "
Logger No.: " + UseNolog
        DoEvents
        MSComm1.OutBufferCount = 0
        MSComm1.InputLen = 16
        MSComm1.Output = Chr$(8 * 16 + 8) +
Chr$(UseNolog)
        Start_time = Timer
        Overrun = False
        Do
                DoEvents
                Label1.Caption = "Communicating with
logger..."
                Overrun = (Timer > Start_time + 2)
        Loop Until (MSComm1.InBufferCount = 16) Or
Overrun

        If Not Overrun Then Label1.Caption = "Data
received logger No. " + UseNolog Else
Label1.Caption = "Communication failed. Try again"
        Inputdata = MSComm1.Input
        If Not Overrun Then
        For i = 0 To 15
                Data(i) = Asc(Right(Inputdata, 16 -
i))
        Next

        For i = 0 To 7
        dummy = (Data(2 * i) * 16# + Data(2 * i + 1) /
16#) / 4096 * 2.508
        lblChD(i).Caption = " " + Format(dummy,
"0.0000")
        Next i
        End If
End Sub

Private Sub cmdRead_Click()
Dim dummy As Double
Dim i As Integer
Dim TimeStart As Long
Dim Inputdata As String

If cmbPort.Text = "COM1" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 1
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 1
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True

ElseIf cmbPort.Text = "COM2" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 2
                MSComm1.PortOpen = True
        Else
```

```
                MSComm1.CommPort = 2
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True
        'MSComm1.PortOpen = True

ElseIf cmbPort.Text = "COM3" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 3
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 3
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True

ElseIf cmbPort.Text = "COM4" Then
        If Rsport = True Then
                MSComm1.PortOpen = False
                MSComm1.CommPort = 4
                MSComm1.PortOpen = True
        Else
                MSComm1.CommPort = 4
                MSComm1.PortOpen = True
                MSComm1.PortOpen = False
                MSComm1.PortOpen = True
        End If
        Rsport = True
End If
        Delay (1)
        UsePort = cmbPort.Text
        UseNolog = CmbNolog.Text
        Label1.Caption = "COM port:" + cmbPort + "
Logger No.: " + UseNolog
        DoEvents
        MSComm1.OutBufferCount = 0
        MSComm1.InputLen = 16
        MSComm1.Output = Chr$(8 * 16 + 8) +
Chr$(UseNolog)

        Do
                DoEvents
                Label1.Caption = "Communicating with
the logger..."
        Loop Until MSComm1.InBufferCount = 16

                Label1.Caption = "Data received logger
No. " + UseNolog

                Inputdata = MSComm1.Input

                For i = 0 To 15
                Data(i) = Asc(Right(Inputdata, 16 -
i))
                Debug.Print Data(i);
        Next

        For i = 0 To 7
        dummy = (Data(2 * i) * 16# + Data(2 * i + 1) /
16#) / 4096 * 2.5
        lblChD(i).Caption = " " + Format(dummy,
"0.0000")
                Next I

F:              Filename = "c:\rlg.ini"
                Open Filename For Output As #1
                        Print #1, UsePort
                        Print #1, UseNolog
                Close #1
                Filename = ""
End Sub

Private Sub CmbNolog_GotFocus()
                Label6.Caption = "Remote Logger No. " +
UseNolog
End Sub
Private Sub cmbPort_GotFocus()
Command1.Enabled = True
End Sub

Private Sub Command1_Click()
Log_data
End Sub
Private Sub Command2_Click()
End
End Sub

Private Sub Command3_Click()
                Timer1.Enabled = True
                Command1.Enabled = False

End Sub

Private Sub Command4_Click()
Timer1.Enabled = False
Command1.Enabled = True
End Sub

Private Sub Form_Load()
Timer1.Enabled = False
End Sub

Private Sub Form_MouseMove(Button As Integer, Shift As
Integer, X As Single, Y As Single)
Label5.Caption = "Com port selected:  " + cmbPort.Text
Label6.Caption = "Remote Logger No. " + CmbNolog.Text
End Sub

