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CONTENTS

MARCH 2002 VOLUME 108 NUMBER 1791

3 COMMENT
Equality?

5 NEWS
- New material could give blind people sight
- Welsh firm trials mains comms
- Low-cost bendy displays come a step nearer reality
- LED for torches and bike lights
- Electroluminescent display adds a new dimension to a car's dashboard
- Most powerful 2GHz transistor
- Breakthrough in superconductors
- Micromachined fans

12 BENDY BATTERIES ENABLE SMART SOLUTIONS

Ultra-thin battery technologies look set to add major new functionality to travel tickets, ID tags and greetings cards. **Andrew Emmerson** reports.

14 THE INVENTION OF THE SUPERHET
Ian Poole has been investigating how today's most popular receiver topology – the superheterodyne – made its debut.

18 GANG YOUR OWN POTS
Off-the-shelf, ganged potentiometers are rare and can be very expensive. **Cyril Bateman** has devised a method of ganging your own dual, triple and even quad pots.

21 MEASURING CAPACITANCE
Michael Slifkin and **Shai Kriegman** have been investigating three ways of measuring capacitance – one using phase shift, one using the error signal from a PLL and the third looking at a frequency change due to the unknown capacitor.

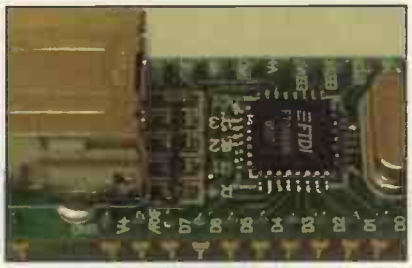
26 DIRECTION FINDER USING VHF
Ian Hickman's final article about a simple direction-finding system describes the RSSI demultiplexer and other circuitry not covered in the two earlier articles.

30 CIRCUIT IDEAS
- Electronic lock with extra security features
- Constant-current diode look-alike
- Power-failure safety interlock
- Battery voltage low/high indicator
- Programmable staircase waveforms
- Stepper motor driver with half stepping

39 NEW PRODUCTS
The month's top new products, selected and edited by **Richard Wilson**

48 DETECTING VIBRATIONS AND TREMORS
In **Joe Carr's** explanation of vibration detectors and seismographs, he details an easy-to-build instrument that's sensitive enough to detect Earth tremors.

54 USB OSCILLOSCOPE FOR THE PC
Eddy Insam shows how easy it is to make an oscilloscope that plugs into your PC's USB port. Its sampling rate may not

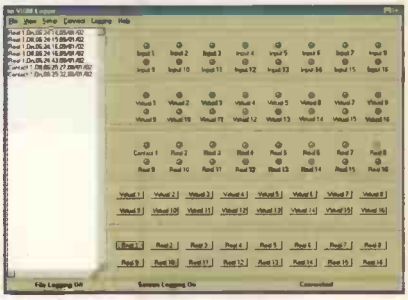


be very exciting, but it can be perfectly acceptable for audio and teaching work.

59 EW SURVEY 2002
Please take a moment to fill in our reader survey. You could win one of five one-year subscriptions!

66 WEB DIRECTIONS
Useful web addresses for electronics engineers.

A new ceramic material from NASA may one day be used in artificial retinas to help the blind to see. For this and the month's other top news stories, turn to page 5.



Exclusive reader offer – save 20% on a 16-channel stand-alone digital i/o controller – page 64.

Ian Poole looks at the invention of one of the biggest breakthroughs in wireless – the superhet. Turn to page 14.

On page 18, Cyril Bateman describes how you can roll your own dual, triple and even quad-ganged potentiometers using off-the-shelf belts and pulleys.

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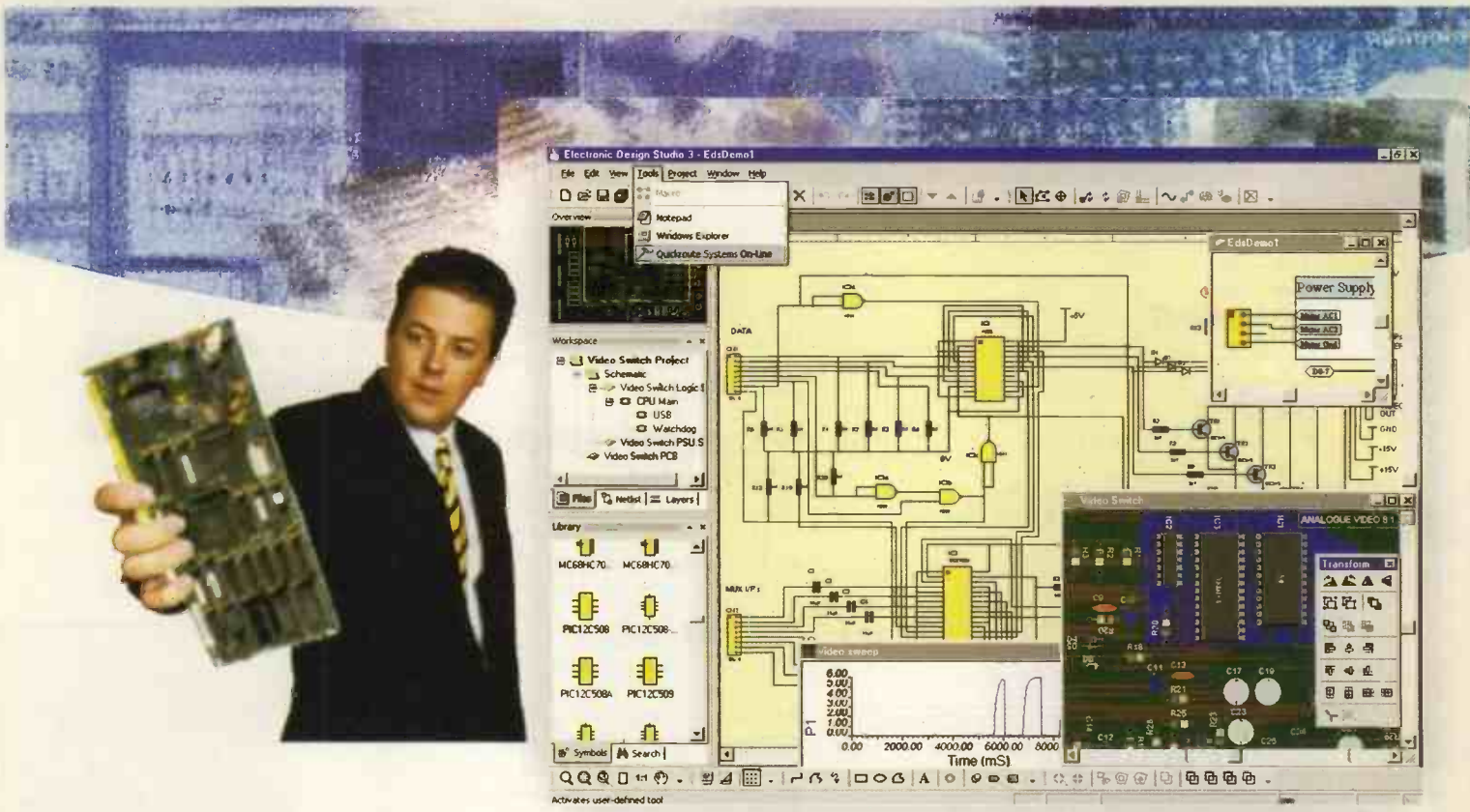

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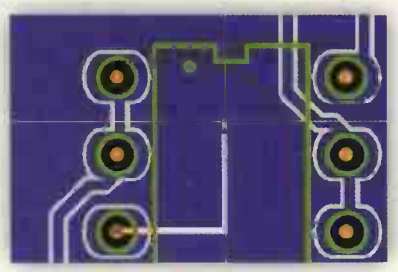

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Equality?

I was listening to Woman's Hour on Radio 4 during the Christmas break and heard an item featuring a woman who was training as an AA technician. This interested me, because in a 25+ year career in manufacturing industry, I have only ever worked with one female graduate design engineer. I have, though, worked with several in Europe, while working for multinational companies, so there is clearly something unique about women and engineering in the UK.

I decided to place a posting on the Woman's Hour message board, commenting on the item and I asked the specific question as to the reasons why women don't want to read engineering at university. I was quite prepared to be informed that it was too difficult, boring, low remuneration etc. However, I wasn't prepared for what actually did happen: not one reply. My posting was removed a week later, because no one had responded.

When I did inspect the messages on either side of mine, they comprised a discussion about pornography, which appeared to contain an infinite number of postings – none of which detailed anything new – together with postings concerning an item about the wisdom of bribing children. It was abundantly clear, though, that a sizeable proportion of these comments were placed by university educated – in arts subjects no doubt – middle-class individuals, working in the service or public sector, who clearly wouldn't know what a shop floor or export was if they fell over it.

I spent two years prior to the economic downturn attempting to recruit senior electronics design engineers, with a good background in analogue electronics and electromganetics. I had to give up in the end, which resulted in two major projects being cancelled and the profits of my company suffered accordingly. The balance of payments deficit isn't an illusion: it is very real.

But did this worrying experience gain any exposure in any news item or newspaper letter (I wrote to the *Independent*)? Of course not, because the engineering profession doesn't have any powerful lobby group to represent it. And, of course, engineering isn't regarded as 'sexy'.

I contrast this with the medical profession. Do *Electronics World* readers remember the outcry when Laura Spence was rejected to read medicine at Oxford? I don't believe this matter would have been reported at all if she'd been rejected to read engineering. Prior to the election, the BMA threatened a mass resignation of GPs, one of the reasons being because of the alleged shortage of GPs. And what was the result of this bully boy approach? Why a whopping inflation-busting pay rise, taking the average salary of a GP to £84.5k. Remember the vilification that Arthur Scargill received when he adopted these tactics in the seventies in an attempt to save the mines?

Clare Roberts has been named as the Young Woman Engineer of the Year for 2001. Roberts, a design engineer for Yorkshire Electricity, was awarded £1000 and a silver rose bowl.

It seems ironic that Dr Smith and I must both have spent many long hours gaining our engineering Ph.Ds, though we are often treated as pretend doctors; the GP who uses 'Dr' as a courtesy title is regarded as the real thing – and paid as such.

I bought my first copy of *EW* when I was twelve years old because, like the young James Clerk Maxwell, I always wanted to know: 'what makes it a goer.' Thinking and acquiring knowledge were my major interests in life, irrespective of whether it was through an intellectual or practical route.

While I doubt whether any politicians ever read Electronics World, I think I'm perfectly justified to ask them what they really do mean by the 'knowledge economy', because it's clear from my experience that it certainly doesn't exist in the UK any more. ■

Lawrence Jones

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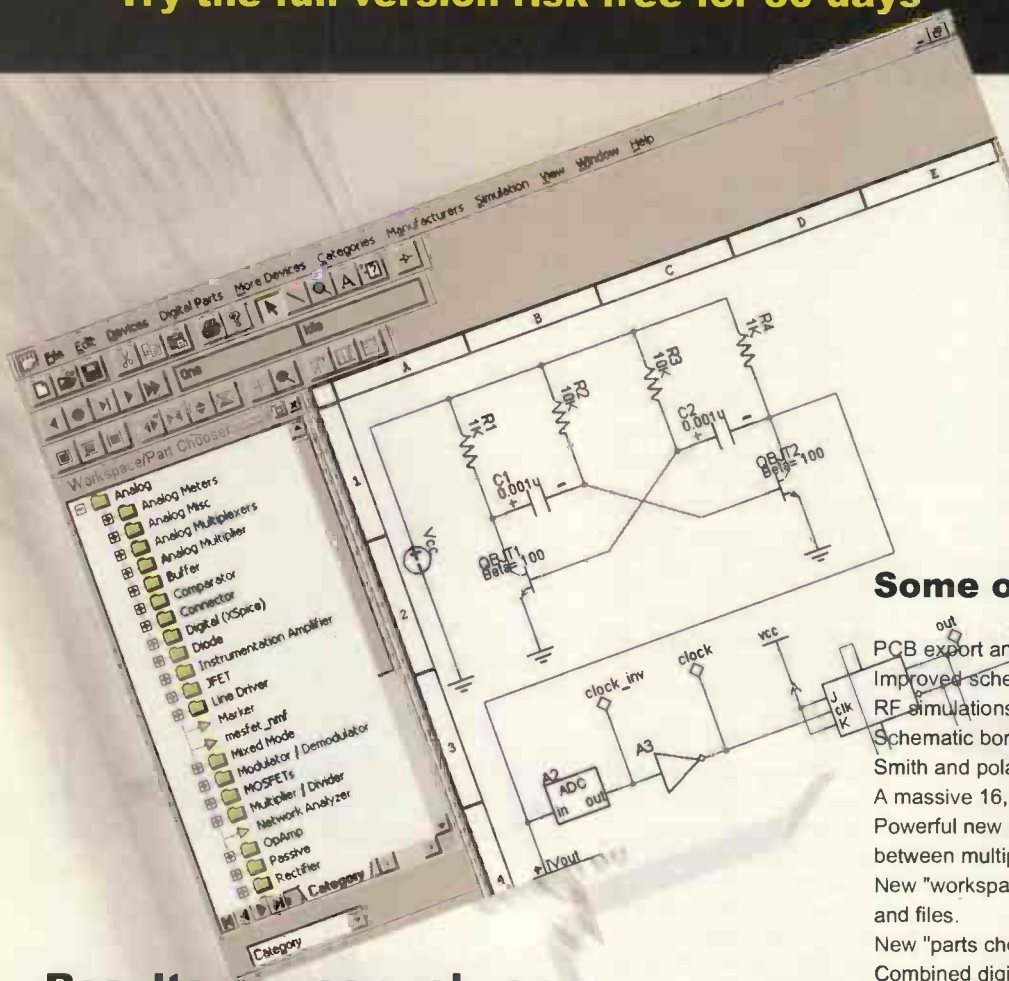

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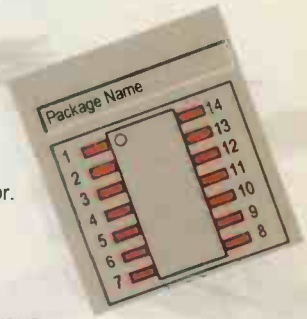

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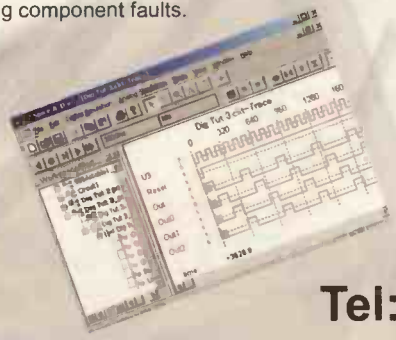

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UPDATE

New material could give blind people sight

A new ceramic material from NASA may one day be used in artificial retinas to help the blind to see.

Artificial retinas have been experimented with before. Most of them have used photo-sensitive silicon detectors.

Unfortunately, silicon needs to be coated as it, and body fluids, mutually deteriorate on contact.

The photo-sensitive ceramic material has been designed from the outset to be non-reactive in the body.

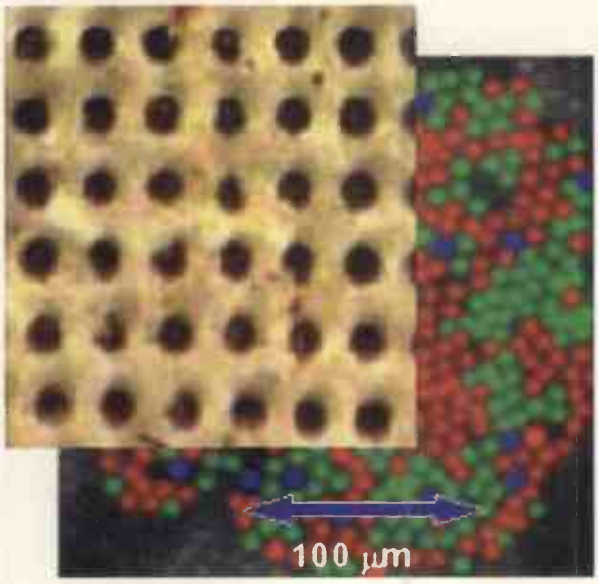
"We are conducting preliminary tests on the ceramic detectors for biocompatibility, and they appear to be totally stable," said NASA scientist Professor Alex Ignatiev.

The epitaxially-grown oxide ceramic detectors are to be implanted as a hexagonal array of 100 000 individual devices each 5μm across. Avoiding one large device allows nutrients, which enter the eye from the back, to reach the rest of the eye.

To make them easy to handle, the devices are attached to a soluble polymer film for insertion.

"An incision is made in the white portion of the eye and the retina is elevated by injecting fluid underneath," said team surgeon Dr Charles Garcia. "Within that little blister, we place the artificial retina."

The first human trials of such detectors will begin this year, said NASA.



New neural network chip has 1024 Risc processors

Aberdeen-based parallel-processor developer Axeon has unveiled its design for a neural network processor.

Called VindAX, a name derived loosely from the Latin for delivering, the design comprises up to 1024 Risc processing elements forming a single instruction, multiple data array.

Axeon calls VindAX the Learning Processor. "Our system learns by example," said Dr Neil Lightowler, Axeon's chief technology officer.

"The architecture was designed to suit a neural-network algorithm. Each of the processing elements – a true processor with memory and ALU – is optimised for this algorithm."

The firm is aiming the processor at complex non-linear systems, especially those for which it would be hard to develop a traditional algorithm. Handwriting recognition software that could be used in hand-held PCs has already been developed internally by Axeon.

Neural networks were hot topics in the eighties, but never lived up to their potential. Lightowler puts this down to silicon not being fast or small enough to implement a decent sized net.

In a 0.18μm process, a 1024 VindAX will occupy 67mm^2, and run at 200MHz. At this speed it could carry out 50 000 classifications a second, consuming 0.1W of power.

A silicon version of VindAX is available for prototyping and small volume systems. It has 256 elements – enough for applications such as handwriting recognition.

The first commercial use of the Axeon neural network might just be in automotive, if the firm's first external collaboration is successful. The firm has teamed up with Lotus Engineering, which is looking at hydraulic operation of valves in engines.

"There's a lot of interest in getting away from fixed mechanical actuation," said John Moore, commercial manager for research and technology at Lotus.

The firm started looking at hydraulics over ten years ago, but it was too complex and the electronics was too slow and expensive. Now the hydraulic actuators and electronics can be made fast enough and at the right price, said Moore.

However, the control problem is non-linear and extremely complex. Axeon's neural network seems an ideal candidate. "Their technology looks like it's able to cope with this very complex control problem," Moore said.

On the left is John Moore of Lotus Engineering and with him is is David Gorshkov, vice president of sales at Axeon.

Welsh firm trials mains comms

A firm from South Wales is the latest to demonstrate communications over mains power lines. LANergy has shown 14Mbit/s links over the standard 230V system.

The Newport-based firm is aiming its technology at home and office networking, linking laptops, PCs, DVD players and other equipment without installing any extra wiring.

"It means a low-cost, easy to install network which will transform the way that small firms and homes are managed," said Brian Lasslett, chairman of LANergy.

The firm has developed hardware to interface equipment with the mains, and software to manage all the nodes on a network. Encryption is used to provide security – which is critical for a mains-based system.

A Welsh venture fund has backed the firm to the tune of £1.35m.

Low-cost bendy displays come a step nearer reality

Philips Research is claiming "A significant step towards low-cost flexible displays," for this polymer-dispersed LCD which it demonstrated recently.

It is a reflective 64 by 64 pixel 256 grey level display with a 5.1cm diagonal and paper-like contrast, which can be refreshed at video speed, said the company.

The active matrix is based on a polymer created from a polythienylenevinylene pre-cursor. It is separated from the liquid crystal by spin-coated polyvinylphenol.

The display fill is polymer-dispersed liquid crystal that can be switched between light-scattering and transparent states by applying a voltage. In the transparent state, the reflective back electrode is exposed. No polariser or alignment layer is needed in the structure.

LED for torches and bike lights

This led assembly from Agilent-Philips joint venture LumiLeds is aimed specifically at torches and bicycle lights.

Called the LuxeonStar/O, the large-die device uses a supplementary lens and state-of-the-art light extraction techniques to squeeze as much useful light as possible into a beam.

Common LED colours are available.

The white version consumes around a watt and is slightly more efficient than a conventional halogen bulb. Maximum operating current is 350mA when the device drops around 3.42V.

A thermal plane is included in the substrate to keep die temperature down.

Other Luxeon devices including un-lensed arrays of various forms are available. www.luxeon.com

Satellites linked by optical beam

The first optical data link between two satellites using a laser beam has been tested by the European Space Agency. Images were sent at 50Mbit/s from the French space agency's earth observation satellite SPOT 4 to its processing centre in Toulouse, via the ESA's Artemis satellite.

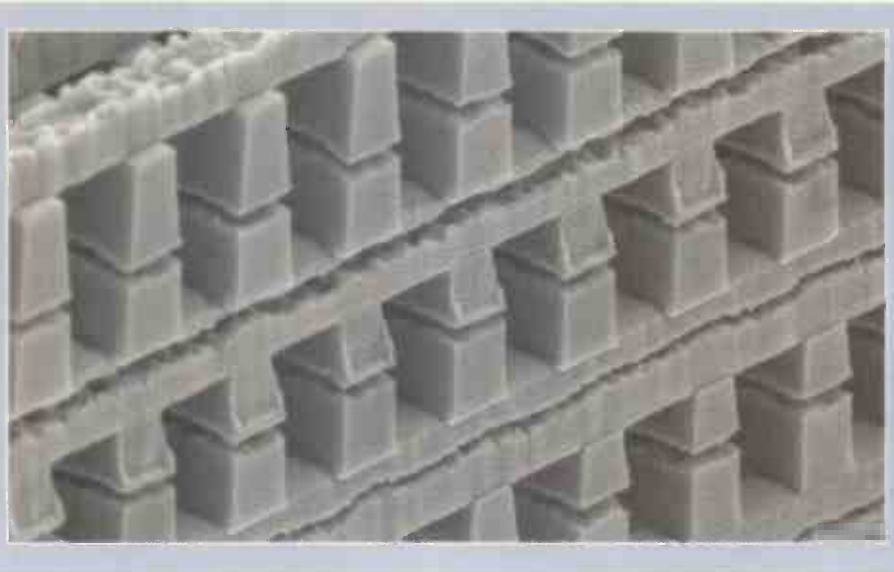
This is a significant achievement, when one considers that the two satellites are moving at some 7km/s. Extreme accuracy is needed to establish such a link, keeping the partner satellite illuminated.

The accuracy of the pointing system must be around 1μrad. Even the time taken for light to travel between the satellites has to be accounted for.

The relay satellite, Artemis, is in a parking orbit with an altitude of 31000km, while SPOT 4 is much closer to Earth, orbiting just 832km up. The laser relay allows SPOT4 to transmit data to its base for much longer periods of time.

Artemis will eventually reach a geostationary orbit, allowing much longer contact periods with for SPOT 4, up to half its orbit time.

Both satellites used on-board SILEX systems built by Astrium. The firm said its equipment can support image data rates of up to 250Mbit/s.



