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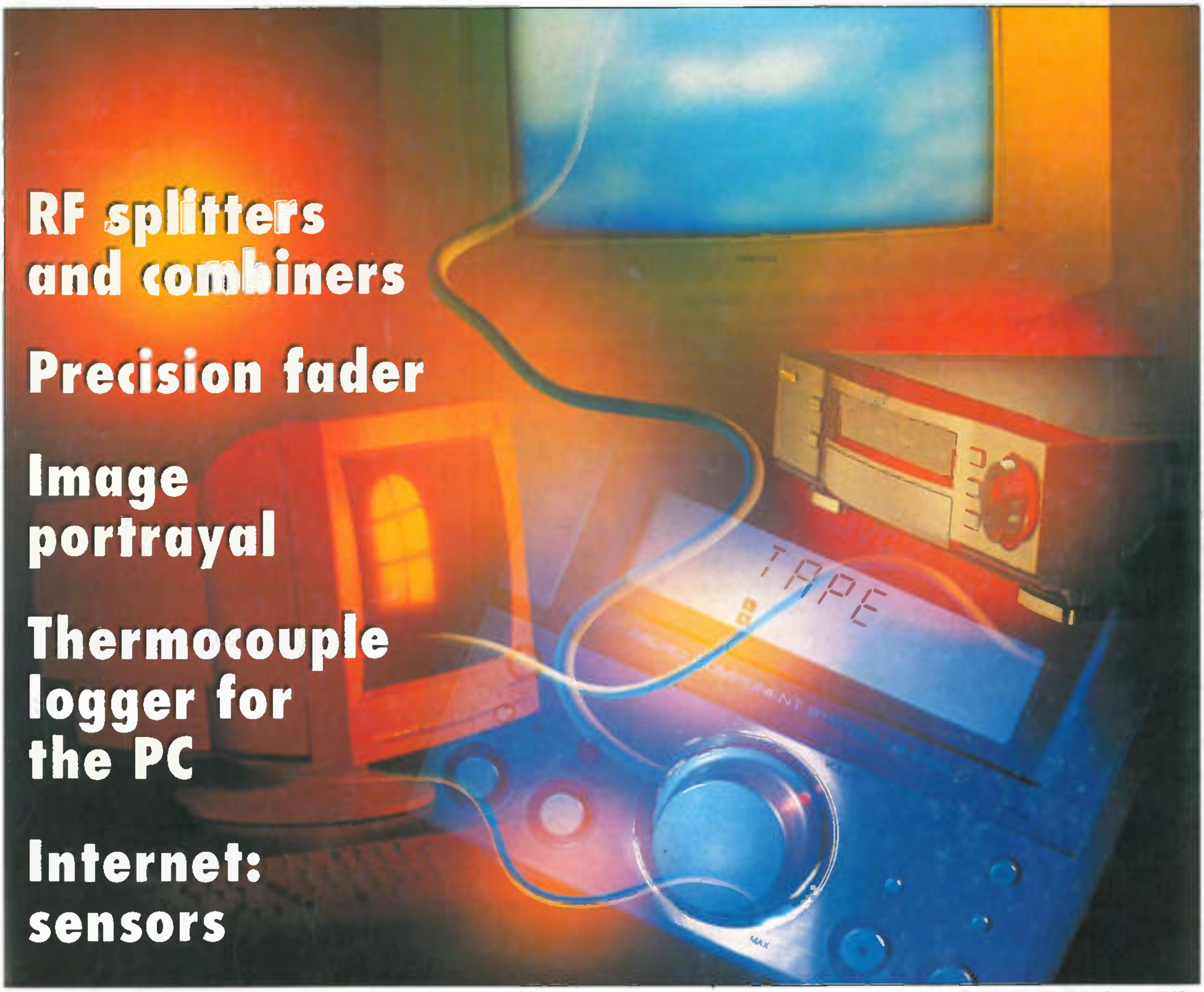

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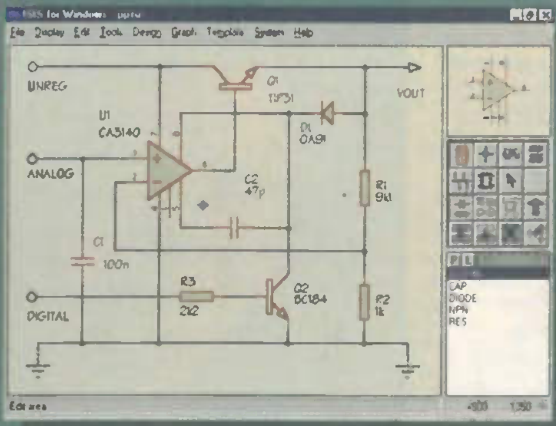

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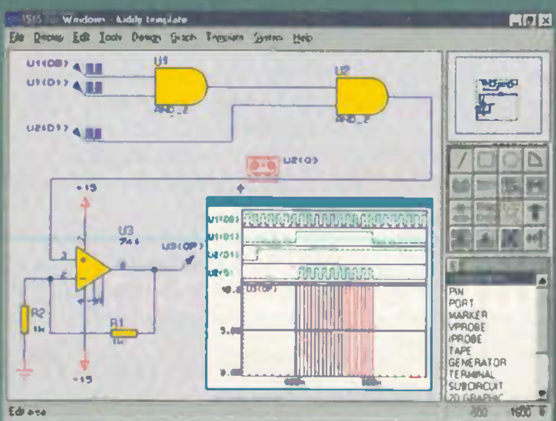

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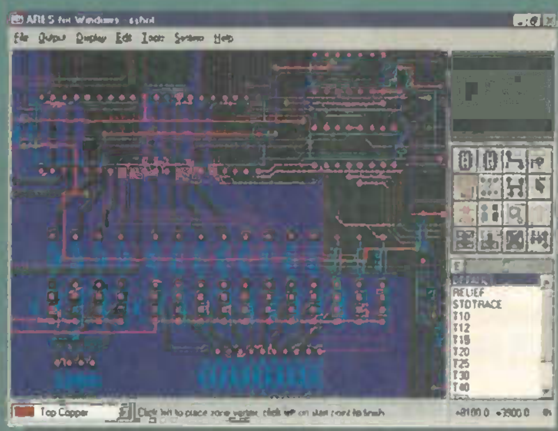

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CIRCLE NO. 106 ON REPLY CARD

Europe leads with new display technology

Europe is aiming to jump ahead of the Japanese and get a slice of the developing reflective-mode colour lcd market with a project called Helicos.

Helicos – hand-held reflective colour displays – is part EC-funded and aims to get European developed-reflective lcds into production within its two year duration.

"We hope to see products from the companies involved within 12 months of the project end," said Helicos project manager Dr Alan Mosley of CRL. The aim is for Europe to get second-generation displays out while others are introducing first-generation products.

Six organisations will pool their lcd knowledge under Helicos. The UK's CRL is one, the others are Asulab, part of the Swiss Swatch organisation; Thomson LCD from France; IMEC, the Belgian semiconductor specialist; telecoms company Alcatel; the University of Stuttgart; and Italian lcd maker Tecdis.

CRL is providing passive matrix lcd technology as is Asulab. Asulab's displays need relatively high drive voltages and this is where IMEC comes in. Asulab and IMEC will work together to make the displays and drivers needed to produce saleable display modules, said Mosley.

Thomson LCD and Tecdis are the display manufacturers involved, while Alcatel is on-board as a consumer of lcds to assist with evaluation. Lastly, the University of Stuttgart is providing active matrix know-how.

The first producable displays out of the Helicos will be 25, 86 and 140mm diagonal displays.

Reflective lcds use far less power than backlit types, but full-colour reflective displays have proved hard to make. Only Sharp is currently in production. These, and others thought to be close to market, use polarisers within their structures.

"Polarisers cut the reflective efficiency of displays," said Mosley. "The next generation of reflective full-colour lcds will have to be polariser-free to increase their brightness." Europe is in a good position to develop these, he added.

Steve Bush *Electronics Weekly*

Excellent outlook for semiconductor demand

Increasing demand for semiconductors across the world is prompting forecasters to predict a return to growth in the chip market next year. This follows this year's steep double-digit decline in revenues.

An upbeat prediction comes from Jean-Philippe Dauvin, chairman of the World Semiconductor Trade Statistics organisation (WSTS), who expects the semiconductor market to grow by 6.6 per cent next year, to reach a value of $130.3bn.

"Best growth should be in analogue, MOS micro and MOS memory," said Dauvin.

US market research firm International Data Corporation (IDC) expects modest growth of eight per cent next year.

"With recovery or improvement in Asia and Japan not expected to start until the second half of 1999, we cannot expect to see double digit growth for the semiconductor market next year," said IDC analyst Mario Morales. "Based on the pulse of the market, we remain cautious and have lowered our projections for 1999."

However, any upturn in chip demand in the second half of 1998 will not prevent global chip markets from a significant decline this year.

Dauvin's WSTS figures suggest an 11 per cent fall in the value of world chip sales which will hit $122bn this year.

Y2k should spark pc boom

A pc market boom is predicted next year as companies replace ageing pcs to tackle the Year 2000 problem.

However, according to market research firm Forrester Research – who made the prediction – pc sales will decline sharply in 2000, ending 17 years of growth. It is then expected to remain stagnant in the year 2001.

"Over the last decade, corporate demand has fuelled the pc industry's growth," said Forrester senior analyst Carl Howe. "But the Year 2000 crisis will upset that demand, and pc makers will get stuck with excess inventory when that demand dries up."

US pc industry revenues are expected to reach $55bn in 1999, however, by 2000, the US pc market will be worth $47bn. The increase in corporate pc buying is expected to be reflected in European markets.

Soldier Antz... Animators have developed a software model of the musculature of a human face to make the expressions of the characters in the film Antz more lifelike. "We wanted to capture the way a face works so that the audience would respond to the acting nuances," said Ken Pearce of Silicon Valley animation firm, Pacific data Images.

UK Philips workers face uncertain future

A significant number of jobs could be lost in the UK following the announcement by Philips' president Cor Boonstra that he is looking to reduce the number of Philips factories worldwide by a third. Philips employs 5500 people in the UK.

Although the company has stressed there is no list of sites to be closed, Boonstra said Philips will reduce site numbers from 244 at present to between 160 and 170 by 2002. Twenty five sites have already been closed this year and a further 18 are to be shut down before 1999.

Philips has seven manufacturing sites and five development facilities in the UK. A kettle factory in Hastings was closed several weeks ago with the loss of 160 jobs. Further UK closures could not be ruled out, said a spokesman.

The future of three other UK sites, which manufacture cathode ray tubes, has already been called into question. Philips is continuing investment discussions with the Department of Trade and Industry about the sites in Durham, Washington and Burnley.

The spokesman said the future of those sites was unrelated to Boonstra's announcement.

As part of its strategic move, Boonstra added Philips may consider acquisitions in the medical, semiconductor and lighting sectors. Such a move would take the company away from consumer electronics.

Philips refused to provide details about the worldwide closures, which it said are part of a business strategy to maintain the company's competitive condition. "There is too big a production capacity at the moment. There will be a drive to make better use of bigger facilities," said a spokesman.

Alex Mayhew-Smith
Electronics Weekly

New battery technology packs a 1.5kA punch

If you need an awful lot of power in a very short time, Bolder Technologies of Colorado may have just the thing.

It has re-spun lead acid rechargeable battery technology to produce more instantaneous power weight for weight than any other battery, or so it claims.

The cells are 9/5 sub-C size, 23mm in diameter and 70mm long, and yet they pack a huge punch. "If you make a 12V battery with six of them," said company spokesman Brian Zonnefeld, "you could start between 15 and 20 V-8 engines on a single charge."

Unlike conventional lead-acid cells, which use a stacked plate construction, Bolder's cells are wound like a capacitor. This is not a new method of constructing lead-acid cells. Hawker Energy (née Gates) has been making Cyclon cells in this way for years.

The difference, said Zonnefeld, is that Bolder is using very thin electrode materials – just 0.05mm thick – and capacitor-like internal electrode terminations.

These measures are designed to reduce the internal cell resistance to 1.5mΩ typically, which gives the 2V cells the ability to deliver bursts of 1.5kA. "It is possible to completely discharge a cell in under three seconds," said Zonnefeld.

The company has patented the thin electrodes, which it calls thin-metal-film (TMF) technology. It has also patented the method of termination. This involves offsetting the internal foils before winding, which results in one entire edge of each foil being exposed at the roll end – the cathode at one end and the anode at the other. Lead terminals are cast onto the exposed edges.

Low internal impedance, said Zonnefeld, brings fast charge capability. "With a charger, specifically for TMF, the cells can be fully charged in five minutes," he said.

Claimed cycle life at a 10A rate with 100 per cent discharging is 500 cycles.

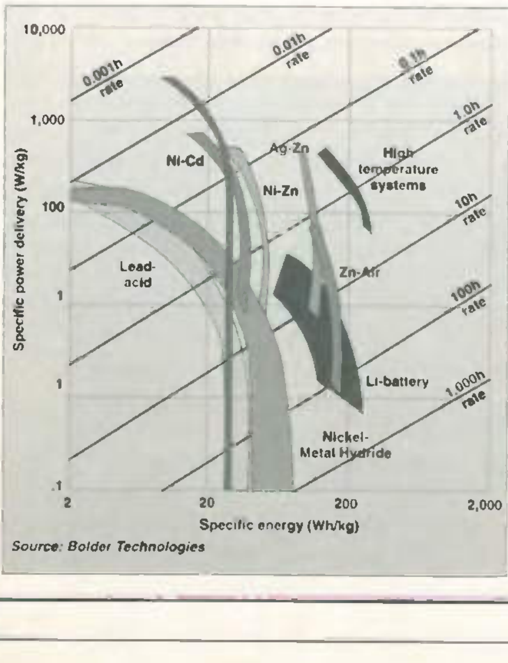
Lead acid cells are damaged by being left in a discharged state. TMF cells are no different. "This has to be taken into account when developing an application," said Zonnefeld.

Overall cell capacity is not high. The cell holds 1Ah, giving a specific capacity of around 30Wh/kg. This is comparable to other lead-acid batteries and below NiCd types. Zonnefeld accepts capacity is lower than NiCds at low discharge currents, but said: "Above 45A, the TMF cell can deliver more power than a 2Ah NiCd."

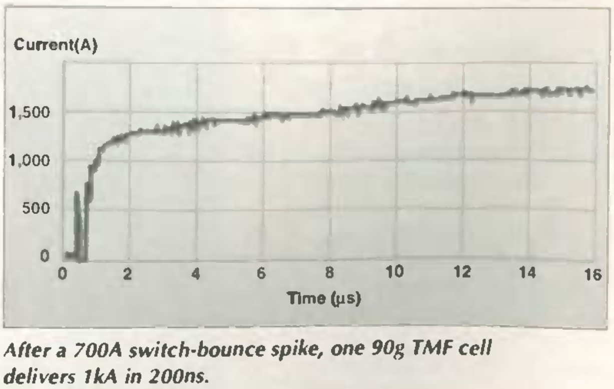
With a cell optimised for high current charge and discharge, Bolder is looking at heavy duty applications. "Engine starting is an obvious one, particularly where light weight is important," said Zonnefeld," Uninterruptible power supply is another. TMF cells are also very well suited to professional cordless power tools."

Environmental legislation could also play a part. NiCds are already banned in parts of Scandinavia. Lead-acid batteries are in no way environmental saints, but at least they have return waste streams that are established and working.

Bolder is represented in the UK by DMS Technologies. Tel: 01794 830111. http:/www.emstech.co.uk



Specific energy density is similar to other lead acid cells. Specific power delivery is claimed to be the best available.



After a 700A switch-bounce spike, one 90g TMF cell delivers 1kA in 200ns.

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TiePie introduces the HANDYSCOPE 2
A powerful 12 bit virtual measuring instrument for the PC

The HANDYSCOPE 2, connected to the parallel printer port of the PC and controlled by very user friendly software under Windows or DOS, gives everybody the possibility to measure within a few minutes. The philosophy of the HANDYSCOPE 2 is:

"PLUG IN AND MEASURE".

Because of the good hardware specs (two channels, 12 bit, 200 kHz sampling on both channels simultaneously, 32 KWord memory, 0.1 to 80 volt full scale, 0.2% absolute accuracy, software controlled AC/DC switch) and the very complete software (oscilloscope, voltmeter, transient recorder and spectrum analyzer) the HANDYSCOPE 2 is the best PC controlled measuring instrument in its category.

The four integrated virtual instruments give lots of possibilities for performing good measurements and making clear documentation. The software for the HANDYSCOPE 2 is suitable for Windows 3.1 and Windows 95. There is also software available for DOS 3.1 and higher.

A key point of the Windows software is the quick and easy control of the instruments. This is done by using:

- the speed button bar. Gives direct access to most settings.
- the mouse. Place the cursor on an object and press the right mouse button for the corresponding settings menu.
- menus. All settings can be changed using the menus.

Some quick examples:
The voltage axis can be set using a drag and drop principle. Both the gain and the position can be changed in an easy way. The time axis is controlled using a scalable scroll bar. With this scroll bar the measured signal (10 to 32K samples) can be zoomed live in and out.

The pre and post trigger moment is displayed graphically and can be adjusted by means of the mouse. For triggering a graphical WYSIWYG trigger symbol is available. This symbol indicates the trigger mode, slope and level. These can be adjusted with the mouse.

The oscilloscope has an AUTO DISK function with which unexpected disturbances can be captured. When the instrument is set up for the disturbance, the AUTO DISK function can be started. Each time the disturbance occurs, it is measured and the measured data is stored on disk. When pre samples are selected, both samples before and after the moment of disturbance are stored.

The spectrum analyzer is capable to calculate an 8K spectrum and disposes of 6 window functions. Because of this higher harmonics can be measured well (e.g. for power line analysis and audio analysis).

The voltmeter has 6 fully configurable displays. 11 different values can be measured and these values can be displayed in 16 different ways. This results in an easy way of reading the requested values. Besides this, for each display a bar graph is available.

When slowly changing events (like temperature or pressure) have to be measured, the transient recorder is the solution. The time between two samples can be set from 0.01 sec to 500 sec, so it is easy to measure events that last up to almost 200 days.

The extensive possibilities of the cursors in the oscilloscope, the transient recorder and the spectrum analyzer can be used to analyze the measured signal. Besides the standard measurements, also True RMS, Peak-Peak, Mean, Max and Min values of the measured signal are available.

To document the measured signal three features is provided for. For common documentation three lines of text are available. These lines are printed on every print out. They can be used e.g. for the company name and address. For measurement specific documentation 240 characters text can be added to the measurement. Also "text balloons" are available, which can be placed within the measurement. These balloons can be configured to your own demands.

For printing both black and white printers and color printers are supported. Exporting data can be done in ASCII (SCV) so the data can be read in a spreadsheet program. All instrument settings are stored in a SET file. By reading a SET file, the instument is configured completely and measuring can start at once. Each data file is accompanied by a settings file. The data file contains the measured values (ASCII or binary) and the settings file contains the settings of the instrument. The settings file is in ASCII and can be read easily by other programs.

Other TiePie measuring instruments are: HS508 (50MHz-8bit), TP112 (1MHz-12bit), TP208 (20MHz-8bit) and TP508 (50MHz-8bit).

Convince yourself and download the demo software from our web page: http://www.tiepie.nl.
When you have questions and / or remarks, contact us via e-mail: support@tiepie.nl

Total Package:
The HANDYSCOPE 2 is delivered with two 1:1/1:10 switchable oscilloscope probe's, a user manual, Windows and DOS software. The price of the HANDYSCOPE 2 is £ 299.00 excl. VAT.

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Internet zone

Radio equipment firms concerned over EC directive

Forthcoming changes in the way that radio transmitting equipment is certified in Europe are causing concern among equipment makers.

A European directive due to become national law in early 2000 will allow makers of radio transmission equipment to self-certify their products, removing the requirement for third-party scrutiny. Existing radio transmitting equipment makers are worried that the forthcoming radio directive will allow foul play in their sector resulting in pollution of the already crowded radio spectrum.

"A lot of *bona fide* members of the radio society are concerned that the European market will be opened up to lesser manufacturers," said Alan McHale, a spokesman for test house and consultancy ERA Technology.

Currently, radio transmitting equipment has to be tested and results submitted to national regulatory bodies for judgement prior to the equipment being sold.

However, the EC believes the changes will prove beneficial, helping manufacturers get their products to market earlier.

"This is a completely new way of approaching the issue," said Mark Bogers, EC spokesman for radio regulation. "The way it is done at the moment is a watchdog at the front gate, a concept that is uncommon in most other product sectors. You should only do this if risks are high, for example if there is a danger to health. With the new set of rules, manufacturers will declare their compliance to standards and the role of governments will change to one of surveillance."

The European Council of Ministers and the European Parliament are due to bring the new directive into force by December, or February 1999 at the latest. National governments will then have one year to make the directive law in their country.

Steve Bush

Satellite phone service flies amid flutter

The Iridium global satellite communications system has begun commercial service despite concerns over completed connections.

The $5bn Iridium system uses 66 low earth orbit satellites to connect handsets between almost any point on the globe.

"An idea proposed by three engineers in Arizona in 1987 has revolutionised the world of telecommunications," said Bary Bertiger, senior v-p and general manager of the Motorola Satellite Communications Group.

The launch had been delayed by two months, and despite problems with land-based gateways, Iridium has moved ahead with the commercial launch.

Motorola, which initiated the project along with other major investors, said it had completed testing of the system and that those tests met its standards.

Some early test users of Iridium had complained that while voice quality was good, there were problems achieving a connection, sometimes taking six or more attempts. Iridium says it has solved some of these gateway problems.

But industry observers warn that Iridium faces fierce competition from other mobile satellite service ventures such as Teledesic and GlobalStar, as well as from terrestrial-based cellular networks.

Get smart with a smartcard bike

Students and staff at Portsmouth University have the use of a 'Bikeabout', a free bike loan scheme controlled by a smartcard. Inserting the Gemplus smartcard releases a bike from a rack at one of three depots. Bikes can be returned to any depot. The security of the system – knowing who took a bike and when – means it is more robust than other cycle loan schemes. The scheme can cope with 2000 users.

Most pens write, but this one...

A smart pen that scans text from the page will be launched this month with the backing of mobile phone giant Ericsson.

Ericsson Mobile Communications is investing in Swedish image-processing firm C Technologies, which is about to launch its first commercial product, the C Pen.

Pocket-sized, it comprises an Intel StrongARM processor, digital camera and optical character recognition software. The digital video camera takes pictures of the text as the user drags the pen over a page. The C pen can read printed text at speeds of 100 characters/s.

Images are converted into computer-readable text using optical character recognition, and stored as a text file in the pen. With 6Mbyte of flash memory, 3000 A4 format pages can be stored.

Ericsson plans to market the smart pen under its own brand name next year. It will use an infra-red data link to connect the device to its handsets, letting scanned text be incorporated in faxes and e-mails, and transmitted over the GSM network.

"The C Pen, and future enhanced versions of it, makes a strategic complement to our existing and future product offerings in mobile phones, wireless data products and technologies such as Bluetooth," said Jan Ahrenbring, v-p of marketing at Ericsson Mobile Communications.

The smart pen developer also claims that with the processing performance of the 100Mips StrongARM, text translation can also be incorporated into the device.

Richard Wilson
Electronics Weekly

Emergency lighting

George Goh explains what to look for when you are choosing a power switching device for use in battery-powered equipment, using a fully-worked emergency lighting circuit as a design example. It turns out that the obvious choice – a power mosfet – becomes less attractive as the supply voltage falls.

Emergency lighting systems are frequently a required safety feature in business premises. Circuits for emergency lighting normally comprise a control circuit, battery pack, charger and a built-in inverter to drive a fluorescent tube.

Rechargeable battery packs are expensive. This makes the efficiency of the lamp driving circuitry crucial to the cost-effectiveness and physical size of the system.

Zetex bipolar transistors are designed using a base matrix, allowing them to offer a distinct advantage in this area. The *FZT689B* and *FZT788B* have the lowest saturation voltage in their class. This – combined with their high gain, and hence low drive requirements – means that efficient, high-current operation is achievable.

This article covers the design of all aspects of an emergency lighting unit, and includes a schematic for a typical circuit.

AC-to-DC converter

The first section of the circuit steps the mains voltage down to a low dc level, normally around 6V. This voltage is used to charge the batteries and illuminate any indicators needed.

The schematic shows a step-down transformer with a rectified output. A single 220μF capacitor is used to smooth the output. It is not imperative to have a smooth output, provided that the dc voltage is higher than that of the battery.

A 22Ω 4W resistor is employed in the circuit to drop any additional power that the battery does not absorb, and to act as a current limit. Across this is a led and resistor network to indicate when mains power is turned on.

Power switching

The second circuit block is that of the inverter power switch. This unit switches battery power into the inverter circuit when mains power is removed. Either relays or transistor switches can be used for this task. The schematic shows a transistor switch.

Conventionally two *BC327*s are used to switch in the battery to the inverter. But due to the exceptionally

Surely a mosfet's better?

The surface-mounting *FZT689B* transistor, and its through-hole counterpart the *ZTX689B*, are designed for use in high-efficiency circuits. They are especially aimed at portable, battery powered equipment where efficient power usage is of prime importance and where operation with low direct voltages is essential.

As circuits relentlessly migrate to 2.4V dc operating voltage – and below – the ability to have devices that can operate at these low voltages will become more and more important.

In some areas, mosfets have seen an increased in popularity due to their low R_{dson}. They are also easy to drive from logic devices, making interfacing with a microprocessor easier.

However, with the anticipated operating voltage heading down to 2.4V and below, it is doubtful that mosfets can operate efficiently at these lower regions. Zetex bi-polars can already operate at these low operating voltages today. With their very low saturation voltages, these devices can more than challenge the R_{dson} of present day fifth generation mosfets.

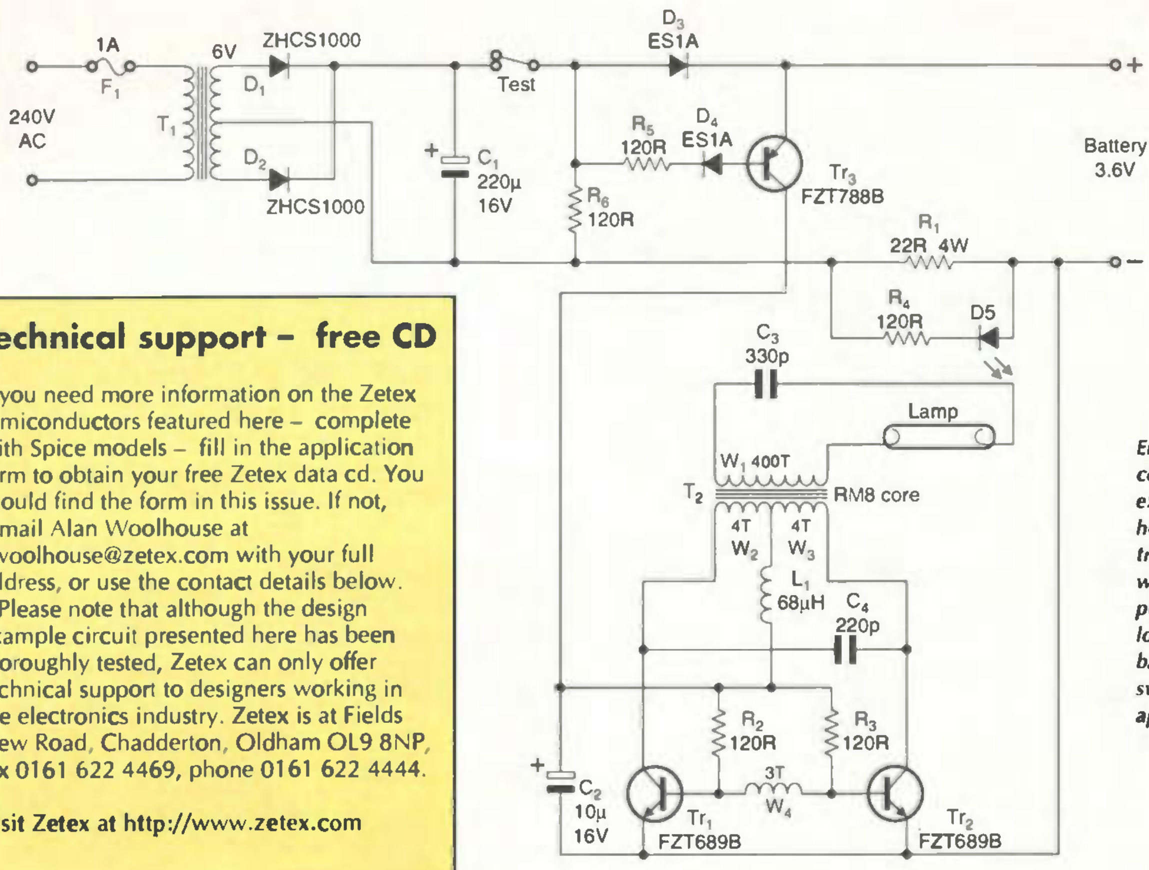
Of course bipolar devices restrict switching frequency to about 400kHz – compared with a megahertz and beyond for mosfets.

Bipolar devices also need a constant base current to keep them turned on. But don't forget that mosfets require the gate-source capacitance to be charged to turn them on. Drive circuits can often be more complex compared to those needed for bi-polar transistors.

Also, bi-polar devices exhibit secondary breakdown, which a mosfet does not. So, in general choosing a device technology for a particular design can be quite complex and needs careful consideration.

The properties we seek in a device for battery application are generally:

- Low $V_{ce(sat)}$, which translates to low conduction loss.
- High h_{fe} gain, which translates to low drive requirements.



Emergency lighting controller. This design example illustrates how well the two transistors given free with this issue perform in low-voltage battery-powered switching applications.

high gain and high continuous current rating of the *FZT788B* only one device need be used.

The low saturation voltage, i.e. on voltage, of the *FZT788B* enhances the efficiency of the circuit, thus the transistor draws very little power.

This device is turned on when the mains voltage is removed. To keep the threshold clear, a diode is incorporated in the base of the *FZT788* to ensure clean switching. In the circuit illustrated, a normally-closed switch has been included to simulate a mains failure. This switch is added for demonstration and test purposes only.

DC-to-AC conversion

Circuitry used to convert the battery voltage to ac to drive the lamp is usually based on a Royer converter. This is a classic inverter topology proposed in the middle fifties. It has been widely used ever since.

The high voltage needed to strike the tube is generated using the push-pull switching of the inverter. The inverter runs in synchronised mode, enabled to do so by the inclusion of a supply inductor.

Output voltage from the inverters is set to approximately 560V peak to provide the capability to strike the

- Good operating frequency
- Good switching speeds and low storage times.

Other properties like small physical size can be important too. We find that in practice, devices with the above properties will also allow the product to be physically small.

An often overlooked feature of bipolar switching devices for switching applications is gain hold up. As collector current rises, gain falls. If you study the curves, you will find that with a collector current of an amp, many TO220 devices have very little gain. This means that the base current required to maintain saturation is increased, becoming a significant proportion of the emitter current. That wastes energy. The *ZTX689*'s matrix chip design provides one of the best gain hold up characteristics available for devices in its power class.

Emergency lighting is a good example of where low saturation devices provide significant benefits. Such lighting is now mandatory in public buildings, offices and factories, where battery powered lighting is automatically switched on in the event of a mains power outage.

A good design will allow such emergency lamps to remain functional far in excess of the national statutory requirements – typically in excess of four hours from 2/3 'D' size rechargeable NiCd cells.

Zetex's *ZTX689B* is a device which fits the above requirements nicely. It has a very low saturation voltage, as can be seen from the graph. It also has good gain characteristics and as the switching frequency is low, in the kilohertz region, the switching properties are more than adequate.

The device is available in E-line form, i.e. in a TO-92-style package, which is small by comparison with the TO-127 or TO-220 packaged transistors normally used in emergency lighting.

No heat sink is required in the circuit presented here.

tube when the supply voltage is low. This enables the circuit to continue running even when the supply voltage has dropped to as low as 2.4V.

Frequency has been set to 50kHz via capacitor C_3. To alter the frequency, this capacitor can be changed. The effect on frequency is proportional to the inverse square of the capacitance. Decreasing the capacitor by a factor of four increases the frequency by a factor of two.

The voltage across each switching transistor when driven off by the feedback winding, is a half sinusoid with a peak value of πV_s. As the supply voltage is small, low saturation voltage is essential if good efficiency is to be achieved.

Design benefits

The design operates from just three series connected NiCd D-cells, supplying 3.6V.

Classic designs for emergency lights employ TO220 type transistors to drive the converter. The use of the Zetex SOT223 surface-mount packages reduces component cost and board size.

The *FZT689B* and *FZT788B* have the lowest saturation voltage in their class. This translates directly to improved efficiency and thus extended battery life. In addition, the low saturation voltage means there is very little power lost in the transistors, so less heat is produced. Reduced heating also has a significant effect on reliability.

Eliminating the TO220 package, with its relatively high epoxy mass and metal tab, reduces potential susceptibility to vibration. The circuit has been designed to withstand reverse battery connection and indefinite operation without a fluorescent tube in place – important in unattended applications.

Add ons

If required additional circuitry can be added to perform virtually any task the designer requires. Included in this example are an audible alarm and a high-power strobe circuit. These are in addition to the main circuit and can be added in a modular form.

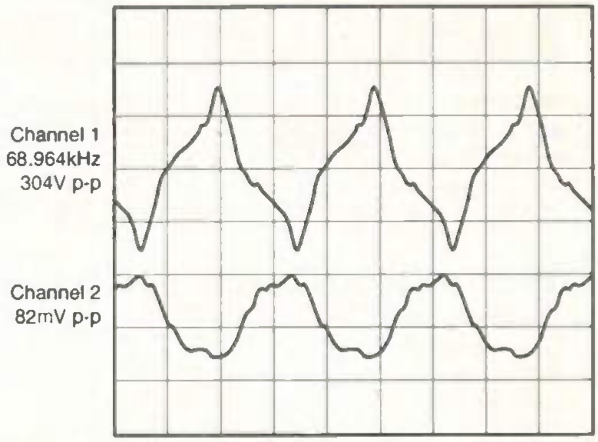
The audible circuit provides the user with a clear audible signal in the event of lamp failure or heavy smoke due to fire. The strobe provides a more powerful visual warning.

Also included in this circuit is a battery monitor led and a normally-closed momentary switch, to disconnect the mains for test purposes.

The voltage across the tube is 304V peak to peak. This is more than sufficient to maintain a strike voltage across the tube. The important trace is that of the current. It is this current that determines how long the emergency light will stay on for.

Using three D-type cells with a life of 4Ah it is possible to determine how long the battery will last. From the trace in the diagram, you can see that peak-to-peak current is 82mA. Current consumption for the circuit is 1A, measured while the circuit is powered from the battery. Thus life expectancy for the battery is 4/1=4 hours –well within specification.

This longevity figure can be lengthened or shortened by adjusting the value of C_3. Increasing C_3 increases the brightness of the tube but increases current consumption. Consequently the battery will not last as long. A balance has to be struck between brightness of tube and life expectancy of the battery. ■



Voltage and current plots for a fluorescent tube. The upper trace shows the voltage across a struck tube while the lower trace shows current flowing through the tube.

SEE OVER FOR OFFER

Emergency lighting parts list

Ref	Description	Qty	Cost (£)	Farnell / RS
T_1	Mains transformer (PTH)	1	4.15	RS 201-8362
T_2	DC-DC transformer (PTH) (RM8)	1		See info.
D_1	ZHCS1000 diode (SOT23)	1		
D_2	ZHCS1000 diode (SOT23)	1		
D_3	ES1A diode	1	0.255	RS 269-984
D_4	ES1A diode	1	0.255	RS 269-984
D_5	Super-bright LED	1	0.28	RS 247-0962
C_1	220µF 16V	1		
C_2	10µF 16V	1	0.26	RS 262-4349
C_3	330pF 1kV (1812)	1	0.13	
C_4	220pF	1	0.298	RS 174-921
R_1	22R 4W (PTH)	1	0.268	RS 206-0442
R_2	120R 1/8W (1206)	1	0.026	RS 223-2136
R_3	120R 1/8W (1206)	1	0.026	RS 223-2136
R_4	120R 1/8W (1206)	1	0.026	RS 223-2136
R_5	120R 1/8W (1206)	1	0.026	RS 223-2136
R_6	120R 1/8W (1206)	1	0.026	RS 223-2136
L_1	68µH	1	0.267	RS 235-149
S_1	Test microswitch (PTH)	1	3.65	RS 228-3752
	Lens for S_1	1	0.95	RS 228-3796
Tr_1	FZT689B (SOT223)	1		
Tr_2	FZT689B (SOT223)	1		
Tr_3	FZT788B (SOT223)	1		
F_1	Fuse holder (mains) (PTH)	1	0.488	RS 417-098
F_1	Fuse (1A)	1	0.176	RS 265-1149
	Battery 3xD-type NiCd	1	16.75	RS 595-025
CFL	Tube 8W 300mm	1	1.30	RS 561-606
	Screw terminal 5A (PTH)	1	0.452	RS 425-099

Connectors

Mains, fluorescent tube holder, battery, switch.

Free with this month's issue

On the cover of this month's issue are two Zetex ZTX689B n-p-n high gain medium-power transistors (UK issues only). Their f_T is at least 150MHz and they exhibit typical turn-on and turn-off times of 30 and 800ns respectively at half an amp collector current. Here's their details:

Features
- 20 volt V_{CEO}
- Gain of 400 at 2A collector current
- Very low saturation voltage

Applications
- Darlington replacement
- Flash-gun converters
- Battery-powered circuits
- Motor drivers

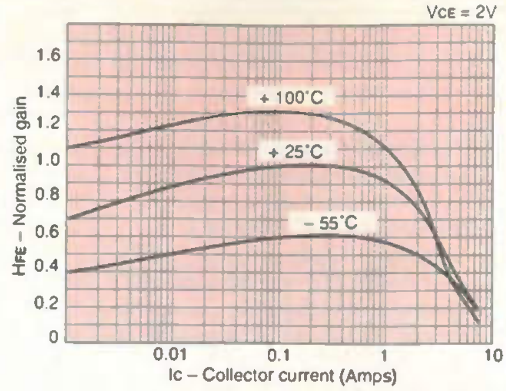
Electrical characteristics at 25°C ambient

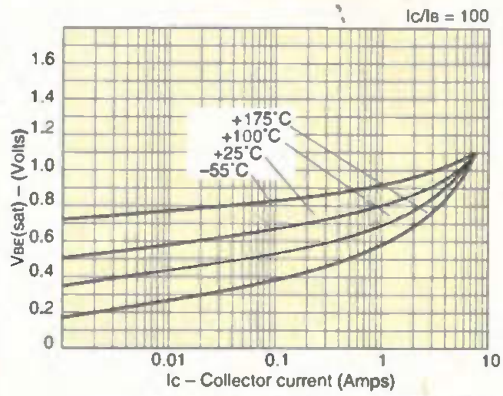
Parameter	Symbol	Min.	Max.	Conditions
Collector-base breakdown voltage	$V_{(BR)CBO}$	20V		I_C=100mA
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	20V		I_C=10mA*
Emitter-base breakdown voltage	$V_{(BR)EBO}$	5V		I_E=100mA
Collector cut-off current	I_{CBO}		0.1μA	V_{CB}=16V
Emitter cut-off current	I_{EBO}		0.1μA	V_{EB}=4V
Collector-emitter saturation voltage	$V_{CE(sat)}$		0.1V	I_C=0.1A, I_B=0.5mA*
			0.5V	I_C=2A, I_B=10mA*
Base-emitter saturation voltage	$V_{BE(sat)}$		0.9V	I_C=1A, I_B=10mA*
Base-emitter turn-on voltage	$V_{BE(on)}$		0.9V	I_C=1A, V_{CE}=2V*
Static forward current transfer ratio	h_{FE}	500		I_C=0.1A, V_{CE}=2V*
		400		I_C=2A, V_{CE}=2V*
		150		I_C=6A, V_{CE}=2V*

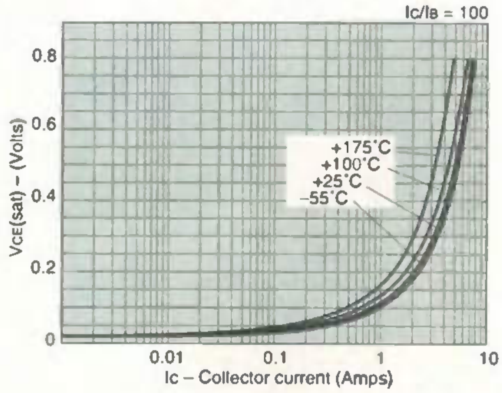
Absolute maximum ratings

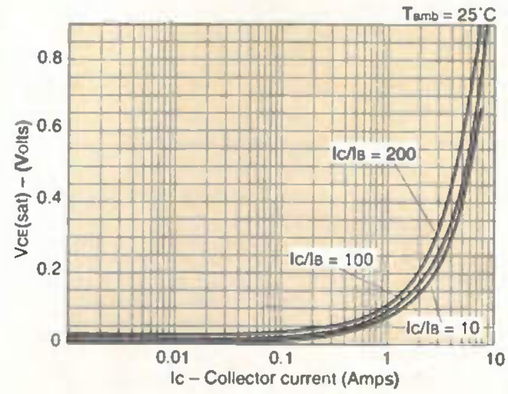
Parameter	Symbol	Value
Collector-base voltage	V_{CBO}	20V
Collector-emitter voltage	V_{CEO}	20V
Emitter-base voltage	V_{EBO}	5V
Peak pulse current	I_{CM}	8A
Continuous collector current	I_C	3A
Practical power dissipation*	P_{totp}	1.5W
Dissipation at T_{amb} of 25°C	P_{tot}	1W
derate above 25°C		5.7mW/°C
Operating/storage temperature		-55 to 200°C

*This is power that can be dissipated assuming the device is mounted in a typical manner on a pcb with copper of at least a square inch.





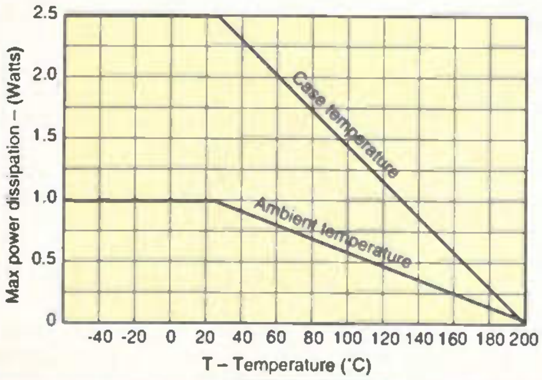


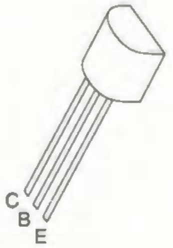


ZTX6898 performance curves.

E-line package performance

The E-line package housing the ZTX689B is pin compatible with the industry standard TO92 package. While its outline is actually smaller than TO92 it is still able to dissipate 25% more power at an ambient temperature of 25°C and 42% more at 100°C.





Pin-out of the TO92-compatible ZTX689B medium-power transistor.

This table shows that at low temperature, the TO220 package performs much better than the much smaller TO92-style e-line casing, as you would expect. But by 125°C, the two are almost neck and neck in terms of their dissipation capability.

