Seven pages of circuit ideas – see page 1010...

ELECTRONICS WORLD

INCORPORATING WIRELESS WORLD

DECEMBER 1998 £2.45

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Denmark DKr. 69.00
Germany DM 18.00
Greece Dra.1300.00
Holland Dfl. 12.50
Italy L. 9000.00
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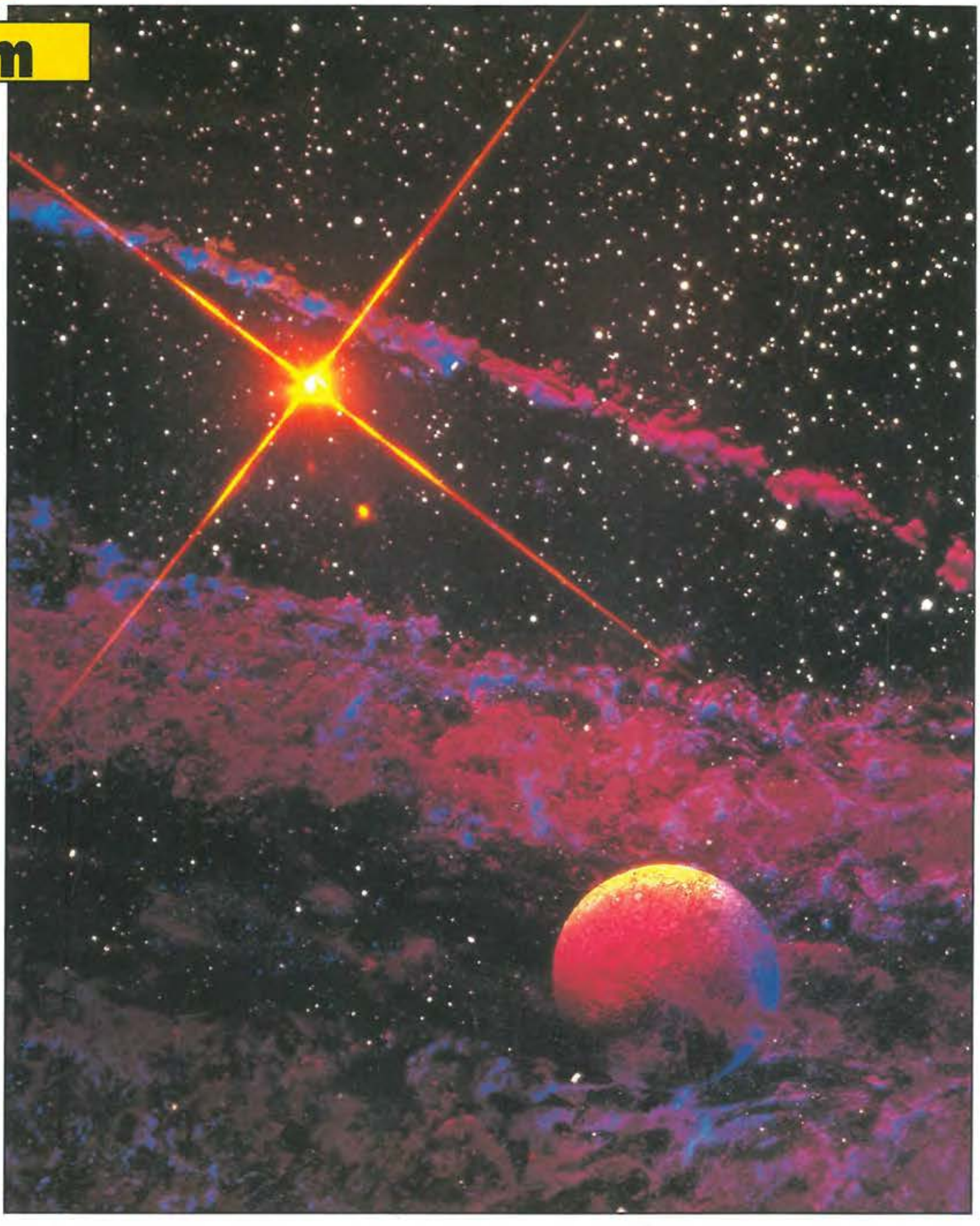

Stars on film

Motor drive for ultra-long exposures

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RMS watts, or not?

Speaker coil design

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Is there a link between the Eagle magazine and ISDN? Andy Emmerson explains on page 987.

Have you heard Ruby Wax explaining the BBC's digital tv services? Why not read Richard Wilson's side of the story on page 1061?

This Grundig 30MHz oscilloscope worth £450 is ours to give away. Want it? See page 1007.

JANUARY ISSUE ON SALE 3 DECEMBER

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0171 261 7704

ISSN 0959-8332

SUBSCRIPTION HOTLINE
01622 778000

SUBSCRIPTION QUERIES
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Super highway or yellow brick road?

Are you old enough to remember the *Meccano Magazine*, the *Eagle* and those Boy's Book of Modern Marvels publications? Can you recall those spectacular artist's impressions and hand-crafted cutaway drawings depicting miracles of technology that were just around the corner?

Those were the days. Aircraft refuelling stations that floated in mid-Atlantic, towering cities of the future with autogiros circling skyscrapers like moths around a light bulb. Magical pictures portrayed us using motorways surfaced with rubber, "for reduced noise and better roadholding." And people living in fabulous ranch-style houses with personal helicopter pads atop the garage roof.

Atomic power and fuel cells would bring us cheap, abundant electricity, while high-speed hovertrains would replace normal railways, with multi-lane motorway bridges spanning the English Channel.

All spiffing good stuff in the Tomorrow's World mould – but also all so hopelessly over-optimistic. How could professional engineers and seasoned futurologists manage to get things wrong each time? Never mind. At least this stupidity was confined to civil and mechanical engineering. Information-technology people and other denizens of the electronics world always kept their feet on the ground – not in their mouths.

Actually, if you believe that, you'll believe anything. The fields of computing and communications are thoroughly littered with comparable cock-ups. Flashback to the early eighties: Kenneth Baker, Minister of State for Industry and Information Technology, talks confidently about wiring every house and office to a national grid of optical fibres. Did it happen?

Flashback to autumn 1996: the *Financial Times* reports that cable modems will, "change publishing, telecommunications and working habits all over the world" and Telewest announces at the European Cable Communications Show that its cable modems will "show any doubting Thomases what we can do with cable and the right technology".

My name's definitely Thomas – and cable modems have yet to make any serious impact.

How on Earth do these highly paid – I almost wrote 'qualified' – pundits manage to get things so wrong? Oh never mind, we must move on.

Now journey back to a year ago and to this very magazine. In this self-same editorial slot I described how a solution had finally arrived for small office and home users waiting for a cost-effective connection to the information superhighway. The prospect of 'real' ISDN at an affordable price had been made possible by new technology, being rolled out a year later by BT under the service names *Home Highway* and *Business Highway*.

And was it all worth waiting for? Huh! Once again the dream of low-cost ISDN service for the mass market of small business and residential customers has eluded us. The tariffs that BT has published for Home Highway are uncompetitive and totally unrealistic for all bar the most self-indulgent of telecomms junkies.

The prices may indeed reflect the costs involved but they will certainly not attract the vast majority of those previously tempted to join the digital revolution.

Naturally BT will say that its operating licence clauses forbidding cross-subsidy prevent a lower-cost launch of Highway services. It may also point to the fact that its competitors are not exactly rushing in to fill the vacuum by providing alternative low-cost ISDN services. Nonetheless, a major window of opportunity has been missed and the dream of ubiquitous ISDN connection still eludes us.

Was ISDN just a wild dream then? Not at all. According to Margrit Sessions, managing director of consultancy Phillips Tarifica Ltd, "most of Europe has recognised the benefits of ISDN, and in Germany and France business applications such as teleworking and videoconferencing are almost commonplace."

The problem lies entirely in pricing and a report just issued by Tarifica indicates that ISDN connection and rental charges in Britain are up to six times higher than in other leading European nations. "The UK is in danger of becoming a technological outcast; [ISDN] prices must come down further to ensure that British businesses are given the opportunity to remain competitive on every level – including technologically," warns Sessions.

Should we be concerned? I think we should. The ISDN fiasco is not unique; I could cite many more marketing foul-ups. And we should not tolerate them. Sure, we can live with the enthusiasm of technologists for their latest developments; after all, most technology relies on the successful fulfilment of dreams.

The danger arises when technologists allow their dreams to be hijacked by others. Some product managers have a distorted view of reality and then innocent customers are misled because the marketeers fail to deliver their promises. Credibility is at stake – not to mention the livelihoods of all those who depend on technology for a living. We should be selling science fact, not science fiction.

Or am I taking things too seriously? Is there a problem at all? Perhaps I need to lighten up and take a holiday. I'd really love to know. ■

Andrew Emmerson

Electronics World is published monthly. By post, current issue £2.45, back issues (if available £3.00). Orders, payments and general correspondence to **L333, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS**. Tlx:892984 REED BP G. Cheques should be made payable to Reed Business Information Ltd

Newstrade: Distributed by Marketforce (UK) Ltd, 247 Tottenham Court Road London W1P OAU 0171 261-5108.

Subscriptions: Quadrant Subscription Services, Oakfield House Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 01444 445566. Please notify change of address.

Subscription rates 1 year UK £34.00 2 years £54.00 3 years £68.00. Europe/Eu 1 year £49.00 2 years £78.00 3 years £98.00 ROW 1 year £59.00 2 years £94.00 3 years £119

Overseas advertising agents: France and Belgium: Pierre Mussard, 18-20 Place de la Madeleine, Paris 75008. United States of America: Ray Barnes, Reed Business Publishing Ltd, 475 Park Avenue South, 2nd Fl New York, NY 10016 Tel; (212) 679 8888 Fax; (212) 679 9455

USA mailing agents: Mercury Airfreight International Ltd Inc, 10(b) Englehard Ave, Avenel NJ 07001. Periodicles Postage Paid at Rahway NJ Postmaster. Send address changes to above.

Printed by BPCC Magazines (Carlisle) Ltd, Newtown Trading Estate Carlisle. Cumbria, CA2 7NR

Filmsetting by JJ Typographics Ltd, Unit 4 Baron Court, Chandlers Way, Southend-on-Sea, Essex SS2 5SE.

Web access on a chip...

Toshiba launched its first Internet tuner chips in Autumn '98. These deliver Internet functionality for any electronics product. The so-called Internet tuner ICs are based on a core from Santa Clara start-up iReady Corporation.

Seiko is to use the same iReady core in a range of miniature lcds, with 240 by 160 or 320 by 240 pixels, which will have Internet tuners built into the display.

"We have four licensees all working on products," said Ryo Koyama, founder and president of the two year old iReady adding, "we'll announce a fifth licensee next month."

The iReady core gives any product the ability to surf the Web, receive e-mail instructions or deliver faxes over the Internet. "The joke everyone makes is 'Why send e-mails to your refrigerator?'," said Koyama. But one benefit of the system is that there are some household appliances which would benefit-from being capable of remote operation.

Early next year, a toy manufacturer will bring out an Internet-connected toy using an Asic incorporating the iReady and fabricated by Toshiba.

Koyama said that the iReady is implemented in 120000 logic gates which, he said, only cost $6. This means that Internet capability can be added to a product for a cost of $10 compared to the $40+ solutions offered by a microprocessor, operating system and applications software.

iReady has raised $8.5m in two rounds of venture capital funding and is now looking for a third round from corporate investors.

David Manners, *Electronics Weekly*

Electronic book standard sought

Major computer, software and book publishers have launched an initiative to set standards for the first electronic books.

Known as eBook, the hand held terminal could become a mass market electronics product fuelling demand for chips and displays.

"The Open eBook standard announced today is designed so that early purchasers of eBook titles will be able to read their 'books' on all devices supporting the standard," said Microsoft v-p Dick Brass, in charge of Microsoft's eBook projects.

Japanese electronics giant Sharp teamed up with US firm NuvoMedia to develop Rocket eBooks. These will be 600g hand-held computer devices with a high resolution Sharp lcd screen. Rocket eBooks will hold 4000 pages of text.

...and on a phone

Motorola has unveiled its VoxML technology which allows people to access Web sites via the telephone.

Using voice commands, users can navigate to Web sites and hear the pages' contents. "VoxML will revolutionise the way people access on-line information and Web content," claimed Motorola v-p Maria Martinez.

Motorola gives the example of a user checking an airline departure time. They would ask "Is ABC Airline's flight from Washington DC on time? The airline's VoxML application interprets the the voice request and translates it to a Web request. The application locates and publishes the requested information in VoxML, which is then translated from text to speech for the user.

Edwin demonstration goes ahead

After enjoying the Edwin CAD package tour on the CD presented with last month's issue, some readers found that they could not load the working demonstration under Windows 95. If you have experienced such problems, click on the Windows 95 'Start' button and select 'Run'. Clear any file path entry text in the panel that appears.

Now type d:\edwincd\workdemo\setup2.exe in the 'Run' window, where d: is the letter belonging to your CD drive. When asked where the Visionics Products source files are, type d:\edwincd\workdemo\, again making sure that d: is the letter of your cd rom drive.

This should work regardless of how your version of Windows 95 is set up, and as a bonus, it also works for Windows 98 users.We trust that you will find the working demonstration worth the wait.

Mobile phone health research...
The absorption from mobile phones is being tested using an anatomically correct head. The experiment is part of an EU funded testing programme involving 14 partners and led by the University of Rome. The head has been constructed at Bristol University from new dielectric simulation materials using forensic techniques to simulate the bone, brain, muscle, skin and eye. The University of Bradford and the National Physical Laboratory are involved in the measurements for the project.

David White/Rex Features

Fab closures could spark UK talent drain

The UK is set to lose some of the most skilled engineers anywhere in the semiconductor industry unless potential buyers are quickly found for the two North Tyneside wafer fabrication plants.

A Siemens manager said it would be a tragedy if the engineering talent at North Tyneside was lost, and that many of those employed at Siemens, and at Fujitsu's fabrication plant in Newton Aycliffe, were preparing to leave the country for jobs overseas.

Siemens' personnel director Llew Aviss confirmed that up to 150 Tyneside staff have been offered jobs at other Siemens plants. "There are 500 openings with Siemens worldwide, from Taiwan to the US," he said.

Employees were encouraged to apply for those positions. "One hundred to 150 are settling on those jobs. They are visiting the locations at the moment," Aviss added.

Siemens will start moving equipment out of the plant later this month. "But no equipment essential to manufacturing will move until the end of November," said Aviss.

Taiwanese foundry TSMC has been linked with the Siemens fab after it was announced it is considering a formal offer of a fab from a European company.

"We will not comment on any organisation until we get to the point where we have a firm interest," said Aviss. "We will not confirm or deny any talks with TSMC."

First programmable dual op-amp

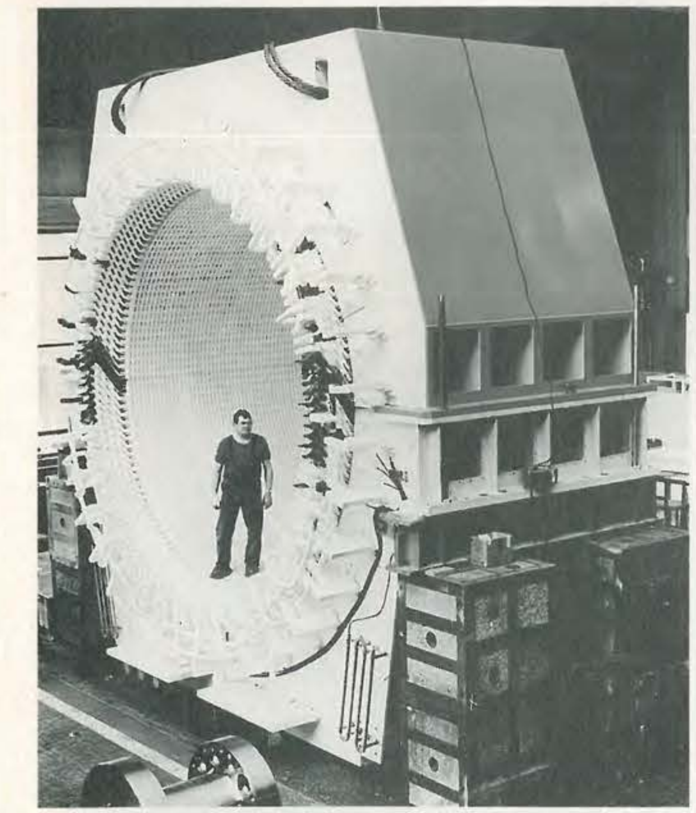
Xicor has introduced a digitally programmable dual op-amp, which it claims to be the first of its kind.

"Our customers throughout the electronics industry are calling for a single chip that integrates many of the traditional building blocks of analogue and digital non-volatile memory," said Bob Anderson, product line manager.

Called the X9430, it is programmable for gain, offset and power level through either SP1 or I^2C serial busses.

No performance figures have been released, but the company does say that it can replace *741, 301A* and *OP07* amplifiers.

Xicor sees the chip being used for applications such as pagers, cellular telephones, DVD players, printers and copiers. It comes in a 24-pin SOIC.



135 000 horses... At 101MW, ABB is claiming to have made the world's largest variable speed ac drive and motor system. It runs up to 600rev/min and will power NASA's transonic wind tunnel at the Langley Research Centre in Virginia. The drive is a 'load commutated inverter' type and fills a 10 by 10 by 10cm cube. The motor, anchored 10m away, is 6 by 6 by 7m, excluding its cooling and ancillary system. It weighs 360 tonnes.

New technology and life quality

There has been a call for an 'informed' pubic debate over the quality of life implications of new technologies like smartcards and the Internet. Dr John Taylor, in his inaugural address as president of the Institute of Electrical Engineers, told some of the UK's most influential engineers that an individual's life will be tracked with ever greater precision. "Might we need a right to fuzziness which outlaws such accurate and fine-grained surveillance," said Taylor, who is director of Hewlett-Packard's European research laboratories.

Digital radio licence

The Radio Authority has awarded a national digital radio licence to the Digital One consortium. NTL, one of three companies that makes up the consortium, will build the national transmitter network for commercial digital radio.

UK votes for TV voting

Sixty per cent of the British adult population would be happy to vote for a future prime minister via the television. The survey, from set-top manufacturer Pace Micro technology, also found that 41 per cent would welcome the opportunity to interact with their local MPs through the tv.

Spot the antenna...

Tiny mobile phone base stations just a few inches high are being introduced by Vodafone. Known as Street Furniture, the antennas are attached to street lamps, sign posts or CCTV poles. Twenty sites are now on-air, including the pictured site in Bristol.

"Start planning for Year 2000 failures" call

Cabinet Millennium bug supremo Margaret Beckett is urging public and private sectors to start planning for failures in the Year 2000. She said contingency plans for equipment that will not be Millennium compliant by the year 2000 had to start being made now.

The leader of the Commons was speaking in an exclusive interview after she admitted at the Labour conference in Blackpool that it was too late to ensure that computers and electronics systems in both sectors could be made safe from the Year 2000 time-bomb.

She told the fringe meeting at the gathering organised by Labour Industry Forum: "I have come late and reluctantly to the view that we cannot be confident we can deal with all the problems." Afterwards she said "Obviously we need to continue to work towards compliance but some systems will not be able to cope. It may not be the firm or department's computers but those of a supplier."

The international situation is not good: "Both public and private sector organisations need to start to identify those areas which will not be ready and plan for how to deal with any problems that arise," she said.

While Robin Guenier, head of the Year 2000 taskforce said her comments were refreshingly honest, Tory trade and industry spokesman John Redwood said the government was to blame for there now being too little time to deal with the bug.

It's getting better, say analysts

Latest semiconductor market figures herald a brighter future from next year. But chip manufacturers must do more to reduce oversupply in the memory market.

Dataquest, Future Horizons and IC Insights have all reported an improved outlook for 1999. Europe could even rebound this year, but Asia's problems will delay any world-wide bounce back until mid-1999.

Dataquest is most optimistic, stating an overall decline of six per cent this year will turn into growth of 12 per cent in 1999.

"A stronger dynamic ram market is fuelled primarily by the move to the PC100 specification," said Richard Gordon, memory analyst at Dataquest. The IC Insight report believes the bottom of the cycle has been reached and echoes Dataquest with a ten per cent growth forecast next year. Year 200 will be very good, says Future Horizons' MD Malcolm Penn: "The long term is going to be fantastic."

IC Insight says the average selling price of ICs has increased. It believes dynamic-ram manufacturers are breaking even, rather than loosing money.

Future Horizons, the European analyst, believes the opposite, that all dynamic-ram manufacturers are selling below cost of production.

A few fab closures have done little to affect over supply. "We need at least three Siemens type fabs to close," said Penn.

Oversupply will continue, says Dataquest, for another 18 months in foundries and two years for dynamic ram.

Fortunately, the transition to 0.8µm processing is delayed due to the increased number of defects. This will help demand catch up with supply.

Richard Ball, *Electronics Weekly*

Chip sales saw autumn rise

World-wide chip sales showed signs of an upturn last August, according to the Semiconductor Industry Association (SIA).

Global chip sales rose by 1.5 per cent – the first month-on-month gain this year – but were 16 per cent below the same month last year. Total sales increased by $147m from July to $9.81bn in August. The sales increase came despite a large drop in sales in Japan, down 30 per cent from last year's figures.

"We are cautiously optimistic about the industry's prospects for additional gains in the fourth quarter," said SIA president George Scalise.

Output declines...

There has been a sharp decline in engineering output for the second consecutive quarter, according to a survey by the Engineering Employers' Federation (EEF). Export orders also fell steeply for the seventh consecutive quarter. "Our survey shows that the recession in engineering is becoming deeply entrenched," said Graham Mackenzie, EEF's director general.

...but pay is stable

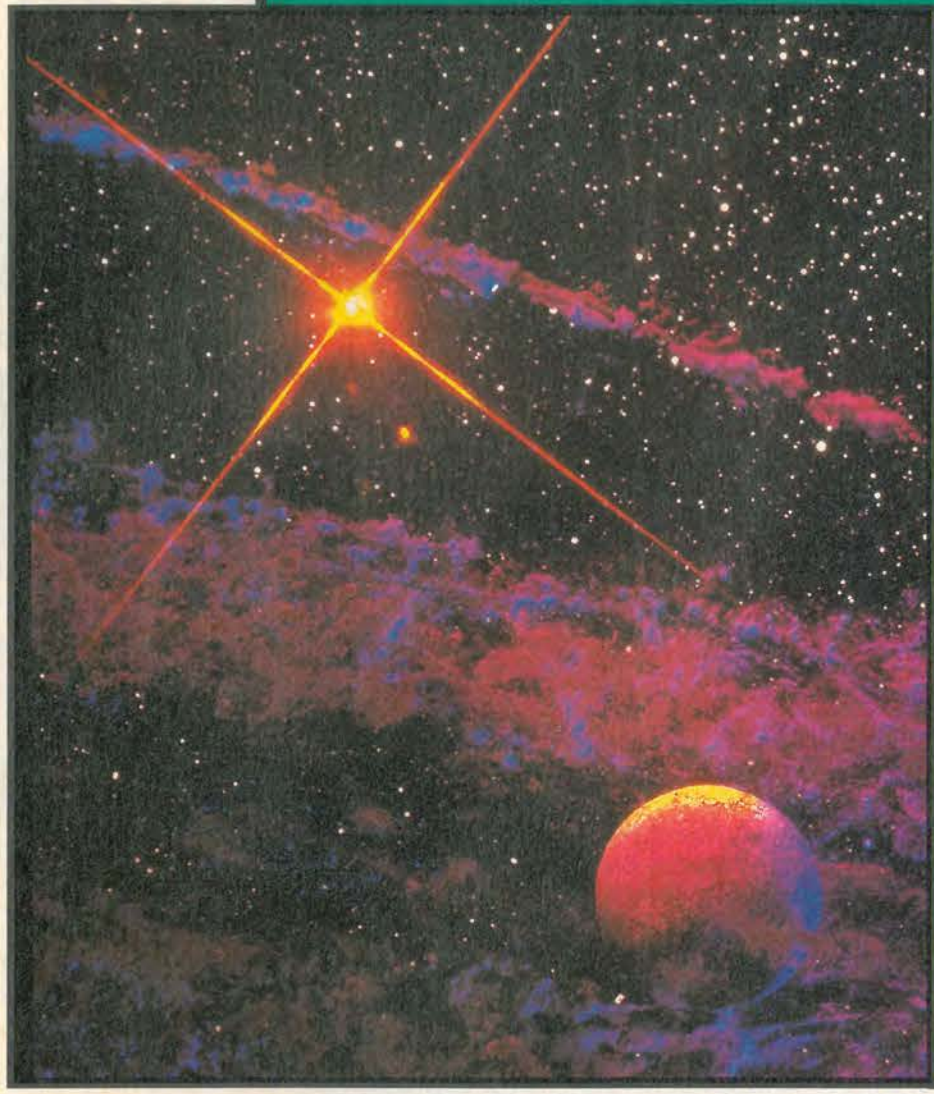
Pay settlements in the engineering sector have remained stable in the three month period up till August.

According to the latest EEF survey, the average settlement level was 3.5 per cent. This follows a fall in settlement rates during the previous three month period.

Are you there?

The first thing you get asked when you answer a mobile phone is: "Where are you?" But if mobile phone operator Orange has its way this won't happen again. The downside is that it will be difficult to lie about where you are. The full colour mobile videophone to make this possible will be available by Christmas 1999. Co-developed with the University of Strathclyde, the phone will work over all the networks, via a data capability that Orange's phones use.

Drive time



Taking a photograph of a distant star at night needs a long exposure. But while the shutter is open, the star is moving. Ian Hickman describes a precise motor drive for tracking such celestial bodies, and explains why the task is not as simple as it first appears.

A while ago, I designed a sidereal motor drive and clock for a keen amateur astronomer colleague of mine in exchange for an old Hewlett-Packard spectrum analyser. His specification called for a self-contained and easily portable unit with enough output power to drive a small 50Hz synchronous motor.

The drive had to be capable of working in ambient temperatures from +40°C down to –10°C. It can be cold at 2 a.m. on top of the South Downs. In addition, the motor had to run for at least two hours from a 12V NiCd battery. For longer periods of use, a breakjack was to be included to allow the drive to be powered from the cigar-lighter socket of a car.

The output frequency was to be stabilised to ±10ppm or as near to this as was economically possible. A variable output frequency facility, covering 40 to 60Hz, was also required, as was a clock capable of reading astronomical time, or alternatively, normal time.

Astronomical time and normal time are not the same, as explained in the panel entitled 'About time'. The information in that panel is reproduced courtesy Datum-Austron, whose details are given later.

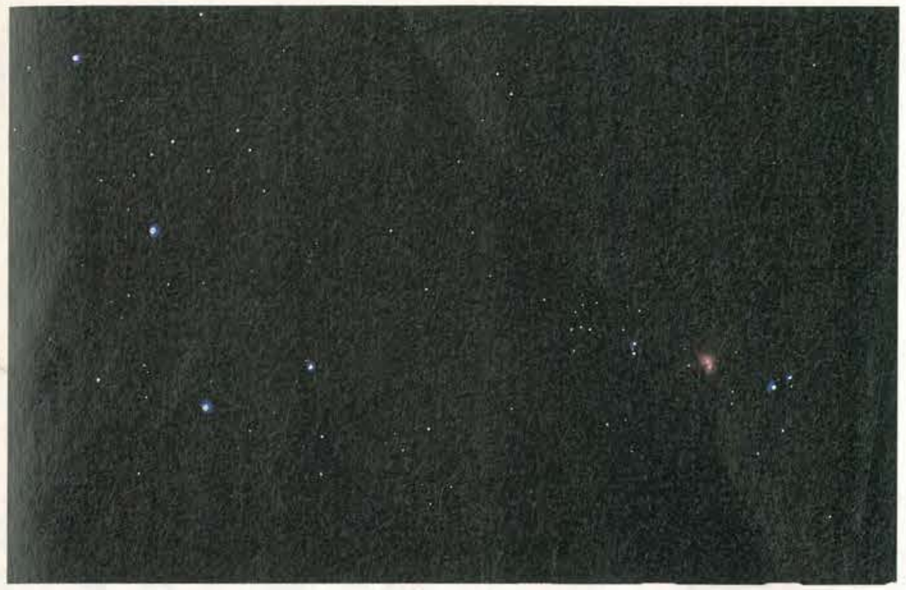
Implementing the drive

The said keen amateur astronomer had a fair-sized telescope, but it was nonetheless readily portable.

He had built himself an equatorial mount for it. Such a mount, set up with its axis at the appropriate angle, i.e. parallel to the Earth's axis of rotation, allows the telescope to follow the passage of the stars as they journey across the night sky.

When observing a particular small area of sky, turning a knob geared to the shaft mount keeps the stars in the same position. Tracking a celestial object in this way is simple enough while you are watching through the telescope, but if the observer is replaced by a camera, the task is more complex.

In contrast with the human eye, a camera has an almost indefinite integrating period. Imagine a steadily illumi-



Typical results

Photo 1 is of the Pleiades or 'Seven Sisters', 300 light years away. Six of these are visible with the naked eye. The photo was taken with a ten-inch reflector telescope, with a five minute exposure, on 400 ASA Ektachrome, home developed. The sidereal drive has completely eliminated blurring due to apparent motion of the subject across the sky. A longer exposure would show the famous nebulous veils surrounding the bright stars. All photos here courtesy Rod Armstrong.

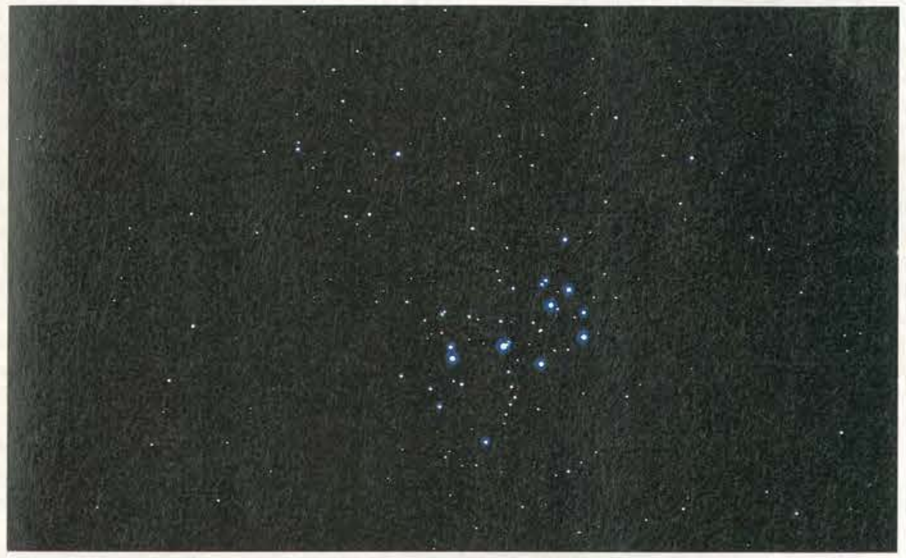


Photo 2 shows the M42 Nebula in Orion. Taken with a 10 inch Newtonian reflector, using a seven minute exposure. Again on home processed Ektachrome, and using the sidereal drive.

Photo 4 is a long-exposure negative of the night sky taken using a fixed camera and is included to illustrate why the sidereal drive is necessary.

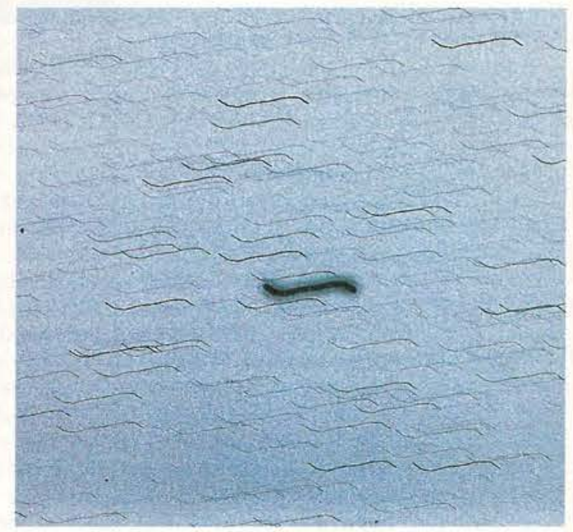
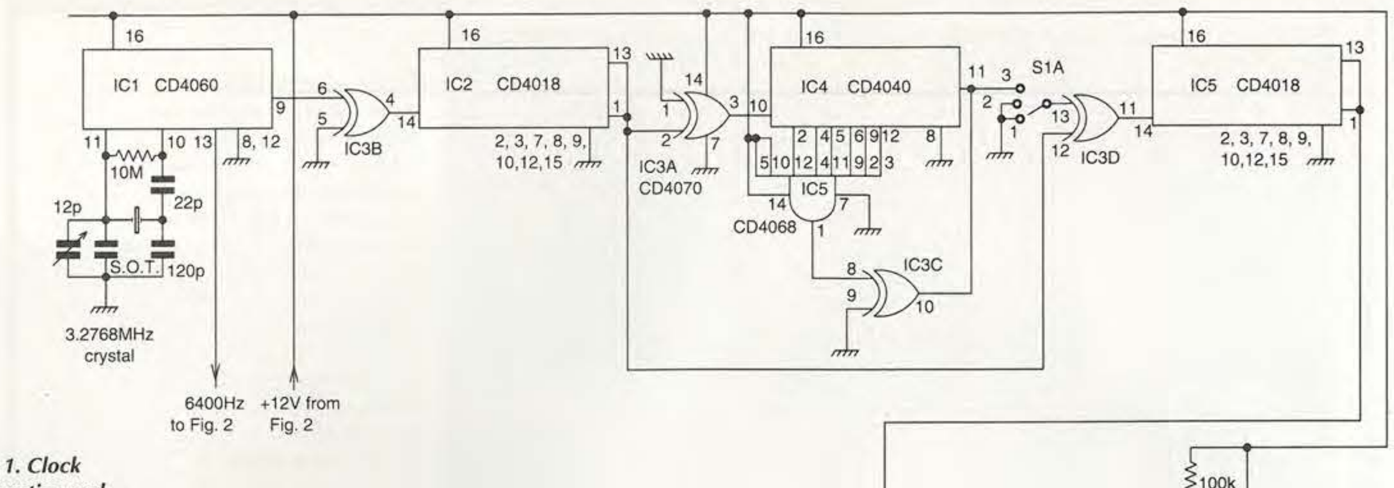


Photo 3 shows the moon. Not perhaps a great test for the accuracy of the quartz driven motor speed, but to obtain crystal sharp images, the moon is a difficult subject. The sidereal drive is necessary to avoid blurring due to movement, even at the comparatively short exposure of 1/8th of a second, on Kodachrome. With this length exposure, great care is needed to avoid blurring caused by vibration due to the firing of the shutter. This shot was taken with a 4 inch GRUBB refractor, the image being magnified with a ×2 photographic multiplier attached to the camera. The effective aperture of around f32 required the longish exposure.



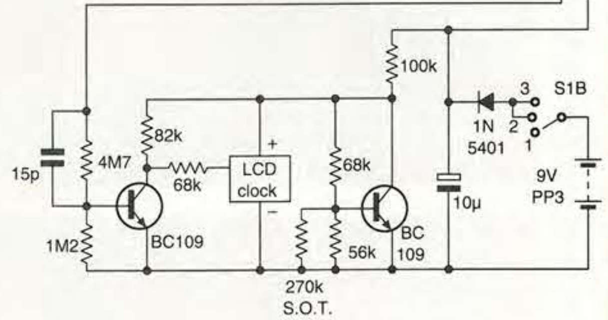


Fig. 1. Clock generation and display circuitry comprising an ordinary digital clock with lcd. The 32kHz crystal is removed from the clock and the crystal's function is replaced by reference pulses derived from the clock generator shown.

nated light at the lower limit of visibility to the dark-adapted eye.

If instead the light is flashed on for a short period, it may in fact be invisible. This is because the human eye is a 'leaky integrator', integrating only over about one to two hundred milliseconds. If you can't see the light after you have been looking at it for that amount of time, you won't see it at all. But a camera does not have this limitation.

With the fastest available film and an exposure time of minutes – or even hours – the amateur astronomer can record stars, nebulae, comets and other astronomical curiosities invisible to the naked eye. Normally, such objects could only be observed directly via the largest telescopes in the world – and perhaps not even then.

A proviso is of course that the telescope can be panned to follow the progress of the stars. To do so, it is only necessary to fit a small synchronous motor to the gearing of the equatorial mount, with the right gear ratio, and hey presto.

For this application, the motor runs at 50Hz, supplied by the NiCd-powered inverter mentioned earlier. There is however just one small complication. The 50 cycles per second must be 50 cycles per *sidereal* second – not per GMT second.

A sidereal day lasts 23 hours 56 minutes and 4.09 seconds, reckoned by GMT, so the required motor drive frequency must run a little fast, at 50×1.00273792Hz. A variable frequency is also handy. This enables the motor to be run faster or slower than the sidereal rate. By altering the speed in this way, a vernier position control is provided enabling the field of view to be accurately centred on the precise area of sky to be studied.

The solution

Figure 1 shows the timekeeping part of the circuitry. With the aid of a 3.2768MHz crystal, IC_1 produces a clock frequency of 2^{16}×50Hz.

Components IC_2 and IC_5, both dividing by ten, tear this down to the 32.768kHz needed for a small clock with digital lcd. At least, they do while S_{1A} is in position 2, which causes the lcd clock to display GMT. Counter IC_4 counts to 365 and then resets itself, cycling round repeatedly.

When S_{1A} is in position 3, an extra clock pulse is fed to IC_5 for every 365 pulses from IC_2. In this way, the clock reads faster than GMT by the ratio 365/366=1.002739726. This is within the specified 1.8 parts per million. In addition, the difference is also small compared with the accuracy that you could expect from the crystal over the operating temperature range.

