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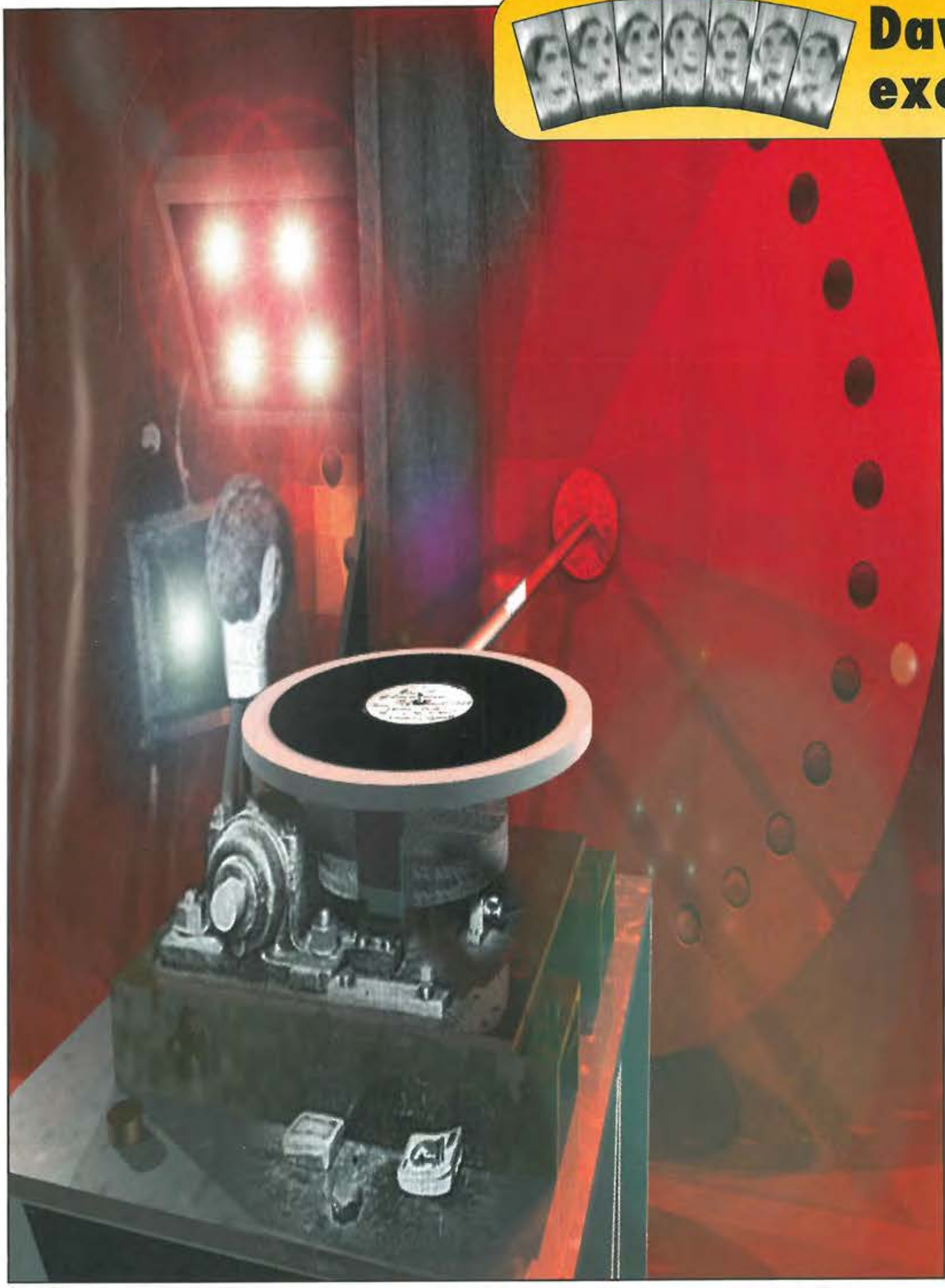

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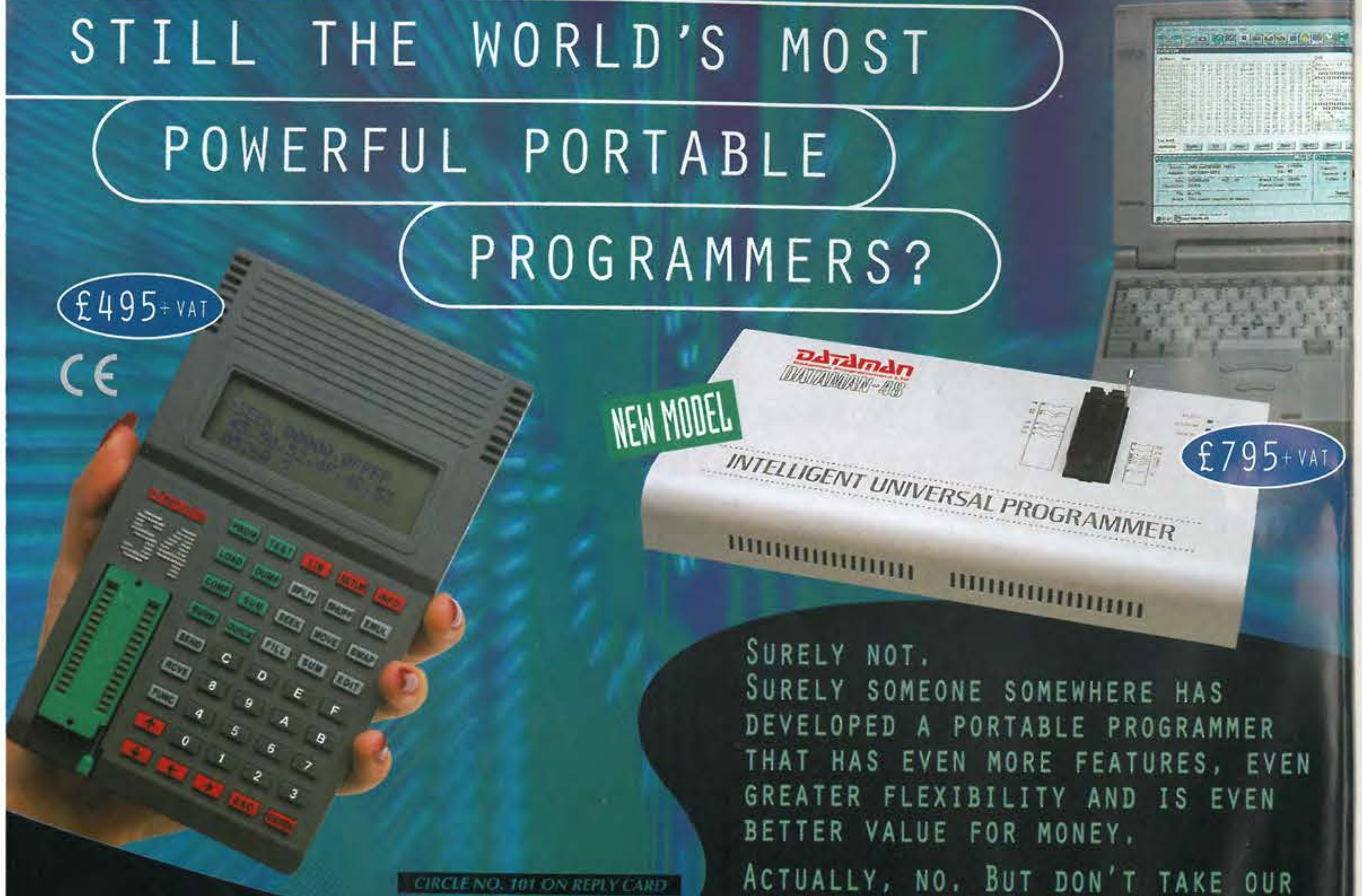

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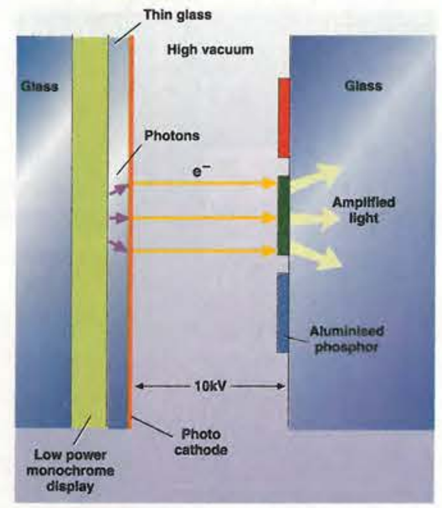


This new display technology produces crt brightness and viewing angle without the bulk. Steve Bush explains how on page 775.

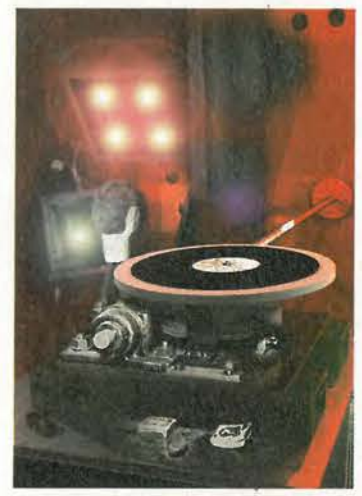


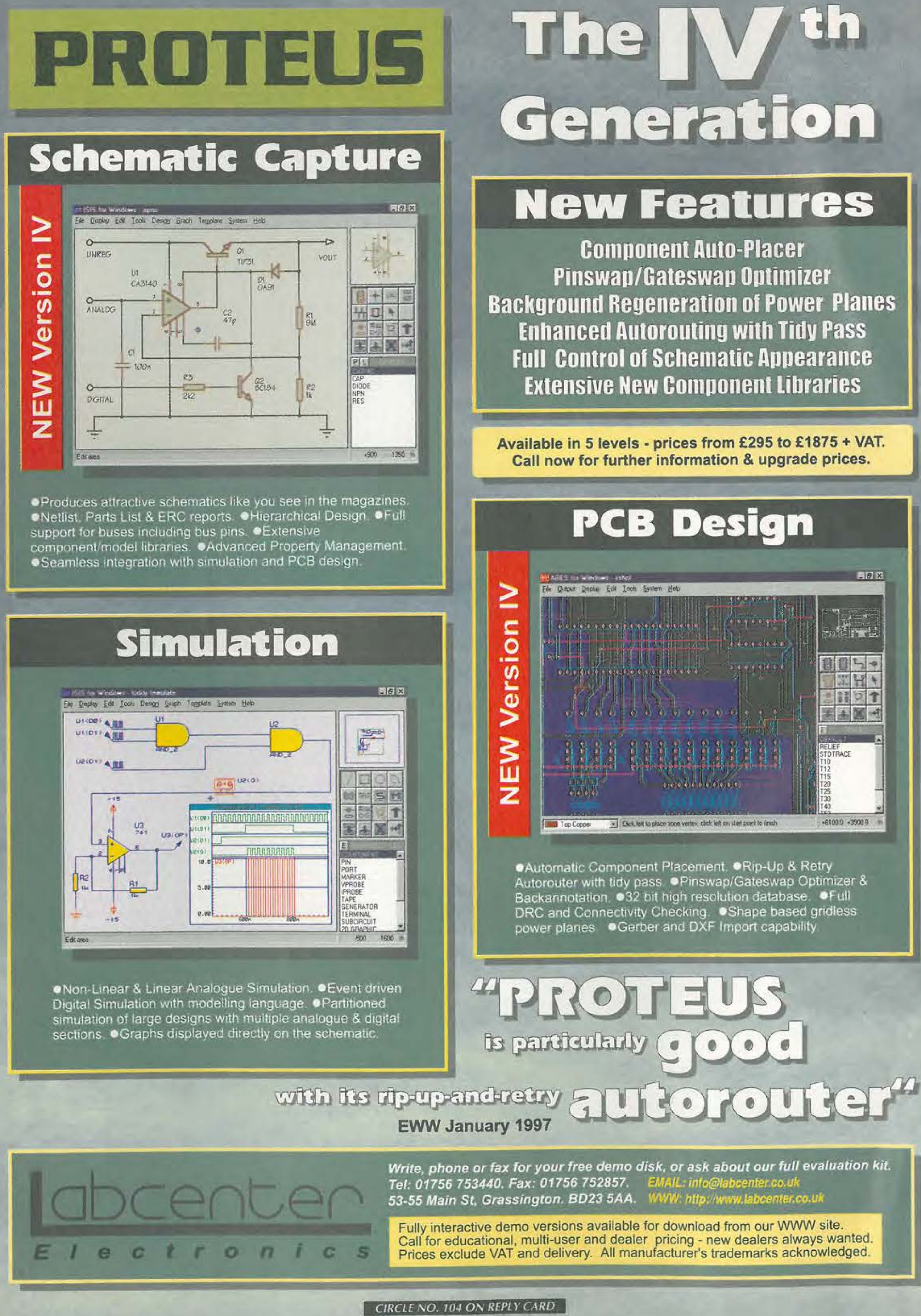
Photo: Donald McLean

At last – a mega source of components all available in low volume quantities and off the shelf. See page 738.

High-speed Internet access will soon be possible via a constellation of 288 satellites. Read about this and other present and future access alternatives on page 760.

After you have flipped the thumbnail pictures starting backwards from page 773, read how they were produced on page 745.

OCTOBER ISSUE ON SALE 10 SEPTEMBER



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REED BUSINESS INFORMATION

Sound advice

Naim Audio is 25 years old this year. We are one of Britain's few remaining independent hifi companies, surviving where many others have either disappeared or been swallowed up by larger conglomerates – and I'm often asked how we've done it.

There are never any simple answers. The number of places in business where you can make mistakes is huge, we certainly make mistakes at Naim. But we don't make really stupid ones. Importantly, we don't forget our original starting-point, and even though we now employ 90 people, we're still a small company, especially where it counts, which is in the way we think about our products, and about ourselves.

So where did we start? Hi-fi systems should play music. Music is a language, a way composer and musicians communicate emotions to the listener, and if it's good, if it's played with passion and enthusiasm, this what reaches us. Or so I thought, back in 1970, before I started Naim. I wanted to be thrilled and excited and have my emotions addressed when I listened to reproduced music, and this didn't happen. So I felt very frustrated. It took me about a year and a bit to learn enough electronics to design the classic amplifiers that – give or take 25 years of development – we now still make, as well, of course, as a whole range of complementary electronics, cd players and speakers, and our own CD label.

Because we are independent, we don't suffer from short-termist pressures, and need only think about what's best for the company, or simply best. Our products may have a ten-year lifespan, in some cases more, so we can afford to do good research and have time to get things right. We don't follow fashion. My marketing director has as strong a voice as any other member of the team, but as far as he is concerned – and everyone else here too – we are in business to deliver performance products.

The basic team at Naim is a diverse group of people with very different skills and motivations, but we all have the same underlying idea of what the company is about. So, while each of us does the things they do best and care about most, there's a high level of mutual trust.

For me, for all of us, its very important to run the company in a way that we all feel comfortable with. Of course a business has to make decent profits to stay healthy, and this, obviously, we've done. But it doesn't have to make profits to the exclusion of everything else. What on Earth is work for? It takes up a very large amount of our waking lives. It should be satisfying. That means for everyone.

I think it's important to remember that on the whole people develop rather than change. Our kind of business is actually pretty complex, with a wide variety of functions suited to different skills. But it can look like a game of three-dimensional chess in which all the pieces decide for themselves what they are: you thought one of them was a bishop but they have an absolute view that they're a knight, or a rook, and behave like that, and that's what they do well. It's fascinating. I like to let people make the most of themselves. It works better than trying to make them over.

What on Earth is work for? It takes up a very large amount of our waking lives. It should be satisfying. That means for everyone...

I think we've had an unusually stable environment, and that's healthy. It lets people look at what really interests them – technology, organisation, whatever – and follow through. In some ways we've been very modern, though not necessarily for the same reasons as other businesses.

We invested in robotic assembly very early, when few companies our size could have justified it, which we hardly could. But what we homed in on, and what we still really like about our robots, is that they don't care at all whether they work a 60-hour week or stand idle, whereas people don't get on at all well under either of these conditions. I'm a bit choosy about modern management theories, there seem to be a lot of buzz-words that boil down to mnemonics for what many of us discovered years ago and may still be working at, since few good ideas are easy.

I'd agree with everyone else that the toughest thing is communication: some of it can be improved by better structures, some of it still works well down at the pub, some of it straightens out with the kind of red tape that would have appalled me when we started. But I don't know of anything to replace continuous optimistic effort by individual people – which doesn't apply to businesses alone.

Nothing magic about that, is there? ■

Julian Vereker MBE, Managing Director Naim Audio

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UP DATE

Electronic tagging trial suffers legal glitch

A magistrates court has raised the issue of the legal effectiveness of electronic tagging of offenders after a prostitute successfully evaded punishment for breaching her curfew by claiming her answerphone and fax machine "overrode" the electronic tagging monitoring equipment.

Initially mystified by the incident, the Home Office has said it was satisfied that the tagging equipment was not affected by fax and answering machines.

Summonses against Sonia Louise Allen from Bolton issued by Securicor Custodial Services were withdrawn on the orders of the town's magistrates after the 21-year old pleaded the effects of interference with the monitoring equipment.

Securicor and the Home Office both deny any equipment compatibility problem, but the decision by a court in one of the pilot areas for tagging could be embarrassing for the scheme which is being rolled out nationwide.

The Magistrates accepted evidence that the answerphone and fax machine "overrode" the tagging device when they were in use and that therefore the summonses alleging breach of the 6 pm to 6 am curfew could not be proved.

Securicor said in a statement: "In our experience fax and answering machines have not interfered with the satisfactory operation of the electronic monitoring equipment."

It continued: "As a precautionary measure, we instruct offenders not to attach such devices to the telephone line. This is simply to ensure that the line is free when the unit has to make its standard calls and in the event of any violation."

Securicor went on to say that Allen's absence was verified after it was reported by the home monitoring unit and by a visit from Securicor officers.

Securicor said that they agreed that the summons be withdrawn "in the interests of saving court time," on the grounds that if the summons was contested by Allen then it would not be returned to court until after the curfew order had concluded.

BBC previews digital terrestrial television

The first public broadcasts of digital terrestrial tv have been conducted by the BBC at several locations around the country.

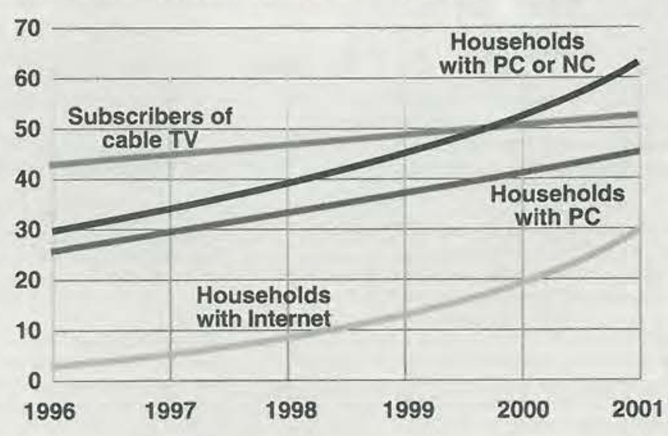
"This is a preview service until the real thing starts in earnest," said a BBC spokesman.

Three companies, Hitachi, Philips and Sony, are involved in the trials. Hitachi has been showing live coverage of selected World Cup games in 16:9 wide- screen format on its video wall at the Trocadero, London. Philips' installations are at Heathrow's Terminals One and Two, while Sony demonstrated digital broadcasts at the South of England, Three Counties and Royal Highland shows in June.

"The screenings demonstrate wide-screen at its best," said Mike Gleave, BBC technical advisor.

The terrestrial digital tv signal is being transmitted from Crystal Palace, which is being fed by a satellite link.

European households with information & communication devices and services 1996 - 2001 (millions)



Source: EITO 98 /IDC Internet Commerce Market Model,1997

Cash level for UK innovation falls further

UK companies are investing less money in innovation than they were five years ago, according to a recent survey carried out by the CBI. The 1998 Innovation Trends Survey shows that manufacturers are spending only five per cent of their turnover on innovation. The drop is part of a trend showing a steady decline from seven per cent in 1994.

Single bid for digital auction

The licence auction for a national digital radio service has attracted just one applicant. The Digital One consortium is backed by GWR, NTL and Talk Radio. Other commercial radio groups are expected to bid for regional licences.

Smart Web trial

Barclays Bank has launched a smartcard trial which allows the self employed to register their status with government departments over the Internet. The card will allow users to access registration documents, electronically sign them and then return them for processing.

Warnings over global mobile standard bid

Senior mobile phone executives have warned about the problems ahead in creating a global standard out of the third generation digital mobile phone proposal.

"To have a single global standard is going to be very difficult," believes Heikki Ahava, Nokia mobile phones' v-p of new system technologies.

This is also the view of Thomas Beijer, chairman of the UMTS Forum which is working on issues such as spectrum allocation and its licensing. However, he stresses that UMTS has strong support outside Europe, and even with US mobile phone operators where it is competing with the CDMAOne proposal.

Since ETSI's decision that the UMTS radio interface would be based on W-CDMA and time-division/CDMA schemes, work has concentrated on harmonising the two to achieve simpler – and cheaper – UMTS dual mode handsets.

This, according to Nokia's Ahava, has now been achieved. "In the spring, we were able to agree on key parameters such as frame lengths and chip rates to harmonise the two."

An ITU workshop, planned for November, will determine if a common global IMT-2000 standard can be achieved from the various submissions. A final decision on the nature of IMT-2000 will be made next March.

• The most ambitious trial to date of third generation mobile phone technology is being carried out by Ericsson. Working with Swedish mobile phone operator Telia, Ericsson plans to have W-CDMA technology, a component of Europe's UMTS third generation proposal, up and running in Stockholm by the autumn.

The system will be used to test multimedia content transmissions and wireless Internet access.

Roy Rubenstein, *Electronics Weekly*

Internet voice phone calls will dominate by 2000

The use of the Internet for making telephone calls will overtake fixed network traffic by 2000, according to a report by industry research company Analysys.

As Internet telephone calls become cheaper and easier to make, the service will begin to threaten the established operators, says the report.

However, the major European companies won't be introducing their own Internet telephony technology until they are forced to.

Price differences will disappear in the next three to five years but for the moment international calls are cheaper on the Internet. Other long-term technological advantages will ensure the rise of the Internet call over fixed networks.

Efficiency gains offered by the use of packet networks, the low cost of deploying gateways and the potential for computer telephony integration are all set to drive the long term growth of Internet telephony.

Providers of Internet telephony already offer their services to people without pcs by use of a code that connects the user to a local Internet service.

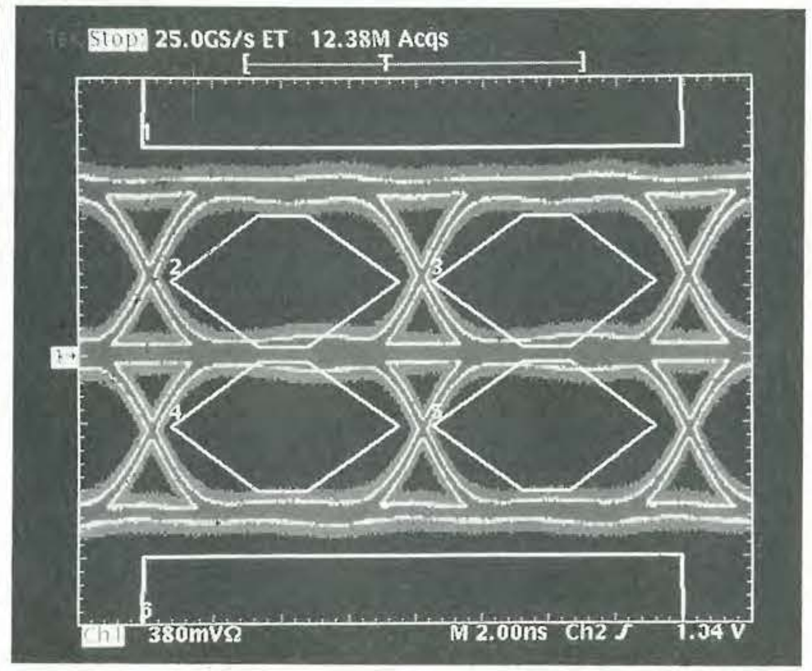
Carlton buys UK DVD firm Nimbus

Nimbus, the cd and digital versatile disc (DVD) manufacturer, has been acquired by the US company Carlton Communications. The $264m purchase was made to ensure that Carlton's film and video business was not left behind by the new technology. The agreed bid was supported by shareholders with 44 per cent of the company stock. Nimbus recently launched the UK's first commercially available DVDs.

UK has most home pcs

Britain has more home pcs per head of the population than the US. This was one of the findings of market research carried out by Roper Starch Worldwide. It found that 38 per cent of the UK population has a pc, compared with 36 per cent in the US and 24 per cent in Germany.

The survey also indicated that UK home pc users are more likely to use their computers for work or educational activities than any other European country.



More scope for scopes... Tektronix has called the digital phosphor oscilloscope (DPO) its most important oscilloscope announcement this year. The instrument combines new display and signal processing capabilities to give what the company calls a three-dimensional representation of signal traces. The intention has been to combine the real-time capability of an analogue oscilloscope with the digital storage and signal processing functions of a DSO.

Summer launch planned for digital broadcast receivers

The first commercial digital audio broadcasting (DAB) receivers will be launched by five manufacturers this summer.

Blaupunkt, Clarion, Grundig, Kenwood and Pioneer will unveil car receivers which can be added to existing systems or used on their own. The BBC, which has been transmitting digital programmes for three years, is co-ordinating the launch.

Car radio accounts for 25 per cent of all radios sold and is seen as the ideal market to spearhead the launch of DAB. Digital radio transmissions currently reach over 60 per cent of the UK population.

"We always knew we were switching on our transmitter as a pioneering act," said Glyn Jones, the BBC's DAB project director. "It was part of a strategy to build confidence and create the right conditions for manufacturers."

The BBC is keen to see digital radio technology moving into other market segments. "A couple of years ago digital radio was cutting edge technology," said Jones. Now DAB receivers are coming down in price, he said.

Jones... DAB receiver prices are coming down.

One-chip mobiles are only three years away

The single-chip mobile phone is only three years away, according to US phone chip maker CommQuest.

"We will have samples of the chip at the end of 2000 and expect production a year later," said Marilyn Jordan, spokesman for CommQuest.

A popular industry view is that the one chip phone is further off still. The penalty of having a two-chip solution – a cmos baseband processor and an rf section made on a high-speed analogue process – is seen as a small price to pay compared to the cost of developing one process that combines both sections.

CommQuest was bought by IBM earlier this year with the goal of adding CommQuest's phone chip expertise to IBM's advanced process capability.

"There will be two stages to the development," said Jordan. "First we will produce the whole rf section, including the output devices, in silicon-germanium. This product should sample next year. The second phase will be to add the baseband processor using SOI [silicon-on-insulator] technology."

SOI chip construction prevents the noise generated by the digital baseband processing from getting into the rf section. But both SiGe and SOI are complex processes.

Does Jordan believe that CommQuest's solution can undercut a two-chip one? "Absolutely," he said, "the total cost of the phone, which includes integration and testing, will be lower."

Jordan was speaking at the launch of his company's TriBand Chipset, a two-chip phone GSM chipset which covers 900MHz, 1.8GHz and 1.9GHz.

Blue laser diode is imminent

Commercial sample blue laser diodes will be available from July, according to Japanese semiconductor company Nichia.

The shorter wavelength of blue and violet laser diodes promises to bring about optical storage devices with higher data densities.

"Blue lasers are still under development, a commercial sample would be available early next month," said Nichia's Gaku Ueyama.

Blue laser diodes have until now proved extremely difficult to make. Lifetimes in experimental devices are frequently only a few hours, and often less than a second.

Nichia has been leading the pack in their development, spearheaded by chief researcher Shuji Nakamura.

Last year, while other companies had achieved diodes with lifetimes of only a few seconds, Nakamura astonished competitors by lecturing using a blue laser pointer.

This spring Nichia announced a 300-hour operation blue laser diode after Fujitsu claimed to have made a device lasting five hours.

US firms Cree and Hewlett-Packard are playing catch-up although neither has announced device lifetimes of more than one second. "Our aim is to be number one in green, blue and ultra-violet lasers," said Waguih Ishak, head of blue laser research at HP earlier this year.

Satellite makes a recovery

A motor vehicle was recovered by police within 15 minutes of being stolen using a satellite tracking system.

The roadside recovery vehicle was stolen as its driver worked under the bonnet of another car. Using the GPS (global positioning system) satellite vehicle tracking system fitted to the vehicle, the control room dispatcher was able to tell the police the vehicle's exact position, which was recovered intact.

The tracking system fitted operates via Turbo Dispatch, a mobile job dispatch system, and the RAM Network, a two-way, real-time data communication system which operates over dedicated radio frequencies.

New nanosecond ram

Fujitsu has developed a novel memory which significantly improves the access speed of dynamic ram.

Called fast cycle RAM, or FCRAM, first 64Mbit silicon achieves a 26ns random access time and an address cycle time of 20ns.

Fujitsu has achieved the speedier performance by doing away with the convention of multiplexed addressing.

Investment up

A 4.7 per cent increase in manufacturing investment in the last three months helped boost British business investment figures in the year's first quarter. Government figures indicate that overall investment rose by 5.8 per cent in the year's first quarter compared to the last quarter of 1997.

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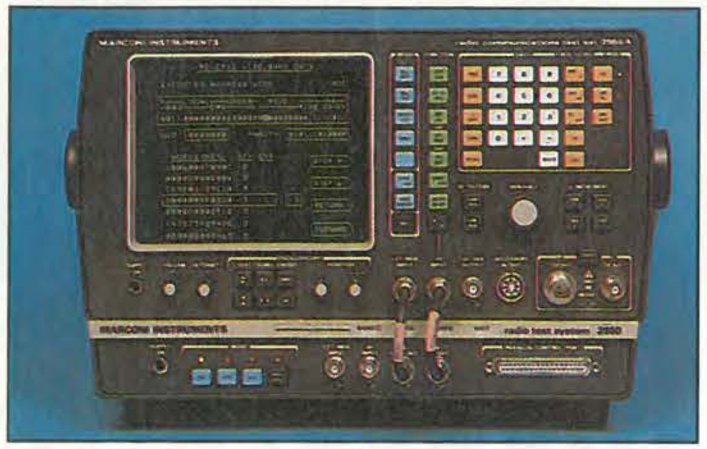

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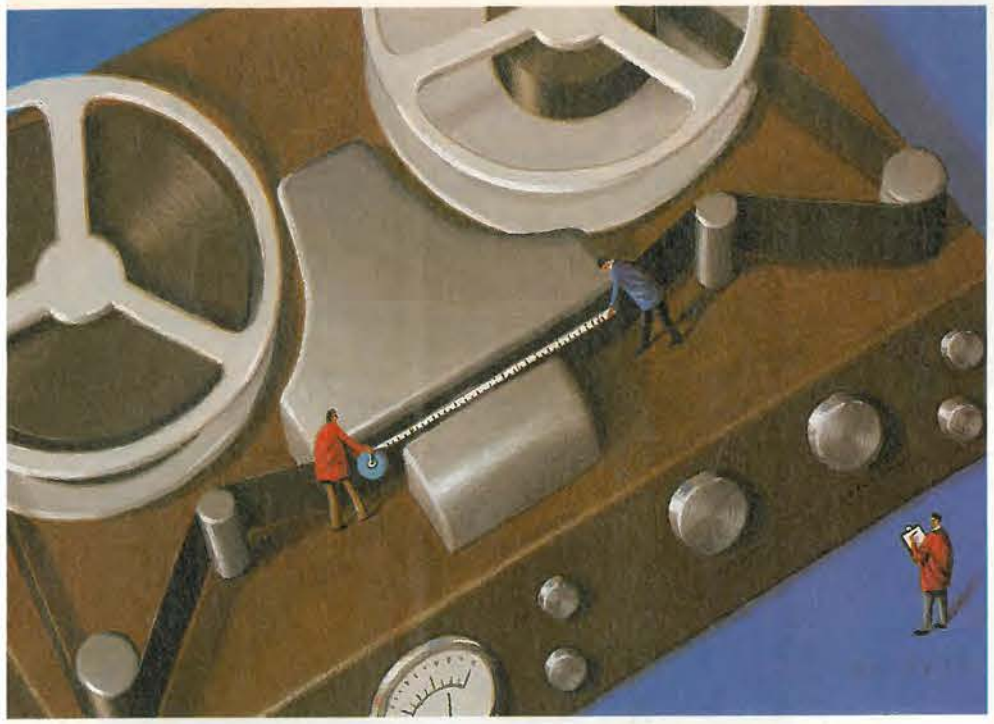


Measure wow and flutter

Unable to find an affordable wow and flutter meter, David Lane set about designing his own. The resulting instrument is not only low cost. It uses widely available components and is easy to calibrate.

In an analogue record/replay system – whether tape, disc or film – the average speed of the reproducing equipment must be the same as that of the recording equipment if the absolute pitch and duration of the original material is to be preserved.

The average speed may be measured via one or more of several well known methods. These include stroboscopic tapes and discs, replaying a recording of known frequency and measuring the reproduced frequency, timing a measured length of tape or film past a fixed reference point, and in the case of disc simply measuring the time taken for a given number of revolutions of the platter.

Because it is impossible to make a mechanically perfect drive system, the instantaneous speed will not be constant. Changes in instantaneous speed will be perceived as variations in pitch. Slow changes (<10Hz) caused for instance by an eccentric capstan, are termed 'wow' whilst faster changes (>10Hz) due perhaps to variations in back-tension on the supply spool of a tape recorder, caused by non-uniform friction, are called 'flutter'.

Instruments to measure wow and flutter are now either quite expensive or part of even more expensive complete audio measurement systems (Audio Precision System One and Wandel & Goltermann NFA-1) placing them beyond the reach of most people.

I felt, therefore, that a basic meter – perhaps with the additional facility of being able to measure the wow and the flutter separately – would appeal to those of you wanting to assess, or investigate, the performance of your analogue recording and replay equipment.

Professional, and the best semi-professional, open-reel tape recorders can have wow and flutter figures as low as 0.015% (weighted), so it seemed sensible to aim for a design with a residual noise level of about one tenth of this value (0.0015%). The instrument described in this article indicates just 0.0007% in the weighted mode, when the internal oscillator is connected directly to the input.

Performance of the wow and flutter meter

Specification of the wow and flutter meter, based on the performance of the prototype:

Input:

minimum level	30mV rms
impedance	300kΩ

Measurement modes:

flat	0.5Hz to 300Hz (–3dB)
weighted	to IEC 386:1972 recommendation
wow	0.5Hz to 6Hz (–3dB, 18dB/octave above 6Hz)
flutter	6Hz to 300Hz (–3dB, 18dB/octave below 6Hz)

Ranges:
1%, 0.316%, 0.1%, 0.0316% fsd

Rectifier:
Full–wave, quasi–peak indicating based on IEC 386:1972 recommendation

Residual reading:
Using internal oscillator,

flat	0.002%
weighted	0.0007%
wow	0.0007%
flutter	0.002%

Using 3150Hz digitally generated signal from Denon test CD 38C39–7147,

flat	0.0015%
weighted	0.0005%
wow	0.0004%
flutter	0.0015%

Internal oscillator:
frequency 3150Hz
amplitude 500mV rms approx.

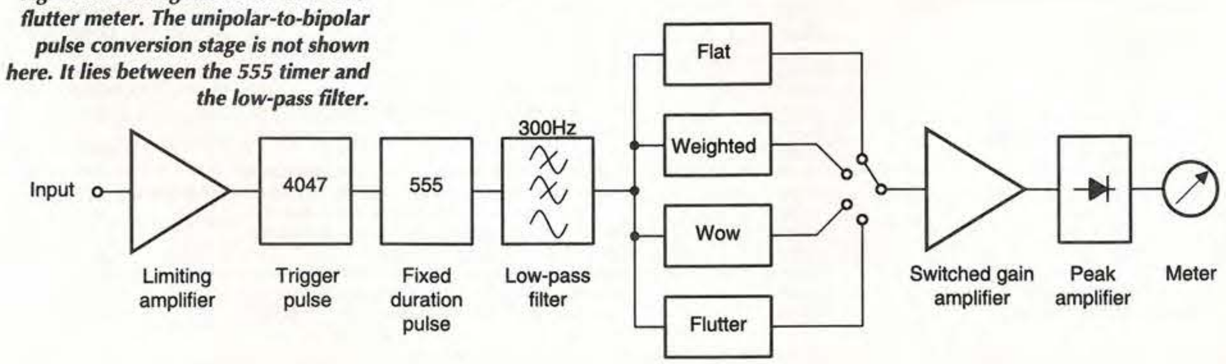


Fig. 1. Block diagram of the wow and flutter meter. The unipolar-to-bipolar pulse conversion stage is not shown here. It lies between the 555 timer and the low-pass filter.

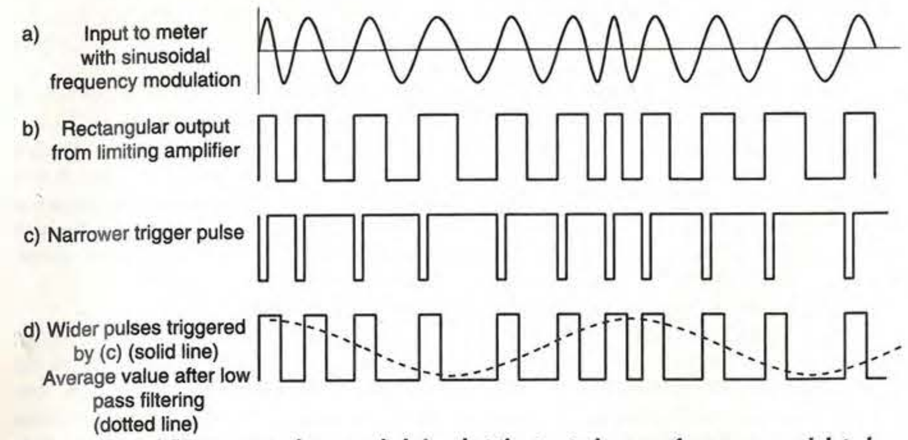


Fig. 2. Wow and flutter cause the recorded signal at the top to become frequency modulated. Demodulating allows the wow and flutter content to be separated and quantified.

Design considerations

Wow and flutter is nothing more than low-rate frequency modulation of the audio signal. It is measured by demodulating a 3150Hz tone from a test tape, film or disc. Alternatively, where these are not available, a 3150Hz tone can be recorded then replayed: there's more on this later.

Demodulator output is then measured according to the IEC standard[1] by either a statistical method or a quasi-peak reading meter. This instrument uses the latter technique.

The difficulties inherent in implementing and aligning a tuned-circuit discriminator have led to the use of a pulse-counting demodulator here. The input waveform triggers a pulse of fixed duration and amplitude, so if the input frequency rises the pulses move closer together and the average – or dc – voltage of the pulse train consequently rises.

Conversely, if the input frequency falls the pulses become more widely spaced and the average voltage of the pulse train now falls. The average voltage is extracted by passing the pulse train through a suitable low pass filter.

The basic block diagram of the meter is shown in **Fig. 1** and the demodulator waveforms are illustrated by **Fig. 2**. The nominally sinusoidal input with sinusoidal frequency modulation, Fig. **2a)**, is turned into a rectangular output Fig. **2b)** by the high gain limiting amplifier; the rising edge of this waveform

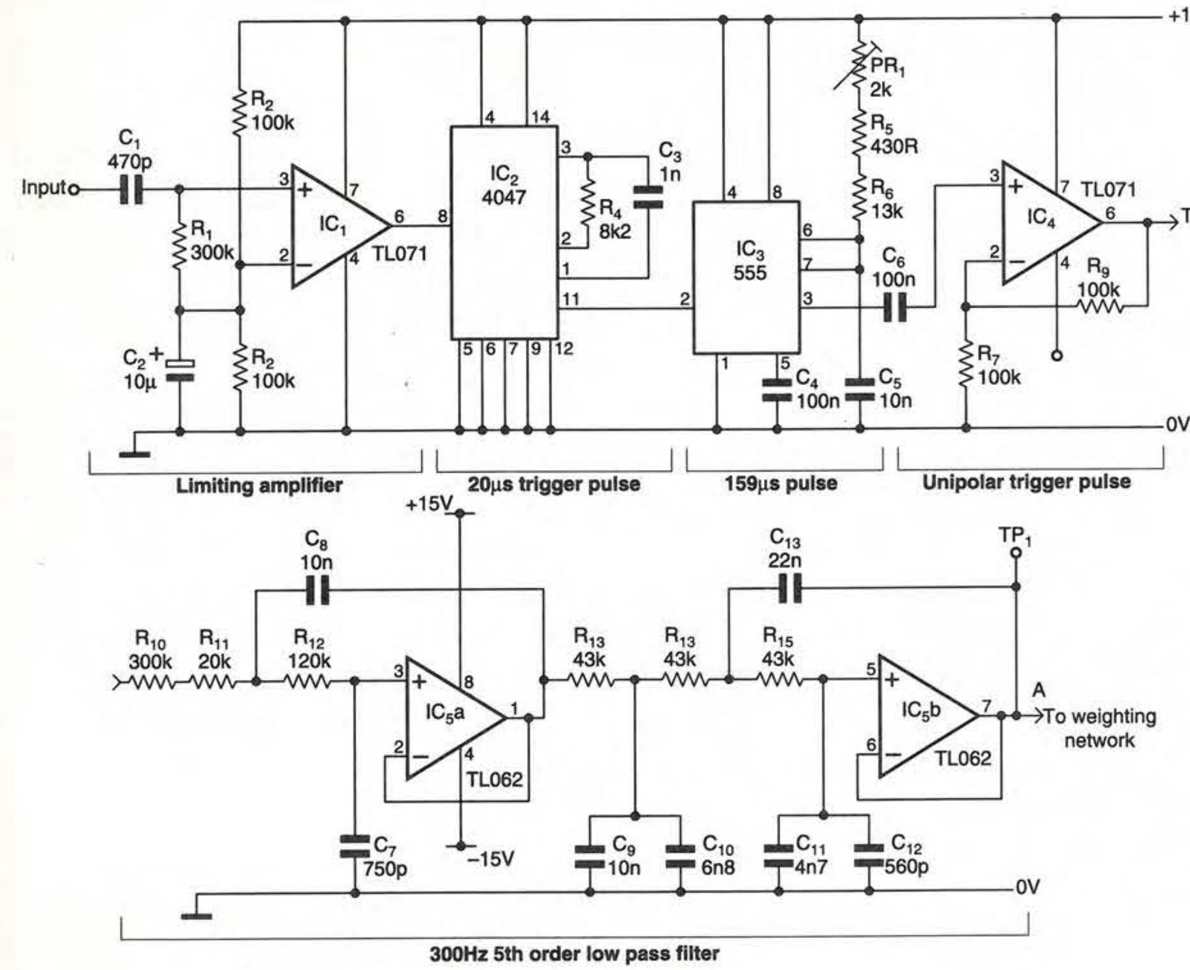


Fig. 3. Input and low-pass filter detail. This section can accommodate a wide range of input voltages from a few tens of millivolts to several volts.

triggers a narrower, negative-going pulse Fig. **2c)**; this in turn triggers a positive-going pulse of fixed duration and amplitude Fig. **2d)**, solid line.

In Fig. 2d), the dotted line shows the output after the low pass filter. It will be apparent from Fig. 2 that the rectangular waveform could be used to trigger directly the fixed duration pulse, but for reasons to be explained later this has not been done.

Output from the low-pass filter is passed via a weighting network – or optional 'flat', wow, and flutter filters – to a switched gain amplifier which provides range selection for the rectifier; this incorporates appropriate attack and decay time constants to give the quasi-peak characteristic.

The circuit from input to low-pass filter output is shown in **Fig. 3** and since this differs slightly from the block diagram of Fig. 1 it is described in some detail.

Input amplifier

A wide range of input levels, from a few tens of millivolts to several volts may be encountered, and these are usually accommodated by an agc amplifier. The complexity of this is avoided by allowing a high gain amplifier to limit on positive peaks of the input; this also provides the required rectangular waveform.

Op-amp IC_1 is used open loop as the limiting amplifier. Its inputs are held at half the rail voltage by $R_{2,3}$ (–) and via R_1 (+), while C_2 bypasses rail noise to ground. Resistor R_1 also sets the input resistance to the IEC recommended value of 300kΩ.

Open-loop gain of IC_1 is approximately 1000 at 3150Hz and since its slew rate is 13V/μs an input of 464mV rms is required for slew rate limiting at the output. However, a respectable 13.5V peak rectangular output with 10μs rise and fall times can be produced from an input of just 48mV rms.

My prototype works satisfactorily with an input as low as 30mV rms, where there is a just perceptible rise in the residual noise reading but no change in the measured demodulator sensitivity. In practice the input will be higher than 30mV, so there is no point in pursuing a better performance. The IEC standard specifies a minimum input of 100mV, which is presumably rms.

Open-loop gain of IC_1 rises at the rate of 6dB/octave with falling frequency. This is countered by the low value of input coupling capacitor C_1, which flattens the gain below 1kHz. This would otherwise be 30dB higher at 100Hz and might cause a problem if a high level of hum were present on the input signal.

Generating pulses

As shown in the panel, the sensitivity of the demodulator is directly proportional to the amplitude of the pulse and to its duration. Any drift in the pulse duration will affect the meter calibration. In addition, any pulse jitter below the low-pass filter cut off will be converted into noise.

To minimise these potential problems a 555 timer was chosen for IC_3. If the pulse duration is set at 159μs, half the period of the measurement frequency, a square wave results. In theory, this square wave would permit the input to swing between dc and 6.3kHz – a peak deviation of ±100% – and still produce a linear output from the low-pass filter. This is clearly overkill.

A useful increase in demodulator output could be obtained by widening the pulse to say 80% of the period of the measurement frequency, restricting the peak positive deviation to 25%. The falling edge of the output from IC_1 could then be used to trigger IC_3 directly, since the input pulse is now narrower than the output pulse.

There is, however, a drawback in connecting the output of IC_3 directly to the low-pass filter, which I discovered when working on an earlier version of the instrument. A step change in dc voltage at the low-pass filter output is produced whenever the input signal is applied or removed. This is due to the difference in the average value of IC_3 output in the repetitively triggered and the untriggered states.

This step is passed in distorted form – due to the differentiation/integration action – either by the weighting network or by one of the other filters, **Fig. 4**, to the switched gain amplifier. This presents the amplified transient to the rectifier which charges C_{27} in **Fig. 5** to a voltage far greater than that required for full scale deflection of the meter. This voltage takes a long time to decay, which leads to a good deal of thumb twiddling while the meter returns to an on-scale reading.

If the low-pass filter dc output could be made 0V in both the presence and absence of an input, then the effects of any step changes in dc voltage here, caused by applying or removing the input or when switching on, would be greatly reduced. This is achieved by ac coupling the output of IC_3 to the low-pass filter via amplifier IC_4 which converts the pulses from single to dual polarity. Gain of IC_4 is set at 11 to guarantee a slew rate limited output.

With no input, IC_3 is untriggered and so IC_4 output is 0V. When an input is applied, the pulses from IC_3 force IC_4 output to within a volt or so of each rail. By making the 'on' time of IC_3 equal to half the period of the input frequency, a symmetrical waveform having an average value of 0V is generated.

The output of IC_1 cannot now be used to trigger IC_3 directly, since the trigger and output pulse have the same duration. A narrower trigger pulse, of arbitrary duration 20μs, is provided by monostable IC_2.

The larger output available from IC_4 also has the benefit of doubling the demodulator sensitivity. It might be thought that ac coupling would remove the dc component, but we

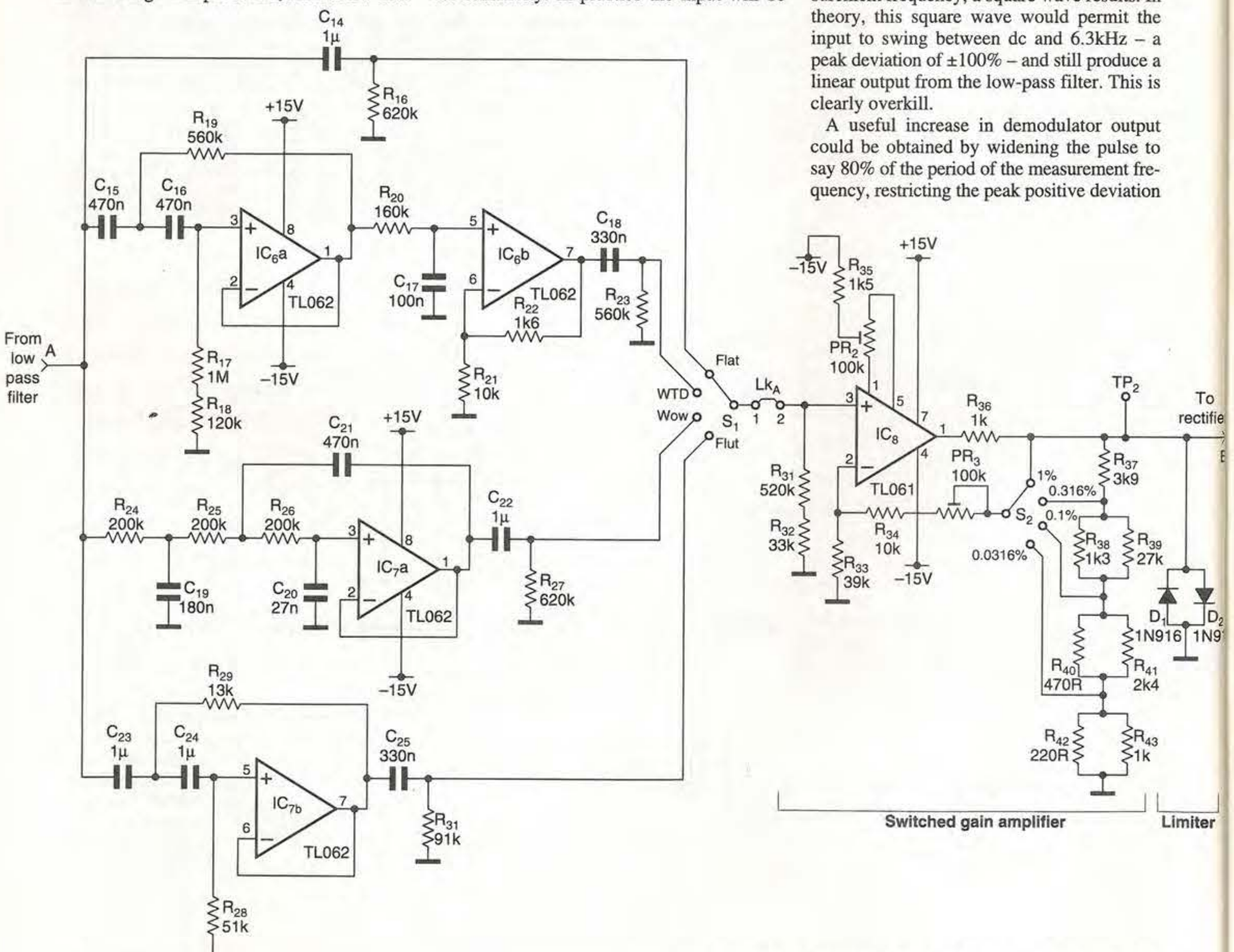


Fig. 4. Flat, weighting, wow and flutter filters, followed by the switched-gain amplifier.

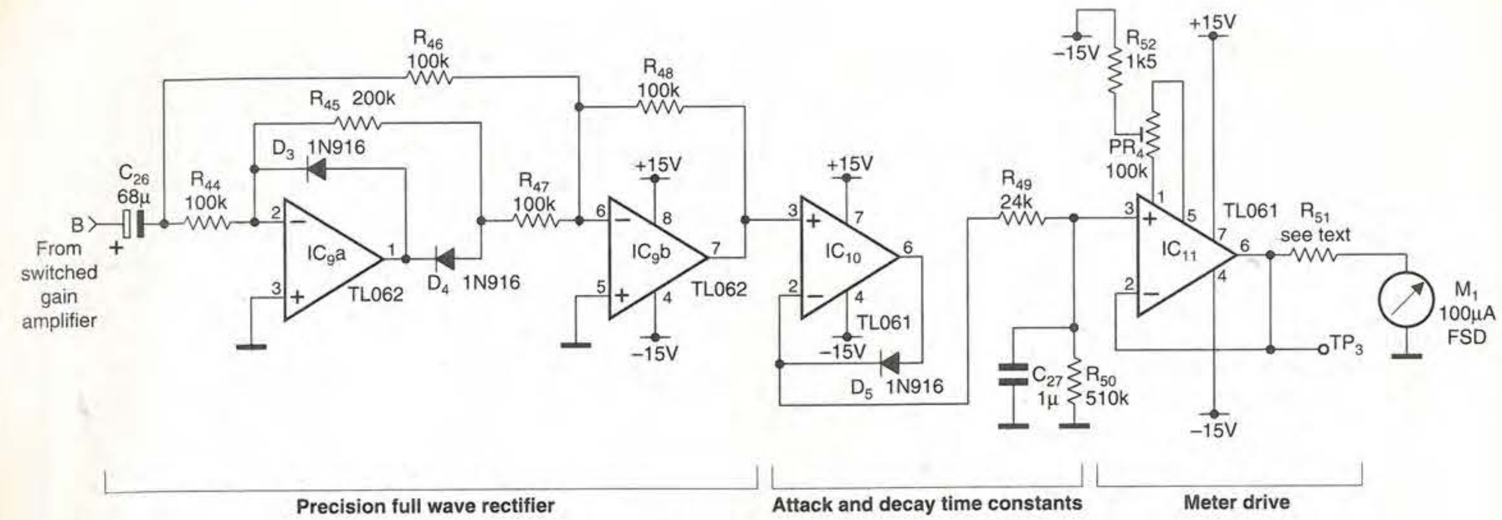


Fig. 5. Quasi-peak indicating full-wave rectifier with meter-drive and the circuitry determining attack/decay time constants.