Ambient	Dissipation in milliwatts			
	TO92	TO126	E-line	TO220
25°C	800	1500	1000	2000
50°C	640	1200	870	1600
100°C	320	600	570	800
125°C	160	300	429	400
150°C	0	0	285	0
200°C	0	0	0	0

All fired up

FireWire – a bus for all systems?

FireWire serial comms networking bus is not new. But Geoff Lewis believes its versatility, speed – and its acceptance as an IEEE standard – could very soon see it making massive inroads in a broad spectrum of applications.

The term *FireWire* is the intellectual property of Apple Computers Inc. The company originally established the concept as a basis for a very fast, low cost and easy to use network system as long ago as 1988. Since then the network has become an established IEEE standard supported by a world wide trade organisation of more than 90 manufacturers and constructors.

IEEE 1394-1995 – as *FireWire* is now technically recognised – is a cross between a network and a bus extension system. It allows any device equipped with a suitable interface to be simply coupled to form a communicating network.

Originally, the system was intended for distributing digital audio through Apple computers, but over the years, it has expanded into many other areas. In the very near future *FireWire* could be found to be the main mover of any digital signals in both the telecommunications and domestic entertainment industries.

Such flexibility would ensure the convergence between the home pc, the television receiver and telephony systems. Furthermore, the concept of hot-plugging has increased the urgency for a standardised means of interconnections.

A very readable history of the development of this bus is included in the references.[1]

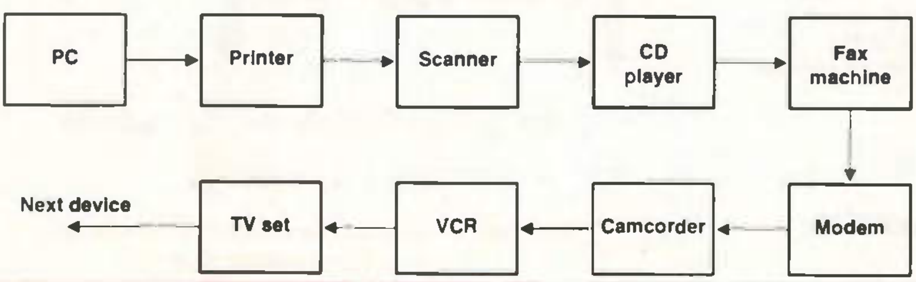
Firewire interconnections

Figure 1 gives an indication of the wide range of devices that can be linked together via *FireWire*. Any device that is fitted with the necessary interface can be coupled together through one of a number of ports via a simple cable without any consideration for the logical location on the network.

The new services currently available include home video editing, photo-cd handling, image enhancement and at a later date, video and teleconferencing might well be added. Such is the adaptability of this networking system that it is also likely to find many professional and industrial applications.

FireWire devices may be fitted with one or three-port interfaces which can be coupled together through a special

Fig. 1. Example of devices that can be linked via an IEEE 1394 FireWire *bus.*



cable unit. Any new device can be added to the network by simply plugging into a spare port anywhere on the network.

The devices may be coupled in a mixture of clusters or stars or the daisy chain format. The only restrictions are that there should be no more than 16 hops between any two nodes and without any loops being formed.

The network is usually described in terms of a root, tree and branch or parent and child configuration with the root or parent being the nearest to the controlling device. The serial transmission network is currently available for bit rates of 100, 200 and 400Mbit/s, but this will be extended very considerably when optical fibre is introduced into the system. FireWire could then run at speeds up to 3.2Gbit/s, which is considerably faster than *FibreNet* which runs at a mere 1Gbit/s.

Cabling and transmission

Construction of the special screened cabling is shown in **Fig. 2**. This consists of three individually shielded cable pairs. Two of them are screened and twisted signal pairs and the other pair is two power lines, one designated as ground, i.e. V_g, and the other positive, V_p. Keyed connectors also incorporated.

The power line pair is capable of carrying up to 1.5A at 8 to 40V dc. For special applications, a cable without the power pair can be used where the device so coupled has its own power supply.

By using repeaters, it is possible to extend the interconnections to a maximum of about 70m. The un-repeatered length is about 10m maximum, but 4.5m lengths are more common.

Perhaps the most important feature of this network is its simplicity – at least as far as the user is concerned. Any new device may be plugged into a spare port without switching the power off. The system then automatically reconfigures and reprogrammes itself for the new situation.

This plug and play ability arises because the signal lines are balanced to earth through the use of the particular signal format. In addition, the driver transceivers in the interface provide a further isolation between the signal and power lines.

The high data rates are achieved by using differential non return to zero, or nrz, signalling on each shielded twisted pair at a level of about 220mV, superimposed on a common mode voltage of about 1.9V. At these high data rates it is important that the system maintains an accurate clock signal and this is achieved as follows.

The data signal is carried on twisted pair TP_A with a strobe signal on TP_B. It is arranged so that the strobe signal changes state on every bit period that the data signal does not. In this way, either the data or the strobe signals change state at every bit period.

Creating a strobe

As shown in **Figure 3**, at the transmitter the signal data stream and the clock signal are combined using exclusive-or logic to create the strobe signal. At the receiver, the strobe and data signals are then recombined exclusive-or to regen-

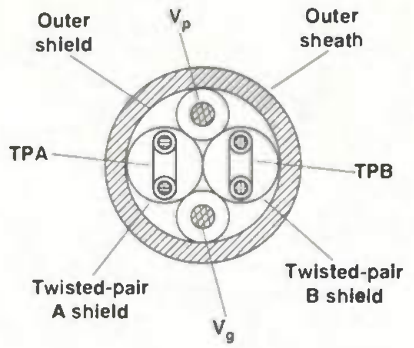


Fig. 2. Section through the IEEE 1394 interface cable showing that both power and signal lines are carried.

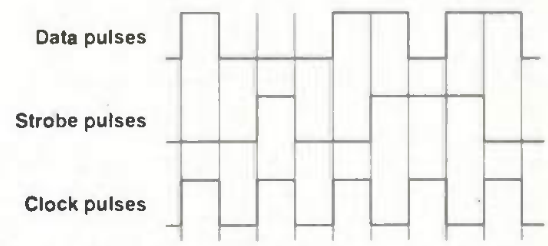


Fig. 3. FireWire signal format. At the transmitter, the clock and data are combined using exclusive-or logic, resulting in the nrz strobe signal.

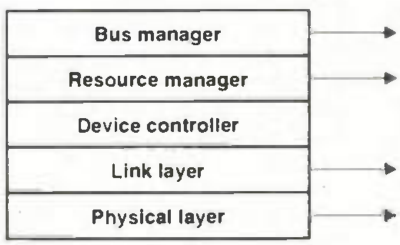
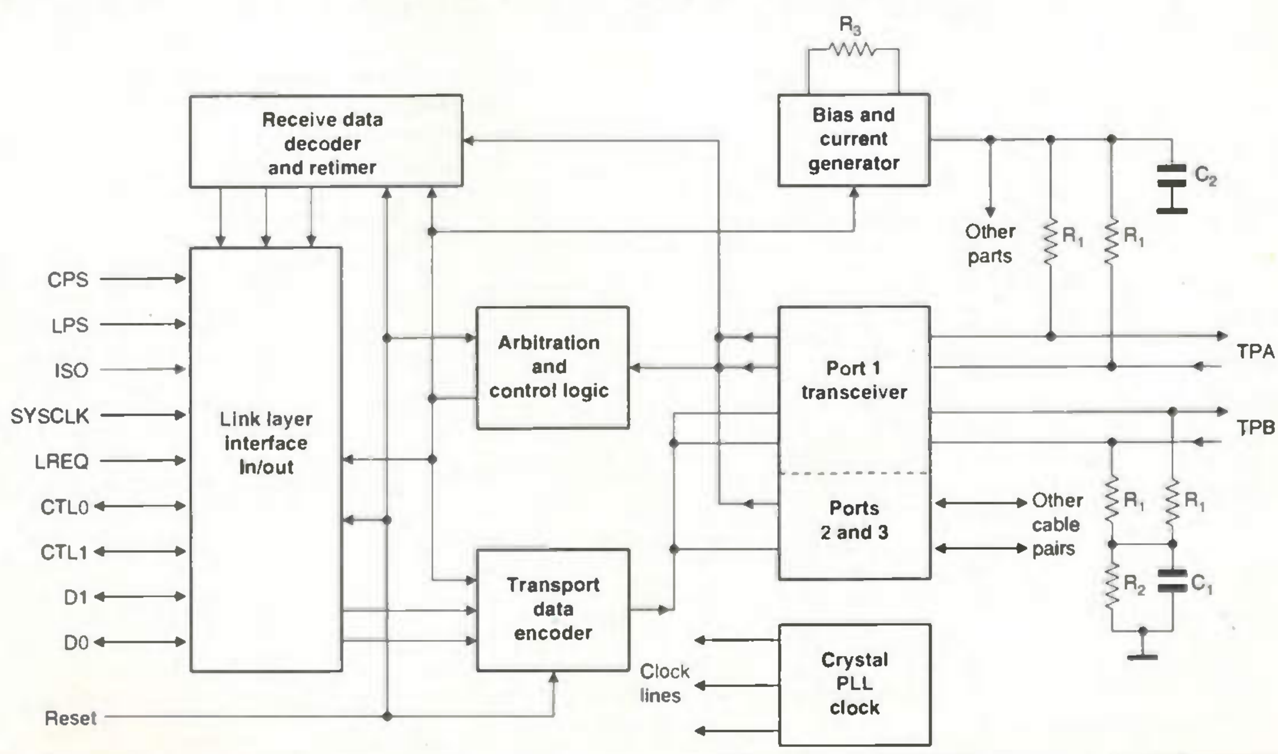


Fig.4. FireWire bus-control arrangement.

Below, Fig. 5. Physical layer control chip arrangement (Texas Instruments). Resistor R_1 *is* 56Ω, R_2 5kΩ, R_3 *6.36kΩ ±0.5%,* C_1 *250pF and* C_2 *1μF.*



erate an accurate clock signal.

The bus data streams are organised into two time division multiplex, or tdm, formats. These are a one way, low bit-rate asynchronous stream used for control purposes and a high bit-rate isochronous payload data for service distribution.

An asynchronous stream is one in which the data is transmitted in blocks together with start and stop signals. By comparison, the data for an isochronous network is synchronised to the same master clock for the whole system. In this case, the clock comes from the controlling node currently acting as the 'cycle master'. Since the data rate is constant, any local clock can be regenerated from the data stream.

Both asynchronous and isochronous signals employ a variable length packet format, but perhaps the most important advantage of the latter lies in the fact that this methods needs less first-in-first-out memory before and after transmission across the *FireWire* bus. This significantly reduces the die size of the interface IC and hence ultimately the semiconductor chip costs.

This memory would need to be larger for non-isochronous data transfers because of the inherent wide range of data rates and variable transport delays involved.

Communication protocols

The communicating protocols may be explained by the relationship to the ISO-7 layer model developed by the International Standards Organisation for open systems interconnect.

The general arrangement for *FireWire* control, Fig. 4, shows how the two lower levels of the ISO-7 model are retained. Layer 1 is the physical layer and layer 2 the link layer. System control functions concentrated into Layers 3 through to 7.

The physical layer, labelled PHY, has four main functions:

- to translate the symbols used by the Link layer control, or llc, into the appropriate cable signals and *vice versa*,
- to define the mechanical and electrical connections for the bus,
- to provide arbitration to ensure that only one node or device can transmit data at a given time,
- to ensure that all devices have an equitable access to the bus.

The link-layer control manages the data packet assembly and disassembly for both the asynchronous control data and the isochronous payload data. The former one way packets which are transmitted to the transaction layer contain delimiting signals and their reception must be acknowledged. The isochronous data stream is transferred direct to the applications receiver.

In addition, the link-layer control chip handles addressing, error control, data framing and generates the packet cycle timing and synchronising signals.

The resources manager layer acts as the transaction layer as regards to control of the asynchronous data stream. A write operation sends data from the source to the receiver, while a read operation functions in the reverse direction.

A lock operation is also possible in which data is sent on a round trip through the processing at both ends of the chain and can be used as a test and control function.

The bus management layer is quite complex and operates in both the hardware and software of the individual node interface. It controls the operation of the physical, link and transaction layers. If there is a pc on the network this will most likely act as the bus manager which runs its own special applications program, but other arrangements are possible.

A fully managed system includes either a pc or other similar smart device. This option supports all modes of data transfers for up to 64 channels and is capable of power management and bus optimisation. The pc can also create data rate maps and network topology diagrams.

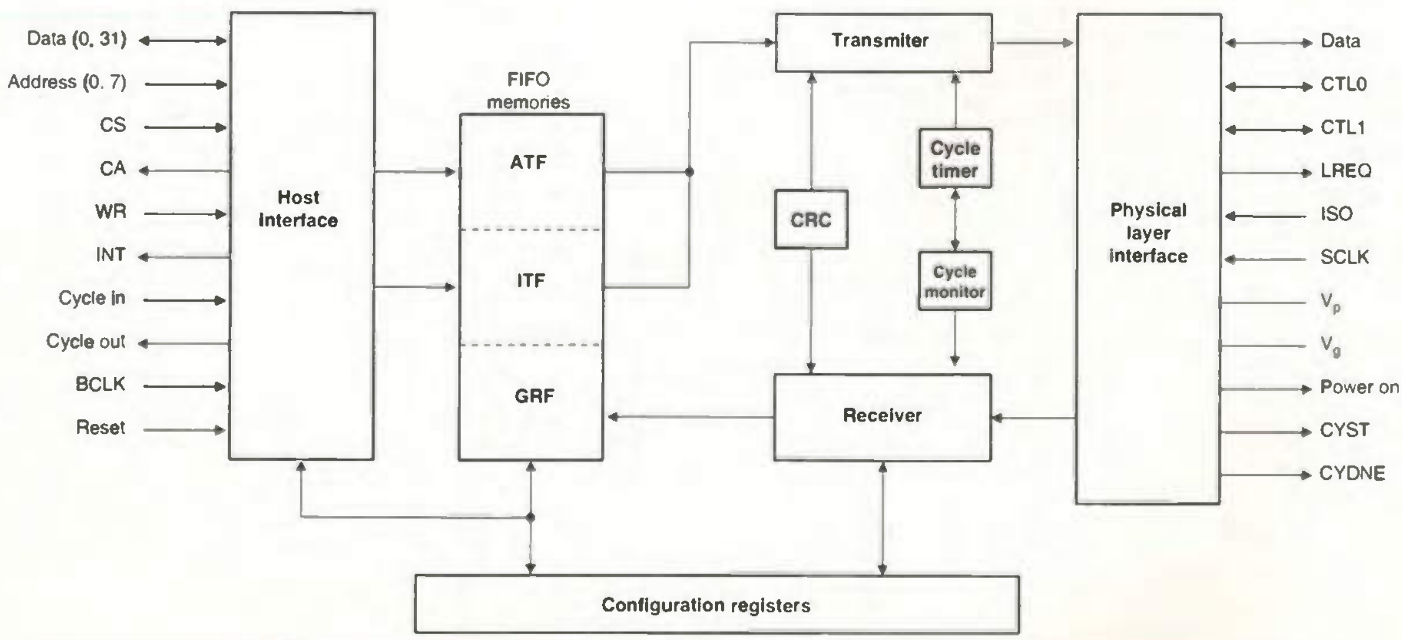
A non-managed bus also has a cycle master but is then only capable of asynchronous data transfers for control functions. Such an application might be the direct data transfer between say a camera and the hard disk or between the hard disk and the printer, without the direct intervention of a computer.

A limited bus management system falls someway between these two extremes. It has a limited power management ability, but can handle both asynchronous and isochronous data transfers for between 8 and 64 channels.

A network includes up to 63 nodes or devices each with a six-bit identification number. Multiple networks may be interconnected via bridges with up to 1023 separate buses, each with a 10-bit ID. This combination allows for up to 63 by 1023, or 64 449 nodes on the total system. The figure 64 449 equates to 16 bits.

Device addresses are 64 bits wide;

Fig. 6. Link-layer control-chip arrangement (Texas Instruments).



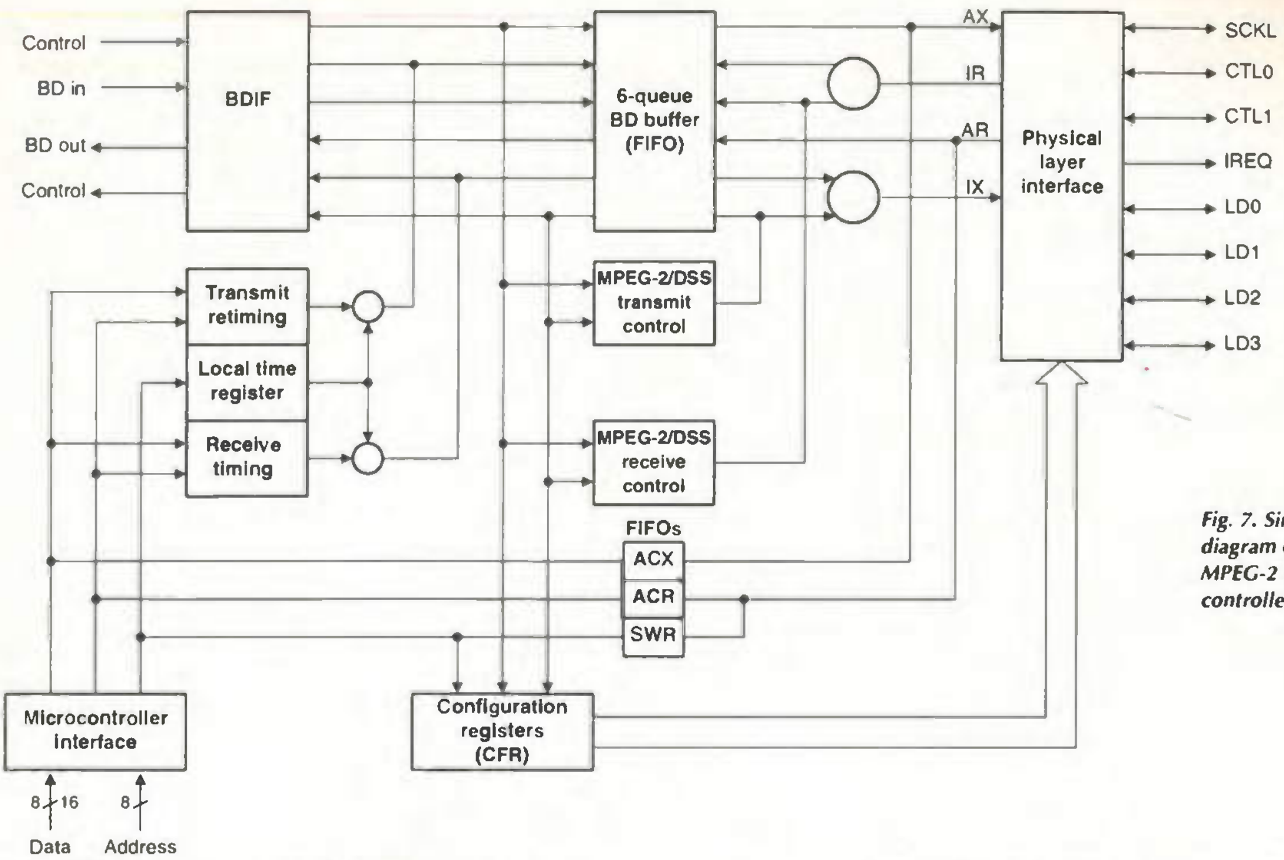


Fig. 7. Simplified block diagram of Texas's MPEG-2 Lynx FireWire controller chip.

16 specify the nodes and networks and the remaining 48 bits are for memory addressing. Thus the network can uniquely identify 2^{48}=2.8×10^{14} bytes or 280Tbyte of memory in total.

Initialising and configuring

Initialisation occurs at power up or whenever a node is added or removed – a process that generate a reset signal. At the end of this operation, the root device will have been chosen and this selected node retains the control function as long as it is connected to the bus.

At the start of this operation, all the information about the network topology that is held in the node registers is cleared. The physical layer of each node first checks the connection status of its ports.

Each port signals a 1 if it is connected, otherwise the device is considered to be disconnected. If there is more than one port set to 1, the device can be a branch. As this process continues, a tree structure begins to form so that a root node can be selected and all the remaining physical connections referred to it.

Generally the last device selected in this process is designated as the root. However, if it is required that one particular pc should be designated as the root, then the process time can be forcibly extended to ensure that this end result is achieved.

After the tree has been formed, each node is allocated an ID for asynchronous traffic.

During the initialisation process, the various management roles will have been allocated. Most importantly the cycle master, which is usually the root and with the highest priority for bus access, will have been selected.

The cycle master provides and maintains the clock signal for the isochronous data transfers. In certain cases, some of the management roles may be allocated to a device other than the root. The isochronous resource manager allocates time slots to those devices with isochronous data to transmit.

Whenever hot plugging generates a reset signal, the isochronous resource and bus manager functions remain with the original devices – assuming of course, that this node was not disconnected. The next stage of initialisation involves allocating the channels 0 to 63 and giving time slots to those devices that need to communicate. Only channels that are free can be allocated. This information is held in the channel called 'available registers'.

Following a reset action, the reallocation of time slots may leave one node short of its previous allotted capacity. Such a node then periodically makes requests for an increased allocation until this is granted through others nodes giving up their time slots.

When configuration is completed, the nodes arbitrate for access to the bus. In addition, asynchronous and isochronous data also compete for access. All this is controlled via the cycle master which transmits a timing signal known as the cycle start, typically once every 125μs.

This very complex protocol that appears so simple to the user is largely controlled through a collection of single bits stored in a number of registers.

System timing and arbitration

The system timing is based on a phase locked loop crystal oscillator in each node interface running at either 24.576MHz or 98.304MHz. The clock in the interface of node chosen as the cycle master is the one that is actually in use.

The 24.576MHz frequency is divided down to create 1Hz and 8kHz timing control signals and it is from these that time-division multiplexing is controlled. Cycle status and control bits are contained within bits 20 to 24 of the third, fourth and fifth quadlets.

The basic cycle duration lasts for 125μs and repeats at the rate of 8000 per second. Of the total cycle period at least 20% is allocated to asynchronous control data, with the remaining maximum of 80% for the isochronous payload data.

Nodes arbitrate for bus access on every cycle, but only one is allowed to transmit at a time. The nodes with reserved isochronous channels arbitrate first.

When the node receives a cycle start signal it sends a request for access to the root. The root accepts the first request that it receives and this is always from the arbitrating node nearest to it. This is followed by a small isochronous gap period after which the arbitration begins again and the next nearest node is granted access. This process continues until all the isochronous nodes that have data to transmit have been granted access.

A longer gap period called the 'sub-action gap' then follows so that asynchronous arbitration can start. Both gaps are proportional to twice the number of connecting hops in the network.

Sub-action gaps are needed to allow time for the transmission of the acknowledge signals. In order to allow a fair access, each node is allowed to transmit only once during the asynchronous part of each cycle. The cycle time is ended with a longer idle period gap called the arbitration reset gap. Following this, the process restarts.

Data packet structures

All the serial data is first organised into quadlets each four bytes long; 32 bits in total. Each packet must contain at least two bytes as a header and two bytes of data.

The quadlets are time aligned for accuracy so that they may be loaded into the first-in-first-out registers which are 32 bits wide and 64 quadlets deep. To make the quadlets consist of integer multiples of bytes, meaningless bits may be stuffed into the registers as padding.

Cyclic redundancy checks, or crcs, are included at the end of both header and payload data blocks. These basic elements are common to both asynchronous and isochronous packets but the headers for the two differ in length and content.

Asynchronous packets must include at least four quadlets to specify destination ID, source ID and various control functions such as packet priority. By comparison, isochronous packet headers include the channel number, plus control information and these may be as short as two quadlets because the destination and source addresses are inherent in the channel number.

The isochronous packet structure is summarised in Table 1.

How a typical interface works

The interface consists of little more than two vlsi, ASIC chips that act as the physical layer, abbreviated to PHY, and link-layer controller, LLC.

The limited glue logic components in the early chip sets is fast disappearing into the ASICs. Typical of these are the Texas Instruments *TSB11CO1* (PHY) and *TSB12CO1* (LLC). These are provided in low-power cmos technology, but with inputs designed to allow hot plugging.

The physical layer chip is a three-port device that includes the logic to perform the arbitration and bus initialisation functions. The link-layer controller transmits and receives correctly formatted isochronous data in real time. It carries reconfigurable first-in-first-out memories for data as well the necessary configuration registers needed to operate the device. The essential part of the architecture of the physical-layer chip is shown in Fig. 5.

The crystal-controlled phase-locked loop clock provides three important frequencies via digital dividers. These are 98.304MHz, 49.152MHz and 24.576MHz. The 49.152MHz signal is maintained to an accuracy of ±100 ppm, which equates to ±4.9152kHz, to control the outbound encoded strobe and data signals. This frequency is also needed at the link-layer controller to resynchronise the received data.

Figure 5 shows the basic functions of the physical layer with three identical ports. Data bits to be transmitted are received from the link-layer controller over the two-pair cables TP_A and TP_B in synchronism with the 49.152MHz clock. These bits are encoded and transmitted as outbound encoded data on TP_A with the encoded strobe on TP_B, at 98.304Mbit/s.

During packet reception the transmitters of the transceivers for TP_A and TP_B are disabled while the receiver ports are enabled. This is achieved by the use of a simple bistable control bit.

Differential encoding

Both the data and the strobe signals are differentially encoded. They swing the signal equally about the 1.86 volts nominal bias level. Typically these signals are restricted to a swing range between 172mV and 265mV, which is about 220mV ±40mV. These levels were chosen to allow interoperability between chip sets using either 3 or 5V cmos technology.

Resistors R_1 are designed to achieve an optimum loading on the line drivers of 112Ω. Network R_2C_1 acts as a filter to ground the centre point of the TP_B lines. Resistor R_3 sets the driver stage output currents and controls the bias level. Ports 2 and 3 act in an identical manner.

The link interface of this chip directs the data between the receive and transmit modes under the influence of a range of control signals, of which the most important are shown below.

Cable power status, CPS. This pin connects to the cable power through the 400kΩ resistor which feeds the circuit. It detects the presence of the cable power supply and also feeds this information to the link-level protocol chip.

Link power status, LPS. When the link is not powered the SYSCLK is disabled and the chip performs only the basic repeater functions needed for network initialisation and operation.

System clock, SYSCLK. This terminal provides the 49.152 MHz clock signal to which the data, control and link requests are synchronised.

Link request, LREQ. This signal from link-layer controller is used to make a request for some particular service.

Control input/outputs, CTL0/CTL1. These bidirectional terminals communicate between physical and link-layer controllers to control the exchange of information.

Data input/outputs, D_0/D_1. These bidirectional terminals provide the communicating paths between physical and link-layer controllers.

Logic reset input, RESET. When this line is forced low, this causes a bus reset operation on the active cable ports and resets the internal logic to the start state.

The link layer control

The Texas Instruments *TBS12CO1* is a

Table 1. Summary of isochronous packet structure. These packets are short since the destination and source addresses are inherent in the channel number.

Field name	Bit size	Comments
Data length	16	Indicates number of bytes in current packet
TAG	2	Data format (see footnote)
Channel number	6	Indicates which channel is associated with data
Transaction code	4	Code for current isochronous packet
Synchronism code	4	Carries the transaction layer specific sync. code
Header CRC	32	All isochronous packets
Data block payload	–	All data block packets
Data block CRC	32	All data block packets

Footnote. The TAG field is used to define the data format. For example, 00 represents data formatted for normal 1394 operation and 01 is used to indicate that HyperLynx for MPEG-2 data is in use. The other two codes are currently not allocated.

high speed link-layer controller allowing easy integration into an i/o sub-system. It transmits and receives correctly formatted IEEE-1394 packets and generates and evaluates the 32-bit cyclic-redundancy check used to verify header and payload data blocks. It is capable of operating as a cycle master and supports reception on two isochronous channels.

The basic architecture of this chip is shown in **Fig. 6**. The chip integrates directly with either physical layer chips such as the *TSB11C01* mentioned earlier, or the *TSB21LV03* which is used for processing an MPEG-2 data stream.[2] This link-layer controller supports 100, 200 and 400Mbit/s rates and its 32-bit bus is compatible with most other available 32-bit proprietory buses.

The first-in-first-out memories are software adjustable for performance optimisation. The device allows for the variable-length asynchronous transfer first-in-first-out, or ATF, the isochronous transfer first-in-first-out, or ITF, and the general receive first-in-first-out, known as GRF. The physical interface i/o signals have been described above.

The transmitter retrieves data from either the ATF or the ITF and generates correctly formatted serial packets for transmission through the physical-layer interface. When data is present at the ATF interface, the transmitter arbitrates for bus access and then sends this data packet.

Similarly when data is present at the ITF interface the arbitration results in data being transmitted on the next isochronous cycle. When this chip is acting as cycle master, the transmitter automatically sends the cycle start packet.

The receiver accepts the data from the PHY interface and checks the address. If the data is addressed to this node and if the cyclic-redundancy check is correct, the header is confirmed in the GRF.

For block and isochronous packets the rest of each is checked on a quadlet by quadlet basis through to the end of the packet and then confirmed in the GRF. The error code for the packet is thus contained in a status quadlet which is sent as acknowledgement for that particular packet.

For isochronous packets that need no acknowledgement, the error code signals the transaction layer if the data cyclic redundancy check is correct or not. If the header is in error, the memory is flushed and the remainder of the packet ignored.

When a cycle start message is received it is detected and sent to the cycle timer but not placed in the GRF. At the end of an isochronous cycle, if the cycle mark enable bit described as CyMrkEn in the control register is set, the receiver inserts a cycle mark packet in the GRF to indicate the end of the cycle.

Live insertion or Plug & Play?

With many of today's computer or microcomputer controlled environments, it is unsafe to power down the system to modify its configuration without a complete loss of service. Unless specific design steps are taken however, removing or inserting any module with power on could be destructive.

In general, most ICs are protected at the inputs and outputs either by specially included shunt diodes or the parasitic diodes inherent in the fabrication process.

When a circuit board is plugged into a slot, the contacts are made in a random fashion due to the mechanical tolerances and position of the operator. Furthermore, inserting or extracting under power is likely to induce arcing and electrostatic discharges. If either the ground or V_{cc} lines make contact simultaneously with a signal line, then the protective diodes can create a destructive current along the signal path.

To avoid this, the connectors are modified so that both V_{cc} and ground lines make before, or break after, any signal bus lines.

In some large systems, each module can be equipped with a switch. This is operated in conjunction with a circuit board clamp to ensure that the module has its power lines disconnected from the system. In addition, the circuit may be modified to ensure that the bus lines are precharged to about half the logic voltages in order to minimise such disturbances.

For *FireWire* applications, the signal lines are fairly well protected by virtue of the bus driver transceivers at the inputs of each interface. In general, it is only necessary to include a series forward biased diode and resettable polymeric fuse in the positive power line to each interface to provide over-voltage and short-circuit protection.

Software-adjustable registers

The transmit and receive first-in-first-out registers, both asynchronous and isochronous, are software adjustable to cater for individual applications. The maximum memory capacity is 509 quadlets and this can be shared between the ATF, ITF and GRF sections.

The cycle timer is used by all nodes that support isochronous data transfers and consists of a 32-bit register. The lower 12 bits form a modulo-3072 counter that increments once every 24.576MHz clock periods, or 40.69ns.

The next 13 higher-order bits are used to count up to 8000Hz cycles, i.e. 125μs. The higher seven bits then form a seconds count. A cycle source bit, CySrc, in the configuration register can be set to indicate which node is acting as the cycle master.

The CYCLEIN input causes the cycle count to start to increment and the CYCLEOUT signal indicates that it is time to send the cycle start packet. Only those nodes that support isochronous data transfers use the cycle monitor, which monitors the chip activity and schedules the operations.

The host interface consists of a 32-bit parallel data bus together with an eight-bit address bus. The BCLK signal represents the bus clock which is asynchronous to the system clock, SCLK. The CA and CS inputs denote the cycle acknowledge and cycle start signals respectively.

The WR input is a read/write signal used in conjunction with cycle-start. When both of these are driven high, a read from the chip is indicated. Low inputs produce a write operation.

For speed of operation, this chip is interrupt driven. When the INT line is driven low it indicates that some particular service function needs to be performed.

Perhaps the most significant feature of *FireWire* is its ability to move packetised data around a system at very high speed. In the MPEG digital television system the compressed data format is also uniquely packetised. It has been successfully demonstrated that a compressed bit rate of 50Mbit/s can handle MPEG video signals within the studio and production environment at ten bits per sample resolution. A rate of 6Mbit/s can provide very adequate definition for the broadcast receivers.

Furthermore, an MPEG2 data rate of about 2Mbit/s will create VHS recorder quality images. Even the new North American high-definition tv format proposed by the Advanced Television System Committee, ASTC, can be coded into 120Mbit/s. It has been proposed that the 155Mbit/s telecommunications standard,asynchronous-transfer mode, or ATM, will be used for distribution purposes.

The final distribution bit rate allows high-definition signals to fit within the current 6MHz NTSC bandwidth. Again, these are data rates well within the capabilities of *FireWire*.

Consumer market developments

For the consumer side of the television industry, there is a developing need to allow amateur users to perform video/audio editing from vcrs. With such developments, it is little wonder that the IEEE 1394 bus system has been extended to handle MPEG2 compressed video/audio signals.

Texas Instruments has produced a highly integrated link-layer controller – the *TSB12LV41* or *MPEG2Lynx*. It comes in a 100-pin plastic quad flat

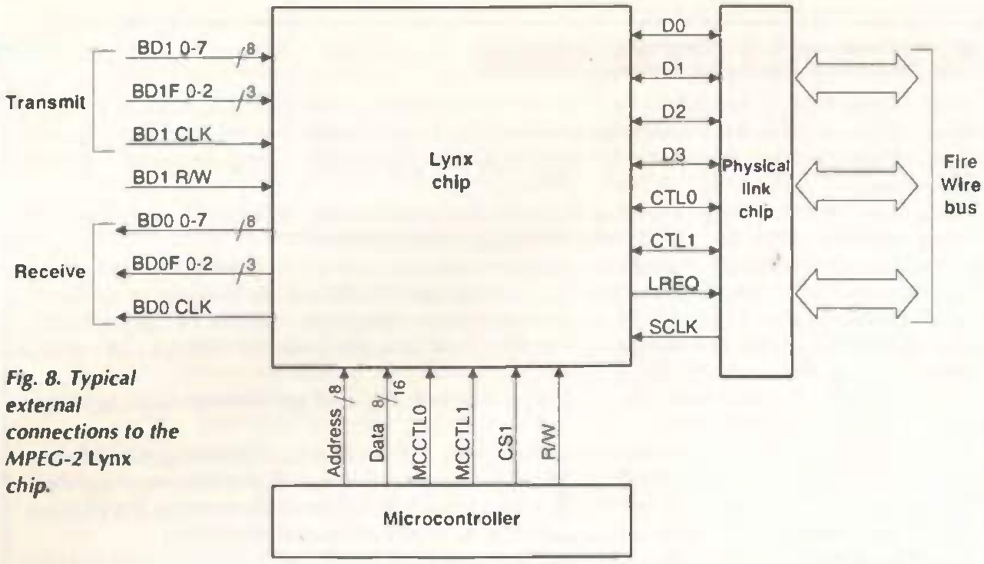


Fig. 8. Typical external connections to the MPEG-2 Lynx chip.

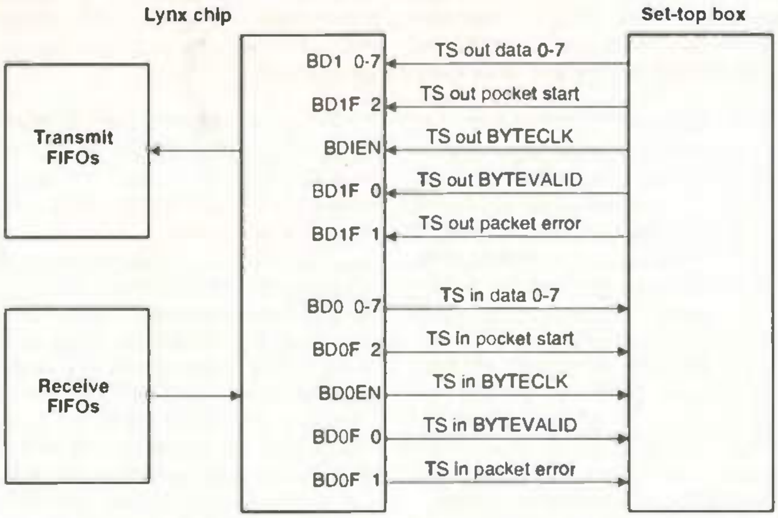


Fig. 9. Asynchronous connections between the MPEG-2 Lynx and set-top box circuitry.

pack known as a PQFP.

The device acts as an interface between the PCI bus system and the IEEE-1394 bus. It can transmit and receive *FireWire* formatted serial data packets. It also detects lost cycle-start packets, generates and tests the 32-bit cyclic redundancy check stream. In addition it can perform the functions of cycle-master (CM), isochronous-resource manager (IRM) and bus manager (BM).

This chip accepts decoded MPEG2 data from the system processor, automatically inserts the time stamp and reformats the data packets. The first-in-first-out memory is large enough to permit bidirectional transmission and reception of either MPEG2 or the Digital satellite system, or DSS, data. *Lynx* thus performs the functions of the system core by handling the protocols that govern the interoperability and sits between the system application software and the hardware.

The *MPEG2Lynx* provides for audio, video and data applications up to 200Mbit/s. It can be used for set-top box, multimedia, tape and disk-drive applications that require MPEG2 formatted isochronous data transfers.

How the MPEG2 *Lynx* chip works

The major functionality of this link-layer controller is shown in **Fig. 7**. Here the BDIF performs the interface between the *FireWire* bus system and the internal chip memory.

These functions are in turn managed via the logic settings of four status lines that control the reception or transmission of MPEG2/DSS data.

The internal memory is partitioned to form a six queue first-in-first-out register that buffers the data stream in four quadlet groups, with one first-in-first-out register for each of MPEG2/DSS transmit and receive data, asynchronous transmit and receive data, and isochronous transmit and receive data.

Table 2. Control functions are determined by two groups of three lines.

001	MPEG2 cell
010	I-packet byte
011	A-packet byte
100	BDIF reset receiver, BDOF no output data available
101	First byte of an MPEG2 cell
110	Last byte of I-packet
111	Last byte of A-packet

Contents of the local-time register acts as the system cycle timer (CT). This is used to time stamp the data packets to ensure the up-to-date nature of the data. The output from this stage is then used to control the transmit or receive function of the common isochronous packets, or CIPs. The ageing function is used to invalidate those packets that are out of date.

The microprocessor interface supports both 8 and 16-bit wide data busses allowing the *MPEG2Lynx* to be matched to a range of different processors. It interfaces with the most common microprocessor and micro-controllers, such as the Texas *TMS320AV700*, Motorola *68xxx* and Intel *80xx*.

Device selection is achieved via a pair of chip external control lines known as MCSEL0 and MCSEL1: these are not shown in Fig. 7. Logic within the chip automatically converts between data in the Big-Endian or Little-Endian formats, i.e. most-significant-byte first or last respectively. The choice is dictated by the actual processor being employed.

Because the Motorola microprocessor has a 16-bit data bus, only the lower byte carries actual data. The upper byte is padded out with all zeros.

Three further first-in-first-out registers are allocated to system control and are shown as ACX, ACR and BWR. Data held in ACX and ACR is used to control the asynchronous transmission and reception respectively, whilst the BWR first-in-first-out register is used to receive asynchronous broadcast write request packets. This is basically low-speed control data.

Data held in the configuration registers, designated CFR, controls the various modes of operation and are accessed via the microcontroller.

The physical layer interface services the transmitter and receiver sections in the manner described above. This includes gaining access to the serial bus, sending and receiving data and control packets and receiving acknowledgement packets.

The microcontroller interface

Typical interconnection of the microprocessor is shown in **Fig. 8**. As described here, the *TSB12LV41* supports the *TMS320AV700*, *680x0* and *8051* controllers.

Once the type has been set at power up through the logic levels of the two lines MCSEL, all the microprocessor i/o lines are mapped to the actual pin functions for that device. Using the Texas controller, this interface is synchronised to the *Lynx* block clock, designated BClk. The other two devices are synchronised to the SClk provided by the physical-layer device.

Both CS1 and R/W lines perform con-

USB – the Universal Serial Bus

Personal computer connectivity has been enhanced by the introduction of the Universal Serial Bus, known as USB. This permits communications between devices equipped with suitable interfaces at serial data rates ranging from 1.5Mbit/s to 1.5Mbyte/s.

The low-capacitance interconnecting lead involved in USB has a maximum reach of 5m. It consists of two twisted-pair cables, one for power and the other for signalling. This is terminated in standard XLR connectors and has a nominal line impedance of 90Ω. Like the *FireWire* system, USB devices are also hot pluggable.

Terminal devices are are added to the basic pc in a daisy-chain fashion and each forms one station on an addressable local area network (LAN). With 7-bit addressing, a maximum of 127 nodes can be assembled. The all zero address is non-valid.

Each USB interface device can have up to four outputs so that such a node can form the hub for a mini-star network. Typical terminal devices can range from a fax machine, through mouse, printer, telephone, to a multi-media display and recording sub-system.

The line code employs a differential non-return-to-zero format with each signal line taking up opposite polarity signals. This effectively doubles the signal amplitude to provide a significant signal to noise ratio advantage. The basic power supply has to provide 5V dc, with the signalling interface being driven from 3.3V.

Data transfers. The USB system employs four different types of signalling. Isochronous format caters for real-time data, such as audio, that must be delivered at a constant rate. Bulk format handles large amounts of data that does not require real time transmission. Output from a scanner or printer is an example of such data.

Interrupt signals are used for requests for service and the delivery of data from slow devices such as mouse or pointer. Finally, control signals are used for bus management, initialisation and set-up.

The data stream between the host pc and any terminal may be either uni-directional or bidirectional, with the data being organised into packets or frames of 1ms duration, **Fig. A.**

Each data packet contains up to 1023 bytes and is shifted in or out least-significant bit first.

Each packet is preceded by an identity code (PID). With the exception of the handshake byte, which carries its own error correction, each ends with a cyclic redundancy check group.

The token packet can only be issued by the host pc. It consists of a PID byte, 7-bit address group, a 4-bit end-of-packet nibble, designated ENDP, and five bits for cyclic redundancy checking.

The PID byte specifies either in, out or set-up. PIDs specify 'out' data transfers send data from the host pc to a terminal, Both 'in' and 'set-up' groups function in the opposite direction.

The handshake PID is only used to signify the status of a data transfer, which is either ready or received. The start-of-frame packet is issued by the host pc at 1ms intervals and the 11 bits allow for up to 2048 frames to be identified.

USB hardware. Several semiconductor manufacturers have developed dedicated ICs which are bus powered to perform most of the interface functions. Provision is also contained within the USB standard to allow for connecting self or battery powered terminal devices.

Typical of the self-powered terminal ICs are Texas's *TUSB2040* and *TUSB2070* chips. These support either four or seven downstream ports from a single up stream port respectively.

