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ELECTRONICS WORLD

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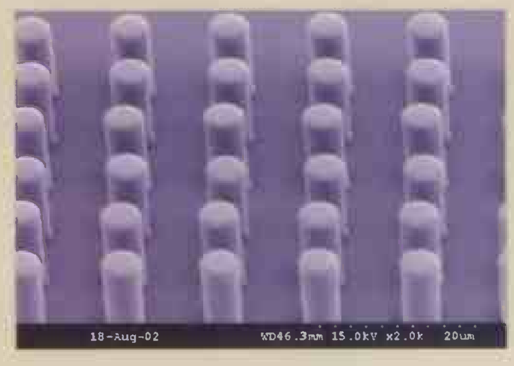

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Software grief

I am often amazed how bad software can be – not doing things properly, conflicts with other software etc. Up until now, AOL had my vote as the worst piece of software on my machine – poor functionality, bugs and lousy customer support. But a few weeks ago I went out and dipped my toe into new technology waters (for me at least) and got myself a GPRS mobile phone. As I'm often out and about and nowhere near an internet connection or even a POTS land line – it gets quite frustrating not to be able to email – especially if there's some urgent *EW* business to be done.

So the latest Nokia 7650 leapt into my shopping basket. And I thought it would be nice to be 'cable free' and got myself a Belkin Bluetooth adaptor. The first problem was making the Belkin 'pair' to the phone. Various changes to parameters (none of which were documented) finally got that bit working. In fact it was an email I received from O2 (my airtime supplier) that got this going, as both manufacturers' documentation was absolute rubbish. Then came the phone talking to the computer. No mention of my operating system (XP) – and more exceedingly poor documentation. Until the Bluetooth connection is running – the software will do nothing. You can't change any parameters or fault find – and when it finally started working (I've spent about 10 hours on it by now) – the software is terribly clunky. Getting on the internet is not plain sailing – and even trying to sign up to AOL's WAP service is a nightmare. In fact I've given up with that. So, the point I'm trying to make here is that as engineers, we owe it to the end users to make this stuff work. It is no wonder that the take-up of these new technologies is slow – as word must get around that it needs an IT expert to get it going. And they think G3 will take off? I don't think so.

A few apologies are in order this month as we pulled a special offer page by mistake in the last issue. The RD Research Spice offer should have been in – but got dropped by mistake. Sorry to all readers who were looking for it and to RD themselves. Suffice to say that the offer is in this issue.

Also apologies to readers who may be waiting for an email reply – we had someone hack into our system a few weeks ago and this and main server problems mean that we have lost correspondence. If you've not had a reply – please mail in again.

Phil Reed

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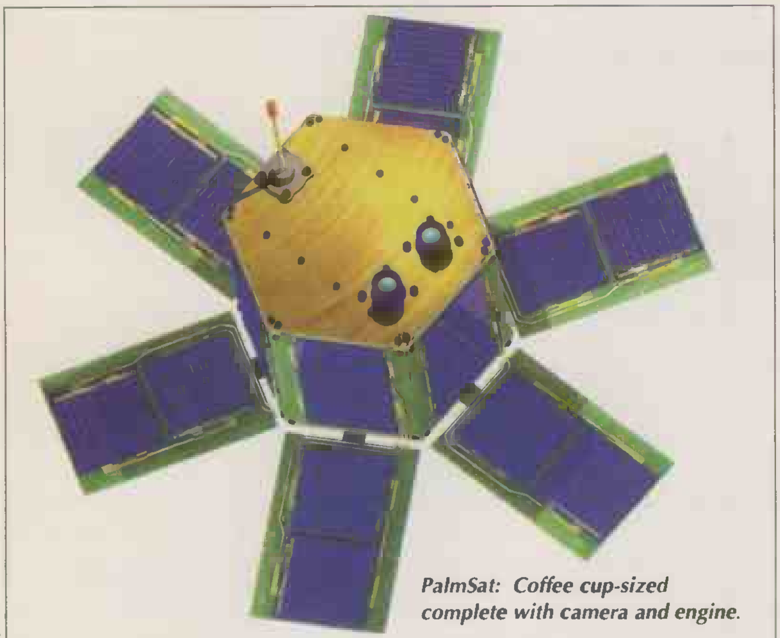
UK 'coffee cup' fit for space

Surrey students are working on PalmSat, a sub-1kg satellite.

"It will fit into the palm of your hand, coffee cup sized," said Dr Craig Underwood of the Surrey Space Centre - part of the University of Surrey. "The ultimate goal is to see just how small one can build a satellite and get a useful function out of it."

Whereas this would be a purely academic exercise at most universities, the Space Centre has close links with satellite builders Surrey Satellite Technology. The last time Underwood challenged his students to design something small and useful, the result was SNAP1, the football-sized satellite launched in 2000. "It went from paper to orbit in nine months," said Underwood.



PalmSat: Coffee cup-sized complete with camera and engine.

PalmSat - Preliminary key features

- <1 kg mass - COTS (commercial off-the-shelf) design
- 36 4x4cm GaAs/Ge dual-junction solar cells (20% efficient)
- - 4V panels delivering ~1.3A max.
- 4 cell NiCd battery to deliver ~2W orbit-average power.
- 20 MHz PIC Micro-Controller; Flash memory.
- Amateur band VHF uplink, UHF downlink - 9.6Kbit/s FSK packet-link
- Passive magnetic orientation control
- VGA CMOS camera payload
- All subsystems on credit-card sized PCBs
- 12cm diameter by approximately 10cm height overall.

Options

- Advanced triple junction solar cells (28% efficient) GPS positioning
- Active magnetic attitude control
- Micromachine gyro inertial navigation
- Optical attitude determination
- Micromachine micro-Thruster
- 2.4GHz spread-spectrum inter-satellite link

Algorithm reads history

A US professor has developed method computers to find important topics in history by scanning large collections of documents for sudden, rapid bursts of words.

Jon Kleinberg, of Cornell University, New York, devised a search algorithm that looks for what he calls "burstiness". This measures not just the number of times words appear, but the rate of increase in those numbers over time.

"The method is motivated by probability models used to analyse the behaviour of communication networks, where burstiness occurs in the traffic due to congestion and hot spots," he explained.

Inspiration came from dealing with a flood of incoming e-mail. Kleinberg reasoned that when an important topic comes up for discussion, keywords related to the topic will show a sudden increase in frequency.

After sorting his inbox, he tried the technique on State of the Union address texts, between 1790 and 2002, from the Web. What he got was a list of words that summarised American politics over the period.

"While we already know about these trends in American history, a computer doesn't," said Kleinberg, "and it has found these ideas just by scanning raw text. So such a technique should work just as well on historical records in obscure situations where we have no idea what the important terms or keywords are."

It might even be used, he speculated, to screen e-mail 'chatter' by terrorists.

Kleinberg presented his technique at the annual meeting of the American Association for the Advancement of Science.

www.cs.cornell.edu/home/kleinbe/

LED power hits 10W

Taiwan-based United Epitaxy Company has announced a record-breaking 10W LED. Total flux from the 2.5x2.5mm AlGaInP (red, orange and yellow) die is over 200lm.

Getting heat out is the most significant problem as the LED structure must be grown on a GaAs substrate, whose conductivity (44W/mK) is too low.

By bonding the wafer face down to a silicon wafer (146W/mK), a far more conductive path can be established.

To expose the emitting junction, the remaining GaAs wafer is etched away, leaving the LED to emit through its back face.

UEC will start to mass-production from the first quarter of next year and intends also to bond its wafers to aluminium (237W/mK) and copper (401W/mK) - samples of which are due this year.

Power efficiency of these LEDs is currently only just better than light bulbs, but UEC is aiming for low cost.

According to it, and incandescent bulb costs about $0.001/lumen. LEDs now cost $0.1/lumen now and UEC's target is $0.01/lumen in 2005.

Mast emissions safe, says Govt

Continuing work to assess the emissions output of mobile phone masts has yet to find a mast that breaches international guidelines. In 2002 the Radiocommunications Agency tested masts at 82 schools and 27 hospitals, with the highest reading being 731 times lower than the legal limit. Further studies are planned, said the Government.

"We are aware of public concerns and it is important to give the public the information they need. These results continue to show that exposure levels of the public are well below recommended limits," said Stephen Timms, Telecoms Minister.

Exposure limits for mobile phone masts are set by the International Commission for Non-Ionizing Radiation Protection (ICNIRP). For the 400MHz to 2GHz range, the ICNIRP specifies a power density limit of f/200W/m^2, where f is the frequency.

The RA's testing team measures emissions in µV/m at various locations around each school or hospital. This is then converted to W/m^2 for comparison to the limit.

The RA also hosts the very useful sitefinder website, which allows the public to locate any mobile phone mast in the UK. Details of the operator, frequency, maximum licensed power and actual power are available. Try it out at www.sitefinder.radio.gov.uk

Battery gets under your skin

The flexible battery technology from Power Paper in Israel could be used as cosmetic patches, boosting efficiency of treatments.

The firm is working with a leading UK consultancy, Cambridge Consultants Ltd (CCL), to develop the technology. Applying micro-scale currents to the skin can restore elasticity and hydration, the firm claimed, and is a well used technique in the beauty industry.

Power Paper already has agreements with three cosmetics firms. CCL will help to develop large scale manufacturing techniques.

The firm's aim "is to develop PowerCosmetics patch production lines that are capable of manufacturing tens of millions of patches per year", said Zohar Sagi from Power Paper.

Pillars connect chips

Polymer materials could be used to connect both electrical and optical signals between integrated circuits, according to researchers at the US Georgia Institute of Technology.

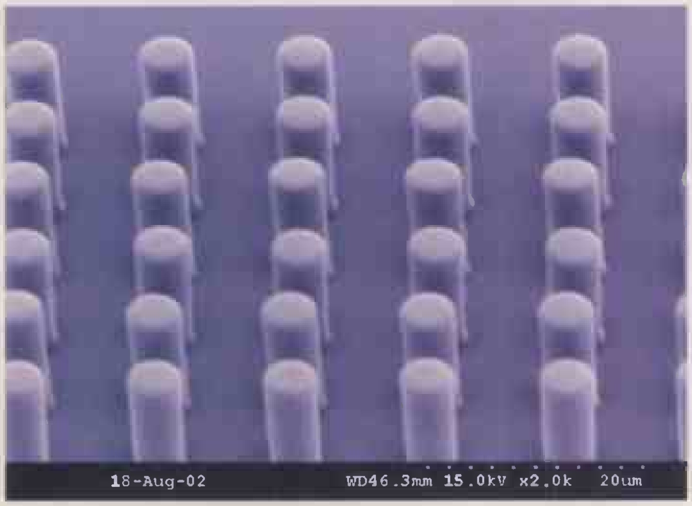
A team from the Microelectronics Research Centre at the Institute have built pillars from a polynorbornene polymer. The resulting columns are just 10µm in diameter and could give up to 10^5 connections per cm^2.

To make the pillars the material is spun onto the die, exposed using a mask and etched. Pillars are formed on the die, cups in corresponding positions on the substrate to which the die is being attached.

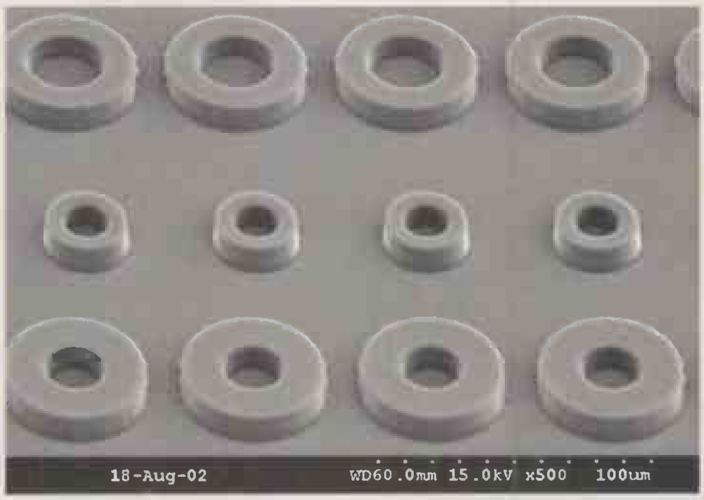
To make electrical links the cups are filled with solder and the pillars coated with gold. This could be used for digital, analogue or even RF signals. A grating structure on the end of a pillar would be used to couple light into a waveguide.

Pillars could be formed directly on top of a vertical emitting laser, photodetector or waveguide grating. The pillar's short length (under 200µm) means it does not need to be formed from a low-absorption material.

A single pillar could also carry an electrical and an optical signal. The base of the pillar is cleaved at 45° and coated with metal on one side. The metal coated angle provides a mirror for the optical half of the connection.



Micrograph of 5µm wide polymer pillars distributed on a 12µm pitch.



Micrograph of a set of polymer cups.

Government has green energy plan

The Government has set an ambitious target of generating 20 per cent of electricity from renewable sources by 2020, and plans to phase out nuclear power stations.

Details of the plans, including £348m in spending on renewable energy projects over four years, were outlined in the Government's energy white paper.

"The Government is serious about cutting carbon emissions, but we know this cannot be achieved without a fundamental review of the way we produce and consume energy," said Trade and Industry Secretary Patricia Hewitt.

"We need to use less by improving energy efficiency and we must match this with a major expansion in renewable energy."

Today the UK generates 38 per cent of its energy from gas, 32 per cent from coal and 23 per cent from nuclear. Just three per cent comes from renewable sources.

By 2010 the energy from wind, wave and other renewable sources should reach ten per cent, with the 20 per cent target reached ten years later.

New energy sources and more efficient use of electricity present a major opportunity for electronics firms, especially in automotive, lighting and motor drives.

By 2050 the Government plans to cut emissions of carbon dioxide to 60 per cent of 1990 levels.

Moreover, new nuclear power stations will not be built, said the white paper, leaving perhaps just one station running by 2025. However, nuclear could still figure in future energy plans should it become economically viable.

Battery gets simpler

A firm from Mansfield has demonstrated a replacement for the standard lead-acid battery that could halve the weight of automotive batteries.

Atraverda is developing its 'bipolar' battery for the 42V automotive market. At this voltage the firm expects to be able to produce 9kW.

Rather than using two plates per cell as in a lead-acid battery, the bipolar cell has just one plate. One side of the plate acts as the anode for one cell, the other side the cathode for another cell.

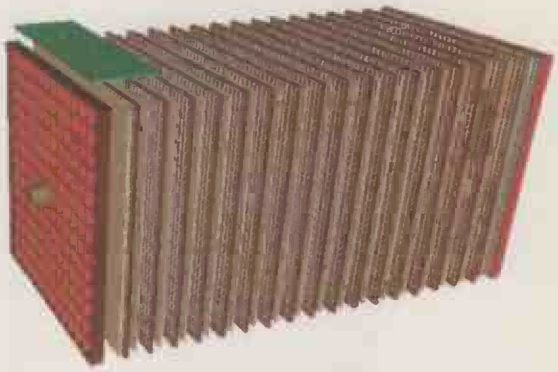
By stacking plates a battery of the required voltage is produced. At each end of the stack single plates act as the final anode and cathode.

This simpler construction leads to the reduced weight, not only because of the fewer number of plates, but also due to the fact that bus bars are not needed to join cells together.

"Existing batteries contain lots of inactive parts - a top tab on each plate, bus bars and lots of plastic to house the plates," said Dr Andrew Loyns, chief executive at Atraverda.

"Our plates cost more than lead, but total production costs will be the same."

Each plate can produce about 50Ah, so the battery is better suited to higher voltage systems.



Plates themselves are made from oxides of titanium, which are claimed to be conductive like a metal, but resist corrosion of the acid like a ceramic. This, said the firm, will lead to longer battery lifetimes.

Old processor gets new life on glass

Sharp has made a Z80 processor from polysilicon on glass.

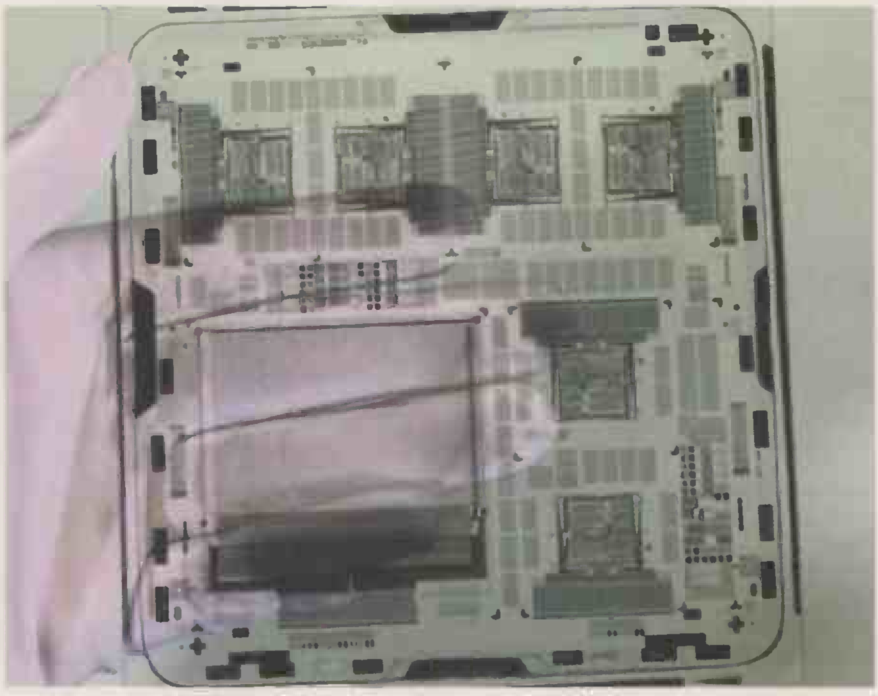
"We chose the Z80 because we have good experience with it and this is good for characterisation," said company engineer Beyeol Lee.

The company has been making more and more complex logic using a modification of its CGS (continuous-grain silicon) polysilicon process, normally used to make active matrices for displays.

The intention is eventually to make display control logic alongside displays.

Occupying 13x13mm, the Z80 operates at 1.25 or 3MHz, depending on whether is it made with 3μm or 2μm channel transistors. To prove it is a proper Z80, engineers wired the glass processor into an aging MZ80 desktop computer - and it ran.

Lee estimates Sharp will be making simple displays with all logic on-glass in 2005 using 0.8μm transistors running at 20MHz.



Six Z80s and a display in a standard 2.2inch display substrate.

Hydraulics power cars

An energy recycling system for use in cars and commercial vehicles is to be developed further in the UK.

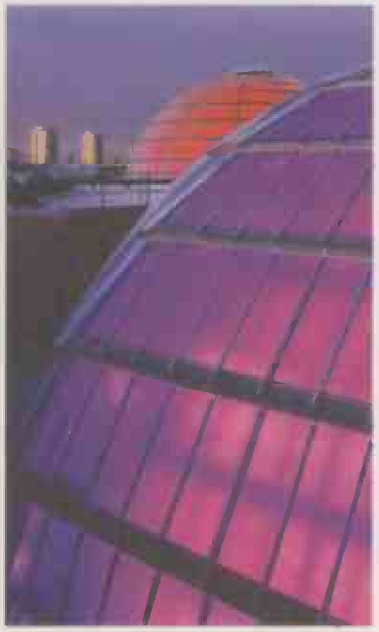
Pi Technology from Cambridge has signed a deal to build a controller system for the stored hydraulic power system developed by SHEP Technologies.

The SHEP system uses a two-way hydraulic pump attached to the driveshaft of a vehicle. When the car or truck brakes to a halt, energy from the shaft is transferred through the pump and is used to pressurise a gas.

As the vehicle begins to accelerate, the system works in reverse, adding power to the drivetrain. The technique eases the load on the engine, which when moving off from a standstill is at its least efficient.

Large vehicle tests have demonstrated the system is capable of storing enough energy to power a truck from standstill to 30mph without the engine. This process is said to reduce fuel consumption, pollution, brake wear and engine wear. Overall operating costs can be cut by up to 50 per cent, claimed SHEP.

The first test vehicle fitted out by Pi will be a Jaguar X-type. Pi hopes its experience with petrol engine management systems will allow it to build a smooth switching interface between the two systems.



Photograph:Timothy Soar

LEDs light the domes of Whiteleys Shopping Centre in Bayswater

LEDs light London skyline

The domes at Whiteleys Shopping Centre, Bayswater, London, have been lit with high brightness LEDs - in this case from Californian firm Lumileds.

Central to the design are 60 million colour LED floodlights developed by London-base Light Projects

"This is the first lighting solution of its kind in the world," said Graham Baxter of engineering firm Rybka. "Light Projects has taken a tested and proven housing and combined it with the Luxeon light source to create a powerful floodlight, which offers incredible colour intensity and flexibility."

While the initial purchase cost of the LED solution was higher, overall costs of ownership is cut through power savings and the installation will pay for itself within four years, is claimed.

Together the central and main domes have been lit using over 2,000 Luxeon LEDs in red, green and blue.

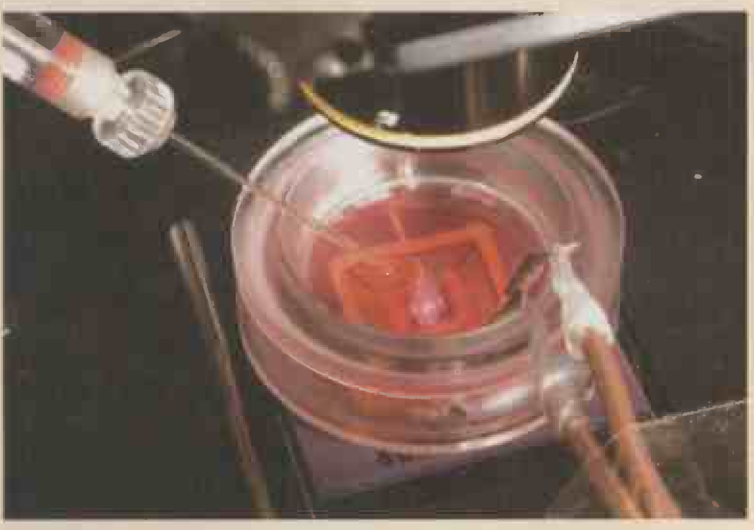
The scheme was the initial concept of lighting architects Speirs & Major, with the engineering and design development by Edinburgh-based Rybka.

The LED floodlights are located in the maintenance space between the inner and outer layers of each dome. The inner dome is colour saturated from behind using a 'Grazing' technique, whereby the coloured light from the Luxeon LED floodlights is directed to follow the curve of the dome. The outer dome glows as a result of the reflection from the internal surfaces.

Biosensor

A sensor that interfaces to neurons and amplifies the signals for processing by computer has been developed in Germany.

Infineon Technologies has collaborated with the Max Planck Institute to produce the sensor, which could lead to better understanding of brain diseases and how information is processed and stored.



Neurons are kept alive on a bios chip.

Neurons output very weak electrical signals, perhaps just 5mV. This is read by a sensor array and amplified by circuitry underneath the sensor.

Each chip contains 16,384 sensors spaced 8µm apart. A neuron is typically 10 to 50µm in diameter.

The research team said the sensor could be used to analyse how individual neurons or groups of cells react to electrical or chemical stimulus. Cells can be grown in to networks on the array and kept alive for weeks at a time.

"That our long-lasting basic research on neuron-semiconductor interfaces now sees a high-tech chip, is like a dream coming true," said Professor Peter Fromherz from the MPI.

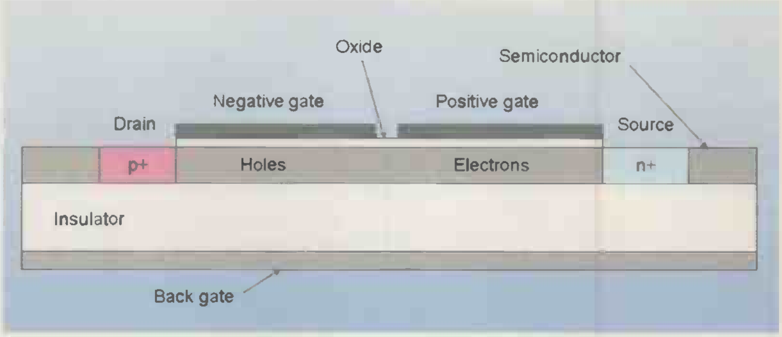
CMOS challenged by novel diode

Field-emission diode (FED) logic could beat cmos on both speed and power, claims Farshid Raissi, a researcher at KN Toosi University of Technology in Tehran, Iran.

Raissi originally invented the FED after he graduated from University of Wisconsin-Madison in the US.

Although he left for Iran without getting a chance to fabricate one, modeling suggested the device will work and Raissi is now designed and modeling a series of logic gates around it.

Essentially, a FED is similar to a mosfet although instead of a single gate over its channel, there are two, one over each end. As well as this, the channel is doped differently at each end. The result can be likened to two half mosfets, a p-channel and an n-channel, in series.



By tying one gate to the appropriate power rail and using the remaining gate, the device can either act as a p or n channel transistor.

In these modes, the most significant difference between the FED and a normal fet is the diode formed mid-channel as a result of the doping: which is where the name comes from.

According to Raissi, who describes his work in detail in the IEE publication Electronics Letters, in operation the FED has a far lower on-resistance compared with a conventional fet. This is because pinch off, which is the current limiting factor in mosfets, does not occur. More current means parasitic capacitance is charged more quickly and logic is faster. "It is worth noting that for comparable performance the total area of a circuit made by FED is less than the CMOS version because FED provides larger current," he said, adding: "And FEDs scale [can be shrunk] like cmos."

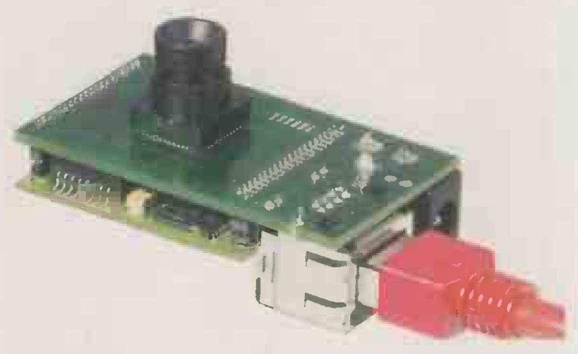
Although speed is the key for Raissi, he sees other benefits. "In introducing the FED digital family we concentrated on its speed, but it is not the only advantage," he said." Although FED provides large currents, when switching action is taking place, the power consumption for FED circuit is less than CMOS version because it provides current for a very short period of time. For all the circuits that we have examined, the power consumption and the chip area is less for FED version."

One further possible advantage could be gained by using both gates as logic inputs: "It is possible to use FED as a three state NAND and NOR gate. Having such a possibility simplifies many digital circuits and increases memory storage."

There are disadvantages, FEDs must be made on more expensive silicon-on-insulator wafers, otherwise one end of the channel would short to ground. And the logic needs both positive and negative supplies.

Security camera for under €70

This networked security camera, with a materials cost of just €70, has been developed by German firm Smart Network Devices. The camera can capture colour CIF resolution images (352 x 288 pixels) at between 5 and 10frames/s. With its Ethernet connection it is ideal in security applications over both Internet and Intranet, said the firm. SND is also planning a Bluetooth version. Reference designs and evaluation kits are available.



Thicker means smaller

Neah Power Systems from the US has outlined a modified type of fuel cell that promises to be smaller and more efficient than existing designs. The firm is developing a unit to power laptop PCs to demonstrate the concept.