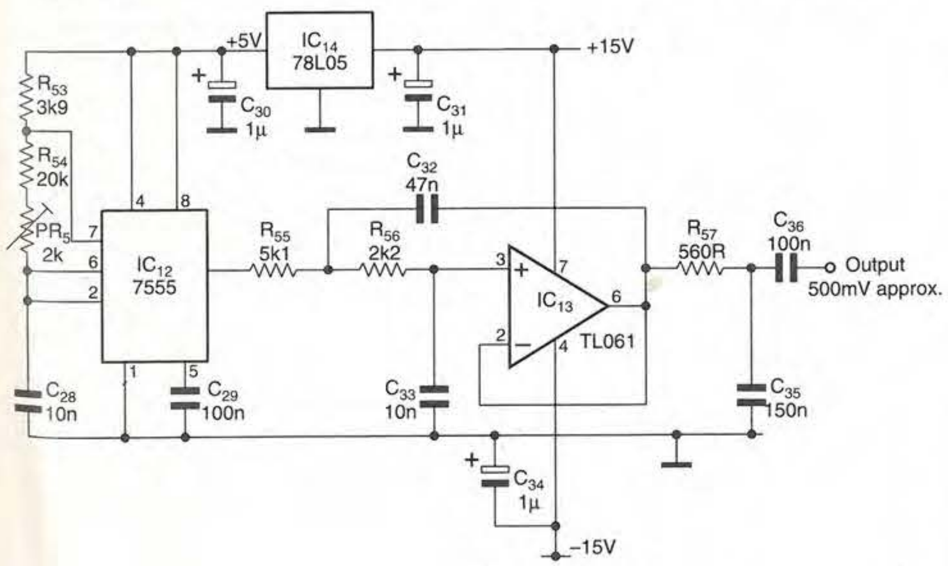


Fig. 6. 3150Hz reference oscillator. A divided-down crystal reference is often used here, but this circuit was found to give adequate stability, as you will see from Table 2. The circuitry conditioning the 555 output turns the rectangular wave into a sinusoidal one.

Demodulator sensitivity

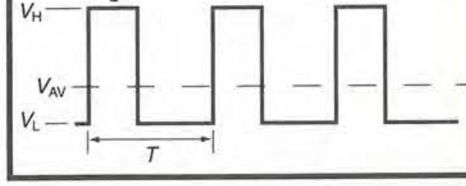
The sensitivity of a pulse-counting demodulator can be determined as follows.

For the waveform shown, pulse duration b is fixed. The time T between successive pulses depends on the frequency f of the input, which triggers the pulses. The areas below and above the average voltage V_{AV}, must be equal.

$$(V_{AV}-V_L)(T-b)=(V_H-V_{AV})b$$
$$V_{AV}T-V_LT-V_{AV}b+V_Lb=V_Hb-V_{AV}b$$
$$V_{AV}T=V_Hb+V_LT-V_Lb$$
$$V_{AV}=\frac{(V_H-V_L)b}{T}+V_L$$
$$V_{AV}=(V_H-V_L)bf+V_L$$
$$\frac{dV_{AV}}{df}=(V_H-V_L)b$$

where:
b = duration of pulse
T = period of input
$f=1/T$
V_L = lower voltage of pulse
V_H = upper voltage of pulse
V_{AV} = average voltage

In this design V_H is +13.5V, V_L is –13.5V and b is 159μs, so the demodulator sensitivity will be 4.29mV/Hz.



are dealing with frequency modulation here; IC_4 output moves between fixed limits, and the information is carried by the mark/space ratio. Preset PR_1 sets the pulse duration and is adjusted to give a unity mark/space ratio, indicated by 0V at the low-pass filter output at TP_1 with an input of exactly 3150Hz.

An on-scale reading now occurs just a few seconds after applying the input. Note that IC_3 must be a bipolar 555; I tried the cmos version in the interests of current economy, but with this device the complete meter showed a gradual rise in the residual noise level, almost doubling after some hours use. This is probably due to an increase in jitter.

Timing capacitor C_5 should be 1% polystyrene to ensure long-term stability of the meter calibration.

Low-pass filtering

It seems to be accepted practice to set the upper frequency limit in the unweighted (flat) mode to 300Hz. This determines the requirements of the low-pass filter, which must adequately suppress the fundamental 3150Hz component, and its harmonics, at the output of IC_4.

An under-damped two-pole Sallen and Key filter, IC_{5a}, is followed by an over-damped three-pole Sallen and Key filter, IC_{5b}. This gives a fifth-order Butterworth response with a –3dB point at 297Hz, and an attenuation at 3150Hz of 102dB. For a ±13.5V square wave and a demodulator sensitivity of 4.3mV/Hz this equates to an unweighted reading of 0.00094%, and is below the noise in the weighted mode.

Table 1. Required performance of the weighting network and the calculated response of the circuit used in Fig.4.

Frequency (Hz)	Response (dB)	Tolerance (dB)	Circuit of Fig. 4 (dB)
0.1	–48.0	+10/–4	–48.08
0.2	–30.6	+10/–4	–30.26
0.315	–19.7	+4/–4	–19.44
0.4	–15.0	+4/–4	–14.66
0.63	–8.4	+2/–2	–8.29
0.8	–6.0	+2/–2	–6.07
1	–4.2	+2/–2	–4.41
1.6	–1.8	+2/–2	–1.85
2	–0.9	+2/–2	–1.04
4	0	0	0.00
6.3	–0.9	+2/–2	–0.45
10	–2.1	+2/–2	–1.85
20	–5.9	+2/–2	–5.77
40	–10.4	+2/–2	–11.07
63	–14.2	+4/–4	–14.85
100	–17.3	+4/–4	–18.80
200	–23.0	+4/–4	–24.79

The figures in columns 2 and 3 above are taken from BS 4847:1989, which is directly equivalent to IEC 386:1972, and are reproduced with the permission of BSI.[2]

Table 2. The figures for oscillator stability given below were obtained from the prototype, which had previously been set to 3150.0Hz. Measurements taken at room temperature.

Time (min)	F (Hz)
0	3149.8
1	3149.8
2	3149.8
3	3149.8
4	3149.8
5	3149.8
10	3149.7
15	3149.8
20	3149.8
30	3149.8
45	3149.8
60	3149.7
75	3149.7
180	3149.4

To ensure an accurate filter response, capacitors $C_{7\text{-}13}$ should be 1% polystyrene. Resistors throughout should be 1% metal film; these are now widely and inexpensively available. The demodulator sensitivity is measured at TP_1 – see section on calibration.

Weighting, wow, and flutter

Our sensitivity to frequency modulation of an audio tone depends on the modulating frequency. We are less aware of changes in pitch slower than 1Hz and faster than 20Hz, than we are of changes between these two rates. This makes it necessary to use a weighting filter to ensure that the measured value of wow and flutter correlates closely with its perceived nuisance.

The circuit of the weighting filter is shown in Fig. 4. It is implemented by a two-pole high-pass filter with a –3dB point at 0.428Hz, IC_{6a}, followed by a low-pass corner at 10Hz resulting from R_{20}, C_{17} and a high-pass corner at 1.6Hz due to C_{18} and the parallel combination of R_{23} and $R_{31,32}$.

Op-amp IC_{6b} isolates the low and high-pass sections and makes up for the loss of the weighting network. Resistor R_{23} provides a permanent charging path for C_{18}, minimising transients when switch S_1 selects the weighted mode.

The weighting curve has its 0dB point – and peak – at 4Hz; component values shown will give a response at the centre of the IEC tolerance over the specified range of 0.1Hz to 200Hz, **Table 1**. Capacitors $C_{15\text{-}18}$ should be 5% tolerance, as should C_{14} and $C_{19\text{-}25}$.

It is useful to be able to measure the wow and the flutter separately. Most instruments place the crossover at 6Hz, and this convention has been adopted here. A three-pole 6Hz low-pass filter IC_{7a}, is followed by 0.5Hz high-pass filter to isolate the wow components. This comprises C_{22} and parallel combination of R_{27} and $R_{31,32}$.

As before, R_{27} provides a permanent charging path for C_{22}. The flutter components are extracted by a three-pole 6Hz high-pass filter around IC_{7b} – an under-damped two-pole filter and a single-pole passive section C_{25}, $R_{30,31,32}$.

In the flat position, the upper frequency limit is set at 300Hz by the preceding low-pass filter, while C_{14}, $R_{16,31,32}$ set the lower –3dB point at 0.5Hz, by convention. All the filter network inputs are permanently connected to the low-pass filter output to minimise transients when switching between modes.

Calibration

The usual calibration procedure is to apply a known amount of sinusoidal frequency modulation – say 1% peak – at a rate of 4Hz to a 3150Hz carrier. This is then connected to the wow and flutter meter input, the weighted mode selected and the meter gain adjusted to give 1% fsd.

This requires a 3150Hz oscillator capable of being frequency modulated at 4Hz, a 4Hz sine wave source and a means of accurately measuring the modulation. If these facilities are not available, then the method described below, which needs only an audio signal generator, digital voltmeter, frequency counter and a calculator can be used instead.

1. With an input of exactly 3150.0Hz adjust PR_1 for 0V at TP_1. This adjustment must be made first, since this sets the pulse duration which also determines the demodulator sensitivity. If there is insufficient range with PR_1, check that the rails are close to ±15V and adjust with $R_{60,61}$ if necessary.
2. The demodulator is so linear that its slope can be measured by using just two points. Select two input frequencies F_1 and F_2 either side of 3150Hz, which give voltages V_1 and V_2 (just under ±2V) at TP_1. The demodulator sensitivity D, is simply,

$$D = \frac{V_1 - V_2}{F_1 - F_2}$$

For the prototype V_1=+1.940V at F_1=3600Hz and V_2=–1.941V at F_2=2700Hz, giving a sensitivity of 4.312mV/Hz.

3. With no input connected, adjust PR_2 for 0V at TP_2 with S_2 on the 0.0316% range and adjust PR_4 for 0V at TP_3 with S_2 set for the 1% range.
4. Calculate the rms voltage V_3 at TP_1 equivalent to 1% peak deviation of a 3150Hz carrier,

$$V_3 = \frac{D \times 3150}{100 \times \sqrt{2}}$$

This is 96.05mV rms for the prototype.

5. A 4Hz signal will have the same amplitude at TP_1 and LK_A, since the weighting network has nominally unity gain at this frequency. From LK_A onwards the frequency response is flat, so a signal higher than 4Hz, but of the correct amplitude, can be connected at LK_A for calibration. This method does not include the insertion loss of the weighting network at 4Hz in the calibration. If 1% resistors and 5% capacitors are used the maximum error will be +1.9%/–2.0%.
6. Open LK_A and connect a 50Hz signal of rms amplitude V_3 to LK_A pin 2. The voltmeter should be capable of reading the voltage accurately at this frequency. With S_2 on the 1% range adjust PR_3 for full scale deflection of the meter.
7. Remove all connections and remake LK_A. The wow and flutter meter is now calibrated and ready for use. Calibration accuracy will be the sum of errors in measuring D and setting V_3 due to the voltmeter together with the uncertainty in the weighting network loss. It is not expected that these errors will total more than ±5%.

Switched gain amplifier

The measurement function is selected by S_1. Output from the switch goes via LK_A, which is used for calibration, to the switched gain amplifier IC_8 in Fig. 4.

Switch S_2 changes the gain in 10dB steps, giving fsd sensitivities of 1%, 0.316%, 0.1% and 0.0316%. The instrument is calibrated on the 1% range by adjusting PR_3. There will be a change in loading on the divider network as PR_3 is adjusted over its full range, but at worst this only alters the accuracy of the gain steps by 1.2%.

To maintain the accuracy of the weighted response at very low frequencies, IC_8 is dc coupled. Potentiometer PR_2 adjusts the output to 0V dc, eliminating spurious deflections of the meter caused by a change in dc offset at IC_8 output, when switching ranges.

Diodes $D_{1,2}$ limit the output to approximately ±600mV, preventing C_{27} in Fig. 5 from charging to an excessively high voltage – especially if S_2 is in the highest gain position.

Rectification and read-out

The IEC standard specifies peak measurement of both the positive and negative deviations from average speed. It also specifies a meter which, due to its dynamic characteristics (attack and decay time constants), will under-read the peak value of short repetitive bursts of unidirectional frequency modulation.

This method is often referred to as quasi-peak measurement. See reference 1 for details of the required performance.

Figure 5 shows the circuit used here. Op-amp IC_9 forms the basis of a standard precision full-wave rectifier. Inverted double amplitude half-cycles of the positive input appear at the junction of D_4, R_{45}. These are summed with the input by IC_{9b} and the result inverted to give a positive full-wave rectified signal at IC_{9b} output.

The peaks are stored in C_{27}. Resistor R_{49} in parallel with R_{50} determines the charging time constant, while R_{50} sets the discharge time constant. Diode D_5 is linearised in forward conduction by IC_{10} and prevents C_{27} from discharging through R_{49}.

Although the electrical time constants primarily set the attack and decay times, they are also influenced by the mechanical properties of the meter movement. It is impossible to specify a single set of values for C_{27}, $R_{49,50}$ which will give the IEC recommended ballistics with all movements, but those suggested here were found to give the best compromise when tried with a number of 2in and 4in panel meters.

Unity-gain buffer IC_{11} isolates the time constant network from the meter. The output of IC_{11} is nulled by PR_4 since only a few millivolts here will cause a small but significant deflection of the meter.

There is sufficient adjustment range with gain preset PR_3 to accommodate meters having internal resistances in the range 2kΩ to 4kΩ. For meters less than 2kΩ an external resistor, R_{51} will be needed to bring the total series resistance within the range quoted above.

Oscillator details

The stable 3150Hz test signal required for the measurement of wow and flutter is normally derived by either dividing down the output from a crystal oscillator or by digital synthesis. The problem of obtaining a suitable crystal for the former and the complexity of the latter ruled these two methods out.

When operated from a +5V supply, the cmos variant of the 555 was found to provide adequate stability, see **Table 2** and **Fig. 6**. Frequency is adjusted by preset PR_5. Capacitor C_{28} should be 1% polystyrene to ensure good short term and long term stability of the oscillator frequency.

The nominally square wave output goes via a three-pole 2kHz low-pass filter IC_{13} to give a sinusoidal signal of about 500mV rms and 3% thd. Component tolerances in this filter are not critical.

Power supply

Output from IC_4 switches between the positive and negative rails and spends most of its time at either one or the other. Any ripple or noise on the rails below 300Hz will be dutifully extracted by low-pass filter IC_5, and contributes towards the residual wow and flutter reading. Just 96μV rms of ripple on the supplies translates into an unweighted reading of 0.001%.

The conventional bridge-rectifier power sup-

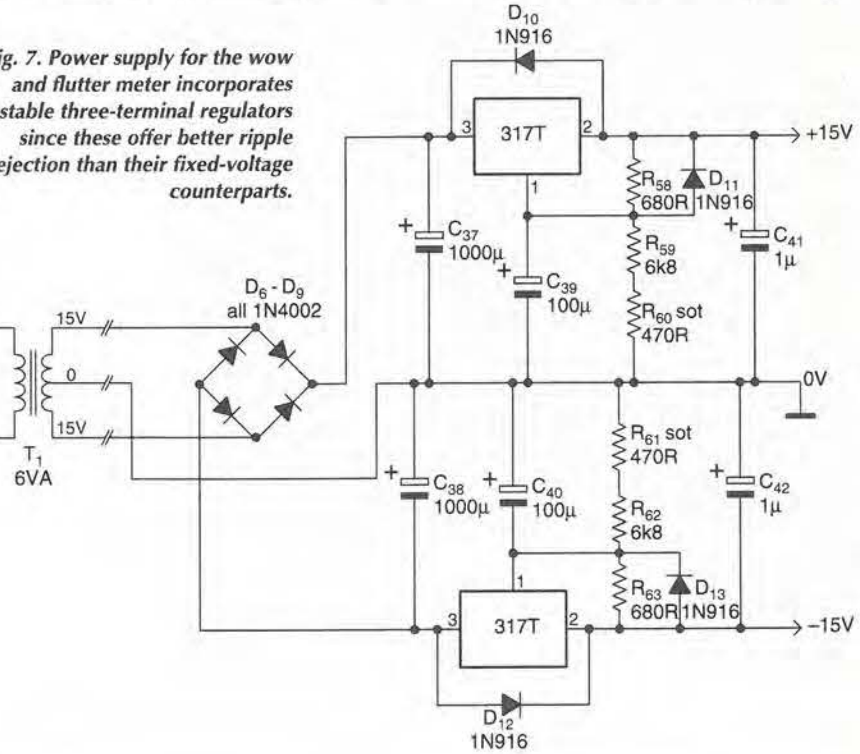


Fig. 7. Power supply for the wow and flutter meter incorporates adjustable three-terminal regulators since these offer better ripple rejection than their fixed-voltage counterparts.

ply shown in **Fig. 7** uses *LM317T* and *LM337T* adjustable regulators. These have better ripple rejection than their fixed-output counterparts.

Ripple is further reduced by making the reservoir capacitors, $C_{37,38}$, together with the adjustment terminal decoupling capacitors, $C_{39,40}$, larger than normal. Diodes $D_{10\text{-}13}$ provide a discharge path for the latter, protecting the regulators.

Low power *TLO61/62* op-amps have been specified where their lower gain-bandwidth product and lower slew rate are not important. This reduces dissipation in the regulators – which do not require heatsinks – and allows a miniature 15V-0-15V, 6VA mains transformer to be used. With this, the input to the regulators is about 20V, providing sufficient headroom to accommodate a drop in the mains voltage of 10%.

If necessary, the output voltages can be adjusted to the specified values of ±15V by means of the select-on-test resistors $R_{60,61}$.

Since some parts of the circuit, such as the weighting and wow filters, operate at high impedance, they will be susceptible to the external field from the mains transformer. This field must be either shielded or kept away from these areas.

Fresh air is cheaper – and easier to obtain – than mu-metal, so as much of the former as possible is used here by housing the transformer in a plastic case close to the mains plug. Alternatively, you could use a suitable plastic plug-box.

I ran the 15V transformer secondary output via three-core cable to the case containing the instrument, which for my prototype was a standard diecast box. The 0V line is connected to the case at one point only, preferably near the input.

Making measurements

The following is a guide for those unfamiliar with wow and flutter measurement.

A test record is essential for measuring the wow and flutter of a turntable. Such discs were widely available in the heyday of the LP, but may be harder to obtain now. Some older discs may have a 3kHz tone – corresponding to a previous measurement standard – and the readings from these will be 4.8% low on instruments intended for use with a 3150Hz tone.

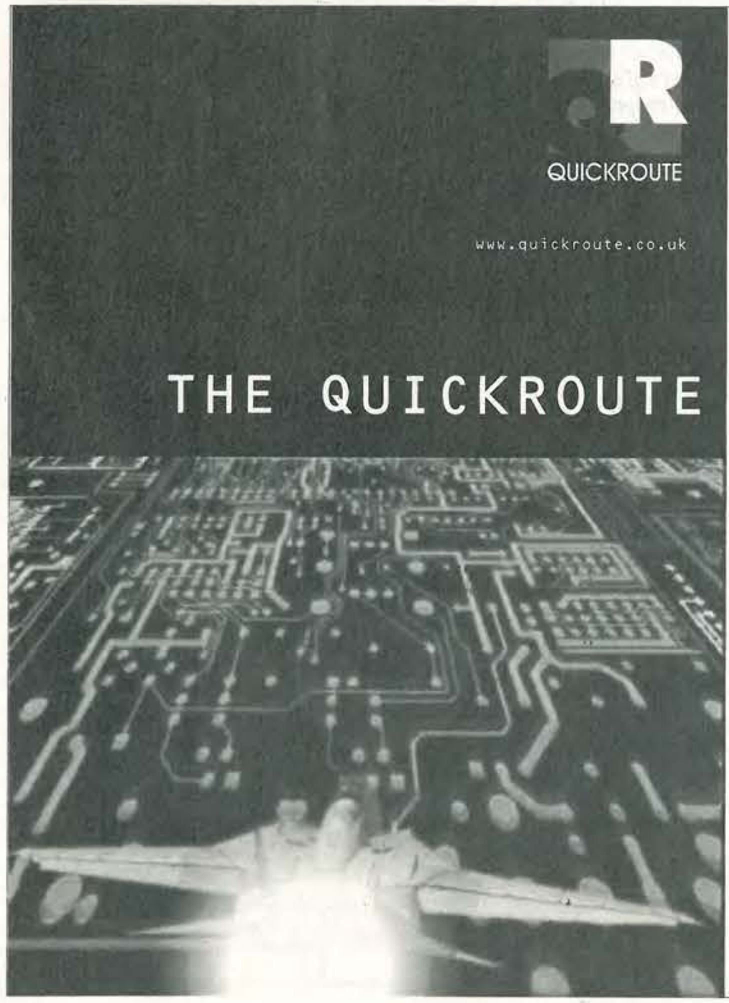
In the case of tape recorders, where no suitable test tape is available, a recording of the signal from the 3150Hz oscillator is made on the machine under test, and subsequently replayed on the same machine.

The measurement of wow and flutter so obtained is the vector addition of two (identical) variations. The result will change as the phase difference between the two components alters. This can give in extreme cases complete cancellation (out of phase) or doubling (in phase) of the true value. A more accurate result can be obtained by taking the arithmetic mean of several separate record/replay measurements.

When a test tape or disc is used, the measurement will be replay only; when recording and replaying on the same machine the measurement will be of the combined record/replay system. ■

References

1. IEC 386:1972 'Method of measurement of speed fluctuations in sound recording and reproducing equipment'. International Electrotechnical Commission (IEC), including Amendment No 1 published March 1988.
2. BS 4847:1989 obtainable from BSI Customer Services, 389 Chiswick High Road, London W4 4AL.



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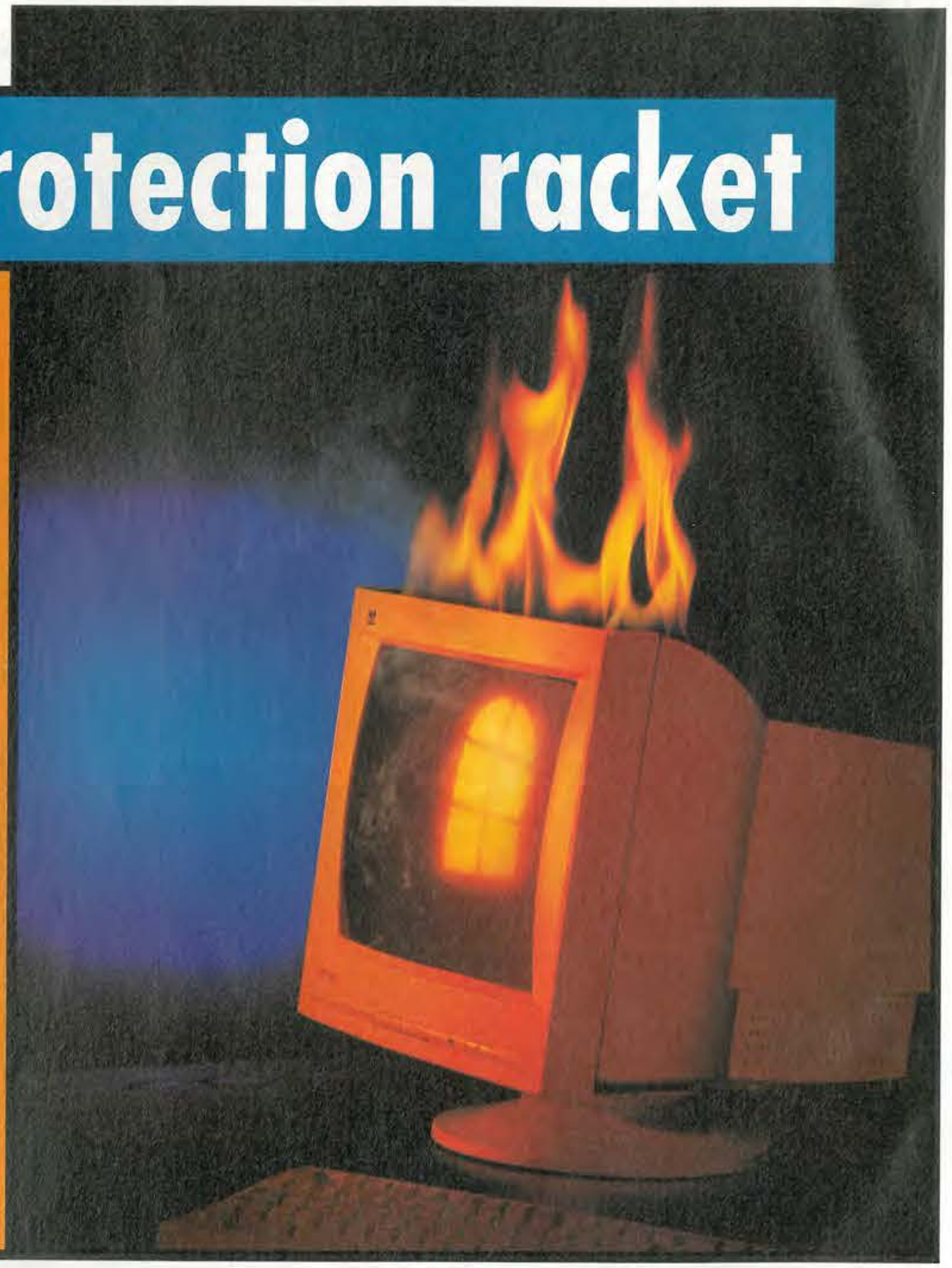
The protection racket



Ian Hickman **looks at a variety of methods for increasing reliability by protecting circuitry from abuse – including the fuse.**

Circuits of all sorts need protection from the damaging effects of excessive voltage or current. The potential damage may be due to an accident – a short circuit say – or to chance or deliberate electrical abuse.

Inputs of measuring instruments need special consideration, in the interests of reliability. A variety of protection components and techniques are available.

Background

Like fire and water, electricity is a good servant but a bad master. When too much of it gets in the wrong place at the wrong time, substantial damage can occur.

In some eventualities, such as a direct lightning strike of large proportions, some damage must be expected, as is not uncommon in the case of overhead power lines in the far southwest of England. But in many cases, damage can be largely or completely avoided by proper design, particularly in the case of electronic instruments.

Protection against power sources

Some sources, such as the output of a signal generator, **Fig. 1a)**, are inherently protected against the effects of a short circuit. Designed to produce a signal power of say 0dBm or 1mW (225mV) into a matched 50Ω load, an equal power is dissipated internally in the 50Ω source, making a total of 2mW.

In the case of the output being short circuited, the generator output current doubles. So the total dissipation is now 4mW, all internal to the source and four times the designed power which would have been delivered to a matched load.

Should the output become open circuited, or nearly so, as with a dummy load representing a short aerial for

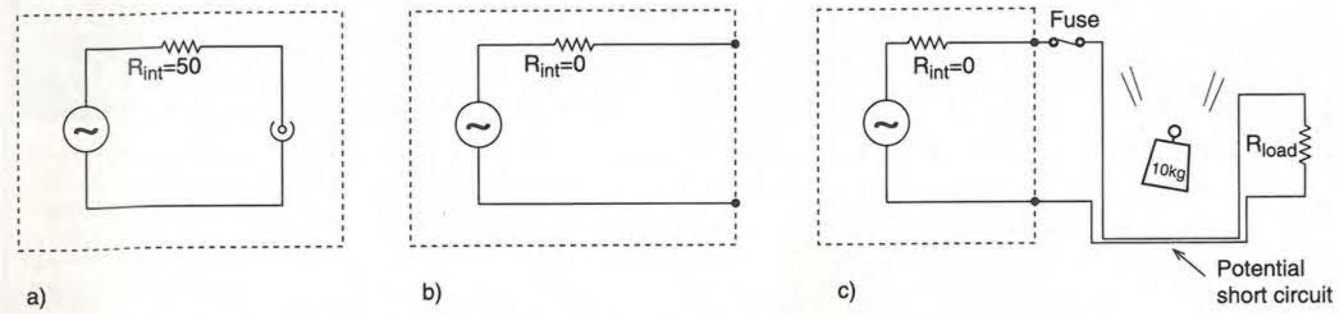


Fig. 1a). An rf signal generator typically has a source resistance (internal resistance) of 50Ω.
b) An ideal constant voltage generator has an internal resistance of zero.
c) Consequently, if its output is short circuited, a very large fault current will flow, unless fuse protection is provided.

example, the terminal voltage rises to equal the internal emf of the generator. Traditionally, some makes of signal generator were in fact calibrated in terms of open circuit emf as well as dBm.

The designer of a signal generator accepts – for very good reasons – that 50% of the power will normally be 'wasted' in dissipation within the signal generator.

A designer involved with multi-megawatt turbo alternators for power stations takes a very different view. Power stations are designed for an efficiency of as near 100% as possible. Even so, the designer still has a job getting rid of the heat from the inevitable odd percent or two of internal dissipation at full load.

The ideal power generator is a pure voltage source, whose output voltage is constant however much current is drawn, Fig. **1b)**. This implies that the internal resistance R_{int} is zero. So if a short circuit occurs in the connections, Fig. **1c)**, this implies that an infinite current will flow.

In practice, the short circuit must involve a conductor, which will have a finite resistance, however small. But the resultant dissipation in the conductor may melt the insulation, raise the wire to red heat and start a fire. By definition, the internal dissipation in an ideal constant-voltage generator is zero however large the current

Enter the fuse

So someone – Edison, I think – had the bright idea of deliberately making a short length of the conductor of much thinner wire than the rest, so it could burn out in a controlled manner and clear the short circuit.

By 1900, fuse wire made of low melting point tin alloy was already in widespread use. Given such precautions, it seems surprising that today, wires with damaged insulation, rubbing against the fuel tank of a 737, can cause holes by spark erosion, allowing fuel to escape.

Fuse technology has long since reached a high degree of maturity, with current developments being in the area of new applications. Examples are wire-ended and surface-mount fuses for use on pcbs. But the very familiarity of the common or garden fuse means that many designers are not aware of the finer points of its application.

A fuse should be chosen for any given application such that the normal running current is not more than 75% of its nominal rating. When operating in a normal room ambient temperature, the fuse should then last indefinitely, with no nuisance tripping.

Note that the nominal rating is for operation at an ambient of 25°C, **Fig. 2**. At 100°C, the rating may have decreased by up to 10% for many fuse types, and by over 30% for some slow blow types. Note also that the relevant ambient temperature is the temperature in which the fuse actually operates – not room ambient.

The fuse may well be fitted within an enclosed fuseholder, and this in turn inside a piece of equipment with an appreciable internal temperature rise.

Blow time

The other main characteristic to be considered is the I^2t rating of the fuse. This represents the current pulse needed to open the fuse 'immediately', in the event of a gross overload, such as a short circuit. Immediately, here, means in less than half a cycle of the mains, typically 8ms or less.

When a short occurs, the current through the fuse increases rapidly to a peak. This phase represents the melting time, at the end of which the circuit opens. Thereafter, the current falls again, during some small but finite time. This phase is the arcing time, at the end of which, the current has fallen to zero.

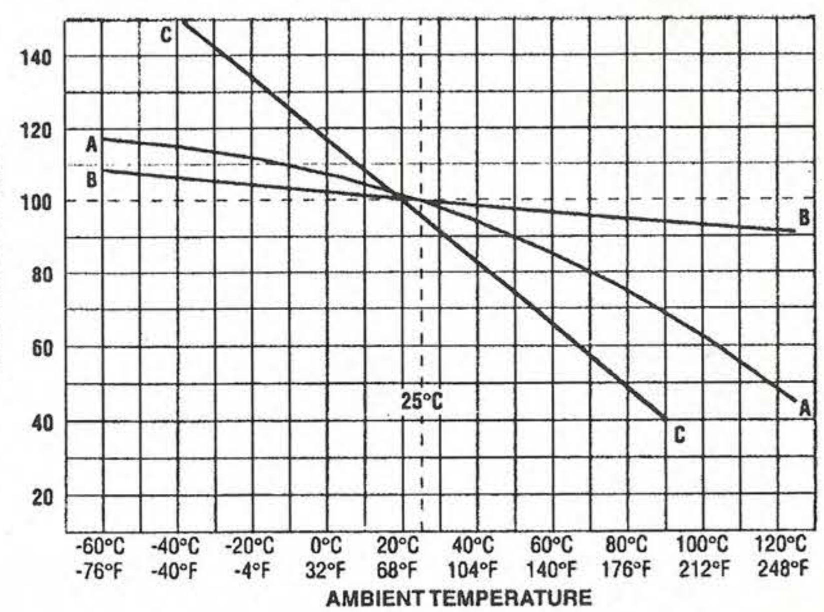
The fuse will open 'immediately' if the 'prospective fault current' – the maximum current which might have flowed had the fuse not blown – is greatly in excess of the peak current at the end of the melting time.

Peak times are worst

A fuse in the primary circuit of a transformer may experience a peak current of several or many times the normal operating current.

The worst case is when equipment switch-on coincides with a zero of the mains supply voltage. For then, the voltage-time product ($E.t$) volt-seconds of a complete half cycle will cause the magnetising current to increase

Fig. 2. The rating of fast acting fuses (B), slow blow fuses (A) and PTC thermistors (C) varies with ambient temperature. Reproduced courtesy of Littelfuse.



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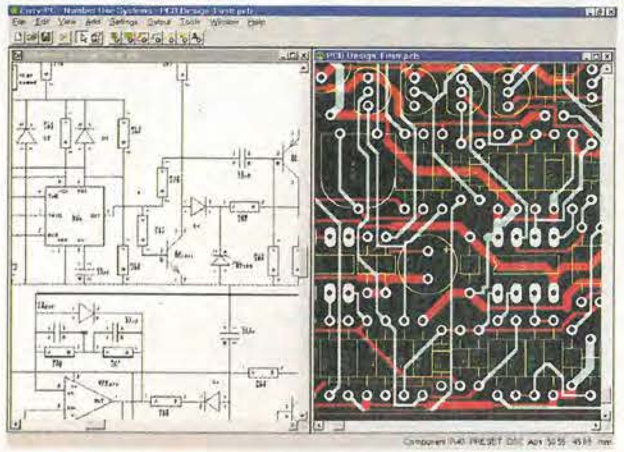

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starting from zero, rather than from its opposite peak.

At the end of the first half cycle, the peak required flux will thus be twice the normal maximum, and the core will consequently be well into saturation. The current to produce this flux will therefore be many times the normal peak of the magnetising current. It is uneconomical to design a transformer which normally operates at half the saturation flux level or less.

But simply fitting a fuse with a higher current rating is not a good idea. It may fail to open if there is a short circuit on a secondary winding of the transformer.

It is usual therefore, to fit a slow-blow fuse. This is a T or TT (time) style fuse, where the element is designed with a larger than usual thermal inertia. It will thus survive the in-rush current of a transformer, where a faster acting F or FF (fast) type fuse would open.

Note that where a transformer supplies rectified and smoothed dc outputs, the in-rush current is due not only to the core saturation just mentioned, but also to the charging current of the electrolytic smoothing capacitors.

Further details of fuses and their characteristics can be found in references 1 and 2, as applicable to Europe and the Americas respectively.

To fuse or not to fuse...

An alternative approach to protection is provided by thermistors. These come in two distinct flavours – those with a negative temperature coefficient and their younger counterparts, those with a positive temperature coefficient.

Negative temperature coefficient, or ntc, types have long been used, not to provide protection against short circuits, but to extend the life of compact high wattage projector lamps, amongst many other uses.

An incandescent lamp is most likely to fail at the moment of switch-on. There is a large initial in-rush current, as the filament is initially cold, and its resistance only a tenth or less of the hot value. A severe thermal shock is therefore experienced by the filament.

Negative temperature coefficient thermistors are available with a suitable rating for connection in series with the lamp, and these greatly reduce the current at switch-on. As the thermistor warms up, its resistance drops, allowing the current to increase further until, at the normal thermistor running temperature, the lamp receives very nearly the full mains voltage.

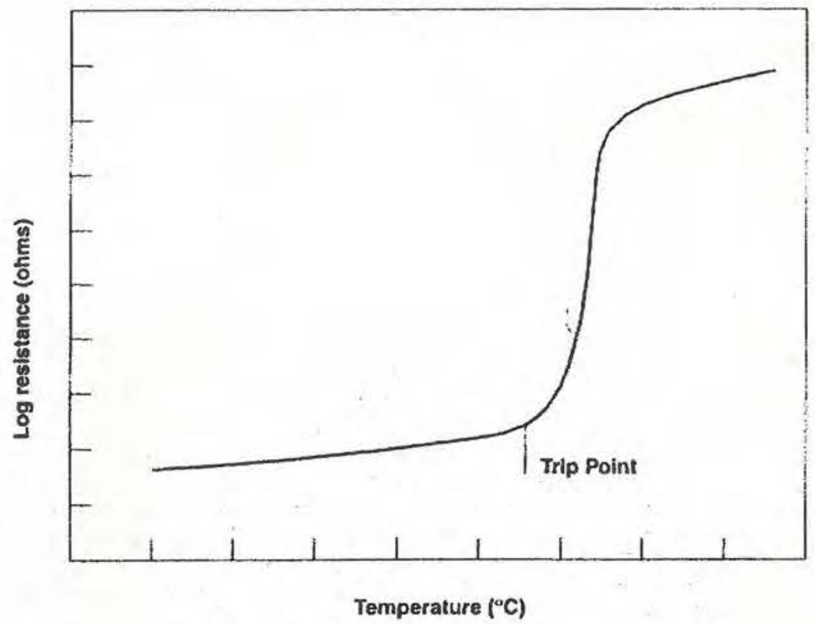


Fig. 3. Above a certain temperature, the resistance of a positive temperature coefficient thermistor rises dramatically. Reproduced courtesy of Littelfuse.

Light output is reduced by only a few percent, but lamp life is greatly extended.

Positive temperature coefficient, or ptc, thermistors can also be fitted in series with a load, and can in suitable circumstances replace a conventional fuse. They have come into prominence because of the convenience of a means of protection which, unlike a fuse, is self-resetting.

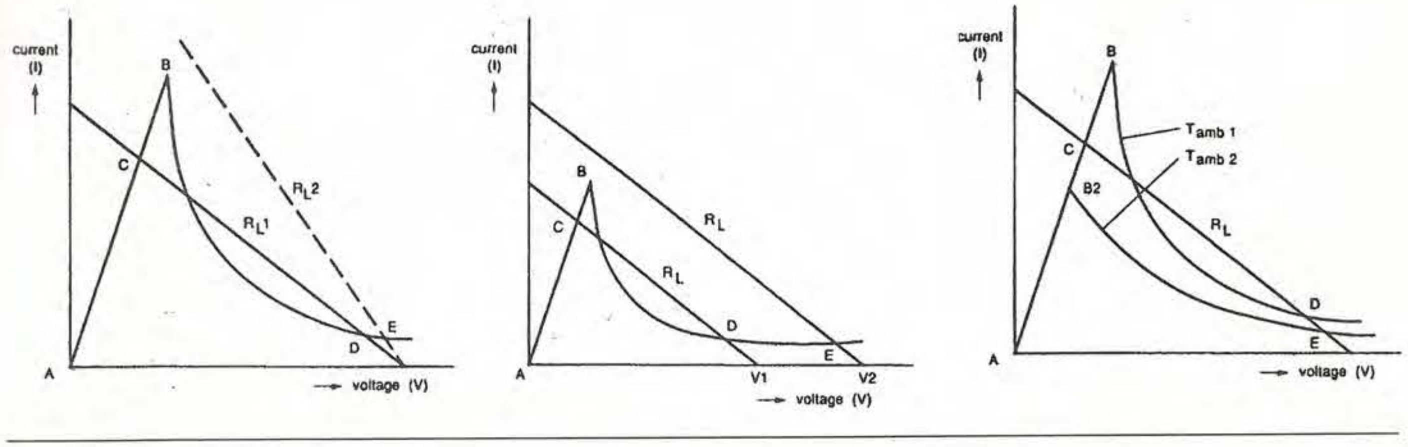
Fuses and Gates...

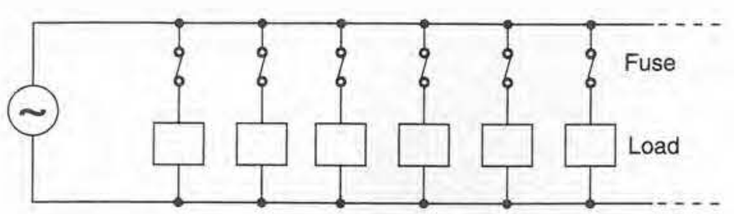
The design work for personal computers and related equipment has been influenced by the Microsoft and Intel Design Guide, which states that "Using a fuse that must be replaced each time an overload condition occurs is unacceptable." And the Plug and Play SCSI (Small Computer Systems Interface) specification states that, "...must provide a self-resetting device to limit the maximum amount of current sourced".

A ptc thermistor can in fact provide protection against over-current, over-voltage and over-temperature, all in one fell swoop. This is by virtue of the dissipation in the device, in conjunction with its resistance versus temperature characteristic.

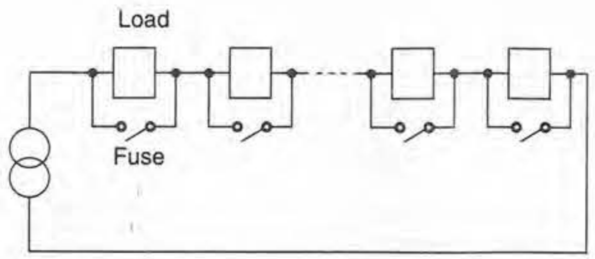
Figure 3 shows the general shape of the resistance versus temperature curve of a typical ptc device. Note that this is the 'static' characteristic, i.e. assuming there is zero dissipation in the device. Also note the dramatic increase in resistance above the 'trip temperature'. The vertical axis in Fig. 3, representing resistance is logarithmic, not linear.

Fig. 4. A ptc thermistor can provide protection against overcurrent (left), overvoltage (middle) and overtemperature (right). Reproduced courtesy of Philips.





a)



b)

Fig. 5. Whereas a constant voltage generator supplies many loads in parallel (a), a constant current generator supplies many loads in series, protection being by overvoltage fuses which 'blow' to a short circuit, (b).

Depending on the particular manufacturer, the trip temperature, or Curie point, is typically about 85°C. Clearly those devices are only suitable for applications where the maximum ambient temperature is less than this. On the other hand, conventional wire fuses can be used up to 125°C, suitably derated.

However, some manufacturers list devices with Curie points up to 125°C or higher. One company – which has been manufacturing ptc devices, under the trade name *Positor*, since 1961 – offers a range of devices with Curie points from 30 to 320°C. The rate of change of resistance with temperature of these devices can be as much as 60% per °C.

When connected in series with a load to be protected, operation depends upon the interaction between the load line, determined by the supply voltage and the impedance of the load, and the device's current versus voltage characteristic. This is illustrated in **Fig. 4a)**.

The circuit is designed so that in normal operation, the load line lies at C, below the peak point B of the thermistor's current versus voltage characteristic (ABD). Under this condition, the thermistor's resistance is low, so that most of the voltage V will appear across the load R_L1. Point D would also be a stable point, since although the current is lower than at C, the voltage across the device is much higher.

A ptc thermistor under overload

Under overload conditions, the load line becomes steeper, reflecting the lower impedance of the load, shown as R_L2 in Fig. 4a). The thermistor switches to its high resistance state and the operating point then settles at E.

Now, the current through the load is small, and most of the supply voltage is dropped across the ptc thermistor, the dissipation in the latter keeping it above the trip temperature. Even if the fault disappears and the load line returns to R_L1, the circuit will settle at point D. It will only return to point C if the supply voltage is removed, and the thermistor allowed to cool before switching on again.

Figure **4b)** shows what happens when the load is correct, but an overvoltage occurs, e.g. a 115V appliance is connected to 230V mains. Again, most of the voltage is dropped across the thermistor, in its high resistance state.

Figure **4c)** shows what happens in the over-temperature condition, for example where an electric motor is stalled. The ptc thermistor would typically be buried in the field winding of the machine. In each case, the 'fuse' will 'reset' itself, provided the supply is disconnected and the fault cleared, allowing the ptc thermistor to cool.

Through the looking glass

So used are we to living in the CV world, that the word fuse conjures up the idea of a melting wire causing an open circuit.

Figure 5a) shows the usual arrangement. You can have as many loads as you like – all with the same design supply voltage – connected in parallel across the source, provided the total current is within the source's maximum rating. Each load is protected by its own fuse, so that if it fails short circuit, the service to the other loads is unaffected. And if it fails open circuit, well, they are unaffected anyway.

Things are quite the reverse in the constant current world, Fig. **5b)**. Here, you can have as many loads as you like – all with the same design supply current, but each with a rated voltage proportional to its power rating. They can all be connected in series with the source, provided the total voltage is within the source's rated maximum voltage capability.

Each load is protected by a normally open 'fuse', with a suitable voltage rating, in parallel with it. If a load fails, the circuit is momentarily opened, and a potentially infinite voltage starts to develop across it.

At some voltage, in excess of the load's normal operating volt drop, the 'fuse' closes. So if a load fails open circuit, the service to the other loads is unaffected, and if it fails short circuit they are unaffected anyway.

Now constant current systems are in generally rather short supply, though one fairly common example is a nickel-cadmium battery charger, designed to charge any number of cells from one, up to some maximum. But sometimes a constant-voltage system is used as if it were a constant-current generator.

One example is a series string of lamps across the 600V traction supply in a tube train. Another is a Christmas decoration 40 light set. Inevitably, a bulb will burn out and a replacement may not be to hand. But to avoid disappointing the children, many sets have bulbs with built-in over-voltage fuses. So when a bulb goes open circuit, the normally open fuse rapidly develops into a short circuit, keeping the other 39 bulbs alight.

In a true constant-current system, the 240V supply voltage would then automatically readjust itself to 234V, but being in reality a CV system, it doesn't – so the remain-

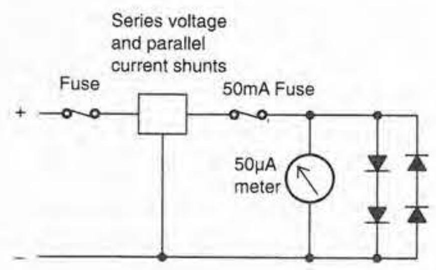


Fig. 6. A 50µA meter can be protected by a 50mA fuse, with the aid of some diodes.

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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.

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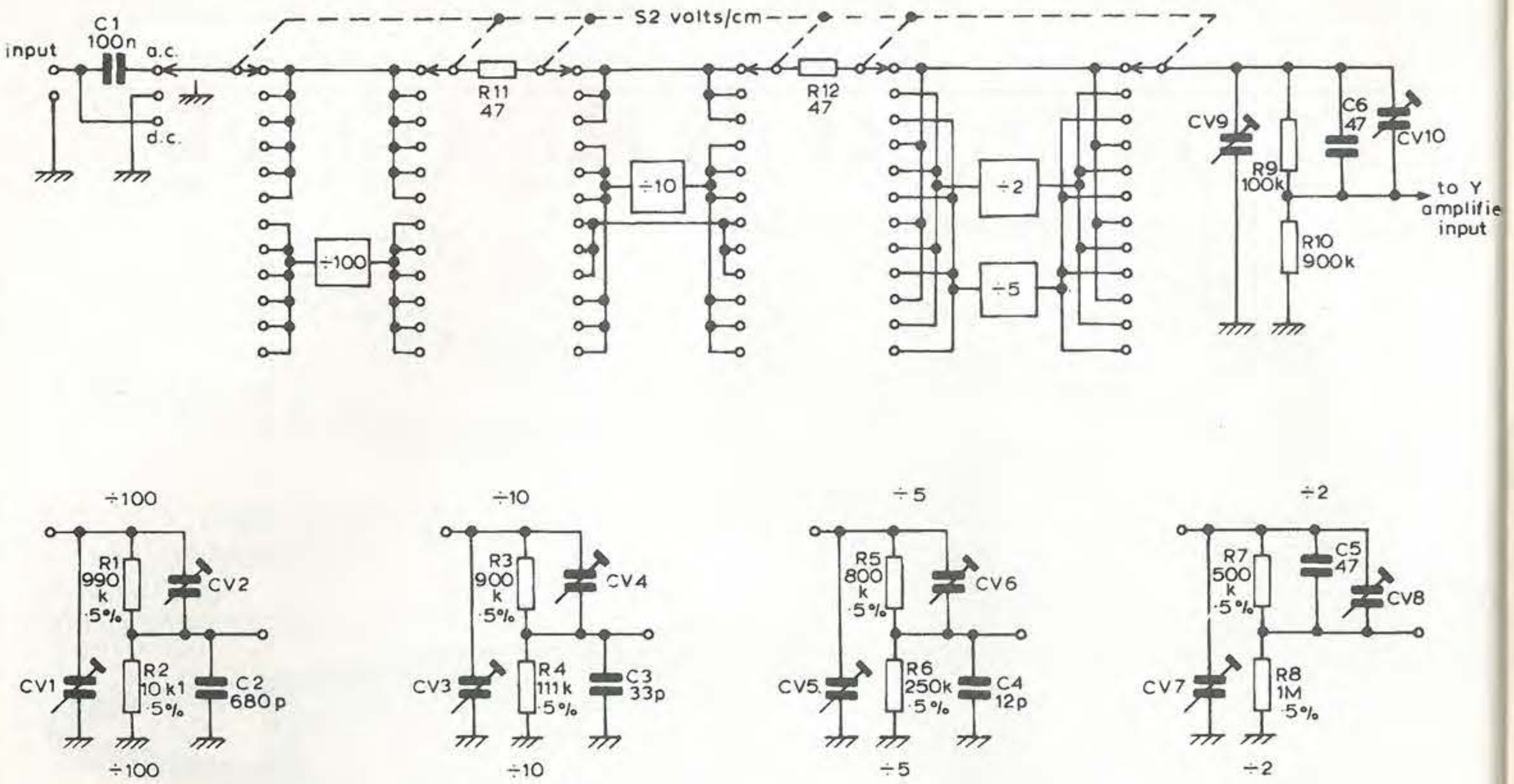

Fig. 7. Due to the high values of the resistances involved, the input attenuator of an oscilloscope is robust against overvoltages. The first stage fet is similarly protected. (Reproduced from ref. 3)

ing bulbs are over-run by 2.5%. Thus a conventional series fuse is needed, to allow for the possibility of cascaded popping of all the rest when yet another bulb goes, if the lazy user failed to act when several bulbs had gone already.

Protecting inputs against voltages

The input of any measuring instrument is at risk of occasional accidental electrical abuse, in the form of the application of an excessively large voltage, either ac or dc. So protection against both of these eventualities is essential.

In many cases, protection against dc is easy. For example, spectrum analysers have a response which does not reach down to 0Hz. One of mine goes down only to 100kHz, the other to 5Hz, and as is usual for such instruments, the inputs are dc blocked by capacitive coupling.

The RF spectrum analyser's lower limit of 100kHz permits a fairly small value of coupling capacitor, even though its input impedance is 50Ω. This thus provides good protection against 50Hz, as well as dc.

The audio-frequency spectrum analyser's response is from 50kHz down to 5Hz, with a dc blocked input impedance of 1MΩ in parallel with 28pF. Consequently, even given the internal protection circuits, the maximum continuous non-damaging input is limited to 50V rms on the six most sensitive ranges, and 100V rms on the others.

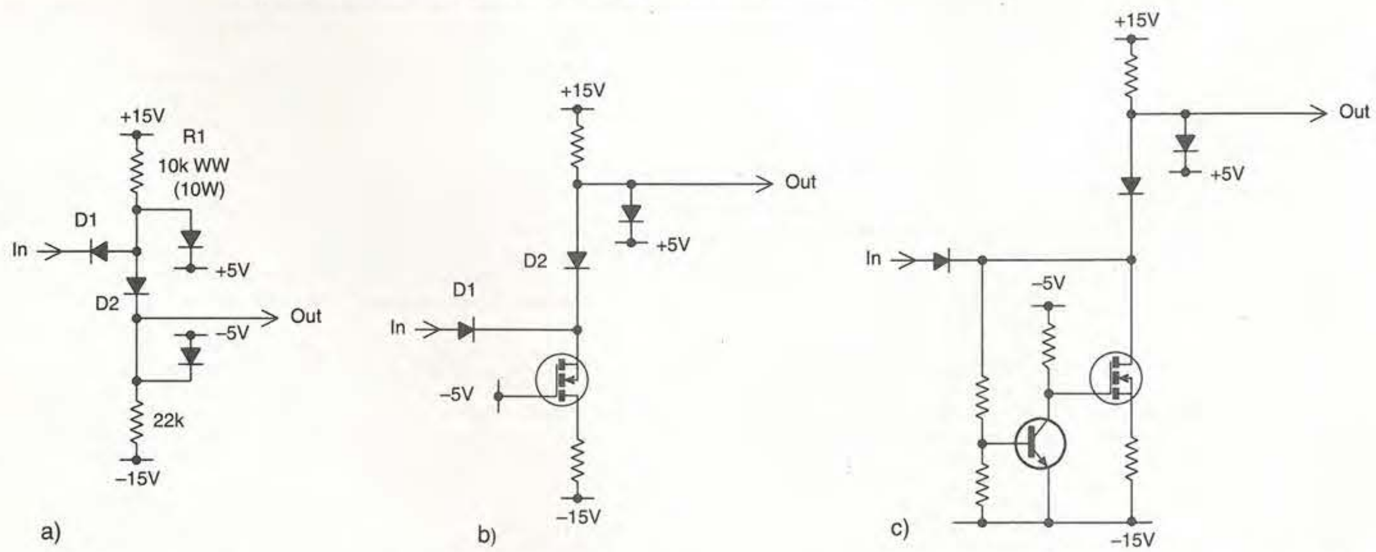

Fig. 8a). Given suitably rated diodes, this frequency-counter input-stage provides protection up to 316V dc, 612V rms continuous, 1kV rms short term.
b) Substituting a mosfet constant-current generator for R_1 greatly reduces the maximum dissipation...
c) ...which can be reduced further still if the mosfet drain current is shut down beyond some positive-going limit.