Private Sub Timer1_Timer()
Log_data
End Sub
```

Here's a list of sensors that should interface with the remote data logger with little signal conditioning circuitry.

Sensor type	Part ID	Source
Temperature sensors, °C	LM35	Available from most stockists
Temperature sensors, K	LM135, AD590KH	Available from most stockists
Infrared thermometer	Calex T sensor	RS3299326
Humidity sensors	Mercator RHU217-AT	Farnell 540997
Pressure sensors	PTE5000 series	Sensor Technics
Force sensor	Honeywell	Farnell 7216671
Light intensity sensors	TSL250	Available from most stockists
Human eye light detector	IS474	RS2678447
Acceleration	ADXL05	Available from most stockists
Angular velocity	Murata Gyrostar	Farnell 731985
Magnetic field	Honeywell HMC2003	Farnell 7220121
Ultrasonic distance sensor	UNDK 30U6103	Baumer electric



Central station board, right, and remote data logger board, left.

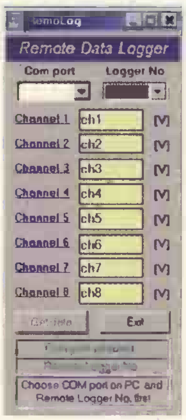


Fig. 9. Screen dump of the Visual Basic 4 control software.

Circuit of the remote data logger

The remote logger is built around a PIC16F84, a MAX147 a-to-d converter and an RPC, Fig. 7. Lines PA0 and PA1 of the PIC set the local address of the logger to 0, 1, 2 or 3.

The MAX147 is a 12-bit 8-channel a-to-d converter. The 2.5V reference is supplied by a TLE2425CPL IC.

Port B of the PIC controls the RPC as well as the MAX147. The power supply to the central station is again 5.5V to 10V DC. A low-power TC55RP5002 regulator produces the 5V rail. Component layout and connections of the board are shown in Fig. 8b).

The flow of the PIC software is as follows. After a power reset, the RPC is in listening mode. Once a two-byte packet – as broadcast by the central station – is received by the RPC, the PIC checks whether the address byte matches its own address. If they match, the PIC reads eight voltages from the a-to-d converter.

As the conversion result is 12-bit, two bytes are used to present one voltage. Next a data packet is written into the RPC for radio transmission. The packet has 17 bytes – one control byte and 16 data bytes for eight 12-bit data words.

The PIC program also ensures that a remote logger only responds to the message sent by the central station, not to the message sent by remote loggers. This is done by checking the content of the control byte. The control byte sent by the station is 02_{16}, whereas it is 11_{16} for the remote loggers.

PIC software

The PIC software for the central station and the remote data logger are developed using the PIC assembly language in the MPLAB environment. Both programs are lengthy. They are available from authors. Please see details in the technical support section.

PC software for the central station

The software drive for the central station is written in Visual Basic 4.

Figure 6 shows the screen of the driver. In the window, you should first select a COM port to be used and the address of the remote logger. Next, click the 'Get Data' button.

If data logging is successful, measured voltage from a remote data logger will appear on the screen. On-line messages are shown at the bottom of the screen.

Application ideas

The analogue input channels require that the input voltage is within 0 to 2.5V. Any sensors having that voltage output level can be connected directly to the logger.

Sensors with other types of outputs require signal conditioning circuitry. A list of sensors that can be used easily with the remote logger is given separately.

Finally, I would like to thank Mr. Kangyan from Radiometrix Ltd for his help and advice on this project. ■

References

1. Data sheets on Radio Packet Controller available from Radiometrix's website www.radiometrix.co.uk.
Telephone +44 (0)208 428 1220

Communication between RPCs

RPC encoder. Data bytes to be transmitted by the RPC are converted into a packet before being transmitted. This is to ensure a reliable radio digital data transmission. A packet consists of four parts: preamble, frame synchronisation, data and check sum.

Preamble. The preamble is a 20kHz square wave. The number of cycles can be defined by the user. The initial 3ms portion of the preamble is used to allow the receiving circuitry of the remote RPCs to settle. The remaining 15-cycle portion of the preamble is used by the remote RPCs to phase lock onto the incoming signal. The preamble may be extended to wake-up remote RPCs that are in power-saving mode.

Frame sync
A 7-bit Barker sequence is used to identify the start of the data. An eighth balancing bit is added after the Barker sequence.

Data. Each byte in the RPC's buffer is expanded into a 12-bit symbol prior to sending. The symbol coding has the following properties:

- Perfect 50:50 balance – always 6 zeros and 6 ones
- There are never more than 4 consecutive ones or zeros in a byte.
- Each code is different from any other codes by a minimum of 2 bits.
- Only 256 of 4096 (6.25%) possible codes are valid. This means a 93.75% probability of trapping a byte error.
- Preamble and the frame sync codes are not part of the symbols. A clash signal will cause immediate termination of the current decoding process.

Check sum. An eight-bit check sum is used to test for overall packet integrity. This is also coded into a 12-bit symbol prior to transmission.

RPC decoder. Radio-signal decoding consists of four steps:

Search. First, the RPC searches for valid preamble comprising a 20kHz square wave. The search is performed by a 16-times over-sampling detector which computes the spectral level of 20kHz in 240 samples of the incoming signal.

Lock-in. The 240 samples are also used to compute the phase of the incoming preamble and synchronise the internal recovery clock to an accuracy of ±2μs. When the frame sync is detected the decoder attains full synchronisation and will move the next stage.

Decode. Data is taken in 12 bits at a time, decoded into the original byte and placed in the buffer. The symbol decoder verifies each received symbol as valid (only 256 out of a possible 4096 are valid) and will abort the decoding process on a symbol failure. The first byte contains the byte count and is used to determine the end of message.

Check sum
The last byte is the received check sum. If the check sum matches the locally calculated one, the RXR line becomes low to inform the host that a packet is ready for downloading.

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HP8444A OPT 059 Tracking Gen • 5-1500Mc/s - £650.
HP35601A Spectrum Anz Interface - £300.
HP4953A Protocol Anz - 3400.
HP8970A Noise Figure Meter + 346B Noise Head - £3k.
HP8755A+B+C Scalar Network Anz PI - £250 + MF 180C - Heads 11664 Extra - £150 each.
HP3709B Constellation ANZ £1,000.
FARNELL TVS70MKII PU 0-70V 10 amps - £150.
MARCONI 6500 Network Scaler Anz - £500. Heads available to 40GHz many types in stock.
Mixers are available forANZs to 60GHz.
Marconi TF2374 Zero Loss Probe - £200.
Racal/Dana 1250-1261 Universal Switch Controller + 200Mc/s PI Cards and other types.
Racal/Dana 9303 True RMS Levelmeter + Head - £450.
TEKA6902A also A6902B Isolator - £300-£400.
TEK CT-5 High Current Transformer Probe - £250.
HP Frequency comb generator type 8406 - £400.
HP Sweep Oscillators type 8690 A+B + plug-ins from 20Mc/s to 18GHz also 18-40GHz.
HP Network Analyser type 8407A + 8412A + 8601A - 100Kc/s - 110Mc/s - £500 - £1000.
HP 8410-A-B-C Network Analyser 110Mc/s to 12 GHz or 18 GHz - plus most other units and displays used in this set-up - 8411a-8412-8413-8414-8418-8740-8741-8742-8743-8746-8650. From £1k.
Racal/Dana 9301A-9302 RF millivoltmeter - 1.5-2GHz - qty in stock £250-£400.
Racal/Dana Modulation Meter Type 9009-9008 - 8Mc/s - 1.5GHz - £150/£250 – 9009A £350.
Marconi Microwave 6600A 1 sweep osc., mainframe with 6650PI - 18-26.5 GHz + 6651 PI - 26.5-40GHz-£750 or PI only £600. MF only £250.
Gould J3B test oscillator + manual - £150.
Barr & Stroud Variable filter EF3 0.1Hz-100Kc/s + high pass + low pass - £150, other makes in stock.
Racal/Dana 9300 RMS voltmeter - £250.
HP 8750A storage normalizer - £400 with lead + S.A. or N.A.
Marconi mod meters type TF2304 - £250 – TF2305 - £1,000.
Racal/Dana counters-99904-9905-9906-9915-9916-9917-9921-50Mc/s-3GHz - £100 - £400 - all fitted with FX standards.
HP180TR. HP181T, HP182T mainframes £300 - £500.
HP432A-435A or B-436A power meters + powerheads to 60GHz - £150 - £1750 - spare heads available.
HP3586A or C selective level meter - £500.
HP86222A+B Sweep PI .01-2.4GHz + ATT £1000-£1250.
HP86290A+B Sweep PI-2 - 18GHz - £1000 - £1250.
HP8620C Mainframe - £250. IEEE £350.
HP8165A Programmable signal source - 1MHz - 50Mc/s - £1k.
HP3455/3456A Digital voltmeter - £400.
HP5370A Universal time interval counter - £1k.
HP5335A Universal counter - 200Mc/s-£1000.
TEKTRONIX 577 Curve tracer + adaptors - £900.
TEKTRONIX 1502/1503 TDR cable test set - £400.
HP8699B Sweep PI YIG oscillator .01 - 4GHz - £300. 8690B MF-£250. Both £500.
Dummy Loads & Power att up to 2.5 kilowatts FX up to 18GHz - microwave parts new and ex equipt - relays - attenuators - switches - waveguides - Yigs - SMA - APC7 plugs - adaptors etc. qty. in stock.
B&K Items in stock - ask for list.
Power Supplies Heavy duty + bench in stock - Farnell - HP - Weir - Thurlby - Racal etc. Ask for list. Large quantity in stock, all types to 400 amp - 100Kv.
HP8405A Vector voltmeter - late colour - £400.
HP8508A Vector voltmeter - £2500.

LIGHT AND OPTICAL EQUIPMENT
Anritsu ML93A & Optical Lead Power Meter - £250.
Anritsu ML93B & Optical Lead Power Meter - £350.
Power Sensors for above MA96A - MA98A - MA913A.
Battery Pack MZ95A.
Anritsu MW97A Pulse Echo Tester.
PI available - MH914C 1.3 - MH915B 1.3 - MH913B 0.85 - MH925A 1.3 - MH929A 1.55 - MH925A 1.3GI - MH914C 1.3SM - £500 + one P.I.
Anritsu MW98A Time Domain Reflector.
PI available - MH914C 1.3 - MH915B 1.3 - MH913B 0.85 - MH925A 1.3 - MH929A 1.55 - MH925A 1.3GI - MH914C 1.3SM - £500 + one P.I.
Anritsu MZ100A E/O Converter.
+ MG912B (LD 1.35) Light Source + MG92B (LD 0.85) Light Source £350.
Anritsu MZ118A O/E Converter.
+MH922A 0.8 O/E unit + MH923 A1.3 O/E unit £350.
Anritsu ML96B Power Meter & Charger £450.

Anritsu MN95B Variable Att. 1300 £100.
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Cossor-Raytheon 108L Optical Cable Fault Locator 0-1000M 0-10kM £200.
TEK P6701 Optical Converter 700 MC/S-850 £250.
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HP84801A Fibre Power Sensor 600-1200 £250.
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HP 4274 FX LCR meter – £1,500.
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HP 75000 VXI Bus Controllers + E1326B DVM-quantity.
HP 83220A GSM DCS/PCS 1805-1990MC/S convertor for use with 8922A - £2,000.
HP 1630-1631-1650 Logic ANZ's in stock.
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HP 8754A Network ANZ H26 + ...0MC/S + 8502A + Cables – £2,000.
HP 8350A Sweeper MF + 83540A PI 2-8.4GHz + 83545A PI 5.9-12.4GHz all 3 – £3,500.
HP MICROWAVE TWT AMPLIFIER 489A 1-2GHz-30DB – £400.
HP PREAMPLIFIER 8447A 0.1-400MC/S - £200. Dual – £300.
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HP POWER AMPLIFIER 8447E 0.01-1.3GHz – £400
HP PRE + POWER AMPLIFIER 8447F 0.01-1.3GHz – £500.
HP 3574 Gain-Phase Meter 1Hz-13MC/S OPT 001 Dual – £400.
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MARCONI 2610 True RMS Meter – £450.
MARCONI 893B AF Power Meter (opt Sinad filter) – £250-£350.
MARCONI 6950-6960B Power Meters + Heads – £400-£900.
MARCONI SIGNAL SOURCE-6055-6056-6057-6058-6059 FX Range 4-18GHz– £250-£400.
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RACAL 1772 COMMUNICATION RX – £400-£500.
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TEK 7000 OSCILLOSCOPE MAINFRAMES – 7603-...-7834-7854-7904-7904A-7104 – £150-£1,000.
TEK 7000 PI's – 7A11-7A12-7A13-7A18-7A19-7A22-7A24-7A26-7A29-7A42-7B10-7B15-7B53A-7B80-7B85-7B92A-7D15-7D20.
TEK 7000 – 7S1...-7S12-7S14-7M11-S1-S2-S3A-S4-S5-S6-S51-S53-S54.
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HP 3588A 10Hz-150MC/S – £7,500.
HP 8568A 100Hz-1.5GHz – £3,500.
HP 8568B 100Hz-1.5GHz – £4,500.
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TEK492 50kHz-21GHz OPT 2 – £2,500.
TEK492P 50kHz-21GHz OPT 1-2-3 – £3,...0.
TEK492AP 50kHz-21GHz OPT 1-2-3 – £...000.
TEK492BP 50kHz-21GHz – £3,000-£4,000.
TEK495 100kHz-1.8GHz – £2,000.
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HP 8558B 0.01-1500MC/S – £750 – MF180T or 180C – £150 – 182T – £500.
HP 8559A 0.01-21GHz – £1,000 – MF180T or 180C – £150 – 182T – £500.
HP 8901A AM FM Modulation ANZ Meter – £800.
HP 8901B AM FM Modulation ANZ Meter – £1,750.
HP 8903A Audio Analyzer – £1,000.
HP 8903B Audio Analyzer – £1,500.

MARCONI 2370 SPECTRUM ANALYZERS – HIGH QUALITY – DIGITAL STORAGE – 30Hz-110MC/S Large qty to clear as received from Gov – all sold as is from ... complete or add £100 for basic testing and adjustment – callers preferred – pick your own from over sixty units – discount on qtys of five.
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B LATE MODEL GREY – vertical alloy cooling fins – £300.
C LATE MODEL BROWN – as above (few only) – £500.

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TEK 2465 4ch 300MC/S – £1,150.
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HP1741A – 100MC/S storage + 2 probes – £200.
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HP8660C SYN AM-FM-PM-0.01-1300MC/S-2600MC/S – £2K.
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HP3336A-B-C SYN Func/Level Gen 21MC/S – £400-£300-£500.
Racal/Dana 9081 SYN S/G AM-FM-PH-5-520MC/S – £300.
Racal/Dana 9082 SYN S/G AM-FM-PH-1.5-520MC/S – £400.
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CIRCLE NO. 111 ON REPLY CARD

Hard drive havoc

Your hard drive just took a dive and you haven't backed it up for months. Is there any hope of recovering your information, or is everything lost? Andrew Emmerson reports.

Once bitten, twice shy, that's me. Learning the hard way is the only real way of finding out what a data loss really means and boy, do I know now! That gut-wrenching feeling as your hard drive stops and a reboot brings up the message, "primary device failure," followed by the realisation that the back-up you meant to do last month never happened.

Having not practised what I preached, I had to come to terms with the loss of 15 years' accumulated data – my contact details, my accounts records, the text files including a complete book I was working on. All gone, or so I thought.

In fact I had a month-old partial backup so I could re-create most of my appointments and accounting data. But all my current writing assignments, half-started articles, related notes and briefs for new jobs had vanished. And all because I hadn't backed up.

But what about you? Forget about my problem now; are you backed up? Do you rely on your PC for your livelihood? If it went into meltdown mode could you laugh it off and start again? Would insurance help? How long would it take to re-create the lost data and what would this cost in lost earnings? Or should you be thinking of taking the frazzled drive to a data recovery specialist in the hope it can be fixed?

What to do

To begin, start backing up regularly if you're not already doing so. But if you do have the misfortune to suffer hard-disk failure, don't try and fix it yourself. There's nothing useful that keen users or PC technicians can do to mend hard drives; any tinkering will only do harm. All you can do is replace the hard drive, reload the operating system and application software and start over again.

If you're intending to use a data recovery service, save the drive and pack it carefully with the original documentation. But don't investigate it yourself.*

How drives fail...

Hard drives are remarkably reliable in the main; until my recent escapade I suffered no failure in 15 years and most other users are equally fortunate. But that's purely a statistic, just as the mean time between failure (MTBF) quoted in hard-drive specifications is purely an average.

In fact malfunctions of this kind can come at any time and make up the prime cause of data loss according to data recovery specialists Ontrack, as the chart shows. What's more, as storage capacities and density get ever higher, the impact of data loss problems can only increase. You have been warned!

Hard-drive failures are classed as either physical or logical. Of course I had to have both kinds of failure simultaneously, which is most unusual and typical bad luck!

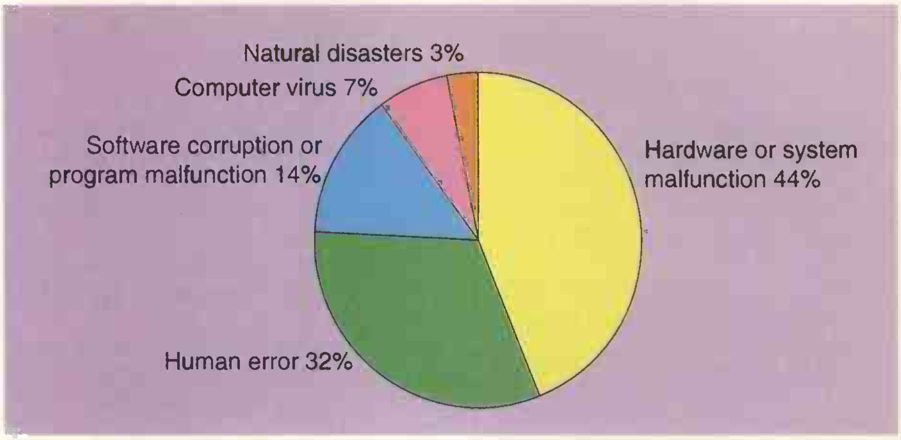
Physical failure implies some kind of physical destruction; it can be electronic (one of the control chips may have given up the ghost) or else mechanical, such as the dreaded head crash.

The read/write heads float above the magnetic platter on a cushion of air narrower than a human hair, so it doesn't take much disturbance to cause the most almighty ploughing up of data. The fact that grief is so rare is a tribute to the engineering standards and the hermetically sealed container in which the heads and platter reside.

Logical failure is less catastrophic; in this case the data is not actually destroyed but still effectively lost because something has wiped the disk's file allocation table (FAT) or partition information, thus erasing the directory that catalogues your data. Imagine, if you like, dropping a ring binder of 10000 un-numbered data sheets written in Chinese. You could gather up every piece of paper but without page numbers you'd never assemble them in the right order again.

...and why they fail

Accidents don't happen; they are caused. Power surges, malicious disk activity and supply interruptions are the chief sources of disk failure.



Leading causes of data loss, information courtesy Ontrack.

Surge filters and anti-virus software will go a long way to curing the first two evils and these are both low-cost solutions. Uninterruptible power supplies (UPS devices) will sort out supply fluctuations at a higher (but not outrageous) price.

Sometimes impending disk failure gives warning signs; very sluggish disk activity and ominous clicking sounds – both caused by repeated read/write attempts – are a clue. By this time the damage is probably done, however. Bad news.

Mission impossible?

Data recovery from dead disk drives is not impossible. Specialist firms boast of 95 per cent success rates, but the rates they charge may put you off. In most cases you can expect little change out of £1000 and only you can decide if the lost data is worth this price. If, as in my case, your livelihood genuinely depends on it, then the cost is irrelevant. For what you get it's not bad value really.

Physical failures demand repair in a clean-room atmosphere with skills approaching those of a brain surgeon. They also involve the procurement of an identical drive for replacement parts. Finding old-production disk drives can be acutely difficult.

The work may be done on a 'no fix, no fee' basis and since the difference of just

* If the data on your corrupted hard drive isn't that dear to you, try using Norton Utilities or a similar rescue package to recover it. Such software usually allows you to make a rescue floppy disk while your system is working properly. This disk is supposed to increase your chances of recovering data on the next crash.

Before you give up on a corrupted hard drive, try low-level formatting it. The only low-level formatter that I've found that wipes a drive clean enough to allow the OEM version of Windows 98 to load is SGATFMT from Seagate. It is only supposed to work with Seagate drives but I've used the 'custom' option many times on many different makes up to 5Gbyte.

I have read that low-level formatting can render a hard drive unusable though, and it will no doubt void any warranties, so be warned. Let the drive run for half an hour before formatting.

This software can be made to write a test pattern in each location then read it and report any errors. I believe that it also locks out any bad sectors. If the software finds catastrophic errors, it aborts the format. You will need to run it from a system floppy. A search using SGATFMT4 via Google should turn up Seagate's web site.

Windows' Scandisk utility can be set to check your hard drive's integrity using the 'thorough' option. According to its description, a package called Spinrite constantly monitors your hard drive for impending failures. It is available from the GRC site whose address is in the contacts panel. Ed.

Tips from the professionals

- Successful data recovery takes time, no matter how high its priority. There are no magic machines or instant utilities that can do the job; it's a highly specialised skill.
- There are occasions when data is damaged beyond any kind of recovery but it's a rare case when absolutely no data is retrievable. Most companies claim a data recovery success rate of around 85%.
- More data is lost every year to failed recovery attempts, than to actual breakdown or malfunction. Frequently there is no second chance so don't even think of tinkering!
- Hard disks are sealed units and just disturbing screws on the mechanical casing can destroy a drive.
- Despite a rash of new companies, there are still only a handful of legitimate, professional recovery services. Ask for references and make your choice carefully! Would you trust your valuable data to un-named individuals on an anonymous web site?
- Where the recovery company is located is irrelevant; your choice should be based on what they can do not where they are. Whether they are five or 500 miles away will make no difference in the time it takes to evaluate and recover your information.
- Maybe you do have backups but have you considered keeping them off-site, where they may be safer?
- Your problem may not be the media you've stored your data on at all. Are the drives connectors all seated properly? Is your hardware or driver configuration correct?

Useful contacts

This is not an exhaustive list nor to be taken as endorsement or recommendation. Other firms can be found on the WWW by using a search engine and the phrase 'data recovery'.

- CBL Data Recovery Technologies Limited. 0800 028 2069, http://www.cbltech.co.uk
- MjM Data Recovery Ltd. 01462 680 733 http://www.mjm.co.uk