Neah's design is based around the proton exchange membrane (PEM) cell, but uses much thicker porous silicon rather than the thin polymer membrane.

The honeycomb structure of the silicon gives the catalyst in the fuel cell a much larger area over which to work, leading to increased efficiency. The silicon can also be exposed to more concentrated methanol fuel. Existing PEM fuel cells are only around 30 per cent efficient.

The firm said it expects to be able to offer fuel cells with two to three time more storage capacity than rechargeable batteries.

Neah Power Systems' fuel cell could be the answer to mobile power problems.

Electronics gets Smart

Electronics companies are leading the pack when it comes to winning Smart Awards and taking a significant portion of the Government money.

At the recent Smart Achievement Awards in London, four of the 11 firms winning awards for commercial success were electronics-based.

Diamond Consulting Services used its Smart Award to develop a road tolling system that uses inductive loops to count vehicle axles. Oxford Semiconductor won a £150,000 award that it used to develop its family of FireWire communications chips.

And Isle of Wight-based RF Engines has developed a new form of frequency transform that is far simpler to implement than FFTs.

"With our national tradition of inventiveness, the UK is second to none at generating ideas," said Small Business Minister Nigel Griffiths. "Smart provides grants to small firms to help with the cost of researching and developing innovative and forward-thinking products."

Several levels of Smart Award are available to small firms in England (Wales, Scotland and Northern Ireland have their own systems).

Technology reviews can win a firm £2,500, while micro projects for firms with fewer than ten people are worth up to £10,000. Feasibility studies have a £45,000 limit, while up to £150,000 is available for full scale product development.

"Smart is a long-running, well-established scheme. And a recent independent evaluation has shown just how successful it's been. Smart has increased annual turnover in the economy by £500m," said Griffiths.

"This financial year we have seen an increasing number of Smart projects being supported nationally with nearly 700 offers of grant made by the end of December 2002. This means a total of £34m worth of investment in innovative Smart projects."

CMOS catches up with CCD

CMOS image sensors can now equal the quality of charge coupled device (CCD) sensors, according to Micron Technology. Better known for its DRAM, Micron has been working on CMOS imagers for some time.

The firm's latest sensor, a 1.3 million pixel device, is a progressive scan design, capable of capturing 30frames/s. A dark current of 20 electrons/s, and 10 electron noise level are similar to CCD-based devices, claimed the firm.

Micron also recently announced smaller VGA resolution sensors aimed at handheld equipment. With all the associated control circuits, the device consumes 85mW at 15frames/s output.

Diamond glitters for transistors

Jose Garrido of the Technical University of Munich has created a diamond transistor by exploiting its surface properties.
Diamond is attractive as a semiconductor as it had exceptionally good thermal properties. Unfortunately n-doping is extremely difficult so conventional transistors are next-to impossible.

The material in bulk has a tetrahedral structure which gets jumbled at its surface. However, by eroding the tangles and terminating its dangling carbon bonds with hydrogen, the diamond surface can be made conductive.

The channel of the 'in-plane gated' diamond transistor is a 100nm to 1μm wide strip of hydrogenated diamond surface between two (drain and source) aluminium electrodes.

Two further aluminium electrodes at the sides of the channel form the gate.

Gate-channel isolation comes from 100nm strips either side of the channel made by electron-beam lithography. Here surface oxidation replaces the hydrogen with oxygen - making a naturally-insulating oxygen-terminated surface with a leakage current of 0.3pA/μm at 100V and room temperature.

Biasing the gate to +15V causes complete pinch-off, and its makers claim the device has excellent switching characteristics and good saturation.

Researchers claim their approach can be used to make other components including single-hole transistors and point-contact devices - and diamond's bio-compatibility could also be exploited.

Plastic semiconductor made in-situ

Better conductive polymer films could spring from work at the University of Illinois at Chicago.

The techniques involves turning pre-cursor chemicals, in this case thiophene, into polymers as they hit the surface.

"Basically, the way it works is you have a surface upon which you want to grow a thin film. You put that into a vacuum chamber, pump all the air out, and you simultaneously deposit charged ions on to the surface and evaporate neutral molecules onto the surface. These ions and neutrals meet at the surface and form this continuous polymeric film," said chemist Luke Hanley.

The process is called surface polymerisation by ion-assisted deposition, or SPIAD.

"We've been able to show we can control the chemistry and shape of the surface on a nanometer scale," said Hanley. "It allows you to control what this thin film is on the sub-nanometer scale."

Commercial deposition looks possible. "We can actually grow large areas of films fairly quickly by this method. We're not quite at manufacturing scale yet, but we've demonstrated that we know how to get to that point," he said. "Essentially, this is another tool in the toolbox for producing these useful devices."

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Quickie – the Inside Story

Many readers will know of the TV programme Robot Wars, in which home-made so-called 'robots' beat one another up. Following its success, a sister programme Techno Games was launched, in which the contests are not so violent. It includes a number of events, many based loosely on the Olympics, such as walking, jumping, and swimming. Alan Heath Robinson describes how he made a practical entrant to one of these events.

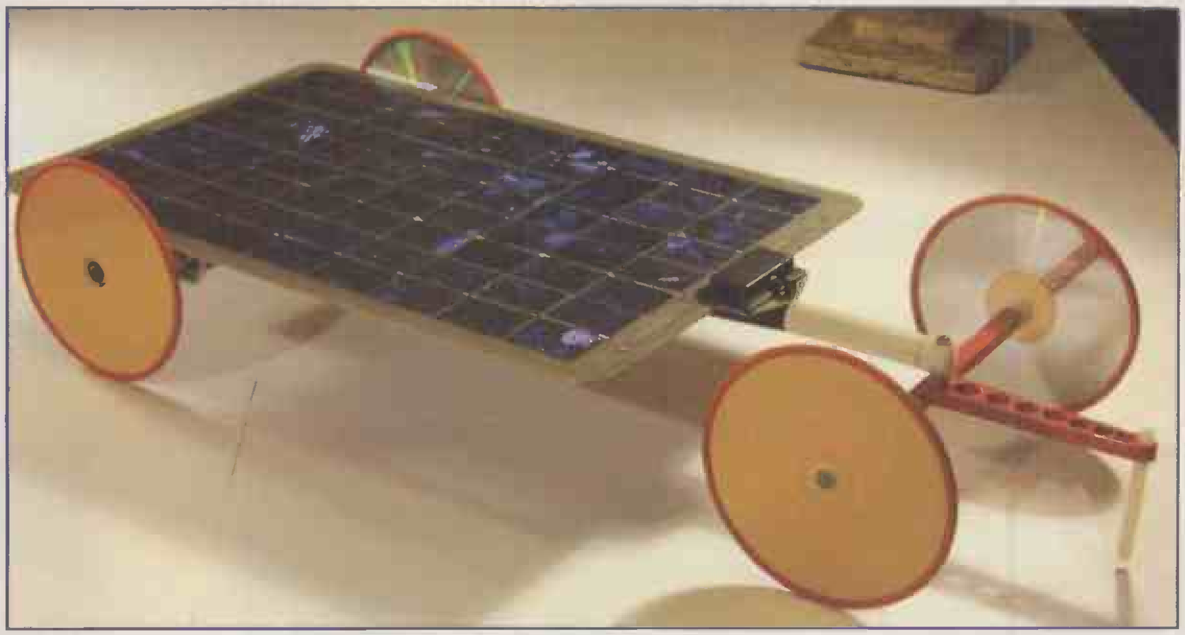
One of the events is the *Solar Challenge*, which is essentially a solar powered buggy race. In *Techno Games 2001* it had just three entrants. One didn't turn up for the race. One didn't start, because the team expected to be able to charge batteries from the solar panel beforehand, but the producers quite rightly insisted they start with them flat. The third entrant, *Push It*, made the 15m distance in 2 minutes 8·5 seconds, or 117mms^{-1} on average. I found it all disappointing. The game needed raising, and there was only one way to do that – build something better for the 2002 series.

The Challenge

The rules gave the maximum physical dimensions, the minimum weight, and the maximum size of panel to use, which was 8W nominal. Looking around, the only readily available 8W panel I could find, in the Maplin catalogue, was too large for the given dimensions, even though there were 10W panels that would do. The programme makers changed the rules to allow 10W panels.

There was one piece of information I could not get at all. The games are filmed in December, so they wisely don't rely on sunlight. Instead, the race occurs indoors under an enormous bank of incandescent lamps. How much power would a 10W solar panel deliver under these conditions? They couldn't tell me. I don't think anyone had ever measured it.

Despite the unknowns, something had to be built. An ideal machine would have no friction at all, 100% efficient motors, and electrical arrangements to transfer as much energy as possible from the panel to the motors. That way all possible available energy would be converted to kinetic energy. The lighter the machine the better, too, since less energy would be needed to get it up to the same speed. This ideal cannot of course be achieved in practice, but did underlie the thinking behind the design.



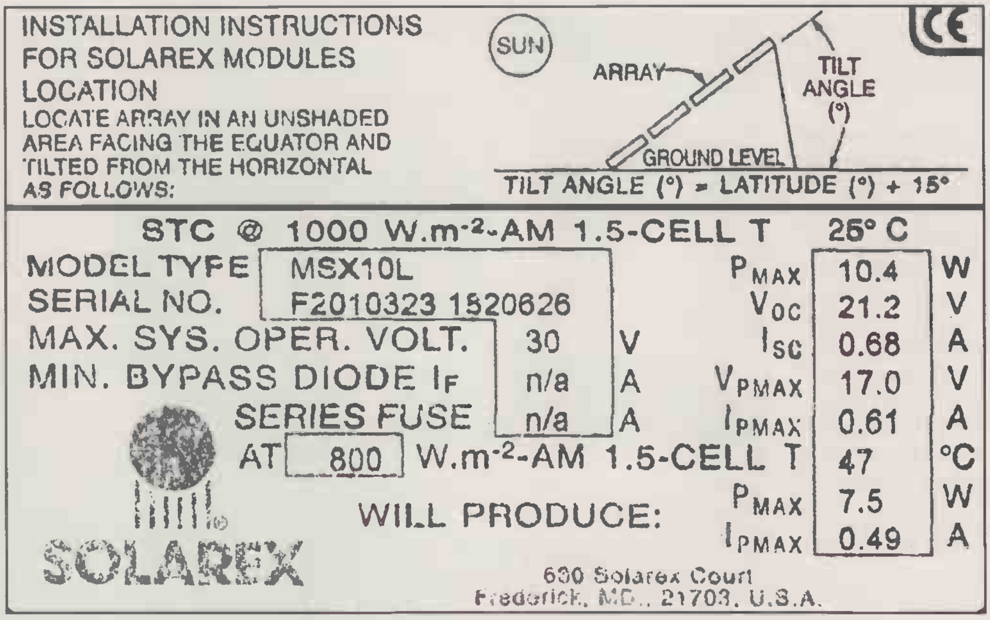


Fig. 1. Solarex solar panel label.

The mechanics

Some design decisions are easy. Since friction had to be kept low, very free running disc wheels seemed the best option. *Quickie's* wheels are made from four of those unsolicited CD-ROMs people insist on putting through my letterbox. In the hubs are miniature ball bearings. Around the rims are slim tyres made from bits of rubber tubing.

The rules state a minimum weight of 1kg. The solar panel as supplied weighs 1.1kg, due almost entirely to its stainless steel backing plate. I trimmed some metal off the edges, but the panel is still by far the heaviest component. The total mass came out at 1·4kg, so there is still scope for improvement there.

Early on it was unclear whether the race would be in a straight line or round a figure-of-eight, so I decided to allow for bends. Along the centre of each lane is a channel that accepts a guide pin. To make the pin forcibly push the machine sideways to keep it on track would involve a lot of friction, so the pin steers the front wheels instead, leaving the back wheels to drive it. Fixing both back wheels to a single driven axle was not an option because there would be wheel slip on curves, and consequent energy loss. Using a single motor and a differential in the back axle would be one possibility, but I settled for independent back wheels, each with its own motor.

Choice of Motor

Picking the right motor is crucial. There are plenty of very cheap model motors available, but they are inefficient and suffer from 'cogging' i.e. that tendency of the rotor to jump from one preferred position to another as you turn it with your fingers. Cogging is a problem if there is very little power available, because there may not even be enough to overcome the detent torque. Inefficiency is to be avoided at all power levels.

There are however far better motors available, known as 'ironless rotor' motors. These are permanent magnet DC motors in which the armature is a wound cylinder, or 'basket' of copper wire. The complete lack of iron in the rotor means there is no cogging, so very low currents will turn them over. The lack of iron also means there are no 'iron losses', the magnetic hysteresis and eddy current losses due to the rotating magnetic field in the rotor. The major losses are only the 'copper losses' due to winding resistance, a small amount of windage, and friction in the precious metal commutator.

There is a downside to using these motors. They cost over £20 apiece, compared to the 50p you can get cheap ones for. But it seems daft to spend £100 or so on a solar panel and throw half its output away by using poor motors.

Quickie uses two 6V 5W Maxon 'A-Max' ironless rotor motors, which have a terminal resistance of about 3·5Ω and need less than 5mA to turn over. They are wired in series, which allows the wheels to run at different speeds, so going round corners would be no problem at all. Otherwise the pair behaves effectively as a single 12V 10W motor.

The Solar Panel

The solar panel, made by Solarex (now part of BP Solar) has a 10W nominal output. This power is specified under standardised conditions, with 1kW/m^2 insolation normal to the panel at 25°C. Each panel is tested by the manufacturers, who put the results on a label on the back. Fig.1 shows the label from *Quickie's* panel.

This panel contains 36 polycrystalline solar cells wired in series. Each cell is a large silicon diode. When light falls on a cell it kicks electrons across the diode junction, generating a voltage that tends to forward bias the diode. When the cell is open circuit, the light-induced current returns across the junction. When the cell is short-circuited, it flows round the external circuit. In between these two extremes current and voltage are both present at the terminals, and power is output.

To get the maximum power from a cell it must be operated at its maximum power transfer point, or MPTP. This occurs when the terminal voltage has been loaded down enough for the majority of the light-induced current to flow round the external circuit, at something like 80% of the open-circuit voltage and 90% of the short-circuit current.

Fig. 2 shows the voltage/current characteristic of a typical solar cell. Depending on insolation and temperature, it will typically have an open-circuit voltage a little below 600mV. The short-circuit current varies greatly, depending on insolation and cell area. The MPTP lies on the knee of the curve, between 450mV and 500mV.

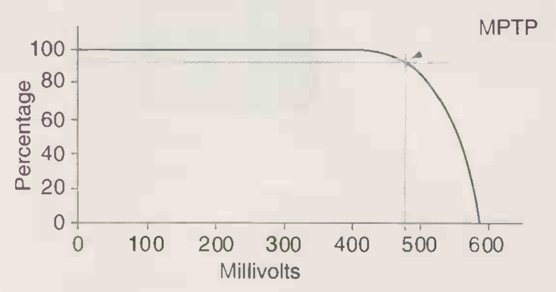


Fig. 2. The voltage/current characteristic of a typical solar cell at 25°C. The MPTP lies on the knee of the curve, between 450mV and 500mV.

View of the underside. The drive circuitry is in a tinplate screening box glued to the stainless steel backing plate with conductive epoxy. The clip-on cover has been removed. The dark 'blob' visible in the gear wheel is a ferrite magnet which operates a reed relay once per revolution.

The characteristics of solar cells are also temperature dependent. The short-circuit current increases slightly with temperature, but this effect is swamped by the reduction in diode forward drop, at about 2mV/°C. Cold cells can deliver more power than hot ones.

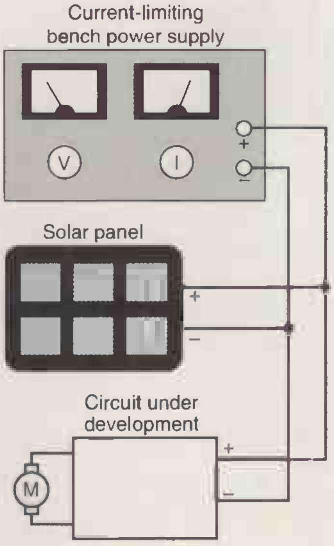


Fig. 3. Simulation set-up to see how the circuitry would behave with different amounts of light.

All Power to the Motors

An object of the exercise is to transfer as much power as possible to the motors. As *Quickie's* solar panel data in Fig. 2 shows, its MPTP is at 17·0V and 610mA, but that is under standard conditions including a known insolation and known panel temperature. What these would be on the day was quite unknown, and to make things even trickier the motor's back emf depends on its speed, and its winding resistance increases if it warms up.

To go as fast as possible some way of matching these unknown and changing characteristics is needed. Simply connecting the panel to the motors is not the way to do it, at least, not if you want that gold medal. *Techno Games* gold medals are quite remarkable, being made from a kind of gold you can pick up with a magnet. But anyway.......

A standard well-known switch-mode power circuit is the 'buck converter' (see Box). Since *Quickie's* panel would be working at an unknown voltage, but in the region of 16V, and the motors at a lower but rising voltage, a buck converter seemed a good way to transfer maximum power to the motors. By varying the duty factor, the panel could hopefully be kept working at its MPTP at all times. The truth is I decided to use a buck converter before deciding what motor voltage to use. Their combined voltage had to be lower than the panel voltage, but not too much.

Having decided to use a buck converter, the question became one of how to control the duty factor. One way, which should achieve good results, would be to vary it to keep the panel voltage at about 16V, regardless of the current. I gave this quite some consideration, too. It shouldn't be hard to devise a simple analogue circuit, based around a few op-amps, and perhaps a 555 timer, that would generate a PWM waveform with a duty factor dependent on the panel voltage. It might perhaps be 0% below 15V, and vary from 0% to 100% between 15V and 17V, and be 100% above 17V. The sensible thing to do would be to make the voltage thresholds adjustable so it could be tweaked for best results.

Microprocessor Control

What I actually did was somewhat more sophisticated, perhaps unnecessarily so, because I had an idea I wanted to try out. If current and voltage were measured and multiplied, that would give the power transferred. It should be possible to devise a simple algorithm, running on a microprocessor that would hunt for the MPTP.

A time-honoured principle often applied when building one-off circuits like this is to use bits you already have. I happened to have some SGS-Thomson ST6260E single-chip microprocessors from a previous project. Compared to the popular PIC they have very little processing power, but they do have an on-board analogue to digital converter with input multiplexer, and a timer circuit that can be used to generate the PWM waveform to drive the buck converter. Even better, they consume very little power, which means there's more for the motors.

For this job this micro was just right. The hopelessly low processing power didn't matter. All that was needed was to include power supply

Buck Converters

Buck converters behave like non-isolating step-down DC transformers, in which the output voltage is lower than the input voltage, but the output current is higher than the input current. With ideal components the efficiency would be 100%, but there are losses in practice. Nevertheless, efficiencies above 90% are quite possible.
In principle, the converter is simply a changeover switch and LC smoothing circuit, as shown in Fig. 7a. The switch S alternates between V_{IN} and common at a frequency usually well above the resonant frequency of the LC circuit, so there is little switching frequency ripple at the output. V_{OUT} is then V_{IN} multiplied by the proportion of time the switch connects to V_{IN}. This proportion, anywhere between 0% and 100%, is known as the duty factor.
Buck converters are most often used to regulate their output voltage, despite input voltage variations, by making the duty factor depend on the output voltage, in a feedback arrangement. Usually the switching waveform will be generated by a regulator IC designed specifically for this job. The IC may well also include the switching transistor. This type of circuit is commonly called a buck *regulator.* Practical buck converters can usefully use the positive supply rail as the common connection, and a combination of a power transistor and diode as the changeover switch, as shown in Fig.7b. The advantage is that npn power transistors and n-channel MOSFETS of the same performance are easier to make. Here, an n-channel MOSFET acts as the switch. When turned on, the 'freewheel' diode D is reverse biased, and turns off. When the MOSFET turns off, the current through the inductor is diverted through the diode. Schottky barrier diodes are often used in low voltage converters because their low forward voltage drop and very fast switching time make for greater efficiency. The duty factor is the proportion of time the MOSFET is turned on. *Quickie* uses an arrangement just like this.

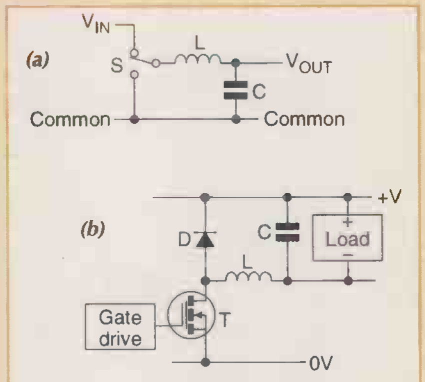


Fig. 7. The converter is simply a changeover switch and LC smoothing circuit.

circuitry to give it some 5V, a reset circuit, simple circuits to allow it to measure current and voltage, and the power stage of the buck converter. Oh, yes, and some software, too.

The job of the software is to find the MPTP, using a simple algorithm executed every 10ms. On each pass it measures current and voltage and multiplies them to arrive at the power transferred. Then it increments or decrements the PWM duty factor by one notch, depending on the results of the power measurement. If the power transferred has increased since the last pass, the previous step in the duty factor is assumed to have taken it nearer to the MPTP, so it keeps going in the same direction. Conversely, if the power has reduced, it is assumed that it is moving away from the MPTP, so it reverses direction.

There were some added complications to get round problems at very low insolation, and to home rapidly in on the MPTP at the start, but that is basically how it works. Because all it does is hunt for maximum power, it does not need to know what the insolation, panel temperature, motor winding temperature, or back emf are. The current and voltage measurements do not need to be accurate either, provided they are proportional to the actual values.

Testing the Circuitry

Circuits can be built and software written, but it all has to be tested somehow. It isn't possible to banish the clouds or turn the sun up and down at will. Another way is needed to simulate different amounts of light.

One thing not to do is partially shield the panel from the light. The trouble is this doesn't affect the cells equally, unless you are very careful. You could stick black insulating tape over equal proportions of all the cells, but this is time consuming, and anyway is no use at all if the sun isn't out. I did most of my development on a few autumn 2001 evenings, and wanted a much easier way.

Fortunately, there is one. All you need do is shield the panel from bright light and connect a controllable

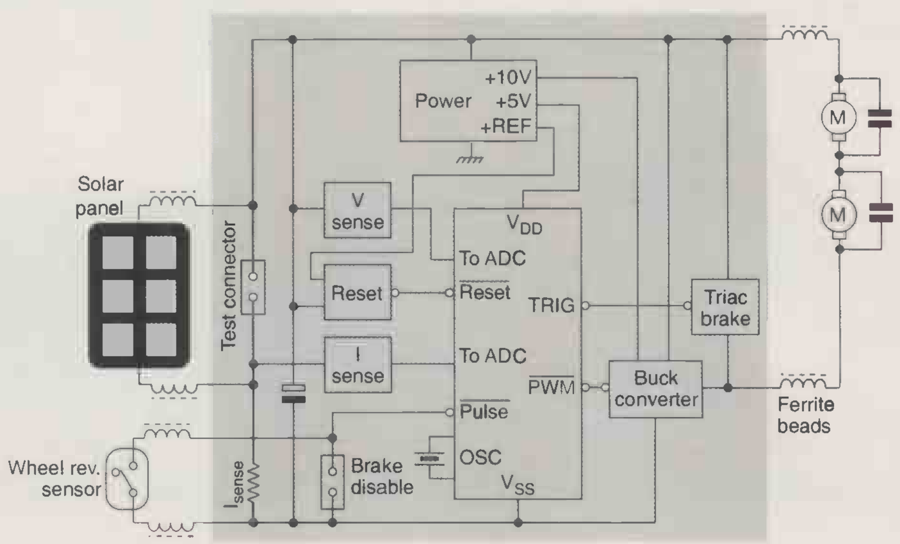


Fig. 4. Quickie block diagram.

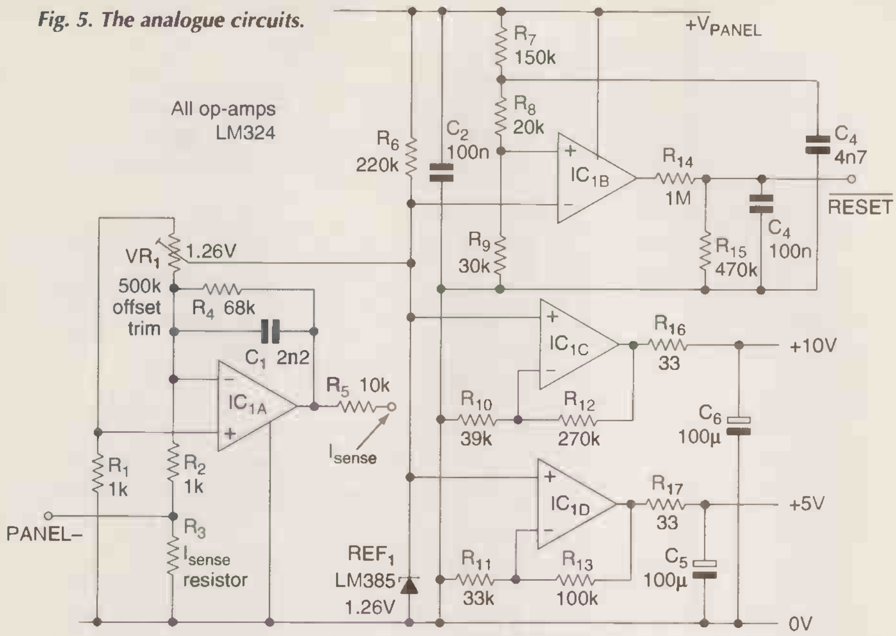


Fig. 5. The analogue circuits.

current source to it, as in Fig .3. The current source substitutes for the light-induced current in the cells, and forward biases the diodes. It is especially easy if you have a bench power supply with a controllable current limit. When the power supply open-circuit voltage is set higher than the solar panel open-circuit voltage, the power supply goes into current limiting. Then the current limit control can be used to vary the 'insolation' and see how the circuitry would behave with different amounts of light.

This simulation isn't perfectly accurate because the current is generated externally, which has two effects. Firstly, the currents in the connecting conductors are in the opposite direction, so the panel voltage will be a little bit higher. Secondly, the real light-induced currents in the cells are not identical, whereas this test set-up passes exactly the same current through every cell. Nevertheless, it provides a close approximation and is a very convenient way to test the circuitry on the bench.

When testing *Quickie*, I set the power supply at about 24V and varied the current up to 1A, even though the panel's nominal short-circuit current is only 680mA. This gave about 150% of nominal panel power, and ensured the circuits were tested well beyond anything they would meet in the real world. The buck converter got a bit warm, of course, but nothing blew up. To avoid overheating the motors, I used a 7Ω dummy load in their place, or only used such high power briefly.

A header on the circuit board was used to connect the power supply to the solar panel. An ammeter can also be connected here, which shorts out all the power control circuitry and diverts the panel current through the meter, thus measuring the panel short circuit current. This was to prove useful.

Avoiding Disaster at the Finish

I gave the microprocessor one more little job, because I couldn't find out was what was going to happen at the end of the track. *Quickie* doesn't hang about, but isn't built to withstand collisions either. The extra circuitry was a wheel revolution counter and a triac across the motors, to act as a brake. The sensor is simply a magnet in the wheel, operating a reed switch. The microprocessor counts wheel pulses and fires the triac when it has travelled far enough to be beyond the finish line. A jumper can be used to short-circuit the wheel pulses and disable all this. In the event a sack of polystyrene beads was dumped on the end of the track, so this feature wasn't needed on the day.