The general chip organisation is shown in **Fig. B.** This indicates how these can be combined with power management and electrostatic discharge protection devices to provide a mini-star distribution system.

Power is supplied at 5V via the down stream port and this is converted into 3.3V by the voltage regulator, *TPS7133* for the signalling control circuits. This chip provides up to 100mA of current to each output. It also generates a 'power-good' signal which creates the reset action at power-up.

The set of *SN75240* ICs perform the function of electrostatic discharge protection during hot plugging. These act as transient suppressors to reduce the in-rush current and voltage spikes. Such transients could not only damage the interface, but also interfere with the operation of the terminal devices connected to the output ports. Over-current protection may be provided by series type resettable fuses.

The *TPS2015* chip is a multi-port power management IC used to monitor both supply voltage and over-current situations and in addition it provides the short circuit protection for the downstream ports.

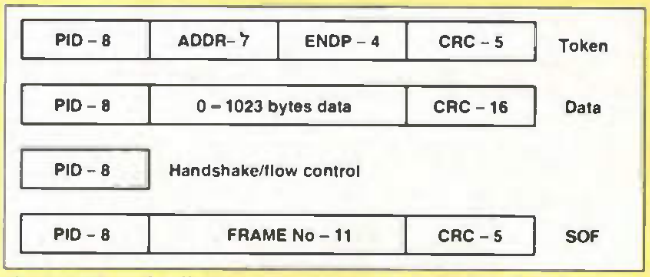


Fig. A. USB packet/frame arrangement. PID is packet identify, ADDR is address and CRC is cyclic redundancy check.

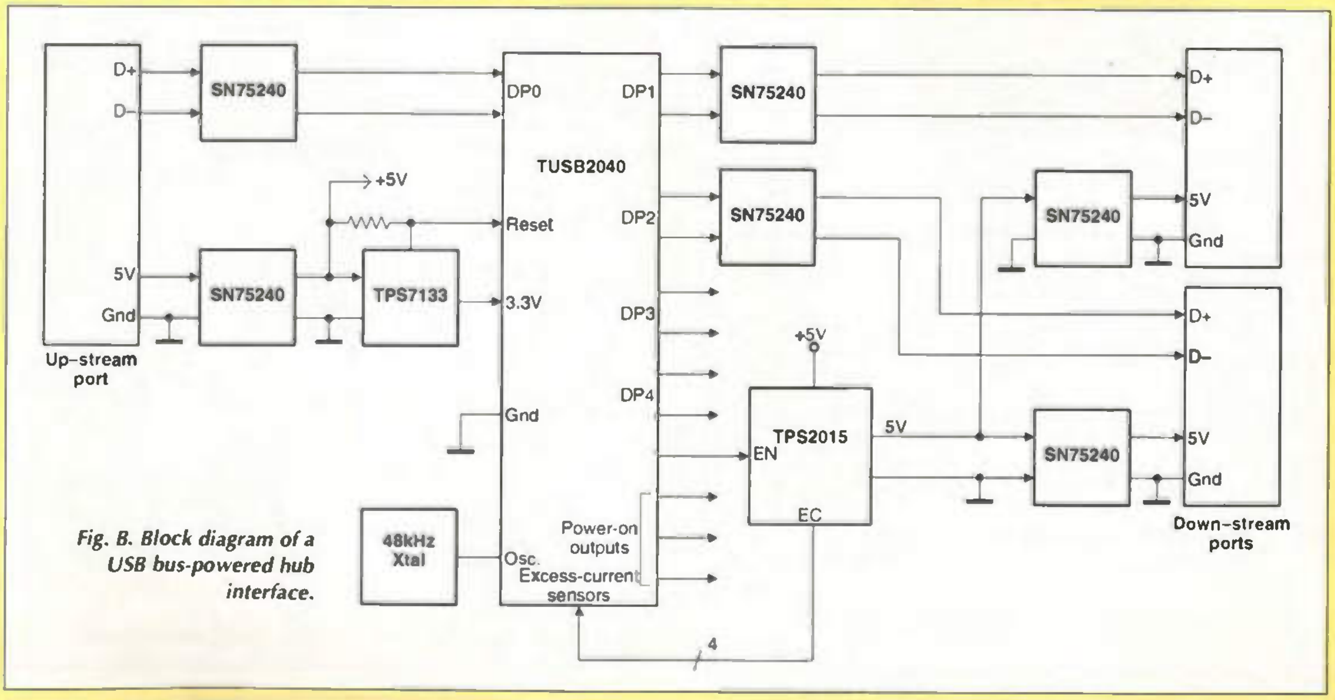


Fig. B. Block diagram of a USB bus-powered hub interface.

ventionally, as do the address and data buses. The signal line, BDIR/W controls the direction of the MPEG2/DSS data transfers. The bulky data input or output is carried over the eight parallel lines $BDI_{(0,7)}$ or $BDO_{(0,7)}$. Each mode is driven by the appropriate clock signal.

The two MCCTL lines define the read/write functions for the selected microprocessor. The two groups of three lines, $BDIF_{(0,2)}$ and $BDOF_{(0,2)}$ perform the control functions described in **Table 2**.

Figure 9 gives an indication of the way in which the MPEG2 *Lynx* time-stamped (TS) asynchronous control data is passed between this chip and the set top box STB, together with the error control checks and timing signals.

Expanding *FireWire*

In spite of the intentions, at present there are only a few examples of domestic entertainment units that are *FireWire* ready. But the professional interest is gaining a significant impetus.

While the above descriptions and explanations have been based on first generation chip sets, third generation hardware is already becoming available. Furthermore, due to the degree of embedded intelligence in each node interface, there is a considerable scope for software expansion.

Technology Rendezvous Inc – an embedded systems developer – has produced an architecture providing software and protocols for use with their *pSOSystem* real-time operating system.

This concept is referred to as *FireStack* and is intended for use with embedded systems. It provides access to a *FireWire* network through the use of a serial bus protocol, or SBP, which was originally intended to provide links to SCSI (Small Computer Systems Interface) systems or PCI networks. In addition, *FireStack* provides a link between *FireWire* and the TCP/IP Internet protocols.

With software solutions available to link systems employing different protocols, in can only be a matter of time before a Java solution is used to link digital set top boxes and integrated receiver decoders to the domestic network.

Since the IEEE-1394 network is compatible with the MPEG-2 video and audio data streams,[2] it will also be compatible with the asynchronous-transfer-mode system used for telecommunications. This has a maximum data rate of 622Mbit/s.

FireWire could therefore be a solution for delivering digital television signals directly to the home via a cable network system.

Sharp has recently produced a new digital camcorder, the *VL-PD1H Viewcam*. This camera is equipped with an IEEE 1394 interface. For industrial instrumentation applications, National Instruments now provides interfaces to allow both the GPIB and VXI bus systems to be able to handle up to 14 simultaneous and programmable measuring instruments to be linked into a FireWire network.

FireWire was certainly aptly named: it is anyone's guess where it is going to break out next.

Finally, I would like to thank Colin Davies of Texas Instruments and Mike Osler of Integrated Systems for their help with this article. ■

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Thermocouple logger

Plugging into a pc's printer port, Pei An's thermocouple-based temperature logger gives you six channels each capable of measurements in the range –270°C to 1370°C. Measurement resolution is 19 bits.

This article describes a low-cost six-channel temperature data logger using thermocouples. The device connects to the printer port of a pc via a standard printer cable. Six K-type thermocouples can be connected to the device using industry standard thermocouple connectors.

With the right thermocouples, temperatures in the range –270°C to 1370°C can be measured. **Figure 1** shows the complete system.

Thermocouple principles

When the junction of two dissimilar metals is heated, an e.m.f. is generated. This is known as the *Seebeck* effect and the junction is called a thermocouple.

Junctions are formed by twisting the ends of two wires together and then welding them. The basic operation of a thermocouple is shown in **Fig. 2**. The sensing junction – i.e. the hot junction – is at the temperature to be measured. The reference junction, which is the cold junction, is held at a reference temperature.

Resulting emf is proportional to the difference between the temperatures of the two junctions. The amplitude of the emf depends on the composition of the two wires.

There is a family of industrial standard thermocouples and they are identified by types, Fig. 2. Operating temperature range, composition and accuracy of thermocouples are defined in the IEC584 standard, which is called a code for temperature measurement using thermocouples.

Type K thermocouple is probably the most widely used. It is suitable for temperatures ranging from –270°C to + 1370°C. Its positive arm is 95% nickel balanced by Al, Si and Mn – an alloy known as Alumel. The negative arm is an alloy known as chromel which comprises 90% nickel and 10% chrome.

Type K thermocouples have three classes of accuracy:

Class 1:	range:	–40°C to +1000°C
	accuracy:	±0.004*T* or ±1.5°C
Class 2:	range:	–40°C to +1200°C
	accuracy:	±0.0075*T* or ±2.5°C
Class 3:	range:	–200°C to +100°C
	accuracy:	±0.015T or ±2.5°C

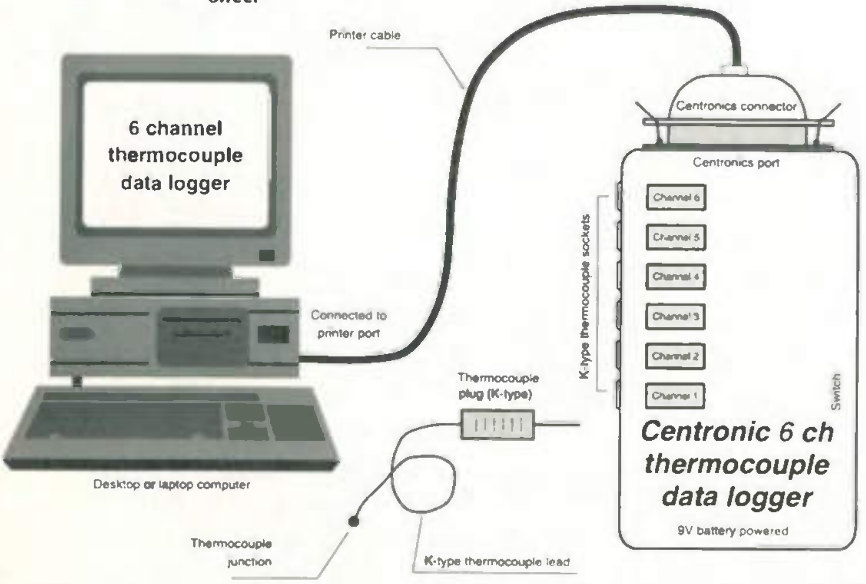


Fig. 1. Linking to the pc via its LPT port, the data logger takes readings of up to six thermocouples at once.

Since the logger is based on cmos devices, it can be implemented compactly and operated from a 9V battery.

The larger of the two deviation values should be chosen. Value T is the temperature measured by the thermocouple.

Figure 3 illustrates the emf values as a function of temperature in degrees celsius for various types of thermocouples. The output is reasonably linear over a wide temperature range. But above a certain temperature, the emf falls off. Knowing the emf, you can find the temperature using a polynomial,

$$T = A_0 + A_1X + A_2X^2 + A_3X^3 ... + A_nX^n$$

in which T is the temperature in degrees celsius, X is the thermocouple output voltage in volts, A_{0-n} are polynomial coefficients which are unique to each type of thermocouple and n is the order of the polynomial. The relationship between the e.m.f. versus temperature can be found in the IEC584 international thermocouple reference tables.

Thermocouple wires can be as small as 50µm in diameter – or even less. As a result, thermocouple junctions can be made very small, especially if a butt joint is used. Due to the low mass involved, small thermocouples can have fast response times of a few milliseconds. They are also cheap and have a wide operating temperature range.

Industrial thermocouples come in different forms. They have to be chosen to suit the individual application.

A classical way to measure temperature using thermocouples is shown in **Fig. 4a**. The sensing junction is at the temperature to be measured. The reference junction is placed at a reference temperature.

One way of providing the reference temperature is to use an insulated bath containing water and ice. This will give a temperature exactly at 0°C. The emf is proportional to the temperature difference between the junctions and is measured by a voltmeter.

The emf from multiple thermocouples can be measured using methods shown in Figures **4b** and **4c**. Such methods are especially useful for multi-channel thermocouple measurements.

These methods require the temperature of the connection terminals to be known. This can be done using a reference thermocouple connected to one of terminals, as in Fig. 4b), or using a temperature sensor attached to the terminals for mea-

Continued on page 31 after listing

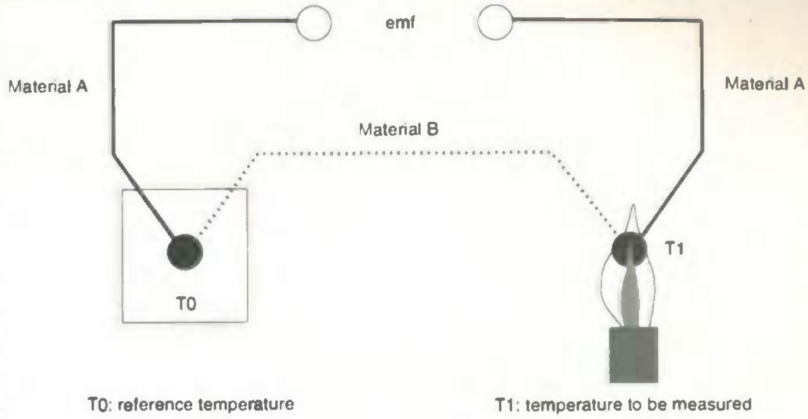


Fig. 2. In a conventional thermocouple sensing arrangement, emf produced is proportional to the difference between two thermocouple junctions – one at a reference temperature, the other at the temperature to be determined.

Thermocouple types	Materials
E	chromel vs constantan
J	iron vs constantan
K	chromel vs alumel
R	platinum vs platinum+13% rhodium
S	platinum vs platinum+10% rhodium
T	copper vs constantan

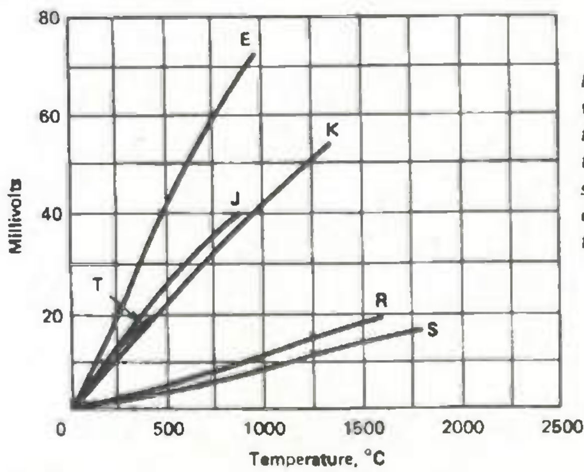


Fig. 3. EMF variations as a function of temperature for a selection of commonly used thermocouples.

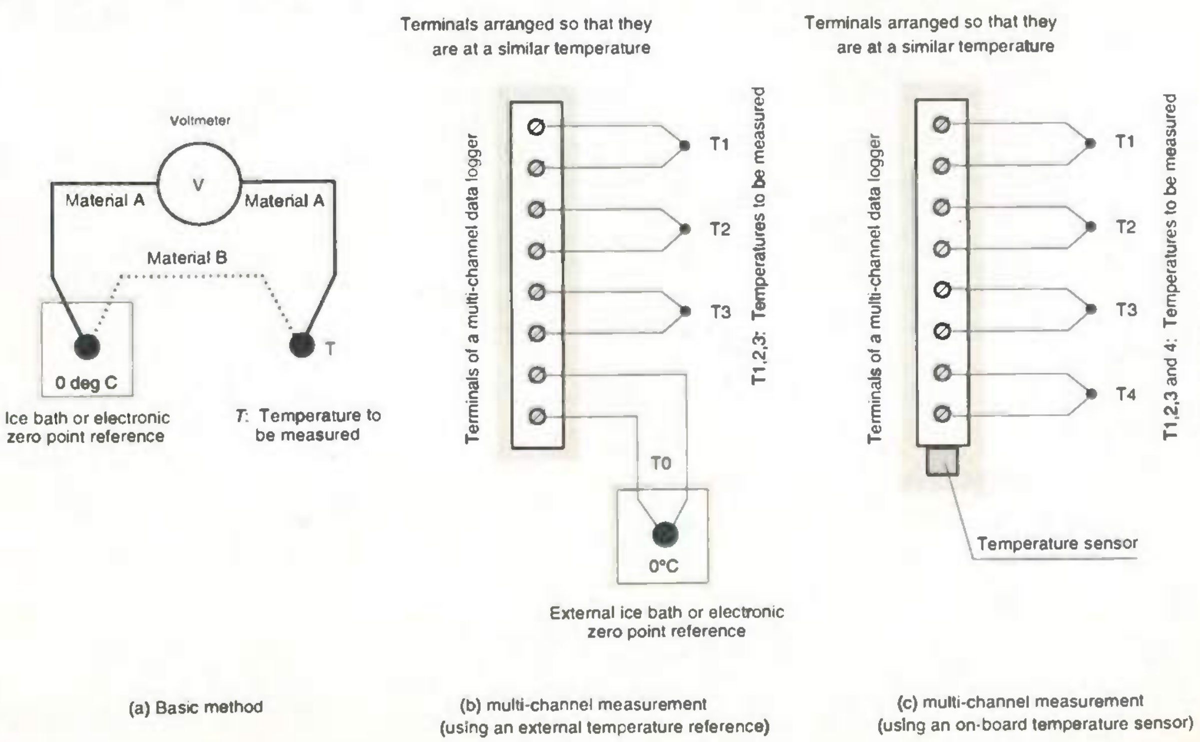


Fig. 4. In practice, there are several different ways of configuring the thermocouple circuit.

```
Program thermocouple_logger;
(*6 channel temperature logger using thermocouples
   Hardware and software developed by Dr Pei An, 1/98*)
(DATA PORT:  DB0-CLK,  DB1-A0, DB2-CONV, DB3-CAL, DB4-ADD0;
             DB5-ADD1, DB6-ADD2 DB7-ADD3
             ADD1 to ADD3 connected to A0,A2 and A3 on multiplexer
 STATUS PORT DB6-READY, DB7-DATA IN }
{  A0=0 selects expanded analogue input channel
   A0=1 selects on-board analogue multiplexer }
{  address=0 for batter voltage monitoring
   address=1 for on-board temperature sensor, 10mV/deg C
   address=2-7 for voltages inputs (6 off) }
uses
   Crt, dos;
Var
   ch,command,i:byte;
   Datax:array[1..30] of byte;
   unitx:char;
   P_address,dummy:integer;
Function bitweight(bit:byte):real;
var
   p1,i:longint;
begin
   P1:=1;
   if bit=1 then bitweight:=1
         else begin
              for i:=1 to bit-1 do P1:=P1*2;
              bitweight:=p1;
              end;
end;
(*---Detect LPT base addresses---*)
Procedure Centronics_address;
(* $000:$0408 holds the printer base address for LPT1
   $000:$040A holds the printer base address for LPT2
   $000:$040C holds the printer base address for LPT3
   $000:$040e holds the printer base address for LPT4
   $000:$0411 number of parallel interfaces in binary format*)
var
   lpt:array[1..4] of integer;
   number_of_lpt,LPT_number,code:integer;
   kbchar:char;
begin
   clrscr;
   LPT_number:=1;                       (*to set default printer*)
   number_of_lpt:=mem[$0000:$0411];
                                        (*to read number of installed Centronics ports*)
   number_of_lpt:=(number_of_lpt and (128+64)) shr 6;        (*Bit manipulation*)
   lpt[1]:=memw[$0000:$0408];           (*Memory read procedure*)
   lpt[2]:=memw[$0000:$040A];
   lpt[3]:=memw[$0000:$040C];
   lpt[4]:=memw[$0000:$040E];
   textbackground(blue); clrscr;
   textcolor(yellow); textbackground(red); window(10,22,70,24); clrscr;
   writeln('Number of LPT installed         :        ',number_of_lpt:2);
   writeln('Addresses for LPT1 to LPT 4:    ',lpt[1]:3,'      ', lpt[2]:3,'     ', lpt[3]:3,'     ',
lpt[4]:3);
   write('Select LPT to be used (1,2,3,4)   :        ');
   delay(1000);
   if number_of_lpt>1 then begin
                      {select LPT1 through LPT4 if more than 1 LPT installed}
        repeat
        kbchar:=readkey;                (*read input key*)
        val(kbchar, LPT_number, code);  (*change character to value*)
        until (LPT_number>=1) and (LPT_number<=4) and (lpt[LPT_number]<>0);
                      end;
   clrscr;
   P_address:=lpt[LPT_number];
   writeln('Your selected printer interface:        LPT',LPT_number:1);
   write('LPT    Address                  :        ',P_address:3);
   delay(1000);
   textbackground(black); window(1,1,80,25); clrscr;
end;
(*---read data from STATUS port of pc---*)
Function Read_status_port(P_address:integer):byte;
var
   byte1:byte;
 begin
   byte1:=port[P_address+1];        (*read a byte from the status port*)
   byte1:=byte1 and (120+128);
                 (*11111000 (MSB to LSB) and 0dddd... = 0dddd000*)
   Read_status_port:=byte1 shr 3;
                 (*shift 3 bit right, Read_status_port = 0000hhhh*)
end;
(*---Write data to DATA port of pc---*)
Procedure Write_data_port(P_address:integer; port_data:byte);
(*no lines in the Data port are not inverted*)
begin
   port[P_address]:=port_data;      (*output a byte to the data port*)
```

```
end;
Function Input_data:byte;
begin
   input_data:=read_status_port(P_address);
 end;
Function CAD:longint;
{Calibrating the A/D converter}
begin
   command:=0;
   port[P_address]:=0+8+command; {CONV=0, CAL=1}
   delay(20);
   Port[P_address]:=4+8+Command; {CONV=1 and CAL=1, calibrating started}
   repeat until ((input_data and 8)=       0) or keypressed;
                  {-REDY goes low to indicate a complete conversion}
   port[P_address]:=command;       {CONV=0, CAL=0}
   delay(2000);
end;
Function voltage(address:byte):real;
{read voltage }
var
   sum:real;
   v:array [1..10] of real;
   i,ix:integer;
begin
   sum:=0;
   command:=A0*2+address*32;
   Port[P_address]:=4+Command; {CONV=1, CAL=0}
   repeat until (input_data and 8)=        0;
                  {-REDY goes low to indicate a complete conversion}
   delay(1);
   for i:=1 to 20 do
        begin
            datax[21-i]:=1-round((input_data and 16)/16);
                  {note: DB7 of the status port is inverted}
            port[P_address]:=1+command;
                  {CLK goes from low to high to start shifting}
            port[P_address]:=command;
                  {CLK goes from high to low to clock out next bit}
        end;
   for i:=1 to 20 do begin sum:=sum+bitweight(i)*datax[i] end;
   voltage:=(sum - 8*256*256) /8/256/256*2.500; {bipolar shifting}
   port[P_address]:=command;
   delay(100);
end;
Function TC(channel:byte):real;
(*read temperature from a channel, channel=1 to 6*)
var
   temp:real;
begin
   temp:=(voltage(1,1)/0.01 + (voltage(1,channel+1))/0.0000405);
   TC:=temp;
   if (temp>=1500) then TC:=0;
   if (temp<=-100) then TC:=0;
end;
Procedure Measure_all;
begin
   gotoxy(10,25); write('          Press any key to stop logging');
   gotoxy(10,1) ; write('          Data read from the data logger');
   repeat
      gotoxy(21,10); write('Battery voltage     :',voltage(1,0)*5.7:10:1,'  [V]');
      gotoxy(21,11); write('On-board temp.:',voltage(1,1)/0.01:10:1,'       [deg C]');
      for i:=1 to 6 do
      begin
            gotoxy(21,11+i);
            write('Temperature ',i,'      :',TC(i):10:1,'  [deg C]');
      end;
   until keypressed;
end;
Procedure Diagram;
{A diagram showing the layout of the data logger}
begin
   window(1,1,80,25);
   Textbackground(blue);
   textcolor(yellow);
   clrscr;
   writeln('          Layout of the 6 channel thermocouple data logger');
   writeln;

   writeln('      .     Éffffffffffffffffffffffffffffffff»                         Features');
   writeln('            • Computer Thermocouple Logger     •       ********************************');
   writeln('            º                                  •       ß     6 K-type thermocouple sockets');
   writeln('            º                                  •       ß     19-bit A/D conversion accuracy');
   writeln('      <<<<  •       Channel 6                  •       ß     Measurement range');
   writeln('            º                                  •             -100 to 1350°C ');
   writeln('      <<<<  º       Channel 5                  •             ±2°C accuracy');
   writeln('            ¶                                  •       ß     Centronics port connection');
   writeln('      <<<<  º       Channel 4                  •       ß     On-board temperature sensor');
   writeln('            º                                  •       ß     A PP3 9V battery required');
```

```
    writeln('    <<<<    •        Channel 3          •        ß     Battery low voltage warning');
    writeln('            •                           •        ');
    writeln('    <<<<    •        Channel 2          •        ß     Slim size');
    writeln('            •                           •        ');
    writeln('    <<<<    •        Channel 1          •        ');
    writeln('            •                           •              Applications');
    writeln('            •                           •        ');
    writeln('            •                           •        ß     Temperature monitoring');
    writeln('            ¶                           •');
    writeln('            •                           •        ');
    writeln('            Èfffffffffffffffffffffffffff_        ');
    writeln('                                                 ');
    writeln('                                                 ');
    write ('                                         ');
                                                 Press any key to continue');
  end;
  Procedure manual;
  begin
    window(1,1,80,25);
    textbackground(blue);
    textcolor(yellow);
    clrscr;
    gotoxy(10,1) ; write('        6 channel thermocouple data logger');
    gotoxy(10,2) ; write('        Chose the number and pressed RETURN');
    gotoxy(20,10); write('[1]     Diagram of the data logger');
    gotoxy(20,11); write('[2]     Calibration');
    gotoxy(20,12); write('[3]     Measure all');
    gotoxy(20,13); write('[4]     Quit the session');
    textbackground(green);
    textcolor(white);
    window(1,25,80,25);
    clrscr;
    gotoxy(1,10); write(' Press [1] to [4]');
    gotoxy(80,25);
  end;
  Procedure manual_selection;
  var
    key_char:char;
  begin
    manual;
  repeat
    key_char:=readkey;
    if key_char='1' then begin
                      diagram;
                      repeat until keypressed;
                      readln;
                      manual;
                      end;
    if key_char='2' then begin
                      window(1,1,80,25);
                      dummy:=CAD;
                      manual;
                      end;
    if key_char='3' then begin
                      window(1,1,80,25);
                      textbackground(blue);
                      textcolor(yellow);
                      clrscr;
                      measure_all;
                      manual;
                      end;
    if key_char='4' then begin
                      halt;
                      end;
until (key_char)='7';
    delay(1000);
    clrscr;
end;
(*****MAIN PROGRAM*****)
begin
    Centronics_address; (*select a Centronics interface*)
    Port[P_address]:=0; (all lines of the DATA port are zero)
    command:=0;
    clrscr;
    dummy:=cad;
    delay(10000);
    dummy:=cad;
    delay(10000);
    dummy:=round(voltage(1,0));
    clrscr;
    manual;
    manual_selection;
end.
```

Software driver

The software driver is written in Turbo Pascal 6 **List. 1**. This program only demonstrates how the hardware of the device is controlled by a software.

It shows how to calibrate the a-to-d converter and how to get a conversion data from the converter. It does not have functions to log data continuously and save the data into a file.

Here's an outline of what the functions and procedures do. The procedure,

`Centronics_address`

detects the number of Centronics ports installed on your computer and allows you to select which port to use. The function,

`Read_status_port(P_address:integer)`

reads data from the status port. The procedure,

`Write_data_port(P_address:integer; port_data:byte)`

outputs a data byte from the data port. The function,

`CAD:longint`

performs calibration of the a-to-d converter. The function,

`voltage(address:byte)`

controls the a-to-d converter and measures a voltage from an analogue channel specified by address. The function,

`TC(channel:byte)`

converts the voltage into a temperature value. Here the relationship between e.m.f. and temperature is treated as a linear one. Finally, the procedure,

`Measure_all`

measures temperatures from all six channels.

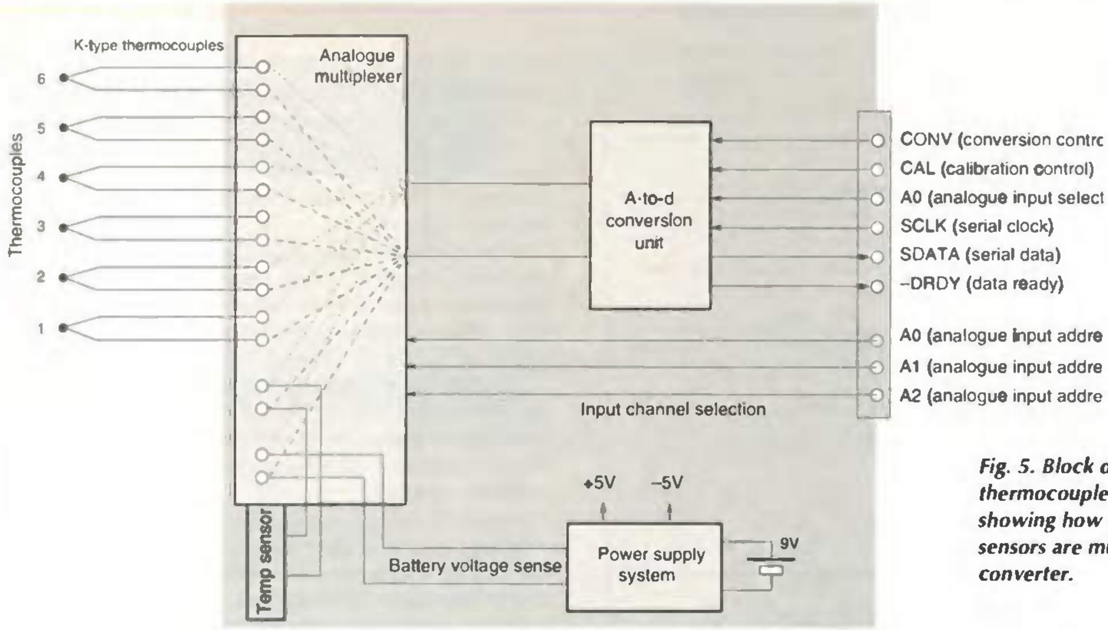


Fig. 5. Block diagram of the thermocouple measurement subsystem showing how readings from the six sensors are multiplexed into one a-to-d converter.

suring the temperature, Fig. 4c.

All the terminals should be kept at a similar temperature to minimise errors in the reference temperature. This can be done by mounting all the terminals on a piece of copper plate and keeping them away from heat sources.

Overview of the hardware

Figure 5 is a block diagram of the thermocouple data logger. The device consists of four units: the a-to-d conversion unit, the analogue multiplexer unit, the temperature sensing unit and the power supply unit.

The a-to-d conversion unit is based on a *CS5504* 20-bit a-to-d converter. When it operates in bipolar mode and the voltage reference is 2.5V, it could measure an input voltage as small as ±5.45μV. Note that the K-type thermocouple gives 40μV/°C.

In order to measure six channels of thermocouple signals, the data logger uses a *MAX337* analogue multiplexer. This device provides eight differential analogue inputs. Six of them are used for thermocouples. One is used for the on-board temperature sensor and one is used for monitoring the voltage of the battery.

The temperature sensing unit is based on an *LM35DZ* celsius temperature sensor. It measures the temperature of the terminals on the circuit board. This is the reference temperature for calculating temperatures measured by thermocouples.

The power supply unit comprises a low-power, low-voltage-drop +5V *HT1050* voltage regulator and a *7660* voltage inverter to generate a –5V supply from the +5V power supply. The –5V power supply is used by the *CS5504* and the *MAX337*.

The CS5504 a-to-d converter

For a-to-d conversion, I chose the dual-channel 20-bit *CS5504*. This device uses delta-sigma conversion and has serial i/o. It provides low-cost, high-resolution measurement at output word rates up to 200 samples per second.

Being a cmos device, the *CS5504* draws less than a milliamp from the supply. It consists of a delta-sigma converter, a voltage reference, a calibration microcontroller, a static ram, a digital filter and a serial interface, Fig. 6.

The on-chip digital filter provides mains rejection at 50Hz and 60Hz when the device is operated from a 32.768kHz crystal, which gives a 20Hz sampling rate. The on-chip self-calibration circuitry ensures minimum offset and full-scale errors in a conversion.

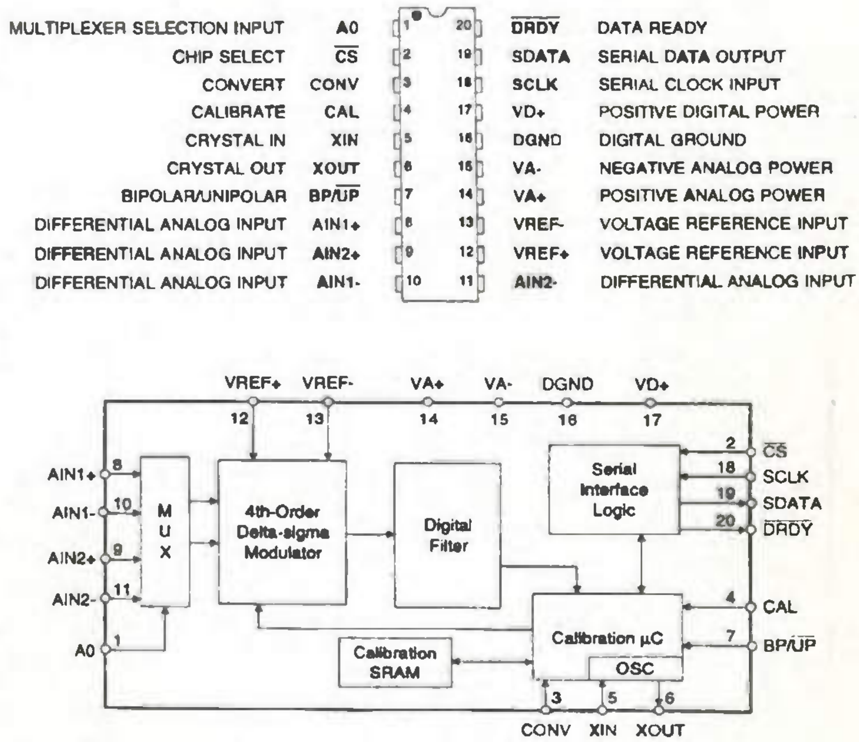
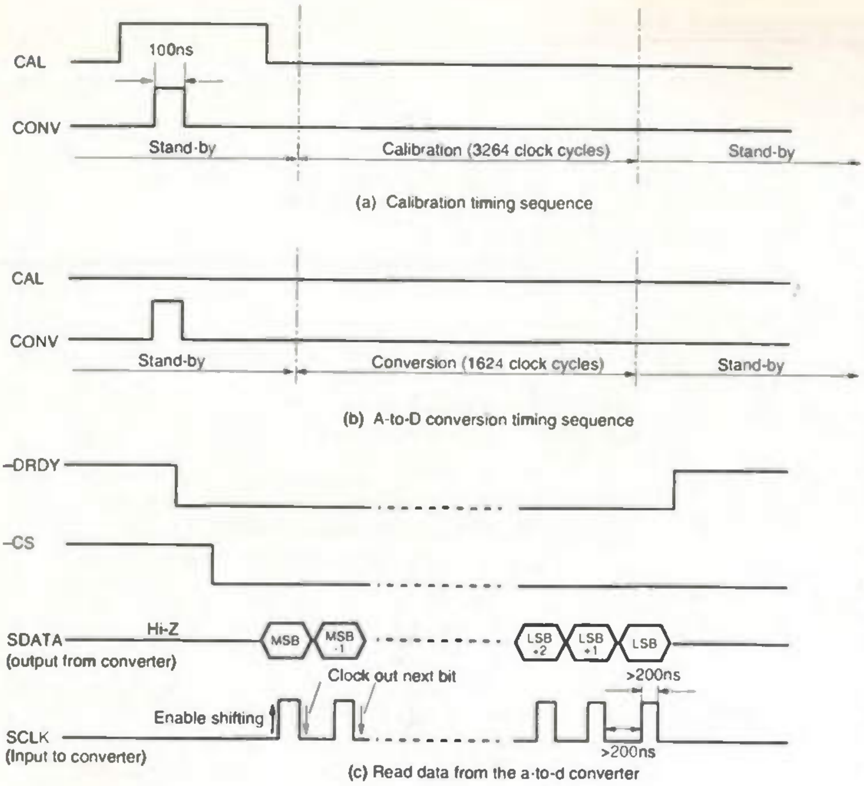


Fig. 6. At relatively low cost, the CS5504 cmos a-to-d converter provides 20-bit measurement resolution and has on-chip mains rejection filtering.

Three operating states are possible with the device: standby, calibration and conversion. Stand-by state is entered after the device has completed an operation and no command is given to it. After a power-on, a wake-up period comprising 1800 clock periods exists before the device enters the standby state.

Calibration must be performed before a valid conversion can be made. The calibration state is entered when CAL is high and CONV goes from low to high. During calibration, the device first performs an offset calibration and then a gain calibration. This is conducted by the on-board calibration micro-controller. Calibration takes 3246 clock cycles and the calibration coefficients are stored in the calibration static ram for use during conversion.

At the end of the calibration cycle, the microcontroller checks the logic state of the CONV signal. If it is low, the device enters the stand-by mode, waiting for further instruction. If it is high, the device performs conversion on one of



the input channels specified by the state of A_0 at the rising edge of CONV signal.

If CAL and CONV signals are both high, after the calibration, the device automatically performs a conversion. At the end of the conversion, –DRDY become low to indicate a valid conversion has been completed. Here, the minus sign indicates negative logic.

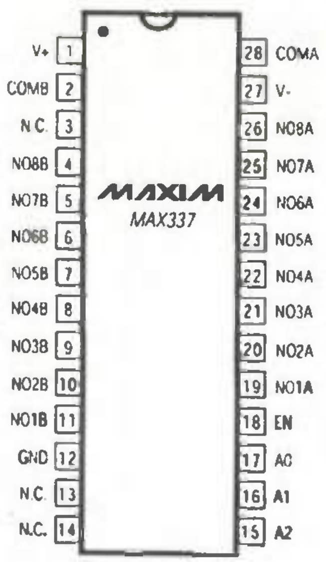
Conversion state is entered at the low-to-high transition of the CONV, when CAL is low. One of the two analogue input channels is selected by A_0 when CONV goes from low to high. When A_0 is low, analogue input channel 1 is selected and when A_0 is high, channel 2 is selected.

The CONV line is kept high during the conversion. After the conversion is completed and the data is latched into the serial data register, the –DRDY goes from high to low. This flags a completed conversion. After that the CONV can be pulled to logic low.

When –CS goes from high to low after new data becomes available, i.e. after –DRDY goes low, the most-significant bit, DB_{19}, of the conversion data is output on the SDATA pin. The first rising edge of SCLK enables the data shifting. In stand-by mode, the SCLK line should be held low.

At the falling edge of the SCLK, the next data bit appears on the SDATA pin. Each subsequent falling edge shifts out the serial data bits. Once the least-significant bit of the conversion data is preset, the falling edge of SCLK causes the SDATA output to go to tri-state and –DRDY to return high.

Fig. 7. Timing sequences for the CS5504 20-bit digitiser chip.



MAX337				
A2	A1	A0	EN	ON SWITCH
X	X	X	0	NONE
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8

LOGIC "0" = $V_{AL} \leq 0.8V$, LOGIC "1" = $V_{AH} \geq 2$

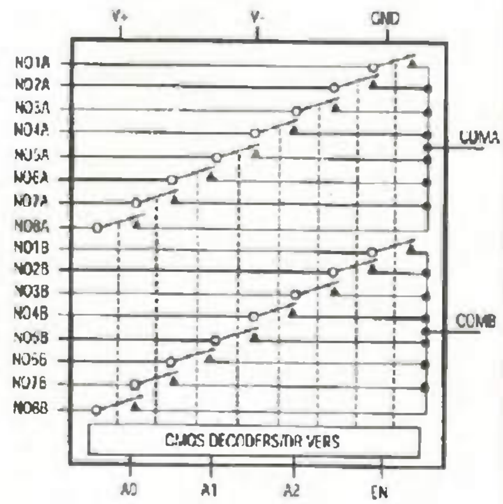
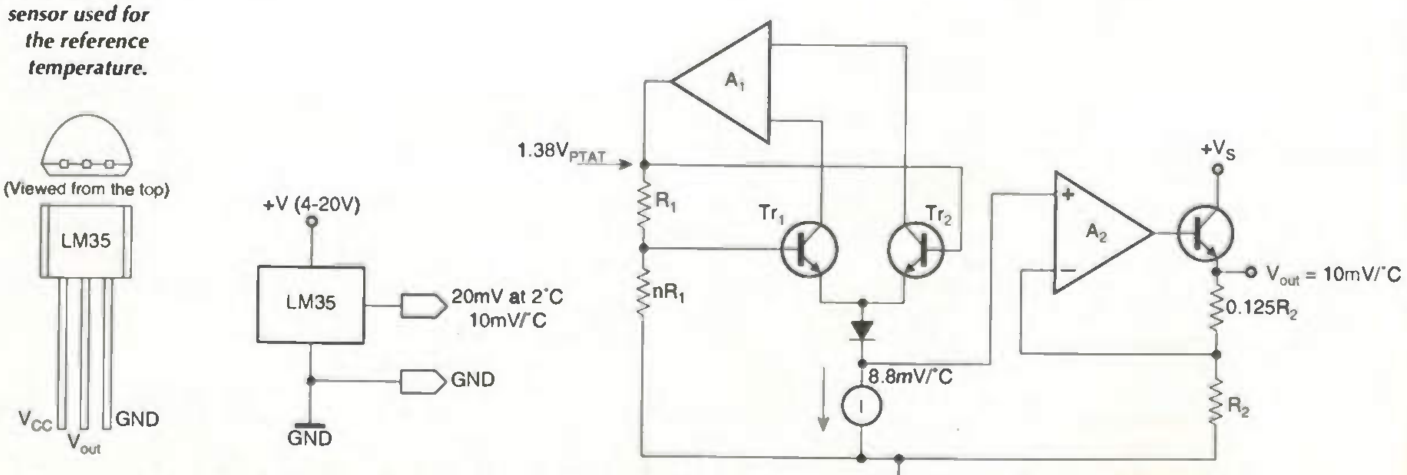
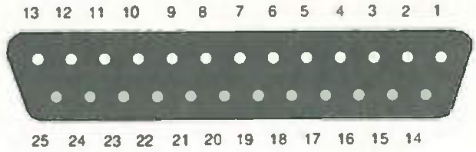


Fig. 8. MAX337 is a dual eight-into-one multiplexer featuring an on resistance of 400Ω and less than 20pA leakage current at room temperature.

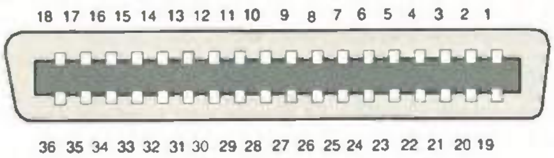
Fig. 9. Details of the temperature sensor used for the reference temperature.