I mounted the small lcd clock on the front panel of the enclosure. Normally powered by a small watch type button cell, here it is fed with the appropriate supply voltage via a 100kΩ resistor and a BC109.

The clock's original internal 32.768kHz crystal was removed, and external clock pulses gently fed in via another BC109 and a 68kΩ resistor. Switch S_1 provides a choice of GMT or sidereal time. Its third position allows you to turn the unit off, although off does not mean disconnected from the supply. More on this later.

Figure 2 shows the equatorial mount drive part of the circuitry. The divide-by-512 output from IC_1 provides a 6400Hz clock to $IC_{7,8}$. These ICs provide the same 365/366 choice as in Fig. 1.

The GMT or sidereal-time clock frequency is then divided by 128 in IC_{11}, to provide a 50Hz output. Timer IC_{10} provides an alternative frequency range at IC_{11}. This is adjustable between 40 and 60Hz.

Gate IC_{7B} provides the alternative phase. The Phase A and Phase B signals drive a simple inverter involving a standard mains transformer working in reverse.

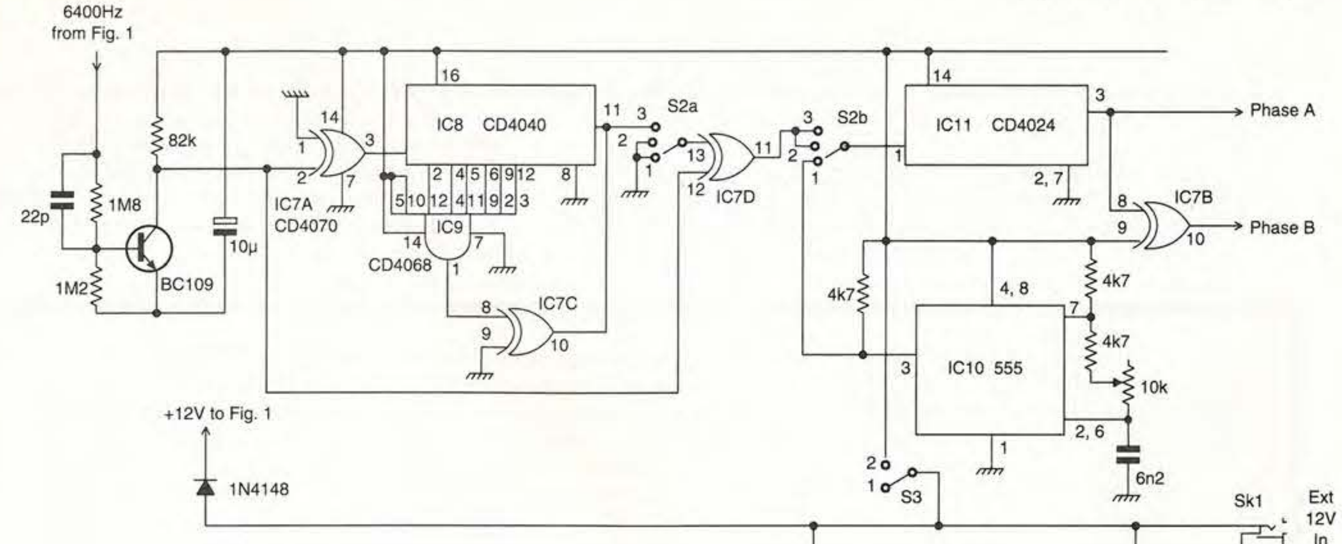
The low voltage windings are 15V nominal, corresponding to 21.2V peak, and the average value of a 21.2V peak sinewave is 13.5V, the form factor of a sinewave being 1.11.

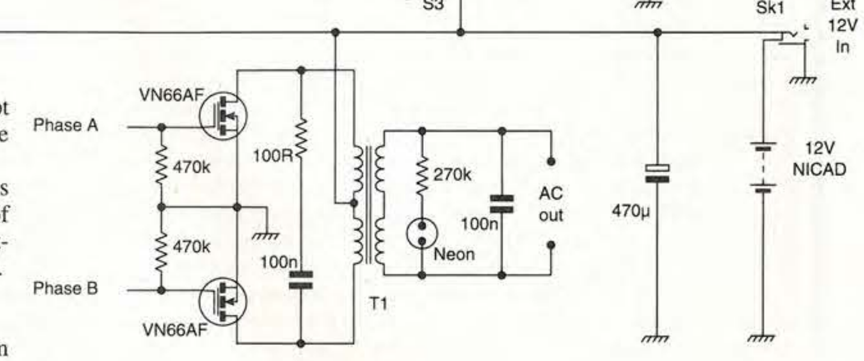
With this arrangement, the 12V squarewave applied by the fets is well clear of exceeding the allowable volt-second product, avoiding any possibility of core saturation. The resulting 240V output at nominal 50Hz was a little on the low side. But the synchronous motor ran perfectly happily, easily coping with turning the mount in view of the mechanical advantage provided by enormous gear ratio. After all, at one revolution per day, the speed of the output shaft is only 0.000696347rev/min!

When S_3 is on, the 12V NiCd battery pack powers the inverter. With it in the 'off' position, in the absence of base drive waveforms to the fets, the inverter is effectively off, although it is still connected to the supply.

Either way, the NiCd battery pack keeps the clock running continuously, via the *1N4148* diode. The clock will register GMT or sidereal time according to the setting of S_{1A}. Provided that S_1 is not in position 1, the 9V PP3 battery will keep the clock running, even if the NiCd battery should become exhausted or be removed.

The clock and the motor drive can each be set either to GMT or sidereal time, independently of the other. In practice,





there is not much call for GMT on the motor drive, except perhaps to demonstrate – streakily – how it is not appropriate to a long exposure.

A useful refinement is to connect a suitable resistor across the normally closed contacts of SK_1. A voltage in excess of 12V, but within the V_{dd} rating of the cmos, can the be injected via the breakjack, to recharge the NiCd batteries *in situ*.

Using the sidereal drive

For short exposures, say up to 30 seconds using a 35mm camera with 50mm lens, sidereal tracking of the telescope to follow your star is not necessary. For longer exposure times and or longer focal lengths, some form of tracking is necessary, to avoid trailed star images. The sidereal motor drive does the job, provided that the rest of the kit is up to the mark.

In use, the telescope support pillar will typically be driven a metre into the ground, to provide a firm, vibration-free support. The axis must be accurately aligned, for the single axis drive can only follow the object of interest in azimuth, preventing horizontal trailing of the image.

With the telescope aligned parallel to the axis of rotation, it is set to view the pole star in the centre of the field of view. If the axis of the telescope is not accurately aligned, there will still be some trailing of the image on long exposures, but in the vertical direction.

At high magnifications, such as two hundred times and greater, clear images on long exposures will only be obtainable with very high quality mechanics. The final drive to the telescope shaft will typically be a worm and wormwheel, and these are crucial. If not of the best precision, they will impart

Fig. 2. Synchronous motor inverter circuitry for the equatorial drive. The output transformer is a mains isolating transformer used back to front.

About time...

Until fairly recently in man's history, the Sun's position defined the time of day. When the Sun was not visible it was impossible to know exactly what time it was. So man developed clocks to measure out the hours between checks with the sun.

All clocks measure time, but different clocks can have different statuses or importance. For example, a clock can be a primary reference, like the Sun's position. Or it can be a secondary reference, which only interpolates. Such a device provides an approximation of the time between periodic checks with the primary clock or time standard.

Date, duration and synchronisation

The word 'time' can mean either date or time interval – i.e. duration. An example of a date is 15 November 1978, 15h, 35m, 14.2s EST (Eastern Standard Time), where h, m and s denote hours, minutes, and seconds.

An example of a time interval, or duration, is the length of time taken to fly between a certain pair of cities, say 3h, 51m, 2s. This example gives no indication of when the flight occurred, only that it lasted for almost four hours. Note that hours, minutes, and seconds can indicate either time of day or duration.

Synchronisation is the third important time concept. For example, it is not normally crucial for an orchestra to begin its concert at a precise hour of the day. But it is essential that all members of the orchestra begin and stay on the same beat. Many electronic navigation systems, computer networks – and even television receivers – require synchronisation to transmitted signals with an accuracy of a millionth of a second or better.

Time scales

A time scale is a system of assigning dates to events. The Sun's apparent motion in the sky provides one of the most familiar time scales, but it is certainly not the only one.

In order to completely specify a solar date, you must count days – i.e. make a calendar – from some agreed upon beginning. In addition, depending on the accuracy needed, you must measure the fractions of days, commonly in hours, minutes, and seconds. In summary, you must count cycles and fractions of cycles of the Sun's daily apparent motion around the Earth.

Time derived from the Sun's apparent position is called *apparent solar time*. A sundial indicates the fractions of cycles, i.e. time of day, directly. Calendars, like the Gregorian calendar we commonly use, are an aid for counting the days and naming them.

Another system, used by astronomers, is called the Julian day. It numbers the days that have occurred since noon, January 1, 4713 BC. In this system – which is not related to the Julian calendar – noon on a tiny rocking motion to the telescope, in sympathy with each revolution of the worm, blurring the picture.

Talepiece

What happened to that elderly HP spectrum analyser that I received in exchange for this design? Unfortunately, owing to the need for a new backward-wave oscillator, plus a host of other less fundamental faults, it proved beyond economic repair. But as it represented somewhat of a milestone in electronics, being probably the earliest true spectrum analyser and dating form the mid sixties, I was loath to scrap it. In the event, the Science Museum was more than happy to accept it as a donation, where I trust it enjoys a happy and permanent retirement. ■

January 1, 1986 began Julian day 2 446 796. This time scale is useful for calculating the number of days between two events.

Universal time

Since the Earth's orbit around the sun is not a perfect circle, apparent solar time cannot be a uniform time scale. That is, the time interval between successive, apparent, noons changes throughout the year. The length of this solar day is also affected by the inclination of the Earth's spin axis to the plane of the Earth's orbit.

To correct for the non-uniformities, astronomers calculated the effects of the Earth's noncircular orbit and the polar inclination on apparent solar time. Universal Time (UT0) is apparent solar time corrected for these two effects. The correction used to obtain UT0 is called the Equation of Time. It is often engraved on sundials, a correction which adds, or subtracts, up to 15 minutes to – or from – apparent solar time, depending on the season.

Astronomers actually measure Universal Time using the stars rather than the Sun. If you count cycles – and fractions – of a distant star's apparent position, you get a different time scale – sidereal time.

Since the Earth circles the Sun once each year but does not circle the distant star, sidereal time accumulates one more 'day' each year than Universal Time, and our calendar.

The 'clock' for both Universal Time and sidereal time is the spinning Earth; only the counting methods differ. In practice, astronomers observe sidereal time and correct it to get Universal Time.

Time and navigation

Time is essential to navigation. In effect, a navigator, using a sextant, determines local time based on the Sun's apparent position. The difference between the navigator's local time and Universal, or Greenwich, time is equivalent to his longitude, since zero longitude passes through Greenwich, England.

Even though we express longitude in degrees, not hours, minutes, and seconds, the difference in time is proportional to the difference in longitude. Since the earth makes about one revolution relative to the Sun in 24 hours, the translation to degrees is simple: 360°/24 hrs=15°/h.

The navigator's sextant is his means of determining local apparent solar time and the navigator's clock, or chronometer, is his means of determining Universal Time. As a result of using Universal Time for navigation, scientists developed two refinements of UT0, namely UT1 and UT2.

UT1

Scientists discovered many years ago that the Earth is not fixed on its axis. In effect, what one sees is a wandering of the poles relative to the fixed astronomical observatories, which causes UT0 to vary.

The logical response to such a situation is to calculate a correction for polar motion and apply it to UT0. UT1 is the result of this correction. The difference between UT0 and UT1 is quite small; only about ±0.3s.

UT2

As the accuracy and constancy of pendulum and quartz-crystal clocks improved, scientists discovered many years ago that UT1 had periodic fluctuations of unknown origin with periods of one year and one-half year. Since these periodic variations are predictable, astronomers are able to correct UT1 to get a still more uniform time scale, UT2. Again, the corrections are small: about ±0.3s. Thus, there exists a family of universal times based on the Earth's spin and other refinements:

UT0 is apparent solar time corrected for the Earth's noncircular orbit and inclined axis.

UT1 is the true navigator's time scale related to the Earth's actual angular position relative to the sun.

UT2 is a smoothed time scale and does not reflect the real periodic variations in the Earth's angular position. At least in principle, if not in practice, UT2 passed by the navigator's needs. UT2 is not used much any more.

Ephemeris time

Near the end of the 19th century, Simon Newcombe at the US Naval Observatory compiled a set of tables which predicted the future positions of the Sun, Moon, and some planets. He based these predictions on the best data and physical principals available at that time. A table of this sort is called an ephemeris.

Newcombe discovered that the actual positions gradually departed from the predicted positions in a fashion too significant to be explained either by observational errors or approximations in the theory. He noted that if the time were somehow in error, all the tables agreed well with the observations. At this point he correctly determined that in addition to all the variations noted above, there are random fluctuations in the Earth's rotational rate. Later, quartz and atomic clocks confirmed that the variations exist.

The astronomer's natural response to this was, in effect, to use Newcombe's tables for the Sun in reverse to determine time, a time scale called Ephemeris Time, or ET. The Earth's orbital (not rotational) position determine Ephemeris Time, and ET should be more uniform than Universal Time because geometrical changes in the earth's shape do not affect the orbital motion.

Ephemeris Time is not very convenient to use because an accurate determination of it requires literally years of astronomical observations. In the early fifties, more convenient and precise clocks were developed: atomic clocks. The atomic clocks provide the uniformity of ET, but are far more convenient to use.

Atomic time

It was mentioned earlier that counting the number and fractions of cycles of the apparent Sun determines a date on the Universal Time scale. Similarly, counting the number of cycles of an electronic signal whose frequency is controlled by an atomic or molecular resonance determines date on an atomic time scale.

In most atomic clocks, electronic circuits steer a radio frequency into resonance with a specific atomic or molecular transition – i.e. vibration. The resonance is an atomic or molecular property, and its frequency can be relatively insensitive to temperature, magnetic fields, and other experimental conditions. Thus, these resonances form natural standards of frequency.

Atomic clocks are formed by counting the cycles of these atomically or molecularly controlled radio signals.

Today scientists and engineers have perfected clocks based on a resonance in caesium atoms to an accuracy of better than one part in 10^{-13} – one part in 10 trillion. Expressed another way, these clocks keep pace with each other to within two or three millionths of a second over a year's time.

The Earth on the other hand, might randomly accumulate nearly a full second's error during a year. Since there are now literally thousands of atomic clocks in use, and since they all agree well with each other, the variations in the Earth's rotation rate are easily measurable.

International Atomic Time, or TAI, is an atomic time scale maintained by the Bureau International de l'Heure (BIH) in Paris, France. BIH forms TAI from an average of nearly one hundred atomic clocks located in many countries.

The BIH initially synchronised TAI with UT2 at zero hours 1 January, 1958. Since that time TAI and UT2 have accumulated a difference of about 23 seconds (July 1, 1985).

The difference is partly due to variations in the Earth's spin, but mostly to the fact that atomic time was simply defined to run slightly faster than UT2. Even if TAI had been defined to have exactly the same rate as UT2 in the beginning, i.e. 1958, it would soon begin to diverge, because TAI is very constant, while UT2 is always varying with the erratic Earth's rotation.

During the past 27 years, two conflicting demands on standard time have developed. On one hand, science, communications systems and electronic navigation systems have needed and exploited the extreme stabilities offered by atomic clocks. On the other hand, astronomy and celestial navigation still need time related to Earth position, no matter how erratic it might be relative to atomic clocks.

Co-ordinated universal time

To achieve a workable compromise between these two opposing demands, the International Radio Consultative Committee (CCIR) created a compromise time scale called Coordinated Universal Time (UTC), which became effective January 1, 1972.

The rate of UTC is exactly the same as TAI. In fact, the 'ticks' that mark the beginning of each second of TAI and UTC are precisely synchronous. However, the date of any given event on the UTC scale must agree with its date on the UT1 scale – not TAI or UT2 – to within 0.9 seconds.

Offsetting UTC from TAI by a precise, whole number of seconds accomplishes both requirements; as of 1 July, 1985, UTC was 23 seconds behind TAI. However, since the Earth continuously changes its rate of rotation, this 23-second time offset cannot be permanent. In order to keep UTC within 0.9 seconds of UT1, the BIH will occasionally add (or delete) a second to (or from) the UTC scale. Every standard time system in the world follows suit.

The CCIR recommended that these "leap seconds" should occur at the end of December or at the end of June of any year that they are needed. In fact, leap seconds were added at the end of June, 1972 and at the end of every December from 1972 through 1979, and on June 30, 1981. No leap second was added in 1980.

Since the Earth's rotation rate is not perfectly predictable, scientists cannot forecast leap seconds more than a few months in advance.

We will always have to use leap seconds as long as we use UTC and desire to keep our clocks approximately in step with the Sun. Otherwise, our clocks would gradually show the Sun rising later and later until after thousands of years, our clocks would say the Sun was rising at noon.

Local time

In most places, local time differs from UTC by a whole number of hours, depending on the local time zone. For example, you subtract five hours from UTC to get Eastern Standard Time (EST).

In the summer, from 2:00 a.m. on the last Sunday in April until 2:00 a.m. on the last Sunday in October, local time, EST is advanced one hour. Hence, you subtract only four hours from UTC.

Formal definitions of time interval

The Treaty of the Meter, which the US signed in 1875, established an international organisation to oversee and administer the International System of units – i.e. the metric system. This international organisation determines the definitions of the various units of measure, including the unit of time interval, the second.

Prior to 1956, the second was defined to be 1/86 400 of a mean solar day, or 86 400=24x60x60. From 1956 to 1967, the second was defined in terms of Ephemeris Time: 1/31 556925.9747 of the tropical year 1900. In 1967 atomic clocks took over the role of defining time interval. The new definition reads:

"The second is the duration of 9192631770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom." (13th General Conference of Weights and Measures (CGPM) (1967), Resolution 1)

The definition of the International Atomic Time scale (TAI) incorporates the definition of the second. The formal definition of TAI reads:

"International Atomic Time (TAI) is the time reference co-ordinate established by the Bureau International de l'Heure (BIH) on the basis of the readings of atomic clocks operating in accordance with the definition of the second, the time unit of the International System of Units." (14th CGPM) (1971), Resolution 1)

Accurate time: a summary

It was mentioned earlier that local time typically differs from UTC by an integral number of hours, and UTC differs from TAI by an integral number of seconds. Since standard time broadcasts all use UTC by international agreement, almost the whole world runs on UTC.

In many countries the legal basis of 'standard time' is UTC. Thus, from a legal point of view, accurate time must mean UTC, adjusted by the appropriate number of hours to give local time.

To a navigator on the oceans however, accurate time really means UT1. UTC may be close enough – give or take 0.9 seconds – for many navigators but, strictly speaking, navigators need UT1. To a scientist who doesn't want to be bothered with leap seconds, accurate time means TAI.

So, in a very real sense, accurate time has different meanings to different people. The idea of accuracy relates to the use made of the time information.

Fortunately, most of us do not need to bother with all these different time scales, since the time we get from the telephone, radio, or television is adequate. If we trace the telephone, radio, or television time back to its source, however, we would actually find that UTC is the master clock in our lives.

More time

The information on time scales in this article is reproduced from the Austron Timing Reference Handbook, by kind permission of Datum-Austron. Contact information: e-mail telecomsales@datum.com. Web address: www.datum.com, tel. 512 721 4038. In UK, contact Sematron UK Limited, Sandpiper House, Aviary Court, Wade Road, Basingstoke, RG24 8GX, Tel. 01256 812222 or Fax 01256 812666. Web address: www.sematron.com.

Sparks may fly

Irving Gottlieb asks could continuous exposure to electrostatic discharge be affecting our health?

At one time, the marginally-safe level of soft-X-ray radiation from tube-type television receivers was a matter of concern. Not only the picture-tube emitted this form of ionising radiated. The rectifier, damper and regulator tubes gave off X-rays too. In modern solid-state sets, the problem has been largely alleviated; besides, a more-respectable viewing distance is now dictated by the larger display-screens.

But we may be overlooking an elusive, yet possibly health-affecting source of ionising radiation that has always been with us. A useful aspect of the ensuing speculation is that you can make a reasonable appraisal of its merit without having a degree in the life-sciences.

Having had a long-time interest in radiation, I sensed particular relevance in Darren Heywood's article in the May 1998 edition. His allusion to ultra-violet radiation "and perhaps X-rays" resonated my own thought-patterns and experiments.

High-voltage spark discharges can give rise to an extremely wide band of electromagnetic radiation encompassing audio, rf, microwave infra-red and visible-light frequencies.

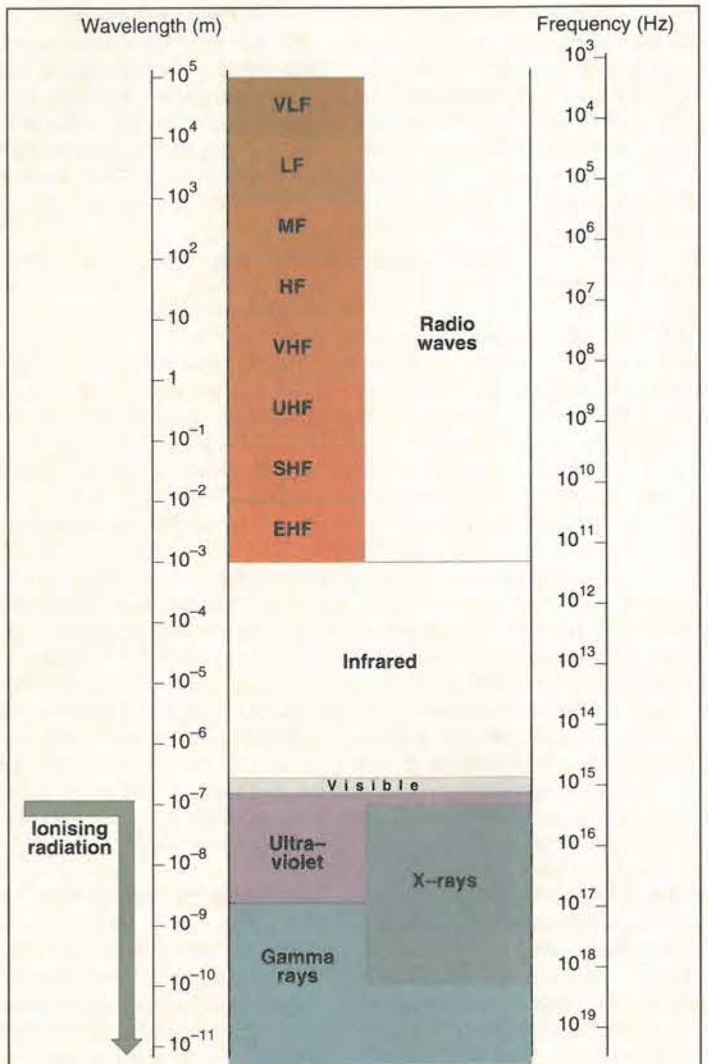
Any ionising radiation in the ultra-violet and soft X-ray portion of the spectrum could logically be anticipated to be negligibly small. It is here that we come to the gist of this article – is 'negligibly small' always negligible?

Imagine a camera with a 'negligibly-small' light leak. We know that in due time, the film will be thoroughly fogged, as if subjected to a single intense burst of light. It may also be that a cumulative effect of long-time bodily exposure to weak ionising radiation could be damage to cell tissue.

The high-voltages required to cause such sparkovers can stem from electrostatically charged dielectric surfaces. Mixing the wrong combinations of clothing textiles, wool and linen for example, causes sparkovers. Synthetic textiles make particularly good generators.

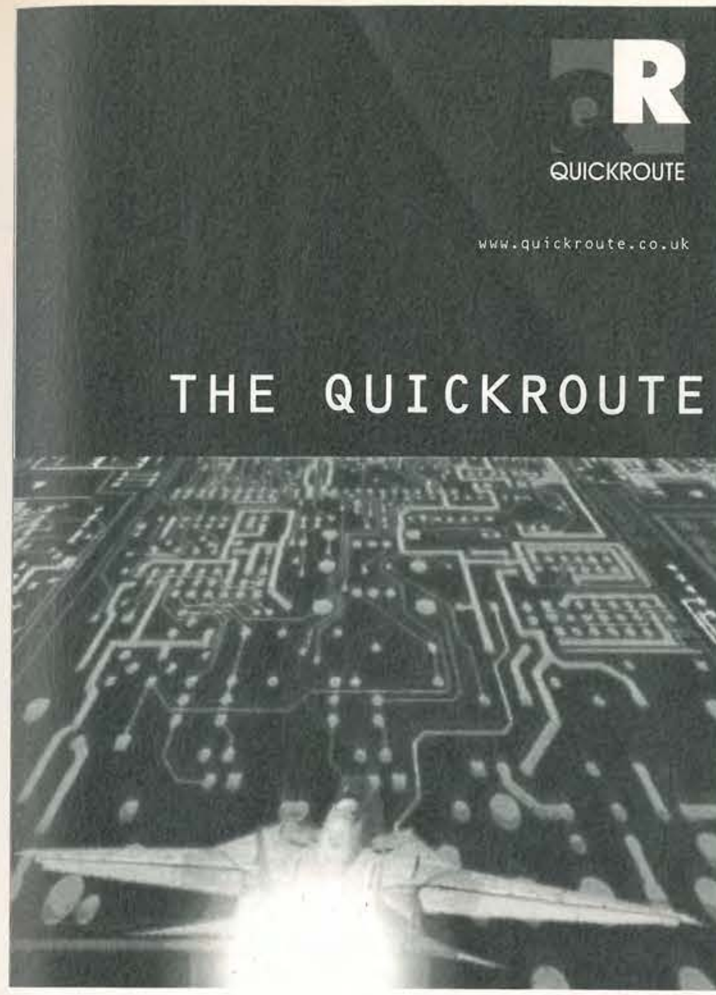
One can envisage weather conditions favourable to round-the-clock discharge of static-electricity. Despite the low energy-level and dose-rate of the accompanying ionising radiation, the intimate proximity of the spark-overs to the skin may be significant. Is it mere coincidence that the relatively small radius of the female breast favours concentration of charge-density?

Not long ago, it was considered that there was a threshold of radiation below which the risk of any adverse health effects were negligible. Today, the prevailing thought is that it is best to avoid exposure altogether, if it is possible and practicable. ■



Salient features of this significant portion of the electromagnetic spectrum are:

- *The visible spectrum is relatively narrow*
- *Ionising radiation commences with long-wave ultra-violet at around 10^{-7}m. Any longer wavelength cannot ionise water molecules or bodily tissue.*
- *Short ultra-violet radiation and 'soft' X-rays merge. They both exhibit penetrating and ionising characteristics.*
- *Similar overlapping occurs with X and gamma rays.*



Measuring Yagis

Paolo Antoniazzi and Marco Arecco have devised a simple yet accurate method of measuring the gain of Yagi antennas for the 2m band.

Measuring a Yagi is much more difficult than simulating one. Henry Jasik[1] once said, "The measurement of total gain of antennas is probably the most difficult measurement of antenna technology..."

For decades the Yagi antenna has been the first choice for television reception and amateur radio applications. But the most important properties – gain, efficiency and radiation pattern – could be evaluated only by difficult and time consuming measurements. The accuracy of these measurements was poor too.

During the seventies, large simulation programs for antennas were developed on mainframe computers for research purposes. These simulators were eventually modified for use on microcomputers.[2]

Today, good programs such as *NEC-Win Pro* for Windows NT/98, are available for all serious experimenters. The simulations they produce are often more accurate than the results obtained from making field measurements.[3] **Figure 1** shows a current-density optimised plot of an eight-element Yagi simulated using *NEC Win Pro*.

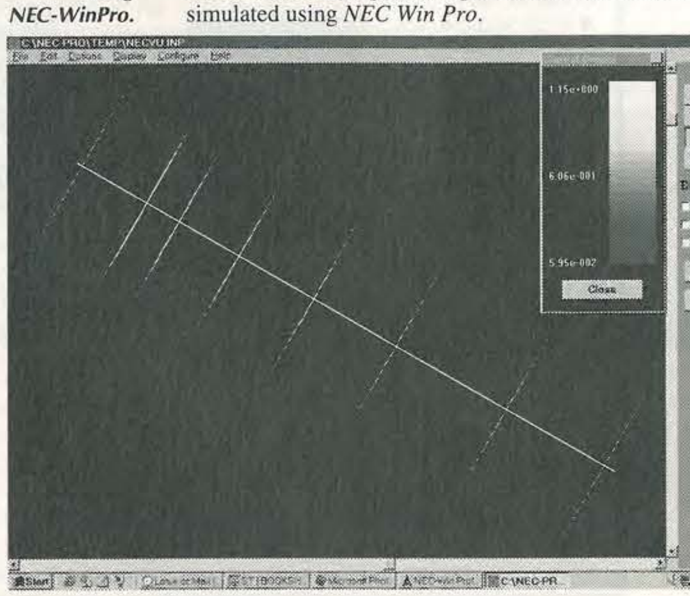


Fig. 1. Current-density optimised eight-element vhf Yagi, simulated using NEC-WinPro.

Measuring antenna gain

Many people have attempted to measure Yagi antennas. For all of them, the biggest problem during tests on field strength has been that of interaction between direct and reflected wave.[4,5,6]

Due to this interaction phenomenon, the level of the signal received by the horizontal Yagi antenna at the receiving site changes when the height of the antenna is altered.

By linearly varying the height of the antenna under test by about 3m, which is slightly more than one wavelength at 144.5MHz, it is easy to see where the minimum received signal occurs, i.e. when the reflected signal at the antenna is in antiphase with the direct signal. If the reflection is almost total, the notch depth can exceed 20dB.

In the case of the maximum reflected signal being in phase with the direct signal, the sum could be as much as, but not exceed, +6dB. Of course, all intermediate values are possible. But when the ratio between the direct and reflected waves exceeds 24dB, the curves in figure 1 have converged to a maximum error of ±0.5dB.

Figure 2 thus shows the maximum error that can occur when positioning the antenna at any given height. Note that it is not easy to reduce the reflected wave significantly. But by measuring and plotting the received signal at various heights, it is possible to determine exactly the direct/reflected signal ratio and, therefore, the value of the direct signal itself.

By comparison with the results for a reference antenna, more accurate results can be derived. These, together with information from the horizontal radiation pattern, permit a more accurate estimation of the true value of the gain of the antenna under test. Note that since the vertical radiation patterns of both the transmit antenna and the antenna under test affect the value of the received wave, it is important to compare both plots of the received signal versus height, and no just the two apparent gains.

One of the most important sources of information is that produced by Kraus.[7] His work shows that the reflected-wave problem can be reduced by making measurements using buildings of 5-10 storeys high, **Fig. 3**.

To obtain a 25-30° angle for the reflected wave over a useful distance of about 100m, two buildings between 30 and 50m high are needed. As you we will see later, the 100m distance necessary for long-Yagis.

We carried out such testing using a 16-element high-gain Yagi. We placed the transmitting antenna on the roof of a 14m high house and orientated it towards a park with no obstacle around, **Fig. 4**. This diagram allows you to calculate the effective radiation angles and the path of direct and reflected signal for the 6dBd reference yagi and for the eight-element antenna under test. The test antenna was 3.2m long and had a simulated gain of about 10.6dBd.

Analysing the theory

The following considerations assume a horizontally polarised wave since horizontal polarisation is most widely used in both television broadcasting, ssb, cw and tropospheric links at 300-1000km.

As is well known, the electrical field received from the antenna is given by the vectorial sum of direct and reflected wave.

The electrical field equation is,[5]

$$E = E_d\sqrt{1 + k^2 + 2k\cos\left(\frac{2\pi\delta}{\lambda} + \pi\right)}$$

where,

E is intensity of the resulting field in V/m,
E_d is field intensity of the direct wave in V/m, k, which is less than unity, is the ratio between reflected and direct electrical field,
π is 180° rotation of the reflected wave relative to the direct one (horizontal polarisation)
δ is the difference of path in metres between direct and reflected wave ($\sim 2h_t h_r/d$)
λ is wavelength in metres.

There is an accurate expression for calculating the difference in distance between direct and reflected wave, δ. This expression was the starting point for a simplified formula that can be used when $(h_t+h_r)^2/d^2$ and $(h_t-h_r)^2/d^2$ are both much less than one,

$$\delta = \sqrt{(h_t + h_r)^2 + d} - \sqrt{(h_t - h_r)^2 + d}$$

Here, h_t is the height of transmitting antenna, h_r is the height of receiving antenna and d is the distance between the foot of the two antennas. All three distances are in metres.

We used this expression for our analyses. Thanks to personal computers, it can be applied for very complicated designs. We estimated that the simplified formula results in an error of about 7%.

To reduce measurement errors, the distance between transmitting and receiving antennas has to be considered. To determine this distance, you need to be able to measure the signal level easily with a filtered rf voltmeter having a 30-40dB dynamic range. Also, the wave reaching the receiving antenna should be as planar as possible.

The first condition can be easy established starting with the received power and calculating the attenuation experienced by the wave in the open space,

$$\alpha = 32.4 + 20\log(f) + 20\log(d) - G_t - G_r$$

Here, α is attenuation in decibels, f is frequency in megahertz, d is distance in km, G_t is the gain of transmitting antenna in dBi and G_r is the gain of receiving antenna, also in dBi, obtained by simulation.

There is also a simple, easy to remember method of calculating the attenuation by considering the distance between the two antennas in terms of wavelengths.

When $d=\lambda$, α is always 22dB between isotropic antennas. This equates to 2.08m at 144MHz. The attenuation increases by 6dB for each doubling of the path distance. This means that the free space attenuation is 22dB at 2m, 28dB at 4m, 34dB at 8m, etc.

To make the wave reaching the receiving antenna as planar as possible, the capture area in square metres of the receiving antenna and the maximum acceptable phase error are needed,

$$A_c = G_r\frac{\lambda^2}{4\pi}$$

This expression is valid for an antenna with no thermal losses and was certainly useful for our experiments.

Assuming that the capture area is circular, the minimum distance in meters between the two antennas will be,

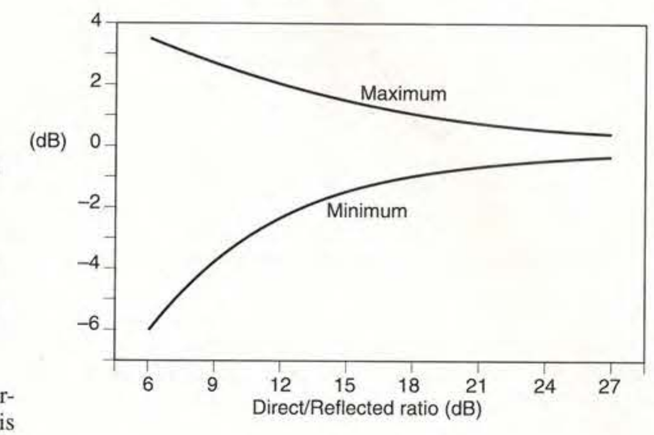


Fig. 2. Absolute maximum test error versus direct/reflected signal ratio. This is the maximum possible gain measurement error when moving the antenna up and down the mast. As you can see, the error in decibels can be positive or negative, depending on the relative phase of the two signals.

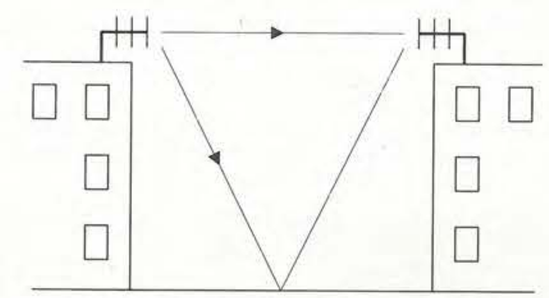


Fig. 3. Kraus suggests that Yagi tests should be carried out using two reasonably high buildings to reduce reflection errors.

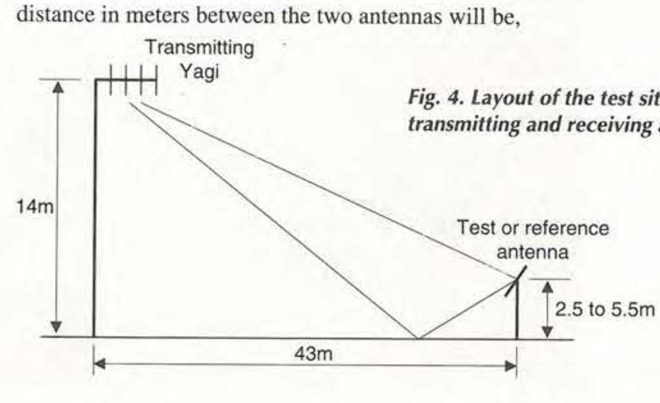


Fig. 4. Layout of the test site with transmitting and receiving antennas.

$$d > nG_r \frac{\lambda}{\pi^2}$$

For a maximum phase difference of 22.5°, which is usually enough, n=2. If a phase error of only 5° is required, n=9. In the case of Yagi antennas, where one dimension prevails over the other ones, the maximum length, instead of the capture diameter, is used. In this case, the minimum distance in metres becomes,[4,8,9]

$$d > n \frac{L}{\lambda^2}$$

where L is the maximum Yagi length in metres.