Other instruments such as multimeters and oscilloscopes need a dc response, at least for some measurements. In some conventional analogue multimeters, having a basic movement sensitivity of 50μA – described as a 20kΩ per volt instrument – fuse protection is used, as in **Fig. 6**. In the event of a large dc voltage being applied on the 50μA range, the 50mA fuse will open, the diodes meanwhile shunting excessive current away from the movement.

The resistance of the meter movement may be several kilo-ohms, resulting in a minimum volt drop of over a volt, so the number of diodes used will be chosen accordingly. Most analogue meter movements will survive an overload of five to ten times full scale deflection. A higher rating fuse may be used at the input to protect the current shunts, in the event of connection to a voltage source.

Early model AVO meters incorporated an ingenious form of mechanical protection. In the event of the needle swinging way off scale, or trying to swing the wrong way, stops connected to a trip mechanism open-circuited the connection to the meter movement. This was restored by pressing the reset button, which naturally should on no account be done until the offending input had been removed.

But most protection schemes for instruments are purely electronic.

Protecting against *big* voltages

An example of circuitry that need protecting against large over voltages is the Y input of an oscilloscope. It requires a response down to 0Hz, and yet may be connected to large voltages of either polarity or large ac inputs, even on the most sensitive range.

Fortunately, the input stage is usually a junction fet, which presents an input impedance which is virtually an open circuit. So a large series resistance can be used, limiting the input fault current, even with mains applied on the most sensitive range, to a few milliamps.

The input capacitance of the fet is built in to a frequency compensated 'L' attenuator section providing a small degree of attenuation. This typically passes 90% of the signal, as shown in **Fig. 7**, reproduced from ref. 3, the relevant components being $R_{9,10}$ and the associated capacitors.

Diodes limit the signal swing at the fet input to within the supply rails, preventing damage to the device. But note, that though the arrangement is effective at dc and low frequencies – such as the mains – damage may still result if a large signal at high frequencies, such as the output of a radio transmitter, is applied on the more sensitive ranges of the oscilloscope.

Where the input of an instrument does not require exceptional linearity, such as the input to a counter, diodes can conveniently be used as protection elements. **Figure 8a)** shows an arrangement I designed into the general purpose counter input of the digital meter.

This ac/dc voltage/frequency/period/ramp-rate meter formed the heart of a piece of sixties missile test equipment. The counter/period input was required not only to survive, but to operate correctly on ac voltages and pulses up to some enormous level.

The A model had used a complicated arrangement of resistors, zeners and diodes, but – landed with responsibility for the B model design – I developed the circuit of Fig. **8a**).

Here, $D_{1,2}$ are high voltage diodes and R_1 was a 10W wirewound resistor. Consequently, the input would withstand any positive input up to the breakdown rating of D_1, and a continuous negative dc input up to 316V. Thus as

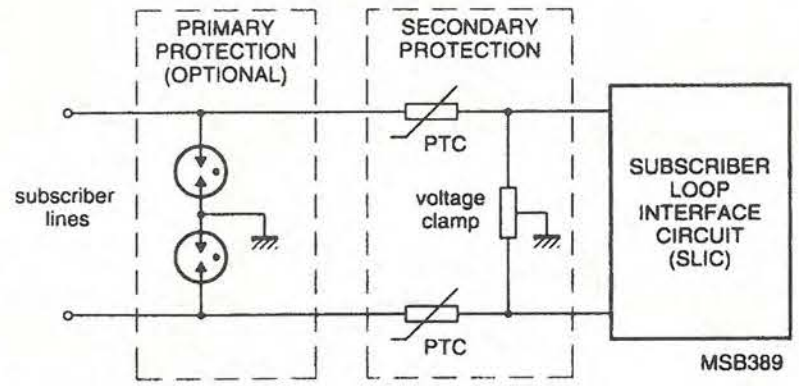

Fig. 9. A SLIC usually has series and shunt protection (secondary protection) for coping with normal transients, and in high lightning risk areas may also have gas-gap arresters for additional protection (primary protection). Reproduced courtesy of Philips.

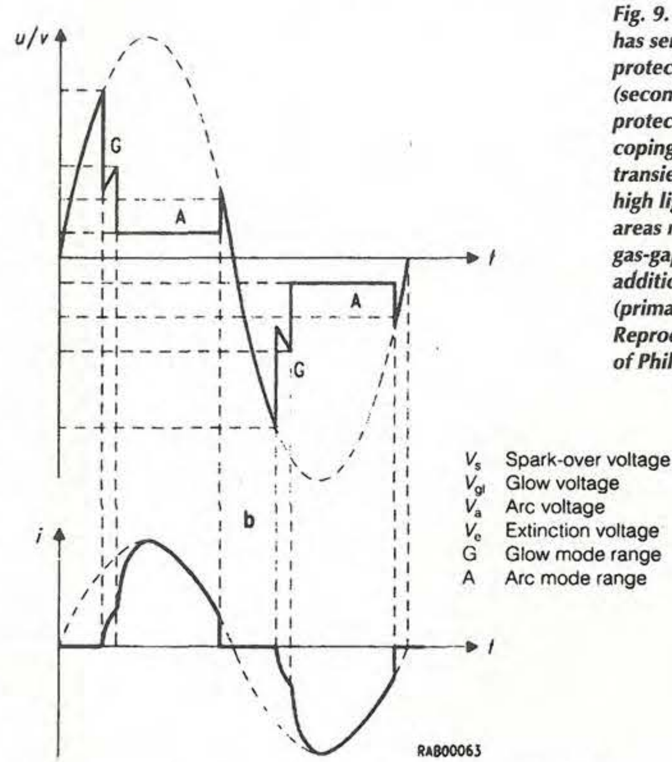

Fig. 10. Showing a) the voltage across and b) the current through a gas-filled surge arrester versus time, and c) the V/I characteristic of the arrester. Reproduced courtesy of Siemens.

Need more information?

This article draws on information provided by the following manufacturers, who kindly supplied technical data on the product ranges listed.

Littelfuse Ltd, 3 Rutherford Road, Stephenson Industrial Estate, Washington, Tyne and Wear. Tel. 0191 4158100. (Fuses)

Murata Electronics (UK) Ltd., Oak House, Ancells Road, Ancells Business Park, Fleet, Aldershot, Hants. GU13 8UN. Tel. 01252 811666. (NTC thermistors, Posistor ptc thermistors)

Philips Components, The Mullard Building, Dorking Business Park, Surrey RH4 1HJ. Tel. 01306 512000. (PTC thermistors, zinc-oxide varistors)

Raychem Corporation, Faraday Road, Dorcan, Swindon, Wilts. SN3 5HH. Tel. 01793 528171. (Polyfuse ptc resettable switches)

Siemens, Siemens House, Oldbury, Bracknell, Berks, RG12 8FZ. Tel. 01344 396000. (Gas-filled surge arresters and switching spark gaps)

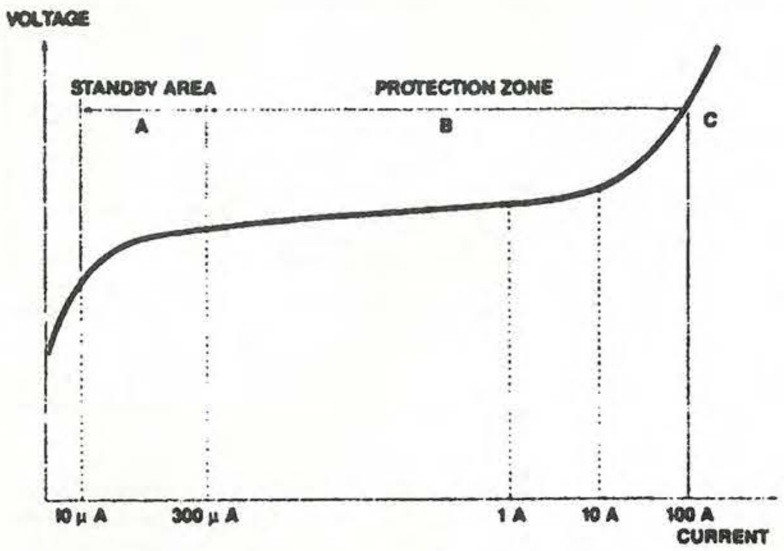

Fig. 11. Current through a zinc-oxide varistor is negligible in the standby area A, but increases rapidly with voltage in the protection zone B. Reproduced courtesy of Philips.

there was no dissipation in R_1 on positive excursions, the ac sinewave input rating was 1kV rms short term, 632V rms continuous – at the cost of 10W worth of heat in R_1. Due to the use of a resistor at R_1, doubling the input voltage inevitably doubles the dissipation.

Had high voltage n-channel mosfets been available, the circuit could have been inverted and redesigned as in Fig. **8b**). Now, the current drawn via D_1 on positive inputs is constant, and the dissipation proportional only to the voltage, not to its square.

An even nattier scheme would be as in Fig. **8c**). Here, above a certain input voltage, the mosfet constant current generator is shut down, leaving the voltage rating of diodes D_1 and D_2 and the mosfet drain voltage rating as the only limiting factors.

And even bigger voltages

Voltage transients don't come much larger than those associated with lightning. And the final overhead subscriber's loop run from a telegraph pole to a building is clearly vulnerable, given that the line makes a pretty good antenna.

In the event of a direct lightning strike, some damage must be expected. But very large voltages can be induced in the line, simply by the electromagnetic coupling from a nearby ground strike. This is due to the enormous rate of change of current di/dt associated with the stroke.

In high lightning risk areas, therefore, a twin gas gap arrester may be fitted at the subscriber's premises. The telephone company is equally worried about its central office apparatus, the front line item being a SLIC - subscriber's line interface card. This will be fitted with series and shunt elements to protect against incoming transient voltages, and will where necessary also have gas gaps, as indicated in **Fig. 9**.

For the protection of a balanced line such as a subscriber loop, a twin gap unit with a centre electrode and two side electrodes would usually be used, rather than the separate arresters shown in Fig. 9. The centre electrode is grounded and the two side electrodes connected one to each conductor of the line – traditionally designated 'tip' and 'ring', from the days of manual exchanges with jack plugs.

Striking

When a rising voltage first appears across the gap, no current flows; the device presents a resistance of some gigaohms. When the source voltage reaches the spark-over voltage V_s – of 70 to 5000V, depending on type – the voltage across the device drops abruptly to something less than the glow voltage V_g. The resulting glow current results in a voltage drop across the internal impedance of the source.

As the source voltage rises further, so does the glow current through the device, and hence also the voltage across the device, as the glow regime has a finite slope resistance. Voltage V_g is in the order of 70 to 150V, the corresponding current being between a few hundred milliamps and an amp or two.

When the voltage across the device reaches Vg, it abruptly drops further to V_a, the arc voltage, which is in the range 10 to 35V. The slope resistance of the device in arc mode is virtually zero, and the device can thus effectively clamp a very large voltage spike, passing up to 40kA in the process, **Fig. 10**.

Following the pulse, as the source voltage collapses, the current through the device falls until it reaches the arc maintaining limit – typically in the range 10mA to a few hundred milliamps. The arc discharge then ceases, as the arrester re-enters the glow discharge regime.

As the voltage across the device falls further, at the extinction voltage V_e, the glow ceases and the device becomes effectively an open circuit again. In the event of the hazard being not an isolated lightning-induced pulse, but an accidental cross with a power line, other considerations such as follow-on current apply.

Shunt clamp options

A variety of devices may be employed for the shunt voltage clamp elements in Fig. 9. High surge rating zener diodes are available for this application, having a faster response than the ptc thermistors with their thermal time constant, which form the series secondary protection.

Another possibility for the shunt voltage clamp is the zinc-oxide varistor. Like the zener diode, it has a very fast response – less than 20ns. These devices are available with a wide range of operating voltages, *viz* 14V to 550V rms.

Assuming a device with an appropriate voltage has been selected for the application, then under normal operating conditions, it will leak less than 300µA, **Fig. 11**. But in the protection zone, these low capacitance devices can tolerate currents of hundreds and indeed thousands of amps.

The series elements of the secondary protection may be ptc thermistors as Fig. 9. Due to their low resistance in the untripped state, these add little attenuation to line signals. However, their resistance is not entirely negligible, so they are available in matched pairs, so as to maintain the line balance. This avoids the conversion of any longitudinal (common mode) pick-up to transverse (normal mode) signals. ■

References

1. International Electrotechnical Commission IEC publication 127.
2. UL/CSA/ANCE (Mexico) 248-14
3. Figure 10.10 from 'Oscilloscopes', Ian Hickman, Newnes, 4th Edition, 1995, ISBN 0 7506 2282 2.

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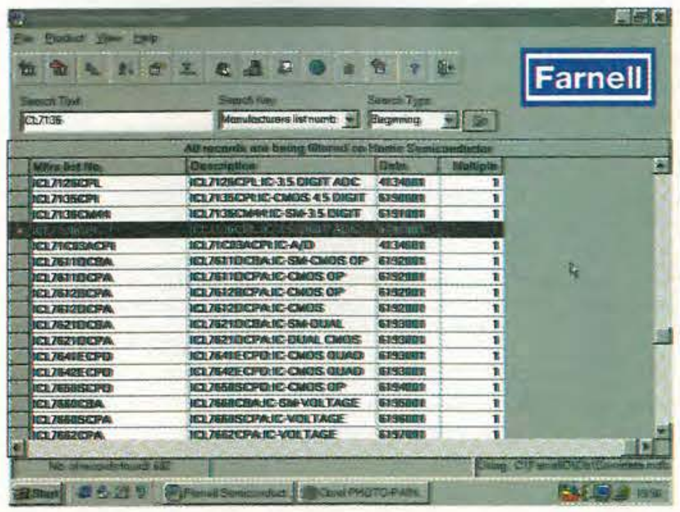

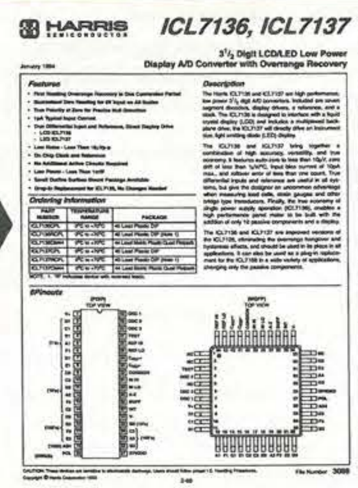

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Motor speed controller

Using back emf rather than a shaft encoder for feedback, Andrew Little's motor speed controller has the potential to fit into a smaller space and reduces costs and power consumption. The circuit shown is a discrete component prototype intended to test the idea before microcontroller implementation. As such, it makes a useful educational aid.

This circuit uses the windings of the motor as a generator to sample the emf produced with the motor free running. It assumes that control of the motor is by pulse width modulation, or pwm.

One of the best speed control methods is to attach an optical encoder to the motor shaft and let a digital system calculate and correct the motor speed. Another method is to attach a generator to the shaft and measure the emf produced.

There may be times though when it is inconvenient or impossible to do either. The motor experimented with here was a three-winding brushed type incorporated into a micro-miniature and lightweight servo with a stated torque of 9.2kg/cm. In this case it was impractical to attach an optical encoder to the motor due to the small case size.

In the pwm method used by this circuit, **Fig. 1** (over page), power to the motor is disconnected at the end of the duty cycle and it is during this part of the cycle that the emf produced at the motor terminals can be sampled. The output of the free-running motor comprises rectified sine waves superimposed, each winding producing one sine wave per revolution rectified by the commutator, **Fig. 2**.

To get an accurate measurement of speed the raw output must be filtered. Firstly the power-on part of the cycle must be removed. I used a Sallen & Key filter for this, but switches are also incorporated (see Circuit Ideas July 1998 page 562, 'Variable corner frequency Sallen & Key low-pass filters). These effectively turn the filter amplifier into a sample-and-hold configuration that samples only during the motor-off part of the cycle, **Fig. 3** (over page).

Benefits of a second pwm circuit

A refinement is to use a second pwm amplifier running at high frequency to control the filter. As the bumps in the input are directly proportional to motor speed it would be nice to be able to control the filter corner frequency to match.

The effect of the second pwm amplifier is to vary the effective resistance of the resistors thus modifying the corner frequency of the filter. The result is that there will be less delay in response at high motor speeds with little loss of accuracy and greater accuracy at low speeds. As a trade-off, response time will be lower, but as the motor is running more slowly the slow response is acceptable.

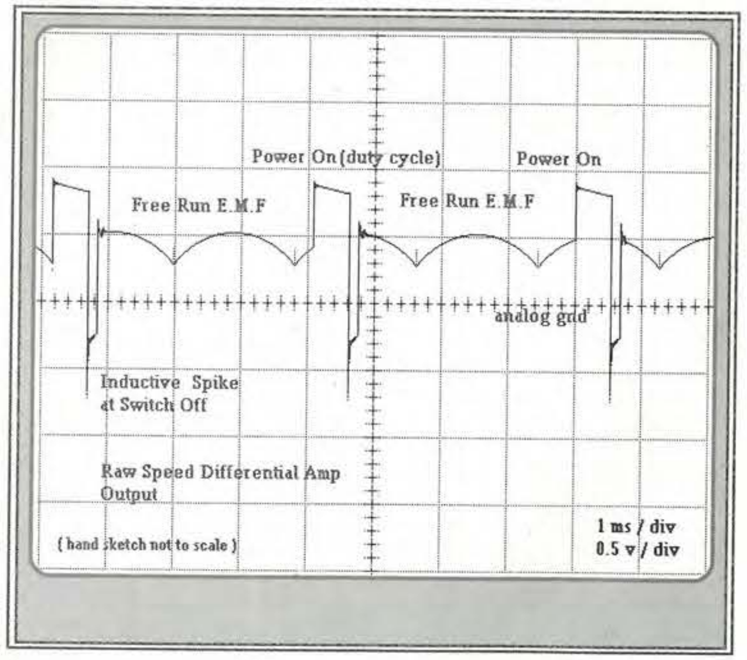


Fig. 2. Representation of the output from the motor between the power-on input pulses from the pwm driver.

During development, I encountered a problem in that at the point where the motor is switched off, the inductance produces an inverse spike, Fig. 2. I allowed for this in the motor 'H' bridge and contained the spike using capacitors and reverse protection diodes.

However this part of the input needs to be removed as it causes large errors, particularly at low speeds. The time length of the corrupted input is roughly proportional to the current through the motor at switch off.

Circuitry to measure this and add a proportional delay

Fig. 1. Drive and pwm circuits of the brushed dc motor speed controller using back emf for speed control.

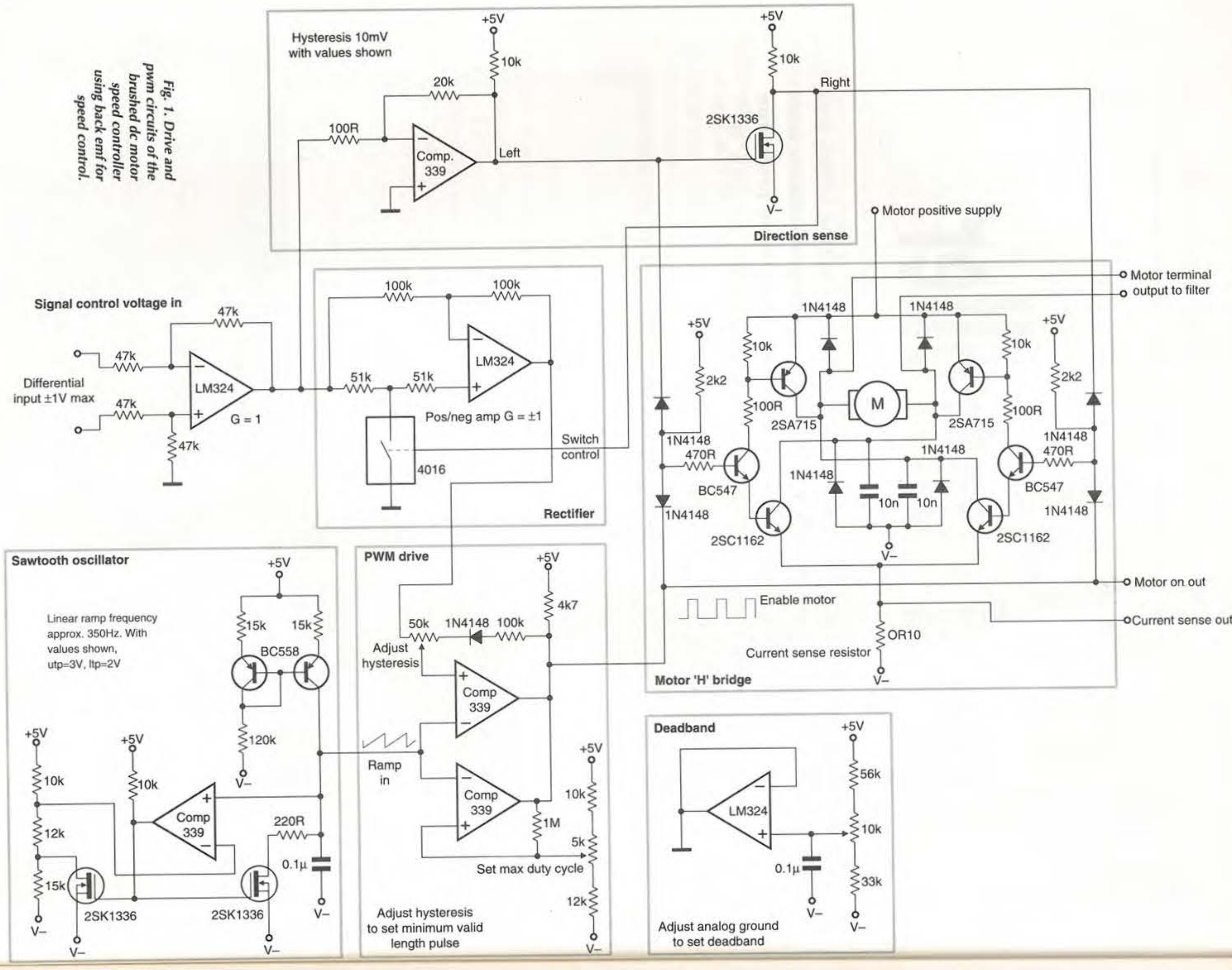
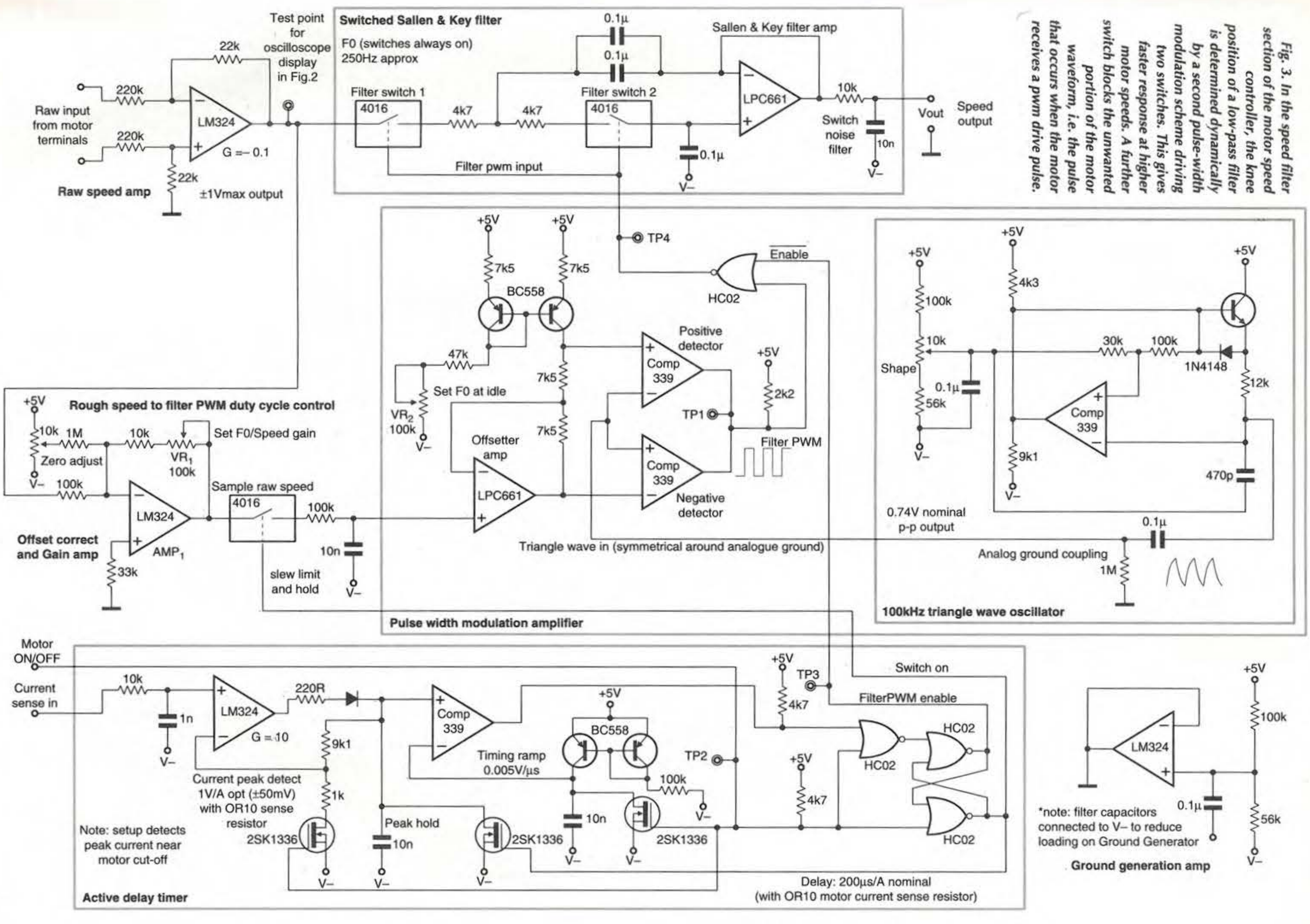


Fig. 3. In the speed filter section of the motor speed controller, the knee position of a low-pass filter is determined dynamically by a second pulse-width modulation scheme driving two switches. This gives faster response at higher motor speeds. A further switch blocks the unwanted portion of the motor waveform, i.e. the pulse that occurs when the motor receives a pwm drive pulse.



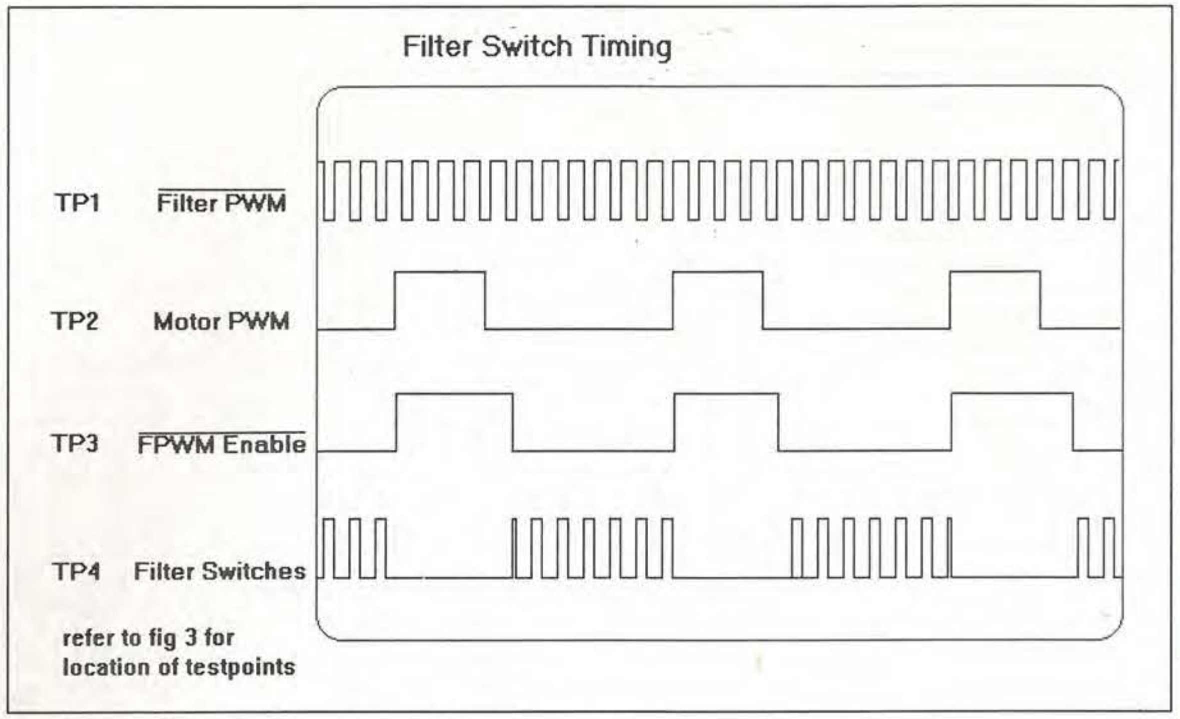


Fig. 4. Timing of the signals around the variable-knee low-pass filter shown in Fig. 3.

before starting to sample is now incorporated. It is labelled in Fig. 3 as 'Active delay timer'.

The active circuitry is not strictly necessary and could be replaced by a fixed delay of longer duration. But it shortens the delay at higher speeds, where current is low, but where the sampling time is short due to the longer motor duty cycle. The more sampling that can be done per cycle the faster the response capability, **Fig. 4**.

Circuit details

Being built from discrete components, the circuit shown is large. All aspects of the system are easy to inspect and modify and most components should be familiar – and cheap.

In a practical version, suitable one-chip pwm amplifiers could be used, or the whole circuit could be modelled in a microcontroller such as the PIC *16C77*. This would make the design very compact. Once the analogue system is optimised it is easier to define mathematical limits, etc.

I have constrained the design to a single 5V supply. In the following, to avoid confusion, bear in mind that there are two pulse-width modulation amplifiers – one in the motor drive and one in the filter.

Motor pwm circuit

This circuit segment takes the plus or minus signed differential input control voltage, determines the required direction and turns this into the the pulses used to drive the H bridge. It incorporates an adjustable dead band, which is the voltage either side of zero where the motor produces no output.

In a positional servo this dead band is the 'off bucket' that you are aiming for when you arrive at the required position. This is achieved by moving the local analogue ground up or down on the saw tooth waveform, Fig. 1.

The other essential is that pulses applied to the motor have some minimum length required to bump the motor into movement. This is adjusted by varying the hysteresis of the output comparator. A diode is incorporated in the comparator positive feedback which removes the need to adjust this control when the dead band is adjusted.

As the control input is signed, i.e. either + or –, rectification is achieved by switching the polarity of the positive/negative amplifier according to the polarity of the input.

The 4016 analogue switch is borrowed from the filter circuit. Offsets are ignored in the current circuit, though a spare amp is available in the *324* pack to deal with them.

Determining direction

Output from the input sense comparator is used to set the direction of the motor H bridge. Logic dictates that the inverting buffer mosfet drives the switch. Hysteresis on the comparator is added to prevent oscillation in the dead band.

The rectified input is then compared with the linear sawtooth produced by the sawtooth oscillator and the comparator output is diode Anded with the direction input to enable the H bridge.

The 220Ω or so resistor in the discharge path prevents discharging the capacitor too far before the comparator has time to catch it. The frequency of the original is about 350Hz with values shown.

A further comparator sets the maximum duty cycle. The circuit provides a 100% duty cycle – i.e. always on. But for the motor speed filter to work correctly the duty cycle needs to be less than 100%.

Operation of the H bridge in Fig. 1 is self explanatory. The only precaution necessary is to use some means to prevent both sides being enabled simultaneously.

With suitable component values the motor supply voltage can be raised as high as you like. The advantage of pwm is that the drive transistors are either off or saturated so that with say an amp of current, dissipation will be, say, 2-400mW for each transistor switched on, which is quite small. When the enable signal is low, both sides are switched off.

Reverse protection diodes and capacitors contain the switch off spikes.

Filtering circuitry

The filter comprises the switched Sallen & Key filter, the filter pwm amplifier and the current sense active delay section.

Values shown give a maximum theoretical corner frequency of around 250Hz. The real maximum frequency will be lower than this due to the on resistance of the switches. Even with the 4016, on-resistance matching is pretty good.

The amplifiers used for sample-and-hold should be cmos types with a very high input impedance. My prototype used a *LPC6621N* but other c-mos types may be more suitable.

In the pwm amplifier, for variety, a different approach is

used from the previous circuit. In this case the oscillator produces an exponential triangle wave. Values shown give a frequency of about 100kHz.

The offsetting amplifier splits the roughly filtered speed input into two versions with equal positive and negative offsets whose span can be varied by means of the current source reference current, adjustable via VR_2. The open-collector outputs of the *339* give a Nor output. Output enable is controlled by the active delay timer.

In this circuit the reference current is adjusted so that there is always some pwm output, even with no motor speed. This is because with no current into the filter, it tends to float, although the effect is small with cmos amplifiers.

In practice, adjustments should be made to give the maximum duty cycle possible consistent with the required output ripple at low speed. Bear in mind that as the pulse width is reduced, the corner frequency and response time of the filter increases towards infinity. A disadvantage of this set-up is that during idling both comparators switch, effectively doubling the frequency. A useful feature of this filter is that the switching frequency otherwise remains constant, making it easier to isolate this source of noise.

Gain of the input amplifier, VR_1 on AMP_1, also modifies the response. In a positional servo, a large gain would give a rough output at high speed but with a fast response. Accuracy would increase as speed is reduced and the required position is approached. In a constant speed servo on the other hand, it may be appropriate to reduce the gain to get the most accurate output.

Active delay timer

Ideally, the delay before enabling the filter pwm at the end of each motor cycle should end just after the raw input has reached the steady free-running state, Fig. 2.

Increasing current causes the delay to lengthen proportionally. At the end of the motor-on cycle, the current peak detector amplifier feedback is switched out to prevent discharging the capacitor. Detected motor current is held in the peak-hold capacitor, the ramp generator starts and the comparator output is high until the delay has elapsed.

The bistable device then flips, enabling the filter pwm until the start of the next motor on cycle when the filter again becomes a sample-and-hold amplifier.

Values shown give a delay of around 200µs per detected amp. At long motor duty cycles, the active delay circuit allows more sampling to be done per cycle thus improving the response time and accuracy of the system. Theoretically for best correlation between accuracy and response the motor pwm duty cycle should be ≤50%.

Performance

In practice, the circuit performs well with good accuracy and linearity at high and low speeds. Performance will probably not match an optical encoder, but the scheme could provide an economical alternative as code in a microcontroller.

Although originally intended as a test bed for a microcontroller based system, the circuit suggests an entirely analogue solution, doing the PID calculations with op-amplifiers. ■

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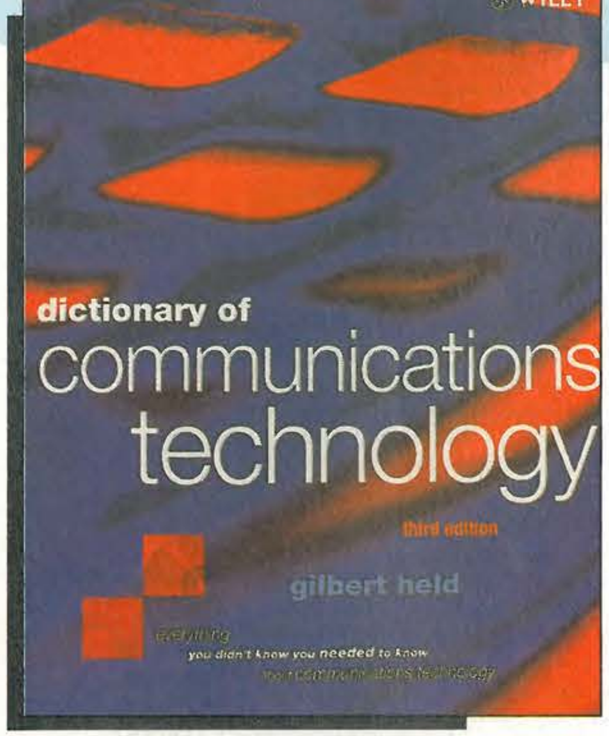

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concatenation

ComWatch An off-site network monitoring service marketed by Timeplex, Inc., of Woodcliff Lake, NJ.

concatenation 1. The linking of transmission channels or subnetworks end to end. 2. The linking of blocks of user data or protocol transmissions. 3. In fiber optic technology, the interconnection of two or more fibers into one continuous length.

concentration Collection of data at an intermediate point from several low- and medium-speed lines for transmission across one high-speed line.

concentrator A device used to divide a data channel into two or more channels of average lower speed, dynamically allocating space according to the demand in order to maximize data throughput at all times. ...

conditioned circuit A circuit that has been electrically altered to obtain the desired characteristics for voice and data transmission. The reader is referred to the entries C-1 through C-8 and D-1 and D-2 for specific information on C-level and D-level conditioning.

conditioned loop A loop that has conditioning equipment, usually equalizers, attached to obtain a desired line characteristic, to facilitate voice or data transmission.

conditioning The "tuning" or addition of equipment to improve the transmission characteristics or quality of a leased voice-grade line so that it meets specifications for data transmission. (See figure below.)

modem

modem, multiport A device that combines a multiplexer and a modem allowing two or more DTEs to be connected to the same line. Also split stream modem.

modem, quick turnaround A modem with minimal turnaround time when the line is used in a half-duplex mode. Also Quick Poll (QP), Fast Poll (FP).

modem, short haul Description of both line drivers and limited distance modems.

modem, wideband A modem designed to operate at speeds greater than those used with high-speed modems, such as 19.2 or 56 Kbps. Wideband modems will not operate over voice-grade circuits but require a wideband circuit.

Modem-7 Communications software program supporting the public-domain, X-modem, error-correcting file transfer protocol. This version of the X-modem has multifile transfer capability.

modem connect The name used in DNA for that class of communications links governed by industry standards for modem connection.

modem eliminator A device used to connect a local terminal and a computer port in lieu of the pair of modems that they would expect to connect to: allows DTE-to-DTE data and control signal connections otherwise not easily achieved by standard cables or connectors. Modified cables (crossover cables) or connectors (adapters) can also perform this function.

modem operation characteristics See page 270.

modem pooling A feature of a PABX and other communications products that permits subscribers to be automatically or manually connected to a group of shared or "pooled" modems.

modem sharing unit A device that splits a signal among a cluster of terminals and allows them to share one modem.

modem substitution switch An external option that allows you to reroute your data through a "hot" spare (a modem that is already powered up) in the event the original modem fails.

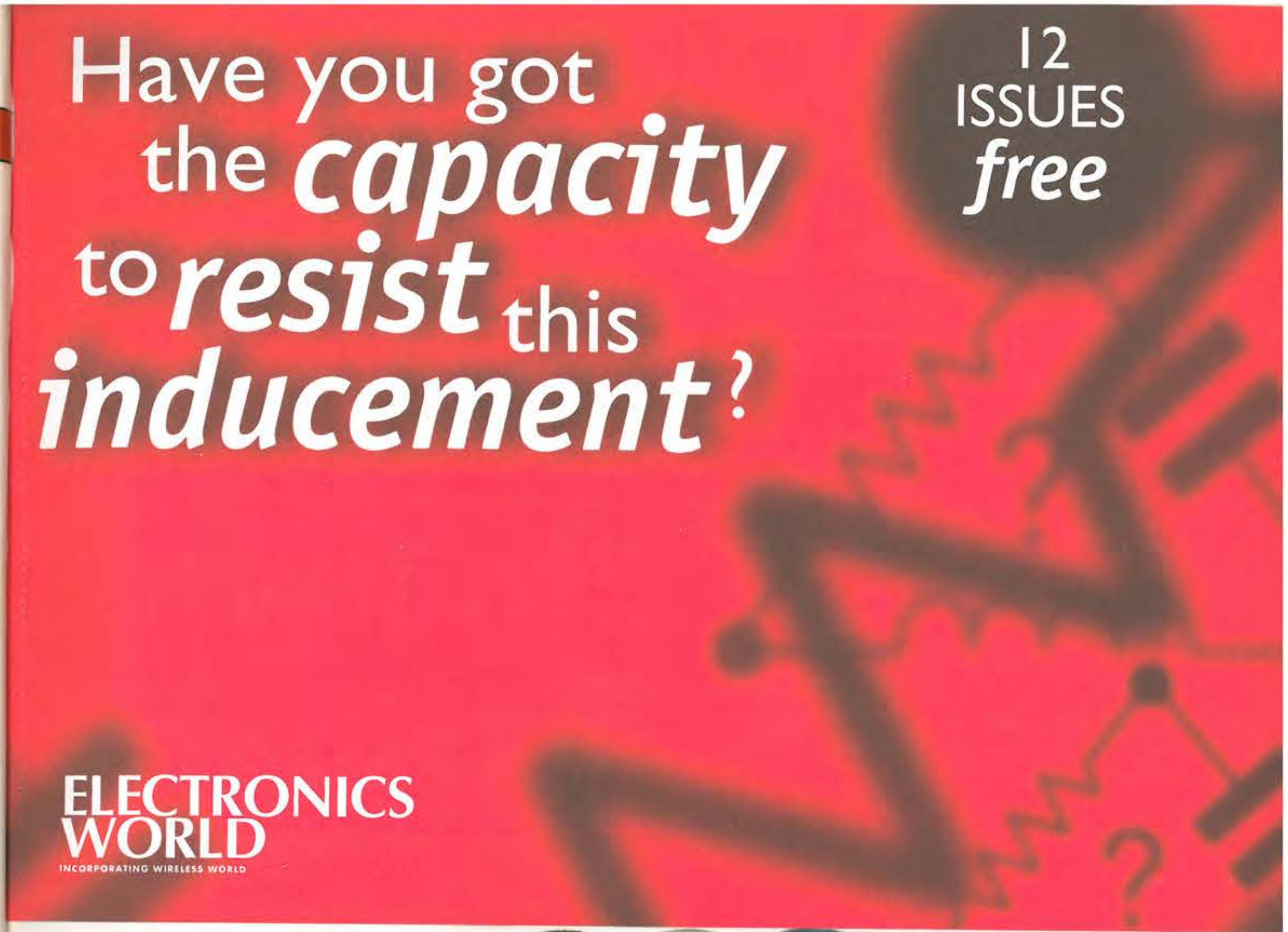
moderator A participant who is in charge of a conference. A moderator is responsible for keeping the discussion on track, for alleviating fights, and for similar functions.

MODES Discrete optical waves that can propagate in optical waveguides. Whereas, in a single-mode fiber, only one mode, the fundamental mode, can propagate. There are several hundred modes in a multimode fiber which differ in field pattern and propagation velocity (multimode dispersion). The upper limit to the number of modes is determined by the core diameter and numerical aperture of the waveguide.

Modified Chemical Vapor Deposition An AT&T Bell Laboratories-patented process that uses high temperatures to speed the manufacture of large quantities of fiber lightguide. The glass is made by allowing hot vapors to form a coating inside a tube of heated silica, which is later drawn into fiber. Temperatures reach 4000 degrees F. (The melting point of steel is 2800 degrees F.)

Modified Final Judgment (MFJ) The 1982 Federal Court ruling that determined the rules governing the divestiture of the Bell Operating Companies from AT&T and other antitrust and deregulation issues. Presided over by Judge Harold Greene, as was the AT&T Antitrust settlement which the MFJ modified. Judge Greene continues his involvement in enforcing and interpreting the provisions of this settlement.

modular distribution accessories A term used to reference splitters, modular adapters and modular



Thirty years before videotape recording, between 1927 and 1928, John Logie Baird experimented with recording his television signal onto discs. Five years later, enthusiasts made a few off-air disc recordings of the BBC's 30-line tv broadcasts. The discs have remained as curiosities since then, defying attempts to retrieve recognisable pictures.

For many years I have been seeking out and restoring these discs using software signal and image processing. The images recovered from the discs give a remarkable insight into those pioneering days of tv. As a bonus, analysing the recorded signal and its distortions unfolds a wealth of new information on the mechanical tv era.

Fig. 1. Resembling contemporary audio discs, these are the different types of discs that contain the world's earliest-known recordings of television.

Recorded *live...*

In television's short history, the development of video recording technology has lagged behind broadcast television by decades. In 1956, Ampex in the USA demonstrated and marketed the world's first practical broadcast video recorder.[1] It was one of the great technological achievements of the television age and transformed broadcast television services, rapidly becoming essential to programme production.

Before videotape, 'tele-recording' – filming a television display – was the only method of capturing the fleeting images. Broadcast companies used the technique widely and for many years after the introduction of videotape. The quality, however, was always poorer than the original material largely because it had the extra distortion incurred by being displayed and filmed.

The first recordings?

The earliest direct video recordings appear to come from Ampex's video recorder between 1951-56, or the

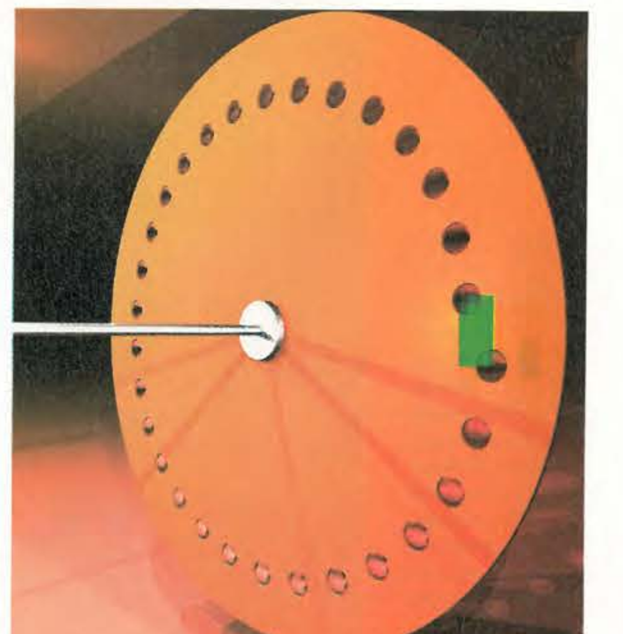


Fig. 2. A single spiral 30-line Nipkow lens disc set up for the Baird standard. The area for imaging or display is shown in green. For a 1.5m diameter disc, this area is only about 6cm horizontal by 14cm vertical.

*Donald F McLean BSc (Hons) CEng FIEE

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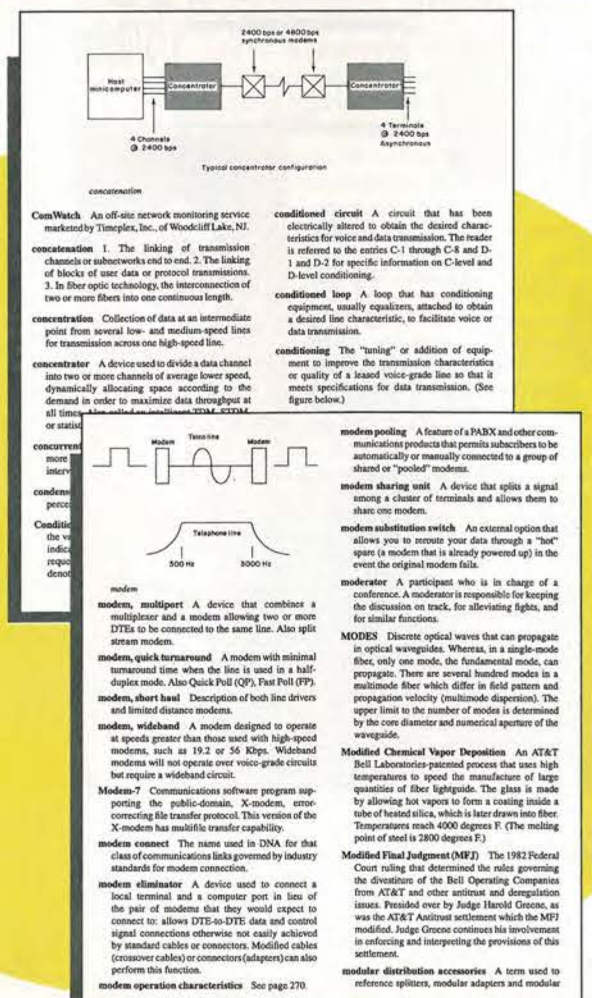

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Dawn of television

Using computer enhancement techniques, Donald McLean* has managed to look at television recorded on disc seventy years ago – thirty years before video tape recording became possible. What is more, this is the first time it has been seen since it was recorded.

Thirty years before videotape recording, between 1927 and 1928, John Logie Baird experimented with recording his television signal onto discs. Five years later, enthusiasts made a few off-air disc recordings of the BBC's 30-line tv broadcasts. The discs have remained as curiosities since then, defying attempts to retrieve recognisable pictures.

For many years I have been seeking out and restoring these discs using software signal and image processing. The images recovered from the discs give a remarkable insight into those pioneering days of tv. As a bonus, analysing the recorded signal and its distortions unfolds a wealth of new information on the mechanical tv era.

Recorded *live...*

In television's short history, the development of video recording technology has lagged behind broadcast television by decades. In 1956, Ampex in the USA demonstrated and marketed the world's first practical broadcast video recorder.[1] It was one of the great technological achievements of the television age and transformed broadcast television services, rapidly becoming essential to programme production.

Before videotape, 'tele-recording' – filming a television display – was the only method of capturing the fleeting images. Broadcast companies used the technique widely and for many years after the introduction of videotape. The quality, however, was always poorer than the original material largely because it had the extra distortion incurred by being displayed and filmed.

The first recordings?

The earliest direct video recordings appear to come from Ampex's video recorder between 1951-56, or the

Fig. 1. Resembling contemporary audio discs, these are the different types of discs that contain the world's earliest-known recordings of television.

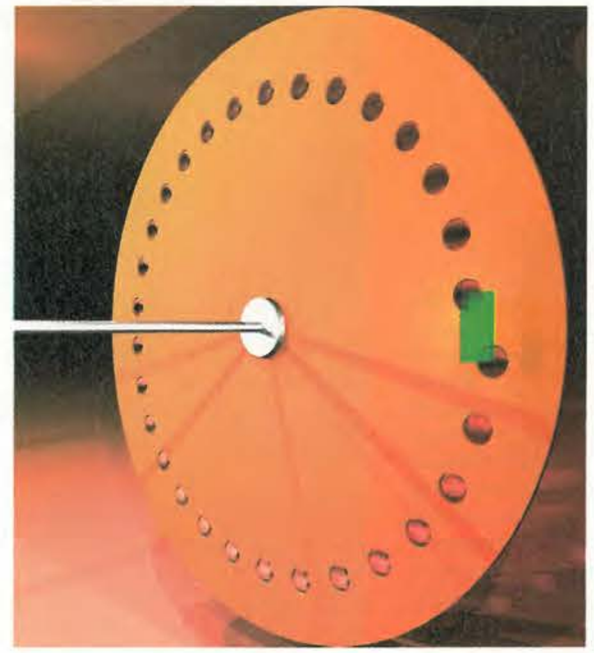


Fig. 2. A single spiral 30-line Nipkow lens disc set up for the Baird standard. The area for imaging or display is shown in green. For a 1.5m diameter disc, this area is only about 6cm horizontal by 14cm vertical.

*Donald F McLean BSc (Hons) CEng FIEE

Fig. 3. The Baird standard called for a vertical letter-box format designed for viewing people from head-and shoulders to long-shot. The subjects that came across best were those that showed plenty of movement. The characteristic curved picture comes from using a Nipkow disc.

BBC's VERA and RCA's 1953[2] experimental linear video recorders.

In the UK, the earliest tele-recordings come from just after the Second World War. In the USA, the earliest recording appears to be of 48-line mechanical television made in 1930 by GE of Schenectady, New York. Of the BBC's historic pre-war 405-line service that started in 1936, there is no recorded material other than newsreel and film inserts used to support live television.

Recently, I restored several direct video recordings, **Fig. 1**, that pre-date that period. They span the pioneering days from soon after the world's first demonstration of television by John Logie Baird in 1926 to the BBC 30-line Television Service that ended in 1935. They are now recognised as being the earliest video recordings in the world.

How could such recordings have been made decades before Ampex's achievement? To answer this, we need to review television's roots.

Fig. 4. John Logie Baird in 1927 at the Leeds demonstration to the BA. He is posing with a wax cylinder video record/playback system – the precursor to 'Phonovision'. The drive shaft probably connected the Nipkow camera disc with the cylinder drive. No cylinder recordings have survived.

Fig. 5. This frame-sequential colour 15-line dithered image from normal audio cassette tape was generated by the author to simulate what Baird may have seen in his studio in 1928.

Fig. 6. The author's modelling of Baird's Phonovision recording studio of 1927/28 shows the drive-shaft from the scanning disc connected through a 3:1 worm gear to the record platter.

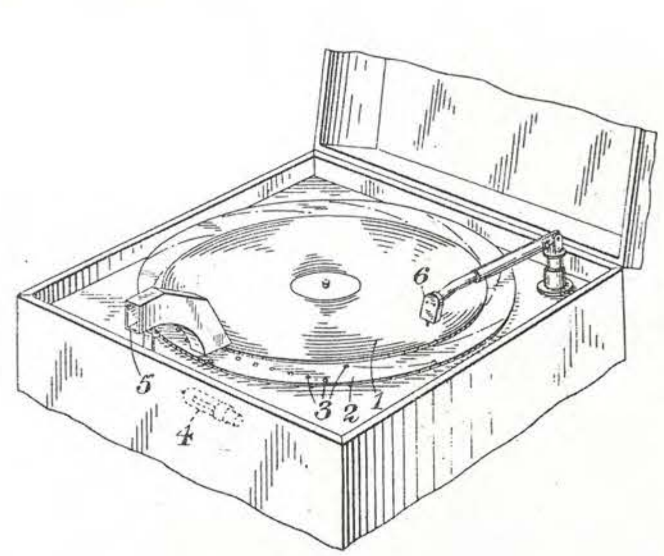


Fig. 7. Baird's patent for the 'Phonovisor'. A Nipkow disc under the record platter provides what must be the cheapest and simplest video replay device ever designed. The Phonovisor required the specially prepared Phonovision discs to be recorded synchronously with the camera disc. Looking into the viewport, the picture would be seen perfectly stable, independent of playback speed.