(a) Pin-out of LM35DZ (b) Temperature sensor based on LM35DZ (c) Internal block diagram



(a) Pin-out of the Centronics connector on pc compatibles - viewed from the back of the pc
Connector type: 25-pin female D-type



(b) Pin-out of the Centronics connector on printers - viewed from the back of the printer
Connector type: 36-pin female Centronics-type

Pin functions of the Centronics port connectors

Connector computer	Connector printer	Direction	Name	Explanation
1	1	C to P	STROBE	Strobe data
2	2	C to P	DB0	Data bit 0
3	3	C to P	DB1	Data bit 1
4	4	C to P	DB2	Data bit 2
5	5	C to P	DB3	Data bit 3
6	6	C to P	DB4	Data bit 4
7	7	C to P	DB5	Data bit 5
8	8	C to P	DB6	Data bit 6
9	9	C to P	DB7	Data bit 7
10	10	P to C	ACK	Indicating data received
11	11	P to C	BUSY	Indicating printer busy
12	12	P to C	PE	Indicating paper empty
13	13	P to C	SLCT	Indicating printer on line
14	14	C to P	LF/CR	Auto linefeed after carriage return
15	32	P to C	ERROR	Indicating printer error
16	31	C to P	INITIALISE	Initialise printer
17	36	C to P	SLIN	Select/deselect printer
18-25	19-30 and 33		GND	Twisted-pair return ground
	18,34		Unused	
	16		Logic GND	Logic ground
	17		Chasis GND	Chasis ground

'C' = Computer 'P' = Printer

Fig. 10. Functions of a standard pc's LPT port connections follow the long-established Centronics standard.

The Centronics printer port

Pin layout and functions of a pc's Centronics printer port is shown in **Fig. 10**.

Details of the port can be found in reference 3. In brief, a standard Centronics port contains three i/o ports. One port is the DATA port, comprising eight outputs, another is the CONTROL port which consists of four outputs and the third is the STATUS port which is made up of five inputs.

The DATA and CONTROL ports are output ports and the status port is an input. The computer uses these ports to output data and the STATUS port to input a five-bit word.

Table 1. Output coding for unipolar and bipolar modes.

Unipolar mode	Output codes	Bipolar mode
$>V_{ref}-1.5$ lsb	$FFFFF_{16}$	$>V_{ref}-1.5$ lsb
$V_{ref}-1.5$ lsb	$FFFFF_{16}$	$V_{ref}-1.5$ lsb
$V_{ref}/2-0.5$ lsb	80000_{16}-$FFFFF_{16}$	-0.5 lsb
0.5 lsb	00001_{16}-00000_{16}	$-V_{ref}+0.5$ lsb
<0.5 lsb	00000_{16}	$<V_{ref}+0.5$ lsb

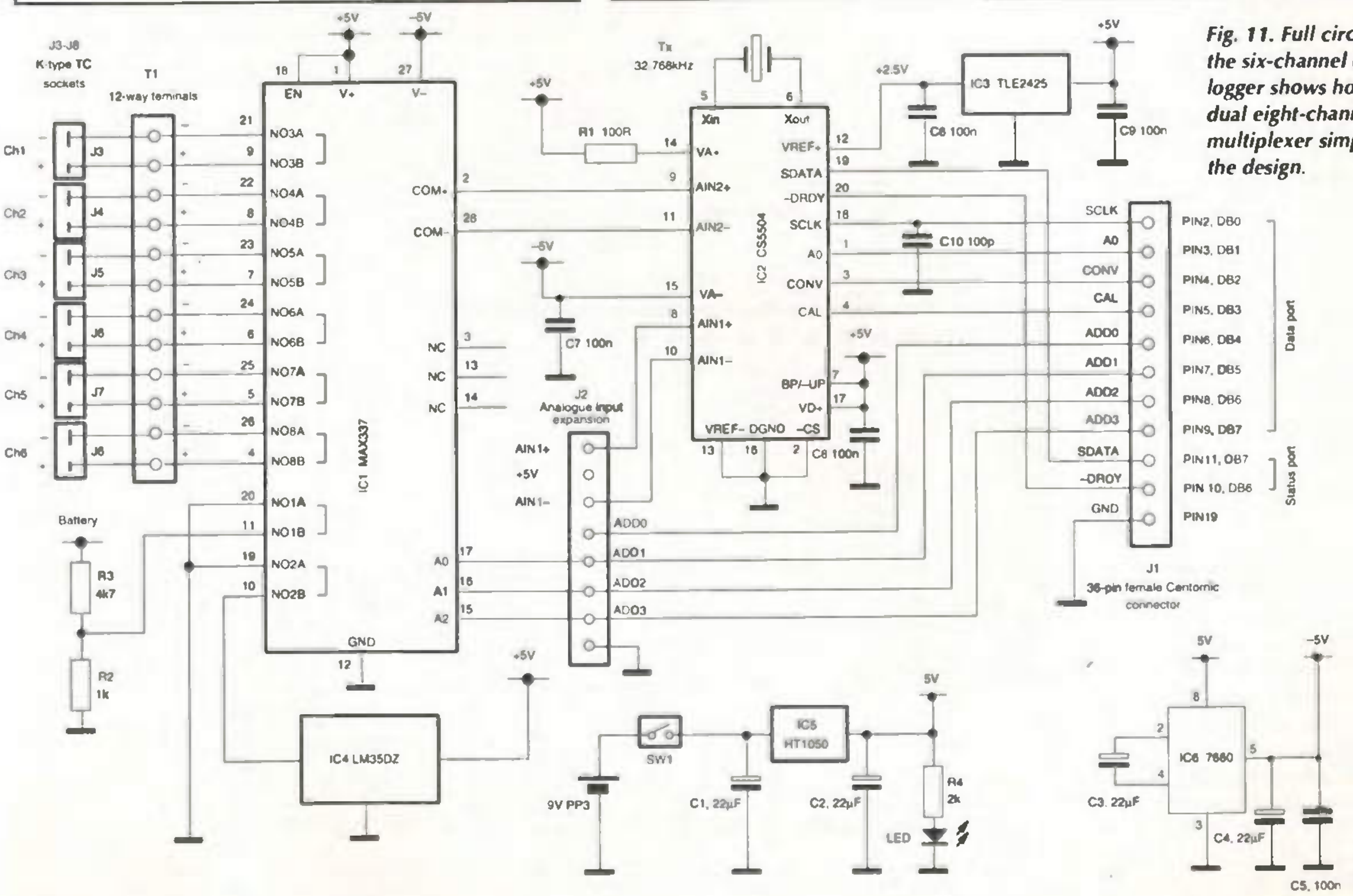


Fig. 11. Full circuit of the six-channel data logger shows how the dual eight-channel multiplexer simplifies the design.

This indicates that the serial data register is emptied. Only under this condition can the serial port registers be updated with new data on completion of another conversion, Fig. 7.

The input signal can be configured for a unipolar or bipolar signal depending on the status of BP/–UP line. The *CS5504* converter outputs data in a binary format when converting unipolar or in offset binary form when converting a bipolar signal. **Table 1** shows the output coding for the two measurement modes.

More details on the *CS5504* are available in the manufacturer's data sheet.[1]

Eight-into-one multiplexing

The *MAX337* is a dual eight-to-one cmos analogue multiplexer. It features a maximum on resistance of 400Ω and the device conducts current equally well in both directions. It has an extremely low off leakage – less than 20pA at room temperature – and an on channel leakage figure of less than 50pA.

The device operates from a single supply of between +4.5V and +30V, or from a dual power supply of ±4.5V to ±20V. All control pins are ttl compatible.

Pin-out, pin functions and internal block diagram of the *MAX337* are given in **Fig. 8**. The device contains two eight-to-one analogue multiplexers. One of the eight inputs is connected to the common output by control of a three-bit binary address, $A_{0\text{-}2}$.

In the present circuit, the two multiplexers are used together to provide differential multiplexed inputs. More details on the *MAX337* can be found in the maker's data sheet.[2]

Temperature referencing

An *LM35DZ* is used as the on-board temperature sensor, Fig. 9. This is a precision temperature sensor whose output voltage is linearly proportional to the celsius temperature in a range from 0°C to 100°C. Without calibration, it is able to achieve an accuracy of 0.6°C at 25°C.

The sensitivity of the sensor is 10mV per degree celsius. The device requires a supply from +4V to 30V. Its quiescent current is only 56μA with a voltage supply of +5V. This makes the sensor ideal for battery operated applications. Low quiescent current also ensures that the self-heating of the device is below 0.08°C in still air.

Circuit detail

You will see from **Fig. 11** that the DATA and the STATUS ports of the Centronics port are used for controlling the operations of the data logger and for reading data from it.

Lines in the DATA port are used as shown in **Table 2**. Two lines in the STATUS port are used for receiving data from the logger into the computer. Lines $DB_{3\text{-}5}$ are not used, DB_6 connects to the –DRDY line of the a-to-d converter and DB_7 connects to the SDATA line of the a-to-d converter. This line is inverted.

Figure 12 shows how compact the system can be. ■

References

1. Data sheet CS5504, Crystal Semiconductor Corporation.
2. Data sheet MAX336/MAX337, Maxim Corporation.
3. PC Interfacing – Using Centronics, RS232 and game ports, Pei An. Newnes, Butterworth-Heinemann, 1998, ISBN0240514483.

Table 2. Summary of the functions of the printer port data pins.

DB0: serial clock SCLK for a-to-d conversion
DB1: analogue multiplexer selection line, A_0 on a-to-d converter,
DB2: conversion line CONV on a-to-d converter
DB3: calibration line CAL on a-to-d converter
DB4: ADD0, not used
DB5: ADD1, connects to *MAX337* pin A_0
DB6: ADD2, connects to *MAX337* pin A_1
DB7: ADD3, connects to *MAX337* pin A_2

Technical support

Designers' kits including all necessary components to construct a complete thermocouple data logger and the TP6 source codes are available from the author. Please make your enquiry to Dr Pei An, 11 Sandpiper Drive, Stockport, Manchester SK3 8UL, UK. Tel/fax/answer m/c +44-(0)161-477-9583. Pei's e-mail address is PAN@FS1.ENG.MAN.AC. UK.

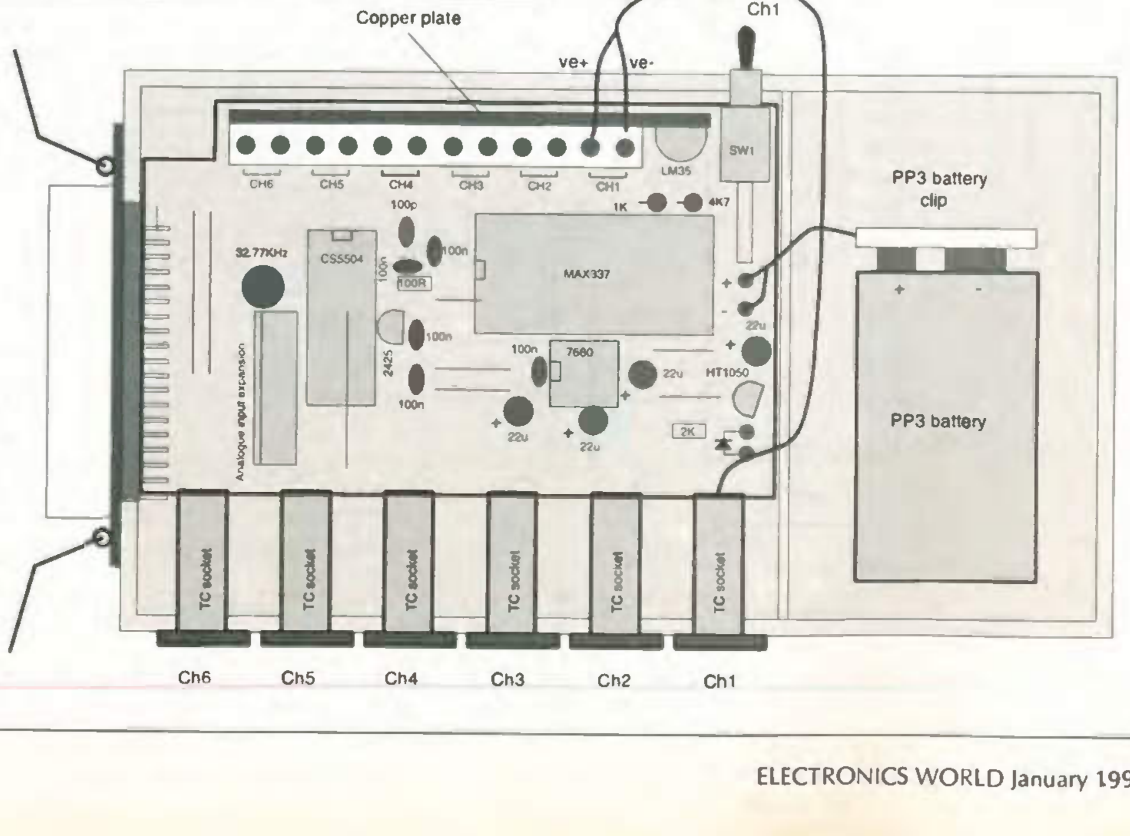


Fig. 12. Pei's self-contained thermocouple measurement subsystem is a compact design running from its own power source. As a reader service, the design is being made available from the author, together with its software.

Precision fader

Disillusioned with conventional faders, David Birt designed this digitally-driven potentiometer that allows clean, smooth and precise fading without resorting to a microcontroller.

This design was produced for controlling the record level of a DAT or CD-R recorder at live recording sessions. So what is wrong with conventional ganged logarithmic potentiometers?

- They are prone to wear,
- Their law is only approximately logarithmic,
- Poor tracking between the two channels can cause the stereo image to shift as the record level is adjusted.
- The range of adjustment is too large to allow accurate re-setting to a previous desired setting, following a fade-down for applauds, or fade-up for announcements.
- The usual 0 to 10 scale does not relate to the decibel scale on the recorder's level meters.

This new design provides equally-spaced decibel increments – accurate to 0.1dB – which do relate directly to the readings on the level meters. Thus it is very easy to implement a desired reduction or increase of headroom of say 6dB quickly, and to reset precisely to a previous level after fades. The tracking is also within 0.1dB.

How it works

The fader control is a 16-position hexadecimal switch, RS part number 322-142.

It provides 16 attenuation settings in 1.5dB increments ranging from 0 to 22.5dB. Its four-bit output serves as data B which is fed to IC_3 magnitude comparator. Data A to the comparator comprises bits $D_{5\text{-}2}$ from the up/down counter $IC_{1,2}$.

At power-up, a pulse from 'IC_6' loads the counter with $3C_{16}$. On the first clock edge, the counter outputs $3C_{16}$ corresponding to 22.5dB attenuation, to the *AD7112* logarithmic multiplying digital-to-analogue converter.

When the control knob is turned so that data A is not equal to data B, the counter counts up or down until data A equals data B, and D_1 and D_0 are both logic zero and then stops. The counter is clocked at 25Hz by the clock generator 'IC_7'. This gives a fade rate of about 10dB per second, which I find to be just right.

Implementing the design

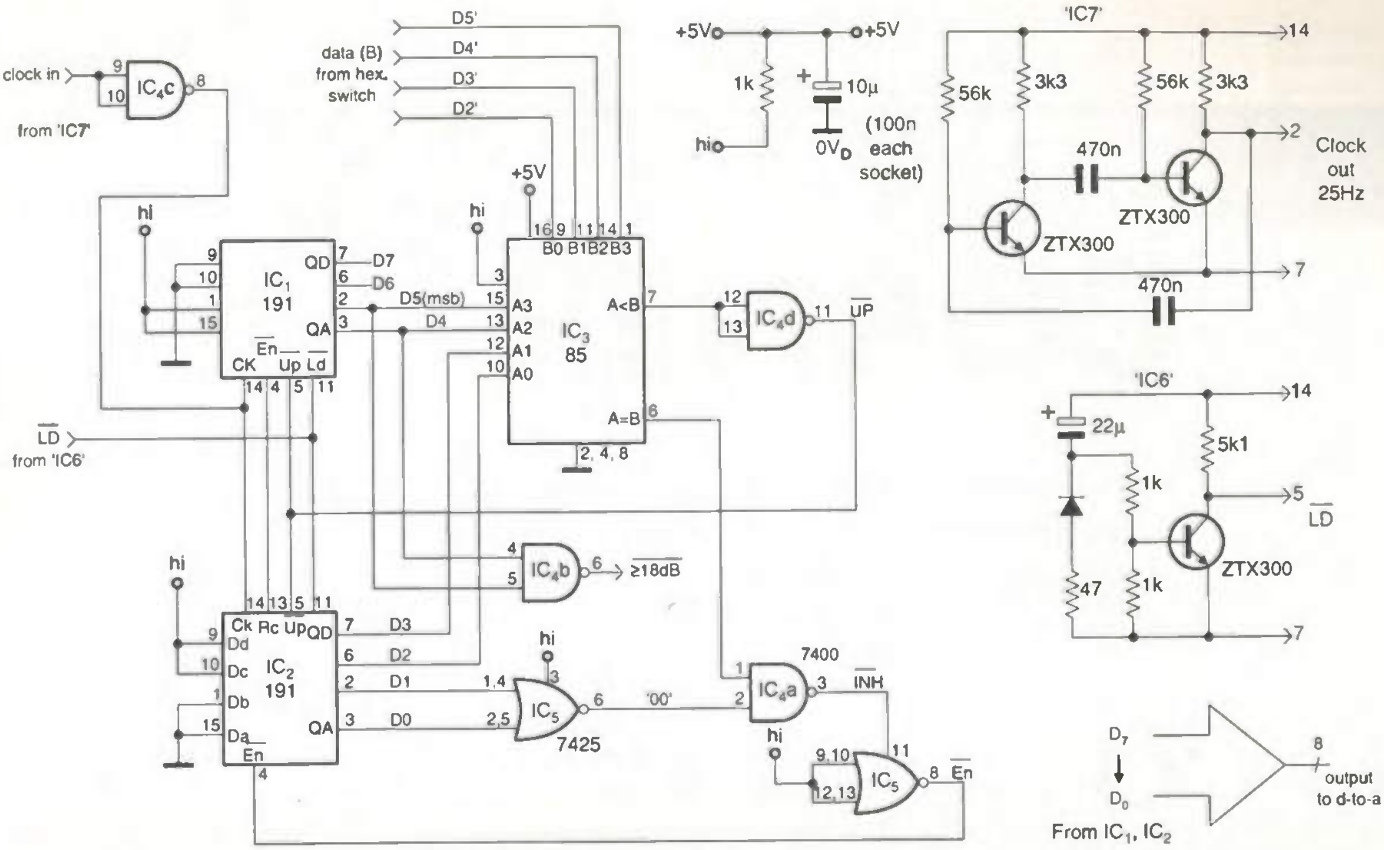
The digital parts should be separated from the analogue parts. I wire-wrapped the digital ICs, and 'IC_6' and 'IC_7' were constructed on 14-pin DIL headers which plug into sockets in the digital card. The analogue circuitry was built on strip board, as were the supply regulators.

Special features

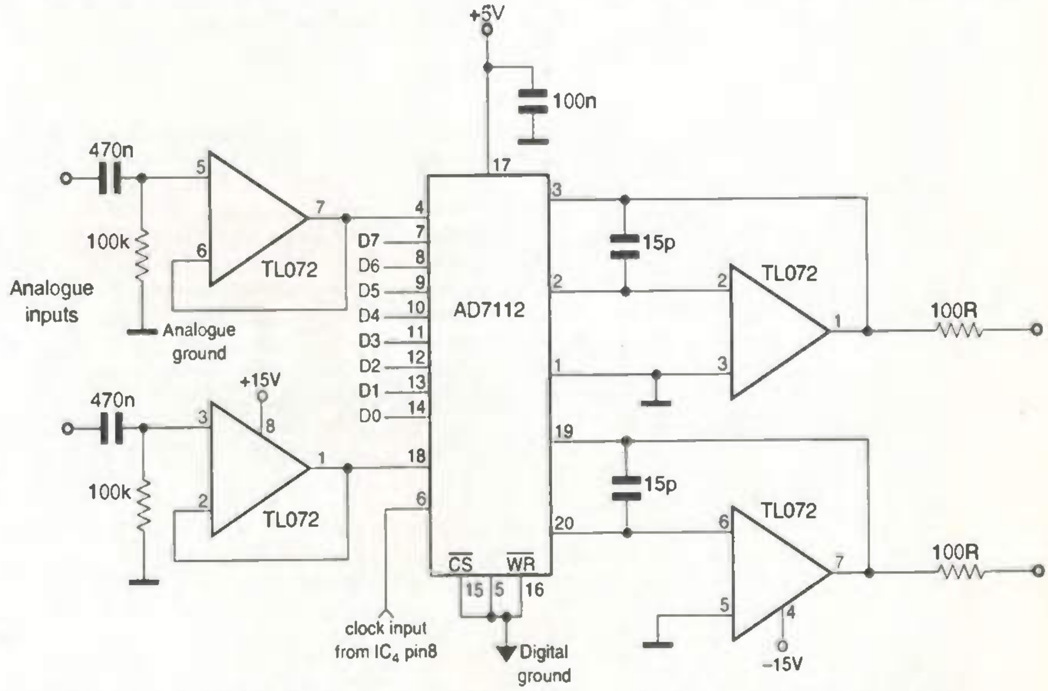
The fader increments in steps of 0.375dB between the 1.5dB switch indents, which gives a very smooth fade. An 18dB warning led is mounted adjacent to the 18dB switch position so as to alert the operator that there are only two counter-clockwise positions remaining, and that the preceding pre-amplifier will soon run out of headroom unless its gain is reduced.

Attenuation obtained for each digital value that can be fed to the d-to-a converter.

Atten (dB)	Data A D_7	D_6	D_5*	D_4*	D_3*	D_2*	D_1	D_0	Data B*	
0	0	0	0	0	0	0	0	0	00_{16}	0_{16}
1.5	0	0	0	0	0	1	0	0	04_{16}	1_{16}
3	0	0	0	0	1	0	0	0	08_{16}	2_{16}
4.5	0	0	0	0	1	1	0	0	$0C_{16}$	3_{16}
6	0	0	0	1	0	0	0	0	10_{16}	4_{16}
7.5	0	0	0	1	0	1	0	0	14_{16}	5_{16}
9	0	0	0	1	1	0	0	0	18_{16}	6_{16}
10.5	0	0	0	1	1	1	0	0	$1C_{16}$	7_{16}
12	0	0	1	0	0	0	0	0	20_{16}	8_{16}
13.5	0	0	1	0	0	1	0	0	24_{16}	9_{16}
15	0	0	1	0	1	0	0	0	28_{16}	A_{16}
16.5	0	0	1	0	1	1	0	0	$2C_{16}$	B_{16}
18	0	0	1	1	0	0	0	0	30_{16}	C_{16}
19.5	0	0	1	1	0	1	0	0	34_{16}	D_{16}
21	0	0	1	1	1	0	0	0	38_{16}	E_{16}
22.5	0	0	1	1	1	1	0	0	$3C_{16}$	F_{16}



Digital side of the fader. The clocking and data-loading subcircuits on the right are called 'ICs' since they were built as modules that plugged into IC sockets for convenience. Circuitry on the left is devoted to producing the digital word representing the amount of attenuation. This word is fed to the digital-to-analogue circuit below.



The fader is designed for use at output levels of around 0dBm, i.e. 0.775Vrms. At this level 'zipper' noise during fading – caused by inherent charge transfer in the d-to-a converter – is not audible on 'silence' or music programme. It can just be detected as a quiet 'cat-purr' on pure test tones of frequency below about 250Hz, but at higher frequencies one just hears a perfectly smooth fade.

Variants

If a wider control range of 45dB in 3dB increments is preferred, this can be implemented by changing the data A inputs to the magnitude comparator to $D_{6\text{-}3}$ from the counter, and using a third input to IC_5 nor gate to sense when lines $D_{2\text{-}0}$ are all at logic zero.

Muting on the last switch position can be implemented via a four-input nand gate whose inputs are the B data from the switch, and whose output sets the d-to-a converter control data to FX and lights a mute led.

A programmable memory is probably the easiest way to provide an lcd or led display of decibels attenuation.

Looping back from the fader output to the input buffer amplifiers could provide an amplifier with gain selectable between 0 and +22.5dB or 0 to 45dB.

Arranging for inverted data to be fed to one channel of the d-to-a converter provides a pan potentiometer.

The table lists the data A and data B* values corresponding to the sixteen available switch steps. ■

Simplicity. The binary word from the digital circuit feeds $D_{0\text{-}7}$ of the d-to-a converter to provide 0 to 22.5dB of attenuation in 1.5dB steps. The clever part is that although the switch selects 1.5dB attenuation increments, the fader transits between each step in much smaller increments, giving a smooth fade.

SPEAKERS' CORNER

Linearity – John Watkinson looks at what happens in the speaker's gap, and how different design slants affect sound quality.

One of the hardest parameters to optimise in a moving coil transducer is linearity. Unfortunately, the criteria for linearity in loudspeakers increases as other defects are removed. For example if a diffraction controlled cabinet shape is used, the stereophonic imaging accuracy will improve, but the drive units will have to be made more linear.

This is because in an intensity stereo system, all of the virtual sound sources which are created at different points between the speakers are due to signal pairs presented to the speakers. These differ only in amplitude.

When there are many sound sources, each speaker gets a waveform which is the sum of a large number of different sounds. If there is the slightest non-linearity, there will be intermodulation which will produce sound sources which were not in the original sound.

In monophonic reproduction, these intermodulated sound sources will be in the same place as the original sounds and so will be partially masked. But in stereo, intermodulated sources will not be masked so well because attentional selectivity – also known as the cocktail party effect – allows the listener to concentrate on sound from a particular direction to the partial exclusion of other sounds. This phenomenon allows intermodulation products to be heard when they are in a different location in the image. Thus the better the imaging performance of a pair of loudspeakers, the lower the intermodulation distortion allowable.

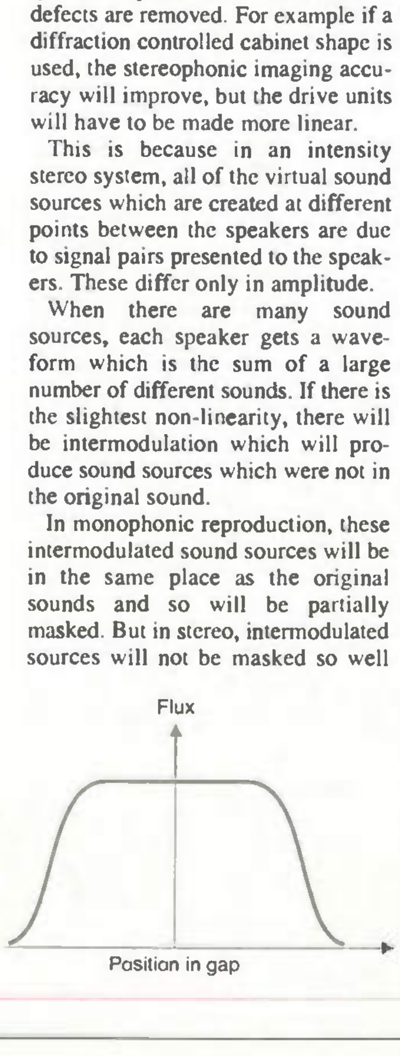


Fig. 1. Flux distribution in the loudspeaker coil's gap should be symmetrical.

Intermodulation at mid and top frequencies is most obvious on choral music where there are many similar sound sources in different places in the image, and in flute music.

Does distortion at lf matter?

In low-frequency speakers, the widespread – and incorrect – use of porting and resonance means that most speakers suffer linear distortion. This can mask non-linear distortion, leading to the popular myth that distortion doesn't matter at low frequencies.

If I can hear the difference between a real bodhran or a real tympanum and the version from a loudspeaker, I have to conclude it's the speaker that's wrong.

The linearity of a driver used in a sealed enclosure probably has to be better than that used in a ported alignment. Drive units intended for high-quality speakers must be designed to eliminate all potential sources of non-linearity, of which there are many. Only when all of these have been dealt with will the necessary performance be realised.

Remedying all problems but one may result in little improvement because the remaining problem prevents the other improvements being heard.

Most of the non-linearities in a moving coil transducer originate with the motor system. One fundamental requirement is that the force generated by the motor should be independent of the coil position. **Figure 1** shows that this requires the flux distribution in the gap to be exactly symmetrical so that as part of the coil moves out of one side of the field it is exactly balanced by the part of the coil moving in on the other side.

Designing a symmetrical field motor is not especially difficult, but the parts have more complex shapes and cost a little more to make. The result is that the overwhelming majority of magnetic circuits in today's drive units are sub-optimal because they are designed for economy.

Spider webs

In woofers, the cone travel is such that the performance of the spider and surround can affect linearity. The majority of spiders in use today are highly non-linear because the restoring force isn't proportional to deflection. Instead it increases disproportionately as the cone moves away from the neutral point.

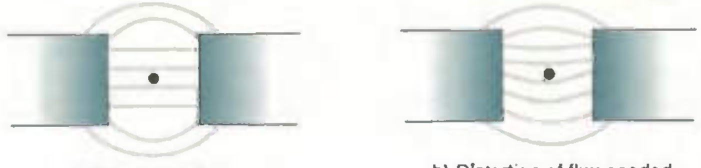
This form of distortion can be reduced dramatically by studying how spiders actually work and formally designing them rather than just copying what the industry normally produces.

In tweeters, the amplitude of motion is relatively small and the operating frequency range is well above resonance so that the motion of the cone is mass controlled. Here the linearity of the spider is not so important, but other effects are.

The force created in the coil is caused by the flow of current interacting with the magnetic field from the magnet. The lines of flux of a quiescent speaker motor are precisely orthogonal to the direction of motion and act as though they are in tension as shown in **Fig. 2a)**. The only way a force can be created is if the lines of force are deflected as in **2b)** so that a component of tension acts in the direction of coil motion.

As a result, as the coil accelerates forwards, the gap flux is pushed backwards – that Newton chap again – and *vice versa*. The motion of the flux within the magnet and the magnetic circuit can produce distortion.

Inside the magnet, the only way that the flux can move is by the shifting of domain walls. This requires energy, is hysteretic and fundamentally non-linear. Thus the flux does not move smoothly, but in a series of jumps.



a) Flux in gap with no coil current

b) Distortion of flux needed to create drive force

Fig. 2. Flux in gap with no coil current, a), and distortion of field needed to create drive force, b).

In magnetic tape and disk heads the result is called Barkhausen noise. In loudspeakers the effect is that of program modulated noise, similar but not identical to the modulation noise of an analogue tape recorder.

One way of stopping flux modulation is to use an electrically conductive magnet material. If the magnet is conductive, field shifts will have to generate huge eddy currents in a short circuit.

Useful for clamping shopping lists

Neodymium magnets are clearly superior here as they are highly conductive. As for ferrite magnets, well, they are insulators and serious loudspeaker designers only use them to hold shopping lists onto the door of the fridge.

Flux modulation in steel pole pieces is resisted by the same effect because steel is a conductor, but some designers use copper plated pole pieces because copper has much lower resistivity than steel.

It is instructive to compare transducer construction technologies practically. One comparison which is striking is to make a tweeter in which the magnetic circuit can be interchanged. Using the same software with a traditional ferrite magnet having mass produced poles or with a designer neodymium magnetic circuit produces a remarkable difference in clarity.

Finally, linearity can potentially be improved using motional feedback, but that will have to wait for another time.■

Despite being passive, the hybrid coupler-combiner-splitter is a remarkably useful rf component that solves a lot of practical problems. Joseph Carr explains how.

The rf hybrid coupler

The hybrid coupler, Fig. 1, is an audio or radio frequency device that will either split a signal source into two directions, or combine two signals sources into a common path.

The symbol shown in Fig. 1 is essentially a signal path schematic. Consider the situation where an rf signal is applied to port 1. This signal is divided equally, flowing to both ports 2 and 3.

Because the power is divided equally the hybrid is called a 3dB divider, i.e. the power level at each adjacent port is one-half of the power applied to the input port, i.e. –3dB.

If the ports are properly terminated in the system impedance, then all power is absorbed in the loads connected to the ports adjacent to the injection port. None travels to the opposite port. The termination of the opposite port is required, but it does not dissipate power because the power level is zero.

The one general rule to remember about hybrids is that *opposite ports cancel*. That is, power applied to one port in a properly terminated hybrid will not appear at the opposite port. In the case cited above, the power was applied to port 1, so no power appeared at port 4.

One of the incredibly useful features of the hybrid is that it accomplishes this task while allowing all devices connected to it to see the system impedance, R_0. For example, if the output impedance of the signal source connected to port 1 is 50Ω, the loads of ports 2 and 3 are 50Ω, and the dummy load attached to port 4 is 50Ω, then all devices are either looking into, or driven by, the 50Ω system impedance.

One source of reasonably priced hybrid devices is Mini-Circuits Laboratories. This company has a large selection of 0°, 90° and 180° hybrid combiners and splitters.

Applications of hybrids

The hybrid can be used for a variety of applications where either combining or splitting signals is required.

Combining signal sources. In Fig. 2, two signal generators connect to opposite ports of a hybrid, i.e. ports 2 and 3. Power at port 2 from signal generator 1 is therefore cancelled at port 3, and power from signal generator 2, port 3, is cancelled at port 2. Therefore, the signals from the two signal generators will not interfere with each other.

In both cases, the power splits two ways. For example, the power from signal generator 1 flows into port 2 and splits two ways. Half of it, i.e. 3dB, flows the path from port 2 to port 1, while the other half flows from port 2 to port 4. Similarly with the power from signal generator 2 applied to port 3. It splits into two equal portions, with one flowing to port 1 and the device under test, and half flowing to the dummy load.

Bi-directional amplifiers. A number of different applications exists for bi-

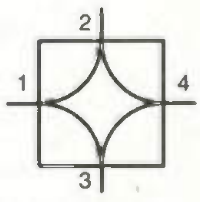


Fig. 1. Symbol for hybrid – a device that can split or combine two signals.

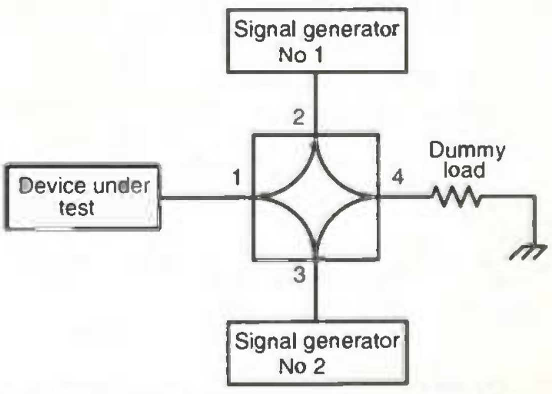


Fig. 2. Combining two signal sources. Power at port 2 is cancelled at port 3 and power at port 3 is cancelled at port 2 so the signals from the two signal generators will not interfere with each other.

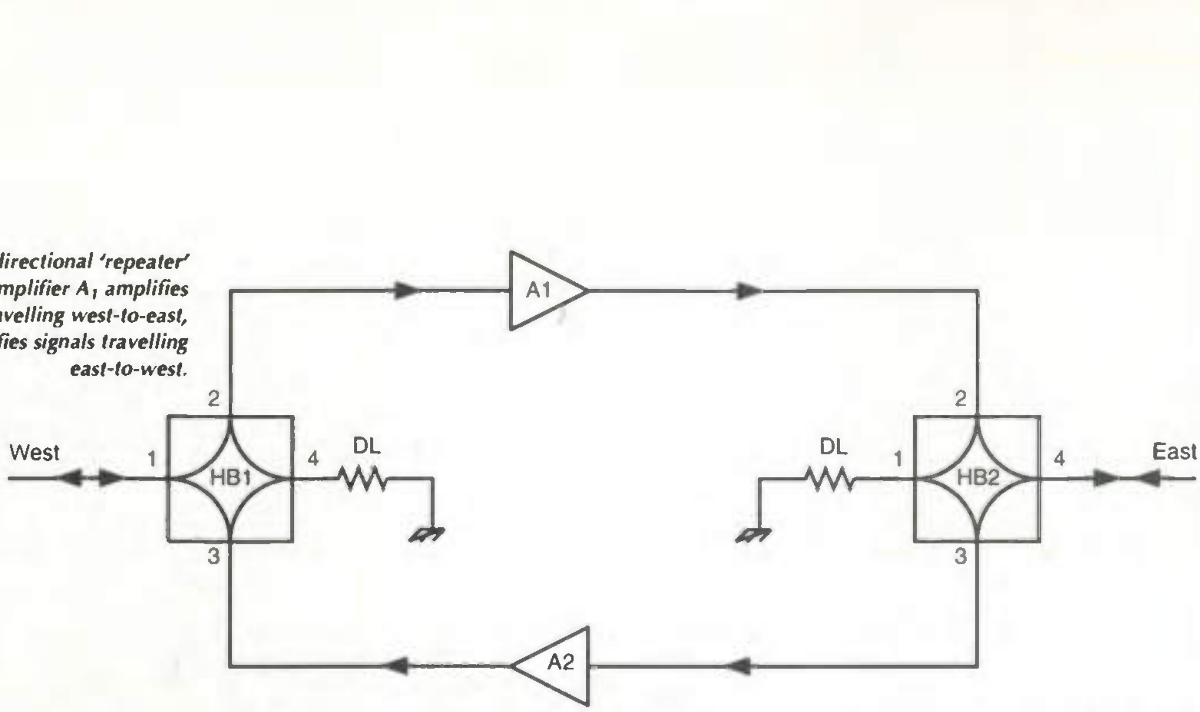


Fig. 3. Bidirectional 'repeater' amplifier. Here, amplifier A_1 amplifies the signals travelling west-to-east, while A_2 amplifies signals travelling east-to-west.

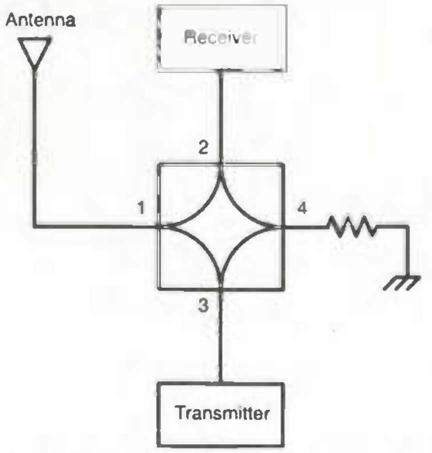


Fig. 4. Use of hybrid as a transmit/receive switch. Here, the transmitter output and receiver input connect to opposite ports of a hybrid device so transmitter power does not reach the receiver input.

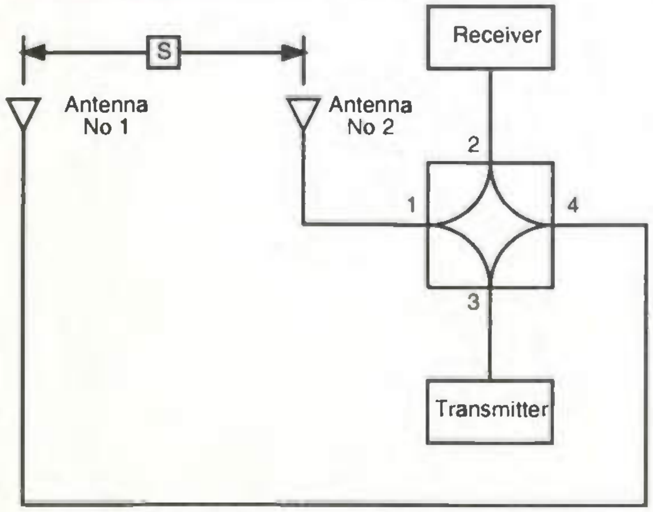


Fig. 5. Combining two antennas in transmit/receive switch. Using a second antenna instead of the dummy load reduces losses. With this configuration, you can get various directivity patterns using two identical antennas.

directional amplifiers. These are amplifiers that can handle signals from two opposing directions on a single line.

The telecommunications industry, for example, uses such systems to send full duplex signals over the same lines. Similarly, cable tv systems that use two-way cable modems require two-way amplifiers.

Figure 3 shows how the hybrid coupler can be used to make such an amplifier. In some telecommunications textbooks the two directions are called east and west, so this amplifier is occasionally called an east-west amplifier. At other times this circuit is called a repeater.

In the bidirectional east-west amplifier of **Fig. 3**, amplifier A_1 amplifies the signals travelling west-to-east, while A_2 amplifies signals travelling east-to-west. In each case, the amplifiers are connected to hybrids HB_1 and HB_2 via opposite ports, so will not interfere with each other.

Otherwise, connecting two amplifiers input-to-output-to-input-to-output is a recipe for disaster... even if only a large amount of destructive feedback results.

Transmitter/receiver isolation. One of the problems that exists when using a transmitter and receiver together on the same antenna is isolating the receiver input from the transmitter input. Even a weak transmitter will burn out the receiver input if its power were allowed to reach the receiver input circuits.

One solution is to use one form of transmit/receive relay. But that solution relies on an electromechanical device, which adds problems of its own – not the least of which is reliability.

A solution to the transmit/receive problem using a hybrid is shown in **Fig. 4**. Here, the transmitter output and receiver input are connected to opposite ports of a hybrid device. Thus, the transmitter power does not reach the receiver input.

The antenna connects to the adjacent port between the transmitter port and the receiver port. Signal from the antenna will flow over the port 1 to port 2 path to reach the receiver input. Transmitter power, on the other hand, will enter at port 3, and is split into two equal portions. Half the power flows to the antenna over the port 3 to port 1 path, while half the power flows to a dummy load through the port 3 to port 4 path.

There is a problem with this configuration. Because half the power is routed to a dummy load, there is a 3dB reduction in the power available to the antenna. A solution is shown in **Fig. 5**. In this configuration a second antenna is connected in place of the dummy load. Depending on the spacing, *S*, and the phasing, various directivity patterns can be created using two identical antennas.

If the hybrid produces no phase shift of its own, then the relative phase shift of the signals exciting the antennas is determined by the length of the transmission line between the hybrid and that antenna. A 0° phase shift is created when both transmission lines are the same length.

Making one transmission line half wavelength longer than the other results in a 180° phase shift. These two relative phase relationships are the basis for two popular configurations of phased array antenna.

You'll find more options in a good antenna book.