In one way the behaviour of this circuit was unexpected. It turned out that it would still work in *total darkness* beyond the finish line. What happens is that the motors act as generators, the diodes in the power stage (one of them being the body diode in the power MOSFET) pass the motor output back into the power supply, and this is enough to keep the control circuits up and running. It wasn't intentional, but there is something rather elegant about it.

The drive circuit removed from its box. The wire link parallel to the board edge near the end of the cage-clamp terminal strip is actually the piece of resistance wire used to sense the solar panel current.

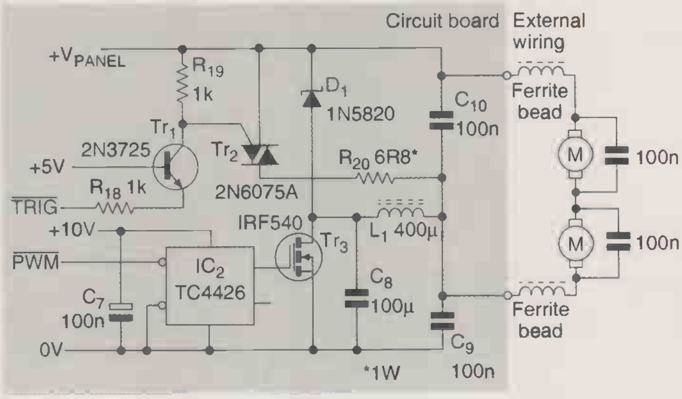


Fig. 6. The motor drive circuits, including the buck converter and triac brake.

Choosing the Gear Ratio

The gear ratio between the motors and the wheels had to be decided. Too high a gear ratio would result in very rapid initial acceleration, but top speed would be too low. Once the motor back emf had risen to the panel MPTP voltage, the PWM duty factor would be stuck at 100% and little further acceleration would be possible. On the other hand too low a gear ratio would result in poor initial acceleration.

To solve this problem I knocked up a small simulator program to run on a PC. Using this, various gear ratios and insolations could be tried out. The result was something of a surprise, because the ratio turned out to be less critical than I had imagined. The gears in the final design used a two-stage reduction with an overall ratio of 50:3, near the middle of the range the computer suggested would be best.

The Circuitry in More Detail

Fig.4 is a block diagram. The circuitry within the tone area is on a piece of Veroboard. Because it includes a microprocessor and switch-mode power circuit which might cause interference in a place where radio controls would be in use, I played safe and put it in a tinplate screening can stuck to the back of the solar panel with conductive epoxy, so the stainless steel backplate forms the top face. The bottom is a clip-on tinplate cover. All wires leaving the can have ferrite beads on them.

Strictly speaking, the object of the exercise is to deliver maximum power to the motors, so it ought to be the motor current and voltage that are measured. But the use of a low side switch in the buck converter makes it less easy to measure these, so the panel power is monitored instead, which should give near enough the same end result.

Fig. 5 shows the analogue circuits, built round an LM324, chosen because of its low quiescent power consumption, its low cost, and its input common mode voltage range includes 0V. And I've already got some. Audiophiles might justifiably disparage them, but for this job they're brilliant.

IC1A is the current sense amplifier. The panel current passes through R3, which is a short length of resistance wire. The voltage on the panel negative terminal is small, and negative compared to 0V. IC1A and associated components amplify and invert this, to give a voltage between 0 and 5V, the range required by the microprocessor's ADC.

IC1B and components are the reset circuit. When the panel voltage is below about 8·5V the processor is held reset. The reset circuit shares the panel voltage divider R7, R8, R9 with the voltage sensor. The panel voltage is divided by four and fed to the microprocessor's ADC, giving a measurement range of 0 to 20V.

IC1C and IC1D are regulated power supplies, 5V for the microprocessor, and 10V for the buck converter MOSFET gate drive. Both these circuits consume very little current, so the op-amps are more than up to the job.

Fig.6 shows the motor drive circuits, including the buck converter and triac brake. The power switch is Tr3, whose gate is driven by half of a TC4426 dual MOSFET gate driver (that time-honoured principle again). When the microprocessor is reset its outputs are pulled high, so using an inverting driver ensures a reset will turn off the MOSFET. I found that with the unused input tied low the driver chip consumed about 1mA less than when it was tied high, so low won.

A Schottky barrier diode is used for D1. L1 was made by taking the windings off a 100μH iron powder core toroidal inductor, then hand-winding twice the number of turns onto it. Because it is hand wound, I could use thicker wire than winding machines would have been able to handle, which gives it a lower resistance.

Normally a converter like this would include current limiting circuitry, but in this case the solar panel's inherent current limit gives enough protection.

A triac is used instead of an SCR for the brake because it can be triggered by a negative gate current, which simplifies the circuitry a little. The triac is fired when the microprocessor thinks it has got past the finish line. Pulling its trigger output low sinks current from the gate via the cascode-connected Tr1. The 2N6075A has a sensitive gate that is easily driven by this circuit.

The time-honoured principle is operating with a vengeance here. The 2N3725 is a ridiculous choice of transistor, being a 500mA switching device in a TO-39 can. Any old NPN signal tranny would have done just fine, but I've got a fistful of 2N3725s I probably won't ever use up, even though they do also make good relay drivers.

The microprocessor itself hardly needs a detailed circuit diagram, so there isn't one. The ST62E60 is an 8MHz device, operated here with a 7·3728MHz crystal. The auto-reload timer used for the PWM generator divides this by 128, to give a switching frequency of 57·6kHz. The PWM duty factor can be varied to the nearest oscillator clock period, or 1/128 of the period. Each increment/decrement 'notch' used by the MPTP search algorithm is this size – about 0·78%.

On the Day

The race was held on a December evening at Shepperton Studios, just outside London. There were seventeen entrants in a knock-out competition with two machines per heat. As it turned out, the day's previous events had taken so long to film we were running out of time, and at the last minute the contest was turned into a time trial instead, still with two machines per heat. They don't do rule changes like *that* at the Olympics!

While waiting for the event to start, I was given an opportunity to measure the solar panel short circuit current under the lamps, using the test connector and a multimeter. The current varied from place to place but averaged out at roughly 400mA, compared to the 680mA given in the manufacturer's test results. 400mA would translate into something like 5·5W or 6W, higher than I expected. Vaguely remembering the results of the computer simulations, I guessed *Quickie* might take 6 or 7 seconds to do the 15m track distance. Since the previous year's winner took over 2 minutes, all present must have assumed this to be a bit of pre-race bluster. They appeared not to believe a word of it.

There were problems with the starting method. The original idea was to put covers over the machines and whip them off at the starting whistle. The low tables meant to be used as covers let past enough light for some machines to start anyway, so there was another rule change. Now the starting method is to switch the lights on. The switch-on surge must have been over a megawatt.

The previous 'World Record' of over two minutes was blown away right from the start, when *Apollo Guys* won its heat in 9·75 seconds. Soon after, *Lightspeed* came a fairly close second with a time of 10·07 seconds, and later *Solar Slug* managed 11·35 seconds. *Quickie* was in the very last heat, along with *Push It V2*, a new machine built by the previous year's winners. *Quickie* sped to the finish line in just 6·91 seconds. The TV people were stunned. I was relieved! Now they are upping the distance from 15m to 25m for the 2003 series.

Quickie's Performance

To go faster by a factor k requires k^{-2} times as much kinetic energy, to be collected in a period only k^{-1} times as long. To a rough first approximation, then, the speed varies with the cube root of the power conversion efficiency. It isn't really that simple, of course, but according to this crude index *Quickie* was better than the second place *Apollo Guys* by a factor of about 2·8. Its victory was much more decisive than most will realise, and just goes to show what *Electronics World* readers can do when having a bit of fun.

Is the performance really that amazing though? An Inter-City 125 High Speed Train weighs about 450 tons and has a 2250hp diesel engine at each end – its power-to-weight ratio is about 10hp/ton. *Quickie* weighs about 1·4kg and has a panel power of 10·4W, which works out at 7·4W/kg, or about 10hp/ton. So it shouldn't hang about, should it?

Quickie weighed 40% more than the permitted minimum, and under the lighting conditions on the day the power-to-weight ratio was more like 6hp/ton, which is nearer that of an ordinary 100mph (160kph) express train, but that detracts little from the point. I found it fascinating that one of the programme's resident expert professors should doubt this comparison with high speed trains when the power-to-weight ratio is a product of the rules of the event, not engineering ability on any contestant's part.

It is hard to know how fast it was going at the finish line. The average speed was about 2·2ms^{-1}. At a final speed of 3·8ms^{-1} (which sounds decidedly on the high side) its kinetic energy would be 10J, ignoring the rotation of the motors. At 5·5W to 6W, the panel would have delivered in the region of 40J in 6·91s, so it seems less than a quarter of the panel's potential output ended up as kinetic energy. Clearly there is room for further improvement. ■

HJ Round- the unknown genius

Henry Round is not the most well known of scientific pioneers but he had a great impact on British history as well as being one of the leading lights in early radio development. If it was not for him, the Battle of Jutland, the largest naval battle of the First World War would not have occurred and neither would valve or radio development have progressed so swiftly during the first half of the twentieth century. Ian Poole reports.

H J Round.

On top of the valve and radio developments, he made significant contributions to the development of ASDIC. As for his character, Round himself was an individualist. Short in stature, he was something of an extrovert and rather Churchillian in appearance, even down to a cigar. He also had a dislike for unnecessary protocol, preferring to get to the right person and to the point as soon as possible

Henry Joseph Round was born on 2nd June 1881 in the small Staffordshire town of Kingswinford. He was the eldest child of Joseph and Gertrude Round. His early education took place at Cheltenham Grammar School, but later he studied at the Royal College of Science where he gained first class honours.

Early work for Marconi

He started work by joining the relatively newly formed Marconi Company in 1902. It was a year after Marconi had made his historic first crossing of the Atlantic by radio. At the time the company was struggling financially as a result of the enormous outlay in building the transmitter sites for the Atlantic crossing, and revenues were only coming in slowly. Nevertheless Round was sent to the USA where his office junior was David Sarnoff, the man who was later to become the chairman of RCA (Radio Corporation of America), which was interestingly formed from the American Marconi Company. Here in the USA Round experimented with a variety of aspects of wireless. Between 1903 and 1904 his main focus of activity was dust cored tuning inductors. However he also found time to undertake some experiments with transmission paths over land and sea by day and night, as well as looking at direction finding using frame antennas. Although this work did not yield any patents, it proved to be very a very useful foundation for future investigations he was to undertake.

In one area Round made a discovery that was many years ahead of his time. In 1906 H. H. Dunwoody had discovered the crystal detector - an important rival to Fleming's diode valve. Round performed a number of experiments on the detector. During his experiments he used a variety of semiconductors and even applied a direct current to them. Whilst doing this he noticed that some emitted light. Round reported this in the 9th February 1907 edition of Electrical World. This is the first known report of the effect of the light emitting diode. Unfortunately Round was well ahead of his time and it took until the 1960s before it was fully exploited.

Redundant

Whilst the Marconi Company was breaking much new ground, its finances were far from sound. Large amounts of money needed to be invested into research and development as well as the installation of expensive new equipment. This meant that money was very short within the company, particularly the American Marconi Company. Accordingly Round found himself without a job. After being turned away by Edison, Round found employment with the New York Telephone Laboratories. However he did not stay long with the Telephone Laboratories because Marconi soon found himself in a position to re-instate Round and he returned to England. Here he became deeply involved in the problems of valve amplification. This work soon paid dividends and in 1913-14 he patented a number of ideas for valve improvements including that of an indirectly heated cathode, which became the key to enabling valves to be used far more effectively and far more widely. Also during this time he patented his auto-heterodyne (autodyne) receiver and developed the first use of automatic grid bias.

War

At the outbreak of the First World War, Round was seconded to Military Intelligence. With his previous experience in direction finding, he set up a chain of direction finding stations along the Western Front. These were so successful that he was requested to install a second system in England. It was on 30th May 1916 that these stations reported a 1.5 degree change in the direction of the communications from the German fleet that was supposedly at anchor at Wilhelmshaven. Combined with an increase in the level of traffic, the Admiralty correctly reasoned that they had put to sea. They ordered the British Fleet to put to sea to intercept the Germans, and the following day the Battle of Jutland was fought. It was the largest sea battle of all time. Although the British lost seven ships and about 7000 men and the Germans three ships and around 2500 men, it meant that the German fleet did not sail. After the war it was revealed that it was as a result of Round's endeavours that the Battle had taken place. Round made other contributions to the war effort, designing the first telephony transmitters and receivers for airborne use. For all his services during the war, Round was awarded the Military Cross.

Type CA Valve designed by HJ Round, circa 1916

Peace

With his return to civilian life, Round turned his energies to more peaceful and commercially profitable developments for the Marconi Company. His first activities were focussed towards new valve developments. He developed two new transmitting valves that were given the part numbers MT1 and MT2. Using these valves he developed transmitters that were capable of producing up to 20 kilowatts of power. In March 1919 he undertook the installation of a telephony station at Ballybunion in Ireland. Operating at a wavelength of 3800 metres, this was the first European station to be heard in North America.

Later in 1919 Round developed more transmitters for range testing. These were located at the Marconi works in Chelmsford and radio amateurs were invited to listen and report on the transmissions. To provide some interest the carrier was modulated with a variety of sounds. When this included music, many enthusiastic reports were received from listeners who had enjoyed listening. As a result the idea of broadcasting as we know it today had dawned. Accordingly a regular wireless telephony news service was inaugurated on 23rd February 1920. Three and a half months later on 15th June Dame Nellie Melba, the famous Australian soprano, took part in a broadcast concert organised by the Daily Mail. This created a significant amount of public interest and many people listened to it. Unfortunately these entertainment transmissions were soon stopped because of the interference that was being caused to 'more serious' uses for wireless. Nevertheless, two years later more entertainment broadcasts were licensed, but this time from Writtle just outside Chelmsford. With the call sign Two Emma Tock (2MT) the station took to the air using a transmitter again designed by Round. The success of this station lead to the establishment of another station at Marconi House in the Strand. With the call sign 2LO this station was taken over by the BBC at its formation in 1922. Round naturally played a very significant role in the foundation of broadcasting, providing much of the technical expertise and drive to ensure that it succeeded.

Despite his enormous efforts in establishing broadcasting, Round was still working on other projects. One of these was to convert the Marconi station at Caernarfon from a spark transmitter to valve transmission. This was no small undertaking. Using 56 MT2 valves with a plate high tension supply of 10kV the transmitter was very powerful and on 19th November 1921 signals from the station were heard in Australia.

Other work

Round was appointed chief of Marconi Research in 1921, and he remained with the company until 1931, continuing to provide a phenomenal rate of output. During the remainder of his time with the company he designed and built maritime valve receivers and transmitters, a broadcast receiver, a gramophone recording system and a large public address system that was used to relay King George V's speech at the Wembley Exhibition. He also devised a system for providing sound with films during the 1930 cinema boom.

Despite all these successes, in 1930 Round decided to go into private practice as a consultant. However, he still worked very closely with the Marconi Company, frequently returning to undertake consultancy work there. Shortly after the outbreak of World War Two he worked for the Admiralty on ASDIC, continuing to work on this until 1950. After this period he undertook some more work for Marconi, primarily working on echo sounding.

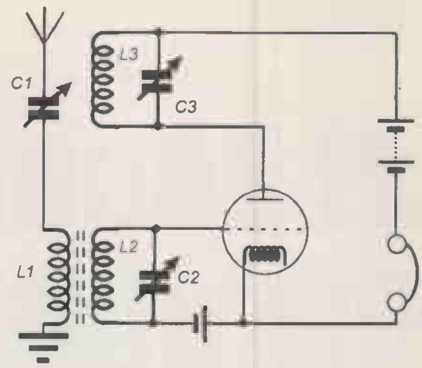


Fig. 1. Round's Autodyne receiver.

Private Life

Round was married in 1911 to Olive Wright Evans. They were blessed with seven children, two sons and five daughters. Sadly his eldest son John was a Spitfire pilot and was killed in action in World War Two. He outlived Olive and remarried in 1960 to Evelyn Bays. Round himself died in August 1966 in a nursing home in Bognor Regis after a short illness.

During his life he had achieved an astounding amount. He revolutionised the receiver design of the day. He developed new valves and moved thermionic technology forward. In addition to this he played a significant role in the technology used for the war effort in two world wars. He also had the distinction of being the first person to note the effect used today in light emitting diodes. He was awarded two main honours. In the First World War there was the Military Cross for his efforts mainly on direction finding and then in 1951 he was awarded the coveted Armstrong Medal by the Radio Club of America. Despite these two awards his name is not widely known and he is very much an unknown genius.

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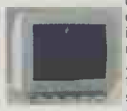

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NT4 WorkStation, complete with service pack 3 and licence - OEM packaged. ***ONLY £89.00*** (B)

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SOLID STATE LASERS

Visible red, 670nm laser diode assembly. Unit runs from 5 V DC at approx 50 mA. Originally made for continuous use in industrial barcode scanners, the laser is mounted in a removable solid aluminium block, which functions as a heatsink and rigid optical mount. Dims of block are 50 w x 50 d x 15 h mm. Integral features include over temperature shutdown, current control, laser OK ouput, and gated TTL ON / OFF. Many uses for experimental optics, comms & lightshows etc. Supplied complete with data sheet.

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Wayne Kerr RA200 Audio frequency response analyser	£2500
INFODEC 1U, 24 port, RJ45 network patchpanels. #TH93	£49
3COM 16670 12 Port Ethernet hub - RJ45 connectors #LD97	£69
3COM 16671 24 Port Ethernet hub - RJ45 connectors	£89
3COM 16700 8 Port Ethernet hub - RJ45 connectors NEW	£39
IBM 53F5501 Token Ring ICS 20 port lobe modules	£POA
IBM MAU Token ring distribution panel 8228-23-5050N	£45
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ALLGON 8360.11805-1880 MHz hybrid power combiners	£250
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
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Marconi 2022C 10KHz-1GHz RF signal generator	£1550
HP1650B Logic Analyser	£3750
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HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£475
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Racal ICR40 dual 40 channel voice recorder system	£3750
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Emerson AP130 2.5KVA industrial spec.UPS	£1499
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945

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Intel SBC 486/125C08 Enhanced Multibus (MSA) New	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
PHILIPS PM5518 pro. TV signal generator	£1250
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
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Fujitsu M3041D 600 LPM printer with network interface	£1250
Siemens K4400 64Kb to 140Mb demux analyser	£2950
Perkin Elmer 299B Infrared spectrophotometer	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3250
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
B&K 2633 Microphone pre amp	£300
Taylor Hobson Tallysurf amplifier / recorder	£750
ADC SS200 Carbon dioxide gas detector / monitor	£1450
BEK AM20/3 PPM Meter (Ernest Turner) + drive electronics	£75
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	£5650
ANRITSU ML93A optical power meter	£990
ANRITSU Fibre optic characteristic test set	£POA
R&S FTDZ Dual sound unit	£650
R&S SBUF-E1 Vision modulator	£775
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TEK 2445 150 MHz 4 trace oscilloscope	£1250
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount	£1955
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc	£2900
TEK TDS524A 500Mhz digital realtime + colour display etc	£5100
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NEWPRODUCTS

Please quote *Electronics World* when seeking further information

Sensing leaky bottles

The SUNX EX-F70 series of sensors from MEW-UK is designed to detect small liquid leaks and inform a control system. Particularly suitable for use in applications such as bottle or container filling, it will enable technicians to monitor for spillage. The sensor head itself consists of a transmitter and receiver. When mounted in a liquid-free environment, the receiver collects light from the transmitter after it has passed through a specially designed sensing surface. When a liquid is placed within the area of the sensor the capillary effect causes the beam to be disrupted and no longer detected by the receiver. This will then switch the NPN transistor output.

MEW-UK
Tel: +44(0) 1908 350700

Fast recovery Mosfet for zero-voltage switching

International Rectifier has introduced a 500V L-Series Hexfet power Mosfet with fast recovery body diode for reliable operation of zero-voltage switching (ZVS) power supplies, especially at light loads. According to the company, the Mosfets eliminate the need for series Schottky and anti-parallel high voltage diodes used in conventional designs, thereby reducing part count, simplifying PCB layouts, reducing overall losses and improving power density. Power supplies using ZVS circuits are designed to optimise efficiently at high frequencies. When Mosfets are used in ZVS circuits operating at frequencies up to 250kHz, body diode reverse recovery characteristics become critical, especially under light load conditions when the device on-time is very short. Mosfets can only withstand voltage across drain and source after the integral body diode has completed the reverse recovery period. The reverse recovery time of the integral body diode has a direct impact on the minimum duty cycle. The L-series have improved body diode characteristics with close to 70 per cent reduction in reverse recovery time, which is 250ns.

International Rectifier
www.irf.com
Tel: +44(0) 20 8645 8003

Die-cast backshells in four sizes

Die-cast backshells from Tyco Electronics are available in four shell sizes to suit 9 to 37 position D-sub connectors. Typical applications for the ADK series include high integrity data links in applications such as computer peripherals, industrial equipment, medical and instrumentation. The backshells feature straight or 45 degree cable entry, rugged and compact design as well as excellent EMI/RFI shielding performance. They are suitable for a range of cable sizes while a unique metal filled cable grommet ensures 360 degree shielding. The zinc die-cast nickel plated shells have a –40 to 120°C temperature range, 4.0 to 13.0mm cable diameter and an attenuation factor of over 40dB between 30MHz and 1GHz. The back-shells meet the requirements of VDE 0871, FCC 20780 and 89/336/EU. ADK back-shells come as a complete kit comprising shells, jackscrews and four sizes of cable grommets. Available as an upgrade to the standard product is a high performance cable crimp kit offering a full crimped termination to the cable braid for greater screening integrity and enhanced cable strain relief.

Tyco Electronics
www.tycoelectronics.com
Tel: +44(0) 20 8954 2356

IDE for Motorola star core

Green Hills Software has released the Multi 2000 integrated development environment (IDE) and probe for the StarCore-based MSC8102 digital signal processor, from Motorola. The IDE, featuring C and C++ optimising compilers and a multi-core debugger, provides a DSP-optimised superset of Multi's editing, debugging, profiling, and project management capabilities. The MSC8102 combines four StarCore SC140 cores running at speeds of up to 300MHz with four enhanced filter co-processors, delivering a peak performance of 6000 million multiply accumulates per second (MMACs). The IDE automates all aspects of software development for the MSC8102. Optimised for the MSC8102's SC140 core architecture, it features a window-oriented editor. RTOS-aware, multi-core source-level debugger graphical program builder, run-time error checker, version control system, and performance profiler. It also supports Motorola's StareCore instruction set simulator and multi-core cycle-accurate simulator, which enable programmers to develop and test MSC8102 code on a PC or workstation without the need for the target hardware.

Green Hills Software
www.ghs.com
Tel: +44(0) 1962 829820

Please quote *Electronics World* when seeking further information

Analysers support 10Gbit/s comms

A software package from Tektronix gives support to designers of comms systems using SPI-3 and SPI-4.2 interfaces. The system packet interfaces run at 2.5 and 10Gbit/s respectively. The TCS101 software runs on the firm's TLA series of logic analysers and provides system level design and debug tools. These can solve the challenges of gaining access to signals with minimal effect on signal integrity; laying out test connectors in limited development board space; real-time triggering on data errors, protocol violations and other anomalies; and correlation of events on microprocessor, internal system bus and external serial bus ports. Analogue and digital timing uses a listing window display.

Tektronix
Tel: +44(0) 1344 392241

Kit for USB to PCI without firmware

A development kit for prototyping PCI-based USB devices using NetChip Technology's NET2280, is available from Silicon Concepts. On connection the NET 2280 RDK (reference design kit) allows any PCI host systems to be specified by a USB host without firmware, said the supplier. USB device side firmware and API's as well as USB host side drivers and sample applications are provided

to support data transfer and systems management. NET 2280 RDK is supplied in standard PCI form factor. Features include 3.3V or 5V universal PCI connections, complete PCI test headers, standard USB B connector, debug serial port and socketed EEPROM.
The NET2280 peripheral controller features PCI host adapter modes, a PCI initiator and target interface, 4 scatter gather DMA channels, a high speed USB 2.0 interface, 12 USB endpoints and an integrated 8051 CPU.

Silicon Concepts
Tel: +44(0) 1420 537100

Composite video chipset

The ZXFV4583 sync separator and ZXFV4089 DC restoration amplifier from Zetex form a chipset managing composite video signals. Designed for applications including CCTV, video capture, mixing and special effects, the pair are pin compatible with standard industry alternatives. Acting as a black level clamp, the ZXFV4089 provides brightness level stability in video systems. Configured using three external resistors, the ZXFV4583 separates out vertical, horizontal and composite synchronisation signals from PAL, NTSC, SECAM, and other standard and non-standard composite video signals. Timing of sync extraction is achieved by the device through a sample and hold process that determines the 50 per cent point on the negative edge of the sync pulse. An optional on-chip low pass filter can also be employed to alleviate the effects of the colour subcarrier.

Zetex
www.zetex.com
Tel: +44(0) 161 6224444

Switch with five separate movements

Knitter Switch has introduced a micro-miniature surface mount switch with five separate switch movements. The single actuator may be moved north, south, east, west and pushed down to select different functions. This means that up to five separate switches may be replaced by one or TSSJ-2 switch may be used as a joystick controller. Designed for scanning and navigation functions such as menu scrolling and selection, the switch has body dimensions of 10.8 x 2.25mm with the actuator making the overall height 5mm. The maximum contact rating is 10mA at 5V DC, insulation resistance better than 100MΩ and operating temperature is in the range –20 to +60°C.

Knitter Switch
Tel: +44(0) 1256 338670

Colour TFT has 300nits

Apollo Displays Technologies has introduced a low cost VGA resolution 6.4in colour TFT display featuring 300-nit brightness plus integrated touch screen. The touch screen eliminates the pixel haze created by standard touch screens used on high pixel density displays, said the supplier. This 4-wire technology, called "Clear-Clear" touch, employs both highly transmissive (85 per cent) and optically smooth ITO (indium tin oxide) substances for improved clarity. The VGA (640x480pixel) display has a pixel pitch of 0.675mm (W) x 0.203mm (H). Two field replaceable CCT backlights are included. The touch-screen is mounted directly to the display matching viewing areas and gives no restriction to the display's mounting holes. The flex tail is made of a durable metal foil stiffener for easy insertion to standard connectors. The assembly can be supplied with an RS-232 or PS/2 touch controller mounted to the display. Other options include display inverter, anti-reflection film, analogue RGB/Video

OSCILLOSCOPE | FFT ANALYSER | VOLTMETER | RECORDER

The Handyscope 3 is a powerful and versatile two channel measuring instrument with an integrated function generator.