Fig. 8. The experimental 'Phonovisor' replay device used a large diameter Nipkow disc underneath the record platter. A light source at the right shines up through the disc via a mirror. This arrangement could also have been used for recording.

The dawn of television

Spurred on by the discovery of the light sensitivity of selenium in 1873, the transmission and reception of still pictures over cable was demonstrated in the late 19th century without the advantage of electronics. Fleming's thermionic diode valve in 1904 and de Forest's triode valve and amplifier of 1912 kicked off the electronic revolution that was essential for television. By the early twenties, news-picture 'facsimiles', some even using digital coding,[3] spanned thousands of miles.

In contrast to these slow, yet high quality transmissions, television required several pictures per second to give the perception of motion. The advantages offered by electron tubes for television camera and display were recognised (1908[4], 1911[5]) well before their practicality. The practical electron tube display first appeared in the twenties and the camera – a major technological challenge in itself – in the thirties.

Several mostly independent pioneers around the world, including Baird in the UK and Jenkins in the USA, focused on the achievement of a practical television system by adapting what already existed to their purpose. They used the only method of scanning the scene available – mechanical scanning. Of the many methods developed for scanning, the Nipkow disc[6] became the most popular. It supported the development of several of the first practical television systems for almost half a century after its patent.

The Nipkow disc was normally one spiral of holes or apertures spread equally around the outer part of a flat disc, **Fig. 2**. The path each aperture swept out, through the angle between apertures, corresponded to a line in the image. The radial distance of each successive aperture changed in equal steps so that, in one revolution, all the apertures swept out the area of one tv frame.

By masking off the area and placing a photocell behind it, we have a television camera. By placing a variable light source – usually a neon – behind a similar disc, we have a television display. With synchronisation of camera with display, we have the vision channel for television.

The first demonstration of television

First with a demonstration of scanning and display of moving pictures in reflected light was John Logie Baird on 26th January 1926. Baird's transmitted standard of 1929-1935 was 30 lines per frame refreshing 12.5 times per second **Fig. 3**.

Line scanning was vertical, from bottom to top with frame scanning from right to left. Baird chose an aspect ratio of 3:7 – a vertical letterbox, optimised for televising individuals from close-up portrait to long-shots.

The mechanical nature of his Nipkow-disc-based system, and the sensitivity and bandwidth of photocell-amplifiers, constrained his television picture to mere tens of lines rather than the hundreds of lines of the electronic systems emerging in the thirties.

However, this low definition turned out to offer a distinct advantage. The highest vision frequency was so low that it was in the audio spectrum. Both this narrow bandwidth and the ease of creating different scanning arrangements were the main reasons why Baird was able to achieve so many 'firsts' – years before they were repeated in electronic television.

Inventions

Spurred on financially and technically by his early demonstrations, from 1926 to 1928 Baird patented and developed a series of innovations that covered almost every engineering aspect of television, **Fig. 4**.

He demonstrated colour television, **Fig. 5**, stereoscopic television, (near) infrared, and long-distance transmission. In early 1928, he demonstrated reception of pictures across the Atlantic in East Coast USA from transmissions in Surrey, England.

In the months leading up to that event, he not only transmitted live images, but also used his latest experiment, videodisc recordings.[7] These and other demonstrations served to establish Baird in the public's eye and to raise general awareness of a television revolution.

Today, little evidence remains of these early achievements. This makes it difficult to be factual about Baird's contribution to television – especially in his most publicised creative era of the late 1920s.

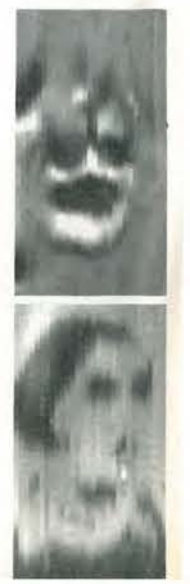
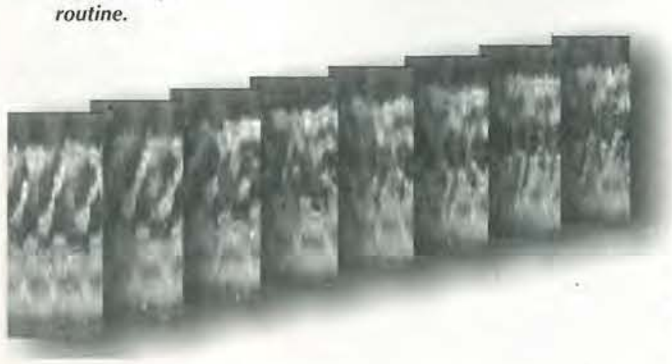


Fig. 9. On the left is an attempt from the seventies at replaying a Phonovision disc (10th January 1928) without using a computer. On the right is the same disc and subject enhanced by custom software signal and image processing.

Fig. 10. Baird's temp secretary, Mabel Pounsford, captured on disc on 28 March 1928. Her identity was discovered after the restored pictures were broadcast in 1993 on Channel 4 and recognised by a relative.

Fig. 11. The earliest-known video recording of broadcast television from the BBC, 21 April 1933. The main feature, captured on disc, was the Paramount Astoria Girls with their high-kicking routine.



Various interpretations of his works have both over- and under-stated Baird's importance. However, the significance of one of his achievements from that period has only recently been recognised. This is his recording of television – the first in the world.

Phonovision and the 'Phonovisor'

In 1926, Baird applied for a patent on an idea for recording vision and sound signals.[8] He called this process 'Phonovision'.

What made Phonovision unique was its mechanical coupling of the camera mechanism to the record platter, **Fig. 6**. The same linkage on playback would have ensured a rock-steady picture from the disc. In one simple concept, Baird eliminated the effect of speed variation during recording and playback.

A subsequent patent[9] described the 'Phonovisor', **Fig. 7**. This was to be a simple machine used for both playing back and displaying pictures from the Phonovision discs. The Phonovisor would have looked like a conventional gramophone. However, mounted coaxially with the disc platter was a horizontal Nipkow disc with the apertures on the rim outside the disc platter.

Although highly innovative in its simplicity and inherently cheap, neither Phonovision discs nor the Phonovisor ever appeared commercially. Unlike Baird's other experiments, the reproduction of pictures from the Phonovision discs – though undoubtedly attempted in the laboratory, **Fig. 8** – was never publicly demonstrated. From his own comments, it would seem that Baird was never sufficiently satisfied with the picture quality to give such a demonstration.

Baird moved on to other ideas and abandoned Phonovision. He passed a few of the discs to museums[10] and to his friends and employees. Over subsequent years, many people attempted reproduction of images from the Phonovision discs.[11] Their efforts yielded only crude distorted images, **Fig. 9**.

What Baird could not have realised is that more than sixty years later the faults during recording could be corrected in a personal computer,[12,13] restoring the latent image on his discs to a recognisable form. Those images give a remarkable insight into those pioneering days of television, **Fig. 10**.

But the images are only part of the discoveries made. Studying the details of the video signal tells us the camera type and even how well it was built. In addition, analysing the faults on the recordings gives a unique and in-depth understanding of the difficulties Baird encountered.[14] From previously being mere curiosities, the discs have today become one of Baird's most historical legacies.

The 30-line broadcasts

In September 1929, after much lobbying, the Baird Television Development Company started a series of experimental transmissions through the BBC transmitters.

For nearly three years, for no fewer than five times a week, the Baird Company produced its own programmes from its laboratories in Long Acre. In August 1932, the BBC took over full control and started the BBC Television Service with regular programming from studio 'BB' in the basement of Broadcasting House.

It now seems that a few of the enthusiasts watching the television programmes on their Baird 'Televisors' were moved to use their domestic audio recorders to record the vision signal for subsequent playback. Although the quality of the result would have seriously disappointed them, they very fortunately kept the discs safe rather than destroying them.

Off-air recordings

News of my discoveries from the Phonovision discs triggered some tremendous finds. A single privately recorded aluminium disc found in 1996, with just the cryptic words "Television 1933" written in ink on the label, was the first.

The material on the disc overturns established views on the 30-line BBC programmes. After restoration and analysis, this disc contains the earliest known recording of a television broadcast – in fact, a television special **Fig. 11**. It was broadcast in April 1933, just eight months after the start of the BBC 30-line Television Service.

The camera technique, lighting technique and production features are all unusual and unique. The rapid pace of the performance is stunning and provides us today with a true measure of Britain's heritage of television programme making.

In early 1998, another discovery was made. A set of unmarked privately recorded aluminium discs has turned out to contain the highest quality original 30-line vision recordings known to exist.

From the video characteristics, they were extracts from BBC transmissions from the latter part of the 30-line service. By that time, the BBC had moved out of Broadcasting House into a new studio in 16 Portland Place.

One of the singers on the discs is Betty Bolton, **Fig. 12**. Betty is a well-known contralto, who performed over a dozen times in front of the 30-line cameras. Her visual performance on disc is exceptional – even on a sixty-year old corroded aluminium disc she still managed to charm her re-discoverer.

In 1935, the first video disc was sold in the UK. A 78 rev/min test disc intended for 'lining up' displays, it contains only static lantern slides of cartoon figures, **Fig. 13**. Although a collector's item today, this, the 'Major Radiovision' disc, contains little of interest for the historian. It is certainly not, as has been claimed, 'Phonovision'.

The parallel developments of television in other countries suggest that there should be similar discs around the world. To date, I have only found discs of British television. It may be simply that, like the British discs before this restoration work, recordings made in other countries were written off as unplayable.

In summary

The discovery and restoration of the discs falls somewhere between being a computer-age detective story and a practical example of technological archaeology.

Applying the latest technological advances of the eighties and nineties has given us a unique view of the latest technological developments of the twenties and thirties. What makes this so fascinating is that the material comes from such a dynamic and important period in Britain's technological history.

After 1500 programmes, the BBC 30-line service closed on 11 September 1935. In November 1936, the BBC re-opened its television service with high-definition television. The massive technology leap that television had made left recording technology far behind. It would be nearly twenty years before direct video recording could catch up.

I plan to produce two follow-up articles covering in more detail the discoveries from Baird's Phonovision and the restoration techniques used, the later BBC tansmissions and how they appear in context with today's television.

Fig. 12. Far left Believed to be from a BBC broadcast in 1934-35, this is Betty Bolton. Her performance is stunning and easily makes her the 'Madonna' of thirties videos.

Fig. 13. In early 1935, a test disc of still images was sold for 'lining up' 30-line displays. A few months later, the 30-line service was terminated, rendering thousands of receivers, and this test disc, obsolete.

Acknowledgements

My thanks go to all those who have supported and encouraged this private research throughout the years. Special thanks go to Ray Herbert, Eliot Levin of Symposium Records, Nicholas Moss of the BBC and the owners of the discs for their freely-given help and support for the recent discoveries. ■

See more...

The author's website at http://www.dfm.dircon.co.uk contains sound and video clips from all the restored discs. Bear in mind that the images shown here have been restored from poor quality, distorted audio recordings, so they do not represent the quality of the original 30-line broadcasts.

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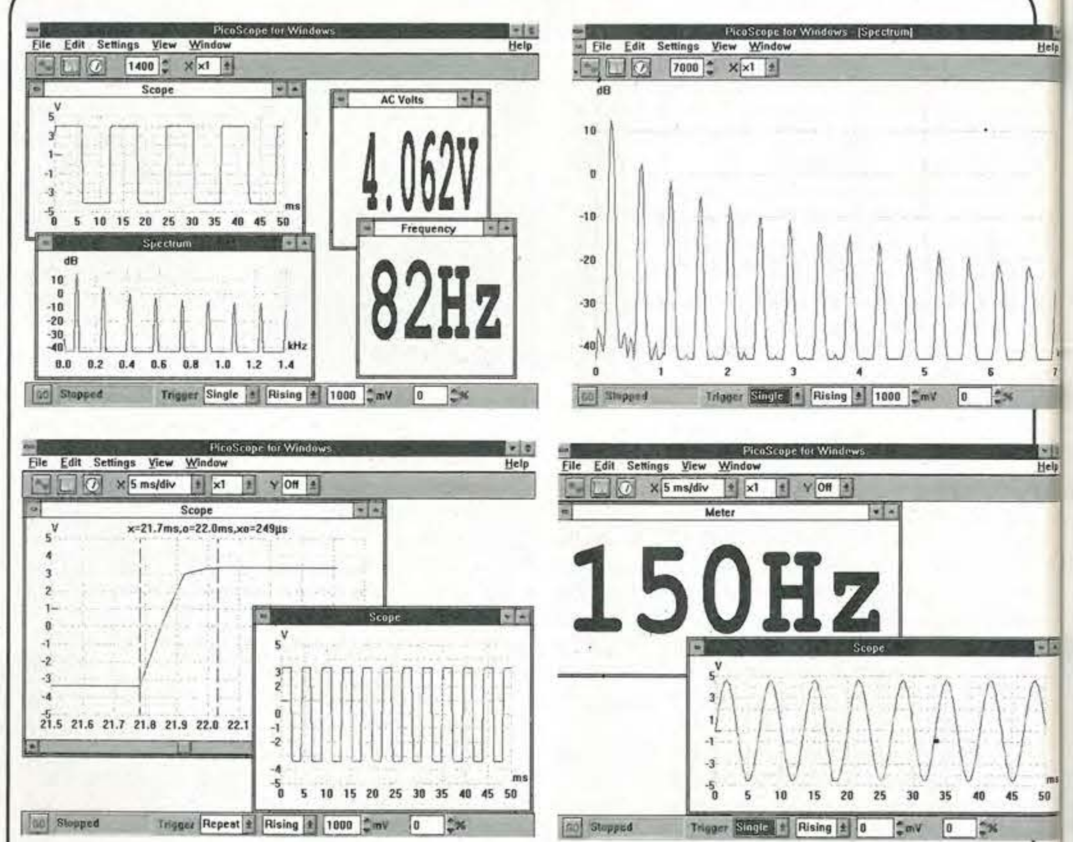

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Under/overvoltage protection

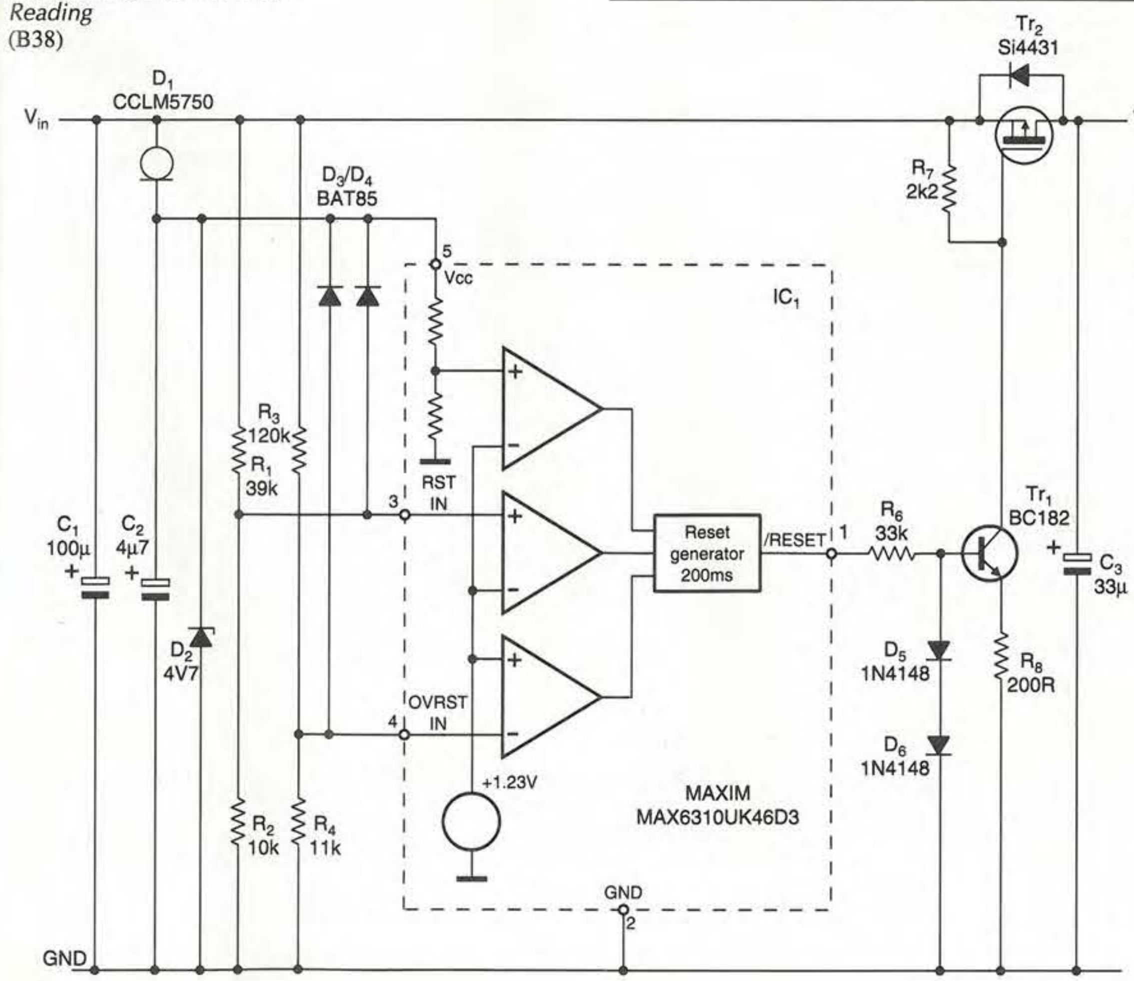
Equipment taking its power from an external supply is sometimes exposed to the risk of being connected to a higher or lower voltage than is wanted. The diagram shows a circuit that will prevent damage while drawing little current from the supply in an overvoltage state.

Maxim's *MAX6310* is a multiple-input, programmable reset ic, arranged to monitor the input for voltages less than 6V dc at pin 3 and voltages over 15V dc at pin 4, dividers $R_{1,2}$ and $R_{3,4}$ programming the ic inputs. Current-limiting diode D_1 supplies a nominal 5.75mA to the zener diode D_2 to provide a 4.7V supply to the ic, this rail also being monitored by pin 5.

When the input from the power supply is within the 6-15V window, /Reset is high, Tr_1 is on, taking 2mA, Tr_2 is on and the power supply is connected to the equipment. Inputs outside the 6-15V window turn Tr_2 off, protecting both Tr_2 from undervoltage and the equipment from overvoltage. The transistors shown will block up to 30V, but devices with higher ratings may be used. Diodes $D_{3,4}$ protect the ic pins 3 and 4 during an overvoltage condition.

An overvoltage input causes a response within 20µs, C_3 being large enough to prevent the output voltage rising very far in that time.

Terry Millward
Maxim Integrated Products
Reading
(B38)



If the power supply voltage is under or over preset limits, it is disconnected from the equipment within 20µs.

Thermometer for the –40°C to 150°C range

An *MTS 102* current-controlled temperature sensor, controlled by a transconductance amplifier, will indicate temperature to within 2°C.

Output voltage and base-emitter voltage are related by,

$$V_{out}=\frac{R_1+R_2-R_2R_zg_m}{R_1+R_2}=V_{EB}$$

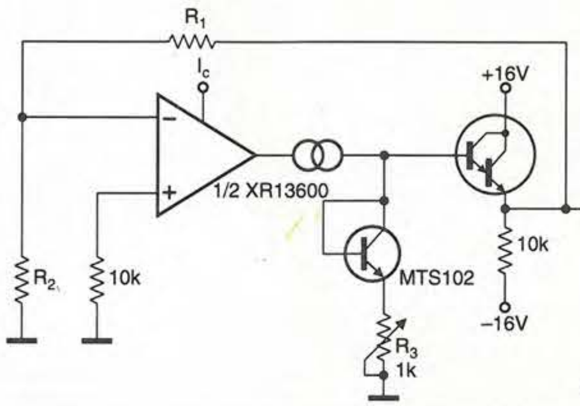
in which the transconductance $g_m \cong 19.2I_c$, I_c being the op-amp control current.

If $1-R_zg_m=0$, then $R_z \cong 1/19.2I_c$ and, since the best current for the sensor is 100µA, R_z=500Ω, making the output voltage

$$V_{out}=(1+R_2/R_1)V_{BE}.$$

For more electronic thermometer circuitry, see the application note from Burr-Brown in the April, 1993 issue, page 331.

Kamil Kraus
Rokycany
Czech Republic
B18



Wide-range thermometer using a diode-connected MTS 102 as the sensor, its current controlled by the op-amp.

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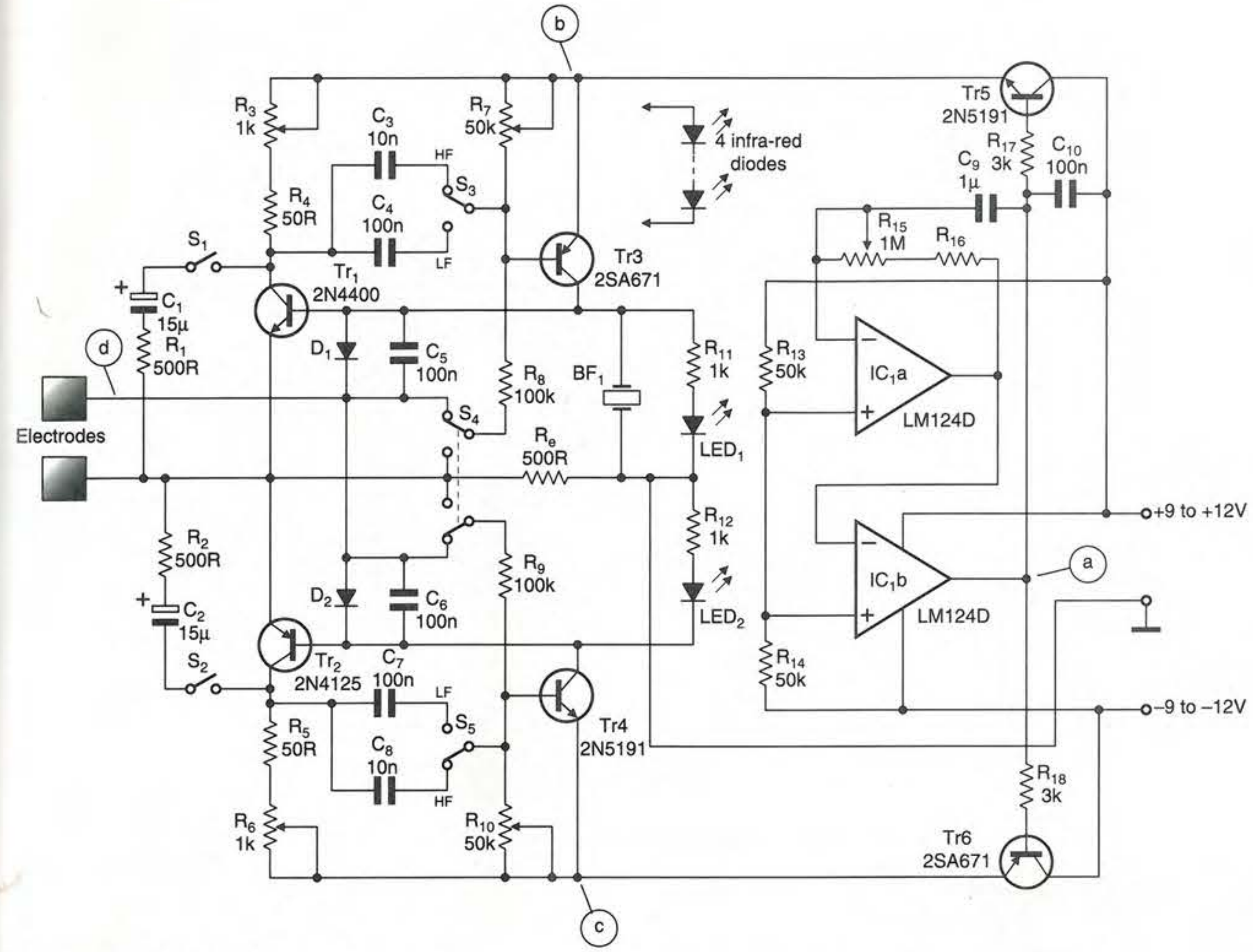


Modulated, bipolar electrostimulator

This is an improved and extended version of the stimulator published in the February 1998 issue, providing bipolar trains of pulses with variable amplitude and frequency .

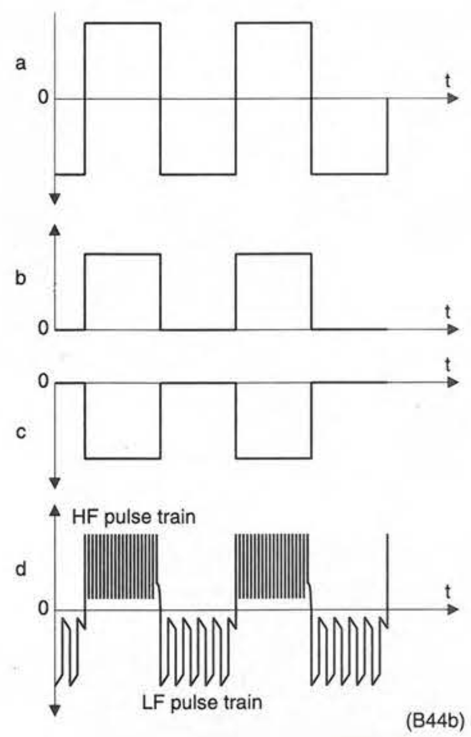
Oscillators $Tr_{1,3}$ and $Tr_{2,4}$ only operate when the active electrode at *d* touches a biologically active point on the body, effectively grounding D_1 and C_5, since these points exhibit less resistance than is shown elsewhere. The oscillators switch on in turn as the lf oscillator formed by IC_1 alternately turns on $Tr_{5,6}$, so that the output at the active electrode is alternate positive and negative pulses at frequencies determined by the settings of $R_{3,6}$ and the switching of $C_{3,4,7,8}$.

The level of resistance at the electrode required to switch on the oscillators is set by $R_{7,10}$; R_{15} determines the switching frequency of the IC_1 oscillator and S_4 switches the oscillators on continuously, if required. The common resistor R_e limits current during an accidental short on the electrodes.

To indicate operation, $D_{1,2}$ and the piezoelectric transducer BF_1 are provided. The four infrared diodes across each led afford the possibility of combined electrostimulation and infrared therapy.

Vasiliy D Borodai
Zaporozhje
Ukraine
(B44)

Improvements shown by this electrostimulator over an earlier design include bipolar pulses of variable amplitude and frequency.



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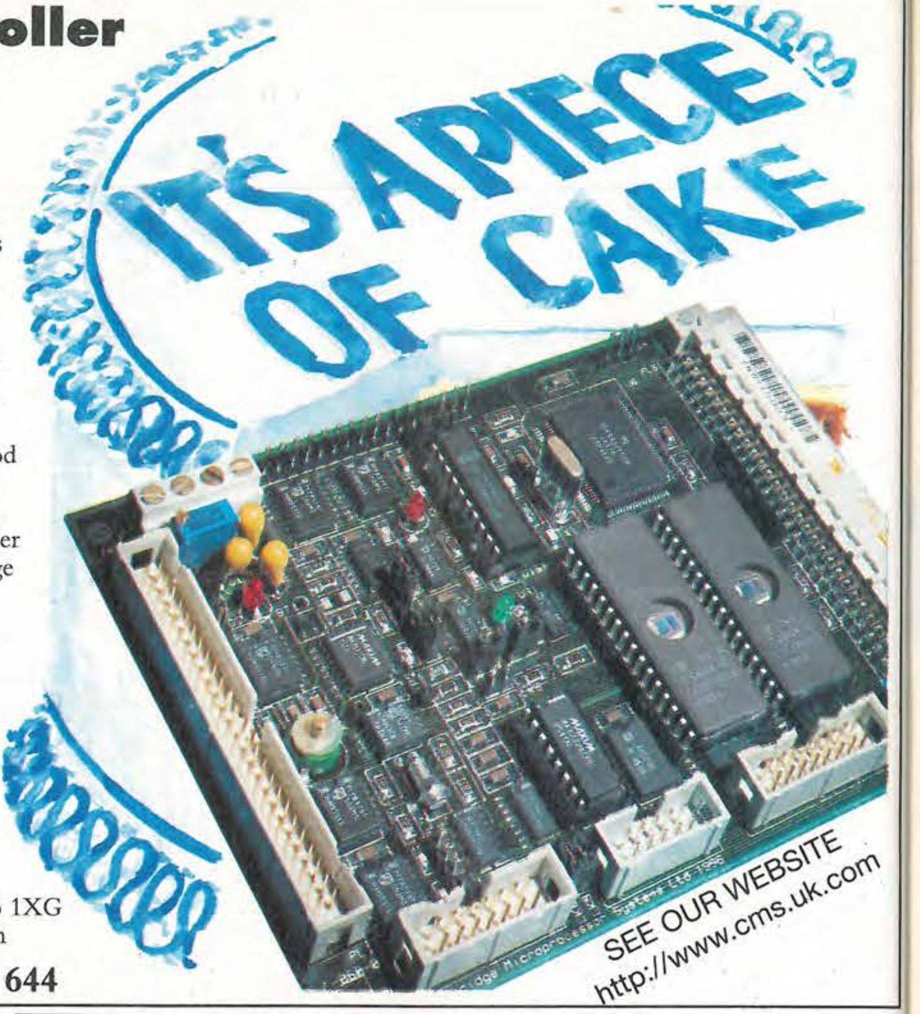

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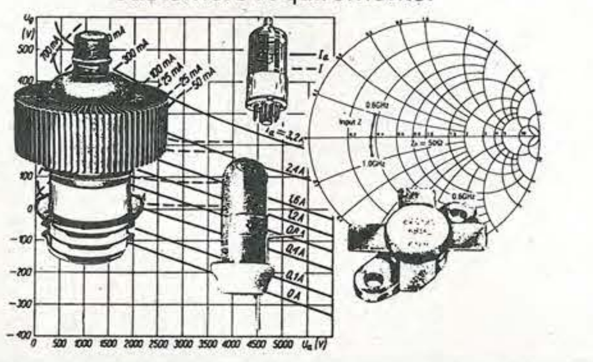

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Delay circuit for frequency and duty-cycle changing

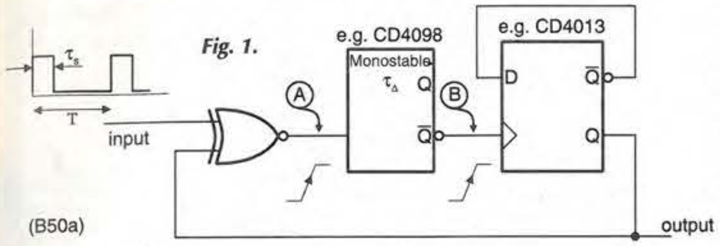
Originally designed to delay a 50% duty-cycle waveform without changing any of its timing, the circuit shown in **Fig. 1** will also change the duty cycle or the frequency of an input, depending on its pulse width.

The duty cycle of the input to the circuit is τ_s/T and τ_Δ the width of the monostable output pulse; the circuit only works if $\tau_\Delta \leq T/2$, in which case there are two possibilities.

If $\tau_\Delta \leq \tau_s$, the circuit delays the input pulse by t_Δ, as shown by the *Electronic Workbench* analysis in **Fig. 2**, still keeping the same duty cycle. For τ_Δ of $T/4$ and a 50% duty cycle, **Fig. 3** shows that the frequency at A is twice that of the input.

If, however, $\tau_\Delta \geq \tau_s$, the duty cycle changes to τ_Δ / T as in **Fig. 4**, the duty cycle of the output being independent of the input. With $\tau_\Delta = T/2$, the output would have a 50% duty cycle, as in **Fig. 5**.

E Ahmad
Damascus-Harasta
Syria
(B50)



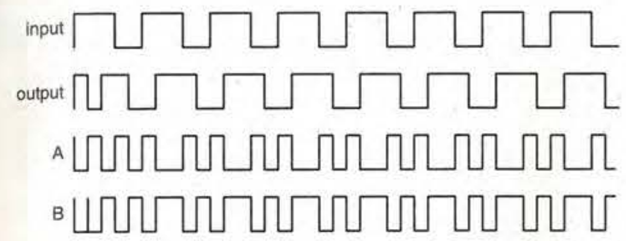


Fig. 2.

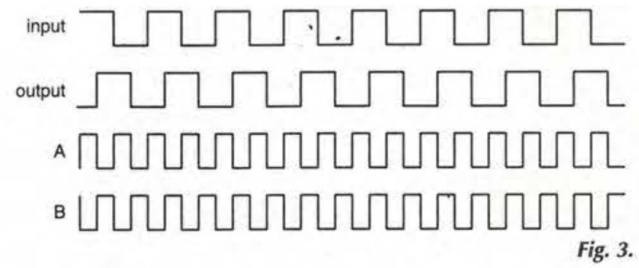


Fig. 3.

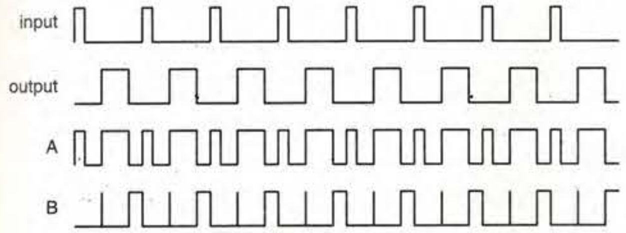


Fig. 4.

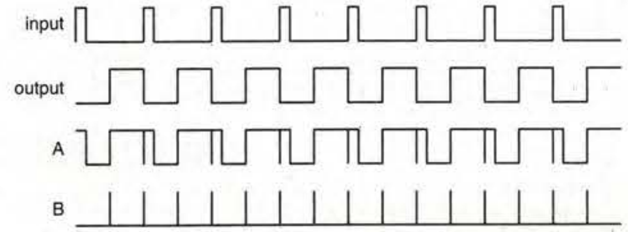


Fig. 5.

Fig. 1. Delay circuit, top left, may be used, depending on settings, to delay without change, or to change frequency or duty cycle. In Fig. 2, $\tau_\Delta \leq \tau_s$, in Fig. 3, $\tau_\Delta = T/4$, in Fig. 4, $\tau_\Delta \geq \tau_s$ and in Fig. 5, $\tau_\Delta = T/2$.

Telephone interface

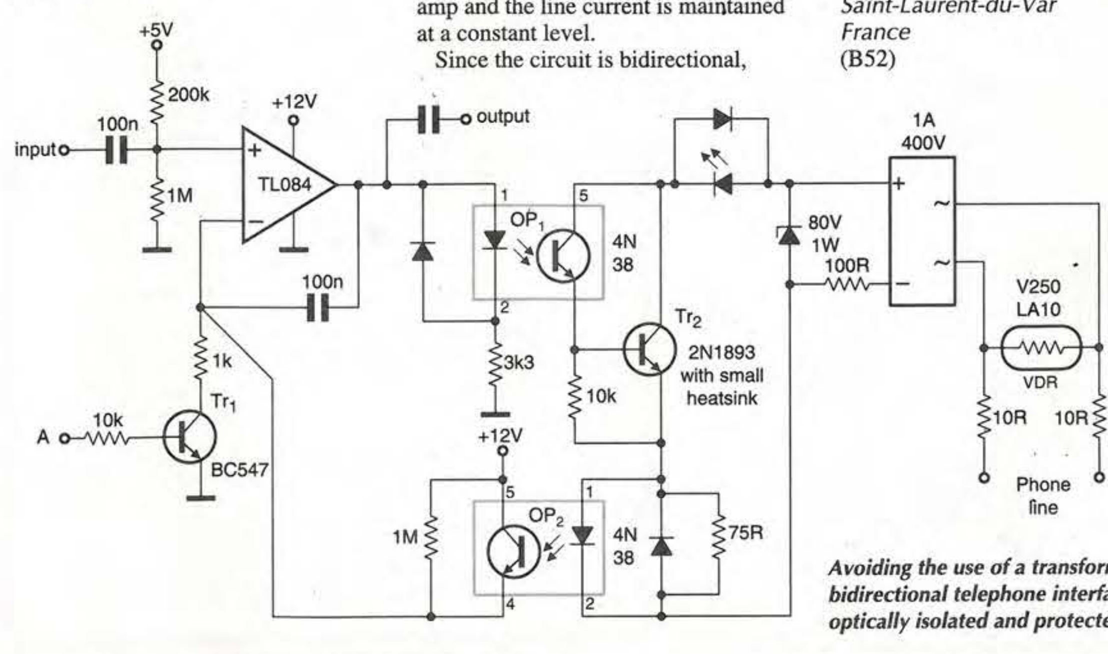
Instead of the special transformer and line-current vdr normally used in a telephone interface, this circuit performs that function using an op-amp and two optocouplers.

As input A turns Tr_1 on, the op-amp output rises and turns on the coupler OP_1. This, in turn, switches on OP_2 when line current through Tr_2 has risen sufficiently to develop the photodiode voltage across the 75Ω resistor. This closes the feedback loop around the op-amp and the line current is maintained at a constant level.

Since the circuit is bidirectional, outgoing signal is input to the op-amp and received signal picked up at its output.

For protection against interference pulses on the line, the 250V vdr and 80V zener are included.

Jean-Marc Brassart
Saint-Laurent-du-Var
France
(B52)



Avoiding the use of a transformer, this bidirectional telephone interface is optically isolated and protected.

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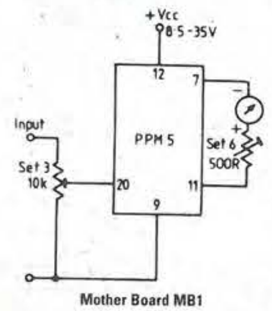

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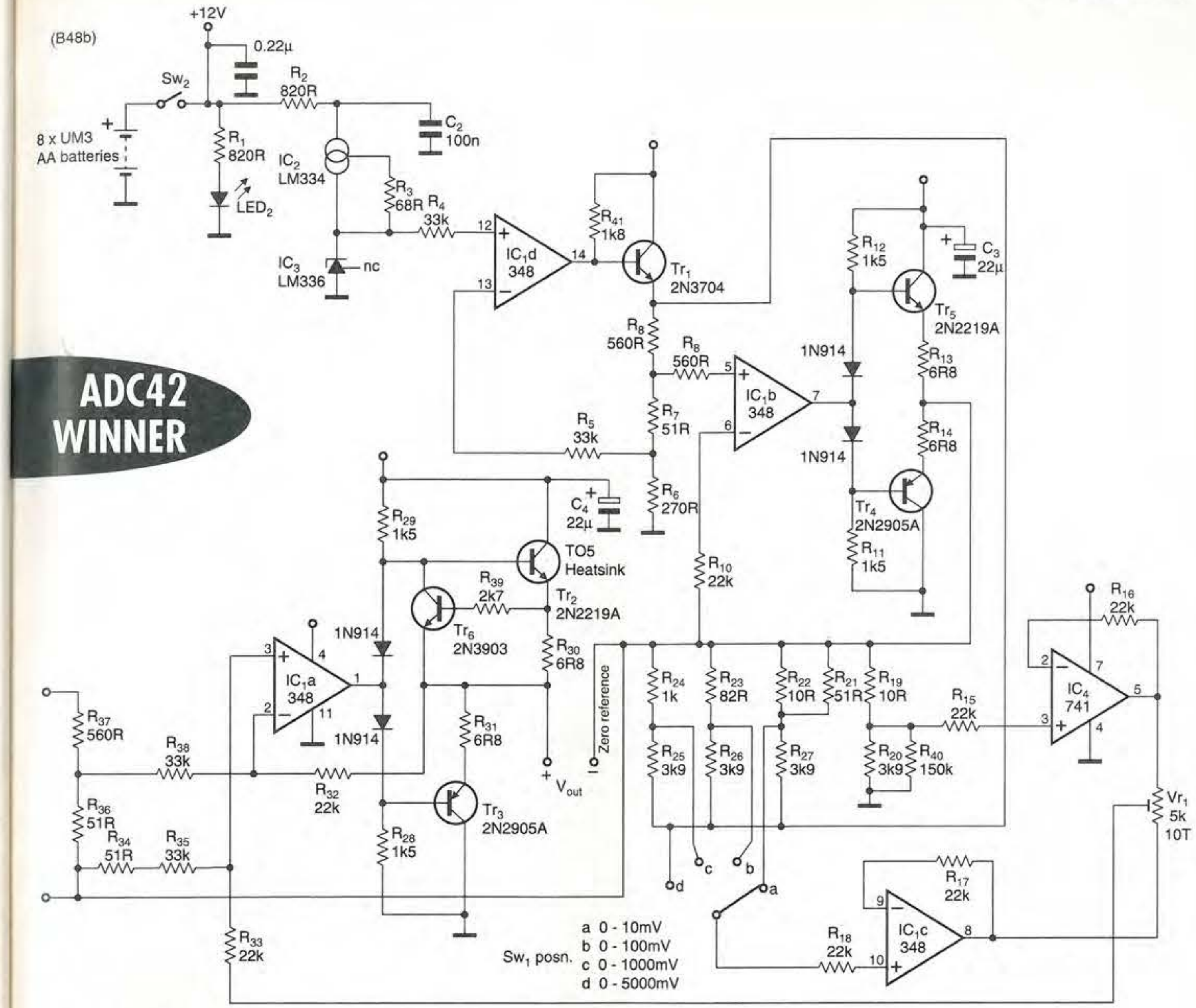

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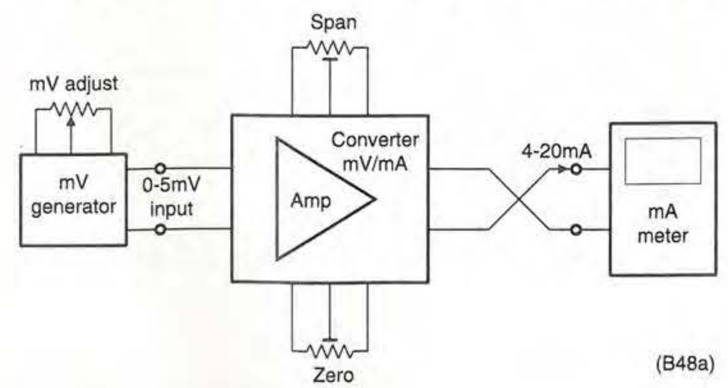
The reference voltage is buffered in IC_{1d}, the output from Tr_1 being 3V to IC_{1b}, which provides the zero reference and 8V to give the various ranges by means of potential dividers, whose outputs are then buffered in IC_{1c} after selection by Sw_1. The output of IC_4 is slightly negative of zero, being driven by a potential derived from the battery zero and the zero reference to give a negative swing to the output of about 6mV.

Potentiometer Vr_1 is a ten-turn type, the output going to the Class AB amplifier to provide the output, Tr_2 being protected by Tr_6.

Modulation input is attenuated by 22dB for my particular application, but may be varied by $R_{36,37}$, bearing in mind that R_{36} must equal R_{34}. I recommend the use of 1% resistors throughout.

D Heywood
Buckley
Flintshire
(B48)



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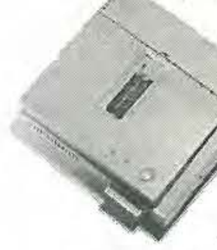

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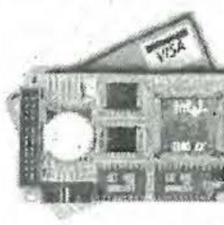

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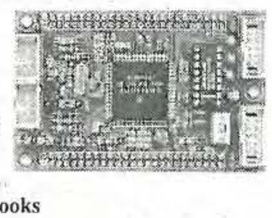

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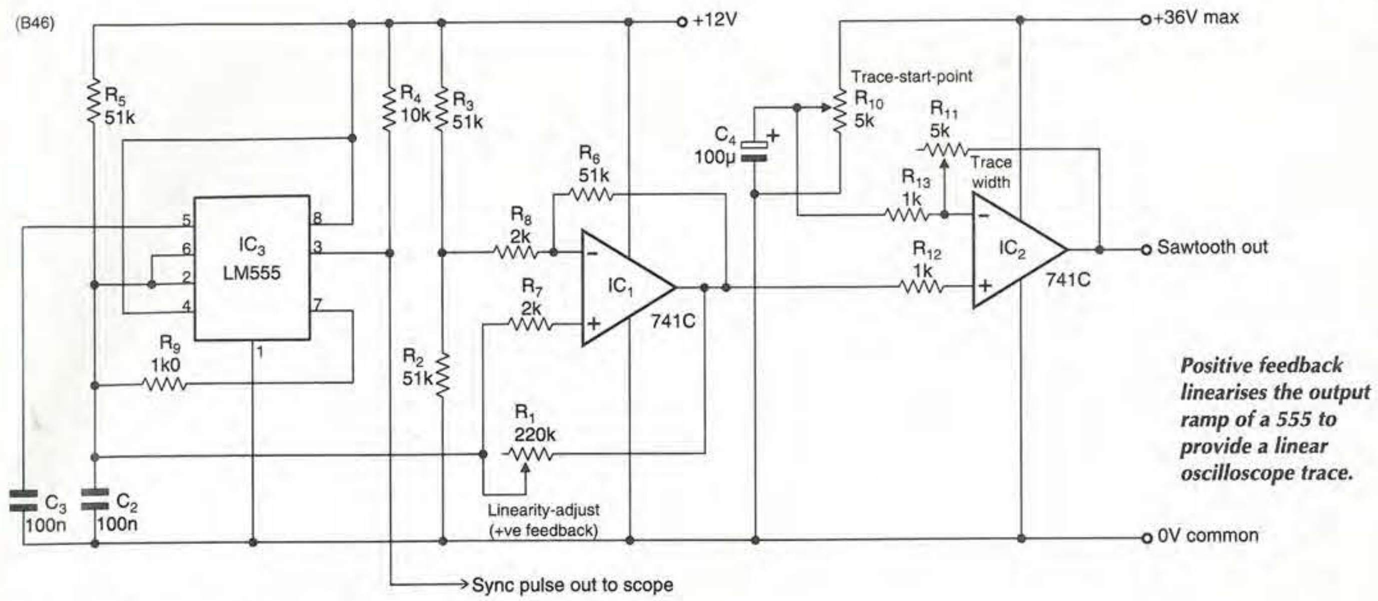


Positive feedback linearises the output ramp of a 555 to provide a linear oscilloscope trace.

LM555 sawtooth generator

Needing a rapid and cheap method of generating a sawtooth for a panoramic receiver, I tried shaping the output of a *555*, which produces the exponential waveform, but was unsuccessful and tried a *741* to provide gain and some isolation but, even with negative feedback, the output was still non-linear. Positive feedback around the first 741 in the diagram, however, provided a linear ramp.

Adjustments on the second 741 are for the start point and trace width, the original 555 output pin giving a pulse to trigger an oscilloscope.

Brian Olliver
St Georges
Telford
(B46)

Voltage converter disconnects load until output regulated

Battery-powered, this boost converter supplies up to 500mA at a regulated 5V and, after start-up or brown-out, disconnects the load until its output is again regulated.

Pin 2 of the converter, IC_1, conveys both power and feedback to the device – it derives power from its own output. It will start on inputs as low as 1.8V, except in the presence of heavy loads, when gate drive to the switching mosfet is at battery voltage and start-up may not happen. To avoid this state of affairs, output and load are only connected after V_{out} has risen enough to turn the mosfet on fully.

N-channel mosfets in IC_2 act as switching transistor (left) and high-side load switch. Gate drive for the load switch comes from a charge pump consisting of C_4 and the dual diode D_2, which is driven by the switching node on the drain of the switching transistor.

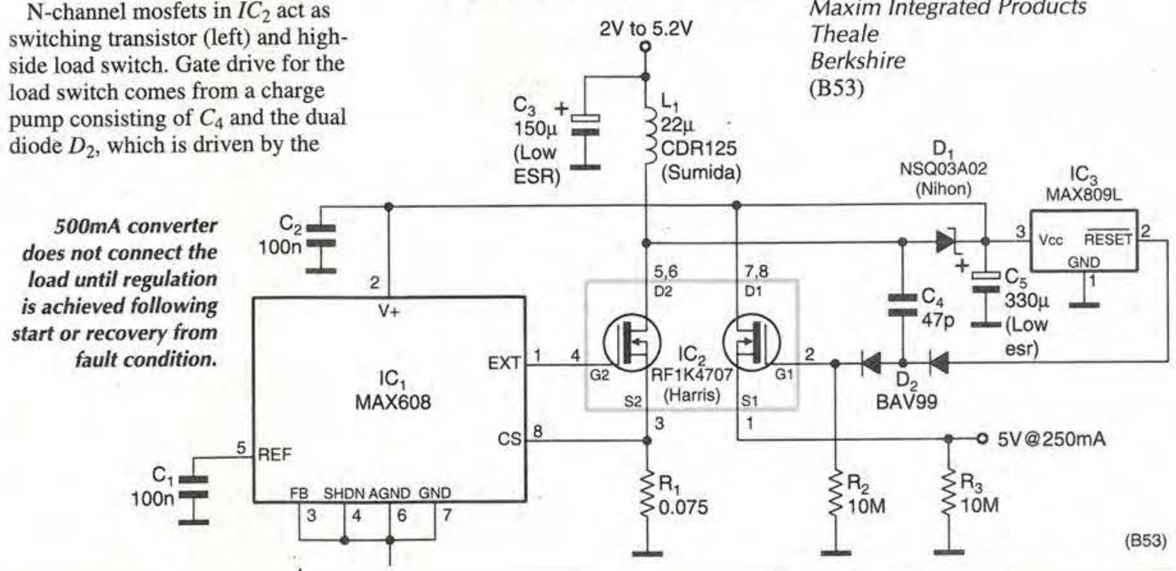
At start-up, the microprocessor reset ic IC_3 puts out a low voltage on its pin 3 to prevent C_4 charging. When its V_{cc} pin rises above 4.65V, the reset pin goes high and allows C_4 to charge through the right-hand diode in response to the switching node going low. When the node again goes high, the existing charge on C_4 adds to the output voltage to produce 9.5V, this level being maintained by the gate-source capacitance. The high-side load switch now turns on and connects the load.

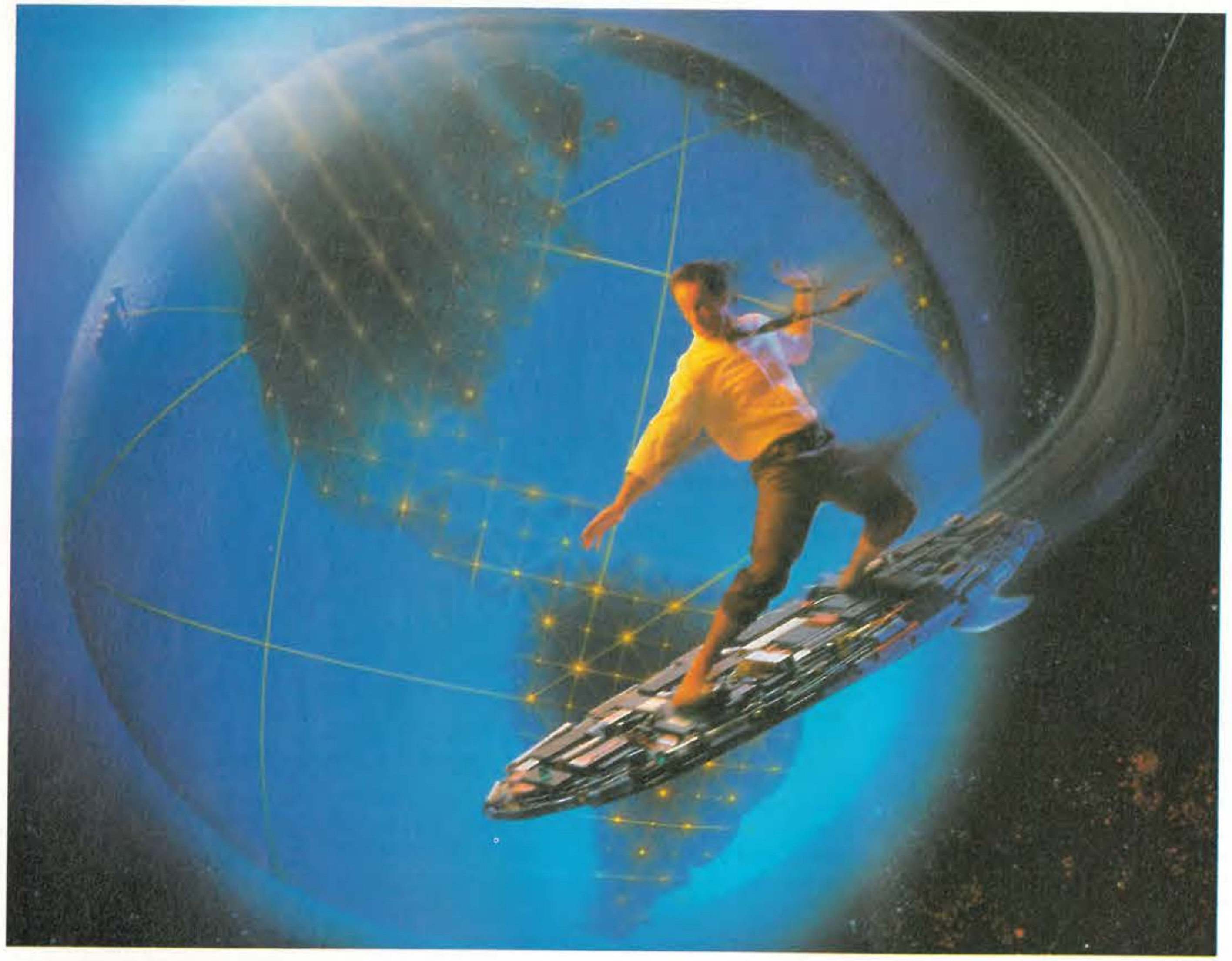
Pulse-frequency modulation is used in this converter, which means that a minimum of 5µA of load is needed to ensure occasional operation of converter and charge pump. Normally, reverse leakage in the schottky diode D_1 will provide the 5µA but, if a low-leakage diode is used or you simply want to make sure of the minimum load, reduce R_3 to 1MΩ.

Efficiency is more than 80% at 250mA from 2.0V or 500mA from 2.7V. If power-up delay is too long, replace the *MAX809L* with a *MAX821*, which allows the selection of delays from 1ms, 40ms or 200ms.