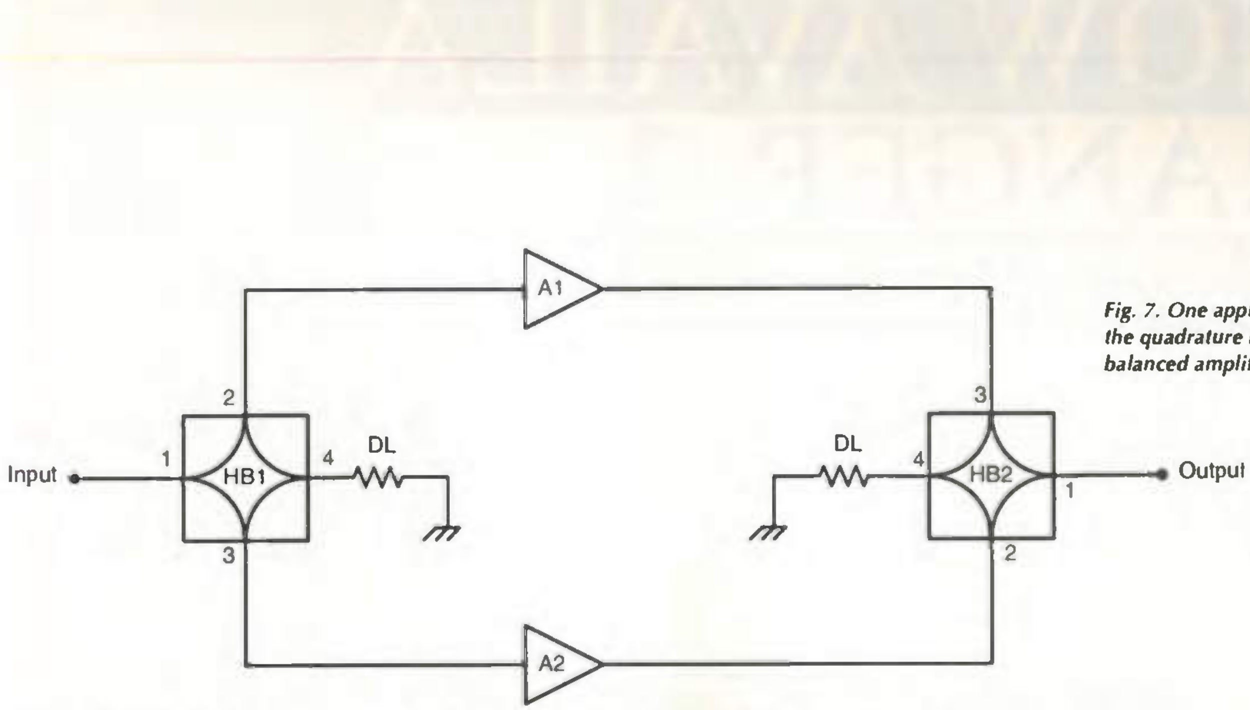


Fig. 7. One application for the quadrature hybrid is the balanced amplifier.

Phase-shifted hybrids

The hybrids discussed thus far split the power half to each adjacent port, but the signals at those ports are in-phase with each other. That is, there is a zero degree phase shift over the paths from the input to the two output ports.

There are, however, two forms of phase shifted hybrids. The one shown in **Fig. 6a)** is a 0°-180° hybrid. The signal over the port 1 to port 2 path is not phase shifted (0°), while that between port 1 and port 3 is phase shifted 180°. Most transformer-based hybrids are inherently 0°-180° hybrids.

A 0°-90° hybrid is shown in Fig. **6b)**. This hybrid shows a 90° phase shift over the port-1/port-2 path, and a 0° phase shift over the port-1/port-3 path. This type of hybrid is also called a quadrature hybrid.

One application for the quadrature hybrid is the balanced amplifier shown in **Fig. 7**. Two amplifiers, A_1 and A_2 are used to process the same input signal arriving via hybrid HB_1. The signal splits in HB_1, so becomes inputs to both A_1 and A_2. If the input impedances the amplifiers are not matched to the system impedance, then signal will be reflected from the inputs back towards HB_1.

The reflected signal from A_2 arrives back at the input in-phase, at 0°, but that reflected from A_1 has to pass through the 90° phase shift arm twice, so has a total phase shift of 180°. Thus, the reflections caused by mismatching the amplifier inputs are cancelled out.

The output signals of A_1 and A_2 are combined in hybrid HB_2. The phase balance is restored by the fact that the output of A_1 passes through the 0° leg of HB_2, while the output of A_2 passes through the 90° leg. Thus, both signals have undergone a 90° phase shift, so are now restored to the in-phase condition.

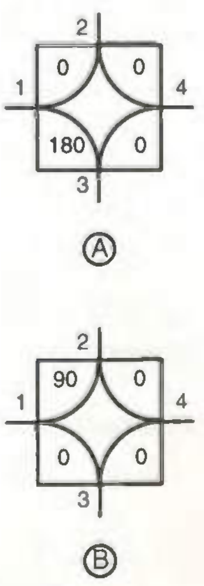


Fig. 6. Symbolic phase shifted hybrids, a 180° hybrid, a) and a 90° hybrid, b).

Use with receiving antennas. Examples given above combine a receiver and transmitter on a single antenna or antenna system. It's also possible to use the hybrid for antenna arrays intended for receivers.

Antennas spaced some distance *X* apart will have different patterns and gains depending on the value of *X* and the relative phase of the currents in the two antennas. This means that you can connect the antennas to ports 2 and 3, and the receiver antenna input to port 1. A terminating resistor would be used at port 4.

You can use either 0°, 90° or 180° hybrids depending on the particular antenna system.

In summary

The hybrid coupler-combiner-splitter is a remarkably useful passive rf component that will solve a lot of practical problems. ■

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HP532B Frequency Meter £200.00
HP536A Frequency Meter 3.7-12.4GHz £200.00
HP54111A 2GHz S/S Test Set £580.00
HP8410B £200.00
HP8414A £175.00

DATA/TELECOMS

Anritsu MS334A PCM Error Detector £120.00
BT (Fulcrum) T1020 Network Transmission Performance Analyzer £500.00
Cushman CE24 FX Selection Level Meter £400.00
Datalab DL1000 Programmable Transient Recorder £250.00
GN Elmi EPR31 PCM Signalling Recorder £5000.00
HP1350A Graphics Translator £200.00
HP1631D Logic Analyzer £650.00
HP3336A Synthesized/Level Generator £1300.00
HP3497A Data/Acquisition Control Unit £400.00
HP3586B Selective Meter from £850.00
HP3717A 70MHz Modulator/Demodulator £POA
HP37201A HP-IB Extender £300.00
HP37204 HP-IB Extender £300.00
HP3762A Data Generator £350.00
HP3763A Error Detector £800.00
HP3764A Digital Transmission Analyzer £3200.00
HP3770B Telephone Line Analyzer £200.00
H3780A Pattern Generator/Error Detector £1100.00
HP3781A Pattern Generator £500.00
HP3782A Error Detector £500.00
HP4935A Transmission Tester £1100.00
HP4984A In-service Transmission Impairment Measuring Set £POA
HP5005B Signature Tester £950.00
HP5006A Signature Analyzer £50.00
HP6942A Multiprogrammer £200.00
HP8170A Logic Pattern Generator £600.00
HP8954A Transceiver Interface £600.00
Iwatsu DM2350 Digital Memory 10 bit/20ns £400.00
Marconi 2828A Digital Simulator £200.00
Marconi 2829 Digital Analyzer £200.00
Marconi 2831 Channel Access Switch £200.00
Marconi OA2805 PCM Regenerator Test Set £250.00
Marconi TF2019C Noise Generator – many filters available £250.00
Marconi TF2092C Noise Receiver £250.00
Marconi TF2808/2 Pattern Generator and SLMS £120.00
Marconi TF2807A PCM Multiplex Tester £200.00
Marconi TF2830 Multiplex Tester £200.00

OSCILLOSCOPES

Tektronix TAS455 60MHz Dual Channel Oscilloscope £800.00
Gould 1602 Digital Storage Oscilloscope 20MHz £1250.000
Gould OS300 20MHz Oscilloscope £120.00
Hitachi VC6015 Digital Storage Oscilloscope £300.00
Hitachi VC222 20MHz Oscilloscope £225.00
Iso-Tech ISR640 40MHz £200.00
Philips PM3340 2GHz Digital £3000.00
Philips PM3305 35MHz £250.00
Philips PM3325A 60MHz DSO £1000.00
Philips PM3262 100MHz £250.00
Philips PM3352A 50MHz Storage £900.00
Tek 2215 60MHz £300.00
Tek 2225 50MHz £350.00
Tek 2235 600MHz £500.00
Tek 2236 100MHz £500.00
Tek 465 100MHz £250.00
Tek 475 200MHz £350.00
Tek 468 100MHz DSO £500.00

POWER SUPPLIES

Farnell PDA3502A 0-35V 0-2A £160.00
HP6634A Systems DC Power Supply 0-100V 0-1A 100W £650.00
HP6653A Systems DC Power Supply 0-35V 0-15A £800.00
HP6264B 0-20V 0-20A £250.00
HP6181C DC Current Source 0-100V 0-250mA £300.00
Powerline Electronics 0-70V 0-10A £175.00
Farnell Type. 60/25 0-60V 0-25A Metered – Brand New £400.00
General Radio 1265A DC Power Supply 0-400V 0-5A £475.00
Farnell TSV70 MK2 Stabilised Power Supply £180.00
Farnell 30/100 30V 100A £700.00
Power Ten Systems Power Supply 0-30V 0-60A £300.00
Powerline Type: LAB510 0-30V 0-10A £175.00
Powerline Type: LAB532 5V-5A + 15V-0.5A, –15V-0.5A, 0-30v-2A £200.00

SIGNAL ANALYZERS

HP8903B Audio Analyzer £2500.00
HP3708A Noise & Interference Test Set £POA
HP3561A Dynamics Signal Analyzer £4000.00
HP8980A Vector Analyzer £5000.00
Takeda Riken TR4172 Spectrum/Network Analyzer 1.8GHz £8500.00
HP8901A Modulation Analyzer £1500.00
HP5370A Universal Counter/Timer £850.00
Philips PM6680 High Resolution Programmable Timer/Counter option C fitted £1350.00
Philips PM6666 Timer/Counter £300.00
Philips PM6666 Option C fitted Timer/Counter £650.00
Marconi 2955 Test Set £1850.00
Advantest TR4132 Spectrum Analyzer 1GHz £1500.00
B&K 2033 Signal Analyzer £2000.00
B&K 2636 Measuring Amplifier £4000.00
B&K 5935 Dual Microphone Supply £650.00
HP182T + HP8558B Spectrum Analyzer 100KHz-1.5GHz £1200.00
HP334A Distortion Analyzer £250.00
HP339A Distortion Measuring Set £1200.00
HP3580A 25KHz Spectrum Analyzer £600.00
Marconi 2306 Modulation Meter £2000.00
Marconi 2382 + 2380 400MHz Spectrum Analyzer £3500.00
Marconi 2601 True RMS Voltmeter £500.00
Marconi TF2370 110MHz Spectrum Analyzer £600.00
R&S URE RMS Voltmeter £800.00
R&S ZPV + E3 Plug-in .3-2GHz £1800.00
R&S CMS52 Comms. Service Monitor £5000.00
Tektronix DA4084 Programmable Distortion Analyzer £700.00

SIGNAL GENERATORS

Adret 7100B 300KHz-650MHz £700.00
Cushman CE12 Two Tone Generator £150.00
Farnell DSG2 Synthesized 0.1MHz-110KHz £185.00
Flann 4311A 12-18GHz £50.00
Fluke 6010A 10Hz-11MHz Synthesized £175.00
HP11710B Down Convertor (HP8640B) £275.00
HP214B Pulse Generator 100V 2A £1200.00
HP3325A Synthesized Generator 1Hz-21MHz £1250.00
HP4204A Oscillator 10Hz-1MHz £125.00
HP654A Test Oscillator 10MHz £225.00
HP8005B 0.3Hz-10MHz £300.00
HP8008A 10Hz-200MHz £450.00
HP8015A 1Hz-50MHz Pulse £450.00
HP8165A Programmable Signal Source £1200.00
HP8620C + HP86222B 0.01-2.4GHz Sweeper £1200.00
HP8642M 0.1-2100MHz £17500.00
HP8657A 0.1-1040MHz £3500.00
HP8684B 5.4-12.5GHz £1950.00
Marconi 2019A 80KHz-1040MHz £1450.00
Marconi 2022 10KHz-1GHz £900.00
Marconi 6057 Signal Source 5.5-8.5GHz £200.00
Marconi 6059A 12-18GHz Signal Source £200.00
Racal 9053 Two Tone £120.00
Systron Donner 1702 Audio-1GHz £600.00
Tektronix 504 0.001-240MHz £350.00
Tektronix FG501A 2MHz Function £250.00
Wavetek 1080 1-1000MHz Sweeper £800.00
Wavetek 157 Programmable Waveform £150.00
Wavetek 159 Waveform Generator 1Hz-3MHz £300.00
Wavetek 171 Synthesizer/Function £400.00
Wavetek 185 Sweeper/Function 0-5MHz £350.00
Wavetek 2001 1-1400MHz £600.00
Wavetek 907A 7-12.4GHz £900.00
Wiltron 610D + 6223B Sweeper 4-12.4GHz £500.00
Systron Donner 1720 Signal Source 50MHz-18GHz £2000.00
HP8091A + 8092A + 8093A (x2) 1GHz Pulse Generator System £650.00
Marconi TF2015 + TF2017 10-520MHz £200.00

MISCELLANEOUS

I. L. X. LIGHTWAVE EQUIPMENT.
LDT5901B Temperature Controller
PDA6424 Photo Diode Amplifier
LDX3742 Laser Diode Controller
LDX3207B Precision Current Source
3M Fibre Splice Preparation Kit
Cossor Optical Cable Fault Locator Type: OFL108L
Laser Precision Type: DB2900 Single Mode Variable Attenuator
Schlumberger Type: S17780 DTDR + S177823 Plug-in
Solomat MPM4000 Matrix Processor c/w Software. Portable multichannel, datalogger, alarm monitor. Battery/Mains Operated Kane-May. KM4003 Air Velocity 0-30 in metres/seconds Air Temperature (C) –30 to +200C. Battery Operated
Portaflow MK11: Portable diagonal beam flowmeter. Made by: Micronics
Bacharach: Combustion Analyzer/Environmental monitor Type: 300NSX Kane-May Combustion Analyzer Type: 9004
Kane-May: Temperature Sensor Type: 1204 c/w 8004
Temperature & humidity sensor. GGA-26 Thermo-Anemometer + KM801 Infratrace
Casella: Aerosol Monitoring System Type. AMS950 Ranges: 0-20mg/m 0-200mg/m
CEL Instruments: Precision Intergrating Impulse Meter Type: CEL 493 c/w CEL 296 Octave & third octave scan filter set + CEL 284/2 Calibrator
Hoffmann SWM3 Flow Meter
CEL 281 + 281 Keypad + Programmable Noise Dosemeter
Neotronics Exotox 75 Ambilog + Charger. Portable atmosphere monitor

PRINTERS

HP2225A/D Thinkjet Printer HPIB £95.00
HP7550A Plotter £250.00
HP Draft Master RX £500.00

NEW STOCK

HP8753C + HP85047A 300KHz-6GHz Network Analyser System Option: 002, 006 & 010 fitted £11,000.00
HP8672A 2-18Ghz Synthesised Signal Generator £4,850.00
HP8673D 0.05-26GHz Synthesised Signal Generator £9,000.00
HP8756A Scaler/Network Analyser £950.00
HP436 Power Meter + HP8481 Sensor £900.00
HP8111A 20MHz Programmable Pulse Generator £1,200.00
Tek 2465/A/B/CT: 300MHz + Oscilloscope From £1,500.00
R&S AFG Function Generator 10mHz-20MHz £2,000.00
Philips PM5786B Pulse Generator 1Hz-125MHz rise time 2ns to 0.1s £1,250.00
Gould 4072 400Ms/s 100MHz DSO c/w Integral Printer £750.00

CIRCLE NO.121 ON REPLY CARD

This designers' note written by Minicircuits looks at how power splitters work, what parameters are critical, and how to select the best value for your application.

Understanding power splitters

Basically, a 0° splitter is a passive device which accepts an input signal and delivers multiple output signals with specific phase and amplitude characteristics.

Theoretically, the output signals possess the following characteristics:

- equal amplitude
- 0° phase relationship between any two output signals
- high isolation between each output signal
- insertion loss as in the **Table**.

Since the 0° power splitter is a reciprocal passive device it may be used as a power combiner simply by applying each signal singularly into each of the splitter output ports. The vector sum of the signals appears as a single output at the splitter input port.

The power combiner exhibits an insertion loss that varies depending on the phase and amplitude relationship of the signals being combined. For example, in a two-way 0° power splitter/combiner, as outlined in **Fig. 1**, if the two input signals are equal in amplitude and are in-phase then the insertion loss is zero.

However, if the signals are 180° out of phase the insertion loss is infinite. And, if the two signals are at different frequencies, the insertion loss will equal the theoretical insertion loss shown in the Table.

The power combiner also exhibits isolation between the input ports. The amount of isolation depends on the impedance termination at the combiner output or sum port. For example, in the two-way 0° power splitter/combiner of Fig. 1, if port S is open then the isolation between ports A and B would be 6dB. And, if port S is terminated by a matched impedance for maximum power transfer, then the isolation between ports A and B would be infinite.

The following signal processing functions can be accomplished by power splitter/combiners:

- Add or subtract signals vectorially.
- Obtain multi in-phase output signals proportional to the level of a common input signal.
- Split an input signal into multi-outputs.
- Combine signals from different sources to obtain a single port output.
- Provide a capability to obtain rf logic arrangements.

Basic power splitter analysis

The most basic form of a power splitter is a simple 'T' connection, which has one input and two outputs, **Fig. 2**. If the T is mechanically symmetrical, a signal applied to the input is divided into two output signals, equal in amplitude and phase.

This arrangement is simple and it

Table. Theoretical power splitter insertion losses for different numbers of output ports.

Ports	Loss
2	3.0dB
3	4.8dB
4	6.0dB
5	7.0dB
6	7.8dB
8	9.0dB
10	10.0dB
12	10.8dB
16	12.0dB
24	13.8dB
48	16.8dB

Fig. 1. When the combiner/splitter is used as a 0° power splitter, the input is applied to port S and equal outputs appear at ports A and B. When used as a power combiner, both inputs are applied to ports A and B and the sum taken from port S.

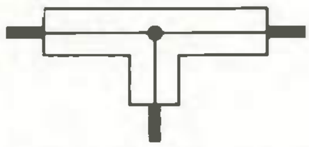


Fig. 2. Basic two-way or power splitter is a simple 'T'.

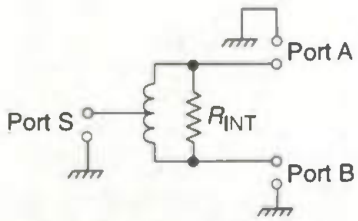


Fig. 3. In two-way splitter/combiner, equal and opposite currents flow through the internal resistor and transformer and cancel each other. This provides high isolation between ports A and B.

works, but with limitations. Two obvious limitations are impedance mismatch and poor isolation.

In a 50Ω system, each output would be connected to a 50Ω impedance, resulting in a 25Ω impedance to the input port. Thus, the impedance looking into the common or input port would present a mismatch in a 50Ω system. To correct this mismatch, a 25 to 50Ω matching transformer is necessary for the simple T.

Now, consider the second serious limitation of a simple T – poor isolation.

Suppose, for example, that two antennas were fed to a receiver input using a simple T as a combiner. If one antenna appears as a short at its resonant frequency, it would load down the other antenna and, in effect, wipe out the receiver input.

However, a properly designed power combiner would provide high isolation between inputs so that the antenna 'short condition' at one input would have little influence on the other input and would cause approximately a 3:1 vswr mismatch at the output port – in this case, the receiver input.

In a simple T-circuit power combiner the isolation between input ports depends on the impedance termination at the output port. If the output port is open then the input ports would have zero isolation between them. And, if the output port is terminated by a matched impedance the isolation would be 3dB.

Improving upon the simple T circuit, consider the basic lumped element power splitter/combiner circuit of Fig. 3. The transformer has an equal number of turns from the centre tap to each end. Therefore, as an auto transformer with a 2-to-1 turns ratio, the impedance across the output ends is four times larger than the impedance across the centre tap to one end.

Let's examine how this circuit enables high isolation between ports A and B. As a power combiner, an input signal applied to port A causes a current to flow through the transformer and experience a 180° phase shift by the time it arrives at port B. Similarly, a current will also flow through R_{INT} and will not experience a phase shift by the time it arrives at port B.

When R_{INT} equals the impedance value across the transformer ends then, the currents appearing at port B will be equal in amplitude but opposite in phase and cancel. The net result is that no voltage appears at port B from the input signal applied at port A. Thus, there is theoretically infinite isolation between the ports.

Find insertion loss

Further examining the circuit of Fig. 3, let's determine the theoretical insertion loss between port S and ports A and B. As a power splitter, a signal applied at port S will be split so that identical signals appear at ports A and B, due to the circuit symmetry.

If the impedance values are matched then maximum power transfer will take place and half the input power would appear at each port resulting in a 3dB theoretical loss at each port. Furthermore, under the conditions described the circuit is lossless since the voltage across R_{INT} is zero.

Let's take an example to illustrate the concepts described. Suppose we have a 50Ω system so that ports A and B are each terminated in 50Ω. They appear across the transformer in series so that a 100Ω transformer impedance is required for optimum power match. Since the transformer has a 4 to 1 impedance ratio, the impedance at port S is 25Ω.

In this example we have to add a 2 to 1, i.e. 50 to 25Ω, transformer at port S so that its impedance is matched to the 50Ω system. Remember that to obtain maximum isolation the value of R_{INT} equals the transformer impedance, i.e. 100Ω.

We have now completely specified the circuit values of the 50Ω two-way 0° power splitter.

How does mismatch affect isolation?

Consider the ideal situation in a two-way power combiner where there is infinite isolation between the two input ports. A signal applied to port A will be routed to port S, minus a 3dB loss in the internal resistor; since isolation is perfect, none of the input signal will reach the other input port.

Now, if port S is properly terminated, the sum signals will be absorbed and nothing will be reflected back to the input ports. This is fine, as long as port S is properly terminated and there is thus no mismatch.

Now, let's consider two examples of mismatch at port S, one slight, the another large. Assume a + 20dBm signal is applied to port A; with perfect isolation, none of this signal reaches port B.

Since there is a 3dB loss between input A and port S due to the loss in the internal resistor, +17dBm arrives at port S ignoring any slight transformer loss. If a slight impedance mismatch exists at port S, which causes a –20dB signal refection, then a signal of –3dBm, i.e. + 17dBm attenuated by 20dB, is sent back to ports A and B. This –3dBm signal experiences a 3dB loss as it is fed to port B, and the mismatch has now resulted in a –6dB signal at input B from port A.

Now, isolation between both input ports is not infinite; there is a +20dBm signal at port A and a –6 dBm signal at port B for an isolation of 26dB. Reason? Slight impedance mismatch at port S.

What about a more serious mismatch? Suppose the +17dBm signal arrives at port S and a mismatch produces a –10dB signal reflection. Now +7dBm is fed back to port B (+17dBm with 10dB loss); add the additional return 3dB loss, and a +4dBm signal appears at port B.

Now isolation is only 16dB – the difference between port A's 20dBm and the 4dBm signal at port B due to the mismatch.

It is important to make sure that port S is properly matched to eliminate reflections and thus maintain high isolation. Mismatch at either port A or B is not critical if port S of a power combiner is properly matched.

If cancellation through the transformer and internal resistor is taking place, there will not be any voltage drop across port A and B and thus no effect on isolation. ■

Hands-on Internet

Cyril Bateman points you in the direction of useful sensor information on the web, and to reports of a new type of bug that reflashes your bios. There's also a note on the benefits and pitfalls of life-time e-mail addresses.

Netscape - [Windows 98 vulnerable to hacking]

File Edit View Go Bookmarks Links Options Directory Window Help

cnet NEWS.COM

MENU
Front Door
The Net
Computing
Intranets
Business
Investor
CNET Radio
Perspectives
Newsmakers
Rumor Mill

NEWS OPTIONS
All the Headlines
Desktop News
News Alerts

Computing

Windows 98 vulnerable to hacking

By Stephanie Miles
Staff Writer, CNET News.com
August 28, 1998 2:20 p.m. PT

update An old feature of the Windows operating system which enables networked PCs to access shared files may expose users of the newest Windows software to hackers, although there is disagreement as to how likely the scenario is.

The problem lies in the fact that Windows 98—like Windows 95 and Windows 3.11 before it—allows users to create shared files without passwords, although not easily. But once those files are created, anyone who can access that system's IP (Internet Protocol) address can access private documents, spreadsheets, or other sensitive data residing on that system's hard drive.

While Windows 95 became the operating system (OS) of

Fig. 1. If your Windows network accesses Internet and uses shared files with no password controls – beware.

Many Internet reports continue to criticise the released version of Windows 98. Instances of upgrade installation difficulties and system crashes are frequently cited. Perhaps the most public reported crash occurred during Gates's keynote speech[1] at the Microsoft Chicago convention.

The most recent Windows98 warning however[2] concerns files that have been given sharing permissions. While single users do not need to permit file sharing, networked users of Windows 3.11, Windows 95 and Windows 98 will have shared files, which may not be password protected.

Any such workgroup with Internet access is vulnerable to hacking should its IP address become known. Hacker software designed to gather IP addresses and ascertain your file security is freely available. Users of on-line messaging services such as ICQ or Internet Relay Chat are particularly vulnerable to such attacks, **Fig. 1**.

New bios-bugging bug

Until now, viruses have only caused damage to software or disk files.[3] Removal using virus cleaning software then restores normal computer functions. The new Win95-CIH virus, which originated from Taiwan in April, infects Windows95/98 32-bit program executable files and can also re-program flashable bios chipsets.

Win95-CIH has two payloads. When an infected file is run, the virus becomes memory resident, infecting any EXE file opened or copied and can overwrite the hard disk MBR and boot sectors. Perhaps more importantly, triggered by date, it tries to overwrite or reprogram your computer bios.[4]

Where to surf...

1	Windows98 crashes on Gates.	http://www.news.com/News/Item/0,4,21284,00.html
2	Windows98 vulnerable to hacking.	http://www.news.com/News/Item/0,4,25795,00.html
3	CIH Virus Report	http://www.ontrack.com
4	BIOS Virus Turns PC's into Paperweights.	http://pubs.cmpnet.com/internetwk/news/news0721-4.htm
5	Beware the 26 th.	http://www.wired.com/news/technology/story/14699.html
6	Win95/CIH.	http://www.virusbtn.com//cih.html
7	Freemail services:Do you get what you pay for?	http://www.zdnet.com/zdnn/stories/zdnnsmgraph_display/ 0,3441,21232873,00.html
8	New bugs plague Freemailers.	http://www.news.com/News/Item/0,4,25792,00.html
9	The "Hot" Mail exploit & how to protect yourself.	http://www.because-we-can.com/hotmail/default.htm
10	Speciality Installations.	http://www.speciality.ab.ca
11	Sensors Magazine	http://www.sensorsmag.com
12	DesignInfo.	http://www.designinfo.com
13	Kodak Ektachrome Professional Infrared Film.	http://www.kodak.com
14	Applied Infrared Photography.	Kodak Publication No. M-28
15	Non-Contact Infrared Temperature Probes.	http://www.fluke.com/handheld/260.htm
16	Electronics Cooling.	http://www.electronicscooling.com/Resources/EC_Articles/ JAN97/jan97_02.htm

Three versions have been found. The first triggered only on April 26, when several computers failed. The second which triggered on 26 June, caused computer failure reports from most computer using countries. The worst version is triggered on the 26 of *every* month.

With July 26 falling on a Sunday, few failures were reported, but August 26 resulted in thousands of damaged computers.[5] Further reports are still coming in as I write.

Also known as Spacefiller, this virus resides in empty spaces in files, so does not change file size. It can only be detected using the latest virus detection software.

With a corrupted bios, the computer will not even boot up from your floppy recovery disks, so cannot be restored using software alone.[6] Obviously if your machine's flash bios is write disabled by setting a write protect switch or link, then its bios is safe. Unfortunately many new motherboards have a bios that cannot be so protected. Those having soldered-in bios chips will usually require a replacement motherboard, to restore life to the computer, Fig. 2.

Virus check all files you receive on floppy disk and avoid opening attachments sent via e-mail from unknown sources.

More e-mail trouble

One problem with E-mail is that changing your service provider inevitably changes your e-mail address. To avoid this, many sites now offer life-time e-mail addresses, independent of your service provider. Called *Freemail*, this service allows you to access your account from machines other than your own.

Freemail systems are more susceptible to intrusion than a conventional desktop based application. With some 400 Freemail providers, differing levels of security must be anticipated.[7,8,9]

Speciality Installations,[10] whose password stealing demonstration first drew attention to Microsoft's Hotmail security problem, has posted a chart listing Freemail services which now filter for these four most common security problems.

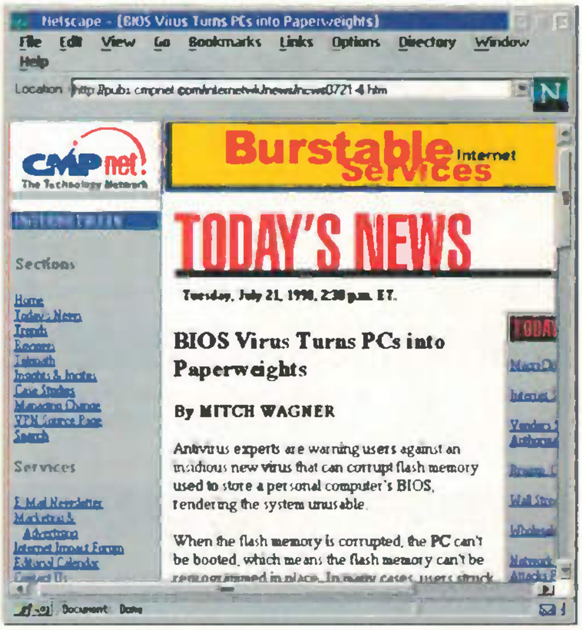


Fig. 2. Have you a flash-programmable bios? If so, don't forget to write protect it.

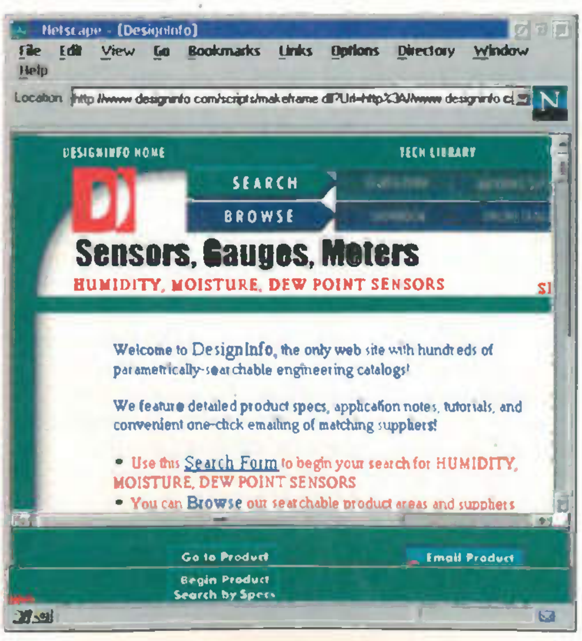


Fig. 3. Use this specialist site to facilitate searching for any type of sensor – including humidity monitors.

Sensing applications

In last year's October issue, I introduced the Philips Humidity sensing capacitor, with typical application circuits. Such components are secondary sensors which measure the effect of humidity on themselves, rather than being primary or direct reading. These sensors exhibit a change of impedance, capacitance or resistance, with humidity. Capacitive sensors can be used with the circuits shown in the Philips application

Fig. 4. This low cost non-contact hand-held infra-red probe could be ideal for measuring the temperature rise of your plastic IC package.

Fig. 5. Liquid crystal temperature indication method can measure the smallest components, but not without a fair amount of equipment.

'Moisture.PDF' to give a linear voltage/RH output, see October Figs. 3,4.

Sensors Magazine[11] has tutorials by Robert Brown on sensor repeatability, and by Mark Brownall on choosing relative-humidity sensors. Fundamental or primary humidity sensors based on well-defined thermodynamic principles such as dew-point temperature, or the weight of water in a given volume of air, require no calibration. Secondary sensors must always be calibrated.

Individually calibrated sensors, which replace sensor calibration during equipment assembly with simple trimming of the electronic circuits, are available. Alternatively, factory calibrated, interchangeable sensors, manufactured with very small part-to-part variation, can eliminate these assembly adjustments.

Most low-cost capacitive sensors made using polymer film cannot be used at high humidity or high temperatures for extended periods. Alternative materials have been evaluated, ranging from chemically-resistant fluorocarbon polymer films, to porous silicon and niobium oxide films.

Pollution or chemical resistant sensors able to operate at 100% relative humidity are available in package sizes as small as TO18 headers and for temperatures to 180°C. Some makers can supply laser trimmed sensors, complete with integrated electronics, giving a linear voltage output with humidity.

A wide variety of sensors is available. My AltaVista search using

```
+humidity +sensor
+electronic
```

resulted in more than 4000 hits. One I examined led to a dedicated site, *Design Info*[12] which provides a dedicated search engine selection, Fig. 3.

Temperature sensing

In October, when I suggested that temperature is more easily measured than humidity, I was assuming a direct thermal contact was possible.

Surface-mounted components such as 1206 size resistors or capacitors have little thermal capacity. Even thin thermocouple wire conducts too much heat, significantly reducing the measured component temperature. A non-contact method is needed.

Temperatures of 250-500°C can be observed using infra-red sensitive film in a metal bodied camera,[13] but the long wavelength infra-red rays which represent temperatures between room ambient and 200°C, are absorbed by camera lenses.[14] These long wavelengths are outside the range of silicon photodiodes and digital camera sensors.

Measurement of the infra-red emitted by the component, in the 0.7 to 14µm waveband, poses two other problems.[11] For accuracy the infra-red emissivity of the surface being measured must be known. Surface emissivity ranges from typically 0.1 for metals to 1.0 for the theoretical 'black body'. It is particularly important the infra-red detector 'sees' only the required surface.

While large surface areas are easily measured, in electronics design, infra-red will mostly be used only for measurements of small components, requiring an optical system with expensive long wave infra-red capable lenses.

Fluke manufactures a non-contact infra-red measuring multimeter accessory, usable over the desired temperature range.[15] Two limitations are its fixed emissivity, set at 0.95 which equates to a good matt black: its 4:1 optical resolution is suitable when measuring DIL packages, but much too coarse for small chip components, Fig. 4.

Liquid-crystal inks

Thermochromic liquid crystal inks, either as temperature sensitive labels or as a paint-on liquid, are particularly suitable for large-area parts. These paint on liquid inks reflect a colour which varies with temperature. Colour ranges from red for the lowest temperatures, through the visible colour spectrum to violet for the highest temperature.

By choice of ink, temperatures from 60°C to 115°C can be observed. Outside the working range of the ink, no colour is visible.

Electronics Cooling's[16] article 'Measuring chip temperatures with thermochromic liquid crystals' describes a practical technique using two examples – an IC chip 10mm square and a 0.5mm square resistor. Using a low power microscope, the paint-on liquid's colour is used to judge temperature change of these components.

Visual observation of this colour change is possible, but accuracy requires use of colour camera imaging with computer analysis techniques, as described in the article, Fig. 5. ■

LETTERS

Letters to "Electronics World" Quodront House, The Quodront, Sutton, Surrey, SM2 5AS
E-MAIL jockie.lowe@rbi.co.uk

VHS is the key

Keith Saxon writing in the October issue Letters column is clearly not versed in current economic thinking. A *Scientific American* article on positive feedback in economics explains how VHS became the video cassette standard. It was published on page 80 of the February 1990 issue.

Incidentally, the press never mentions Acorn, so perhaps it is understandable that he did not. Its processor and operating system still have great merits.

David Greenslade
Colchester

Why patent?

I refer to the feature in your October 1998 issue from the Chartered Institute of Patent Agents.

One alternative to patenting that was not mentioned was the course of action followed by some small inventors who don't have time for the legal professions. This is to deliberately publish details of their invention in an obscure journal. I seem to recall reading somewhere that a popular one was a local paper in a northernmost outpost of Canada.

The reason for doing this is that no one else can patent the invention because of prior publication. The product covered is then put into production and marketed at a price low enough to make undercutting uneconomical.

Obviously this is not appropriate in every case, but for novelty items it could well save the aggravation of getting and defending a patent. Even if this is not wildly rewarding in financial terms, the inventor can still get personal kudos from the invention. And if it is that successful future inventions could well be bought by companies providing financial return.

John de Rivaz
Truro
Cornwall

Baird's image

I was very impressed by Donald McLean's excellent articles 'Dawn of Television' September 1998 and 'Restoring Baird's Image' October 1998.

However, one point. All the line scanning pictures shown had vertical scanning. I have a book 'Television for All' by Charles G Philips. It was published by Percival Morchall and Co Ltd, London, in around 1930 and cost one shilling.

In this book it mentions that Baird solved the problem of synchronisation by using the picture sequencing or 'non-currents' to control, in this case, the disc drive motor.

The book also mentions that vertical and horizontal scanning can be used. A diagram shows the scanning disc, high-frequency lamp, reflector and object being used at the top of the scanning disc.

So it seems that horizontal scanning would appear at the top of the disc and vertical scanning at the side of the disc as required.

Ray Stead
Hampton
Middlesex

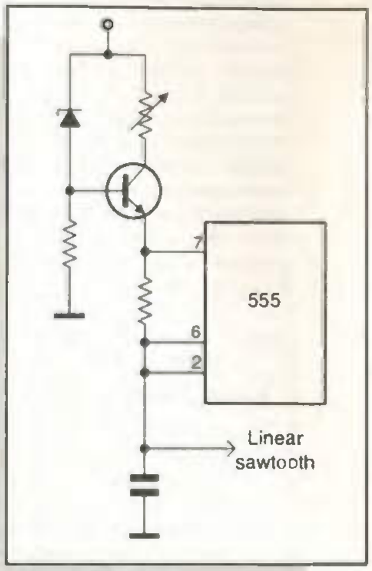
Don replies...
Horizontal scanning on mechanical systems was used on the continent and in the USA. It was not used in the UK for broadcast tv until the start of electronic television in 1936.

On synchronisation, Mr Stead quite rightly points out that Baird had a mechanism in his Televisors for attempting synchronisation. However it used video energy rather than sync pulses. This meant that when the picture faded to black, synchronisation was lost.

Baird's 30-line format called for a small portion of the start of every line to be blanked. This is not present on the 1927 to 1928 Phonovision recordings.

In addition, the technique in the Televisor used no sync extraction and merely fed the high voltage video to electromagnetic coils around a toothed wheel on the drive shaft of the display. The torque applied was microscopic.

Some have said it didn't work, others that with clean video the image remained stable for the one hour of transmission.



Sweep clean

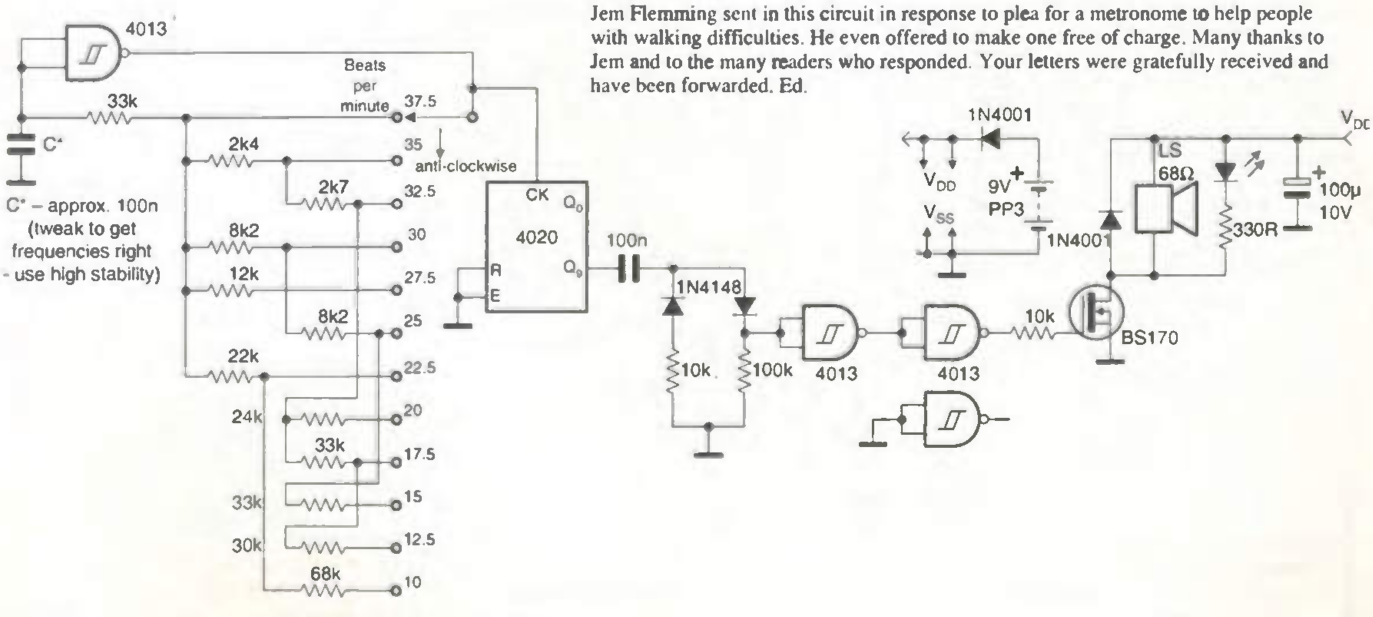
Brian Oliver can more easily obtain a linear sweep from a 555 (Circuit Ideas September 1998), with the old trick of using a current source in place of the charging resistor, as in the diagram shown.

My sweep generator article, in the February 1992 issue, will give him more ideas on adjusting its size to taste.

D M Brigden
Camberley
Surrey

Beat this

Jem Flemming sent in this circuit in response to plea for a metronome to help people with walking difficulties. He even offered to make one free of charge. Many thanks to Jem and to the many readers who responded. Your letters were gratefully received and have been forwarded. Ed.



Baird's method was questionable in its performance but appears to have been adequate for a stable and clean source of video. Any slight disturbance in the video however would unlock the display. To say that synchronisation was 'solved' would be a serious understatement in today's terms.

Of course, Mr Stead must realise that once the video signal is recorded, the signal would be subjected to speed variations in the recording process.

Without sync pulses, with distorted video content and with fast variations in speed, the restoration of the timebase required the computer-based techniques mentioned in the articles.

Tap it again...

With reference to 'Tap it and see' in the July '98 issue Letters column, I was part of a group that designed and built a 144MHz direct-conversion transceiver. This had excessive microphony and hum on receive.

Most rf circuit designers know that if you build a breadboard rf circuit, it will work until you put it in a box.

I realised that the direct-conversion receiver had an almost unique property: it wouldn't work until I put it in a box. This was because both effects are caused by local-oscillator leakage. As a result, the higher the receiver's working frequency, the worse the local oscillator leakage, and the worse the hum and microphony.

In rf microphony, the local oscillator leaks into the direct-conversion receiver's front end. The receiver detects this as a very powerful signal at the receiver frequency. This has no effect other than to produce a dc offset at the mixer output.

The trouble comes when you tap one of the front-end tuned circuits. This modulates tiny amplitude and phase sidebands onto the local oscillator leakage. These sidebands may be 80dB less than the local oscillator leakage carrier, but they are still detected and appear above the noise floor at the mixer output.

In rf hum, the local oscillator radiates into the direct-conversion receiver's power supply wiring. This contains a rectifier, whose diodes switch on and off with the incoming 50/60Hz supply.

The diodes present an rf impedance that varies with the mains cycle. This action forms an efficient rf modulator. The local oscillator leakage is then re-radiated back into the front end to be demodulated by the mixer to appear as 'power line' hum.

These effects, and some palliative measures, are described in more detail in '*Aspects of Direct Conversion Receiver Design*', by NC Hamilton in the Proc IEE Conf. Radio, July 1991 IEE pub. No 339 pp. 299-303, and in *Radcom* April 1991 pp. 39-44.