3-D chips... This structure can be made "using the standard materials, equipment, and processes already present and very well understood in the world's semiconductor manufacturing foundries", said Matrix Semiconductor, revealing this three-dimensional structure. The one pictured was made at a TSMC foundry for Matrix. The company is going into production with devices made using the same technique, the first of which will be Matrix 3-D Memory – a write-once memory developed as a consumable, much like traditional camera film. Intended markets include archival storage for digital cameras, audio players, portable games, PDAs and cell phones. These 3-D memory cards will be interchangeable with standard flash cards.

Electroluminescent display adds a new dimension to a car's dashboard

Planar Systems has developed a new type of instrument cluster display for cars.

The display, developed with automotive suppliers Sagem and Johnson Controls, is transparent and appears to float, allowing other displays to be viewed through it. In the version shown, a speedometer, gear selection and fuel level information are displayed on the new display that uses electroluminescent (EL) technology.

Johnson's industrial designers initially came up with a concept that could not be realised with displays readily available on the market. Sagem and Planar came to the rescue with the EL device.

"The prospect of adding a depth dimension to the already crowded instrument cluster really appeals to the transportation industry," said Erick Petersen, director of business development at Planar. "Planar is currently investigating a number of other applications for this technology."

www.planar.com

Head-up display works in full daylight

Microvision has begun shipping its Nomad personal head-up display.

Nomad has VGA resolution and is said to be readable in full daylight.

The company is aiming at applications in four markets - industrial, aerospace, medical, and military.

Several companies are already signed up to evaluate the display.

Eurocontrol, the European agency for the safety of air navigation, is to evaluate Nomad to reduce air traffic controller workload.

Medical firm Stryker Leibinger will couple Nomad with a surgical workstation and Telesensory is working on a device to help partially sighted people read.

www.mvis.com

Most powerful 2GHz transistor will transmit to 500W

NEC has made a single chip 113W 2GHz transistor from a nitride semiconductor and claims it to be the most powerful yet.

Two features contribute to the transistor's power output: a GaN-AlGaN heterojunction allows it to operate with a 40V rail and its thinned (50μm) sapphire substrate triples thermal conductivity compared with earlier devices.

Combining four nitride transistor chips in one package will make possible a transmission power output of 400 to 500W for mobile phone base stations.

Commercialisation is predicted within two to three years. 113W is delivered at 10% duty cycle.

Breakthrough in room temperature superconductors

New findings may bring room-temperature superconductors closer.

North American scientists, based at the Universities of Maryland and Toronto, claim to have the first clear evidence that electrons in so-called high-temperature superconductors behave differently relative to electrons in any other material.

In a research paper, the team show that electrons in a copper oxide (high-temperature) superconductor violate a fundamental theory of modern physics known as the Fermi-liquid theory. This theory forms the foundation for scientists' understanding of metals.

One tenet of the Fermi-liquid theory is that electrons in a metal can be treated as 'quasi-particles' whose ability to transport heat is strictly determined by their ability to transport charge.

However, the new findings show that, in at least one type of superconductor, the electron system can conduct heat in a way that is largely unrelated to the way it carries charge.

"In spite of intense research by condensed matter theorists and experimentalists all over the world, nobody yet understands the mechanism by which high-temperature superconductivity can occur," said Professor Richard Greene of Maryland's department of physics. "Our experiment shows that the very low temperature, normal metal state of so-called high-temperature superconducting materials is unlike any other material known. These findings represent a significant fundamental scientific result. And although they are not of practical significance at present, they may be a step toward someday finding a room-temperature superconductor."

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CIRCLE NO. 113 ON REPLY CARD

Compressing compiler claimed to reduce embedded code by up to 40%

A microprocessor developer from Ireland has developed hardware and compiler techniques that it claims can reduce the size of embedded code by up to 40 per cent.

Silaria, from Dublin, calls the technique Crush. It finds frequently used sequences of instructions in the code, and replaces them with a single custom instruction.

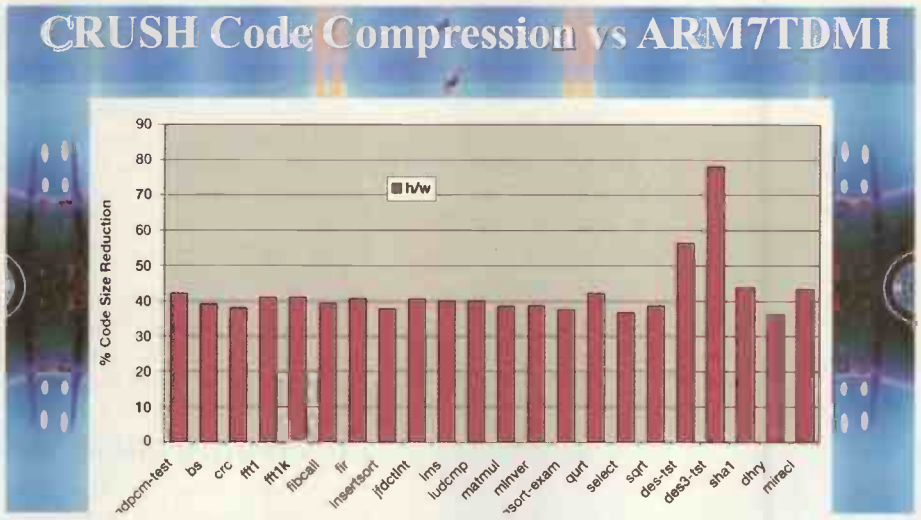
"Code density is key because it has a direct impact on cost," said John Hickey, Silaria's president and CEO.

Crush is designed to be used with the firm's Proteus3 processor core, which has a fine-grained instruction set architecture, with variable instruction lengths of 8, 16, 24 and 32-bits.

Rather than encode all instructions as 32 bits, Proteus3 allows commonly used instructions, such as Add or Return, to use perhaps 16 bits. This is similar to other code compression techniques such as ARM's Thumb.

Proteus3 alone, Hickey claimed, can be five to ten per cent better than ARM7 Thumb on code density, as some instructions, such as a return, can be 8 bits, whereas Thumb is 16 bits.

However, this replacement of certain 32-bit instructions with smaller versions is based on a general analysis of all programs. Crush can replace commonly used 32-bit instructions in an individual program.



"This allows individual programs to be compressed by crushing the most used 32-bit instructions," said Hickey.

More significantly, it can also spot commonly occurring sequences of instructions and replace them with a single custom instruction. This has no effect on execution time, Hickey said.

A table of the custom instructions is loaded into the processor design, making the whole process transparent to the user.

The architecture has over a thousand custom instruction slots, but Hickey reckons 64 to 128 is enough to get a 40 per cent code density improvement.

Crushed instructions need extra on-chip hardware, and for between 64 and 128 custom instructions this would mean around 25000 extra gates, doubling the size of a 32-bit, 32-register core.

If the final chip design uses a cache, then the denser code could lead to faster operation by avoiding cache misses. Alternatively, the cache could be made smaller.

Crush will form part of the company's tool set, and will be released early next year.

A thin film substrate for stacking multiple die in a package has been developed by Swedish firm Strand Interconnect. In order to avoid thermal expansion problems, the interposer material is made from silicon.

Tiny fans wiggle to cause a draught

Wiggling fans made using micromachining could cool future generations of consumer electronics and semiconductor ICs, if scientists from Purdue University have their way.

The researchers create a micromachine that waves a small blade back and forth, much like a Chinese fan. Piezoelectric material is used to move the blades of the fan, which therefore use little power – around 2mW.

Importantly, the fans do not need magnets, which removes any undesirable electromagnetic interference.

As transistor densities increase on chips, the need to remove heat close to the source becomes more important, both to increase reliability and improve performance.

"Even if it's just a bit overheated, its performance and reliability goes down," said Suresh Garimella, an associate professor of mechanical engineering at Purdue. "Another reason for cooling is to improve performance as you go to smaller and smaller devices."

Small fans for use on a chip would have a length of around 100μm, while a fan inside a laptop PC or mobile phone could have blades somewhat longer, perhaps an inch long.

While the idea of a piezo fan is not new, the Purdue team claim its design is quiet and efficient. A mathematical process for determining the best design for a specific application has also been developed.

"What we bring to the table is a knowledge of the modelling of these fans," Garimella said. "[we have determined] how to analyse the design, to figure out how large a patch should be for how long a blade, how thick the patch should be and what happens if you modify all these quantities – in short, how to optimise the performance of these fans."

The Australia Telescope can now receive frequencies of up to 100GHz, following an upgrade with indium phosphide chips. Velocium, part of US electronics firm TRW, supplied the amplifiers and digital receivers. "The extremely high frequencies allow astronomers to take pictures of new phenomena with greater detail than ever before." said Dwight Streit, boss of Velocium. The image shows one of the upgraded receivers.

Electronic nose firm sniffs out US market

UK electronic 'nose' firm Osmetech has started clinical trials in the US of its bacterial vaginosis (BV) sensor device.

Previously the firm had received regulatory approval from the US Food and Drug Administration (FDA) for its urinary tract infection (UTI) sensor.

"This announcement is a landmark achievement for Osmetech and a first for the e-nose industry," said James White, Osmetech's chief executive. "We are delighted to have reached the milestone of FDA approval and to have done so in the time scale we set at the start of the FDA submission process."

Trials of the BV sensor will take place at three hospitals, including St Georges Hospital in London. Data from the trials will be used to apply for FDA approval to market the product, expected by the summer.

According to the firm, a study at John Hopkins Hospital in the US showed the sensor gave diagnostic readings that were both quicker and more objective than current sensing methods.

In October 2000, a large study in London showed the device matched the existing 'gold standard' methods, Osmetech said.

Researchers seek to improve 3D-sound experience

Individually-tailored surround-sound systems could come out of research at the University of California, Davis.

It has long been known that adding certain acoustic artefacts to stereo audio signals can make sounds appear to come from different directions to the listener.

The artefacts mimic various filtering effects that occur to sound waves as they are diffracted, refracted and absorbed by the body, head and ears of the listener on the way to the listener's inner ears.

Several commercial 3D sound systems exist, but all are based on a single, averaged head and ears model. This model is called an HRTF, or head-related transfer function.

Listeners who closely resemble the model get the best 3D effect, which worsens as the subject differs further from the average.

The researchers, Richard Duda and Ralph Algazi, have measured the 3D hearing of 45 humans and also measured their torsos, heads and ears in an attempt to find some form of correlation between physical shape and 3D sound perception.

The eventual aim is to somehow scan listeners with a video camera, then automatically adjust the sound characteristics to suit them.

"I believe that this customisation of systems to individual characteristics represents an important and achievable goal for computer technology. Our current work, with colleagues at the University of Maryland and Duke University, is taking the next step toward this goal by using computer vision techniques and high-performance computing to obtain personalised HRTFs," said Duda.

To allow others to have a go at finding correlation between physical and acoustic characteristics, Duda and Algazi have put their measurements up on the Web at interface.cipic.ucdavis.edu/. Click on HRTF data. The US National Science Foundation funded Duda and Algazi's work.

Disney's Wurlitzer gets a face lift

Devon-based Musicom has updated Disney's mighty Wurlitzer to bring its reliability into the 21st century – and add some new features at the same time.

"The old system had about 50 miles of cable and 25000 different sets of contacts," said Musicom's founder and MD Tony Koorlander. The contacts tend to wear out, making maintenance a headache and "the Wurlitzer [console] comes out of the floor on a lift. The original bundle of cables didn't like all the flexing and was a nightmare", said Koorlander.

Musicom's system replaces everything except the key contacts and solenoids with electronics.

A proprietary nine-wire bus in a flexible cable takes data from a computer in the console to the various organ pipes.

PIC microcontrollers running Musicom software de-multiplex the bus signals and operate solenoids through Musicom interface cards.

Opto-isolation is used extensively to beat electrical noise, which is considerable according to Koorlander. Heavy ground is used for the same reason.

The console computer is a TP300 Pentium-level machine from DSP Design. It runs Musicom software over a QNX operating system.

This set-up replaced the in-house Z80 system Musicom had used before, but which proved inadequate for the Wurlitzer.

www.musicom-ltd.com

Wurlitzer console rear view with standard Musicom hardware and the TP300 rack at the back.

TI combines DSP and Risc cores

Standard chips combining advanced signal processing and Risc cores are now available, following Texas Instruments' launch of its C5470/1.

The devices combine a C54x class DSP with an ARM7 processor and a host of peripheral circuitry.

"On one device we tried to get the best each core can offer," said Arnaud Duclap, European business development manager at TI.

A 100MHz C54x DSP with 72kwords of RAM shares 8kwords of RAM with a 47 5MHz ARM7, which has its own 16kbyte of memory.

The chips are aimed at applications with both signal processing and control requirements. For example, in a text-to-speech system, the DSP performs speech synthesis, while the ARM7 carries out linguistic processing functions.

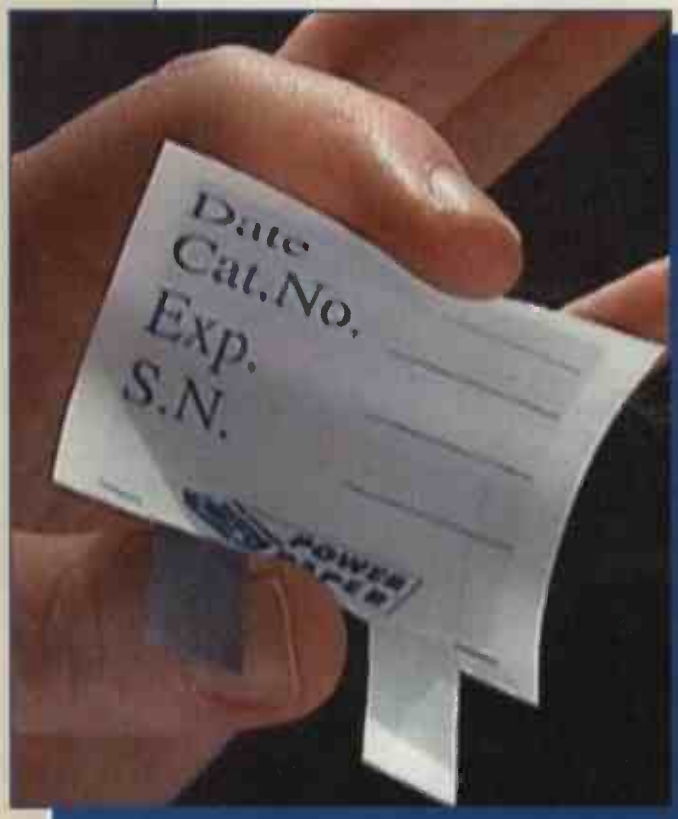
But why not just use two separate processors? By combining the cores on a single die, "we reduce the system size, we reduce the cost and the power by 40 per cent", said Duclap.

Peripherals common to both chips include two multichannel buffered serial ports, two UARTs, serial port, I^2C, and general purpose I/O. A keypad, LCD, USB and Bluetooth links can be directly control. ■

Exploding ICs... Chemists at the University of California, San Diego have discovered that silicon wafers can be easily made into tiny explosives that might be used one day to chemically analyze samples in the field or serve as power sources for tiny electronic sensors the size of a speck of dust.

"Most people are familiar with silicon as the material that's used in computer chips for circuits," says Michael J. Sailor, a professor of chemistry and biochemistry who headed the research project. "This is the same material, but we're making it into a very finely divided form of silicon – a nanocrystal – that has such a high surface area that it burns very quickly. The faster the burn, the bigger the bang."

Bendy batteries enable smart solutions



Ultra-thin battery technologies look set to add major new functionality to travel tickets, ID tags and greetings cards. They're making smart cards smarter too, as *Andrew Emmerson* reports.

Batteries add bulk, not to mention cost. But if you had access to low-cost, paper-thin batteries, the possibilities would be endless. You could embed them in credit and identity cards, in baggage labels, in RF-enabled price and product tags, in contactless car-park and travel tickets, in novelty greetings cards and in all manner of toys and games.

Cheaper, lighter batteries would benefit existing products as well as these more novel applications. Thinner batteries could bring down the cost of the disposable cellphone as well as reduce the size and weight of all manner of portable and mobile devices, such as notebook computers and personal digital assistants.

All these possibilities are just around the corner, according to the Power Paper company of Israel, whose product of the same name works exactly like a traditional battery but is nearly as thin as a piece of paper. Power Paper cells make an ideal replacement for watch or calculator batteries but unlike existing button cells, Power Paper is just half a millimetre thick.

The cell is made up of five ink-like layers of material – a collector and cathode layer on one side, a collector and anode layer on the other and an electrolyte core. This produces a dry battery that's not only flexible but also has no need for a hermetically sealed metal case. It's 'green' too; all ingredients are non-toxic and safe, permitting disposal without endangering the environment.

Output is 1.5 volts and cells can be used in multiples to provide more power. A $1in^2$ ($25mm^2$) printed cell will provide this voltage with a capacity of 15mAh and a shelf-life of more than two years. They can be used in multiple combinations for greater voltage requirements in any shape or size.

A rechargeable version is planned, although the first production of Power Paper batteries will be targeted at disposable products, such as travel cards, car park season tickets, greeting cards, toys and industrial tags.

Standard silk-screen printing presses are used to print the batteries onto paper and other substrates, giving amazing versatility and allowing them to be manufactured into any shape or size. They can also be integrated with printed circuits, RFID patch antennas and microchips, enabling them to perform functions such as controlling prescription drug injections, monitoring smart tags and labels or transmitting radio frequency identification label information over long distances.

Another promising niche market is in medical applications. These include bracelets that monitor temperature and provide health readings, prescription labels that read directions aloud to patients and remind them to take their medication, powered transdermal patches that deliver medication and combined

Power Paper's cells are made up of five ink-like layers of material – a collector and cathode layer on one side, a collector and anode layer on the other and an electrolyte core.

microsensors and readouts on disposable strips for performing complex diagnosis at home.

Unlike other batteries, Power Paper's energy cell is open and requires no casing to hold chemicals. It can be printed, pasted, or laminated onto paper, plastic, and other media. The actual power source is a zinc and manganese-dioxide (MnO_2) based cathode and anode. Both are fabricated from proprietary inks. As these are dry, the metal casing needed in conventional batteries to contain active chemicals is unnecessary. No special production equipment is required, nor does Power Paper require to be made under clean-room conditions, lowering manufacturing costs.

Power Paper expects to form a broad range of joint ventures and licensing agreements with companies wishing to integrate the technology into their manufacturing process and the first such deal was announced in July 2001. Graphic Solutions, Inc., of Burr Ridge, Illinois (USA) will use the technology to enhance its existing business making printed circuitry, electroluminescent products, antennas for RF tags, labels, name plates and panels.

Another ultra-thin battery technology about to hit the market is the dry-polymer battery supplied by Leading Edge Technologies, Lakeland, Florida. It is slender enough to fit between the laminated outer layers of a credit card and this is the prime application currently. Battery life is stated to be three to five years, depending on use, and contacts on the card allow it to be recharged. The company is aiming for a price of 10 cents or less per unit once production volumes enter the millions.

First user of this technology is a smart electronic credit card with a built-in battery and microprocessor that's ready to be trialled by 200000 users in the USA. The card manufacturer is called PrivaSys and their CEO, Joan Ziegler, states that tests will begin with these battery-powered cards shortly with several US credit and debit card issuers.

The PIN-activated card protects card-holders' credit information through the use of secure card numbers that are created dynamically for each purchase. When consumers need to pay, they tap their personal identification number into the keypad.

A microprocessor chip on the card generates a random number that is visible on the liquid-crystal display and is also transmitted to the card's magnetic stripe. The one-time code is converted into the consumer's actual card number at the card issuer's mainframe computer after it has been swiped through the point-of-sale terminal and sent up line. This, says PrivaSys, entirely eliminates unauthorised cloning or 'skimming', one of the key methods of counterfeiting credit and debit cards. The number display allows card-holders to use the cards to make purchases by telephone or over the Internet.

New battery materials don't stop here either. Another thin and flexible – but intrinsically more expensive – battery technology uses lithium polymer and offers more power. One model, developed by a research team of the Korea Institute of Science and Technology, uses polyacrylonitrile as an electrolyte and is aimed at use in portable computers.

In the USA researchers at The Johns Hopkins University have developed a polymer-based all-plastic battery that is rechargeable and environmentally friendly. This has military and space applications but would also be cost-effective in small consumer devices, such as hearing aids and wristwatches.

In the longer term batteries may be commercialised using 'cages' of the pure carbon variant known as buckminsterfullerene ('buckyball') to contain lithium and fluorine or methanol. For these we may have to wait rather longer, however. ■

Contacts:
http://www.powerpaper.com
http://www.privasys.com/Prod_SecurSys.htm

Flat batteries allow smarter cards to be made that entirely eliminate unauthorised cloning or 'skimming' – one of the key methods of counterfeiting credit and debit cards.

The invention of the superhet

Ian Poole has been investigating how today's most popular receiver topology – the superheterodyne – made its debut.

From the very earliest days of radio, the two aspects of radio performance – sensitivity and selectivity – have been of paramount importance. Shortly after the beginning of the twentieth century when coherers and spark transmitters were in use, the lack of receiver sensitivity seriously limited the range over which transmissions could be made.

The limited selectivity also hampered performance. Indeed, after the *Titanic* sank, the number of stations transmitting and aiming to help caused congestion on the airwaves and actually impaired the rescue.

To overcome these problems, receiver performance needed to be greatly improved. This resulted in the invention of the superheterodyne or superhet receiver. The name is derived from the words supersonic – i.e. above the audible range – and heterodyne from the fact that two signals are mixed together.

The basic concept was invented during the First World War, and many basic broadcast sets today are little more complicated than the first superhet built, although most sets today are somewhat more sophisticated and

1934 Marconiphone

1936 Murphy A30

Note: some components in the following diagrams are not to today's standards The conventions used have tried to follow those of the original diagrams as closely as possible.

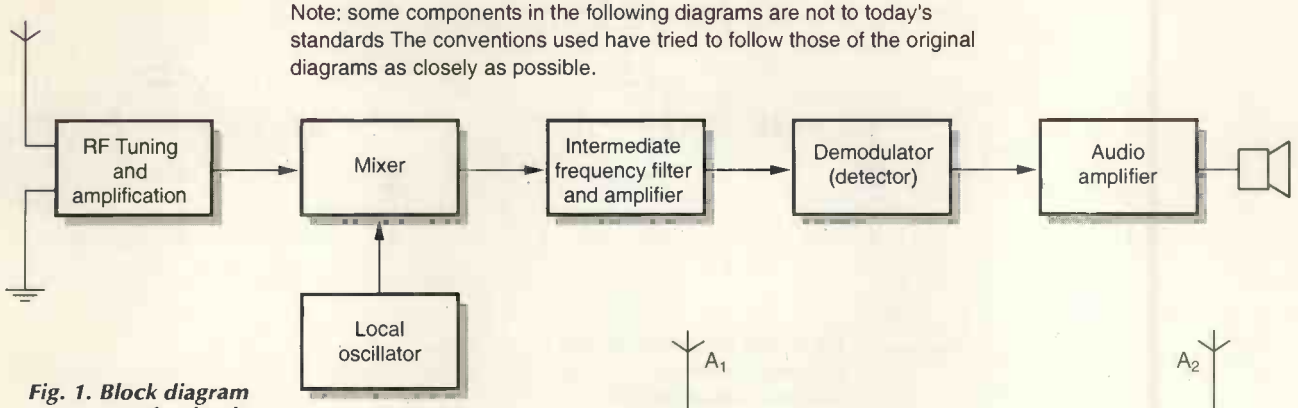


Fig. 1. Block diagram of a simple superheterodyne receiver.