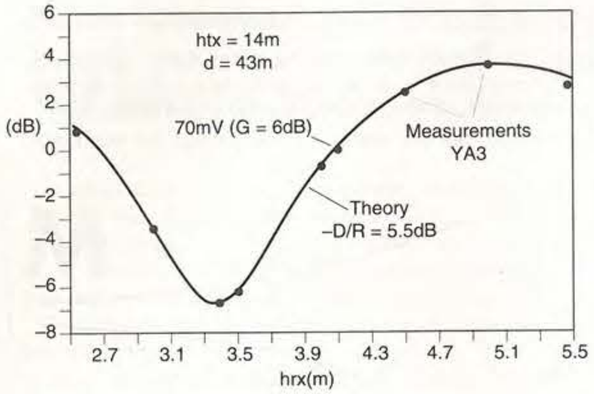


Fig. 5. Calculated and measured values of signal level versus antenna height and direct-to-reflected signal ratio. These values are for the three-element reference Yagi at 144.5MHz.

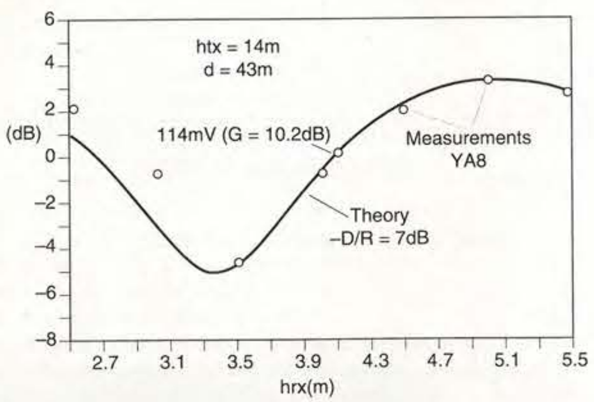


Fig. 6. Performance of the eight-element Yagi at 144.5MHz. As with the previous graph, these are calculated and measured values of signal level versus antenna height and direct-to-reflected signal ratio.

Siting and antenna height

The minimum height from ground of the antenna under test is another parameter to be controlled during the measurements. This is because the proximity of ground can modify the radiation resistance.

In our case, the minimum height is h_r is more than λ, but the relevant points of the curve have been measured at 2λ and above. Note that the simulation software that we used used (NEC-WinPro) does not take into account the ground plane. Also, the typical parameters of the antenna – gain, radiation angles, impedance – are calculated in the free space.

To define the correct receiving height, it must be considered that the electrical field, and hence the voltage measured by the millivoltmeter – have maximum and minimum values due to the different path of direct and reflected wave, sum or difference.

To be confident about the measurements, it is necessary to find at least a maximum and the nearest minimum using the first two formulas. This was done allow us to draw the curves of **Figs 5, 6**.

A suggestion from an article that appeared in *VHF Communication*[10] convinced us to incline the antenna to be measured with respect to ground. This allowed us to have the maximum signal for the direct wave and the maximum attenuation for the reflected one, exploiting the shape of Yagi radiation diagram. In particular, the approximate 40° angle of reflected wave relative to the receiving antenna attenuates it by around 2 to 4dB.

We decided not to incline the transmitting antenna to improve the ratio between reflected and direct wave. Instead, we exploited the directivity of the antenna. The advantage is about 5dB as the reflected wave is about 23° under the plane of maximum radiation and 13° under the direct wave path.

Another way to reduce the reflected wave, which we did not try, is to place a metal screen near the reflection point. This plate needs to have significant dimensions with respect to the wavelength: 2 by 4m for instance.

According to previous considerations and the availability of a suitable area for field testing, the conditions of the measurement site are defined as follows:

Transmitting Yagi, – 16 elements, G=13dBi, h_t=14m with the boom parallel to the earth plane.

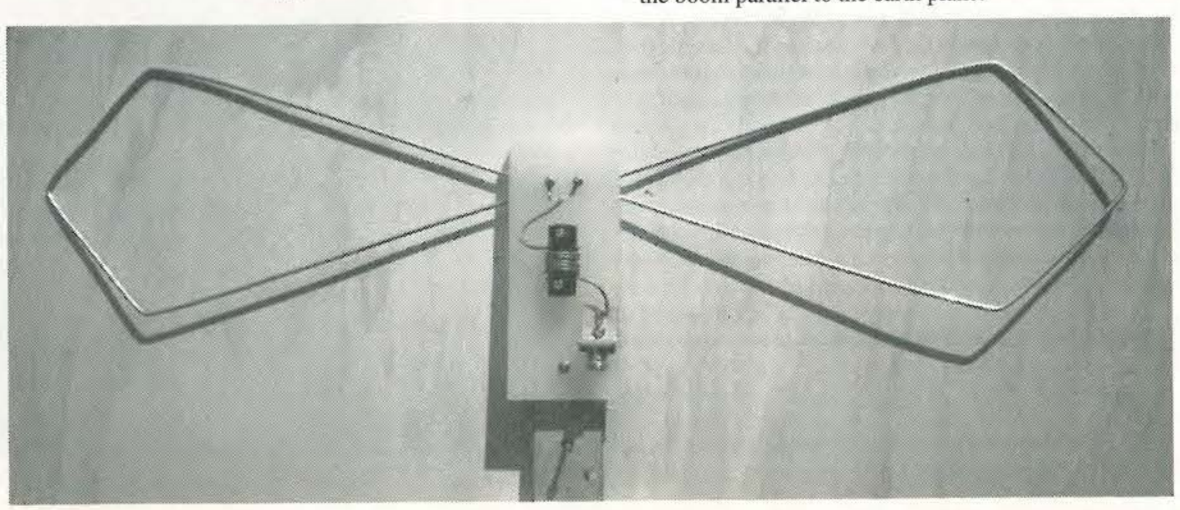


Fig. 7. Rhombic reference dipole realised for comparison tests.

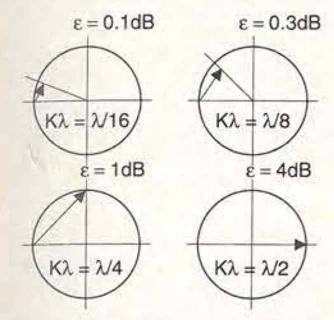


Fig. 8. Planar wave concept and phase error.

Reference antenna – home-made three-element Yagi, G=6dBd, calibrated by the reference dipole described next and shown in **Fig. 7**, h_r=2.5 to 5.5m. Minimum received signal was at 3.4m and maximum at 5.1m. The boom had a 13° angle with respect to the ground plane.

Antenna under test – this was a 3.2m long (1.8λ) eight-element home-made Yagi.

The site we selected is useful for measurements of antennas up to 6m long. This equates to about 3λ at 144.5MHz).

For accurate antenna gain measurements, the distance between the transmitting and receiving (test) antennas should be greater than that needed to satisfy the far-field conditions for d>5λ and greater than the approximate uniform plane wave.

So if you want to measure a 10m long Yagi, it is necessary to increase the distance using,

$$d > n \frac{L}{\lambda^2}$$

to maintain the error due to a non-uniform plane wave within a fraction of decibel, **Fig. 8**.

To detect the received signal at the receiving antenna we used a Boonton *92B* millivoltmeter. This meter is well suited for these applications but it is possible to make your own instruments with good sensitivity and accuracy. The signal under test ranged from 143 to 146MHz and was swept by means of a small remote control.

To conclude, Figs 5 and 6 show the obtained values superimposed with the curves calculated with the first two formulas, normalised to the direct wave and given in decibels.

The difference in signal between the 6dBd reference Yagi YA3 and YA8 at the null point – i.e. with no reflected wave – is 4.2dB. This allowed us to conclude, after a critical analysis, that the gain of the 1.8λ long eight-element Yagi is 10.2dB.

The analysis considered the optimum matching between measured and simulated radiation diagram was ±20° at –3dB. The maximum test error is probably around 0.5dB.

The measured value of front-to-back ratio at 180° is 21.5dB.

Error sources

Most errors that occur during antenna measurements are related to the reflected wave. The total error can vary from a maximum of +6dB, when the direct wave is summed to the

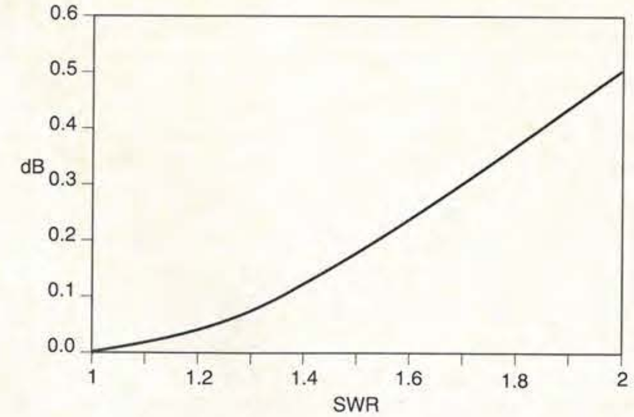


Fig. 9. Maximum error versus standing-wave ratio of the antenna under test.

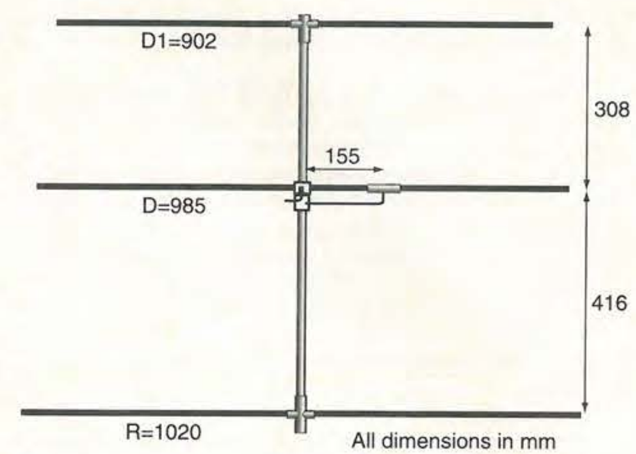


Fig. 10. Three-element reference Yagi dimensions.

reflected one, to –20dB or less when the two components of received signal are subtracted each other according to the first mathematic relation we presented.

Broadcast fm signals received by the antenna under test can affect the measured voltage significantly. To minimise this problem, we performed the measurements as near to the antenna as possible. How close the measurements can be made depends on the antenna dimensions and the planar wave effect must be catered for. We incorporated a good helical filter for 144.5MHz, ±5MHz to reduce interference and obtained a useful received signal of about 100mV.

Another source of error is related to the antenna impedance mismatch, relative to 50Ω. The mathematical relationship that describes the signal loss on the receiving antenna output or on the load is given by the following equation when the antenna impedance is greater than 50Ω,

$$\frac{V_a}{V_o}(\text{dB}) = 20\log\left[2\frac{1}{1+SWR}\sqrt{\frac{Z_a}{Z_o}}\right]$$

Here,

V_a is antenna voltage in volts when Z_a≥50Ω
V_o is antenna voltage when Z_a=50Ω
SWR is standing wave ratio
Z_a is antenna radiation impedance
Z_o is load impedance (50Ω)

When $Z_a>Z_o$, $SWR=Z_a/Z_o$. For an antenna impedance of less than 50Ω, the equation becomes,

$$\frac{V_a}{V_o}(\text{dB}) = 20\log\left[2\frac{SWR}{1+SWR}\sqrt{\frac{Z_a}{Z_o}}\right]$$

Here, $SWR=Z_o/Z_a$ when $Z_o>Z_a$. The behaviour of the maximum error versus receiving antenna standing-wave ratio is shown in **Fig. 9**.

A load impedance different from 50Ω can also introduce a measurement error which is minimised using a 10dB fixed attenuator connected directly to the antenna output. In our practical case, load standing-wave ratio was better than 1.05 with a tiny error of less than 0.03 dB.

A 10MHz-wide band-pass filter is normally included to screen out possible out-of-band strong signals mainly from fm broadcasting stations.

Reference antenna

The reference antenna is a log-periodic wide-band type that is frequently used in this type of application. Its approximate bandwidth can be calculated by using the lengths of shorter and longer elements. Bandwidth is about half of the maximum and the minimum wavelength at which the antenna can be used.

When working at a single frequency, only part of the whole antenna is active: the elements have a physical dimension nearest to one half of the wavelength. It is important to remember that input impedance and radiation properties of this antenna are repeated periodically with the logarithm of the frequency.

Commercial log-periodic antennas often used in electro-magnetic-compatibility measurements are manufactured by companies including Hewlett Packard and Emco and are available with calibration graphs. The *HP11966D* for example covers the range 300-1000MHz and costs around £1500 pounds.

Considering the narrow band involved in our measurements, and the consequent small variation of standing wave ratio versus frequency we decided to build-in a reference Yagi with similar behaviour and accuracy as the log-periodic.

We calibrated our Yagi with reference to a half-wave dipole, the performance of which is well documented.[9] Assuming no losses, the features of a half-wave dipole are,

Horizontal half-power beamwidth	78.1°
Directivity	2.14dBi
Receiving area	0.131λ
Effective length	0.318λ.

The main characteristic needed for our reference dipole is a standing-wave ratio lower than 1.2 with a negligible error of ±0.05dB. As a result, we made our dipole rhombic in shape. Its length is 798mm, its width is 180mm and it is made from 4mm diameter aluminium wire.

It is necessary to 'balance' the antenna using a choke comprising six turns of teflon-coated cable on a 20mm diameter insulated support. Due to the addition of this cable, 0.2dB must be subtracted from the gain of the dipole, making it –0.2dBd instead of the 0dBd theoretical value.

We do not advise the use a dipole for repeated tests since it is omnidirectional. It also has a significant gain in the fm broadcast range, which contains strong unwanted signals.

A dipoles[11] can be useful as a reference, but it does not have the flexibility and measurement reliability of a Yagi with more than 25dB of front-to-back ratio.

At the beginning we though of a two element Yagi, i.e. a dipole plus reflector, but its front-to-back ratio was not high enough for our needs. Also, to optimise standing-wave ratio, we would have had to work with many different values of gain.

After may hours of simulation with NEC-Win Pro 1.1[3] and some field measurements, our choice was a three-element Yagi built with 10mm diameter rod. It had a gamma matcher made from copper and teflon.[10] Its gain was 6dBd and it had a high front-to-back ratio.

The passive elements have insulated supports 30mm high, while the dipole has an aluminium support, connected electrically with the boom via a type-N connector.

The final reference antenna, **Fig. 10**, is easy to make and repeatable. When made precisely to the drawing and well trimmed for standing-wave ratio, it meets the design requirements of 6dBd gain at 144.5MHz.

In summary

There are many potential sources of error when performing Yagi gain measurements and there has been a great deal of optimism when analysing them.

If you consider that a typical site for professional measurements described in reference 12 certifies the gains of the antennas under test within ±2dB between 30 and 1000MHz, you can better understand the difficulties that arise.

We have examined the subject of dipole calibration and presented a three-element reference yagi for easy comparison tests at very high frequencies.

We believe that by averaging repeated measurements, it is possible to obtain results with maximum error of around ±0.5 dB. ■

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Further reading

Brown, F, W6HPH, 'Antenna Gain Measurements,' *QST*, Nov. and Dec. 1982.

* **Reference Data for Engineers** is now published by Newnes and available via *Electronics World's* editorial offices. E-mail jackie.lowe@rbi.co.uk or fax 0181 652 8111 for details.

CIRCUIT IDEAS

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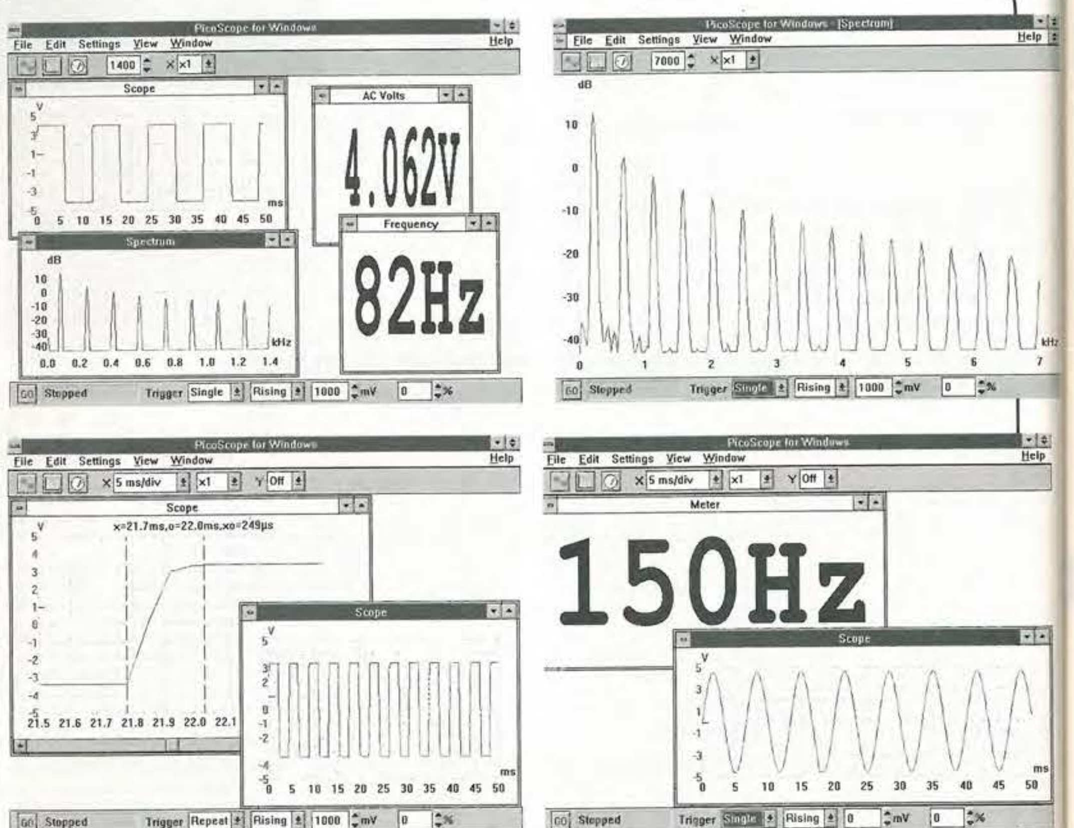

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Monitoring two temperatures

A *PIC16C72* controls the unit, being chosen for its 8-bit a-to-d converter to give the 1°C resolution wanted and because it will drive the four-digit display and the a-to-d conversion simultaneously.

All the PIC's B port is taken up with drive for the *4511* decoder/driver and the four cathode resistors, port A accepting analogue input from the sensors and 2.55V reference. The 2.55V would give 255 10mV steps, but only 100 of them are used to give 1°C steps from 10mV to 990mV.

Temperature sensing is carried out by the two *LM35Zs*, which give an output of 10mV/°C, taken to the PIC analogue input. If this input exceeds 990mV, a subroutine detects the fact and blinks the display with a reading of 99.

To ensure PIC reset, I used the *HT7044A* 4.4V detector, the output of which zero if its input is less than that level.