As local-oscillator leakage

Year 2000 bugs

I see from the news story 'NHS year 2000 problems...' on page 630 of the August issue that your magazine is still presenting scare stories related to the year 2000 problem. I am used to daily newspapers and the like coming up with tales of horrors to come, but surely a professional electronics magazine should be able to offer a more informed position on this problem.

I do not deny that in some quarters a problem may exist, especially in custom accounting software and the like. And the business implications, if the companies have never heard of contingency planning, will be very dire indeed. But in the vast majority of cases there will be no problem whatsoever.

Take the ordinary desktop pc. First of all, most pcs will automatically cope with the millennium, and most of those that don't just need you to type in the correct date on 01/01/2000 and all will be well.

Even the venerable 386 machine in my collection responds to this cure.

After that, how many people have programs that could care less about the date? Even if your machine cannot cope with the bug, most software doesn't need to know the date.

But, more important is the constant scare about embedded processors. I am amazed at the tales about washing machines and such failing come the millennium. First, I do not know of any current popular microcontroller that has a built in real time clock calendar. But working on the principle that I am uninformed, for there to be a problem there has to be one of two situations. One is that this micro with the built in clock must behave such that when the millennium rolls round the program will hang. I just cannot imagine this happening, as any counters involved will just wrap around and start again from zero, so nothing there. The second is where the programmer has decreed that if the date is invalid then the program will stop. If this is the case then he should be shot.

Taking the case on page 630 of *Electronics World*, that of medical equipment, have they never heard of fail-safe? If anyone has designed a piece of medical equipment that checks the date, finds out it is beyond its service date, or whatever, and so stops, that person could surely be taken to court for attempted manslaughter, or at least negligence.

I have to suppose that there are cases out there that justify these scares, but I cannot for the life of me understand either how they could occur, or how the perpetrator cannot be held legally liable. In the weeks following the millennium there will no doubt be a few horror stories. Portions of the national press could not survive without them. But I guarantee there will be no stories about the millions of computers that just did not care and carried on in happy ignorance, like most of us.

Mike Bull
Cambridge

With reference to the Year 2000 debugged article in your June issue, I understand that Windows 98 will reset the cmos clock to 2000 if the century is 1900. This reminds me of a tiny program I wrote, which calls the `Date` command in the same circumstances. It is invoked by inserting the following in `AUTOEXEC.BAT`:

```
DATEFIX
IF ERRORLEVEL 1 DATE
```

The program `Datefix.com` sets Errorlevel to 1 if the cmos year is 1900. It was created using DEBUG by entering List 1.

Since the century is stored in the cmos memory section of the real-time clock, Debug can be used to test it more conveniently than rebooting the computer.

The address lines of the real-time clock are connected to i/o port 70_{16} and the data lines to i/o port 71_{16}. The century is stored at address 32_{16}. (For IBM PS2 and other MCA bus machines the address is 37_{16}).

In Debug type:

```
O 70,32   ;Output the address
I 71      ;Read memory (century)
```

The century is not included in the cyclic redundancy check calculation of the cmos, nor is it subject to update lock, so there is no complication in updating the century from 1900 to 2000 automatically, but you would then receive no notification that the event had taken place.

Finally I would like to point out that dos increments the date only once at midnight, unless the `Date` or `Time` commands are used in the next 24 hours.

R. Toogood
March
Cambridgeshire

List 1. Year 2000 bug aid – C:\DOS\DEBUG.

```
A 100              ;Assemble starting at address 100, because it is a COM file.

mov    AH,04       ;Service 4 of BIOS interrupt 1A gets the RTC date.
int    1A          ;The year is returned in CX, the carry flag is set if the
jb     110         ;RTC is not working. So we call Date in this case.
cmp    CH,20       ;If the century is 20 we go to the Int 20 exit.
jz     115
cmp    CL,00       ;If the year is not 00 we go the Int 20 exit.
jnz    115
mov    AX,4C01     ;Date must be 1900. Interrupt 21 function 4C will
int    21          ;terminate with return code set in AL.
int    20

now press return again

R      CX          ;Debug requires the number of characters to write
17                 ;is placed in CX. Remember the rhyme, because it starts at nought, one more
                    than you thought.

N DATEFIX.COM      ;Give the file a name.

W                  ;Write it away.
Q                  ;Quit.
```

determines hum and microphony, then I suggest that Ian Braithwaite digs out his 28MHz direct-conversion receiver, puts in some rf screening and 'isolator' stages, and enjoys some of the best receiver performance achievable.

With care, direct conversion receivers work well in the microwave bands; I think they have yet to come into their own.

Nic Hamilton
Bedford

Crossover comments

I would like to offer some comments on John Watkinson's 'Speakers' Corner' item from the August issue.

His statement that, "The conventional high-pass/low-pass of Fig. 3 can never be phase linear," is almost correct.

One very commonly used crossover can indeed be linear phase and have zero group delay. It is possible to build a linear phase crossover circuit with a first-order filter in conjunction with a second-order filter.

It is also possible to build a second-order or fourth-order crossover network, in conjunction with a passive all-pass correction circuit that will produce a second-order of fourth-order linear phase response.

Why are none of theses methods popular? The first solution with the first-order response does not provide enough attenuation outside the required pass-band. These out-of-band frequencies cause many undesired results.

The second method has some of the same problems the first method has. The third method has a high component count and is extremely sensitive to component tolerances. I am not sure the use of active filters and separate power amplifiers is any better.

I have seen crossover designs that make no sense, and yet produce excellent results while text book designs produce clearly inferior results – both designs using the same drivers.

I have been chasing the speaker crossover problem for years. My conclusions? We don't yet know what we are doing.

Jack Kouzoujian
Mill Neck
USA

Hot water

We would like to find out about electrical induction heating as

Longer life from rechargeables

In reply to Frank Eliason's letter 'One, flat, one not' by in the November 1998 issue. you can be sure that no two cells will ever have the same characteristics. The internal resistance of all primary cells rises as the cell ages. The only way to get a good life from them is to move them into devices that draw a smaller current.

Rather than worrying about it, I suggest learning to live with it. When the cells in your torch, or Walkman run low, try them in your remote control handset or radio/pager/etc. When they are too low for that, they will probably still operate a clock. I've been migrating cells like this for years, and it's the best way to get value for money.

The AA cells that my son discards from his Walkman are more than capable of running my workshop radio for several months. I haven't had to buy AA cells since he bought his Walkman.

Graham J Field
Forest Gate
London

I would like to add to Reg Moores' comments on recharging NiCd cells in the November issue Letters pages.

Multiple-cells, i.e. batteries, also suffer from situation whereby one or more cells completely discharge before the rest. Continued discharge of the pack will result in reverse-charge of the 'dead' cells.

Such 'dead' cells – especially if left in that condition for any length of time – end up suffering a heavy dendrite growth, and cannot be revived with a 'normal' charging regime. This was mentioned in an article some years earlier in this journal, which I have not been able to trace.

Unless the charger used is 'intelligent' enough to recognise this condition it can continue to overcharge the remaining cells in an attempt to reach its expected cut-off point, resulting in a useless pack.

While the majority of readers may well be qualified to recognise this problem, not everyone wants the bother of breaking into the casing to obtain access to the terminals of the individual cells; so that each cell can be given the treatment it requires. Given that I've known AA cells that have required over 30A to break the dendrites free, not everybody would have the equipment to do it either!

If you do want to try reviving 'dead' cells with a large current – do be careful. Use short pulses of current, and watch that the cell case does not get too hot, or start to expand.

Graham Field

Frank Eliason's problem with NiCd cells in his radio is almost certainly due to over discharge. To understand the problem and how it comes about it is necessary to know that all NiCd cells have slightly differing capacities. They are all different when they are new, and they all change at varying rates during their working lives. Because cells vary, it is probably uneconomical and ineffective to select cells for equal capacity.

Imagine an application where a two-cell battery is discharged continuously, with one cell having, for arguments sake, 100% of its nominal rated capacity and the other 95% of nominal capacity. It is obvious that as the cell with the lower capacity reaches its end point – i.e. the terminal voltage related to the current drain at which the cell is considered by its maker to be exhausted – the other cell will continue to force current through the exhausted cell.

In light-current applications this is not detrimental. It usually leads to the problem under discussion. But if the discharge current is significant, i.e. C/5 or greater, then forcing current through the cell leads to over discharge, with evolution of hydrogen in the cell which does not recombine, and possible venting of the cell. At this point moisture is lost and the cell fails rapidly.

The situation is worsened by failure to recharge for sufficient time. Over-discharged cells require slightly longer to get back to normal. The result is that the cell with the slight capacity deficit is returned to service with, perhaps, only 90% of its actual, not nominal, capacity returned. Maths show that 90% of 95% is only 85.5%!

The over-discharge situation will then occur even earlier and rapid failure of this cell is assured.

Nickel-cadmium cells benefit from care and attention, repaying many times in greater life the small amount of effort involved. Where possible, NiCd batteries should always be discharged to their 'end point' before recharging at the approved rate.

It is worth noting too that the higher the charge current – expressed as a fraction of the cell's capacity *C*/10, *C*/5 or even *C*/1, where *C* is nominal capacity – the lower the amount of charge stored. An hour charging could return as little as 70% of the figure that may be returned at the ten-hour rate C/10.

This means that to ensure 100% capacity, a suitable period of 'trickle' charge current is always beneficial and will result in longer service life. Since the conversion efficiency of the cell is not 100% it follows that charging will need to be longer than the ten hours in the example above. The usual figure is 1.4 times the C/10 rate, or 14 hours.

I discovered that the car cigar-lighter charger for my mobile phone, although very sophisticated, failed in one respect. It always started with a high rate charge after power on. This meant that whenever I started the engine, the battery voltage fell below the charger's input threshold and the power supply was effectively interrupted. After this event, the device recommenced charging at high rate. Thus the phone battery's life was measured in months rather than years because it was always being cooked.

Buying a charging base that has a discharge-before-recharge facility has extended battery life to more than a year with no discernable loss of capacity. This is for a phone used every day. All I have to do is put the battery on the discharge base before retiring at night and in the morning the battery is revitalised, properly charged and full of life, just like its owner.

The application of tlc is also useful for NiMH cells and to a lesser extent lead-acid types.

Remember that charge current of NiCd and NiMH cells does not reduce as the state of charge increases, as it does with a lead acid cell. The poor NiCd cell goes on passing current even when all of the possible energy that can be converted to stored charge has been converted.

Resultant I^2R losses comes out as heat. Constant overcharge at too high a rate kills cells like nothing else.

Nic Houslip
Birmingham

You may like to know that the problems with nickel-cadmium batteries that Frank Eliason has been experiencing, Letters November 1998, and a possible cure for them, were described in detail in a series in the May, June, July and September 1985 issues of *Electronics World*.

It is significant that the problem of "one flat, one not" is still with us some 14 years on, and is indicative of the state of development in rechargeable cells, often made worse by the poor design of electronic equipment that uses them.

Rod Cooper
Sutton Coldfield

Rod is too modest to mention that he wrote those fine articles: Ed.

applied to heating water in a closed system and would much appreciate it if you could point us in the right direction.
Renahall Limited
Rugby
Warwickshire

First voice+data comms device?

In the 'Internet inroads' article in the September issue, Andy says that the first ever integrated digital voice and data communications device was the Nokia Communicator 9000.

I am reasonably certain that this was preceded by the HP700LX, which is still obtainable. This is an HP2000LX – a CGA XT computer rather smaller than the current CE2 palmtops – which can take a Nokia 2110 on top piggy-back fashion to make a single unit. Nokia linking software is built in.
Jeffery Cragg
Plymouth

Filament failure

In answer to Bob Pearson's letter on valve filament failure, there are no better experts on this problem than the designers of the old valved tv sets which we all used to watch as recently as the early seventies.

In these sets, all the heaters were connected together in series, Christmas-tree lamp fashion. With as many as fifteen valves, the size of dropper resister needed to apply the correct working voltage to the heater chain was not sufficient to give any significant protection from switch-on current surges.

By this time, technology had advanced to the point that reliable negative temperature coefficient thermistors had become available. The device used was constructed such that its electrical and thermal inertia characteristic – when used to replace a small section of the dropper – gave roughly constant current characteristics to the whole heater supply circuit. The penalty was a somewhat lengthened warm-up time.

Before such devices became available though, an old fashioned yet effective solution was often used; that of connecting a relatively unsophisticated filament bulb in series with the chain instead.

Constructed with a very fine filament, this device, known as a 'Barretter', had a very low thermal inertia, so its very short switch on surge was not long enough to strain the very much thicker valve filaments. Its effect was similar to the later thermistor: that of providing a roughly constant current supply to the heater chain whatever its resistance.

It would appear that, to take a leaf out of these old designers' books, that if you cannot connect all the heaters in series, the answer is to supply each heater from a constant current source set up for the correct value for that particular valve.
A. Ziemacki
Rotherham
South Yorkshire

In his letter in the October issue, Bob Pearson suggests some additional mechanisms for the failure of light-bulb filaments. I would like to suggest another, namely the uneven loss of material from the filament due to evaporation.

There is an avalanche effect here, in that the thinnest part of the filament will run hottest, therefore will evaporate fastest, and so on. Failure will still be most likely to occur at switch-on, since the low resistance of the bulk of the filament will accentuate the heating of the thin part.

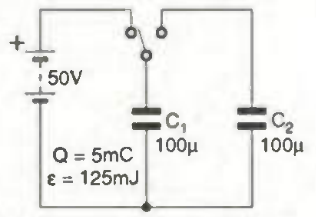
Readers who remember the old type of electric fire with open wire elements will have noted a similar effect, although the cause in this case was presumably oxidation rather than evaporation. Sooner or later, a hot-spot always appeared, visibly brighter than the rest of the element, and within a short time the wire would part at that point.
Ronald Ogilvie
Killearn
Stirlingshire

Now where *did* that charge go?

As a young student forty years ago, I was introduced to an apparent paradox concerning the charging of one capacitor from another. It appears that in the process, energy 'vanishes' in defiance of the Conservation of Energy Theorem. I had cause recently to revisit this old chestnut and on re-examination came to conclusions at odds with standard explanations presented in many well known, respected textbooks (references below).

The solution to the problem presented here seems obvious to me. The example shown in the diagrams illustrates the paradox.

It might be expected that the total energy $\varepsilon_{C1}+\varepsilon_{C2}$ will equal the original energy of 125mJ, but something interesting happens when the total energy is calculated.



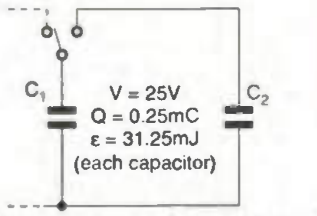
A 100µF capacitor is charged to 50V so its energy is $0.5\times100\times10^{-6}$, or 125mJ. The charge on the same capacitor will be $100\times10^{-6}\times50$, i.e. 5mC.

Energy accumulated by each capacitor is now: $0.5\times100\times10^{-6}\times25^2$, which is 31.25mJ, i.e. a quarter of the original. Thus the total; $\varepsilon_{C1}+\varepsilon_{C2}$=62.5mJ; is only half the starting energy. It appears – in this case – that half the energy has been lost.

The calculations are very simple but the solution to the paradox is obscured in most textbooks when unequal capacitor values are chosen to illustrate the problem. But when equal value capacitors are selected, the maths shows the 'loss' clearly enough.

Energy is proportional to V^2. So if V reduces by half, as in this case, ε goes down to a quarter the starting energy. As a result, the total energy is half what we started with, i.e. 'energy loss' is directly related to the V^2.

The explanation commonly given is that energy is dissipated as heat in the



If C_1 is now connected to C_2, charge and energy will be shared. Charge must be conserved in in this action (2.5mC for each C_1 and C_2)and the two must be at equal voltage: V=Q/C=2.5mC/100µF=25V, as you might expect.

Updates

Synchrodyne/homodyne receiver. The following is a letter from John Mann of Banbury. Prof. Slifkin has seen the letter and agrees that the points are valid, apart from the one on labelling of the DEMO pin. This discrepancy is due to different manufacturers using different names for the same pin. Apologies for any inconvenience.

John writes, "I was interested to read the synchrodyne/homodyne receiver article in the November issue. But when attempting to construct a circuit based on the designs shown I found some errors in the circuits printed.

I suggest that: Fig. 5, IC_3 pin numbering is wrong. Capacitor C_{in} should be pin 3 not 2, C_X should be pin 6 not pin 5, INH should be pin 5 not 6, the pin labelled DEMO should be SFO and on pin 10 not 16. Component IC_{6b} should be IC_{5b} and IC_5 should be IC_6.

Figures 4a and 5, pins 1 and 2 of IC_1 and the centre tap of T_2 primary should be connect to the +12V rail, not the rf output.

Figure 5, the mode switching, $S_{1,2}$ appears to be wrong. In synchrodyne mode there is no path for the modulated wave to the mixer, and the limiter is still in circuit. Presumably C_{13} should be permanently connected to Tr_1 emitter and $S_{1,2}$ should switch either the pll or limiter into circuit."

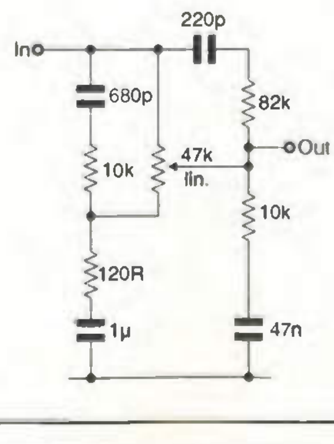
Charging the unchargeable. In this article on charging alkaline cells by Michael Slifkin in the April 1998 issue, there were a few component misinterpretations. Sorry.

In the panel entitled 'The charger', for R_5 and R_9 read R_3. For R_6 and R_{10} read R_4. For R_7 and R_{11}, read R_5. For R_8 and R_{12} read R_6. For R_7 read 2kΩ. For R_8 and for R_{10} read 1kΩ. Values of C are not given as any large value electrolytic capacitor will do. The value of V_{ref} should be adjusted so that the leds light at the desired voltages.

Binary adder with analogue output. In this circuit idea in the October issue by V. Manoharan, we printed the final equation wrongly. It should have read,

$$V_{out(A+B\ or\ A-B)} = \frac{5}{256}\times(N_A \pm N_B)$$

Present, but not correct. Alan Frobisher sent us this passive presence control, described in the October issue. Alan also sent us a note that we incorrectly had a 180kΩ resistor where the left-hand 10kΩ component is now shown.



wires connecting the capacitors together, sparks at the point of connection, causing electromagnetic radiation, etc. But this cannot be so because the energy 'disappears' in the theoretical case, where wire resistance and other quoted factors are not included in the calculations.

So what happens to this energy ? Much energy has been dissipated in trying to explain the paradox.

The maths reveals the situation clearly enough but this does not explain the matter at the physical level. The explanation seems almost too obvious and I ask you to test my logic for yourselves.

Power is the product of *V×I*. But this equation does not reveal the dependency of *I* on *V*. If the voltage across a resistor is increased, the current must increase at the same rate. The resulting power increase is due to both factors, i.e. power is proportional to the square of the independent factor – voltage.

This is true in any system, be it force for mechanical systems, temperature for heat systems, etc. If the applied voltage across a resistor is halved the power goes down by a quarter. All this is basic and no one asks where the missing power has gone.

But energy is simply *power×time* and so energy levels change at the same rate i.e. by the square of the voltage change. The resistance example is dynamic but the same applies to static or potential energy.

If voltage is reduced, the energy – i.e. ability to do work – will go down by the square of the voltage reduction. No energy mysteriously vanishes in the connection of one capacitor to another and so there is no need to try and account for the 'missing' energy by factors that do not appear in the idealised calculations.

The losses quoted in the text books will occur in a practical case, but will be in addition to the apparent loss calculated in the example above. I believe this misconception has led to generations of confused students whose ability to think clearly about fundamentals is not helped by these kind of explanations.

References

Electrical Technology - Hughes, Electricity - Nelkon, A level Physics - Muncastor, Electrical Engineering Principles - Stott and Birchall.

Brian Cox
Exeter
Devon

Can anyone give me a lift please?

I am researching the history of a supposed antigravity device which was the subject of a number of articles in *Practical Mechanics* between 1942 and 1958. I am particularly interested in any information on W. D. Verschoyle, who wrote the first article, and Swinfen Bramley-Moore, who wrote a booklet; 'The Apple in the Orchard'.

I have also lost my copy of the first article which was published in the magazine in February 1942 and reprinted in August 1958.

If anyone can supply a copy, or has any information on the subject, would they please write to me? I am W. J. Williamson at Leeskol, North-a-Voe, Yell, Shetland ZE2 9DA.

Rewriting history

I read with interest the myth about the German magnetic recorder in the article 'Rewriting History' by Andrew Emmerson in the November issue.

Around 1943, the signals organisation I belonged to had a Magnetophon machine captured in the North Africa campaign. A memorable thing about it – apart from its size – was that the tape was oxide coated paper and more time was spent repairing the tape when it broke than recording on it.

However this brittleness may have been due to storage in the heat of North Africa and in any case was no worse than the breakages on the wire medium of the then current USA wire recorders.

N L Smith
Wetley Rocks
Stoke-on-Trent

Colour vision gone grey

Your correspondent Bryce Smith has misunderstood the whole mechanism of colour vision in his suggestion for 'Light Gates...' in the November 1998 issue.

Briefly, while it is true that light of different wavelengths is mixed according to well-understood rules to produce different perceived colours, the actual logical 'mixing process' is carried out by the brain processing the signals from the eye. Similarly the colour tv picture is produced on the screen purely as red, green and blue dots. It is the subjective effect of these primary colours processed by the brain which gives all the intermediate hues.

The action of a conventional optical filter is merely to selectively pass or block light of different wavelengths. Thus the so-called yellow filter in his first example will act by blocking blue light but will always allow both red and green light through. Our eyes then perceive this as 'yellow'.

This is definitely not the same as the filter 'adding' red and green light to produce new light of yellow wavelength. We can regard optical filters as essentially 'linear' band-pass or band-stop devices.

In his last example, the red filter will pass red light regardless of whether green light is incident upon the filter – unless of course the green light is sufficient intensity to heat up and char the filter material – an extreme case of non-linearity!

I think that this simplistic approach is very unlikely to work.

However, there is scope for work to develop new materials and devices in which two or more beams of light can actually interact in a non-linear fashion to replicate logic functions. But before jumping on this as a new band-wagon, these new materials will still be subject to the same quantum effects as our current semiconductors. I have a feeling that the ultimate limitations on computational speed may well be very similar for optical or electronic logic devices when the structures are perhaps just a few atoms across. The technical problems of handling signals of just a few electrons or a few photons will be challenging – to say the least.

Rod Hine MA(Cantab) AMIEE
Bradford
West Yorkshire

The brief answer to Bryce Smith's question in the November 1998 issue concerning his idea of light gate is, "No, it would not work".

The reason lies in the misconception that mixing together light of two different colours – i.e. two different frequencies – produces a new colour. It is true that presenting two colours such as red and green to the eye gives the impression of a different colour, namely yellow, but this is due to the way in which the retina and brain respond and not to the actual creation of a new colour.

Red light remains red and green light remains green, so the output from his 'And' and 'Or' gates would always be zero, and the output from the 'Not' function would always be red. This would be true even if the outputs were viewed by eye, since the yellow filter would pass neither red nor green and the red filter would pass only red.

It is possible to achieve true mixing of two light frequencies, resulting in one or more new frequencies, by combining two laser beams in a material having non-linear electro-optic properties. However, the sum and difference mixer products for red and green laser frequencies would be in the ultra-violet and infra-red.

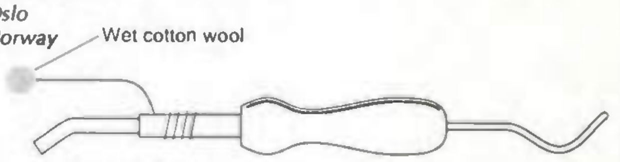
Keith Barnes
Whitwell
Hertfordshire ■

Solder wetting

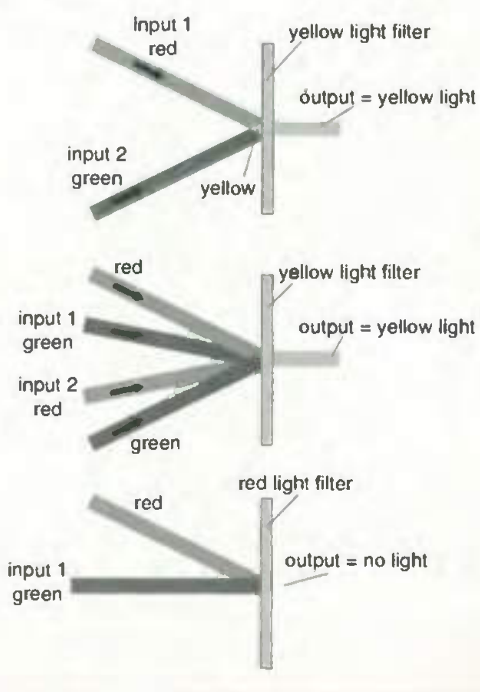
Soldering and desoldering may ruin temperature-sensitive components if the heat is not removed quickly after operation. A piece of wet cotton wool on a separate pin may be of great help.

It is much quicker to have the cotton wool fastened directly to the soldering iron as shown. Just twist the soldering Iron and apply.

Scott Arnesen
Oslo
Norway



Remove heat rapidly from sensitive components.



Bryce Smith's light gates, detailed in the November issue.

Over £600 for a circuit idea?

New awards scheme for circuit ideas

- Every circuit idea published in *Electronics World* receives £35.
- The pick of the month circuit idea receives a Pico Technology ADC42 – worth over £90 – in addition to £35.
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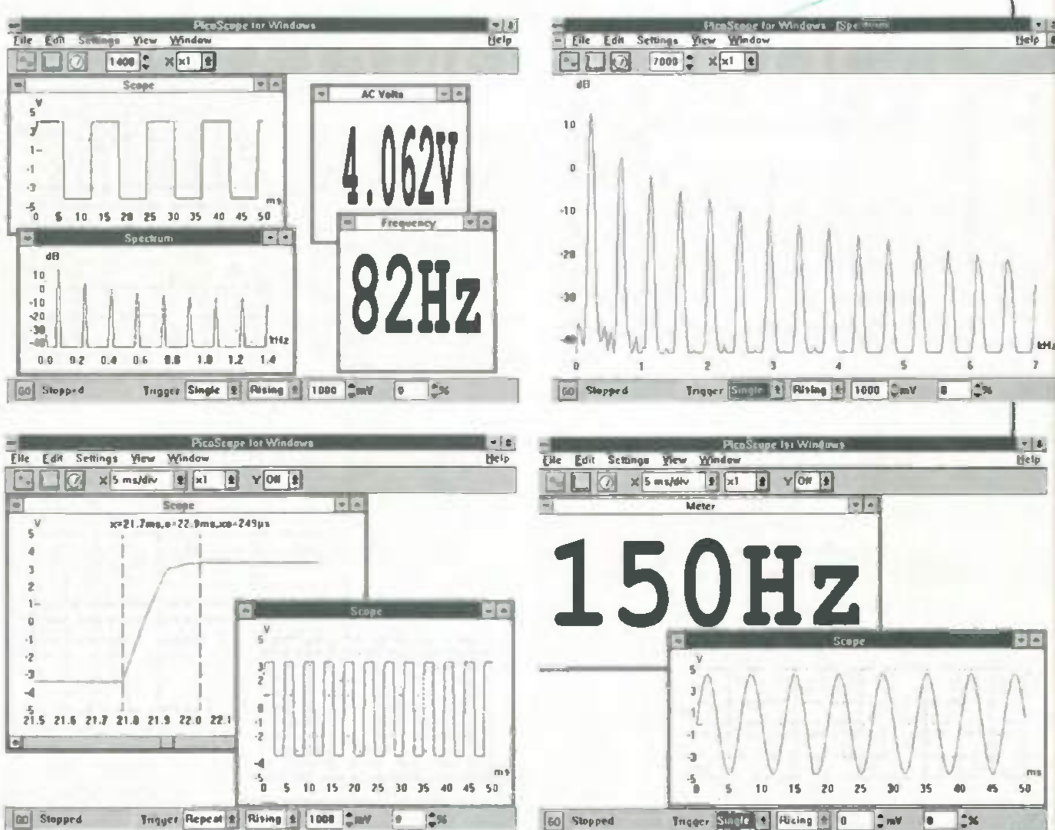
How to submit your ideas

The best ideas are the ones that save readers time or money, or that solve a problem in a better or more elegant way than existing circuits. We will also consider the odd solution looking for a problem – if it has a degree of ingenuity.

Your submission will be judged on its originality. This means that the idea should certainly not have been published before. Useful modifications to existing circuits will be considered though – provided that they are original.

Don't forget to say why you think your idea is worthy. We can accept anything from clear hand writing and hand-drawn circuits on the back of an envelope. Type written text is better. But it helps us if the idea is on disk in a popular pc or Mac format. Include an ascii file and hard-copy drawing as a safety net and please label the disk with as much information as you can.



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ADC42 is a low-cost, high-resolution a-to-d converter sampling to 12 bits at 20ksample/s. This single-channel converter benefits from all the instrumentation features of the ADC200-50.

"Bullet-proof" rf mixer

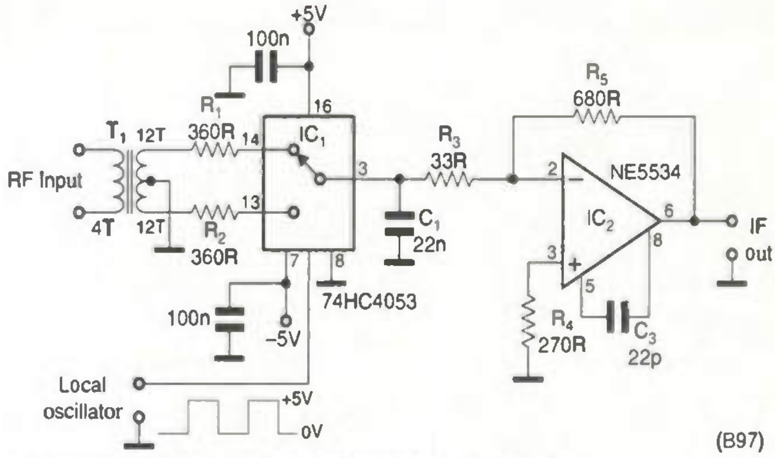
This mixer was designed for use in an image-cancelling superheterodyne with a low if and may be used in a direct-conversion receiver.

An input transformer takes the rf input, matching the source impedance of the signal to the mixer and providing two signals in antiphase to the *74HC4053* multiplexer/demultiplexer. Resistors $R_{1,2}$ terminate the mixer and provide a current drive, no diplexer being needed in this type of circuit.

This current is amplified in the current-to-voltage converter IC_2, overall mixer gain being set by R_5. Low-pass filter $R_{1,2}C_1$ limits unwanted mixer products to IC_2 and R_3 isolates C_1 from the op-amp input at high frequencies

Using this mixer a receiver will provide a dynamic range of 132dB and a noise figure of 12dB.

Rod Green
Bedford
Western Australia
B97



Rod Green calls this the Ned Kelly mixer, since it is relatively bullet-proof.

Bias voltage generator

As an example of the advantages of on-chip transistors over the discrete type, the current through Tr_2 in **Fig. 1** is virtually constant, as is Tr_2 bias voltage. In the absence of resistor R_2, the circuit would be a simple current mirror, I_2 being the same as that in R_1.

If R_2 is made equal to the emitter resistance of Tr_1 i.e., R_e=26/I_1, current I_2 will be almost constant, since R_2 and Tr_2 behave as a zero-gain amplifier; as the current changes the voltage across R_2 matches the change in base/emitter voltage, so long as the change is not great. Bias voltage V_2 may then be used as a constant bias for other circuits.

Since matched transistors on a chip are considerably more expensive than matched discrete ones, the variation in **Fig. 2** can be used. In this, R_2 is 52/I_1 to take diode D_1 into account. Voltage V_1 is around $2V_{BE}$ or 1.3V and V_2 about the same, since R_2 only drops about 52mV.

Ripple voltage turns out to be,

$$\Delta V_2 \approx 2V_T\left[\ln(1+K) - K\right]$$

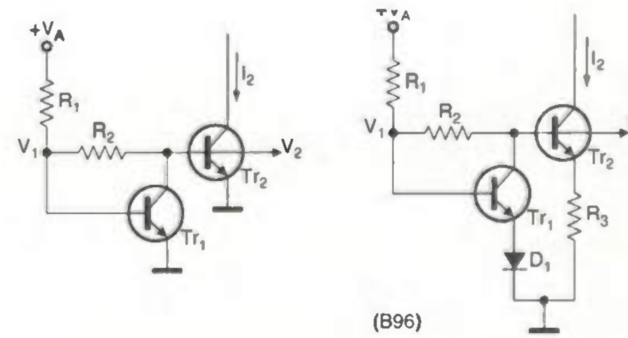
$$\text{where } K = \frac{\Delta I_1}{I_1} = \frac{\Delta V_A}{V_A - 2V_{BE}}$$

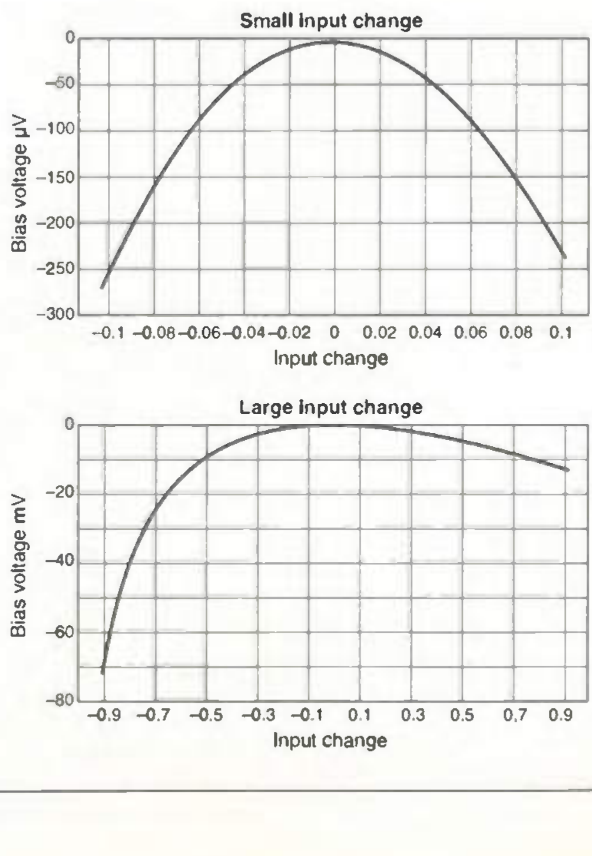
$$V_T \approx 26\text{mV at } 30^{\circ}\text{C}$$

Improved ripple and temperature performance result from using a zener of around 6V instead of D_1, at which voltage temperature coefficient is small. With this arrangement, temperature coefficient of the current in Tr_2 is substantially reduced and the output voltage is now V_{BE} plus the zener voltage.

Resistor R_2 should now be equal to the intrinsic emitter resistance plus the zener slope resistance.

Mark Hughes
Ashby de la Zouche
Leicestershire
B96





Simple modification to the current mirror circuit produces a constant current and bias voltage.

Generating multiple pulse-modulated signals

Our circuit produces four different modulation types – pulse-position, pulse-code, pulse-width and pulse-amplitude modulation.

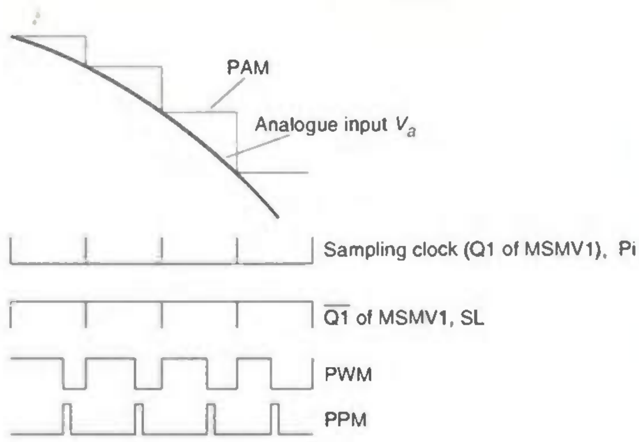
For pam, the sample-and-hold circuit takes the form of an amplifier, an analogue switch and a voltage follower, the input being sampled by the input from the monostable to produce flat-topped pam.

Comparator C output changes from low to high when the d-to-a converter output reaches the analogue input voltage. The change is detected by the positive edge detector and used to latch the outputs of the counter into an eight-bit latch. This latch then passes the parallel count to a parallel-in, serial-out shift register on the signal to the Pi pin from the monostable.

A shift left (SL) instruction from the monostable then shifts the data serially out to become the pulse-code output.

Flip-flop FF, which is preset by the monostable, is cleared by the edge detector to give the pulse-width modulation and the edge detector itself produces the pulse-position output.

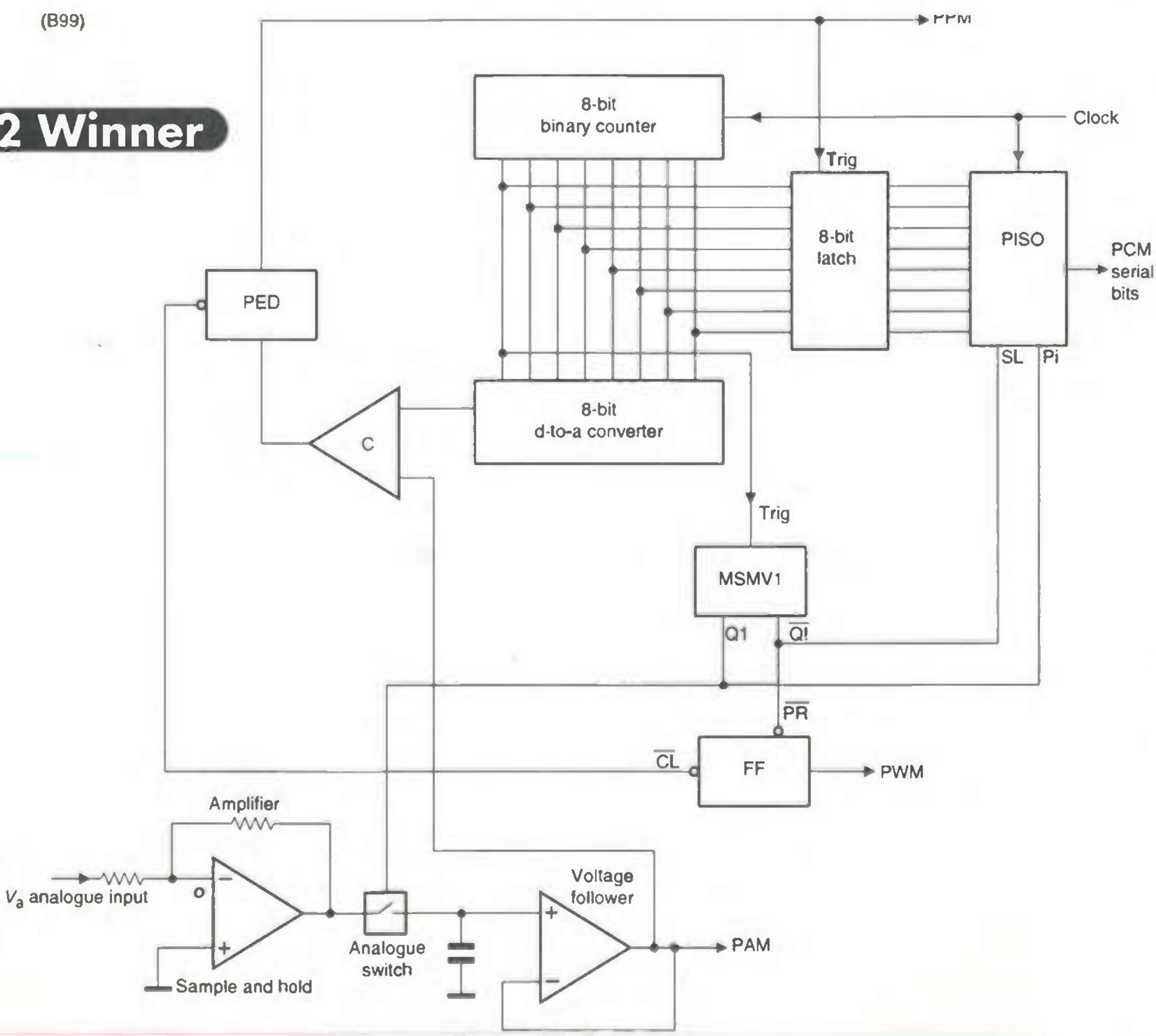
K Balasubramanian
Husseyin Camur
European University of Lefke
Turkish Republic of Northern Cyprus
B99



Four type of pulse modulation come from this simple circuit.

(B99)

ADC42 Winner



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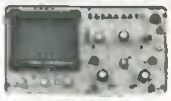

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CIRCLE NO.130 ON REPLY CARD

Low-distortion phono amplifier

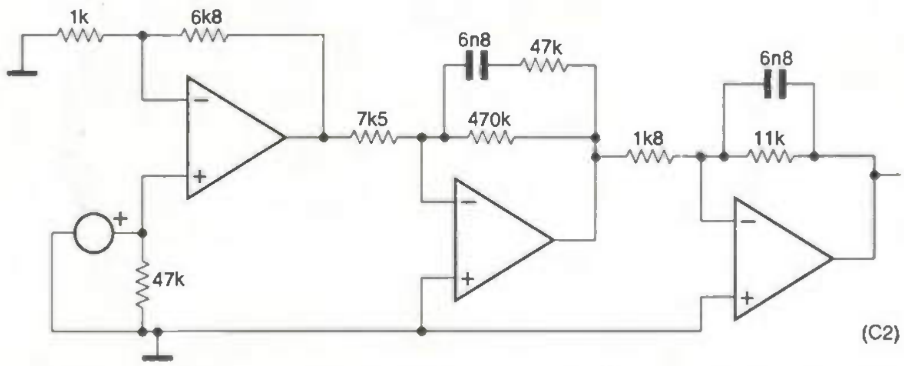
Traditional phono equalisers use one high-gain amplifier, in which the RIAA equalisation is provided by tailoring the feedback loop. In this circuit, amplification and equalisation are split into three stages and the amplifier produces a standard line-level output from a 3.5mV phono input.

Each stage has a gain of 6, so the distortion level of the whole circuit is around 23dB less than that found in a single-stage design. In addition, the equalisation is split into two non-interacting networks. Each is a simple low-pass filter, in which, since they are based on the shunt layout, frequency response falls indefinitely at high frequencies instead of flattening out.

Two such circuits have been tested: one used the elderly *TL074* and the other the faster and less noisy *OP275*. Both work well, but the *275* has a slight edge.

If a high-output, moving-coil cartridge is to be used, the 1kΩ input resistor may be reduced in value to suit.

Jeff Macaulay
Chichester
West Sussex
C2



Three-stage phono amplifier separates the amplifying and equalising functions to produce around 23dB lower distortion than traditional designs.

6V automatic battery backup

Automatic battery backup for a 6V supply is provided by a 4.8V battery and a *MAX770* adjustable, step-up, dc-to-dc controller, with no additional control logic or diode circuitry.