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- several trigger features
- auto start/stop triggering
- auto disk function up to 1000 files
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- auto trigger level and hysteresis setting
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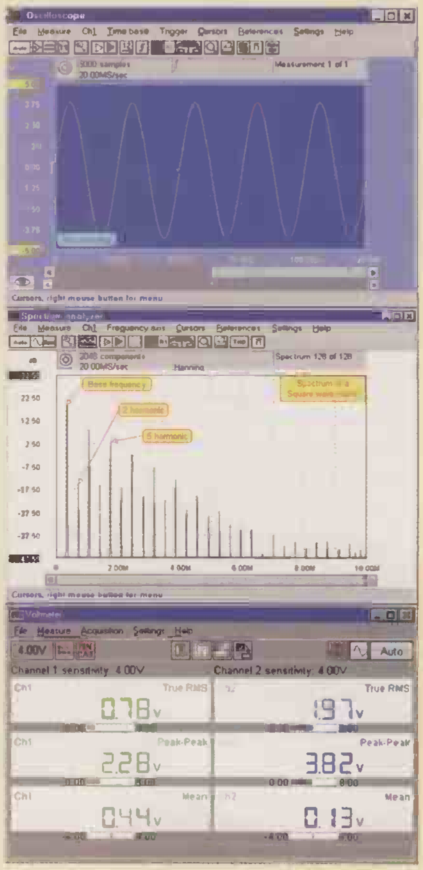
- very extensive function generator (AWG) 0-2 MHz , 0-12 Volt



HANDYSCOPE HS3

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for more information, demo software, software, source code and DLL's visit our Internet page: http://www.tiepie.nl

TiePie engineering (NL)
Koperslagersstraat 37
8601 WL SNEEK
The Netherlands
Tel: +31 515 415 416
Fax: +31 515 418 819

TiePie engineering (UK)
28, Stephenson Road, St. Ives
Cambridgeshire, PE17 3WJ, UK
Tel: 01480-460028
Fax: 01480-460340

Please quote *Electronics World* when seeking further information

controllers, PC-BUS and SBC kits. Sample delivery is typically 2 weeks from order.
Apollo Displays Technologies
www.apollodisplays.com
Tel: +44(0) 1634 226880

CD-ROM on lead-free soldering

A training and interactive technical CD-ROM on lead-free soldering technology has just been updated. It also includes over 20 video interviews with engineers from around the world on their views on lead-free materials and processes. The CD-ROM has been produced jointly by the National Physical Laboratory and Bob Willis to address the lack of practical information that is available in the industry for small and medium volume producers. The CD covers the following aspects of the technology: design rules, PCB soldering finishes, component terminations, impact on process conditions, impact on existing equipment, hand soldering, screen printing, reflow soldering, wave soldering, cleaning, rework, visual inspection, joint reliability, and in circuit test. Additional features will include lead-free alloy selection, interactive lead-free soldering guide, case studies, and a reference bibliography. The interactive defect guide provide solutions to many of the common process issues. Further information on the interactive CD-ROM is available from the website.
Bob Willis
www.bobwillis.co.uk
E-mail: bob@bobwillis.co.uk

Board-to board connector with 1.5mm stacking height

JAE Europe has introduced a board-to-board connector series with a surface mount contact pitch of 0.5mm which allows the stacking height to be 1.5mm between parallel PCBs. Supplied on embossed tape and reel packaging as standard, the new connectors feature reinforced plastic insulators as well as integral hold-downs. Contact resistance is less than 70mΩ

(while insulation resistance is more than 100MΩ). The AA01 series available with 10, 30, 40 or 60 contacts rated at 0.2A per contact, the parts are rated for 30 mating cycles and can be driven with an AC or DC voltage of 50V. A withstandvoltage of 250V AC rms per min contributes to increased reliability.
JAE Europe
www.jae.co.uk
Tel: +44(0) 1276 404000

Test probe spring contacts

The P25/Z series of spring-contact test probes has been introduced by Peak Test

Services to meet the demands of greater accuracy in ATE systems for printed-circuit board testing at 0.1-inch centres, and achieve their accuracy through the use of an additional crimp at the top of the barrel, which optimises the point positioning. The P25/Z series fit all existing P25 Series receptacles, and can directly replace most probes already in use on ATE fixtures. Most of the tip styles in the standard P25 Series are available. The probes are available directly from PeakTest Services in the united Kingdom and Eire.
Peak Test Services
www.thepeakgroup.com
Tel: +44(0) 191 3871923

Multi-layering API for mixed graphics

QNX Software Systems has incorporated into its Photon microGUI, the native windowing system for the Neutrino RTOS, an API (application programme interface) designed to streamline the development of multi-layered graphical interfaces. Using this API, it is expected that developers will build multi-layered displays for applications that display a mix of static and dynamic content on a single screen.
QNX Software Systems
www.qnx.com
Tel: +44(0) 1223 204800

Quad switches have low leakage

Intersil has made three additions to its MightyMUX high-performance analogue switch line. ISL84521, ISL84522 and the ISL84523 quad switches are aimed at applications including portable battery-powered equipment such as mobile phones, pagers, notebooks and PDAs in which space and power consumption are concerns, as well as high-precision equipment used in medical, communications, and test fields. The quad switches feature low

Connectors share footprint

Honda Connectors has coaxial connectors for fibre-optic backplanes. The FXMU series features coaxial plugs, jacks and adapters, and comes in the same footprint as the firm's high-density MU optical interconnection systems. The interconnection system comprises a single-contact coaxial plug, high-density plug-in jack, single-contact coaxial connector and H-type vertical two-contact adapter. Standard coaxial connectors consist of an MU-type plug combined with the single-contact adapter, while plug-in connectors are assembled by adding backplane and package housings to the MU-style coaxial plug and jack. Connections benefit from 50Ω

characteristic impedance and 10MΩ contact resistance, with a frequency range from DC to 5GHz and VSWR of 1.25 or lower. The connectors can withstand 500V AC for up to one minute and provide insulation resistance of over 500MΩ at 500V DC. Operating temperature range is from –20 to +650°C.
Honda Connectors
www.hondaconnectors.com
Tel: +44(0) 1793 523388

£2 BARGAIN PACKS

30A 600V BRIDGE RECTIFIER. Order Ref: 2P474.
10 HOOK-UP LEADS. Assorted colours terminating with insulated crocodile clips each end, each lead length 36cm. Order Ref: 2P459.
PHILIPS STEPPER MOTOR. 12V 7.5 degrees. Order Ref: 2P457.
32µF 250V A.C. CAPACITOR. Order Ref: 2P452.
4µF 440V A.C. CAPACITOR. Order Ref: 2P454.
VERY POWERFUL MOTOR. Operates off 6, 9 or 12V D.C. 2½in. long, 1½in. diameter. Order Ref: 2P456.
HIGH VOLTAGE STRIPPER. Contains many items for 10kV working. Order Ref: 2P388.
GALVANISED EQUIPMENT BOX. 150mm square without lid. Order Ref: 2P391.
4 r.p.m. GEARED MAINS MOTOR. 115V but supplied with mains adaptor. Order Ref: 2P393.
TWIN 50pF AIR-SPACED TUNING CAPACITOR, the veins wide spaced so suitable for transmitting. Order Ref: 2P394.
20 R.P.M. GEARED MAINS MOTOR. 115V but supplied with mains adaptor. Order Ref: 2P396.
20µF 375V CAPACITOR. Aluminium cased. Order Ref: 2P406.
9V-0V-9V MAINS TRANSFORMER. 25VA, upright mounting with fixings. Order Ref: 2P408.
COPPER CLAD BOARD. Size 15in. x 10in. x 1/16in. thick for making p.c.b.s etc. Order Ref: 2P409.
20W TWEETER. 4in. x 4in. 8 ohm by Goodmans. Order Ref: 2P403.
BATTERY CHARGER METER. 0A-3A. Order Ref: 2P366.
W-SHAPED 30W FLUORESCENT. Philips, ideal name plate illuminator. Order Ref: 2P372.
DIMMER SWITCH. Standard size flush place, state colour – red, yellow, green or blue. Order Ref: 2P380.
TELEPHONE EXTENSION LEAD. 12m with plug end, socket ends. Order Ref: 2P338.
FIGURE-8 FLEX. Mains voltage, 50m. Order Ref: 2P345.
INFRA-RED UNIT. As fitted TV receiver. Order Ref: 2P304.
L.C.D. CLOCK MODULE with details of other uses. Order Ref: 2P307.
AM/FM RADIO RECEIVER with speaker but not cased. Order Ref: 2P308.
2A MAINS FILTER AND PEAK SUPPRESSOR. Order Ref: 2P315.
45A DP 250V SWITCH. on 6in. x 3in. gold plate. Order Ref: 2P316.
SOLAR CELL. 3V 200mA, 5 of these in series would make you a 12V battery charger, £2 each. Order Ref: 2P374.
PERMANENT MAGNET SOLENOID. Opposite action, core is released when voltage is applied. Order Ref: 2P327.
HEATER PAD. Not waterproof. Order Ref: 2P329.
DISK DRIVE. Complete less stepper motor, has all the electronics to control stepper motor. Order Ref: 2P280.
15V 320mA A.C. POWER SUPPLY. In case with 13A base, ideal for bell or chime controller. Order Ref: 2P281.
POWERFUL MAINS MOTOR with 4in. spindle. Order Ref: 2P262.
20M 80 OHM TV COAX. Order Ref: 2P270.
LOCTITE METAL ADHESIVE. Tube and some accessories. Order Ref: 2P215.
6-DIGIT COUNTER. Mains operated. Order Ref: 2P235.
13A ADAPTORS. Take two 13A plugs, pack of 5, £2. Order Ref: 2P187.
3-CORE 5A PVC FLEX. 15m. Order Ref: 2P189.
MAINS TRANSFORMER. 15V, 1A. Order Ref: 2P198.
7-SEGMENT NEON DISPLAYS. Pack of 8. Order Ref: 2P126.
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PAD SWITCH for under carpets, doormats etc. Order Ref: 2P119.
ROTARY SWITCH. 40A with porcelain pointer control knob. Order Ref: 2P419.
AIR-SPACED TUNING CAP with one section 350pF, the other 250pF, with 1/4in. spindle and slow motion drive. Order Ref: 2P422.
DITTO but 150pF and 300pF. Order Ref: 2P423.
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SELLING WELL BUT STILL AVAILABLE

IT IS A DIGITAL MULTI-TESTER, complete with backrest to stand it and hands-free test prod holder. This tester measures d.c. volts up to 1,000 and a.c. volts up to 750; d.c.current up to 10A and resistance up to 2 megs. Also tests transistors and diodes and has an internal buzzer for continuity tests. Comes complete with test prods, battery and instructions. Price £6.99. Order Ref: 7P29.
INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges: AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. These instruments are ex-British Telecom but in very good condition, tested and guaranteed OK, probably cost at least £50 each, yours for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P4.
REPAIRABLE METERS. We have some of the above testers but slightly faulty, not working on all ranges, should be repairable, we supply diagram, £3. Order Ref: 3P176.
BT TELEPHONE EXTENSION WIRE. This is proper heavy duty cable for running around the skirting board when you want to make a permanent extension. Four cores properly colour coded, 25m length only £1. Order Ref: 1067.
HEAVY DUTY POT. Rated at 25W, this is 20 ohm resistance so it could be just right for speed controlling a d.c. motor or device or to control the output of a high current. Price £1. Order Ref: 1/33L1.
1mA PANEL METER. Approximately 80mm x 55mm, front engraved 0-1000. Price £1.50 each. Order Ref: 1/16R2.
D.C. MOTOR WITH GEARBOX. Size 60mm long, 30mm diameter. Very powerful, operates off any voltage between 6V and 24V D.C. Speed at 6V is 200 rpm, speed controller available. Special price £3 each. Order Ref: 3P108.
FLASHING BEACON. Ideal for putting on a van, a tractor or any vehicle that should always be seen. Uses a Xenon tube and has an amber coloured dome. Separate fixing base is included so unit can be put away if desirable. Price £5. Order Ref: 5P267.
MOST USEFUL POWER SUPPLY. Rated at 9V 1A, this plugs into a 13A socket, is really nicely boxed. £2. Order Ref: 2P733.
MOTOR SPEED CONTROLLER. These are suitable for D.C. motors for voltages up to 12V and any power up to 1/6h.p. They reduce the speed by intermittent full voltage pulses so there should be no loss of power. Made up and tested, £18. Order Ref: 20P39.
BALANCE ASSEMBLY KITS. Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0.5 to 5 grams. Price £2. Order Ref: 2P44.
CYCLE LAMP BARGAIN. You can have 100 6V 0.2A MES bulbs for just £2.50 or 1,000 for £20. They are beautifully made, slightly larger than the standard 6.3V pilot bulb so they would be ideal for making displays for night lights and similar applications.
SOLDERING IRON, super mains powered with long-life ceramic element, heavy duty 40W for the extra special job, complete with plated wire stand and 245mm lead, £3. Order Ref: 3P221.

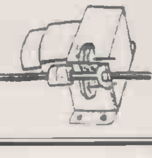
RELAYS

ENGINEERS BENCH PANEL
This has 2 x 13A mains sockets which are switched and illuminated, thus saving you having to keep pulling out the plugs. Nicely cased. Only £2. Order Ref: 2P461.

We have thousands of relays of various sorts in stock, so if you need anything special give us a ring. A few new ones that have just arrived are special in that they are plug-in and come complete with a special base which enables you to check voltages of connections of it without having to go underneath.
We have 6 different types with varying coil voltages and contact arrangements.

Coil Voltage	Contacts	Price	Order Ref:
12V DC	4-pole changeover	£2.00	FR10
24V DC	2-pole changeover	£1.50	FR12
24V DC	4-pole changeover	£2.00	FR13

Price includes base
MINI POWER RELAYS. For p.c.b. mounting, size 28mm x 25mm x 12 mm, all have 16A changeover contacts for up to 250V. Four versions available, they all look the same but have different coils:
6V – Order Ref: FR17 24V – Order Ref: FR19
12V – Order Ref: FR18 48V – Order Ref: FR20
Price £1 each less 10% if ordered in quantities of 10, same or mixed values.
RECHARGEABLE NICAD BATTERIES. AA size, 25p each, which is a real bargain considering many firms charge as much as £2 each. These are in packs of 10, coupled together with an output lead so are a 12V unit but easily divideable into a **2x** 6V or 10 x 1.2V. £2.50 per pack, 10 packs for £25 including carriage. Order Ref: 2.5P34.
4 CIRCUIT 12V RELAY. Quite small, clear plastic enclosed and with plug-in tags, £1. Order Ref: 205N.
NOT MUCH BIGGER THAN AN OXO CUBE. Another relay just arrived is extra small with a 12V coil and 6A changeover contacts. It is sealed so it can be mounted in any position or on a p.c.b. Price 75p each, 10 for £6 or 100 for £50. Order Ref: FR16
1.5-6V MOTOR WITH GEARBOX. Motor is mounted on the gearbox which has interchangeable gears giving a range of speeds and motor torques. Comes with full instructions for changing gears and calculating speeds, £7. Order Ref: 7P26.



£2 BARGAIN PACKS

24V STEREO POWER SUPPLY. Mullard. Order Ref: 2P80.
UP TO 90 MIN 25A SWITCH. Clockwork. Order Ref: 2P90.
POWERFUL MAINS MOTOR. 1½in. stack, double spindle. Order Ref: 2P55.
SPEED CONTROL FOR MODELS. 6V-12V variable p.s.u., also reverse. Order Ref: 2P3.
MAINS TIME AND SET SWITCH. 25A, up to 6 hours delay. Order Ref: 2P9.
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TIME AND SET SWITCH. 15A mains. Order Ref: 2P104.
D.C. VOLT REDUCER. 12V-6V, fits into car lighter socket. Order Ref: 2P318.
CAPACITOR, VARIABLE. For tuning AM/FM with 1/4in. spindle. Order Ref: 2P269.
CAPACITOR, VARIABLE. 0.0005 solid dia. 1/4in. spindle. Order Ref: 2P268.
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20V-0V-20V DITTO. Order Ref: 2P411.
80mm x 46mm 65mm METAL PROJECT BOX with rubber feet, supplied as flat pack. Order Ref: 2P412.
24V 1A MAINS TRANSFORMER. Order Ref: 2P413.
12V 2A MAINS TRANSFORMER. Order Ref: 2P414.
80 OHM COAX. Extra thin, 15m. Order Ref: 2P417.
A.C. 250V CAPACITOR. 20µF. Order Ref: 2P427.
12V P.S.U. 800mA D.C. with pins for shaver socket. Order Ref: 2P428.
MAINS MOTOR WITH GEARBOX giving 6 revs per hour. Order Ref: 2P430.
CLOCKWORK TIMESWITCH with scale settable up to 6 hours. Order Ref: 2P432.
OLD TIME RADIO CASE for the Good Companion. Order Ref: 2P436.
4 OHM TWEETER. 20W, by Goodmans. Order Ref: 2P437.
OLD TYPE 15A ROUND PIN PLUGS. Order Ref: 2P438.
BT ENGINEER'S PHONE. Unused but missing some parts, ideal for stripping. Order Ref: 2P439.
FLUORESCENT TUBE CHOKE. 65W or 80W. Order Ref: 2P440.
MINI MOTOR WITH GEARBOX, giving 16 r.p.m. Order Ref: 2P442.
ICESTAT. Cuts in just above freezing. Order Ref: 2P443.
BALANCE KIT with gram weights for chemical experiments etc. Order Ref: 2P444.
Vu METER. 40mm square. Order Ref: 2P445.
SLYDLOK FUSE. 30A. Order Ref: 2P447.
KV CAP. 1µF 1500V. Order Ref: 2P448.
9V P.S.U. 1A D.C., plugs into 13A socket. Order Ref: 2P450.
6-CORE 3AFLEX. 15m. Order Ref: 2P451.

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DYNAMIC MICROPHONE. 500 ohm, plastic body with black mesh head, on/off switch, good length lead and terminated with audio plug. Price £1. Order Ref: 2P220.

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E-mail: jnfactors@aol.com

Please quote *Electronics World* when seeking further information

leakage currents (10nA max), to lengthen hold times in sample-and-hold circuits, and fast switching speeds (t_{on}=45ns, t_{off}=15ns), to reduce propagation delays in timing sensitive applications.
Intersil
Tel: +44(0) 1276 686 886

Hotswap controllers cope with 110V backplanes

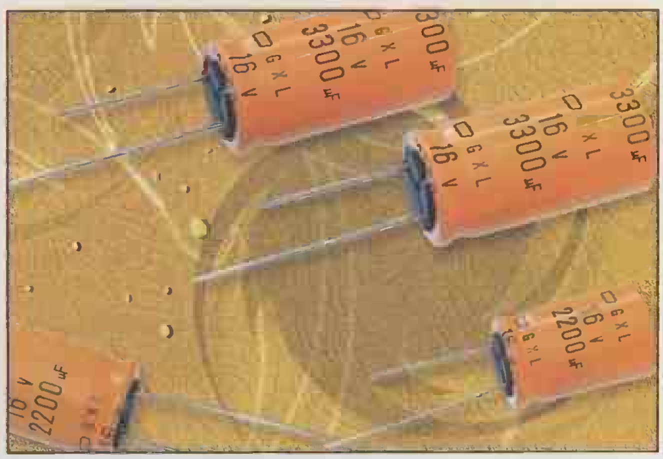
Xicor has a range of negative supply hotswap controllers that integrate functions promoting system reliability. Dubbed X80070, X80071, X80072, and X80073, the devices allow for hardware design flexibility by solving problems associated with high current glitches on the backplane, power Mosfet stress due to overheating, and variations due to capacitive load and downstream DC-DC modules. Hotswap features allow for insertion and extraction of line cards, network interface cards and other peripherals while 48V power is present on the

backplane. The controllers integrate several new hotswap functions to meet the demands of 30V to 110V live power backplanes. A selectable gate current feature provides for design flexibility to account for variations of load, current and transients. Hardshort detection with retry, overcurrent safety limit during insertion, and built-in contact bounce and high frequency noise filter allow for additional protection during live insertion and system start-up.

The integrated overvoltage, undervoltage, and overcurrent protection circuits can be used as a complete electronic circuit breaker.
Xicor
www.xicor.com
Tel: +44(0) 1993 700544

Electrolytics for use in automotive & industrial

Designed for high temperature and long-life applications, such as automotive electronics, GXL series capacitors from Young ECC are rated at 5,000 to 10,000 hours at 125°C. Manufactured by Nippon Chemi-Con, the capacitors are also available in Pb-free versions that meet all the requirements of next-generation lead-free soldering processes. Rated voltage range is 10 to $50V_{DC}$, capacitance value range is 100µF to 4,700µF and capacitance tolerance is ±20 per cent. Case sizes cover 12.5x10mm diameter to 31.5x16mm diameter.
Young ECC
www.youngecc.com
Tel: +44(0) 1494 753500



Halogen-free cables

Users can now switch easily from fluorine-containing cables to halogen-free alternatives, using the Enviroflex cable family from Huber+Suhner. The new range is environmentally friendly and more cost effective than equivalent RG cable types. Using flame retardant LSFH (low smoke free of halogen) Radox materials, Enviroflex cables are highly flexible and easier to handle and dispose of than PTFE based RG cables. The polyethylene (PE) is foamed just to the point where a dielectric constant of 2.0 is obtained to ensure the dimensional compatibilty with the corresponding RG types. This ensures that standard connectors can be used without any restrictions. Radiation crosslinking allows the maximum application temperature of the PE to be increased from +70 to +105°C. This extended temperature range covers most applications and allows for operation in a higher power range, and connectors with soldered inner conductors can be applied. Seven different Enviroflex cable types (ranging from 1.84 to 10.1mm diameter) are available for applications such as radio basestations, antenna systems and closed environment applications, where PTFE cables are currently used.
Huber+Suhner
www.hubersuhner.co.uk
Tel: +44(0) 1869 364229

Solid state interface relay

Relays and timer maker Finder has introduced a solid state interface relay aimed at applications requiring a high isolation, high speed, easy

maintenance interface between processor based control logic and the industrial environment. Dubbed 38.81 in screw terminal form and 38.91 in screwless guise, the relay is designed as a modular unit to provide input/output buffering and isolation within industrial control systems and similar applications. The DIN rail mounted relay

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TEK 2465-2465A-2465B etc available

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RACAL DANA 1999 COUNTERS 2.6GHZ tested from £400

H.P. 53131A COUNTERS 3.0GHZ tested from £750

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H.P. POWER UNITS 66311B-66312A-66309D in large qtys from £250

H.P. 8922 RADIO TEST SETS TYPE G-H-M-M010 with HP83220 A OR E GSM CONVERTOR from £500-£1,000 options available including Spectrum Anz. quantity in stock.

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The Phantom Power Box

48 volt microphone phantom powering unit

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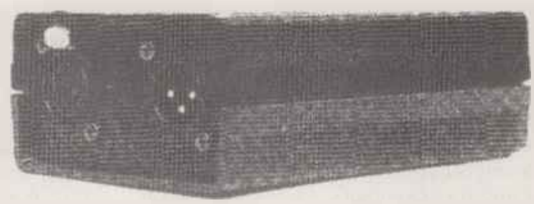

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SPECIAL OFFERS

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CIRRUS CRL254 Sound Level Meter with Calibrator, 80-120dB, LEQ £150
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9916 Counter, 10Hz-520MHz £75
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WAYNE KERR B424 Component Bridge £125
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TEKTRONIX TDS310 Dual Trace 50MHz 200M/S £950
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HITACHI VC6523 Dual Trace 20MHz 20M/S etc unused £500
PHILIPS PM3092 2+2Ch 200MHz Delay .... £800 As New £950
PHILIPS PM3082 2+2Ch 100MHz Delay etc .... £700 As New £800
TEKTRONIX TAS465 Dual Trace 100MHz Delay etc £750
TEKTRONIX 2465B 4Ch 400MHz Delay Cursors etc £1500
TEKTRONIX 2465 4Ch 300MHz Delay Cursors etc £900
TEKTRONIX 468 Dig Storage Dual Trace 100MHz Delay £450
TEKTRONIX 466 Analogue Storage Dual Trace 100MHz £250
TEKTRONIX 485 Dual Trace 350MHz Delay Sweep £550
TEKTRONIX 475 Dual Trace 200MHz Delay Sweep £350
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PHILIPS PM3217 Dual Trace 50MHz Delay .... £200 - £250
GOULD OS1100 Dual Trace 30MHz Delay £125
HAMEG HM303.6 Dual Trace 35MHz Component Tester. As new £240
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H.P. 8656A Syn 100KHz - 990 MHz Sig Gen £995
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KEITHLEY 2010 DMM $7\frac{1}{2}$ digit £950
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H.P. 4338B Milliohmmeter £1500
RACAL Counter type 1999 2.6 GHz £500
H.P. Counter type 53131A 3GHz £850
H.P./Agilent 33120A Function Gen/ARB .... £900/£1000 100microHz - 15MHz
SONY/TEKTRONIX AFG320 Arbitary Function Gen £1250
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BLACK STAR JUPITOR 2010 Function Gen 0.2Hz - 2MHz with Frequency Counter £140
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H.P. 853A with 8559A 100KHz - 21GHz £1750
H.P. 8558B with Main Frame 100KHz - 1500MHz £750
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H.P. 3580A 5Hz - 50KHz £600
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occupies a panel width of 6.2mm complete with integrated indication and coil suppression circuitry. Essential for high-speed automation, the relay offers on and off times of 90μs and 18μs respectively. With a virtually infinite life output switching capability of 2A or 100mA for rated voltages of 24V DC and 48V DC respectively, the device is similarly well specified for high-speed automation applications. The product has an integral ejector mechanism and the 38.81/91 series is available in familiar 'Finder' blue or black.
Finder
www.findernet.com
Tel: +44(0) 1785 815500

Air flow detector for filters

Omron has introduced an 'air flow detector' specifically to efficiently detect clogged conditions in air filters on servers and other types of

computer equipment. Aimed especially at large server farm type installations, the D6A-N sensor uses a thermistor to measure the velocity of the air passing through the air filter, detecting when filters become clogged with dust particles more efficiently than a conventional time totalling meter. By designing an appropriate response to the 0-5V output signal from the detector, engineers can provide a reliable indication of which servers' filters need cleaning or replacing, before a more serious fault develops. Driven from a standard 12V DC supply, the sensor is installed vertically in the flow being monitored. It is fitted using Nylon rivets.
Omron
www.omroncomponents.co.uk
Tel: +44(0) 870 7505662

Analyser for GSM handover

Tektronix is offering a 2.5G and 3G wireless communications signal analyser that combines vector signal analysis and spectrum analysis in one instrument. The WCA200A analyser features simultaneous multi-domain analysis, frequency mask trigger, unmatched memory capture (up to 10 seconds of WCDMA signals), and rapid adjacent channel leakage ratio measurement speeds. The analyser is equipped to perform everyday RF characterisation and verification, it also allows engineers to analyse WCDMA and GSM handovers by analysing WCDMA compressed mode, unique in any class of communications analyser. The WCA200A series includes the WCA230A (3GHz) and the WCA280A (8GHz). It features a frequency mask trigger which has both frequency and amplitude parameters that can be set independently of one another. The instrument triggers only on signals that meet the amplitude settings within the chosen frequency ranges. Two trigger amplitude levels can be specified: one with the "masked" frequency area and a different level for all other frequency bands. Acquisition memory is up to 256Mbytes supporting acquisitions up to 10 seconds in length at the 5MHz span required for W-CDMA work.
Tektronix
www.tektronix.co.uk
Tel: +44(0) 1344 392000

Lightning and surge protection for UHF communications

PolyPhaser now offers UHF communications lightning and surge protection with its UF50 surge protector. Available in type N or 7/16 DIN connector configurations, both models are fully weatherproof and capable of handling up to 750W (single channel). The high frequency devices offer very low

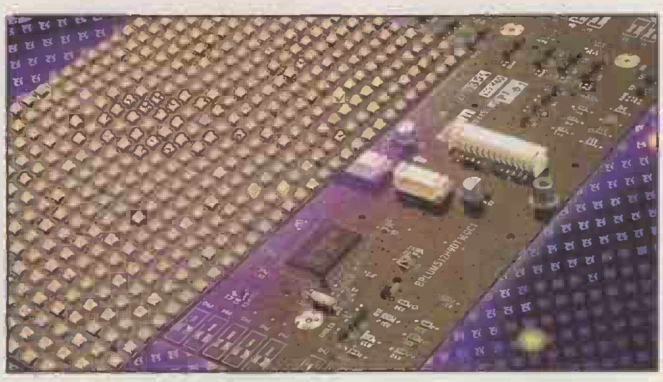
throughput energy. The UF series can be used for transmitters as well as receivers. It also provides positive and reverse voltage protection. Both models feature multi-strike and multi-carrier capability, and are designed to operate over a temperature range of –40 to +85°C. Surge throughout has been measured at significantly less than 5μJ at 3kA (8/20ms waveform).
PolyPhaser
www.polyphaser.com
Tel: +44(0) 7818 457998

STN LCDs get low power backlights

Trident Displays is offering an upgraded range of mono and colour STN LCD modules, featuring improved, long life, low power backlights, and wider operating temperature ranges. The first module to be upgraded is the Hitachi SP14N 240x128 5.5in. mono LCD, with CCFL (cold cathode fluorescent lamp) backlight, giving 150cd/m^2 and up to 50,000 hours useful life. a feature is the display's working temperature range of –10 to +60°C. The module has the Toshiba T6963C controller on board, giving an 8-bit interface and a range of built-in character sets to simplify host system design. There is also a mechanically compatible touchscreen equipped version, the Hitachi SP14N001-ZIA, which has a 4-wire resistive analogue touch sensor factory-bonded to the display.
Trident Displays
www.tridentmicrosystems.co.uk
Tel: +44(0) 1737 771908

Dot matrix displays have 512 LEDs

Rohm has expanded its family of dot matrix LED displays with two low weight, highly integrated 512 dot single



colour design and implementation of large scale indoor and outdoor display screens. Combining high brightness yellow or high brightness orange output with low current operation, the LUM-512Hx351 single-colour 16 x 32 displays feature 512 chip LEDs and all of the necessary driving and control circuitry for operation.
Rohm
www.rohm.co.uk
Tel: +44(0) 1908 282666

Fact: most circuit ideas sent to *Electronics World* get published

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

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

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

Clear hand-written notes on paper are a minimum requirement: disks with separate drawing and text files in a popular form are best – but please label the disk clearly. Where software or files are available from us, please email Jackie Lowe with the circuit idea name as the subject.