Tim Herklots
Maxim Integrated Products
Theale
Berkshire
(B53)

500mA converter does not connect the load until regulation is achieved following start or recovery from fault condition.





INTERNET INROADS

Dial-up phone lines may meet the needs of casual web surfers but their inadequacies are forcing more demanding users along other, less congested routes. Andrew Emmerson surveys the competing technologies for accessing the Net.

Stuck with snarl-ups on the information superhighway? Fed up with the WorldWide Wait? Then perhaps it's time to unhook your analogue modem from the phone line and try a different approach.

There's no shortage of alternative routes, although users hoping for more connectivity in return for less money may be disappointed.

You may nonetheless welcome this traveller's guide to dozen or so technologies vaunted as access routes to the Internet, setting out the various mechanisms along with their pros, cons and some assessment of their commercial prospects.

The survey takes an international outlook and is concerned more with technologies than with individual service providers, so detailed tariff comparisons and implementation schedules are not on the menu.

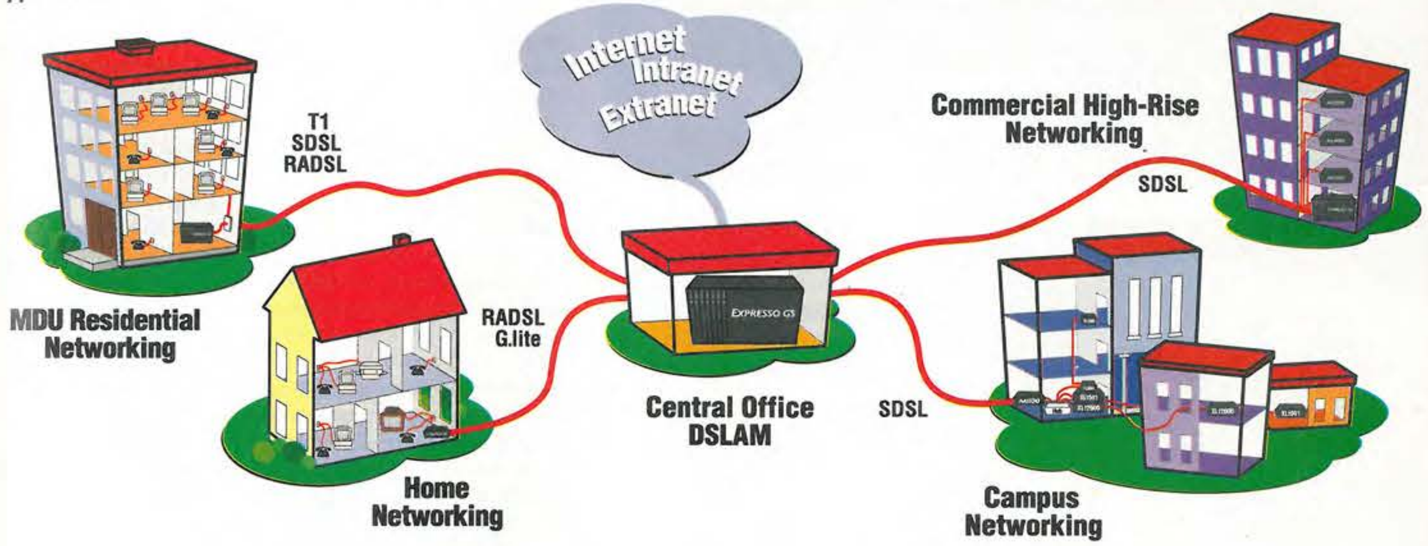
PSTN dial-up

The most widespread and longest established access means is inevitably simple dial-up, using a standard analogue telephone line and modem. Cheap and cheerful, the system is also pretty robust, allowing users to achieve data rates of 40kbit/s or more with the latest generation of modems.

Techniques also exist to double these rates by using two

Fig. 1. First ever integrated digital voice and data communications device was the Communicator 9000 from Nokia, a combined electronic organiser and telephone.

Fig. 2. Much better use of a telephone cable's bandwidth capability can be made by using xDSL digital transfer. There's a variety of DSL, or digital subscriber line, techniques, each with its own forte. The term xDSL covers them all. This diagram comes from Tut Systems – a company which claims to be unique in delivering plug-and-play Internet access solutions for domestic and commercial applications.



telephone lines simultaneously. With current technology it appears unlikely that this method is capable of further improvement – but that's what people said after 28kbit/s modems were introduced.

Many of the shortcomings of dial-up access in fact have their origin elsewhere, such as the frustrating negotiation and verification processes that make establishing a link to your ISP take up to 30 seconds. Frequently, moreover, the real hold-ups are further back up the chain deep within the Internet, meaning that the telephone connection is not to blame for slow downloads.

Analogue dial-up, although inefficient and old-fashioned, still has a lot going for it and will not die out overnight. It is simple and could well become even cheaper in real terms, as competition grows among telephone companies and service providers. For low-volume users it will remain the most cost-effective solution for some time to come.

ISDN

A key weakness of analogue Internet access is the reliance on analogue connections for what is a link between two digital devices – namely the subscriber's pc and the host computer. The inherent analogue-to-digital and digital-to-analogue conversion processes are inefficient.

All this is eliminated in the Integrated Services Digital Network, or ISDN, which provides users with guaranteed 64kbit/s digital circuits. The entry-level offering (ISDN2 or Basic Rate) provides two 64kbit/s channels, which can be aggregated if desired to create a 128kbit/s data path. Heavier users can order Primary Rate ISDN, which delivers thirty 64kbit/s channels.

As well as the guaranteed 64kbit/s connectivity, ISDN also has minimal call set-up time, providing virtually instant connection. If pc users are in future to treat the Internet as an extension of their hard disk, as Microsoft would like us to do, rapid connections – and telephone charges which do not penalise frequent short calls – are essential.

Mass-markets for ISDN exist in some countries, although the need to recoup the cost of providing it has resulted in fairly substantial charges. While large organisations have no difficulty in cost-justifying these charges, the cost of entry has effectively barred the wider army of hobbyists, home-based workers and small businesses from exploiting the undoubted benefits of ISDN.

Up to now the cost of retrofitting ISDN capability to most telephone exchanges has been substantial and where regulatory regimes forbid cross-subsidisation – such as in Britain – none of the operators have found it possible to offer ISDN economically to low-volume users.

This is set to change with developments by Ericsson and GPT, however, that offer the key to providing affordable ISDN service. The solution consists of an enhancement for telephone exchanges along with an easy-to-install adapter box installed on subscribers' premises.

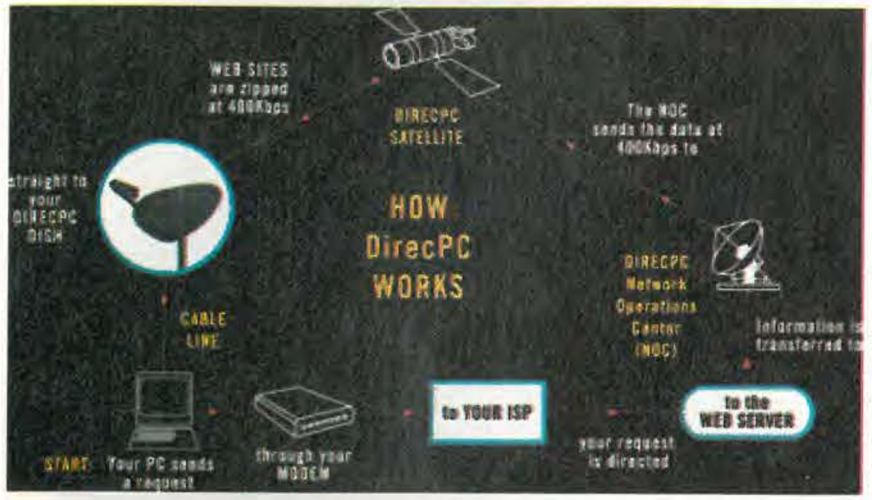
Upgraded subscriber installations can provide, over a single pair of wires, two ISDN or two analogue connections or

a combination of one analogue and one digital.

The concept is being trialled in Britain by BT under the name Home Highway and similar offerings can be expected in due course from other manufacturers and network operators.

Mobile radio

Most facilities that are practical on wired circuits can be provided over the airwaves as well. Internet access over digital cellular radio is a straightforward application.



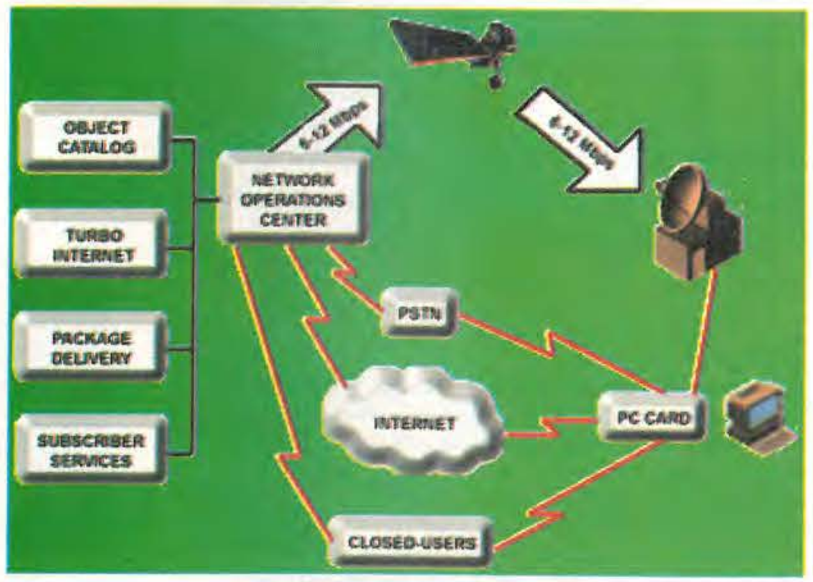


Fig. 3 With DirecPC, since Internet data is transmitted via satellite, downloading speed has a theoretical rate of 400kbit/s. Uploading still relies on a 14.4kbit/s modem connected to your telephone.

The limiting factors are the practical data rates in a mobile situation and also the usability of the mobile data terminal. The standard data speed over GSM digital cellular radio is 9.6kbit/s, although users can improve on this if data compression is used.

The latest units from Motorola incorporate the company's *Digital Data Fast* data compression technology. With this speeds of up to 36kbit/s are promised with data that is amenable to compression.

On the next generation of cellular radio – called UMTS, which stands for Universal Mobile Telecommunications System, data rates of up to 2Mbit/s will be achievable, opening up the prospect of full multimedia computing on the move.

UMTS is due for introduction in the year 2002. By that time sophisticated terminals will be available; current offerings display some constraints. The first ever integrated digital voice and data communications device was the *Communicator 9000* from Nokia, a combined electronic organiser and telephone, **Fig. 1**. Improved versions of this have been joined by a separate cellphone-cum-PDA (personal digital assistant) package from Ericsson. Both of these have small displays and keyboards, adequate for e-mail but unsuitable for general web surfing.

A larger but less restricting alternative is the range of plug-in radio cards for normal laptop computers; Ericsson, Motorola and Nokia make these adapters.

Currently mobile Internet access is a slow, expensive and not always convenient exercise. The arrival of UMTS will not only shorten the time needed for connection. The greater integration of fixed and mobile telephony that will accompany it will probably mean that rates will fall as well.

xDSL

It has long been known that copper cables are capable of supporting a far broader frequency spectrum than the 4kHz that a single telephone conversation occupies.

In recent times considerable thought has been given to 'partitioning' this bandwidth to make better use of it. In this way the normal telephone wires connecting subscribers to the exchange could be made to support some entirely separate broadband signal without disturbing normal phone conversations; the broadband signals might be video-on-demand, cable television programmes or they might equally be used for Internet access.

This partitioning is best done digitally, using one of a variety of digital subscriber line (DSL) techniques. There are a number of these – Asymmetric DSL (ADSL), High data rate DSL (HDSL) and Single-line DSL (SDSL) – and each offers particular advantages. Generically they are all classed together as xDSL, the small x substituting the particular initial concerned, **Fig. 2**.

All these techniques use sophisticated modulation schemes to pack as much data as possible onto copper wires. Compared with ISDN, xDSL offers far higher speeds – from 2Mbit/s up to 32Mbit/s for downstream traffic and from 32kbit/s to over 1Mbit/s for upstream traffic.

Commercial applications for this bandwidth have yet to appear. Although they will enable telephone companies to extract valuable new revenue streams from the line plant already buried in the ground, substantial new investment and time will be needed to roll out the new services delivered by xDSL.

High-speed Internet connection is only one of a raft of customer offerings to be harnessed to xDSL technology. Other services proposed include video-on-demand, pay-per-view programmes, home banking and home shopping, all without disruption to speech calls.

Satellite

The high data rates of xDSL belong in the future. For some early adopters and 'power users', this delay is costing them money.

An ingenious solution being exploited here and now by Hughes Olivetti Telecom (HOT) retains the dial-up telephone connection for upstream data requests but delivers data to customers at a far higher rate by satellite link. At the same time it 'spoofs' the Internet service provider into thinking nothing abnormal is going on.

DirecPC is the marketing name given to this service, which the proprietors term Turbo-Internet Satellite Access, **Fig. 3**. Data is delivered at 400kbit/s – more than three times faster than ISDN and fourteen times faster than 28.8kbit/s modems. Signals are received on a straightforward 21-inch diameter elliptical dish, which is connected by coaxial cable to a card installed inside the user's pc.

Launched in September 1996, the service is currently marketed in Europe, north Asia, the USA, Canada and Mexico. It is available from retailers selling direct over the Internet and from local dealers.

Internet access is asymmetrical, the outgoing channel or upstream channel operating at 14.4kbit/s and the incoming or downstream channel at 400kbit/s. This last figure is the optimal value, since bandwidth is not dedicated to any single user but shared by all. In addition, several services – including video and other subscription services – are multiplexed onto a single 6-12Mbit/s satellite carrier.

Data is DES-encrypted and Windows based software supplied with the package manages the data stream at the pc or local-area network server. Users still require a Hayes-compatible modem and a telephone line for sending upstream data; it is only downstream data that is delivered via satellite.

It is a matter of conjecture whether customer take-up has met the company's original expectations but what it indisputable is that recent actions to limit the amount of data downloaded by individuals have upset many users. In fact a Usenet newsgroup on the Internet (alt.satellite.direcpc) is swamped with rants from embittered users; some have already abandoned the system while other claim they will ditch the system as soon as cable modems or affordable ISDN are available.

A few are even threatening to file a class action suit against the company, claiming that they never achieve the purported 400kbit/s download speed, which is entirely possible since the company claims that other customers are abusing the service by, "using it for purposes it was not designed for".

In any case, *DirecPC*'s monopoly may not last long, since two rival operations have been announced, Internet Satellite Systems and CyberStar, both claiming to offer broadly similar service to the continental United States. Time will tell if these proposals bear fruit.

The Internet in the Sky

Another, radically different satellite-and-Internet combination is Teledesic. This is a partnership of Motorola, Boeing and Matra Marconi that intends to create the world's first advanced telecommunications network to provide high-speed data connections to businesses, institutions and individuals everywhere on Earth – regardless of location, **Fig. 4**.

Teledesic and its service provider partners will create the world's first network to provide affordable, world-wide high-bandwidth access to telecommunications services, such as linking enterprise computing networks, broadband Internet access, videoconferencing and other digital data needs.

Service is expected to begin in 2003 and will provide two-way, broadband network connections through service partners in countries world-wide. Federal Communications Commission licensing to build, launch and operate the network has been received and all significant regulatory hurdles overcome.

The Teledesic network is described as a high-capacity broadband network that combines the global coverage and low latency of a low-Earth-orbit (LEO) constellation of satellites, the flexibility and robustness of the Internet, and "fibre-like" quality of service.

Essentially an "Internet-in-the-Sky" operating in Ka band, the Teledesic network aims to bring affordable access to interactive broadband communication to all areas of the Earth, including those areas that could not be served economically by any other means.

User terminals will communicate directly with the satellite network and with a wide range of data rates being supported. The terminals can also interface with a wide range of standard network protocols, including IP, ISDN, ATM and others. Although optimised for service to fixed-site terminals, the Teledesic network can serve transportable and mobile terminals, such as those for maritime and aviation applications.

Most users will have two-way connections that provide up to 64Mbit/s on the downlink and up to 2Mbit/s on the uplink. Broadband terminals will offer 64Mbit/s of two-way capacity, which represents access speeds up to 2000 times faster than conventional 28.8kbit/s analogue modems.

Mains-borne

So far all the communication bearers described for Internet access are ones already being exploited for mainstream telecommunications. The power line or mains-borne connection breaks that mould by using electricity mains as the conductor for widespread, third-party communications.

Of course it must be said that the notion of exploiting the electricity mains for data signalling is not a new one. But hitherto its main application has been confined to triggering devices for switching street lamps on and off.

The arguments in favour of the idea are obvious; the infrastructure exists already and reaches all premises likely to require Internet connection. The various power supply networks are interconnected and cover the country on a national basis.

Against the idea are (possibly minor) safety considerations, a possibility of unwanted radiation from poorly screened cables and potential interference from arc blasts, spikes, surges and other transients.

Commercial exploitation of the technique is a British first and began in March of this year as a joint venture between telecomms manufacturer Nortel (Northern Telecom) and electric power generator United Utilities plc. The outcome is a company called NOR.WEB DPL, which will market the digital power line technology world-wide.

The actual communications platform can be configured to provide varying bandwidth services according to customers' needs. It is possible to condition an electricity distribution network such that it can carry, simultaneously, two or more electrical signals extending from ultra low frequencies around 50/60Hz up to ultra high frequencies (e.g. 500/600MHz) without any mutual impairment.

For home-based domestic customers, the electricity distribution cables form the basic access network offering digital telecommunications data rates in multiples of 32kbit/s. The characteristics of a typical network are said to be extremely stable and tolerant to noise. Between 6 and 10MHz of usable spectrum can be offered to customers remote from the sub-station and over 20MHz to those located nearer.

A technical trial in Manchester has focused on simple telephony service (POTS) but it can also deliver Internet and computer access.

Considerable attention is now focussed on the results of practical installations and the joint venture company's com-

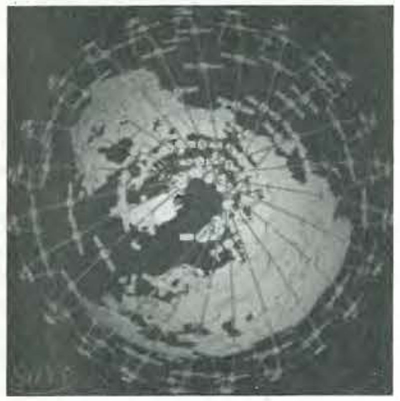
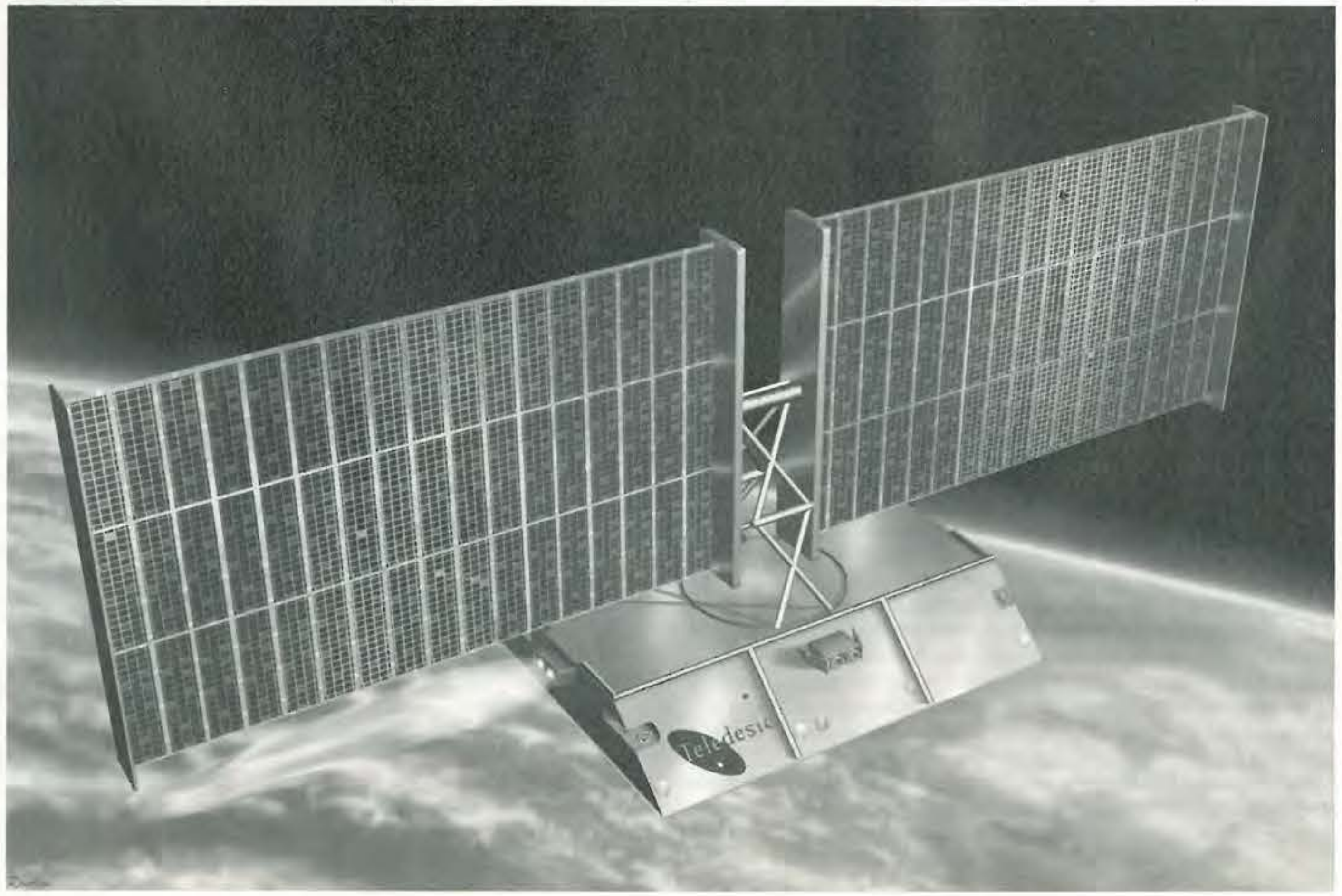


Fig. 4. Expected to begin in 2003, Teledesic will be the world's first network to provide affordable, world-wide high-bandwidth access to telecommunications services. It will comprise 288 satellites divided into 12 planes, each with 24 satellites.



mercial progress. Early press reports of unacceptable levels of radio frequency radiation in Manchester from street lamps using the same power supply as triallists were promptly refuted by the company and by the Radiocommunications Agency. Nevertheless, careful watch must be maintained over of this aspect.

According to the company, Digital PowerLine operates at very low power and at particular frequencies. It is specifically designed to avoid sensitive areas of the frequency spectrum.

Cable modems

On the face of it, the cable modem concept offers an attractive prospect of always-available high-speed Internet service to those connected to cable television networks who subscribe also to the cable modem service. Speeds of up to 20Mbit/s are promised in return for a flat monthly charge around double that of most dial-up Internet service providers.

The cost to operators of the additional head-end equipment is substantial but it should not be too difficult to recoup if large numbers sign up for the service. Because the bandwidth is shared between what may be a large number of customers, the true data transfer rate they see may be significantly less than the 20Mbit/s maximum.

The pros of cable modem Internet service delivery are speed and economy, although 'serious' users may find these offset by some cons. For a start, not everybody's pc is located conveniently next to a cable tv outlet, meaning that additional wiring (and delay) will be involved. More serious is a significant security problem; a report on the Internet (www.L0phT.com/~sciri/cable) claims there are serious security loopholes associated with cable modems.

The technology proposed by ComTel is typical of the genre; it uses two-way rf cable modems to provide unfiltered, un-firewalled Internet access. The 20Mbit/s data rate claimed is the theoretical maximum; user reports on the Internet describe typical rates of 300-600kbits/s.

Another description of cable modem speaks of data speeds of 27 or 36Mbit/s from supplier to home, with between 320Kbit/s and 10Mbit/s in the other direction, noting that the channel may be shared with up to 600 users, with consequential slow service. Most providers restrict use to residential customers and the use of in-house servers and programs that pay 'binge' visits to websites for subsequent reading off-line are taboo.

The widest deployment of cable modems is in the USA; the rest of the world lags behind by comparison. Although Telewest plc started trials in Britain as long ago as October 1996, little of substance has been heard of cable modems since then.

Instead we are treated to vacuous statements. ComTel for instance asserts that its forthcoming *@Home Network* service will attract new users because "the content offers a richer, more exciting Internet experience." This statement successfully combines both marketing drivel and a classic *non sequitur*.

Some observers now declare cable modems to have missed their window of opportunity; it remains to be seen if they have a role to play in mass-market Internet access.

Television

For causal users who would welcome occasional access to the Internet at low cost, without tying up the telephone line and without needing to own a computer, delivery over television channels could be an attractive option. Implicit in this solution is an adapter box equipped with a keyboard or an adapted television receiver.

In contrast to delivering video over the Internet, television can also deliver Internet material in a number of ways. Internet protocol (IP) data can be transmitted during the vertical blanking interval on analogue television or else included in the data stream of digital television; several broadcasters are looking at this approach.

With cable television the prospect looks even brighter; an elaborate Internet offering can be carried on a single rf carrier frequency as a normal cable tv channel, with any level of message security and encryption desired.

Data rates are an aggregated 10Mbit/s in the downlink direction with a 6.4kbit/s return path for users' keystrokes.

Some hardware manufacturers see plenty of mileage in this approach, one being Britain's largest telecomms manufacturer, GPT Ltd. This company's ICTV (interactive cable television) package offers a low-cost method of using existing home tv sets for surfing the Internet, sending and receiving e-mail, playing interactive games and indulging in a bit of teleshopping.

For undemanding users this approach has merit, although small text will be hard to read on the average coarse-pitch television screen. While ICTV and its ilk may well win devotees, it is more likely to be for teleshopping and playing games rather than serious web surfing.

Websites to visit

Cable modems	www.cablemodem.com
Digital Powerline (Nor.Web)	www.nortel.com/powerline/
DirecPC	www.direcpc.com
Unofficial DirecPC page	www.wojo.com/direcpc/news.html
Teledesic	www.teledesic.com
xDSL technologies and links	www.xdsl.com
WWW Encyclopedia	www.webopedia.com
P&P Internet xDSL	www.tutsys.com

Way to go

None of the schemes described represents absolute perfection and an objective observer might care to synthesise the best elements from each scheme. That observer would also recognise the futility of routeing Internet traffic through telephone switches optimised for short holding times, not for lengthy data downloads.

Unnecessary investment would be minimised by exploiting existing telephone lines linking homes and offices to exchanges, where Internet calls would be filtered off 'outside' the exchange and diverted to new, separate Internet servers. In certain circles this is known as the 'datadial' concept and although many details remain to be resolved, it would relieve the growing data burden borne by the telephone network.

Meanwhile technologies come and go. This is inevitable. In five years from now some of the technologies described here will surely have been abandoned. Doubts are already being expressed over the technical feasibility of some of these schemes, while others will turn out too expensive or miss their window of opportunity.

This is compounded by the perversity of the Internet connection market. Statistics compiled by Durlacher Research Ltd indicate that while 91 per cent of UK residential respondents are aware of the Internet, of the homes with Internet-capable pcs as many as 35 per cent are not in fact accessing the Internet. This might indicate that although there is a large potential market for Internet service, many potential users see phone-line access as too expensive and too slow.

At the same time, over-promotion of forthcoming digital access methods has created unrealistic expectations along with a vociferous minority of users who demand advanced facilities but are not prepared to pay the going rate for same. For marketeers intent on making profits this is a depressing prospect! ■

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Powerline	Power Supply Type: LAB510 0-30V 0-10A	£175.00
Powerline	Power Supply Type: LAB532 5V-5A, +15V-0.5A, -15V-0.5A, 0-30V-2A	£200.00
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3M Fibre Splice Preperation Kit
Cossor Optical Cable Fault Locator Type: OFL108L
Laser Precision Type: DB2900 Single Mode Variable Attenuator
Schlumberger Type: S17780 OTDR + S177822 + S177823 Plug-Ins
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Types: BX300E, ZX9, 680ZX

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Hitachi	V222 20MHz	£225.00
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HP54200A	50MHz Digital	£750.00
HP54501A	100MHz Digital	£1,600.00
Iso-Tech	ISR640 40MHz	£300.00
Iso-Tech	ISR640 40MHz	£225.00
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Iwatsu SAS8130	Waveform Analyser DC-3.5GHz	£1,500.00
Leader	LBO-522 20MHz	£200.00
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Philips	PM3352A 50MHz Digital Storage	£1,200.00
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HP33305A	Programmable Attenuator 18GHz 0-110dB	£175.00
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HP8410B		£200.00
HP8414A		£175.00
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HP8743B	Reflection-Transmission Test Set Unit 2-12.4GHz	£600.00
HP8745A	S-Parameter Test Set 0.1-2GHz	£560.00
Marconi 6019/2	Calibrated Variable Attenuator 12.4-18GHz	£200.00
Marconi 6030/10	Directional Coupler X Band	£200.00
Marconi 6052/3	Rotary Vane Attenuator 8.12-12.4GHz	£120.00
Marconi 6960+6910	Power Meter 10MHz-20GHz	£900.00
Maury Microwave	Sliding Termination 8035H up to 20GHz	£600.00
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Farnell PSG1000	10KHz-1GHz	£1,200.00
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Tek 504	0.001-240MHz	£350.00
Tek 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

HP3708A
Noise & Interferance Test Set
£11,500.00

SIGNAL ANALYZERS

AD 352	FFT Analyzer	£300.00
Advantest	TR4132 Spectrum Analyzer 1-1GHz	£1,800.00
B&K 2033	Signal Analyzer	£2,000.00
HP182T+HP8557A	Spectrum Analyzer .01-350MHz	£800.00
HP182T+HP8558B	Spectrum Analyzer 100KHz-1.5GHz	£1,350.00
HP334A	Distortion Analyzer	£250.00
HP339A	Distortion Measuring Set	£1,200.00
HP3581C	Selective Volt Meter	£600.00
HP3582A	0.02Hz-25.999KHz Spectrum Analyzer	£1,500.00
HP8903B	Audio Analyzer	£3,200.00
Marconi 2305	Modulation Meter	£2,000.00
Marconi 2382+2380	400MHz Spectrum Analyzer	£3,500.00
Marconi 2601	True RMS Voltmeter	£500.00
Marconi 2955	Test Set+2960 TACS Unit	£2,400.00
Marconi TF2370	110MHz Spectrum Analyzer	£600.00
R&S	SMDU Z1	£400.00
R&S	Ure RMS Voltmeter	£800.00
R&S	ZPV + E3 P.I. Vector Analyzer 0.3-2GHz	£2,000.00
R&S CMS52	Comms. Service Monitor	£6,500.00
Racal 9302	RF Millivolt Meter	£350.00
Racal Dana	9702 Spectrum Analyzer 1-1GHz	£1,300.00
Spectral DY. SD37	FFT Analyzer	£1,800.00
Tek 7L12	100KHz-1.8GHz	£800.00
Tek DA4084	Programmable Distortion Analyzer	£700.00

HP8657A
Signal Generator
0.1-1040MHz
£3,500.00

DATA/TELECOMS

Anritsu	MS334A PCM Error Detector	£120.00
BT (Fulcrum)	T1020 Network Transmission Performance Analyzer	£500.00
Cushman	CE24 FX Selective Level Meter	£400
Datalab DL1000	Programmable Transient Recorder	£250.00
GN Elmi EPR31	PCM Signalling Recorder	£5,000.00
HP1350A	Graphics Translator	£200.00
HP1631D	Logic Analyzer	£650.00
HP3336A	Synthesizer/Level Generator	£1,300.00
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 Analyser	£3,200.00
HP3770B	Telephone Line Analyzer	£200.00
HP3780A	Pattern Generator/Error Detector	£1,100.00
HP3781A	Pattern Generator	£500.00
HP3782A	Error Detector	£500.00
HP4935A	Transmission Tester	£1,100.00
HP4984A	In-Service Transmission Impairment Measuring Set	£POA
HP5005B	Signature Tester	£950.00
HP5006A	Signature Analyzer	£50.00
HP6942A	Multiprogrammer	£200.00
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Marconi 2829	Digital Analyzer	£200.00
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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 (Brand New/Boxed)	£120.00
Marconi TF2807A	P.C.M. Multiplex Tester	£200.00
Marconi TF2830	Multiplex Tester	£200.00
Meguro	MK612A VTR Jitter Meter	£75.00
Phoenix	5500A Telecommunications Analyzer	£1,500.00
Racal 202, 205	State Logic Analyzer	£150.00
Schlumberger	7700 140 m Bit/s Filtermeter/Generator	£125.00
Schlumberger	7710 Mainframe Set 34/140 M Bit/s	£125.00
Siemens	D2155 Level Meter/W3155 Tracking Oscillator	£150.00
Siemens P2032	Bit Error Measuring Set	£900.00
Tek 834	Programmable Date Comms Tester	£150.00
Thurlby	LA4800 Logic Analyzer	£500.00
W&G	SPM15 Level Meter	£800.00
W&G	PS12 Level Generator	£300.00
W&G	SPM12 Level Meter	£POA
W&G	PCM2-3 PCM Test Set	£300.00
W&G	SBG-1 SSB Level Generator	£150.00
W&G	DLM3 Data Line Test Set	£500.00
W&G	SPM19 Level Meter	£2,500.00
W&G	MU3 Test Point Selector	£POA
W&G	PJM-1 PCM Jitter Meter	£250.00

ROHDE & SCHWARZ
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0.1-1000MHz
Communications Test Set
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HP Colour Pro		£45.00
HP DraFt Pro-DXL	7575A	£250.00
HP7475A	Plotter RS232	£150.00
HP7550A	Plotter	£250.00
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HP2225D	Thinkjet Printer RS323C	£POA

SEMI-RIGID CO-AXIAL CABLE
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0-20GHz 3M Lengths
Brand new: £10.00 per length
Discount on Qty: (100pcs = £500.00)

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MOTOROLA BATTERY CHARGER; TYPE NTN4922A, GOOD CONDITION. PRICE: £85.00

MATCH BOX: MATCH EFFICIENCY METER MODEL: MB800. MADE BY HELPER INSTRUMENTS: PRICE: £150.00. FREQUENCY RANGE: 775-1025MHz SWR (VSWR) INDICATION RANGE: 1.0:1 TO 5.0:1

Adret	5104 Drving Synthesizer 90-120MHz	£125.00
Aeritalia	Type: TE307 Electric & Magnetic Field Sensor	£150.00
Bird	Coaxial Attenuator 30dB 50 2KW	£300.00
Boonton	82AD Modulation Meter	£200.00
Farnell	E350 Stabilised Voltage Supply	£120.00
Farnell	RB1030/35 Electronic Load 1kW 30A 35V	£300.00
Farnell	TSV70 Mk2 Stabilised Power Supply	£180.00
Ferrograph	RTS2 Recorder Test Set	£200.00
Fluke	8520A Digital Multi Meter	£250.00
Fluke	8860A Digital Multi Meter	£150.00
General Radio	1265A DC Power Supply 0-400V 0-5A	£475.00
General Radio	1308A Audio Oscillator + Power Amplifier	£1,500.00
General Radio	1633A Incremental Inductance Bridge	£375.00
Giga	GR1101A 12-18 GHz Microwave Signal Generator	£150.00
Giga	GU1328A 2-8GHz Microwave Signal Generator	£150.00
Harris	RF/2305 Receiver/Exciter	£200.00
HF Multicoupler	1 Input 8/16 Outputs 1-40MHz	£300.00
HP	11713A Attenuator Switch Driver	£300.00
HP	1741A 100MHz Oscilloscope	£300.00
HP	1742A 100MHz Oscilloscope	£275.00
HP	181A Main Frame c/w 1840A+1825A	£125.00
HP	3400A RMS Volt Meter	£120.00
HP	3570A Network Analyser 50Hz-13MHz	£150.00
HP	4333A Distribution Analyser	£300.00
HP	435A Power Meter	£175.00
HP	435B Power Meter	£250.00
HP	489A Microwave Amplifier 1-2GHz	£125.00
HP	5315A Universal Counter 100MHz	£200.00
HP	5328A Universal Counter 100MHz	£120.00
HP	5363A Time Interval Probes	£150.00
HP	8412B Phase Magnitude Display	£175.00
HP	8443B Tracking Generator/Counter	£250.00
HP	8445B Automatic Preselector	£300.00
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HP	8553B RF Section 0-100MHz	£200.00
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HP	8556A LF Spectrum Analyser	£200.00
HP	86601A RF Section 0.1-110MHz	£300.00
HP	8750A Storage Normalizer	£200.00
HP	491C Microwave Amplifier 2-4GHz	£125.00
HP	8413A Phase Gain Indicator Unit	£175.00
HP3488A	Switch Control Unit	£800.00
HP8508A	Vector Voltmeter	£2,500.00
Iwatsu	SC/7103 Frequency Counter	£160.00
Keithley	192 Programmable Digital Multimeter	£200.00
Marconi	6056B Signal Source 2-4GHz	£150.00
Marconi	TF2337A Auto Distortion Meter	£150.00
Megger Pat 2	Portable Appliance Tester c/w Calibration	£420.00
Polarad	1105E/FT 0.8-2.4GHz Signal Generator	£250.00
Racal	9104 RF Power Meter	£200.00
Racal	9300 RMS Volt Meter	£175.00
Racal	9301A RF Millivoltmeter True RMS	£180.00
Racal	9921 UHF Frequency Counter	£275.00
Racal	MA1720 Drive Unit	£300.00
Racal	9081 5-520MHz Synthesized Signal Generator	£375.00
Racal Dana	9478 Frequency Distribution Unit	£200.00
Schlumberger	7055 Micro Volt Meter	£150.00
Systron Donner	5000A Sweeper c/w Oscillator 5014/26 3.2-6.5GHz	£250.00
Tektronix	464 Oscilloscope	£300.00
Tinsley	5761 Resistance Bridge	£200.00
W&J	3737A/10 HF Receiver	£120.00
W&J	DMS107 Demodulator	£120.00
W&J	565 Receiver	£200.00
W&J	DM/112 Demodulator	£250.00
W&J	MTF/106A Microwave Tuning	£150.00
W&J	WJ9518AE/9 FDM Demodulator	£250.00

CIRCLE NO. 126 ON REPLY CARD

Reader offer – save £230

X7000 license exempt data radio transceiver

Available only to readers of *Electronics World*

Only £359 for two synthesised transceivers. List price £594.

Warwick Industrial is offering a pair of X7000 synthesised data radio transceivers with a £230 discount – exclusively to *Electronics World* readers. The normal list price of a pair of transceivers is £594.15. Until 31 October 1998, you can buy a pair for £359 – fully inclusive. This offer is limited to one pair per reader or company.

Features of the X7000 are:

- Type approved to MPT1329 UK License Exempt
- Up tp 32 rf channels set by 6 DIL switches or serial port
- Range 10-20km line of sight, 1-3km in buildings
- RF power output 5mW to 500mW
- Data rates up to 9600 bits/sec at 25kHz channel spacing
- Voltage range 8.5V to 13V
- Consumption 5mA in standby
- Size 93mm by 60mm by 17mm

The X7000 module can be easily integrated into new or existing products and provides a flexible low cost means for communicating analogue or digital data over distances of around 20km line of sight or 1 to 3km in buildings.

Warwick Industrial Electronics Ltd, The Manor, Aston Flamville, Leicestershire, LE10 3AQ, tel 01455 233616, fax 01455 233 179. E-mail warwick@pipemedia.co.uk

Telemetry transceiver specifications

Frequency range, standard	456MHz to 460MHz
Frequency range option	420MHz to 470MHz in 1MHz bands
Maximum data rate	9600bit/s
Channel selection	DIL switches, single step or serial data communication
Supply voltage	8.5V to 13V dc
Supply current	Transmit <295mA
	Receive <70mA
	Standby <5mA
Size	93mm x 60mm x17mm
Signal connector	26 way on 2mm pitch
Power connector	2 way on 5mm pitch
RF antenna connector	MCX type socket
Transmitter	
RF output power	5mW to 500mW
Channel separation	12.5kHz or 25MHz
Frequency deviation	±3kHz at 25kHz channel separation
	±1.5kHz at 12.5kHz
Receiver	
Type	Dual conversion superhet
Intermediate frequencies	45MHz and 455kHz
Sensitivity	0.3µV for –10dB SINAD
Bandwidth	±7.5kHz

Use this coupon for your order

Please send me two X7000 radio modules at £359 fully inclusive.

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Warwick Industrial Electronics Ltd, The Manor, Aston Flamville, Leicestershire LE10 3AQ, tel 01455 233616, fax 01455 233179.

Operating the transceiver

Signals to and from the X7000 data radio are presented on a 26-way pcb connector on the bottom of the module. The transmitter section has three data inputs; one for analogue data, one for digital data and one for direct modulation. Two data outputs are provided from the receiver section; these are digital data out and analogue data out.

The transmitter and receiver can be switched independently. Additional signals are available such as relative signal strength indication, rf carrier detect, synthesiser locked and synthesiser out of lock.

The radio frequency can be set in three different ways. Six DIL switches on the front of the module set the default frequency. This can be incremented or decremented by pulsing the input in conjunction with the clock input. In addition a serial data stream can be used to set the radio frequency directly.

The moment of truth – Rod Cooper sums up his series of pcb cad reviews. But first, he presents the final review in this round, for WinDraft and WinBoard.

The route to pcb cad

The *Windraft* and *Winboard* combination is a schematic capture and manual layout package, with an interface to an external autorouter, the *Specctra SP2*. Its pin limit is 650 pins and it is supplied on compact disk. In total, the program occupies about 36Mbyte. The autorouter is protected from piracy with both dongle and password.

This is a complex program with many options and choices and this complexity leads to a steep learning curve. Once again, there are some differences in terminology, with words not used in other programs occasionally encountered. For example, the word 'module' refers to the pcb footprint, with associated words like 'net-list module' and 'library module' following on from this.

The term 'isolation' is used where other programs use 'clearance'. Hence track isolation = track clearance, so if you have already been using another pcb-cad program, a modicum of re-learning will be required.

Documentation for this package is comprehensive. There are four manuals; the first, entitled 'Getting Started', is a brief introduction and includes tutorials for schematic drawing and pcb layout.

Two larger books cover schematic drawing in detail, and interactive pcb layout, and the *Specctra* interface. Finally, one written by Cadence (formerly Cooper & Chyan) deals with just the *Specctra* autorouter. All the manuals are well written and cover every aspect thoroughly. Strangely, the tutorial puts board layout before schematic drawing, i.e. the cart before the horse.

There is an excellent glossary in the two larger manuals so clarification of terminology is possible.

Schematic drawing

As **Fig. 1** shows, this is in conventional Windows format, with scroll bars for panning, a menu bar, two top tool bars, and a parts palette on the right.

At first glance, it might seem that this is not efficient use of valuable screen drawing area, but you have the option to turn off some of these functions to increase drawing area. On the comparative check with the standard 14in monitor, the available drawing area with the options on was 8.3in by 5.3in.

The parts palette is not a temporary parts bin, but a system like that in *CircuitMaker* for quick selection of most-used parts. This is an alternative to picking the parts from a library list. It can be configured to suit the operator.

Pop-up text, also known as Tool Tips, identifies the various buttons. There is no map showing drawing location, but selecting 'Zoom,best' will find any lost drawings.

Access to the library of symbols is easy, you just select the 'part' button, or go via the top menu, and the list of library volumes appears. Although some volumes can be readily identified, such as connect.clb and transist.clb, the rest of the codes, like IEEEECL.clb are not intuitive. With 10 000 devices listed in the library, it is well stocked.

On selecting a volume and picking a part number, you get a clear graphical representation of the part before transfer to the schematic. The symbol is placed with drag-and-drop, and duplicates can be placed at this stage with the left mouse button. The drawing area auto-pans during parts placement.

Mouse use

The program makes good use of left and right mouse buttons – generally the left to start or select, and the right to terminate an action.

Rotation of symbols is done by selecting the symbol with the left mouse button, holding it down, then pressing left or right arrow cursor keys on the keyboard. Similarly, the symbol can be mirrored by pressing the up/down arrow cursor keys. When you get used to it, this is an efficient system.

Symbol text stays upright so you are relieved of the chore of un-rotating it, as you have to do with certain other programs. Text can be moved round independently of the symbol so that a neat diagram can be produced. Surprisingly, connections do not stay attached during rotation, but they do stay attached during symbol moving.

Drawing connections is carried out by selecting the drawing tool and clicking once on a valid connection with the left mouse button. A small box appears, confirming that you have hit a connection. Drawing then starts, and the drawing screen auto-pans during this operation.

Corners can be inserted with one click. Another small box appears when you reach the intended terminal. You can then single left click to make the connection and continue on, or press right-click to finish. There is a medium-strength snap-to system, but this can be made stronger by pressing 's' on the keyboard when making the connection. Overall, this is a good drawing system, as it is difficult to mis-draw a connection and make a bad net list.

A further drawing aid

There is another aid to drawing called Target Mode. With this function, you can select two terminals, create a rat-line, then convert it to an orthogonal connection using a modified rubber-band technique. During drawing the connection, the rat-line stays attached to the mouse pointer, thus indicating the general direction of the far terminal. Obviously you would not use this method for two points that were close together, but reserve it for long connections.

As well as any-angle drawing there is the usual orthogonal option for drawing connections. In addition to drawing with square corners, there are two refinements, namely a choice of rounded corners or mitred corners. These can give a distinctive appearance to a schematic. All three methods are easy to use.

There is no inhibition of errors, lines drawn in space for example, and these do not disappear when the 'cleanup' function is selected. Any such errors have to be removed manually.

Junction dots can be automatically set, and the drawing can be auto-annotated. Multi-sheet schematics are supported and a hierarchy-type system can be chosen if required. The zoom system is the conventional Windows type, and it auto-pans during operation.

Operator error in drafting the schematic can be revealed by using *WinDraft*'s detailed electrical/electronic rules check, or ERC.

WinDraft P650, WinBoard 650 and Specctra

Maker; Ivex (USA)
UK supplier; The PC Solution, tel 0181 926 1161, fax 0181 926 1160
Price £800

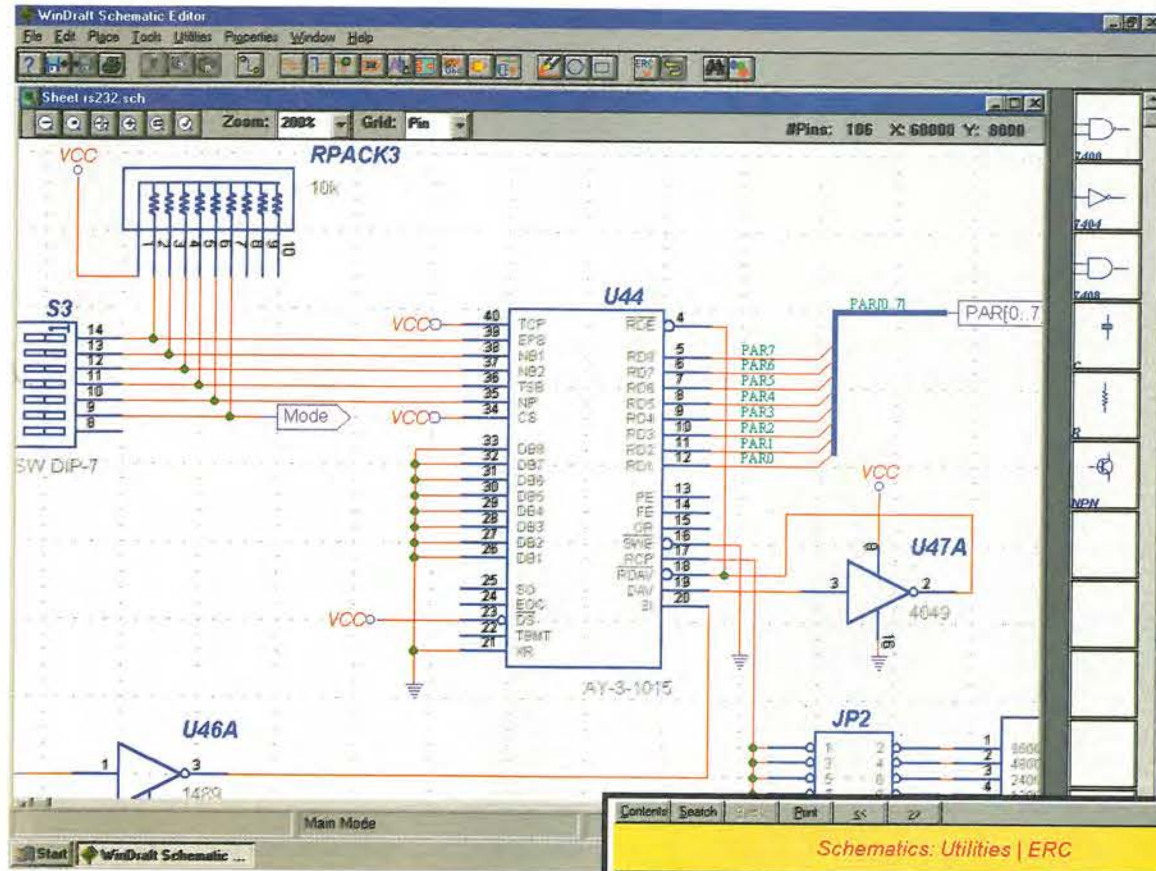


Fig. 1. View of WinDraft schematic drawing. Note the symbol palette on the right, which can be turned off to increase screen area.

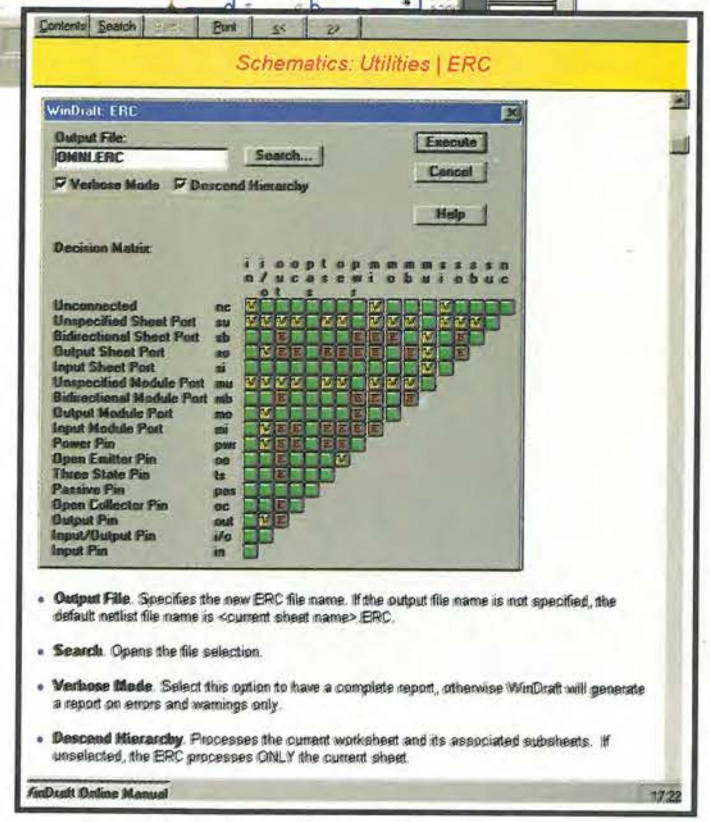


Fig. 2. The electronic rules check or ERC is a relatively comprehensive menu compared to other programs. This is typical of configuration menus in this program.

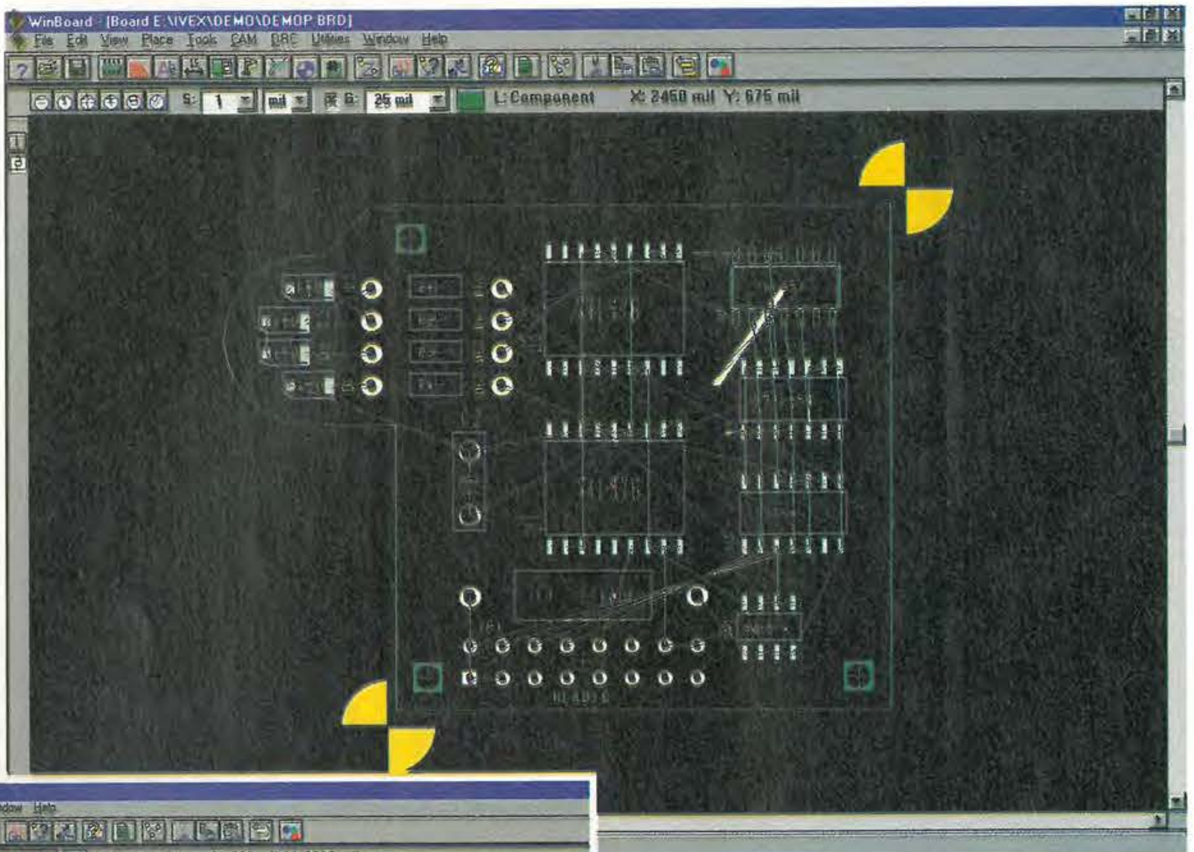


Fig. 3. The rat's nest can be interactively sorted with the help of force vectors, and one of these is shown as the thick white line on the top right IC in this view.