Output of the controller is set to be slightly lower than the minimum voltage from the primary supply in normal operation by the selection of $R_{2,3}$, the regulator holding itself in the minimum output state and drawing little current. Regulator output diode D_1 protects the inductor from reverse current flow into the battery.

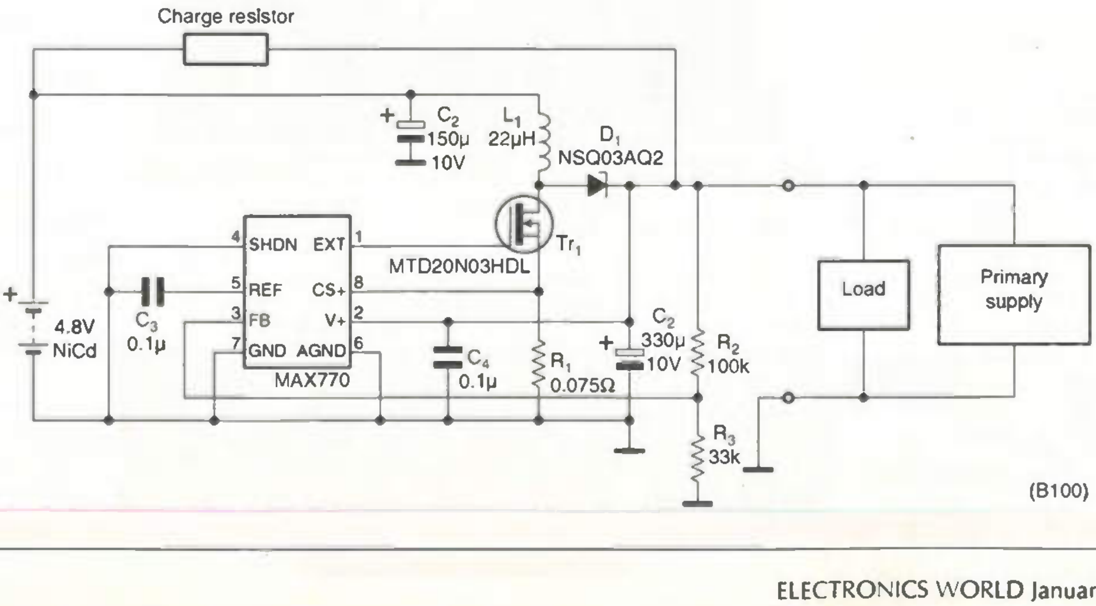
When the primary supply is normal, a trickle charge comes from the primary supply via the charge resistor, which should be carefully chosen, the maximum continuous charge for a NiCd being usually 0.1 of its capacity in ampere-hours.

When the primary falls below the set output voltage of the regulator, the *770* comes smoothly into operation and supplies the load until the primary is restored or the battery goes flat. In the circuit shown, values of $R_{2,3}$ set the output to 6.00V for connection to supply rails not dipping below 6.05V in normal working.

The primary must be able to take 6V on its output even when it comes from another source.

Many of the circuit values came from the Maxim *MAX770* evaluation board.

Steve Tree
Epsom
Surrey
B100



With no need for additional controls or diode circuitry, this circuit provides automatic backup for a 6V rail, derived from a 4.8V NiCd.

Pink noise generator

Not pseudo, but real random noise generator, output being filtered to give pink noise for speaker testing.

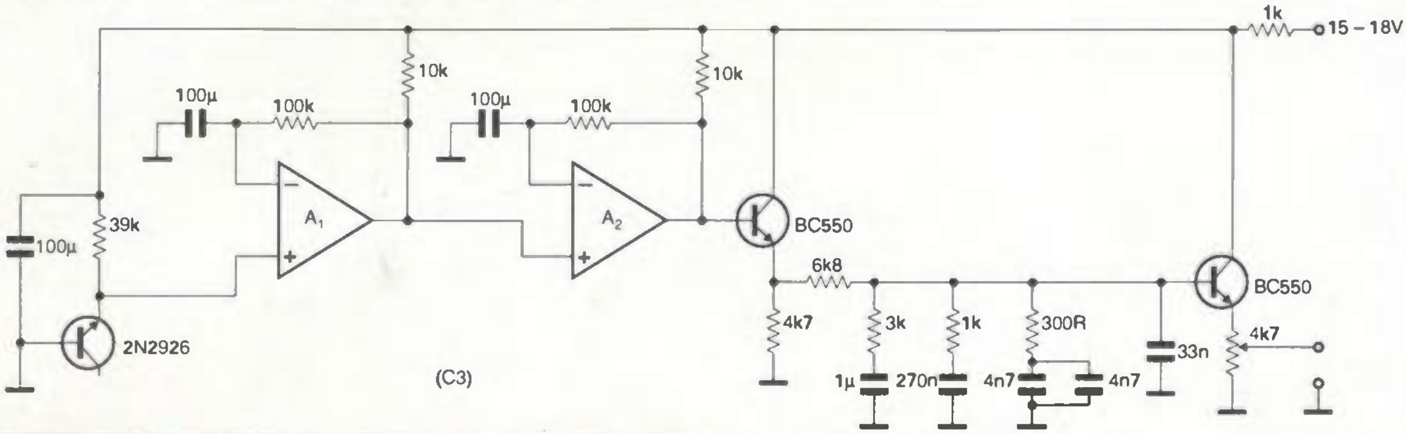
Although pseudo-random noise generator chips are available and convenient, the circuit shown is simple and uses real random noise to produce pink noise at the output.

The 2N2926 is reverse-biased and connected as a noisy zener diode, the noise from which is amplified by comparators $A_{1,2}$. Output from the amplifier is buffered by the emitter follower and consists of a random-frequency squarewave train – pure white noise.

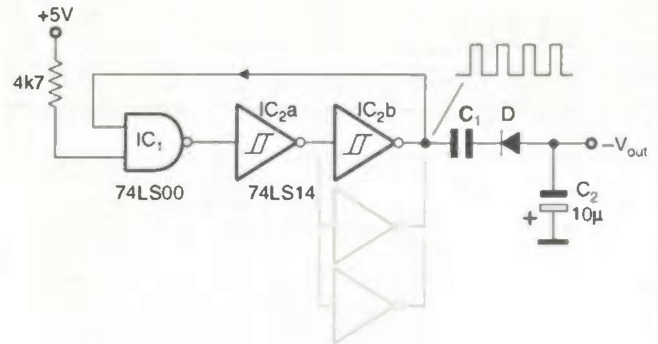
For loudspeaker testing, however, pink noise is rather more useful, this being the function of the rest of the circuit, which filters the square wave at –3dB/octave. By cascading poles and zeros, the required roll-off, with the values shown, is within 0.25dB between 10Hz and 40kHz. This output is then buffered to present a low-impedance drive.

A pair of PP3 cells will power the circuit for several weeks.

Jeff Macaulay
Chichester
West Sussex
C3



Negative voltage converter



Although simple in the extreme, this circuit converts a positive voltage supply to a negative one without using an oscillator, regulator or translator.

It relies on propagation delay between stages to produce a ringing oscillator whose output is a ttl-level pulse in the region of a few tens of megahertz. This output is isolated by C_1 and rectified by D to obtain the negative voltage, C_2 filtering the rectified voltage to provide the output.

To obtain more power, the other sections of the *74LS14* can be paralleled.

J Jayapandian
Tamil Nadu
India
C4

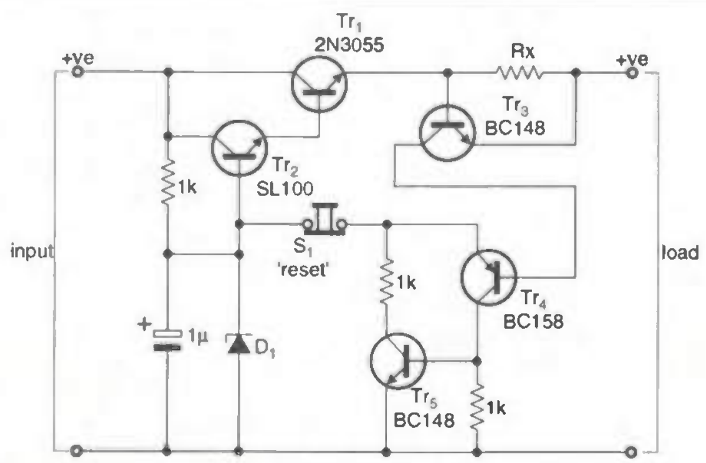
Electronic dc circuit breaker

This arrangement replaces an ordinary fuse in a dc circuit and has the advantage of a reset switch.

Transistor Tr_1 is a series-pass device, forming a darlington pair with Tr_2, the pair being biased by the zener diode. If current through R_x becomes excessive and the voltage drop is more than 0.6V, Tr_3 turns on and triggers the thyristor $Tr_{4,5}$, cutting off the series pair. Switch S_1 restores the *status quo*.

Series resistor R_x should be selected to drop 0.6V at the required current.

Rupen Chanda
Madras
India
B56



Replacement for a wire-type fuse has a reset facility.

Fx(mA)	Rx	Watt
100	6	0.25
500	1.2	0.5
1000	0.6	1.0
5000	0.12	3.0

(B56)

Multiplying frequency synthesiser

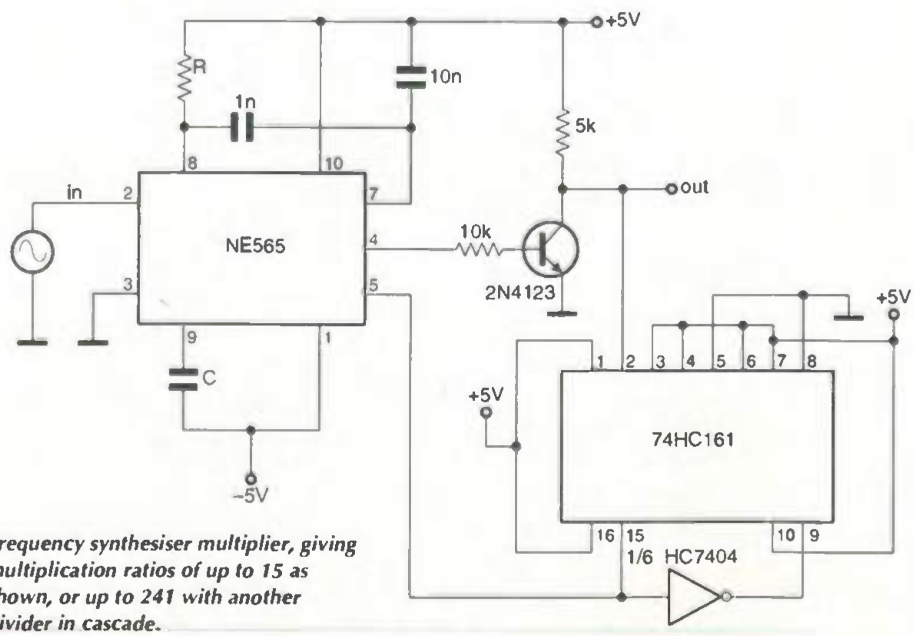
If the loop between the voltage-controlled oscillator and the phase comparator in a phase-locked loop contains a divider, the circuit becomes a multiplier.

In this case, the divider is a *74HC161* programmable counter, programming being applied to pins 3, 4, 5 and 6, which are weighted as 1, 2, 4 and 8 respectively. If *n* is the sum of the weights of the pins tied high in the diagram, the division ratio is 16–*n*, in this case 5. Output from the circuit is then five times the fundamental frequency.

Since the phase comparator is a mixer, the output of which therefore contains sum and difference frequencies, it is necessary to filter out the sum component which may otherwise cause a reduced capture range.

As mentioned by Wheeler (*EW*, November 1996, p.892), using two cascaded dividers gives a division ratio of 256–*n*–16, giving frequency multiplication by all integers to 241.

Kamil Kraus
Rokycany
Czech Republic
B72

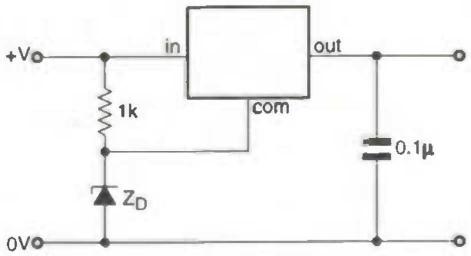


Frequency synthesiser multiplier, giving multiplication ratios of up to 15 as shown, or up to 241 with another divider in cascade.

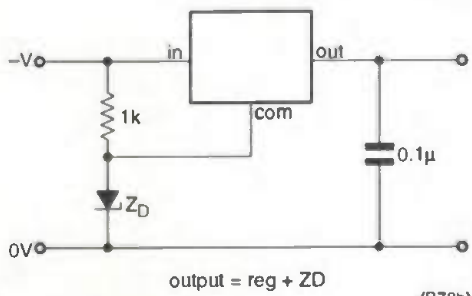
High-power, low-cost supplies

Regulated power supplies to provide positive and negative rails at 3A or more can be expensive. Using *78xx Series* positive and *79xx Series* negative 1A voltage regulators allows the design of supplies to give 5V, 12V and 15V output, but it is often necessary to obtain odd voltages. There are variable regulators such as the *LM317T*, but they cost about three times as much as fixed ones, are single-rail output types and only provide up to 37V at 1.5A. Circuit arrangements shown here illustrate just how versatile the *78/9* devices can be.

Increased voltage. These regulators have in, out and common pins and, to obtain more output it is only necessary to connect a zener between common and circuit 0V, as in **Fig. 1**, to get the regulator output plus the voltage of the zener. A 20V zener and a *7805* would therefore give 25V. For a negative output, simply reverse the zener, as in **Fig. 2**.

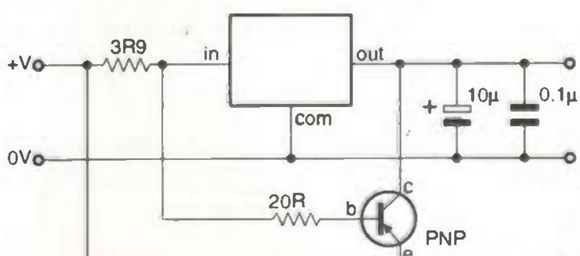


(B78a)

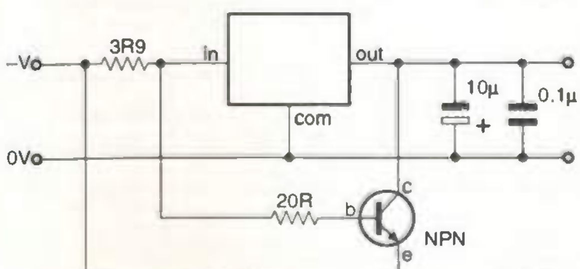


(B78b)

Figs 1 and 2. Increasing regulator output voltage by the addition of zener to give an output of V_z+V_{reg}.

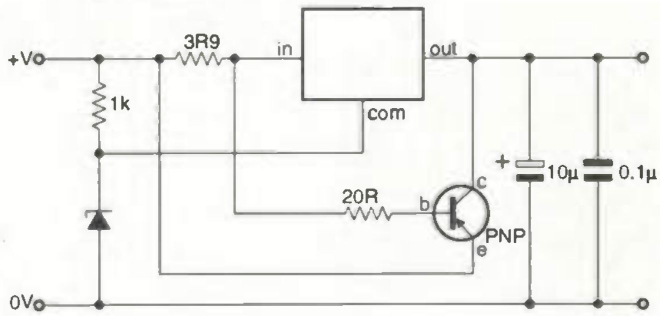


(B78c)



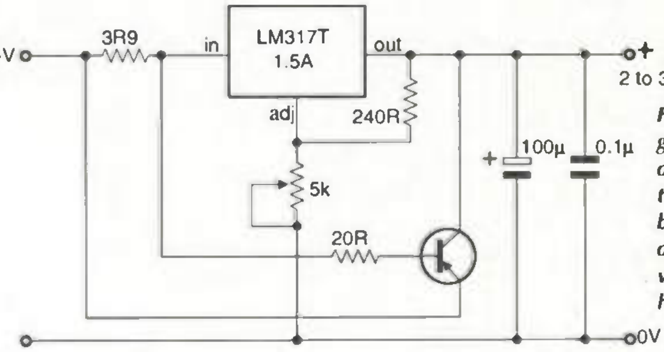
(B78d)

Figs 3 and 4. For more current, use a bypass transistor of the current rating required.



(B78e)

Fig. 5. Both circuits may be used together to give both voltage and current increase.



(B78f)

Fig. 6. The LM317T gives an adjustable output, but only up to 1.5A. Use the bypass transistor to obtain adjustable voltage output at a higher current.

(B78g)

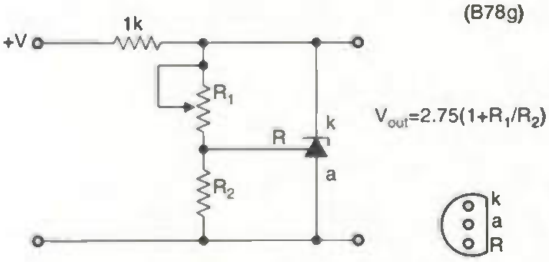


Fig. 7. Alternatively, an adjustable zener used in place of the fixed one in Figs 1, 2 and 5, will give the same performance as the circuit in Fig. 6.

More current. A bypass transistor and two resistors, arranged as is shown in **Fig. 3** with a 78xx regulator for a positive supply, will give more current up to a maximum set by the current rating of the transistor. For example, a *BD540C* would provide 5A and a *BD54C* 8A. The 3.9Ω resistor limits regulator current to the 1A maximum. **Figure** 4 shows a *79xx* regulator and an n-p-n transistor to give a negative output. Both the increased current circuit and the voltage augmenters may be used together, as in **Fig. 5**, to provide both increased voltage and current, thereby allowing the design of single or dual rail supplies with almost any voltage and current output needed.

High-current, variable voltage. A popular variable-output regulator, the *LM317T*, gives a 1.2-37V output and may be used with the bypass transistor arrangement to give more than the 1.5A provided by the regulator itself, **Fig. 6**. An alternative to an adjustable regulator is seen in **Fig. 7**, where an adjustable zener performs the same function in the circuit of Fig. 1.

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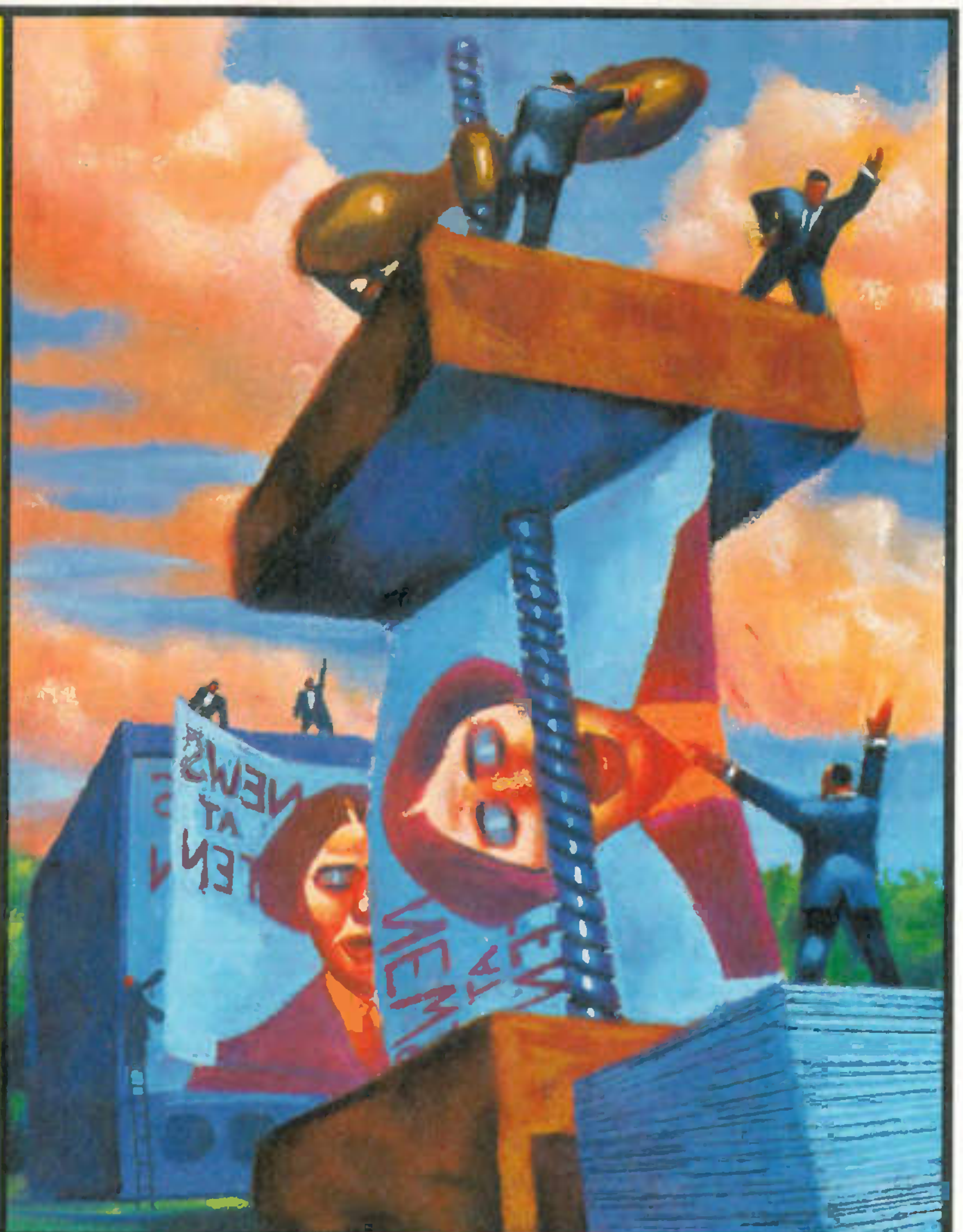

Look again

The technologies of film, television and computers began quite independently and remained this way for some time. However, the development of digital representations of film and television has made data the universal medium, and the merging of these technologies inevitable.

This process has come to be known as 'convergence' and as it advances, the traditionally separate approaches are now a source of incompatibility which threatens to hinder progress to no-one's benefit.

Digital television technology has advanced to the point where broadcasting in the digital domain is now preferable to analogue technology on performance and economic grounds. The design of a new television broadcasting format is an opportunity which occurs rarely. The decisions made have a long lasting effect and must therefore be well considered. If a sub-optimal system is chosen, it becomes a liability rather than a legacy.

In my view, the only way to proceed is to design a format which, for reasonable complexity, gives the best subjective results for a given bandwidth versus data rate ratio. Anything else will simply cost more to run.

Trade-offs

Within this criterion of efficiency, the viewer can be offered any balance of quality and bit rate. The efficiency can be used to minimise bit rate in cost conscious applications, or to maximise quality in prestige applications.

In order to implement this strategy, only two important steps are needed.

John Watkinson
BSc MSc FAES MBCS

These are as follows:

- Obtain an accurate model of the human visual system so that the sensitivity of the viewer to all relevant quality parameters is known.
- Use that model to make objective comparisons between what is theoretically possible and any proposals. Any proposal coming close to the ideal can be selected, but if none do, work remains to be done.

Here I intend to show that little work remains to be done. Sufficient knowledge of the human visual system exists, and all of the fundamental technical concepts exist. An efficient, convergent, moving image portrayal system with complete interoperability between film, television broadcasts and computer graphics can be created today with no more than an intelligent combination of existing technologies.

The greatest difficulties are not technological, but in the incomplete experience of the converging technologies. Broadcasters, with their analogue background, still lack a wide and deep understanding of digital technology. Many aspects of today's television standards were established empirically before the relevant theory was understood. The computer industry naturally knows digital techniques backwards but tends to lack knowledge of psycho-optics and psycho-acoustics.

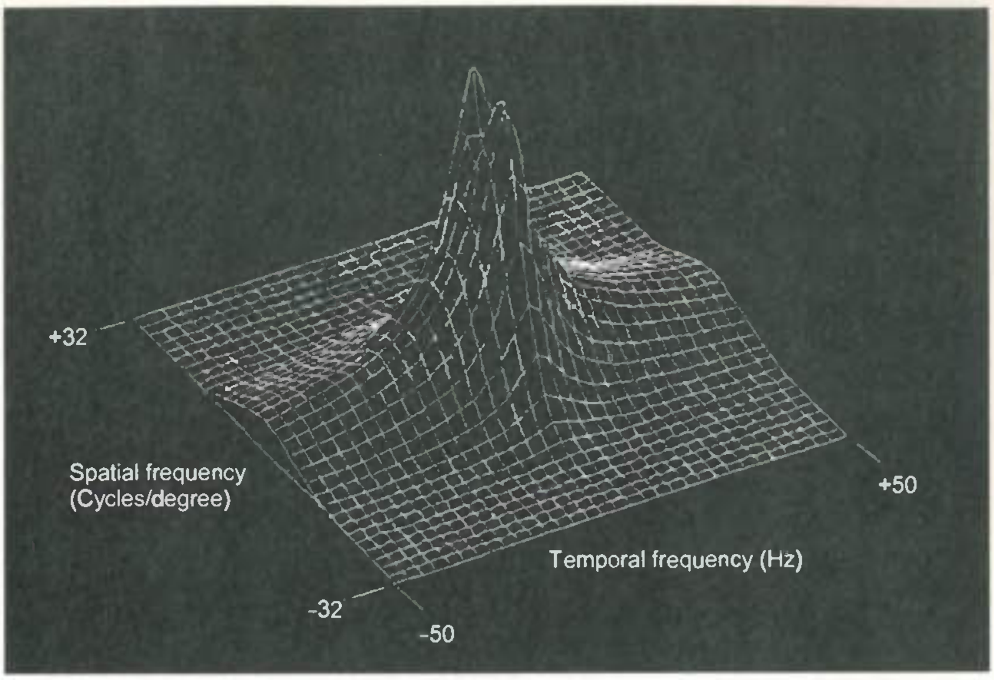

Fig. 1. Two-dimensional, i.e. spatio-temporal, response of the eye.

Human vision

All television signals ultimately excite some response in the eye and the viewer can only describe the result subjectively. Familiarity with the operation and limitations of the eye is essential to an understanding of television principles.

Human vision is too complex to be treated fully here. This article concentrates on resolution or definition. While important and interesting, subjects such as gamma and colorimetry[1] cannot be treated here as they are not central to the argument.

The eyeball is nearly spherical and is swivelled by muscles. The space between the cornea and the lens is filled with transparent fluid known as aqueous humour. The remainder of the eyeball is filled with a transparent jelly known as vitreous humour.

Light enters the cornea, and the amount of light admitted is controlled by the pupil in the iris. Light entering is involuntarily focussed on the retina by the lens in a process called visual accommodation.

The lens is the only part of the eye which is not nourished by the bloodstream and its centre is technically dead. In a young person the lens is flexible and muscles distort it to perform the focussing action.

In old age the lens loses some flexibility and causes presbyopia or limited accommodation. In some people the length of the eyeball is incorrect, resulting in myopia – short sightedness – or hypermetropia – long sightedness. The cornea should have the same curvature in all meridia, and if this is not the case, astigmatism results.

The retina is responsible for light sensing and contains a number of layers. The surface of the retina is covered with arteries, veins and nerve fibres. Light has to penetrate these in order to reach the sensitive layer. This layer contains two types of discrete receptors known as rods and cones from their shape. The distribution and characteristics of these two receptors are quite different.

Rods and cones

Rods dominate the periphery of the retina whereas cones dominate a central area known as the fovea outside which their density drops off. Vision using the rods is monochromatic and has poor resolution but remains effective at very low light levels, whereas the cones provide high resolution and colour vision but require more light.

The cones in the fovea are densely packed and directly connected to the nervous system, allowing the highest resolution. Resolution then falls off away from the fovea. As a result the eye must move to scan large areas of detail.

The image perceived is not just a function of the retinal response, but is also affected by processing of the nerve signals. The overall acuity of the eye can be displayed as a graph of the response plotted against the degree of detail being viewed.

Detail is generally measured in lines per millimetre or cycles per picture height, but this takes no account of the distance from the eye. A better unit for eye resolution is one based upon the subtended angle of detail as this will be independent of distance. Units of

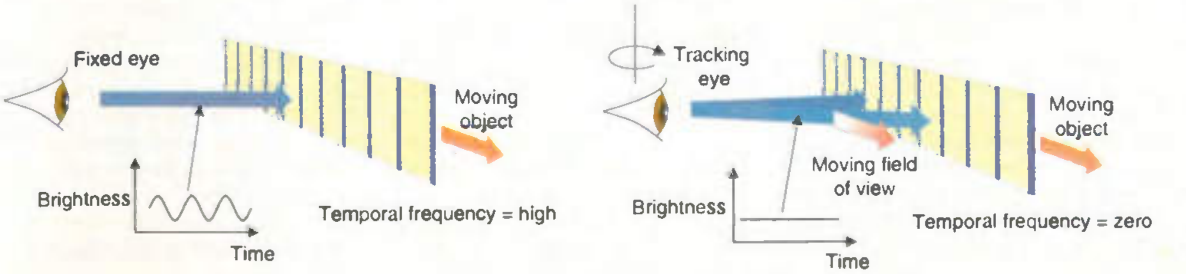

Fig. 2. If the eye were static, a detailed object moving past it would give rise to temporal frequencies, as in a). However, the human viewer has an interactive visual system which causes the eyes to track the movement of any object of interest, as in b).

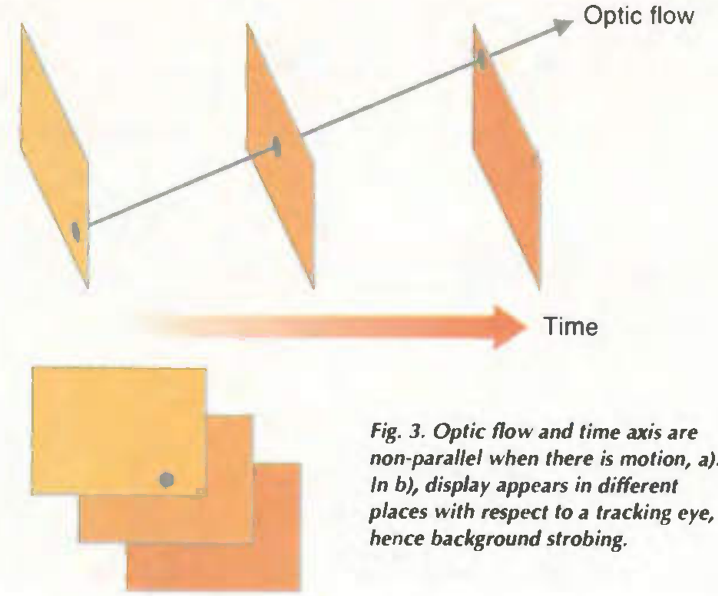

Fig. 3. Optic flow and time axis are non-parallel when there is motion, a). In b), display appears in different places with respect to a tracking eye, hence background strobing.

cycles per degree are then appropriate.

The response of the eye to static detail falls at both high and low spatial frequencies. An extension of this characteristic allows the vision system to ignore the fixed pattern of shadow on the retina due to the nerves and arteries.

The retina does not respond instantly to light, but requires between 0.15 and 0.3 seconds before the brain perceives an image. The resolution of the eye is primarily a spatio-temporal compromise. The eye is a spatial sampling device; the spacing of the rods and cones on the retina represents a spatial sampling frequency. The measured acuity of the eye exceeds the value calculated from the sample site spacing because a form of oversampling is used.

Eyes in constant motion

The eye is in a continuous state of unconscious vibration called saccadic motion. This causes the sampling sites to exist in more than one location, effectively increasing the spatial sampling rate provided there is a temporal filter which is able to integrate the information from the various different positions of the retina.

This temporal filtering is responsible for 'persistence of vision'. Flashing lights are perceived to flicker until the critical flicker frequency, or cff, is reached; the light appears continuous for higher frequencies. The critical flicker frequency is not constant but changes with brightness.

Note that the field rate of European television at 50 fields per second is marginal with bright images. **Fig. 1** shows the two dimensional or spatio-temporal response of the eye.

If the eye were static, a detailed object moving past it would give rise to temporal frequencies, as **Fig. 2a)** shows. The temporal frequency is given by the detail in the object, in lines per millimetre, multiplied by the speed. Clearly a highly detailed object can reach high temporal frequencies even at slow speeds. Yet Fig. 1 shows that the eye cannot respond to high temporal frequencies.

However, the human viewer has an interactive visual system which causes the eyes to track the movement of any object of interest. Figure **2b)** shows that when eye tracking is considered, a moving object is rendered stationary with respect to the retina. As a result, temporal frequencies fall to zero and much the same acuity to detail is available despite motion. This is known as dynamic resolution and it's how humans judge the detail in real moving pictures.

It astonishes me that video engineers so often state that softening of moving objects is inevitable and acceptable, when it plainly isn't.

Dynamic resolution

As the eye uses involuntary tracking at all times, the criterion for measuring the definition of moving image portrayal systems has to be dynamic resolution. This is defined as the apparent resolution perceived by the viewer in an object moving within the limits of accurate eye tracking. The traditional metric of static resolution in film and television has to be abandoned as unrepresentative.

Figure 3a) shows that when the moving eye tracks an object on the screen, the viewer is watching with respect to the optic flow axis, not the time axis, and these are not parallel when there is motion. The optic flow axis is defined as an imaginary axis in the spatio-temporal volume which joins the same points on objects in successive frames. Clearly when many objects move independently there will be one optic flow axis for each.

The optic flow axis is identified by motion compensated standards converters to eliminate judder and also by MPEG compressors. This is because the greatest similarity from one picture to the next is along that axis. The success of these devices is testimony to the importance of the theory.

Figure **3b)** shows that when the eye is tracking, successive pictures appear in different places with respect to the retina. In other words if an object is moving down the screen and followed by the eye, the raster is actually moving up with respect to the retina.

Although the tracked object is stationary with respect to the retina and temporal frequencies are zero, the object is moving with respect to the sensor and the display. In those units, high temporal frequencies will exist. If the motion of the object on the sensor is not correctly portrayed, dynamic resolution will suffer.

In real-life eye tracking, the motion of the background will be smooth, but in an image portrayal system based on periodic presentation of frames, the background will be presented to the retina in a different position in each frame. The retina separately perceives each impression of the background leading to an effect called background strobing.

The criterion for the selection of a display frame rate in an imaging system is sufficient reduction of background strobing. It is a complete myth that the display rate simply needs to exceed the critical flicker frequency. Manufacturers of graphics displays which use frame rates well in excess of those used in film and television are doing so for a valid reason: it gives better results! Note that the display rate and the transmission rate need not be the same in an advanced system.

Dynamic resolution analysis confirms that both interlaced television and conventionally projected cinema film are both seriously sub-optimal. In contrast, progressively scanned television systems have no such defects.

Interlace

Interlaced scanning is a crude bandwidth reduction technique which was developed empirically in the early days of television. Instead of transmitting entire frames, the lines of the frame are sorted into odd lines and even lines. Odd lines are transmitted in one field, even lines in the next. A pair of fields will interlace to produce a frame. Vertical detail such as an edge may only be present in one field of the pair and this results in frame rate flicker called 'interlace twitter'.

Figure 4 shows a dynamic resolution analysis of interlaced scanning. When there is no motion, **4a)** the optic flow axis and the time axis are parallel and the apparent vertical sampling rate is the number of lines in a frame. However, when there is vertical motion, **4b)**, the optic flow axis turns. In the case shown, the sampling structure due to interlace results in the vertical sampling rate falling to one half of its stationary value.

Consequently interlace does exactly what would be expected from a half-bandwidth filter. It halves the vertical resolution when any motion with a vertical component occurs. In a practical television system, there is no anti-aliasing filter in the vertical axis. As a result, when the vertical sampling rate of an interlaced system is halved by motion, high spatial frequencies will alias or heterodyne causing annoying artifacts in the picture. This is easily demonstrated.

Figure 4c) shows how a vertical spatial frequency well within the static resolution of the system aliases when motion occurs. In a progressive scan system this effect is absent and the dynamic resolution due to scanning can be the same as the static case.

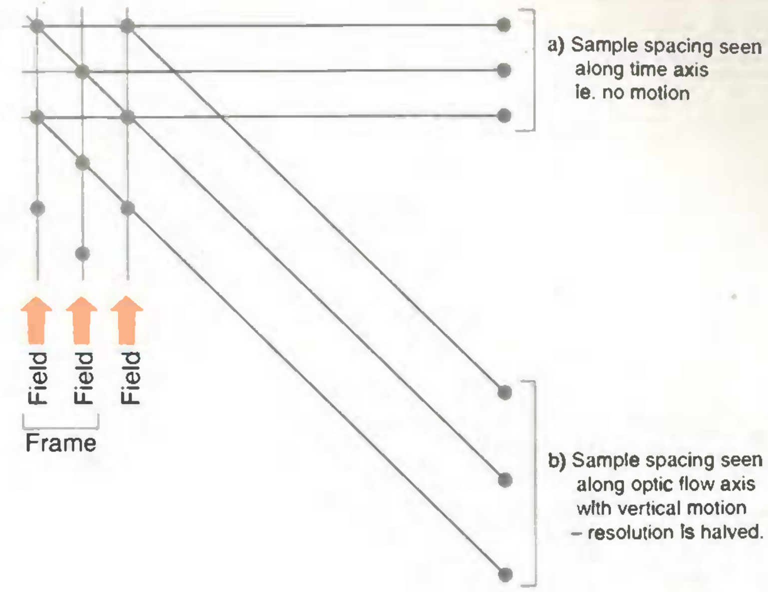

Fig. 4. With no motion, interlaced system has resolution based on number of lines in a frame, a). In the presence of motion, b), the interlaced system has vertical resolution halved to the number of lines in a field.

Why not have a vertical raster?

This analysis also illustrates why interlaced television systems have to have horizontal raster lines. The reason is that in real life, horizontal motion is more common than vertical.

It is easy to calculate the vertical image motion velocity needed to obtain the half-bandwidth speed of interlace, because it amounts to one raster line per field.

In 525/60 NTSC there are about 500 active lines, so motion as slow as one picture height in eight seconds will halve the dynamic resolution. In 625/50 PAL there are about 600 lines, so the half-bandwidth speed falls to one picture height in 12 seconds. This is why NTSC, with fewer lines and lower bandwidth, doesn't look as soft as it should compared to PAL, because it has better dynamic resolution.

The situation deteriorates rapidly if an attempt is made to use interlaced scanning in systems with a lot of lines. In 1250/50, the resolution is halved at a vertical speed of just one picture height in 24 seconds. In other words on real moving video a 1250/50 interlaced system has the same dynamic resolution as a 625/50 progressive system. By the same argument a 1080 I system has the same performance as a 480 P system.

While horizontal raster lines palliate the drawbacks of interlace, they do nothing to help the crt designer. This is because this arrangement combines the highest scanning frequency with the greatest scanning deflection.

With the move to 16:9 aspect ratio, the difficulty becomes even greater. With such a wide tube, it becomes logical to have vertical raster lines so that the deflection of the high frequency scan – and the current required – is nearly halved. The wide angle deflection is now only required at the frame rate. The use of interlace prevents this technique.

Interlaced signals are also harder for MPEG to compress. The confusion of temporal and spatial information makes accurate motion estimation more difficult and this reflects in a higher bit rate being required for a given quality.

Long live interlacing...

Following this analysis, I conclude that interlaced scanning has too many drawbacks to be considered in an advanced imaging system. Theoretical and subjective efficiency is low and and interlace represents poor value for money. Widescreen displays cost more than necessary, consume more power and dissipate more heat. Compression systems have to use a higher bit rate.

Interlacing was the best that could be managed with thermionic valve technology sixty years ago. We should respect the achievement of its developers at a time when things were so much harder. However, we must also recognise that the context in which interlace made sense no longer exists. ■

In a second article on this topic, John looks at moving image portrayal in film and in MPEG and considers advanced sensor and display techniques.