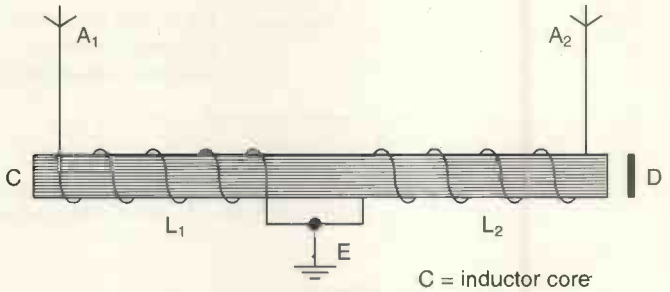


Fig. 2. A receiver arrangement for using the Fessenden's idea of transmitting signals that beat together in the receiver.

certainly have a far superior performance. Even so the basic concept is still the same.

Superhet principle

The superhet principle involves the use of a local oscillator to convert the incoming signals down to a fixed frequency, an intermediate frequency amplifier and a filter. Tuning the receiver is effected by changing the frequency of the local oscillator so that signals on different incoming frequencies are able to pass through the filter, **Fig. 1**.

The advantage of this technique is that a high-performance filter can be designed for a fixed frequency. Designing variable-frequency filters would be far more difficult and expensive and the level of performance would be far inferior.

Early ideas

The story of the superhet starts with some early experiments that were performed by an American Engineer named R. A. Fessenden. He thought that the sensitivity of receivers could be improved if the transmitter were made to send out a signal that would produce the desired signal in the receiver.

Fessenden proposed that one way this could be done was to transmit two signals close in frequency to one another. Once received and detected at the receiver, audible beat notes would be heard. He patented the idea on 28 September 1901. It is particularly important because this was the first recorded instance of using the beat-frequency phenomenon for wireless communication, **Fig. 2.**

Having formulated his first idea, Fessenden started to refine it. Transmitting two high-power signals to beat with one another in the receiver wasted power and required two transmitters. His next idea used a locally generated signal from the receiver to interact with the incoming signal to form the audible beat note.

Apart from being considerably more efficient this second method had the further advantage that it enabled the receiver operator to vary the frequency of the beat note at the receiver by simply changing the frequency of the locally generated signal, **Fig. 3**.

The idea was successfully used with a distance of over 3000 miles (5560km) achieved using the system. However

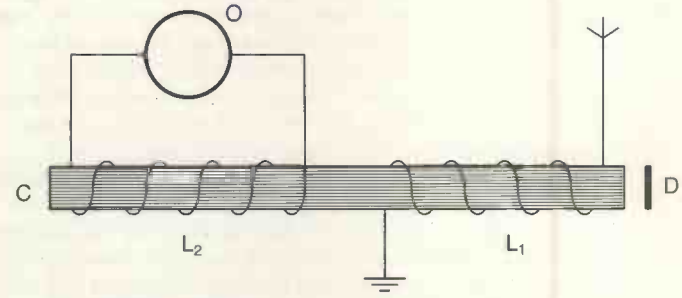


Fig. 3. The concept of a receiver using a locally-generated signal to beat with the incoming signals.

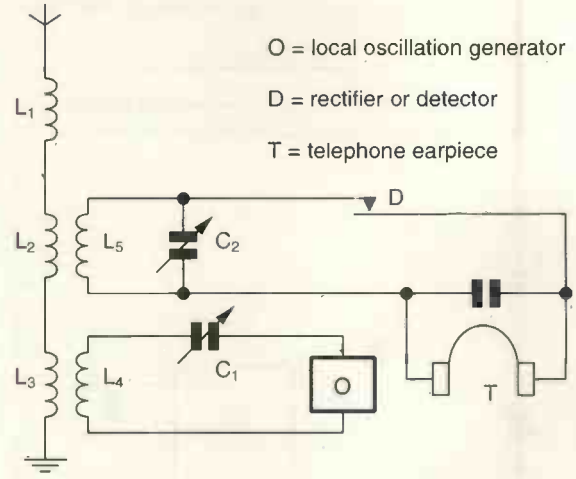


Fig. 4. An early circuit for a heterodyne receiver using a rectifier to create the heterodynes.

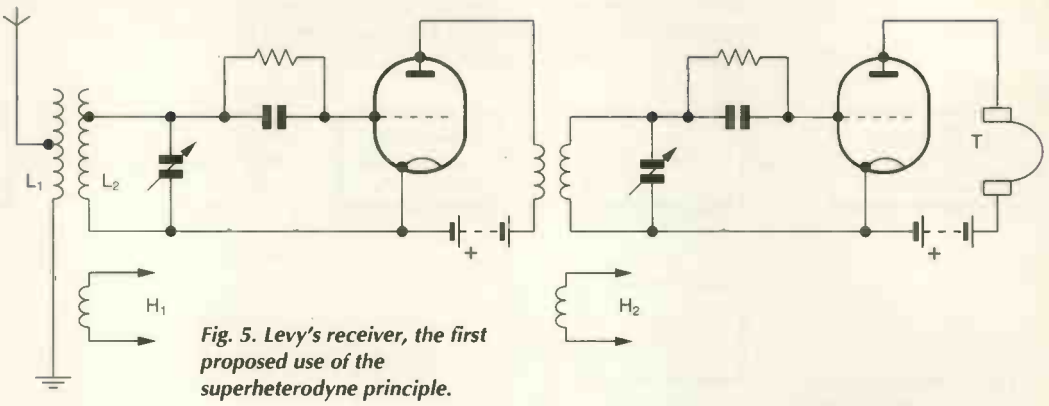


Fig. 5. Levy's receiver, the first proposed use of the superheterodyne principle.

its efficiency was low as a result of the very low sensitivity of the non-polarised telephone receivers that had to be used. As a result the idea remained dormant for several years.

Renewed interest

The next time the idea of beats was renewed was in 1910 after some tests between two American cruisers. During the course of these experiments, one of the wireless operators noticed several unusual effects in the receiver when the transmitter on the ship was started up.

The beat note would have been at around 20kHz, well above the frequency response of any transducers and hence difficult to detect. Nevertheless, the resulting observations lead to a more detailed investigation of local oscillators and the effects of signals beating with one another.

The result of this investigation was a far more sensitive receiver. A rectifier and normal moving-coil telephone earpiece replaced the original earpieces and the design of the circuitry was optimised. Tuning was accomplished by varying the frequency of the local oscillator, which in these early receivers used a high-frequency alternator, Fig. 4.

In 1913, the heterodyne receiver was used in some more naval tests, but this time between Arlington Virginia and the warship *Salem*. Here the new receiver performed well, enabling communication to be established over distances up to 6400 miles.

Not only was the set more sensitive, but it also gave superior performance under conditions of interference, proving itself against magnetic detector and ticker receivers.

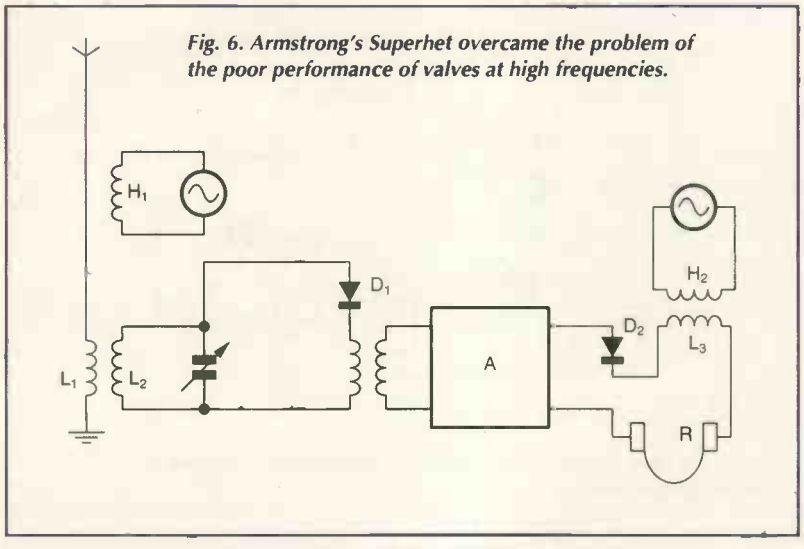


Fig. 6. Armstrong's Superhet overcame the problem of the poor performance of valves at high frequencies.

Valves

One of the major enabling factors in the development of the superhet was the invention and development of the valve, or tube.

Initially, the invention of a diode detector was made by Ambrose Fleming, professor of electrical engineering at University College London in 1904. This formed the platform for de Forest to develop the triode valve in the USA two years later. This was initially used only as a detector, but later it was discovered the device could amplify signals.

Naturally the performance of these early valves was very poor. Gain was limited and the frequency response restricted their use to a few hundred kilohertz.

Valves were used in many types of receiver, including direct-conversion receivers. Here they made the generation of the local-oscillator signal much easier. The first instance of a valve being used as an oscillator in this way was by Arco and Meissner of the Telefunken company in Germany in 1913.

Although valves were very expensive around this time they were less expensive than a high-frequency alternator and they were also much more compact. As a result a considerable amount of interest in their use was stimulated by their use in this application. A number of people including H. J. Round, an employee of the Marconi Company, experimented with their use as a source of a heterodyne signal for use in receivers.

Wartime impetus

The next major impetus for the development of radio technology arose from the hostilities in Europe during the First World War.

The advantages of wireless had been recognised by the military authorities on both sides of the divide and as a result many of the leaders in wireless development were looking to methods by which they could improve the technology. On the side of the Allies H. J. Round, M. Latour and later E. H. Armstrong were some of the leading lights in the developments being made, and for the Germans, there was W. Schottky.

All these scientists had a common goal – that of giving higher degrees of amplification and better selectivity. This proved to be very difficult between frequencies of 500 and 3000 kilocycles. These were considered to be very high frequencies.

Many of the problems arose from the limitations in the development of the valves of the day. Here inter-electrode capacitances meant that frequencies above about 500 kilocycles presented considerable difficulties when using valves. They lost gain and became very unstable. This set people thinking how these problems could be overcome.

One method was naturally to look at the root cause and investigate how the performance of valves could be improved. H. J. Round undertook much valuable work in this area. He developed a new valve type known as the V24 that had low levels of inter-electrode capacitance. He also introduced a number of other measures to improve receiver performance, and made some significant advances, but they did not provide the complete solution.

Accordingly others looked to means whereby greater improvements in performance could be gained.

Lucien Levy

The next major development was made by a French engineer named Lucien Levy. He was mainly interested in reducing the effects of interference and he developed an idea that he claimed would completely eliminate the effects of "parasites and ordinary interference". His method of reception used the superheterodyne principle and the patent covering his proposal was filed on 4 August 1917.

Levy's receiver had a first mixer where the signals were converted down in frequency. The output, or beats, were said to be 'ultra-acoustical' but sufficiently low in frequency that they could be easily tuned.

A second heterodyne converted the keyed carriers that were to be received into audible beat notes. By using this principle, Levy believed that the ultra-acoustical beats would be so far separated in frequency from the atmospheric disturbances and interfering stations that the wanted signal could be easily separated and interference would be completely eliminated, **Fig. 5**.

Although the receiver shown only has two valves in the signal path, Levy intended that further stages of amplification would be added in the intermediate frequency stages to boost the signal level. This would be tuned if necessary. The main difference between Levy's superhet and the principle used today is that the intermediate frequency stages were variable in frequency.

Armstrong's idea

When the American forces arrived in Europe to join the other forces in the struggle against Germany, they found that the receivers they possessed were not suitable for the high frequency work required.

Edwin Armstrong spent some time researching the problem and came up with a similar solution to that proposed by Levy. However, he proposed that a receiver would have a fixed-frequency intermediate stage instead of a variable-frequency one.

One of the main advantages of this approach at the time was that it overcame the poor performance of valves at high frequencies. By using a low-frequency IF stage, the required level of gain could be achieved without the problems of instability that would be encountered at higher frequencies. Armstrong stated that incoming signals along with their modulation would be converted down to the lower frequency where they would be amplified and tuned and finally rectified in the normal way, **Fig. 6**.

Armstrong filed the patent for his idea on 30 December 1918 and it included the possibility of multiple conversions. It was over six months behind one filed in Germany by Schottky. Armstrong though had built and tested an eight-valve superhet. It consisted of a first detector or mixer, heterodyne oscillator, three stages of intermediate frequency amplification second detector and two stages of low frequency amplification.

Schottky had not built and tested his idea so Armstrong is generally credited with the invention of the superhet radio.

In abeyance

With the cessation of hostilities the need for the superhet wireless set reduced. Valves were very expensive and few wireless stations were active. Accordingly little was heard of the idea for a number of years.

Soon, many developments were made. Valves became cheaper. Indirectly-heated valves were introduced so that a common heated supply could be used and individual bias batteries were not required, making valves much cheaper to use.

More components such as dual-gang capacitors were developed. All of these combined with the increasing number of stations broadcasting meant that higher levels of performance were required. As a result the superhet started to be used for broadcast sets. This occurred during the late 1920s in the US and early 1930s in Europe where the growth in broadcasting was slower.

Now the superhet radio is used almost universally for broadcast and most other types of receiver, and it looks to remain in its position of dominance for very many years to come. ■

More information about radio and electronics history as well as today's technology can be found at: www.radio-electronics.com.

Make sure of your copy of *Electronics World*

It can be difficult finding a copy of *Electronics World* at local newsagents. The number of magazines being published keeps increasing, which means that newsagents have less shelf space for the display of particular titles. Specialist magazines in particular get crowded out.

There's a solution to the problem. Most newsagents provide "shop-save" and/or home-delivery services. There's no charge for a shop save. You simply ask your newsagent to order a copy for you: it will be kept on one side each month ready for you to collect. Home-delivered copies are ordered in the same way, but generally incur a delivery charge.

A newsagent can order any magazine for you, whether or not the shop normally stocks it. If you buy your copies of *Electronics World* from a newsagent and want to make sure you get every issue, just ask at the counter.

Gang your own pots

Off-the-shelf, ganged potentiometers are rare and can be very expensive. Cyril Bateman has devised a method of ganging your own pots in multiples of two, three or even four gangs.

Quality double-ganged potentiometers needed to build a low-distortion test oscillator can prove difficult to source. Triple and quadruple ganged devices needed for a distortion analyser are almost impossible to locate anywhere.

One major supplier of precision potentiometers – B.I. Technologies – catalogues a variety of styles having a small diameter rear extension spindle. Perhaps this could be used to gang together the required number of controls.

The company's Web page provides a stock-finding facility which accesses both distributor and factory stocks. Unfortunately, despite repeated searches using this facility, I failed to find a single usable item listed as being in stock anywhere – world-wide.

For many years, the Alps factory has provided good-quality carbon-track linear and logarithmic controls, in 27mm and 40mm sizes. These are manufactured as single, double and quadruple-ganged assemblies. These used to be available, both motorised and non-motorised, from hi-fi kit specialists such as Hart Electronics.

Today these double-ganged devices can still be obtained from stockists, but usually only in a limited range and with logarithmic tapers. Double-ganged linear styles proved difficult to source and regardless of value or taper, I could not find any quadruple-ganged stocks.

Fig. 1. This semi-overhead view of my dual gang version, illustrates both types of outrigger bearing. Clearly shown is the possibility of reducing the depth needed for all three assemblies. Unwanted spindle length will be removed at final installation. For this assembly, the potentiometer spindles were spaced on 40.5mm centres. This spacing provided easy connections to my circuit board.

Occasionally, good quality carbon track dual controls intended for audio amplifiers can be obtained These are matched to 1dB. But ganged multi-turn precision wire-wound controls simply do not exist – unless you want to order a very large quantity.

The tracks of potentiometers matched to 1dB can vary considerably relative to each other as the control is rotated. While this tolerance is adequate for many audio purposes, better than 1dB matching is needed when building low-distortion oscillators and low-distortion notch filters.

Having wasted much time attempting to source the ganged components that I needed to build a new distortion analyser,[1] I decided to explore other means to provide suitable variable controls.

Ganging methods

I decided to mechanically gang together the required number of conventional multi-turn precision wire-wound controls. These are standard distributor stock items and are available in many values. Ganging these together would also allow using mixed values as needed for, say, a twin-tee filter, as well as making identical multiples.

Like John Linsley-Hood,[1] I too recalled the special dial drive pulleys once used with spring tensioned wire belts as reduction tuning drives for receivers. However I was unable to find a supplier. On reflection, I don't think that they would be all that useful for ganging together multi-turn potentiometers.

Initial attempts to 'gear' together two controls using pulleys or gear wheels failed, so I sought another method. It had proved almost impossible to source suitable light-duty small pulleys, chains or gear wheels for shaft diameters larger than 3mm. Most suitable potentiometers come with either 6mm or 0.25in shafts.

After many catalogue searches I decided to use the smallest and lightest toothed belt and matching pulley drive wheels I could find. Such drives are noiseless at low speed. Being backlash free, it looked as though they would provide a possible, if slightly heavy duty, solution.

Implementing the idea

I mounted two ten-turn wire-wound potentiometers onto an experimental slotted aluminium face plate. Initial experiments ganging these together using 14-tooth pulleys and a 60XL025 belt obtained from RS worked well, but the idea needed refining. The potentiometer spindle reached only into the middle of this pulley wheel so some means to mount a control knob was needed.

Initially I tried simply extending one spindle by super gluing a short length into the pulley boss. This worked quite well, but still needed improving. The main problem now was that the slack in the potentiometer spindle bearings did not ensure that both spindles remained parallel.* This allowed some 'run-out' of the belt on the pulley wheels. With the spindles glued or pinned into the pulley, brute force would be needed in order to replace a control.

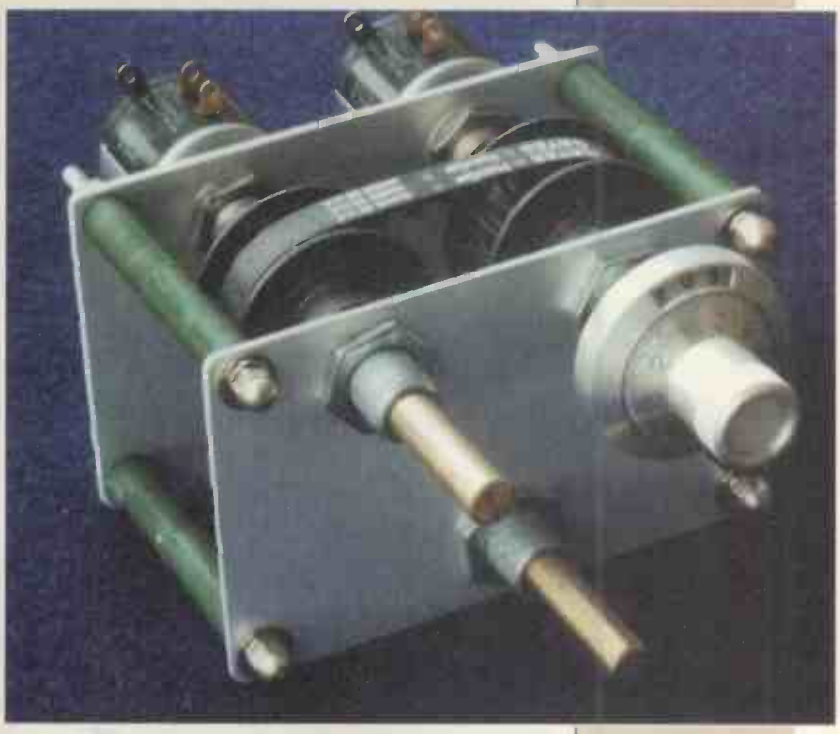


Fig. 2. This triple gang version required care when marking out the drill centres for each potentiometer. Because of the 120° belt wrap-around, my original calculations resulted in too much tension in the belt. I found best results when the spindles were equi-spaced by 35.5mm, at the corners of an equilateral triangle.

Outrigger bearings would ensure the necessary spindle alignment. At some increase in the depth required for an assembly, commercial spindle extensions would then allow the potentiometers to be

*There's a chance that using Loctite as opposed Superglue might improve this situation as it tends to have a slight centring effect as it expands. If you try it, let the Loctite cure with the spindle vertical. If your drilling isn't too accurate, try drilling the holes half a millimetre or so further apart than they should be then file them out with a rat's tail until the belt's a snug fit. If you tend to get three-cornered holes when you drill sheet metal, try putting a small (25mm or so) square of rag over the position of the hole you're about to make so that the drill grabs the rag just before it starts to drill the hole. Any theories as to how this works? Ed.

Materials used

Pulleys	14 tooth Martin 14XL037 obtained from RS as part number 350-8052.
Two gang belt	60XL025 obtained from RS as part number 338-7524.
Triple gang belt	70XL025 obtained from RS as part number 338-7530.
Quadruple gang belt	80XL025 obtained from RS as part number 338-7546.
Extension spindles type 56	obtained from Farnell as part number 101-603.
Quality outrigger bearing	obtained from Farnell as part number 321-345.
Low cost outrigger bearing	obtained from Electrovalue as part number 12MMB.

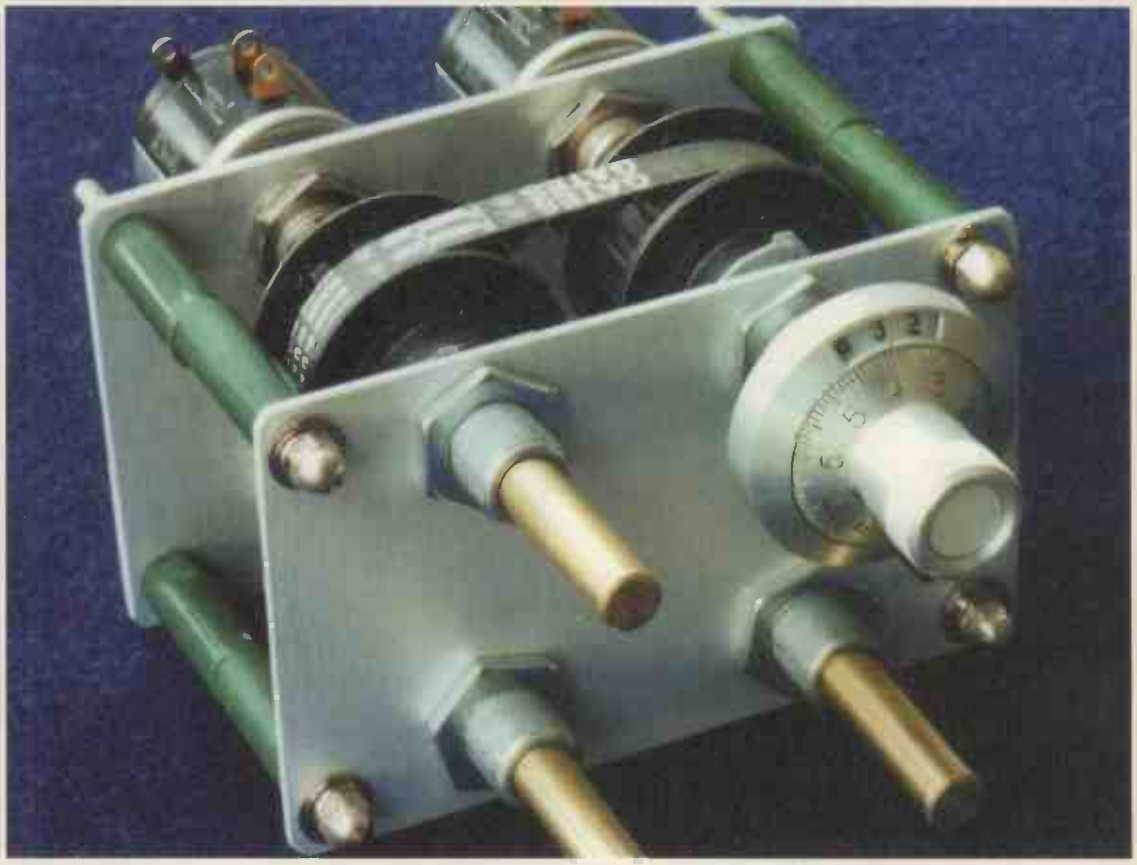


Fig. 3. Needing little more space than for the triple gang version, this quad version with its spindles spaced by 33mm, is free from backlash yet rotates freely, with little effort. It could be used for the two-stage Linsley-Hood distortion meter design, or to make a tracking spectrum analyser/tracking generator assembly.

adjusted to synchronise their values, or be easily replaced when necessary.