- Vogon International. 01869 355255 vogoninternational.com
- Data recovery problem solver wizard: http://www.ontrack.com/help-wizard/index.asp
- The (in)famous Click of death resource page – essential reading for Zip and Jaz drive users: http://www.grc.com/clickdeath.htm

one month in manufacturing date can render a potential donor unit useless, the repair process can be a slow and expensive task.

No mechanical skills are needed for repairing logical failures but the work is just as involved. Hours of patient bit twiddling may be needed to recreate the file structure of a confused hard drive, the more so if the data had not been defragmented recently.

Last words

By now you should be dashing to make a backup. Either that or you're smiling because your backups are fully up to date. Pride goes before a fall, though; backups assume that your hardware and storage media are in working order; that the data is not corrupted, and that your backup is recent enough to provide full recovery. In reality, hardware and software do fail and backups don't always contain current enough data. Maybe it's time to make sure!

Fatalists will argue it's all inevitable and that data loss happens to us all sooner or later. No matter how fastidious we are about backing up there will always be a crucial file created after the backup and thus lost to Silicon Heaven.

What's more, every cloud has a silver lining; as a result of my mishap I bought a new, faster, larger drive and now my PC loads far quicker and runs more efficiently. I also bought a second drive and 'mirroring' software by DataKeeper so that all work created on Drive C: is copied automatically to the D: drive as a back-up.

I'm still out of pocket though, and a lot of data that I carefully saved over the years is gone forever. It's a crying shame but a useful lesson!

How a UPS can help

An uninterruptible power supply, or UPS, is a kind of power station in miniature, using battery-powered electronics to produce a limited quantity of mains electricity as and when needed. It cuts in when there's a total outage (black-out), temporary hiccup (drop-out) or voltage reduction (brown-out).

A UPS also buffers the supply by filtering out the excess voltage surges that can destroy chips and data. It won't hold for long, but it will keep your computer running long enough to save data held in memory and shut down the computer gracefully.

Some UPS models come with power-save software that handles these back-up and shut-down procedures automatically if there's a power failure in your absence.

With a UPS, the more you pay, the better you get. Simple 'standby' systems monitor the mains and switch over to battery power when a problem is detected. Even if this is only a millisecond or two, this delay may be too long.

'On-line' models eliminate even momentary power cuts. They do this by providing power constantly from their own battery, even when the mains supply is normal. The battery is constantly under charge. On-line UPSs are superior but more expensive.

Would insurance help?

Data that has taken a lot of time to assemble can have a very high value, whether it's a Eurocard interface design, the accounts database of your business or your twenty-volume family history. Consequently an insurance policy is no substitute for proper back-ups. Moreover you'll find that many home and small business insurance policies specifically exclude computer hardware failure too.

In some cases the insurers will pay the cost of manually recreating lost data and of replacing hardware destroyed by fire or lightning. In my own case, in which the hard drives were zapped by a power surge, the company was prepared to treat this as lightning and paid up the replacement cost – minus a standard 'excess' of £100. They also paid for the services of a data recovery expert, which made me mighty pleased I had taken out cover.

What will it cost?

Some data recovery firms work on a 'no fix, no fee' basis, while others charge an initial diagnosis fee of around £150. It is most likely that you will end up paying the same overall if recovery is possible.

Repairing a logical failure could cost between £350 and £500, while curing physical damage could easily double that cost. Worse still, work may be delayed while the contractor finds a suitable donor drive; because of constant firmware revisions and design improvements the precise characteristics of hard drives change over time. Consequently, if your drive was made in February 1998, parts from an August 1999 model may be totally unsuitable. Only an expert can tell, and finding NOS (new old stock) drives can be an expensive and very time-consuming task.

Add VAT to all these prices of course.

What if it still doesn't work?

You may have some problems when your data is recovered, but don't despair. Some DIY tasks remain even after the data recovery firm has handed you a fistful of CD-Rs containing what they have found for you.

Assuming you're using Windows Explorer, the folder names will probably show the ~ symbol (swung dash, tilde or 'twiddle') as their first character. The rest of the folder name will give you a good clue to the real name.

Most programs should now work, although you may find that document files refuse to load. The trick is to bypass Word or whatever and use Wordpad or a file viewer such as Quick View Plus. You'll find your text inside the files plus a load of garbage that was preventing it loading. Select the meaningful parts you want, then copy this into a brand new file and save it. ■

Put it in the fridge then tap it...

Just in case you didn't see it in the August 2000 issue, Ed Dell's letter advises owners of failed hard drives to try putting the drive in the refrigerator for an hour. Take it out, then tap it lightly and re-install. This works most of the time for Ed. A follow-up letter from Chris Eccles in the September issue explains why this trick might work.

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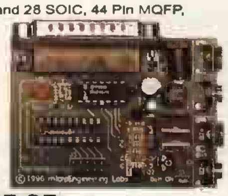

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Parallel port extension cable - £5.95
40Pin ZIF socket - £22.50
8/18Pin ZIF Socket - £22.50
PIC8 Prototype board - £4.50
PIC18 Prototype board - £5.50
PIC64 Prototype board - £8.50

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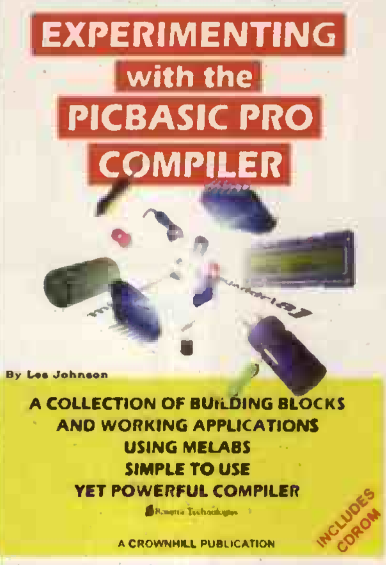

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CIRCLE NO. 112 ON REPLY CARD

New filter/mixer chip

A versatile high-Q bandpass filter chip with integral mixer has recently been launched by UK semiconductor manufacturer Zetex. The subject of our design competition on page 187, this filter operates to 150kHz and its mixer extends operation to 700kHz.

The new ZXF36L01 is a versatile analogue high-Q filter chip. In addition to its variable-Q bandpass or bandstop filter, the device also contains a mixer block, extending its range of applications.

To set the centre frequency, the basic filter section requires two resistors and two capacitors. Filter Q is controlled by two external resistors and can be varied up to about 50, **Fig. 1**.

While the filter operates up to 150kHz, the mixer extends the useful frequency range up to 700kHz and allows the frequency to be tuned. The local oscillator can be any waveform, making microprocessor control convenient.

The device is expected to be useful in audio gear and instrumentation for bandpass, notch and adaptive filtering. As the waveform at the local oscillator's input is irrelevant, a microcontroller can be used to produce a low-cost and variable frequency input.

Combining the filter and mixer functions in one low-cost chip makes the device interesting for sonar and ultrasonics, as you will see from the application outlined in the separate panel.

Typical operating current of this 5V device is 3.4mA and there's a shutdown mode reducing current to just 160μA. Devices are easily cascaded.

Filter circuits

From **Figs 2, 3 & 4**, you can see how easy it is to implement various notch filters. Centre frequency, f_c, is given by,

$$f_c = \frac{1}{2\pi RC}$$

while Q is,

$$Q \propto \frac{R_f}{R_i}$$

Here R, R_i and $R_f \geq 10k\Omega$ and $C \geq 50pF$.

There's more on designing for a value of Q in the device data sheet.

Figure 5 shows how the device's frequency range can be extended using the mixer block. ■

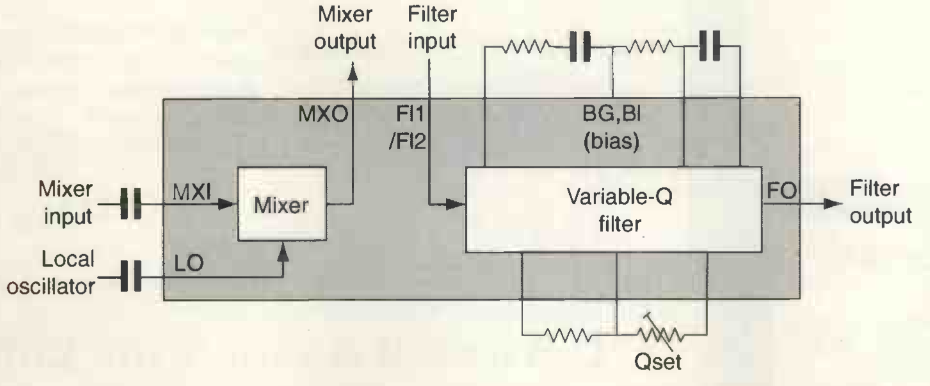


Fig. 1. Outline of the new variable-Q filter and mixer chip. Since the local-oscillator can be driven by a squarewave, it is easy to present it with an input whose frequency is determined under software control using a micro.

Fig. 2. Circuit for a notch band-stop filter using the ZXF36L01, together with its gain and phase response graphs.

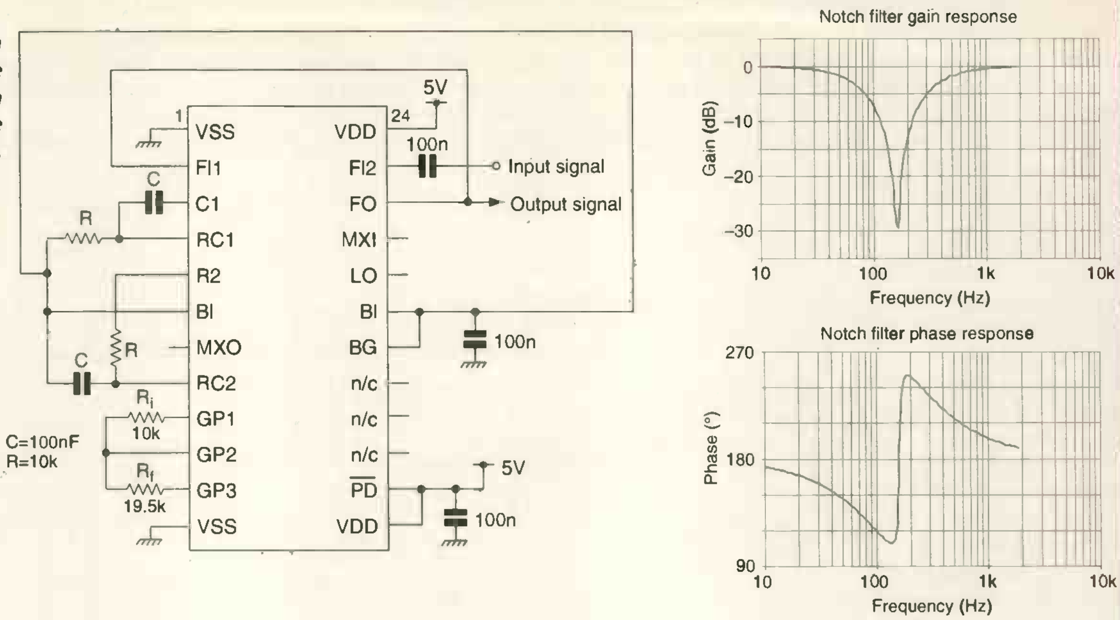


Fig. 3. Circuit for a band-pass filter with 0dB stop level.

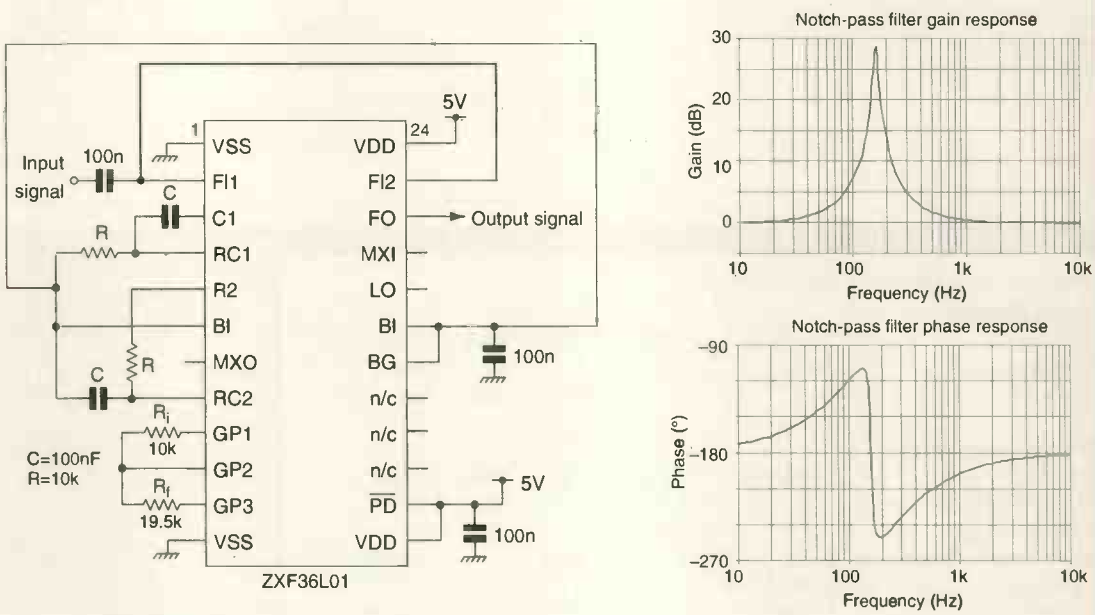
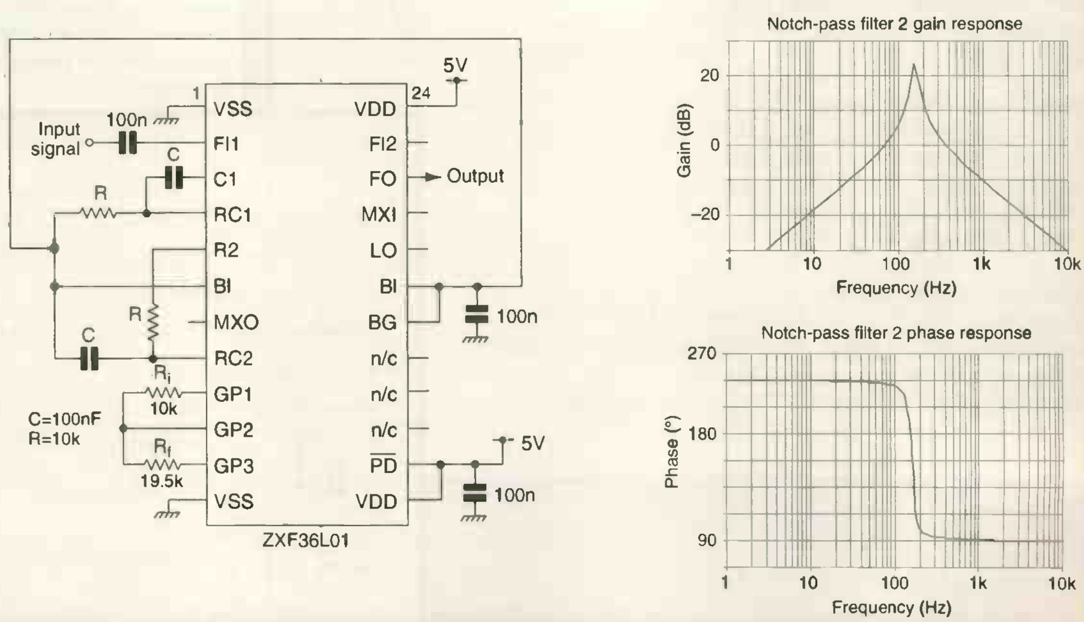


Fig. 4. Notch filter with attenuating skirts. Skirt 'roll-off' away from the peak is –20dB/decade, regardless of Q.



Deign example – using the ZXF36L01 in a sonar application

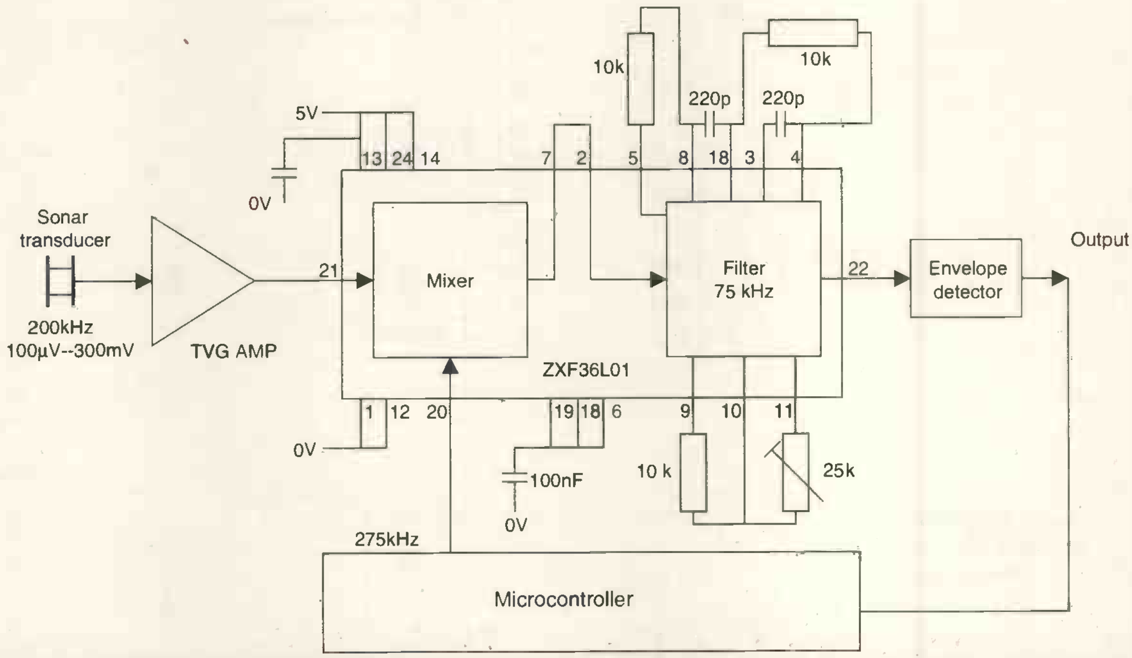
In a typical sonar system, the transducer is pulsed at its resonant frequency and the reflection is received after a period proportional to distance. The ZXF36L01 variable-Q filter is used to maximise the sensitivity at the required frequency and reduce noise. The on-chip mixer allows the received frequency to be tuned to accommodate different transducer frequencies.

The diagram shows how the ZXF36L01 provides a tuning and filtering solution for a sonar system. The received signal is first processed by an amplifier. This amplifier's gain increases with time to compensate for the reduction in reflected signal with time. At the same time, this amplifier reduces problems due to input overload.

From here, the signal is mixed with a local oscillator generated by a micro-controller. The filter then selects the appropriate signal.

In this example for a 200kHz transducer, the filter is set at 75kHz and the local oscillator at 275kHz. The mixer output contains the sum at 475kHz and the difference at 75kHz and the filter selects the 75kHz signal.

An envelope detector follows the filter to provide a voltage proportional to the received signal. A microcontroller can now be used to process the time delay and signal strength to provide distance information.



Electrical characteristics of the ZXF36L01

Supply current

Parameter	Conditions	Min.	Typ.	Max.	Units
Operating	Filter	2.2	3.4	4.5	mA
Shutdown			160	300	µA

Filter characteristics

Parameter	Conditions	Min.	Typ.	Max.	Units
Max. operating frequency				150	kHz
Q usable range		0.5		50	
Centre frequency temp. co.	Q=30, f_o=1kHz		2000		ppm/°C
Q temp. co.	Q=30, f_o=1kHz		0.7		% /°C
Voltage Noise	1-100kHz		20		nV/√Hz
Input Impedance		30		50	kΩ
Linear output range	10kΩ load		1.6		V p-p
Sink current			150		µA
Source current			150		µA

Typical mixer characteristics

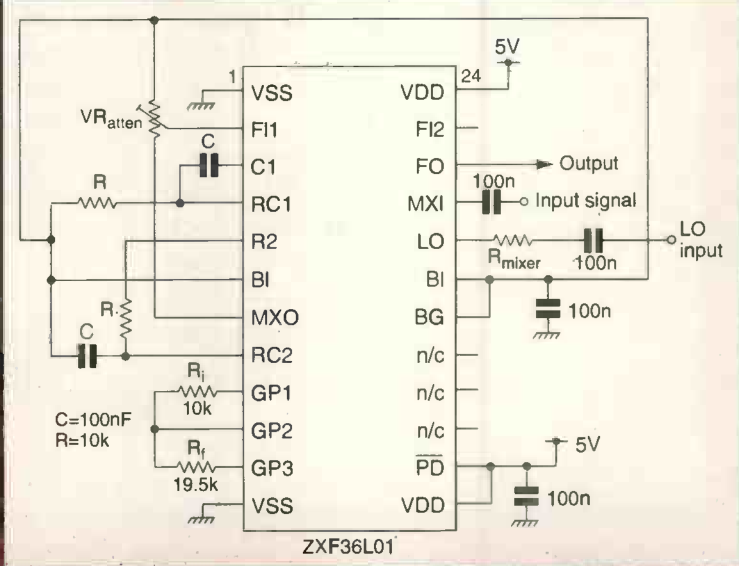
Max. operating frequency	700kHz
Maximum signal input	300mV p-p
Maximum LO input	100mV p-p
Minimum LO input	5mV p-p
LO input impedance	60Ω

Absolute maximum ratings

Voltage on any pin	7.0V relative to V_{ss}
Operating temperature range	0 to 70°C, derated for –40 to 85°C
Storage temperature	–55 to 125°C

Test conditions: temperature 25°C, V_{DD} = 5.00, V_{SS} = 0V

Fig. 5. Filtering higher frequencies using the mixer. The signal to be filtered is mixed with the LO, whose frequency is chosen so that the difference, or intermediate, frequency equals the filter's centre frequency.



Design competition

Devise a useful and/or ingenious application for the ZXF36L01 versatile high-Q bandpass filter with integral mixer and you could win a £500 voucher to spend with Farnell. There's two runner up prizes of £100 vouchers too.

Launched this year, the ZXF36L01 is a versatile high-Q bandpass 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.

All you have to do to enter the competition is send a design idea incorporating the ZXF36L01 to the address below. Entries will be judged on ingenuity, originality and usefulness. All entries are subject to the rules set out below.

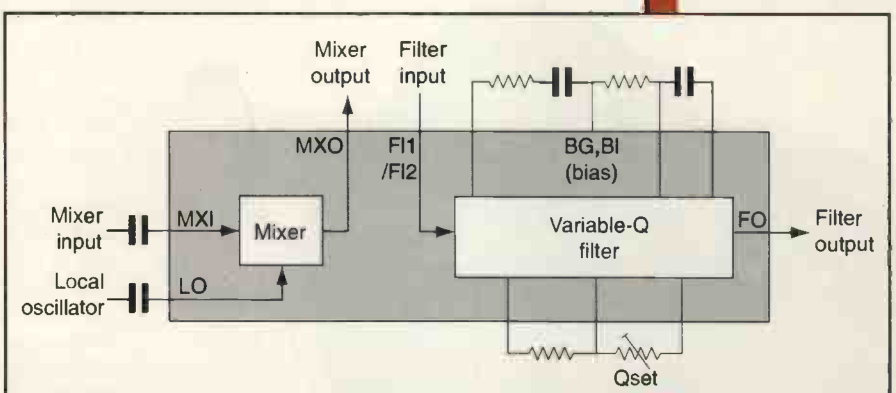
A designer's kit is available from Farnell and you can find full data on the device on Zetex's web site http://www.zetex.com/pdf/ics/zxf36101.pdf.

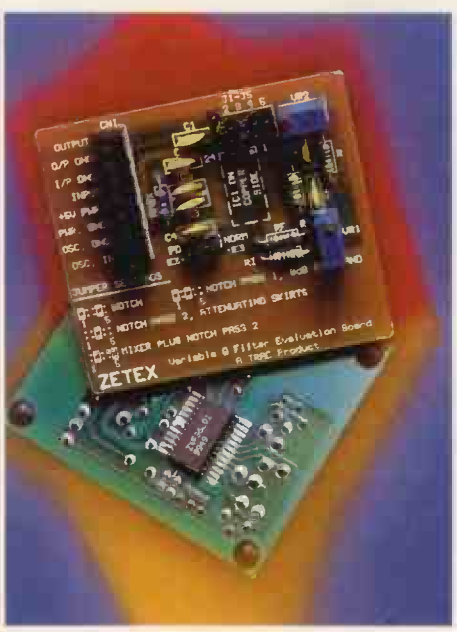
It is not necessary for you to prove your design, and buying the kit is not a condition of entry into the competition. The design you submit has to work in practice but you will not be penalised for not having built a prototype.

If you do submit a design that meets the competition criteria and you *have* bought the kit, then you will receive a Farnell voucher for £15, courtesy of Zetex.

Send your entry to Filter Design, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Note that it is not necessary to send your prototype! Simply send the circuit diagram and a clear, concise description of the circuit. It will help if you describe why you think that your circuit should be among the winners. You can also e-mail your entry to jackie.lowe@rbi.co.uk, but unless the e-mail has a subject heading that reads 'Filter Design' it will not be eligible. Please attach diagrams and text separately and include a daytime phone number with your entry if possible.

The closing date for the competition is 30 April.





You don't need to buy this this new development board for the ZXF36L01 in order to enter the competition, but if you do, and your entry meets the competition requirements, you will receive a Farnell voucher for £15 to help cover its cost.

Win a £500 voucher redeemable at Farnell.

For more information...
Visit http://www.farnell.co for details of the ZXF36L01 development kit or http://www.zetex.com/pdf/ics/zxf36101.pdf for more data on the filter chip.

This *Electronics World* competition is sponsored by UK semiconductor manufacturer Zetex and distributor Farnell Electronics Components.

Rules

- Electronics World reserves the right to publish submitted entries. All designs published will be attributed to their designers. A minimum payment of £50 will be made for each design published.
- Submission of an entry does not remove your right to exploit your design, but it does give Zetex the right to use the entry as an application note, or as the basis thereof, effectively making the design public domain.
- Winners will be chosen jointly by technical experts from Zetex, Farnell and the editor of Electronics World. The judges' choice will be final and no correspondence will be entered into regarding the choice of winner.
- No employee of Reed Business Information, Zetex and Farnell, or any of their associated companies, may enter this competition, nor may members of their families.
- No entry will win more than one prize, but multiple entries may be submitted.
- Prizes are as stated here and not negotiable.
- Entries arriving after the closing date will be void.
- No purchase in necessary to enter this competition.
- Winners will be notified by post, and the results may be publicised.
- For a list of winning entries, send an SAE to the editorial offices.
- Submitting an entry for the competition implies acceptance of these rules.

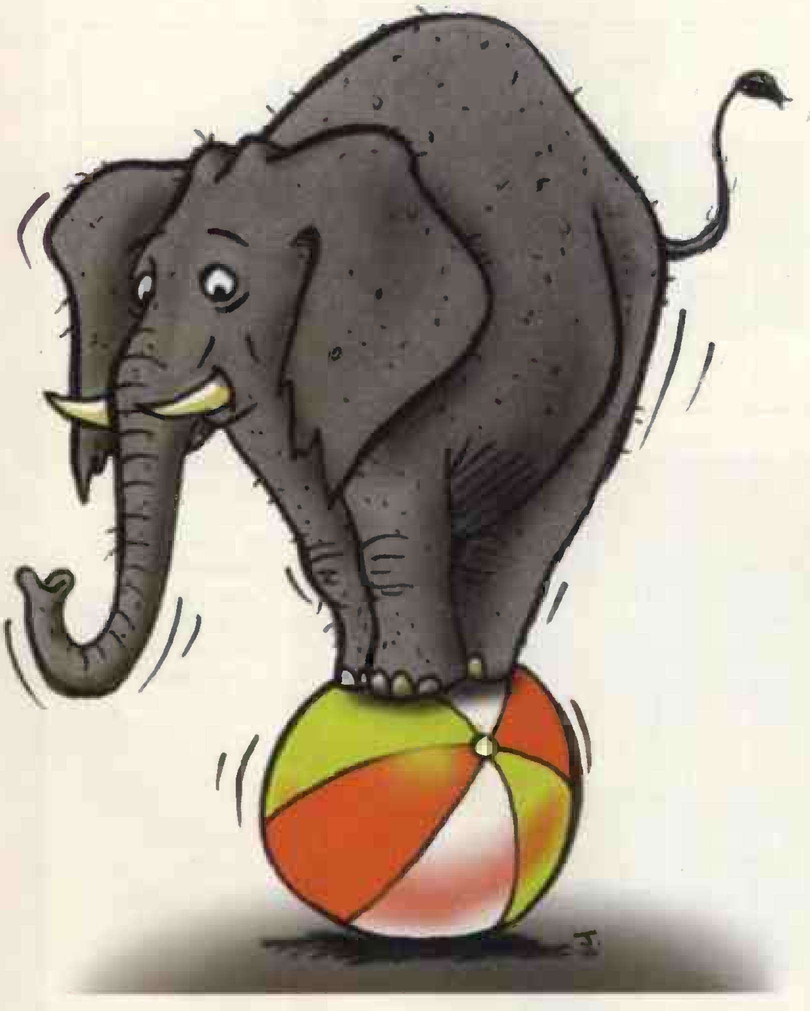
Beginners' corner

Balanced circuits

Balanced circuits play an important role in communications and in many other applications from audio to microwave frequencies. Ian Hickman explains why they are so widely used.

Balanced circuits have played an important part in communications, since before the days of 'electronics' as a recognisable branch of engineering. They continue to do so today.

Many circuits, such as a 75Ω coaxial television feeder cable for example, are unbalanced. That means that the signal is conveyed on one conductor, while the other remains at zero or ground potential – at least nominally.



Typically, unbalanced circuits are physically asymmetrical; in the case of coaxial cable, one conductor completely surrounds the other, hopefully screening it from any outside interference.

Balanced circuits, on the other hand, are both physically and electrically symmetrical. For audio-frequency signals, a typical arrangement consists of two wires side by side, spaced several inches apart.

Such wire pairs carrying telephone signals and supported on telegraph poles used to be a common sight alongside railway tracks. You can still see them in some rural areas of the country, and in many places throughout the world.

Depending on the gauge of the wire and the spacing, such circuits have a nominal characteristic impedance of 600Ω, 900Ω or 1200Ω. The latter two are more common abroad than in the United Kingdom.

If you were to climb a telegraph pole with a portable battery-operated oscilloscope, and view the signal on one wire with a high impedance probe, you would find it looked much the same as the signal on the other. But if you viewed them both at once, using a dual channel scope, you would see that the signal on one wire was the same as on the other, but inverted.

The telephone on the far end of the line responds to the voltage *difference* between the wires, i.e. the voltage on one with respect to the other. Any interference induced in the wires will produce the same voltage with respect to ground, on both lines. Such interference might be caused by electrostatic or electromagnetic coupling between the pair of wires and an overhead power transmission line for example.

In UK telephone engineers' parlance, this type of signal is called a 'longitudinal voltage'. In the US, it would be referred to as a 'voltage to ground'. It is also called a common-mode or 'push-push' signal.

The differential voltage – the voltage on one wire with respect to the other – is called the 'transverse' or 'metallic' signal by UK or US telephone engineers, or the normal-mode or push-pull voltage.

Although the circuitry within a telephone handset is not itself balanced, it responds to the transverse voltage while largely ignoring any longitudinal voltage. This is because it is 'floating', i.e. no part of it is ground referenced.

The handset also of course has to transmit outgoing speech to the line – a function traditionally performed with the aid of a specially wound transformer or 'hybrid'.

Nowadays, an electronic hybrid avoids the use of a costly, bulky wound component; various circuit arrangements can be used, such as those in reference 1.

Balanced circuits abound

That basic building block of analogue electronics, the op-amp, is equipped with a balanced floating input. This means that the output voltage should depend only upon the voltage of one input with respect to the other, regardless of whether their average potential is 0V or some other value.

Manufacturers' data sheets always quote the degree of balance or 'common-mode rejection ratio', which is frequently shortened to CMRR.

For example, the popular and long established TL081 op-amp typically provides a CMRR of 86dB, with a minimum of 70dB for the commercial TL081C, 75dB minimum for premium types. The differential input voltage amplification of the device is 200V/mV typical – 25V/mV or 50V/mV minimum, depending on version.

The typical figure corresponds to 106dB and the common-mode input voltage amplification should therefore typically be 86dB less than this, or just 20dB. In principle, you could measure the common-mode gain using the circuit of **Figure 1a)**. With no negative feedback around the op-amp though, the offset voltage adjustment needed to set the mean output voltage level to 0V ground would be very critical.

There is a way around this problem. Instead of returning the wiper of the offset adjustment potentiometer via 1.5kΩ to the negative rail, it can be returned through a high resistance to the op-amp's output, although this back door negative feedback will of course affect the gain. I once used this scheme to make a CA3130 provide a very high impedance balanced floating input, for use as the null detector in an AC bridge.

In practice, an op-amp is always used with negative feedback applied, to define the gain to the desired value. **Figure 1b)** shows inverting and non-inverting amplifiers, each with an unbalanced input.

Although the input terminals themselves provide a balanced input, applying negative feedback causes unbalanced operation. Balance can be restored by a modification to the circuit, shown in **Fig. 2**. Here, the device inputs connect to a bridge of resistors, providing a balanced input and a gain of 20dB, if $R_2=10\times R_1$.

If a common mode input of say +1V is applied, the non-inverting input rises to 10÷11=0.909V. If the output stays at zero volts, the inverting input will rise to the same voltage, provided that the resistor values are accurate. Thus there is no change in the differential input voltage. Hence, due to the device's common-mode rejection, there is no change in output voltage.

But while the Fig. 2 circuit provides a balanced input, i.e. one with common-mode rejection, it is not ideal. In the case of the TL081, the op-amp's input pins are virtual open circuits, each looking like a resistance of $10^{12}\Omega$. So assuming that R_1 is 10kΩ and R_2 is 100kΩ, the circuit's input resistance at the non-inverting input terminal is just 110kΩ.

However, if you work it out for the inverting input, you will find that with a balanced input signal, it comes to 5.238kΩ. Thus the circuit will unbalance the output of a balanced source with a finite output resistance. This could be a problem when making 'bridging' measurements, i.e. tapping across a line in service.

Of course if the source were truly floating, there would not be a problem, but then a truly floating source could equally well use either of the Figure 1b) circuits.

There are several ways round this. For example, the LT1193 high slew-rate video difference amplifier from Linear Technology features two identical parallel input stages. These have closely defined gain, and both of them control the output. Thus one pair of input terminals can be used to set the gain, leaving the other pair floating free[2].