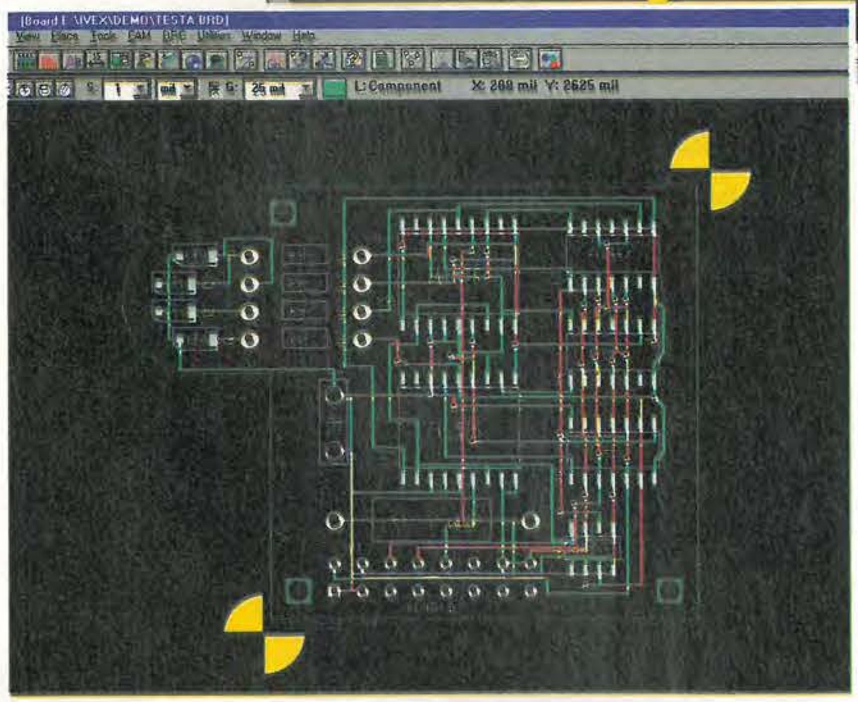


Fig. 4. The rat's nest of Fig. 3 autorouted in Specctra and returned to WinBoard format. Note the non-mitred corners. See the text for an explanation of this.

As **Fig. 2** shows this can be set up to give either a warning, an error, or to show a valid, i.e. no error, connection for a variety of conditions. This menu is more elaborate than the ERC systems found in other, more straightforward programs. This illustrates a point I made earlier – that this is a complex program – and it needs considerable input on the part of the operator to make the most of it. Potential buyers should ask themselves if such sophistication would help or hinder their particular style of working.

Graphics quality of schematics is good.

Drafting a pcb

As you would expect, operating WinBoard is very similar in style to using *WinDraft*. As **Figs 3** and **4** show, the screen layout is almost the same. There are no Tool-tips for the toolbars, though. Instead, descriptions of the button functions appear at the bottom of the screen, which is not quite so handy.

WinBoard could be used as a stand-alone program to make manually-drawn boards, placing devices by hand and then drawing in the tracks. This is actually a pleasant program to use in this mode, but it would be a waste of the the program's capabilities.

For making a pcb via schematic capture in *WinDraft*, *WinBoard* follows a well-structured course. To commence, the net-list that was generated in *WinDraft* is selected via the File menu. Note that it can be made in several net-list formats in addition to Ivex's own, so there is a possibility of connecting to other programs. The formats available are FutureNet, Protel, Tango, EDIF, Pads. The next stage is to specify the setup menus – for example layers, design rules, autosave time, etc.

Following this, allocation of pcb footprints – or modules, as Ivex refer to them – can be done automatically or interactively, or more usually a mixture of both, through a scrolling menu system. This is similar to the schematic symbol system, and you get a graphical view of the pcb outline and pins against a dot-matrix.

Having picked the modules, the rat's nest can then be generated, and it appears as a grouped collection of spaced components. Note that this is *not* an autoplacer system, the parts have simply been placed with a sensible clearance from each other, rather than as an overlapping heap or on a linear grid like other systems.

Although it is a better method for subsequent manipulation than an overlapping dump or linear grid, there are no strategies involved in placement as there are in *TraxMaker* or *Proteus*. The rat's nest still has to be manually sorted out.

Moving and rotating

Movement and rotation of parts is very similar to that described in *WinDraft*, except that rat lines stay attached during rotation. Sorting of the rat's nest is assisted by force vectors. These appear as bold white direction lines whenever a part is selected for movement with the mouse.

Vectors are not shown until selection, which means that you have no idea what the vectors are on other components, vectors that may well influence how you move a selected component. However, there are two other optional systems which can help.

First, there is a Density Map. This is a multi-colour overlay on the rat's nest showing where the routing may be easiest. By default, red shows densest routing, white medium, and black low density, and many shades in between. Of course in a complex program like this you can modify this system with other colours if you wish.

Secondly, a histogram displayed at the side of the rat's nest can indicate where routes are densest or lightest. Using both these tools is an acquired skill.

Rat lines can be converted into tracks using a rubber-banding method. The process is not as 'rubbery' as in some systems – a distinct advantage which those familiar with this technique will appreciate. Drawing a track is very similar to the Target Mode already described in *WinDraft*. Tracks stay attached and rubber-band during component movement. As an option, tracks can have mitred or curved corners.

A design rule checker can flag errors, referred to as bookmarks, on the artwork or make a report. Once again, the design-rule check dialogue box gives a generous number of checking functions.

Autorouteing with Specctra

Specctra SP2 has already been mentioned other reviews. It is accessed via an Ivex interface which converts *WinBoard* pcb files to *Specctra* format and *vice-versa*.

The interface is started from the 'autoroute' menu, **Fig. 5**.

Previous review subjects

PCB Designer: Niche Software Ltd, tel 01432 355414 – reviewed September 1996.
PIA:AW Software Ltd, Germany tel +49 89 6915352 – reviewed September 1996.
Easytrax: Protel International pty, Australia. Available from PDSL, tel 01892 663298 – reviewed September 1996.
Ranger 2: Seetrax CAE Ltd, tel. 01705 591037 – reviewed October 1996.
Electronics Workbench: Interactive Image Technologies Ltd Canada, tel. 00141 69 775 550 – reviewed October 1996.
CircuitMaker: MicroCode Engineering USA, UK agent Labvolt, tel 01480 300695 – reviewed November 1996.
Quickroute 3.5 Pro+: Quickroute Systems Ltd, tel 0161 449 7101 – reviewed December 1996.
Propak: Labcenter Electronics, tel 01756 753440 – reviewed December 1996.
Proteus: Labcenter Electronics, Schematic capture and pcb design – reviewed January 1997.
EasyPc Pro XM: Number One Systems, tel 01480 461778 – reviewed January 1997.
Challenger: Ultimate Technology, Tel 01594 810100 – reviewed June 1998.
Ranger 2: Seetrax CAE Ltd, Tel 01730 260062 – reviewed June 1998.
EDWin: Visionics, UK supplier Swift Eurotech, Tel. 01992 570006, fax 570220 – reviewed July 1998.
Traxmaker & Circuitmaker: Microcode, UK supplier Labvolt, Tel. 01480 300695 – reviewed July 1998.
EasyPC & Multirouter. Number One Systems, Tel; 01480 461778 fax 01480 494042 – reviewed August 1998.

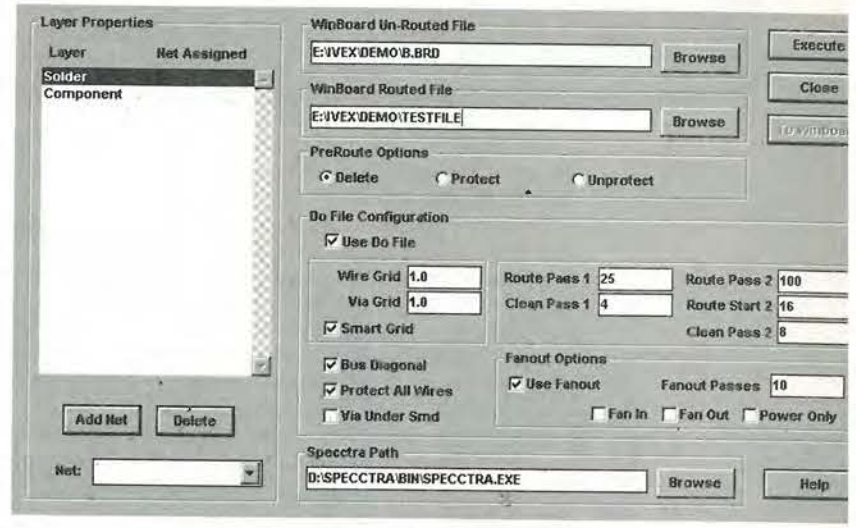


Fig. 5. Access to the Specctra autorouter is done via an interface, shown here with input and output files specified in the appropriate boxes and the autorouter path in directory D:.

To reach this stage, the interactively-sorted rat's nest should be saved as a file in *WinBoard*, and this file loaded in the 'placed file' box in the interface menu. A file for the completed board must also be placed in the 'routed file' box in order that the *Specctra* results can be transferred to it after auto-routing has finished.

You may also have to specify the path for *Specctra* if it is not in the C: directory. As you can see from Fig. 5, all this is very dos-like. An external autorouter is not as easy to use as a built-in autorouter designed by the same program makers as the main program. However, an interface like this is still better than using an external autorouter on its own.

Note that there is no single-sided board option in the interface. If you want to do such a board, you have to enter *Specctra*.

Having specified the paths, and configured the autorouter with the menu of Fig. 5, pressing the execute button will automatically start the autorouter.

Although you can see routes being formed while *Specctra* runs, you must go back to *WinBoard* to see the final result. This is done via the interface. Note that boards made using the interface will not have mitred corners on the tracks, so the results will have a distinctly square appearance as in Fig. 4. To mitre the corners, you must enter *Specctra* and use the post-routing function called 'recorner'. This method of mitreing the corners is not user-friendly.

Not having mitred corners is technically unacceptable in this day and age, so why the interface does not offer this feature is hard to understand.

Outputs

Hard copy is generated with the Windows printer and plotter drivers. There is no dedicated plotter driver – a big disadvantage if you prefer a plotter.

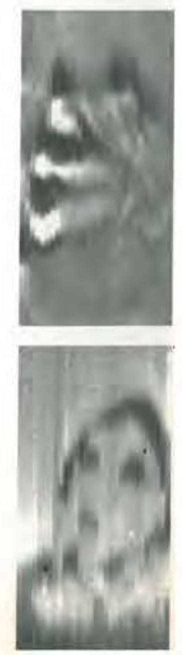
Like the other menus in *WinBoard*, the menus for configuring the output are extensive, and include a mirror function among the many other options. There are Gerber and NC drill-file outputs.

In summary

WinDraft is a well-designed program. As already mentioned, it is full of features and has lengthy options on just about everything, so the learning curve is steep.

Despite this, most of the basic actions of drafting a schematic is easy. It has all the features needed for rapid drafting and few of the drawbacks found in other programs – no double-clicks and no tedious un-rotating of text.

It would be useful to have a parts bin option, but there is the symbol palette to compensate for this. Bear in mind the pin limit to these programs, which is by far the most restric-



tive of those programs in this review with a limit.

WinBoard is also a well-made program. Like *WinDraft*, once the rather steep learning part is accomplished, drafting a pcb is fairly easy. Being in almost exactly the same style as *WinDraft* helps with the learning curve.

Not having a good plotter driver is snag. All the major players in this league have realised the necessity of having an accurate plotter driver, so Ivex should do the same.

The interface to *Specctra* works well, but the inability to make single-sided boards and mitre corners using the interface is very limiting. To do these very basic functions it is necessary to plunge into *Specctra*, and learn how it works. But *Specctra* is an entirely different program with its own learning curve to ascend. It is odd that this interface is the only menu in the product that is not comprehensive, yet in many ways it is the most important.

Attaching an external autorouter – especially one with the universally disliked dongle – is very much a compromise solution, or a stop-gap measure. What is really required is an autorouter of comparable power made by Ivex, in the same format as *WinBoard*, and fully integrated into it.

Considering that Ivex clearly knows how to make a good program, it is surprising that the company hasn't done this.

Round up

With respect to the products reviewed here, most program makers seem to have sorted out a workable approach to schematic drawing and symbol libraries, with varying degrees of user-friendliness.

The biggest difference between programs now lies in the rat's-nest/autorouter area. Designing a good autorouter appears to give programmers most difficulty, and it is the autorouter that gives users the most cause for complaint. Users expect, perhaps unrealistically, that their autorouter results will be as good as those from a human source, at the same time being simple to operate.

Specctra is probably the autorouter that is most proficient at finding routes. I say probably, because both the new autorouter in *Proteus IV*, and *MultiRouter* are now so good at this aspect that the difference is not worth considering on many boards. But on its own, the ability to find routes, although of prime importance, has limited benefits.

Both *MultiRouter* and *Proteus* autorouters can autoneck, which is a big help in autorouteing – especially getting out of difficult situations, like the bottlenecks which rat's nests present either because they are densely packed or poorly constructed. The versions of *Specctra* reviewed here do not. On balance, and considering the relatively high price of other autorouters, this puts *Proteus* slightly ahead.

There is no doubt that a capable autoplacer helps reduce problems for both the autorouter and user simultaneously. On larger boards, the saving in time and effort is very significant. Here, the products in this review using *Specctra* are at a disadvantage. Although *Specctra* has a good autoplacement system, the programs that use it simply do not promote this feature.

To use *Specctra*'s autoplacement, you would have to learn two different programs, namely the main program and then *Specctra*. Once again, of the autoplacers reviewed, it is the one in *Proteus* which was the most accessible, and thus effective.

The ability of a pcb layout program to gate-and-pin-swap is also a big help, although boards must of course have swappable gates and pins present to take advantage of it.

The programs

Proteus IV from Labcenter stands out as the best all-round program in this review. While the other programs reviewed have strengths at various places in the pcb design process, *Proteus IV* maintains a constant high level of capability throughout. Whether it is a well turned out schematic, user-friendly interactive routing, effective and configurable autoplacing, competent autorouteing, or a combination of autorouteing and interactive routing, *Proteus* handles everything very well.

Many programs seem to have a superfluity of features that are seldom used, if at all. In contrast, by developing its autoplacer feature, force vectors concept and the versatile Tidy strategy, Labcenter seems to be concentrating on what is important – i.e. shifting the burden of pcb design from the user onto the pc. This should strike a chord with many designers.

The first-time buyers that this review is aimed at should note that *Proteus IV* has an integrated simulator as an optional extra. They should look ahead to the day they will need to add a simulator. With an integrated simulator there is there is a minimal amount of program re-learning. And there is no need to get entangled with Spice net-list transfers and the attendant difficulties of mis-match and incompatibility with third-party simulators.

If you favour pen-plotting your artwork, remember that *Proteus* has an excellent plotter driver.

Ranger 2 for Windows from Seetrax at £250 is half the price of *Proteus IV*. Although it has no integrated simulator, and has less attractive interactive routeing than *Proteus*, and no autoplacer, *Ranger 2* has a lot to recommend it. It has the advantage of having no pin limit, it has a good schematic drawing system, a rip-up-and-retry autorouter that, with judicious handling, gives good results, has its own plotter driver, and is generally user-friendly. And even with the recent price increase on the *Specctra* autorouter, *Ranger 2* combined with the *Specctra SP2* is still the least expensive way to acquire a *Specctra* autorouter.

Remember, if you are on a tight budget, you can have *Ranger 2* with all these features for much less money – if you don't mind running it under dos.

EDWin NC from Visionics at £114 is simply a bargain buy. If you are prepared to put in more operating effort, if you do not mind a steep learning curve, and you do not want to pen-plot pcb artwork, then *EDWin* must be a very attractive purchase. And if you do undemanding double-sided boards, its autorouter in category C may be acceptable.

Remember that for this price you get not just a full schematic-capture/autorouter program but an integrated simulator as well. So on a straight cost-benefit basis, *EDWin* scores very well. If you could find a better autorouter to complement it, *EDWin* would be a powerful system.

CircuitMaker v.5.0 from MicroCode has one the easiest, simplest, most intuitive and quickest schematic drawing programs around, ideal for a first-time buyer. It's also good value for money – you get schematic capture and simulation for about the same price that most companies charge just for capture. The simulator is of course an integral part of the package, the best type to have.

The *Traxmaker* pcb layout is also user-friendly, and was one of the earliest programs to offer auto-placement, but the autorouter is still not very powerful. This is why, at £400 for the complete schematic capture/autorouter package, I cannot yet unequivocally recommend it unless, as in the *EDWin* case, your aim is to do undemanding double-sided or multilayer boards and expect to help out the autorouter with some manual work on other types of board. However, the fact that a Windows version of *TraxMaker* has appeared is proof that the makers intend to develop it.

For want of a better autorouter to do it justice, I consider that this package is, in effect, still waiting to take its proper place in the marketplace. It will be interesting to see what MicroCode do in the future with *TraxMaker*'s autorouter. If they give it rip-up-and-retry, autonecking and track-spread, it would have a very sizeable impact.

Easy-PC for Windows from Number One Systems is a noticeable improvement in many respects over the previous Dos version. However, the schematic capture section needs more effort than competing products to do the same amount of work. The autorouter is very capable. But without force vectors or autoplacement to assist with the rat's nest, and no gate-and-pin-swap, a lot of hard work is still needed to enable this autorouter to produce the good results it is capable of.

The total cost of *Easy-PC* with *MultiRouter* is £890 – a bit over the stated budget level and the highest-priced package in this review. True, it has no pin limits, but considering the comments above, I think this promising product needs further development. It has great potential.

Challenger from Ultimate is much like *EDWin* in many aspects, being endowed with plenty of features and a similar schematic and pcb layout style. Similar that is, until you come to the *Challenger GXR* autorouter, which is better than the one in *EDWin*. Of course, *Challenger 1500* is six times the price of *EDWin*, does not include a simulator, and has a pin restriction, so this may influence potential purchasers.

Being a dos/Windows hybrid may also deter some buyers. It will be interesting to see Ultimate's all-Windows version when it arrives.

WinDraft and WinBoard from Ivex is a well-designed program, with a learning curve about as steep as *Challenger*. Although a sound product, it has a high price tag, but it does not have any overwhelming advantage over other comparable programs to justify the high cost. Moreover, I think most designers will find the 650 pin limit too severe and the presence of a dongle a hindrance.

I think one reason for the relatively high price is the inclusion of a *Specctra* autorouter. Cadence which has now acquired Cooper and Chyan, recently increased the price of *Specctra*. Even so, the package as a whole is at a price disadvantage compared to other similar programs reviewed here. *Ranger 2* for example, offers the *Specctra* autorouter with DFM for only £600 for the complete system and has a better interface and no pin limit. The pin-restricted Ivex package with the same highly desirable DFM function at £200 extra would cost £400 more than this. These figures speak for themselves.

Final shot

One final piece of advice; the prospective buyer must completely disregard the marketing hype that has become more strident recently. Advertisements with statements along the lines of 'The most powerful autorouter the World has ever seen' and 'Packed with features no other program has' must be totally and utterly disregarded.

Note that the two or three firms who are leaders in the field of low and mid-price range pcb-cad have quite modest advertising. ■

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CIRCLE NO. 131 ON REPLY CARD

New display technologies

Steve Bush looks at a new display technology that promises crt performance without the bulk. He also presents a round up other new display ideas on the horizon.

Photocathode displays, or pcds, are a made using a new technology from a Californian company called New Logic. They may well put the cat among the pigeons in the display industry.

New Logic claims several benefits for pcds, including high brightness and a wide viewing angle, equal to those of cathode ray tubes, but without the associated bulk.

Photocathode displays rely on the emissive properties of phosphors when they are struck by electrons. In this respect it is the same as both crts and field emission displays. Phosphors bestow the same performance advantages on all three display types.

These are that:

- Light is emitted randomly so there are no viewing angle limitations.
- There are no control mechanisms needed in front of the phosphors, so no emitted light is wasted – except where contrast enhancement filters are applied.
- Excellent colour rendition and saturation is available.

The difference between cathode-ray tubes, field-emission displays and pcds is in the way the phosphor-exciting electrons are generated.

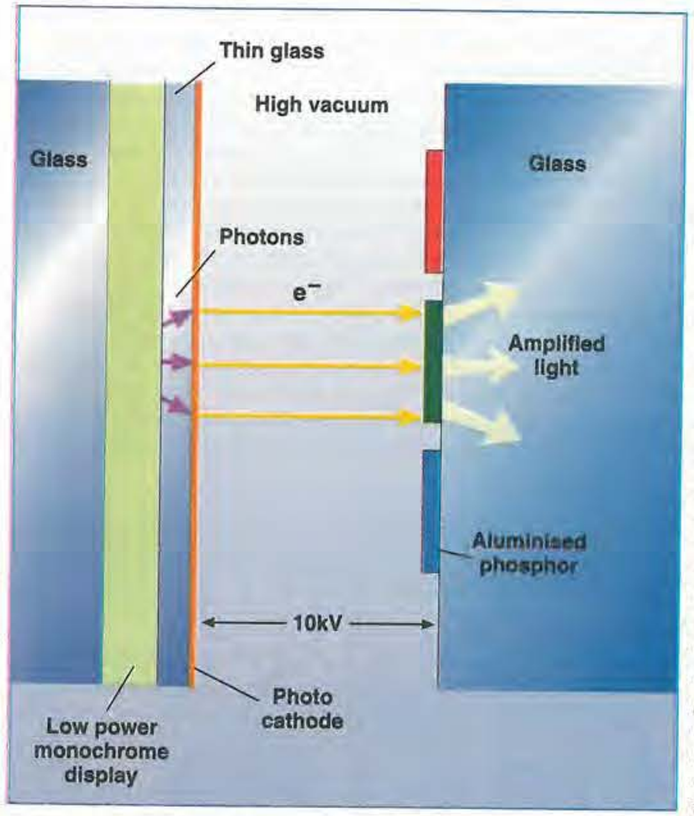
In crts, an electron beam from a single electron source is swept across the back of a phosphor screen. Where the beam strikes the screen, a spot of light results. The crt tube's bulky conical shape comes from the need to bend the path of the beam to cause it to strike each part of the display screen sequentially to form a rectangular image – starting at the top and moving down as a series of almost horizontal lines.

The concepts for both feds and pcds result from answering the question, "Is there a way to put a separated source of electrons behind each point on the screen and avoid having to bend a beam?"

The answer is yes. All you need is to get the electron sources really close to the phosphors and apply a few kilovolts to ensure the electrons fly into the screen before they drift away – a technique called proximity focussing.

In the case of a fed, the electrons come from a patch of material which sheds electrons when raised to a high positive potential. Favoured materials are either coated to enhance emissive properties or covered with a series of tiny points to achieve the same effect. Making such coatings or fabricating micro-tips successfully have both proved problematic for the fed companies, which include Motorola and Pixtech.

New Logic has taken a completely different approach to generating electrons in the pcd. It has based its concept on



In a night-sight image intensifier, light impinging on the cathode causes localised electron emission. In this new technology, the photocathode is activated by a low power electroluminescent, or similar, display. Note the similarities between the photocathode display and a conventional cathode-ray tube.

established image intensifier, or 'night-sight,' technology where light striking a photocathode is used to produce electrons.

Resolution, claims New Logic, is better in photocathode displays because photoelectrons have little energy initially, around 0.2eV. As a result, they are less likely to have significant lateral velocity when compared with field-emission electrons which are more energetic. This leads the company to predict 70 line pairs per millimetre is achievable.

Stimulating the cathode

Unlike feds, photocathode displays need some source of photocathode-stimulating.

New Logic argues that this is not a problem. Any form of low cost, easy-to-drive type will do. It favours an ac powder electroluminescent display which can be screen printed inside the pcd to stimulate the photocathode directly.

Efficiency of the initial light source is not significant because it only consumes a small fraction of device power, the bulk of which is due to maintaining the main acceleration voltage.

One of the more noticeable difference between the fed and pcd is that the fed relies on high-voltage emission, all scanning signals are at voltages between 200 and several kilovolts, depending on fed type. Although not technically insurmountable, this can have a strong effect on the cost and power consumption of the surrounding drive circuitry.

The switched voltages in the pcd are lower and likely to be under 100V. They are therefore much easier to deal with.

In both the fed and the pcd, the field used to guide and accelerate the electrons into the phosphor is in the region of 10kV. The gap they move across is between 0.25 and 1mm. Maintaining this gap against atmospheric pressure is a problem.

In small displays the glass is stiff enough not to distort significantly with only edge support. Larger displays need spacers to prevent the structure from collapsing and there are now methods available to fix glass fibres up to 1.2mm long, but under 20μm (0.02mm) thick, across the gap.

It appears that the pcd is a worthy advisory for the crt. Both have good optical characteristics and, whereas the crt is well developed and inexpensive to make, the pcd is thin and flat. In this it shares the advantages of the fed. New Logic has put forward some strong arguments for the potential superiority of the pcd, but it has to be remembered that the fed is proven, albeit new, technology, already in production whereas the pcd has yet to leave the laboratory. ■

More new technologies...

The pcd was introduced to the world at SID '98, the showcase event of the displays industry held recently in Anaheim California.

Organised by the Society for Information Display, the exhibition and conference was where display companies competed to show off their technology.

As usual, lcds and crts dominated the papers at the conference, but there were also some weird and wonderful highlights. For instance, Xerox introduced *Gyricon*, an 'electronic' paper material on which images form when a patterned electric field is applied. Another novelty was a paper by MicroOptical of Boston which discussed the issues involved in fitting a head-up display into a pair of glasses and proposed a practical solution.

Among the main-stream papers at the conference was one by NEC on its 50-inch colour ac plasma display. This huge thing has 1356 by 768 pixels with 17 million colours. Both high-definition tv images and XGA graphics can be displayed and contrast is high at a claimed 350:1.

The UK was represented by, among others, Philips Research Labs in Surrey. It was invited to talk about its plastic substrate active matrix lcds. Plastic is highly desirable as a substrate material, particularly for portable applications, because it is light and rugged. But thin film transistor (tft) processing temperatures are too high and damage it. Philips has a low temperature 180°C 'top-gate' tft made from amorphous silicon and silicon nitride that could be the solution.

A world record was claimed by Sarnoff, Planar Systems and AlliedSignal for a jointly developed active matrix electroluminescent display. It has a total pixel rate of 800Mbit/s – the highest ever for a flat panel display. Eight channels at 100MHz feed a 1280 by1024 array of 12 by 12μm pixels. The key to speed is its crystalline silicon transistors with a 1.2μm effective channel length.

Motorola, one of the quieter developers of field emission displays (feds), showed a 5.1-inch full-colour quarter VGA display. It is a Spindt-tip type and has both NTSC and VGA controllers built in. Other colour QVGA feds on show were a 5-inch one from Samsung and a 4.4-inch one from Candescent Technologies of San Jose.

To add a touch of reality to SID this year, 31 different display types were operated side by side to allow delegates to judge the relative merits for themselves. Conditions were strictly controlled and the same display patterns were shown on all displays simultaneously.

Comparison of various display technologies.

	CRT	TFTLCD	TFEL	PDP	LVFED	PCD
Luminance (cd/m²)	300	80-200	80	300	80	300
Life (yrs)	>3	>3	>3	<3	<1	>3
Efficiency (1m/watt)	5-10	2-3	0.5	0.2	0.5	30
Colour	excellent	good	no blue	good	not yet	CRT
Contrast	400:1	60:1	100:1	400:1	30:1	400:1
View angle (°)	160	80	160	160	160	160
Resolution (lp/mm)	5-10	50	50	2	3	50
Speed	video	barely video	video	video	video	video
Size	big	small	small	big	small	big+small
Weight	heavy	light	light	light	light	light
Cost	cheap	expensive	expensive	expensive	expensive	expensive

And what of the future?

There are a lot of display technologies. But the cathode ray tube, for all its bulk, weight and power consumption, is still cheaper and brighter than its competitors. As a bonus, it has a wider viewing angle.

This said, the crt is unlikely to remain at the top of the heap forever.

There is a growing demand for 'flat' displays that take up less desk space in the office and less living space in the home.

Flat monitors using large liquid crystal displays can now be seen in offices, particularly in environments like dealing rooms where multiple crt displays dissipate too much heat and additional expense is less of an issue.

Domestic hang-on-the-wall tvs, mostly based on plasma flat screen technology, are appearing in Japanese homes where there is more consumer demand for 'cutting-edge' technology. It cannot be long before those Europe and the US start wanting something similar.

Although industry opinions vary, there is a general consensus among pundits that the uptake of flat displays will really take off if the price can be bought down to within 1.5, or perhaps even two times, the cost of a similar size crt.

Liquid-crystal displays may hit this threshold in time, but not within the next few years for tv and monitor-sized devices. First will be graphics displays where slower – and far cheaper – passive matrix techniques can be used. Video speeds need active matrix displays which will remain costly particularly as size increases forcing yields down. 17-inch diagonal lcds are still pushing existing production techniques.

Plasma displays are arriving in the tv market. Although expensive to make, they will first capture the vert large crt market – 42 inches and above – where crts are impracticably heavy to handle.

In the wings are several projection systems which can be used over the users head, as in a cinema, or from behind the screen. Here, admittedly bulk returns as an issue, but not weight.

The Texas *Micro-mirror* device and emerging miniature lcd shutters may still form an effective opposition to increasingly complex flat display technologies.

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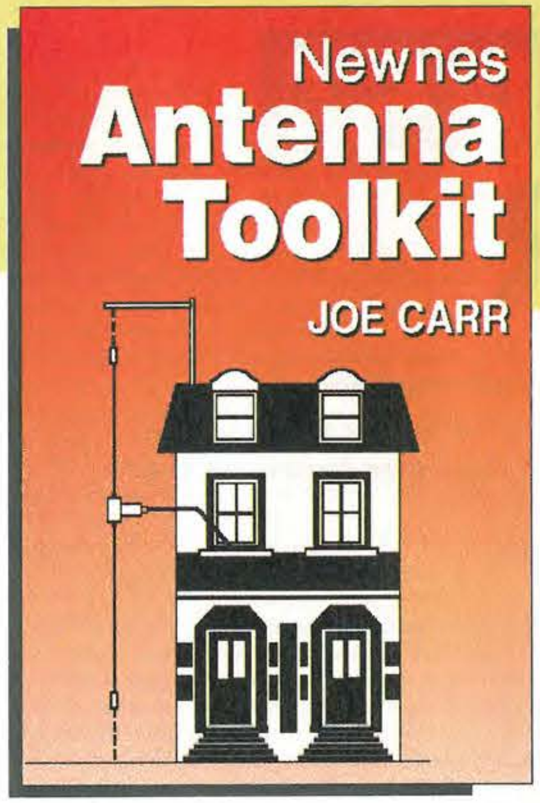

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SPEAKERS' CORNER

As a sound reproduction medium, the electrostatic transducer has many advantages and only a few drawbacks, finds John Watkinson. Here, he takes a balanced view of the technology and comes out in favour.

The electrostatic loudspeaker works on the simple principle that an electric field exerts a force on a charge. As **Fig. 1** shows, the charge is provided by a high voltage polarising power supply and it is trapped in a marginally conductive layer on a very thin diaphragm. A polarising voltage of up to 5kV is common. The source impedance of the supply is deliberately made very high for safety reasons.

The electric field is provided by a pair of electrodes which are perforated to let the sound out. The electrodes are connected to a balanced high voltage audio signal. Several kilovolts may be used. Enthusiasts may build direct drive amplifiers using transmitter valves, but commercially available units employ step-up transformers so that a fairly conventional amplifier may be used.

The great advantage of the electrostatic speaker is that the electric field between the electrodes is absolutely uniform and so the driving force on the diaphragm is independent of its position. This makes the electrostatic speaker fundamentally linear, which is not true of any other transduction system.

In addition, the drive force is applied uniformly over the diaphragm which in turn drives a uniform air load. There is thus no reason why the diaphragm should break up and so the diaphragm can be very thin indeed. Typically the diaphragm is no heavier than a few millimetres of air and so the mechanical efficiency of the electrostatic speaker is very high. There is no heat dissipation mechanism in the speaker itself.

In comparison with the moving coil transducer, the electrostatic principle will always display lower distortion and freedom from thermal compression. Distortion is a particular problem in stereo systems because intermodulation between sounds located at different places in the stereo image may produce phantom sound sources which are in a third place in the image so they are not masked.

Figure 2 shows some ways of constructing electrostatic panels. They are inevitably labour intensive and this reflects in the price of commercially available units. However, building an electrostatic panel is well within the abilities of the home constructor and the materials are not expensive. Several books are available with designs for the home builder.

The structure of the *Quad ELS-63* panel is shown at 2a). This uses perforated printed circuit board electrodes. The copper layer is on the outside of the circuit board so that the diaphragm can contact the electrode without harm. The electrodes are supported by a cellular plastic moulding resembling a fluorescent light diffuser. This moulding also supports the edge of the diaphragm. The advantage of the circuit board is that the copper coating can be segmented to create a phased-array electrode pattern.

As the Quad is a full range speaker, some damping is provided for the fundamental resonance of the diaphragm in the form of a light gauze attached to the rear electrode. This is not needed where the electrostatic speaker is used as a tweeter.

An alternative construction using metal rods is shown at **2b**). The round cross section of the rods causes less turbulence than holes punched in a plate, but construction takes longer. One approach is to spot weld the rods to supports crossing at right angles.

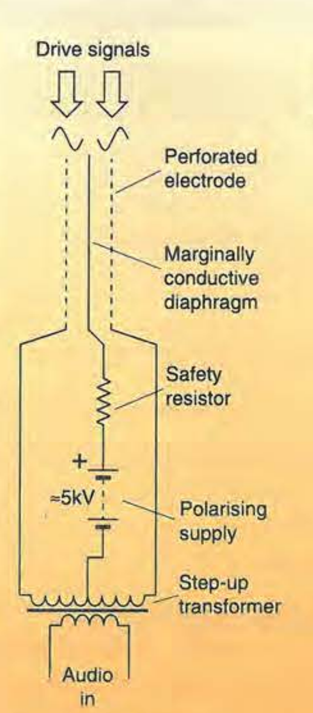

Fig. 1. In an electrostatic loudspeaker, an electric field exerts a force on a charge.

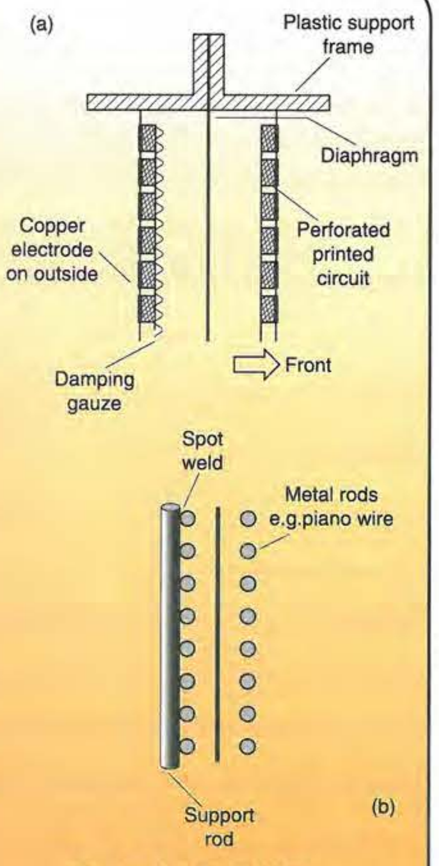

Fig. 2a). The Quad ELS-63 uses perforated printed circuit board electrodes. 2b) shows an alternative arrangement using metal rods.

The construction of the electrostatic panel basically creates a large capacitor. Thus although the transduction principle is very efficient, the amplifier has to drive large quadrature currents in and out of the panel capacitance and conventional amplifiers are very inefficient when used in this way.

However, a switched-mode amplifier has no difficulty with capacitive loads because it can return power to the supply instead of dissipating it as heat. Thus a battery powered electrostatic transistor radio is perfectly feasible provided a switching amplifier is used. The quality obtained would leave more recent flat panel technology in the dust.

The electrostatic panel is fundamentally a dipole and radiates from the rear in antiphase with the same quality as from the front. This has the advantage of making the frequency response of the reverberation more similar to that of the direct sound. This improves realism and is particularly noticeable when listening in the next room through an open door – a case where conventional speakers perform very poorly.

The down side of the dipole is that it becomes very inefficient at low frequencies. The panel has to be very large and the electrode spacing has to be large to allow sufficient diaphragm travel. Wide spacing reduces the electrostatic field strength and the high voltages then required cause a risk of breakdown. The Quad speaker has extensive breakdown sensing and protection circuits.

When designing a reference grade speaker, it is best to accept the low frequency limitations of the electrostatic panel and to use it only as a mid- and treble unit in conjunction with a moving coil woofer. This allows much greater sound-pressure level.

When the Quad was designed, the performance of moving coil woofers was so poor that it would have been impossible to provide a quality match between the panel and the woofer and so it was wisely concluded that a full range speaker should be built which accepted the sound-pressure level limitations of the full-range approach.

With modern active speaker technology it is now possible to make unported woofers which have sufficiently low distortion that they will not be shamed by an electrostatic top end. It is also possible to make active crossovers of sufficient precision to match the transducers in use.

Hybrid active speakers of this kind are rare not only because few manufacturers have a skill set which includes electrostatics, electrodynamics and electronics but also because they are inevitably expensive. However if the criterion is simply one of precision, the active electrostatic hybrid represents the state of the art in sound reproduction. ■

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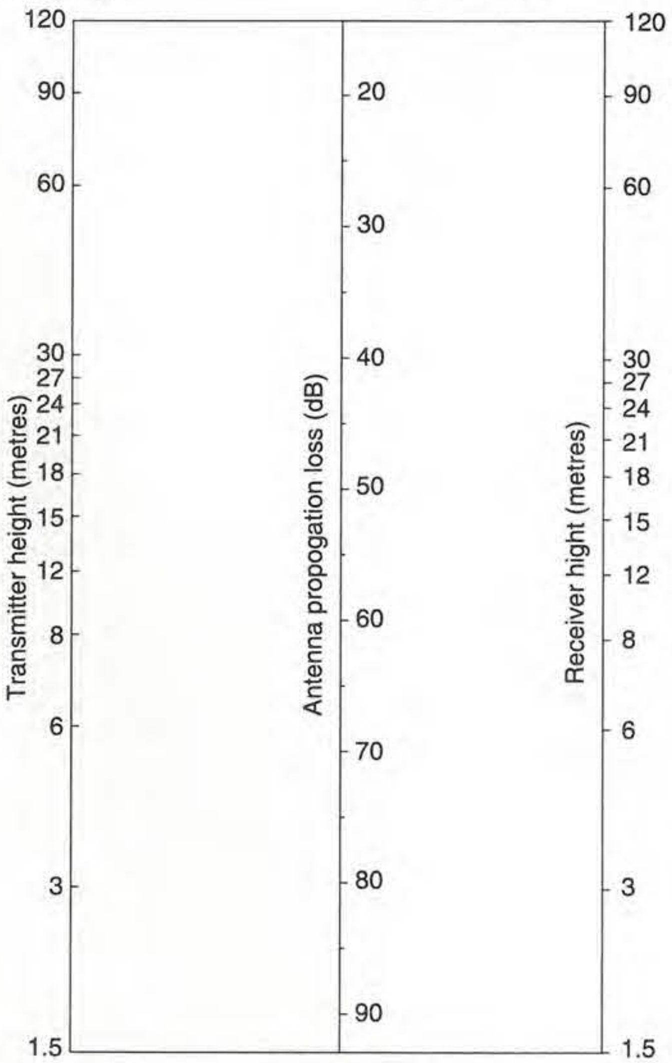
CIRCLE NO.129 ON REPLY CARD

How far will it go?

Roger Simms explains how you can determine the distance that a licence-exempt wireless telemetry link will cover.

With the advent of deregulated low power data radio the economics of using traditional wire links for telemetry need to be examined. Licence-exempt data radio has low infrastructure costs, low installation cost and provides good system flexibility.



Antenna propagation loss due to transmitter and receiver height. Line a rule up with the two antenna heights on the left and right-hand scales then read off loss at the rule crossing point on the middle scale.

The uhf band between 410MHz to 480MHz has become internationally adopted for low power licence exempt use for digital data, telemetry and telecommand systems. It has the advantage of propagating in direct line of sight and will penetrate conventional build materials.

The rf signal fades quickly at the edge of its range. This factor allows multiple use of the same or adjacent frequencies in close proximity.

International perspective

Although a common uhf band is used, national authorities have defined different specifications for licence exempt radio data transmissions.

They differ in the number of allocated rf channels, their bandwidth, spurious emissions and maximum rf power that can be transmitted. In the UK, the MPT1340 specification for operating on the 418MHz channel, allows one channel at 0.25mW rf power.

The radio range is limited to a few tens of metres. But the power consumption is low, as is the unit cost of the transmitters and receivers. Radios conforming to this specification are widely used in portable battery equipment or communicating with moving machinery.

The UK MPT1329 specification covers operation at frequencies of 458.500MHz to 458.950MHz. Either 15 channels at 25kHz or 31 channels at 12.5kHz spacing are allowed with a maximum transmitter power of 500mW.

Radios using this band have data rates of up to 10kbit/s with good in building penetration and can achieve ranges of 10 to 20km, depending on the antenna configuration.

Most continental European countries adopt the ETSI 300-220 standard covering the 433.10MHz to 434.75MHz band with a transmitter power of 10mW. Data radios operating on this band have a range of up to 2km in free space and are used for short range data transfer.

The USA has various data and telemetry bands on frequencies between 440MHz to 470MHz with rf powers of between 100mW to 5W and are specified by FCC regulations CFR47 Pt2.

Estimating radio range

Range is the most important parameter when assessing the practical implication of using a low power, licence exempt, radio system. It is sometimes difficult to correlate the transmitter rf power to the receiver sensitivity and estimate an effective range.

The main factors effecting the performance of a radio system are:

- Transmitter power
- Receiver sensitivity
- Terrain
- Antenna height
- Antenna feeder cable loss

UHF signals on the 410MHz to 480MHz band propagate directly between the transmitter and receiver and act in a similar way to light. There is therefore a maximum distance that a uhf signal can travel due to the curvature of the earth.

With both the transmitter and receiving antenna at a height of three meters and assuming there are no geographical obstacles, the radio horizon will be around 16 kilometres. If both antennas are raised to 100 metres the radio horizon would extend to around 90 kilometres.

With all licence-exempt radios, the rf power is strictly limited. The achievable range can therefore be much less than the radio horizon.

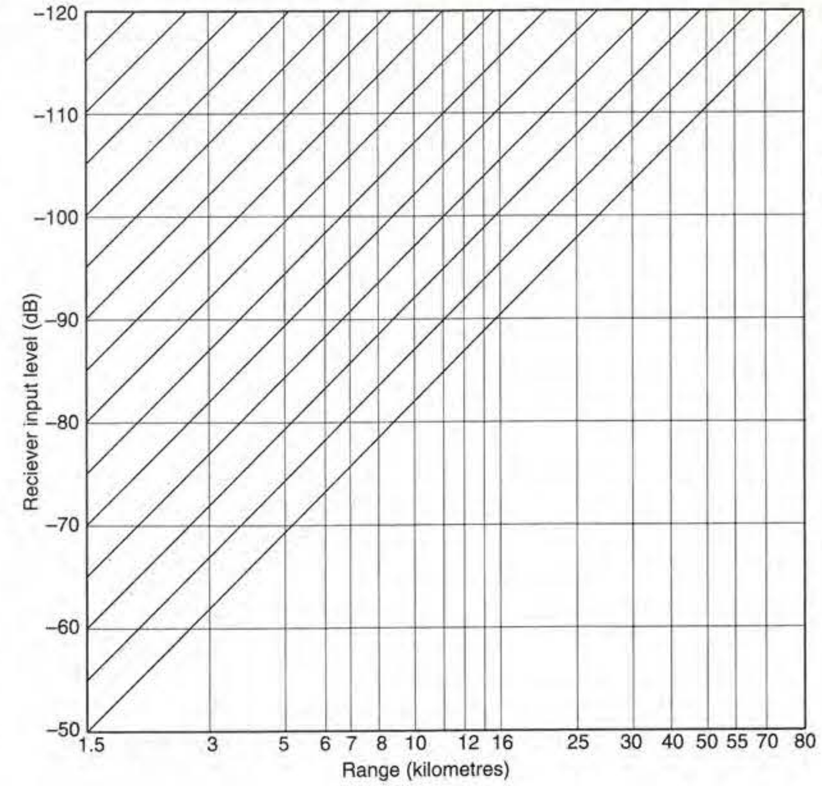
The radio range can be calculated by subtracting the factors causing the attenuation of the signal from the transmitter power. These include losses due to the antenna configuration, losses due to the terrain over which the signal will pass and the loss caused by the antenna feeder cable.

The propagation of the signal will depend on the height at which the receiver and transmitter antenna is above the ground. The higher the antenna the better the propagation.

Figure 1 correlates the height of both antennas to the expected propagation loss. The left and right scales give the height of the transmitter and receiver antenna. By placing a ruler between the two, a propagation loss can be estimated for any combination of heights.

Losses caused by the terrain can be estimated at around 50dB in open country or over water. This would be considerably more if the transmission path was to pass through buildings.

By subtracting all the propagation losses from the power irradiated from the transmitter, the required sensitivity at a near distance can be determined. The diagonal lines in **Fig. 2** can then be used to determine the required receiver sensitivity at any given distance from the transmitter.



This chart is for finding the required receiver sensitivity at any distance from the transmitter.

For example, if a licence exempt MPT1329 radio, radiating 500mW (27dBm) was transmitting at full power and both transmitting and receiving antenna were at 12 meters high, then from Fig. 1 the antenna propagation loss would be 55dB. If five meters of low-loss coaxial cable was used to connect the antenna to the transmitter and to the receiver there would be a further loss of 2dB.

Receiver sensitivity is the transmitter power minus propagation, terrain and antenna feeder losses. At approximately 1.5 kilometres would be –80dB assuming a 27dBm transmission, 55dB propagation loss, 50dB terrain loss and 2dB loss due to the antenna feeder.

Using the diagonal lines in **Fig. 2** the required sensitivity of the receiver starting at –80dB can then be obtained at any distance from the transmitter. The maximum range using this configuration would be around 16 kilometres, given that the sensitivity of the receiver was as good as –120dBm.

Installation criteria

Where ever possible, it is important to beam the rf signal by using a directional Yagi antenna. This reduces interference from other users that might be on the same channel. It also prevents the transmitter radiating its signal over more area than it needs to.

Yagi antennas have a specified power gain. Therefore the transmitting power must be adjusted to conform with both the licence exempt regulations and the power to which the transmitter has been type approved.

If care is not taken to make this adjustment then both the rf power and the spurious emmissions will be amplified. This will cause rf pollution over the band, rendering nearby channels inoperable.

Before installing a licence exempt radio system it is also important to check that the intended channel is free. Most receivers have a relative signal strength indication (rssi). This gives a voltage output if the rf channel is in use. Hence a voltmeter can be used to check that no other signal is being transmitted on the frequency.

When a free channel has been found the receiver rssi signal can then be used to check the signal strength of the distant transmitter signal. This also provides a good method of finding the best position for the antenna and checking its alignment.

In summary

Low power, licence-exempt data radio is a powerful alternative to wire over short and medium ranges. The cost compares well with dedicated telephone lines, data cabling in buildings and communicating with moving machinery. Added to this are the low cost of installation and physical flexibility afforded by radio communications. ■

Roger Simms is a director of Warwick Industrial Electronics Ltd.

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HP8601A Sweep generator .1-110Mc/s £300.
HP8349A Microwave Amp 2 - 20GHz Solid state - £1500.
HP1980B Oscillascope measurement system - £300.
HP3455/3456A Digital voltmeter - £400.
HP5370A Universal time interval counter - £1k.
HP5335A Universal counter - 200Mc/s-£500.
HP5328A Universal counter - 500Mc/s - £250.
HP6034A Power supply -0-60V-0-10 amps - £500.
HP3710A 3715A-3716A-3702B-3703B-3705A-3711A-3791B-3712A-3793B microwave link analyser.
HP3552A Transmission test set - £350.
HP3763A Error detector - £500.
HP3764A Digital transmission analyser - £600.
HP3770A Amp delay distortion analyser - £400.
HP3770B - £450.
HP3780A Pattern generator detector - £400.
HP3781A Pattern generator - £400.
HP3782A Error detector - £400.
TEKTRONIX 577 Curve tracer + adaptors - £900.
TEKTRONIX 1502/1503 TDR cable test set - £400.
Racal 1991-1992-1998 - 1300Mc/s counters - £400-£900.
Fluke 80K-40 high voltage probe in case - BN - £50-£75.
EIP545 micorwave 18GHz counter - £1200.
Fluke 510A AC ref standard - 400Hz-£200.
Fluke 355A DC voltage standard - £300.
Wiltron 610D Sweep Gen + 6124C PI-4-8GHz-£400.
Wiltron 610D Sweep Generator +61084D PI - 1Mc/s - 1500Mc/s £500 - 10 Mc/s - 18GHz - £1000.
HP8699B Sweep PI YIG oscillator .01 - 4GHz - £300. 8690B MF-£250. Both £500.
Dummy Loads & Power att up to 2.5 kilowatts FX up to 18GHz - microwave parts new and ex equipt - relays - attenuators - switches - waveguides - Yigs - SMA - APC7 plugs - adaptors etc. qty. in stock.
B&K Items in stock - ask for list.
Power Supplies Heavy duty + bench in stock - Farnell - HP - Weir - Thurlby - Racal etc. Ask for list. Large quantity in stock, all types to 400 amp - 100Kv.
Marconi 2955 Radio Test set - £1800.
Marconi 2955 + 2958 Tacs radio test set - £2000.
Marconi 2955R Radio test set - £2000.
Marconi TF2015 S/G 10Mc/s - 520Mc/s AM/FM - £100.
Marconi TF2016A S/G 10Kc/s-120Mc/s. AM/FM - £100.
Marconi TF2171 Digital syncronizer for 2015/2016 - £50.
Marconi TF2017 S/G .01-1024Mc/s. AM/FM. High grade - low noise - LED readout. - £1k.
Marconi TF2018 S/G 80Kc/s-520Mc/s. AM/FM - £600.
Marconi TF2018A S/G 80Kc/s-520Mc/s. AM/FM - £800.
Marconi TF2019 S/G 80Kc/s-1040Mc/s. AM/FM - £1000.
Marconi TF2019A S/G 80Kc/s-1040Mc/s. AM/FM - £1250.
Marconi TF2022E S/G 10Kc/s-1.01GHzs. AM/FM - £1250.
Marconi TF2022E As above but as new + Cal cert - £1500.
Marconi TF6311 Microwave Sweep S/G 10Mc/s - 20GHz c/w TF6501 amplitude Anz. plus heads 10Kc/s-20GHz. Heads available to 40GHz - £4000.
Farnell S/G ESG1000 10Hz-1000Mc/s. AM/FM - £800.
IFR 1200S Communications radio test set - £2500.
TF2370 Spectrum Anz's 30Hz-110Mc/s. Large qty to clear as received from Gov - all sold as is from pile complete or add £100 for basic testing and adjustment. Callers preferred - Pick your own from over sixty units.
A. Early Model - Grey - Rear horizontal alloy cooling fins - qty of 5 - £750 lot - singly - £200.
B. Late Model - Grey-Vertical alloy cooling fins - £300.
Marconi TK2373 Extender to 1.25GHz - £300 - £400.
HP3325A Synthesized function generator - £1000 - £1500.
HP3325B Synthesized function generator - £2500.
HP8405A Vector voltmeter - late colour - £400.
HP8508A Vector voltmeter - £2500.
HP8505A Network Anz 500KHz-1.3GHz - £1000.
HP8505A + 8502A or 8503A test sets- £1200 - £1500.
HP8505A + 8502A or 8503A + 8501A normalizer - £1750-£2000.
HP8557A .01Mc/s-350Mc/s - **8558B** 0.1-1500Mc/s - **8559A** .01-21GHz 180T or 180C-D-T £500 - £2000.
TEK492 Spectrum Anz-OPT 2-50Kc/s-21GHz - £2.5k.
TEK492P S.A. opt 1-2-3-50 Kc/s - 21GHz £4k.
TEK495 S.A. 100Hz - 1.8GHz - £3k.
TEKTRONIX - **HP Oscilloscopes** - 100Mc/s-465-465B-1740-1741 etc - £300 - qty in stock.
Phillips 3217 50Mc/s oscilloscopes - £150-£250.
Phillips 3296 350Mc/s IR remote oscilloscope - £750.