To carry these outrigger bearings, a second identical mounting plate would be needed. Both plates would then be mechanically secured together using low cost 40mm long plastic spacers.

For this two-gang version, I used two identical mounting plates measuring 80mm by 25mm. The two potentiometer mounting holes were spaced at 40.5mm centres.

Ten-turn wirewounds are relatively expensive so I preferred to not shorten their spindles. These were all left standard for the photographs. However when ready for final installation, each assembly could be slightly foreshortened by cutting these spindles as required. This possibility is clearly visible in the photograph of my two gang assembly, **Fig. 1**.

While all three versions used the same 14-tooth pulley wheels, to minimise size, each needs a different length toothed belt. Being of US origin, these belts are specified by their circumference in tenths of one inch and each tooth is spaced by 0.2in. Hence the belt 60XL025 I used for the two-gang design comprises thirty teeth and has a width of 0.25in. Since each pulley contains 14 teeth, this is the shortest usable belt with these two pulleys.

As you can in this photograph, I demonstrate two different outrigger bearings. The deeper one behind the knob is a very low cost, £0.07 die-cast moulding, suitable for intermittent use.

The second bearing, nearest the camera, is much more expensive, listing at £1.26. Made by Radiatron it is a quality brass turned part, so more suited to continuous rotations.

Triple and quad gangs

Mounting plate blanks measuring 80mm by 50mm were used for both the triple and quadruple ganged versions. For the triple-ganged design I used a Gates 35-tooth belt, 70XL025. With three 14-tooth pulleys, the potentiometers were mounted on a pitch-circle diameter of 41mm. This results in the spindles being spaced by 35.5mm at the corners of an equilateral triangle. This triple-gang version was assembled using two 20kΩ potentiometers and one of 10kΩ for use in a twin-tee notch filter, **Fig. 2**.

The quadruple-ganged version is easier to produce than is the triple gang and takes up little extra space. Using a 40-tooth 80XL025 belt with four 14-tooth pulleys, the spindles were equally spaced at the corners of a 33mm square **Fig. 3**.

Pulleys with fewer teeth and shorter toothed belts are listed, but at the time I built my units, all were on very extended lead times.

Having determined the spacing and materials needed for these ganged pot assemblies has provided me with a very low-cost and instant solution for what had previously appeared to be an insoluble problem. ■

Reference

1. John Linsley-Hood, 'Measure thd to 0.001%', *Electronics World*, Feb.1998, pp.104-108.

Michael Slifkin and Shai Kriegman have been investigating three ways of measuring capacitance – one using phase shift, one using the error signal from a PLL and the third looking at a frequency change caused by the unknown capacitor.

Measuring capacitance

Michael and Shai are with the Jerusalem College of Technology

Reactance – i.e. capacitance and inductance – can be measured in various ways. Any change in the way that a circuit functions due to the addition of a reactance can be measured and used to determine the reactance.

It is preferable that such measurements have high resolution, good linearity and low noise. Linearity is not an absolute requirement; it can often be compensated for by adjusting readings. However it certainly makes life easier if measurements are linear.

There are many devices now on the market whose action is controlled or modified by reactance. Our aim here is to take some of these devices and see whether they can be used to measure capacitance.

One of us has already described a high-performance inductance meter using modern integrated circuitry[1]. This is certainly cheap compared to comparable commercially available meters, but not that cheap in absolute terms. Here we describe three methods of measuring capacitance. All use minimal chip count and are very cheap.

The first method consists of adding the capacitance to an LC resonant circuit and measuring the phase shift using a phase detector. The second consists of altering the free running frequency of an analogue phase lock loop and measuring the error signal between this oscillation and that of a fixed frequency input signal. In the third method, the capacitance is used to shift the frequency of an oscillator i.e. to obtain frequency modulation and the modulation is measured with an FM demodulator.

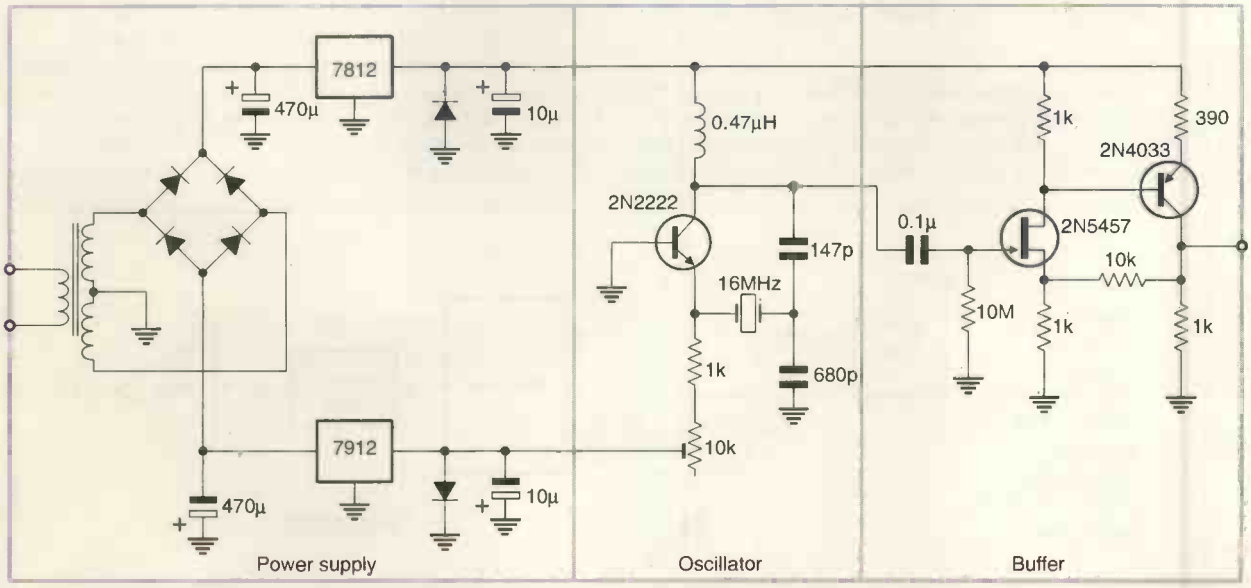


Fig. 1. Test oscillator running at 16MHz. A higher frequency oscillator might have made the measurements more accurate, but it would also have made construction more complicated.

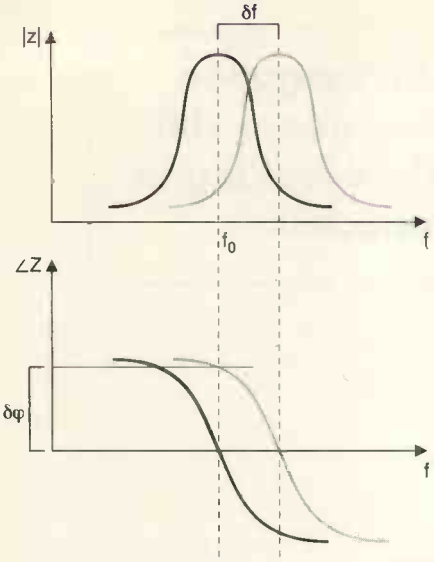


Fig. 2. A simple LC filter has a maximum at some frequency so that the signal of that frequency will pass through with minimum attenuation and zero change of phase. Adding a small reactance changes the maximum of the filter and so causes some attenuation of the original signal and more importantly a change of phase.

Data sheet sources

A data sheet for the MC1496 can be downloaded from:

http://www.onsemi.com/pub/Collateral/MC1496-D.PDF=20

The web address for the NE564 is:

http://xanadu.ece.ucsb.edu/~long/ece145b/NE564.pdf=20

A high-quality fixed-frequency oscillator is needed for the first two of these measurements. You could use a laboratory signal generator, but we built a crystal-controlled 16MHz oscillator for used in two of the methods.

Figure 1 shows the circuit diagram of that oscillator. Its frequency has been chosen as a compromise between high frequency for high accuracy and simplicity of construction. A higher frequency oscillator would have made construction more complicated. Additionally we had the crystal to hand, which was probably the most pressing reason for choosing it.

Resistor R_1 in the circuit limits the amplitude it can be adjusted to give more or less output but in any event one should not allow a current greater than about 1mA to flow.

Method 1

The phase shift method works as follows. A simple *LC* filter will have a maximum at some frequency so that the signal of that frequency will pass through with minimum attenuation and zero change of phase. Adding a small reactance changes the maximum of the filter and so causes some attenuation of the original signal and more importantly a change of phase. This is illustrated in **Fig. 2**.

For small phase changes, the attenuation will be very small as the top of the response curve of this simple filter is almost flat. Hence an accurate measurement of the phase gives a measure of the capacitance.

It is possible to show mathematically what ought to happen. The resonant frequency f_0 is given by:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

A change of capacitance dC gives a change of frequency:

$$df = dC \times \frac{f_0}{2C}$$

and the change in phase $d\phi$ is given by;

$$\frac{d\phi}{dC} = -\omega^2 LQ$$

Here, ω is $2\pi f$ and Q is the Q-factor of the coil $\omega L \div r$. Variable r represents the internal resistance of the coil.

The phase change is linear with C for small changes in phase and increase in amplitude with increasing frequency and increasing Q-factor. This is why we picked 16MHz for our test frequency. Interestingly enough most commercial instruments use a lower frequency of 1MHz.

We proceeded to measure the phase using a simple phase detector. This is an analogue multiplier or mixer followed by a low-pass filter. **Figure 3** shows the block diagram.

If there are two signals:

$$V_1 = A \times \cos(\omega t + \Phi_1)$$

and:

$$V_2 = A \times \sin(\omega t + \Phi_2)$$

then the product:

$$V_1 \times V_2 = \frac{A^2}{4} \times \cos(2\omega t + \Phi_1 + \Phi_2) + \frac{A^2}{4} \times \sin(\Phi_1 \pm \Phi_2)$$

(Apologies, the ± in the above equation should be a –). The first term is at twice the frequency of the test signal and can be removed with a low-pass filter. The second term is DC and proportional to the sine of the phase shift. For small angles the sine equals the angle in radians. So that we now have a voltage from the multiplier proportional to the phase shift and hence to the capacitance but only for small phase shifts.

The circuit diagram is shown in **Fig. 4**. C_9 in the *LC* circuit gives the 90° phase shift. Capacitor C_{11} is a trimmer that's adjusted to give the resonant condition. The phase detector

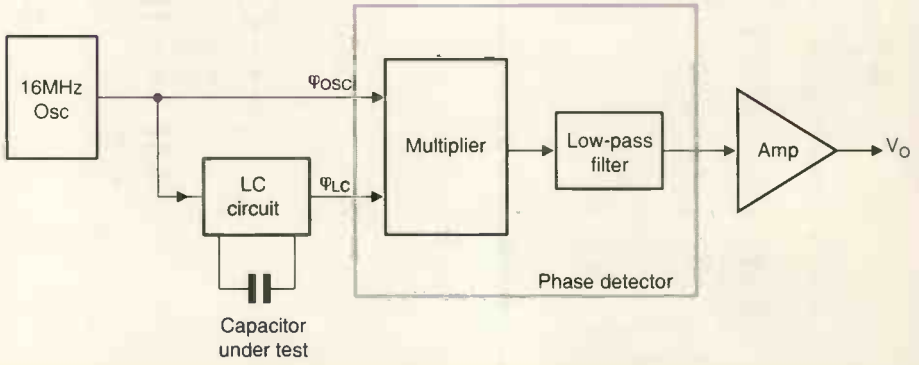


Fig. 3. Block diagram of a circuit for comparing phases of a test signal and the same signal subjected to a phase shift due to an LC filter.

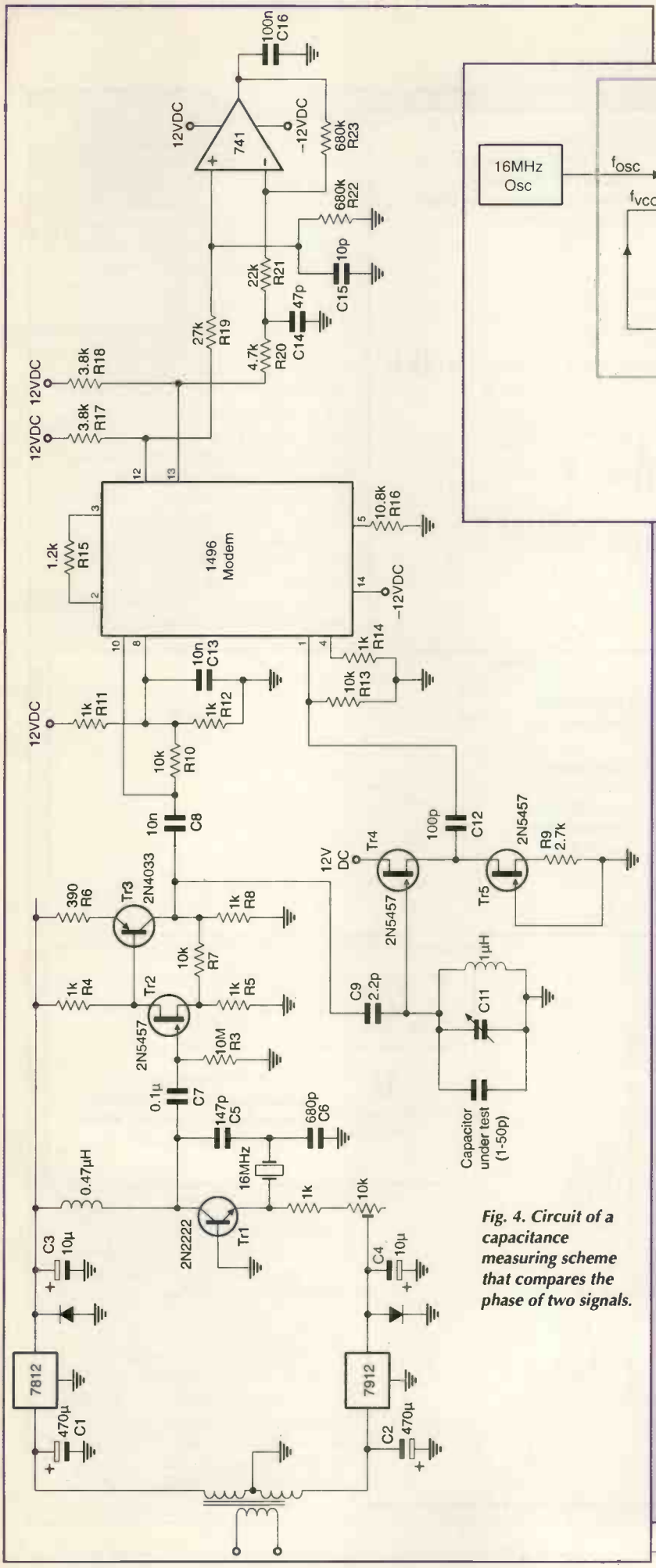


Fig. 4. Circuit of a capacitance measuring scheme that compares the phase of two signals.

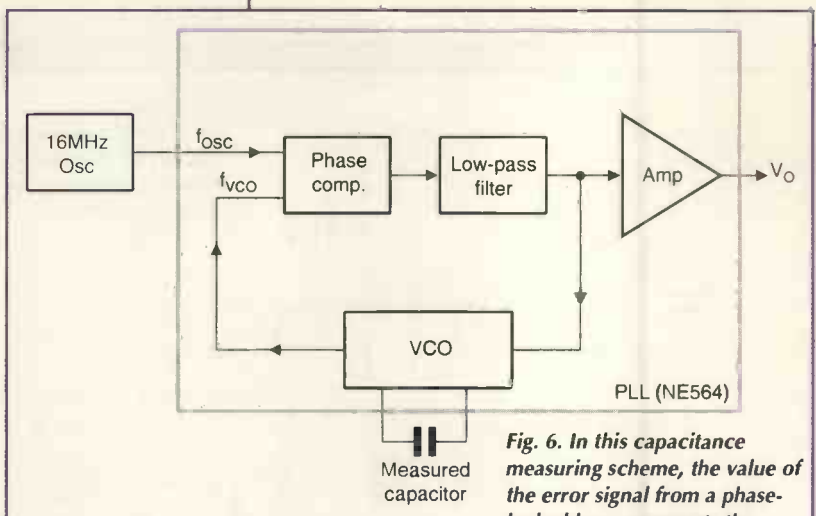


Fig. 6. In this capacitance measuring scheme, the value of the error signal from a phase-locked loop represents the unknown capacitor's value.

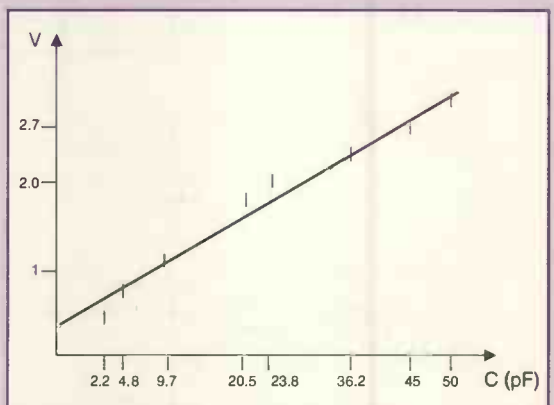


Fig. 5. Results obtained from measuring capacitors using the phase-shift comparator of Fig. 4.

circuit is based on a well-tried industrial standard chip the 1495. This multiplies the two signals and gives an output proportional to the phase difference.

The low-pass filter removes the 32MHz signal and a ×25 difference amplifier gives the final voltage. Results are shown in **Fig. 5**.This diagram shows the output voltage plotted against a number of capacitances that have been measured to 1% on a commercial laboratory capacitance meter.

The linearity is not as good as one might expect. We feel that some more experimentation might have produced better linearity. Certainly smaller values of capacitance should give better linearity.

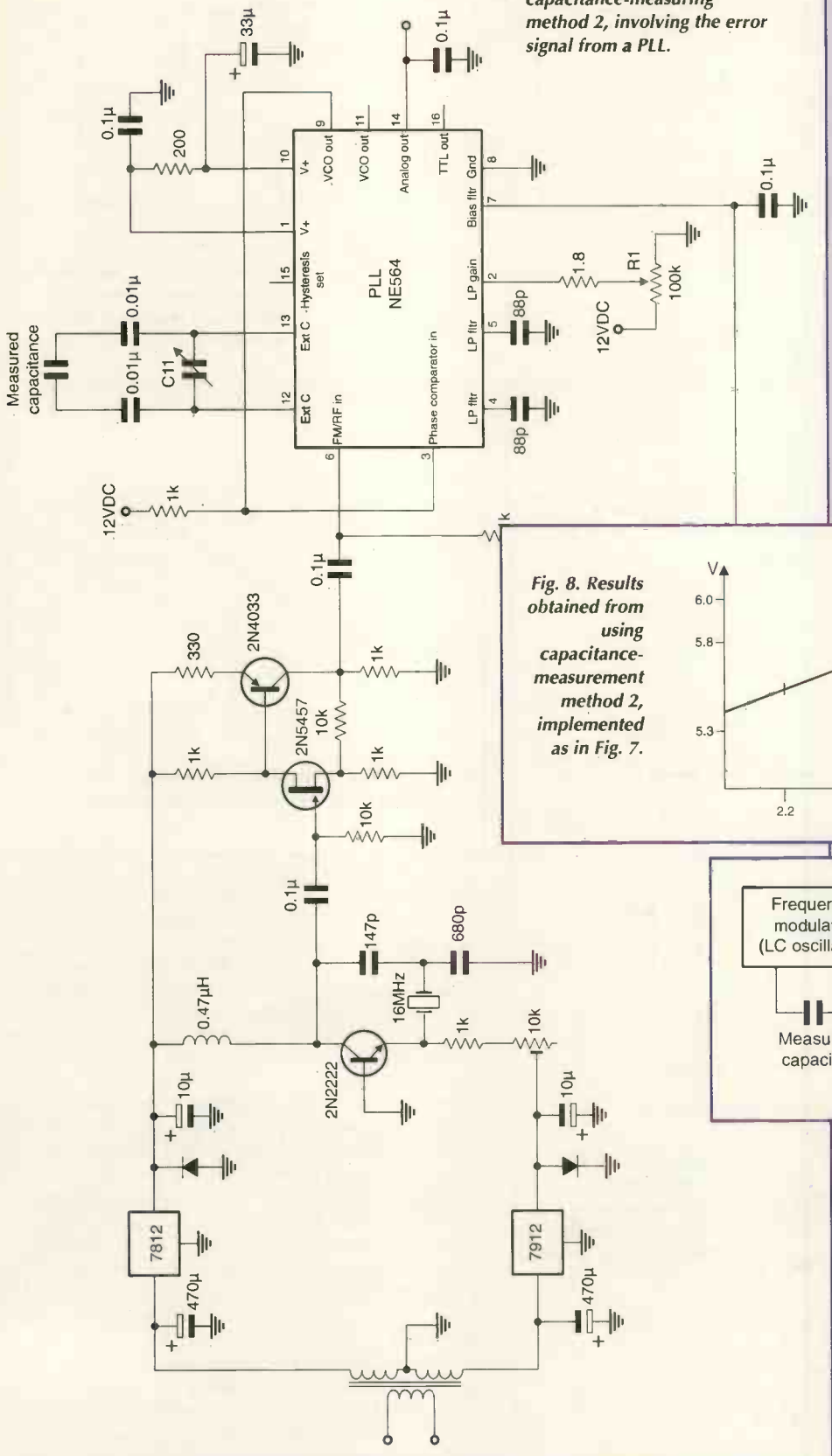
With the given coil and trimming capacitor, it is only possible to cover a limited range of capacitance. A more serious instrument would require a number of switched coils to increase the range. Alternatively, you could use different frequencies.

Method 2

A block description of the second capacitance-measurement method is given in **Fig. 6**.

The NE564 phase-lock loop is another industry standard chip that has been around for a very long time. The phase comparator compares the difference in frequency/phase

Fig. 7. Circuit diagram of capacitance-measuring method 2, involving the error signal from a PLL.