Jose Luis Cavasassi
Buenos Aires
Argentina
B93

Object code in hexadecimal form.

```
:040000008316FF293B
:080008008207633462346134A5
:1000100060345F345E345D345C345B345A3459345C
:100020005834573456345534543453345234513448C
:10003000503444F344E344D344C344B344A344934BC
:1000400048344734463445344434433442344134EC
:10005000403443F343E343D343C343B343A3439341C
:1000600038343734363435343434333432343134 4C
:100070003034 2F342E342D342C342B342A3429347C
:1000800028342734263425342434233422342134AC
:10009000203441F341E341D341C341B341A341934DC
:1000A000183417341634153414341334123411340C
:1000B00010340F340E340D340C340B340A3409343C
:1000C000083407340634053404340334023401346C
:0400D000000340034C4
:0203FE000030CD
:1004000086001F308500C03062000814881083 12F7
:100410008501A00186019B01633099000F2A80307D
:10042000880008148810201000000000815881C9F
:10043000172A09081902031C202AA0139800B72ABA
:100440000003098 00A017B72A18088D00883088005F
:100450000814881020140000000000000815881CF3
:100460002F2A09081902031C382A20139800B72ADA
:10047000003098002017B72A18088E000D08812236
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:100540000000940B9E2A930B9C2A0034FF309200EB
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:1005600000000000910BA82A920BAA2A0034180858
:0A0570000420980 0201C242A3C2AD5
:00000001FF
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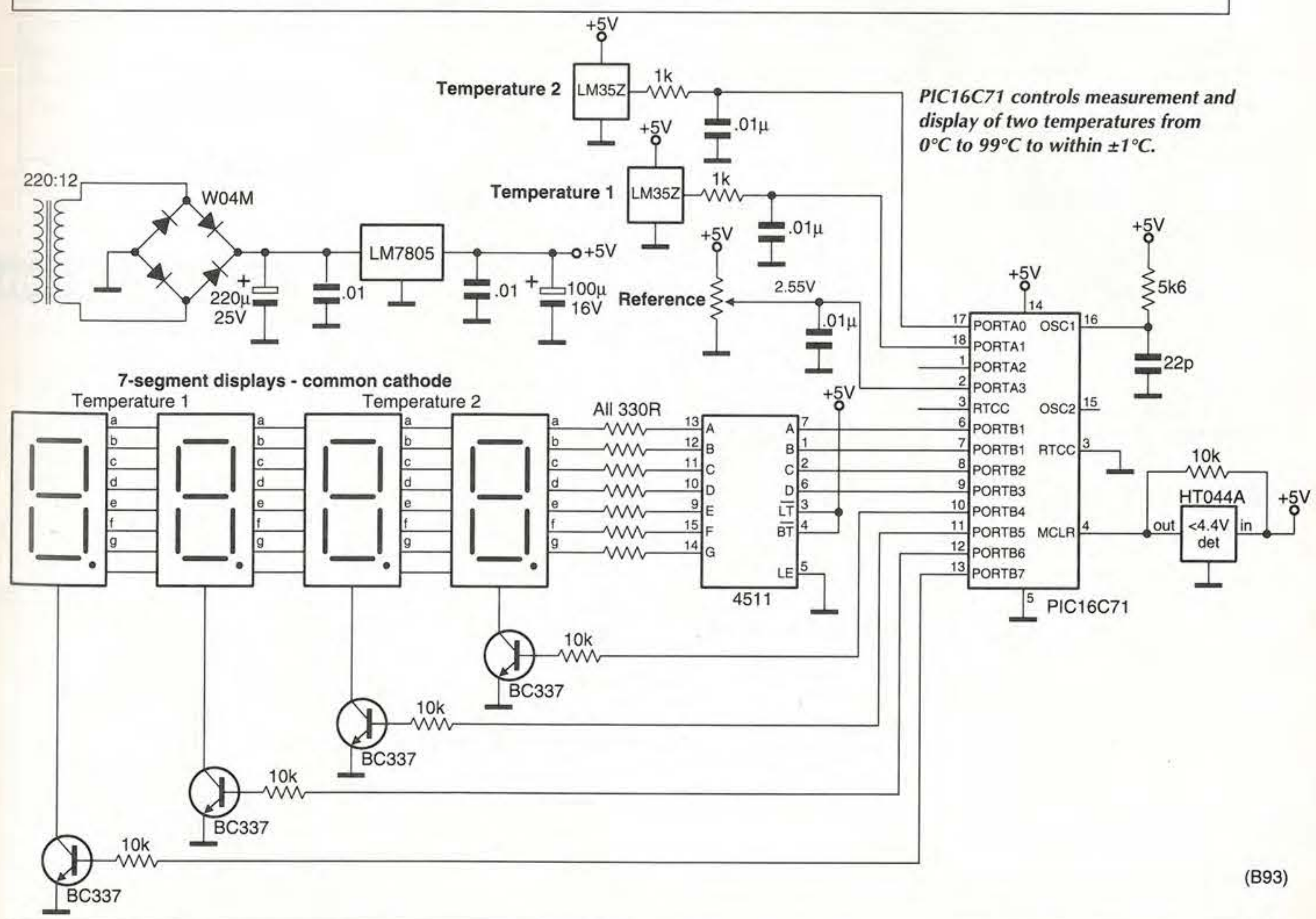
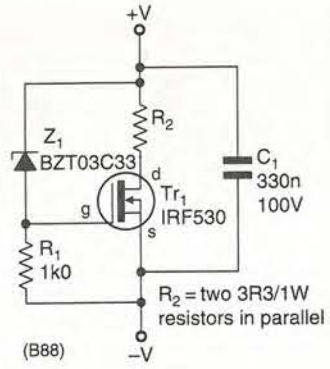


PIC16C71 controls measurement and display of two temperatures from 0°C to 99°C to within ±1°C.

Super zener voltage clamp

To absorb more pulse energy than a zener diode or transient voltage suppressor alone is able to, a mosfet and resistor across the zener "amplifies" the zener's power rating. A 33V zener (more of an avalanche diode at this voltage) turns the mosfet on, R_2 dissipating most of the power and ensuring that the mosfet is safe. Current pulses of 20-25A at 10kHz were clamped at 41-45V; at lower currents, the mosfet does not saturate and the clamp voltage barely rises over 39V. Before the mosfet turns on, there is an initial transient of about 100ns, which may be absorbed by the addition of C_1 and, if the duty cycle is likely to be more than 0.2%, both mosfet and R_2 may well need heatsinks.

CJD Catto
Cambridge
B88



Extending the pulse-clamping capabilities of a zener with a mosfet and resistor.

Variable-gain, differential instrumentation amplifier

Unlike many such circuits, this one has differential input and output, which reduces noise caused by large ground currents.

Voltage drop across R_1 is amplified by A_1, which controls the $Tr_{5,6}$ pair, driving them to the state in which the collector currents of $Tr_{3,4}$ are equal. This feedback greatly reduces the effect of the non-linear base voltage/collector current characteristic of the transistors. Op-amp A_1 also drives Tr_7 to produce a current signal proportional to input voltage, after which A_2 provides a voltage output.

Circuit gain is,

$$A_v = (I_{s2} / I_{s1})\,(R_2 + R_3) / R_1.$$

If $R_2=R_3$, this is equal to $2R_2 I_{s2}/R_1 I_{s1}$.

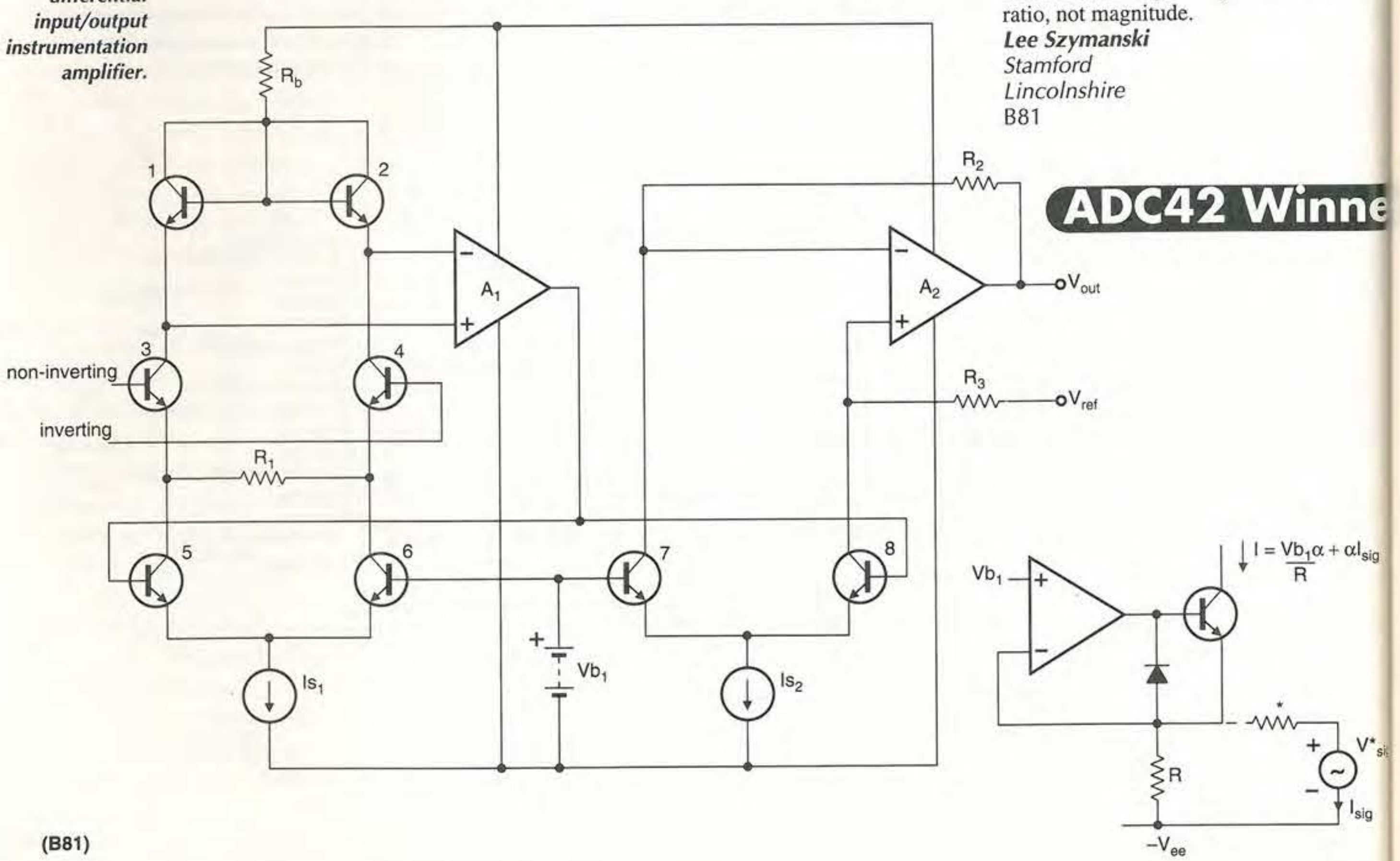
The current sources may be formed by op-amp circuits or by current mirrors and made variable, if required. Transistors $Tr_{1,2}$ were used instead of resistors to remove the effect of I_{s1} and varying temperature on the stage gain.

Current I_{s1}, together with R_1, sets the differential input range. It must not be set so low that the transistor f_T is low enough to affect the phase margin round the feedback loop; resistor R_b prevents the inputs exceeding their common-mode range.

For best distortion performance, transistors $Tr_{5,6,7,8}$ should be matched. The bias voltage may be a simple resistive voltage divider and the current sources may use the same reference, since gain depends on their ratio, not magnitude.

Lee Szymanski
Stamford
Lincolnshire
B81

Variable-gain, differential input/output instrumentation amplifier.



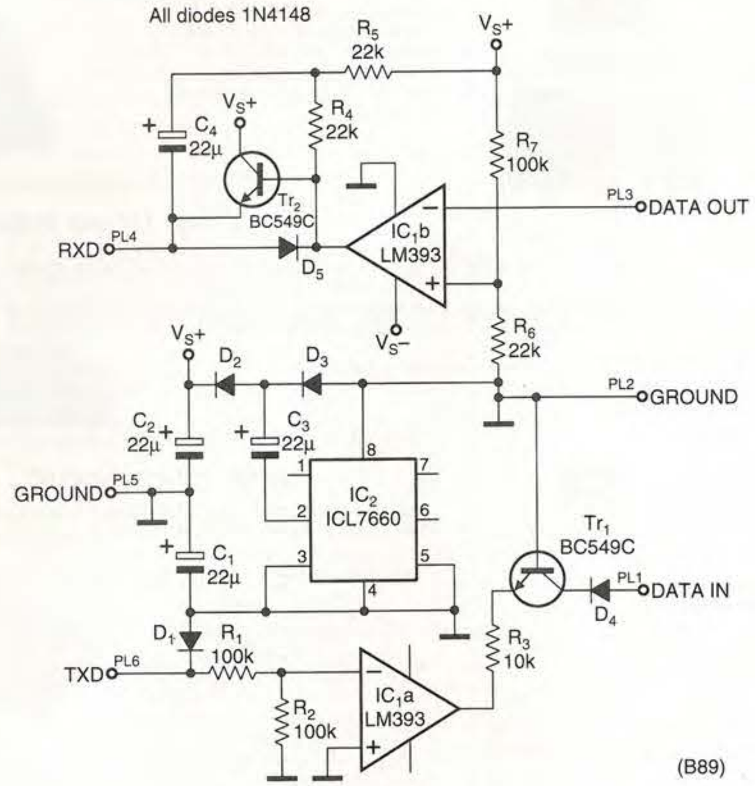
(B81)

ADC42 Winne

Temporary RS232 hookup

Using a host computer to hold register contents and data during the development of a microprocessor system, when the target has no RS232 interface or available voltage supplies.

It can be convenient, when developing software for a microprocessor project, to be able to dump register contents and data to a computer terminal from which commands may also be obtained. If, however, the project in question needs no RS232 interface and does not have the relevant voltages available, it presents a difficulty. This device takes its voltages from the host without overloading it.



In essence, it is a level shifter and inverter between the logic levels of target and host, which needs symmetrical voltages. For most of the time, the TXD line is held at –12V idle line voltage, which can vary. Capacitor C_1 charges via D_1 to this voltage, which is the negative power rail to IC_2 and the rest of the circuit. IC_2, an *ICL7660*, acts as a voltage doubler and generates the positive supply. Diode drops prevent the rails being symmetrical, but they are near enough.

Level shifting is performed by the *LM393* comparator. Data Out from the microprocessor idles at 5V in its logic 1 state, which is higher than the comparison level at $R_{6,7}$ junction and RXD is held at idle low. When data takes Data Out to ground, RXD is taken high by the emitter follower, the bootstrap C_4 making the output as near +12V as possible. This is effective for the short duty cycles needed.

For data coming back from the terminal, the idle TXD and the junction of $R_{1,2}$ is below ground, turning Q_1 off and allowing Data In to the processor to float high. Data takes TXD high therefore turns Q_1 on and pulls Data In low.

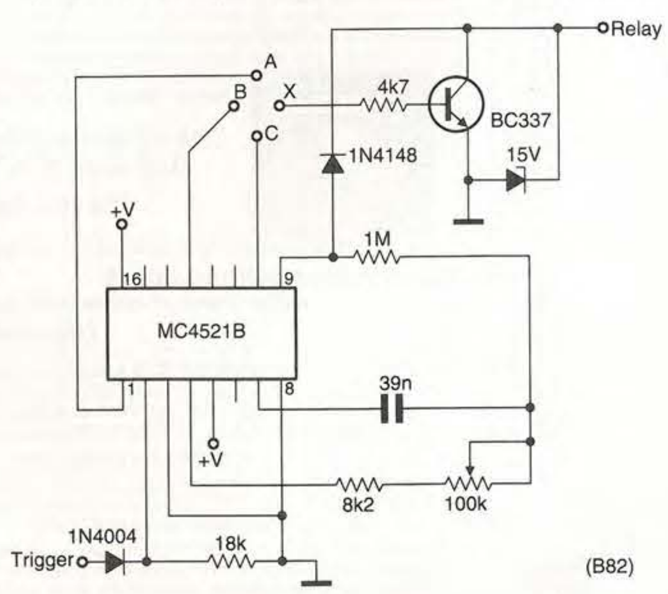
Peter Levesley
Walsall
West Midlands
B89

Long-delay generator

Delays of more than a week without the use of huge capacitors or high impedances, using a 24-stage frequency divider and oscillator.

While not being totally original, this timer avoids the need to design a circuit using electrolytic capacitors or high-impedance circuitry.

The *MC14521B* is a 24-stage frequency divider with an input usable as an oscillator. With ground or no signal applied to the trigger input, the relay output goes low after a delay determined by the potentiometer setting and the range selected.

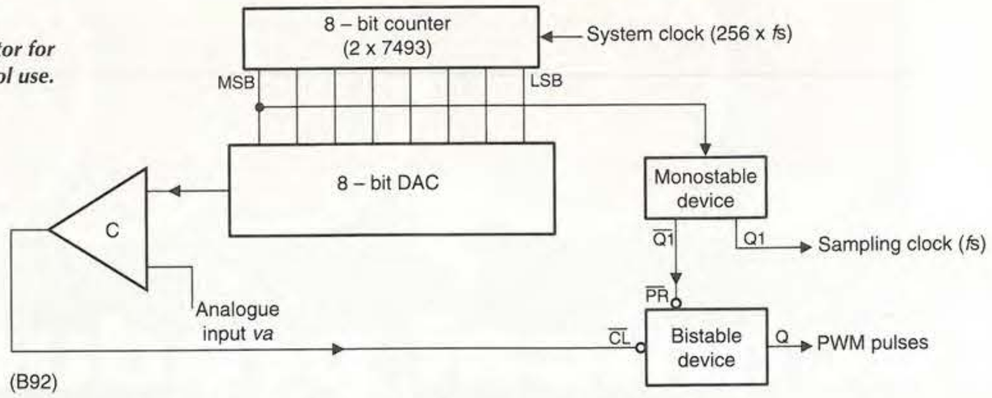


Connecting point X to C gives a delay between 1m40s and 18m30s, while at B the delay obtained is 13m20s to 2h28m. Connection to point A results in delays variable between 1h47m and 20h and using a bigger capacitor will give delays of over a week. A positive signal at the trigger input resets the divider.

Timing is reliable and stable, but a regulated power rail is to be recommended, producing 6-15V. The above results were obtained using 12V.

D Di Mario
Milan
Italy
B82

Simple pwm modulator for communications or control use.



Linear pulse-width modulator

The output *Q* of the flip-flop consists of positive-going pulses whose width is dependent on the voltage at the analogue input, the circuit therefore constituting a pulse-width modulator.

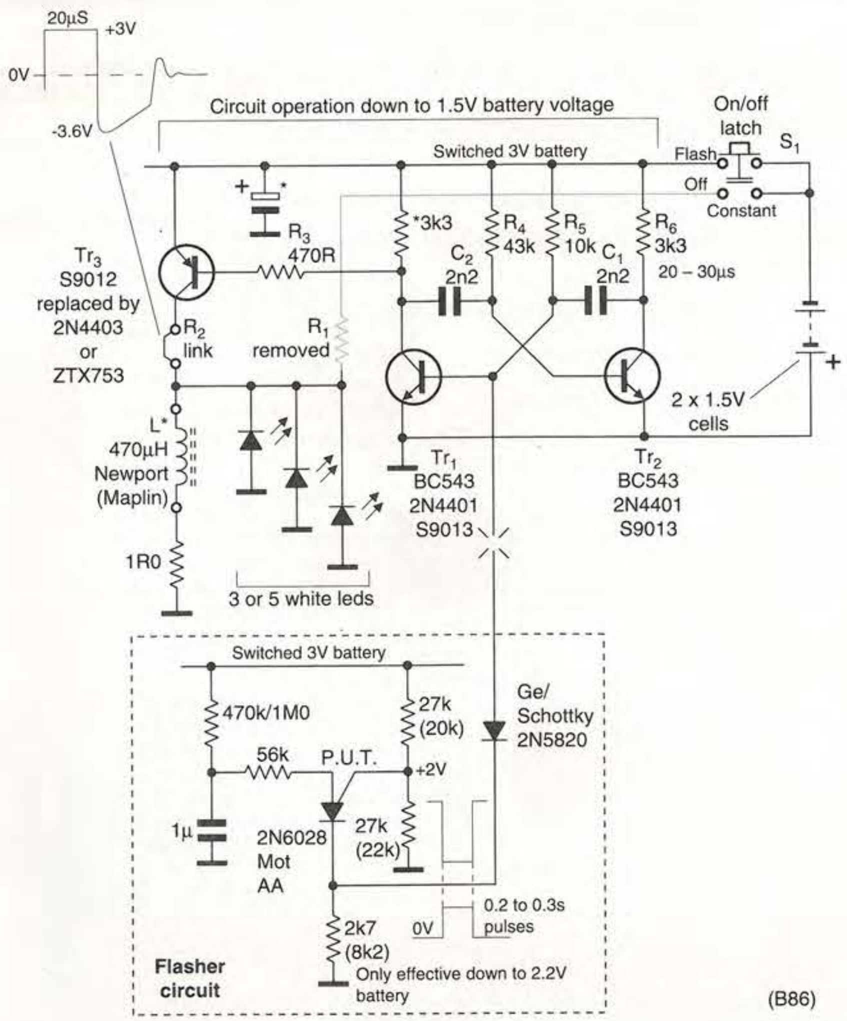
At a frequency of 256 times the signal frequency, the system clock drives an 8-bit counter, whose outputs go to an analogue-to-digital converter driving a comparator with the resultant staircase waveform.

A monostable, triggered by the falling edge of the most significant bit of the counter, presets the flip-flop with its /*Q* output, so setting the rising edge of the width-modulated output pulse.

As the analogue output from the digital-to-analogue converter reaches the level of the analogue input, the comparator flips and terminates the output pulse from the flip-flop, the width of which is therefore dependent only on the analogue input.

Sampling clock signals are produced by the Q_1 monostable output.

K Balasubramanian
Husseyin Camur
European University of Lefke
Turkish Republic of Northern Cyprus
B92



White-light leds operate down to 1.5V

Two 1.5V cells are enough to operate three or five white leds, the original circuit, from which most of the components have been discarded, being a *Vistalite 300* cycle lamp.

The inductor increases the forward bias on the leds, since white leds need between 3 and 3.6V; it is also a more efficient method. If flashing is wanted, the circuit shown dotted may be used to switch the multivibrator on and off, a programmable unijunction providing the waveform, but the battery voltage needed for this is a little higher at 2.4V. The original Tr_3 was replaced by the one shown to obtain a better saturation voltage.

At an operating frequency of 20kHz, the free-running multivibrator causes a little interference with long-wave radio at distances under 1m.

Robert Comer
Edinburgh
B86

A much-modified cycle lamp was the starting point for this two-cell white led driver and flasher.

Optically isolated I²C interface

The I²C interface format uses data and clock wires to transfer addresses, data, read/write commands and acknowledgements and, in some applications, the two users of the bus must be isolated. This circuit performs that function.

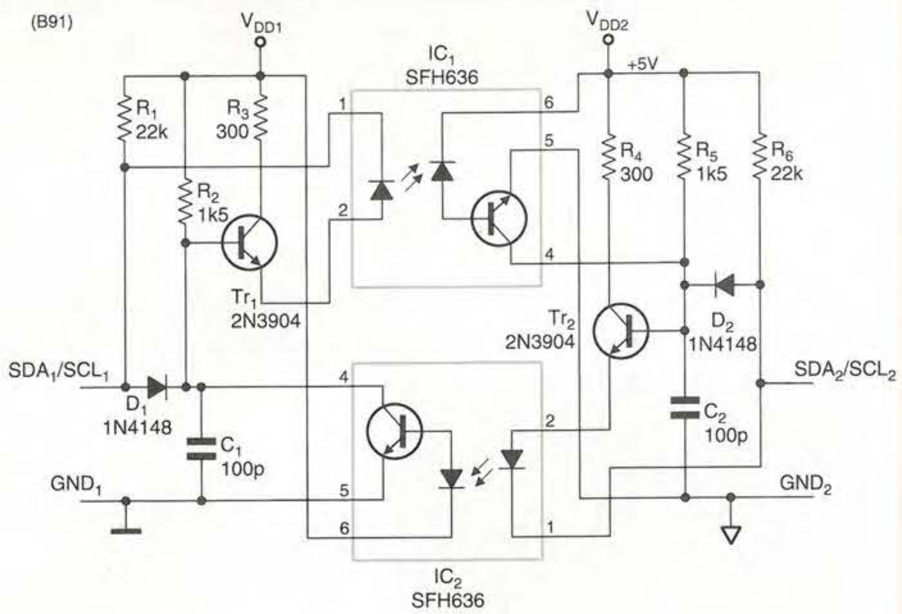
Both ics are high-speed optocouplers by Siemens, the *SFH636*, which has a gallium aluminium arsenide infra-red-emitting diode and integrated photodetector and transistor.

When there is no signal, both SDA (data) and SCL (clock) lines are held up by $R_{1,6}$, so that, although the internal transistors are on, no current passes since the emitting diode is off.

A low on, say, SDA_1/SCL_1 turns IC_1's emitting diode on, its current going through R_3 and Tr_1. IC_1's internal transistor turns on, pulling down SDA/SCL_2 through D_2 and by-passing Tr_2's base current from R_5. This cuts Tr_2 off to avoid lockup through feedback from IC_2.

Propagation delay is 0.8μs low to high and 0.4μs high to low.

Yongping Xia
Torrance
California
USA
B91



For use when both parties using the I²C interface must be isolated, this symmetrical circuit uses high-speed optocoupling.

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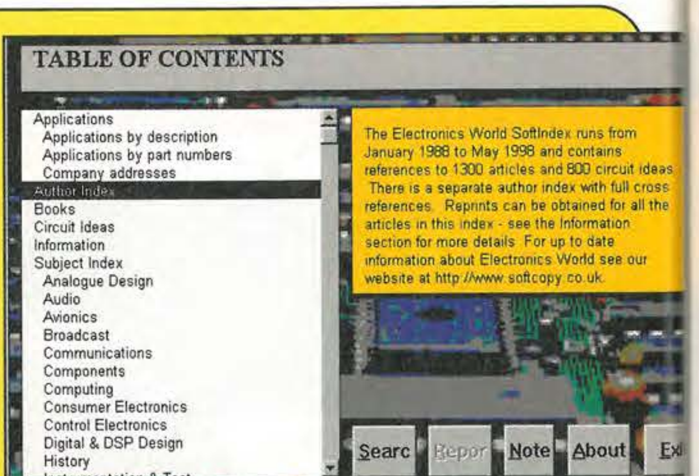

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Simple wideband detector for 10.7MHz

This wideband fm detector for 10.7MHz needs only a single quad 74LS00 NAND gate. It works in a similar way to a zero crossing or pulse-count detector.

Incoming limited signal at 10.7MHz intermediate frequency is NANDed with itself through the delay of around 27ns caused by the three in-line gates. This greatly narrows the rectangular pulse.

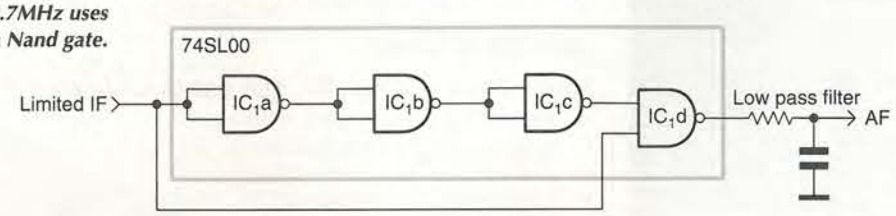
Pulses are formed between 19 and 21.5ns wide at the extremes of the deviation which is ±90kHz as compared to an original width of 46.7ns. Higher frequencies give more pulses than lower frequencies.

These pulses are converted to audio frequency by the low-pass filter after the IC. An alternative although equivalent explanation is that the action in the IC is a differentiation of the signal together with rectification. This is the exact reverse of the process giving rise to frequency modulation.

Because the pulse widths are also a function of deviation, the detector is not ideally linear. But as most of the deviation in normal broadcast signals lies well within ±90kHz, the average variation is not more than 6%. This means that in practice, the signal distortion is unnoticeable.

The detector is approximately linear over 180kHz deviation. It has two major advantages over the standard quadrature and ratio detectors in that it is both cheap and requires no adjustment or external parts other than the very simple low-pass audio filter.

Michael Slifkin and David Papirov
Jerusalem College of Technology
Jerusalem



Wideband detector for 10.7MHz uses only a Nand gate.

Insulation and earth continuity tester

After an embarrassing experience involving an rcd, a recording studio and red faces, this test set was built to avoid a repetition. Clearly the rcd must not be tripped by the test set and that is achieved by the use of independent supplies of 500V dc at 2mA maximum and 12V ac limited to 3.5A. Leakage current and earth resistance are shown simultaneously on two meters.

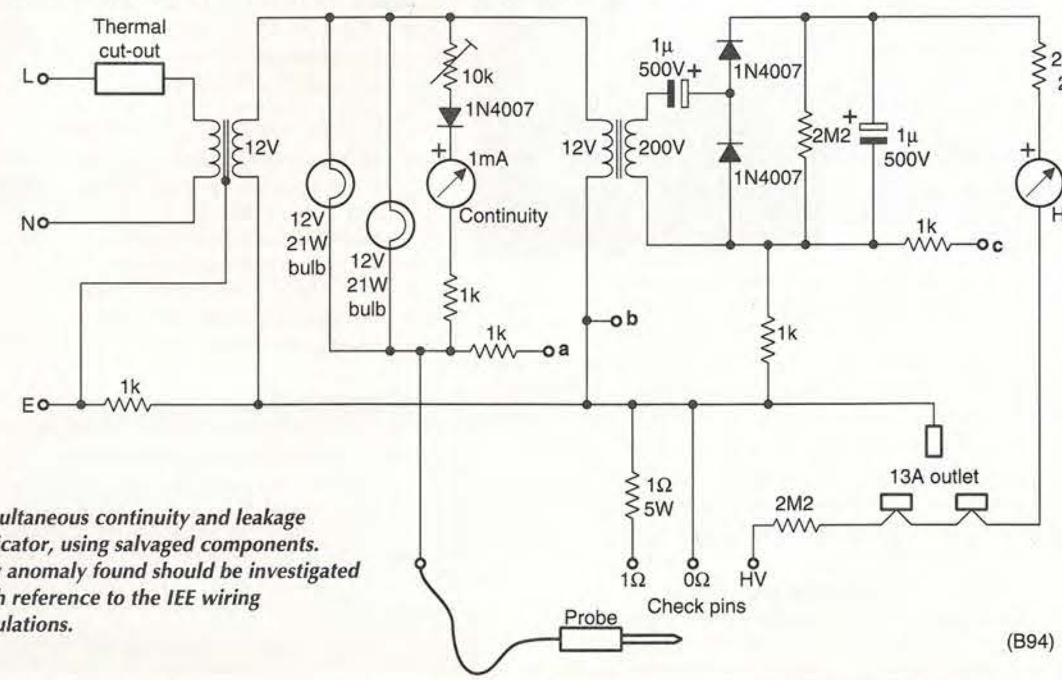
Operation is simple. Firstly, test the instrument itself: place the probe on the hv test pin and obtain the normal reading; with the probe on the zero ohms check pin confirm continuity with the bulb in circuit then put the probe on the 1Ω check pin and confirm continuity with the 1Ω resistor in circuit.

To test an appliance, plug it into the test socket and switch it on. Place the probe on any metal part that should be earthed, when the continuity meter should read near zero ohms for Class 1 appliances. For most appliances and electronic equipment, there should be no leakage wherever the probe is placed in either Class 1 or Class 2 equipment.

A defined leakage current is allowed by the regulations for some domestic appliances such as heaters but, if leakage is shown it should be investigated.

As regards components, the transformers shown could take the form of a dual secondary type, if one is available. Capacitors must be of at least 500V wkg and it might be borne in mind that they will hold a charge for some time. The 270Ω and 2.2MΩ resistors should be suitable for high-voltage use and a pair of car stop-lamp bulbs are used to limit continuity test current to 3A. I find that older, more massive meters are helpful in their ability to smooth out half-wave rectified input and to withstand overload. Points a, b and c go to a small socket for a data recorder.

M Mucklow
Newport Pagnell
Buckinghamshire
B94



Simultaneous continuity and leakage indicator, using salvaged components. Any anomaly found should be investigated with reference to the IEE wiring regulations.

Single-transistor constant-current generator

This may not be the last word in constant-current generators, but it is simple and cheap and is well suited to use as a bias current generator with a small compliance, in which less than perfect accuracy and a certain temperature dependence are not problems. It is an obvious application for what appears to be an emitter-follower.

Choose R_e to give the required output current I_g; then,

$$Ig \approx \frac{V_{be}}{R_b} \approx \frac{0.65 \pm 0.1V}{R_b}$$

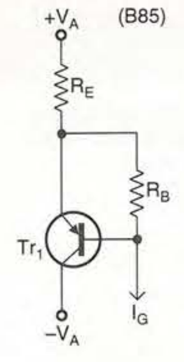
Then choose R_e so that, at maximum compliance, the current in $R_e > 0$;

$$\frac{V_a - V_{be} - V_{g(\max)}}{R_e} > \frac{V_{be}}{R_b},$$

where V_g is the output voltage.

Transistor current variation directly affects performance; a 10:1 variation in transistor current causes a 10% output current change, a 2:1 variation causing 2.5%. For example, with $R_b = 680\Omega$ and $R_e = 6.8k\Omega$, a supply $V_a = 15V$ into a circuit compliance of 1V-3V gives an output of 1mA from an equivalent resistance of 150kΩ. Temperature dependence is –0.3%/°C.

Mark Hughes
Ashby de la Zouche, Leicestershire



Low-cost and very simple constant-current source.

Cellphone ringer repeater

Ringers in some mobile telephones are so muted that they cannot be heard over traffic noise or through clothes. This circuit rectifies that, producing a screech when the 'phone rings. No modifications to the 'phone are needed; it simply needs to be near the 'phone.

Transistors $Tr_{1,2}$ form a Knock-White oscillator, which is set by the adjustment of VR_1 to be just short of oscillation. An electromagnetic disturbance from the 'phone, a pulsed rf field, produces damped oscillations appearing as negative-going pulses at Tr_2 collector, being converted to current pulses in $Tr_{3,4}$ to charge C_4, which turns Tr_5 on and applies power to the sounder drive circuit. Since the waveform applied to the sounder, and in antiphase to its its common terminal, is a rough square wave, the normal sinusoidal output from the feedback terminal is replaced by a mass of harmonics. Circuitry around Tr_6 low-pass filters this and provides phase shift and gain to allow circuit to oscillate at the sounder's resonant frequency of 3kHz.

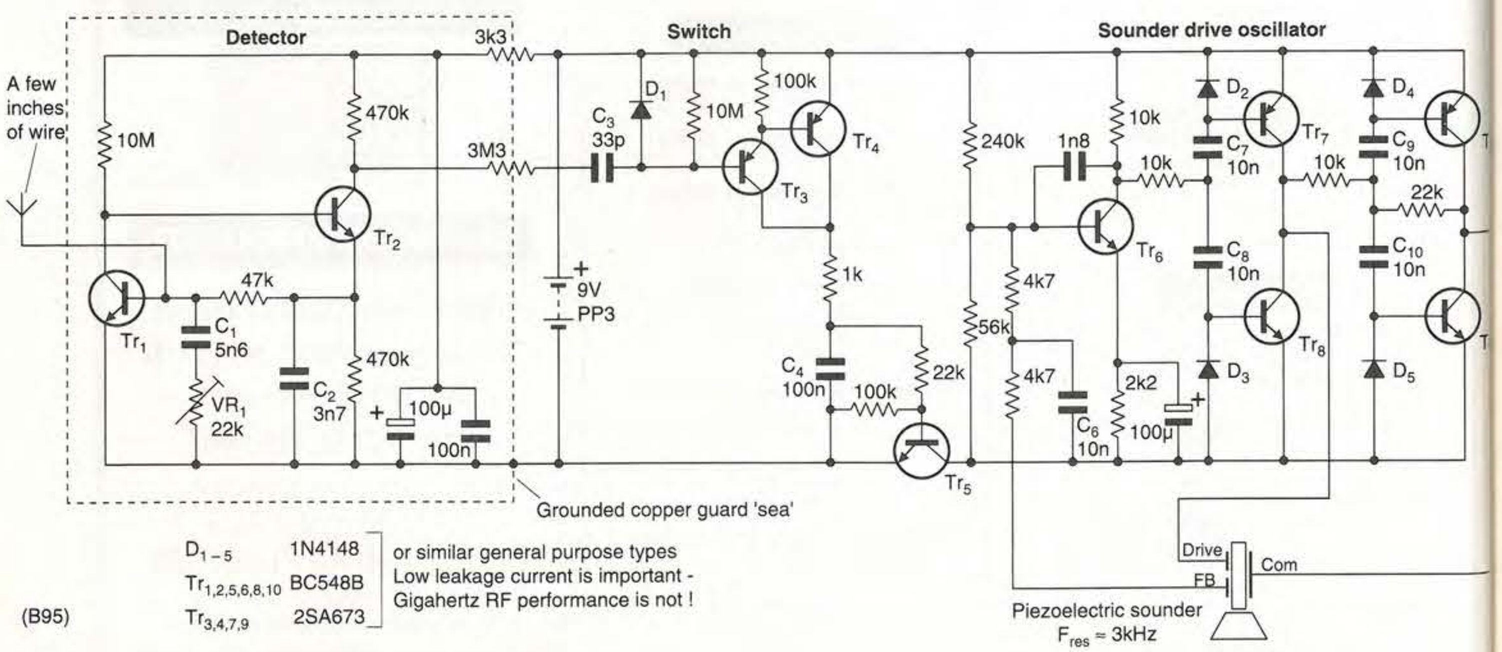
To set the circuit up, reduce the resistance of VR_1 until the sounder starts and then increase it until the sound just stops. Call a "dummy" number such as a call box on the 'phone and hold it near the circuit, when the sounder should come on and then quiet as the 'phone is moved away.; if the sounder stays on, increase the setting of VR_1. Bear in mind that in a good reception areas, the 'phone will start operating at full transmit power and reduce it to the required minimum; if, therefore, the circuit seems to fade out, there is no fault. If necessary, increase sensitivity by putting a few inches of wire on the base of Tr_1.

A series of clicks will be heard when the 'phone receives a call, followed by a squeal as the 'phone transmits continuously; the 'phone will then ring and, when it is picked up, will go out of range of the sounder, which will stop. There is the occasional muttering in periods of inactivity as the 'phone converses with the network. You can replace the sounder with another type of warning device such as a vibrator or lamp, if you feel that a sounder might bring vengeance from those close by.

The whole thing draws around 1.5µA when inactive, 4.5mA when sounding, and needs no on/off switch.

Chris Bulman
Bedford

If you find that your mobile phone ringer doesn't annoy enough people, this circuit should do the trick, but may also be used to drive a vibrator or a lamp.



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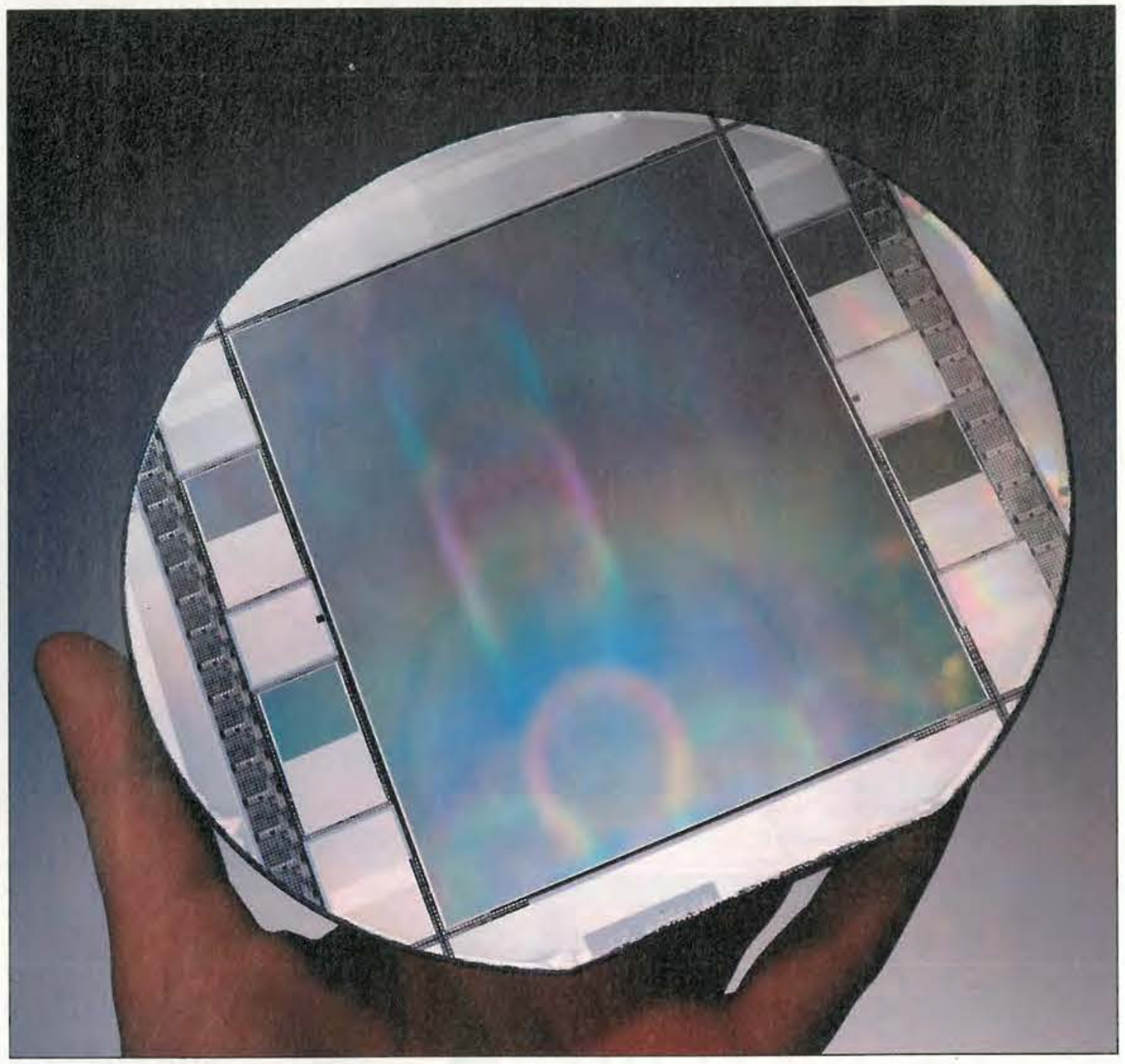


A 6in wafer containing a 7k by 9k ccd with two 1k by 2k frame-transfer ccds on either side.

CCD developments

Leslie Warwick looks at two breakthroughs in ccd technology for imaging – one the smallest pixel, the other the largest ccd sensor module.

Philips Research has broken world records at the two extremes of ccd technology: for the largest ccd measuring 86 by 110mm and, in a separate development, for a ccd with pixels of just 2.4 by 2.4μm, compared to 4.5 by 4.5μm previously attained. Both developments open the way to new applications.

The largest ccd is modular and consists of an array of 7-by-9 ccds each containing 1024 by 1024 pixels. This equates to over 66 million pixels in total. And each elementary sensor is constructed from component blocks. Joining the individual parts electrically in the silicon is achieved by a patented 'stitching' technique that is claimed not to produce any visible seams in the image.

A 7k by 9k array is the maximum at present due to the choice of 12 by 12μm pixels and the necessity of fitting it onto a 6in silicon wafer. The minimum for this process is obviously one ccd; and there can be any number between that and the maximum to suit the application.

By using this construction, the configuration can be realised in the production phase rather than the design phase. This lowers development time and costs significantly.

Step and repeat

The technology takes advantage of the repetitive structure of ccd imagers to use a step and repeat process. This overcomes the present inability of lithography equipment to produce fine details over a large area. Because the component blocks are standardised, a universal mask set can be used. The only unique mask needed is the one used to make the interconnect between the bonding pads.

Figure 1 shows how a 3 by 4 layout is produced using four basic blocks: imaging area blocks, vertical blocks, horizontal output register blocks and output amplifier blocks. **Figure 2** shows the functions of the individual blocks.

The four phase pixels are constructed using two layers of polysilicon. Eight variations of the vertical blocks are required and four variations of the 40MHz horizontal blocks are needed to allow for all possible working configurations.

Figure 3 shows the architecture of a modular sensor. The vertical and horizontal ccds are divided in the middle of the device. This arrangement allows all the integrated charge packets in each half to be clocked to the same side of the device, or to opposite sides – dividing the ccd into two.

It is possible to read the whole sensor through any one amplifier. Each vertical or horizontal section can be read through two amplifiers and each quadrant can be read through its own amplifier. Using all four amplifiers allows higher frame rates; also the quicker the charge is removed, the less dark current will be generated.

Building in an image buffer

Both full-frame and frame-transfer devices can be produced. With the full-frame type, the whole area is used for imaging; with frame-transfer devices, half the area is masked with aluminium to create an opaque charge storage area. This area is then used to hold an image while it is clocked out, simultaneously with capturing a new image in the non-masked area.

If larger pixels are required, to increase light sensitivity, then 2 by 2 or 3 by 3 pixels can be combined in a process known as 'binning'. Vertical binning is achieved by clocking multiple lines into the horizontal register and horizontal binning by clocking multiple pixels under the summing gate used reading the sensor. If the application requires colour, then a colour mask can be added to the ccd.

A 7k by 9k ccd is initially being used for astronomy. The Steward Observatory ccd Laboratory in Arizona has been collaborating with American Digital Imaging to package and characterise the Philips ccd.

Uses for the new devices

The device is also expected to be used for digital photography; here, the current maximum for an area array ccd is 6 by 6cm – the size of a medium format film frame.

A 1k by 2k ccd is already in production as a progressive-scan frame-transfer type. It is being used for still imaging, together with medical and scientific applications.

Another possibility for modular construction is high speed imaging, where one block receives the image and eight blocks around it store sequential frames.

Applications for ccds based on the 2.4 by 2.4μm pixels include miniaturised cameras that can be used for blood vessel and lung inspection, as well as replacing the existing imagers in the endoscopic field – to the probable relief of patients.

The technology is also advantageous when it comes to fabricating pixels of conventional size: with the functional parts miniaturised the light-gathering area of the pixels can be maximised, increasing both sensitivity and dynamic range.

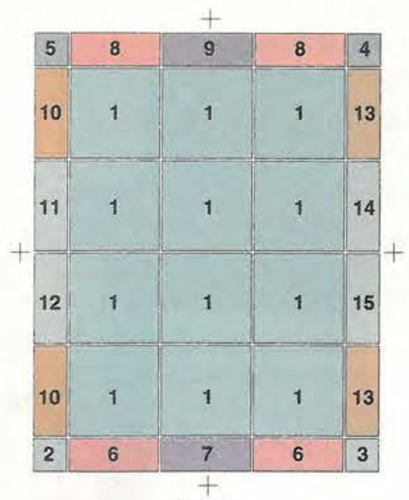


Fig. 1. Block diagram of a 3-by-4 ccd showing the arrangement of the basic building blocks.

Block key

1	Image (1k x 1k)	10/13	Vertical Block bonding pads continuous routing
2/3	Amplifier W/X	11/14	Vertical Block no bonding pads routing split on edge
4/5	Amplifier Y/x	12/15	Vertical Block no bonding pads routing split on edge
6/8	Horizontal Block bonding pads continuous routing		
7/9	Horizontal Block no bonding pads routing split middle		

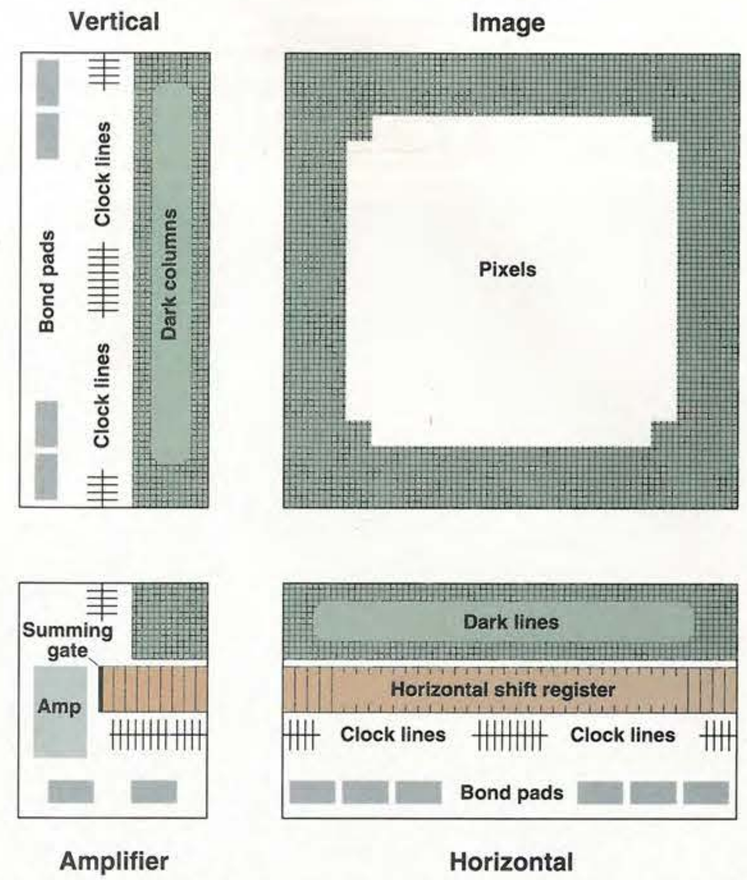


Fig. 2. Basic distribution of the new ccd's layout. A matrix of 1024-by-1024 pixels forms the image block. Included in the the horizontal block are dark lines, shift register, clock lines and possibly bonding pads. The vertical block has dark columns, clock lines and possibly bonding pads. In the bottom left-hand corner are the amplifier, the end of the register, the summing gate, pixels common to the extra lines and columns, and bonding pads.

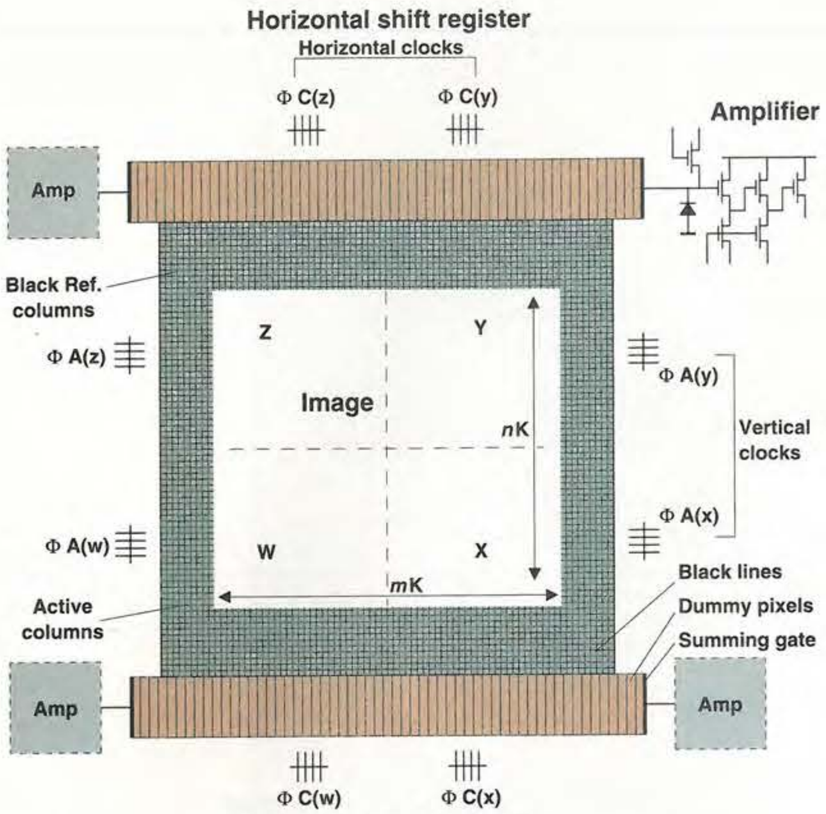
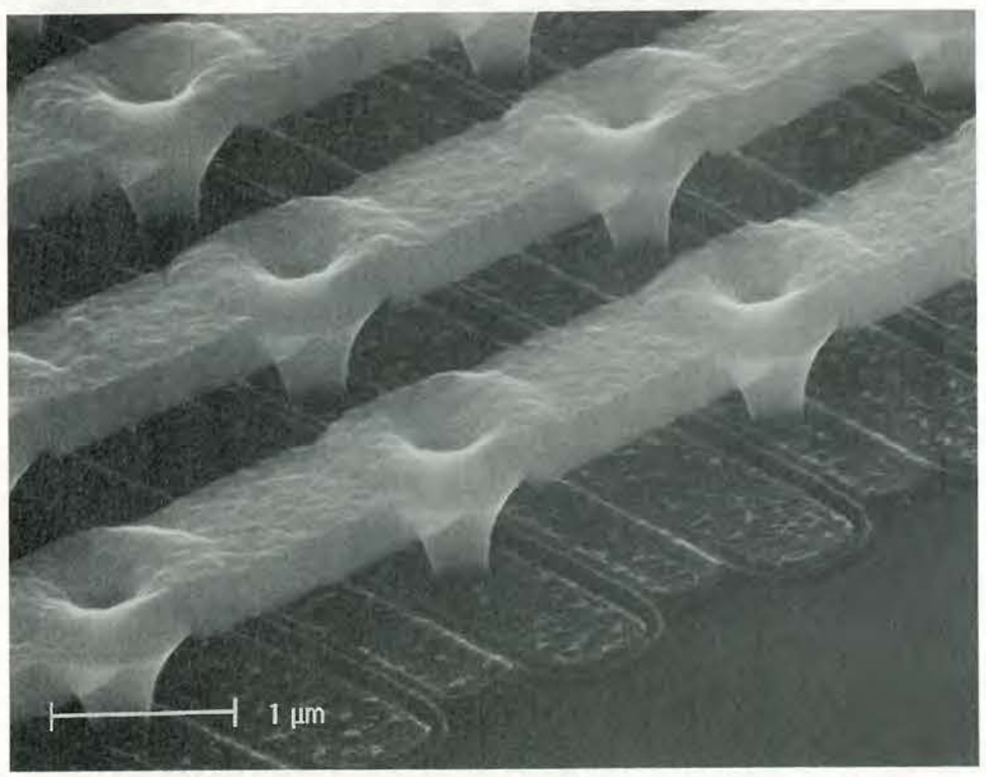


Fig. 3. Architecture of the modular ccd. Vertical and horizontal ccds are split in the middle of the device. Each half is capable of clocking in the same or opposite direction. And read-out can be carried out through one, two or four amplifiers. This division means that frame-transfer ccds, which require two sets of vertical clocks, can be made.



Perspective view of a few 2.4 by 2.4μm ccd pixels with their transparent electrodes. Electrode-interconnect lines with their tapered contacts are also visible.

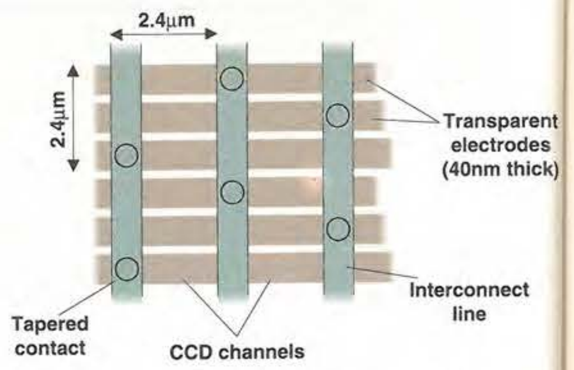


Fig. 4. Schematic top view of the world's smallest image pixels, measuring just 2.4 by 2.4μm².

Is the lens the limit?

Figure 4 shows a schematic view of the pixels. Charges are integrated in wells under the central electrode, and then transferred along the ccd channels by appropriate clock voltages applied through the tapered contacts. The electron microscope photograph shows a perspective view of the actual pixels.

Very small ccds will create a problem for manufacturers attempting to design miniature cameras, because the lens will then determine just how small it can be. However, for those applications where lenses are not needed, where there can be direct contact between the ccd and the object, the only limitation is the size of the sensor and the light-gathering capacity of such small pixels.

Since the announcement of the world's smallest pixels, Philips Research has conceived a ccd with 1.3 million pixels of 3.7 by 3.7μm. This is intended for use in consumer high-resolution digital still cameras.

On-chip data compression

The use of on-chip data compression will also enable the device to operate in lower resolution monitor mode to feed an lcd viewfinder, and for functions such as autofocus and autoexposure. Switching between still picture and monitor modes is achieved on-chip to obviate the need for additional processing in-camera.

The principle of charge coupling was invented by Teer and Sangster of Philips Research Laboratories in 1966. Their bucket brigade devices were mainly used for analogue delay lines. However, the potential of bucket brigade devices to be turned into solid-state imagers was realised by the inventors before Boyle and Smith of Bell Labs actually managed to construct working ccds in 1972.

These latest developments show that Philips is still keeping its hand in. ■

SPEAKERS CORNER

The coil is a vital part of an electromagnetic loudspeaker. Here John Watkinson considers the choices facing the coil designer.

The coil is the part of the loudspeaker which develops the driving force. This is its only desirable feature; everything else the coil does is a drawback. The coil designer has to maximise the desirable while minimising the drawbacks.

The coil works by allowing a current to flow in a magnetic field. This current reacts against the field to produce a force. Force is obtained by multiplying the current by the length of wire, l, in the magnetic field and then by the field strength, B.

The last two parameters are seldom quoted singly as only their product, known as Bl, matters. Unfortunately Bl is not the product of the flux density and the length of the coil. **Figure 1** shows that the flux density in the gap is not constant, but falls at the edges. Fringing flux effectively extends the gap. Not all of the coil is in the field.

In the case of a woofer, there may be more coil length outside the field than inside, and the part outside contributes no force. The actual Bl product is found by calculating the integral of the field strength over the length of the coil, or by actual measurement.

Above resonance, the moving part of the speaker is mass controlled. If the moving mass is known, it is not hard to find the acceleration for a given force. If the cone remains a rigid piston, knowing its effective area allows the resulting sound pressure to be calculated.

For a given cone area, increasing the Bl product increases output, whereas increasing the moving mass reduces output. Output is specified as the sensitivity of the driver. This may be power sensitivity or voltage sensitivity.

Power sensitivity is independent of coil impedance whereas voltage sensitivity isn't. In practice both are needed. Power sensitivity allows the necessary amplifier power to be calculated. But it doesn't specify whether that power is delivered as a low current at a high voltage or a high current at a low voltage. Knowing the voltage sensitivity allows that to be worked out.

Every coil has a finite resistance and this is undesirable as it results in heating. Long-throw woofers are especially vulnerable. This is because the heat is developed over the whole coil whereas only that part in the field of the gap is producing a force.

There is always a penalty associated with the field in the gap. The gap has a finite volume due to its radial spacing and its length along the coil axis. If the gap spacing is increased, the reluctance goes up and the length of the magnet has to be increased to drive the same amount of flux through the gap. If the gap length is increased, the flux density goes down unless a magnet of larger cross sectional area is used. Thus the magnet volume tends to be proportional to the gap volume.

Maximum efficiency – or the lowest magnet cost – is obtained when the gap is filled with copper. Unfortunately, this ideal can never be reached because some of the gap volume is occupied by clearances to allow motion and by insulation and, generally, a coil former.

Figure 2a) shows how ordinary circular section wire is poor at filling the gap because only 78% of the space is conducting. Square wire, shown in Fig. **2b)**, gives a much better utilisation of the available flux. Using square wire, the coil would only have 78% of the resistance of an identical unit using round wire.