Hitachi VC6041 Dig storage oscilloscope - 40Mc/s - £500.
TEK2430A Dig storage oscilloscope 100Mc/s - £2000.
TEK2440 Dig storage oscilloscope 400Mc/s - £2200.
TEKTRONIX 2245A Oscilloscope 100Mc/s - £500.
TEKTRONIX 2445 + DMM - 250Mc/s - £800.
TEKTRONIX 2445A - 150Mc/s - 4 CH - £800.
Schaffner NSG 200E Mainframe - NSG203A low volt var simulator - NSG22A. Interface simulator - NSG226 Data line simulator - all six items at £1500.
Schaffner NSG200E - NSG203E low volt var simulator - NSG222A Interface simulator - all three - £1000.
LIGHT AND OPTICAL EQUIPMENT
Anritsu ML93A & Optical Lead Power Meter.
Anritsu ML93B & Optical Lead Power Meter.
Power Sensors for above **MA96A - MA98A - MA913A** - Battery Pack **MZ95A.**
Anritsu MW97A Pulse Echo Tester.
PI available - **MH914C 1.3 - MH915B 1.3 - MH913B 0.85 - MH925A 1.3 - MH929A 1.55 - MH925A 1.3GI - MH914C 1.3SM.**
Anritsu MW98A Time Domain Reflector.
PI available - **MH914C 1.3 - MH915B 1.3 - MH913B 0.85 - MH925A 1.3 - MH929A 1.55 - MH925A 1.3GI - MH914C 1.3SM.**
Anritsu MZ100A E/O Converter.
+ MG912B (LD 1.35) Light Source + MG92B (LD 0.85) Light Source
Anritsu MZ118A O/E Converter.
+MH922A 0.8 O/E unit + **MH923 A1.3** O/E unit.
Anritsu ML96B Power Meter & Charger.
Anritsu MN95B Variable Att. 1300.
Barr & Stroud LS10 Light Source.
BT Power Unit 850 - 1300 - 1500.
Photo Dyne 1950 XR Continuous Att. 1300 - 1500.
Photo Dyne 1800 FA. Att.
NKT Electronic QAM30 Att Meter (MN3032TX) 1300 out.
Electo Optic Developments FO-500 TX Laser.
Cossor-Raytheon 108L Optical Cable Fault Locator 0-1000M 0-10kM.
Intelco 220 Single Mode Att 1532.
TEK P6701 Optical Converter 700 MC/S-850.
TEK Orionics 7000 Type PI OTDR-103A.
HP81512A Head 150MC/S 950-1700.
HP84801A Fibre Power Sensor 600-1200.
HP8158B ATT OPT 002+011 1300-1550.
HP81519A RX DC-400MC/S 550-950.
STC OFTX-3 Laser source.
STC OFRX-3.
STC OFR10 Reflectometer.
STC OFSK15 Machine jointing + eye magnifier.
Anritsu ME453L RX Microwave ANZ.
Anritsu ME453L TX Microwave ANZ.
Anritsu MS420B Network Spectrum ANZ.
Anritsu MH370A Jitter Mod Oscillator.
Anritsu MG642A Pulse Patt Gen.
Complete MS65A Error Detector.
System MS02A Timer & Digital Printer.
Anritsu ML612A Sel Level Meter.
Anritsu MS2802A Spectrum ANZ 100Hz-32GHz.
Anritsu ML244A Sel Level Meter.
Advantest TR98201 Signal Gen.
Advantest TR9402 Digital Spectrum ANZ.
Siemens D2108 Level Meter.
Siemens D2150 Bit Error Meter.
W&G PCM3 Auto Measuring Set.
W&G SPM14 Sel Level Meter.
W&G SPM15 Sel Level Meter.
W&G SPM16 Sel Level Meter.
W&G PS19 Level Gen – £1k.
W&G DA20+DA1 Data ANZ.
W&G PMG3 Transmission Measuring Set.
W&G PSS16 Generator.
W&G PS14 Level Generator.
W&G EPM-1 Plus Head Milliwatt Power Meter – £450.
W&G DLM3 Phase Jitter & Noise – £500
W&G DLM4 Data Line Test Set – £750.
W&G PS10 & PM10 Level Gen.
HP8660C S/G AM/FM - Phase • 01-110MC/s - 1300MC/s - 2600 MC/s £1-£2k.
HP4274A LCR Meter + Adaptor.
HP8566A High Performance S.A. - 100Hz - 2.5GHz - 2GHz - 22GHz - 300 GHz with mixers.
HP8754A Network ANZ 4-1300MC/s + 8502A + cables.
HP8754A Network ANZ H26 - 2600MC/s + 8502A + cables.
HP8116A Pulse function Gen £2200.
HP3588A S.A. 10Hz - 150MC/s opt 001-003.
HP54100A DIG Oscilloscope 1GHz - P.O.R.
HP54200A DIG Oscilloscope 1GHz - P.O.R.
HP54501A DIG Oscilloscope 100MC/s - P.O.R.
R&S CMTA 54 Radio Comms. ANZ - 0.1 - 1000MC/s – £4k.
R&S PSA 5 Process Controller 1006-3008. 02.
TEK TDS360 200 MC/s Oscilloscope. £1750.
TEK OF150 Fibre Optic TDR.
MAR S/G 2022D 10KC/s - 1GHz - White - £1650.
MAR S/G 2022C 10KC/s - 1GHz - £1400.
HP1630-1631-1650 Logic ANZs.
BELLING LEE rayproof screened rooms.
Size: 16ft x 10ft x 8ft, 12ft x 8ft x 8ft – all inc lighting plus fans.

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PASSIVE AND ACTIVE COMPONENTS

Arrays

Mosfet arrays. Two low-voltage mosfet arrays from Rohm, *UM5K1N* and *UM6K1N*, are meant for interfacing and switching at up to 30V and 0.1A. Each device has two mosfets in one UMT package with a built-in free-wheeling diode for protection against static, no external protection device being necessary. A silicon n-channel structure provides $R_{DS(on)}$ down to 5Ω, total power dissipation is 150mW and drain/source and gate/source voltages are 30V and ±20V.
Rohm Electronics UK Ltd. Tel., 01908 282666; fax, 01908 282528; web, www.rohm.co.jp.
Enq no 501

960-macrocell, 6ns cpld. *CoolRunner 960* by Philips is said to be the first complex programmable logic device to offer 960 macrocells and to exhibit propagation delays of 6ns – twice as fast as an fpga. The *960* is a true cpld with a 36-wide logic input connecting to variable-configuration registers. The device consists of 12 *Fast* modules of 80 macrocells, connected by a global zero-power interconnect array, each macrocell being preceded by wide-combinatorial logic. Philips' *Fast Zero Power* technique is responsible for the speed and density and also for the fact that devices use zero power in stand-by, reducing a normal cpld's static current of around 250mA to 100μA from 3V. Software support is available.
Philips Semiconductors (Eindhoven). Tel., 00 31 40 2722091; fax, 00 31 40 2724825, web, www.semiconductors.philips.com.
Enq no 502

Connectors and cabling

Small, filtered D connectors. Cambridge Connectors can supply a range of miniature D connectors, in which each pin is decoupled to ground by 1nF or other capacitances on request; capacitance does not have to be the same for each pin. Connectors come in 9, 15, 25 and 37 ways, the straight or right-angled pins being gold-plated and the shells tin-plated steel.
Cambridge Connectors Ltd. Tel., 01223 860041; fax, 01223 863625
Enq no 503

Board-mounted receptacle. WW Fischer's range of right-angled, board-mounted connectors now includes a *19-way receptacle*, extending capability from 2-7 contacts in a 9mm diameter shell to 10-19 in a 14mm shell. Pins are already formed and kept in alignment with a spreader pad, the pins being of different lengths to ease assembly. Correct mating is ensured by a locking technique involving an external collar which must be operated before release. Contacts are rated at 1.8A at 20°C; isolation is 1.2kV rms contact/body and 900V rms contact/contact/.
WW Fischer Electrical Connectors Ltd. Tel., 01705 241122; fax, 01705 257596; E-mail, sales@fischerconnectors.co.uk; web, www.fischerconnectors.co.uk
Enq no 504

Crystals

Small resonators. Murata has a new range of *Ceralock* piezoceramic resonators that are 55% smaller than others in the range, being only 1mm high and having a footprint of 3.7 by 3.1mm, integral load capacitors affecting the height. The *CSACV* and *CSTCV* families are for use at frequencies from 8MHz to 60MHz, with initial tolerances of ±0.5%, temperature stability and ageing varying with the type. Both are suitable for reflow soldering and ultrasonic cleaning.
Murata Electronics (UK) Ltd. Tel., 01252 811666; fax, 01252 811777.
Enq no 505

Data converters

8/10-bit dual-channel a-to-ds. Analog has introduced the *AD9281* (8-bit) and the *9201* (10-bit) dual-channel, 20Msample/s, cmos analogue-to-digital converters. Both have input buffer amplifiers, a voltage reference and multiplexed digital output buffers and are meant mainly for use in applications where close matching of two a-to-ds is needed. All a-to-ds have a simultaneous sampling s/h amplifier and, since the inputs are buffered, no external buffering is needed in most applications. Both devices work on a single 2.7V-5.5V supply, take single-ended or differential inputs and use 175mW from 3V. Signal:noise ratio is 49dB(*9281*)/56dB(*9201*), at 1MHz, sfdr –62dB, sinad 49dB/55dB and thd –60dB/–61dB.
Analog Devices Ltd. Tel., 01932 266000; fax, 01932 247401.
Enq no 506

Fast, 10-bit a-to-ds. Signal Processing Technologies claims its *SPT7870/1* analogue-to-digital converters to be the fastest available, providing 10-bit performance at 100Msample/s, the *7870* accepting ecl and positive ecl, and the *7871* taking high-speed ttl. Both use a two-stage, sub-ranging format, incorporating a 3-bit flash msb conversion stage and an 8-bit interpolating folder conversion, digital error-correction logic combining the outputs of both to give the 10-bit digital output. The devices work on ±5V, with a –1V to 1V input range.
Signal Processing Technology. Tel., 01932 254904; fax, 01932 254903.
Enq no 507

Digital signal processors

Digital de-skewers. From Vitesse Semiconductor comes a line of low-cost digital 125MHz de-skew ics, intended for use in automatic test gear. *VS6280/81/82* devices will independently adjust delay in eight signals over 6ns to a resolution of 6ps, compensating for path-length differences in shared-resource equipment. Rising and falling signal edges are adjusted to correct pulse-width distortion and there is no requirement for external d-to-as. Further improvement in timing accuracy may be achieved by placing the timing generator on the same board as the de-skewer. Packaging is 128-pin pqfp.
Broadband Technology 2000Ltd. Tel., 01494 474800; fax, 01494 443100; e-mail, 100616.3040@compuserve.com.
Enq no 508

Displays

12.1in tft lcd. Hitachi's *TX31D27VC1CAB* is the snappy title of a new, high-brightness, colour, thin-film transistor lc display. It is an svga active-matrix type showing 256 colours with a display area of 246 by 184.5mm, having a cmos interface. Contrast ratio is 150:1 and brightness 150cd/m². Total power consumption, including that of the backlight, is 3.4W from a single 3.3V supply.
Hitachi Europe Ltd. Tel., 01628 585163; fax, 01628 585160.
Enq no 509

Hardware

Versatile range of power sockets. Interpower Components can supply a range of panel-mounted, multi-function power-entry modules. They come in a variety of styles to fit short, wide or tall, narrow panel spaces, and may be fitted with fuseholders of several types, voltage selectors for 100-120V or 220-240V, or switches. There are also circuit breakers, models with outlets for accessories and built-in filters to meet IEC950. Units may be specified for medical use.
Interpower Components Ltd. Tel., 01243 842323; fax, 01243 842066.
Enq no 510

Motors and drivers

Custom stepper/encoders. Sanyo Denki stepper motors, available from EAO, are available with motor shafts modified in a number of ways and with Hewlett-Packard *HEDS* optical encoders. Shafts may have standard flats, pinions can be cut into them and they may have customer-specified pulleys; the encoders will produce 500 or 360 pulses per revolution. High-current and high-torque motors are also available, examples being a 4A/phase size 23,single-stack motor with 1.3Nm holding torque.
EAO Ltd. Tel., 01444 236000; fax, 01444 236641; e-mail uksales@eao.com; web, www.eao-group.com.
Enq no 517

Linear integrated circuits

10-bit, 170MHz d-to-a. *AD9731* by Analog Devices is a 10-bit, 170Msample/s bipolar digital-to-analogue converter giving a large dynamic range, 453mW dissipation and a lower cost than other bipolar d-to-as. The design is optimised for direct digital synthesis waveform reconstruction, providing 55dB of spurious-free dynamic range at 40MHz and 50dB wideband harmonic suppression over a 0-65MHz analogue output bandwidth; narrow-band performance is 79dB sfdr, centred at 2MHz. Package is a 28-pin ssop.
Analog Devices Ltd. Tel., 01932 266000; fax, 01932 247401.
Enq no 511

Materials

Front-panel labelling. A two-part, chemical-free process from Mega Electronics, *Quick-mark*, is a durable, self-adhesive labelling system for quick production of front panels, nameplates and the like. The required image is created or copied onto a translucent background and an imaging film made in uv light; after exposure, the film is placed on an adhesive-covered board and the two peeled apart. Either part can be

laminated onto a plastic or metal base sheet, available in several colours, the label being self-laminating if the emulsion side of the film is on the underside. If not, laminating films are available.
Mega Electronics Ltd. Tel., 01223 893900; fax, 01223 893894.
Enq no 512

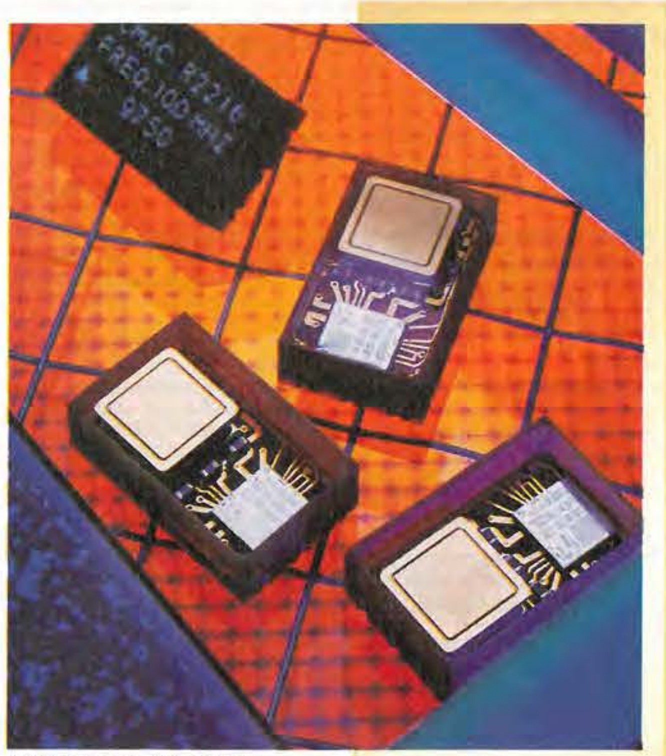
Bendy ferrite film. (Since 'flexible' has been perverted to mean 'versatile', one must now say 'bendy' to avoid misunderstanding). Siemens' range of ferrite polymer composite films now includes *C351*, which is meant for high-temperature use and which may be made self-adhesive or copper-coated. It is usable at up to 200°C and is available in thicknesses of 0.2-0.4mm with copper coating of 35-100µm thickness and may be used for emc applications or coil shielding, or to form flat coil cores in sensors and contactless cards.
Siemens plc. Tel., 0990 550500; fax, 01344 396721.
Enq no 513

Conductive heat-shrunk tubing. Methode's *shrinkMate* heat-shrink tubing provides a simple electrical connection between the external surfaces of coaxial cables or between cables and shielded housings. It consists of MIL Std R-46846 polyolefin tube with an inner coat of silvered thick-film polymer, which shrinks to half its original diameter when heated. The material may also be used to make connections between components of other shapes and sizes or between solderable and non-solderable stamped metal, plated metal or surfaces coated with shielding paint. Diameters available are 0.25-1in in lengths of 1in-4ft.
Surtech Distribution Ltd. Tel., 01256 840055; fax, 01256 479785
Enq no 514

Microprocessors and controllers

32-bit risc controllers. NEC's *µPD70300x* is a family inside the *V850* series of 32-bit single-chip microcontrollers and has a 32-bit risc cpu, a choice of ram/rom sizes, an interrupt controller, a real-time pulse unit, data converters and serial interface. Cycle times are down to 33ns at 33MHz to give 38mips and the cpu has a 32 by 32-bit g-p register and a set of 74 instructions. Rom or flash can be up to 256Kbyte and ram up to 8Kbyte; there are 123 i/o pins, two or four pwm channels, a built-in 10-bit a-to-d and an 8-bit d-to-a. Communications is taken care of by a selection of usarts, csis, I^{2}C serial ports with dedicated baud-rate generators and on-board phase-locked loops.
Sunrise Electronics Ltd. Tel., 01908 263999; fax, 01908 263003; web, www.sunrise.co.uk
Enq no 515

16-bit PICs. Three new microcontrollers from Microchip, the 16-bit *PIC17CXXX* family, show a 33MHz performance of 8.25mips. All three have 10-bit a-to-d converters and two 8.25Mb/s usarts, 16K by 16 one-time-programmable eprom program memory and up to 902 by 8byte of user ram in 64-pin and 84-pin packages. There is also a 120ns single-cycle 8 by 8 hardware multiply. All devices are code-compatible with the *PIC16XXX* and *PIC17C4X* families and are supported by v.2.10 of Microchip's *MPLAB-C17* C compiler, the *PICmaster* universal development system and *PICstart Plus* development system that has programmer, assembler and simulator software tools.
Arizona Microchip Technology Ltd. Tel., 0118 9215858; fax, 0118 9215835.
Enq no 516



Optical devices

Optocouplers. Hermetic couplers from Micropac are military qualified to Mil-std 1772 and provide High isolation voltage, high current transfer, high-speed switching and the option of multiple packages. The range is contained in TO-5, TO-18 and 8-pin and 16-pin dips in a variety of mounting choices, operating temperature being –65°C to 125°C. Faraday screening in the multiple units avoids common-mode interference and assists with radiation performance.
Advanced Power Components Ltd. Tel., 01634 290588; fax, 01634 290591.
Enq no 518

Air-cored coils. *Type SC* coils by Total Frequency Control are air-cored types in nine standard winding formats, including a surface-mounted style. The coils are made to customers' specifications for wire diameter, coil length and inside diameter using enamelled copper wire with tinned connections. Prototypes and production quantities can be produced in ten working days.
Total Frequency Control Ltd. Tel., 01903 745513; fax, 01903 742208; e-mail, eddie @ tfc.co.uk.
Enq no 523

Passive components

Chip inductors. Tekelec Temex offers two new families of chip inductor. The standard series in sizes 0603, 0805, 1206 and 1210 covers values from 0.047µH to 220µH, self-resonating at 5-260MHz, while the hf series in sizes 0603 and 0805 comes in values of 1.2-100nH to resonate at up to 6GHz.
Tekelec Temex. Tel., 01256 883340; fax, 01256 883350; web,www.tekelec-temex.com.
Enq no 520

Capacitor arrays. Saving in both space and the cost of installation, Murata's 0805 ceramic capacitor arrays contain up to four components in values from 10pF to 100nF at rated voltages of 16-50V dc.
Murata Electronics (UK) Ltd. Tel., 01252 811666; fax, 01252 811777.
Enq no 521

Linear solenoids. Linear solenoids from BLP come in a variety of sizes and types and include ac/dc, miniature, heavy duty, high force/size ratio, combined pull and thrust and low-noise types. A range of latching types incorporates permanent magnets, pulse operation making lower power operation possible and no heating. Designs may be tailored to customers' specifications.
Aerco Ltd. Tel., 01403 260206; fax, 01403 259760.
Enq no 522

Oscillators

T-c crystal oscillators. New from C-Mac is a family of surface-mounted, temperature-compensated crystal oscillators, which use an analogue asic to provide compensation rather than the bulkier and more power-hungry oven control; these units run from a 3V battery supply. The compensation circuitry recognises and corrects for sixth-order effects to provide stability of ±4.6ppm in 15 years at up to 52MHz, which is inside the Stratum III requirement for telecommunications, as is the hold-over performance for frequencies up to 16.384MHz. Ageing is down to ±0.5ppm in the first year, hermetic sealing in a metal-capped case excluding stability-degrading contaminants. A frequency-control pin is provided for residual ageing correction or to allow use of the oscillator in a voltage-controlled circuit.
C-MAC Quartz Crystals Ltd. Tel., 01279 626626; fax, 01279 454825.
Enq no 519

Power semiconductors

Solenoid and valve driver. In Burr-Brown's *DRV101* low-side power switch, the initial complete switch-on is followed by a pulse-width-modulated state, so that solenoids, for example, that need a surge to pull in are provided with a pwm holding waveform after an adjustable interval. The device exploits this mode in its other role of proportional controller for heaters, lamps and positioners. Supply range is 9-60V dc, output drive 2.3A and pwm control input to the integral 24kHz oscillator is ttl level. It is contained in a 7-lead TO-220 or s-m plastic DDPAK.
Burr-Brown International. Tel., 01923 233837; fax, 01923 233979.
Enq no 524

Switches and relays

Microswitches. To extend the application of its *SSG* range of microswitches, Omron now makes them with custom lever designs to suit most uses and conditions. The switches themselves measure 10 by 19.8 by 6.4mm and are made with a standard pin plunger or with all the usual lever designs; external lever mounting allows the tailoring of lever design. Two types of switch provide switching of 5A at 250V ac and 0.1A at 30V dc or 125V ac.
Omron Electronics Ltd. Tel., 0181 450 4646; fax, 0181 450 8087.
Enq no 525

Transducers and sensors

Optical sensors. Matsushita's *UZD6* sensors are of the fixed-focus triangulation type and provide a sensing range of up to 70mm with a repeatability of 0.05mm, colour changing in targets or uneven surfaces having little effect. Models are available with infrared leds for long-range operation, with red leds for visible aiming, with adjustable sensitivity and with an off delay timer. They need a 12-24V supply and provide n-p-n output, the response time of which is under 0.5ms.
Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599; e-mail, info@macuk.co.uk; web, www.mac-europe.com.
Enq no 527

Small pcb relay. With two changeovers in monostable or bistable form with one or two coils, the *Siemens P2* board-mounted relay is available with coils needing 3-24V dc and gold-plated silver palladium contacts rated at 2A or 220V dc; power rating 60W. The relay stands 9.9mm above the board, is 14.6mm long and 7.2mm wide and is fully sealed to withstand board cleaning.
Easby Electronics Ltd. Tel., 01748 850555; fax, 01748 850556; web, sales@easby.co.uk.
Enq no 526

EQUIPMENT

Power supplies

Step-down power controller. As part of a two-chip power supply for notebook computers, National announces the *LM2640* synchronous step-down controller with dual outputs adjustable between 2.2V and 6V, a 5V/50mA linear regulator and a 2.5V reference, the regulator serving as a backup to stay in operation even when the controllers and reference are down. Regulation is obtained by a current-mode feedback control, providing 0.002% error-rate line regulation and 0.5% load regulation. Protection includes programmable soft-start, thermal shutdown and under/overvoltage latch-off. Input needed is 5.5-30V and switching rate is 200kHz or, optionally, 400kHz, synchronised to an external source.
National Instruments UK. Tel., 01635 572400; fax, 01635 524395. europe.support@nsc.com
Enq no 528

Small, 30W switchers. Traco's new *TPM* series of universal ac-input switched-mode power supplies are quite a bit smaller than the average, yet put out up to 30W. The units are CE-marked and come in board-mounted or chassis types; they are potted and further encased in non-conductive material. There are four ranges, from 5W to 30W, each with single, dual and triple output at voltages of 5-24V dc in various arrangements. Short-circuit and overload protection is present and rfi/emi characteristics are to EN55011 level B.
XP plc. Tel., 0118 9845515; fax, 0118 9843423. E-mail, sales@xpplc.co.uk; web, www.xpplc.co.uk
Enq no 529

Test and measurement

Recording oscilloscope. In addition to providing the functions of a 200MHz digital storage oscilloscope, the Gould *DataSYS 7200* fast recording oscilloscope is also able to capture signals such as 10ns glitches, recording direct to disk; and to record to disk in a 12-bit mode or output to paper by means of an integral plotter. The instrument can search for timing errors in logic circuitry, measure power dissipation and performance of high-voltage switching devices and record lf effects such as strain and temperature. Other features include input scaling, fast Fourier analysis, trending and histogram presentation and a colour display. Several serial and parallel interfaces, with software, are provided for data transfer to a pc.
Gould Instrument Systems Ltd. Tel., 0181 500 1000; fax, 0181 501 0116; web, www.gould.co.uk.
Enq no 530

Logic analyser with analogue display. TTi's *LA4800* 48-channel, 100MHz logic analyser has been enhanced by the addition of an analogue display to allow the output from 8-bit data converters to be viewed while the state listing is also displayed. Multi-level triggering provides event counting, branching or restart on each level and up to four sequencer words may be used, each term being the logical combination of any number of words, including Nots. Any word or block may be located in any memory and the acquisition may be stopped on an equality or inequality. Optional disassembler pods support a range of 8-bit and 16-bit microprocessors, each pod containing its own software.
Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409.
Enq no 531

Calibrator. For calibration and maintenance in process plant and production, Yokogawa's *CA100* calibrator, which is paperback-sized, supplies direct voltage and current at 1µV-10V and 1µA-22mA, sinusoidal and pulse frequency to 50kHz and resistance (10mΩ-55kΩ) calibration standards. It simulates a range of thermocouple and resistive temperature sensors and it also measures direct current and voltage. There is a 24V dc power supply available for transmitters and transducers. Overall accuracy is within 0.02%. The liquid-crystal display simultaneously shows output from the calibrator and the measured input. An RS-232 interface is included.
Martron Instruments Ltd. Tel., 01494 459200; fax, 01494 535002. E-mail info@martron.co.uk; web www.martron.co.uk
Enq no 532

Four-channel waveform recorder. Latest in the Hioki *8830* series of waveform recorders is the *8835 Memory Hicorder*, which possesses a 6.4in colour lc display, a Type III card slot and floppy disk drive. The card slot enables the use of up to 32Mbyte of sram, hard-disk cards and flash ata cards of up to 500Mbyte capacity, together with i/o cards for GPIB or RS-232 interfaces. Four analogue waveforms and 16 logic waveforms may be monitored and recorded at 1Msample/s and 12-bit a-to-d resolution.The whole thing occupies the area of a copy of *Electronics World*.
Telonic Instruments Ltd. Tel., 01734 786911; fax, 01734 792338.
Enq no 533

Surface resistance measurement. *Auto-Sir* by Concoat Ltd measures the real surface insulation resistance of a board or assembly to predict reliability, rather than simply determining which contaminants, such as the residue of no-clean flux, solder masks and the like, are present. Normally, a special board with a comb pattern of copper is used, but it is also possible to conduct the measurement on a real board, although at somewhat lower accuracy. Voltage applied is 50V and the result is presented in ohms per square. *Auto-*

H8S evaluation board. An evaluation board by Hitachi, the *EVB2655* for the company's H8S 16-bit microcontrollers, has an *H8S/2655* microcontroller running at 20MHz, fully configured and having all the features of the rest of the *H8S* family, so that the board may be used to develop applications for the other devices in the series. The board has 256Kbyte of expandable sram, an RS-232 link to a pc, a reset mode, nmi control and user and power leds. All i/o is available to the user. Included are documentation, and a tutorial cd-rom, software including an IAR C compiler, HDI Windows C debugger and GNU C compiler and C debugger.
Hitachi Europe Ltd. Tel., 01628 585163; fax, 01628 585160.
Enq no 538

Please quote *"Electronics World"* when seeking further information

Sir has been selected by the Design Council for display in the Millenium Dome. *Concoat Ltd. Tel., 01276 691100; fax, 01276 691227. E-mail, graham.naisbitt@Concoat.co.uk*
Enq no 534

COMPUTER AND DATA HANDLING

Computer board-level products

Pentium II main board. Soyo's *SY-6KM* mother board uses a 233-333MHz Pentium II processor, the high-speed AGP graphics interface and three 168-pin dimm sockets, which support up to 384Mbyte of sdram or 768Mbyte of EDO dram. It is made in the MicroATX form intended for compact or entry-level systems. Two 32-bit PCI bus mastering slots and two standard ISDA slots, with two USB ports provide system expansion, two serial and one parallel port and a PS/2 mouse connector are provided, as are disk drive ports and an infrared port. *Soyo UK Ltd. 0181 481 9720; fax, 0181 481 9725.*
Enq no 535

Pcb layout. *Electronics Workbench Layout* by Image Technologies may be used on its own or with Electronics Workbench design and simulation software to transfer simulated designs to a multi-layer printed board. Its list of facilities includes real-time design-rule checks, autorouteing and an interactive editor to make new components or very existing ones. Any board shape can be used and modified during the design process, components from the 3500-strong library may be rotated or placed on the other side of the board and placed using absolute or relative coordinates; users may also make their own components. High completion is claimed for the autorouter, which uses "via reduction" to reduce the number of through holes and "force vectors" to find the best component positions for minimum trace lengths and board sizes.
Adept Scientific Micro Systems Ltd. Tel., 01462 480055; fax, 01462 480213; e-mail, info@adeptscience.co.uk; web, www.adeptscience.co.uk.
Enq no 541

Data acquisition

Thermocouple and voltage inputs. Keithley's *DAS-TC/B* plug-in board for a pc accepts both voltage and thermocouple input, to any mixture of 16 differential inputs, without external conditioning and at up to 100sample/s. For temperature, there are 16 differential inputs and a cold-junction channel, supporting J, K, T, E, R, S and B thermocouples, providing accuracy to within ±0.5°C. An on-board *v*-to-*f* converter provides stable readings in the presence of noise, signal conditioning including calibration, gain setting, linearisation and conversion to degrees or volts is provided.The 16 differential inputs give four voltage ranges covering measurements of –6.25mV to 10V. Software support includes 16-bit and 32-bit Windows 95 dll drivers for programming in VBasic, C and C++ and Turbo Pascal.
Keithley Instruments Ltd. Tel., 0118 575666; fax, 0118 596469.
Enq no 536

Development and evaluation

Am186CC development. Beacon Development Tools has complete Windows 95 development support for AMD's 50MHz, 3.3V, *Am186CC* embedded processor. *BeaconSuite 186* supports full C/C++ development with Microsoft v.1.52 and Borland v.5 compilers, while the VisualProbe debugger has three operating modes: simulation, remote and in-circuit, with the dame graphic interface for all. The QED emulator works with all key features of the 186 such as direct support for the internal dram controller and execution from 4-50MHz clocks at 3.3V, tracking execution memory from chip-select defined space to dram to allow breakpoint and execution tracing. Trace memory is 64K bus instruction cycles deep.
Beacon Development Tools Ltd. Tel., 0117 987 0444; fax, 0117 986 0401; e-mail, sales@gwg.co.uk; web, www.beacontools.com
Enq no 537

Programmers

Field programmer. For operation either alone in the field or with a pc, the *Stag P301* hand-held programmer supports a range of devices from the major makers. Running from mains or battery, the *P301* has 1Mbyte of ram as standard with the option of expansion to 8Mbyte. Eproms, eeproms, flash, cmos proms and serial eeproms in 8, 16 and 32-bit form are all supported in 8, 24, 28, and 32-pin dips on 0.3in or 0.6in pitch, adaptors taking plcc, soic and tsop packs. Windows or dos software is available to enable the programmer to be used remotely from a pc. *Farnell Components Ltd. Tel., 0113 263 6311; fax, 0113 263 3411, web, www.farnell.com.*
Enq no 539

Gang programmer. HiLo Systems UK's new *GANG-08* universal programmer has eight sockets to take up to eight plug-in heads, allowing the programming of devices in dip, sdip, plcc, soic, ssop, tsop and qfp packages and various pin counts. Support for new devices, needing both standard and low-voltage supplies, expands continuously. There is a fast cpu and an expandable 1Mb memory, a serial port connecting to a pc running Windows 95 or 3.1.
Smart Communications. Tel., 0181 953 9292; fax, 0181 953 9299. E-mail, Sales@Smartcom.co.uk. Web, www.Smartcom.co.uk
Enq no 540

Software

Pcb development. INCASES Engineering has *THEDA v. 5.2*, which is for the design of printed circuit boards, multi-chip modules and hybrids from schematic entry, through interactive and automatic placement and routeing and emc analysis, to manufacturing. CE-Router performance, memory use and routeing algorithms, used for both interactive and automatic routeing, have been improved, automatic routeing times being reduced by approximately 65%, while completion rates and routeing topologies have also been improved; routeing operations take approximately 50% of the time previously taken.The introduction of new 'escape' algorithms within a 'fan-out' pass of the CE-Router enables THEDA to perform high-class routeing of complex and tight arrays of pins as found on ball-grid arrays, flip-chips and some complex connectors.
Incases Engineering GmbH. Tel., 01473 273300 Fax, 01473 274333 E-mail: 100736.1475@compuserve.com
Enq no 542

PUBLICATIONS

Catalogues

Flexible heaters. Elmwood Sensors makes flexible (as in bendy, not versatile) heaters and has a 6-page brochure, with a sample heater, to describe them and to describe selection. Options available are wire-wound, printed etched foil and ITO resistive coated types, all on materials including Kapton silicone, polyester and glass fibre. Heaters with thermostatic control can be arranged.
Radiatron Components Ltd. Tel., 01784 439393; fax, 01784 477333.
Enq no 543

Communications ics. In over 650 pages, TDK's free data book of communications devices, also available on cd-rom, gives full information on a range of embedded modems, microcontrollers, Ethernet and Fast Ethernet, atm/wan transceivers, analogue tone signalling and set-top boxes of various types.TDK *UK Ltd. Tel., 0181 443 7061; fax, 0181 443 7022; e-mail, europe.sales@tsc.tdk.com; web, www.tsc.tdk.com*
Enq no 544

Filtered connectors. FCI has a brochure on a range of circular *Cristal Clear* planar filter connectors, which consist of a planar, metallised ceramic capacitor and ferrites, the assembly attenuating by 55dB at 1GHz. *FCI UK Ltd. Tel., 01582 814800.*
Enq no 545

Battery protection devices. *Circuit Protection for Batteries Applications Databook* from Raychem provides assistance on the selection and use of *PolySwitch* overtemperature and overcurrent protection devices for batteries and packs.
Raychem Ltd. Tel., 0800 968626 (free); fax, 0800 968627; web, www.Raychem.com.
Enq no 546

Murata from Anglia. Anglia has recently taken on the range of components made by Murata and now has a short catalogue, in which are described capacitors, inductors, resonators, sensors, sounders and suppressors. It contains all electrical and mechanical details and, if all else fails, there is a team of people ready and willing to leap to your assistance.
Anglia. Tel., 01945 474747; fax, 01945 474849. E-mail, angliac.co.uk.
Enq no 547

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RLH11 Reprints of latest Amplifier articles £1.80
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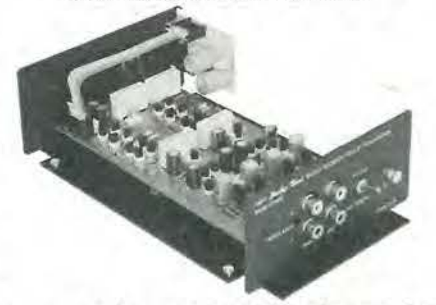

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CIRCLE NO. 134 ON REPLY CARD

Antennas from co-ax

Antennas built from coaxial cable are easy to implement, can be matched using the same coaxial cable wired as baluns and give a good compromise between gain and size. Dominic DiMario explains.

The type and number of designs concerning antennas and related components is bewildering. Yet I get the impression that there is still a lot to discover, experiment and field test – especially now that computers provide a means of optimising complex antenna designs.

Using coaxial cable as part of the radiating element of an antenna goes back many decades and several designs have been proposed.[1] The approach used here is to devise a dipole where the matching stub, instead of being hidden somewhere, becomes an integral part of the radiating element.

I chose citizens'-band (cb) equipment to experiment with because it can be easily found and it is relatively cheap. Also, the mechanical construction of the relevant antenna is not critical, although the size can be a problem on occasions.

Figure 1 shoes the basic approach. The stub is a short-circuited length $\ell_1=(\lambda/4)\times P$ of 50Ω coaxial cable, shorted at one end. The propagation speed factor of the cable is represented by P. This factor is 0.665 for standard solid dielectric (polyethylene) and 0.82 for the foamy type dielectric (usually polyethylene/air).

The non-coaxial part of the antenna is made with a 2mm solid copper electric cable cut to a length $\ell_2=(\lambda/4)\times 0.96$ to compensate for the proximity effect.

Although I found this antenna satisfactory when used for receiving, it had a relatively high standing-wave ratio when used in transmit mode. There are two evident drawbacks: first there is a mismatch between the 50Ω impedance of the cable and the 73Ω of the antenna. Secondly, the feed line is unbalanced while the antenna requires a balanced feed.

Solving the mis-match

One quick way to solve the mismatch problem is to connect a standard 50Ω car antenna intended for cb use in place of the non-coaxial portion of the antenna.

Under normal circumstances a ground plane is required, and the car body does just that. But with the coaxial solution it is possible to install a car antenna in an apartment or under the roof without the need of a ground plane. Eventually it worked very well, although the actual length had to be slightly shortened.

The second problem is solved by adding a balun which, believe it or not, uses coaxial cable only. This balun's design, **Fig. 2**, is often found in literature[2] and it is always shown as a 4:1 or 1:4 transmission line transformer.

But if the coaxial cables involved have all the same impedance, 50Ω in our case, there is no impedance transformation. Only an easy to make 1:1 balun is needed with practically no losses and perfect matching.

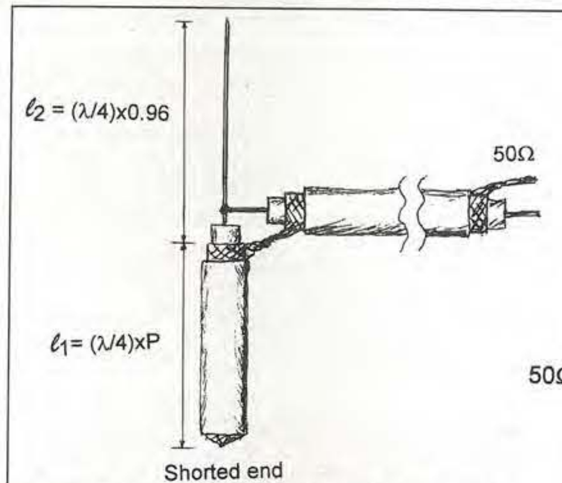

Fig. 1. In this coaxial cable antenna, the matching stub is actually half the radiating dipole. Physical length of the coaxial portion depends on the propagation speed and the frequency of operation. Unbalanced feed and the impedance mismatch limit the performance of this antenna. P is 0.665 for a solid dielectric cable.

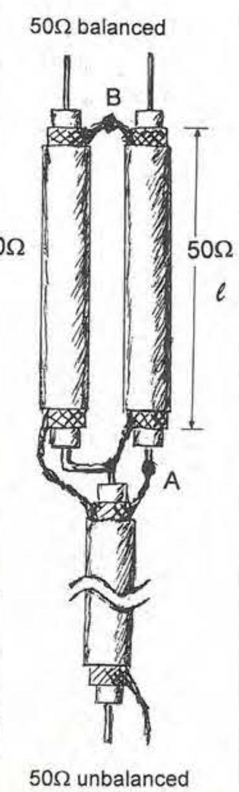

Fig. 2. When fed with a 50Ω coaxial cable, this transmission line transformer will have a 1:1 ratio, from 50Ω unbalanced to 50Ω balanced. Point A and B could be connected together. Length ℓ is always (λ/4)×P. This type of balun is effective only for a limited band around the calculated frequency. If broadband baluns are required it is better to resort to toroidal transformers.

It is worth mentioning that points A and B are at the same potential so they can be connected together thus getting a more compact balun, **Fig. 3**. Eventually the complete antenna was wired as in **Fig. 4**.

It can be placed horizontally or vertically. The standing-wave ratio is 1:1 at the band centre. Bandwidth depends on the length of the antenna in use: the longer the antenna the wider the bandwidth. With a 1.1m cb car antenna, the standing-wave ratio was 1:1.8 at ±200kHz with respect to the centre frequency of 27.185MHz.

Working at other frequencies

This set up should work fine also at other frequencies as the design can be scaled up to the low uhf range. Operation at a higher frequency could be critical due to mechanical tolerance. I made no attempt was made to apply this design at uhf.

An alternative solution to the car antenna is to use straight 2mm electric wire slightly longer than λ/4, ℓ_2=2.97m for the cb frequency of 27.185MHz, **Fig. 5**. At this length the resistive part of the antenna is 50Ω but there is also an inductive part matched by shortening the coaxial portion, now reduced to 1.32m. This gives an overall length of 4.29m.

Although it is not clear at this point if this antenna is to be considered as a matched λ/4 or an off-centre fed dipole,[3] it works quite well in practice. It has a much wider bandwidth than the car antenna mentioned earlier. It is also less critical when it comes to make the final length adjustment which is influenced by the surroundings and distance from the ground.

The suggestion here is to substitute the end of the wire with a telescopic antenna and adjust its length until the lowest standing-wave ratio is attained. It should be 1. Next solder an equal length of 2mm wire in place of the telescopic antenna and the construction is over.

Admittedly, the size of this antenna, at least for cb frequencies, does not make it very handy. Its best location could be horizontally under a roof, on a balcony or between trees, national regulations permitting.

Radio and television reception

This design is scalable to higher frequency ranges. I tested it at vhf receiving fm broadcast radio and also tried receiving a television channel transmitting at 220MHz in a fringe area.

Receiving the television channel, the result was compara-

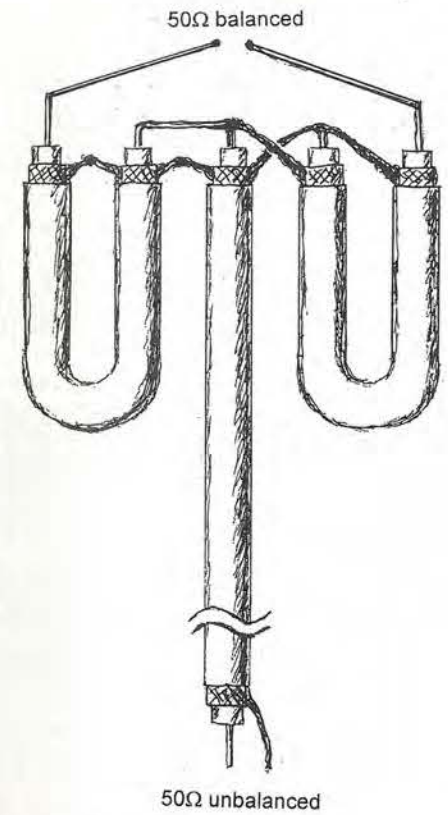

Fig. 3. This short balun is obtained by connecting A and B of Fig. 2. There is no difference in implementing the long or the short balun. It is just a matter of practical convenience with respect to the frequency of operation and grounding requirements.

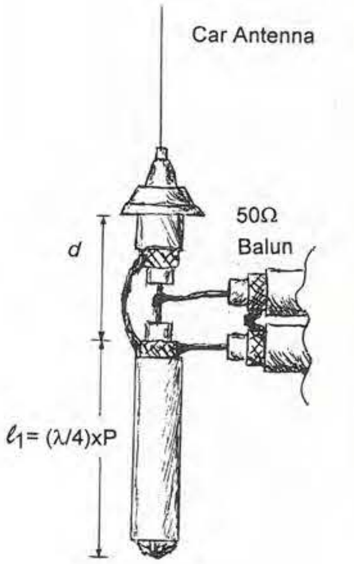

Fig. 4. CB car antenna can be part of a dipole by means of a radiating stub. Distance d should be kept as short as possible as any additional length has to be removed from the total length of the antenna that will be unavoidably shortened. Perfect tuning is critical and any trimming should be accomplished with the antenna already in its final place.

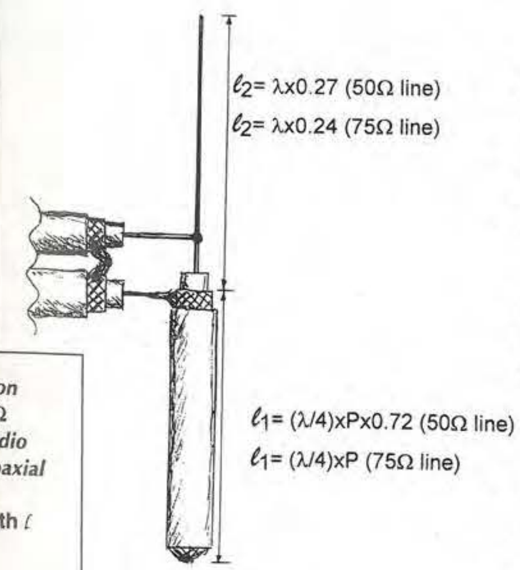

Fig. 5. An antenna longer than λ/4 could be used instead of the car antenna in order to match the 50Ω feed line. This solution has given the best performance, although its overall length of 4.29m in the Citizen Band may pose some problems regarding its physical installation. This is a scalable solution right up to uhf and has given good results also as a receiving tv antenna over a limited frequency range.

Table 1. Segment length of Fig. 5 in millimetres. The vhf television channel is located at 220MHz. The cb antenna is made with 50Ω coaxial cable with solid dielectric while the television and fm radio antennas – including baluns – are made with standard 75Ω tv coaxial cable cable with foam type dielectric.

	ℓ_1	ℓ_2	ℓ_2 dia.	Balun length ℓ
CB	1320	2970 (2)	2	1830
FM	630	730 (2)	2	630
VHF tv	280	320 (1)	1	280
UHF tv	90	150 (1)	1	110

ble to a four-element Yagi antenna. This is not surprising when you consider that a television Yagi is designed to cover a wide frequency range while this coaxial antenna is designed for a specific frequency only.

This solution is best suited where space is limited, as in the case of portable television sets. It will give an improved performance with respect to the existing vhf antenna. Of course, the length of each section must be adjusted for the frequency in use if it is different from 220MHz.

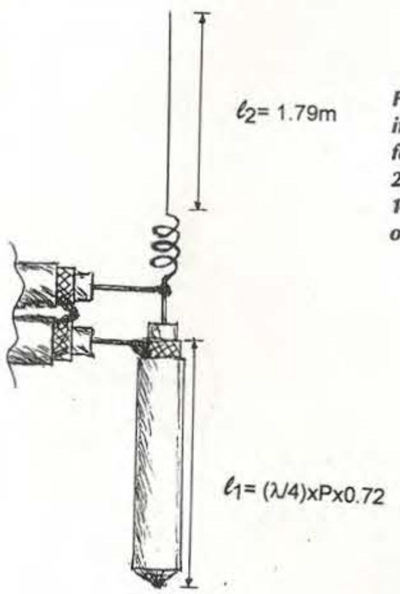

Fig. 6. A shorter antenna is feasible if a coil is added near the dipole feed point. 17 turns of insulated 2mm wire are closely wound on a 17mm form. The total length is now only 3.19m at f=27.185MHz.

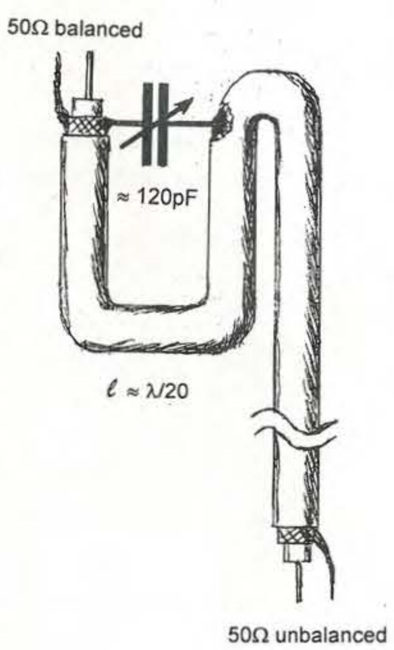

Fig. 7. Variable balancing unit. The capacitor is part of a tuned circuit where a length of the coaxial cable, typically around λ/20 corresponding to a length of 0.55m in the citizens' band, represents the inductance. There is little improvement with respect to a standard balun and its best use could be as a variable splitter. The capacitance, measured at 120pF, could be substituted by a silvered mica capacitor once its exact value is known.

Useful for television?

I attempted to design a coaxial antenna for receiving uhf television channels: due to the large bandwidth required, the segments were cut according to different frequencies and the deliberate mismatch helps to cover a wider band.

In the uhf and vhf range, the line between the antenna and the receiver is a standard 75Ω coaxial cable. This means that the mismatch with the antenna is minimal. It does not require any additional adjustment but the length of the segments is again different with respect to the design intended for cb use, **Table 1**.

If the antenna of Fig. 5 is found to be a little too long for the specific frequency in use, it is always possible to shorten it by installing a coil at the feed point of the antenna, **Fig. 6**. This solution is just as good as the one without coil although a narrowing of the bandwidth has been observed. Also, of course, you have a more complicated construction due to the presence of the coil. Efficiency will be lower because of the additional losses in the coil.

A question of balance

The suggested designs require a balanced feed. But how balanced?

The devised balun gives a perfect balance but I suspected that if a balun with a *variable* balancing could be connected in the circuit it would be possible to compensate for any antenna residual unbalance and improve performance.

The good news is that a balun of this type could be easily devised **Fig. 7**. But the bad news is that the improvements are only marginal, if any, and did not warrant the extra complication of a variable capacitor.

If you can measure the required capacitance, it is always possible to connect a fixed capacitor, 120pF for *f*=27.185MHz, instead of a variable capacitor. It could have a small trimmer in parallel.

This balun could be useful where you have to tune to more than one frequency and still keep a perfect balance. It could also be useful where you need a splitter to feed two signals, phased 180°, to two unbalanced antenna systems.

What has been said so far does not say anything about efficiency and radiation pattern. No tests were carried out in this regard but a test on the gain gave an average of 6dB for a cb antenna wired as in Fig. 5. The test was done by comparison with a known 3dB gain antenna: about half the power was required from a coaxial antenna to get the same signal reading. ■

References

1) Straw, D R, editor, The ARRL Antenna Book, 17th edition, American Radio Relay League, Inc., Newington, CT, USA, pp. 9-8.
2) Dye, N and Granberg, H, 'Using RF Transistors,' *Electronics World*, August 1994, p. 694.
3) Formato, R, 'Feeding off-centre Dipole,' *Electronics World*, November 1996, p. 853.

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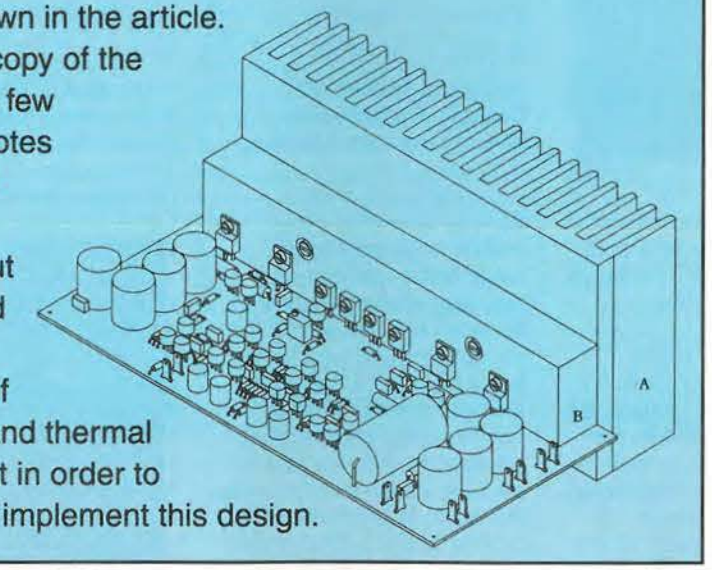

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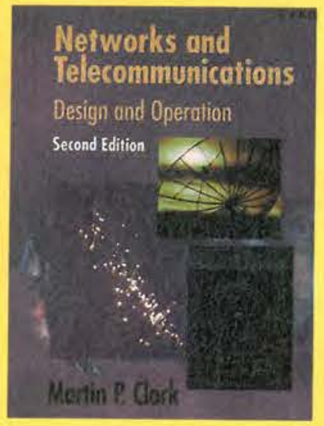

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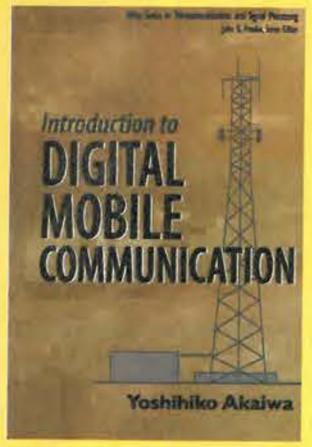

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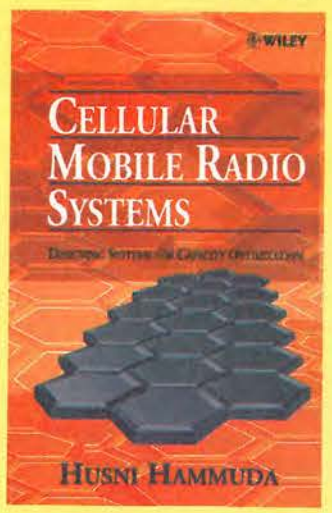

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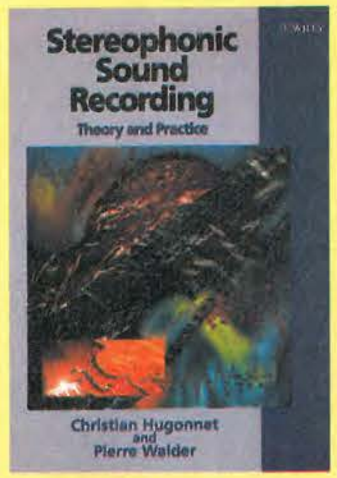

engineering theory.
The book provides a complete overview of well-known sound recording procedures practised world-wide, whilst also presenting a methodology that will provide the reader with an efficient approach to sound recording of classical music, rock and pop music, drama and speech. The widely illustrated theoretical knowledge is presented in clear and simple language.
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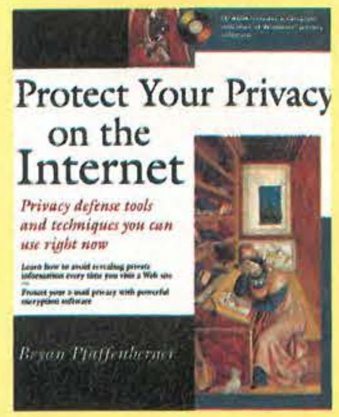

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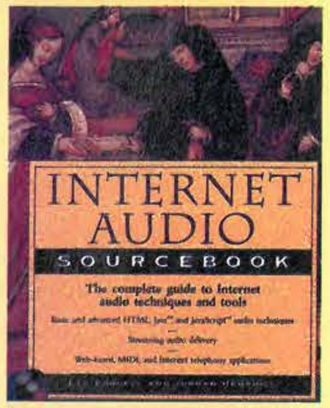

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Hands-on Internet

Cyril Bateman has been delving deeper into the Y2000 problem and has some specific advice for spreadsheet users. He's also found a site covering how to implement dielectric resonators.