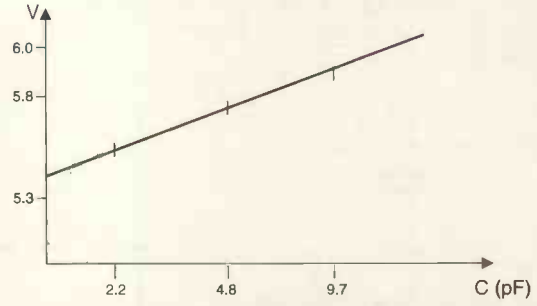
between the a reference signal and an input signal and removes the high-frequency content of the comparison. After amplification, the 'DC-error signal' as is it called is passed to the voltage-controlled oscillator in such a manner as to bring the frequency in line with the signal frequency coming from the 16MHz oscillator. In this state the PLL is said to be locked.

This error signal is a direct measure of the capacitance. **Figure 7** shows the circuit diagram. The results shown in **Fig. 8** are indeed very linear. However the range is limited by the capture frequency of the PLL.

The capture range of the PLL is that range of frequencies around the VCO free running frequency over which the PLL will lock onto the signal, giving a well-defined error signal. This capture range can be extended but only at the expense of a noisier signal.

Loop gain governs the capture range: this gain is determined by the resistance

Fig. 8. Results obtained from using capacitance-measurement method 2, implemented as in Fig. 7.



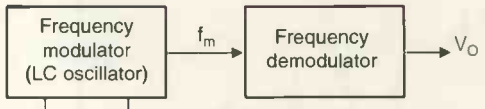


Fig. 9. In this capacitance-measurement scheme, Method 3, the unknown capacitor alters the frequency of a signal.

R_1. In addition, where there is a large capture range, noise pulses can throw the PLL out of lock. We have made this value variable so that you can find the optimum conditions empirically.

Method 3

Referring to **Fig. 9**, in essence, this method consists of changing the tuned circuit of an oscillator to give a shift in frequency and then demodulating the new signal to find the shift in signal as a DC voltage.

Obviously, there are many ways of

doing this but as we already have the PLL, we can use this as the demodulator. In this case we have a fixed capacitor tuning the PLL to the frequency of the oscillator. When the signal frequency is altered by the sample capacitance there is an error signal from the PLL. This error signal should be proportional to the shift in frequency and, if the frequency shift is small, linear with capacitance.

Figure 10 shows the circuit. We have provided it with a power supply. Actually it is the same one we used with the 16MHz crystal oscillator. You could of course use batteries if you don't have the components readily to hand.

There is a buffer after the oscillator to prevent pulling. The demodulator section is just the PLL with a fixed capacitor to make the free running frequency equal to that of the oscillator.

As **Fig. 11** shows, the output is quite linear. It is possible to encompass a greater range with the PLL in this mode than in method 2. Bear in mind though that method 2 uses fewer components and chips. Any form of FM demodulator could be used here, but the one shown is probably the simplest.

In summary

We have barely scratched the surface of this topic. There's a plethora of ICs performing all sorts of functions that are reactance dependent. In addition, method 3 lends itself to all kinds of possibilities. You could of course simply measure the new frequency directly and use a look up table.

A method that we are currently developing and hope to publish soon consists of two identical oscillator circuits. One is detuned with the test capacitance. We measure the beat frequency between the two and get the capacitance directly from this. This is particularly suitable for very low values of capacitance. ■

Reference

1. Michael Slifkin and Alexander Gornstein, 'A novel inductance meter', *Electronics World* May 2000, p. 424-428.

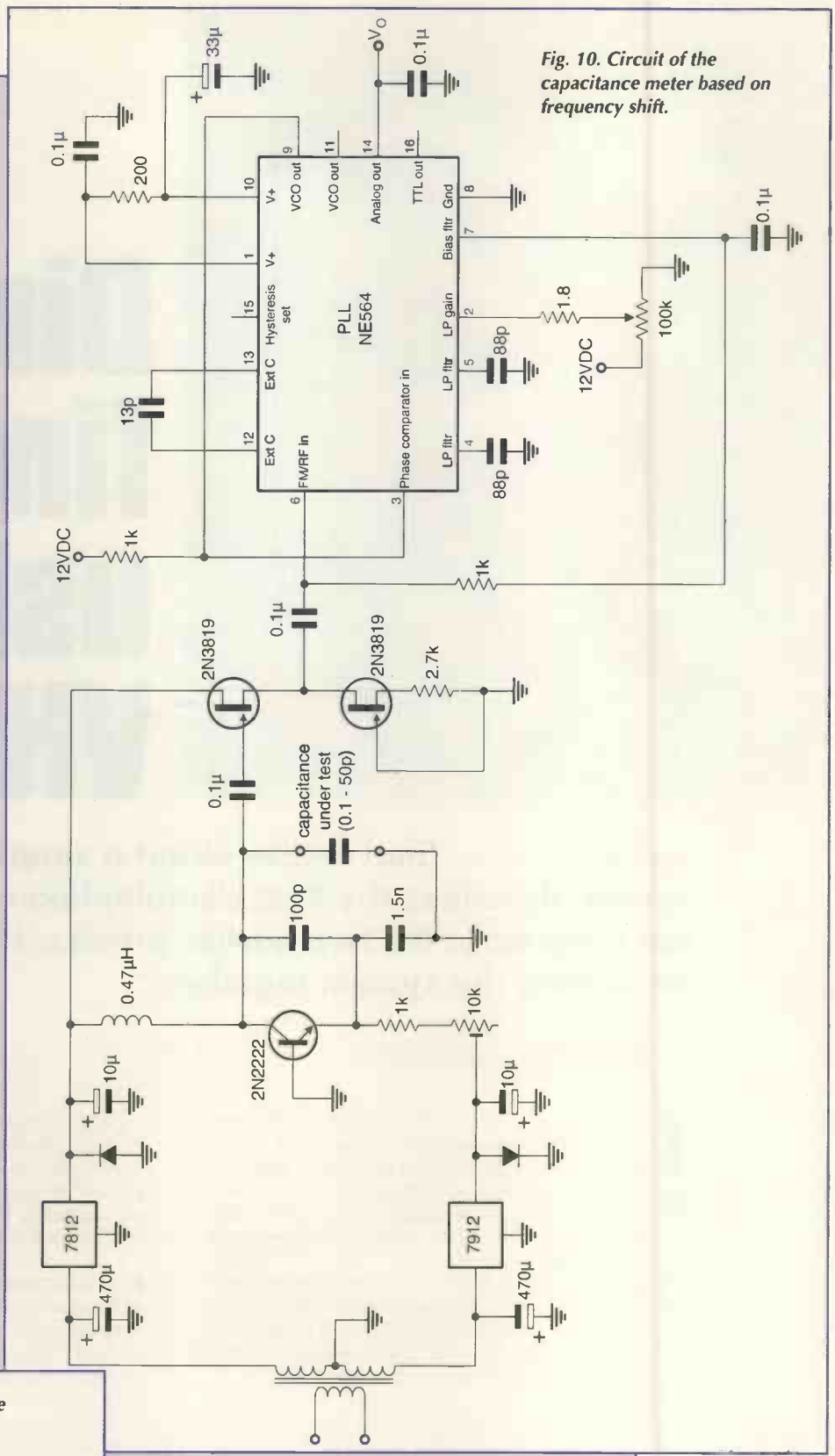


Fig. 10. Circuit of the capacitance meter based on frequency shift.

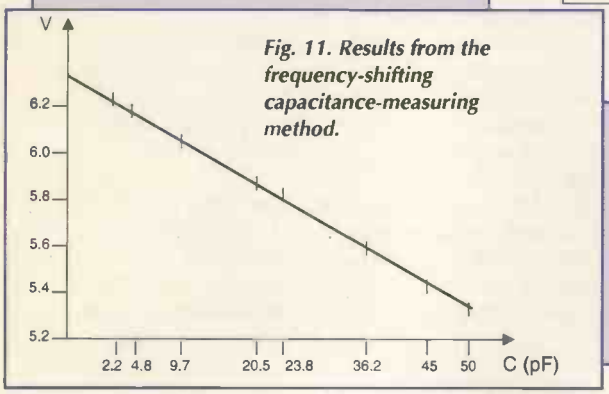


Fig. 11. Results from the frequency-shifting capacitance-measuring method.

Direction finder using VHF

Ian Hickman's final article about a simple direction-finding system describes the RSSI demultiplexer and other circuitry not covered in the two earlier articles. He also provides notes on putting the system together.

This is the third and final article in a set that describes a direction finding system. The system locates the orientation of VHF broadcast transmitters relative to where you are, as a means of determining your position. Here I will be discussing the commutation oscillator, the demultiplexer switch, the leaky integrators and the audio section of the direction finder.

Figure 1 shows the complete circuit, with the section relevant to this article highlighted in yellow. The audio department is very straightforward. It simply accepts the audio output from pin 6 of the CA3089 IF subsystem IC via a 50μs de-emphasis time constant produced by a *CR* network.

The two previous articles...

My first article on this topic, in the January issue, introduced the direction-finding concept and discussed the antenna and splitter block. The second article dealt with the sigma blocks, the multiplexer, the local oscillator, the mixer, the IF strip and the quadrature coil.

The audio signal feeds an an LM380 audio amplifier IC via a volume control. From there, it passes to a a 35Ω loudspeaker via a 100μF electrolytic capacitor. Note that in place of the CA3089, used as it was in stock, the more recent pin-compatible CA3189 should prove entirely suitable, offering improved performance.

RSSI processing

At the heart of the system is the processing of the received signal-strength indicator, or RSSI, output at pin 13 of the CA3089. This is used to extract information as to the bearing of the station being received.

Information extraction is performed under the control of the multiplexer clock generator, which uses two of the four sections of a TL084 quad op-amp, running on ±15V stabilised supplies. Consequently, when the output of the right hand op-amp is at +15V, the voltage at its non-inverting input is +5V.

Via the 180kΩ resistor, the 100nF capacitor at the inverting input charges towards +5V. As it reaches this level, the output starts to fall and positive feedback to the non-inverting terminal will drive the output to −15V. The 180kΩ resistor now charges the capacitor towards −5V, the

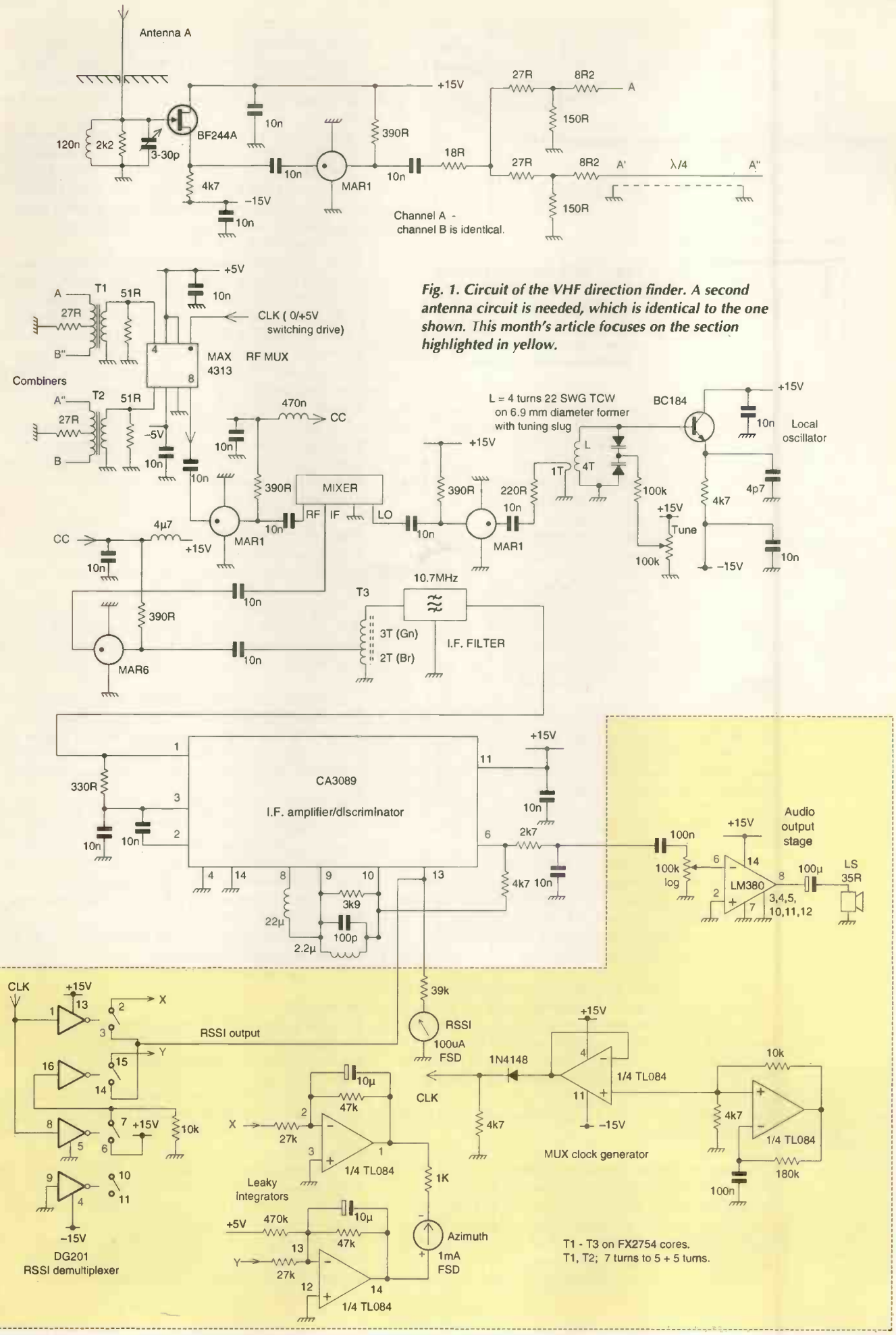


Fig. 1. Circuit of the VHF direction finder. A second antenna circuit is needed, which is identical to the one shown. This month's article focuses on the section highlighted in yellow.

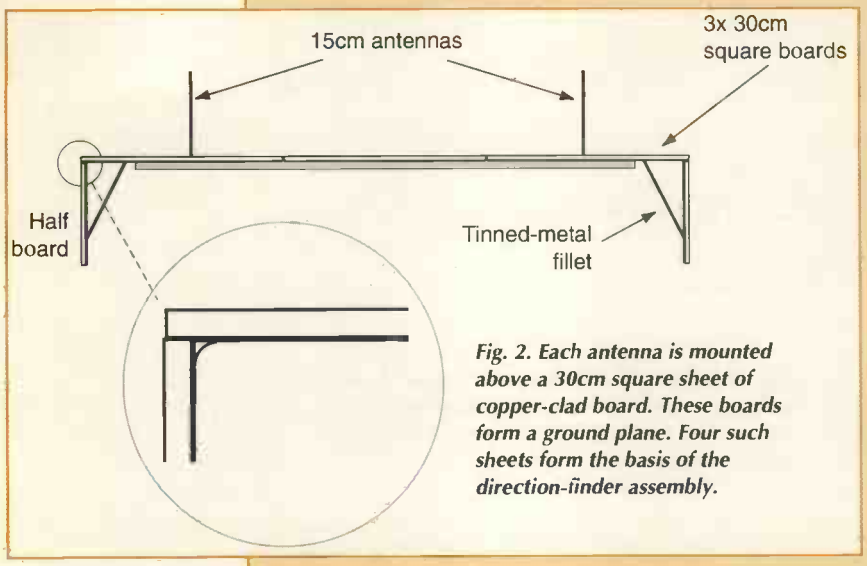


Fig. 2. Each antenna is mounted above a 30cm square sheet of copper-clad board. These boards form a ground plane. Four such sheets form the basis of the direction-finder assembly.

output switching back to +15V as soon as the non-inverting input reaches –5V, and the cycle repeats.

As the ±15V square wave at the output is larger than needed, another op-amp section, connected as a high input impedance unity gain buffer, picks off the ±5V square wave at the non-inverting input.

The 1N4148 diode blocks the negative-going phase, resulting in a clock waveform swinging between 0V and +5V. This is applied to the DG201 quad CMOS switch. The clock drive at pin 8 of the DG201 produces an antiphase clock at pin16. Thus the RSSI output is connected to each of the two leaky integrators in turn via switches on alternate half cycles of the unity mark:space ratio multiplexer clock. Switch pins 2 and 15 pass the alternating X and Y signals respectively to the leaky integrator.

As I explained earlier, the amplitude of the RSSI voltage will vary at the clock rate of the multiplexer clock generator, unless of course the signal arrives at each of the two antennas in exactly the same phase. If the two are in phase, then the output voltages of the two leaky integrators would sit at the same negative voltage, were it not for the 470kΩ resistor to +5V at the inverting input of the lower integrator.

The 470kΩ resistor results in a –0.5V offset at its output, relative to the output of the upper leaky integrator. Hence the 1mA full-scale-deflection meter reads half scale when the RSSI output is the same on both phases of the multiplexer clock. This means that a normal 1mA FSD moving coil meter can be used; a centre-zero meter is not required.

The time constant of the leaky integrators is long compared to the period of the multiplexer clock, so that the outputs are ripple free and a steady meter reading results. If however the signal being received arrives from an off-centre direction, the phases at the two antennas will differ. This is converted to an amplitude difference, as described earlier. Current through the meter will therefore be less than or more than 0.5mA, and the pointer will move to left or right accordingly.

Implementing the direction finder

The two antennas I used were electrically-short monopoles, about 15cm long. This means that they were around a twentieth of a wavelength at the operating frequency in the VHF FM 88-108MHz broadcast band, as against the 75cm length of a resonant quarter-wave whip.

Each antenna was mounted above a 30cm square sheet of single-sided copper-clad FGRP board. The system was constructed from four such sheets, as shown in **Fig. 2**. Three were secured, side by side, to two wooden battens. The fourth board was halved, and used as feet, one at each end.

Each foot was sweated to the copper side of one of the outer boards; the solder fillet is detailed in the inset of Fig. 2. Two tin-plate gusset pieces, similarly sweated in place, were used for bracing. The edges of the copper on the centremost sheet were connected to the adjacent sheets with soldered wire links every 3cm, providing an effective ground plane of 30 × 90cm.

Two 1mm sockets were mounted on the centreline, separated by 45cm, or 60%, of a quarter of a wavelength. The 18SWG TCu antennas were mounted on 1mm-pin plugs, making the antennas demountable for transport.

The sockets carry the signal through to the copper-faced underside of the ground plane, where all the circuitry is mounted. The circuitry of each input stage, see Figure 1 on page 64 of the January issue, was mounted adjacent to its antenna socket.

Components with one lead grounded, such as decoupling capacitors, resistors, etc., were soldered directly to the ground plane, and their other ends used as mounting points for the other components; so-called 'fresh air' construction.

Mounting remaining circuitry

The remaining circuit blocks were built up as separate entities and tested, before being mounted on the copper-faced underside of the ground plane.

Non-RF sections, like the multiplexer clock oscillator, were constructed by groups of students on 0.1in-matrix copper-strip board, other such units being the audio output stage and the leaky integrators plus RSSI demultiplexing switches.

Another solution is to use fresh air construction to build the RF sections, the local oscillator and its associated output amplifier IC on a 5cm square piece of copper-clad. When tested and working, this can be secured to the centre of the ground plane with multiple wire straps round the edge.

The MAX4313 RF multiplexer, with the mixer and its output amplifier formed a unit. This unit's 51Ω terminated inputs were fed via miniature 50Ω coax leads from the outputs of the two Σ hybrids at the antenna circuits. The IF filter together with the CA3089 and its associated components formed a third RF unit, likewise mounted with multiple ground straps.

The meter was mounted in the position shown in **Fig. 3**, and the tuning and volume controls on a small subpanel below the meter on the underside of the ground plane.

Setting up

The tuning range of the local oscillator should be checked to ensure that it covers the VHF FM 88-108MHz broadcast band. If a spectrum analyser is not available, an FM receiver can be used.

The local oscillator, with a few centimetres of wire tacked onto the output of its amplifier, should provide marked quieting of background noise of a nearby receiver when tuned in.

As the oscillator is required to run 10.7MHz higher than a station being received, this should apply for receiver settings of 98.7MHz to the top of the band, with some further range on the 100kΩ tuning potentiometer still in hand. Adjust the tuning slug in the 6.9mm diameter former of four turn oscillator coil to achieve this.

Assuming all the other units have been verified

beforehand, there just remains the final alignment. Tune a strong local station, and adjust each of the antenna trimmers for maximum readings at the outputs of the leaky integrators.

Finally, the system should be aligned with the major axis of the ground plane at right angles to the known position of the station, the latter being on the side of the kit away from the meter.

Note that this setting up must be done in a large open space; a park or sports field, preferably not surrounded by high buildings, should be chosen. If it isn't, multipath propagation via reflections may vitiate the proceedings. A slight adjustment to one of the antenna circuit trimmers should now result in the meter pointer sitting centre scale.

The equipment should now be rotated 45° to the left. If the pointer moves to the right, i.e. tends to remain pointing at the source of the signal, all is well. If it moves to the left, interchange the X and Y outputs to the leaky integrators.

An alternative procedure, which may be more convenient, is to provide your own 'local station', using a signal generator, although a clear open space is still needed. Set the signal generator output to maximum at, say, 100MHz. Lay it on its back, fit a quarter wavelength – 0.75m – of stiff wire sticking up from the output socket, and position it about three metres away from the direction-finding equipment. Then proceed as above.

Using the equipment

To find the bearing of a transmission that's being received, the equipment should be rotated in the horizontal plane, until the meter reads centre scale. On rotating the kit somewhat to the left or right, the pointer should move to the right or left respectively. If it moves the other way, the source is behind you, so an about face is called for.

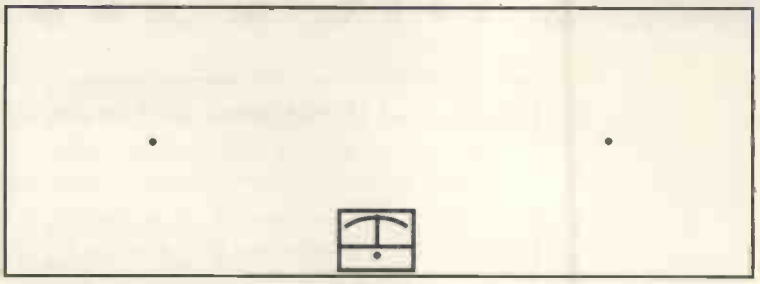


Fig. 3. The completed direction finder viewed from above, showing the two antennas as dots in the centre of the two outer panels, and the meter.

When the pointer is centre scale it indicates the bearing of the source, which can be plotted on a map as a line through your map position. Another bearing, taken from a different place, should give you a cross bearing, indicating the approximate map coordinates of the source.