Alternatively, three op-amps can be harnessed together to provide an 'instrumentation amplifier', as in **Fig. 3a)**. This provides a very high input impedance at both input terminals, converting the signal to an unbalanced output.

Note that the two input op-amps provide no common-mode rejection. It is all obtained from the second stage. This has the same configuration as Fig. 2, and as noted above, it has an unbalanced input resistance. But it is driven from the output impedance of the first stage, which is near zero due to the negative feedback around the input op-amps.

The arrangement is so useful that the three op-amps together with their various resistors are available from most semiconductor manufacturers, integrated into a single IC. A typical example is the AD624 from Analog Devices, providing pin-programmable gains from ×1 to ×1000, a gain bandwidth product of 25MHz, low noise, high linearity and low input-offset voltage. In addition, its CMRR is 130dB minimum at gains of ×500 or above.

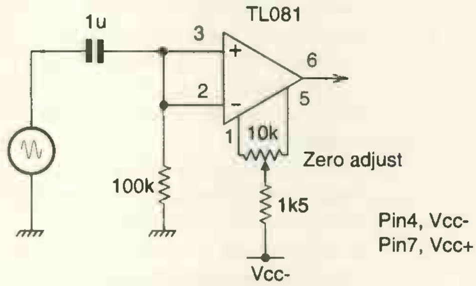


Fig. 1a). Illustrating common-mode rejection. Applying an identical signal to both inputs of an ideal op-amp would result in zero output.

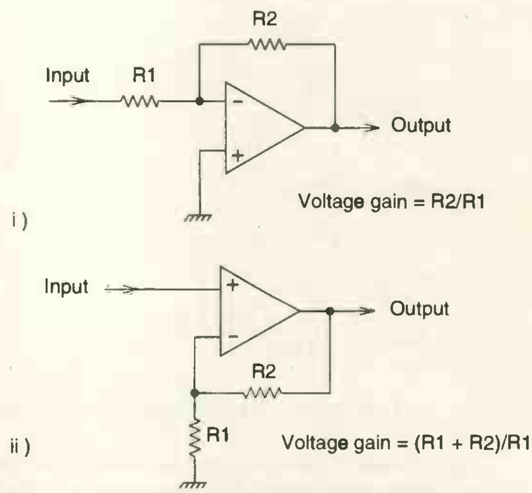


Fig. 1b). Adding negative feedback to define the gain accurately converts the op-amp to an unbalanced input circuit, either inverting with an input resistance R_1 (i), or non-inverting with a high input resistance (ii).

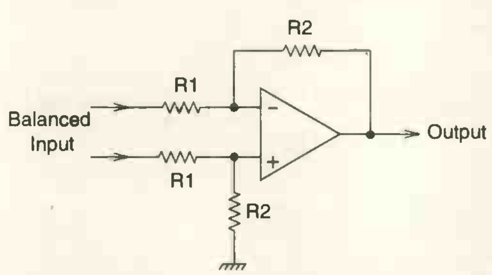


Fig. 2. This circuit provides a balanced input and converts the signal to a single-ended output.

An alternative circuit arrangement can provide the floating high input impedance of an instrumentation amplifier with just two op-amps, Fig. 3b).

Applications for balanced circuits

Balanced circuits are widely used. A common example is the 300Ω balanced feeder often used for the run between a dipole antenna and a VHF broadcast receiver. Any interference picked up on the feeder is a common-mode signal, which is ignored by the balanced floating input of the receiver.

At much lower frequencies, instrumentation amplifiers are used in situations where it is required to accurately record or process small signals that may be contaminated with much larger unwanted common mode voltages.

Many instances occur in manufacturing process-control, with sensors measuring strain, temperature, pH, etc. At one time I was involved with measuring the performance of telephone transmission circuits. I have already mentioned 600Ω balanced open wire lines, but many a subscriber's 'local loop', or connection to their local exchange, is via a multi-cored twisted-pair cable for most of its length. Such twisted pairs have a lower characteristic impedance than open-wire lines. Values of 135Ω, 140Ω (standard in UK) and 150Ω are common.

On both types of line, quite large longitudinal voltages may be experienced from time to time, so telephone transmission test equipment is designed to be very well balanced. This applies particularly to a psophometer, which must meet the stringent requirements laid down in the relevant CCITT specification.

A psophometer is an instrument for measuring the perceived level of noise on a telephone circuit, using a true rms meter circuit. It includes a 'telephone weighting filter' (CCITT Rec. P53, 1970), which takes into account the variation of efficiency of a telephone earpiece with frequency, and the acuity of the ear likewise.

A 'broadcast filter' is also supplied for use on the higher bandwidth lines working at 50Hz to 15kHz. These are provided for linking studios. The filter also has a 'flat' position.

The CCITT-specified degree of balance or rejection of longitudinal (common-mode) signals is not a unique figure, but varies according to the frequency. At 50Hz, the requirement is that when 200V rms is applied between the instrument's input and its case, the reading shall not exceed 100μV, i.e. a CMRR of 126dB. For this test, the two input terminals are strapped together.

In an instrument I designed, subsequently bought in quantity by the then GPO, roughly half the required rejection was obtained in an input transformer with a balanced floating primary. The other half was obtained from a modified version of the circuit in Fig. 2.

For signal level adjustments and measurement purposes, balanced systems need balanced attenuators. **Figure 4a)** shows a switched 0 or 60dB balanced 600Ω attenuator stage. Together with a bridged balanced-tee 0-50dB stage with 10dB steps and a similar 0-11dB stage with 1dB steps, it was used in another GPO contract, for a balanced attenuator covering 0-121dB in 1dB steps.

The original specification demanded a very high degree of balance – 60dB – at any attenuation setting up to the maximum, over the audio band. This was tested by applying an input between the input terminals, which were strapped together, and the case. The output was measured at various frequencies with a balanced instrument, such as a psophometer.

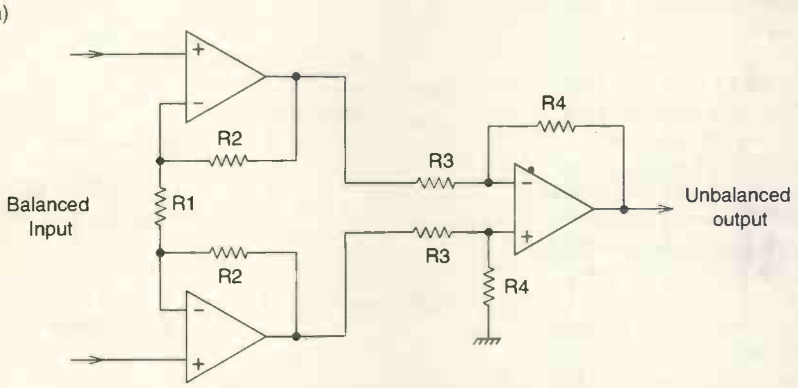
With careful design, the required performance can be met at low and medium values of attenuation. But if the measuring instrument's input is balanced floating, whether 'bridging' (high impedance) or 'terminating' (600Ω), the attenuator in Fig. 4a) provides no attenuation of the longitudinal signal. So one is in effect measuring the balance of the measuring instrument, rather than that of the attenuator.

The situation is little changed if the measuring instrument's input is bridging, centre tapped to ground. It is rather better if the measuring instrument's input is also set to terminating. Thus at the maximum attenuation, the degree of balance demanded could be around 180dB – which is clearly impracticable.

So the customer agreed to change the specification, and the pad was redesigned as a balanced-tee pad, with a centre tap brought out to a terminal on the front panel, Fig. **4b)**.

When using high attenuations of 60dB and above, the pad centre tap could be earthed, making the attenuation of longitudinal components equal

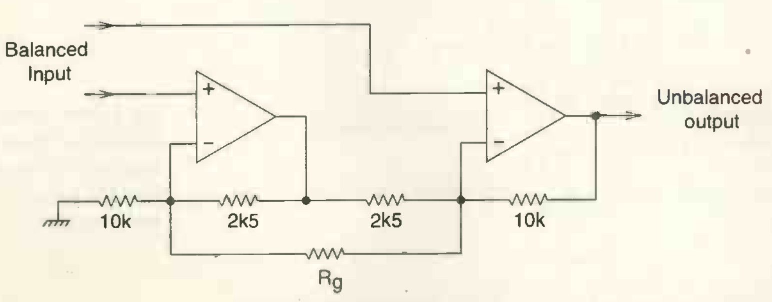
a)



Voltage gain = (2 x R2/R1)(R4/R3) = unbalanced output voltage / balanced input voltage

Fig. 3. Circuit a) provides a high impedance balanced floating input and converts the signal to a single-ended output. Fig. 3b) is similar to a) but uses only two op-amps.

b)



Voltage gain = 5 + 20k / R_g

to that of transverse. Evidently, when considering a balanced transmission system, it is necessary to know if the receive end is floating or centre-tapped to ground, and whether terminated or bridging.

Balanced circuits are also used on printed circuit boards, where very high frequency emitter-coupled logic (ECL) signals must be routed from one place to another without corruption by cross-talk, etc.

Rise times of the signals concerned are of the order of a nanosecond, so correspondingly fast test signals are required. Testing of unbalanced transmission lines for data is usually carried out using time domain reflectometer (TDR) measurements.

A voltage step with a very short rise time is applied to the input of the line from a matched generator. The line input voltage is monitored by a sampling oscilloscope, and if the line is good, and correctly terminated in its characteristic impedance, 50Ω say, then the step is undistorted. But if the line is short circuited, the input voltage will collapse again to zero after a time equal to the round trip time from the input to the short and back again.

Similarly, any impedance variations at any point along the line will cause a reflection of some magnitude and sign. A measurement of the time between the step and the returned echo gives the distance to the fault.

For such measurements on a balanced line, two step generators and line input voltage monitors are necessary, one for each line. The Tektronix 11801C oscilloscope, with option SD-24, is designed for just this purpose.

With one step positive-going and the other negative-going, the performance of the balanced line as such can be determined. The effective rise time of the instrument, taking into account the rise time of the step and the rise time of the line voltage monitor section, is 35ps or less.

Further tests are possible – and desirable – given that any induced crosstalk may be a common mode component. So there is provision to reverse the polarity of the negative-going step. With both steps positive-going, the characteristics of the line to ground, as an unbalanced system can be investigated, as can its response to common-mode signals. ■

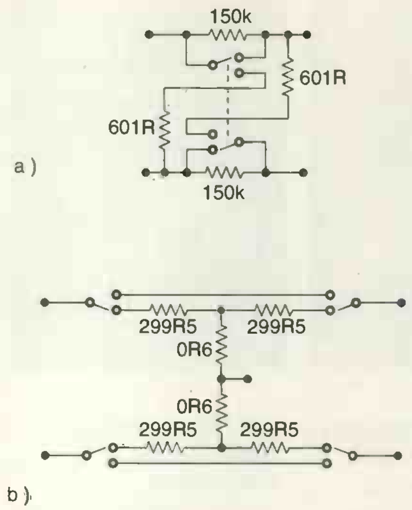


Fig. 4a). A switched 0 or 60dB 600Ω balanced π or 'box' attenuator pad. In Fig. 4b), the balanced tee or 'H' version is provided with an optionally grounded centre tap.

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2. Hickman, Ian, 'Four op-amp inputs are better than two,' *Electronics World*, May 1992 pp. 399-401.

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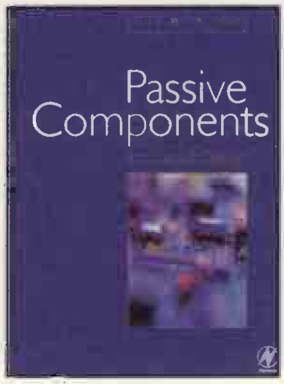

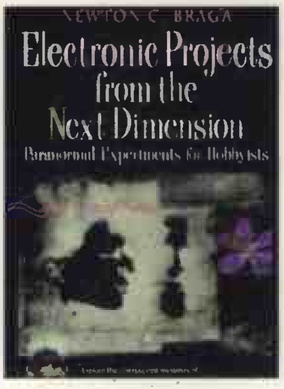

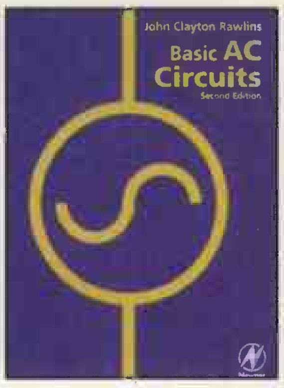

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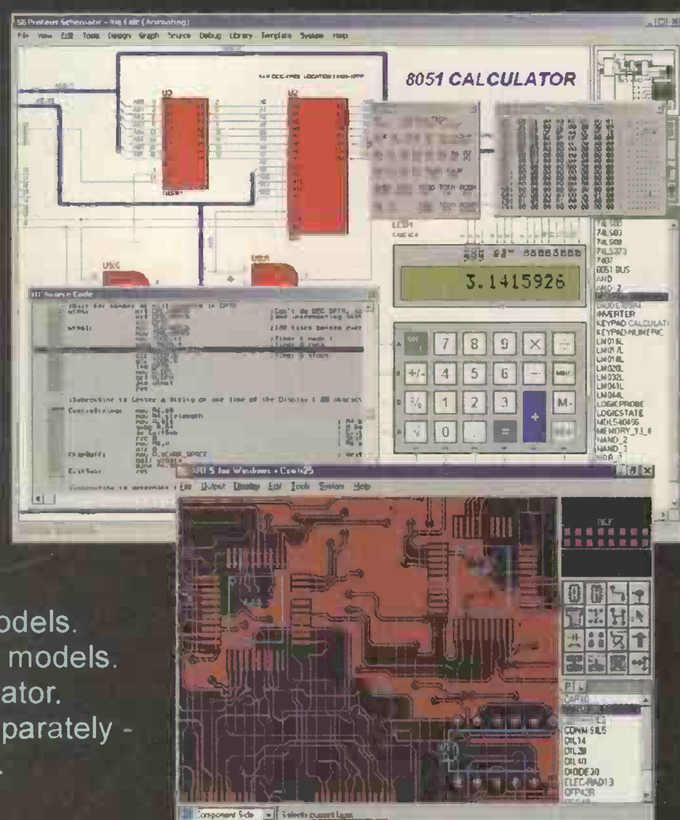

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Beautiful resistors

Les Green looks at the rarely discussed topic of the effects of stress in planar resistors, and he explains how to reduce it.

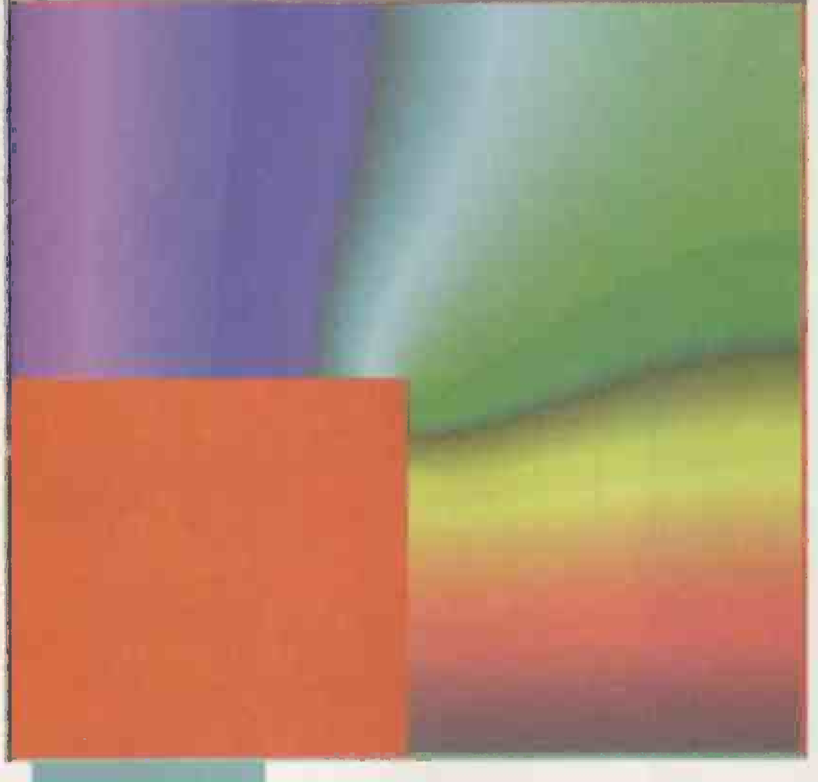


Fig. 1. Equipotential plot of a square-corner turn. Orange is insulator. The blue and green lines, left and bottom respectively, are electrodes.

You may never get the chance to design your own custom resistor network. In fact you may not think there is anything interesting involved in resistor design, but every electronics designer should be able to appreciate the beauty of a well designed resistor.

The subject of resistor design is seldom taught in electronics courses, possibly because most of the techniques are computer based rather than mathematically biased. In fact it is the development of computer graphics which has really made the subject come alive.

A brief history

Early electrical research was not restricted to one or two experimenters; a great many researchers contributed along the way. The short list of discoveries shown in the panel fits the history of resistance into its proper historical perspective.

Resistors were originally coils of thin wire. As this construction method is bulky and expensive, it is now only used on laboratory standard resistors and power wire-wound resistors.

For some time, ordinary resistors were made of a mixture of carbon and insulating binding material, forming the 'carbon composition' construction. These were horribly unstable, noisy and inaccurate by modern standards.

The modern form of resistors is always a thin film*

Resistance-related discoveries

1785 Coulomb, discovered that electric charges exert forces on each other.

1800 Volta, invented the primary battery.

1820 Oersted, discovered that an electric current deflected a magnetic compass needle.

1820 Ampère, discovered that electric currents exert forces on each other.

1826 Ohm, identified the relationship between electric current, potential difference and resistance

1831 Faraday, discovered electromagnetic induction.

1845 Kirchhoff, formulated the basic laws of electrical networks.

*Technically, thick film usually refers to a screen-printed resistor, while thin film refers to a vacuum deposited resistor. Here I mean 'thin' in the usual English sense, rather than the specialist sense.

of conducting material on an insulating substrate; either in tubular form or as a flat film (planar). It is this planar form that is the chief target of this article.

Rectangular film resistance

The resistance, *R*, of a block of conductive material is given by the formula:

$$R = \frac{\rho \times L}{T \times W}$$

Here, *L* is the length, *T* is the thickness, *W* is the width and ρ is the resistivity. Since *R* has units of ohms, it should be clear that the units of ρ are $\Omega \times$ metre, often written as Ω·m.

For a thin film it is convenient to consider a new formula, where the resistivity and the thickness are combined into one term:

$$R = R_{SQ} \times \frac{L}{W}$$

It is evident that if the length of the film and the width of the film are equal, forming a square of resistive material, the resistance is a constant value of R_{SQ}. This is therefore known as the 'ohm per square', or Ω/sq for short, which is more formally called the sheet resistivity. It is not ohms per square metre or ohms per square foot; it is just ohms per geometric square.

This resistive film may be screen printed ('thick film') or vacuum deposited ('thin film'), but its primary characteristic is its Ω/sq. To make a resistor of a particular value, the aspect ratio, i.e. the ratio of the length to the width, is designed along with the Ω/sq parameter. Thus resistors are made short and fat, or long and thin, according to whether the desired resistance is greater or lesser than the Ω/sq for that film.

Resistor shape options

There is obviously a problem with high value resistors in relatively low resistance films; you need lots of squares in series. Therefore you either have to have a long resistor or a very thin resistor.

Given that the width of the resistor is governed by the manufacturing tolerances, there is obviously a limit as to how narrow you can make the resistive path. In order to make a long path in a small size, there is a need to go around corners.

Our nice simple formula now falls to pieces in the face of this geometrically simple rectangular corner. We have gone from simple geometry to a two-dimensional field pattern.

The resistance is no longer calculable without advanced mathematical formulae. We now enter the domain of finite element analysis by computer.

In **Fig. 1**, the orange area represents insulator. The blue line on the left is one electrode and the other electrode is below the bottom of the plot. This equipotential field plot clearly shows how the current flows around the corner. This shape has a resistance of 2.57 squares. In other words, if the sheet resistivity were 100Ω/sq, the resistance would be 257Ω.

By inspection we could have known that the resistance would be somewhere between 2 and 3 squares. Getting a more accurate answer would not have been possible without some sort of field plot. In fact manually produced field plots have been used for at least 100 years, as they appear in Maxwell's treatise[1].

Fig. 2. Gradient field plot of the square corner turn.

Fig. 3. Gradient plot of a bevelled corner turn.

Another way of looking at the field plot is in terms of the electric field intensity. This is the voltage gradient within the resistive film and represents electric stress on the film.

You can see from **Fig. 2** that there is a lot of stress at the corner. On this simulation the electric field is around 38 units near the electrodes, but rises to 175 units at the corner.

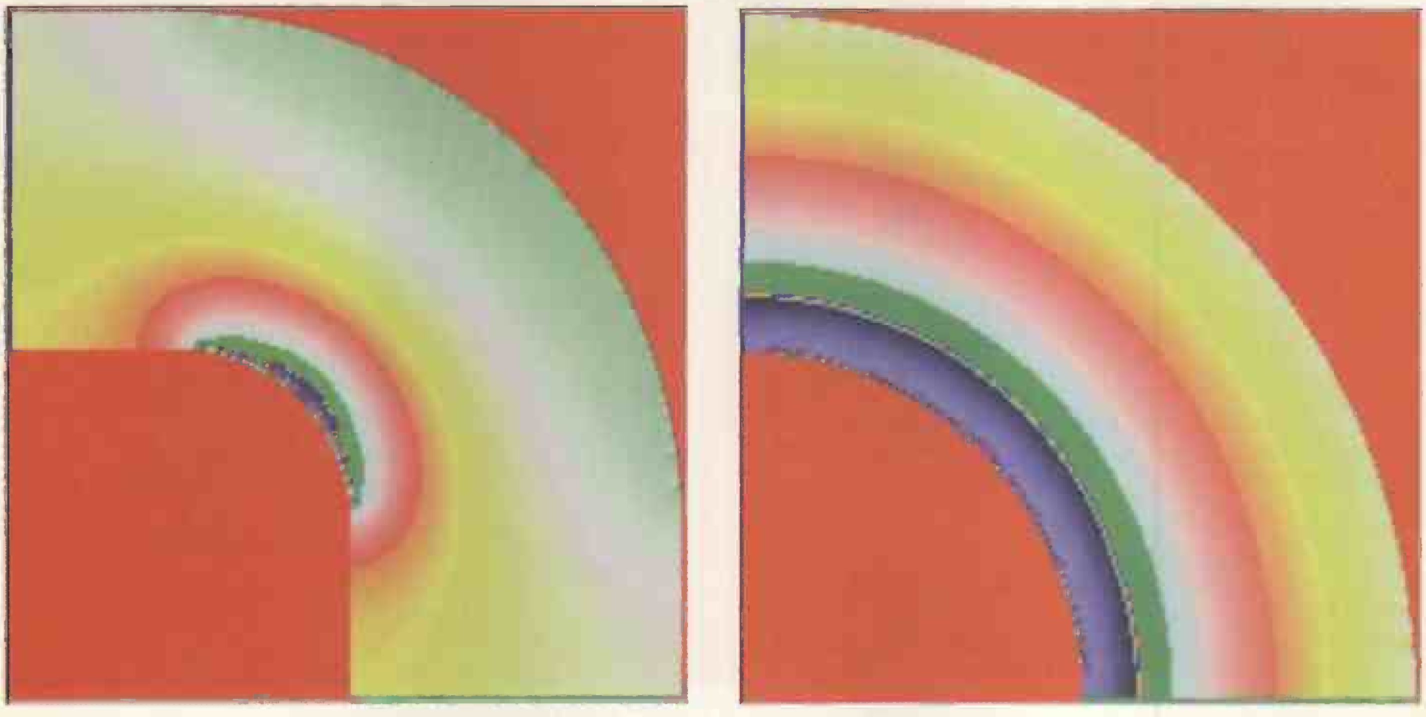


Fig. 4. Plot a) is the gradient of a half-width inner radius turn. In b) is a gradient plot of a full-width inner radius turn and in c) a gradient plot of the new style improved corner turn.

The current is taking a 'short-cut' around the corner and bunching up. This high stress point is a weakness in the design, as it will be damaged by over-voltage events more readily.

You should also realise that the power dissipated in a small element is proportional to the square of the voltage across it. Thus an element that has 5 times the electric stress across it, will actually be generating 25 times the heat. This is not a good way of making a stable resistor!

These points of stress also have a disproportionately large effect on the overall resistance compared to the rest of the pattern. This is another factor limiting the long term stability of the resistor.

The resistor is the wrong shape for accuracy and stability. What is needed is a smoother transition. Just bevelling the inside corner slightly has a useful effect, **Fig.** 3. The resistance has reduced to 2.4 squares, but the peak stress has reduced to 106 units at the corners, with 40 units near the conductors.

The other point about having stress in the resistive film is that current noise ($1/f$ noise) is increased[2].

Stress ratio

The ratio of the peak electric field strength to some sort of average field strength is obviously important. Up to this point I have been using a fairly imprecise measure, as the field around the electrodes is not constant. What is desirable is a more definitive measure with which to make quantitative comparisons between resistor shapes.

$$\text{Stress ratio} = \frac{\text{Peak electric field strength}}{\text{Mean active field strength}}$$

The term 'mean active field strength' needs defining and explaining. If an extra resistive area is added on to any field pattern, it is possible that there will be little or no voltage gradient in that area. In this sense the area is inactive.

If we average this new area in with all the rest, the stress ratio would get worse although the resistor would not actually be under any more stress. The inactive area would have skewed the stress ratio and given a misleading result.

A simple way to overcome this problem is to define an active area as one where the voltage gradient is greater than 5% of the peak gradient. The inactive areas are then neglected when calculating the mean electric field strength and the stress ratio.

Using this new measure the 'square corner turn' has a stress ratio of 4.94. The bevelled corner turn has a stress ratio of 2.99. This is a considerable improvement for little effort.

A radius on the inside corner of half the resistor width, with the outer radius $1^1/_2$ widths, both on the same centre, reduces the stress ratio to 2.05, **Fig. 4a)**.

Increasing the inner radius to equal the resistor width, and making the outer radius double the resistor width, gives a slight improvement to a stress ratio of 1.71, Fig. **4b)**.

There is a law of diminishing returns here. The best possible stress ratio is of course 1. The half-width-radius bend achieves a stress ratio of 2.05 with a resistance of 2.515 squares. The full width radius gives a stress ratio of 1.71 and a resistance of 2.323.

We want a maximum amount of resistance in a given space, but without putting the resistor under too much stress.

An interesting compromise is to deliberately make the short-cut around the corner less 'attractive' to the current flow. By pushing the inner corner out into the flow, the path length, and therefore the path resistance, is increased, Fig. **4c)**.

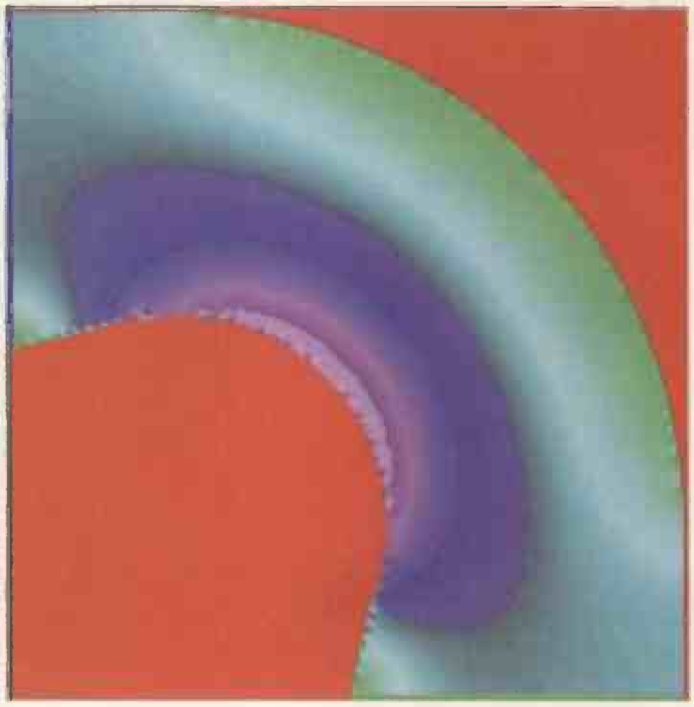
This new shape has a stress ratio of 1.9 and a resistance of 2.87 squares. As it gives more resistance with less stress in the same space, it is undeniably preferable to the half-radius bend.

No hard and fast rule can be made about what stress ratio is acceptable for a resistor in general, because the design environment and required specification for the resistor have not been stated. If pushed, I would say that a stress ratio of above 3 would give a poor resistor and that a stress ratio below 2 is desirable.

So far in this article, a quantitative measure of the stress in a resistive pattern has been presented. This then gives a quantitative way of saying which is a good pattern and which is a bad pattern.

In a second article on this topic, I will be discussing the subject of trimming. This is vitally important because poor trimming causes increased stress and therefore worse stability. The amount of trimming necessary on a thick film resistor is around ±19% so the subject is not trivial.

The reason why this is important to the non-specialist is that because of the large trimming range, one batch of resistors can work whilst the next batch can be utterly useless. This is of considerable importance to any designer! ■



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2. Yoshida, H, 'The Effect of Resistor Geometry on Current Noise', IEEE Transactions on Components, Hybrids and Manufacturing Technology: Vol. 16, No 3; May 1993, pp. 344-349.

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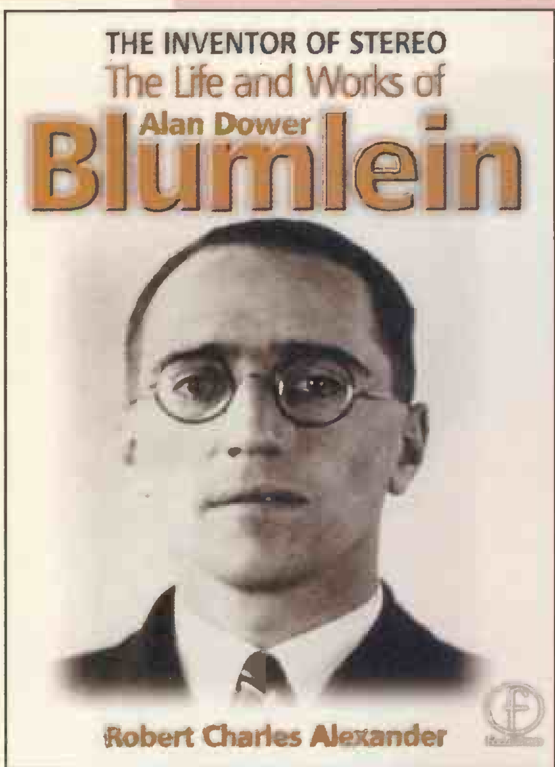

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His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among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

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

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

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White Electronic Designs is offering three 32Mbit synchronous SRAMs, the WED2ZL361MS-BC and the WED2ZL361MV-BC are 2.5V and 3.3V versions, respectively, of 1M x 36-bit NBL (no bus latency) synchronous SRAM. Each integrates two 1M x 18 SRAMs into a single 17mm x 23mm, 119 BGA package. The WED2ZL2365 12S-BC, also a 119 BGA, is a 2.5V version configured as two banks of 512K x 36. All three products are available in speed ranges from 100MHz to 166MHz, making them suitable for high-end networking applications such as Gigabit/Terabit Ethernet, ATM Switches, Add/Drop Multiplexers and Optical Switches. The NBL Synchronous SRAMs are designed to sustain 100 per cent bus bandwidth by eliminating turnaround cycles when there is a transition from read to write, or *vice versa*. All inputs are synchronised to rising clock edges with the exception of output enable and linear burst order. Asynchronous inputs include sleep mode enable. Write cycles are internally self-timed and initiated by the rising edge of the clock input. This feature eliminates complex off-chip write pulse generation and provides increased timing flexibility for incoming signals.

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SuperH processors run up to 200MHz