For the same dc resistance and power sensitivity, a square wire coil could be made 27% longer, allowing longer linear cone travel. As an alternative, coils have been made with hexagonal wire and with flat wire, Figs **2c), d)**. Both of these methods allow an improvement in packing.

The improved packing makes the coil more rigid and improves heat transfer along the coil. The extra mass of the square wire must reduce the sensitivity slightly, but the moving mass includes the coil former, the cone and dust cap as well as part of the masses of the spider, leadout wires and surround. As a result the increased coil mass does not affect the overall mass significantly.

The interaction of mass and wire conductivity leads to another approach. Copper has very good conductivity, but its specific gravity is quite high: at 8.9 it is not far short of that of lead at 11.3. Thus in some applications, better results may be obtained by using aluminium whose specific gravity is only 2.7. Although the conductivity of aluminium is only 60% as good as copper, weight for weight the conductivity is twice as good.

For a long throw woofer where the coil mass is a significant part of the moving mass, an aluminium coil can give a significant improvement in efficiency – especially if the wire is square or rectangular. The cross sectional area of the aluminium has to be higher, and this requires a wider gap. However, rectangular aluminium wire can be made self supporting so no coil former is needed, allowing the same gap as for a copper coil to be used.

The problem with aluminium wire is that it's difficult to make connections to it without oxidisation. This is solved by giving it a copper coating. For real perfectionists, a silver coat may go on top of the copper.

The presence of the coatings changes the conductivity and the manufacturers quote it as a percentage of what it would be for solid copper of the same dimensions. ■

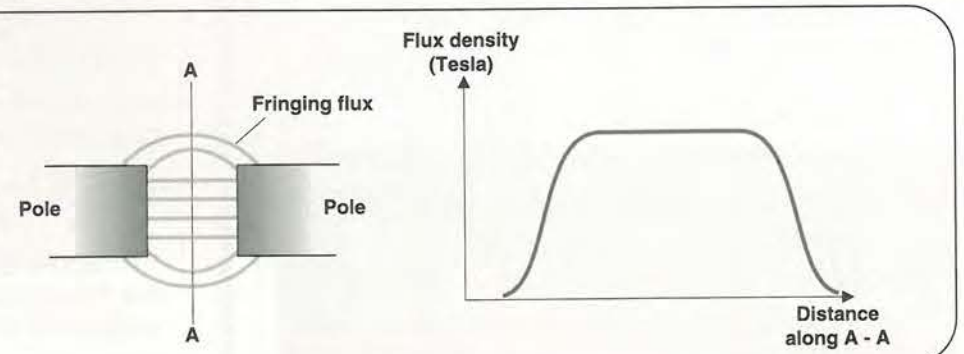


Fig. 1. Flux density in the gap is not constant, but falls at the edges. It has to be integrated to find the Bl product.

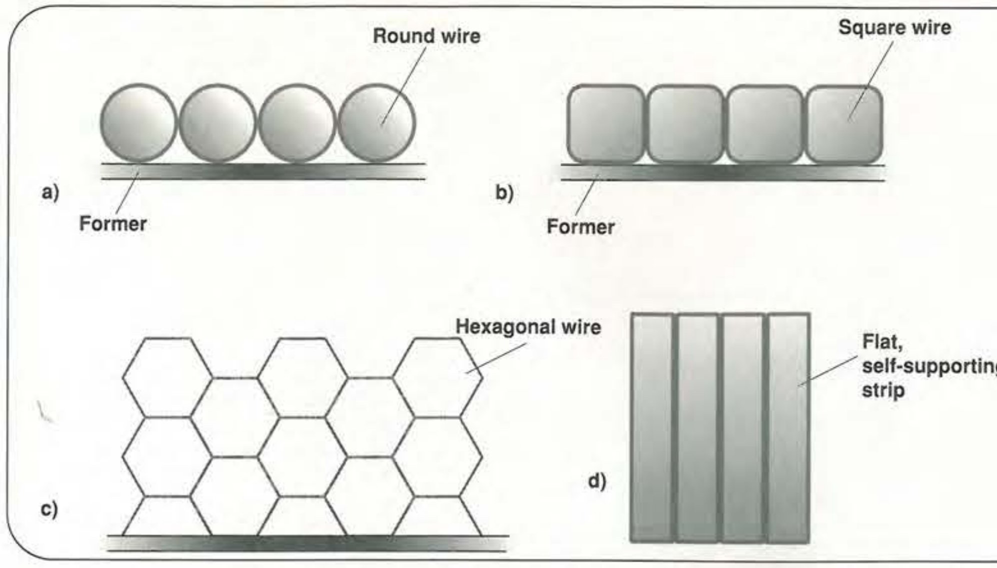


Fig. 2. The more conductive the coil material in the gap, the better. Square and hexagonal cross-section wire reduces the amount of air relative to round cross section. Flat wire goes a step further since it can be wound without needing a coil former.

Fig. 1. The photograph that directly gave rise to identification of the performers and the performance. These are the Paramount Astoria Girls rehearsing for the programme on the disc.

In last month's issue, Don McLean described the BBC's first television service and the earliest-known recording of broadcast television. This month Don reveals how he restored that video recording.

Looking in...

In August 1932, after three years of experimental television broadcasting by John Logie Baird, the BBC's first Television Service started on the low-definition 30-line format.

No means of high quality video recording was available and no professional broadcast video recordings exist from this period. Some viewers, however, tried recording the broadcast video signal onto audio discs.

In April 1933, a mere eight months after the start of BBC tv broadcasting, one viewer recorded part of a famous pioneering programme – the world's first television revue.

Dancing girls

The key to identifying the recording was an 80-second segment of a 'high-kicking' dance group. By chance, I recognised them by their costumes in a photograph, **Fig. 1**, in a magazine[1] that reviewed the highlights of 1933. Ray Herbert identified the dance group in the photograph as the Paramount Astoria Girls and Nicholas Moss of the BBC was able to retrieve the only two dates[2] in 1933 when they performed.

Matching up the programme with what I could see from the disc confirmed the programme was transmitted on 21 April 1933 from the small television studio BB in the sub-basement of BBC Broadcasting House. This was a television special called "Looking In" – the world's first television revue produced by Eustace Robb.

A myth challenged

Despite its poor quality, this recording is arguably even more important than Baird's experimental television recordings back in 1927-28. It lets us see exactly what the public saw in the early thirties. And what they saw has come as a great surprise: fast-paced entertainment, full of movement.

At the start of a sequence totalling four minutes there's a caption brought towards the camera in a 'zooming' action. Then five individual presenters make their introductions, **Fig. 2**. Each of six dancers next gives a 'cameo' head and shoulders introduction. Finally there is a long-shot eighty second dance routine, **Fig. 3**. This is followed by an announcer, **Fig. 4**.

Each of the twelve performers and presenters, **Fig. 5**, are in shot for no more than twenty seconds – long enough to be recognised but not so long that the viewers get bored. This is unique to 30-line television and would not be out of place in a fast-moving production today.

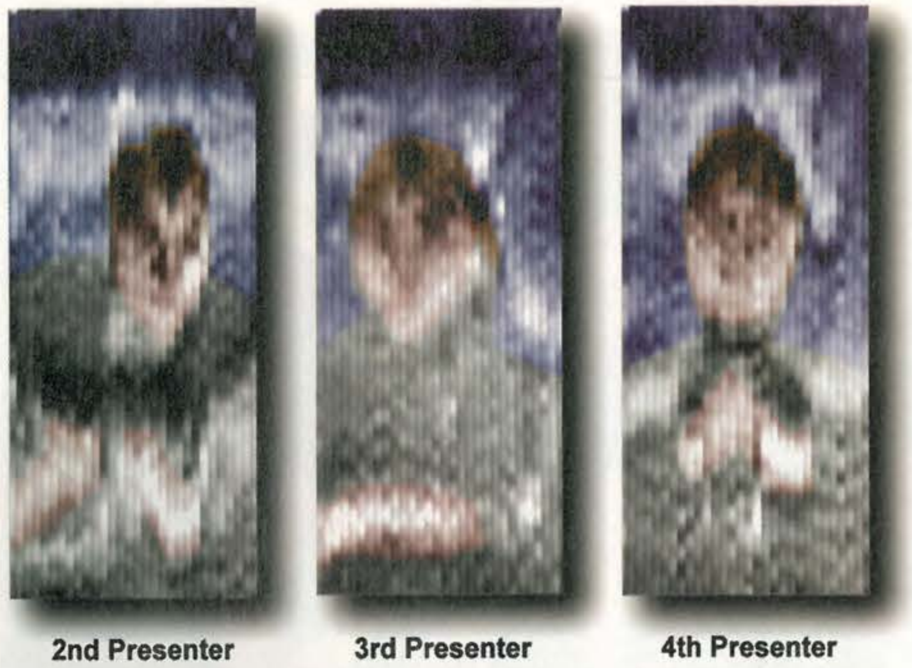


Fig. 2. The second, third and fourth presenters from the start of the recording. These and other stills from the disc are difficult to recognise and have been colour-tinted to aid recognition. Such poor quality pictures are more to do with the crudeness of the home recorder than the quality of the received video signal.

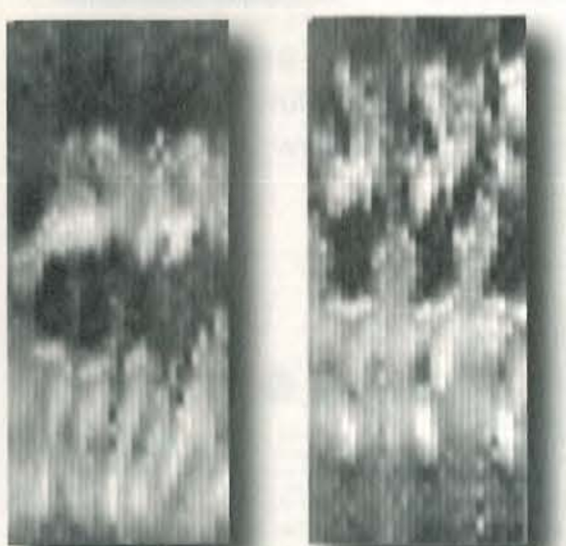


Fig. 3. Two single frames of the Paramount Astoria Girls in long shot during their dance number. As with the other stills shown here, the action and subjects become clear and recognisable when the pictures are shown as a video sequence.

Fig. 4. This unknown presenter appears a few seconds before the end of the recording and just after the dance sequence.

What the critics said

"Looking In" was important enough to be cited by Swift (1950),[3] though his dismissive remarks do not match what we see today. Ross (1961)[4] also cites this programme but prints a scathing *Daily Telegraph* review of its technical quality. Viewer's reports on the programme were, by contrast, very positive – and not included by either author.

The evidence we have on the disc does not fit well with what these eminent BBC authors have written. Today, we have the benefit of being truly objective about this historic programme rather than having, as they did, to rely on twenty year-old hearsay to describe it.

What this disc has shown us is that, although technically constrained, 30-line BBC Television was packed with action and as professional and as professionally produced as its higher definition successor.

Production features

In 1933, the 'camera' being used, **Fig. 6**, was based on a mirror-drum. This was a cylinder with 30 angled mirrors around its circumference.

The sensitivity and size of the photocells dictated that the most efficient arrangement was to reverse lighting and sensors. The mirror-drum sprayed a raster of intense light into a pitch-black studio and the photocells, mounted where the lights would have been, were fed to a mixing panel in the control room.

The camera could pan across the field-of-view but could not easily be adjusted for tilt.[5] Hence for each of the performers we can tell their relative heights. Indeed we can see that the dancers were all much shorter than the other performers as their heads only just appear in frame, **Fig. 7**.

When the girls dance in a line, we get a perfect example of that bugbear of amateur home videos – 'hose-piping' – panning left and right across the girls, **Fig. 8**.

The producer used two types of shots: the long-shot for the dancers and the medium close-up of the performers from waist-height up. This loose shot allows us to see not just hand gestures of the presenters but also the heads of the height-challenged dancing girls, Fig. 7.

From the action on the disc, the studio had a movable curtain for close-ups. This obscured the long-shot background – probably for scene changing – and came down to about waist height. Each of the performers entered and exited not from the left or right, but unusually from below, from underneath this curtain.

Viewers from around the country described detail[6] that the disc has not been able to capture. The recording, **Fig. 9**, is but a pale echo of the received transmission and can merely hint at what people saw.

If a television producer today had just one television camera that could only pan, had no zoom and was fixed to the floor, and if he were told to make a live 30-minute programme, I would be surprised if he could better the efforts of the BBC in 1933.

Movement – the key to clarity

The technical quality of the BBC 30-line transmissions was in itself excellent. However, 30 lines are only barely adequate to represent people and not suitable as a broadcast medium for any more complex or obscure subjects.

When we watch restored 30-line programmes, there appears to be much more information present than 30 lines could possibly convey. For facial and body movement, our brain fills in and 'builds up' the detail. We see, and

Fig. 5. Iris Kirkwhite was one of the presenter/performers on the disc. She appeared often on early BBC Television and was renowned for her toe-tap dancing.

Fig. 7. One of the taller Paramount Astoria Girls appearing just in frame. This image has been colour-tinted to aid understanding.

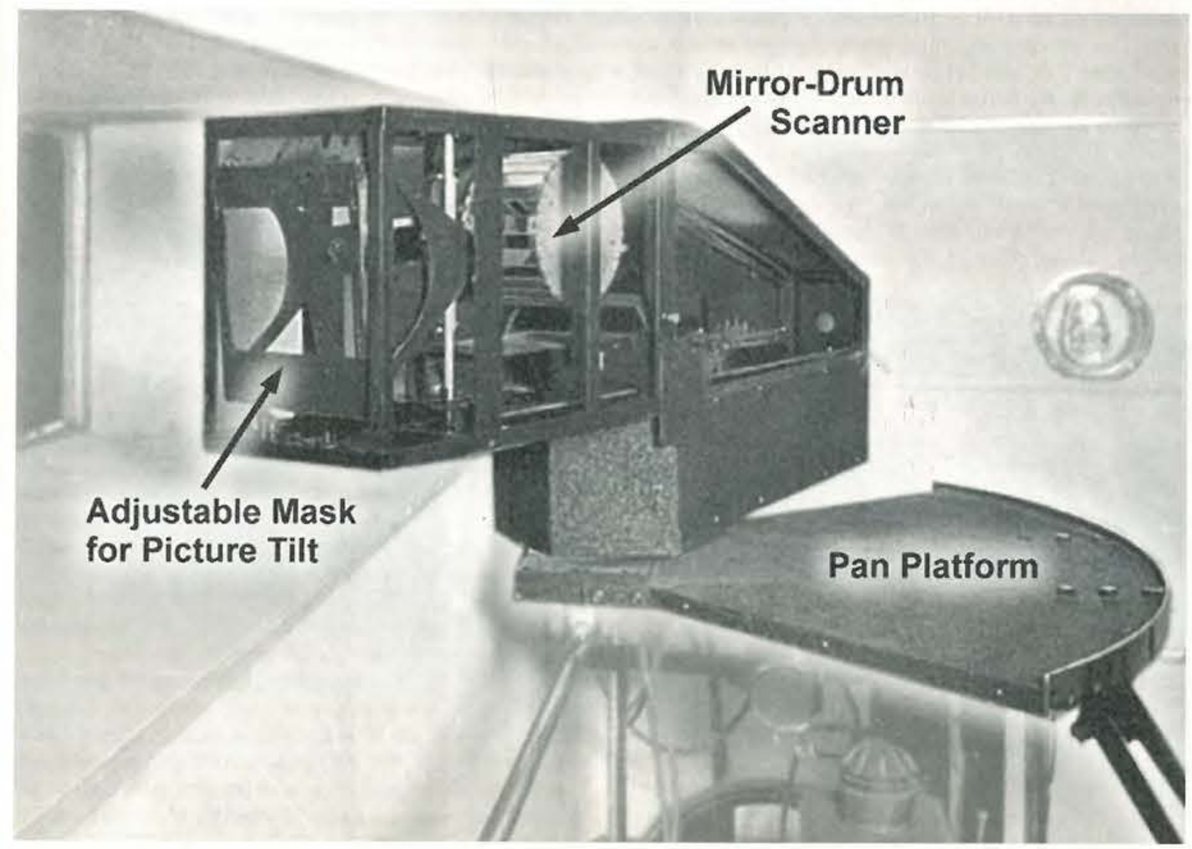


Fig. 6. The spotlight 'camera' in Studio BB of Broadcasting House. This projected a brilliant white raster into the darkened studio. Photocells, positioned as lights, fed the video signal into the control room. The camera rests on a platform allowing only panning. Moving the mask on the left adjusted tilt. Unfortunately this also altered the video timing.

Fig. 8. A publicity shot of the Paramount Astoria Girls made at the time of the recording. The images off disc do not resolve a chequer-board floor pattern.

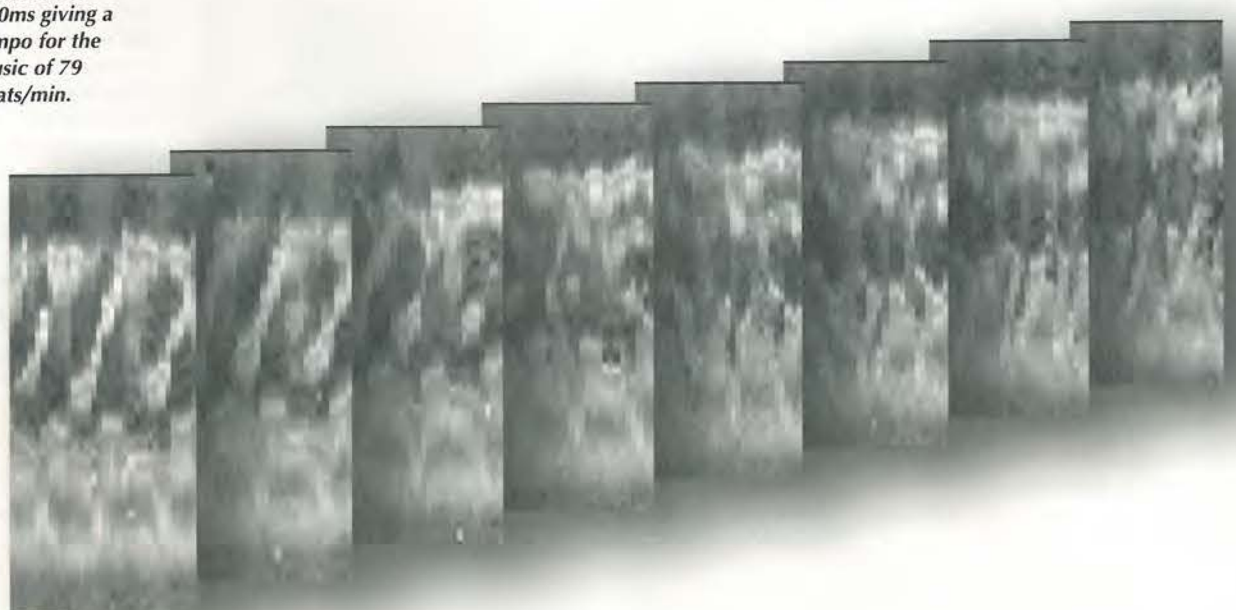


Fig. 9. A sequence of the Paramount Astoria Girls from the vision-only disc. The period between the girls' high kicks is 760ms giving a tempo for the music of 79 beats/min.

more importantly recognise, the events in the studio through the limitations of the system.

Low-definition television becomes more effective the more movement there is. From the "Looking In" disc, the producer, Eustace Robb, understood very well the limitations of the 30-line system and exploited movement to increase its impact.

Indeed, the techniques of lighting, camera work and production were all pioneered on the BBC's 30-line service. This provided essential experience for the BBC production staff and engineers for the introduction of high definition television in 1936.[7]

The first age of tv ends

Developments and demonstrations in electronically scanned television lead to the BBC's 30-line Television Service being stopped in 1935. The viewing public were keen for transmissions to continue, even in parallel with a high-resolution service.

The service closed however on 11 September 1935. Less than a year later, the BBC started its second Television Service in not one but two new incompatible high-definition formats with the very latest in technology.

In its first few months, the new service was far more 'experimental' than its 30-line predecessor.

In summary

For now, the amateur video recording of part of a BBC programme has the accolade of being the earliest-known recording of BBC Television or indeed of any broadcast television service. As you might expect, our unknown viewer was selective about making video recordings on his 'write-once' aluminium discs.

Fortunately, he chose for us the world's first television revue, giving us a marvellous opportunity to share in a historic event. Although he could not have known it at the time, he made the world's oldest time-shifted home video recording in 1933 – not to be seen again for 63 years.

The last word will go to a viewer in London, who, after watching the high-kicking Paramount Astoria Girls in this programme, made this comment on the future of television – "Sound without sight lacks kick".[8]

My thanks to Dave Mason, Eliot Levin, Ray Herbert and Nicholas Moss for helping me make this discovery. ■

References

1. *Television*, January 1934, p. 18.
2. Via the BBC Written Archives Centre at Caversham.
3. Swift J, 'Adventure in Vision', Lehmann, 1950 p. 58. Incorrect reference to Paramount Victoria Girls.
4. Ross G, 'Television Jubilee', W H Allen, 1961 p. 24.
5. Bridgewater, T H, 1986, private communication.
6. *Television*, May 1933, pp. 170-171.
7. Bridgewater, T H, 1983 interviewed by Bruce Norman in 'Here's Looking at You', BBC/RTS, 1984 p. 109.
8. *Television*, May 1933, ibid.

Ultra-fast pulses

Emitter-coupled logic offers sub-nanosecond switching times combined with 50Ω output capability. Nick Wheeler outlines the benefits of these features in relation to pulse-shaping applications. His simple circuit outputs very fast rise and fall time pulses whose width is easily and accurately determined by a length of coaxial cable.

In its January 1996 issue, *Electronics World* published a circuit idea of mine entitled 'Fast, precise pulse generator'. What follows is a development of this. By using some specialised emitter-coupled logic, rather than advanced cmos, I have managed to obtain some very interesting results.

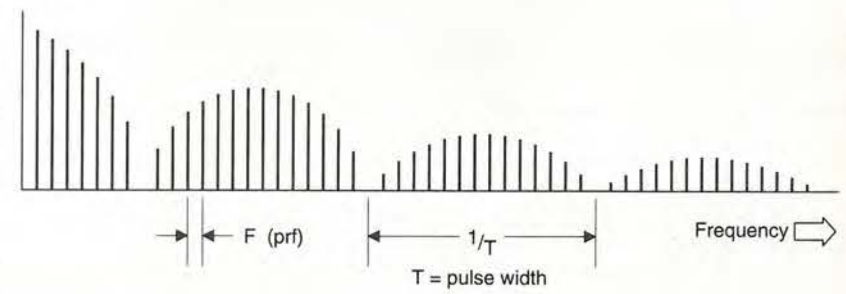


Fig. 1. Theoretical spectrum of a pulse train with pulse width T *and pulse-repetition frequency* F.

Repetitive pulse theory

Mathematical analysis of a series of perfect pulses – i.e. pulses with zero rise and fall times and flat tops – is simple. It is set out in reference 1.

The spectrum is a series of lines separated by the pulse-repetition frequency *F*. The amplitude of these lines fluctuates similarly to a damped cosine wave, passing through maxima and minima separated by frequencies represented by 1/*T*, where *T* is the pulse's duration. I have sketched what one should expect to see on a spectrum analyser at **Fig. 1**.

Emitter-coupled logic, with its sub-nanosecond rise and fall times, produces results which accord closely with theory. **Figure 2**, which was extremely difficult to capture, shows a 180MHz segment of the spectrum. The difficulty in capturing the segment arises from the interaction between pulse width and repetition frequency.

This photo is not perfect but makes the point. It indicates a pulse width of about 5.5ns. My 100MHz oscilloscope responds to this with very small blips, corresponding with the rising edge of the pulse repetition frequency input.

The spectral lines are 11.5MHz apart. The largest-amplitude blip, just right of centre, is a strobe at 310MHz, conveniently provided by the synthesised source described in reference 3.

Implementing an ecl pulse generator

Figure 3 shows the circuit diagram, and **Fig. 4** the pcb artwork. The large features at the top of the artwork are the footprints for two SMA sockets (RS 111-712). The ends of the coaxial cable referred to below connect to these sockets.

The *SY100EL16* differential receiver is manufactured by Synergy Semiconductors. It conditions the sinusoidal pulse-repetition frequency input to ecl levels. Output /Q is grounded through 560Ω. Output Q goes directly to D_1 of the *SY100EL04* And gate and also directly to D_1 of the *SY100EL07* exclusive-or gate.

Output Q also goes to D_0 of the exclusive-or gate gate via a length of 50Ω coaxial cable. The length of this cable determines the pulse width. In the example described here, it was 95cm long.

The traces on the pcb add another 3cm. This amounts to a delay of about 4.7ns. The velocity factor for solid ptfe dielectric is 0.7. There are two transit delays of the order of 250ps in the parts, so it all works according to theory.

The D_0 input to the exclusive-or gate is set at the proper dc level and termination impedance using the Thévenin method. This calls for 81Ω to V_{cc} and 130Ω to ground. I used 100Ω||470Ω and 150Ω||1kΩ standard values for these.

This circuit produces a pulse on the positive-going edge of the prf signal. The And gate prevents another pulse occurring on the negative going transition.

The And gate has an inverted Q output, /Q, so a negative going pulse can be produced if need be.

Finger on the pulse

Apart from the fact that the very high speed of ecl produces

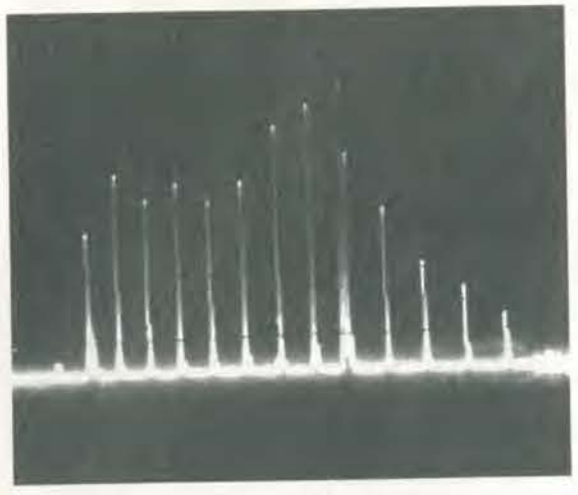


Fig. 2. Partial spectrum of fast pulse train with a pulse-repetition frequency of 11.5MHz and a pulse duration of around 5.5ns.

a nice conformity of practice with theory, the main point of this circuit is the convenience with which pulse length can be determined, since this is by transit time down 50Ω coaxial cable.

Moreover, the spectral lines give an easy way of measuring the pulse width to an accuracy of a few percent, by counting the number between minima. This would be difficult even with an oscilloscope with adequate frequency response.

Separation between the spectral lines can be accurately set to any value, to over 100MHz. The circuit is, in effect, a most useful calibrator for spectrum analysis.

If you need to set the pulse width in a stable, permanent, manner, the coaxial link can be made using semi-rigid cable such as RG405. Ordinary general-purpose SMA-terminated laboratory cables of various lengths can be used to determine approximately the right length.

Another, less flexible, approach might be to establish the delay using a convoluted microstripline . A note on how to implement this appears in reference 2.

It occurs to me that the circuit described could form the modulator for a very short range radar, but I leave experimentation in that area to you. ■

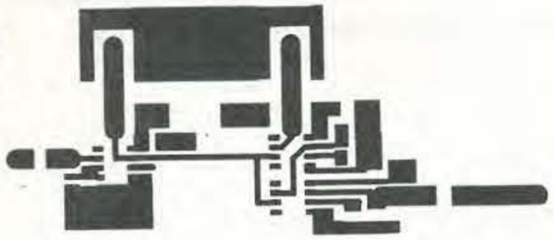


Fig. 4. Circuit layout of the pulse generator. Synergy's number is 0121 7338033.

References

1. Services textbook of Radio. Vol. 7, HMSO 1960, p. 104.
2. Wheeler, N, 'Microstrip made easy,' *Electronics World*, Dec. 1997.
3. Wheeler, N, '50-950MHz signal source,' *Electronics World*, Oct. 1998.

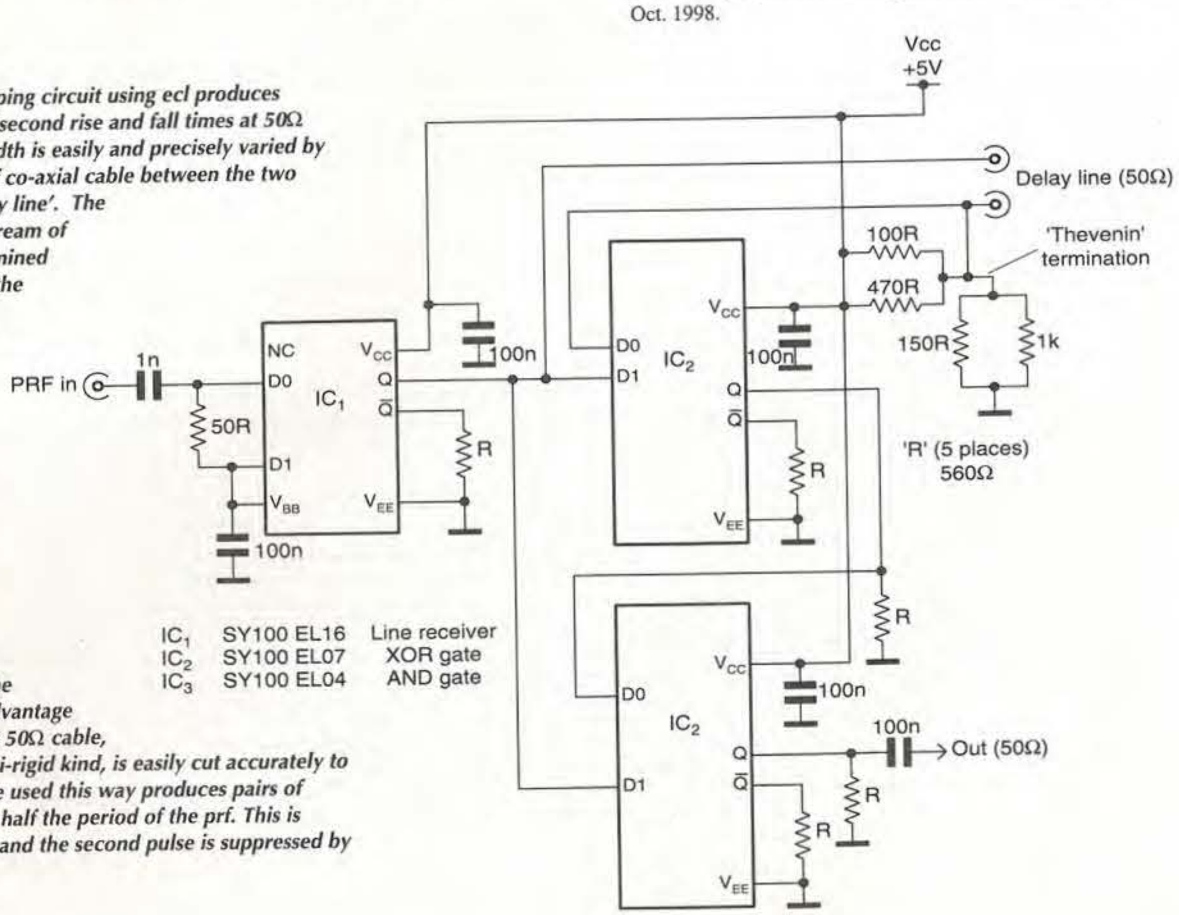
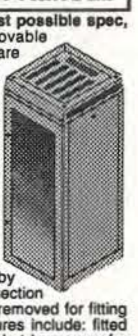


Fig. 3. Fast pulse-shaping circuit using ecl produces pulses with sub-nanosecond rise and fall times at 50Ω impedance. Pulse width is easily and precisely varied by altering the length of co-axial cable between the two points labelled 'Delay line'. The circuit produces a stream of pulses at a prf determined by the frequency of the input to the line receiver. This can be sinusoidal so long as it exceeds 150mV pk-pk. Such a signal is obtainable from most signal generators. The circuit works up to at least 100MHz. Pulse duration is determined by the transit time down the coaxial cable. An advantage of this circuit is that 50Ω cable, particularly the semi-rigid kind, is easily cut accurately to length. An XOR gate used this way produces pairs of pulses separated by half the period of the prf. This is usually undesirable and the second pulse is suppressed by the AND gate.



Notes on ecl

Emitter-coupled logic is inherently very fast and low noise, yet often avoided as it needs a –5.2V supply. But as Nick Wheeler shows here, ecl has moved forward. Nick presents a frequency-doubler design example that runs from a simple 5V rail.

This short article is intended to encourage those of you who regard c-mos as the zenith of logic to consider the remarkable features of modern emitter-coupled logic.

To illustrate the article, I will use Synergy's *SY100EL16V* differential line receiver. Once you understand this part, you will be able to apply all the basic logic building bricks, and more complex parts such as the *SY89430V* programmable synthesiser.[1]

Emitter-coupled logic characteristics

The basic circuit element of ecl is a long-tailed-pair comprising conventional bipolar transistors, **Fig. 1**. The tail is a constant-current source. As a result, the transistors are never driven far into saturation. It is this fact that gives ecl its outstandingly high speed.

Many designers are put off by the apparently odd logic voltage levels of ecl parts, even though they have usable clock rates of hundreds of megahertz, which is undoubtedly attractive.

The long-tailed-pair configuration calls for voltage excursions referenced to the supply voltage V_{CC}. In the early days of ecl, and because of the small excursions involved, the standard was adopted of grounding the positive V_{CC} rail and holding V_{EE} at a nominal –5V. This results in a logic-high voltage of about –900mV and a logic Low of about –1680mV.

The outputs of most ecl parts are differential and can drive 50Ω transmission lines. These must be properly terminated if more than a few centimetres long. Correct dc conditions are achieved by returning the cold ends of the terminating resistors to –2V dc, a rail normally called V_{TT}. Under such conditions successive stages can be dc coupled.

Provided the V_{CC} rail is noise free and reasonably well regulated, a conventional +5V rail can be used, with V_{EE} grounded. This is termed pecl, or positive ecl, and is becoming increasingly common.

Special translator parts are available which interface between ecl and ttl and *vice versa*. Operation in the pecl mode is mandatory for this.

Some ecl parts, including the *SY100EL16V*, are provided with a pin termed V_{BB}. This provides a bias voltage to which the inputs can be referenced for ac coupling or single ended operation.

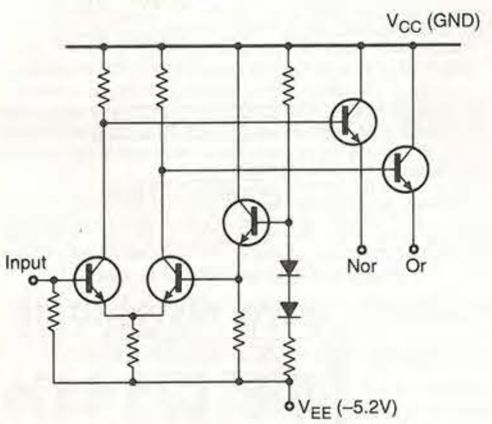


Fig. 1. Basic, traditional ecl gate. Emitter coupled logic is sometimes called current-mode logic. It is fast because, unlike ttl, there's no transistor storage time involved.

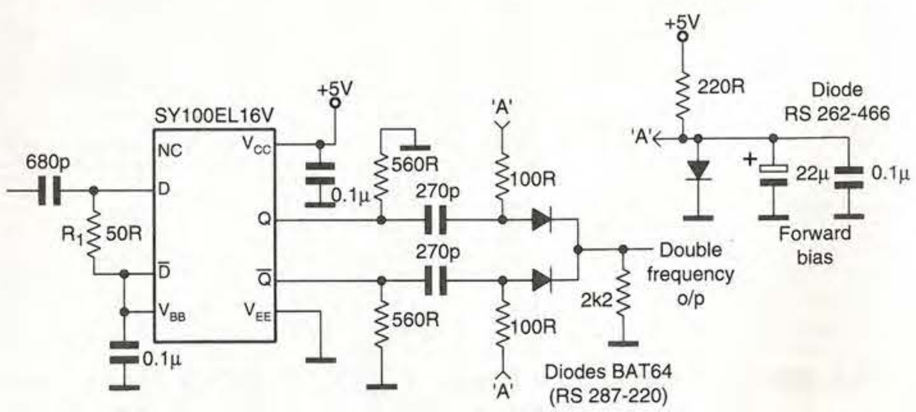


Fig. 2. Frequency doubler made from emitter-coupled logic. This configuration works between 10MHz and at least 250MHz. Input amplitude must be 150mV or more. Output is a good square wave at twice the input frequency.

Using the *SY100EL16V ecl* receiver

The *SY100EL16V* comprises two cascaded long-tailed pairs followed by dual emitter followers with open emitters. These followers need to be returned to a suitable negative voltage. More on this later.

My demonstration circuit diagram is shown in **Fig. 2** while **Fig. 3** illustrates conventional operation at 60MHz. The lower trace in Fig. 3 shows what a good 60MHz square wave looks like on a 100MHz oscilloscope.

A small response at the third harmonic causes the peakiness of the waveform. On a spectrum analyser strong harmonics are detectable up to the 13th.

Output amplitude is virtually independent of the sinusoidal input provided the latter exceeds the specified minimum swing of 150mV. Presence of these high-order harmonics confirms that sub-nanosecond rise and fall times are being achieved.

The circuit diagram illustrates how ecl is driven in ac-coupled, single-ended mode. At the frequencies for which ecl is useful, this will usually be via a 50Ω transmission line. This is terminated properly by R_1.

The dc conditions at the two inputs are set by using V_{BB}. For ecl parts with 100 in their part number, this lies in the range of V_{CC}–1.38 to V_{CC}–1.26 and is thermally compensated. One of the inputs, /D, and V_{BB} are grounded for ac as shown.

There are three possible ways of setting the correct dc conditions at Q and /Q. They are fully discussed in reference 2, but are summarised here for completeness.

Where the distance to the next stage is less than 2cm or so, a matched transmission line is unnecessary. A suitable resistor from each open emitter to V_{EE} is all that is needed to permit emitter-follower action. A value of 510Ω is often quoted, but anything over this and up to 1kΩ works. I used 560Ω.

As I already mentioned, another method, the use of a terminating voltage, V_{TT}, is most easily implemented, when V_{CC} is 5V. The 5V rail can be used to feed a low-dropout 3V regulator such as the *LP3982-3.0* (RS 285-4124). Output swing of ecl parts is usually specified for a 50Ω termination at the Q and /Q outputs. The other end of the termination is returned to V_{cc}–2V. This sets the emitters at the right voltage, i.e. V_{TT}.

Finally there is the Thévenin termination. In a 50Ω system, at the receiving end, an 81Ω resistor goes to V_{CC} and a 130Ω resistor to V_{EE}. In parallel, which these effectively are for signals, they look like 50Ω and at the same time set the correct dc level.

Other uses for the SY100EL16V

Most logic families are characterised by specifying a maximum voltage which is recognised as a logic zero or low input and a minimum which is recognised as high or logic one. Between these thresholds is a region of uncertainty.

Small input excursions around the middle of this uncertain region are, in some cases, linearly reproduced at the output. This is the basis of such circuits as crystal oscillators, which are readily be realised with cmos. I decided to test the *EL16* using the circuit of Fig. 1 with an input well below the specified minimum of 150mV.

A particular attraction of ecl parts with a V_{BB} output is that using this automatically biasses the inputs correctly for this linear mode of operation. I used of 17.5mV pk-pk.

At 60MHz the Q and /Q outputs were a pair of good sinewaves in antiphase. The voltage gain was 37.5, which, allowing for measurement errors, agrees well with the specified dc gain of 40 for this part.

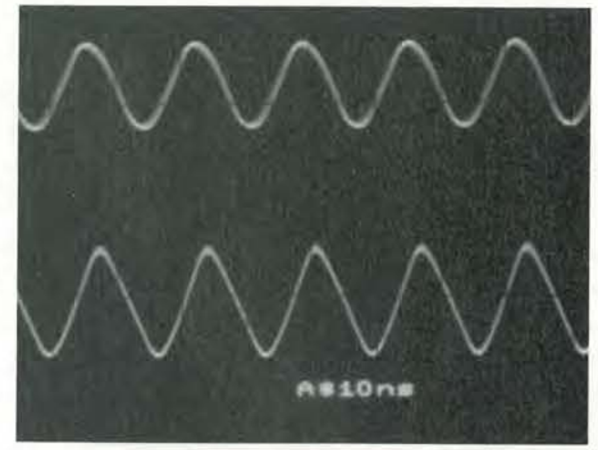


Fig. 3.The lower trace shows what a good 60MHz square wave looks like on a 100MHz oscilloscope. A small response at the third harmonic causes the peakiness of the waveform. The upper trace is a good sinewave at 60MHz and 150mV pk-pk.

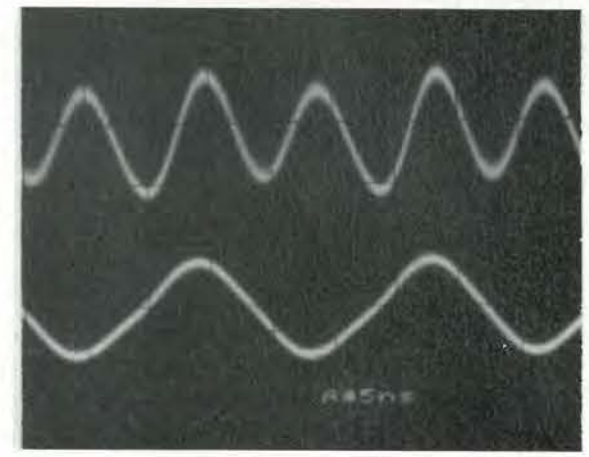


Fig. 4. Frequency doubler output with input at 60MHz, illustrating the effects of differences in stray capacitance.

Since the transistors within the device have frequency responses of the order of a gigahertz, the part can clearly be used as a vhf/uhf phase splitter. There are several applications for such a circuit since it is aperiodic, e.g. as a constant amplitude phase shifter.[3]

Aperiodic frequency doublers all depend, basically, on full-wave rectification. They can be passive, using carefully constructed trifilar transformers, but use of the *EL16* provides a compact alternative.

Figure 4 illustrates this at 60MHz input. At such frequencies the smallest differences in stray capacitance produce the effect shown. The circuit works quite well over a 2:1 frequency range, but the time constants need to be optimised for best results.

Both Q and /Q excursions are about 750mV. These are capacitively coupled to the two Schottky diodes, which have a forward voltage of about 300mV. I biassed these forward by 180mV.

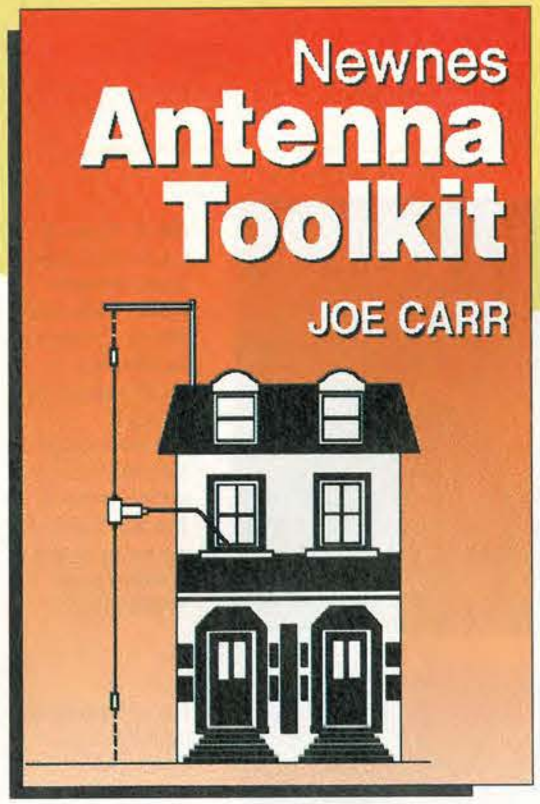
Voltages of this order can be obtained using the forward voltage of a Schottky power rectifier diode. These parts are specially made to keep this figure well below that of the 600mV associated with ordinary diodes. ■

References

1. Wheeler, N, '50-950MHz frequency source', *Electronics World*, Oct. 98.
2. MECL System Design Handbook, Motorola.
3. The Art of Electronics written by Horowitz and Hill, pub. CUP. (Constant amplitude phase shifter, p. 78.)

Technical support

For information on availability of the *SY100EL16*, contact Nic Houslip via nic_houslip@compuserve.com or fax him on 0121 7337772. Prototyping boards for the pulse generator may also be available. Synergy's number is 0121 7338033.



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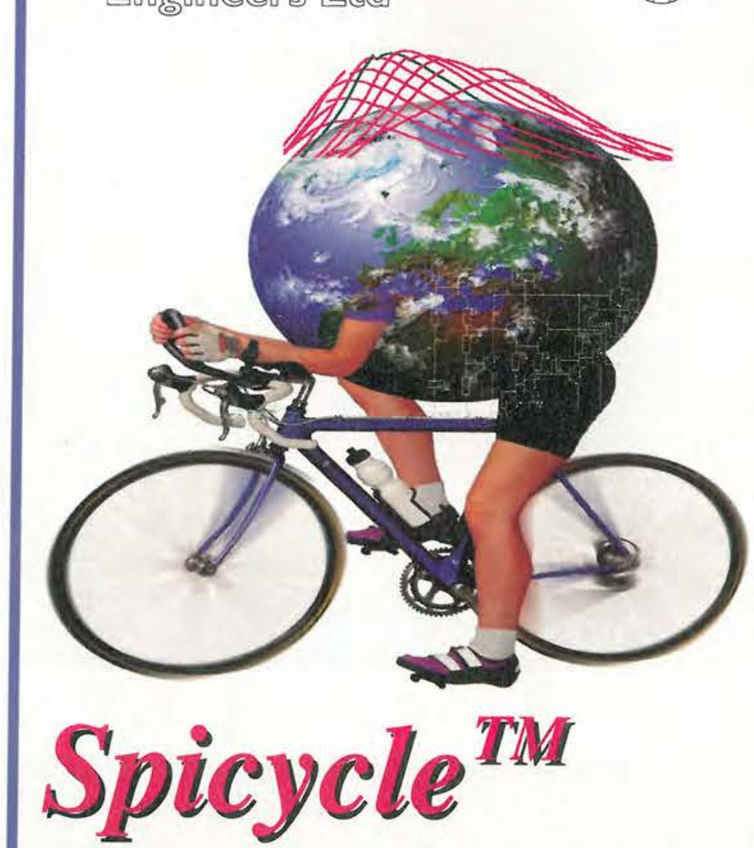

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CIRCLE NO.134 ON REPLY CARD

RMS watt, or not?

When you see a power amplifier advertised as 100 watts rms, what – if anything – does it mean? Lawrence Woolf explains.

I sometimes see the term 'watts rms' used in published text and advertisements. As 'rms' may be correctly applied to voltage and current it seemed worth while to examine the implications and meaning, if any, of applying it to power. This requires a degree of mathematics. Even if you are not interested in the maths, you might still find the summary interesting.

DC power

If you apply a constant dc voltage to a fixed resistor, the current through the resistor and the power dissipated in it are easily calculated using Ohm's law,

$$I = \frac{E}{R} \qquad (1)$$

where E is the applied voltage, or electromotive force, R is the resistance in ohms and I is the load current in amps. For power,

$$W = E \times I \qquad (2)$$

or,

$$W = \frac{E^2}{R} \qquad (3)$$

where W is the power dissipated in watts.

This power may be used in various ways but here we only need to consider that heat is generated. The rise in temperature that results from the power applied will depend on factors such as the power dissipated and the power radiated.

After a period of time a steady state is achieved. At this point, the radiated power balances the applied power and the load stays at a constant temperature somewhere above the ambient temperature.

As an example, a soldering iron takes some time to reach its working temperature and then should maintain it steadily.

AC power

As far as heating the soldering iron is concerned, it does not matter whether the energy applied involves an alternating voltage or a direct voltage. The next task is to define the alternating voltage that will supply the same heating energy as the direct voltage.

The problem is that the alternating voltage voltage is, by definition, constantly varying. If the iron is powered by our mains at a frequency of 50Hz then each repeated sinusoidal cycle takes 20ms which is $^1/_{50}$th of a second, **Fig. 1a)**. At time 0, the voltage is zero but rising.