Send your ideas to: Jackie Lowe, Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8BZ *email j.lowe@highburybiz.com*

A new voltage-mode active-only universal filter

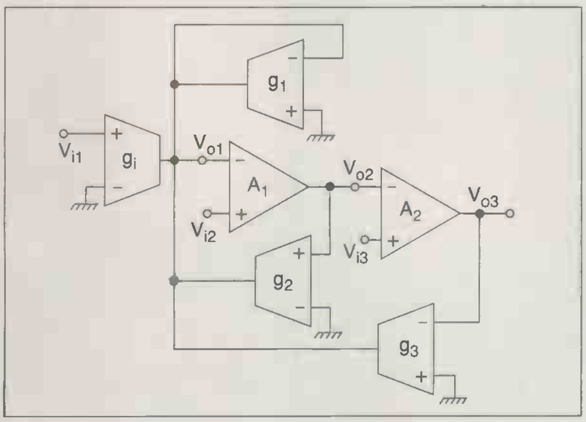
We propose here a new voltage-mode universal filter implementing all of the five generic filtering signals. It involves only active components and is fully integratable.

Two op-amps and four operational transconductance amps are used and the circuit has three inputs and outputs. For simultaneous implementation of low-pass, band-pass and high-pass filtering functions, the circuit requires only one input, resulting in economy in chip area. The other filtering responses – all-pass and notch – are realised through suitable selection of inputs.

Offering independent electronic tuning adjustment of the filtering characteristics, the circuit needs no external passive components. This makes it integratable and programmable which highly suits IC construction.

Circuit designers endeavour to develop multifunction filter structures using the advantages offered by IC design techniques. But the continuous time filters reported in the literature are constrained. Typical problems are as follows.

- They use a large number of components.
- They use components having more spread than is permissible in IC design
- They use components that need to be matched
- They don't have an independent electronic tuning feature for all filtering characteristics
- They don't realise all five standard filter responses
- They require changes in topology and/or use of additional components to implement all five standard filter functions.



The proposed circuit besides circumvent these problems. Electronic adjustment of ω_0 and Q is achieved in a sequential manner through g_3 and g_2 respectively. Pass-band gain H is also electronically controllable through g_1 and its adjustment is independent of preset values of ω_0 and Q.

For biquadratic filtering, the number of op-amps required is two and to electronically adjust ω_0, Q and H in a non-interactive manner, three OTAs are needed.

To stabilise the performance factors against temperature variations, a fourth OTA is inevitable.

How it works

A routine analysis of the proposed filter circuit shown yields the following voltage transfer functions:

$$V_{01} = \frac{s^2 V_{i1} g_i + s\left(V_{i2} B_1 g_2 - V_{i3} B_2 g_3\right) + V_{i2} B_1 B_2 g_3}{D(s)} \quad (1)$$

$$V_{02} = \frac{-s V_{i1} g_i B_1 + s V_{i2} B_1 g_1 + V_{i3} B_1 B_2 g_3}{D(s)} \quad (2)$$

$$V_{03} = \frac{V_{i1} g_i B_1 B_2 + s V_{i3} g_1 B_2 + \left(V_{i3} g_2 - V_{i2} g_1\right) B_1 B_2}{D(s)} \quad (3)$$

Here:

$$D(s) = s^2 g_1 + s B_1 g_2 + B_1 B_2 g_3$$

The open-loop gain of op-amp at higher frequencies is assumed to be of the form:

$$A_i(s) = \frac{B_i}{s} \quad (i = 1, 2) \quad (4)$$

where B_i is the gain-bandwidth product of the i^{th} op-amp.

Equations (1), (2) and (3) reveal the capability of the

circuit to implement a variety of filtering functions by choosing different combinations of inputs and outputs as depicted in the Table.

Filter performance factors are:

$$\omega_0 = \sqrt{B_1 B_2}\,\frac{g_3}{g_1} \qquad (5)$$

$$Q = \frac{1}{g_2}\sqrt{B_2 g_3}\,\frac{g_1}{B_1} \qquad (6)$$

$$H = \frac{g_i}{g_1} \qquad (7)$$

Equations (5), (6) and (7) reveal that ω_0, Q and H can be tuned via the transconductance gains of the operational transconductance amplifiers. To achieve non-interactive tuning of ω_0 and Q it is essential to first tune ω_0 through g_3 and then Q through g_2.

The pass-band gain, H, can be controlled by g_i and its adjustment does not affect the values of ω_0 and Q. The transconductance gain, g_i, helps to stabilise these parameters against temperature variations.

The active sensitivities of ω_0, Q and H are given as:

$$S^{\omega_0}_{B_1,B_2,g_3} = -S^{\omega_0}_{g_1} = 0.5$$

$$S^{Q}_{B_2,g_3,g_1} = -S^{Q}_{B_1} = 0.5$$

$$-S^{Q}_{g_2} = 1$$

$$S^{H}_{g_i} = -S^{H}_{g_1} = 1$$

which are less than or equal to unity in magnitude.

Table. Relationship between inputs, outputs and filter functions.

Input	Output V_{01}	V_{02}	V_{03}
V_{i1}	HP	BP	LP
V_{i2}		BP	LP
V_{i3}	BP	BP	
V_{i123}	AP/notch		

Here, V_{i123} implies that inputs 1, 2 and 3 are tied together, i.e. $V_{i1}=V_{i2}=V_{i3}$. The conditions for implementing all-pass and notch responses are $B_2g_3=2B_1g_2$ for all pass and $B_1g_2=2B_2g_3$ for a notch.

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Making a stop-less digitally programmable potentiometer

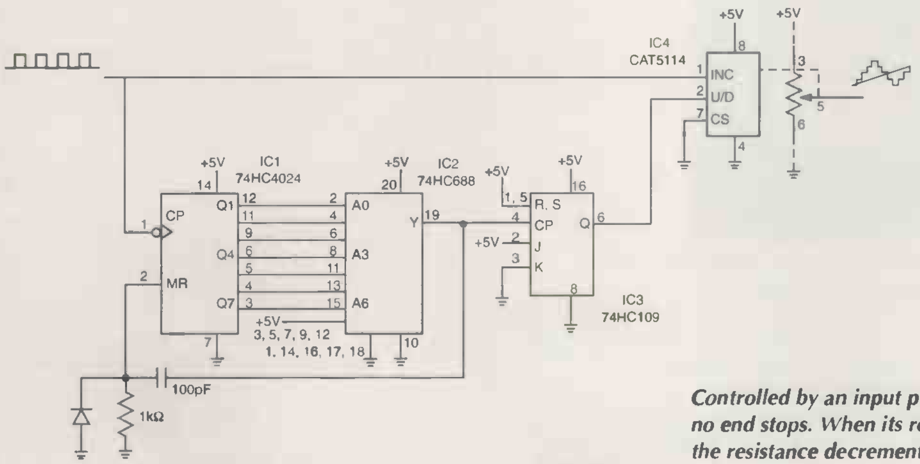
Digitally-programmable potentiometers with an increment/decrement interface have limits or stops when moving the wiper in one direction or the other. A number of applications require the wiper to *automatically* reverse direction and move in the new direction.

The circuit shown is a stop-less digitally programmable potentiometer. Pulses that drive the /INC pin of the DPP are counted by a seven-bit binary counter, U_1. Output from the counter is compared by a magnitude comparator, U_2, with a fixed number.

Using a 32-tap potentiometer as an example, the magnitude comparator is programmed (by connecting high and lows on its input pins) to the fixed number 31. Output from the magnitude comparator drives a JK bistable device connected in toggle mode. When the number of input pulses to the DPP equals the number 31, U_2's output toggles the output of a JK bistable device to the opposite state. The output of the bistable drives the up/down input of the DPP, causing the change in direction of the movement of the wiper.

This stop-less digitally programmable potentiometer has the added benefit of requiring only one digital input.

Chuck Wojslaw
Auburn
California
USA



Controlled by an input pulse train, this digital potentiometer has no end stops. When its resistance reaches minimum or maximum, the resistance decrement or increment changes direction.

LETTERS to the editor

Letters to "Electronics World" Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam Road, Surrey SM3 8BZ e-mail j.lowe@highburybiz.com using subject heading 'Letters'.

The EMC Directive

My congratulations to Ivor Catt for blowing the whistle! He is absolutely correct in stating that the directive fails to achieve its stated purpose. I am involved in building industrial control systems (a mixture of microprocessor equipment and PWM drives) comprised entirely of CE marked equipment. The directive should have ensured that electrical noise is not a problem but, in fact, problems are very common and very expensive to fix in the field.

A simple example is that of the humble relay, operating once or twice per shift, its un-suppressed contacts can cause havoc among state-of-the-art gizmos but the EMC directive completely ignores it!

I recently came across the following quotation, which seems to me to explain a great deal: "Europe must set standards worldwide just as it did in the past. We must take care not to allow other countries and regions to set international standards and thereby pre-empt the markets for themselves. European standardisation is a tool for creating competitive advantage... and should come to dominate the contents of international standards"

SIEMENS (Chairman of the Supervisory Board) Business Week October 1995

Clearly, it is irrelevant whether the directive works or not provided it acts as a trade barrier! My suspicions now fall on ISO9000 and its kin.

Graham Elvis
Cannock
Staffordshire
UK

Motor Identified

I met several tape recorder motors of this type, (*Identity Crisis, EW letters*, March) made by Papst in Germany, while developing a studio tape deck. They have an external rotor which gives high inertia for smooth quiet operation. The external rotor also serves to contain the hum field. These motors usually have three identical windings in a star configuration, with no external connection to the star point. They are used with a permanently connected capacitor of about 2 microfarads; a 'motor run' mains rated type. One pair of wires is connected to the mains and the third is connected to line or neutral via the capacitor. Swapping the capacitor connection between line and neutral will reverse the motor. There are synchronous types for use as the capstan motor and eddy current types for spooling. The best 'three motor decks' used one for capstan drive and one for each spool, all by direct drive, which made the deck mechanics very simple and therefore robust. The capstan motor can be made a switched pole type to give two tape speeds. One professional deck intended for tape editing had the spool motors connected to either end of a large (20watt!) wire-wound pot, with the slider connected to the supply. With the deck in 'variable rewind' mode, the pinch roller was lifted from the capstan and the tape stayed in contact with the heads while the spooling speed could be continuously varied from full speed forwards to full speed rewind. The manual control was so smooth that it was easy to find an edit point and stop the tape on it.

Brian Johnson
London

Fatally Flawed EMC

As an engineer responsible for EMC compliance of radio products from a small company, I am well aware that many EMC rules are nonsense. I am in the position of having to improvise all kinds of test at minimum cost, which if done 'by the book' would make our products so expensive that there would be no market.

One prime example of EMC nonsense is the measurement of spurious emissions from transmitters. The ratio of maximum permitted spurious emissions to carrier power is the same regardless of whether you are testing a broadcast transmitter with an ERP of 100kW or a low power device with a maximum RF output of 2mW. With a 2mW transmitter, you can have trouble even being able to measure the required level of spurious, because it is down in the noise floor of many spectrum analysers!

I have seen how the system works when these limits are set. For each type of product there is a committee of the great and the good from government departments, interested companies and "EMC Magicians". Certain of these Magicians crop up on many different committees and, as only they know the buzzwords, they can often single handed set standards for areas with which that they have had no contact. I cannot see that fighting the resulting mess in the courts could help. The technical issues would be beyond the grasp of the average juror (or judge?) and the prosecution only has to prove that the law has been broken, not that the law is sensible or just.

Where there is a serious gaff, it can be caught at the "draft for public comment" stage or with an amendment. Many EMC documents do get amended. Some are first issued with glaring mistakes, which show that nobody on the relevant committee has read the final draft! Once a standard has been in force for a while it is harder to get any change. The emphasis on measurements rather than calculation for approvals is understandable because in the real world of leakage, inter-modulation, production variables, etc.

Theremin lives

This is a response to the letter from Robin Clark (UK) in the Jan '03 issue of *Electronics World*. (they arrive a few weeks late here in the states!)

A Kit of the Theremin you wished to see in a future issue is available (and was recently highlighted in a series of articles in "Poptronics" (electronics magazine here in the states)

The kit comes from PAIA Music Electronics (www.Paia.com)
3200 Teakwood Lane
Edmond, OK
73013, USA
Voice: (405)-340-6300
Fax: (405)-340-6378
The complete kit (Kit # 9505K), including tax, shipping, handling, etc, is $150 US

Ray Gordon
Larkspur
California
USA.

measurement of some kind is the only proof that EMC measures have had any positive effect. For the sake of standardisation some of the test procedures do seem bizarre and tell you little that is relevant to the real world. The way to better and more realistic standards is better education on EMC matters for all involved in the process so that a single "expert" on a committee cannot just trot out his favourite numbers unchallenged.

All this is rather missing the point. Much of the recent EMC activity is concerned with the imposition of standards throughout the EC as an end in itself to regulate trade. The 'CE' mark on products is just a visible symbol that Brussels has cocked its collective leg and marked its territory. Actual compliance is a secondary matter. In most areas, manufacturers can now 'self certify' products. This was rendered necessary because third party testing for every minor change to every product proved to be hopelessly impractical. Now, as before, only the worst excesses ever come to light and I suspect many are hushed up or ignored if egg on government faces is involved. The words "TETRA" and "Channel 5" spring to mind.

Attention to good EMC practice is essential to make certain products work properly or even at all, regardless of any regulation, but there are many managers and engineers who still regard EMC as an bolt on extra. Good EMC performance must start on the 'back of the envelope' with the first ideas of a new design.

Name and address supplied. ■

Mobiles in fuel stations

Who said that mobile phones were a safety hazard at petrol stations? Their use is only banned because some early analogue (high power) models could upset the electronic counter in some petrol pumps and hence were used by the criminally ingenious to obtain free petrol. That's all!

Richard Black,
London,
UK

I don't think that the current worry about the use of mobile phones in filling stations is based on any known characteristic of these devices. The whole panic probably dates back some 20 years or so, during the brief craze for illegal AM CB. (Whatever happened to CB?)

Some comedians were not content with breaking the law, but wanted to do it in spades; to this end they installed RF pa stages, spewing out several tens of watts, in their car boots. To their delight they found that this much RF would immobilize the electronics in the pretty new digital petrol pumps which had become fashionable - result, free petrol!

This should have surprised no one; at work we had already found that you could not run even a properly engineered 20W transmitter from the new generation of lab power supplies with programmable everything, the soup just got into the inputs of all the chips where it was rectified on the spot and blanked out all signals. Anyway, the upshot was a big panic and a general prohibition on the operation of all transmitters in petrol stations. No doubt pump designs have been refined in the meantime and mobile phones do not present any threat, but it is nice to have them banned, if only on social grounds.

Michael Hawkins
Farnborough
Hants
UK

On the demise of Electronics magazines

One of the major problems facing electronics magazines, including *Electronics World* formerly *Wireless World*, is that electronics has become a mature industry. Let me explain.

In the early 20th century many of the people fortunate enough to have cars, used to do all the work on maintaining them, often rebuilding them. Today there are many more cars, most are factory built, and only the dedicated few ever bother to do much more than put fuel in. The electronics industry is similar. At the time when I became interested in electronics, the early 1960's, transistors were just starting to make an impact in domestic equipment, although most of it was run on thermionic valves. The great boom of magazines was built on this upcoming technology and many new designs were devised to take advantage of this new technology. The production of both analogue and digital ICs, largely a by-product of the cold war and space race, continued to bolster interest and articles for the electronics magazine. The introduction of microprocessers in the 1970's caused the launching a whole new raft of magazines with hobby computing as the main interest.

One incentive for the hobbyist was that often, new designs, and leading edge domestic products could be built from their component parts more cheaply, or certainly not much more expensively, than a comparative commercial product. Since then most of the factories for both ICs and domestic products have been re-sited in third world countries, where people are paid a pittance to run production lines turning out well tested and proven designs. Apart from the few purists who are prepared to spend more time, effort and money on building things themselves, even many radio amateurs now rely heavily on manufactured equipment. One can today for instance buy a DVD recorder for £400, which yields better recordings than the state of the art professional video recorders of the late 1960's which were then around £_ million.

Today the only real incentives are for one off designs, where no commercial product exits, or the market is so limited as to make commercial products comparable or more expensive than home built devices. However there will always be a small number of people, (like those who still build their own cars) who will want the satisfaction of building their own electronic devices no matter what the cost. Whether an electronics magazine such as EW can find enough to sustain it on that basis remains to be seen.

I agree that current education methods may not help, and that there must surely be a role in teaching fundamentals. Also there must be a role in exploring the latest developments, thinking, theories etc. But the great designs, which sustained *EW* (then *WW*) e.g. Lindsey Hood's, amplifiers, cassette recorders, FM tuners, and the great *WW* colour TV design, are no longer relevant. Much of today's consumer electronics requires factory facilities and specialist equipment to produce and set up. Most designs are proved in software, before ever a prototype printed circuit board is produced.

What concerns me is that today's young graduates using many of these design tools do not understand fundamental principles and are not taught how to do rough and ready calculations to know when the software, or calculator they are using, has given them a wrong answer. Speak to them about log tables, slide rules, etc. and you get a glazed blank look. Likewise some of the people using CAD for audio designs fail to appreciate the importance of earth return routing for instance.

I hope this letter will spark some debate as to how a magazine like *EW* can survive in the modern mature electronics industry, as I for one would miss it.

Regarding C. Holwill's "Identity Crisis" (*letters* March). Many tape recorders used what were essentially 3 phase induction motors sometimes with a permanent magnet in the rotor, to make it synchronous to mains. The single-phase mains was then 'capacitor split' using a large capacitor 4 to 8μF and the inductive reactance of the windings, to provide a pseudo 3 phase. This was a reliable way of getting a constant speed for the tape transport.

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Ten-Tec RX-320 DSP radio

The RX-320 DSP PC radio is manufactured by Ten-Tec located in Tennessee, USA. It is a computer controlled general coverage receiver with a frequency coverage of 100kHz to 30 MHz. Reception modes are AM, USB/LSB and CW. Demodulation of the radio signal is all done entirely by Digital Signal Processing (DSP) software in the RX-320. The received audio from the radio is usually fed through the line input of the computer's sound card as the radio does not have a built-in loudspeaker. Review by Roger Thomas

The radio is not a new product and has been on sale in the USA for a few years. It was not originally available to UK or European radio enthusiasts as it was not CE approved. This radio has now got CE approval.

The distributor for Ten-Tec products in the UK is TenTec DIRECT, part of AOR UK Ltd. The advantage of dealing with AOR is that they are also a radio manufacturer and their technical support and after sales service is highly regarded. Indeed, when I was originally considering this radio I contacted TenTec DIRECT and they were prepared to take apart their demo receiver to check the device number of one of the ceramic filters for me and to measure and confirm the last IF frequency was 12kHz. Why this was important will be explained later.

Black box

The RX-320 radio is the proverbial 'black box' and is constructed using an aluminium chassis with the top and bottom 'U' shaped panels made of steel, all sprayed black. Even the telescopic aerial is black! The front panel is entirely blank except for the Ten-Tec logo and the two screws that attach the internal aluminium to the panel. The only control is an on-off toggle switch located on the rear panel.

Since all the radio's control functions and signal processing is done via on-board DSP the number of components required, and therefore cost, is significantly reduced. Consequently the radio has an excellent price to performance ratio but this makes the operation of the RX-320 totally dependent on the PC and the controlling program.

Fig. 1. RX-320 blank front panel with the top panel removed showing the RF board.

Fig. 2. RX-320 back panel showing connections and the all important CE mark (top panel removed showing the RF board).

Components supplied

The RX-320 radio comes with a mains power supply adapter - output rated at 12 volts at 500mA, phono to BNC aerial adapter, phono plug for external aerial, open ended lead with power supply plug, 9-pin serial computer lead, 3.5mm stereo jack audio lead, telescopic aerial (black). In fact all the necessary cables are supplied so that connection and operation of the radio straight from the box is possible.

Ten-Tec Windows control software (version V1.29) was supplied on 3.5" floppy disk (a rarity these days) and also included on the disk is a programming guide (rx320prg) and circuit diagram (rx320tec) both in PDF format. This software and both documents are also available for download from the Ten-Tec web site.

User manual

The RX-320 PC radio comes with a 31 page booklet which is mostly an overview of the operation of the PC control software and includes an 'Introduction to Short Wave Listening' written by the late Joseph J. Carr, K4IPV. As it was written entirely for North American users some of the frequencies and descriptions do not apply to the UK or Europe. There are no technical details regarding how the radio or DSP operates.

This user's manual was written when the radio was first sold (1998) but has not been updated since, there are references to Microsoft Windows 3.1 and 95 but no mention of Windows 98/ME/XP, etc. Also, some of the control program examples and text refer to a 6kHz bandwidth filter, originally this was the widest audio filter but an 8kHz filter option was added later. This also explains the inconsistent filter numbering **Fig 4.**

Software

The software is easy to use and most functions do what is expected and obviously the layout is designed to resemble a real radio. When running the Ten-Tec Windows program the 'radio', 'spectrum' and 'memories' buttons toggle the visibility of the appropriate form. Figure 3 shows the screen of the Ten-Tec control program with the memories form enabled and a completed spectrum scan of part of the 31m broadcast band, centred on the BBC World Service transmission. The strong radio signal next to the BBC signal is Radio Bulgaria on 9.40 MHz.

As can be seen, the top portion of the RX-320 control window has on the left the (optional) signal strength display, to the right of the frequency display there are the values for the various receiver options, local and UTC time.

Fig. 3. Ten-Tec RX-320 control program screen.

Selectivity

To the left of the tuning knob are the buttons for audio bandwidth selectivity and any of these values can be selected irrespective of mode. The DSP audio filtering works well, with the 8kHz audio bandwidth normally selected for medium wave reception. If there was adjacent channel interference, or when listening to short wave, the 6kHz or 5.1kHz option usually worked well. The various filters around 2kHz are designed primarily for listening to amateur radio SSB signals. Narrow filters are used for Morse and some data transmissions. The program only shows five filter values but these can be any five out of the 34 different audio filter settings.

Audio quality from the radio is very good considering it has been processed and generated by the DSP, but what you hear is dependent on the quality of the soundcard and loudspeakers that are connected to your PC.

Memory

Further to the left of the selectivity options are the memory functions, the three buttons duplicating the options found on the memories form. Above these buttons is the name of the radio station (if available) that the RX-320 is currently tuned to.

On the memory form is a list of radio stations and this information can be displayed in various ways. The frequency list should be in ascending order but there is a numerical software bug. Pressing the 'add' button pops up an input form that permits the user to enter the radio station name, frequency, mode, bandwidth, country, language and other information. The other buttons on this form allow individual entries to be deleted or amended. These are all useful features that allow a user to build and maintain a list of favourite radio stations.

The option of 'auto tune', when enabled, will automatically tune to the desired frequency and mode by a

Figure 4 list of audio filter bandwidth

filter#	bandwidth
0	6000Hz
1	5700Hz
2	5400Hz
3	5100Hz
4	4800Hz
5	4500Hz
6	4200Hz
7	3900Hz
8	3600Hz
9	3300Hz
10	3000Hz
11	2850Hz
12	2700Hz
13	2550Hz
14	2400Hz
15	2250Hz
16	2100Hz
17	1950Hz
18	1800Hz
19	1650Hz
20	1500Hz
21	1350Hz
22	1200Hz
23	1050Hz
24	900Hz
25	750Hz
26	675Hz
27	600Hz
28	525Hz
29	450Hz
30	375Hz
31	330Hz
32	300Hz
33	8000Hz

single left click of the mouse on the name of the radio station, or double click if auto tune is disabled. Alternatively, select the radio station and press the 'tune' button. This allows quick switching between stations that you listen to regularly or to monitor the same radio station broadcasting on different frequencies.

Mode

To the right of the tuning knob is the mode selection. When a mode is selected a default bandwidth and frequency step can also be automatically selected. This feature is enabled or disabled in the options menu. When clicking on AM mode the 8kHz filter and 5kHz frequency step can be automatically selected, for LSB/USB mode the 2.7kHz filter is selected with 100Hz frequency step, and 600Hz filter for CW with 100Hz step. Changing the mode can also change the tuned frequency. For example, if the radio is tuned to 909kHz then pressing AM mode will change the frequency to 905, the RX-320 will re-tune down to the nearest frequency (which is not necessarily the nearest frequency) divisible by 5 or 0. This is inconvenient when tuning to long or medium wave and then switching from another mode. If the RX-320 is already on such a frequency, then no re-tuning occurs.

The RX-320 can operate with slow, medium or fast AGC depending on the current propagation conditions. At power-up the radio will default to medium AGC mode. Fast AGC option is useful for SSB signals.