Naturally, if the bearings differ but little, the result will not be very reliable. A second site giving a bearing at right angles to the first provides the greatest accuracy. But always bear in mind that reflections from large buildings, etc., can influence your readings. ■

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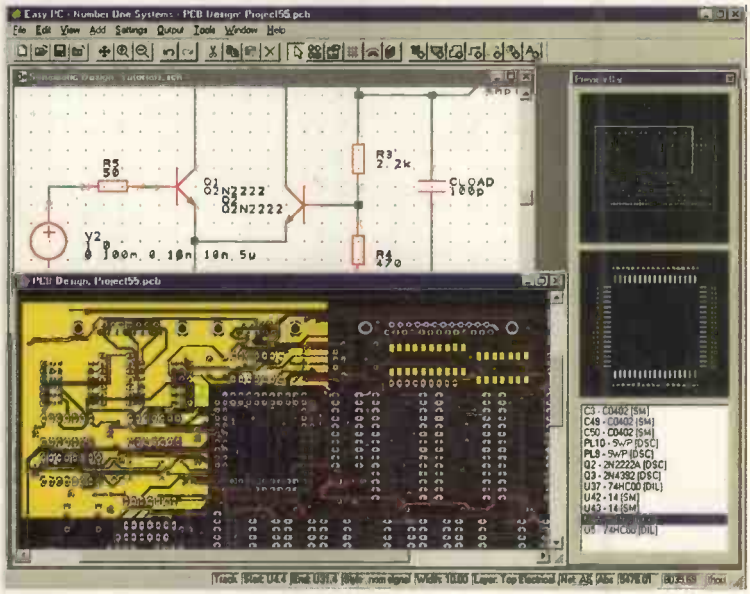

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Exclusive-OR gates compare the word entered against bit-level switch settings. A mismatch means that one or more gate outputs will be high, causing current to be drawn to ground, via 4047 pin 14 and Tr_1's base. Thus Tr_1 holds off Tr_2, the output driver.

All bits the same demands no base current and Tr_2 is free to turn on via the 18kΩ sink path. Jumper 'A' alone activates the first four bits. Jumper 'B' activates the last four. Both jumpers in place require all eight to match. Remove the jumpers to force a continuous output. This bypasses the lock.

Transistor Tr_2 can easily supply 10mA for a load compatible with the chosen supply voltage; a reed relay or opto coupler would give power amplification as required by a solenoid actuated mechanical latch.

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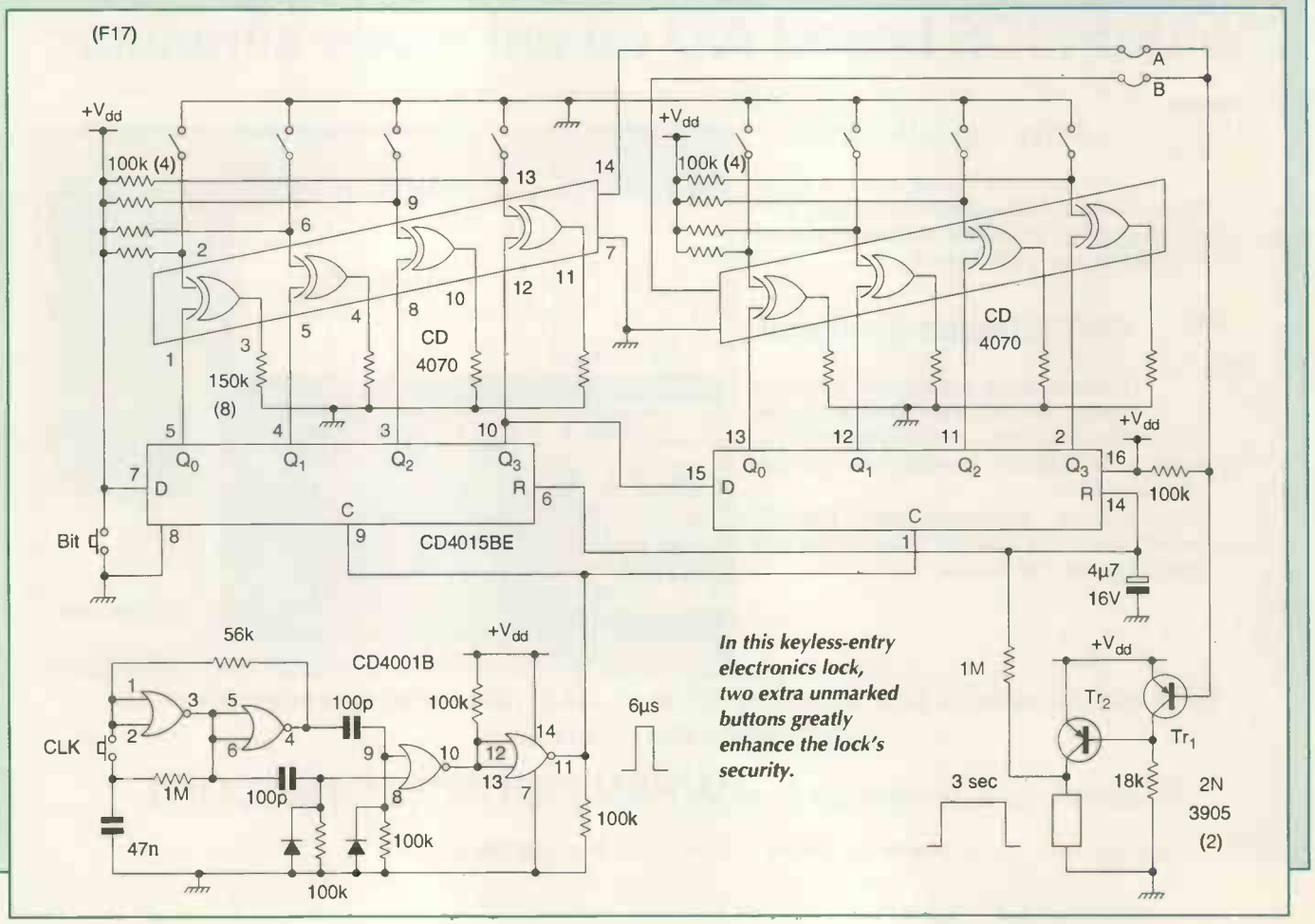

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Constant-current diode look-alike

Constant-current sources are widely used in electronics. Most are of the diode/transistor or transistor/transistor three-terminal variety.

Constant-current diodes are two-terminal devices, ideal drop-in substitutes for resistors in many instances. However, they suffer from relatively poor compliance, limited power dissipation – 300mW typical – small range of currents available (15mA max.), and only moderate voltage withstand (100V max.) when compared with the less convenient three-terminal current sources constructed from discrete components.

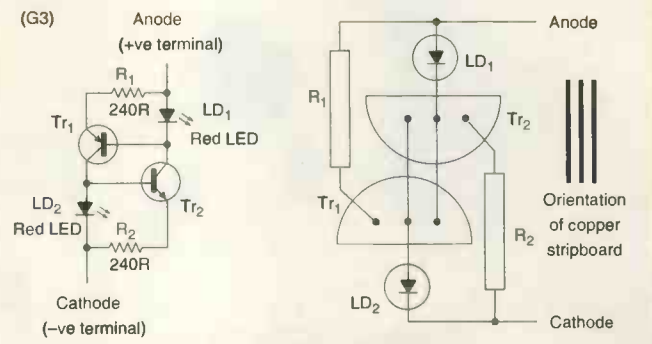
The two-terminal circuit shown here is composed of a pair of complementary constant-current sources, where each provides a constant current for the voltage reference of the other, thereby improving performance. Compliance is excellent and the current can be set to almost any value.

Power dissipation and voltage withstand are limited only by the transistors chosen. The constant current can be calculated from the forward voltage of the LEDs, V_F; V_{BE} for Tr_1 and Tr_2; and the resistor values $R=R_1=R_2$. In the example:

$$I_{CONST} = 2\frac{V_F - V_{BE}}{240} = 2\frac{1.6 - 0.6}{240} = 8.33mA$$

The circuit can be made up on a tiny piece of stripboard using the layout shown, and makes an excellent replacement for current setting resistors in many audio power amplifiers.

David N J White
Bearsden
Glasgow
G3



Two-terminal constant-current diode equivalent.

Power-failure safety interlock

Most of the costly analytical instruments used in laboratories, like mass spectrometers and gas chromatography instruments, are designed to be run continuously. This is because of their requirement for extreme hardware stabilisation and sustaining a high vacuum by constant operation of ion pumps.

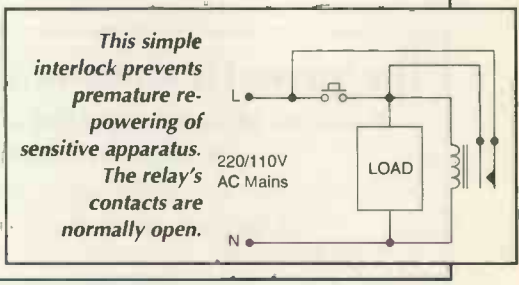
Once shut off, such instruments take days to regain full operating efficiency. If restarted immediately following shut off, serious damage their sensitive systems can result.

Commercial modules are available for incorporation between an interruptible power supply unit and such instruments. Their function is to disconnect the instrument from the supply in case of power failure. After restoration of mains supply the instrument is held disconnected until an operator resets the module whenever it is considered that the conditions suitable for the particular instrument.

The circuit here presented consists of a relay and a push switch. The rating of the selected relay and switch depends on the power consumption of the instrument to be protected. When the power is present, pressing the push switch will energise the relay, and the instrument is powered up. When the power fails and then restores, the relay remains de-energised until the operator pushes the button again.

This simple idea is a useful and cheap alternative to costly commercial modules performing the same function.

***Ejaz Rehman** Islamabad Pakistan*
F94



This simple interlock prevents premature re-powering of sensitive apparatus. The relay's contacts are normally open.

Battery voltage low/high indicator

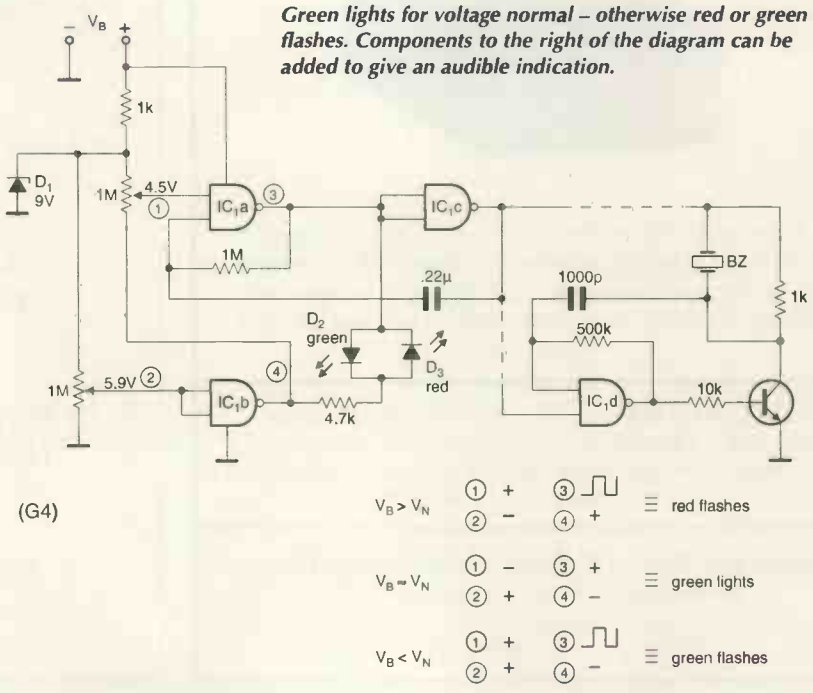
In the simple battery discharge/overcharge indicator shown, when $V_b>V_n$, red LED D_3 flashes because of the high voltage level on the output of IC_{1b} and pulses on output of IC_{1a}. When $V_b=V_n$, green LED D_2 lights because of the high voltage level on IC_{1a} output and low voltage level on IC_{1b} output. When $V_b<V_n$ green LED D_2 flashes because of the low voltage level on the output IC_{1b} and pulses on output IC_{1a}.

For my application V_n (normal) was defined as from 11V to 12.5V, with nearly 4.5 V on IC_{1a} input (when the voltage on IC_{1b} output is low) and nearly 5.9V on IC_{1b} input.

If an audible discharge-overcharge alarm is needed, an *RC*-oscillator driven by the pulses from IC_{1c} output may be used, as in the figure.

Vasiliy D Borodai
Zaporozhje
Ukraine

Green lights for voltage normal – otherwise red or green flashes. Components to the right of the diagram can be added to give an audible indication.



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AS3123	Assembled 3123	£47.95

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ABC Mini 'Hotchip' Board

ABC Starter Pack

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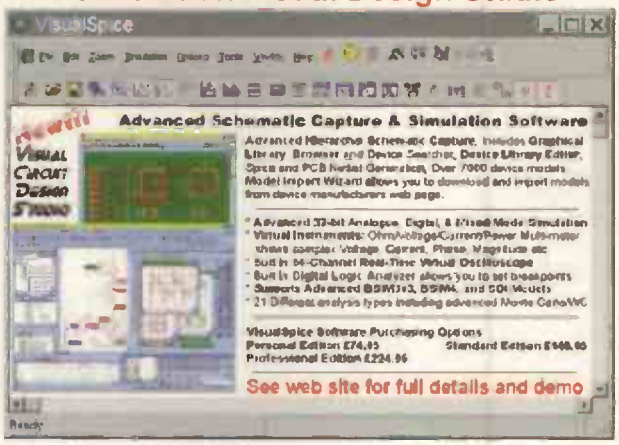

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Programmable staircase waveforms

Laboratory experimentation often needs staircase like waveforms in addition to the standard signals like sine wave, step, pulse, square wave, triangular and saw tooth waveforms, which are normally available from standard signal generators. This idea produces staircase waveforms with adjustable steps and frequency.

Figure 1 shows a circuit that provides $n-1$ steps in the up direction, where n is an external input whose value is between 2 and 15 for the 4-bit up counter. When the state reaches the given data of 'n' the counter resets producing the 0000 state.

The D-to-A converter produces the analogue equivalent of the counter data, giving the staircase signal. A variant using a down counter with feedback to the preset rather than the clear input produces a downward staircase signal. When the counter reaches the data of 'n' the counter presets producing the 1111_2 state.

A triangular-like staircase signal producing 15 up steps and down steps is generated by the circuit shown in **Fig. 2**. An up/down counter is used. Its up and down controls are generated from a bistable device, where PR and CLR asynchronous inputs are derived from the bottom (0000) and top (1111_2) states. The triangular staircase is available at the D-to-A converter output.

Initially, when the state is 0000, OR gate output is '0' and NAND gate output is '1', providing an UP control input to the up/down counter. Subsequently both the PR and CLR are '1' until the count reaches the 1111_2 state. When it reaches 1111_2, the CLR input to the bistable device is '0' making the 'down' control input active for the counter. Output from the D-to-A converter is a triangular-shaped staircase wave.

Figure 3 shows the circuit for adjusting the number of up steps and down steps. The four most-significant bits of two analogue to digital converters control the maximum and the minimum states of the up/down counter. This is achieved through manual potentiometer adjustment; changing the analogue inputs to the A-to-D converters controls the limits.

The frequency may also be adjusted by feeding the clock through a programmable divider, which can be controlled by a potentiometer and D-to-A converter arrangement, similar to that shown for controlling the number of steps.

K Balasubramanian
Mersin
Turkey
F54

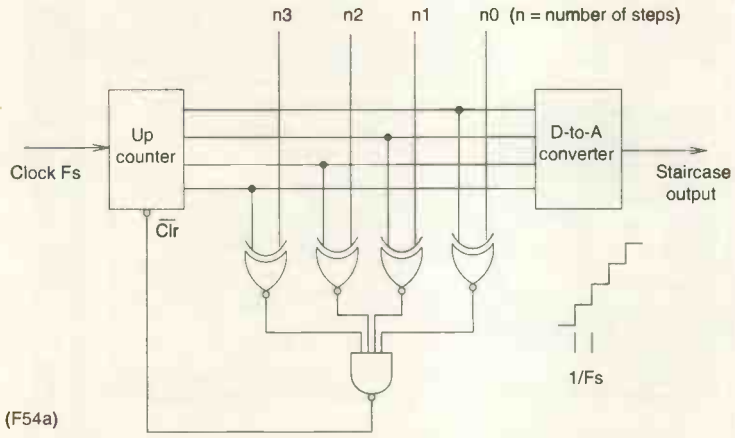

Fig. 1. The circuit produces a staircase waveform with up to fifteen steps.

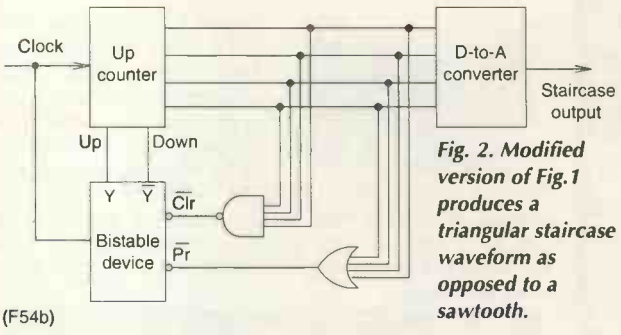

Fig. 2. Modified version of Fig.1 produces a triangular staircase waveform as opposed to a sawtooth.

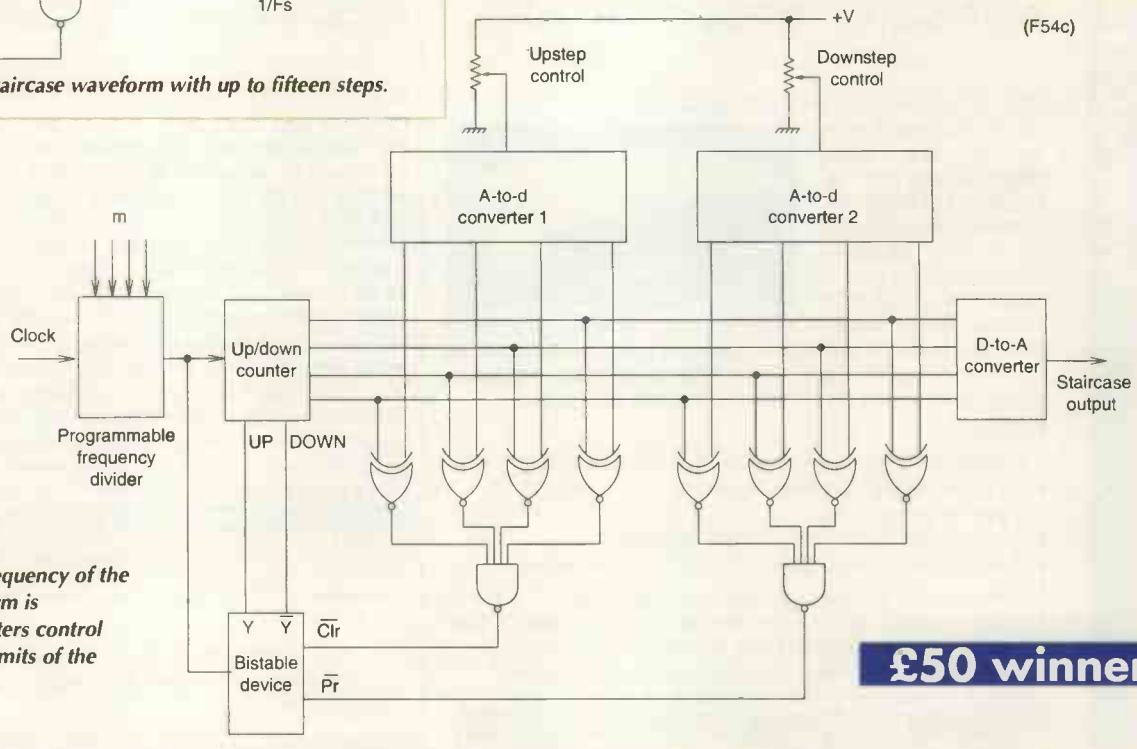

Fig. 3. In this circuit, the frequency of the triangular staircase waveform is adjustable, and potentiometers control both the upper and lower limits of the waveform.

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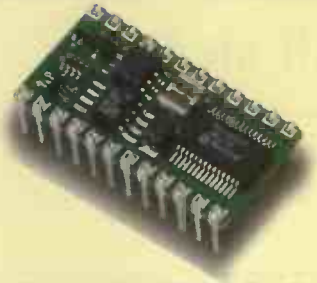

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Stepper-motor drive sequencer with half stepping

In **Fig. 1**, the stepper motor half-step drive uses an astable multivibrator made from a 555. Output from the astable drives two shift registers and, via an inverter, a decade counter. Outputs from the decade counter drive a decoder. Switch *R* is a common reset for shift registers, decade counter and astable.

When clocked, shift registers 1 and 2 produce a wave-drive sequence for a stepper motor as shown in the table in Fig. 1. Shift register 2 outputs go to four two-input NOR gates in cyclic order, as in **Fig. 2**.

Outputs from the NOR gates are the two phase drive sequence as shown in the table in Fig. 2. The first shift register and NOR outputs of Fig. 2 with decoder outputs are connected to inverters, AND and OR gates as in **Fig. 3**. Signals P1, P2, P3, P4 are the half step drive sequence as shown in the table in Fig. 3.

Each P output drives one of four power amplifiers as shown in **Fig. 4**. Thus the half step drive sequence which is the hybrid of wave drive and two phase drive is achieved.

Switch SW selects the direction of rotation of the stepper motor.

At the count of 9 of the decade counter it is reset automatically and the sequence starts afresh. **Figure 5** shows the motor's windings.

V Gopalakrishnan
Bangalore
India

F75

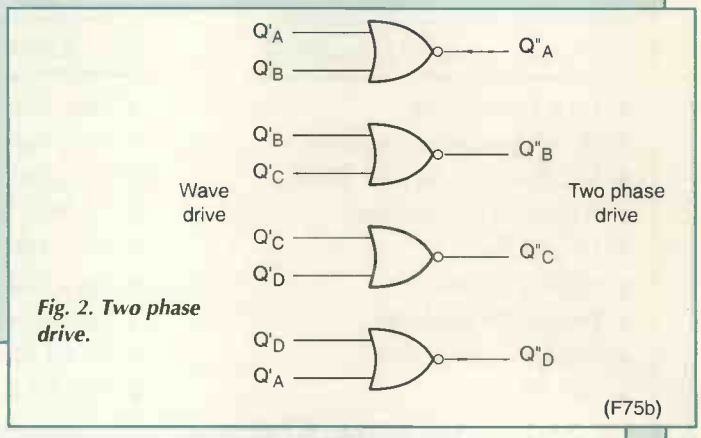


Fig. 2. Two phase drive.