Hitachi has announced two microprocessors in the SuperH 32-bit Risc family, the SH7729R and SH7709S. Based on the SH3-DSP and SH-3 cores respectively, each device offers a high performance of 217/260Mips at operating frequencies of 167MHz/200MHz. The SH7709S achieves low power consumption with the SH-3 as its CPU core, making it suitable for use in portable information devices such as hand-held PCs and PDAs. The SH7729R in particular, with its on-chip DSP, can handle high-speed processing of voice recorder and image data in portable information devices. This allows for the high-speed execution of middleware, for example VoIP, in products such as voice codecs. The SH7729R is also capable of simultaneously executing browser display and voice codec processing, for instance in Windows CE, which has been difficult with previous products.

Hitachi
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Web: www.global.hitachi.com

Mobile phone driver IC generates 128 colours

Rohm has expanded its family of miniature LED driver ICs with a surface mount device that allows 128 different colours to be generated from a single tri-colour LED. Designed for portable, battery-powered applications such as mobile phones, the BU8770FV LED driver can be used to optimise LED colours dependent on certain operating conditions. The BU8770FV integrates an oscillator, a CPU interface block, a DC/DC converter for driving the LED and three PWM controllers for red, green and blue output respectively. The PWM circuitry allows the LED to generate up to 128 different colour shades. Device input is via a serial interface. Supplied in an SSOP 16-pin package with dimensions of 5 x 4.4 x 1.5mm, the device will operate from a 3.3V supply and incorporates a standby mode that minimises power consumption when driver operation is not required.

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Single-cell lithium-ion battery charger IC

TelCom Semiconductor's first battery charger IC, the TC3827, is a controller designed to carry out safe and fast charging of a single lithium-ion cell. The device's accuracy is ±1 per cent and shutdown current is 1μA. With an overall system accuracy of 1 per cent, the company says this device ensures the cell capacity is fully utilised without life cycle degradation.

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Circular connectors are very small

Flint is offering Hirose's miniature circular connector range, the HR25 which provides up to 20 contacts in an outside diameter of 12.5mm. Designers have a choice of 4, 6, 8, 12, 16 or 20 contacts, and a variety of wiring options including crimp-style and direct board mounting as well as soldered wiring types. The HR25 is available in screw-lock or push-type mating. Their construction ensures that pins cannot bend if the male pins are inserted incorrectly, even if the two pieces are engaged, safe positioning of male contacts prevents any possibility of collision, says the supplier. A combination of watertight coupling and gold-plated contacts comes as standard.

Flint
Tel: 01530 510 333
Web: www.flint.co.uk

200W modules output at 30, 40 and 50kV

Applied Kilovolts has introduced a range of 200W modules with output voltages of 30kV, 40kV & 50kV at 200W. The supplies use an energy recovery circuit to achieve high oscillator conversion efficiency and as a result are small in size for such high voltage power supplies, said the supplier. Operation is from 24V DC and uses a high frequency (50kHz) switch mode FET oscillator with the energy recovery circuits. All high voltage components are generously de-rated to give a design life of ten years or more and are vacuum encapsulated in silicone rubber. The modules are high stability with a load and line regulation of better than 0.1 per cent and a temperature co-efficient of better than 300ppm/°C. Output ripple is better than one per cent peak to peak.

Applied Kilovolts
Tel: 01273 439440
www.appliedkilovolts.com

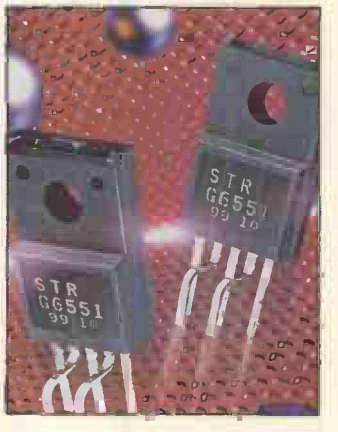
Vandal resistant keyboard is sensitive

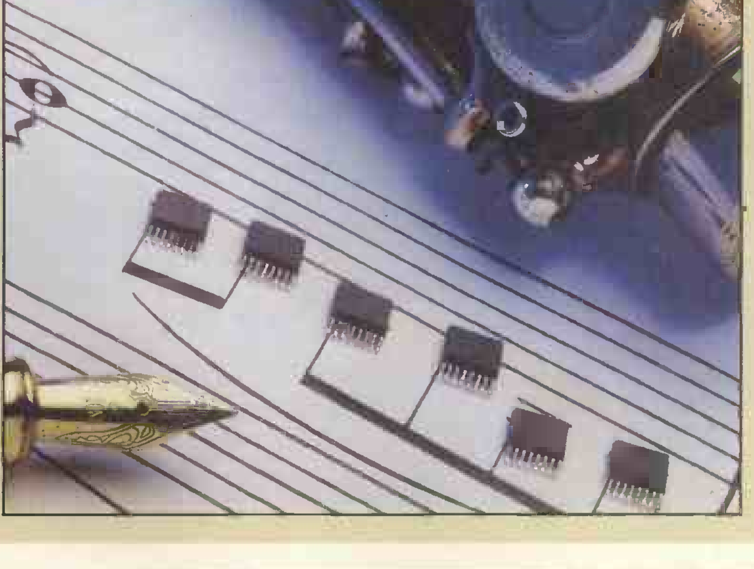
Using high frequency touch sensitive technology, Sussex-based EAO has produced a rugged PC compatible 105-key keyboard. For Larger volume applications, touch sensitive keyboards or keypads may be customised to customers' specific needs regarding the number of keys, design, shape, colour and functionality. The keyboards are PCB based and designed to be used through a glass or polycarbonate front plate. This makes them completely sealed and resistant to chemical attack as well as vandal resistant and easy to clean. They can also be operated using gloved hands. Available either as a stand-alone desktop unit, or a PCB version for mounting behind the customer front panel, the series 75 keyboard comprises an oscillator, a detection cell per key and an output signal processor. The keys are activated by dampening the oscillator's high frequency signal with a finger.

EAO
Tel: 01444 236000
www.eao-group.com

Hybrid IC switches varying loads

The STR-G6551 is an off-line switching IC from Ultimate Renaissance which operates in 'fixed off-time' mode with a maximum frequency of 60kHz. The device features a 3.9Ω $R_{DS(on)}$ avalanche rated 650V, 158mJ FET and includes over voltage protection (OVP), under voltage lockout (UVLO) and





Class-D audio amplifier gives a virtuoso performance

Zetex has announced the first product in its Class-D audio amplifier family. The ZXCD1000 switching amplifier controller offers efficiency greater than 90 per cent, claims the supplier. This allows the amplifier to be offered in a compact package, and to generate much less heat than a comparable Class A/B linear amplifier - which would typically have an efficiency of around 65 per cent. It offers THD + N (total harmonic distortion and noise) of typically 0.2 per cent open loop, or typically less than 0.1 per cent with a 10dB feedback loop (measurements are taken at 90 per cent power, full band). Depending on the choice of output filter, the ZXCD1000 provides true high fidelity performance at an output of 25W or 50W and can drive either a 4Ω or 8Ω load, says the firm.

Zetex
Tel: 0161 622 4422
Web: www.zetex.com

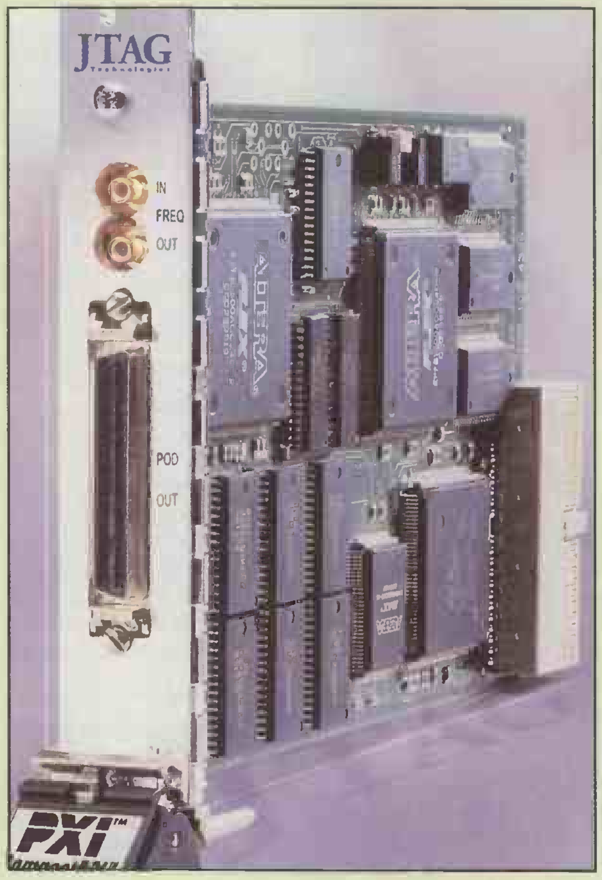
thermal shutdown (TSD) circuitry. Available in a 5-pin isolated TO-220 package the STR-G6551 operates up to 60W on a European input voltage range and 30W on a world-wide input voltage range. Ambient operating temperature range is –20°C to +125°C.

Ultimate Renaissance
Tel: 01793 439310
www.ur-home.com

Boundary scan controller supports compactpci/pxi

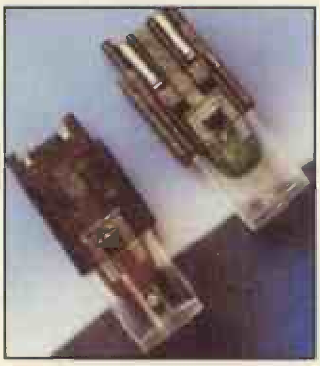
JTAG Technologies has extended its line of high-performance boundary-scan controllers with an addition to the JTAGTAPS family, the JT3710/PXI DataBlaster. The controller supports the CompactPCI/PXI format and its software structure is identical to the previous ISA, PCI, VXI and USB versions of the DataBlaster. The PXI-based controller offers 32-bit operation with data transfer speeds up to 25MHz. To accommodate the high data rates and lengthy vectors demanded by boundary-scan applications, such as flash memory In-System Programming, the JT3710/PXI uses a unique boundary scan implementation. This includes the firm's chipset for real-time data decompression, high-speed TAP (test access port) drivers and AutoWrite used to boost boundary-scan-based flash ISP performance. A high capacity memory is also incorporated onboard for local ISP data storage.

JTAG Technologies
Tel: 01234 272226
www.jtag.com



SM LEDs protect against discharge

Lumex's latest family of surface mount technology LEDs are designed to offer protection from electrostatic discharge (ESD). Applications include right-angle panel or fault



indicators, where the light source is exposed to an end user. The SMF-HM1340XD-L series of LED indicators are available in right-angle or straight-up packaging. They can be equipped with any of the supplier's off-the-shelf lensed T-3mm (T-1) light emitting diodes. Typical choices include standard low-current (I_F=2mA) LEDs in red, green, yellow or amber, with blue and white also available. An ESD-safe lens snaps over the LED to complete the package. The base unit is designed as a mate-able unit.

Lumex
Tel: 001 800 278 5666
www.lumex.com

DC supplies range from 13.3 to 30kW

The Magna-Power SQ Series of DC supplies range from 13.3kW to 30kW. They are sold by Kingshill in the UK. Developed from the established PQ series, these current-fed units combine high and medium frequency power processing technologies to reduce package size. There are 50 models with outputs from 16-625V, DC, 21-1800A, DC. They are fully programmable through resistance, voltage, current or optional JEEE-488/R5232. Over-voltage and over-current are also programmable. Constant monitoring ensures shutdown if a line opens or a programmed input is exceeded. Units function as voltage or current sources, depending on control settings and load conditions. As a voltage source, if the load increases beyond the current command setting, the unit automatically crosses over to current mode. Diagnostics are embodied within the control loop, while proprietary circuitry identifies whether voltage, current or a fault condition has control. If the fault condition demands user intervention, mains power is disconnected and the diagnostic status latched into memory.

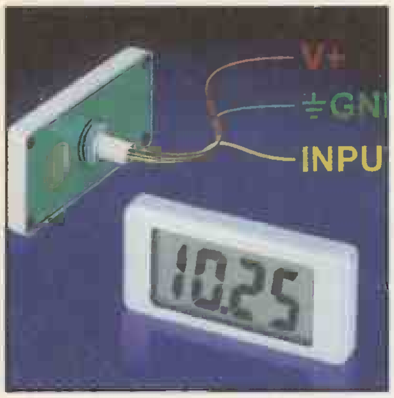
Kingshill
Tel: 01634 821200
www.kingshill.com

Adapter board connects CompactPCI supplies

Schroff's latest adapter board is a CompactPCI connection system using the power supply's M-connectors. It is intended to allow a user to carry out prototyping and small scale production work without having to manufacture an application specific backplane with integral power supply connections. It is based on a two layer intermediate board, which is used as an adapter between the power supplies and the backplane of a 19in. subrack. Available in heights of 3U and 6U, these boards like the backplane itself can be mounted onto the rear horizontal rails. All signals including drive supply, sense line and current share bus signals are fed from the DIN-M24/8 connector of the CompactPCI by cable to the intermediate board and then to the backplane.

Schroff
Tel: 01442 240471
www.schroff.co.uk

Please quote *Electronics World* when seeking further information



Custom voltmeter for under £15

Lascar has launched a custom-scaled addition to its EM series of drill mountable panel meters - the EMV 1025S-XX. This new 3-wire, 3½ digit LCD voltmeter has 'factory set' scaling. According to the supplier, the user orders a 10-wire evaluation unit, confirming preferred scaling and decimal point options. All subsequent meters ordered in quantities over 50 pcs will be provided in the particular configuration chosen for only £14.94 per unit, says the firm. As with each of the modules in the EM Series, the EMV 1025S-XX is fitted with a threaded stud, mountable through a 5.5mm hole, is 43.5mm by 21.4mm in size and has a low profile finish of 5mm.

Lascar Electronics
Tel: 01794 884616
www.lascarelectronics.com

1.4MHz buck converter offers 95% efficiency

Linear Technology's LTC3404, 1.4MHz current mode monolithic synchronous step-down DC/DC is capable of delivering up to 600mA of output current. The buck converter has an operating quiescent current for less than 1MHz operation of 10μA with no load and less than 1μA in shutdown. Efficiency is rated at 95 per cent.

Linear Technology
Tel: 01276 677676
www.linear.com

Comms modules for industrial PCs

Xycom Automation has extended its range of Industry Pack (IP) industrial PC communications modules. The module can be used on processor boards with IP sites, on XVME-9660 6U carrier cards (four per card) or XVME-9630 3U carrier cards (two per card). The XIP-4520 offers 8 channels of RS-232 communications with 64 bytes each of transmit and receive FIFO buffers and bit rate programmable up to 230kbit/s.

Xycom Automation
Tel: 01604 790767
www.xycomautomation.com

32-bit configurable chip

Triscend has introduced a 32-bit configurable device which integrates an ARM7TDMI processor core with programmable logic, representing over 3000 flip-flops and 300 programmable I/O. The A7 configurable system-on-chip device includes a dedicated system bus with a transfer rate of 264Mbit/s and system features such as a four-channel DMA controller, an external memory interface unit, full power management utilities and JTAG debug interface. Additional peripherals include timers, UARTs, interrupt and watchdog. Alongside the ARM core is an SRAM-based configurable logic matrix with over 3000 flip-flops and 300 programmable I/O. The system interconnect bus combines 32-bit addressing with 32-bit data

Clock generators for digital set-top boxes

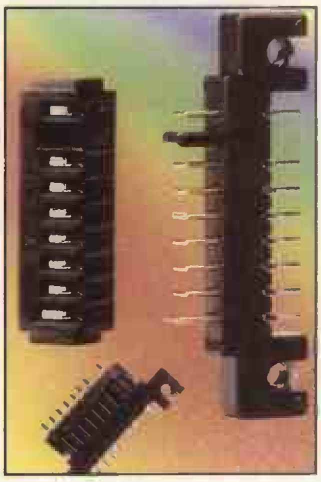
AMI has introduced a family of single phase-lock loop (PLL) clock generator ICs that support a variety of platforms. Each device contains an on-chip voltage-controlled crystal oscillator (VCXO) that develops the PLL reference frequency when combined with a crystal resonator. The VCXO allows designers to adjust the timing in systems that have frequency matching requirements, such as digital satellite receivers. The AMI devices also feature a phase-locked loop (PLL) that drives one or more clock outputs. The clock outputs are phase- and frequency-locked to the VCXO reference frequency. This locking of the output frequencies to the reference tackles unpredictable artifacts in video systems and reduces electromagnetic interference (EMI) caused by harmonic frequency stacking. Individual device pin-outs vary, but all packaging features a small circuit board footprint to contribute to reduced end-product size. Both 3.3V and 5V versions are available.

AMI
Tel: 000 49 351 530 331

carriage. The first device available, the TA7S20, offers 2048 configurable logic cells, 16K RAM and 251 programmable I/O. It is packaged in 128LQFP, 208QFP and 484BGA styles.
Triscend
Tel: 01628 681565
www.triscend.com

SM connector is metric

The BP2 2mm contact pitch connector is an eight contact, surface mounting connector capable of handling up to 3A DC on two contacts and 0.5A on the remainder. The UL-rated insulator is high temperature and

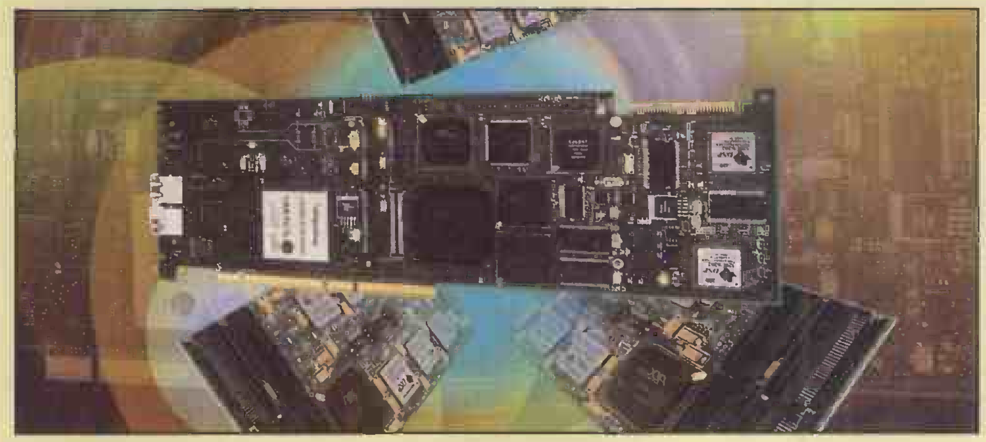


the operating range of the connector is –55°C to +85°C. The sideways mounted copper alloy blade contacts can endure 5000 mating cycles and all are gold plated. When mated the connector provides a co-planar (end to end) style board mating. Packaging options include embossed tape or semi-hard tray for auto placement.
Robinson Nugent
Tel: 01227 794495
www.robinsonnugent.com

LED Indicators for low or mains voltage

Hero Electronics is stocking a range of 22mm LED Indicators from German manufacturer Signal Constructs. The range includes products suitable for 130 and 230V AC mains operation as well as 20-28V AC or DC operation. The indicators are sealed to meet IP67 standards, overall diameter of

the lens is 30mm and mounting hole diameter is 22mm + 0.5mm. Designed for front panel mounting, the devices are secured with a circular fixing nut that is supplied along with an O-ring seal. A feature of the range is a 180° viewing angle. Five different LED colours are available as well as a bi-colour version. Luminous intensities range from 160 to 350mcd at 20mA operating current.
Hero Electronics
Tel: 01525 405015
www.heroelec.co.uk



Media platform in single pci slot

RadiSys' next generation family of Spirit-6000 media processing platforms is claimed to offer four-times the performance of its predecessor, the Spirit-6020, in a single PCI slot. Delivering up to 128 compressed voice or fax channels, the platform is intended for medium to high-end enterprise and media gateways including voice/fax over packet, CTI/IVR, audio conferencing, voice record and playback and other voice, fax and telephony signal processing applications. With the ability to packetise voice and send the data over a LAN using on-board 10/100Base-T network interfaces, the board is both PCI and H.100 bus compliant. Each of the board's eight TI DSPs runs at an internal clock speed of 300MHz providing a total of 2400Mcycles/s per PCI slot. The system is available with a choice of voice coders and telephony algorithms.
RadiSys
Tel: 01793 411200
www.radisys.com

In-circuit emulation support for STAR12

iSYSTEM has in-circuit emulation support for the Star12 micro controller family from Motorola. The system supports the Star12's 25MHz bus clock (50MHz clock). Based on the firm's ActivePOD technology, a high-speed probe for real time in-circuit emulation was developed and tested with Motorola. It supports the 68HC9S12DP256 microcontroller with 256Kbyte of flash memory and can be used with all iC3000 and iC4000 systems. There is an adapter for Star12's 112-pin QFP package. The overlay RAM is on-board to provide the fast access times. The integrated trace buffer offers 16K x 160-bit capture at an upload speed of 100Msample/s. In addition to complete in-circuit emulation, iSYSTEM also provides serial debug (BDM – background debug mode) support for the STAR12 family.
iSYSTEM
Tel: 01280 700262
www.directinsight.co.uk

Emergency stop switch is foolproof

EAO's series 04 and 61 ranges of panel mounting switches now include a selection of emergency stop switches that have a foolproof actuation

method. The term foolproof means that the switch contacts cannot be accidentally operated without fully actuating the mushroom head. Available in both twist-to-release and key-to-release options, both series of emergency stop switches conform to the latest approvals and machinery directives and are environmentally protected to IP65. Available in both 16 and 22.5mm mounting dimensions and 27 and 37mm front dimensions.
EAO
Tel: 01444 236000
www.eao-group.com

RF amplifiers operate at Bluetooth frequencies

NEC has introduced three monolithic integrated amplifiers (μPC8178TB, μPC8179TB and μPC8182TB) covering the 0.1 to 2.9GHz frequency range which makes them suitable for Bluetooth designs as well as CATV and wideband-CDMA applications. Supplied in a six-pin super minimould package (SOT-363) in tape and reel format with 3k pieces per reel, the μPC8178/79 are manufactured using the firm's 30GHz silicon bipolar process which uses direct silicon nitride passivation film and gold electrodes, enabling a bandwidth of 0.1 to 2.4GHz. Power consumption is 4mA or less at 3V, power gain is between 11.5 and 15.5dB at 2.4GHz for the two devices and typical signal isolation is 44dB at 1GHz. It is suggested that the devices are suitable for designing buffer amplifiers in the final stages of Bluetooth receivers. For applications where a higher frequency response is required, the μPC8182TB has a range of 0.9 to 2.9GHz, with a power gain of 20.5dB at 2.4GHz.

NEC
Tel: 01908 691133
www.nec.de

Single latching relay in small footprint

The subminiature G6KU, DPDT single pole latching relay from Omron is suitable for high density mounting, with its compact dimensions of 5.2mm x 6.5mm x 10mm and weight of 0.7g. Operating at less than 100mW, the relay also conforms to UL and CSA standards and is plastic sealed for use in most soldering and washing processes. Also available is the G6KU-Y version which conforms to Bellcore specifications offering an impulse withstand voltage of 2500V for 2 x 10μs. Models offering outside-L SM terminals, inside-L SM terminals and PCB terminal shape options are available, with surface mount terminals incorporating a specially developed terminal structure with high infrared irradiation efficiency, allowing terminal temperature to rise easily when mounting the IRS, thereby ensuring excellent soldering. Mechanical life expectancy is in excess of 50 million operations and an electrical life expectancy of 100000 operations minimum.

Omron
Tel: 0208 450 4646
www.eu.omron.com

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TELEBOX ST for composite video input type monitors	£36.95
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TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

NEW State of the art PAL (UK spec) UHF TV tuner module with composite 1V pp video & NICAM hi fi stereo sound outputs. Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a simple 3 wire link to an IBM pc type computer. Supplied complete with simple working program and documentation. Requires +12V & + 5V DC to operate. *BRAND NEW - Order as MY00.* **Only £49.95** code (B)
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3½" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
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5¼" CDC 94205-51 40mb HH MFM I/F RFE tested	£69.95
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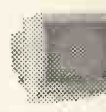

Mitsubishi FA3415ETKL 14" SVGA Multisync colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including IBM PC's in CGA, EGA, VGA & SVGA modes, BBC, COMMODORE (including Amiga 1200), ARCHIMEDES and APPLE. Many features: Etched faceplate, text switching and LOW RADIATION MPR specification. Fully guaranteed, in EXCELLENT little used condition.
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PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both RGB and standard composite 15.625 Khz video inputs via SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses. Will connect direct to Amiga and Atari BBC computers. Ideal for all video monitoring / security applications with direct connection to most colour cameras. High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99.00** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with standard composite 15.625 Khz video input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

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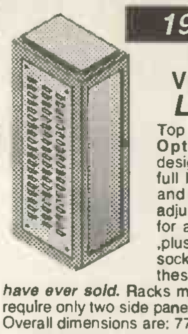

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OPT Rack 1 Complete with removable side panels.	£345.00 (G)
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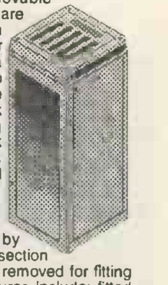

Made by Eurocraft Enclosures Ltd to the highest possible spec, rack features all steel construction with removable side, front and back doors. Front and back doors are hinged for easy access and all are lockable with five secure 5 lever barrel locks. The front door is constructed of double walled steel with a 'designer style' smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to take the heaviest of 19" rack equipment. The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A mains distribution panel internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin switched utility socket. Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of integral fans to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in excellent, slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)