To the right of the mode options are the step selection options. There are actually 12 different frequency steps available, although only five steps are displayed. Steps available are 1Hz, 5Hz, 10Hz, 50Hz, 100Hz, 500Hz, 1kHz, 2.5kHz, 5kHz, 10kHz, 50kHz, or 100kHz. Note that there is no provision for 9kHz steps for UK listeners tuning long or medium wave. Changing the frequency step can also change the frequency the RX-320 is tuned to according to the step selected.

Tuning

A fundamental operational requirement is to be able to alter the frequency that the radio is tuned to and there are a number of ways of achieving this. This demonstrates the advantage of computer control. Below the frequency display is a linear scale, the actual frequency coverage depends on the mode selected. The red line in the middle indicates the currently tuned frequency. This scale can be used to quickly retune the receiver by holding down the left mouse button and dragging the scale, or double left click at a particular frequency.

At the end of the scale are right and left arrows. When these arrows are clicked the radio will tune in steps based on the currently selected step size in the direction of the arrow. With the double arrows the radio is tuned by ten times the step size. By placing the cursor on the upper half of the knob the receiver tunes up in frequency by the selected step size for each left mouse click; move the cursor to the lower half of the knob to tune the radio down in frequency. The receiver tunes continuously if the left mouse button is held down. Using the up and down cursor arrows on the keyboard has exactly the same effect. A right mouse click while the cursor is over the tuning knob brings up the frequency step selection menu.

Direct frequency entry is also possible via the numeric keypad. Type in the frequency and press 'k' for frequency in kHz or press 'return' for frequency in MHz. For frequencies below 1MHz the software works out the correct frequency so it does not matter whether 'k' or 'return' is pressed. To tune the radio to long wave Radio 4 typing '198' and pressing 'K' or 'return' on the keyboard tunes the radio to 198kHz (0.198 is displayed). Unfortunately there is a bug in the software when entering medium wave frequencies over 1000kHz. For example, typing in '1170' and pressing 'return' tunes the radio to 0.001170MHz (i.e. 1170Hz!). Instead type '1170k' or '1.170' and press 'return' and the radio will tune as expected.

Time

Clicking either button marked TIME/UTC brings up a list of frequency and time signal stations, such as the American WWV, WWVH (2.5MHz, 5MHz, 10MHz, 15MHz, and 20MHz) and Canadian CHU (3.330MHz, 7.335MHz, 14.670MHz). As these broadcast on short wave they may be audible in the UK when propagation conditions allow. These stations can be used to check the RX-320 calibration and a receiver frequency offset can be entered on the options form.

The CHU broadcasts on 14.670MHz give the time both in voice and data and this is a useful guide to current propagation conditions if you are interested in amateur radio on 20 metres. When Ten-Tec refers to world time they mean time in UTC.

Displays

There is a software option to display the received station's signal strength. This analogue meter has a 0 to 80 scale, representing a range of approximately 80dB, rather than the more usual 'S' units format. the lower needle indicates the current received signal strength while the upper needle shows a peak average. I did not find this meter very useful as the needles

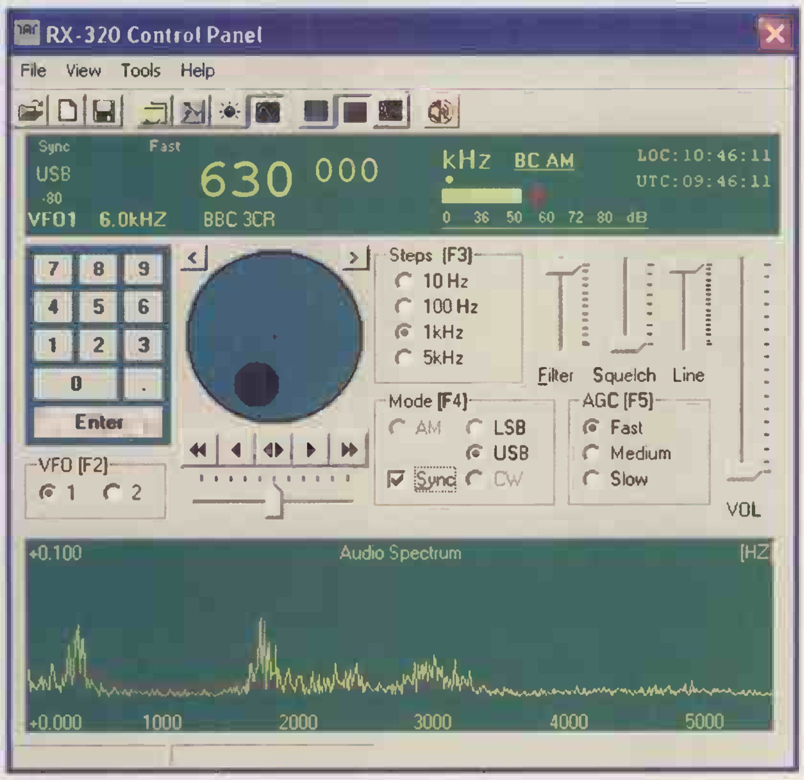

Fig. 5. Example of RX-320 control software (written by George Privalov).

spent most of their time at maximum and rarely dropped below 30. For the most part I left this option switched off.

One of the advantages of controlling a radio by PC is having options like this spectrum analyser. This remarkable feature can display a plot of signal strength versus frequency from scan data generated by the DSP. The sweep bandwidths available are 1.5MHz, 750kHz, 300kHz, 150kHz, 75kHz, 30kHz or 3kHz. Sweep time is around 30 seconds, irrespective of scan bandwidth. The receiver audio is muted while the scan takes place.

Once the scan is completed, moving the mouse cursor over the spectrum display will display the frequency and you can tune to that frequency by clicking the right mouse button. The scan centre frequency is the current tuned frequency and each scan will produce a slightly different pattern as the spectrum and signal strength of each radio station is constantly changing. The RX-320 is not accurately calibrated to determine actual signal strength of the individual radio stations. Nevertheless using the spectrum scan can provide very useful information on the number and signal strength of radio stations broadcasting on a particular band.

Other software

Ten-Tec control software is rather basic in design but quite functional. The weakness of this software is that there is no 9kHz channel step for long and medium wave. All North American short wave and medium wave broadcasts use 10kHz channel spacing. However, there are a number of other control programs available which offer different options, including a 9kHz step (such as the freeware program written by Clifton Turner). Some of these programs are freely available and others are commercial products. Many have an option to integrate to a radio station schedule database. The Ten-Tec web site has a link to this third party software list.

One of these programs (written by George Privalov) features a pseudo AM synchronous mode. If there is a heterodyne (whistle) caused by an adjacent radio station, then using this mode may help remove the annoying tone. As the RX-320 is very stable it is possible to zero-beat with the AM carrier (exalted-carrier type operation) and then either sideband can be selected as it is likely that the interference is only audible on one of the sidebands. The program will track any small changes in the carrier frequency to maintain synchronisation. When using other control programs in AM mode simply tuning off-frequency will have a similar effect.

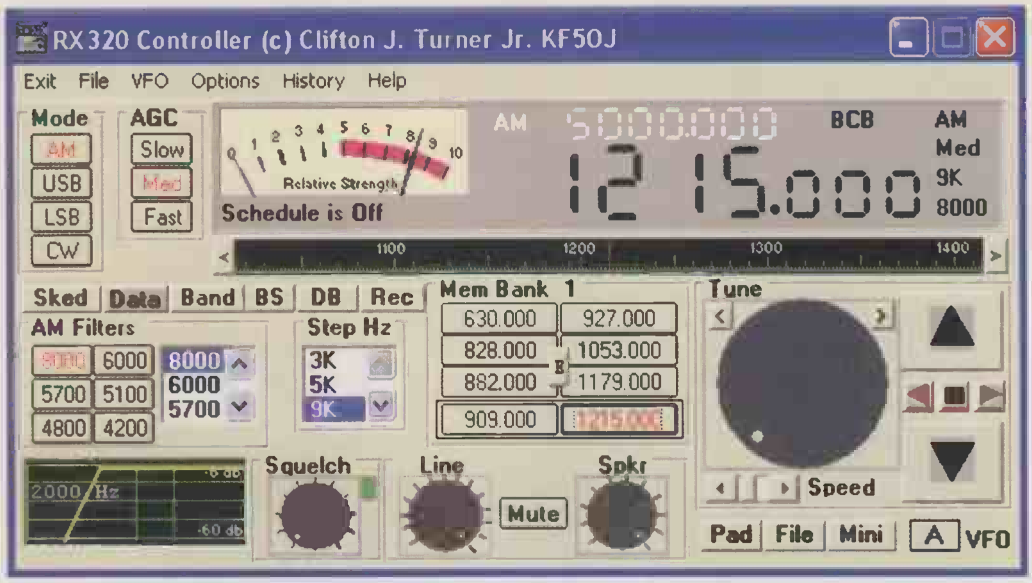

Fig. 6. Example of RX-320 control software (written by Clifton Turner).

RX-320 set-up

The telescopic aerial screws directly into the radio board connector via a hole in the top panel. When fully extended the 6 section telescopic aerial measures only 21" (530 mm). On the back panel is a standard 9-pin D-type connector for the PC to RX-320 serial communications. A 3.5mm to 3.5mm stereo jack lead connects the radio's audio output (marked line out on the panel) to the line input of the PC's sound card. Both of these cables are two metres in length.

The 12V output of the supplied mains adapter was plugged into the DC input but using a Thurlby power supply the current required by the radio was measured at 335mA at 12V. Internally the RX-320 has five volt and ten volt voltage regulators.

Installation of the software is straightforward and very quick. The only program set-up required was to select which serial COM port the RX-320 is connected to and the time offset between local time and 'world time'. The Windows program only requires 796kB of hard disk space.

The PC's sound card mixer program needed to be run to select the line input option (which has the audio from the RX-320) and to set the overall audio volume. Selecting 'sound and audio devices properties' and enabling the 'place volume in the taskbar' option from the control panel placed the loudspeaker icon on the taskbar (Windows XP). Both the line out and external speaker output levels of the RX-320 are set using the volume control slider on the Ten-Tec software.

Long wave reception

Although the RX-320 tunes down to 100kHz, sensitivity on long wave is poor. According to the specification there is reduced sensitivity of around 10dB on frequencies below 1.5MHz to prevent overloading of the receiver by strong medium wave radio stations. The RX-320 does not have any selectable attenuators.

Using the Ten-Tec control software and telescopic aerial, reception of Radio 4 on 198kHz was noisy ('S' meter reading of 46) and only four long wave stations were audible. An 8 metre external wire was temporarily

Figure 7 Long wave stations received

frequency	radio station	aerial	
		telescopic	long wire
162kHz	France Inter	38	42
183kHz	Europe 1	32	38
198kHz	BBC Radio 4	46	60
216kHz	Radio Monte Carlo	no signal	30
234kHz	RTL France	30	40

connected to the aerial phono connection and this improved reception. The telescopic aerial is automatically switched out of circuit when an external antenna is connected to the phono antenna (50 ohm input impedance) connection.

The Radio 4 'S' meter reading when using the wire aerial was increased to 60 and Radio Monte Carlo on 216kHz became audible. It is not surprising that this American radio should have a poor performance on long wave as this is not designated a broadcast band within North America.

Medium wave

Reception on medium wave is good using the telescopic aerial. **Figure 8** and **Figure 9** demonstrate a spectrum scan of part of medium wave centred on 1053kHz and scanning 375kHz each side. One scan was taken during the day, the other scan taken at night. Along the top of the scan is the frequency scale in kHz. Looking at the daytime scan starting on the left, and ignoring stations with a signal strength of less than 0.25, the first radio station is 693kHz (Radio 5 Live), then 828kHz (Classic Gold - Luton), 882kHz (Radio Wales), 909kHz (Radio 5 Live, again), 1053kHz (TalkSPORT), 1089kHz (TalkSPORT, again), 1197kHz (Virgin Radio), and 1215kHz (Virgin Radio, again). This scan also confirms the wasted spectrum required to maintain national coverage of a synchronised radio network. Comparing the two spectrum scans show that at night more distant UK stations and European stations become audible. This radio and control software is also designed for short wave reception of both broadcast stations and amateur radio.

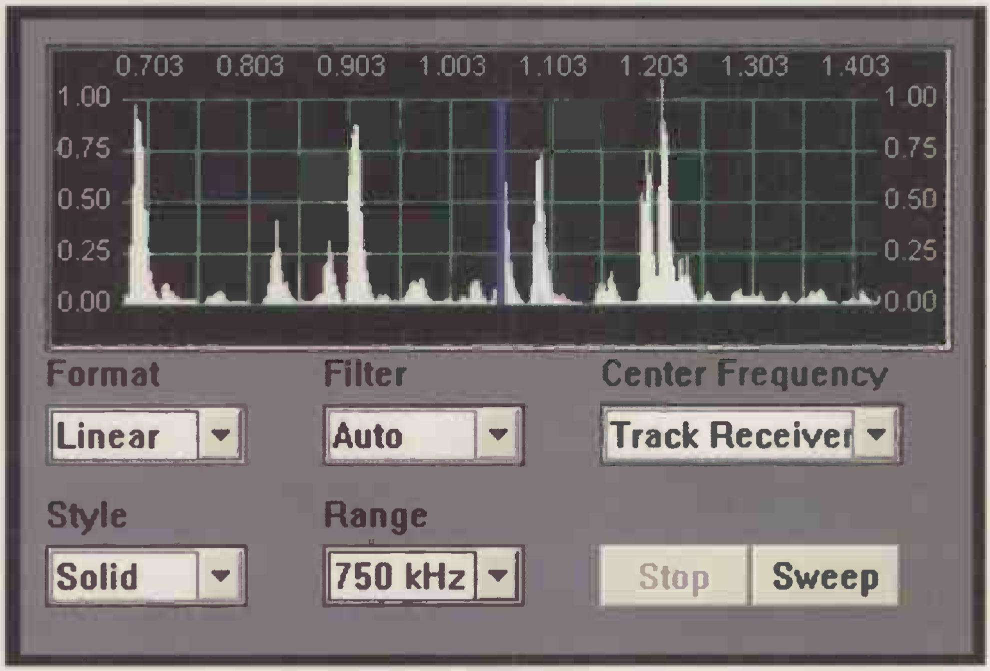

Fig. 8. Spectrum scan taken during the day (10:00 AM).

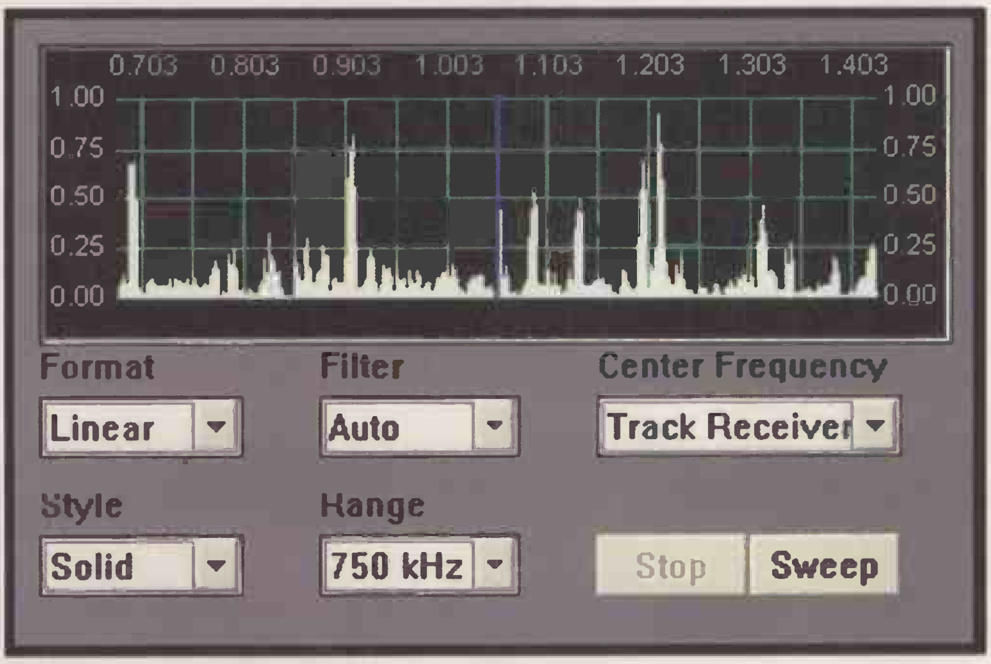

Fig. 9. Spectrum scan taken during the night (10:00 PM).

Internal construction

The RX-320 consists of two printed circuit boards, on top is the RF board and underneath is the DSP board. The DSP board controls the RF board functions. These two boards are connected either side to the aluminium middle plate using stand-offs. Surprisingly even with the small size of the RX-320, there is still some room inside the black box. Incidentally, the Ten-Tec user's manual states that '.... Taking the covers off does not void the warranty'.

The top printed circuit board has all the radio frequency components for amplification and frequency translation. Also the 15kHz ceramic IF filter is mounted on this board and provides the receiver's selectivity. The telescopic aerial screws into a socket directly mounted on the board, located on the left below the power input socket. Visible on the right edge is the +10 volt regulator mounted on a heat sink.

There are surface mount components located on the underside of this board. These components include a TL082 op-amp used for the 12kHz IF filter, a 74LS390 counter and an MC145170 PLL chip for generating the local oscillators. After mixing and down converting the radio signals to 12kHz this signal is then passed to the DSP board.

The DSP board uses the Analog Devices ADSP-2101 DSP housed in a 68-pin PLCC (Plastic Leaded Chip Carrier) socket. The ADSP-2101 is a 16-bit fixed point DSP processor running at 16.66 MHz with a 60ns instruction cycle time.

The programmable audio analogue to digital converter and digital to analogue converter functions are handled by an Analog Devices AD1847 housed in a 44-pin PLCC socket. This device is now obsolete and has not been manufactured in recent years. Between these two components is the DSP software in a

28-pin EPROM (version 1.06).

The external loudspeaker audio amplifier can just be seen bottom left of the picture in a plastic in-line power package, surrounded by capacitors. Top left is the +5 volt regulator. The underside of this board has mostly surface mount digital logic and the Analog Devices RS-232 serial interface driver.

As well as signal processing and control, the DSP device provides the serial communication interface to the computer via the 9-pin connector mounted on the board. The serial speed is rather low at only 1200 baud, with 8 data bits and no parity. In operation there is little data traffic between the PC and radio as there are only 8 commands necessary to control the RX-320 (commands described later).

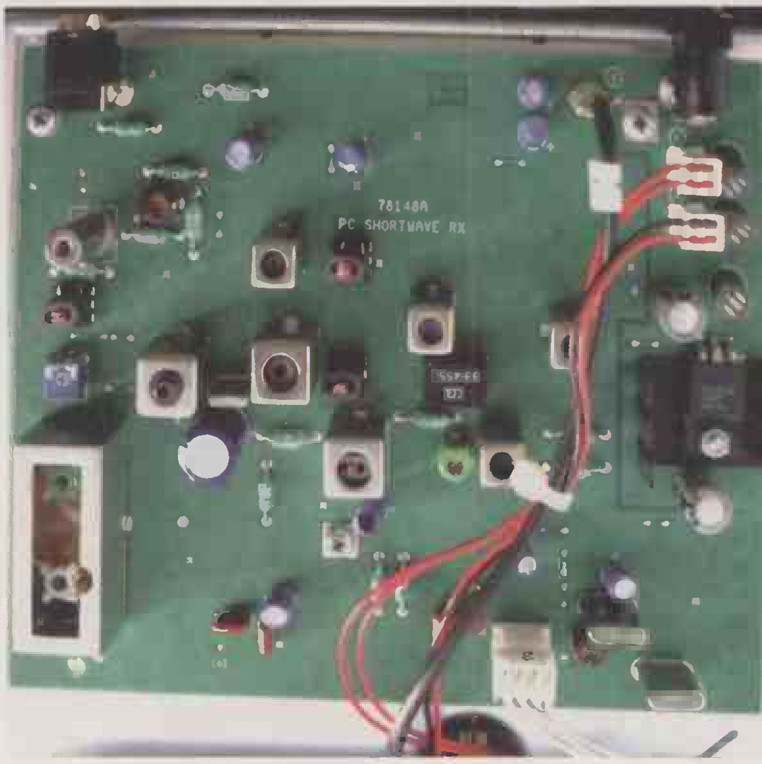

Fig. 10. RF board - rear panel at top of picture.

Fig. 11. DSP board.

Triple superhet

RX-320 radio is a triple superhet design with intermediate frequencies (IF) of 45MHz, 455kHz and 12kHz. The first local oscillator in the RX-320 operates over a range of 45-75MHz so the incoming radio signal is mixed and shifted up in frequency. The first local oscillator synthesiser is tuned in steps of 2.5kHz controlled by the DSP with the fine-tuning achieved using DSP software.

The first and second local oscillator frequencies are derived from the same 14.84750MHz reference crystal. Any frequency errors in the reference crystal causes the second local oscillator to move in the opposite direction of the first local oscillator. The net result is a reduction in overall drift.

Computers and monitors can create a lot of RFI (Radio Frequency Interference) – not good news when you want to control a nearby radio using a computer. After I had connected the RX-320 to my PC, I found a considerable amount of RFI present which made reception on long and medium wave virtually impossible and severe interference on short wave. The higher frequency bands are less affected by RFI.

By switching off the monitor and unplugging various leads the source of the interference was traced to the PC's switch mode power supply, different earthing arrangements were tried but this made no difference. I also tried extending the serial and audio cable and moving the RX-320 further away from the computer but this made little difference. If the signal meter option is enabled then this constant data exchange can cause some interference to be generated from the serial lead.

The ATX type 300 watt power supply was replaced with a better quality unit, included on this power supply was various QA and test passed stickers including one sticker that stated 'noise killer fitted'. This new power supply reduced the amount RFI generated considerably. Inevitably using the telescopic aerial and the radio located only 6 foot away from the computer there will be some RFI received on the RX-320.

If you are considering buying the RX-320 then check the impact of RFI from your computer and monitor first. Try operating a radio near the computer to determine the source and extent of interference.

Control software

The instruction set required for controlling the RX-320 is only 8 commands. A command instruction is a single command letter (must be in upper case) followed by data in hexadecimal format and then terminated by a carriage return. Only the last two commands in the table return information from the RX-320 radio.

Switch on

When power is first applied the radio will send a 'DSP START' text message and the audio will be muted. When the controlling program receives this text it knows that the

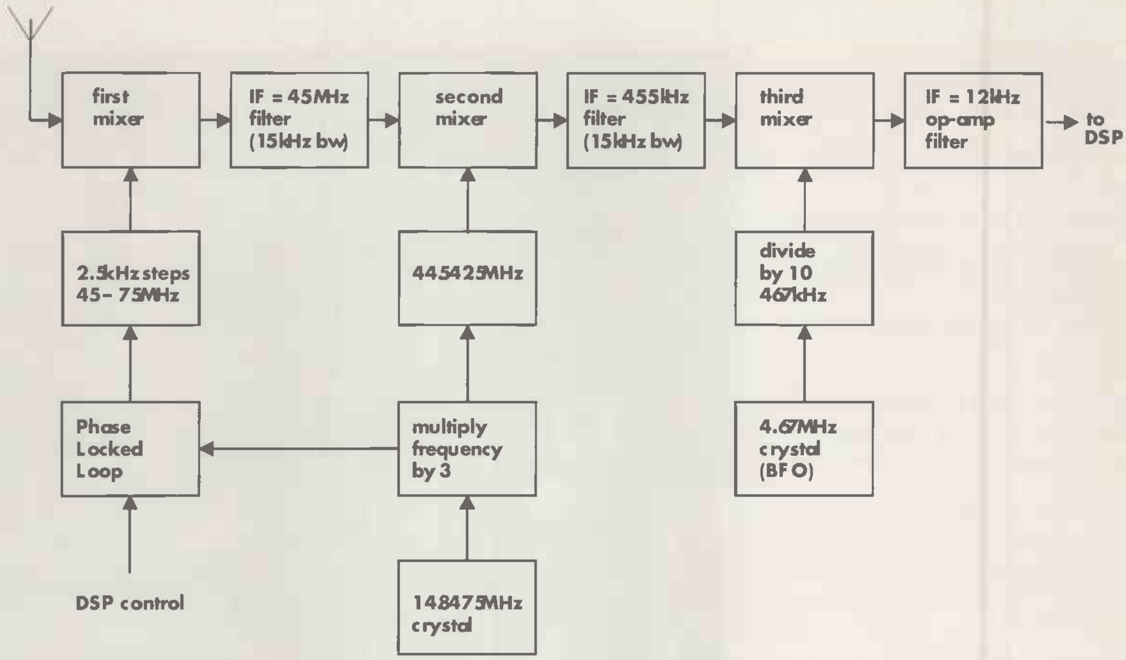

Fig. 12. Block diagram of RX-320 showing frequency translation.

RX-320 has just been switched on and that the radio needs the mode, frequency, filter, agc (optional), speaker level, line output level parameters to be sent. After receiving all these parameters the audio mute is then switched off.

The RX-320 has two audio outputs marked line out and external speaker; these outputs can be controlled separately or together. The line level output can be connected to the line input of a PC sound card or to an external amplifier and speaker. Although the Ten-Tec documentation refers to volume control when setting the audio output, the command actually refers to an attenuation code. The lower the number the louder the audio will be (less attenuation). The range is 0 through 63 where 0 represents the loudest setting (no attenuation) and 63 represents the lowest setting. Each step is equal to approximately 1.5dB of attenuation.

Tuning

The RX-320 DSP is not able to accept a single command instructing the RX-320 to tune to a particular frequency. To tune the radio requires what Ten-Tec refers to as tuning factors. These factors are the results of complicated calculations made by the PC software. There are three factors involved - coarse tuning, DSP fine tuning, and the BFO (Beat Frequency Oscillator) factor when listening in SSB or CW mode. As can be seen on the block diagram, the first local oscillator is tuneable in 2.5kHz steps. The coarse tuning sets this local oscillator as close as possible to the desired frequency. The fine tuning factor represents the difference between the desired frequency and the actual frequency.

There are only two commands that return data from the RX-320, they are requests for signal strength and DSP software firmware version. When the 'X' command is sent, the radio will return a 16-bit integer number that represents the relative signal level. When the radio receives the '?' command it responds with an integer number. Dividing this number by 100 will give the firmware version in N.nn format. When sent this command my RX-320 responded with 'VER 106' (version 1.06).

Conclusion

The RX-320 does not have noise or notch filters that we tend to associate with radios that have a DSP but unlike most other designs the DSP is also controlling the radio functions. The RX-320 radio has a very solid construction and build quality is good.

This radio is not an alternative to expensive DX receivers but works well, is good value for money, and fun. Software control of the radio makes operation easy and there are several different control programs that can be downloaded from the internet for free.

Reception is good using the telescopic aerial, but clearly using an external aerial is a better option. The

Figure 13 RX-320 command summary

function	command	options	description
AGC	'G'	1	slow
		2	medium
		3	fast
filter	'W'	see filter table	
mode	'M'	0	AM
		1	USB
		2	LSB
		3	CW
volume	'V'	0 to 63	0 - loud
			63 - quiet
line out	'A'	0 to 63	0 - loud
			63 - quiet
volume & line out	'C'	0 to 63	0 - loud
			63 - quiet
signal strength	'X'	returns	
		16-bit number	
firmware version	'?'	returns 'VER nnn'	

user's manual gives several examples of how to construct external aerials. As the only alternative aerial connection option is one with a 50 ohm input then using co-ax cable on the down lead will help reduce RFI being picked by the aerial.