After 5ms, the voltage reaches its positive peak, which I will call E_P. After a further 5ms, at 10ms, the voltage is back to zero but falling. At 15ms the voltage reaches its negative peak, $-E_P$. At 20ms the voltage is back to zero again and rising again as the sequence is repeated.

During this cycle the voltage has reached a positive peak and a negative peak. It has also been zero three times and has passed through every possible intermediate value twice. Which of these values, if any, could be used as a definitive value?

What is needed is a value that is numerically the same as for the direct voltage that will heat the iron to the same temperature. This is clearly not the peak value as, for most of the time, the magnitude of the voltage is below this.

We need to find a constant that we can multiply the peak value by to give the equivalent heating power of a known dc voltage. The constant seems likely to be less than one. This now raises the problem of also defining the alternating power which is also varying during the cycle.

In Fig. **1b)** the ac voltage waveform is shown together with the power waveform. As the power is proportional to E^2 both the positive and negative voltage peaks correspond to positive power peaks. When the voltage is zero, so is the power.

The resulting waveform is a raised cosine and has a frequency that is twice that of the voltage waveform. The load is assumed to be purely resistive so the power cannot, at any time, have a negative value.

A mathematical description is given by saying that,

$$E_t = E_P \sin(\omega t) \qquad (4)$$

where E_t is the instantaneous voltage at time t, E_P is the peak voltage and ω is the angular frequency in radians per second, i.e. $2\pi f$ where, f is the frequency in hertz.

Lawrence D. Woolf, BA(Hons), BSc, Dip. Math. (Open), GJ3RAX.

By using equations 3 and 4, with appropriate subscripts, the power waveform may be defined,

$$W_t = E_p^2 \times \frac{\sin^2(\omega t)}{R} \quad (5)$$

$$= E_p^2 \times \frac{1-\cos(2\omega t)}{2R} \quad (6)$$

where W_t is the instantaneous power at time t and R is now the resistance of the soldering iron.

Equation 6 shows, by using a standard trigonometric substitution, that the power waveform is indeed a raised cosine at twice the frequency of the voltage waveform.

Figure **1c)** shows that the average value of the power waveform is half the peak value. The waveform is symmetrical about the average power line,

$$W_{AV} = \frac{W_P}{2} \quad (7)$$

where W_{AV} is the average power and W_P is the peak power.

This average power is the heating power provided to the soldering iron and must be equivalent to the original dc power if it causes the iron to operate at the same temperature.

It is now possible to equate the dc and ac powers to derive the required constant to equate equivalent dc and ac voltages. Using equation 3, but with the peak ac values,

$$W_P = \frac{E_P^2}{R} \quad (8)$$

so that,

$$W_{AV} = \frac{E_P^2}{2R} \quad (9)$$

but,

$$W_{AV} = W_{dc} = \frac{E_{EQ}^2}{R} \quad (10)$$

where W_{dc} is the power from the dc source and E_{EQ} is the equivalent direct voltage.

We can now use equations 9 and 10 to find the relationship between the peak alternating voltage, E_P, and the equivalent direct voltage, E_{EQ}.

$$\frac{E_P^2}{2R} = \frac{E_{EQ}^2}{R} \quad (11)$$

This re-arranges to,

$$E_{EQ}^2 = \frac{E_P^2}{2} \quad \text{so that,} \quad E_{EQ} = \frac{E_P}{\sqrt{2}}$$

or

$$E_{EQ} \approx E_P \times 0.707$$

We now have our conversion factor that gives us the equivalent direct voltage that will produce the same heating effect as an alternating voltage, of known peak value, in a constant resistive load. This equivalent voltage is more commonly known as the rms voltage or E_{RMS} which now needs to be defined.

Root-mean-square

I have now stated that when an alternating voltage is applied to a resistive load it will have the same heating effect, in that load, as a direct voltage whose value is numerically the same as the rms value of the alternating voltage. I will next explain rms, and how to calculate it.

RMS is the abbreviation for root-mean-square. It is used in statistics as well as physics so is a useful concept. In order to apply it to a given waveform, such as a sine wave, rms can be considered in stages.

- Divide the waveform into narrow vertical slices, one is shown in Fig **1d)**. Each slice is narrow enough to consider it as having a single amplitude value.
- Square each value.
- Sum the values then divide the sum by the number of slices. You now have the mean of the squares.
- Finally, take the square root. This gives the square root of the mean of the squares of the sliced waveform.

The equation used in statistics is,

$$RMS\ value = \sqrt{\frac{(x_1^2 + x_2^2 + x_3^2 ... x_n^2)}{n}} \quad (12)$$

where x is the size of each slice or sample and n is the number of slices.

As we are considering a repetitive waveform that is easily defined mathematically there is a simpler way of performing the calculation. At least it is simpler for those of us who are familiar with integral calculus. The appropriate form of the equation is given by,

$$E_{RMS} = E_P \sqrt{\frac{1}{T}\int_0^T \sin^2(\omega t)dt} \quad (13)$$

where

T is the time period under consideration.

The time period could be any that defines the symmetry of the waveform. For a sine wave just a quarter cycle is adequate as the following quarter cycles may be shown to be rotations or reflections of the first one. Therefore a suitable value for T is $\pi/2$, although the same result is achieved using π or 2π.

In order to solve equation 13 we can put in this value and use the same trigonometric substitution used in equation 6.

$$E_{RMS} = E_P \sqrt{\frac{2}{\pi}\int_0^{\frac{\pi}{2}} \frac{1}{2}(1-\cos(2\omega t))dt} \quad (14)$$

$$= E_P \sqrt{\frac{2}{\pi}\left[\frac{1}{2}\left(t - \frac{1}{2}\sin(2\omega t)\right)\right]_0^{\frac{\pi}{2}}}$$

$$= E_P \sqrt{\frac{1}{\pi}\left[\left(\frac{\pi}{2} - \frac{1}{2}\sin(\omega\pi)\right) - \left(0 - \frac{1}{2}\sin(0)\right)\right]}$$

$$= E_P \sqrt{\frac{1}{\pi} \times \frac{\pi}{2}} = \frac{E_P}{\sqrt{2}} \approx E_P \times 0.707$$

This is the same result as found in equation 11. Previously it was found by considering the symmetry of a sine wave. This result has been derived using the definition of rms and may be applied to any waveform.

A true-rms voltmeter displays the rms value even if the waveform is not a sine wave. However most ac voltmeters actually measure the peak value and are scaled to divide by $\sqrt{2}$ even if the waveform is not a sine wave. Exactly the same argument applies to defining rms current as voltage.

But rms *power?*

Suppose we now apply the same calculation to the power function as we have done to the voltage function. We have found the ratio of E_P to E_{RMS} so we should be able to find the ratio of W_P to W_{RMS}.

Where we had to integrate a function involving $\sin^2(\omega t)$, we now have to integrate a function involving $\sin^4(\omega t)$. This is a little more complicated but there are standard trigonometric substitutions available that make the expression easier to handle.

Start by assuming that there is a meaningful relationship between W_{RMS} and W_P. From equations 5 and 8, $W_t = E_P^2 \sin^2(\omega t)/R = W_P \sin^2(\omega t)$. This leads to the assumption that,

$$W_{RMS} = W_P \sqrt{\frac{1}{T}\int_0^T \sin^4(\omega t)dt} \quad (15)$$

Again I am taking T as $\pi/2$. Using the same substitution as in equation 6,

$$\sin^2(\omega t) = \frac{1}{2}(1-\cos(2\omega t))$$

therefore,

$$\sin^4(\omega t) = \frac{1}{4}\left(1 - 2\cos(2\omega t) + \cos^2(2\omega t)\right)$$

also,

$$\cos^2(2\omega t) = \frac{1}{2}(1+\cos(4\omega t))$$

so that,

$$\sin^4(\omega t) = \frac{1}{4}\left(1 - 2\cos(2\omega t) + \frac{1}{2}(1+\cos(4\omega t))\right)$$

$$= \frac{3}{8} - \frac{1}{2}\cos(2\omega t) + \frac{1}{8}\cos(4\omega t)$$

Substituting in equation 15 now gives,

$$W_{RMS} = W_P \sqrt{\frac{2}{\pi}\int_0^{\frac{\pi}{2}}\left(\frac{3}{8} - \frac{1}{2}\cos(2\omega t) + \frac{1}{8}\cos(4\omega t)\right)dt}$$

$$= W_P \sqrt{\frac{2}{\pi}\left[\frac{3t}{8} - \frac{1}{4}\sin(2\omega t) + \frac{1}{32}\sin(4\omega t)\right]_0^{\frac{\pi}{2}}}$$

$$= W_P \sqrt{\frac{2}{\pi}\left(\frac{3\pi}{16}\right)} = W_P \sqrt{\frac{3}{8}} \approx W_P \times 0.612$$

but from equation 7, $W_{AV} = W_P/2$ or $W_P = 2W_{AV}$. This means that $W_{RMS} \approx W_{AV} \times 1.225$.

In summary

The implication of all this is that a transmitter that puts out 100W average power might also be said to have an output of 122.5W rms. This is hardly the same thing and would seem to have no practical or physical significance. It is merely a mathematical curiosity.

Alternatively one might assume that if someone claims an output of 100W rms then they are actually transmitting 81.63W average. The fact that it can be calculated does not, in itself, imply that it could be useful.

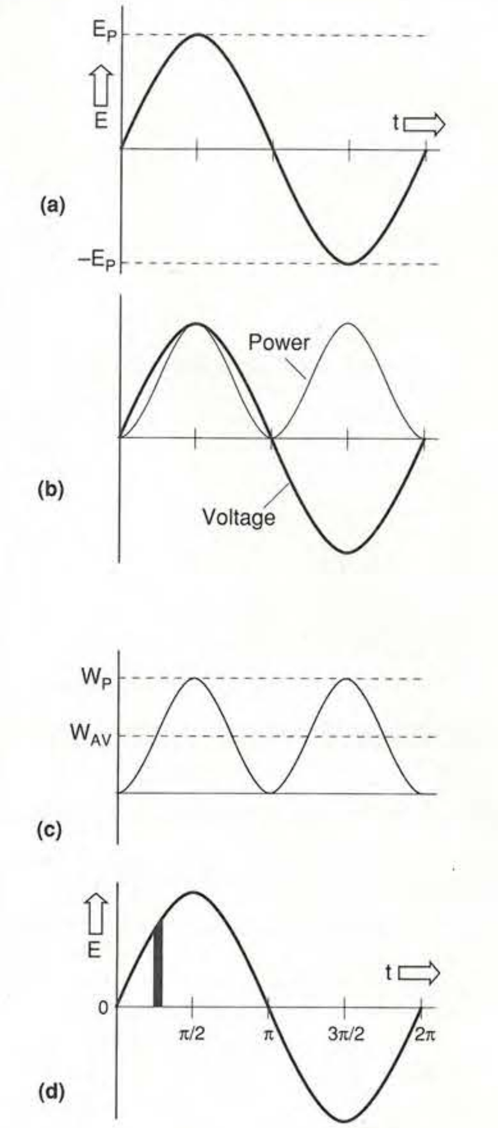

Fig. 1. 50Hz sine wave, a), voltage and power waveforms, b), power waveforms showing peak and average, c) and a sine wave with narrow slice, d).

The only useful result is that the product of rms voltage and rms current is average power. It is not rms power – even if it looks like a logical expectation. This is the same for mains frequency power, audio power and radio frequency power.

I suspect that those that use the term probably mean 'average power under continuous sine wave'. In this case a term such as 'continuous average power' would seem more appropriate, especially if an unregulated power supply is used.

If anyone knows of a genuine reason for using the term 'watts rms' then please let me know (*lawrence@itl.net*). ■

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HP8642M 0.1-2100MHz £12500.00
HP8657A 0.1-1040MHz £3500.00
HP8684B 5.4-12.5GHz £1950.00
Marconi 2019A 80KHz-1040MHz £1450.00
Marconi 2022 10KHz-1GHz £900.00
Marconi 6057 Signal Source 5.5-8.5GHz £200.00
Marconi 6059A 12-18GHz Signal Source £200.00
Racal 9053 Two Tone £120.00
Systron Donner 1702 Audio-1GHz £600.00
Tektronix 504 0.001-240MHz £350.00
Tektronix FG501A 2MHz Function £250.00
Wavetek 1080 1-1000MHz Sweeper £800.00
Wavetek 157 Programmable Waveform £150.00
Wavetek 159 Waveform Generator 1Hz-3MHz £300.00
Wavetek 171 Synthesizer/Function £400.00
Wavetek 185 Sweeper/Function 0-5MHz £350.00
Wavetek 2001 1-1400MHz £600.00
Wavetek 907A 7-12.4GHz £900.00
Wiltron 610D + 6223B Sweeper 4-12.4GHz £500.00
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MISCELLANEOUS

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PDA6424 Photo Diode Amplifier
LDX3742 Laser Diode Controller
LDX3207B Precision Current Source
Anritsu MW920A OTDR + MH951A 850Nm Plug-in + MH952A 1300nM Plug-in
3M Fibre Splice Preparation Kit
Cossor Optical Cable Fault Locator Type: OFL108L
Laser Precision Type: DB2900 Single Mode Variable Attenuator
Schlumberger Type: S17780 OTDR + S177823 Plug-in
Solomat MPM4000 Matrix Processor c/w Software. Portable multichannel, datalogger, alarm monitor. Battery/Mains Operated Kane-May: KM4003 Air Velocity 0-30 in metres/seconds Air Temperature (C) –30 to +200C. Battery Operated.
Portaflow MK11: Portable diagonal beam flowmeter. Made by: Micronics
Bacharach: Combustion Analyzer/Environmental monitor Type: 300NSX Kane-May Combustion Analyzer Type: 9004
Kane-May: Temperature Sensor Type: 1204 c/w 8004 Temperature & humidity sensor. GGA-26 Thermo-Anemometer + KM801 Infratrace
Casella: Aerosol Monitoring System Type: AMS950 Ranges: 0-20mg/m 0-200mg/m
CEL Instruments: Precision Intergrating Impulse Meter Type: CEL 493 c/w: CEL 296 Octave & third octave scan filter set + CEL 284/2 Calibrator
Hoffmann SWM3 Flow Meter
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The test & measurement specialists

Vann Draper has announced that it has signed an agreement with **Grundig Test and Measuring Systems** of Germany to represent their complete product line.
The Grundig range covers three main areas –

Laboratory Measuring Instruments including oscilloscopes, power supplies, function generators, arbitrary function generators, audio signal generators, frequency counters, LF and RF millivolt meters, bench multimeters and RCL meters with a strong emphasis on RS232 and IEEE interfaces.

Video Measuring Instruments including PALplus studio encoders/decoders and PAL/PALplus/NICAM signal generators.

Antenna Measuring Instruments including combination measuring receivers for terrestrial/satellite analogue and digital transmissions.

Brief details and prices (including free delivery) of just some of the products in the Laboratory Measuring Instruments range are shown here. All units with RS232 are available with optional Labview s/w for £45.00 ex vat, inc del.

DM100 4.5 digit multimeter £349 ex vat, inc del
The multimeter features 0.05% accuracy, a 16 digit alphanumeric back lit display, microprocessor self test and RS232 interface.

FG100 20MHz function gen £495 ex vat, inc del
The function generator (synthesiser) operates over the range 0.5Hz to 20MHz and features a 2 x 16 digit alphanumeric back lit display, microprocessor self test and RS232 interface.

MO30 30MHz oscillosacope £399 ex vat, inc del
The oscilloscope features 2 channels, a 3dB bandwidth of 30MHz, 2kV accelerating voltage, 8X10cm screen, and X/Y modes. The vertical sensitivity is 5mV to 20V/div in 1-2-5 sequence and the time base covers the range 0.5us to 200ms also in 1-2-5 sequence

RLC100 RCL meter £329 ex vat, inc del
The meter features 0.5% accuracy, 4 line measurement, 16 digit alphanumeric back lit display, microprocessor self test and RS232 interface.

Vann Draper Electronics Ltd at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL. Tel: 0116 2771400 Fax: 0116 2773945
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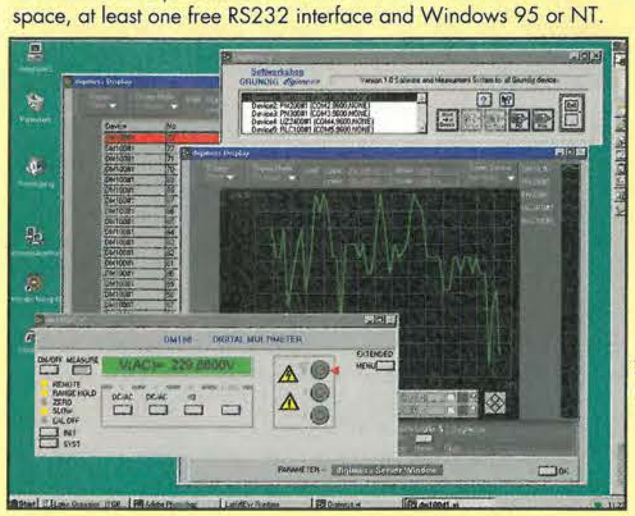
Soft workshop – windows 95/NT £209 ex vat, inc del
The Soft workshop contains a host of features allowing automated measurements from individual instruments running as virtual instruments within the PC environment.
The minimum requirements are a 486DX with 15MB free hard disk space, at least one free RS232 interface and Windows 95 or NT.



SC600 System controller £335 ex vat, inc del
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UZ2400 2.4GHz frequency counter £329 ex vat, inc del
The frequency counter covers the range 10Hz to 2.4GHz and features a 16 digit alphanumeric back lit display, microprocessor self test and RS232 interface.

Flying comms links take off

Iridium and GlobalStar are well known in the wireless communications field as they try to establish a network of low earth orbit communications satellites. But Angel Communications are hoping to leapfrog the big boys by putting wireless datacomms equipment into an airplane. Tom Foremski reports.

In the race to provide low priced, wireless broadband data communications, US firm Angel Technologies stands out from other approaches with a novel solution based on high flying planes.

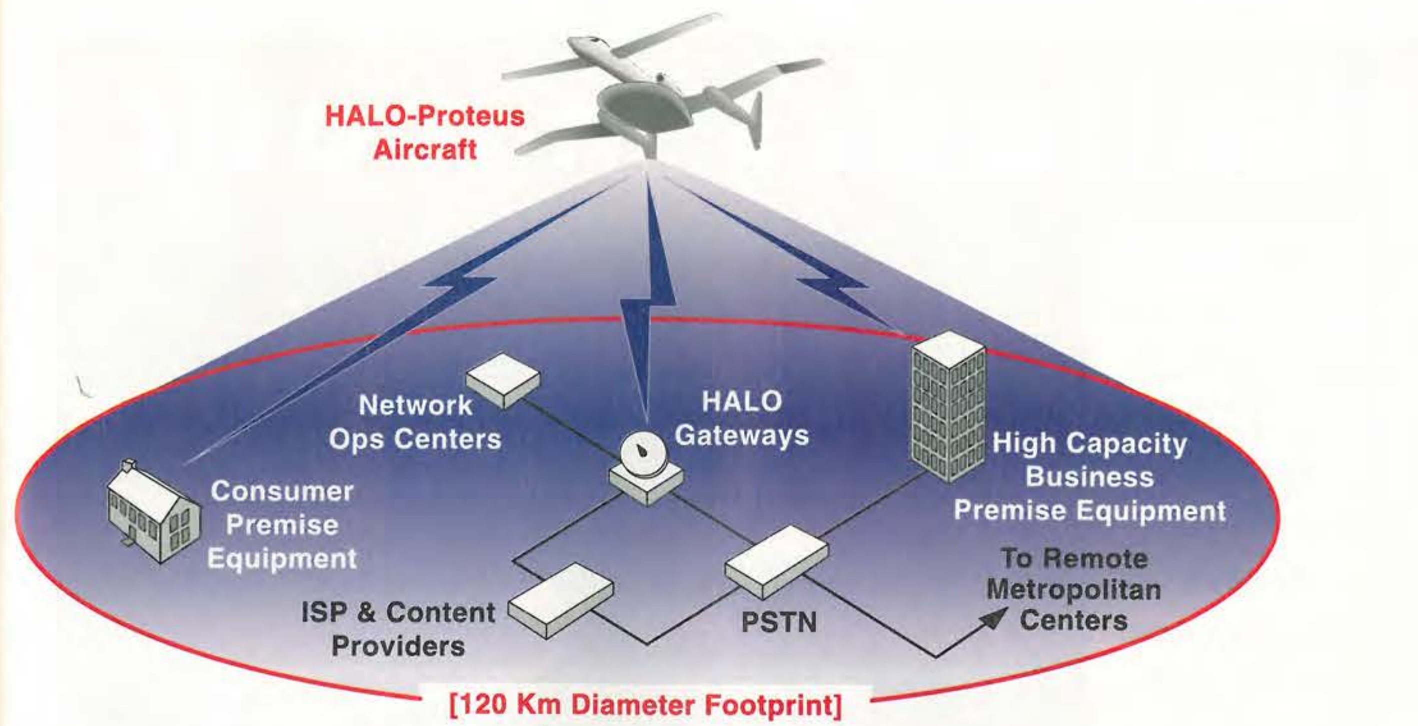
While competitors such as Iridium, and GlobalStar are trying to establish a network of hundreds of low Earth orbit, or LEO, satellites, Angel plans to launch what it terms 'atmospheric satellites' above metropolitan areas around the globe.

By packing wireless data communications equipment into an airplane rather than a satellite, Angel believes its can offer cheaper and better services than satellite-based systems. The plane would fly in about a 30km diameter circle above a metropolitan area offering line of sight communications.

But finding a plane that can carry a payload of about a ton of communications equipment with 30kW of electrical power and fly relatively slowly to conserve fuel, while reaching an altitude of about 16km, well above commercial air traffic, was not easy explains Angel CEO Marc Arnold.

The company eventually found what it needed, the Proteus airplane, an unusual looking craft, 17m with a 28m wing span and a shorter forward wing manufactured by Wyman-Gordon and Raytheon Systems. Designed by Burt Rutan, Proteus is similar to Rutan's famous Voyager aircraft, the first to circle the earth without refuelling. Using Proteus, Angel will build what it calls the High Altitude Long Operation (HALO) network.

Because of the shorter distance from Earth to sky, in this case about 16km compared with more than 600km for low earth orbit satellites, there is less transmission delay and it is less costly than launching satellites. In addition LEO satellite networks have to be constantly replenished with satellites since the slight bit of atmosphere at those altitudes eventually brings down the satellites. This is not to say that a Proteus can stay up indefinitely of course.



The organisation is setting ambitious targets for system capability. "With the HALO network, we start off with 10Gbit/s data capability, and can offer much higher data densities per square mile than satellites," says Arnold. "In addition, it's easy for us to update the communications equipment as we need, eventually offering as much as 200Gbit/s."

Using the stratosphere for a communications platform is not entirely new. The US venture Sky Station International is proposing a similar idea, but using large blimps carrying telecommunications gear. Operating in the stratosphere, the blimp platforms would relay data traffic in a similar plan to that of Angel's HALO planes.

"We share the same view with Sky Station, that the stratosphere is the best place for locating communications systems. But it will be a challenge for Sky Station to receive the regulatory approval from the FAA (Federal Aviation Administration) for their unmanned vehicles. With the HALO planes, we are using FAA approved systems so there are no regulatory hurdles," says Arnold.

The HALO network also avoids regulatory problems on the ground. Terrestrial wireless data networks need to negotiate a complex and lengthy permit process to establish antennas and relay stations. In addition, increasing numbers of US neighbourhoods are becoming more resistant to allowing a proliferation of antennas on hills and tall buildings.

The first inaugural flight of a HALO plane took place in mid-September. A HALO-Proteus plane, its belly bristling with communications gear, took off from an airstrip in the California Mojave desert, and reached an altitude of 10km. It then proceeded to test out various ariel manoeuvres and its communications equipment. The plane passed all tests with flying colours.

"The plane performed flawlessly. It can climb at 1.2km/min, handles beautifully and takes off and lands easily. It is remarkably stable," said chief test pilot Mike Melvill. "We couldn't be more pleased."

The communications equipment also performed well. Angel demonstrated a 52Mbit/s wireless data link with the ground and more than1.5Tbit of data were transported during the eight hour test flight.

Angel is so pleased with the performance of the HALO Proteus planes that he has signed an agreement with manufacturer Wyman-Gordon for exclusive rights to the plane for communications applications and options for 100 aircraft in a deal worth about $760m.

"Making sure that the HALO-Proteus planes can do the job was an important part of reducing the risk in the venture. We can now concentrate on rolling out the system and raising additional financing," said Arnold.

Angel plans to use the best line-of-sight wireless data technologies available. Currently, that would mean microwave Local Multipoint Distribution Service, or LMDS, systems operating in the 20GHz and 24GHz bands. It is currently negotiating for spectrum licenses and is talking with potential investors interested in its first HALO network which will be for the Los Angeles metropolitan area, with a goal to begin services in 2000. That first HALO network will cost about $250m but additional metropolitan areas will cost under $100m.

Angel has plans to roll out similar services in 30 US metropolitan areas and also in overseas locations. But will a communications system based on aircraft succeed, especially since weather conditions regularly ground aircraft?

Angel has it all figured out. "Flying at 52 000 feet [16km] we are above most weather conditions, including hurricanes. And if we cannot take off or land from our primary airport, we use secondary locations. Even large weather systems are only a couple of hundred miles wide, which is nothing for the range of our HALO planes," points out Arnold.

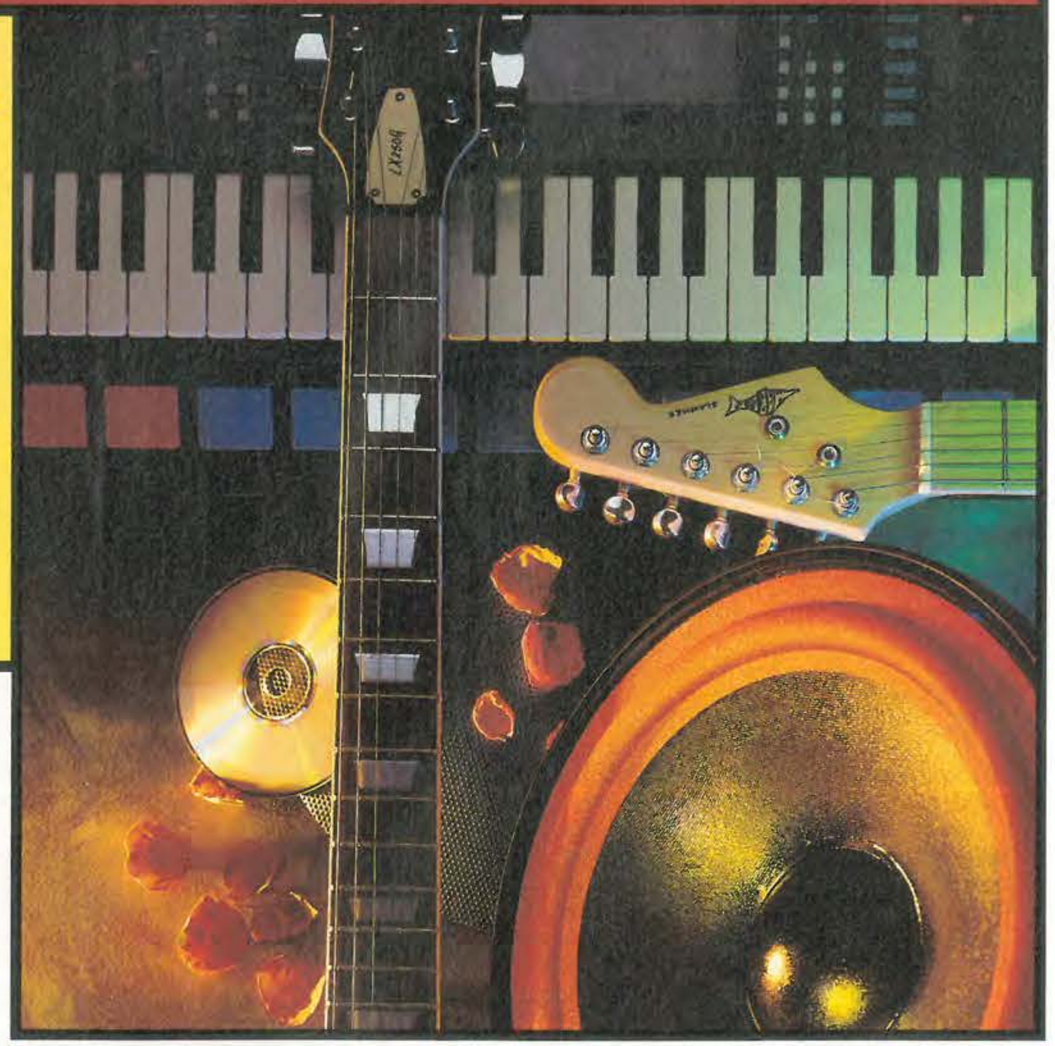
Angel claims that its communications technology can easily handle interference caused by rain attenuation and that alongside a ground network, it can provide the reliability customers need.

The goal is to have three HALO planes for each metropolitan area, with three shifts of a two person pilot crew. The pilots will handle the take-off and landing but once they reach cruising altitude, an autopilot will hold the plane in a gentle circular flight pattern.

"One pilot can snooze while the other monitors the craft and communications gear," says Arnold. "Plus, they'll have the fastest Internet access on the planet." ■

Electronics in music

From the Theremin to the electric guitar: Richard Brice looks at instruments that involve electronics and discusses their uses in modern music.



The invention of the microphone, the loudspeaker and the electronic valve amplifier, brought about a revolution in the art of music making. For several centuries preceding our own, a firm distinction may be made between large-scale music making and music for intimate entertainment; or chamber music.

The ability to amplify instruments and solo voices meant that for the first time 'chamber-music' could become a large-scale musical activity. As I researched and wrote the book[1] 'Music Engineering,' I became convinced that the cultural revolution of rock-and-roll – and later rock music – is as much about how the music is made as it is about its sociological and musicological roots.

For the first time in history, and due solely to the progress in electronics, the world-view of a few young men – in those days it was just men – could capture the hearts and minds of hundreds, thousands of young people. And with the intervention of radio, the numbers increased to millions. Little wonder it is then that the establishment has always had an uneasy relationship with rock music!

Technologically a stone's-throw from the early microphones is that icon of rock-and-roll rebellion, the electric guitar. From Scotty Moore's chiming lead guitar on the early Elvis records to Hendrix's angst-ridden, tortured performances, no other instrument characterises the octane-charged sound of rock-and-roll better than the electric guitar.

So it is with this symbolic, and seminal musical voice that we begin our look at electric instruments.

Electric guitars

A modern electric guitar is illustrated in **Fig. 1**. The earliest electric guitars were created by attaching a contact microphone to the top sound-board of a conventional acoustic guitar, the resulting signal being fed to an external amplifier.

The modern electric guitar was born with the invention of the electro-magnetic pick-up and a typical arrangement is illustrated, diagramatically, in **Fig. 2**. In principle, all electric guitar pick-ups are formed this way; with a coil wound on a permanent bar-magnet former.

The magnet is arranged so that it points with one pole towards the string and with the opposing pole, away from the string. As the string is excited by the player, and moves in close proximity to the magnetic circuit, the flux in the circuit is disturbed and hence a small electric current is induced in the coil.

Early pick-ups used a single magnet for all the strings but later models used separate magnets, or separate pole pieces at different heights relative to the strings. This allowed compensation for the different sensitivity of the pick-up in relation to each of the guitar's six open strings.

Pick-up problems

Guitar pick-up coils contain very many – often several thousand – turns of fine-gauge wire and are thus very sensitive to minute string movements. Unfortunately, this also renders them very sensitive to electromagnetic interference. They are especially sensitive to induced hum due to magnetic fields emanating from the large transformers that find their way into the power supplies of guitar amplifiers.

To counter this, Gibson introduced the Humbucker pick-up. This comprises two magnets and two coils wound electrically in series but arranged in magnetic opposition, **Fig. 3**. The vibrating string will, of course, create a similar signal in both these coils, and these will add due to the series connection. But an external field will induce a signal of opposite phase in either coil. These fields will cancel due to the series connection.

Most guitars are fitted with a number of pick-ups and furnished with a selector switch to allow players to choose their favoured sound. Pick-ups nearest the bridge tend to sound more 'trebly' and bright. Those nearest the fingerboard have a more 'bassy' sound.

Because players like to have a local control over amplification level and tone-colour, all guitars provide volume and tone controls on the guitar itself. The pick-ups themselves have a relatively high output impedance, so it is necessary that they work into a very high impedance source. For this reason, most guitar volume potentiometers are very high value; perhaps 250 or 500kΩ.

Similarly, tone control circuits operate at very high impedance. As you may have already guessed, because of this, the action of the guitar cable itself – as well as the amplifier input impedance – all have a marked effect on the overall sound of an electric guitar set-up. This situation has helped fuel the enormous mythology which surrounds electric guitars, pick-ups and their associated amplifiers.

The circuit schematic for the internal circuitry of the famous Fender Stratocaster guitar is drawn in **Fig. 4**.

Hammond and Compton organs

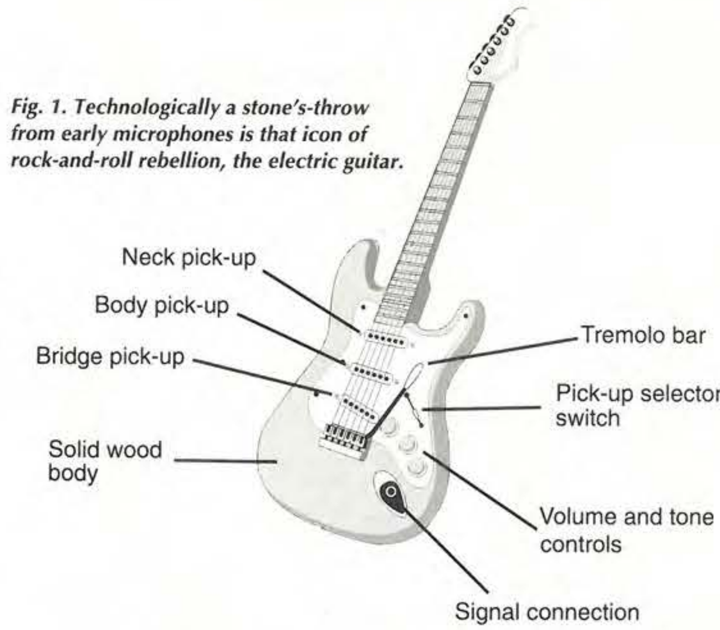
At first, electronic organs sought only to emulate the tone of the acoustic organ – a feat which is now so well accomplished that only experts can tell if the organ in a church is electronic or the acoustic original.

But it wasn't long before the designers of these electronic instruments began experimenting with harmonic combinations. The increased flexibility of electronic coupling relative to the traditional mechanical coupling made such experimentation easy. Just such an ambition led to the development of the classic Hammond B3 organ.

The B3, **Fig. 5**, was developed before solid state electronics became widely available. Its designers wisely forewent the use of electronic oscillators to produce the fundamental sine tones. Instead they opted for an electro-mechanical scheme whereby rotating mechanical discs with shaped edges influenced the magnetic field of electromagnets wound near the edge of the disc. The principle, illustrated in **Fig. 6**, is thus a variable reluctance electro-mechanical oscillator and is pretty well unique.

Other manufacturers displayed equal lateral thinking. Compton used rotary tone generators too, but these operated by means of a variable capacitance technique. Identical electromechanical components were used for each note of the scale, the different pitches being achieved by the choice of pulley ratio used to drive the tone generators form a common mechanical drive.

Fig. 1. Technologically a stone's-throw from early microphones is that icon of rock-and-roll rebellion, the electric guitar.



Hammond's ambitions went far beyond that of reproducing a pipe organ sound. Instead the company aimed at recreating the sounds of other instruments. Hammond's additive synthesis technique involved analysing real instrumental sounds – using a Fourier analyser. These sounds were recreated by selecting and adding sine waves generated from the continuous oscillator 'bank'.

Fascinatingly, it is fair to say that Hammond almost totally failed to achieve what it set out to do with the Hammond organ – that is, to simulate the sounds of other instruments. But they did create a 'classic' sound in its own right.

Theremin

One of the earliest electronic instruments, from around 1920, is the Theremin. This is a monophonic melodic instrument originally developed in Russia by Leon Theremin.[2]

The Theremin player does not touch the instrument and

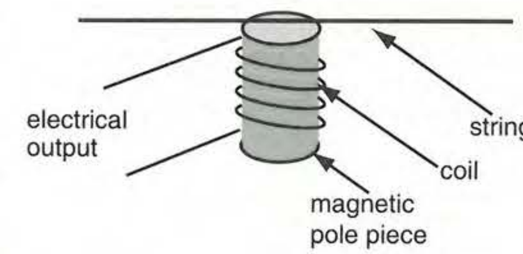


Fig. 2. Electro-magnetic guitar pick-up involves a coil wound on a permanent bar-magnet former. One pole points towards the string. As the string moves, flux is disturbed and a small electric current is induced in the coil.

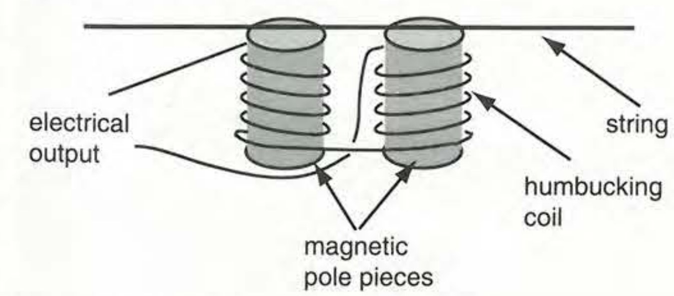


Fig. 3. Since guitar pick-up coils contain sometimes thousands of turns, they are sensitive to electromagnetic interference. This arrangement cancels unwanted fields.

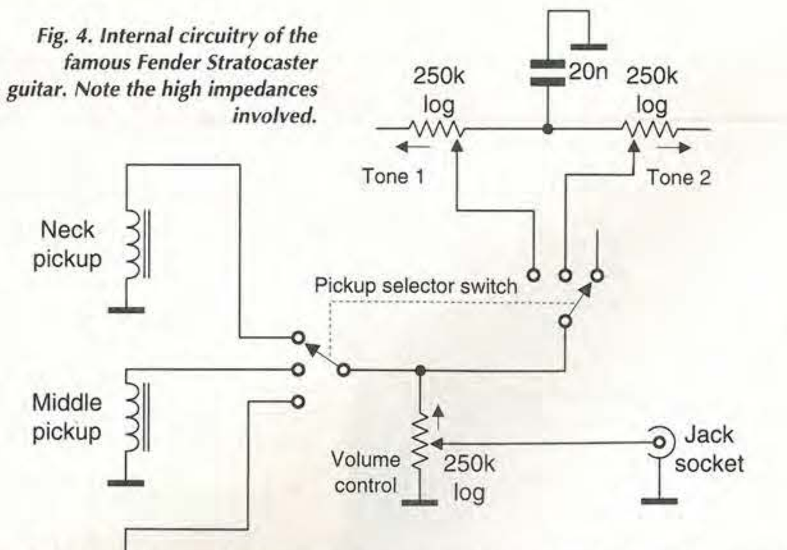


Fig. 4. Internal circuitry of the famous Fender Stratocaster guitar. Note the high impedances involved.

has only to bring a hand within a small distance of a special aerial to control its pitch. In this way, the Theremin is able to produce an endless range of frequencies from the subsonic to the inaudibly high in long sustained glissandi.