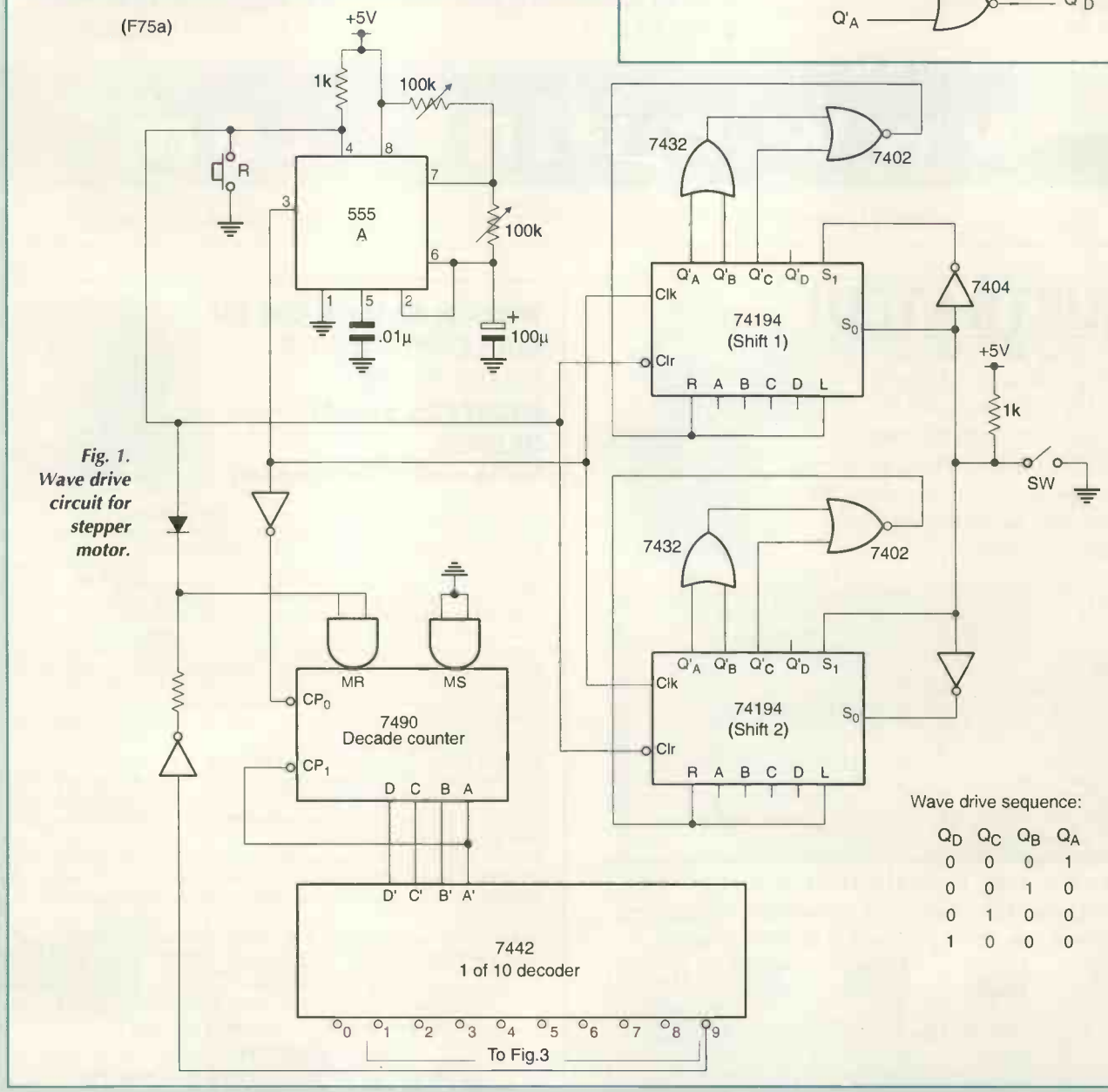


Fig. 1. Wave drive circuit for stepper motor.

Wave drive sequence:

Q_D	Q_C	Q_B	Q_A
0	0	0	1
0	0	1	0
0	1	0	0
1	0	0	0

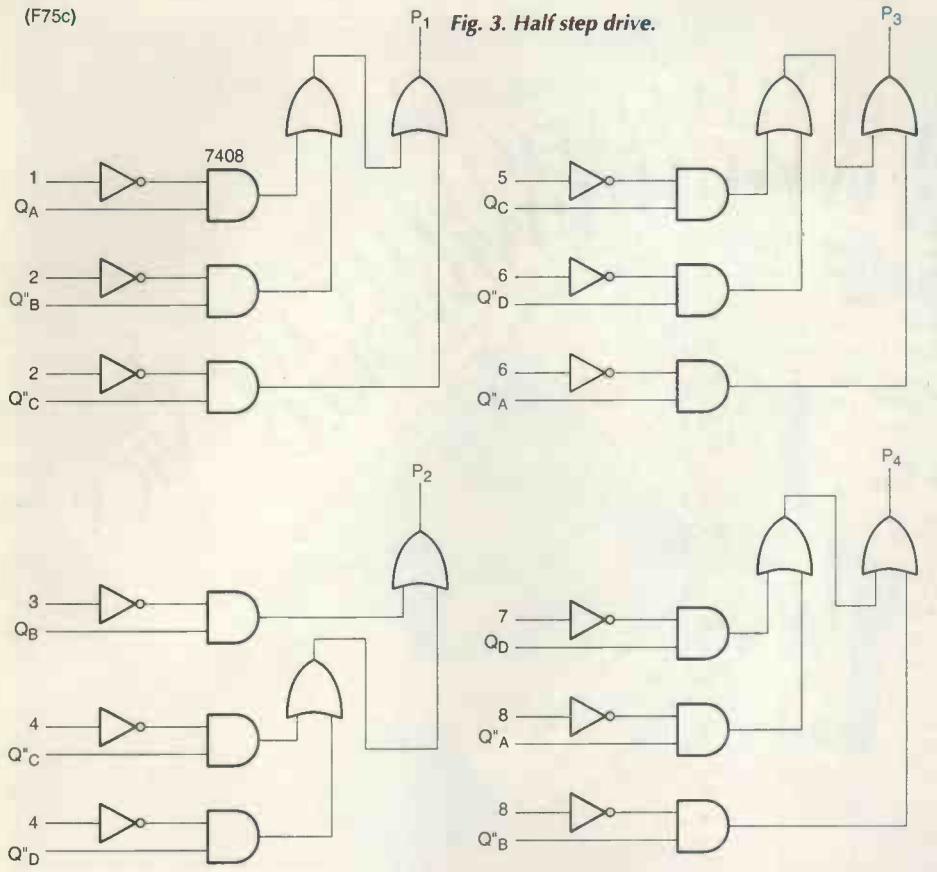


Fig. 3. Half step drive.

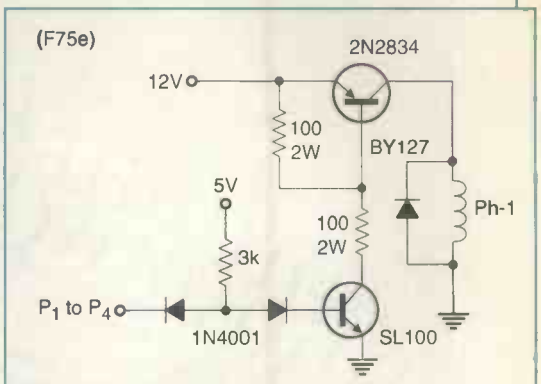


Fig. 4. Stepper-motor drive amplifier.

Half step drive sequence:

P_4	P_3	P_2	P_1
0	0	0	1
0	1	1	0
0	0	1	0
1	1	0	0
0	1	0	0
1	0	0	1
1	0	0	0
0	0	1	1

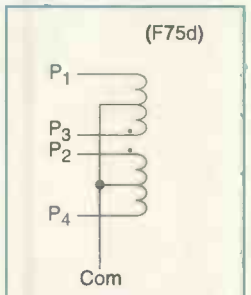
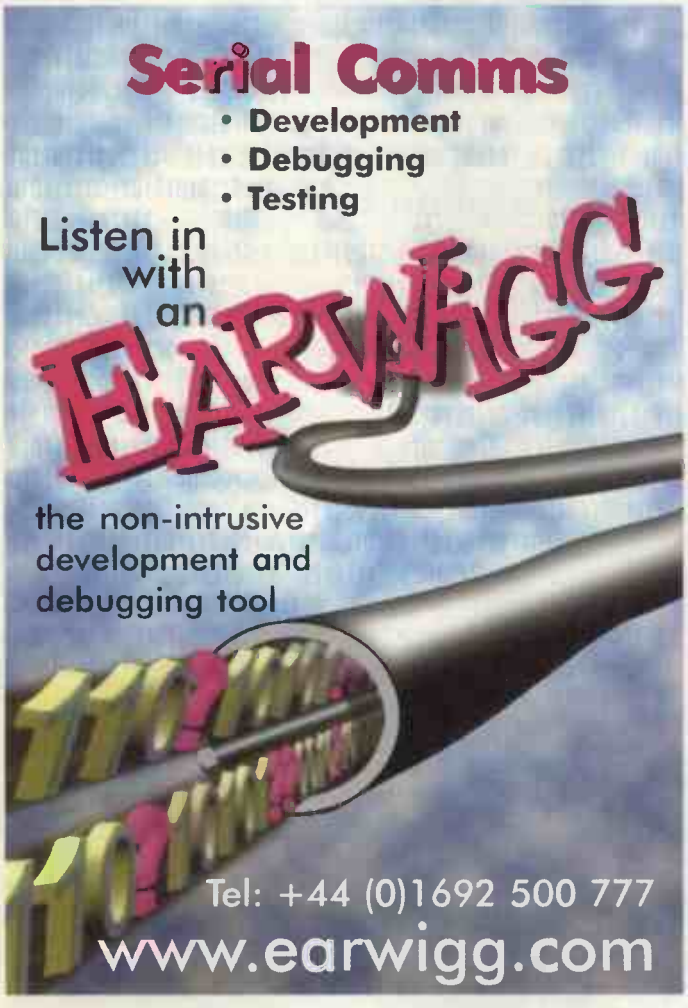


Fig. 5. Stepper-motor connections.



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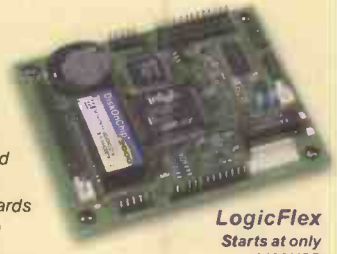

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www.fciconnect.com

12-bit ADC for extended temperature applications

The 12-bit WM2152 analogue-to-digital converter from Wolfson Microelectronics delivers 30Msample/s conversion performance over an extended temperature range. The device has a typical power consumption of 160mW. On-chip features include internal voltage reference to minimise external circuitry, a programmable gain amplifier (PGA), and out of range indicator flag. An external voltage reference can also be selected, for applications where a common system reference or precision reference is required. The differential sample and hold input enables high common mode noise immunity and low distortion, and the PGA supports 1V and 2V maximum differential input modes plus a third mode for single-ended input signals such as composite video. The PGA modes are selected via two external mode selection pins. Conversion is controlled by a single clock input, and an output enable pin is provided allowing several devices to share a common bus.

Wolfson Microelectronics
Tel: 0131 667 9386
www.wolfson.co.uk

3W DC-to-DC in small package

HiTek Power has introduced a range of miniature high voltage DC/DC converters to supply in the kilovolt range. These devices can be directly mounted on the PCB, and are potted to provide a unit that can be used in equipment with a 12V supply, whether fixed or battery operated. The units are priced at under £50. The series A range comprises five models that operate from a nominal 12V input, producing output voltages of 1, 1.5, 2, 3, or 4kV. They accept input voltages ranging from 5 to 14V, with an output proportional to the input voltage. Regulation (half load to full load) is 5 per cent, and output ripple is less than 0.5 per cent. Low noise models are available, which reduce ripple by a further 50 per cent. The devices are rated at 3W and are housed in a package measuring 38 x 66 x

Microcontroller with integrated 433MHz radio

Microchip's rfPIC microcontroller family includes the 18-pin rfPIC12C5O9AG which features an integrated 315/433MHz ASK transmitter, and the 20-pin rfPIC12C5O9AF which features an integrated 315/433MHz FSK/ASK transmitter. They are the first in a range of devices aimed at RF interface design in embedded control applications, such as remote sensing, remote control, toys, security and access control. The on-chip 315/433MHz transmitter enables designs to conform to US FCC Part 15 regulations and European ERC 70-03E and EN 300 220-1 requirements. It features a VCO phase-locked to a quartz crystal reference, which allows narrow receiver bandwidth to maximise range and interference immunity. Both devices contain 1024 words of program memory with 41 bytes of user RAM. They offer six I/O pins with on-chip clock oscillator, 33 single-word instructions, full-speed 1µs instruction cycle at 4MHz, seven special function hardware registers, two-level deep hardware stack, 8-bit real time clock/counter with 8-bit programmable prescaler, watchdog timer and direct LED drive. They feature in-circuit serial programming which allows the devices to be programmed after being placed in a circuit board. The rfPIC devices are supported by the standard range of PICmicro development systems including the MPLAB ICE 2000 universal in-circuit emulator.

Microchip
Tel: 0118 921 5858
www.microchip.com

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19mm. They are designed to be operated from a 12V source of either polarity. Input/output isolation of 2kV allows the user to have an output voltage of either polarity as well as being able to ground the output voltage at a remote point with the lower voltage converters. The units are protected against overvoltage, reversed input polarities and shorts or opens across the output terminals.
HiTek Power
Tel: 01243 841888
www.hitekp.com

TSOP-6 packaged dual Mosfet

International Rectifier has introduced the IRF5810 dual Mosfet in a TSOP-6 package which combines two P-channel HEXFET power Mosfets into a single 1.3 x 2.9mm footprint. Typical applications include load and battery management circuits in cell phones, PDAs, MP3 players, notebook computers and PCMCIA cards. The device has 40 per cent lower device on-resistance than competing dual Mosfets in the TSOP-6 package, claims the company. Each Mosfet within the package performs at 90mΩ $R_{DS(on)}$ each. An extended lead frame maximises the size of each die in the TSOP-6 outline. The lead frame increases current capability and on-state efficiency, yet fits in the standard TSOP-6 footprint, said the supplier. A single IRF5810 can replace two TSOP-6 devices in load management circuits, or a much larger TSSOP-8 packaged dual Mosfet in battery management circuits
International Rectifier
Tel: 020 8645 8003
www.irf.com

Power PC 7400/G4 optimised DSP library

Transtech DSP has released a C-library optimised for the PowerPC 7400/G4 processor and fully compliant with the VSIPL (Vector Signal and Image Processing Library) open-standard. The library APIs have been defined by the VSIPL forum, a group of cross-industry users working to define an open standard and portable library. VSIPL is suitable for applications in both the defence and commercial arena. The library is based on the 'core' VSIPL profile and includes over 500 functions, such as vector & scalar arithmetic, Fast Fourier Transforms (FFTs), window functions, filters, matrix operations, system solvers, logical operations, and OR decomposition. The PowerPC AltiVec processors support multi-media and signal processing through the use of a SIMD vector unit. The VSIPL library has been optimised to tap into this to accelerate these applications. Designed to work with the VQ750 and VQG4 quad Power VME cards, the library has also been optimised to use the PowerPC processor's cache benefits such as transparently decomposing the algorithms to run in L1 cache.
Transtech DSP
Tel: 01494 464432
www.transtech-dsp.com

MPEG-2 core for FPGA implements video decode

Amphion Semiconductor has launched what it claims to be the first application-specific core for MPEG-2 video decode in a single high-density programmable logic device. The Amphion CS6651 MPEG-2 video decoder is an intellectual-property (IP) core for decompression of MPEG-2 main profile at main level and MPEG-1 encoded video streams for implementation in a single FPGA device. The CS6651 incorporates memory controller and display DMA, and maps into single devices in the Altera APEX20K SRAM PLD family and the Xilinx Virtex series FPGA family.
Amphion Semiconductor
Tel: 028 9050 4040
www.amphion.com

1.3MHz switching regulator gets design tools

National Semiconductor has announced a switching regulator with its own design tools. The LM2698 uses current-mode control (without the need for a sense resistor) and pulse-width modulation (PWM). There is a 0.2Ω 1.3A (guaranteed) internal switch and 1.3MHz clock. Features include 2.2V to 12V input voltage range, user selectable 0.6 or 1.3MHz clock and filtered output.
National Semiconductor
Tel: 0870 240 2171
www.national.com

Miniature power relay has Cd-free contacts

Featuring environmentally-friendly cadmium-free contacts, Schrack PB miniature power relays from Tyco Electronics target applications in white goods, small home appliances and heating temperature controllers. The relays have been designed to cater for similar applications in the widely used "sugar cube" type format. They need a PCB area of 225mm^2, compared to the area requirements of the "sugar cube" type relays of approximately 370mm^2 being 15 × 15mm square and 20mm tall. Configured with a single 1 C/O (Normally Closed or Open) or 1 N/O (Normally Open) contact, these relays feature creepage and clearance to VDB 0435 and VDE 0700. Contact ratings are 10A N/O and 3A N/C, with a 15A inrush capability. Maximum switching voltage is 250VA or 100V DC while maximum breaking AC capacity comes in at 2500VA. Coil versions available are 6V, 12V and 24V DC. Normal coil power is 360mW. A Class F coil is also available.
Tyco Electronics
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Bluetooth qualification tool

Nohau UK has been made UK distributor for Telelogic's PreQual software, designed for Bluetooth qualification test suites to be executed by the developer. Qualification requires Bluetooth products to pass a series of tests defined by the Bluetooth Qualification Program. Manufacturers demonstrate interoperability and compliance to the Bluetooth specification as required by the Adopter's agreement. Telelogic's PreQual includes the executable test suites required for Bluetooth certification.
Nohau UK
Tel: 01962 733140
www.nohau.co.uk

3W surface-mount wirewound resistor

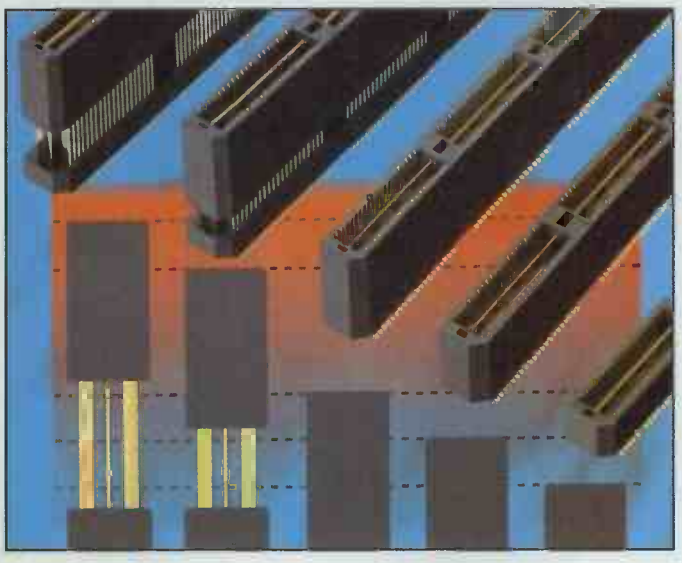
A moulded wirewound resistor from Vishay Intertechnology offers a 3W power rating at 70°C, and derates linearly to 275°C. The WSC6927 extends the derating temperature by as much as 77 per cent compared to competing devices currently on the market, which results in higher power operation at elevated temperatures, said the company. The resistor is available in a resistance range of 0.1Ω to 2.6kΩ, and features tolerance options of ±0.5 per cent, ±1 per cent, and ±5 per cent. The resistor measures 17.53 × 6.98mm, with a 7.11mm height profile. As a surface mount device, it can be used to replace 3W axial leaded components, enabling automatic, high-speed assembly. The resistor also features compliant terminations that eliminate the risk of solder fillet cracking.
Vishay Intertechnology
Tel: 001 610 251 5287
www.vishay.com

Elevated interface for 25mm board spacing

Samtec is offering an expanded range of micro pitch interfaces for matched impedance and high speed applications that require elevated designs with board-to-board spacings greater than the 16mm usually required for clearing common heat sink profiles. Samtec's Q-UP high speed interfaces are available with 19mm, 22mm, 25mm and 30mm board spacings. These are used where increased ventilation and air circulation is required. Full surface mount designs are available on 0.8mm pitch (QTE Series) and 0.5mm pitch (QTH Series), while mixed technology design on 0.635mm pitch (MIT Series) with through-hole ground plane and surface mount signal pins is available with 18.75mm and 22mm stack heights.
Samtec
Tel: 01236 739292
www.samtec.com

GPRS mobile parametric test set in one box

Agilent Technologies is targeting GPRS appliance design with a one box test system for parametric and signalling design validation The E6701A GPRS option for its 8960 series 10 (E5515C) wireless communication test set retains the measurement and call processing capability of the El964A GPRS mobile test application. The test set's protocol logging capabilities facilitate testing and troubleshooting of new signalling features and data channels, so engineers can extract better information about their design. Users of the E6701A can set timing advance and cell parameters, which allows for testing and troubleshooting issues related to timing and base station configuration. The company has also introduced ESG vector signal generator for testing 2.5G, 3G and broadband wireless communications systems and components. It is available with measurement frequency ranges of 250kHz to l, 2, 3, 4, or 6GHz.
Agilent Technologies
Tel: 07004 666 666
www.agilent.com



600V MOSFET relays

Optical isolation provides a rated dielectric strength of 5kV RMS between I/O terminals for Mosfet relays from Omron. With 50mA LED forward current at the input, the G3VM-601xY caters for 600V loads with output loss of 454mW. Designed for switching analogue signals, the six-terminal relay provides 100mA current for AC loads and up to 200mA for DC loads. Standard resistance with the output turned on ranges from 22Ω with AC connection, down to 8.5Ω with DC connection, while leakage current is 10μA when the relay is closed. Turn-on time is 1.5ms maximum, 0.5ms typical, while turn-off occurs in less than 1ms. The device has a single-pole, single-throw, normally-open switching format.
Omron
Tel: 020 8450 4646
www.omron.co.uk

Integrated T1/E1 socket offers protection

Pulse's Pulsejack family of RJ-45 connectors combines isolation transformers and line side protection into a T1/E1 single socket, offering integrated magnetics and telephone network voltages (TNV) circuit protection. The connectors require no separate circuit transceiver, leading to improved electrical performance and space saving. Contech Research has independently verified the RJ-45 family meets all relevant surge immunity and electrical safety standards, including Bellcore GR-1089, FCC Part 68 and UL 1949/1950. Improved electrical performance can be achieved by minimising the electrical trace length between the RJ-45 connector and the integrated circuit transceiver.
Pulse
Tel: 01483 401 700
www.pulseeng.com

Fast 12 and 16-bit ADCs in MSOP package

Linear Technology has introduced the LTC1860 and LTC1864, serial 12-bit and 16-bit, 250ksample/s analogue-to-digital converters (ADCs). Both parts come in 8-lead MSOP packages. The LTC1864 has high resolution and both can sample up to 250ksample/s drawing 850μA at full speed and 2μA at 1ksample/s. A self-clocking conversion enables the accuracy of the ADC to be

Please quote *Electronics World* when seeking further information

independent of the shift clock frequency. This allows the devices to operate with low MCU clock speeds as in opto-isolation applications or with high clock speeds to save processor overhead. They are pin compatible. They are packaged in either MSOP-8 or SO-8. Both are available in the commercial and industrial temperature ranges.

Linear Technology
Tel: 01276 677676
www.linear-tech.com

Resettable fuse with a range of footprints

Wickmann is offering six surface mount devices in its Polyfuse family of resettable fuses. These polymer-based devices provide overcurrent protection in products such as computer motherboards, USB hubs and ports, CD/DVD drives, PDA's, digital cameras and battery packs. There are six surface mount footprints available. The SMD0805 has the smallest footprint. Measuring 2.2 x 1.5mm, it features four hold current ratings from 100mA to 500mA with a current interruption capability of 40A at rated voltage. Both the SMD1206 and SMD1210 series are optimised for protection of computer peripherals, PC Cards and various I/O port types.