Digital Radio Mondiale

One of the reasons that I bought this radio was for the reception of DRM (Digital Radio Mondiale). DRM is set to replace long, medium and short wave AM (Amplitude Modulation) broadcasts, although this will take many years to achieve. June 2003 is the target start date for regular DRM transmissions. At present there are several stations transmitting DRM test signals. To see a list of DRM stations visit the Radio Netherlands web site.

DRM promises much better audio quality than AM - comparable to VHF-FM mono, and thanks to the robust digital modulation scheme signal fading will not directly affect the received audio. Additional features that we associate with RDS and DAB are also included, such as the display of the station name, programme information, programme text, and alternative frequencies.

The spectrum scan Fig. 14. shows a Deutsche Welle DRM test signal received on 15.230 MHz (19 metre band) from their Sines transmitter located in Portugal and transmitting to Europe. If you listen to a DRM signal on a conventional AM radio all you will hear is low level noise, you may have tuned across a DRM signal and not even realised, thinking that the signal was just noise or static.

Apart from expensive receivers used by broadcasting organisations there are no consumer DRM radios available. Currently the only way to listen to DRM is to modify an existing radio and use a PC to decode the digital DRM signal. The DRM signal is extracted before the analogue demodulation stage (usually at the IF stage) and this signal is fed to a PC sound card for processing.

The majority of short wave receivers have a 455kHz IF which is not a suitable signal for feeding directly into a sound card, as this is not within audio input range. The radio's 455kHz IF has to be mixed with an external 467kHz local oscillator (usually a crystal) to generate a 12kHz IF, this frequency is suitable for connecting to a sound card for decoding.

The RX-320 already has this IF frequency feeding the DSP, so I intend to take this 12kHz signal direct to the sound card. Now you know why I needed to be sure that the radio's third IF was at 12kHz as I read a review of the RX-320 that suggested otherwise. I have written an article on decoding DRM using the RX-320 which will be published next month in *EW*.

Note that the DRM signal occupies the whole channel all the time; whereas the bandwidth of AM broadcast signals varies according to the audio modulation. The AM bandwidth required is twice the highest audio frequency being transmitted as the same audio signal is carried on both side bands. This should help explain why I needed to know the actual bandwidth of the ceramic filters used in the RX-320 to ensure that an entire DRM signal can pass through the IF stages. With DRM we are no longer interested in receiving only one of the side bands but the whole radio signal. ■

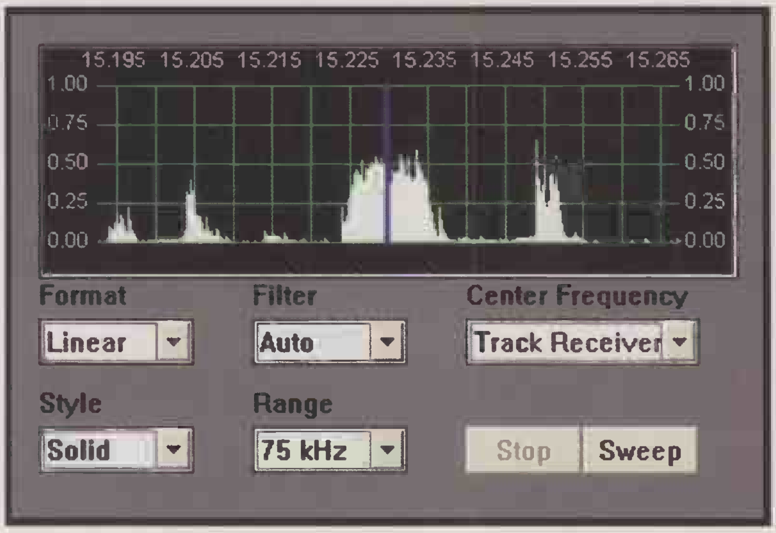

Fig. 14. 19 metre spectrum scan centred on a DRM Deutsche Welle test broadcast.

References:
Ten-Tec RX-320 PC Radio Programmer Guide.
Ten-Tec RX-320 Schematics.
TenTecDIRECT, 4E East Mill, Bridgefoot, Belper, Derbyshire DE56 2UA
www.aoruk.com/tentec
www.tentec.com

For information about DRM - www.drm.org
Radio Netherlands – www.rnw/realradio/html/drm.html

In the UK the radio sells for £259 including VAT and Omega delivery, this compares favourably with the American price of $295 plus shipping.

RX-320 specification summary from manufacturer's data, degraded performance below 1 MHz

Receive mode:	AM, USB, LSB, CW	
Frequency range:	100kHz to 30MHz	
Frequency accuracy:	+/– 100Hz @ 25°C	
Audio output:	1 watt at 4 ohms.	
	>1 v p-p line output into 600 ohms (sound card).	
Mode	bandwidth	sensitivity
AM 80% mod @ 1kHz	6kHz	0.64μV for 12dB S+N/N
SSB/CW	2.5kHz	0.3μV for 10dB S+N/N
Third order intercept (IP3):	+10dBm	
Dynamic range:	90dB @ 2.4kHz bandwidth at 50kHz spacing.	
IF rejection:	>60dB	
Image rejection:	>60dB	
Aerial:	high impedance telescopic connection.	
	50 ohm unbalanced for external antenna.	
Size:	70mm height x 155mm width x 165mm depth (2.7" x 6" x 6.5")	
Weight:	1.2kg (2.5lbs).	

Electronics World reader offer:

x1, x10 switchable oscilloscope probes, only £21.74 a pair, fully inclusive*

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

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

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

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

To order your pair of probes, send the coupon together with £21.74 UK/Europe to ***Probe Offer, Jackie Lowe, Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey, SM3 8BZ***

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

Please supply the following:

Probes

Total__________

Name ____

Address ____

Postcode ______________ Telephone ______________

Method of payment *(please circle)*

Cheques should be made payable to ELECTRONICS WORLD

Access/Mastercard/Visa/Cheque/PO

Credit card no____________________________________

Card expiry date Signed

Please allow up to 28 days for delivery

Specifications

Switch position 1	
Bandwidth	DC to 10MHz
Input resistance	1MΩ – i.e. oscilloscope i/p
Input capacitance	40pF+oscilloscope capacitance
Working voltage	600V DC or pk-pk AC
Switch position 2	
Bandwidth	DC to 150MHz
Rise time	2.4ns
Input resistance	10MΩ ±1% if oscilloscope i/p is 1MΩ
Input capacitance	12pF if oscilloscope i/p is 20pF
Compensation range	10-60pF
Working voltage	600V DC or pk-pk AC
Switch position 'Ref'	
Probe tip grounded via 9MΩ, scope i/p grounded	

Class-AB balanced audio line driver

Wim de Jager has designed a class-AB balanced audio line driver using feed-forward output balancing. It offers improved stability relative to existing configurations without compromising on accuracy.

This is a single supply class-AB line driver for twisted-pair 600Ω audio lines implemented in an 18V bipolar process including vertical p-n-p transistors. Output balancing is achieved with a feed-forward connected transconductor. In contrast with common-mode feedback, this method has no stability constraints while achieving similar accuracy. Measurement results are provided.

Balanced audio line drivers are used to improve the sonic quality of audio systems by eliminating power line hum, RF interference and other externally-generated noise commonly encountered with long audio cables. Implementation can be based on op-amps as illustrated in **Fig. 1**.

In spite of the fact that the circuit is balanced and $R_{f1}=R_{f2}=R_f$, a single-ended input signal applied to one input terminal of the circuit will produce unbalanced output signals. An additional inverting unity gain op amp can be used to obtain balancing, **Fig. 2**. However this results in different signal paths and the need for additional circuitry.

Figure 3 shows a traditional implementation using a common-mode feedback-loop to achieve balanced output signals.[1,2,3]

Output voltages are summed with R_x and R_y and converted into common-mode feedback currents at the inverting input terminals of A_1 and A_2 by means of A_3, which is a dual-output transconductance amplifier.

For low values of closed-loop differential gain, a relatively large amount of common-mode feedback is needed for accurate balancing. This can cause common-mode instability. Moreover, even for an infinite value of the transconductance of A_3, the output balance accuracy still depends on the matching of R_x–R_y and R_{f1}–R_f2.

The balancing of the line driver described here is based on a feed-forward connected transconductor. This avoids common-mode stability constraints while achieving accuracy that's similar to the conventional method.

Feed-forward output balancing

The principle of output balancing based on a feed-forward path shown in **Fig. 4** uses, as well as the feedback circuit shown in Fig. 3, a dual output transconductance amplifier A_3. However, two important aspects are different.

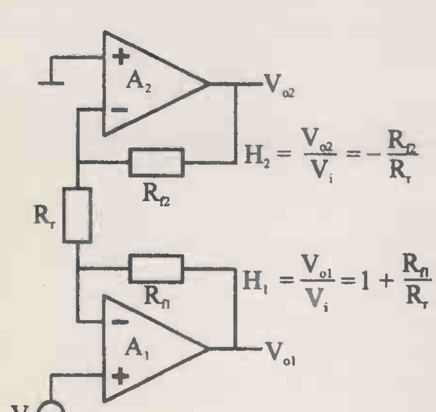

Fig. 1. Op-amp based balanced line driver principle.

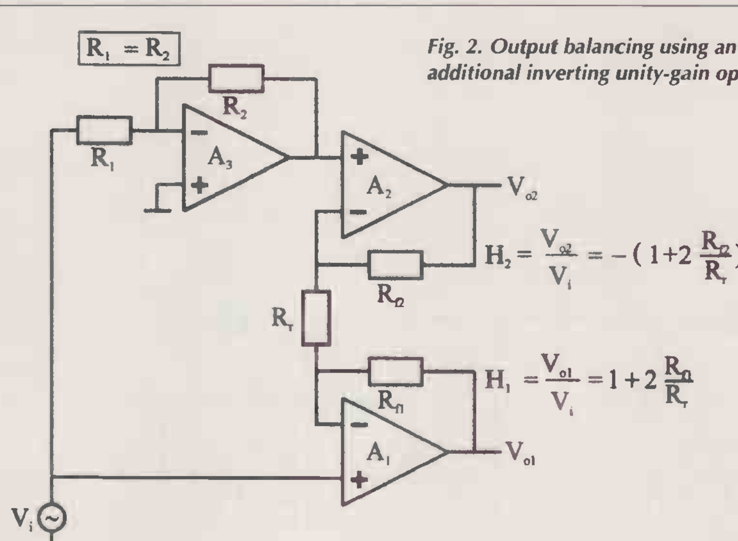

Fig. 2. Output balancing using an additional inverting unity-gain op-amp.

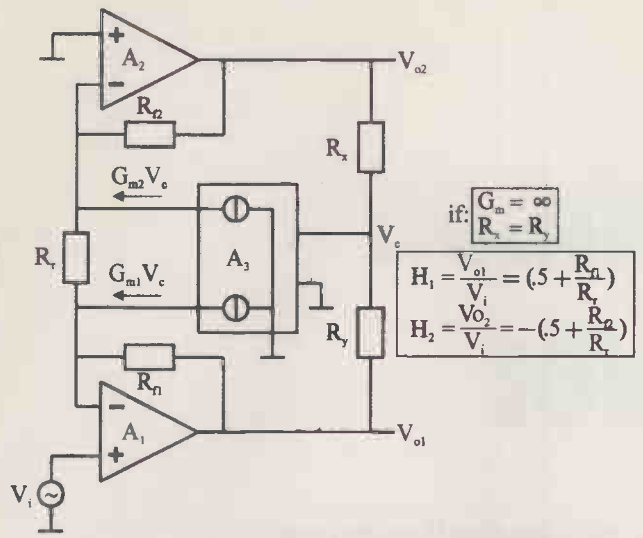

Fig. 3. Output balancing using common-mode feedback.

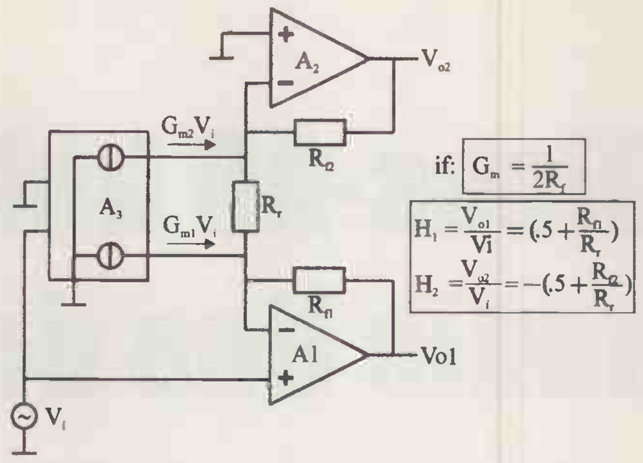

Fig. 4. Output balancing using feed-forward.

Firstly, the input of A_3 is connected to the input of the line driver, so there are no feedback restrictions. Secondly, there is an optimal value of the transconductance.

Symbolic analysis of the transfer of the circuit shown in Fig. 4 using the assumption of idealised op amps, $R_{f1}=R_{f2}=R_f$ and $G_{m1}=G_{m2}=G_m$ show the following results:

$$H_{(differential)} = \frac{V_{o1} - V_{o2}}{V_i} = 1 + 2\frac{R_f}{R_r} \quad (1)$$

$$H_{(common)} = \frac{V_{o1} + V_{o2}}{2V_i} = 1 - 2G_m R_f \quad (2)$$

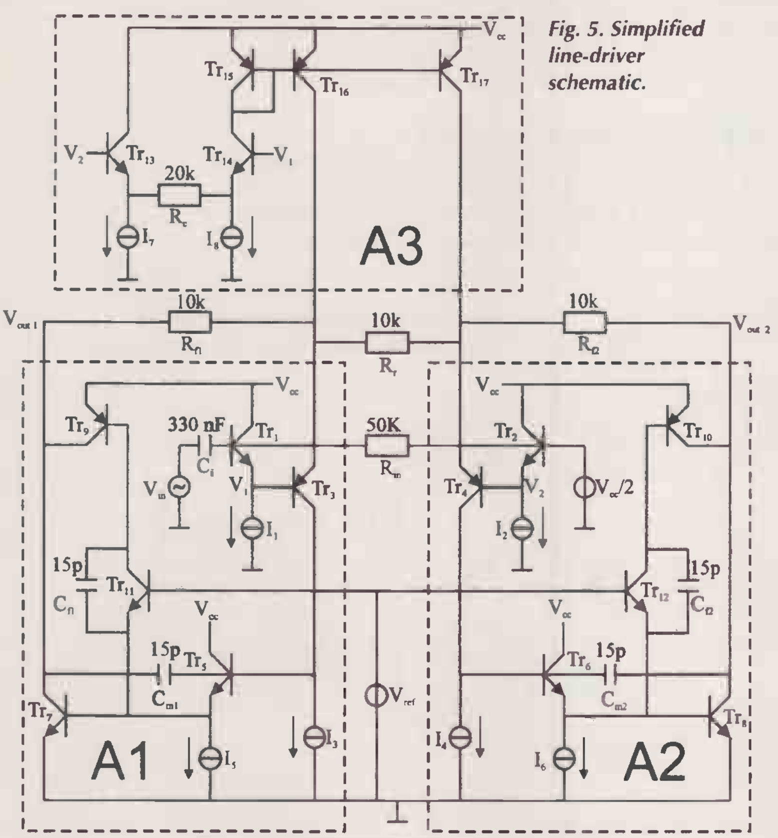

Fig. 5. Simplified line-driver schematic.

A balanced output is obtained, hence expression (2) becomes zero if $G_m=1/2R_f$.

In bipolar technology, the transconductance G_m can be implemented using a resistor-based *V/I* converter. As a result, the accuracy of this method depends on resistor matching.

Note that the accuracy of the common-mode feedback circuit of Fig. 3 also depends on matching of the resistors R_x and R_y used for the output voltage-summing network. So, concerning the output balance accuracy, there is no fundamental difference between the feedback and the feed-forward solution.

In spite of the fact that balancing can be obtained with a single output version of A_3 a dual output version is preferable. Advantages of the dual output version are twofold.

Firstly, the common correction has no influence on the differential gain.

Secondly, the distortion of A_3 is a common-mode error at the output of A_1 and A_2. This distortion will be cancelled in the differential output signal.

Circuit description

Figure 5 shows a simplified balanced line-driver. A balanced current-feedback input stage is formed with Tr_3 and Tr_4. The DC offset V_{BE} (Tr_3, Tr_4) is for the greater part compensated by the use of two additional n-p-n emitter followers, Tr_1 and Tr_2.

Table 1 Measurement results taken using a 12V supply rail.

Input Impedance	45kΩ
Differential output impedance	2.8Ω
Differential gain	3.00V/V
Output unbalance	0.3dB
HF –3dB cut-off frequency	1MHz
Slew Rate	36V/ms
THD, $R_{(load)}$=600Ω, V_o=3.5V (RMS),	
f=1kHz	–80dB
f=10kHz	–65dB
Input voltage noise (f = 80kHz)	46nV/√Hz
Maximum output current	42mA
Supply current (unloaded, V_{in}=0V)	8mA

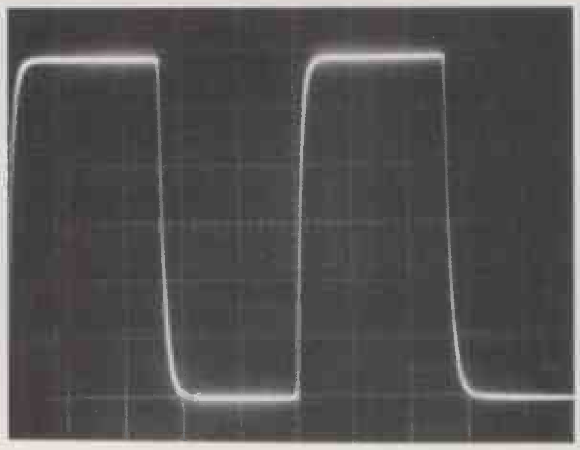

Fig. 6. Square-wave response f=100kHz, vert. 1V/div., $R_{(load)}$=600Ω.

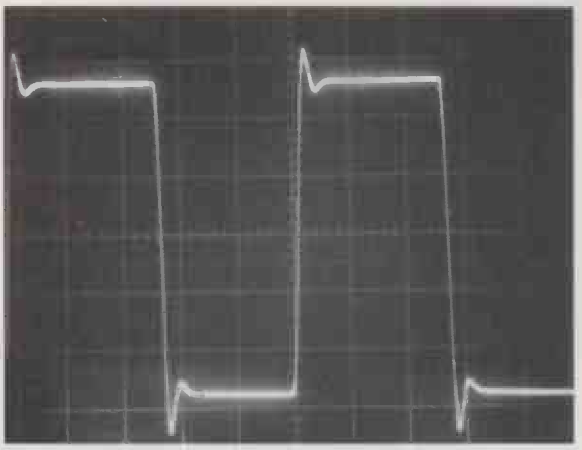

Fig. 7. Square-wave response f=100kHz, vert. 1V/div., $C_{(load)}$=2.2nF.

The upper circuit part enclosed by the dashed line is a transistor-level implementation of the dual output transconductor amplifier A_3 used for feed-forward output balancing. The DC emitter currents of Tr_3 and Tr_4 are equal to the value of I_8 due to a dual output current mirror function of $Tr_{15,16,17}$.

The DC level of V_{out1} and V_{out2} is set by the base-node voltage of Tr_2 and is equal to $V_{cc}/2$ to achieve a single supply operation. AC coupling is obtained with an external coupling capacitor C_i. For R_f=R_r the differential gain is 3.

A balanced output is obtained with R_c=2R_f. Class-AB current-feedback amplifiers A_1 and A_2 are enclosed by dashed lines. The quiescent currents of the output stages are determined by bias control loops formed by V_{ref}, Tr_7, Tr_{11} and V_{ref}, Tr_8, Tr_{12}. They are based on the well-known geometric class-AB control method.

Current sources I_5 and I_6 are needed for push-pull operation of the output stages. Miller frequency compensation is accomplished by means of C_{m1} and C_{m2}. C_{f1} and C_{f2} are used for feed-forward frequency compensation around the common base connected level-shift transistors Tr_{11} and Tr_{12} respectively.

Measurement results

The line driver prototype has been fabricated in a 18V bipolar process which includes vertical p-n-p transistors. Test results at a 12V supply – for automotive

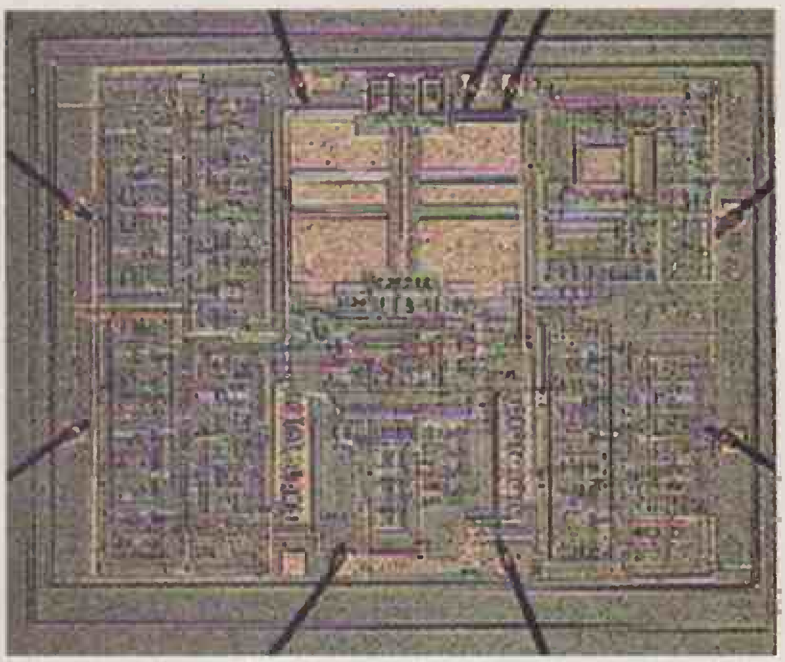

Fig. 8. Chip photograph.

applications – are summarised in **Table 1**.

Input impedance is mainly determined by a 50kΩ built-in resistor and the output unbalance of 0.3dB is mainly caused by resistor mismatch. The HF –3dB cut-off frequency is in agreement with the time constant formed by the feedback resistor R_f and the Miller capacitor C_m that is expected for current-feedback circuits.

Figure 6 shows the square-wave response at a load resistance of 600Ω while **Fig. 7** illustrates a stable response at a load capacitance of 2.2nF. Finally a chip photograph is given in **Fig. 8**.

The circuit operates from a single 12V supply and the output balancing accuracy is comparable with common-mode feedback solutions but has no stability constrains.

We would like to express our thanks to Toine Werner, Eric Klumperink, Bram Nauta and Rien van Leeuwen for helpful comments. ■

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J. N. Babanezhad, 'A Low-Output-Impedance Fully Differential Op Amp with Large Output Swing and Continuous Time Common-Mode Feedback' *IEEE J. Solid-State Circuits,* 1991, vol 26, pp.1825-1833.

M. Banu, J. M. Khoury, Y. Tsividis, 'Fully Differential Amplifiers with Accurate Output Balancing,' *IEEE J. Solid-State Circuits,* 1988 vol 23 pp.1410-1414.

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Power amplifier input currents and their troubles

When power amplifiers are measured, the input is normally driven from a low impedance signal generator. Some test gear, such as the much-loved Audio Precision System-1, has selectable output impedance options of 50, 150, and 600 Ohms. The lowest value available is almost invariably used because 1) it minimises the Johnson noise from the source resistance; 2) it minimises level changes due to loading by the amplifier input impedance. Doug Self explains

This is all very sensible, and exactly the way I do it myself - 99% of the time. There are however two subtle effects that can be missed if the amplifier is always tested this way. These are distortion caused by the non-linear input currents drawn by the typical power amplifier and hum caused by ripple modulation of the same input currents.

Note that this is not the same effect as the excess distortion produced by FET-input opamps when driven from significant source impedances; this is due to their non-linear input capacitances to the IC substrate, and has no equivalent in power amplifiers made of discrete transistors.

Fig. 1 shows both the effects. The amplifier under test was a conventional Blameless design with an EF output stage comprising a single pair of sustained-beta bipolar power transistors; see **Fig. 2** for the basic circuit. Output power was 50 Watts into 8 Ohms. The bottom trace is the distortion plus noise with the usual source impedance of 50 Ohms, and the top one shows how much worse the THD is with a source impedance of 3.9k. Intermediate traces are for 2.2k and 1.1k sources. The THD residual shows both second harmonic distortion and 100Hz ripple components; the latter dominating at low frequencies, while at higher ones the reverse is true. The presence of ripple is signalled by the dip in the top trace at 100Hz, where distortion products and ripple have partially cancelled. The amount of degradation is proportional to the source impedance.

Source impedance

This is not a problem in most cases, where the preamplifier is driven by an active preamplifier, or by a buffer internal to the power amplifier. Competent preamplifiers have a low output impedance, often around 50 -

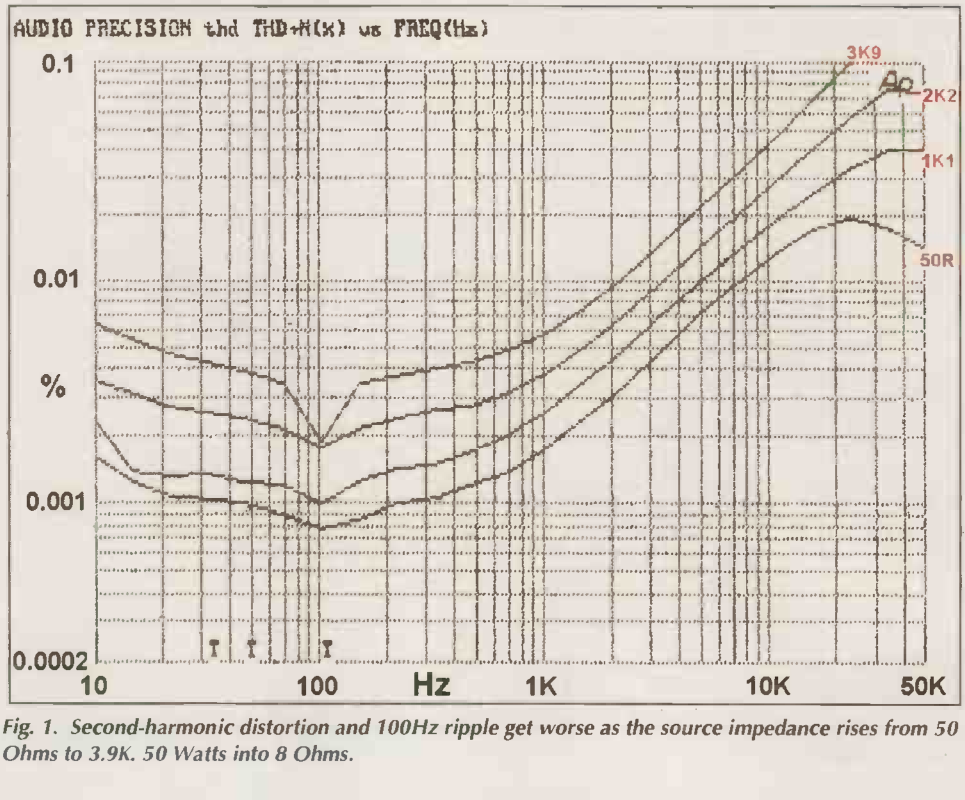


Fig. 1. Second-harmonic distortion and 100Hz ripple get worse as the source impedance rises from 50 Ohms to 3.9K. 50 Watts into 8 Ohms.