Despite being very difficult to play, the Theremin has achieved limited artistic success. It may be heard in several orchestral pieces and has been used on many film and early tv soundtracks. Furthermore the Theremin remains the emblem of experimental electronic music. It enjoys this status because it is one of the very few instruments designed in historical memory to employ a truly novel playing technique.

The operation of the Theremin is illustrated in schematic form in **Fig. 7**. Notice that the instrument contains three radio frequency generators operating in the hundreds of kilohertz region. Radio-frequency oscillators 1 and 2 are pre-tuned to exactly the same frequency.

Clearly, the resulting output from the non-linear circuit, i.e. the rf mixer, will be the sum and difference signal; the sum is subsequently filtered, leaving the difference signal alone to be passed on to the following amplifier stage.

Oscillator 1 differs from oscillator 2 with the addition of the extra tuning capacitance, across the main resonant circuit, formed by the metal aerial and its interaction with ground. The player has only to bring a hand within a small distance of the aerial for there to be a change in oscillation frequency and a resultant audible tone issuing from the process of multiplication.

The nearer the player gets to the plate, the more depressed the oscillation frequency of oscillator 1 and the higher the resultant pitch of the Theremin's audio frequency output.

The expressive potential of such a system is inevitably limited, hence the addition of the third oscillator and its associated circuitry. This third rf circuit produces a tuneable output, once again variable by means of the interaction of the player's anatomy in proximity to another metal aerial or wand.

But this oscillator does not interact with another oscillator, instead its output is fed to a resonant circuit, tuned to the lower end of the variable oscillator's range. As the player approaches the aerial, the generated frequency drops and the output across the resonant filter rises. Suitably rectified, this signal becomes a control voltage which is employed to alter the gain of the final audio stage.

The complete instrument thus has the ability to change pitch and volume and thereby produce articulate musical phrases. It is generally played with two hands; one to adjust the pitch, the other to adjust the intensity.

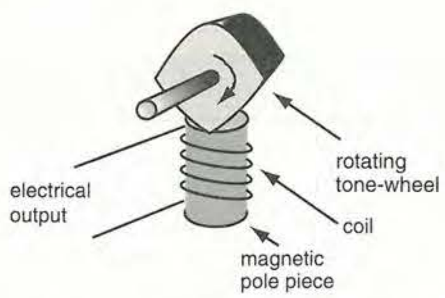


Fig. 6. The Hammond B3 incorporates many rotating cams whose lobes influence a magnetic field.

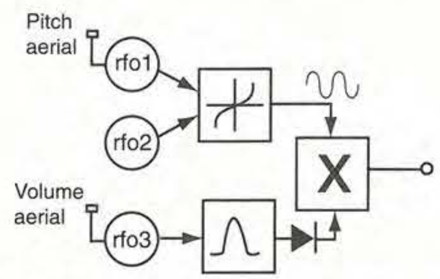


Fig. 7. The Theremin contains three rf generators. Oscillators 1 and 2 are pre-tuned to exactly the same frequency. The third oscillator varies output amplitude.

Fig. 5. Developed before solid-state electronics, Hammond's B3 organ has no oscillators. It uses electromechanics instead.

Electric pianos

The most famous electric piano is, without doubt, the Fender Rhodes. This – and its many imitators – is actually more of an electronic Glockenspiel, or Vibraphone, than an electronic piano because the sound producing mechanism is formed from struck metal bars. The hammers striking the bars are actuated via a conventional keyboard mechanism.

Fender's Rhodes Piano dates from the early forties when Harold Rhodes, an American serviceman, built a 'baby Piano' in which metal rods were struck directly by the wooden keys themselves. It was an immediate success with the servicemen, for whom it was built to entertain, and hundreds were constructed.

Later on, an adaptation of the electric guitar type pickup was added so that the piano could be amplified. It was this unit that attracted the attention of guitar maker Leo Fender and thus the Fender Rhodes, as we know it today, was born.

The operation of a Rhodes is simple. The wooden key activates a hammer via a cam. When the key is depressed, the dampers are lifted above the sounding bars which are struck by the hammer. This bar, known as a tine, vibrates and disturbs the magnetic circuit formed by the permanent magnet within the pickup. The movement is thereby transduced into an electric current.

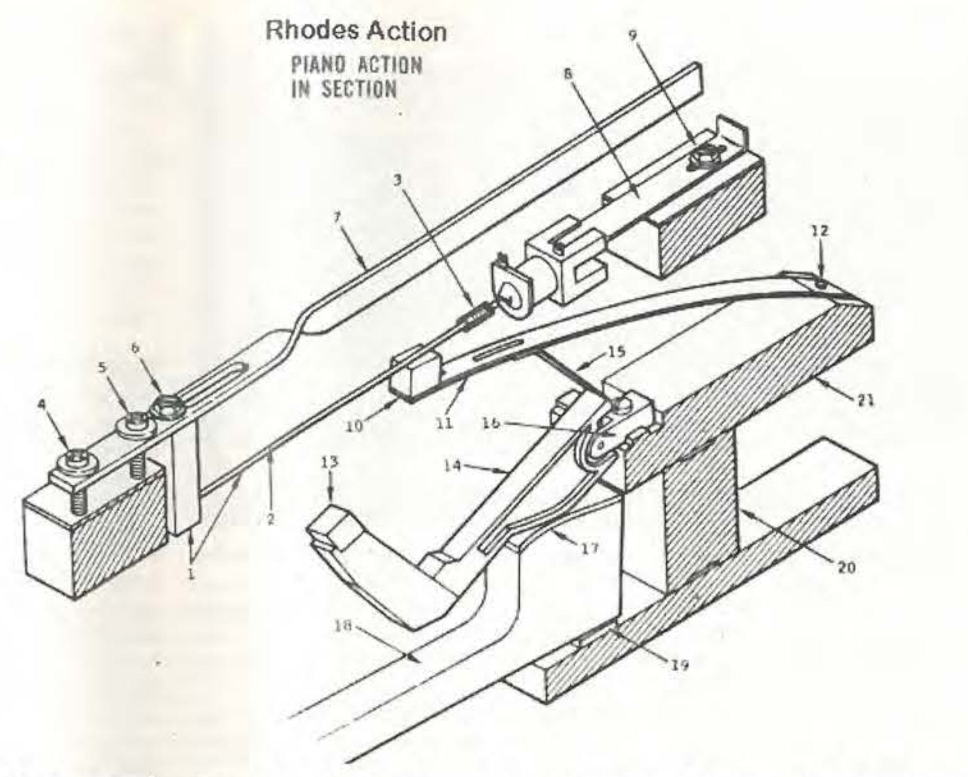


Fig. 8. Fender Rhodes striker. The wooden key activates a hammer via a cam. When the key is pressed, the dampers lift above the sounding bars which are struck by the hammer. This bar vibrates and disturbs the magnetic circuit formed by the permanent magnet within the pickup.

Figure 8 is an illustration of the Fender Rhodes action.[3] Compare this illustration with that of the electric guitar pick-up and the waveform generation mechanism of the Hammond organ.

The Fender Rhodes was made in two types; a Stage model which was entirely passive – just like a guitar – and a Suitcase model which required mains to power the integral amplifier. The physical nature of the mechanism permitted a large variation in expressive tone by means of the force used to strike a key. In addition, the keyboard had naturally unlimited polyphony. These factors ensured the Rhodes was, and continues to be, a widely used instrument.

Martenot

The Ondes Martenot was invented by Maurice Martenot, professor at the Ecole Normale de Musique in Paris. The words Ondes Martenot literally translate to Martenot waves.

The first model was patented in April 1928 under the name "Perfectionnements aux instruments de musique electriques," which means "improvements to electronic music instruments."

Early versions bore a close resemblance to the Theremin. They consisted of two table-mounted units controlled by a performer who manipulated a string attached to a finger ring. They relied on the body's capacitance to control the sound characteristics in a manner very similar to the Theremin. The string device was later incorporated as a fingerboard strip above a standard keyboard.

The Ondes Martenot was first demonstrated in Paris 1928 and it won first prize at the 1937 International Exhibition of Art and Technics. Many of the first composers to hear and take up the instrument were fascinated by the sounds it could produce, as it combined great responsiveness to touch with its eerie and ethereal electronic tones.

The instrument became popular among members of Les Six in France – particularly Milhaud and Honegger. One of the early virtuosi of the Ondes was Martenot's sister, Ginette Martenot. Later instruments also had a bank of expression keys that allowed the player to change the timbre and character of the sounds. One version even featured micro-tonal tuning.

Martenot's aim, to produce a versatile electronic instrument that was immediately familiar to orchestral musicians, paid off. The Ondes Martenot is probably the most widely accepted of all electronic musical instruments in the classical oevre.

The Ondes Martenot therefore has a surprisingly wide repertoire; far wider than that of the Theremin. Works were written for the instrument by distinguished composers including Olivier Messian and Edgard Varese.

Messian orchestrated the Turangalila Symphonie and Trois Petites Liturgies de la Presence Divine to include the instrument. Other composers include Maurice Jarre, Jolivet and Koechlin.

The Martenot often figures either as a solo instrument, as in works such as Marcel Landowski's Jean de la Peur, or as an orchestral instrument. It is employed from time to time within a score for certain special effects. The birdlike calls and trills distinctive of the work of Olivier Messaien are a good example of this usage.

Other composers wrote for ensembles of Ondes, sometimes as many as eight at a time.

Mellotron

Beatles producer George Martin likened the the Mellotron to a Neanderthal piano that had been impregnated a primitive electronic keyboard.[4] But this primitive analogue sampler had a profound effect on the tonal palette of popular music of the nineteen sixties.

The Mellotron operated by means of a length of tape with recordings of real instruments on it. When a key was pressed, the length of tape was drawn over a playback head until it was exhausted, in Martin's words, "whereupon a strong spring snapped it back to the beginning again. This meant that if you held down a note longer than a couple of seconds, the machine would give a loud hiccup and stop while it rewound and reset itself."

The Mellotron was conceived by a Californian, Harry Chamberlin, in the late forties. True to its pedigree as the world first sampler, the original model had 14 loops of drum patterns and was aimed at the home organ market.

For the next ten years, Chamberlin designed and manufactured a series of keyboards culminating in a two 35-note console machine; the first console was devoted to the 'sampled' instrumental sound, the second to rhythm tapes and sound-effects.

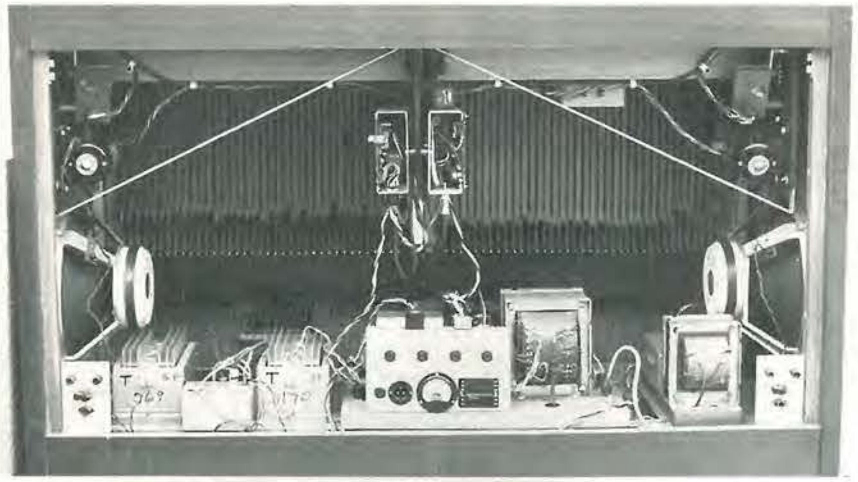


Fig. 9. Inside a Mellotron. This instrument operated by means of a length of tape with recordings of real instruments on it. When a key was pressed, the length of tape was drawn over a playback head until it was exhausted.

In the sixties, Chamberlin hired a salesman who, frustrated by the inventor's inability to resolve various technical problems, took the idea to Bradmatic Ltd in England, who supplied tape heads for the Mellotron. He suggested they production engineer a new model of the Mellotron and this they duly did.

Unfortunately the salesman failed to tell Bradmatic that the concept wasn't his and, similarly, omitted to inform Chamberlin about the new 'arrangement'!

After much acrimony, in 1966, Chamberlin agreed to sell the technology to the Bradleys who renamed their company Bradmatic to Streetly Electronics and commenced production of the mature Mellotron keyboard.

Chamberlin continued on a parallel development path with a series of instruments known simply as the Chamberlin. But it was the Bradleys' new Mellotron keyboard that attracted the attention of British bands who were searching for new additions to their tonal palette. Amongst them were The Beatles, The Rolling Stones and The Kinks.

In 1966, John Lennon composed a small phrase which McCartney played on the Mellotron; it was the beginning of Strawberry Fields Forever. This four-bar phrase alone, forming as it does the opening of one of the most innovative records of all time, guarantees the Mellotron a place in the annuls of sonic history.

The interior of a sixties Mellotron is illustrated in **Fig. 9** in which the individual pieces of tape are clearly visible.

Tape-bow Violin

Akin to the Mellotron is the Tape-bow Violin, the invention of Laurie Anderson who was born in 1948 in Chicago Illinois.

Anderson studied sculpture at Columbia University and engaged in various performance artworks while at college. After qualifying, she remained in New York where she met Philip Glass.

During work with a number of electronic musicians, Anderson designed the Tape-bow Violin; an instrument with magnetic tape instead of a bow, and a playback head instead of strings. The musical 'sample' recorded on the bow could be made to play by drawing the bow across the tape head as in conventional violin technique.

The invention's power lies in that variations in bowing can bring about very flexible sample manipulation. ■

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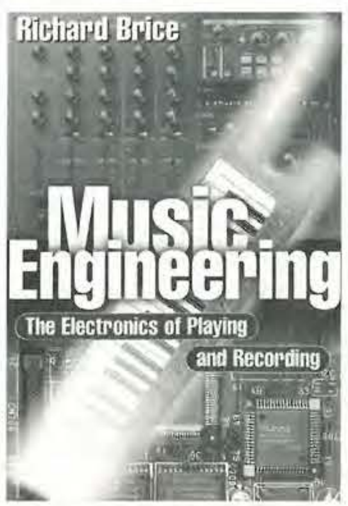
2. Theremin, L.S., US Patent: 'Method of and apparatus for the generation of sound.' Serial No. 73,529, 1925.
3. Coates, B, Melbourne Music Centre Web Pages, 1997.
4. Martin, G and Pearson, W, 'Summer of Love – The Making of Sgt. Pepper,' Macmillan 1994.



NEW PRODUCTS CLASSIFIED

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

PASSIVE AND ACTIVE COMPONENTS

Connectors and cabling

Floppy wire. *Flexiplast* by Multi-Contact is insulated with a thermoplastic elastomer, which makes it not only "green", but also very flexible; the fine-stranded copper conductors also make for more flexibility and the result is a low-cost, but environment-friendly cable – two requirements not always compatible. The cables are available with thin walls or with reinforced insulation, the former in sizes from 0.15mm² to 2.5mm² and taking voltages to 750V, and the latter in sections of 0.5mm² to 2.5mm² and handling up to 1.5kV. Operating temperature is –30°C to 110°C, with short periods at 130°C.
Multi-Contact UK Ltd. Tel., 01908 265544; fax, 01908 262080.
Enq no 501

Better bga sockets. Aries has a new type of ball-grid array socket that reduces solder-ball deformation. It uses the company's *BallLock* contact pins that are in the form of a two-fingered contact to take the solder ball – a design that eliminates the need for a lid. The other end of the pin is another solder ball for attachment to the ball-grid array footprint in the normal way. The socket will take the *SnapAdapt* pins already in the device, or added afterwards. Increased height is a mere 1.27mm. Sockets are available in any grid size on pitches of 1.27mm or 1.5mm. Insertion force is 22grams per contact.
Aries Electronics (Europe). Tel., 01908 260007; fax, 01908 260008; e-mail, ianb@arieselec.com.
Enq no 502

Rf power transistor. Ericsson announces the *PTF10120* rf power device for use in the 1.8-2GHz code/time-division multiple-access band. The device is claimed to provide the highest output power currently available at 120W. It is an ldmos type with gold metallisation, giving a linear response to within ±0.5dB over the band. It operates from 28V, has a useful minimum power gain of 11dB at 1.95GHz and at 100W, the Class AB, two-tone, 3rd-order intermodulation distortion figure is –32dB. Efficiency at 120W is 40%.
Ericsson Components AB. Tel., 01793 488300; fax, 01793 488301.
Enq no 507

Data converters

Fast, low-power a-to-d. Combining high speed and low power, the *SPT7863* analogue-to-digital converter from SPT is a 10-bit type that is capable of word rates of 10Msample/s while consuming 160mW from 5V. It has on-chip track-and-hold and is pin-compatible with other SPT 10-bit converters to ease up-grading. Output levels are selectable to cope with digital asics, microprocessors and dsp chips. It is a 0°C to 70°C device.
Signal Processing Technology. Tel., 01932 254904; fax, 01932 254903; e-mail, spt@intonet.co.uk.
Enq no 503

Digital signal processors

Dual processor dsp board. Blue Wave introduces the *PCI/C6600* dual processor board based on the *C6000* chip. This supports either two *TMS320C6201*s for fixed-point working or two *TMS320C6701* for floating-point use at up to 200MHz. Processing power works out at 3200Mips/2Gflops. The two processors are similar to facilitate designs incorporating both, and to allow simpler software or lower cost. Each processor can access 1Mbyte of flash and a 32Mbyte synchronous dram by way of the external memory interface. A shared bus gives both processors access to a bank of up to 1Mbyte of sram for communication. A large amount of i/o is provided, both analogue and digital, and further processors may be added to a mezzanine site.
Blue Wave Systems Ltd. Tel., 01509 634444; fax, 01509 634450; web, www.bluews.com.
Enq no 504

Discrete active devices

Tuning diodes. SOD323-packed tuner diodes in the *ZMV830* and *ZMV900* ranges by Zetex provide the same performance as alternatives in the larger SOT23 packs. The two new ranges are based on hyperabrupt and high-ratio hyperabrupt junctions. Minimum *Q* at 50MHz and 3-4V is between 80 and 350, depending on the particular device. Reverse breakdown is 25V in the *830* range, which has a capacitance range of 8.2pF and 68pF at 2V and 1MHz. In positions where bias voltage is limited, the higher capacitance ratio of the *900* series is of assistance, being five times that of the hyperabrupt types.
Zetex plc. Tel., 0161 622 4422; fax, 0161 622 4420; web, www.zetex.com.
Enq no 505

Surface-mounted Schottkys. Second-generation, 15V, 30V and 45V Schottky diodes from International Rectifier are in standard SMA packs and are rated at up to 3A dc and have forward voltage drops down to 300mV. Type numbers are *10MQ015N, ..040N, ...060N, ...100N,* all being rated at 1.5A and handling reverse voltages as indicated by the name. An additional type, the *15MQ040N*, is rated at 2A with a reverse voltage of 40V.
International Rectifier. Tel., 01883 732020; fax, 01883 733410
Enq no 508

Minute Schottkys. Rohm's new Schottky barrier diodes, *RB521S-30* and *RB520S-30*, are in the extremely small EMD2 1208 smt pack and also possess the industry's lowest forward voltage and reverse current. The *521S* forward voltage is 0.4V and reverse leakage 4μA, while the *520S* is rated at 0.5V and 0.1μA. Maximum current for both is 200mA and maximum reverse voltage 30V. Highest allowable junction temperature is 125°C.
Rohm Electronics UK Ltd. Tel., 01908 282666; fax, 01908 282528; web, www.rohm.co.jp.
Enq no 509

Inmarsat power transistors. Two ldmos transistors from Ericsson are designed for the 1.5-1.65GHz band used in Inmarsat applications.The *PTF10011/10045* are in driver/ power-amplifier form and are particularly suitable for use in portable equipment. Gain and stability are increased by the use of the laterally diffused process. Power rating is 30W from 28V dc and gain 11.5dB ±0.15dB, this flatness allowing a higher rate of data transfer.
Ericsson Components AB. Tel., 01793 488300; fax, 01793 488301.
Enq no 510

Rf power mosfets. Philips has a range of laterally-diffused mos, (ldmos) rf power mosfets for use in cellular base stations and uhf broadcast transmitters. A result of using the ldmos technique is that one transistor now covers the entire 840-960MHz or 1.9-2GHz cellular bands. There are four *BLF10xx* devices to go up to 1GHz, four *BLF20xx* types for over 2GHz and the *BLF861* for the 470-860MHz broadcast band. The three ranges provide up to 90W, 140W and 120W. Input matching is incorporated and output matching in the higher-power devices.
Philips Semiconductors (Eindhoven). Tel., 00 31 40 2722091; fax, 00 31 40 2724825; web www.semiconductors.philips.com
Enq no 506

Displays

Colour lcd. Sanyo's *LMU-TF150A1* 15in tft lcd colour monitor uses a smoothing function to allow vga/svga images to be expanded without distortion. It also has automatic adjustment for display position and other settings. Power consumption is only 25W maximum and a further attraction is its depth – 20cm.
Semicom UK Ltd. Tel., 01279 422224; fax, 01279 433339; e-mail, sales@semicom.demon.co.uk
Enq no 512

Filters

Dip filters. Multi-line, common-mode and normal-mode chokes by Tokin in the *DIP Series* are in a dil package and are made in various configurations, from a three-circuit type to one with 10 circuits. Voltage rating is 50V and current ratings between 100mA and 2.3A.
Mercator. Tel., 01493 334000; fax, 01493 334050.
Enq no 513

Hardware

Flange knockout enclosures. Ensto Briticent's *CUBO-C* range of enclosures has pre-pressed flange knockouts and come in sizes from 200mm square by 130mm to 400mm by 600mm by 130mm, in seven models. They will survive difficult conditions and, in particular, temperatures between –50°C to 130°C. All are supplied with a 30mm deep lid and mounting screws and there are optional steel plates to take heavy components, amongst other accessories. The boxes may be obtained in colours to suit, with printed logos, shielded, drilled, threaded, countersunk and cut.

Ensto Briticent International. Tel., 01425 474617; fax, 01425 471595; e-mail,briticent@ensto.com; web, www.ensto.com.
Enq no 514

Linear integrated circuits

Better 5532. From New Japan Radio, the *NJM2114D-D* dual op-amp offering some advantages over the industry-standard 5532 and contained in dil, dmp or sil packs. Noise and distortion are reduced and offset is now 0.2mV typical. The device slews at 15V/μs and unity-gain bandwidth is 13MHz. From ±22V, power dissipation is 800mW.
Young-ECC Electronics. Tel., 01494 753500; fax, 01494 753501; e-mail, crown@youngecc.com.
Enq no 515

Logic

3.3V logic family. *LCXPlus* 3.3V logic devices by Quality Semiconductor are 51 in number and all offer the bus hold and output resistors as an improvement over the standard 5V-tolerant *LCX* family. They all perform interface functions in octal, 16-bit and 32-bit form. Bus hold enables a device to hold its last logic state after the removal of signals and avoids the need for external resistors on cmos inputs; output resistors reduce overshoot and undershoot without much effect on speed. Propagation delay is down to 4.1ns.
Quality Semiconductor, Inc. Tel., 01420 563333; fax, 01420 561142.
Enq no 516

Lcd interface controller. Digital View's *SV-N705* is a versatile flat-panel interface controller to drive the whole range of NEC analogue tft displays. It provides quick direct analogue vga-to-svga connection for panels resolving from 640 by 480 to 1280 by 1024 pixels and there is also an optional daughter board to take PAL/NTSC video input, composite and S-video connections and audio. The controller supports VESA power saving and provides an on-screen display of various functions such as brightness, contrast and tuning. The controller takes 12V dc and cables and housings are available.
Digital View Ltd. Tel., 0181 2361112; fax, 0181 2361116; web, www.digitalview.com.
Enq no 511

Materials

Rubber insulation. Warth's *Thermaflex* is a silicone rubber, thermally conductive material that conforms to shape of uneven surfaces. It comes in thicknesses from 0.5mm to 2mm and may be specified for shape. Breakdown voltages are in the 8-20kV range, thermal resistance is 0.92°/W and its UL flame retardant rating is 94V-O. It is an alternative to mica and grease and is suitable for power transistor insulation and transformer bases.
Warth International Ltd. Tel., 01342 315044; fax, 01342 312969; web, www.warth.co.uk..
Enq no 517

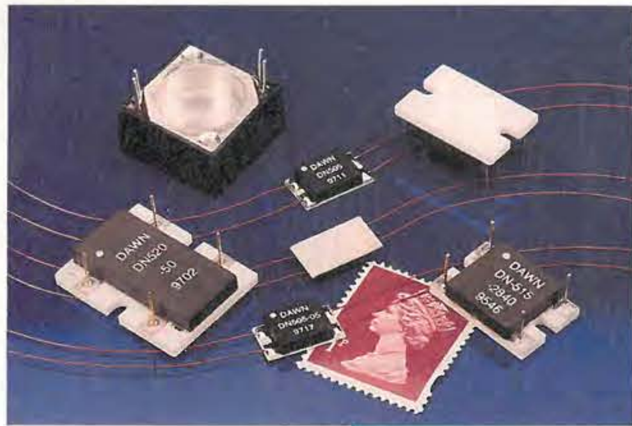
Cable markers. Heat-shrunk cable markers by Raychem may be printed individually or in indexed sets using a dot-matrix printer driven by a pc running Raychem's *TMS Total Software*. The sleeves come in s format to accommodate a tractor printer feed and, when printed, are shrunk round the cable. Operating temperature is –30°C to 105°C, tensile strength 1200lb/in^2 and flammability to UL224. Abrasion, cleaning solvents and other fluids do not affect the markers.
Farnell Components Ltd. Tel., 0113 263 6311; fax, 0113 263 3411, web, ww.farnell.com.
Enq no 518

Memory

Eprom, flash and sram module. BVM's *BVME065* is a 3U memory board for use in development and in data-acquisition systems. There are three separate memory banks which may each have a different type of memory, speed and size, up to 12Mb of eprom, 6Mb of flash and 6Mb of sram, with backup from battery or VMEbus +5STDBY. The battery holds the static ram content when the memory is removed from the system to allow its use as a portable memory card.
BVM Ltd. Tel., 01489 780144; fax, 01489 783589; e-mail, sales@bvmltd.co.uk; web, www.bvmltd.co.uk.
Enq no 519

Microprocessors and controllers

"Fastest" microprocessor. With a claim from IDT that it is the fastest 64-bit microprocessor on the market, the *RC5000* 250MHz device is



announced. It is meant for use in embedded applications in exotic communications, office automation and graphics. Its compatibility with *RC4xxx* and earlier *RC5xxx* devices extends to the use of existing supporting ics and tools. There are dual 32-Kbyte caches and an on-chip secondary cache controller to give a 500Mflops operation .
IDT Europe. Tel., 01372 363339; fax, 01372 378851.
Enq no 520

Motors and drivers

Dual stepper drivers. Three new dual-circuit stepper driver ics from Ericsson are announced. One of these devices forms a complete controller and driver for a two-phase, bipolar motor; the *PBL37751/2/3* provide 500mA/750mA/900mA continuous output current per channel. Each such circuit consists of a fixed-frequency, switched-mode, constant-current driver ic with two channels – one for each motor winding. They will perform microstepping as well as full and half stepping modes of operation, a disable input simplifying half stepping. Supply may be up to 60V and there is a built-in digital filter to avoid the need for external components
Ericsson Components AB. Tel., 01793 488300; fax, 01793 488301.
Enq no 521

Passive components

Aluminium electrolytics. Rubycon *YXG* aluminium electrolytics are expressly designed for secondary smoothing in resonant power supplies. Ethylene glycol with an added ammonium salt base is the electrolyte solvent. A low-loss, low-density electrolytic paper provides low impedance and high ripple-current tolerance. Typically, in a 12.5mm diameter and 25mm long case, figures are: impedance 0.027Ω at 100kHz and 20°C, ripple current 2.23A at 100kHz and 105°C.
Surtech Distribution Ltd. Tel., 01256 840055; fax, 01256 479785
Enq no 524

Protection devices

Resettable circuit protectors. Surface-mounted, positive temperature coefficient circuit protectors in the *1812* range from Littelfuse have large termination pads to ensure good soldering and subsequent inspection to suit the devices to high-volume production. They measure 3.25mm by 4.55mm and are claimed to be the smallest available. The range covers current ratings of 200mA at 30V dc to 1.1A at 6V dc.
DT Electronics Ltd. Tel., 01203 466500; fax, 01203 466501; web, info@dtelectronics.com
Enq no 525

Oscillators

Oscillator heaters. Hawco offers a range of proportionally controlled heaters for the thermal stabilisation of oscillators which are believed to be the smallest available. The smallest type produced measures 12.2 by 7 by 2.8mm. These heaters simply need to be attached to the component in question, no external controller being needed and the temperature being set between 0°C and 100°C by the selection of one resistor. Voltage to the heater is 5-50V dc at up to 40W, ac versions providing 80W. Fast stabilisation is achieved by applying full power at switch-on, this being automatically reduced when the temperature set is reached.
Hawco Ltd. Tel., 01483 560606; fax, 01483 575973; e-mail, sales@hawco.co.uk; web, www.hawco.co.uk.
Enq no 522

Switches and relays

Two specialised relays. International Rectifier announces two new relays: one a semiconductor type to replace mercury-wetted reed relays and the other an electromechanical telecomms relay. *PVT442* replaces reeds in positions where higher-powered loads are controlled, such as small motors and heaters. Output switching is by a pair of inverse-series-connected igbts with fast-recovery epitaxial diodes to give low voltage drop in reverse polarity. Input-to-output isolation is 3.75kV and there is no bounce. Maximum load power is 280Wac/400W ac while input current is 5mA. *PVT422* is a spst, normally open relay for use in telephone equipment in which a connection to the line is needed during power failures.
International Rectifier. Tel., 01883 732020; fax, 01883 733410.
Enq no 526

Coding switches. *Type 07* rotary coding switches by Elma are meant for use in positions where they are set and untouched for long periods. They have hard gold-plated contacts and hermetic sealing, which prevents oxidation and provides a contact resistance of under 25mΩ. There are binary-coded decimal and hexadecimal versions, all of which handle 2A at 42V.
Radiatron Components Ltd. Tel., 01784 439393; fax, 01784 477333.
Enq no 527

Transducers and sensors

Dynamic load cell. To prevent the force produced by the mass and acceleration of fixtures and clamps holding Instron's *Dynacell* load cell to moving machinery from affecting the load cell output, an accelerometer is built into the cell, measuring the acceleration and compensating for it. In conjunction with the company's *FastTrack 8800* electronics, the result is said to be a system with much lower acceleration error than has hitherto been found.
Instron Ltd. Tel., 01494 464646; Fax, 01494 456123; web, www.instron.com
Enq no 528

Dual-range photosensor. Matsushita's *UZD352* has two operating ranges, thereby being effectively two separate sensors. It uses a twin, divided photodiode in the sealed standard *UZD3* body, which measures 68 by 40 by 20mm. All sensors in the *UZD3* range work over the range 20cm to 2m and use area reflective sensing to avoid the effects of dust, mist, smoke or oil. Colour does not affect them and there is cross-talk protection for the close mounting of two sensors.
Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599; e-mail, info@macuk.co.uk; web, www.mac-europe.com.
Enq no 529

EQUIPMENT

Audio products

New B&W speaker. B&W announces its new loudspeaker, the *Nautilus 801*, which incorporates a *Marlan* sphere by Marlan Polylac Holland, to house the mid-range drive. This is said to eliminate, by virtue of its smooth shape and material acoustic properties, the diffraction patterns that are common with baffled designs. The mid-range sphere is floating, decoupled from the bass cabinet and tweeter, by a gel made by Raychem.
B&W Loudspeakers Ltd. Tel., 01903 524801; fax, 01903 524832; e-mail, clivefunnel@compuserve.com.
Marlan Polylac Holland BV. Tel., 0031 594 515080; fax, 0031 594 515520; e-mail, marlannl@bart.nl
Enq no 530

Power supplies

Programmable bench supply. *XKW* bench power supplies combine output powers up to 3kW with GPIB programming facilities, the interface being a single-channel card inside the supply. Connectors and switches are at the rear and front-panel leds provide indication for computer control. The GPIB interface gives 14-bit resolution for control and reading of voltage and current and there is programmable overvoltage protection. Versions are available to give 8V, 350A to 300V, 10A and there is also a 1kW range of supplies.
Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409; e-mail, sales@ttinst.co.uk..