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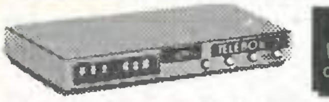

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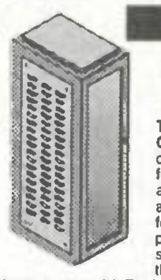

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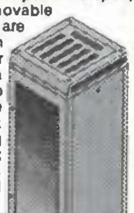

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CIRCLE NO. 134 ON REPLY CARD

NEW PRODUCTS CLASSIFIED

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PASSIVE AND ACTIVE COMPONENTS

Connectors and cabling

Screened pcb connectors. Metal-plated shell housings on Harting's printed-board connectors provide electrical screening in interfaces and racking, attenuation being more than 40dB at up to 10MHz. Metal-plated moulding material is also light and therefore resistant to vibration problems. These *D20* shell housings are available for connector types F, H and MH and incorporate large cable housings with easy access to locking screws and metal-plated mounting elements to give well-screened terminal earthing. Other metal-plated accessories are available, such as polarisation components.
Harting Elektronik Ltd. Tel., 01604 766686; fax, 01604 706777.
Enq no 501

Hybrid rf transistor. Ericsson's *PTF31042* rf power transistor has 50Ω matching networks for input and output impedances and bias and temperature compensation, the avoidance of the need for external components making for improved reliability. Output power is 12W in the 1.9-2GHz band. Bias may be set via an input pin to set quiescent drain current and the temperature compensation takes the form of feedback via the bias circuit to the gain loop, keeping drain current working point constant to provide more output power and intermodulation. (Class AB two-tone IMD3) –40dB at 5W. Power gain is a typical 12.5dB.
Ericsson Components AB. Tel., 01793 488300; fax, 01793 488301.
Enq no 507

High-current mains sockets. Rendar has extended its range of mains inlets and outlets by the addition of 16A versions. They are flanged and screw-mounted and conform to EN60-320, with bodies of UL94-VO thermoplastics, being made in class-I 3-pin style and having 6.3mm or solder terminals. Ratings are 16A at 250V ac or 20A at 125V ac. Moulded cordsets and rewireable plugs and connectors are available.
Rendar Ltd. Tel., 01243 866741; fax, 01243 841486; e-mail, sales@rendar.co.uk; web, www.rendar.co.uk
Enq no 502

Z Pack expanded. The range of AMP's *Z Pack Hard Metric* interconnection system is now enhanced to include higher pin numbers. Conforming to IEC 917, these components are to connect daughter cards to backplanes with low skew and crosstalk and versatile arrangements. A high performance allows the use of higher system speed in the same space as in lower-performing types. They come on 5-row and 5+2-row form and, in an enhanced range, in 8-row and 8+2-row configuration. They are all press-fit types and may be used with power, optical-fibre and coaxial contacts.
Gothic Crellon Ltd. Tel., 01734 788878; fax, 01734 776095; e-mail, gothic@gcrellon.co.uk.
Enq no 503

Earthed power connectors. Interpower's *C5/C6* power entry modules have three pins, including an earth contact, to meet the requirements of IEC60320 and to allow the incorporation of rf filtering in the modules. These are much smaller than other IEC types for use on small panels.
Interpower Components Ltd. Tel., 01243 842323; fax, 01243 842066.
Enq no 504

Data converters

Colour-digitising a-to-d. New from Asahi Kasei, the *AK5420* 20MHz analogue-to-digital converter is for use in digitising colour video images such as photographs or colour scans. From 3V, the device uses only 30mW at 20MHz and comes in a 24-pin package. Differential linearity is 0.5 lsb and integral linearity 1.5 lsb, no calibration being needed.
Asahi Kasei Microsystems Co., Ltd. Tel., 01923 226988; fax, 01923 226933.
Enq no 505

Discrete active devices

"Smallest" power mosfet. IXYS makes the "world's smallest" claim for its *IXFX 55N50* 55A/500V power mosfet. It comes in the company's PLUS247 package, which is the same size as a TO-247 without the mounting hole, clips or bars being used. There has been a 25% reduction in total gate charge to 330nanocoulomb to give higher efficiency and an increased switching speed.
GD Rectifiers Ltd. Tel., 01444 243452; fax, 01444 870722.
Enq no 506

Fast diodes. Fast and ultra-fast surface-mounted diodes by Fagor are now available from Easby. The *FES2A* handles 2A of forward current, has a junction capacitance of 33pF at 1MHz and –4V, and a forward surge rating of 50A for 8.3ms, while the figures for the *FES1A* are 1A, 8pF and 30A. Both are made with dc blocking voltages of 50-400V.
Easby Electronics Ltd. Tel., 01748 850555; fax, 01748 850556; web, sales@easby.co.uk.
Enq no 508

Displays

Pal/NTSC interface. Digital View announces the *AV-0800*, a direct Pal/NTSC video interface controller that supports VGA and SVGA tft lcd panels from all major manufacturers. It has standard BNC and S-video input with auto-detect and a full on-screen display facility with infrared or button control. There is also the facility of autorotation, a run-time counter and audio with a dual-channel daughterboard. It may be switched for 3.3V or 5V and there is provision for full-screen image expansion and smoothing, gamma correction and automatic gain control.
Digital View Ltd. Tel., 0181 2361112; fax, 0181 2361116; web, www.digitalview.com.
Enq no 509

Filters

Emc test kit. A set of eight *EMISTOP* filter adaptors in by Selectronix form a pre-compliance test kit, the price being cut to two-thirds normal. There are four *LC* filters and two T types in 9, 15, 25 and 37 ways and they are designed to assist in the elimination of conducted and radiated emissions over the range 30MHz-1GHz. A low capacitance is used to avoid affecting high-speed data transmission, together with ferrite. Adaptors have male and female connectors, are shielded and are supplied with four 40UNC interlocking screws.
Selectronic Ltd. Tel., 0118 9817387; fax, 0118 9817608; e-mail, sales@selectronix.co.uk; web, www.selectronix.co.uk.
Enq no 510

Anti-emi chip. Syfer Technology has the *1206* single-chip emi filter, which provides line-to-line and line-to-ground filtering simultaneously. It is a surface-mounted device measuring 3.2 by 1.6 by 1.3mm and is rated for working between –55°C and 125°C.
Syfer Technology Ltd. Tel., 01603 629721; fax, 01603 665001.
Enq no 511

Hardware

Nut rings. To save time and cost in the assembly of components in confined spaces, Fastener Specialty makes nut rings, which consist of a ring fitted with captive nuts to eliminate separate nuts, bolts and washers. They come in various sizes and shapes with two or four retaining nuts and suit many types of connector. Since no tools are needed behind the panel, spacing is close and the risk of loose washers or nuts being dropped inside is eliminated.
KEC Ltd. Tel., 0118 9811571; fax, 0118 9811570; web, www.kec.co.uk
Enq no 512

Linear integrated circuits

1μA op-amp. *LMC6442* is a dual, rail-to-rail, single-supply op-amp by National Semiconductor that draws only 0.95μA per amplifier from a 2.2-10V supply. It is intended for use with a single lithium ion cell or a two-cell NiCd battery, the effect of whose performance loss at the end of charge is greatly reduced by the amplifier's input bias current of 5fA, and its small variation in supply current needs over a voltage range.

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Arrow-Jermyn. Tel., 01234 270027; fax, 01234 214674/791501.
Enq no 513

Materials

Printable adhesive. Heraeus announces *PD955PY* – an adhesive with no solvent, which is thermosetting and is a single-component polymer. It allows the printing of adhesive dots of controllable height in one pass for the mounting of sm devices, at the rate of 5000 dots in 30s. Dot heights may be from 0.25mm to 1.3mm, metal stencils giving diameters to 2.2mm; plastic stencils give a height of 1.98mm and a diameter of 3mm. The material possesses a high surface resistivity and its high green strength prevents movement of components during placement. It shows no dendritic growth and its cured adhesion strength is over 25Nmm^2. Defective components may be removed and repaired with no damage.
Heraeus Materials Ltd. Tel., 01932 349315; fax, 01932 347904.
Enq no 514

Optical devices

Optical-fibre interface. Harting's optical-fibre interface is for use in industrial automation applications based on the Arcnet lan standard and converts electrical signals to optical ones and *vice versa* for communications. Electrical signals use a BNC connector, optical inputs and outputs going by way of F-SMA or FH-ST ports. Both star and bus networks may be equipped with the interfaces. Signal format and data rate are to the Arcnet standard at 2.5Mb/s and a 2km transmission distance is possible.
Harting Elektronik Ltd. Tel., 01604 766686; fax, 01604 706777.
Enq no 519

Memory

Graphics ram. NEC's 16-bit synchronous graphics ram will run at clock speeds up to 143MHz. The *µPD4911650* sgram is a cmos device arranged as a dual-bank 256K by 32 dram with a synchronous interface. Automatic and controlled precharge commands are available and, while meant for use with high-performance graphics, the devices are equally well suited to use as memory in systems with wide buses and low granularity. Access time is 7ns and the device supports programmable read or write burst lengths of 1, 2, 4, 8 or full page. Inputs and outputs are compatible with low-voltage ttl, the device itself accepting a 3.3 ±0.3V rail.
Sunrise Electronics Ltd. Tel., 01908 263999; fax, 01908 263003; web, www.sunrise.co.uk
Enq no 515

Microprocessors and controllers

Risc micros. Two new microprocessors from Hitachi are based on the company's *SH-3 Superb* risc engine. *SH7709A/SH7729* are 133MHz, low-power types offering a new on-chip debugger. *SH7729* is the first *SH-3* dsp device, which accelerates modem software, video and image or voice and audio compression and decompression. It has 16K of ram for data storage in dsp processing and will access an instruction in cache and the internal memory in one cycle at 133MHz. On-chip peripherals include data converters, timers, a pll, real-time clock serial comms interface and direct interfacing for many types of memory including synchronous dram.
Hitachi Europe Ltd. Tel., 01628 585163; fax, 01628 585160.
Enq no 516

Secure microcontrollers. Microchip offers 8-bit microcontrollers that protect the eeprom from access. To do that, one would have to reprogram the memory which, since these devices are one-time-programmable, is not possible. *PIC16CE62X* and *PIC12CE67X* are said to be the smallest eight-pin controllers available and compete with 4-bit types while giving enhanced performance. The eeprom will give a million erase/write cycles and a retention time of 40 years or more. There are the *623, 624* and *625* devices, which have 512 to 2048 words of otp memory, 128byte of eeprom and 96-128byte of sram. They run at 5mips at 20MHz and have an analogue comparator module with two comparators and a programmable reference. The *673* and *674* are the first eight-pin types to have an eight-bit a-to-d converter and eeprom, providing 1024 and 2048 by 14 words of otp program memory, the devices taking only 2µA.
Arizona Microchip Technology Ltd. Tel., 0118 9215858; fax, 0118 9215835.
Enq no 517

Motors and drivers

Drive ic. Allegro offers a full-bridge motor drive ic, the *A3957 Series*, which drives one winding of a bipolar stepper motor in microstepping mode. Outputs are rated for ±1.5A continuously and operating voltage up to 50V. An internal pwm current control, with internal mode control, and a 4-bit non-linear d-to-a converter allow motor current control in full, half, quarter, eighth or sixteenth step modes. Current sensing resistor and reference voltage, a digitally selected output current ratio and slow, fast or mixed current-decay modes are provided and various protection circuits are internal.
Allegro MicroSystems Inc. Tel., 01932 253355; fax, 01932 246622; web, www.allegromicro.com
Enq no 518

Oscillators

3.3V smd oscillator. A 5 by 7mm surface-mounted oscillator by MF Electronics, the *Model T3392* works from 3.3V ±10% over the 0-70°C range at frequencies up to 125MHz and at voltages from 3V to 3.6V. Frequency error is less than 50ppm at both ends of the range, drift being less than ±1ppm/year. Frequencies available are 3-125MHz with hcmos/ttl compatibility and there is an internal bypass capacitor to remove supply transients. Output jitter is around 70ps typical at 125MHz.
MF Electronics Corp. Tel., 001 914 5766570; fax, 001 914 5766204; web, www@mfelectronics.com; e-mail, mfsales@mfelectronics.com.
Enq no 522

Implanted keyboard leds. Rowland Automation can supply keyboards with leds implanted in the keyboard membrane, avoiding the need for additional pcbs and providing for flush or embossed mounting for wide angle viewing. Colour filters or diffusing windows may be incorporated to give visible status signals or to obscure the led until it is lit. All interface needs are in the connecting tail.
Rowland Automation Ltd. Tel., 01202 826398; fax, 01202 828205.
Enq no 521

Passive components

Bulk ceramic ***R.*** *Globar* bulk ceramic resistors from PPM are non-inductive, have high power and pulse energy ratings and are meant for use in motor drives. High reliability provided by the Globar components is needed in soft start precharge and braking networks for ac and dc drives; the components also eliminate inductive spikes. They are made of bulk ceramic containing conductive material and withstand heavy overload.
Pulse Power & Measurement Ltd. Tel., 01793 784389; fax, 01793 784391.
Enq no 523

Electrolytics. Nippon ChemiCon's *LXY* series electrolytic capacitors use

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a newly developed, stable electrolyte and other new materials to achieve a useful life of 15000 hours at 105°C with ripple. Case sizes are the same as those in the *LXF* and *LXV* ranges, values being 10-8200µF at ratings of 10-63Vdc.
Young-ECC Electronics. Tel., 01494 753500; fax, 01494 753501; e-mail, crown@youngecc.com.
Enq no 524

Protection devices

Circuit breaker. Airpax *Series 219* circuit breakers are available with a range of mounting methods and in various operational forms. They come with one, two or three poles rated at 0.1A-100A at 240V ac or 125V dc. They will mount on the front or back of panels and each pole may have an auxiliary switch. There are multiple delays available, including separate dc and ac delays. A hydraulic/magnetic current sensor is used which needs no temperature derating, inrush tolerance being such that the breakers will not trip on an 8ms current pulse of up to 30 times the rating.
EAO Ltd. Tel., 01444 236000; fax, 01444 236641; e-mail uksales@eao.com; web, www.eao-group.com
Enq no 525

Resettable 'fuses'. DT Electronics' resettable overcurrent devices use a positive temperature coefficient based on a polymer and are available in ratings of 300mA-2.5A. The *2029 Series* is meant for use in computers and their peripherals and in battery chargers for cellular telephones.

Laser diode array. Newest in Sony's laser diode family is the *SLD402S*, which comes in an open package and which is designed as an excitation source for YAG and other crystals, giving a maximum output of 22W. It is a bar laser diode with a length of 10mm and is claimed to give a life of 5000h operating at 2.1V in the –10°C to 30°C temperature range. There is a selection of wavelengths from 790 to 840mm to match the wavelength of the specified laser.
Sony Computer Peripherals & Components. Tel., 01932 816000; fax, 01932 817001.
Enq no 520

DT Electronics Ltd. Tel., 01203 466500; fax, 01203 466501; web, techdesk@dtelectronics.com
Enq no 526

Switches and relays

Lout-proof keypad. *Series S400* from EAO is a well-protected metal keypad having 16 engraved pull-off keys and is meant for vending machines and petrol pumps. Pad and keys are in chromed zamak and the whole thing can be mounted behind or in front of the panel. Contacts are carbon-over-gold, and there is a contact membrane in silicone and a gold-plated pcb for the switching matrix. Impact resistance is high. Hexadecimal key markings are standard with other forms available. Sealing is to IP67 by O-rings on the membrane and there is a foolproof HE13 connector. Current and voltage needs are 5mA/5V.
EAO Ltd. Tel., 01444 236000; fax, 01444 236641; e-mail uksales@eao.com; web, www.eao-group.com
Enq no 527

Thin switch. Matsushita's new *Ic Card Detection Switch* is only 1.4mm thick by 5.5mm by 4.8mm. Coils spring and contact are integrated for an increase in contact force and reliability and its rotary actuator provides for operation in both vertical and horizontal directions. The switch may be surface mounted or recessed into a pcb with hardly any protrusion at all.
Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599; e-mail, info@macuk.co.uk; web, www.mac-europe.com.
Enq no 528

Triple/quad trip amplifiers. Lee Dickens announces the addition of four new trip amplifiers for process control to its AlphaMINI and AlphaDIN ranges. *MIN 130* (triple-level) and *MIN 140* (quad-level) amplifiers are 12/24V ac/dc powered and are in the TS35 DIN rail mounting style, the DIN 130/140 triple and quad types being 115/230V ac powered and also in the Top Hat mounting. This is said to be the first time triple and quad amplifiers have been available in one case, saving on space and also cost, a 30% reduction being offered between two duals and one quad. Output relays may be set so that the alarm condition for each is above or below a set point to provide normally-on or off states. A catalogue is available.
Envair Ltd. Tel., 01706 228416; fax, 01706 832957; e-mail, envair@dial.pipex.com; web, www.envair.co.uk
Enq no 529

Transducers and sensors

Digital thermometer. Made by Dallas, the *DS1624* is a digital thermometer ic with 256byte of eeprom, converting temperature to a digital word in under one second, to an accuracy between 0°C and 70°C of 0.5°C, the measuring range being –55°C to 125°C. No external probe or sensor is needed, since measurement is performed by a comparison between the number of pulses obtained from low and high temperature coefficient oscillators. It is said to be the most accurate digital thermometer available, providing an output of a 13-bit, two's-complement word. Step size is 0.03125°C.
DT Electronics Ltd. Tel., 01203 466500; fax, 01203 466501; web, techdesk@dtelectronics.com
Enq no 531

Slot sensors. Matsushita's range of sensors now includes the *UZJ3* miniature slot type, which is the smallest of its type and is suitable for use in XY slide overrun, pallet detection, sensing rotating discs and coin sensing. There are many sensing configurations and connection methods and all models have two independent outputs for light-on or dark-on switching and p-n-p or n-p-n output.
Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599; e-mail, info@macuk.co.uk; web, www.mac-europe.com.
Enq no 533

EQUIPMENT

Production equipment

Portable clean air. Envair's *Micro-Iso* is a portable, bench-top unit to provide clean air for the microelectronics industry. It gives a Class 1 environment and is suitable for, for example, the transfer of components between clean areas. It is made in transparent acrylic, is light in weight, easily movable and uses only 40W. Positive or negative internal pressure may be used, separate push-pull fans providing 100% exhaust to give a high rate of change. There is also a Class 10 version.
Envair Ltd. Tel., 01706 228416; fax, 01706 832957; e-mail, envair@dial.pipex.com; web, www.envair.co.uk
Enq no 534

Radio systems

Radio ports for data collection. From RF Solutions, the *RPCDIL - 418A/433A* transceiver modules, which are licence-exempt radio ports to connect microcontrollers in a multi-node network for point-of-sale or security systems. They are plug-in designs to work at distances of 30m in buildings and up to 120m outside with simple antennas, 5V and either a byte-wide i/o port on a host controller or a bidirectional pc port. All low-level packet formatting and packet recovery requirements are provided, packets of 1-27bytes being transmitted . The units interface directly with 5V cmos.
RF Solutions Ltd. Tel., 01273 488880; fax, 01273 480661; e-mail icepic@pavilion.co.uk; web, www.rfsolutions.co.uk.
Enq no 537

Load cells. Designed for force measurement in batch weighing, platforms, tanks or feeders, *S-Type* cells from Control Transducers low-cost types to work in both compression and tension. Measurement range is ±20kg to ±10000kg at an accuracy of ±0.027%, including the effects of non-linearity, hysteresis and repeatability. Overload is 150% of capacity and operating temperature –50 to 200°C. Output from a 5-12V ac/dc input is 2mV/V from 350Ω.
Control Transducers. Tel., 01234 217704; fax, 01234 217083.
Enq no 530

Position sensors. New to Minitran's range of non-contacting position sensors is a model to measure distances of up to 12mm in both static and dynamic modes, using an eddy-current technique in which an hf signal is radiated from the tip into the target. The eddy currents produced are conditioned and represent the gap as a direct voltage or, in a rotating target, as ac. The range now contains four models with ranges from 2mm to 12mm, all having threaded bodies or mounting flanges. Stainless steel is used and cables are armoured. Temperature range is –30°C to 180°C.
Monitran Ltd. Tel., 01494 816569; fax, 01494 812256.
Enq no 532

Please quote *"Electronics World"* when seeking further information

Test and measurement

Waveform analyser. A 10.4in colour tft display is one feature of Yokogawa's *DL708E* waveform recorder and analyser and the provision of slots for eight plug-in signal-conditioning modules is another. It is designed to analyse signals from mechanical, electromechanical and electronic equipment and its light weight makes it particularly suitable for portable use in, for example, vehicle testing. Signal conditioning carried out by the modules includes temperature, strain, logic and voltage signals from electronic systems or transducers. Signals may be at frequencies up to 10MHz and there is an FFT facility and an optional 2.1Gbyte hard disk.
Martron Instruments Ltd. Tel., 01494 459200; fax, 01494 535002; e-mail info@martron.co.uk; web www.martron.co.uk
Enq no 538

Milliohmmeter. Hioki's *3540 HiTester* low-cost instrument comes in four versions with different interfaces. The *HiTester* is intended for use on production lines making wound

Power supplies

0-30/3.3V bench-top supply. *EL302T* from Thurlby Thandar is a bench-top power supply with three outputs: two of them are identical and independent 0-30V, 0-2A supplies and the third a switchable 5V or 3.3V, 1A output. The two 30V outputs may be connected in series or parallel and each will operate in constant-voltage or constant-current mode with automatic crossover and indication. Simultaneous indication of voltage and current on large digital readouts is provided at an update speed of 4/s.
Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409; e-mail, sales@ttinst.co.uk.
Enq no 536

Uv exposure unit for pcbs. For prototype work or small runs, the Mega Electronics *AZ210* ultraviolet exposure unit is a double-sided type, a design that eliminates the problem of artwork registration. Exposure area is more than 10 by 12in. A steel case holds tubes in base and lid, those in the lid being behind flexible Mylar and the others behind glass. Closing the lid forms a seal and starting initiates a vacuum pump to ensure good contact between artwork and board, the tubes only coming on when the vacuum is achieved. A 0-999s timer is included.
Mega Electronics Ltd. Tel., 01223 893900; fax, 01223 893894; e-mail, sales@megaelect.demon.co.uk; web, www/megaelect.demon.co.uk
Enq no 535

components, where speed is needed. It provides a reading in 100ms, which does not fluctuate, and is resistant to extraneous noise and overvoltage. Settings such as the comparator level are quick to carry out. The four-model range includes the basic *3540* without any interface for manual measurement; the *3540-01* with a bcd output; the *35440-02* with a printer interface and the *-03* with an RS232C interface. All have the comparator and sample at 16sample/s.
Telonic Instruments Ltd. Tel., 01734 786911; fax, 01734 792338.
Enq no 539

COMPUTER AND DATA HANDLING

Computers

68060 sbc. The latest version of BVM's *BVME6000* 68060 3.3V single-board computer is an enhanced version specifically for the VMEbus. Versions are available with clock speeds 25-66MHz and the board is usable at temperatures from –20°C to 85°C. Memory is now 96Mbyte of dual-ported ram, 16Mbyte of dual-ported dram, 16Mbyte of flash and 2Mbyte of non-volatile, battery-backed sram as standard, with other options on offer. There is a SCSI interface with dma to give 5Mbyte/s asynchronous or 10Mbyte/s synchronous data transfer, two serial i/o ports for RS232, 422 or 485, a 32-bit dma Ethernet driver and an 8-bit bidirectional Centronics printer port.
BVM Ltd. Tel., 01489 780144; fax, 01489 783589; e-mail, sales@bvmltd.co.uk; web, www.bvmltd.co.uk.
Enq no 540

Computer board-level products

486 computer board. Aaeon Technology's new *SBC-456* 486-based single-board computer has an on-board flat-panel and crt SVGA controller and, on the *SBC-456E*, a PCI Ethernet interface. The cpu is a133MHz AMD DX5 with display functions and the board is half-sized. There is provision for a DiskOnChip 2000 flash disk to allow a bootable virtual hard disk to be installed to provide up to 72Mb without occupying a slot, bus or connector, and there is support for 64Mb of ram.
Display Solutions Ltd. Tel., 01480 463377; fax, 01480 468989.
Enq no 541

VME/VXI interface board. *BUS-65536* from DDC is an interface board meant for testing and simulating bus controllers and multiple remote terminals in Mil-Std-1553 data bus systems. It gives intelligent interfacing between the Mil-Std bus and a VXI bus, which allows it to simulate a bus controller, up to 31 remote terminals and an intelligent bus monitor simultaneously. Errors may be injected into bus controller messages and any terminal responses.
Data Device Corporation. Tel., 01635 40158; fax, 01635 32264.
Enq no 542

Computer peripherals

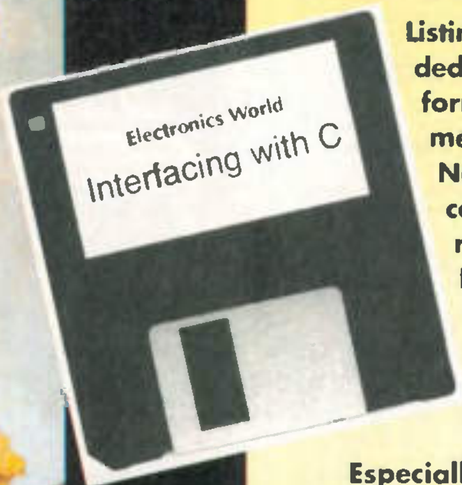
Sharing pcs. *Sharedware*, from the company of the same name, has until now allowed two people to use one Windows 95 pc simultaneously. Now, three can use it and the pc can run Windows 98. Each user has their own monitor, keyboard, mouse and Windows desktop. All users have access to all the pc's facilities and files and may access the Internet and send e-mails. The product combines hardware and software, the card plugging into a spare ISA slot and connecting to a module which is in turn connected to the additional keyboard, monitor and mouse. For the three stations, the recommendation is 54Mb of memory and a 266MHz Pentium; for two, a 166MHz Pentium and 24Mb are sufficient, no performance degradation normally being noticed.
Sharedware Ltd. Tel., 01274 401010; fax, 01274 200311.
Enq no 543

Data acquisition

PXI/CompactPCI data acquisition. Three PXI data acquisition modules by National Instruments use the E-series technique and bus mastering for high rates on PXI and CompactPCI systems. There is also a PXI digital i/o interface. *PXI-6071E* is a 12-bit, 1.25Msample/s E-series module having 64 analogue inputs

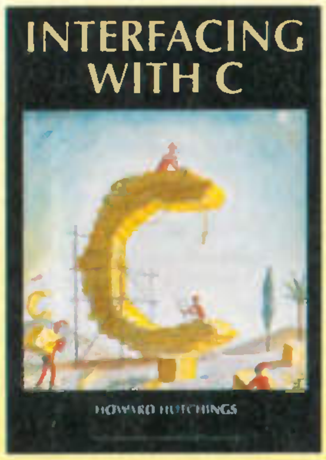
Interfacing with C

Without an engineering degree, a pile of money, or an infinite amount of time, the revised 289-page Interfacing With C is worth serious consideration by anyone interested in controlling equipment via the PC. Featuring extra chapters on Z transforms, audio processing and standard programming structures, the new Interfacing with C will be especially useful to students and engineers interested in ports, transducer interfacing, analogue-to-digital conversion, convolution, digital filters, Fourier transforms and Kalman filtering. Full of tried and tested interfacing routines.
Price £14.99.



Listings on disk – over 50k of C source code dedicated to interfacing. This 3.5in PC format disk includes all the listings mentioned in the book Interfacing with C. Note that this is an upgraded disk containing the original Interfacing With C routines rewritten for Turbo C++ Ver. 3. Price £15, or £7.50 when purchased with the above book.

Especially useful for students, the original Interfacing with C, written for Microsoft C Version 5.1, is still available at the special price of £7.50. Phone 0181 652 3614 for bulk purchase price.



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and two 12-bit analogue outputs, while the *6030E* and *6031E* are 16-bit, 100ksample/s E-series modules with, respectively, 16 and 54 channels and two 16-bit analogue outputs. All have two 24-bit, 20MHz counter-timers, eight digital i/os, analogue and digital triggering and a shielded latching metal connector. *PXI-6508* is a 96-line, parallel digital i/o interface with two-wire handshaking and four 24-bit programmable interfaces. All boards are compatible with LabView and LabWindows.
National Instruments UK. Tel., 01635 572400; fax, 01635 524395; web, www.natinst.com/uk
Enq no 544

Data communications

Modem ic. TDK has the *73K324BL* single-chip modem ic, which possesses all the functions for a V.22bis/V.23 compatible modem to work at up to 2400bit/s over dial-up lines. It will interface with most microprocessors for control purposes and has a hook switch control and hybrid functions. Supply needed is one 5V rail.
TDK UK Semiconductor Corp. Tel., 0181 4437061; fax, 0181 4437022; e-mail, europe.sales@tsc.tdk.com; web, www.tdksemi.demon.co.uk.
Enq no 545

Wireless modem card. Made by Options, the *FirstFone* pc card for mobile data communications is said to be the first such device to provide true wireless data sharing facilities via the GSM network. It will handle file transfer, fax, SMS and e-mail from any portable pc with the necessary slot. An external headset is used for voice communication. The card is a plug-and-play device and has its own antenna.
Premier Electronics Ltd. Tel., 01992 634652; fax, 01992 634616; e-mail, premier@dircon.co.uk
Enq no 546

Software

Temperature control. *CAL COMMS* is windows-based temperature control software, for which CAL Controls has now released a free trial demonstration kit, consisting of a cd or floppy disks and user guide. The kit takes an operator through a simple start-up procedure and demonstrates all the features of the package, which is able to supervise remotely and acquire data from up to 32 instruments. There is an 'Autotune' feature to give control over a wide range of applications. The software takes inputs from most thermocouples and rtds as well as from linear current and voltage transducers, with a choice of five alarm types.
Cal Controls Ltd. Tel., 01462 436161; fax, 01462 451801; e-mail, support@cal-controls.co.uk; web, www.cal-controls.com
Enq no 547

Video and measurement in sync. An extension to the *DIAdem* data acquisition, graphic presentation and analysis program by Strategic Test is *DIAdem-Clip* which allows the display of measurement results at the same time as a video of the test itself, synchronised with each other. Film of the test, a car-crash test, for example, is displayed in one or more windows using one or more cameras, measurement signals being replayed in another window. The cursor may be moved backwards or forwards to display a sequence of particular interest.
Strategic Test and Measurement Systems Ltd. Tel., 01203 323160; fax, 01203 323161; e-mail,info@strategic-test.com; web, www.strategic-test.com
Enq no 548

PUBLICATIONS

Catalogues

Crystals. C-MAC Frequency Products has produced its 344-page 1999 *Crystal Product Data Book*, which is also available on Acrobat-compatible cd-rom and at http://cfpwww.com. The company is a combination of four: C-MAC Quartz Crystals and IQD from the UK, CEPE of France and Greenway of the US. Products on offer cover the low-cost commercial type of thing to military and space products. *C-MAC Quartz Crystals Ltd. Tel., 01460 74433; fax, 01460 72578.*
Enq no 549

Apple Recruitment – The Taste of Success

We currently have many vacancies on our books for RF, Microwave and Antenna Design, Development and Test Engineers. Below is a selection of some positions we have on our records:

RF Engineers

Herts ***£23-40k***
Our client has positions at all levels for engineers with 2.1/1st class honours degrees with a good background in developing ***transmitters, receivers, filters, LNAs*** and ***amplifiers.***

Hants ***£25-36k***
Our client is looking for several RF engineers with good degrees and several years experience developing mobile telecommunications systems. Knowledge of CSM would be an advantage.

Berks ***£24-36k***
Applicants are sought from RF design engineers with a good degree and practical post-grad experience covering some of the following areas – ***RF to 2GHz, LNA design, PLLs, GSM, Filters, power amps, VCOs*** or ***EMC***.

Hants ***£25-36k***
Our client is looking for several RF engineers with good degrees and several years experience developing mobile telecommunications systems. Knowledge of GSM would be an advantage.

Kent ***£28-32k***
Our client is looking to recruit degree qualified RF/Microwave engineers with good post-graduate experience of ***LNAs, filters, diversity systems*** and ***measurement techniques***.

Beds ***£26-34k***
A designer of cellular radio products is looking for experienced RF engineers to design receivers up to 2GHz. Familiarity with digital modulation and DSP would be beneficial.

Cambs ***£28-35k***
Engineers are sought with good degrees and several years post-graduate experience in developing RF circuits and systems. Some of the following skills are needed – ***GSM, PCN, DECT, wireless LAN, antennas, superhet receivers, oscillators, synthesisers, amplifiers*** or ***EMC.***

Antenna Engineers

Surrey ***£23-35k***
Applicants should have two years experience in antenna design, ideally at 1-3GHz. They should have knowledge of antenna manufacturing and testing techniques as well as the design of monopole, dipole, helical and planar antennas.

Essex ***£26-34k***
Our client is looking for qualified engineers with 2 or more years experience in antenna theory and design. You should know antenna arrays as well as near/far field measurements. Knowledge of Radar systems would be a benefit.

London ***£26-36k***
Our client, a major developer of mobile communications equipment, is looking to recruit a Senior Research Engineer in the field of Antennae and Propagation. You should have a good academic record in a relevant field.

Microwave Engineers

Sussex ***£22-34k***
A major developer of radar systems is looking for experienced engineers to develop circuits and sub-systems up to 40GHz. Knowledge of antennas would be beneficial.

Hants ***£25-38k***
Our client is seeking qualified engineers to carry out circuit design and testing with ***MIC*** and ***Ga/ls MMIC circuits*** (e.g. ***low noise amplifiers, phase*** and ***gain control units, oscillators and power amps***) with operating frequencies from ***0.5 to 100GHz.***

Scotland ***£27-35k***
We are looking for several microwave design engineers with skills in ***oscillator*** design, ***amplifiers, filters*** and ***mixer*** design. Knowledge of ***HP EEsof*** design and layout packages would be of help.

Devon ***£22-34k***
A major developer of radar systems is looking for experienced engineers to develop circuits and sub-systems up to 40GHz. Knowledge of antennas would be beneficial.

Sussex ***£22-34k***
A major developer of radar systems is looking for experienced engineers to develop circuits and sub-systems up to 40GHz. Knowledge of antennas would be beneficial.

RF Test Engineers

Surrey ***£16-21k***
We have several positions for ***Test Engineers*** with 1 year + experience testing ***RF systems*** and circuits using ***spectrum analysers, oscilloscopes*** and other ***test equipment.***

Hants ***£17-19k***
Applicants with experience of testing RF systems and circuits down to component level are sought by our clients.

Northants ***£16-20k***
With an HNC and 2 years experience of tesing RF/Microwave products up to 2GHz, you may just be the individual our client is looking for.

1st/2.1 Degree or Ph.D

Nationwide ***£Attractive***
Many of our clients are looking for both fresh and experienced graduates/post graduates for positions in RF/Analogue/Microwave design and development.

Apple Recruitment

3 Branksome Way, New Malden, Surrey KT3 3AX
Tel: 0181 549 0100 Fax: 0181 549 9771
email: consult@applerec.u-net.com
Web: http://applerec.u-net.com/

UK – Wide Vacancies

Kelly Technical Services deals with vacancies for Electronics Engineers nationwide. We would be happy to discuss with you your short and long term career objectives and assist you to find the vacancy most suited to your requirements.

A selection from our current vacancy list is detailed below:

Principal Engineer – Hampshire. Digital design with 16/32 bit embedded microcontrollers. To £35k.

RF Filter Design Engineers – Yorkshire. Development of Microwave filters for Combline and Dielectric Resonator Filters. To £40k package with relocation.

RF Development Engineers – Hampshire. Low power RF circuitry up to 1ghz. To £32k.

RF/Microwave Design Engineers – Yorkshire. Design and Development of RF Tx/Rx components and integrated front-ends for Cellular Radio and PCS/PCN base stations. Package to £40k.

Senior Test Development Engineer – Hampshire. LNA, Oscillators, Mixers and IF design. To £29k.

Test Design Engineer – Hampshire. Telecommunications environment with some knowledge of protocols to support engineering and production. £Negotiable.

For details of these and other electronics vacancies telephone Roy Parrick on 01703 237200 or fax on 01703 634207.
Alternatively E-mail to southtech@kellyservices.co.uk

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SOFTWARE

C/UNIX/MOTIF SOFTWARE ENGINEERS

West of England £20,000 to £33,000

My client is an international communications consultancy specialising in the provision of innovative software products and professional consulting services to network operators and equipment suppliers. My client's products are renowned for their functionality, flexibility and scalability. Due to rapid expansion their requirements are many and spread across a range of disciplines centred around the mobile communications industry, including:

- C, Unix, Motif
- Mobile Comms/GMS
- Network Management
- IN
- SNMP
- Fraud Management Systems
- Signalling System No. 7 (C7)

You can join the cutting edge of mobile Comms consultancy. Contact Toby Walker now.

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West of England £20,000 to £33,000

My client is an international communications consultancy specialising in the provision of innovative software products and professional consulting services. My client's products are renowned for their functionality, flexibility and scalability. Their requirements are many and spread across a range of disciplines centred around the mobile communications industry, including:

- Mobile Comms/GSM
- Network Management/IN/SNMP
- Signalling System No. 7 (C7)
- Oracle Database
- Radio Network Planning/Frequency Planning Software
- Fraud Management Systems

If you have software experience in some of these fields you can join the cutting edge of mobile Comms consultancy. Call Toby Walker now.

PRINCIPAL SOFTWARE ENGINEERS

West of England To £45,000 + Car + Relocation

My client seeks principal software and firmware engineers with at least 5 years' development experience. Software development skills must include C and some Assembler ideally with a thorough understanding of hardware issues. The software will be developed using structured methods and Case Tools. The company is the world leader in the field of computer peripherals. The company is based at a purpose built location designed to make life as easy as possible for developers on site. The remuneration and benefits available are second to none and reflect the company's ethos of continually investing in its people as its key resource. Contact Toby Walker now.

REAL-TIME OS DEVELOPMENT

Berkshire £25,000 to £35,000

My client is the leading supplier of cutting edge operating systems to the real-time software industry. They seek experienced software engineers with RTOS experience, preferably OS-9, and a sound knowledge of C software development, real-time embedded software and ideally networking applications. The role will involve some customer contact for both sales and support issues, with training where applicable. The ability to speak French or German would be useful. In addition to an attractive salary, successful candidates will enjoy a benefits package which includes pension, life assurance and private health cover. Call Toby Walker now.

MOBILE COMMS

GET INTO MOBILE COMMUNICATIONS

M3, M4 To £37,000

Join the successful and expanding development arm of possibly the best known mobile communications company in Europe with over 75,000 employees world-wide. This site specialises in the development of cutting edge mobile communications products. Due to continued investment in R&D they currently require software engineers at all levels. Communications experience is not essential, but is highly desirable. Essential skills are C programming in a real-time environment and structured methods. Desirable skills include:

- Mobile Communications
- Case tools
- GMS/UMTS/DECT/CT2
- DSP

In return for this expertise you will receive excellent remuneration. Contact Toby Walker now.

SOFTWARE ENGINEERS GET INTO MOBILE COMMUNICATIONS

Surrey To £35,000

My client seeks software engineers with good C development skills, familiarity with a PC development environment, a background in embedded systems, and ideally with development experience of consumer products to tight power requirements. With this expertise you can join the fast moving world of international mobile communications development. Due to outstanding product success a number of specialist vacancies exist:

User Interface	MMI design
Hardware Drivers	80x86 assembler, 68 HC11
Call Processing	Protocols (TACS/AMPS/CDMA/PMR)
Data Services	Cellular protocols, TCP/IP
Team Leaders	Communications software development

Highly competitive salary and benefits packages are available for all positions. Relocation assistance is available. Call Toby Walker now.

BIOS SENIOR SOFTWARE ENGINEER

Home Counties £26,000 to £32,000

My client is a leading developer of special-purpose PC products, including smart phones, digital cameras and handheld data acquisition terminals. They are looking for software engineers with at least 2 years' development experience. Some positions are purely 'C' development of protocol layers, where others involve hardware interfacing experience. The job will involve new product development and will also include some marketing and client-facing work. The role requires a detailed understanding of the PC architecture, ideally at the BIOS level. This is an excellent opportunity for an experienced development engineer looking for a fresh challenge. Contact Toby Walker now.

VIDEO WALL/ MULTIMEDIA PRODUCT DEVELOPMENT

Essex/Kent £25,000 to £35,000

Our client is an expanding company developing products at the cutting edge of the Video industry. It has an established product range and due to its market leading innovation further developers are required. Desirable skills include one or more of the following:

- C/Assembler
- Intel x86, Hitachi SH-1 or other RISC
- RTOS and TCP/IP in an embedded environment
- Familiarity with Digital Hardware

This opportunity would suit a Degree qualified software/firmware engineer with at least two years embedded software development experience. Call Toby Walker now.

RF, IC & COMMS

SET YOUR SIGHTS ANALOGUE & MIXED SIGNAL IC ENGINEERS

To £55,000 + Significant Share Options + Benefits

This is an excellent 'Fabless Chip Company' who develop and supply CMOS, BICMOS & Bipolar Integrated Circuits for high volume Fiber Optic Data, LAN and Telecommunications applications.

Recently quoted in the popular electronics press, they have won significant backing from Anglo-American-Japanese venture capitalists. Through the investment they aim to reach $100m flotation on the Stock Exchange within three years. So successful has the venture been so far that in just two years since its conception, the company is now opening sales offices in the US and Japan.

Based in their Bristol office, you will enjoy working on the very latest silicon ICs and fiberoptic components. With either a good degree or excellent industrial experience your background will be in Analogue/Mixed signal IC CMOS, Bipolar or BiCMOS design, with 100Mbps to 10Gbps. 0.5/0.35 CMOS experience which is of particular interest though not essential.

The company are always on the lookout for talented individuals who have the desire to grow and succeed together with the company. In return you will receive both rewarding work and salary in addition to the share options, which will with the company's future flotation plans, become exceptionally valuable. In addition with the opening of the new offices, potential trips and placements abroad are possible. Do not miss out on this exceptional career opportunity. Call Nick Dixon now.

WIRELESS WIZARDS

Cambridge To £53,000 + Benefits + Relocation

Established over 50 years ago, this organisation draws on the knowledge and expertise of over 2,000 employees, whose skills span a wider range of capability than any other major consulting firm. Their Communications Practice focuses on the development of mobile communications and related products. The client list includes many of the world's major communications and electronic equipment supply companies, active in network, terminal and chipset development.

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They are a true technology consultancy. A global company with a multidisciplinary capability where you will be able to work with stimulating colleagues on challenging assignments. You will have your own reasons for making a career move. This company can offer a wealth of world class blue chip clients, reputation, technical involvement, remuneration package, career prospects and development. Call Nick Dixon.

INSANE RF ENGINEER?

You'd have to be to turn down this leader in mobile communications.

M3/M4 Corridor To £42,000 + Benefits + Relocation

Designing and manufacturing digital cellular phones for GSM and satellite networks, this is a focused, well-organised company, capable of rapid innovation and change. They were the first to produce a type approved GSM phone, the first European designer and manufacturer of approved European standards cellular radio. In addition they have the Caesar Award for the best digital phone.

This position suits a degree qualified guru or bright spark with experience in the design of digital communications systems and a thorough understanding of communications principles. They are looking for someone who has the ability to work in a close-knit team in a fast moving and dynamic marketplace. Your role will include the evaluation of next generation technologies and devices as well as the development of new pacesetting RF solutions. You will also study and simulate the latest communications systems and interface with outside parties and other internal development teams. Call me, Nick Dixon, today for a confidential discussion on how to apply to this extraordinary market leader and choose a career not a stopgap!

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VLSI ASIC DESIGN ENGINEER

M4 Corridor Up To £45,000

This is an International semiconductor company which has achieved huge success reaching a multi-billion pound turnover who also employs 3,000 people world-wide. They currently invest over 20% of its sales figure in R&D and is actively involved in Europe's advanced technology research programmes. This company now requires a VLSI ASIC Design Engineer to develop detailed Block/ASIC specification based on general or specific application requirements. Having achieved a good degree in electronics or a related subject you will work as part of a focused and friendly team often on specific projects in addition to general development support. In addition to your experience in VLSI, design and VLSI CAD tools usage, you will be able to demonstrate HDL languages and logic design knowledge. As a reward for utilising your hard earned skills the company will reward you with an excellent salary, Bupa cover, company pension and if necessary a full relocation package. For more information on this choice career move call Nick Dixon today.

ASIC DESIGNER

M4 Corridor Up to £30,000 + benefits

This company's charter is to help their customers to build optimised product development environments with the best combinations of technology, people and processes to help them achieve their business goals. They offer many levels of consulting support to their customers, from assistance with specific designs to a complete re-engineering of the product development process. They work with executive management and the engineering team to assess the customer's design goals and translate them into design solutions. Using HDL technologies you will be involved in ASIC design for consumer or telecom projects. With three to five years' experience of ASIC HDL design, either VHDL or Verilog based designs and familiarity with synthesis, simulation or timing analysis. You will have worked on large ASIC projects over 100,000 gates. A knowledge of Cadence design tools will also be advantageous. In addition to highly competitive salaries, they offer benefit packages that include a share purchase scheme, personal pension, free medical insurance and assistance with relocation where required. They believe in making the most of their people and in helping them make the most of their potential. Whether you are looking to develop personal or technical skills, there are plenty of opportunities. Call Nick Dixon now.

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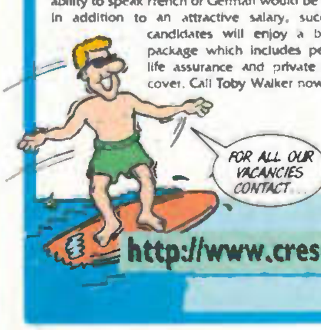
Today, this is the largest company within the electronic design automation market. Of their 3,500 employees world-wide, nearly a third are dedicated to R&D. As electronics become more integral to our everyday existence, the ability to develop and deliver new, innovative products in a globally competitive marketplace is one of the most complex challenges for their customers involved in the growth of technology. You will be responsible for the design, layout and simulation of Bipolar, Bi-CMOS or CMOS designs, as well as being involved in architectural and process trade-offs. You will also have to play in the sales aspect of the work, helping to develop and authorise proposals for analog and mixed-signal projects. With over five years' experience of analog and mixed-signal design in CMOS or Bipolar technologies, you will also be familiar with consumer or telecom designs and with Cadence tools. This is a company which values and rewards people. They want you to help them build a bright future, enjoy a successful career and have fun doing so. Contact Nick Dixon, now for details on this brilliant opportunity.



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