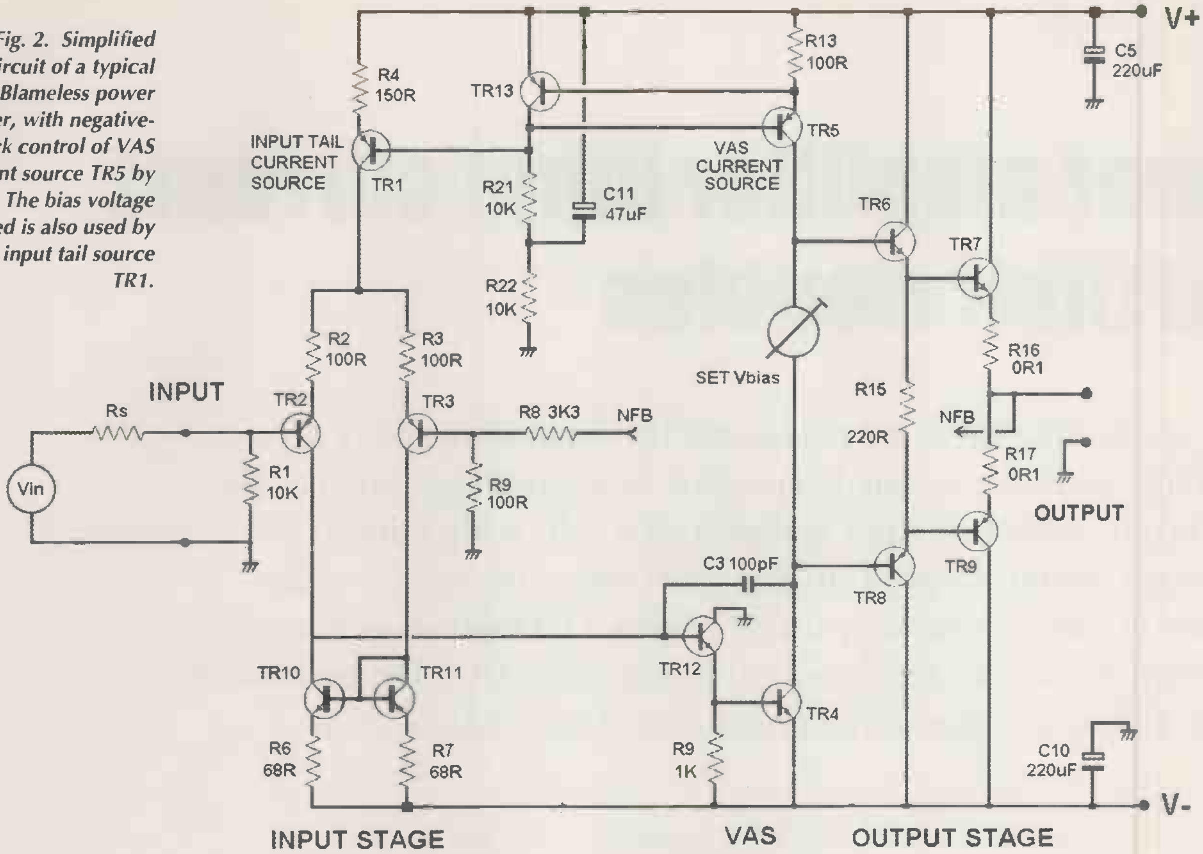


Fig. 2. Simplified circuit of a typical Blameless power amplifier, with negative-feedback control of VAS current source TR5 by TR13. The bias voltage generated is also used by the input tail source TR1.

100 Ohms, to minimise high-frequency losses in cable capacitance. (I have just been hearing of a system with 10 metres of cable between preamp and power amp.)

However, there are two scenarios where the input source resistance is higher than this. If a so-called 'passive preamp' is used then the output impedance is both higher and volume-setting dependent. A 10k volume potentiometer has a maximum output impedance of one-quarter the track resistance, i.e. 2.5k, at its mid-point setting. It is also possible for significant source resistance to exist inside the power amplifier- for example, there might be an balanced input amplifier, which while it has a very low output impedance itself, may have a resistive gain control network between it and the power amp.

So - we have a problem, or rather two of them. It seems very likely that the input transistor base currents are to blame for both, so an obvious option is to minimise these currents by using transistors with the highest available beta in the input pair. In this amplifier the input pair were originally ZTX753, with a beta range of 70 - 200. Replacing these with BC556B input devices (beta range 180 - 460) gives **Fig. 3** which shows a useful improvement in THD above 1kHz; distortion at 10kHz drops from 0.04% to 0.01%. Our theory that the base currents are to blame is clearly correct. The bottom trace is the reference 50 Ohm source plot with the original ZTX753s, and this demonstrates that the problem has been reduced but certainly not eliminated.

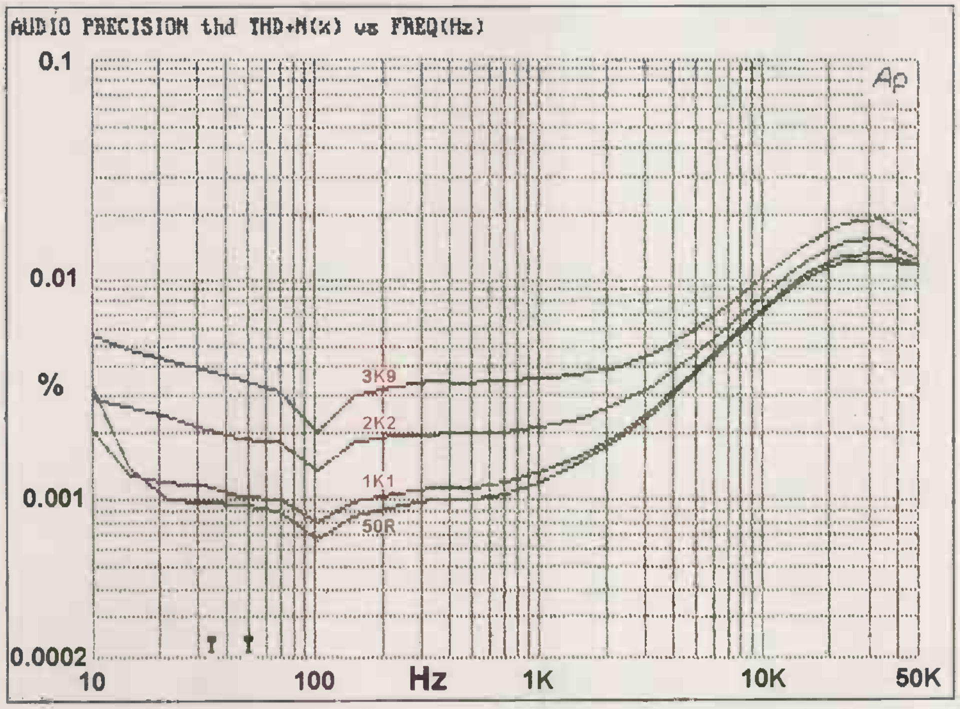


Fig. 3. There is less introduction of ripple and distortion with high-beta input transistors and the same set of source resistances as Fig. 1.

The amplifier here is very linear with a low source impedance, and it might well be questioned as to why the input currents drawn are distorted if the output is beautifully distortion-free. The reason is of course that global negative feedback constrains the output to be linear - because this is where the NFB is taken from, but the internal signals of the amplifier are whatever is required to keep the output linear. The VAS is known to be non-linear, so if the output is sinusoidal the collector currents of the input pair clearly are not. Even if they were, the beta of the input transistors is not constant so the base currents drawn by them would still be non-linear.

It is also possible to get a reduction in hum and distortion by reducing the input pair tail current, but this very important parameter also affects input stage linearity and the slew-rate of the whole amplifier. **Fig. 4** shows the result. The problem is reduced- though far from eliminated- but the high-frequency THD has actually got worse because of poorer linearity in the input stage. This is not a promising route to follow.

Both ripple and THD effects consequent on the base currents drawn could be eliminated by using FETs instead of bipolars in the input stage.

The drawbacks are:

1) Poor Vgs matching, which means that a DC servo becomes essential to control the amplifier output DC offset. Dual FETs do exist but they are discouragingly expensive.

2) Low transconductance, which means the stage cannot be linearised by local feedback as the raw gain is just not available.

3) Although there is no DC gate current, there might well be problems with non-linear input capacitance, as there are with FET-input opamps.

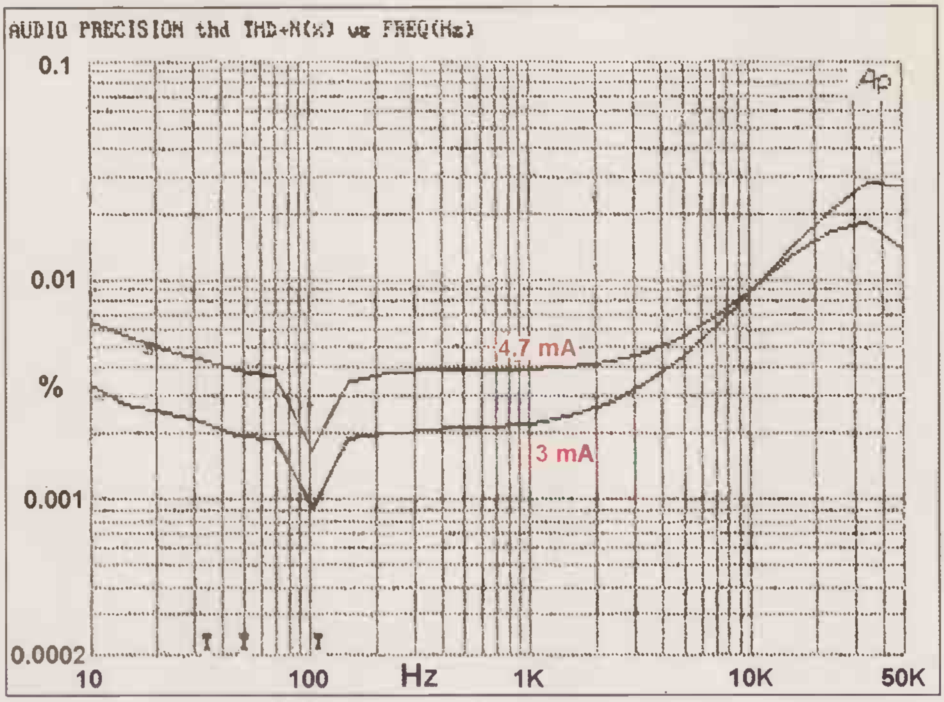


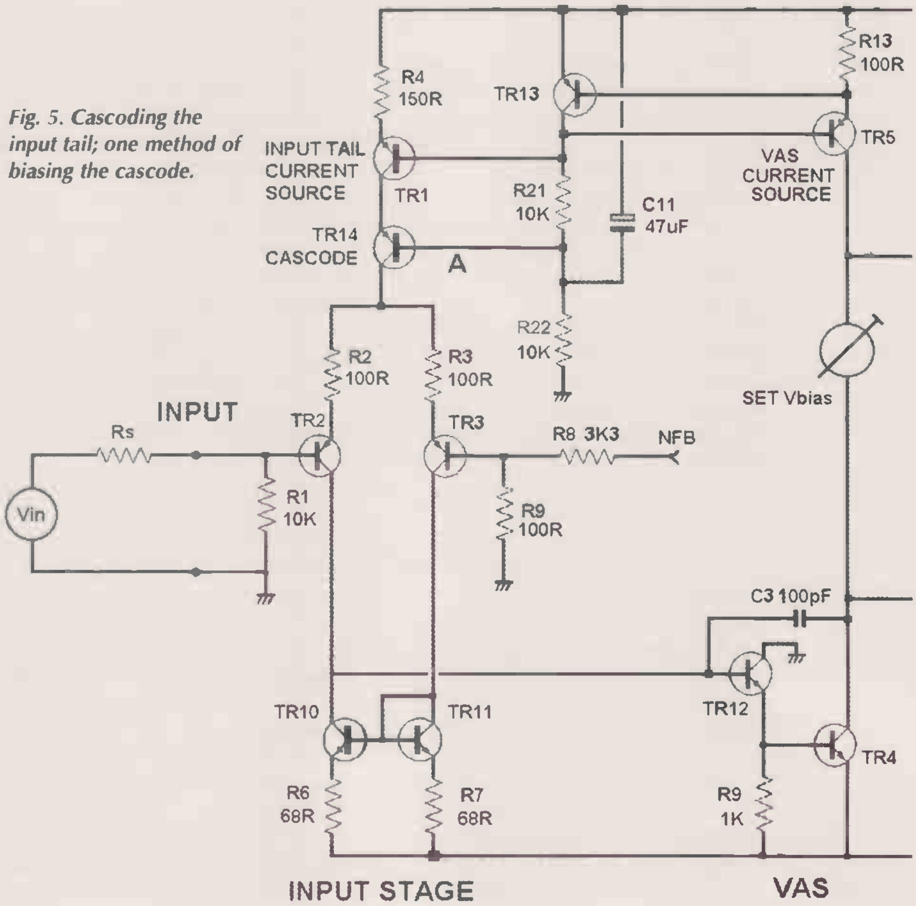
Fig. 4. Reducing the tail current improves things at low frequencies but increases HF distortion above 10kHz. The notches at 100Hz indicate that the ripple content is still substantial.

Component choice

Once again, not a promising route. The distortion problem looks rather intractable; one possible total cure is to put a unity-gain buffer between input and amplifier. The snag (for those seeking the highest possible performance) is that any opamp will compromise the noise and distortion of a Blameless amplifier. It is quite correct to argue that this doesn't matter, as any preamp hooked up to the power amp will have opamps in it anyway, but the preamp is a different box, a different project, and possibly has a different designer, so philosophically this does not appeal to everyone. If a balanced input is required then an opamp stage is mandatory. (Unless you prefer transformers, which of course have their own problems.)

The best choice for the opamp is either the commonplace but extremely capable 5532 (which is

Fig. 5. Cascoding the input tail; one method of biasing the cascode.



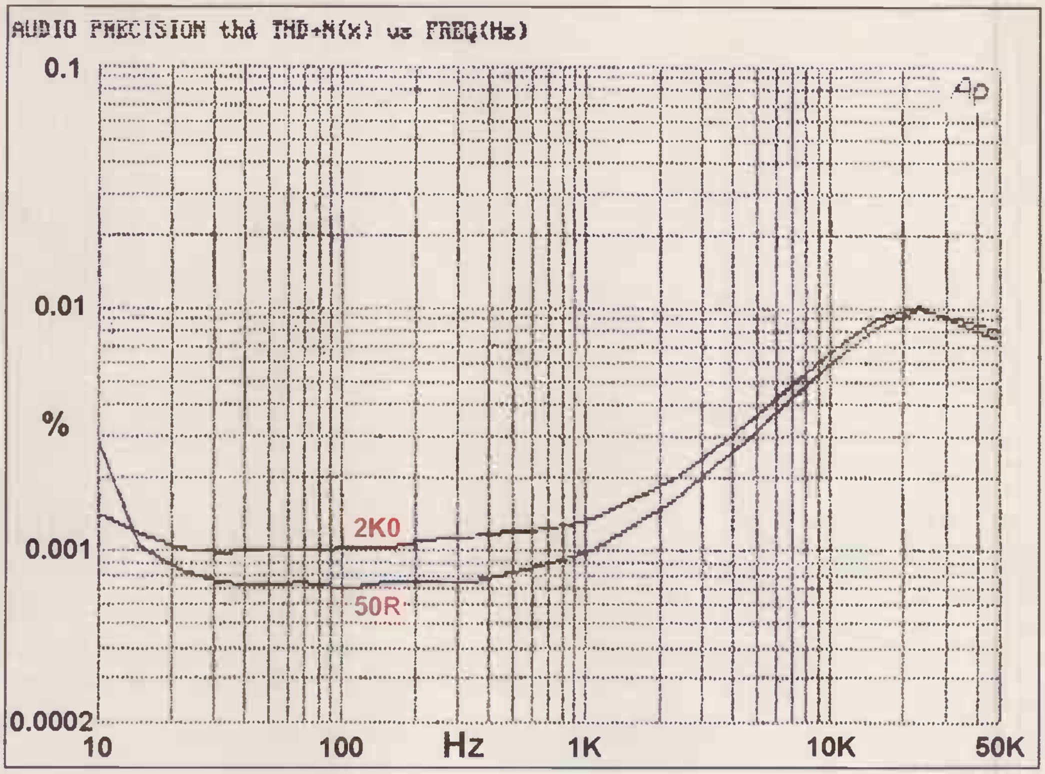


Fig. 6. Cascoding the input tail removes the ripple problem, but not the extra distortion.

pretty much distortion-free, but not alas noise-free, though it is very quiet) or the rather expensive but very quiet AD797.

The ripple problem, however, has a more elegant solution. If there is ripple in the input base current, then clearly there is some ripple in the tail current. This is not normally detectable because the balanced nature of the input stage cancels it out. A significant input source impedance upsets this balance, and the ripple appears.

The tail is fed from constant-current source TR1, and this is clearly not a mathematically perfect circuit element. Investigation showed that the cause of the tail-current ripple contamination is the Early effect in this transistor, which is effectively fed with a constant bias voltage A tapped off from the VAS negative-feedback current source. (Early Effect is the modulation of transistor collector current caused by changing the Vce; as a relatively minor aspect of bipolar transistor behaviour SPICE simulators model it in a rather simplistic way.) Note that this kind of negative-feedback current-source could control the tail current instead of the VAS current, which might well reduce the ripple problem, but is arranged this way as it gives better positive slewing. Another option is two separate negative-feedback current-sources.

The root cause of our hum problem is therefore the modulation of the Vce of TR1 by ripple on the positive rail, and this variation is easily eliminated by cascoding, as shown in **Fig. 5.** This forces TR1 emitter and collector to move up and down together, preventing Vce variations. It completely eradicates the ripple components, but leaves the input-current distortion unaltered, giving the results in **Fig. 6.** where the upper trace is degraded only by the extra distortion introduced by a 2K source impedance; the 100Hz cancellation notch has also disappeared. The reference 50 Ohm source plot is below it.

The voltage at A that determines the Vce of TR1 is not critical. It must be sufficiently below the positive supply rail for TR1 to have enough Vce to conduct properly, and it must be sufficiently above ground to give the input pair enough common-mode range. I usually split the biasing chain R21, R22 in half, as shown, so C11 can be used to filter out rail noise and ripple, and biasing the cascode transistor from the mid-point works very well.

It may have occurred to the reader that simply balancing the impedances seen by the two inputs will cancel out the unwanted noise and distortion. This is not very practical as with discrete transistors there is no guarantee that the two input devices will have the same beta. (I know there are such things as dual bipolars, but once more the cost is depressing) This also implies that the feedback network will have to have its impedance raised to equal that at the input, which would give unnecessarily high levels of Johnson noise.

Conclusion

If the system design requires an opamp at the input, then both hum and distortion problems are removed with no further effort. If not, perhaps because the amplifier must be as quiet as possible, then cascoding the input pair tail cures the ripple problem but not the distortion. Using high-beta input transistors reduces both problems but does not eliminate them.

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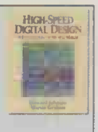

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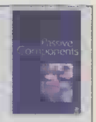

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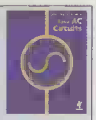

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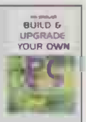

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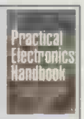

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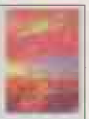

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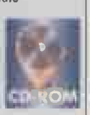

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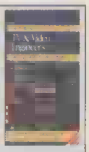

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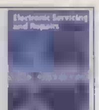

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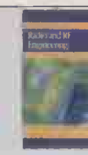

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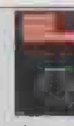

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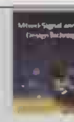

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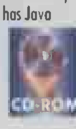

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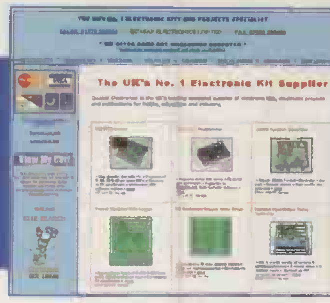

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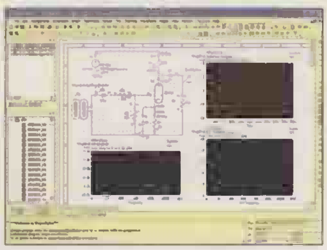

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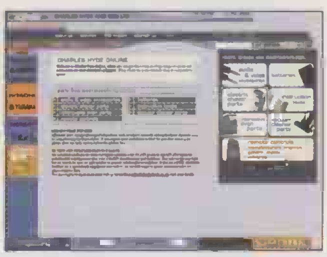

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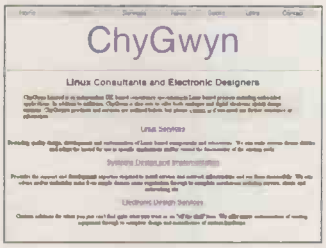

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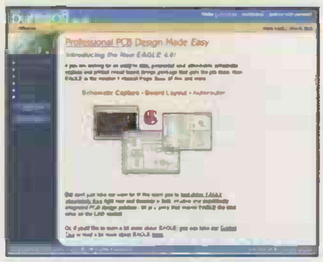

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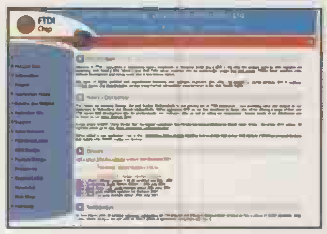

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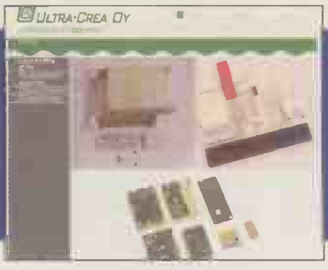

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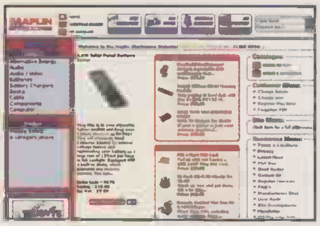

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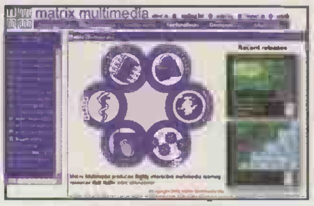

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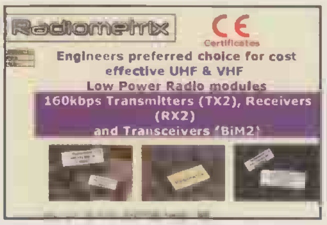

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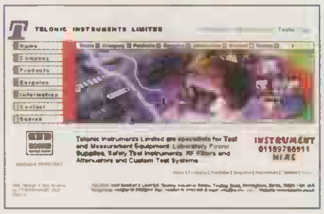

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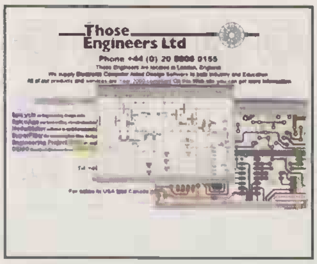

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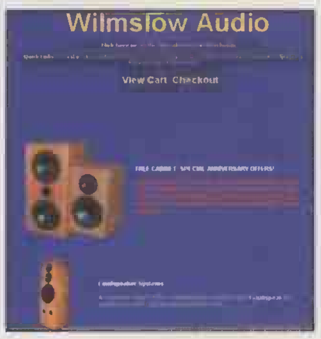

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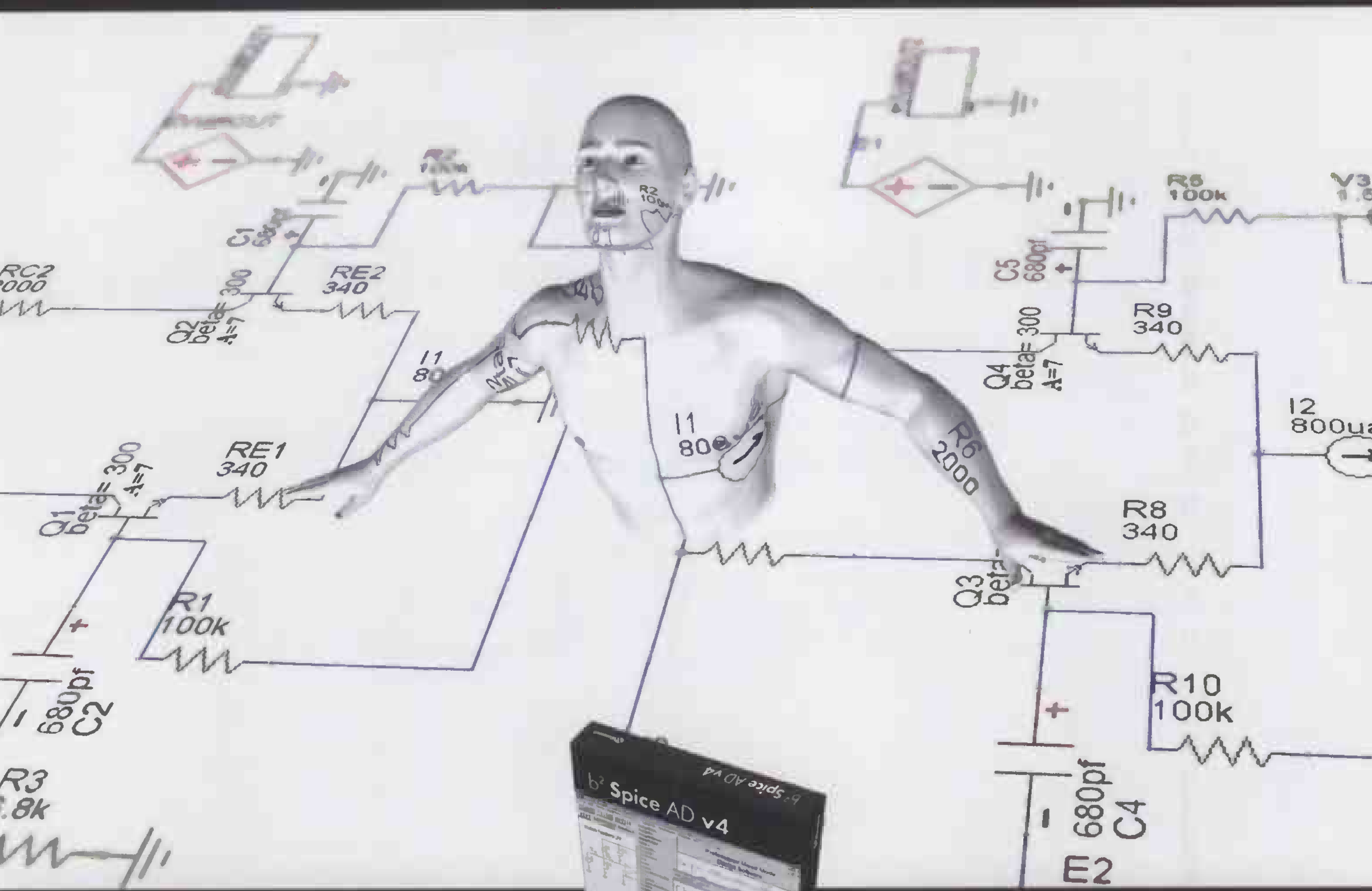

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