Enq no 532

Test and measurement

Three-phase power meter. Hioki's *3331 Power Hitester* measures and integrates power consumption of three-phase and single-phase equipment to a basic accuracy of ±0.2%, handles direct currents of up to 50A and covers the 10Hz-50kHz frequency range. It will also measure peak current and provides analytic functions not seen previously. True-rms measurement is available, as is average measurement, via a low-pass filter to obtain the basic component of inverter waveforms. There are GPIB and RS-232C interfaces to allow computer control and management.
Telonic Instruments Ltd. Tel., 01734 786911; fax, 01734 792338.
Enq no 534

Power harmonic analyser. *OR300* by Yokogawa is a hand-held instrument for harmonic analysis and real-time rms measurement in ac power systems. It will handle live voltages up to 500V and its triggering allow the capture of power disturbances. Harmonics up to the 40th may be analysed, voltage, current, phase and active power being shown for each, its four isolated channels allowing three-phase measurement. When used with a fax modem card, a watchdog function may be set up, any fault being captured, recorded and transmitted automatically, the facility then being reset. There is an internal memory, a flash memory card and RS-232 for transfer of data to a pc.
Martron Instruments Ltd. Tel., 01494 459200; fax, 01494 535002; e-mail info@martron.co.uk; web www.martron.co.uk
Enq no 535

Cameras

High-resolution ccds. Two high-resolution charge-coupled devices, for use in digital still cameras for example, are announced by Sony. *ICX204AK/205AK* are 1/3in and 1/2in sensors which have provision for some "tailoring" to fit individual needs. Both use progressive scanning for low distortion in moving objects and both have a square array to give accurate positioning and measurement. Both use rgb colour mosaic filters and monochrome versions are available. The *204* at 800Kpixels and the *205* with 1.45Mpixels have electronic shutters with variable charge storage time to allow the capture of full-frame images without the use of a mechanical shutter.
Sony Semiconductor Europe. Tel., 01256 478771; fax, 01256 818194.
Enq no 531

COMPUTER AND DATA HANDLING

Computers

Single-board computer. New from Advantech is the *PCM-4823/4823L Biscuit PC*, a compact sbc with a 16-bit Ethernet interface and 32-bit svga and lcd interfaces, making a complete processing board. There is a 5x86-133 embedded processor, floppy controller, a parallel port, EDO dram simm socket, enhanced IDE, keyboard/mouse connector and two serial ports. Power-saving modes are supported and there is provision for expansion modules for communications, analogue/digital control, data handling, GPS and others.
Semicom UK Ltd. Tel., 01279 422224; fax, 01279 433339; e-mail, sales@semicom.demon.co.uk
Enq no 536

PC/104 pc. DSP Designs' *TB486* module is based on the AMD 66MHz *Elan SC410 80486* code-compatible processor and is in effect a full pc, including Ethernet and graphics. There is an on-board, switched-mode supply fed by one 5V input and an Ethernet port for communications. Twisted-pair 10BaseT facilities allow connection to a transformer module with an RJ45 connector and status leds. Hard and floppy-disk and cd-rom interfaces are included. The module also has a solid-state disk with a 2Mbyte flash chip, a 4-channel, 12-bit a-to-d converter and a socket to take up to 64Mbyte of memory. Both lcds and crts may be driven, simultaneously if required, the module having a local bus graphics processor and 2Mbyte of video memory for displays up to svga. All the usual peripherals are supported.
DSP Design. Tel., 01246 545910; fax, 01246 545911; e-mail, info@dspdesign.com; web, www.dspdesign.com.
Enq no 537

Tough laptop. Kontron's new *IP Lite P II* laptop uses a Pentium II 233MHz or 266MHz processor and provides six free PCI/ISA slots. It is contained in a magnesium alloy case for resistance to shock and vibration and has a 12.1in tft display showing 1024 by 768 pixels. Removal storage consists of CD-rom, 650MB MO-drive and hard drive and has a slot cpu board and plug-in Pentium II module

to give additional space for adaptor cards. Power comes from replaceable ac and dc supplies and the display is tiltable, with a detachable keyboard and trackball. There are two serial and one parallel interfaces, a vga connection for an external monitor, two PS/2 connections for mouse or keyboard and a USB connection.
Kontron Elektronik Ltd. Tel., 01923 421528; fax, 01923 254118; e-mail newtonc@kontron.de
Enq no 538

Computer board-level products

I/o for PCIbus. Arcom has a versatile i/o board for builders of PCIbus systems, that gives a selection of functions for engineering and industrial use and forms a single-board interface for smaller-scale control and instrumentation needs. *APCI-ADADIO* provides for analogue input and output, digital i/o and counting/timing. This covers all that is needed for use with most sensors and transducers in addition to the ability to monitor switches, provide digital output and carry out timing for control or the generation of pc interrupts. The 12-bit a-to-d converter has a 10μs conversion time and fast s/h circuitry handling input at 100kHz for a single channel or 10kHz channel-to-channel. There are 16 ttl-level digital i/o lines and the board will go into any PCIbus expansion slot.
Arcom Control Systems Ltd. Tel., 01223 411200; fax, 01223 410457.
Enq no 539

Data acquisition

PCI data acquisition. Datel's *PCI-416L2A* 16-channel analogue input board for PCI computers provides 12-bit resolution, the timing of the a-to-d converter being dissociated from the block bursts of the PCIbus by the use of fifo. The 16 channels are single-ended, sampled at up to 400kHz/channel simultaneously; this being to avoid the phase skew, in parallel sampling applications, associated with data converters. The board gives seamless sampling with no data loss and a pre-trigger arrangement collects data continuously to the host's ring buffer of several megabytes, counting down the number of post-trigger samples and stopping when all have been collected.
Datel (UK) Ltd. Tel., 01256 880444; fax, 01256 880706; e-mail, datel.ltd@ge.geis.com; web, www.datel.com.
Enq no 540

Data communications

Wireless evaluation kit. RF Monolithics has an evaluation kit for low-power, two-way wireless data communications, which uses the company's Virtual Wire technique at 868.35MHz. *DR-1012DK* consists of two transceiver boards, two host protocol boards, two reference antennas, batteries, application software and a manual. Straight from the box, it may be used to make a data link between two RS-232-equipped pcs. When the system is shown to be viable, the boards may then be adapted to exact requirements by the addition of the appropriate protocol and interface.
Acal Electronics Ltd. Tel., 01344 727272; fax, 01344 424263.
Enq no 541

Radio systems

Synthesised Tx/Rx modules. Taking advantage of the new pan-European, licence-free 868-870MHz band for use at short ranges, Wood & Douglas has introduced the *800* version of its synthesised radio transmitter and receiver modules, the *ST/SR800.* These are compatible with the *ST/SR500* range of uhf models, are approved to ETS 300 220 and are suitable for use in data exchange and telemetry, alarms and monitoring. The frequency synthesisers are easily re-programmed by way of a serial interface, frequencies being held in non-volatile memory. Switching bandwidth is 10MHz, channel spacing 25kHz and switching time under 50ms.
Wood and Douglas Ltd. Tel., 0118 9811444; fax, 0118 9811567; e-mail, info@woodanddouglas.co.uk; web, www.woodanddouglas.co.uk.
Enq no 533

BACK ISSUES

Back issues of Electronics World are available, priced at £3.00 UK and £3.50 elsewhere, including postage. Please send your order to Electronics World, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

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Note that stocks of some of the above issues are low and will soon sell out. Please allow 21 days for delivery.

Development and evaluation

***H8S* evaluation.** Hitachi offers the *EVB2655* evaluation kit for the *H8S* family of 16-bit, low-power microcontrollers. It includes a 20MHz H8S/2655 microcontroller, an evaluation board, a copy of the IAR C compiler, source-level debugging, a GNU C compiler and debugger and a cd-rom holding documentation and tutorials. Since the *H8S/2655* is the highest-performance device in the family, the kit is suitable for all the other devices. Memory on the board consists of 256Kbyte of expandable sram and there are two RS-232 links for comms and debugging. All i/o is accessible.
GD Technik Ltd. Tel., 0118 9342277; fax, 0118 9342896.
Enq no 542

Mass storage

Fast *CompactFlash*. Silicon Storage Technology's *SST49CFxx CompactFlash* cards can cope with a 1.4MB/s write from host to card. They come in densities of 4MB to 24MB and are intended for use in such equipment as digital cameras and mobile 'phones. They may also be used in PCMCIA interfaces via 68-pin Type II adaptors.
Silicon Storage Technology Ltd. Tel., 01932 221212; fax, 01932 230565; e-mail, rsawer@ssti.com; web, www.ssti.com.
Enq no 543

Software

Shock/vibration recording. Lamerholm Fleming has produced new software for its *RD298 ShockLog* triaxial shock recorder, which records vibration and shock over a whole journey or static test. The software runs under Windows 95 and NT and the extended recording is seen on a scrollable screen to allow excessive impacts to be identified for analysis by the graphing facility. A 'Timeslot' function in the RD298 provides information on background vibration in three axes as peak readings in any defined time slot, of which there may be up to 250 000 in non-volatile memory.
Lamerholm Fleming Ltd. Tel., 01438 728844; fax, 01438 742236; e-mail, sales@lamerholm.com; web, www.lamerholm.com.
Enq no 544

PUBLICATIONS

Catalogues

Fans. Papst has up-dated its free *Basics* catalogue, the new one having 76 pages, in which more than 100 new products are to be found. Megafans, for example, which have smaller motors with bigger impellers resulting in more air and less racket. Also in are new sleeve-bearing fans using the company's Sintec process to give better performance at reduced cost. There is reference information, advice on fan selection and a section on accessories.
Papst plc. Tel., 01264 333388; fax, 01264 332182.
Enq no 545

Data acquisition. Datel's 1998 data acquisition catalogue presents over 50 new items, those included being high-performance boards for PCI. ISA and VME buses. Features of the products described include on-board dsp c-processors, and fifo memory, simultaneous sampling and non-stop data streaming to disk. Free technical assistance is available from Datel on the web site.
Datel (UK) Ltd. Tel., 01256 880444; fax, 01256 880706; e-mail, datel.ltd@ge.geis.com; web, www.datel.com.
Enq no 546

Application notes

In-circuit testing. Not an application note, but a book from GenRad on the principles of the in-circuit testing of printed-circuit boards, from a review of the manufacturing process and the type of fault often found, to a description of the in-circuit tester and its method of use. For copies, contact *MediaMania. Fax, 0171 499 3417.* ■
Enq no 547

Waxing lyrical... Comedienne Ruby Wax – one of the stars being used, according to the BBC, to, "...guide viewers into the emerging world of digital broadcasting."

Digital outlook

The introduction of digital television services could be a soap opera in itself. SkyDigital, BBC and OnDigital are all hoping to be the station of the nation, but all are realistic in realising the British public will have to be convinced digital tv is something worth paying for. Richard Wilson checks out the viewing figures.

What have Manchester United and October 1st in common? Both will be pencilled prominently in Rupert Murdoch's diary. After the takeover bid for the football team comes the launch of the UK's first satellite digital tv service.

When Murdoch's satellite tv broadcaster launched its UK digital tv service on the first of the month, Sky struck early in a market that is destined to dazzle us all with activity - technical, commercial and social - over the next half year or so.

The next date to ink in on the digital tv calendar is 15 November. This is when the first terrestrial digital tv service from OnDigital, the 50-50 joint venture between independent broadcasters Carlton and Granada, goes live.

That is by no means the end of the digital-tv story. The BBC may have launched its first digital channel – BBCChoice – but it has yet to make its big move in the digital-tv market and no one is underestimating the impact super-quality digital tv and interactive services will have in the country's growing cable sector.

Is talk about a digital-tv market just a little premature? No one is foolish enough to write off digital before it has even appeared. The real question is how quickly the market for digital tv and interactive information services will expand. The answer to that question depends on three things; the cost of the hardware – set-top boxes and tvs, the quality of the programme content and how the three broadcast media, satellite, terrestrial and cable will divide up the market.

In the run up to the launch of its terrestrial service next

Action, cameras... Focusing on the digital tv age.

month, OnDigital estimates that eight million people are prepared to pay £200 for a set-top box that will enable them to receive Coronation Street in glorious digital picture quality.

Digital hardware will also become even more attractive, according to the broadcaster, when the receiver is integrated into the tv set.

With around four million people estimated to buy new tv sets each year in the UK, the change to digital hardware may not be as painful as some have predicted. When buying a new tv consumers may be prepared to absorb the additional cost of the digital receiver.

If getting enough people to buy the wide-screen tv and digital receiver is no longer the major obstacle, then getting the prospective digital viewers to one of the three broadcast media, terrestrial, satellite or cable, will surely remain the big issue for firms like BSkyB, the BBC and OnDigital.

Surprisingly, one market researcher is convinced that terrestrial operator OnDigital will find it difficult to compete with the satellite service of SkyDigital.

Consumer market research carried out by Strategy Analytics forecasts that while SkyDigital could be beaming services to just over a million homes – 5% of the total – by the end of next year. OnDigital's terrestrial service could have just 120 000 viewers.

The prediction of 250 000 digital tv subscribers for cable is only slightly more optimistic.

Such is the expectation that by 2005, the analysts predict that 29 per cent of UK households will have digital satellite tv, and 24 per cent digital cable. Only 5 per cent are predicted to be watching digital terrestrial tv.

So why the confidence about satellite over terrestrial, which is the means by which most of us get today's tv? The argument seems to rest on the fact that satellite pay-per-view approach to broadcasting is ideal for applying to the market for digital services, which will be wide-ranging by today's broadcast standards.

Terrestrial broadcasters do not charge viewers for services, the licence fee excepted, television programmes are just there in the front room, free at the point of use. Digital services will simply not be like that.

"OnDigital is boxed into a corner," says David Mercer, a consultant at Strategy Analytics. "It needs pay tv revenues to survive, but is selling to an audience which doesn't want to pay for tv."

There is also the more practical argument that terrestrial broadcasters will be limited by frequencies available in the range of service they will be able to provide, compared to satellite and cable.

Predictions are there to be accepted or scoffed at, and only time will tell whether the arguments hold true. However, it seems that the BBC is already resigned to losing substantial ground to satellite and cable services in the digital revolution.

"Terrestrial won't be dominant in the future," said Charles Evans, the BBC's project director of digital services, speaking in London at last month.

The BBC has insisted that it will not charge subscription fees for many of its digital tv services. If the finances permit such an approach, then it is hard to see how it will not have a major impact on pay-per-view satellite and cable services, as it does in today's analogue tv.

The technology may change but history tells us that human nature is stubborn to conversion.

Today Sky's satellite viewers total no more than half the regular audience for Coronation Street on one of five free terrestrial television channels.

This tells us that there is a considerable chunk of the tv audience which is not used to paying for its programmes.

The introduction of digital-tv services means that more of us must accept that we will have to pay for what came free in the past. However, as long as there is a choice then SkyDigital, OnDigital and the cable firms will have to convince us that digital television is something worth paying for.

Rupert Murdoch won't be writing off terrestrial tv just yet, which is why 15 November is still an important date in his diary. ■

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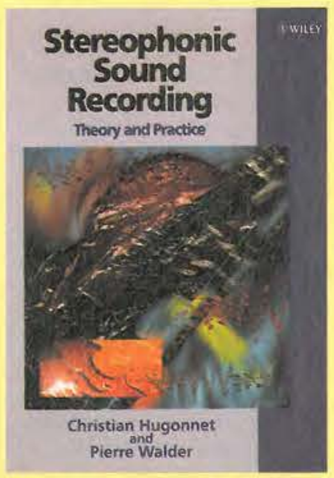
Stereophonic Sound Recording

Theory and Practice
Christian Hugonnet and Pierre Walder

Recent advances in digital audio have heralded substantial innovations in sound recording techniques and increased the importance of applying the latest microphone techniques. The authors of this book focus on these innovations, giving numerous examples of their use within the framework of an analysis-based recording



engineering theory.

The book provides a complete overview of well-known sound recording procedures practised world-wide, whilst also presenting a methodology that will provide the reader with an efficient approach to sound recording of classical music, rock and pop music, drama and speech. The widely illustrated theoretical knowledge is presented in clear and simple language.

Building on their considerable experience of creating innovative recording techniques, the authors provide an authoritative analysis of the subject that offers valuable, practical guidance that will aid the development of new recording methods. Their inside knowledge of the requirements of the phonographic, broadcasting, film and other media industries ensures expert coverage of new products and approaches including:

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For professional audio engineers, this manual provides systematic advice for getting optimal performance from studio equipment. For students of audio engineering it will form a comprehensive introduction to the area of stereophonic recording, backed up by real-world case studies and a wealth of practical experience.
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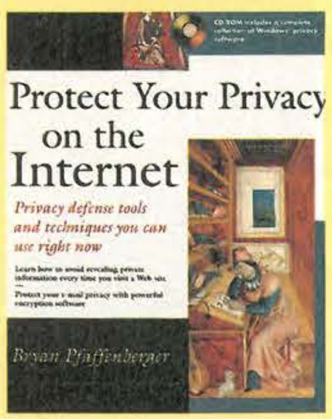

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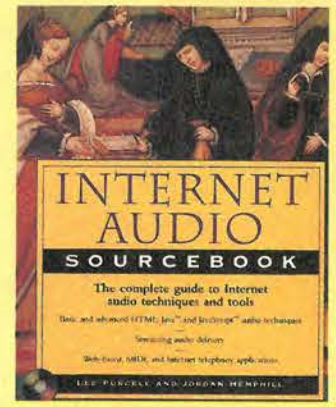

The complete guide to Internet audio techniques and tools
Lee Purcell and Jordan Hemphill

"The World Wide Web has spouted vocal cords, gained a voice, and begun to sing." – Lee Purcell and Jordan Hemphill

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Taking a step-by-step approach, the authors get you up to speed on the latest audio tools and techniques. First they school you in the basics of creating, processing, and storing audio data.

You learn the various methods of working with digital sound and how to use available tools to shape audio content for the Internet. Then they show you how to deliver your digital sound over the Web. They explain the HTML coding used to access audio files and teach you techniques for integrating Java applets, JavaScript code, and VBScript code into your HTML documents.

Finally, the authors show you how to get the most out of new audio technologies, including streaming audio, MIDI applications, voice synthesis and recognition, and Internet telephony, as well as covering hot new products like the Headspace Beatnik audio engine and Liquid Audio.

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Web Security Sourcebook

A Complete Guide to Web Security Threats and Solutions
Aviel D. Rubin, Daniel Geer, and Marcus J. Ranum

The front door is unlocked and wide open. The alarm's not working and no one's home. All of your valuable, money, and intimate details of your life are just sitting inside, waiting to be taken. No, it's not your house, it's your computer.

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We currently have many vacancies on our books for RF, Microwave and Antenna Design, Development and Test Engineers. Below is a selection of some positions we have on our records:

RF Engineers

Herts ***£23-40k***
Our client has positions at all levels for engineers with 2.1/1st class honours degrees with a good background in developing ***transmitters, receivers, filters, I.NAs*** and ***amplifiers***.

Hants ***£25-36k***
Our client is looking for several RF engineers with good degrees and several years experience developing mobile telecommunications systems. Knowledge of CSM would be an advantage.

Berks ***£24-36k***
Applicants are sought from RF design engineers with a good degree and practical post-grad experience covering some of the following areas – ***RF to 2GHz, LNA design, PLLS, GSM, Filters, power amps, VCOs*** or ***EMC***.

Hants ***£25-36k***
Our client is looking for several RF engineers with good degrees and several years experience developing mobile telecommunications systems. Knowledge of GSM would be an advantage.

Kent ***£28-32k***
Our client is looking to recruit degree qualified RF/Microwave engineers with good post-graduate experience of ***I.NAs, filters, diversity systems*** and ***measurement techniques***.

Beds ***£26-34k***
A designer of cellular radio products is looking for experienced RF engineers to design receivers up to 2GHz. Familiarity with digital modulation and DSP would be beneficial.

Cambs ***£28-35k***
Engineers are sought with good degrees and several years post-graduate experience in developing RF circuits and systems. Some of the following skills are needed – ***GSM, PCN, DECT, wireless I.AN, antennas, superhet receivers, oscillators, synthesisers, amplifiers*** or ***EMC***.

Microwave Engineers

Hants ***£25-38k***
Our client is seeking qualified engineers to carry out circuit design and testing with ***MIC*** and ***Ga/ls MMIC circuits*** (e.g. ***low noise amplifiers, phase*** and ***gain control units, oscillators and power amps***) with operating frequencies from ***0.5 to 100GHz***.

Scotland ***£27-35k***
We are looking for several microwave design engineers with skills in ***oscillator*** design, ***amplifiers, filters*** and ***mixer*** design. Knowledge of ***HP EEsof*** design and layout packages would be of help.

Devon ***£22-34k***
A major developer of radar systems is looking for experienced engineers to develop circuits and sub-systems up to 40GHz. Knowledge of antennas would be beneficial.

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RF Test Engineers

Surrey ***£16-21k***
We have several positions for ***Test Engineers*** with 1 year+ experience testing ***RF systems*** and circuits using ***spectrum analysers, oscilloscopes*** and other ***test equipment***.

Hants ***£17-19k***
Applicants with experience of testing RF systems and circuits down to component level are sought by our clients.

Northants ***£16-20k***
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RF Design Engineer
Berkshire
1.5GHZ, Integrated Circuits
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RF Manager
Midlands
GSM
This global leader in the provision of communications sites and network services to broadcasting and telecommunications industries, is currently looking to recruit a key individual to lead a small team of dedicated special projects staff. The ideal candidate will have a minimum of 2 years experience of live networks and a background in planning and analysis of cellular coverage. Please quote reference for more details. **Ref: 61259**

RF Design & Development Engineer
Northern Home Counties
RF, Communications
This communications organisation is one of the UK's leading suppliers of hand portables, vehicular mobiles and base station. The ideal applicant will be involved in the design and development of mobile radio equipment, so it is essential that you have several years experience in this field and in RF circuit design. You must be degree qualified in communications or electronics. To find out more about this vacancy, please call in quoting the reference. **Ref: 61161**

Power Supply Electronics Engineer
Northants
Switch Mode Power Supplies
My client specialises entirely in the design and manufacture of power supplies mainly for the military sector. Due to growth and expansion, they are now seeking to employ a Power Supply Design Electronic Engineer. The ideal candidate will have experience in the design of multi-output switch-mode power supplies. Some of the supplies designed are used in demanding applications, so experience in DEF STAN's and MILL SPEC's would be advantageous. Please quote reference when calling in. **Ref: 61050**

ASIC Design Engineer
NW London
VHDL
This London based company is aiming to lead the emerging market for re-usable semiconductor intellectual property for customisable microprocessor cores. They are currently looking for experienced ASIC Design engineers with a minimum 2 years experience of writing VHDL for Synthesis to ASICs, or integrating microprocessor cores into ASIC designs. If you would like more information on this vacancy, please phone in with reference number. **Ref: 61424**

Analogue Electronics Design Engineer
Middlesex
Analogue, Digital Circuit Design
My client, a large MOD organisation are currently looking to recruit a design engineer to support the VHF and UHF work of their Sonar Products. You will have experience in analogue and digital circuit design and prototypes, PCB design and microprocessor software development and testing. Design experience in UHF and UHF receiver techniques and technology would be preferred as would a sound background in mobile communications. **Ref: 61610**

LSI Engineers
Berkshire
LSI Design, VHDL, ASIC
My client, a leading developer of chip sets for mobile phones is currently recruiting for engineers with at least 2 years experience of LSI design. You will be required to verify and improve new design flows and definition of design procedures, so knowledge of ASIC design is essential as is VHDL and Verilog HDL coding. Experience and knowledge of DSP techniques and CAE tools such as Cadence and Synopsys is also required. An understanding of mobile communications would be an advantage. **Ref: 61714**

Hardware Engineers
Newport
Xilinx, FPGA
Our client, the defence division of a major global telecommunications organisation is currently looking to recruit hardware engineers with a working knowledge of Modeltech Simulation Tools and Synopsis Synthesis Tools. Knowledge of Xilinx 4000 Series FPGA's and digital design experience would be advantageous. **Ref: 61461**

Mixed Signal Engineers
M4 Corridor
CMOS, BICMOS, CADENCE
This global leader in the development of chip sets for mobile phones requires engineers with 5 or more years experience in mixed signal design. You will be responsible for circuit feasibility studies, circuit design, simulation and layout so a good working knowledge of CMOS or BICMOS processes is essential as is experience of Cadence based mixed signal design flow including Saber and Spice. An understanding of mobile communications would be advantageous. Please call in with reference. **Ref: 61715**

Digital Design Engineer
Birmingham
Digital Design, FPGA
Your role will be to specify, design, implement, test and document all aspects of digital hardware design for a telecommunications equipment developer. You will have 2 years of digital design experience, preferably with a telecomms bias. An understanding of current CAE technology with skills in at least 2 of the following: PLDs, FPGA and Embedded Microprocessor/DSP. You will also be up to date with telecommunications standards and implementations for PDH, SDH, ISDN, PSTN and ATM. **Ref: 61470**

RF/Microwave Design Engineers
West Yorkshire
RF/Microwave
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Manufacturing Cell Manager
West Yorkshire
RF Passive Products
A manufacturing cell manager is required by an international manufacturer of passive RF products. You will be responsible for all aspects of the production of these products. You will have 2+ yrs experience in the delivery of 100% defect free products, achievement of delivery schedules, improvement within a production cell and day to day management of staff including the selection, training and development of them. Knowledge of Health and Safety procedures is essential. To find out more details regarding this vacancy, please call in with reference. **Ref: 61783**

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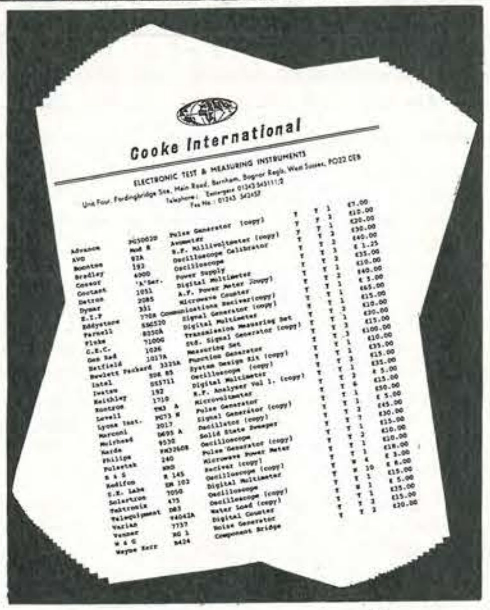

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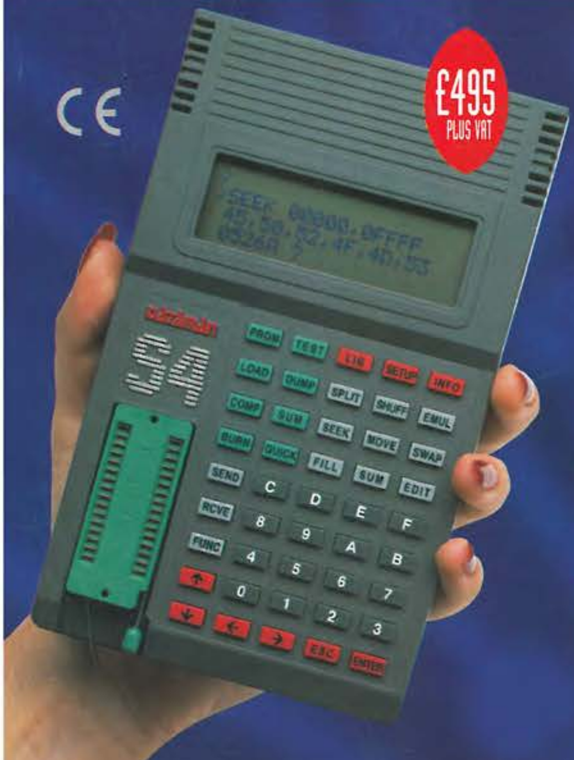

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