Having started looking into the year 2000 implications for my applications software, I now realise why most year 2000 advice, information and software targets the bios and real time clock issues. Some vendors explain this bios focus on the grounds of the high cost of replacement hardware, quite simply it is the easiest and quickest aspect of all to examine.

The quarterly report into Y2K progress of mission critical systems in the US government's 24 largest departments[1] shows a slowdown. It fell from its previous 9.4% rate by February to 7.9% for May. Should this rate continue, many departments will not be ready in time.

A report by *US News & World* on the Y2k News[2] magazine site, which is hosted by Ed Yardeni of Deutche Morgan Grenfell, claims that 44% of US companies have already experienced a year 2000 failure.[3] It debunks five popular myths, believed to promote complacency and thus slow progress to Y2K conformity, **Fig. 1**.

If you need and rely on your computer and have not yet taken any Y2K actions, I suggest you read both reports.

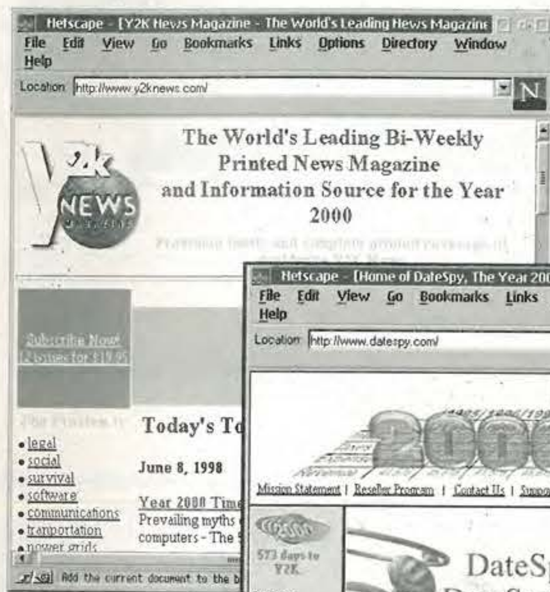


Fig. 1. Subscribe to the magazine or visit this site regularly for Y2K updates.

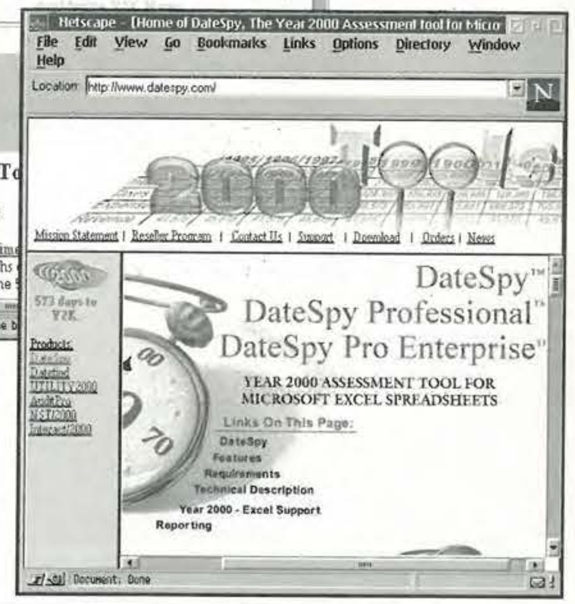


Fig. 2. Whether or not you have a potential spreadsheet date problem, DateSpy should quickly highlight problem areas.

Year 2000 and application software

As a user of an operating system you can perform some limited tests. Ultimately though you have to rely principally on statements of compatibility by the operating system vendor.

When upgraded with the appropriate fix packs, the operating system is claimed to be compliant. Invariably this claim is qualified as 'compliant but with minor issues'. The full implications of these 'minor issues' will only become apparent with testing and as time progresses.

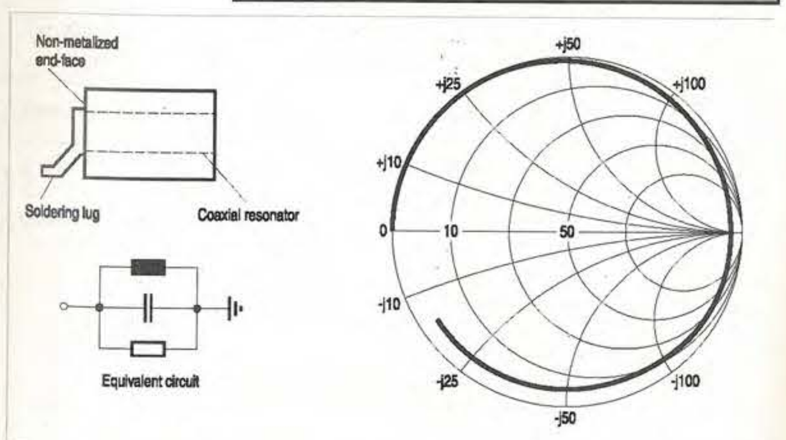
Much application software provides alternative ways to include dates. These alternatives cover not only the difference between the US and UK traditional date formats, but also year values entered using two or four digits by the user.

The first application software which sold computers was the spreadsheet. It has long been favoured for business results and forecasts, but it is also used to simplify repetitive design calculations and data inputs. Since I use both Excel and 123, I decided to look into these applications.

Using a spreadsheet?

A good starting place is the Year 2000 and Spreadsheets.[4] This four-page FAQ should answer many questions for all versions of Excel and 123.

While all spreadsheets can handle any date in the new millennium, the safest course is to always enter dates using four digit years. If you use only two digit years, it is important you know how to do this correctly, taking account of any 'pivot' year assumptions in your spreadsheet software and any linking applications.



Side view and equivalent circuit of a **coaxial resonator**. The measured parameter S11 in the Smith chart is shown on the right up to 3 GHz. The resonant frequency is approximately 2.4 GHz.

Fig. 3. Sectional view and equivalent circuit for a ceramic coaxial resonator. The Smith chart clearly shows this particular device's 2.4GHz self-resonant frequency.

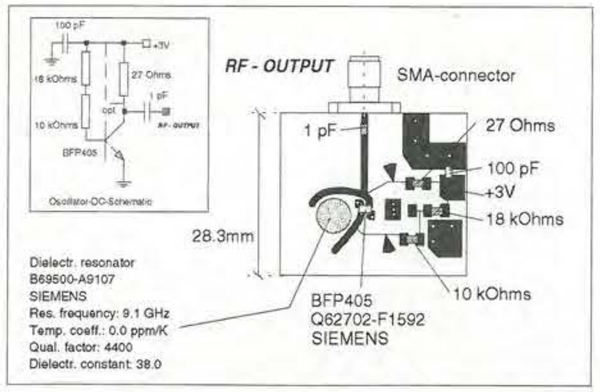


Fig. 4. Usable at frequencies to 12GHz, this Siemens laboratory prototype was built on 0.38mm thick PTFE board.

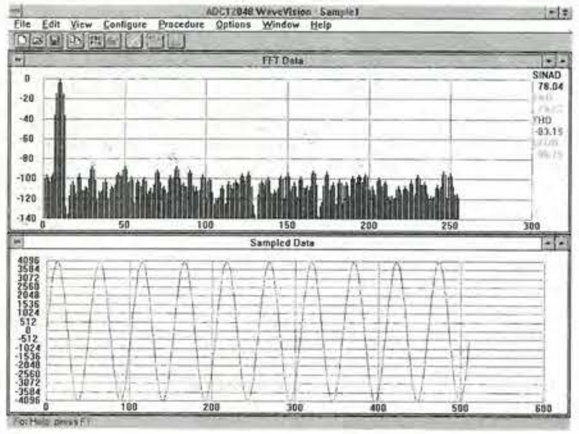


Fig. 5. National's **WaveVision** *software at work, simulating the behaviour of the company's* **ADC12048** *a-to-d converter.*

Spreadsheets also use assumptions when translating data from text fields, or when interchanging between applications via an ODBC layer or OLE. As a result, no simple rule is possible. You must check all software layers.

If you use some Visual Basic code or a macro to assist with data entry, or your spreadsheet includes formulae, then it needs checking. Take care also when copying a table from a word-processor and pasting into a spreadsheet. Data inputs or outputs using CSV or similar formats with two digit year data in the new millennium can produce some quite interesting error results, depending on which spreadsheet you use.

The Microsoft Y2000 Resource Centre compliant product summary[5] states that all versions of Excel are compliant. But this assumes that all dates in the spreadsheet are handled strictly according to Microsoft rules.

The detail sheet for Excel 5, which is the version I use, lists many common date usage errors[6] together with Microsoft's recommended Y2K test methods for Excel.

The Cinderella Community has also investigated spreadsheet problems and devised some spreadsheets tests. These can be downloaded as TDATE.ZIP, which you might like to replicate.[7] In summary, Cinderella found that most spreadsheets will operate into the next century but converting between different spreadsheets is a minefield of traps for the unwary.

If you have many Excel spreadsheets, *DateSpy* should help.[8] It will find all Excel spreadsheets on your drive, then search for date values in cells, date formats, date formula, dates in macros and Visual Basic for applications. **Fig. 2.**

Applications

As circuit operating frequencies increase, ensuring maximum frequency stability and minimum phase noise of fixed frequency oscillators becomes more difficult and or more costly.

Below 3GHz, dedicated ceramic resonators can be used. The dielectric resonator oscillator or DRO can extend oscillation frequency to some 12GHz.

A recent two part article describing both techniques[9] together with an application note[10] can be downloaded from the Siemens Semiconductor Group Web site. It includes printed board layouts and test results.

Ceramic resonators act as a mis-matched coaxial transmission line. The resonant frequency is determined by the 'K' value of the dielectric used and the resonator's physical length. Constructed using low loss dielectric with a relatively low 'K' of 21, or 88, as appropriate, results in a typical working 'Q' between 300 and 400, **Fig. 3**.

Dielectric resonators are made using a dielectric with a 'K' of 38, usually from a compound of barium and titanium oxide. They work by reflecting electromagnetic waves at the boundary layer between the dielectric and the air, within the element. This produces a concentration of energy inside the resonator and in its immediate proximity. Frequency is determined by the resonator's diameter, but it can be fine tuned by screw adjustment of a cover plate.

Perhaps the most common use of a DRO is in the low-noise-block down converter used for satellite television reception. Being exposed to all weathers and aggravated by the sun's heat, which can be focussed and reflected from the dish, requires good oscillator stability over temperature. At 10GHz, a frequency stability of ±3MHz at –20+60°C and phase noise ≤80dBc/Hz at 10kHz offset, can be attained, **Fig. 4**.

Simulation models for the 12GHz grounded emitter transistors used, compatible with most common rf simulators can also be downloaded. For these frequencies you must use an appropriate simulator, such as *Touchstone* or *Harmonica*, not one of the popular low-frequency Spice systems.

Simulation

Simulation of a high speed analogue/digital converter can also be quite difficult using the conventional Spice methods.

National Semiconductor[1] offers its *WaveVision* design evaluation system kit, including evaluation board and dedicated Windows software. This evaluation software can be downloaded from internet, for your evaluation, **Fig. 5.** ■

Where to surf

1. Government's Y2K progress slows.	http://www.news.com/News/Item/0,4,22761,00.html
2. Y2K news magazine.	http://www.news.com
3. Year 2000 time bomb.	http://www.usnews.com/usnews/issue/980608/8y200.htm
4.Year 2000 and Spreadsheets.	http://homepages.iol.ie/~pobeirne/y2ksprds.htm
5. Compliant products.	http://www.microsoft.com/ithome/topics/year2k/product/product.htm
6. Excel 5.0	http://www.microsoft.com/ithome/topics/year2k/product/excel5.htm
7. Y2K Cinderella Spread Sheet Torture Tests.	http://www.cinderella.co.za/test0003.htm
8. DateSpy.	http://www.datespy.com
9. Maximum Stability-98023234 & 98011416.pdf	http://www.siemens.de/semiconductor/news/35news.htm
10. Silicon Bipolar- DRO at 10 GHz - APPLI002.pdf	http://www.siemens.de/semiconductor/products/35/35app3r.htm
11. Wave Vision Design Evaluation Kit.	http://www.national.com/sw/WaveVision/0,1044,0,00.html

Programming silicon floppies

Last month, Pei An illustrated how easy it is to design hardware for programming Toshiba's new silicon alternative to floppy disks – SmartMedia. Here is an idea of how to drive that hardware in Turbo Pascal.

These software listings are examples of how to drive my *SmartMedia* silicon floppy disk programmer described in last month's article.

The driver listed demonstrates how *SmartMedia* disks can be block erased, page programmed, read, etc. It is written in Turbo Pascal 6 for Dos.

The complete program is too long to list here, but is available from the author. In this article, source codes for the most importance procedures and functions are listed.

List 1 checks the number of Centronics ports installed on your pc and allows you to select the port that the programmer is connected to.

List 2 contains three

List 1. This Turbo Pascal routing allows you to select which Centronics port you want to address.

```
Procedure Input_printer_address;
{Universal auto detection of printer base 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; {defaut printer}
      number_of_lpt:=mem[$0000:$0411]; {read number of parallel ports}
      number_of_lpt:=(number_of_lpt and (128+64)) shr 6;
      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;
```

List 2. I/O procedures for the SmartMedia programmer.

```
Procedure data_bus(data:byte);
{load a data on the data bus and enable the data bus}
begin
     port[P_address]:=data;          {output a byte to the data port}
     timedelay;
     port[P_address+2]:=0+0+0+8;     {data bus load = 1, output enable}
     timedelay;
     port[P_address+2]:=0+2+0+8;     {data bus load = 0, output enable}
     timedelay;
end;
Procedure data_float;
{float the data bus}
begin
     port[P_address+2]:=0+2+0+0       {-OE=1}
end;
Procedure control_bus(data,data_bus_enabled:byte);
{load a data on the control bus. control always enabled}
{data_bus_enabled=0: data bus not enabled
 data_bus_enabled=1: data bus enabled}
begin
     port[P_address]:=data;                         {output a byte to the data port}
     timedelay;
     port[P_address+2]:=0+2+4+8*data_bus_enabled; {control bus load = 1, output enable}
     {timedelay;  }
     port[P_address+2]:=0+2+0+8*data_bus_enabled; {control bus load = 0, output enable}
     {timedelay;}
end;
Function inputdata:byte;
{read data into PC from the data bus, during reading, data bus is not enabled}
var
   byte1,byte2:byte;
begin
      data_float; {float the output from the data buffer}
      port[P_address+2]:=1+2+0+0;  {DSL=0, data load=0, control load=0, -OE=1}
      byte1:=port[P_address+1];    {DSL=1, read the high 4 bits}
      port[P_address+2]:=0+2+0+0;  {DSL=1}
      byte2:=port[P_address+1];  {read the 4 low bits}
                                 {binary format of byte1 and byte2
                                         byte1: ...hhhh0 (high 4 bits)
                                         byte2: ...11110 (low  4 bits)
                                 note: .=do not care,  h,l=data}
      byte1:=byte1 and 120;      {00011110 and ...hhhh0 = 000hhhh0}
      byte1:=byte1 shl 1;        {shift 1 bit left,   byte1 = 0000hhhh}
      byte2:=byte2 and 120;      {00011110 and ...11110 = 00011110}
      byte2:=byte2 shr 3;        {shift 3 bits right, byte2 = 11110000}
      inputdata:=byte1 or byte2; {byte1 or byte2 = 11110000 or 0000hhhh = 1111hhhh}
end;
```

procedures and one function. Procedure data_bus(data) loads data into the data bus. Procedure data_float makes the data bus to float. This procedure is used when the memory disk outputs data. Procedure control_bus(data) is used to load a data into the control bus.

The function inputdata reads data from the disk into the pc. You can see from this program list that before reading data form the Centronics port, the data bus is made float first to ensure that the data output from the memory can be read correctly.

List 3 contains a number of procedures for controlling the operations of the memory disk. Procedure RD(A0_7, A9_16, A17_21:byte) reads data from a page specified by addresses A9_16 and A17_21. The term A0_7 specifies the starting address in that page. It is set to zero in the procedure. The procedure will read 528 (or 512) bytes in one go.

Procedure WR(A0_7, A9_16, A17_21:byte) writes 528 (or 512) data into a memory page specified by A9_16 and A17_21. A0_7 is the starting address in that page and is set to zero.

The procedure Read_ID reads the identification numbers of the memory device while erase(A9_16, A17_21:byte) erases a memory block specified by A9_16 and A17_21. Noted that only A13 to A16 are used here. A9 to A12 are ignored.

Finally, the procedure reset resets the memory device. ■

Table 1. Breakdown of current SmartMedia ssfdc products. Note that the programmer described here cover only the 5832DC.

Product	Memory density (Mbyte)	Voltage (V)	Program time (μs/byte)	Erase time (ms)	Access time (ns)	Write/erase cycles
TC5816BDC	2	5.0	1.2	6	80	250000
TC5832DC	4	5.0	0.6	6	50	1000000
TC58V16BDC	2	3.3	1.2	6	80	250000
TC58V32DC	4	3.3	0.6	6	50	1000000
TC58V64DC	8	3.3	0.4	6	50	1000000

Table 2. Summary of commands.

Command	Hex value	Definition
Serial data input	80	Write 528 (or 512) data bytes to data buffer registers. 'OP' pin determines whether 528 bytes (OP=GND) or 512 bytes (OP=VCC) is written
Read mode 1	00	Read bytes from page starting from 0 to 255 addresses
Read mode 2	01	Read bytes from page starting from 255 to 511 addresses
Read mode 3	50	Read bytes from page starting from 512 to 527 addresses
Reset	FF	Stop all operations and set the device in wait state
Auto page program	10	Data in buffer registers is programmed into memory
Auto block erase	60+D0	Erase a block. Verification is performed
Suspend erasing	B0	Suspend erasing
Resume	D0	Resume erasing
Status read	70	Read verification status of programming and erasing Operation pass: I/O1=0; operation fail: I/O1=1 Write protected: I/O8=0; not write protected: I/O8=1
ID read	90	Read ID from device. Values 98 and $8B_{16}$ should be read

List 3. Operations of the memory disk.

```
Procedure RD(A0_7, A9_16, A17_21:byte); {read data from memory into pc
 memory location specified by A0_7, A9_16 and A17_21
 command=00h for sequential reading}
var
   i:integer;
begin
     A0_7:=0;                           {starting memory address in a page is zero}
     control_bus(0+2+4+0+0+32+64+128,0); {initial control bus condition
                                          -RE=1, -WR=1, CLE=0, ALE=0, -CS1-3=1}
     {load command (00h) into memory}
     control_bus(0+2+4+8+0+0+64+128,0); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(0);                       {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     {load address A0_7 into memory}
     data_bus(A0_7);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     {load address A9_16 into memory}
     data_bus(A9_16);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     {load address A17_21 into memory}
     data_bus(A17_21);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,0);
     {float the data bus, memory outputing data}
     data_float;
     control_bus(0+2+4+0+0+0+64+128,0); {-RE=1,-WR=1,CLE=0,ALE=0,-CS1=0,-CS2-3=1}
     for i:=0 to page_number do
       begin
            control_bus(0+0+4+0+0+0+64+128,0); {-RE=0,-WR=1,CLE=0,ALE=0,-CS1=0,-CS2-3=1}
            data[i]:=inputdata;
            control_bus(0+2+4+0+0+0+64+128,0); {-RE=1,-WR=1,CLE=0,ALE=0,-CS1=0,-CS2-3=1}
       end;
end;

Procedure WR(A0_7, A9_16, A17_21:byte);
{write data to memory}
{command=80h, sequential reading}
var
   i,status:integer;
begin
     A0_7:=0;                           {starting memory address in a page is zero}
     control_bus(0+2+4+0+0+32+64+128,0); {initial control bus
                                          -RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2=1, -CS3=1}
     {load command (80h) into memory}
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(8*16);                    {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     data_bus(A0_7);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     data_bus(A9_16);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     data_bus(A17_21);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     control_bus(0+2+4+0+0+0+64+128,1);
     for i:=0 to page_number do
       begin
            data_bus(data_in[i]);              {load command into data bus}
            control_bus(0+2+0+0+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
            control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
       end;
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(1*16+0);                  {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+8+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     repeat until ((port[P_address+1] and 128)=0) or keypressed;
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(7*16);                    {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+0+4+0+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     status:=inputdata;
     writeln('Write status   Pass(0):  ',status and 1);
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     control_bus(0+2+4+0+0+32+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     control_bus(0+2+4+0+0+32+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
end;

Procedure Read_ID;
{read maker code and device code of the memory card}
begin
     control_bus(0+2+4+0+0+32+64+128,0); {initial control bus
                                          -RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2=1, -CS3=1}
     {load command into memory, command = 90H}
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(9*16+0);                  {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+8+0+32+64+128,1);{-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     {load address, address=0}
     data_bus(0);                       {load command into data bus}
     control_bus(0+2+0+0+16+0+64+128,1);{-RE=1, -WR=0, CLE=0, ALE=1, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+16+0+64+128,1);{-RE=1, -WR=1, CLE=0, ALE=1, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=0, -CS2,3=1}
     {read maker number}
     control_bus(0+0+4+0+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=0, -CS2,3=1}
     maker:=inputdata;
     control_bus(0+2+4+0+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=0, -CS2,3=1}
     {read device number}
     control_bus(0+0+4+0+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=0, -CS2,3=1}
     device:=inputdata;
     control_bus(0+2+4+0+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+0+32+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=0, -CS2,3=1}
     write('Maker number: ',maker,'           Device code: ',device,'
                                              Press RETURN');
end;

Procedure erase(A9_16, A17_21:byte);
{earse the memory block specified by A9_16 (high 4 bits of A9_16) and A17_21)
var
   i,status:integer;
begin
     control_bus(0+2+4+0+0+32+64+128,0); {initial control bus
                                          -RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2=1, -CS3=1}
     {load command into memory, command = 00h}
     control_bus(0+2+4+8+0+0+64+128,0); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(6*16);                    {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     data_bus(A9_16);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     data_bus(A17_21);
     control_bus(0+2+0+0+16+0+64+128,1);
     control_bus(0+2+4+0+16+0+64+128,1);
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(13*16);                   {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+8+0+0+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     repeat until ((port[P_address+1] and 128)=0) or keypressed;
     control_bus(0+2+4+8+0+0+64+128,0); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(7*16);                    {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+0+4+0+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     status:=inputdata;
     write('Erase status   Pass(0):  ',status and 1);
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
     control_bus(0+2+4+0+0+32+64+128,0); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
end;

Procedure reset;
{reset the memory card, address registers=0, data registers=1, wait stage}
begin
     control_bus(0+2+4+0+0+32+64+128,1); {initial control bus
                                          -RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2=1, -CS3=1}
     {load command into memory, command = 00h}
     control_bus(0+2+4+8+0+0+64+128,1); {-RE=1, -WR=1, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     data_bus(15*16+15);                    {load command into data bus}
     control_bus(0+2+0+8+0+0+64+128,1); {-RE=1, -WR=0, CLE=1, ALE=0, -CS1=0, -CS2,3=1}
     control_bus(0+2+4+0+0+0+64+128,1); {-RE=1, -WR=1, CLE=0, ALE=0, -CS1=1, -CS2,3=1}
end;
```

Technical support

Kits including all necessary components (including the disk socket) to construct a complete programmer and the TP6 source codes are available from the authors. Please make your enquiry to Dr Pei An at 11 Sandpiper Drive, Stockport, Manchester SK3 8UL, U.K. Tel/Fax/Answer:+44-(0)161-477-9583. Pei's e-mail address is PAN@FS1.ENG.MAN.AC.UK.

Principal RF Engineer
South East
RF, Mobile Radio
A large, successful telecommunications company is currently searching for a Principal RF Engineer/Team Leader. You should be experienced in surface mount techniques and design for high volume low cost manufacture and the design of low power receivers and transmitters up to 2GHz. Previous supervisory and team leadership skills would be advantageous as would a background from a mobile radio or cellular subscriber equipment environment. Call with the reference for more details. **Ref: 59981**

Software Engineer
South
C, Real Time Embedded
My client is seeking a Software Engineer in mobile communications. You must have at least 2 years C design and programming in a real time embedded environment and be able to offer some of the following skills: TCP/IP, PPP and modem network protocols, call processing, windows application development, Visual C++, Win95. Test harness design on various platforms, portable MMI design/specification and serial communications protocols. Call for more information quoting reference. **Ref: 59980**

ASIC/Hardware Engineers
South
ASICs, GSM
My client is searching for ASIC/Hardware engineers with 5-10 years design experience for digital communications systems. Your role will be to evaluate new technologies and devices, the development of new baseband ASICs and the study and simulation of new communication systems. You will need to have excellent communications skills as you will be interfacing with outside parties and internal development teams. Experience in GSM, CDMA is essential. Call in with reference for extra details. **Ref: 59988**

DSP Engineers
Hampshire
DSP, Communication Systems
This role for a telecommunications company will involve you to have a good working knowledge of GSM, CDMA design for high volume manufacture of digital communication systems. You will be involved in the development of new DSP algorithms and the evaluation of new technologies and devices. You will need to be degree qualified and an excellent communicator. For more details of this opportunity call in with reference. **Ref: 59989**

Senior PSU Engineer
South East
PSU (DC-DC)
My client is currently looking to employ a Senior PSU Engineer for the specification of "Power Management Systems" for mobile phones and similar products. You will have at least 2 years design and development of PSUs preferably with EMC knowledge. You will design and develop PSU solutions (DC-DC converters and of-line), design prove PSUs, write reports and meet suppliers. Please quote reference when calling for more details. **Ref: 59992**

COMMS 2000

Communications Consultants
11 Harley Street
London W1N 2EQ
Telephone: 0171-636 7584
Fax: 0171-580 3734
Comms 2000 is a division of
The 2000 Group Plc
e-mail: ctt@2000group.win-uk.net

Hardware/Firmware Development
Hampshire
C, Assembler, Telecoms
One of the world's leading manufacturers of professional voice and data acquisition recorders is looking for a hardware/firmware developer. Your role will include developing hardware and software in C and Assembler for custom designed telephone line interface modules to decode the common telecommunication protocols including analogue, ISDN E1/T1 and proprietary digital signals. You will be degree qualified with at least 2-3 years experience in a similar role. For more details, call with reference. **Ref: 60003**

DSP Development
South
DSP, C
You will need to have at least 3 years previous experience in a development role for this vacancy. My client, manufacturers of voice and data acquisition recorders are seeking an individual to develop mathematical algorithms in C and Assembler for speech processing, compression, decompression and in band signalling extraction for custom designed DSP modules. If you would like more details of this vacancy, please call in with the reference number. **Ref: 60004**

Snr ILS/Reliability Engineer
Middlesex
Reliability, Maintainability and Testability
My client, a large communications organisation are currently looking for an individual with at least 5 years experience of working in a military electronics ILS/ARM environment. You will perform various ILS and ARM tasks including logistics, reliability, maintainability and testability analysis, support ongoing contracts as well as supporting future bids and you must have hands on experience with appropriate CAE tools. You will also be HND/Graduate (minimum 2:2). Call in with reference for more details. **Ref: 60118**

Analogue Electronics Design Engineer
South
Analogue, Digital, Communications
My client requires a versatile analogue design engineer for the design, development and production of microprocessor controlled transmitters and receivers. You will have a strong understanding of communications and good degree in electronics. Your duties will include analogue and digital circuit design and prototyping, PCB design for manufacture, test and cost and microprocessor software development and testing. You will also support existing designs and current production. Please quote reference when calling for more information. **Ref: 60119**

DSP Engineer
South East
Analogue, Digital, Communications
My client, a large MoD organisation requires an experienced individual with a strong theoretical background in a digital signal processing and an interest in working from the mathematical formulation through to software coding and test. The successful candidate will have a strong understanding of DSP with a mathematical and technical background. Some of your duties will be to develop algorithms and software for future processors and assist in developing the processing laboratory. Please call in for more details quoting the reference. **Ref: 60120**

Electronics Engineer
South
Communications, PCM, ISDN
This large MoD organisation is searching for an individual with knowledge of principles of mixed environment electronics design, communications protocols and board level design principles. You will be required to work on state of the art communications products integrating voice, data and video multimedia services. The work will involve elements of development and board design of analogue and digital interfaces between application modules, processors and a fibre optic network. Call now quoting the reference number for more details. **Ref: 60148**

SNR Electronics Engineer
Bedfordshire
FPGA, VHDL
You will have a minimum of 5 years design experience in data communications protocols and standards with extensive knowledge of large and complex designs using FPGA and AHDL (using MaxPlus II tools). You will be working on state of the art communications products with a team of digital design, embedded and applications engineers. It is essential that you have VHDL experience and a good track record in the successful implementation of designs in production ASICS. If you require more information regarding this vacancy, please call in with reference. **Ref: 60150**

Development Engineer
Berkshire
Embedded micro-controllers
My client is currently looking to employ a development engineer who is a graduate with several years experience in developing systems using embedded micro-controllers. It is essential that the successful candidate will be able to demonstrate expertise in programming in C and Assembly language and design of embedded systems. Expertise in PC Architecture, use of emulators, PCB design/layout and PIC micro-controllers would be advantageous. Please call in with reference for more information. **Ref: 60153**

Applications Engineer
Surrey
FPGA, UNIX, CAE
We are looking for an individual with 1-5 years' Digital Design experience with FPGAs. CAE experience (Mentor Graphics, Synopsys etc) is essential, as is experience in UNIX, DOS and Windows based platforms. VHDL experience would be advantageous. You will provide technical support and training for customers and some of your functions will be customer design analysis and conversion, solutions testing and new product specification. Call now with reference for more information. **Ref: 59930**

ARM Engineer
Home Counties
ARM, ILS, LSA
My client is currently searching for an ARM engineer to provide expertise on AR&M to projects and bids in accordance with operating standards. You will be required to keep up-to-date on ARM, ILS, LSA and CALS techniques, methods, tools and developments. You will also assist in the co-ordination of ARM Group tasking and resourcing and provide estimates for ARM tasks as requested. You will have a minimum of 4 years' experience in a related role and be educated to a minimum of HND level. Call quoting reference. **Ref: 59892**

Electronics Engineer
South East
Sparc Processors, UNIX
This vacancy entails you to be involved in the upgrade of an existing System Design to incorporate the latest SPARC/Solaris technology. You will need to have experience with Design Proving and Customer acceptance and an understanding of UNIX, Sparc Processors, Graphics Interfaces, LAN, VME and Multibus Systems. Call now with reference. **Ref: 59893**

Hardware Engineer
South
Embedded Microprocessor, Digital/Analogue
A large communications company are looking for a hardware engineer. Essential skills are embedded 8-bit/16-bit microprocessor equipment, digital and analogue design techniques. A working knowledge of C/Assembler is also required. Surface Mount Technology and Programmable Logic would be advantageous. Call now with reference for more details. **Ref: 59962**

Hardware Engineer
South East
Embedded Processors/DSP
A design engineer is needed by my client to develop advanced Airborne Systems. It is essential that you have a good working knowledge in some of the following areas: Embedded Processors/DSP, Memory, VHDL, Switch Mode Power Supplies, EMC, RF Design, PCM/CEPT Routing, Analogue/Audio Circuits and CAE Tools. For more information on this vacancy call now quoting reference. **Ref: 59843**

Installation Engineer
Home Counties
Installation, Commissioning
Your role is to work on customer sites installing and commissioning systems provided by the company's Airport Information Systems dept. It is essential that you have Networking experience and exposure to installation. Airline Industry or Radio Data Network experience would be advantageous. You will be required to manage sub-contractors, provide reports and assist in the maintenance of installed systems. Call in quoting reference. **Ref: 59889**

COMMS 2000

Communications Consultants
11 Harley Street
London W1N 2EQ
Telephone: 0171-636 7584
Fax: 0171-580 3734
Comms 2000 is a division of
The 2000 Group Plc
e-mail: ctt@2000group.win-uk.net

Mechanical Engineer
South East
CAD, 3D Solid Modelling
Ideally, you should have 5 years' experience in electronic packaging in a defence or commercial environment. You will be providing technical support to the Mechanical Design Group, generating designs on CAD systems and providing prototype manufacturing information. 3D Modelling and Stress Analysis experience would be an advantage as would a Mechanical Engineering qualification. Call quoting reference for more information. **Ref: 59891**

Quality Assurance Engineer
Home Counties
MoD, Electronics
You will need to be familiar with ISO and Quality Management Standards and it is essential that you have knowledge of QA techniques and principles. Some of your duties will be to prepare quality procedural documents, interpret customer quality contract requirements placed on projects and ensure that quality plans are produced to reflect contract requirements. For details call in quoting reference **Ref: 59898**

RF, ASIC Designer
Bristol
2GHz, BiCMOS
This dynamic communications organisation requires an RF, ASIC engineer with at least 5 years' design experience. You will have a good understanding of RF design techniques of up to 2GHz and extensive knowledge of BiCMOS. Call in for more details or send in your CV quoting reference. **Ref: 59947**

RF Designer
South
RF, PMR
We are on the lookout for experienced RF Designers. You will have a minimum of 2 years' experience in receivers, transmitters and mobile radios. You will be part of a multi-disciplined design team and will be competent at every level of design. This is a great opportunity to join a highly successful communications company. Call now with reference for more details. **Ref: 59934**

Semicustom Design Engineer
South
ASICs, VHDL, Design Tools
This is a great opportunity not to be missed! Experience with design tools inc Synopsys Design Compiler/VSS/Test Compiler, Verilog, Leapfrog, Primetime, Motive, PDP Floorplanner or CELL3/Silicon Ensemble would be advantageous. We are seeking a highly motivated individual with excellent telecommunications skills for a customer driven role with extensive travel to Europe supporting the design and development of high complexity digital and mixed signal ASICs. Call now quoting reference. **Ref: 59724**

Senior Electronics Technician
South
Surface-Mount Assembly
We are currently seeking a Snr Electronics Engineer with experience in surface-mount assembly (by hand). You will also have experience in the supervision and time management in a production environment. Provide on-the-job skill training to junior team members and supervise technician staff, sub-contract resources and inspection of work. Please call in quoting reference. **Ref: 59950**

Senior RF Engineer
Cambridge
RF, ASIC
We are currently seeking an RF engineer with 3+ years' experience in a product development environment. You will be degree qualified with excellent working skills in Analogue hardware design, RF circuit design, ASIC and system level radio design. You will be a good communicator and team player but will also be able to operate alone where required. Please call now quoting reference for extra detail. **Ref: 59949**

Software Engineer
South
C, ADA, MASCOT
Have you got experience in Embedded Real-time applications development? If so, then call now quoting reference. It is essential that you have a good working knowledge of C, ADA and/or PASCAL. Experience of MASCOT and Structured Analysis Design is also desirable. You will be working in a disciplined Avionics environment where certification considerations and a quality engineering approach are a major concern. **Ref: 59844**

Technical Author
Surrey
Graphics Hardware/Software
We are seeking a Technical Author to produce hardware and software data books/manuals for a highly successful developer of graphic chips. You will also be involved in the production of product overview documentation and the consistent quality and style for all manuals. You will be experienced in detailed technical writing with a strong engineering background. To find out more details, call now quoting reference. **Ref: 59744**

CONTRACT VACANCIES

APPLICATIONS ENGINEER		
Analogue, Modems.	Suffolk	Ref: 59726
ASIC DESIGN		
Verilog, Synopsys.	Essex	Ref: 19599
ASIC DESIGN		
VHDL, FPGA.	Beds	Ref: 24662
CONTROLS ENGINEER		
PLC, Year 2000.	Germany	Ref: 59756
DATAFIL ENGINEER		
Switching/PMR/SDH.	Hants	Ref: 59709
NETWORK DEVELOPMENT		
GSM/PMR.	UK Wide	Ref: 59754
RADIO NETWORK PLANNERS		
GSM/PMR/CDMA.	Europe	Ref: 59692
RF DESIGN ENGINEER		
0.8-1.2GHz Power Amp.	Bristol	Ref: 59943
RF DESIGN ENGINEER		
1.9GHz, Transmitter.	Beds	Ref: 59926
RF DESIGN ENGINEER		
GSM/CDMA, Prod Des.	Hants	Ref: 48404
SOFTWARE ENGINEER		
C, RTE, MPEG	Yorks	Ref: 59951

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ELECTRONICS**APPOINTMENTS**
Electronics World September 1998 Tel:0181 652 3620

SENIOR ASIC DESIGNER & ASIC DESIGNER

LONDON AREA £25K-£40K

This client is involved in some of the most advanced ASICs around.
- Hons Degree in Electronic Engineering with 4+ years exp.
- Complete ASIC design process from spec, des, coding, synthesis to layout & sample testing.
- Skilled in des/dev of large (>100k gates), complex, high (>40MHz) speed ASICs.
- VHDL & top-down design methods & logic synthesis tools (pref. Synopsys).
- Digital Signal Processing.
- VHDL for synthesis, Testbench Design, Top Down ASIC design, Mentor and/or Synopsys design tools. *(JT10432)*

SYSTEMS ENGINEERS

SUSSEX £22K-£38K

The Company designs and manufactures a comprehensive range of electronic warfare, radar, and command information systems.
- Development background and between 3-5 years experience in systems engineering, in s/w intensive programmes.
- bid development, requirements capture, requirements analysis, systems test, verification, validation, modelling, simulation, customer interaction, algorithm design, DSP, architectural design, and systems partitioning.
- Background in defence industry will be useful.
- Will also consider S/W Engineers/S/W Quality Engineers wishing to change career direction. *(JS14767)*

ENGINEERING MANAGER SOFTWARE

SOUTH COAST £35K-£40K

The Company is a leader in the design and manufacture of instrumentation for monitoring environmental pollution, specifically radiation monitoring, and air and water pollution monitoring.
- Degree or equivalent background in an engineering discipline.
- Broad based engineering experience with an appreciation of software engineering but not necessarily an in-depth knowledge of the subject.
- Proven experience of project planning and control and well developed skills in the management and motivation of an engineering team. Self-motivated, resourceful and a good communicator. *(AF14760)*

TEST DEVELOPMENT

HERTS £14K-£30K

The company is a commercial organisation involved in the approval of products from the IT, Telecomms, Industrial and Domestic business sectors. The job involves developing new test methods and equipment to keep pace with changing international test standards.
- Knowledge of hardware (analogue/digital techniques) and s/w skills (C++, Visual Basic).
- HND or Degree in Physics or Electronics related discipline.
- Successful candidates must above all be willing and enthusiastic to learn. *(JT14758)*

SOFTWARE ENGINEER

HAMPSHIRE £19K-£24K
- 3-5 years experience, hands on senior position.
- Qualified to degree standard.
- Embedded software in C (8 bit to 62 bit).
- Understanding of analogue and digital hardware advantage. *(AO14754)*

HARDWARE / SOFTWARE

BERKSHIRE £NEG

Interesting medium sized client.
- Graduate Engineer with several years in developing systems using embedded micro-controllers.
- Demonstrate expertise in some or all of the following areas:
- Programming in C and assembly language.
- Design of embedded systems, 8051 family and/or PIC micro-controllers, PC architecture; use of emulators.
- PCB design/layout. (AF14745)

SENIOR ELECTRONIC ENGINEER

HANTS £22K-£30K

Innovative high technology client based near Andover
- Analogue design, i.e. linear power supplies
- Mathematical background
- Data acquisition techniques
- Field work involved. *(AO14723)*

ELECTRONIC WARFARE

HANTS £18K-£40K

Small but rapidly growing consultancy & research organisation who are leaders in EW applications. Major new contracts requires more people.
- Good degree/MSc/PhD.
- ECM, ESM, ELINT, GPS, ANTENNA.
- EM Modelling, Signal Processing, Electro-optics.
- EW or RADAR experience. *(JS10612)*

RF DESIGN ENGINEERS

ESSEX £££ DEPENDANT

Well respected supplier of communications industry, currently undergoing massive period of growth.
- Design of amplifiers (low noise & high power), ferrite isolators/circulators & filters for cellular & other radio systems. *(JT8781)*

TEST ENGINEER (X5)

HERTS £14K-£19K

Vacancies with Safety, EMC & Telecommunications Approvals departments in a leading edge company.
- Entails using appropriate hardware & knowledge to test a wide variety of products against written standards.
- Liaise with clients to take remedial action, ensuring products meet European & International standards. *(JTC4299)*

SENIOR DESIGN ENGINEER

CAMBRIDGESHIRE TO £35K

Our client, currently at the forefront of digital colour scanning technology, requires an experienced hardware engineer to play a hands on role within the R & D Dept.
- Min 3 years exp within a R&D department.
- Design in programmable logic for FPGAs using VHDL.
- Exp with 2 or more of the following: Microcontrollers, DSPs, FPGAs, VHDL, high speed logic, analogue circuits & PC based development tools.
- Knowledge of colour theory is desirable. *(WW5596)*

Ref:WW/9852

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Email: sts@tcp.co.uk

Senior Hardware Engineer
Hants £22k to £28k
This well known company is looking to recruit a Hardware Engineer who can offer at least 2 years design experience within the electronics arena. Ideally you will have experience of low power, cost sensitive consumer products. The position involves the design and development of GSM dual mode mobile phones and hands free units, therefore you will need good digital design (80386 and H8 processors) and low level software design experience. Basic analogue knowledge will also be useful. TIME108

Graduate Hardware Engineer
Hants £20k to £25k
An opportunity for a Graduate level hardware engineer currently exists with this company who design and develop inspection equipment for the food and drugs related industries. Ideally you will be a recent graduate with some R&D experience. You should have an understanding of Digital Design, microprocessor design and high level software experience. Technology areas are varied and include analogue RF, digital and 32 bit embedded processors. TIME109

RF/Microwave Design Engineers
Kent to £35k
One of the world's leading companies involved in the design and development of vehicle antenna systems is currently looking to expand its team to keep it at the forefront of communications and intelligent transport systems technologies. You will need to be well qualified with solid experience of RF and Microwave design, LNAs, filters, diversity systems and measurement techniques. Any experience of antenna design would be very beneficial. TIME110

Hardware Design Engineer
Herts £18k to £25k
Good quality position, with a small but very successful company is currently available for an experienced hardware engineer who can offer at least 1 year's proven experience in hardware design for broad level products. A minimum HND is required along with experience of PLDs, FPGAs, TTL/CMOS logic design, analogue and digital interfacing and software design experience in C and Assembler. Any experience of Intel processors would be beneficial. This is an excellent second career move prospect. TIME111

Hardware Design Engineers
Lancs £neg
This progressive company require hardware engineers to join their R&D department involved in the design and development of electronic fire protection systems. You will possess proven skills in hardware and software design. Degree qualified with at least 2 years experience you will have hardware skills in microprocessor and microcontroller design and software skills in embedded C and Asssembler. These are good opportunities with a very stable company. TIME204

Software Engineers
– Digital Broadcast
Bucks to £40k
World leader in the electronics field is currently looking to recruit Software Engineers who have at least 5 years experience in software design, with a solid background in real-time embedded software in C. You will have solid experience of working with custom hardware and have excellent experience in at least one of the following areas: DVB, MPEG, GSM. TIME205

Project Leader
– Digital Broadcasting
M40 (outside M25 belt) £neg
Superb company involved in the development of digital broadcasting products are currently looking for a Project Leader who can offer at least 5 years experience of designing digital and software systems. You will be responsible for developing LSI and PCB based systems for digital audio and video broadcasting. As a project leader you will have strong team leadership skills as well as excellent man-management skills. As a senior level engineer you will need to be able to demonstrate a proven track record in hardware and software design. TIME206

Digital ASIC Design Engineers
Surrey & Hants £25k to £38k
This company releases on average 10 new technically advanced products for the telecommunications industry each year. To maintain this level of commitment they are looking to recruit top level design engineers who are able to design and develop products for the commercial market. Positions exist for graduate level engineers, through to senior/team leaders who have at least 2 years experience of ASIC design. You should have solid VHDL (or similar) tools experience. TIME100

Senior ASIC Designers
Cambs £24k to £35k
A rare opportunity to be involved in the design and development of some of the best future products is currently available with one of the UK's most respected design houses. You will be involved in the design of the latest ASIC technology for implementation into new Multimedia and Communications products. You will need a good degree (1st or 2:1) with an excellent track record in commercial product design. High gate level design experience is required coupled with excellent VHDL/Synopsys (synthesis and simulation). TIME101

Hardware Design Engineers
Surrey, Hants & Berks £20k to £38k
There is a superb array of positions available for hardware engineers who are looking for a fresh challenge. Positions currently exist in the Telecomms, TV and Video and Networking industries. You will need to be a graduate engineer with 2 years+ experience of digital and analogue design with experience gained in FPGAs, PLDs and processor design as well as having good experience of software design for embedded applications (C, C++ and Assembler). Any experience of the following would be highly beneficial: DSP, Audio, RF. TIME102

Learn RF/IC Design
(superb offered prospect)
North London £20k to £36k
This well known company is involved in telecommunications and datacommunications, and has several dedicated design sites throughout the UK, Europe and the US. They are currently looking to recruit several bright engineers who are interested in the prospect of being trained as RF/IC Design Engineers. To qualify for these excellent opportunities you will need to be degree qualified and have at least 1 year's industrial experience in one of the following:
ASICs Optoelectronics Analogue ICs RF Design
You will need to be very bright and be capable of learning very complex design methods used in RF/IC designs. As part of your training, you will be required to spend several weeks abroad. TIME105

contact: Steve Riley
01844 202675
Crendon House Drake's Drive
Long Crendon Aylesbury Bucks HP18 9BB
Fax: 01844 202676
Email: Steve_time@msn.com

ELECTRONICSAPPOINTMENTS
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Time resourcing — hardware software manufacture test

Software Design
M3/M4 £20k to £40k
We are currently looking for up to 6 (six) software engineers (6 in each application area) to work on the design and development of new and existing products within the ATM, telecomms (GSM) and Multimedia markets. You should have good experience in a real-time embedded environment using C, C++ under UNIX. Any experience of the following would be beneficial: DSP, SDH, OO systems design and analysis for real-time embedded systems, VxWorks, GUI design using Visual C++, Graphics, Network Management. TIME106

DSP Design
Surrey, Hants & Cambs £25k to £45k
With good coverage across the country DSP Engineers have got it sorted. There is an impressive mixture of both large and small companies looking for DSP Engineers to work on some very complex projects including algorithm development/analysis and signal fundamentals for areas such as Telecommunications, Musical Instruments, Broadcast and Multimedia. You will need at least 2 years experience of DSP software development using C, C++ and Assembler and be very technically minded. TIME107

RF Design Engineers
M3/M4, Cambs £20k to £45k+
The market for RF Design Engineers increases rapidly due to the continuous introduction of new innovative products mainly for the telecommunications market. This demand for RF Engineers has opened the door of over twenty companies who are looking for designers who have experience of Receiver, Transmitter, Synthesiser, LNA and filter design in the RF ranges 1.8 to 2GHz. Typical technologies include GSM, wireless CDMA and UNITS for mobile and fixed communications products. Naturally you will have good HP EEsof, Touchstone and/or PSPICE experience. TIME103

RF Design Engineers
Wiltshire £24k to £45k
Having already placed several RF Engineers with this company, we now have a requirement to further expand this successful team. For over two years this company has been designing and developing the next generation of basestation products and systems for the telecomms market and is now poised to continue its already enviable reputation for designing some of the best products around. The RF team is looking for engineers who have 1 year's+ experience of RF Design gained within a very strong technically advanced company. You will work as part of a team of engineers designing Rx, Tx, LNAs, Filters. Massive resources of technical talent and financial security make this company one of the best to work for. TIME104

Principal Digital Design Engineer
Surrey £neg
Superb company involved in the design and development of complex electronics instrumentation equipment are looking to recruit an experienced digital design engineer who has at least 3 years experience of PLDs, FPGAs ADC, DAC and H8 microcontroller design and programming. You should also have real-time embedded software design experience with hands-on C. Any experience of DSP and VHDL will be of interest. JUNIOR POSITION ALSO AVAILABLE. TIME112

Hardware and Software Engineers
Cambridge £20k to £35k
Young and dynamic company based in Cambridge who are involved in the design of exciting broadcast and post-production equipment are looking to expand their team of software and hardware design engineers and are currently looking for the following engineering professionals.
DSP Engineers: Algorithm development for digital video processing using DSP, RISC and microprogrammable hardware. Minimum 3 years DSP and C coding experience is required.
Software Engineers: 3 years experience of C within an embedded environment. Development of algorithm and application software for video and audio processing systems.
Digital Designer: Hands-on design for next generation Video and Audio processing equipment. Digital design, 64 and 128 bit RICS technology. Experience of high speed digital design, FPGAs, Power PC, SPARC, DSP, PCI, VME, digital video/audio.

Senior ASIC Designers
Cambridge £24k to £35k
A rare opportunity to be involved in the design and development of some of the best future products is available with one of the UK's most respected design houses. You will be involved in the design of the latest ASIC technology for implementation into new Multimedia and Communications products. You will need a good degree (2:1 or 1st) with an excellent track record in commercial product design. High gate level design experience is required coupled with excellent VHDL/Synopsys. TIME101

Move into Digital ASIC Design
Herts to £35k
Several positions currently exist for design engineers with this very successful young company who are involved in the design and development of very complex ASICs for markets such as datacom, telecomms and wireless. The position requires a good degree with at least 2 years digital design experience. It is not essential that you have ASIC/VHDL experience as a good FPGA/PLD background will be appropriate. TIME200

RISC Design Engineer
Berkshire to £45k
You will be involved in the development of sub-micron implementation and modelling of advanced RISC architectures using design tools and methodologies. The position involves the physical realisation of RISC processor architectures, involving RTL coding in VHDL or Verilog, implementation of designs. You will need to be experienced in the design of ASICs with VHDL and/or Verilog and embedded microprocessor design. You should also be able to perform gate level simulation and verification. TIME201

RF Design Engineers
M3/M4, Cambridge £20k to £45k+
RF Design Engineers are sought by companies both large and small, to be involved in the design and development of new innovative products. This demand for RF Design Engineers has paved the way for some very exciting career opportunities. Positions exist from Graduate level through to Team Leaders with experience levels ranging from 1 year's+ experience for RF Engineers already established in the market. You will have gained experience in the design and development of Receivers, Transmitters, LNAs, Filters and Synthesisers from 1.8 to 2GHz. Technology areas include GSM, UMTS, Wireless CDMA for mobile and fixed communications systems. TIME202

DSP Design Engineer
Cambridge, Surrey, Bristol
£25k to £40k
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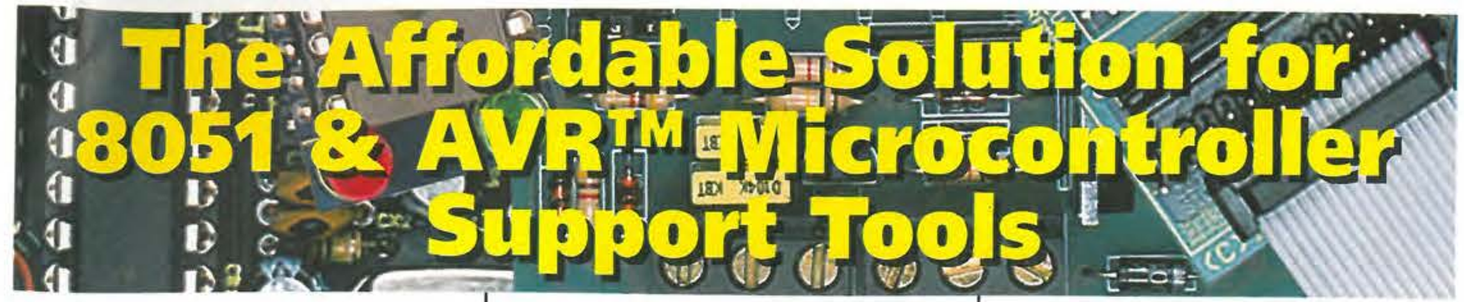

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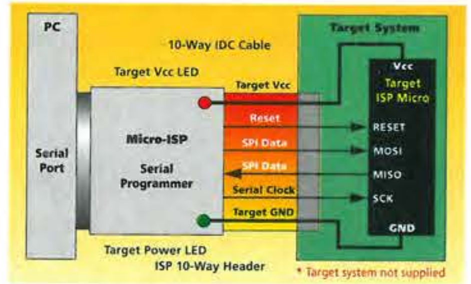

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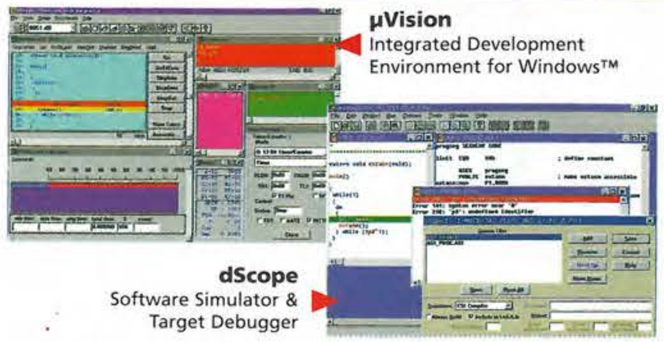

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Modes	AM,SSB/CW,FM-N,FM-W	AM,LSB,USB,CW,FM-N,FM-W
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Receiver type	PLL-based triple-conv. superhet	
Scanning speed	10 ch/sec (AM), 50 ch/sec (FM)	
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Max on one motherboard	8 cards	8 cards
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IF shift (passband tuning)	no	±2 kHz
DSP in hardware	no	yes
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