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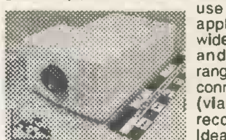

Overall dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

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NT4 WorkStation, complete with service pack 3 and licence - OEM packaged.	***ONLY £89.00*** (B)
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shipping charges for software is code B

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tightening, dispensing, soldering and impulse welding. Using an L-type body structure, and an aluminium-alloy, die cast single-structure base, the Janome JR200 mini desktop robot offers positional repeatability of ±0.01mm. It can also support a portable work weight of 3.5kg (max.) for the Z-axis and 7kg for the X/Yaxes.

Data capacity is up to 6000 points and 100 programs and for storage the robot uses a flash memory card which needs no battery. The product is supplied as standard with two serial (RS232) interfaces (one for the teaching pendant, the other for PC connection), and a third - for external I/O - is available as an option. A simple sequencer is built into the robot, and operates independently. No further hardware is necessary, because the I/O uses part of the robot's main external I/O port. With speeds up to 500mm/s (X/Y), and 250mm/s (Z), the robot is driven by a 5-phase stepping motor operating from a 90-132VAC/180-250VAC supply, with a current consumption of 200VA.

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Rittal's range of compact AE enclosures are now available with integrated aluminium heat sink and are designed for the installation of standard-design frequency converters, together with their corresponding protective devices and power contactors. Designed as a passive heat sink with cooling ribs on the rear of the enclosure, the mounting plate provides space for the mounting of frequency converters, motor circuit breakers, power contactors or terminal strips. Three different sizes of heat sink permit individual adaptation of the cooling capacity and the thermal conductivity of aluminium guarantees reliable dissipation of the generated heat, says the supplier.

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A range of PC power supplies with a number of options offering customisation is now available from Powerline. Designed for use in industrial and critical business PC applications, the units are available with continuous output ratings of up to 400W from a standard ATX package. Options available include power-factor correction to meet the requirements of forthcoming legislation, auto-ranging inputs and approvals for worldwide use, and hot-swap units for mission-critical applications.

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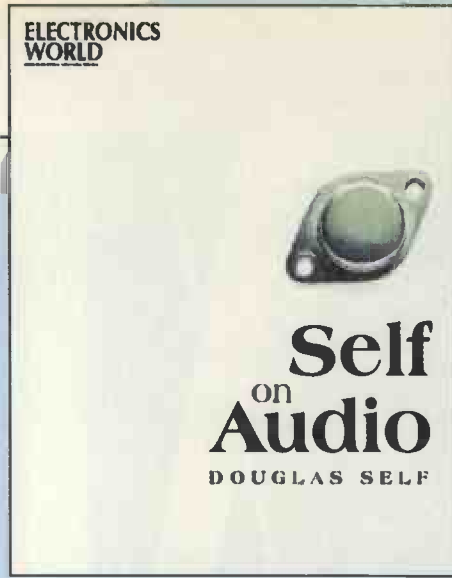

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Sound-reinforcement amplifier

Needing a sound-reinforcement system for use in a medium size hall, Ben Sullivan came up with this unusual and versatile design. Its pre-amp/mixer stage has three mono channels, each of which can take a variety of input options, and it caters for a wide range of input levels.

Meetings of a local society, of which I am a committee member, are due to move to a new location that does not have a sound reinforcement system. So in readiness, I designed the system presented here. Versatility was to be a key design criterion, both as far as amplifier inputs were concerned, and also for connecting different loudspeakers.

For public address, or PA, systems operating in the open air, an amplifier driving a 100V line with multiple horn speakers is the norm. But for this application, a modest maximum output power of something in excess of 15W was deemed sufficient. The equipment is intended solely for indoor use, with conventional loud-speakers.

A pair of surplus-to-requirements sizeable loudspeakers, each including a 10 inch 15Ω WB cambric cone loudspeaker, tweeter and crossover, were donated by a colleague. A suitable microphone was already to hand, so it only remained to produce an amplifier.

The requirement

In addition to using the microphone, some presenters bring along illustrations to their talks, either on cassette or CD, so more than one input channel would be required.

To allow for any contingency, three input channels would be provided. Each would have its own level control and there would be a master overall level control.

For a sound reinforcement system, stereo operation is not appropriate. With one loudspeaker at each side of the hall near the front, most of the audience would not hear any stereo effect, while those near one loud-speaker or the other would receive just the left or right channel alone. So the amplifier was designed to drive the approximately 8Ω load of the two loudspeakers in parallel.

Power-amplifier configuration

Figure 1 shows the configuration usually used for a hi-fi amplifier in

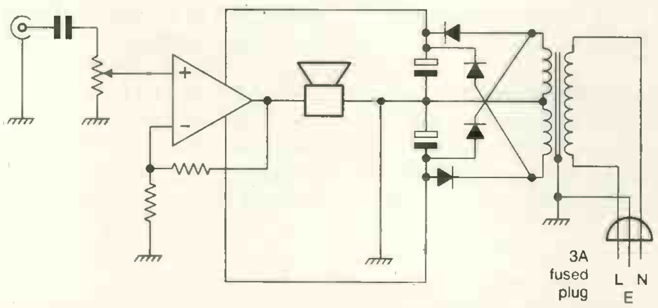

Fig. 1. Skeleton diagram of common hi-fi power-amplifier circuit with direct-coupled loudspeaker. Here, a centre-tapped transformer makes producing the necessary positive and negative rails easy.

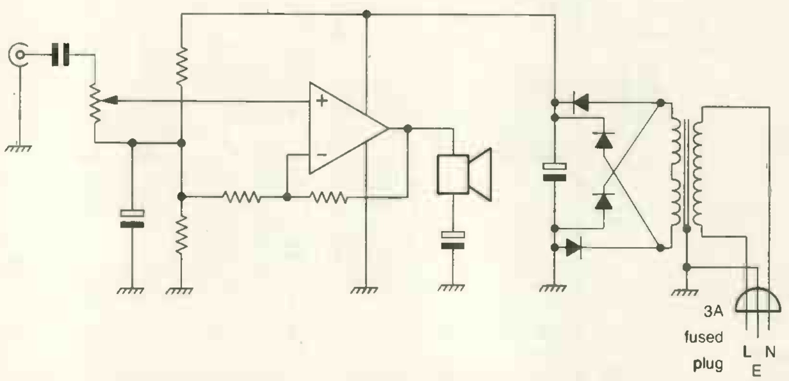

Fig. 2. Power-amplifier circuit using a single rail-supply. Because ground is no longer the same potential as the static voltage at the output of the power amplifier, the speaker has to be connected via a large electrolytic coupling capacitor.

simplified form. A mains transformer with two identical secondary windings, or a centre tapped winding, is used in conjunction with a bridge rectifier to produce plus and minus voltage rails. The arrangement requires two main smoothing capacitors, and has the advantage that the rails can also be stepped down to ±15V to supply a preamplifier design using op-amps.

A high-quality toroidal mains transformer of suitable secondary voltage and VA rating was available from stock. On the face of it though, it was not suitable as its two secondary windings had different voltages.

As the overall voltage of the windings in series was just what was needed, the PA arrangement of **Fig. 2** was viewed as a possible alternative. This needs only a single main smoothing capacitor, though of twice the voltage rating of those in Fig. 1. It is quite convenient if the input signal is large enough to drive the PA to full output, but not so useful if a preamplifier/mixer stage using op-amps is needed.

In the event, the circuit designed circumvented this difficulty.

Power amplifier design

A TDA2050V was chosen as the power amplifier. It proved to be capable of providing over 15W into a dummy load from the nominal 40V supply provided by the transformer. The dummy load consisted of two 15Ω wirewound resistors in parallel.

After some thought and experimentation, it was incorporated into the PA circuit of **Fig. 3**. This can be seen as a cross between the Figure 1 and Figure 2 arrangements.

The circuit design was taken directly from the power amplifier's data sheet as far as component values are concerned. Usefully, the device includes over-temperature and over-current protection, and it provides a massive 90dB of open loop gain. With the 30dB of demanded gain set by R_7/R_6, the 60dB of negative feedback within the loop results in a distortion figure of around 0.02%

The chassis earth symbols shown at R_3 and elsewhere indicate not only the circuit's nominal 0V rail, but also the case metalwork and mains earth. This means that effectively, the power supply provides both positive and negative voltages.

These voltages are used also, suitably stepped down, to supply the earlier preamplifier/mixer stages. This circuit arrangement means that neither side of the loudspeakers is earthed, and both poles of the loudspeaker output sockets must be isolated from ground.

As mentioned, the amplifier is designed to drive two 15Ω loudspeakers in parallel. For versatility, ¼in jack sockets, two-pin DIN loudspeaker sockets and phono (RCA) sockets were provided. All six sockets were connected in parallel.

As the power supply section was mounted at the opposite end of the case from the PA board, C_7 and C_8 were fitted close to the TDA2050V on its 0.1in matrix strip-board circuit, as local decoupling in accordance with good practice.

The TDA2050V was mounted at one end of the stripboard, with its pins twisted to fit a 0.1 inch spacing. The body of the device was bolted to a substantial L shaped bracket, using a mica insulator and silicone mounting grease. This would not have been necessary in the circuit of Fig. 2, as the device's metal heat-sink tab is connected to the negative supply rail.

In turn, the bracket was bolted to the base of the case to provide additional heat-sinking. On soak test, driving 30V peak-to-peak into the 7.5Ω resistive dummy load, the device case temperature eventually just reached 50°C, in a room ambient of 20°C.

Preamplifier and mixer stages

The three input channels and mixer stage are shown in **Fig. 4**. Each channel is provided with an input for a stereo signal, these being resistively combined into a mono signal.

There are also three inputs for mono signals per channel. The sockets are so distributed across the

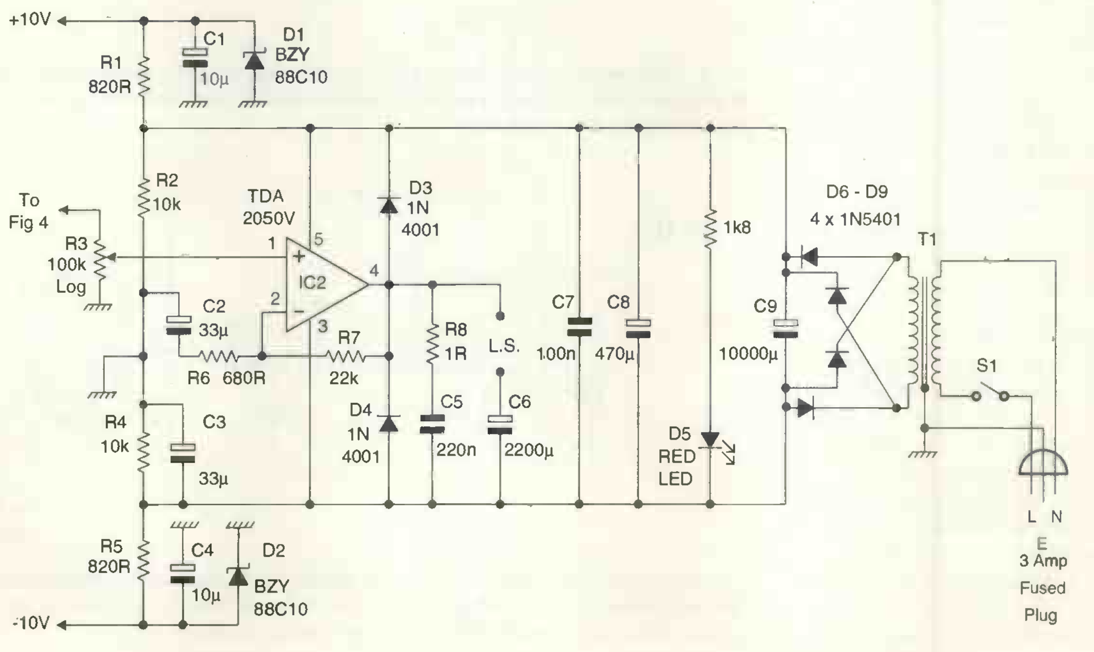

Fig. 3. Circuit of sound reinforcement amplifier using a modified single rail supply.

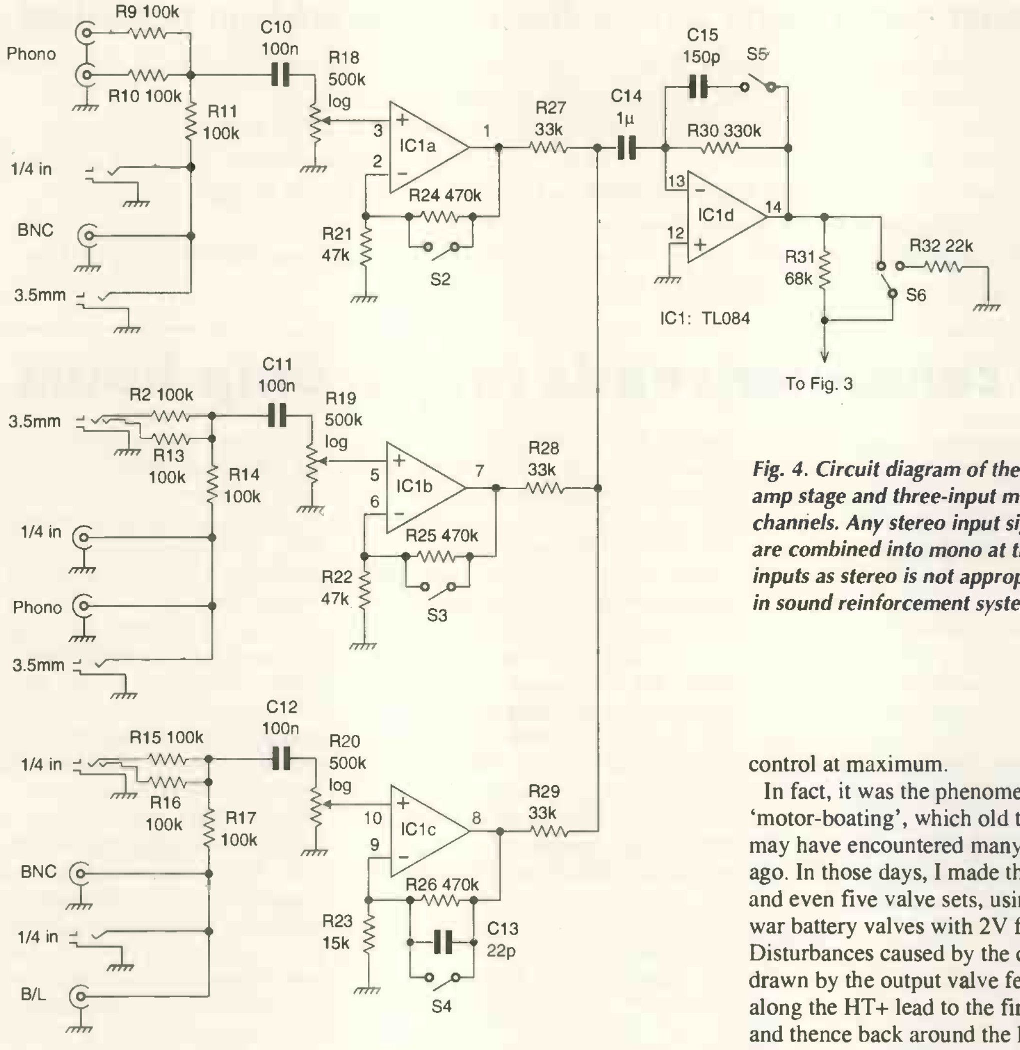

Fig. 4. Circuit diagram of the pre-amp stage and three-input mixer channels. Any stereo input signals are combined into mono at the inputs as stereo is not appropriate in sound reinforcement systems.

channels that almost any conceivable type of input can be accommodated, with the exception of the bulky XLR audio connector. A ¼in jack plug/XLR socket BSA (between series adapter) will cope with this eventuality, should it arise.

Each input signal is routed directly to a volume control. This is not of course good practice in a hi-fi system, but there the amplitude of the inputs is known. The arrangement used here permits the amplifier to accept any conceivable amplitude input.

Output from the pre-amp/mixer feeds the power amplifier stage via a switchable 0 or 10dB attenuator, S_6. Channels 1 and 2 are switchable between a nominal +20dB gain and unity gain. Channel 3 provides the option of unity gain or +30dB.

Capacitor C_{13} was found necessary to ensure stability when both the channel 3 and master level controls were at maximum, S_4 at the +30dB and S_6 at the 0dB settings. Under these conditions, a 1mV rms input will provide around 15W output.

Naturally, with such high gain, there is a little background hiss and the level of this proved to be precisely what should be expected, given the quoted 10Hz to 10kHz voltage noise of the TL084 of 4μV. The treble roll-off available with S_5 could then be useful. It is debatable if the full channel 3 gain will ever be needed, but it is available just in case.

Design anomalies

While the amplifier design described performs perfectly the function required, one or two surprises surfaced during development.

The first concerned a very low frequency instability. This set in as any of the channel level controls was advanced, with the master level control at maximum.

In fact, it was the phenomenon of 'motor-boating', which old timers may have encountered many years ago. In those days, I made three, four and even five valve sets, using pre-war battery valves with 2V filaments. Disturbances caused by the current drawn by the output valve fed back along the HT+ lead to the first stage, and thence back around the loop. Increased decoupling served only to reduce the frequency of the oscillation. So D_1 and D_2 were added, extending the effectiveness of the decoupling down to 0Hz, and completely curing the problem.

The other oddball surfaced during frequency response testing. The bass roll-off set in at a higher frequency than expected, so C_{14} was increased to 1μF. In conjunction with R_{27}, R_{28} or R_{29} – 33kΩ – one might then expect a –3dB point of 4.8Hz, but it was much higher than this.

The reason is that, once the reactance of C_{14} becomes significant, R_{27-29} no longer look into a virtual earth. So the output of IC_{1a} via R_{27}, for example, is subject to attenuation by R_{28} and R_{29} in parallel before being applied to C_{14}.

It is running across points like these, and working out the reasons, that keeps circuit design a constant challenge and joy. ■

CIRCUIT IDEAS

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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.

Bike computer reads amps, amp.hours

A bicycle computer counts wheel revolutions, and displays speed and distance travelled. Depending on the model, it may also show the maximum and average speeds achieved.

The user has to program the computer with the wheel circumference *C* in metres, since velocity *v* in km/h is related to the frequency of wheel rotation, *Frps*, by $(v \div 3.6)/C=F$. Usually, a magnet attached to a wheel operates a reed relay to provide the count pulses, but in this application, a transistor switch is used.

Such a bicycle computer can be used for other purposes, such as measuring the charge rate and total charge stored in a solar panel accumulator charging set-up, **Fig. 1**. To achieve this, the charging current is monitored by a current shunt R_s, controlling a voltage-controlled oscillator.

The voltage controlled oscillator produces an output frequency such that a bicycle computer velocity reading of 120km/h indicates a current of 12A, and a trip reading of 2998.9 km indicates a charge of 299.89Ah.

The programmable value of *C* on the computer used was up to 2.999m. The VCO was designed to produce an output frequency of up to 13.7Hz for a 140mV input, corresponding to a 14A charging current. With this design of oscillator, **Fig. 2**, a circumference setting *C* of 2.671m worked well.

This application is limited by the lowest and highest frequencies that the bicycle computer can count, and by VCO offset and linearity errors.

A minimum output frequency of 0.1Hz is produced by the VCO, even when the drop across R_s is zero. But linearity errors up to the designed maximum, checked with a DVM and DSO, proved to be generally insignificant. There is a slight increase in error at the high frequency end of the range, due to the finite discharge time of C_1.

Heinz Zanke
GR-24002 Messenias
Greece
E10

Winner!
Overall winner of our 2000 circuit ideas competition – sponsored by National Instruments – is Heinz Zanke's ingenious amp.hour meter. Heinz wins a National Instruments LabVIEW graphical programming environment package worth over £700.

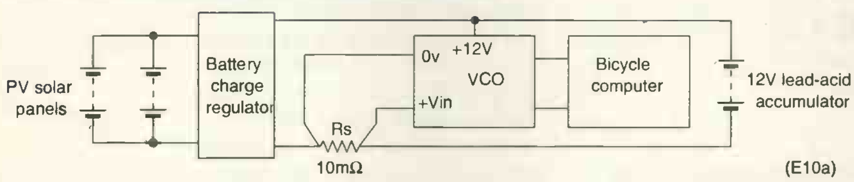


Fig. 1. Block diagram of charger metering system in a solar-energy system, using a bicycle computer to monitor amps and Ah.

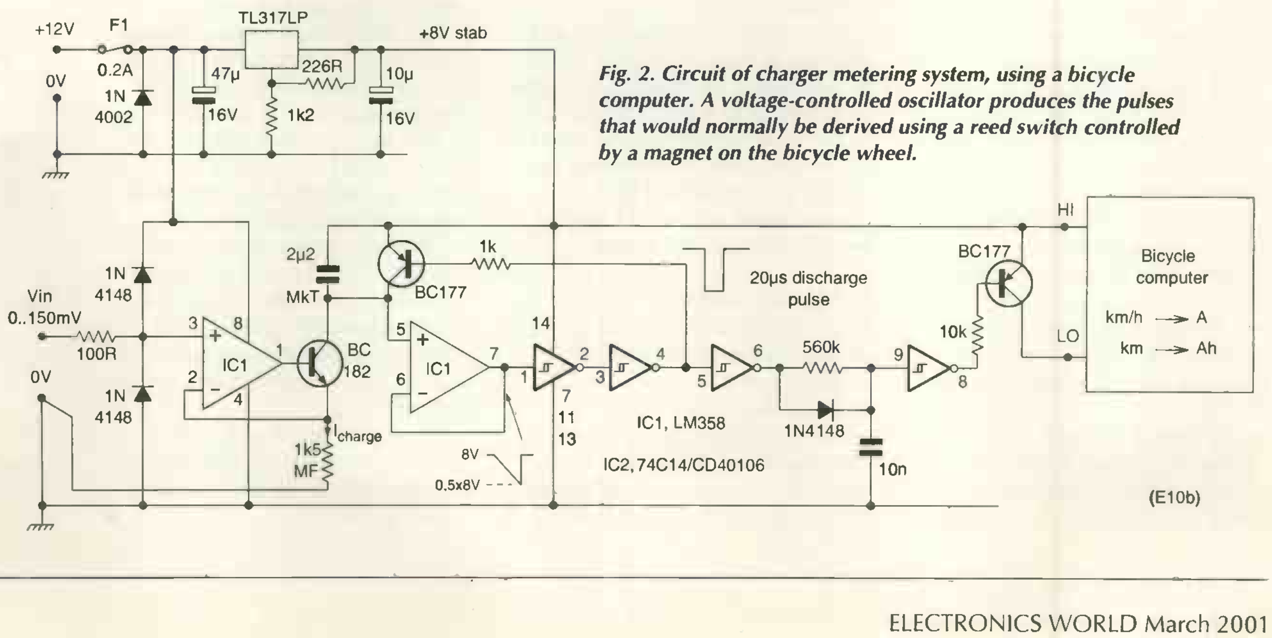


Fig. 2. Circuit of charger metering system, using a bicycle computer. A voltage-controlled oscillator produces the pulses that would normally be derived using a reed switch controlled by a magnet on the bicycle wheel.

Ice alert!

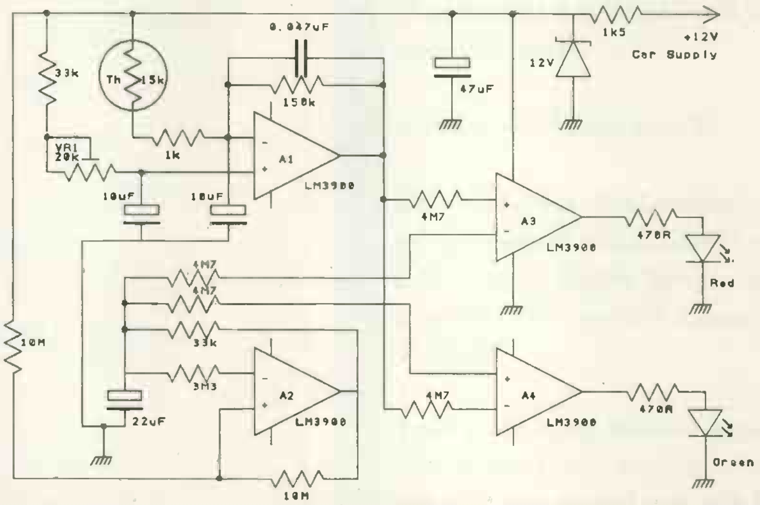
The recent cold weather reminded me of a simple ice alert warning circuit I built in 1974, long before such circuits became available as standard fittings in some cars.

My present car has a factory fitted ice warning which simply lights an orange LED for temperatures below 5°C or red LED below 0°C. This suffers from two problems. When driving in bright winter sunlight, these indicator lights do not easily attract attention, also there is no indication of temperature changes except when it passes the above limits.

My ice alert differs in that for temperatures above some 5°C the green LED glows continuously, to indicate normal function.

As temperature reduces the red LED pulses on and the green LED pulses off, approximately once each second. The a duty cycle increases as the temperature falls. Ultimately at 0°C and at lower temperatures, the green LED remains off and the red LED glows continuously.

I find this most beneficial in bright sunshine, because the brief initial pulses of the red LED as temperature



This ice indicator gives more useful information than a car's simple factory fitted warning indicator.

BOOK TO BUY

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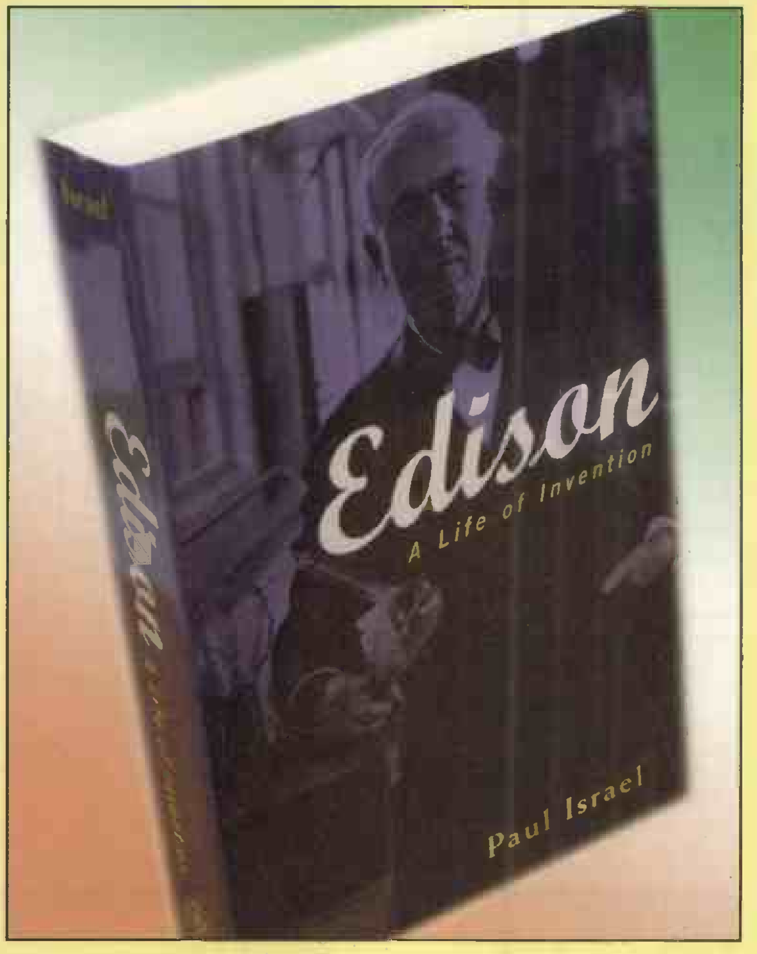

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drops below 5°C attracts attention and the change in duty cycle indicates whether the temperature is rising or it is becoming colder. The LEDs can even be located below your line of sight, so as not to interfere with normal driving, yet still attract your attention when needed.

Using only one IC, the circuit is low cost and easily built. The thermistor should be mounted in a closed housing located behind the front bumper. While I used a thermistor of 15kΩ at 25°C, other values can be accommodated simply by amending the calibration and feedback resistors at A_1.

The LM3900 IC responds to current ratios at its inputs, not voltage as is more usual. Hence it is insensitive to change in battery voltages. The zener is included to clip supply voltage transients caused by load shedding of the alternator.

Amplifier A_1 simply compares the resistance of the thermistor with the series combination of VR_1 and 33kΩ, changing from 0.3 $V_{battery}$ above 5°C to 0.6 $V_{battery}$ at 0°C.

Amplifier A_2 is configured as a free running multivibrator with a repetition rate of approximately one pulse each second and output varying between 0.3 $V_{battery}$ and 0.6 $V_{battery}$.

Outputs of A_1 and A_2 are compared in the remaining amplifiers A_3 and A_4. When the A_2 output is lower than A_1 output the red LED lights. When the A_2 output is higher than A_1, the green LED lights. Since A_3 and A_4 inputs are wired in opposition both LEDs cannot simultaneously be lit.

Calibration at 0°C is simply obtained by immersing the thermistor probe in an ice water mixture, adjusting VR_1, prior to installing in your car.

This now elderly circuit has performed well for many years in a number of different vehicles.

Cyril Bateman
Acle
Norfolk

Battery operated theft alarm

This circuit can be used as either a loop alarm or with a pressure sensor/switch to give a treasured/expensive item 24-hour alarm protection while you are on the premises with your building's burglar alarm switched off. It is simple and cheap enough to build several, with each protected item possibly using a different sounding alarm for identification purposes. Running on a single PP3 battery, it is portable and allows over 12 months use while waiting for action, less if the unit is triggered often.

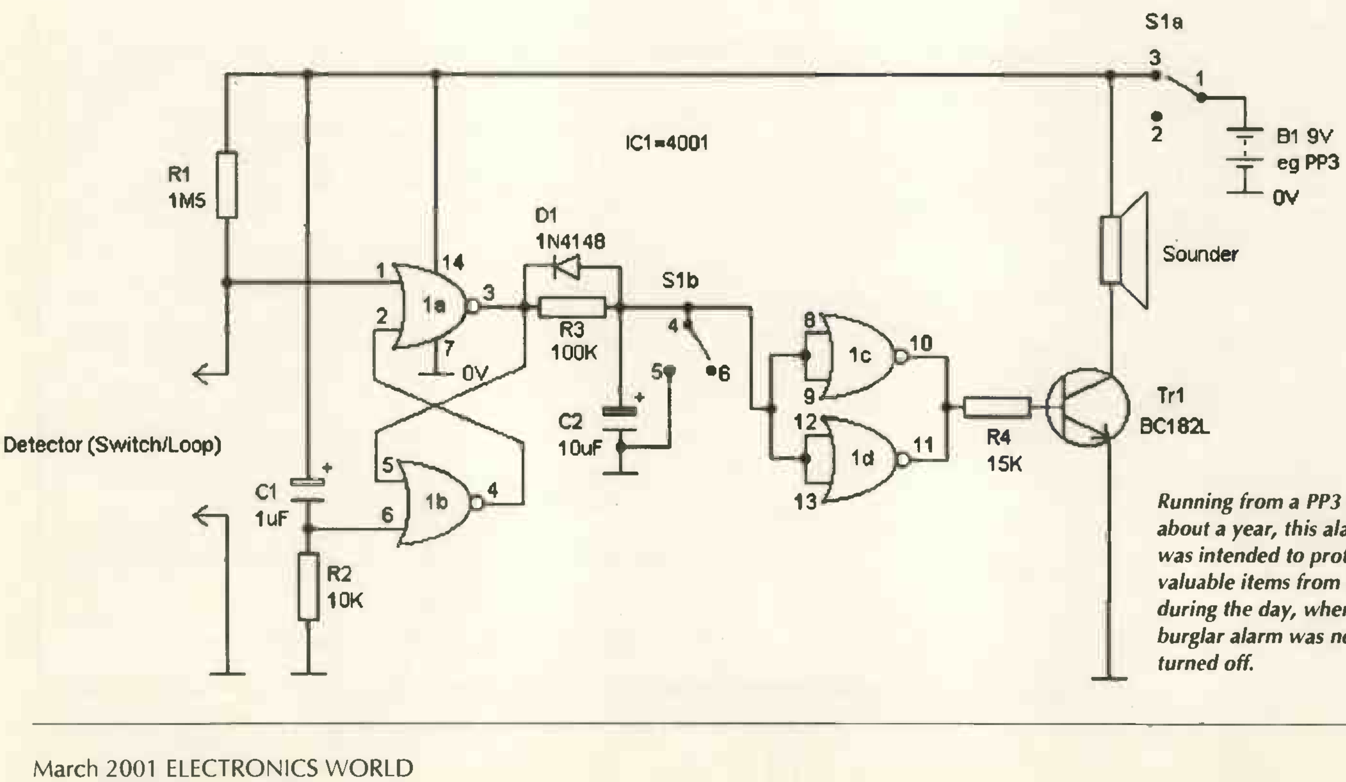
The unit is built around a 4001 quad cmos nor gate with two gates, 1a and 1b, forming a bistable and the remaining two, 1c and 1d, forming an inverting buffer. The main on/off switch S_{1a} is ganged with S_{1b} and is a double-pole double-throw device, which can be key operated for added security. It is wired such that when the alarm is switched on C_2 is open circuit and when the unit is switched off C_2 is shorted out.

At switch on, and assuming that the wire loop/switch is closed and hence holding pin 1 low, a brief high pulse via C_1 at pin 6 causes the bistable to set and its output to go high. As C_2 was initially discharged, via S_{1b} when the unit was off, it charges via R_3 and hence takes a little while before the inverting buffer, 1c and 1d outputs an high. During this time – approximately 1 second – Tr_1 is switched on and the sounder energised. This allows the battery condition to be assessed at switch on. After this delay Tr_1 switches off and the alarm is ready to be triggered.

To trigger the alarm, either the loop must be broken or the sensor switch opened. This sends pin 1 of IC_1 high and resets the bistable. Its output goes low and due to D_1 the capacitor discharges very quickly sending the input to the buffer low, its output high and hence switching Tr_1 and the sounder on rapidly. To reset the unit the power must now be switched off and back on again.

Several items could be protected by a single unit if extra sensor switches are wired in series, avoiding the need to build extra circuits. The maximum current that the sounder can take is limited to 200mA by Tr_1's maximum collector current. Uprating this device would allow a louder unit to be used.

Lee Archer
Ashton-in-Makerfield
Lancashire
E48



Running from a PP3 for about a year, this alarm was intended to protect valuable items from theft during the day, when the burglar alarm was normally turned off.

£70 WINNER

Portable precision programmable reference generator

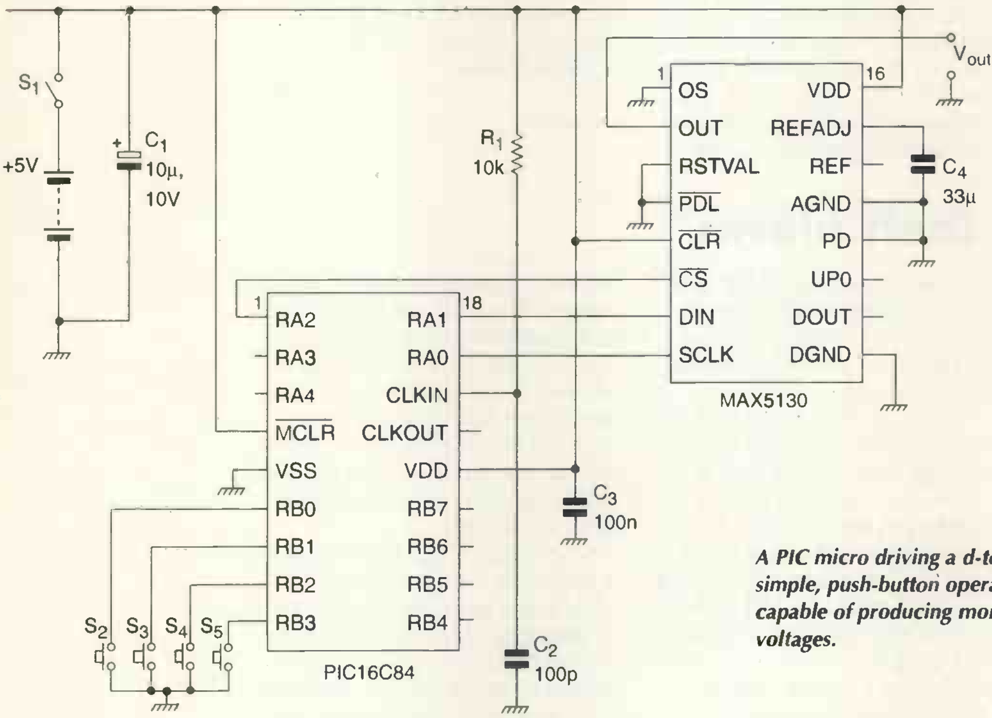
A battery powered programmable voltage reference generator is shown here. Its output range is between 0 and 4.0955V. By pushing up and down buttons, more than 8000 voltages can be selected.

The selected voltage is maintained in non-volatile memory when the power is turned off. A MAX5130 13-bit serial d-to-a converter generates the reference voltage. This device has an internal reference and an operational amplifier so no external components are required to send precision voltage out.

A PIC16C84 microcontroller is used to accept input commands and control the output voltage by sending data into MAX5130 through three wires. This PIC has built-in EEPROMs to store the output data without power supply.

Four buttons control the output voltage up or down. Switches S_2 and S_4 make a step change in 0.5mV increments. Switches S_3 and S_5 change 100 steps (50mV) to make output voltage reach the desired level quickly.

Yongping Xia
Torrence
USA
E49



A PIC micro driving a d-to-a converter makes a very simple, push-button operated voltage reference capable of producing more than 8000 different voltages.

PIC assembler for a very simple reference circuit that can produce more than 8000 voltages between 0 and 4.0955V.

```
LIST        p=16C84

TMR0        equ        0x01
PCL         equ        0x02
STATUS      equ        0x03
PORTA       equ        0x05
PORTB       equ        0x06
EEDATA      equ        0x08
EEADR       equ        0x09
INTCON      equ        0x0b
OPT         equ        0x81
TRISA       equ        0x85
TRISB       equ        0x86
EECON1      equ        0x88
EECON2      equ        0x89

Z           equ        2
C           equ        0
W           equ        0
F           equ        1
RP0         equ        5
RD          equ        0
WR          equ        1
WREN        equ        2

data_1      equ        0x0c    ;
data_2      equ        0x0d    ;
cnt_1       equ        0x0e    ;
cnt_2       equ        0x0f    ;
temp_1      equ        0x10    ;
temp_2      equ        0x11    ;
                               ;
            org        0x0     ;
main                           ;
            clrf       PORTA   ;initialization
            clrf       PORTB   ;
            bsf        STATUS, RP0     ;bank 1
            movlw      0x7f    ;
            option             ;
            movlw      0x00    ;
            movwf      TRISA   ;set PORTA output
            movlw      0x0f    ;
            movwf      TRISB   ;set PB0-PB3 input, PB4-PB7 output
            bcf        STATUS, RP0     ;bank 0
            bsf        PORTA, 2        ;
                               ;
            clrf       EEADR   ;read from eeprom
            bsf        STATUS, RP0     ;bank 1
            bsf        EECON1, RD      ;
            bcf        STATUS, RP0     ;bank 0
            movf       EEDATA, W       ;read data_1 from eeprom
            movwf      data_1  ;
            incf       EEADR, F        ;
            bsf        STATUS, RP0     ;bank 1
```

```
        bsf     EECON1, RD      ;
        bcf     STATUS, RP0     ;bank 0
        movf    EEDATA, W       ;read data_2 from eeprom
        movwf   data_2 ;
        call    send_data       ;
                ;
read_button     ;
        btfss   PORTB, 0        ;test   +1 button
        goto    up_1  ;
        btfss   PORTB, 1        ;test   +100 button
        goto    up_100 ;
        btfss   PORTB, 2        ;test   -1 button
        goto    down_1 ;
        btfss   PORTB, 3        ;test   -100 button
        goto    down_100        ;
        goto    read_button     ;
up_1            ;
        incfsz  data_1, F       ;
        goto    up_date         ;
        incf    data_2, F       ;
        btfss   data_2, 5       ;
        goto    up_date         ;
        decf    data_1, F       ;
        decf    data_2, F       ;
        goto    up_date         ;
up_100          ;
        movlw   0x64  ;
        addwf   data_1, F       ;
        btfss   STATUS, C       ;
        goto    up_date         ;
        incf    data_2, F       ;
        btfss   data_2, 5       ;
        goto    up_date         ;
        movlw   0xff  ;
        movwf   data_1 ;
        movlw   0x1f  ;
        movwf   data_2 ;
        goto    up_date         ;
down_1          ;
        decf    data_1, F       ;
        movf    data_1, W       ;
        sublw   0xff  ;
        btfss   STATUS, Z       ;
        goto    up_date         ;
        decf    data_2, F       ;
        btfss   data_2, 7       ;
        goto    up_date         ;
        clrf    data_1 ;
        clrf    data_2 ;
        goto    up_date         ;
down_100        ;
        movlw   0x64  ;
        subwf   data_1, F       ;
        btfsc   STATUS, C       ;
        goto    up_date         ;
        decf    data_2, F       ;
        btfss   data_2, 7       ;
        goto    up_date         ;
        clrf    data_1 ;
        clrf    data_2 ;
                ;
up_date         ;
        call    send_data       ;
        call    write_data      ;
        call    dly_1 ;
        goto    read_button     ;
                ;
send_data       ;
        movf    data_1, W       ;
        movwf   temp_1 ;
        movf    data_2, W       ;
        movwf   temp_2 ;
        movlw   0x40  ;
        addwf   temp_2, f       ;
        bcf     PORTA, 2        ;cs low
        movlw   0x08  ;
        movwf   cnt_1 ;
lp_1                    ;send high byte
        bcf     PORTA, 1        ;
        rlf     temp_2, F       ;move 1 bit
        btfsc   STATUS, C       ;
        bsf     PORTA, 1        ;
        bsf     PORTA, 0        ;sclk high
        bcf     PORTA, 0        ;sclk low
        decfsz  cnt_1, F        ;
        goto    lp_1  ;
        movlw   0x08  ;
        movwf   cnt_1 ;
lp_2                    ;send low byte
        bcf     PORTA, 1        ;
        rlf     temp_1, F       ;
        btfsc   STATUS, C       ;
        bsf     PORTA, 1        ;
        bsf     PORTA, 0        ;sclk high
        bcf     PORTA, 0        ;sclk low
        decfsz  cnt_1, F        ;
        goto    lp_2  ;
        bcf     PORTA, 1        ;
        bsf     PORTA, 2        ;cs high
        return                  ;
                                ;
write_data                      ;
        movf    data_1, W       ;
        movwf   EEDATA ;
        clrf    EEADR ;
        call    write_eeprom    ;
        movf    data_2, W       ;
        movwf   EEDATA ;
        incf    EEADR, F        ;
        call    write_eeprom    ;
        return
                                ;
dly_1                           ;delay 0.2 seconds
        clrf    cnt_1 ;
        movlw   0x20  ;
        movwf   cnt_2 ;
lp_3    decfsz  cnt_1, F        ;
        goto    lp_3  ;
        decfsz  cnt_2, F        ;
        goto    lp_3  ;
        return                  ;
                                ;
write_eeprom                    ;
        bsf     STATUS, RP0     ;bank 1
        bsf     EECON1, WREN    ;enable to write eeprom
        movlw   0x55  ;
        movwf   EECON2 ;
        movlw   0xaa  ;
        movwf   EECON2 ;
        bsf     EECON1, WR      ;start write
write_dly       ;
        btfsc   EECON1, WR      ;
        goto    write_dly       ;
        bcf     STATUS, RP0     ;bank 0
        return                  ;
                                ;
        end                     ;
```

£50 WINNER

PIC-based frame-check sequence for point-to-point protocol

One of this year's growth areas is likely to be internet-friendly control using the 'point-to-point protocol', or PPP for short, with the popular PIC devices from Microchip likely to lead the way. Although the minimum protocol is relatively straightforward, the generation and verification of the frame check sequence, or FCS, may not be. Here it is as a subroutine in assembler. It is based upon the original 6502 routine[1] and a tidy-up may be in order.

The required 16-bit polynomial is 8408[2,3]. To transmit, remms and remls are initially set to all ones ($FFFF_{16}$) with the 8-bit data byte at 'datl'. At the end of transmit data, the FCS is ones complemented (inverted) and transmitted remls first, lsb first. For example (one data byte only in case you want to wade through the ones and zeros!):

	remms	remls	datl	
	FF	FF	79	
	->	EI	C1	
Invert	1E	3E	79	-> transmit this way

To receive, preload remms/ls with FFFF, and include the FCS bytes in the routine. The remainders remms and remls will be $F0B8_{16}$ for no detected error.

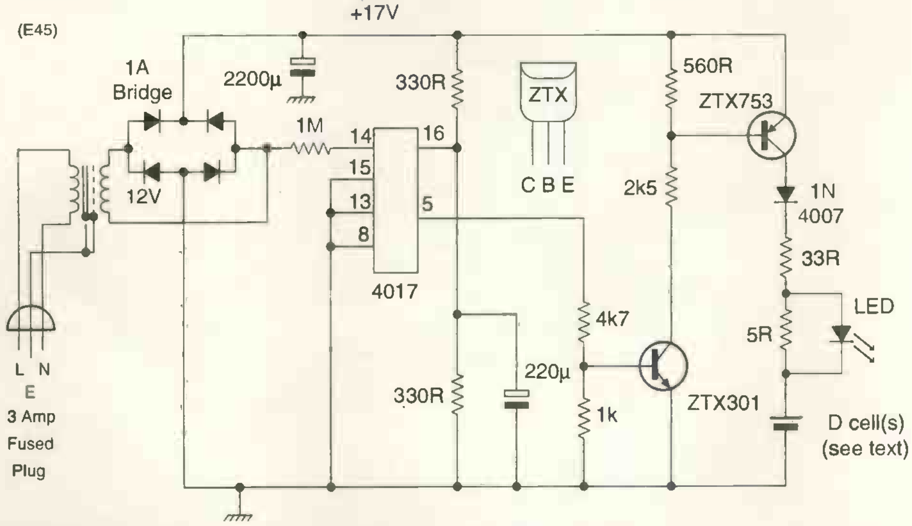
Graham Stephens
Plymouth
E43

References

1. 'The What and How of CRCS' *Electronics & Wireless World*, Sep 1989
2. 'RFC 1662' – Network Working Group
3. 'X.25' – CCITT Blue Book

Frame-check code for PPP in PIC assembler.

```
;***** REGISTER DEFINITIONS*************
cntr     equ     h'10'     ;bit per byte
tmp      equ     cntr+1    ;was A in 6502
remls    equ     tmp+1     ;check byte ls
remms    equ     remls+1   ;ms
polyls   equ     remms+1   ;polynomial ls
polyms   equ     polyls+1  ;ms
datl     equ     polyms+1  ;data byte for crc
;polyms/ls could be in-line
;literals 84 & 08 respectively
;****************************************
;Actual Subroutine for one 8-bit byte
crcl:
         movlw   h'08'     ; 8 bits
         movwf   cntr
crc2:
         movlw   h'00'     ; clear
         movwf   tmp
         rrf     datl,1    ; lsb into c
         rlf     tmp,1     ; and into tmp
         movf    tmp,w
         xorwf   remls,w
         movwf   tmp
         rrf     remms,1
         bcf     remms,7
         rrf     tmp,1
         btfss   status,c
         goto    crc4
         movf    tmp,w
         xorwf   polyls,w
         movwf   remls
         movf    remms,w
         xorwf   polyms,w
         movwf   remms
crc3:
         decfsz  cntr,1
         goto    crc2
         return            ;stop, get next data
byte
crc4:
         movf    tmp,w
         movwf   remls
         goto    crc3
```



Using a 10:1 duty cycle, this circuit gives new life to tired dry cells.

Pulsed dry-cell charger

This circuit produces a charging current in short bursts with a 10% duty cycle. The average charging current is C/100 where C is the cell capacity. Typical average charge currents of 36mA and 18mA are used for the D-size and the AA-sized cells respectively.

A zinc-carbon cell may be considered as being made up of many smaller parallel connected elements. The pulses of current give each element an increased charging voltage, allowing time for all elements to stabilise.

The CMOS counter 4017 is clocked by the AC supply pulses and produces one 20 (or 16) ms pulse for each ten AC input cycles at 50 (or 60) hertz. This establishes the duty cycle ratio of 1 to 9. The AC drive at the counter is rectified by the internal IC protection diodes.

The output pulse operates a transistor switch, which connects the cell or battery to the charging supply via the current limiting resistor and indicating LED. The limiting resistor is chosen to give the appropriate average charge current. The ballast resistor is chosen so that the LED flashes to indicate this current.

For D cells a current limiting resistor of 33Ω and a ballast resistor of 5Ω are used. For AA sized cells 56Ω and 10Ω are used. With a modified current limiting resistor, two or more similar cells can be connected in series, so that a battery can be charged.

I have found that a pulsed charge of twelve to twenty four hours duration or 25% of the original cell's capacity, will greatly rejuvenate weak cycle lamp and personal stereo batteries.

Alkaline cells also benefit, however the total charge given should not be significantly increased, as they tend to be more susceptible to deterioration through over charging.

Warning
Zinc-carbon and alkaline cells can explode due to inappropriate charging, with the potential to cause bodily harm. They may also leak. Take precautions against both of these possible eventualities.

Michael Mucklow
Newport Pagnell
Buckinghamshire
E45

Simple circuit delivers sinewave with crystal frequency accuracy

This circuit uses a digital clock signal up to 20kHz to produce a sinewave with exactly the same frequency. There are no critical components.

Transistor Tr_1 is switched on and off by the clock signal, see schematic, creating a square wave at node A. The amplitude of the square wave at A is determined by the voltage at point B. The square wave at A is filtered by the band-pass filter built around op-amp IC_1, this band pass reduces the harmonics of the square wave to a level such that a very usable sinewave is the result.

To counter variation of the amplitude of the resulting sinewave with the component tolerances of the filter network a simple but effective amplitude stabilisation circuit, built around Tr_2, is used.

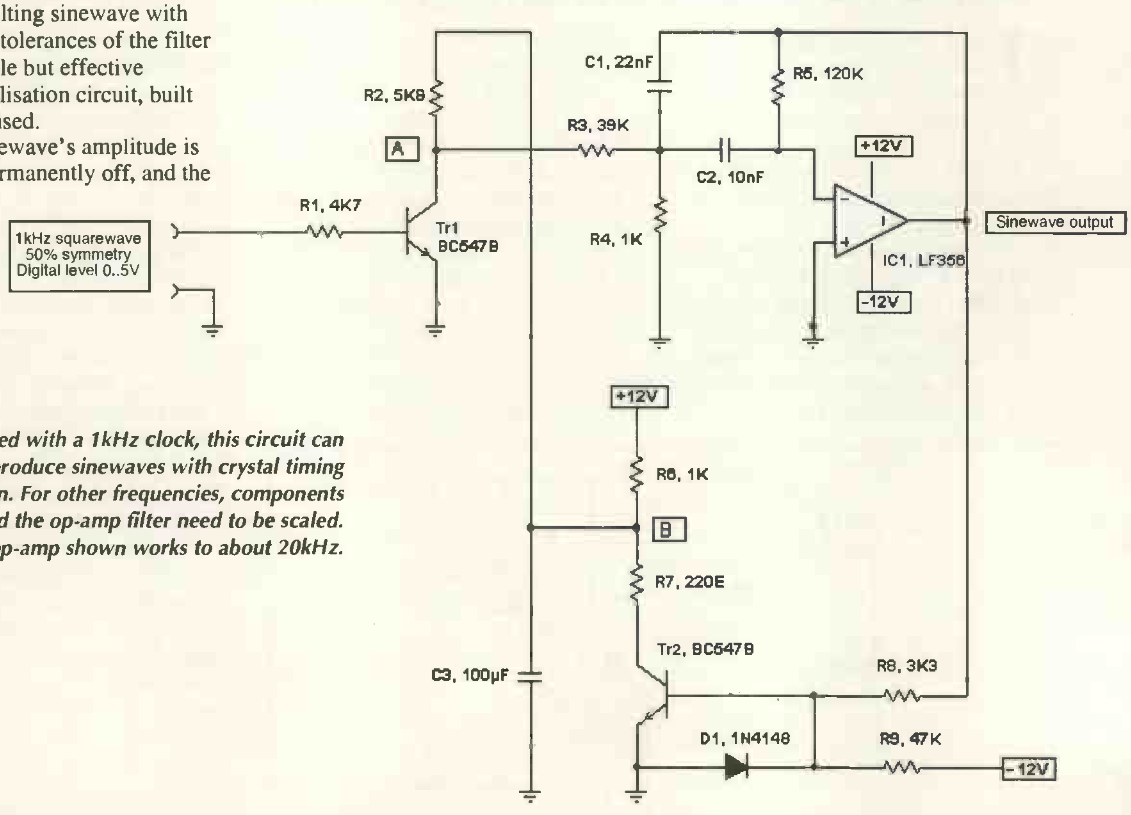
When the sinewave's amplitude is small, Tr_2 is permanently off, and the voltage at node B rises until the amplitude of the square wave at A reaches the designed value. Transistor Tr_2 then periodically draws current out of node B, keeping the sinewave's amplitude constant. At the designed amplitude – a few volts – the influence of temperature on the amplitude is very small.

The clock signal must have a 50% duty-cycle. A low cost divide-by-two IC such as the 74HC74 may be necessary to achieve this.

In many applications a microcontroller can generate the clock signal directly, using a timer function. Alternatively, a divider with built-in crystal oscillator such as the CMOS 4060 may be used. The band-pass filter has a Q value of 5.

Component values in the schematic give a frequency of 1kHz. For other frequencies, the resistor or capacitor values may be simply scaled. The op-amp must have adequate gain-bandwidth product and slew rate; the LF356 works well up to 20kHz and beyond.

Ivan Moerman
Nazareth
Belgium
E44



Fed with a 1kHz clock, this circuit can produce sinewaves with crystal timing precision. For other frequencies, components around the op-amp filter need to be scaled. The op-amp shown works to about 20kHz.

£70 WINNER

Automatic input attenuator for radio receiver antennas

Attenuating an over-strong signal at the antenna greatly reduces cross modulation in comms receivers. This circuit does the job automatically.

An attenuator, located at the aerial input, can greatly reduce cross modulation in communications receivers.

Laurence Cachia has devised a simple magnetic system in which a variable resistor across a tertiary winding on a toroidal core controls the coupling between two signal windings. Subsequent developments involve the use of a FET as a voltage variable resistor to facilitate automatic control.

Unless provision is made to minimise drain/source resistance, the amount of attenuation is limited. By driving the FET's gate positive with respect to its source, residual drain/source resistance can be significantly lowered and performance comes much closer to that achieved with Cachia's original manual control.

In this circuit, the FET is connected across the arms of a bridge formed by Tr_1, R_1, and VR_3. A rising agc voltage of 0V to +0.6V on the base of Tr_1 swings the gate/source voltage of Tr_2 from –2.5V to +2V, thereby maximising the resistance change.

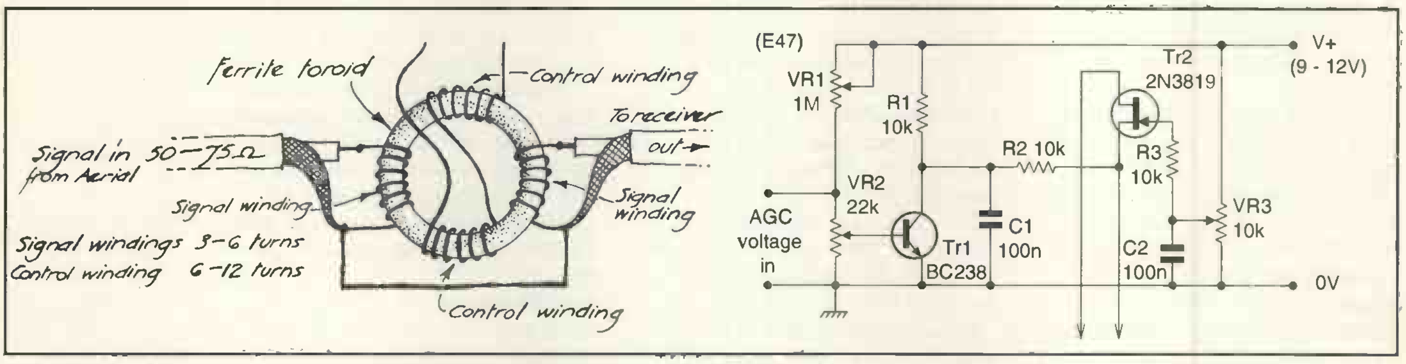
For negative going AGC, the connections to the gate and source of Tr_2 should be reversed, and VR_1 set to increase the bias on the base of Tr_1. The pre-set resistors can be adjusted to introduce delay and to accommodate different agc voltage swings.

A ferrite toroid must be used, but its size is not critical. For general coverage receivers, signal windings of six turns on a core with a permeability of 850 will minimise losses at medium and low frequencies.

Turns can be reduced to three for HF receivers, and a lower permeability core could be used. Control windings should have twice the number of turns of the individual signal windings.

Insertion losses are minimal.

Raymond Haigh
Doncaster
South Yorkshire
E4



Versatile power switching circuit

This is a simple circuit that can be used for a wide range of switching or control applications. The purpose of the original circuit was to reduce rotational speed of a small DC motor. The motor drove a 'mirror ball' and was required to turn the ball at 2rev/min.

The same basic circuit can be used to flash a LED or incandescent filament lamp or even dim a filament lamp. All these applications can be realised with two transistors, three resistors, and one capacitor. An added benefit is that the current consumption can also be made to be extremely small.

The circuit works as a simple proportional control circuit where the ratio of 'on' to 'off' time determines the speed and the effective voltage across the load. Components C_1 and R_2 define the 'on' time while the 'OFF' time is defined by C_1 and R_1.

The load is connected in the collector of Tr_2. In the example given, this load is the 10Ω coil resistance of the motor. When 'on', Tr_2 saturates and when 'off', the circuit consumes very little current, so efficiency is high. This makes the circuit ideal for battery operation with any supply voltage from a single 1.2V NiCd cell up to 24V. Maximum voltage is only limited by the choice of Tr_1 and Tr_2 and of course the motor.

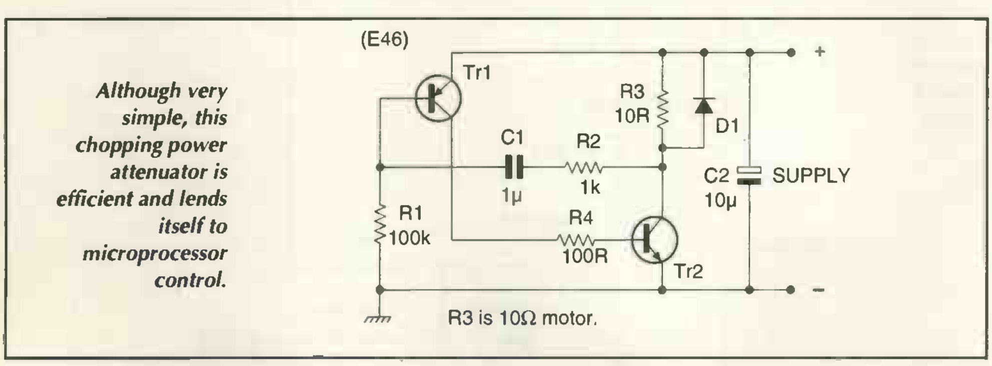
All components are non-critical; in the original application Tr_2 was a small 1A device. Capacitor C_1 should be non-polar. Optimum performance in a given application may require adjustment of the timing by modifying the values of R_1 and R_2.

If a variable speed drive is required, a potentiometer can be used instead of R_1. In this case a fixed resistor must be placed in series, to limit the maximum Tr_1 base current.

For microprocessor control, R_1 could be a digital potentiometer IC. For other applications, alarms, beacons, etc., one or more LEDs may replace the motor.

Alan Jones
Newcastle-under-Lyme
Staffordshire
E46

Although very simple, this chopping power attenuator is efficient and lends itself to microprocessor control.



The only thing scientists agree about on the mobile phone health question is that you cannot rule out the risk factor.
So where does that leave the worried consumer? In limbo for a while yet, says Melanie Reynolds

The fear

Are mobile phones detrimental to human health? This question is likely to trouble us for a very long time. It may be a question we carry on asking forever. For despite numerous studies on the subject, only one aspect of the testing is agreed upon. "One of the things about science is you cannot prove there isn't risk," says Gerd Friedrich, MD of communications industry organisation Forschungsgemeinschaft Funk in Germany.

This means tests that do not show any ill effects are doomed to be repeated to demonstrate there is still no danger. So the message remains that 'the balance of scientific evidence does not suggest that any harm is caused by mobile phone technologies'.

Of course, there have been various reports of studies that do show ill effects, but the scientific community has its rules on research, which have so far meant these studies have been set to one side. The rules mean that before a study is accepted as scientific fact, it must be repeated, with the same results, in other laboratories. To date this has not happened.

"One point we need to bear in mind is that we are dealing with biological organisms and they are notoriously unreliable," explains James Lin, professor of bioengineering at the University of Illinois. "You have to be very cautious and aware of biological variability."

Lin says consistent, dependable and scientific conclusions cannot be drawn yet. He believes that there is no immediate cause for concern. But, "this is the first time in human history that millions of

When do we get the numbers?

It is all very well being told to consider SAR (specific absorption rate) values when choosing a phone, but in Europe they are not available yet. The problem is the standards for testing SARs have not been agreed and are not expected to be available until the middle of this year.

Any SAR values quoted now could have been achieved using one of several test set-ups, all of which can provide vastly different answers.

A CENELEC standard is due this month while an apparently similar IEEE standard is going through internal voting. But the one to wait for is the IEC document, due early 2001, which draws on both these standards.

"For the first time it looks good that we may have a harmonised standard," comments Camelia Gabriel, director of UK-based Microwave Consultants. "It's very important we get there but it's not an easy task."

Of course once the standard has been agreed the phones must be tested to it. It could be a long time before we see SAR figures which we can legitimately compare.

factor

humans have been exposed to a source of radiation close to the head," continues Lin. "There is no question that microwave radiation can be hazardous to human health. The question is, how hazardous is it?"

The speakers at IBC's 'Mobile phones – is there a health risk?' conference were all keen to illustrate how much time and money is being put into this question on a global basis.

"There is a lot of research. The problem is that a lot of people don't understand the research out there, but it is very well planned," explains Sheila Johnston, neuroscience consultant to the UK mobile phone industry. Sheila illustrated her point with an extremely long list of all the research.

Johnston feels the gap right now is in human research, but believes this area will be addressed by the UK Government's £7m research project announced at the end of last year (see news on 164).

Despite this large amount of money there remains scepticism over the issue of public health and cover-ups. You only need to look at recent history to see why. The tobacco companies are a fine example of an industry cover up, while the UK's handling of BSE (mad cow disease) illustrates political inadequacies all too well.

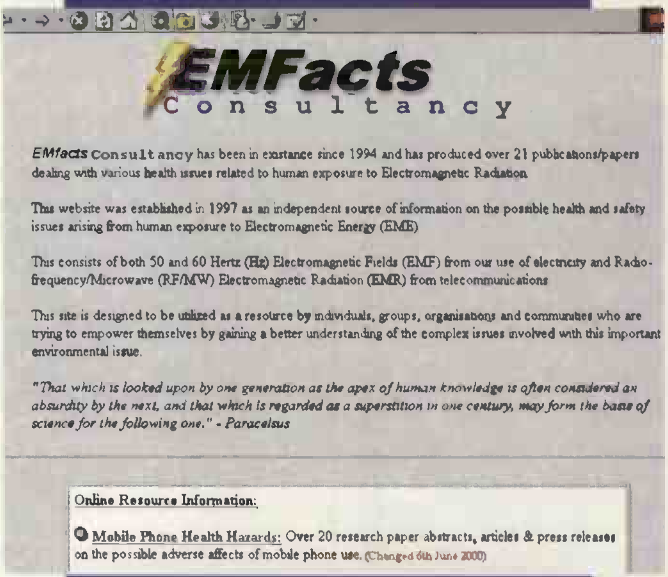
But Michael Repacholi of the World Health Organisation is convinced this will not happen with mobile phones.

Despite the fact a lot of research is industry funded he says there is a "firewall" which keeps industry at arms length from the researchers.

"It won't be the tobacco problem," states Repacholi. "The UK Government is more BSE sensitive which may even cause an over reaction in the EMF situation. They might see it as another situation which could get out of control."

Repacholi also believes adopting a precautionary approach to fixing exposure levels is a mistake. In the UK levels fixed by the National Radiological Protection Board were shifted by the Government simply to bring them in line with other countries. According to Repacholi this, "undermines hundreds of millions of dollars of research for no apparent benefit to health".

"It doesn't matter how far politicians reduce levels. It doesn't reduce anxiety. It needs to be based on scientific fact," says Repacholi who believes public confidence will be increased if governments and scientists agree on the health risks. And after all, the alleviation of public concern is what all this is about. ■



There's plenty of background information on mobile phone health hazards at http://www.tassie.net.au/emfacts/mobiles/iegroup.html.

Advice on using mobile phones

As a result of the Stewart report on mobile phone health issues in May 2000, the Government agreed a leaflet setting out its advice would be handed out with every mobile phone sold.

The leaflet says there is some evidence that changes in brain activity can occur at levels below the guidelines set internationally for exposure to radio waves, but says it is not clear why. As a result it is taking a precautionary approach to the use of mobile phones. Its recommendations include:

- Keep your calls short
- Consider relative SAR values when buying a mobile phone
- Do not use a mobile phone when driving, not even if you have a hands-free kit
- Under 16s should use mobile phones only for essential purposes and keep all calls short

Personal voice communications without a licence over a two mile radius for £75, exclusive.

Reader offer

A *pair* of two-way PMR radios for just £75*

RS 446 personal mobile radio...

To celebrate its launch, new test and instrumentation company Tecstar is offering *Electronics World* readers *two* RS446 personal mobile radios for just £75 excluding VAT and carriage.

Capable of transmitting and receiving voice over a distance of up to two miles, depending on terrain, the PMR 446 needs no licence. It offers eight channels, scanning – and with CTCSS up to 304 channel combinations.

A backlit liquid-crystal display shows volume level, channel number, sub-channel number, battery level and transmit/receive or channel busy. A unique call feature enables the user to alert the person they wish to contact.

Transmission distance is up to 2 miles. The radio has an accessory socket for an external headphone, earpiece or vox-microphone/headphone combination. A keypad lock and battery save feature are also standard.

The unit measures only 120 by 50 by 20mm and weighs less than 150 grams – including batteries. It is supplied complete with instructions and belt/mounting clip.

Compact, lightweight and low cost, the RS446 wireless personal-communications hand set has a wide range of applications. These include fetes, events and rallies. Builders on building sites could benefit from these radios, as could exhibitors at exhibitions and staff at warehouses, winter activities, sports events, maintenance departments, schools and care homes. Of course you can also use the RS446 just to keep contact with someone locally. The uses are almost limitless.

Send a cheques or postal orders to Tecstar Electronics Limited, 1 Nuffield Road, St Ives, Huntingdon Cambridgeshire PE27 3LX.
Tel 01480 399499, fax 01480 399503, e mail sales@tecstar.co.uk

RS446 key features...

- Up to 2 mile coverage radius
- Scans main and subchannels
- Eight channels, each with 38 sub channels
- Backlit display for night time use
- Unique call function
- Headphone and mic sockets allow discrete use
- Battery status indicator
- Auto battery save feature
- Keypad lock-out

What Is CTCSS

CTCSS – or 'continuous-tone controlled squelch system' – allows sub channels of the main channels to be used. There are 38 sub channels to each main channel. Using subchannels decreases the likelihood that someone else will be using the same frequency.

Order coupon

Please send me RS446 personal mobile radios, for which I enclose:

For ___ **pairs** of RS446 radios at £75 per pair ____

Plus VAT at 17.5%, or £13.13 per pair ____

Plus £6 UK postage per order, or £14 overseas ____

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Fill in your name and address and post this coupon together with a cheque for the total amount above payable to Tecstar to the address below.

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____

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Tel 01480 399499, fax 01480 399503, e mail sales@tecstar.co.uk

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CABLE FAULT LOCATOR

David Huddart's simple time-domain reflectometer is used with a reasonably fast oscilloscope to find faults in cables by transmitting a pulse and analysing its echo. It has been tested with cable lengths up to 200m and can resolve down to 100mm yet it comprises only one IC and a three transistors.

This design was developed for locating faults in coaxial cables. A 'time-domain reflectometer', or TDR for short, sends a brief, very fast edged pulse into a cable and then looks for reflections. If the cable is open or short circuit, a return echo that is twice the transit time of the cable will be observed – a so-called 'go and return' echo.

This unit generates the fast pulses needed and uses any reasonably fast oscilloscope to monitor the activity on the line.

How the circuit works

Schmitt trigger IC_{1A} forms a simple 50kHz oscillator. This is a 74HC part. Output from this oscillator triggers an avalanche pulse generator.

The pulse generator,.and its associated voltage clamp, is based on a previous article about sampling oscilloscopes[1]. Pulse transistor Tr_1 is not designed specifically for use in avalanche mode, I found that but several samples of 2N2369, BSX20, and BFR91 all worked reliably in this sort of circuit configuration.

Other transistors such as BC107, BFY50 would not function. I put this down to the fact that the 2N2369, BSX19/20 are all high-

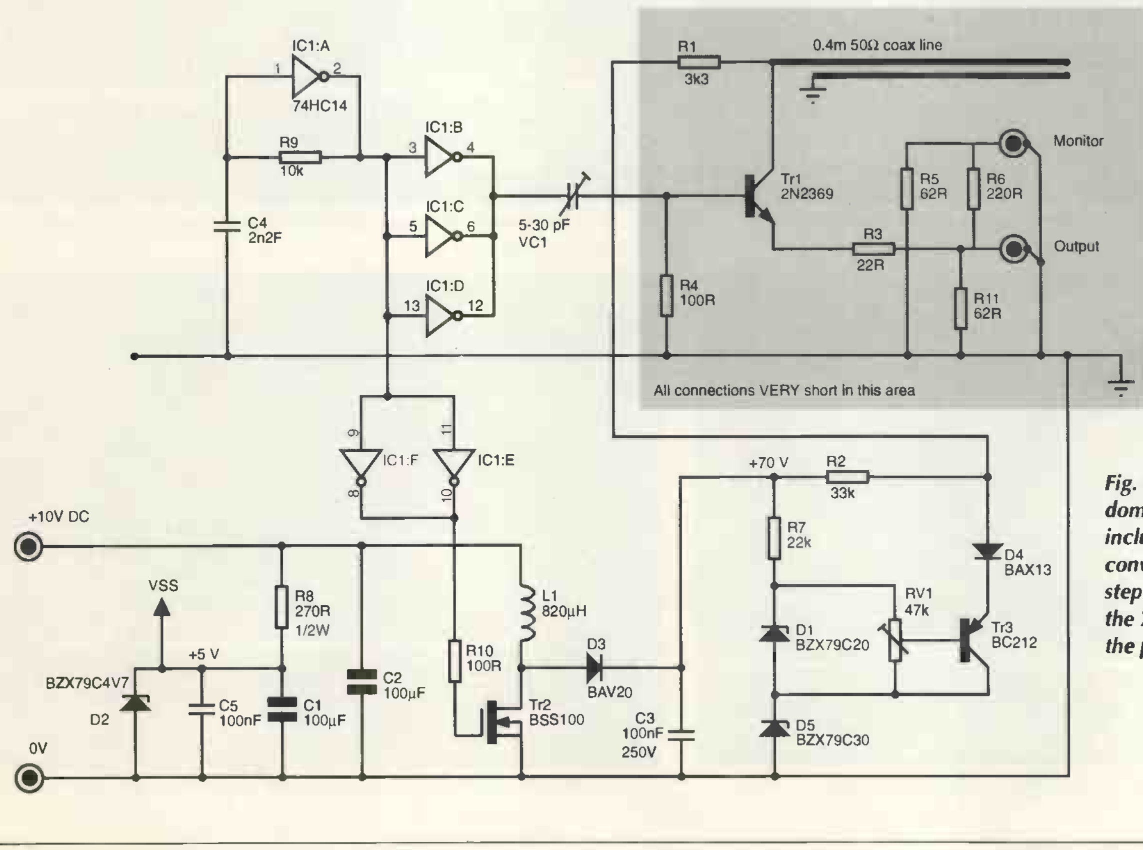


Fig. 1. Circuit of the time-domain reflectometer includes a fly-back converter around Tr_2 to step the 10V supply up to the 70V or so needed for the pulse generator.

speed switching transistors with low V_{ceo}. Ian Hickman's article mentioned in the reference details the operation of the pulse generator but I made a few minor changes:

- The open circuit 50Ω coaxial line is longer so that a pulse of approximately 6ns is generated.
- The trigger pulse feeds Tr_1 via an adjustable capacitor to fine tune the pulse waveform.
- The line charge voltage clamp is modified slightly to allow for the high-voltage supply.

The pulse generator needs at least 70V. Partly because I did not have a suitable bench supply available, I decided to build in a switch mode supply to boost the 10V input to 70V.

This simple power supply is based on the fly-back principle and uses the 50kHz signal available from IC_{1A}, via $IC_{1E,F}$ to drive a MOSFET, Tr_2.

During the on-time of Tr_2, current in L_1 builds to approximately 50mA. When Tr_2 turns off the voltage at the junction of Tr_2, D_3, L_1 'flies' up to be caught by D_3 at the voltage across C_3. All the energy in L_1 is then dumped into C_3 in about 1µs.

Because the load across C_3 is several tens of kilo-ohms, and the energy being delivered is fixed, the voltage across C_3 rises until all the energy is consumed. Expect between 60 and 100V across C_3. The actual value is not critical.

Transistor Tr_3 and its associated components form a variable voltage clamp. This stabilises the charge voltage of the line. Adjustment from 30 to 50V is provided by RV_1.

In operation the open circuit 50Ω line is charged to the preset clamp voltage via R_2 and R_1. On the rising edge of the signal feeding VC_1, current flows into Tr_1 base and starts conduction. The avalanche effect causes Tr_1 to turn on very rapidly and the energy stored in the line is discharged via Tr_1 into R_3 and on to the output.

Resistors R_5 and R_6 form a simple attenuator so that the voltage at the output may be monitored.

Implementing the design

I built the TDR into a small die-cast box and fitted two BNC sockets for the outputs and simple flying leads for the DC power supply.

You can use Veroboard, as I did, but take care to ensure that connections are as short as possible and that decoupling capacitors are close to the source of surge currents. Capacitor C_5 must be a ceramic type and

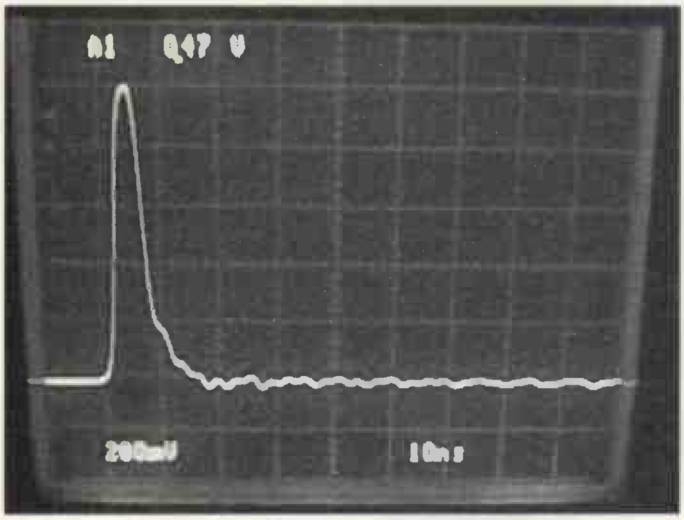


Fig. 2. Output pulse of the instrument with no cable under test connected.

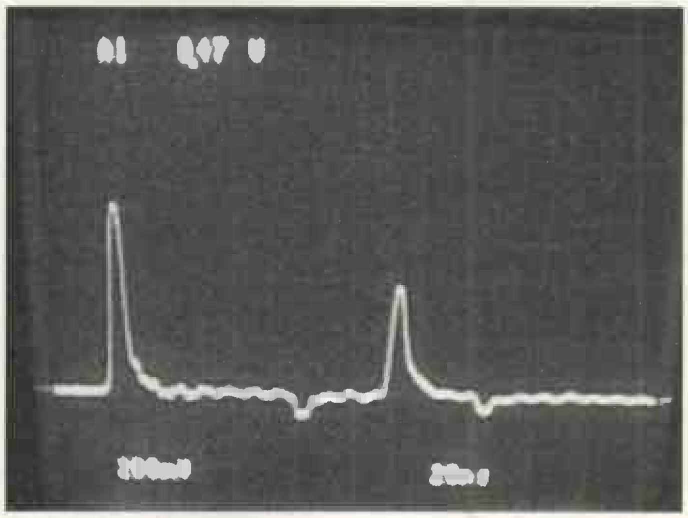


Fig. 4. Reflections from 9m of open-circuit coaxial cable and faulty BNC connector at 6m.

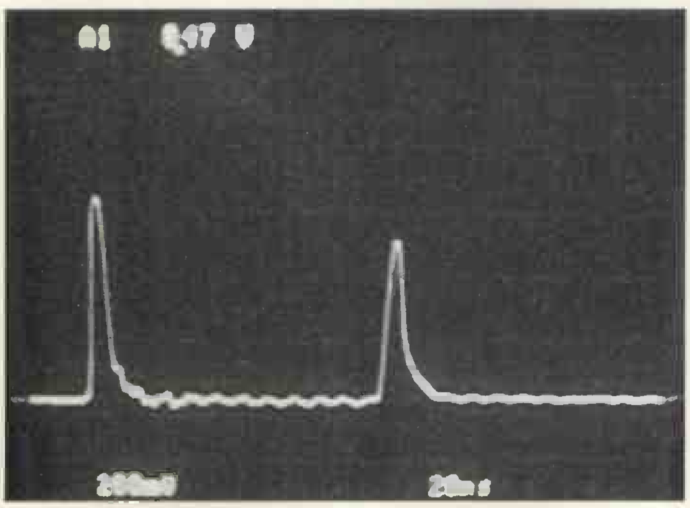


Fig. 3. Reflection from 9m open-circuit coaxial cable cable.

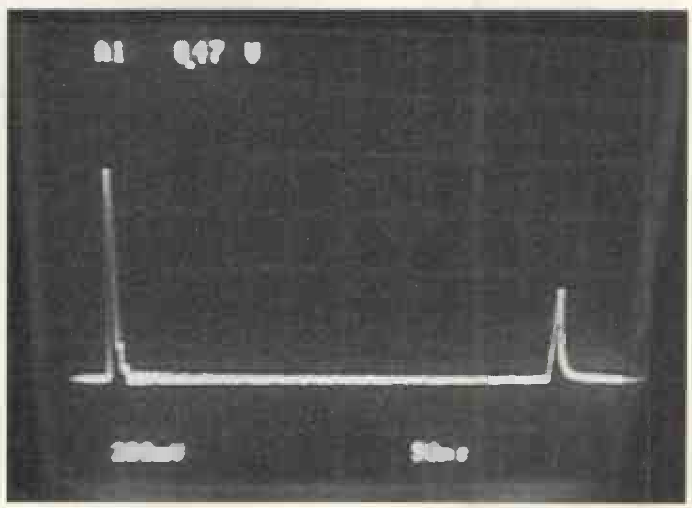
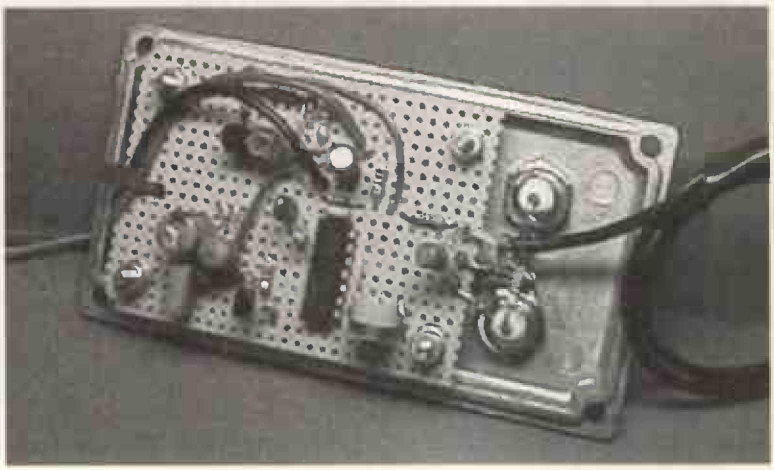


Fig. 5. Reflections from approximately 40m of open-circuit coaxial cable.

connected directly between pins 7 and 14 of IC_1. Capacitor C_2 should be reasonably close to L_1 and Tr_2.

Components shown in the dotted area are the heart of the device and must have very short leads – less than 10mm – to minimise inductance. If they haven't, the rise time of the pulse will be affected. I soldered them to the BNC connectors, providing support for Tr_1 on small, insulated, terminals.

The stub line is a length of RG174 miniature 50Ω coaxial cable coiled to fit inside the box. The far end is open circuit.



Note short leads around avalanche transistor near the two BNC connectors.

Setting up

Apply voltage slowly, watching for excessive current flow. Typical consumption is 40mA at 10V. Monitor Tr_2 for activity and the voltage across C_3. It should be 110V maximum.

Next monitor the output and the collector of Tr_1. Set VC_1 to maximum and RV_1 to give 30V at Tr_3's emitter. Now increase RV_1 until the fall time of the voltage at Tr_1 collector suddenly becomes very sharp.

The output waveform is shown in **Fig. 2**. This is the point where avalanche starts. Increase RV_1 about 4V more and remove the scope probe from Tr_1's collector.

Now the output should show a very fast rising pulse about 6ns long. Adjust VC_1 to reduce the drive current into Tr_1's base. This should clean up the falling edge a little reducing the base current after Tr_1 has triggered.

If the output stops altogether, back off the adjustment a little to give reliable operation. This completes the set-up.

Using the meter

For good results, an oscilloscope with a bandwidth of at least 50MHz is required, otherwise the resolution is limited. My scope has a 150MHz bandwidth and 2.3ns rise time. It is easy to resolve length to 100mm.

In operation the oscilloscope is connected to the monitor output using 50Ω coax and terminated at the input to the scope. The cable under test connects to the output.

The scope should display the transmit pulse and later any returned echo **Fig. 3**. There will be echoes from any point along the test cable where its impedance changes. Typically this would be an open or short circuit.

It is surprising how sensitive this TDR is. For example a reflection can be obtained from the change in impedance that 5mm of stub cable connected to a tee causes, **Fig. 4**. Cable lengths of up to 200m have been tested and reflections easily measured. **Figure 5** shows results from a 40m cable.

The polarity of the echo indicates open or short circuit ($>Z_o$ or $<Z_o$) in the cable. Positive echoes indicate high impedance and *vice versa*.

The time delay can be used to estimate the distance down the cable where a fault is,

$$l = \frac{t \times V_c \times C}{2}$$

Where l is the length of cable in metres, t is the time from transmit pulse to echo in seconds, C is the speed of light, at 3×10^8m/s, and V_c is the velocity coefficient for cable under test.

The velocity coefficient is the ratio of the speed of signals through cable to the speed of light. It varies depending on the exact type of cable but is usually between 0.6 and 0.8. If this coefficient is not known it may be simply calculated using a known length of cable from,

$$V_c = \frac{2l}{t \times C}$$

Measure the round trip delay of a known physical length of cable and calculate V_c.

The TDR has given good service in locating faults in coaxial cable runs, detecting dubious coaxial connections and even measuring the characteristic impedance of an unknown line by adjusting the termination impedance of a length until minimum reflections are observed. It is surprising how useful it has become in the workshop ■

Components

Resistors		
1 off	R_1	3k3
1 off	R_2	33k
1 off	R_3	22R
2 off	$R_{4,10}$	100R
2 off	$R_{5,11}$	62R
1 off	R_6	220R
1 off	R_7	22k
1 off	R_8	270R, 1/2W
1 off	R_9	10k
Capacitors		
2 off	$C_{1,2}$	100μF, 16V
1 off	C_3	100nF, 250V
1 off	C_4	2n2F
1 off	C_5	100nF
Integrated circuits		
1 off	IC1	74HC14
Transistors		
1 off	Tr_1	2N2369
1 off	Tr_2	BSS100
1 off	Tr_3	BC212
Diodes		
1 off	D_1	BZX79C20
1 off	D_2	BZX79C4V7
1 off	D_3	BAV20
1 off	D_4	BAX13
1 off	D_5	BZX79C30
Miscellaneous		
1 off	L_1	820μH
1 off	RV_1	47k
1 off	VC_1	5-30pF

Reference

1. Hickman, Ian, 'Towards a 500MHz scope add-on', *Electronics World*, March 2000.

*UK readers and overseas subscribers only

A low-power 555 timer guaranteed to run from supplies down to 0.9V.

Sponsored by UK semiconductor manufacturer Zetex, this month's cover mount is a state-of-the-art version of one of the most successful ICs ever made – the 555 timer. The device is housed in a dual-in-line package and its pin designations are the same as those of the standard 555.

Featuring a very low quiescent current of 74µA, the ZSCT1555 can be powered by any DC supply from 0.9V up to its absolute maximum rating of 6V.

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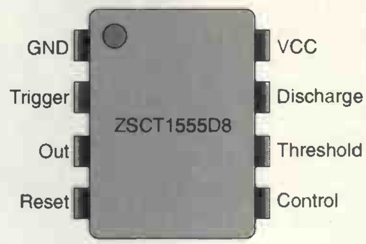

This is the DIL version of Zetex's low-power 555 timer. The device is also available in SOIC with the same pin configuration.

Single-cell boost converter

Relative to similar CMOS 555 timers the ZSCT1555 has a lower operating voltage. But more importantly, it can offer a longer battery life.

The circuit shown in **Fig. 1** generates a 5V output using a boost topology combined with pulse width modulation to regulate the output voltage to 5V. The ZSCT1555 generates the required 150kHz signal for the PWM circuit.

Inductor L_1, with D_2 and Q_2, allow operation up to very high switching frequency. This speed-up circuit uses active base drive, which minimises switching losses. Schottky diode, D3, used for charge steering is unique. In SOT23 the DC rating of the ZHCS750 at 750mA is exceptional.

The circuit features a ZR431 adjustable shunt regulator in the feedback control loop. This device again offers power economy as its quiescent current is only 35µA – ten times lower than other similar parts.

Extremely low saturation voltage, equating to an on-resistance of only 30mΩ at 300mA, of the FMMT617 switching transistor, Q3, further optimises circuit efficiency.

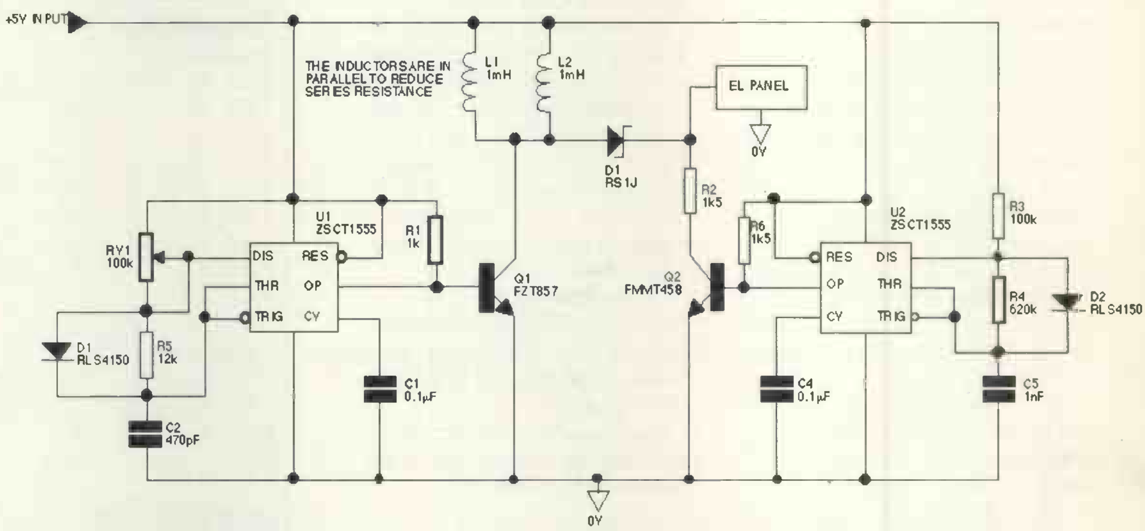

Fig. 2. Electroluminescent display drivers normally need a bulky and heavy transformer. This alternative eliminates the transformer without compromising on efficiency.

Electroluminescent driver

Traditional electroluminescent display driver circuits feature a flyback transformer topology to generate the high AC voltage required to energise the panel. This is expensive – the cost of the transformer and its size, together with a larger PCB area, increases the overall equipment cost.

Eliminating the need for a transformer, the circuit in **Fig 2** is more cost-effective. To add to this, the ZSCT1555's low power consumption and the capabilities of the switching transistors make for a highly efficient solution.

The innovative design uses two combined switching circuits. The first generates a high voltage, approximately 200V, using a 'boost' topology. This voltage is chosen, according to EL-Panel size and brightness, by varying the frequency. Effectively the EL panel behaves like a capacitor. The second circuit converts the high voltage to an 800Hz AC signal to drive the EL-Panel.

The two ZSCT1555 timers form clocks for the switching transistors. High efficiency is ensured by the switching capabilities of the Zetex bipolar transistors. Advanced transistor design gives the lowest saturation voltage in the switch for the lowest dissipation.

These two application examples highlight the specific advantages of the ZSCT1555 for high-efficiency circuits – namely low supply voltage and low power consumption. This Zetex timer offers advantages to many of the thousands of traditional applications for the 555. ■

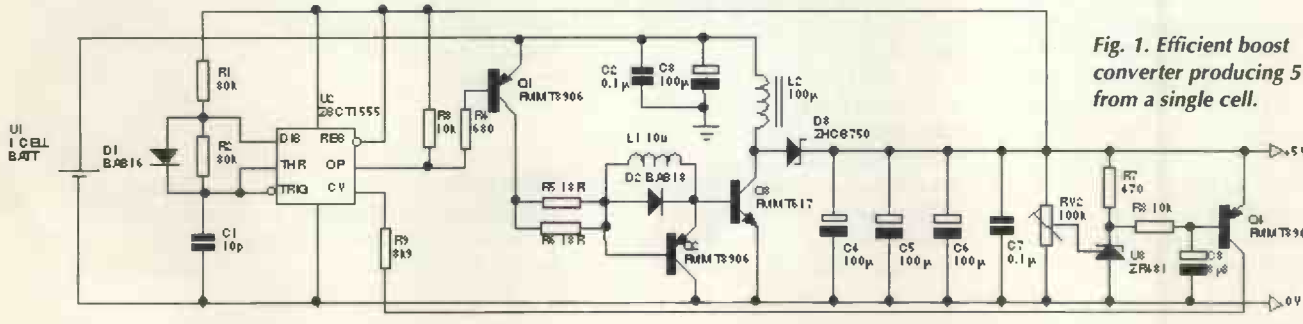

Fig. 1. Efficient boost converter producing 5V from a single cell.

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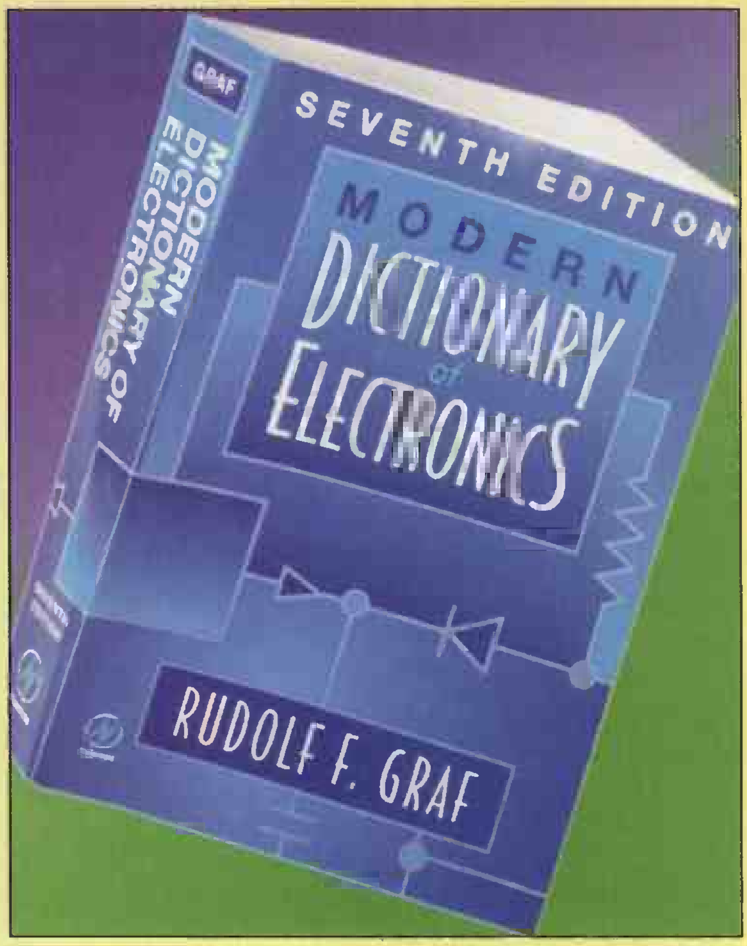

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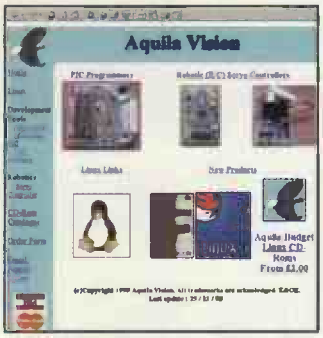

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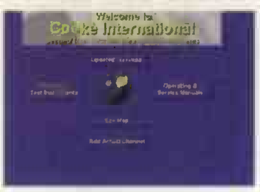

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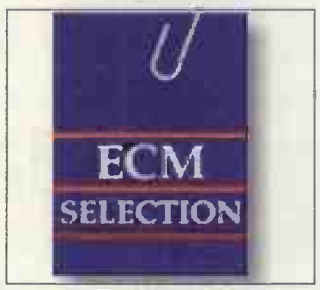

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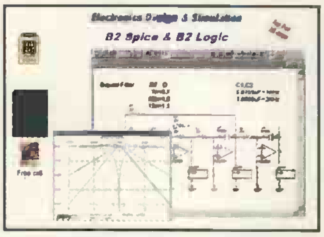

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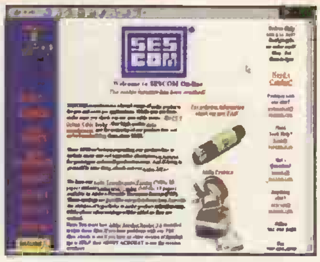

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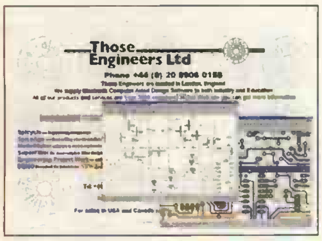

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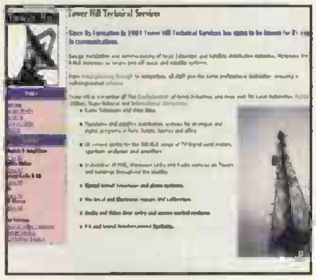

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UK MAILING LIST GROUP

http://www.egroups.com/list/uktvrepair

Following on from the newsgroup discussion last month there is a UK Email group for TV technicians where you can send an Email to everyone in the group. There's just over 30 people in the group at present. For more details and how to register look at the egroup home page. Just a general comment though - you do have to be careful who you give your Email address to so that you can avoid "spamming" - that is getting lots of unwanted Email about dubious Russian site (amongst others).

REED CONNECT

http://www.reedconnect.net/

Another free internet access site, this time from Reed Business Information. However the site possesses a useful UK

People and Business Finder, with an e-mail search. There's also business news and local information, and some good links to directory sites.

REPAIRWORLD

http://www.repairworld.com

Repairworld is a sophisticated US based fault report database which is updated bi-weekly. It operates on a subscription basis and describes itself as an "affordable solution for all technicians". You can see some samples of the material for free, monitors, VCR, DVD and Camcorders being of particular relevance to UK users. The site also provides a "chat room".

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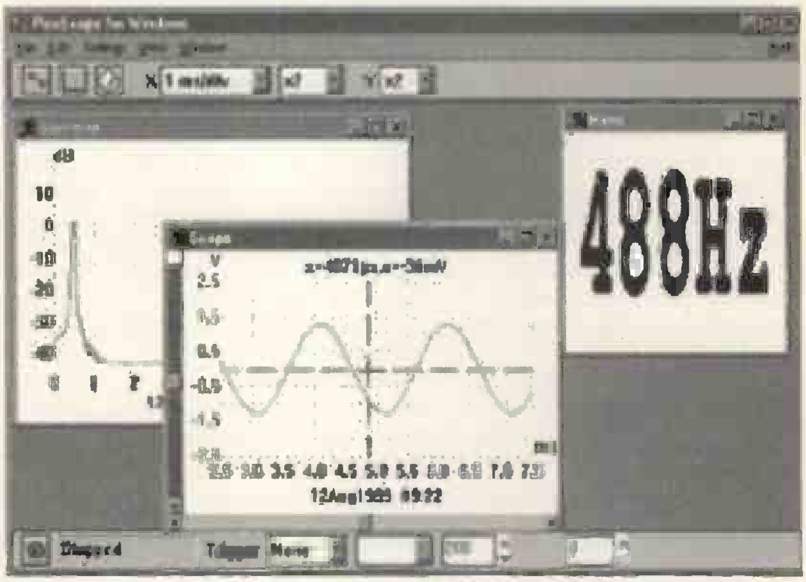

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Letters to the editor

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B-class Class B

In reply to James Bongiorno's in the February 2001 issue's letters section, I must admit that I was not aware that the problem of crossover distortion in Class-B output stages had been completely solved thirty-five years ago. Looks like we're all out of step except Jim.

If Mr Bongiorno feels he has solved a problem that has defeated thousands of engineers, I think we might expect some details, perhaps even a circuit diagram and some test results.

Since I am not quite so ignorant about diodes in output stages as Mr Bongiorno seems to think, I would like to go straight for the jugular and ask what quiescent current is required to make his scheme work properly? Linearity is easy to achieve with amperes of current flowing – but this does not constitute solving the Class-B problem.

I am also unmoved by a THD figure of less than 0.01% at 20kHz, as most versions of the Blameless amplifier can achieve this: many of them do much better. The 'load-invariant' version gives 0.004% at 20 kHz while driving 3Ω.

What exactly are the advantages of a dual-differential input stage? The normal pair gives a differential input, and you cannot make an input more differential than differential can you?

I am perfectly aware that complementary amplifier topologies exist, and given the time, it would be interesting to analyse them properly.

However, the disincentive is that they look unpromising in two areas: maintaining exact I_c balance of the input pair, and maintaining a well-defined current through the output stage bias generator. Both are absolute requirements for good linearity. Perhaps Mr Bongiorno has solutions to these problems.

Douglas Self
London

LF communications

It is with some pleasure that I see real 'wireless' making a return to *Electronics World*, in the article entitled 'Comms at 136kHz' on page 16 of the January issue.

As it happens, the UK is a relatively active region in this area of the amateur radio spectrum. Much of the contact between the widely-spread adherents is conducted via the RSGB's LF Group reflector on the Internet.

Unfortunately, much of the comment in the article about the band is a little dated. There is a growing band of enthusiasts in Europe, Canada, the USA, Australia and New Zealand who are investigating this fascinating region of the radio spectrum again.

While a lot of our initial work was based on guidance from early books like the pre-war Admiralty Handbook, we have progressed rapidly and are probing some of the forgotten corners of technology. Litz wire, and basket weave coils, not considered by your contributors, have proved to still have advantages.

Several UK station have constructed and operate stations running several hundred watts output. This has enabled the Atlantic to be spanned for the first time on this frequency by an amateur signal in September this year. It was done using an ERP of just less than 1W.

Skywave or ionospheric propagation is not only available at night and there a regular instances of contacts over 1200km during daylight hours. Fortunately, as amateurs we do not have to maintain a commercial quality channel, so the exploitation of sporadic events at these frequencies adds greatly to the interest.

The UK 73kHz band has not been closed, as was stated in the article. The licence variation holders have been awarded a further three years use of this band.

Alan Melia G3NYK
Ipswich
Suffolk

Radio interference generator?

I stared with disbelief at your recent presentation of the Circuit Ideas prize to a 'radio interference generator' (p. 892 November 2000 issue), using a technique that does not work, to circumvent the EMC regulations.

Moving the frequency of a poorly designed switching regulator around so that it does not stay in the spectrum analyser bandwidth long enough to register, does not make the amplitude of the interference any less. It merely spreads to misery.

Alan Melia

E, fancy that

Referring to Letters in the December 2000 issue, I suggest that Mr Wells has not thought about the issue of resistor E ranges enough.

I don't know who devised the system, but presumably the object was to find a series of resistor values with nominally 10% tolerance such that the ranges of adjacent values just touched. A moment's calculation indicates that this will involve 12 or 13 per decade, and 12 was chosen.

We would therefore like each value in the series to be related to the previous one by the 12th root of 10. We would also like each value to be readily expressed. In practice, this means to only two significant figures.

If you try to devise a series meeting these criteria, I think you will soon conclude that the present one is the least bad, in that it spreads the values as uniformly as possible logarithmically across the decade.

If you calculate the error in the ratio of each value to its neighbour compared with the ideal 12th root of 10, you will find that any other sequence is worse. In fact, the biggest error is 1.5, not 3.3, and changing 3.3 to 3.2 is too close to 2.7 and too far from 3.9.

Hence I suggest that whoever devised the sequence really did a very good job.

Kenneth Gundry
San Francisco

Speaker performance

Speaking as an engineer who has devoted all his working life to the misguided notion that loudspeakers could be improved by careful design, innovation and
the application of new technologies, I have to take issue with at least one of John Watkinson's statements in his article 'Baffling the speaker buyer'.

In particular, I take issue with the statement referring to the low value of drive units; "...built down to a cost like this, the performance is not going to be special". The cost of manufacturing any object is fundamentally based on four things; the value of raw materials, the ease of manufacture, the cost of labour and number of objects produced. 'Special performance' does not figure in this calculation.

Although good design costs a little more than bad design, cost is of no more relevance to the sound quality of a loudspeaker drive unit than it is to the writing ability of a ball-point pen.

How John can be saddened by purchasers of expensive audiophile cables I just don't understand. He clearly applies their criteria to his selection of drive units.

John's comment that, "CAD reduces costs, but does little for performance," is just a little absurd. Try it out on Ron Dennis and he'll give you the same answer that I would.

A few caveats wouldn't have gone a miss in the article. Some of us really are trying quite hard to improve things.

Stuart Pooert
Brighton

Remote satisfaction

The article 'Remote control the easy way' in the December 2000 issue immediately caught my attention because of the simplicity of the hardware. I already had a Sony remote control for my video, a spare infra-red receiver and an 8051 development board.

I connected the IR receiver to the 8051 board. Because of the broad header pulse and the convenient frame rate, I was able to view the waveform on my oscilloscope using TV frame triggering. The waveform did not match the published diagram though. But after some head scratching, I realised that the published waveform was a mirror image of the oscilloscope's display.

After I began to write the software, I had to do a lot more head scratching before I discovered that my oscilloscope had been set to 'invert', which was why the polarity of my CRO display appeared to agree with the diagram in the article. The output of the IR detector is normally high.

After solving those problems, it didn't take too long to finish a program to select one of two LEDs as in the article. I then modified it to control the volume on my 20 year old TV set, and loaded it into an Atmel AT89C2051, which I mounted on a small piece of Veroboard.

The project was very satisfying. Thank you for the article. Interested readers can view the source code on my web site:

http://www.users.bigpond.com/alphaelectronics.

Ross Willson
Sydney
Australia

Amplifier for electrostatics?

High-voltage, high-power transistors, such as CRT deflection transistors, exist. Two examples are the MJL16218 and S2000AF.

Can anyone tell me if a high-voltage, low-distortion transistor amplifier capable of driving electrostatic loudspeakers directly has ever been designed? If not, does anyone think that such an amplifier would be feasible using such transistors?

Ged Landon
via e-mail

An unskilled generation

With regard to Simon Wright's article 'Exploiting Third World skills', in the January issue, the problem is not a shortage of electronics graduates. The problem is that British companies don't train people.

I have had a degree in Communication and Electronics since 1993 and I am still unemployed. I have only been able to find short-term temporary work from time to time. Of course, reading newspaper jobs sections will reveal many jobs for electronics engineers, but they all require five years experience.

There are very few training positions. The few that do exist usually want recent graduates with a 2.1 or above.

The real problem is not immigration policy. It is that two generations of school and university leavers have grown up unemployable and we have finally run out of skilled workers.

Malcolm Lisle
Gateshead

Is crossover not over?

I was surprised that cross-over distortion can still generate a heated exchange in your columns. I refer to 'Better buffers rebuffed' in February 2001 issue.

For me the problem was largely solved for me by L M Shaw's article in *Wireless World*, June 1969, and the refinement proposed by Peter Baxandall in *Wireless World* for the following September.

Then came the very elegant 'current-dumping' configuration used in the Quad 401. I think this design also originated from Baxandall.

I think the editor should not be afraid to use his blue pencil on comments about correspondents' life styles, and whether they choose to be troglodytes or not. A lot of internet material, mostly from the USA, shows how low things can sink if not moderated.

As cross-over is rather old-hat, perhaps Mr Bongiorno would like to turn his talents to help America find means to reduce its green-house gas production without too much pain for its population?

Justin Underwood
Much Marcle
Herefordshire

Justin, when contributors to the letters pages make unnecessarily harsh or derogatory criticisms, I remove them. However, if I feel that derogatory criticisms are justified, or might give readers a flavour of their author's character, thus adding information to the message being conveyed, I leave them in. Did you notice how Dave Kimber didn't respond in kind? Ed.

What is sky-scattered sunlight?

I have a couple of questions that I would like to put to your readers.

Colour television, based on the British PAL system, started in Australia in 1975. The bible of TV, recommended to all the technicians was 'Colour Television: The PAL System', by G N Pratchett. It was first published 1967 by Norman Price, London.

My question has to do with the colour of TV white, normally called 'illuminant D', which has a colour temperature 6500 kelvin. Pratchett says this is the colour temperature of "sky-scattered sunlight" and/or "sky-scattered daylight".

What do these terms mean and are they the same thing? Does it mean the light reflected off a white sheet of paper placed in the open shade?

Where in Britain was it measured? I've heard Scotland or Wales mentioned.

Gary Yates
Sydney
Australia

Boobs

Two errors appeared in redrawn circuit diagrams in the February 2001 issue. Apologies to you, and to the authors concerned.

On page 134, in the digital metal detector circuit, the device marked IC_3 should be a 7490 – not a 555.

In the ACMOS frequency tripler on page 140, the 47pF capacitor should be in the series path to the *left* of the shunt branch containing the 1μH inductor rather than to the right of it. The circuit will not work as shown. ■

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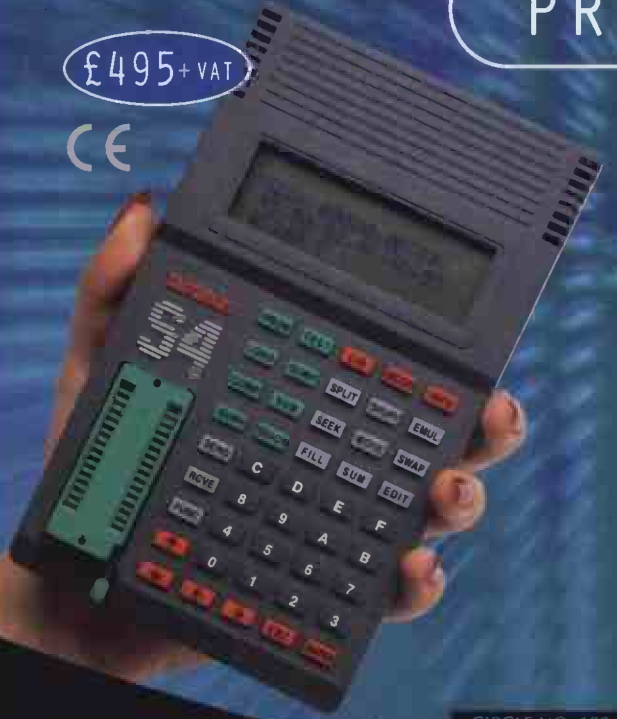

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