Wickmann
Tel: 01527 518841
www.wickman.co.uk

TFT panels from 2.5 to 24 in.

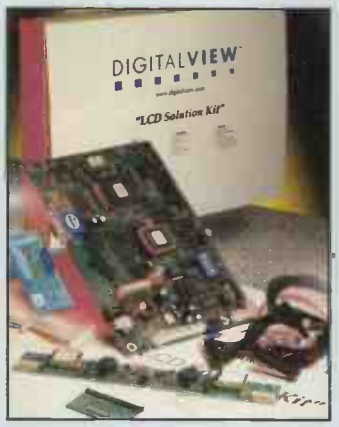
Diamond Electronics is offering a series of TFT LCD displays that are available in a range of sizes from 2.5in (diagonal measurement) to 24in - corresponding to pixel counts of 480 x 234, up to 1900 x 1200. The displays can be supplied as stand-alone panels; with a range of controller cards; as kits with all major components for specific application areas; or as complete packaged designs. The supplier will also undertake custom designs. Controller cards support applications such as acceleration for Microsoft Windows displays; 3-D graphics acceleration; and conversion and display of RGB signal streams.

For users who are incorporating the panels into applications such as industrial monitoring and control displays, a kit is available that includes the TFT panel together with a PC controller card with a full industrial specification, that will easily handle data acquisition, control and display functions. Fully configured kits can also be supplied for RGB conversion applications. Options are also available that upgrade the viewability of the displays with high brightness or high contrast enhancements.

Diamond Electronics
Tel: 01477 500450
www.diamondelec.co.uk

LCD controller design kit

Digital View's latest LCD flat panel display interfacing kit contains all the components necessary to support LCD applications. Consisting of a pre-programmed ACL-1024 RGB controller board, panel connector



cable, inverter, inverter power cable, rotary on screen display, and complete documentation, the Digital View ACL-1024 LCD design kit provides the components necessary to run a range of LCDs from manufacturers such as LG, Mitsubishi, Sharp and Toshiba. The pre-configured board provides connection to TFT LCD panels with a resolution of 640 x 480, 800 x 600 and 1024 x 768. It also provides smooth full screen image expansion for XGA modes, with an optional daughter board offering connectivity to TDMS and LVDS TFT panels. Measuring 179 × 114.3mm the controller features a user programmable on-screen display of functions, integral power/signal protection and on-board circuitry for handling power on/off. The product is VESA DPMS power management compatible. Each kit is also available with an optional DVB-1000 NTSC/PAL add on video board. This new board supports composite, S-video and component video inputs.

Digital View
Tel: 020 8236 1112
www.digitalview.com

PCI bus scope card with 14-bit resolution at 100MS/s

The Gage CompuScope 14100 is available from TTi (Thurlby Thandar Instruments). It is a single slot, PCI bus card capable of performing 14-bit analogue/digital conversion at sampling rates of up to 100Msample/s in single-channel mode and 50Msample/s in dual-channel simultaneous mode. The

unit features a 50MHz analogue bandwidth with over 70dB dynamic range and 63dB signal/noise ratio. One billion samples of on-board memory allows very long data recording sessions for applications including DSL testing, wireless signals and antenna research. The fast data throughput offered by the PCI bus allows for bus mastering, data can be transferred from the on-board memory to the PC's memory at rates of up to 100Mbyte/s. This is typically 100 times faster than using the ISA or VXI bus and more than 1000 times faster than GPIB rates, said the supplier. This fast data throughput allows use in applications such as radar or imaging applications requiring trigger frequencies in excess of 10kHz. With the software, the unit can act as a digital oscilloscope, an FFT analyser, a transient recorder with time and date-stamp capabilities or a waveform analyser.

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www.tti-test.com

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Cooper Electronic Technologies has introduced a range of inductors designed to address the QS9000 certification standards. This series of surface mount electronic power inductors has passed the requirements for shock, temperature, vibration, solderability, flammability, dielectric voltage requirements, and wash process tests, thus making the components suitable for automotive designs. The Coiltronics brand of Uni-Pac inductors are suitable for traditional 12V automotive distribution systems or for 42V systems of the future. Typical uses within 12V systems include boost converters and buck converters. If the engineer is developing around the future 42V requirements, the inductors can again be used in boost converters, buck converters, filtering applications plus isolation controls. All of the inductors have been optimised to operate in ambient temperatures of –40 to +125°C, with storage temperatures of –55 to 150°C.

Cooper ET
Tel: 00561 752 5019
www.cooperet.com

Bluetooth version 1.1 qualified chip set and stack

CSR (Cambridge Silicon Radio) and Open Interface of the US have announced a Bluetooth version 1.1 qualified combined design using CSR's BlueCore Bluetooth silicon and Open Interface's BlueMagic protocol stack. The two firms are already shipping a combined hardware and software design for the earlier version of the Bluetooth specification.

Cambridge Silicon Radio
Tel: 01223 692689
www.csr.com

Large flash-based FPGAs for industrial use

Actel is shipping its largest flash-based field-programmable gate array (FPGA) devices qualified to industrial specifications. The ProASIC A500K180 and A500K270 industrial devices offer 370,000 and 475,000 system gates, respectively. The industrial grade FPCAs are specified to operate at ambient temperatures ranging from –40 to +85°C. The devices are suitable for applications such as remotely deployed networking and telecommunications systems, civilian aircraft avionics and industrial control. These latest devices join the firm's ProASIC A500K050 and -130, which were qualified earlier this year. It offers industrial-qualified devices from 2K to 475K system gates. The A500K270, with 475 000 system gates, offers nearly 27 000 registers and 63Kbits of RAM in 28 blocks of 256 x 9 bits. The 370 000-gate A500K180 offers more than 18 000 registers with 54Kbits of RAM in 24 blocks.

Actel
Tel: 01276 401450
www.actel.com

Plug-in SIM card adapter for test

Orga has announced a plug-in SIM card adapter for testing mobile telephones. The adaptor fits into the mobile's internal SIM connector. Through a thin, flexible connector, the mobile can be completely closed whilst connecting to the testing equipment, said the supplier. There are four versions of the adaptor available. The device also has the same parameters as a full sized paddle, so no adjustment or calibration is necessary. According to the company, the information stored in the SIM is usually passed on to the mobile equipment for processing. External intervention is impossible, and therefore special commands cannot be sent

Fans withstand a splashing

EAO has expanded its offering of Sanyo Denki cooling fans with the addition of a range of San Ace splash proof fans. The IPX7 protection rated fan features a silicone-sealed motor housing, which is capable of withstanding the 1000 hour salt-water spray test. The range which comes in four different frame sizes is available in 12V, 24V or 48V DC. Other options include low, medium and high-speed versions and the inclusion of either a pulse sensor to monitor the operating speed of the fan or a lock sensor to determine whether the fan motor is running or not. High airflow and high static pressure are strong features of the range with 1.06m^3/min typically attained with the 80 by 20mm version (static pressure 39 pascals), 1.38m^3/min with the 92 by 25mm version (static pressure 45 pascals), 3.0m^3/min with the 120 by 38mm (static pressure 70 pascals) version and 5.9m^3/min with the l40 by 51mm version (static pressure 142 pascals). These fans, with UL, TUV and CSA approval, have an LIO life expectancy of 100 000 hours measured at an ambient temperature of 600°C. Operating temperatures range from –10 to +60°C and noise levels from 22 to 52dB.

EAO
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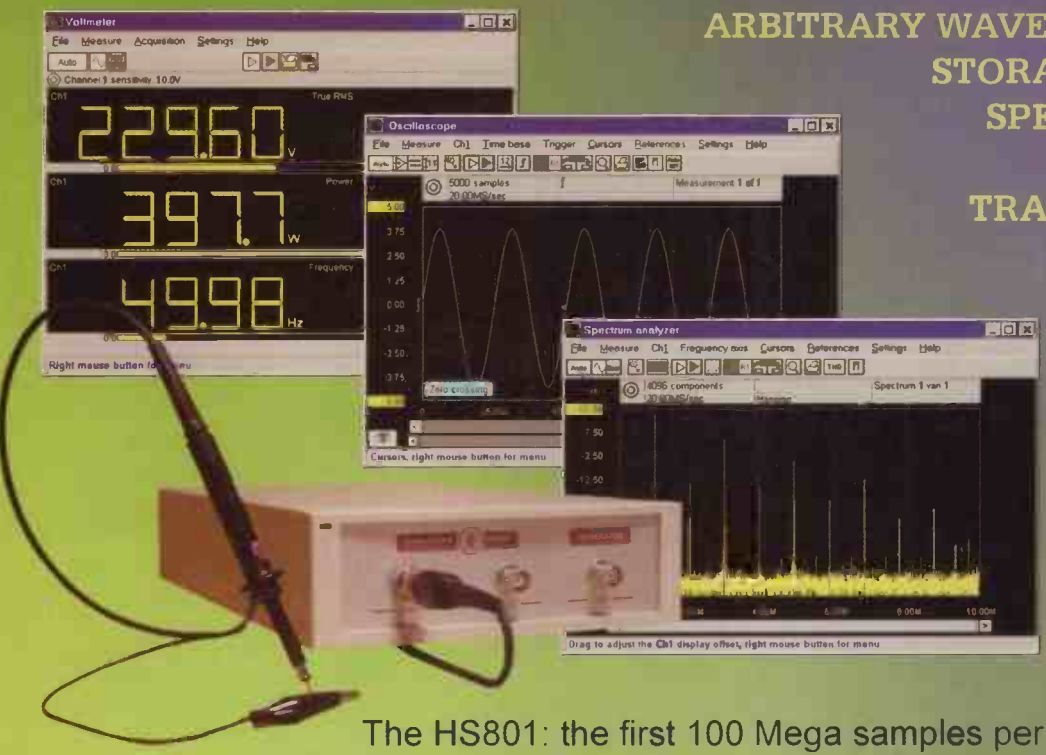

Reliability

The HS801: the first 100 Mega samples per second measuring instrument that consists of a MOST (Multimeter, Oscilloscope, Spectrum analyzer and Transient recorder) and an AWG (Arbitrary Waveform Generator). This new MOST portable and compact measuring instrument can solve almost every measurement problem. With the integrated AWG you can generate every signal you want.

- The versatile software has a user-defined toolbar with which over 50 instrument settings quick and easy can be accessed. An intelligent auto setup allows the inexperienced user to perform measurements immediately. Through the use of a setting file, the user has the possibility to save an instrument setup and recall it at a later moment. The setup time of the instrument is hereby reduced to a minimum.

- When a quick indication of the input signal is required, a simple click on the auto setup button will immediately give a good overview of the signal. The auto setup function ensures a proper setup of the time base, the trigger levels and the input sensitivities.

- The sophisticated cursor read outs have 21 possible read outs. Besides the usual read outs, like voltage and time, also quantities like rise time and frequency are displayed.

- Measured signals and instrument settings can be saved on disk.This enables the creation of a library of measured signals. Text balloons can be added to a signal, for special comments.

- The (colour) print outs can be supplied with three common text lines (e.g. company info) and three lines with measurement specific information.

- The HS801 has an 8 bit resolution and a maximum sampling speed of 100 MHz. The input range is 0.1 volt full scale to 80 volt full scale. The record length is 32K/64K samples. The AWG has a 10 bit resolution and a sample speed of 25 MHz.The HS801 is connected to the parallel printer port of a computer.

- The minimum system requirement is a PC with a 486 processor and 8 Mbyte RAM available. The software runs in Windows 3.xx / 95 / 98 or Windows NT / 2000 / XP and DOS 3.3 or higher.

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

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in order to identify and locate errors. The firm's SIM simulator monitors and tests the reaction of the mobile as it communicates with the card allowing testing at electrical, protocol and application level. This SIM adaptor is designed to simplify the connection so mobiles do not need to be modified and the need to solder connections is eliminated.
Orga
Tel: 0118 377 6000
www.orga.com

SCSI PMC modules claim Ultra 160 lead

BVM has extended its range of SCSI PMC modules with the addition of an Ultra160 SCSI controller. Believed to be the first of its kind, this module designated the PMC-SCU160, allows designers to use current ranges of Ultra160 peripherals that are available. Unlike earlier SCSI controllers, which degrade to match the slowest peripheral on the SCSI bus, this module has domain validation allowing it to talk to each peripheral at its optimum speed.
BVM
Tel: 01489 780144
www.bvmltd.co.uk

1.8V op-amps take 100µA and drive 2kΩ.

Maxim Integrated Products has introduced the MAX4292 dual op amp with rail-to-rail inputs and output in a UCSP package measuring 1.5 by 1.5mm. It consumes 100µA of supply current per channel, yet drives a 2kΩ load and achieves an open-loop gain of 120dB. Operating from a single +1.8V to +5.5V supply, it delivers 20,000 hours of operation from two alkaline AA cells.
Maxim
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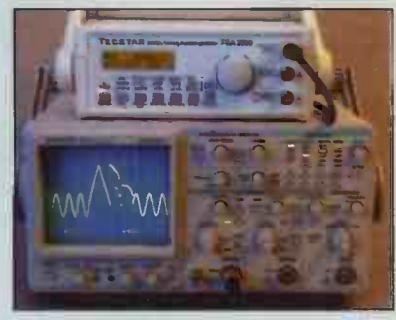
www.maxim.com

Arbitrary waveform generator

It's possible to define, create and modify waveforms for specific applications using Tecstar's new function generator. This is a "fully-featured" programmable-sweep function generator integrated with an arbitrary waveform generator. Designated the FGA2030, the generator delivers from 0.2Hz to 20MHz and its arbitrary facility works from 0.4MS/s to 30MS/s with 12-bit resolution. The unit's 256K non-volatile memory is



configurable as 1 by 256Kwords or 8 by 32Kwords for storing waveforms. A selectable 10MHz Bessel filter and internal/external triggering are standard features. The instrument is supplied with Tecstar's 'Wavegen' Windows software for creating waveforms on the PC. Waveshapes can be drawn freehand or calculated. ■
Tecstar Electronics
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2 Good Old Summertime, The American Quartet 1904
3 Marriage Bells, Bells & xylophone duet, Burckhardt & Daab with orchestra, 1913
4. The Volunteer Organist, Peter Dawson, 1913
5. Dialogue For Three, Flute, Oboe and Clarinet, 1913
6. The Toymaker's Dream, Foxtrot, vocal, B.A. Rolfe and his orchestra, 1929
7 As I Sat Upon My Dear Old Mother's Knee, Will Oakland, 1913
8 Light As A Feather, Bells solo, Charles Daab with orchestra, 1912
9 On Her Pic-Pic-Piccolo, Billy Williams, 1913
10 Polka Des English's, Artist unknown, 1900
11 Somebody's Coming To My House, Walter Van Brunt, 1913
12 Bonny Scotland Medley, Xylophone solo, Charles Daab with orchestra, 1914
13 Doin' the Raccoon, Billy Murray, 1929
14 Luce Mia! Francesco Daddi, 1913
15 The Olio Minstrel, 2nd part, 1913
16 Peg 0' My Heart, Walter Van Brunt, 1913
17 Auf Dem Mississippi, Johann Strauss orchestra, 1913
18 I'm Looking For A Sweetheart And I Think You'll Do, Ada Jones & Billy Murray, 1913
19 Intermezzo, Violin solo, Stroud Haxton, 1910
20 A Juanita, Abrego and Picazo, 1913
21 All Alone, Ada Jones, 1911

Total playing time 72.09

21 tracks – 72 minutes of music.
Published by *Electronics World*. All recordings reproduced by Joe Pengelly.

Detecting vibrations and tremors

Picture courtesy US Geological Survey: http://neic.usgs.gov/

In Joe Carr's explanation of vibration detectors and seismographs, he details an easy-to-build instrument that's sensitive enough to detect Earth tremors.

A number of scientific and engineering investigations involve vibration signals. For example, engineers can often characterise a metal plate or beam by placing a vibration sensor on it, and then subjecting it to an impact.

I've seen one case where strain gauge sensors were placed on a metal beam whose other end was then whacked with a 'dead-blow' hammer, as in **Fig. 1.** A dead-blow hammer is a hammer whose blow reaction is absorbed by some means. The idea behind using a dead-blow hammer is to prevent bouncing of the hammer from creating more than one blow.

In another case, sensors were placed at critical points on a bridge, and then a small explosive charge was ignited at the other end. The charge was of the order of a cherry bomb, so caused no damage. In both cases, the idea was to cause an impact, and then record the vibrations in the structure that result from it.

If you saw the movie Jurassic Park, then you saw another use of vibration sensors. A shotgun shell blank was held in a rig against the ground and exploded. The seismic waves were recorded on a lap-top computer and processed to show the all-too-realistic image of a Raptor skeleton.

Oil exploration is done the same way. An explosion is set off at a site, and a cluster of vibration sensors around a perimeter are used to sense the vibrations. From their data the geologists can construct an image of the underlying structure, and from it predict where oil might be found.

The idea behind any sensor is to find some transducible property that responds to the event being measured. A number of things can be used. For example, the strain gauge consists of a thin resistive wire stretched across a membrane or diaphragm.

When the wire is deformed, its dimensions change, so its resistance will also change. This phenomenon is called piezoresistivity. When the strain gauge resistor is used in a Wheatstone bridge, then a sensitive measure of the deformation caused by vibration can be obtained.

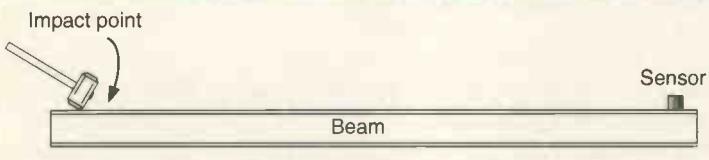

Fig. 1. It is possible to obtain information about a beam by placing vibration sensors on one end of it and hitting the other with a 'dead-blow' hammer.

Inductive sensors

Another transducible property for vibrations is the inductor shown in **Fig. 2a).** Inductance of the coil of wire is determined by the number of turns, diameter of the coil, the length of the coil and the nature of the core.

If a ferrite or powdered iron core is used, then a large increase of inductance occurs when the core is slipped into the coil form. 'Slug-tuned' inductors are used in radio circuits. A threaded core is adjusted to be more or less inside the coil, depending on the value of inductance required.

Vibration sensors can be made by placing the core on a spring, pendulum or some other means of translating the motion caused by vibration into motion of the core – and therefore a change of inductance. In Fig. **2b)** a pendulum is used to move the core in and out of the coil form.

There is a class of motion sensors that depends on the fact that a magnetic field and coil in motion relative to

each other causes a current to be induced into the coil. It doesn't matter whether the coil moves or the magnet moves, so long as there is relative motion.

Figure 3 shows a crude form of permanent magnet moving coil (PMMC) vibration sensor. A horseshoe magnet is positioned such that an inductor can move inside of its field. The coil, which may have many, many turns, is connected to a spring. When vibration is sensed, the coil moves up and down against the spring, causing a current to be induced because of the magnetic field.

A more familiar example is something that you might not at first see as a vibration sensor. The ordinary radio or television loudspeaker, **Fig. 4**, will do this neat trick. The PMMC loudspeaker consists of a fixed permanent magnet – usually made of Alnico – and a lightweight moving coil that is attached to the paper speaker cone.

When an electrical current from the radio output stage flows in the coil it produces a magnetic field that either attracts or repels the permanent magnet's field, depending on the polarity of the audio signal. Thus, as the polarity of the audio signal switches back and forth the coil and cone move in and out.

The same loudspeaker that can be used as a radio output device can also be used as a microphone. Intercom sets that allow talk-back use this phenomenon. When sound vibrations impinge on the cone, they move the coil relative to the magnet, causing a current to be induced into the coil. This tiny current can be amplified and used as an audio signal.

Note that word in the previous paragraph: 'vibration'. If the vibrations being measured can be coupled to the speaker cone, then the speaker will act as a vibration sensor. I've seen speakers placed flat against metal plates for the purpose of recording vibrations.

One science fair student cemented a plastic drinking straw against the bottom of the speaker cone, and used it to couple to the vibration source. Essentially, the kid made a large-scale 'spike microphone'.

Linear differential voltage transformers

Figure 5 shows a special form of vibration or displacement sensor called a linear differential voltage transformer, or LDVT. It consists of three inductors, L_1 through L_3.

Inductor L_1 is excited by an AC signal, which is magnetically coupled to secondary coils L_2 and L_3. When the core is exactly midway between L_2 and L_3 the currents flowing in them will be identical.

The dots indicate the phasing of the two secondary coils. Because of the connection of L_2 and L_3, the currents are in series opposing. Thus, when the core is midway, the currents are equal and opposite, so null to zero. But when the core is offset in one direction or another, then one of the coil currents will predominate.

The amplitude of the output signal – expressed as a voltage – gives an indication of the magnitude of the core shift, while the polarity indicates the direction. When the core is coupled to something like a pendulum or diaphragm, then the vibrations received will move the core in an out of the coil-pair, causing an AC output signal to appear.

Differential capacitor sensors

Capacitance exists whenever two metallic objects are in close proximity to each other, and are separated by an insulating material – i.e. a 'dielectric'. Such a device is called a capacitor.

Capacitance is a measure of the capacitor's ability to store an electrical charge in an electrical field set up between the plates. The value of capacitance is proportional to the area of the metal surfaces and a property of the dielectric called the dielectric constant. For dry air, the dielectric constant ε is 1. Capacitance is inversely proportional to the distance between the metal surfaces – in other words, the closer together they are, the higher the capacitance.

Capacitors are used in a variety of electronic applications. But in this particular case we are interested in a class of capacitors that are variable, and can be made to vary under the influence of vibration.

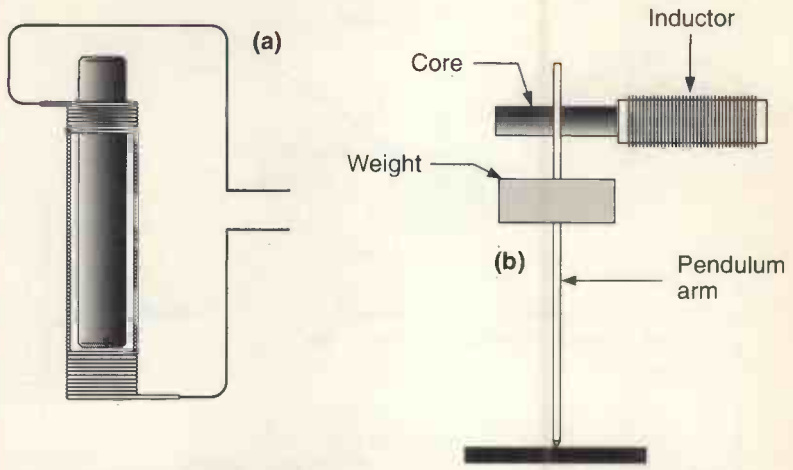

Fig. 2. Inductive vibration sensing. In a) is the basis of such a sensor. If the coil's ferrite core is disturbed, the inductance of the coil changes. In b), the coil and core are attached to a pendulum which transfers movement from the pendulum's base plate to the coil's core.

Differential capacitors

This class of variable capacitor actually consists of two variable capacitors actuated by the same shaft or other mechanical device. They are configured such that one capacitance increases its capacitor while the other decreases its capacitance in the same manner.

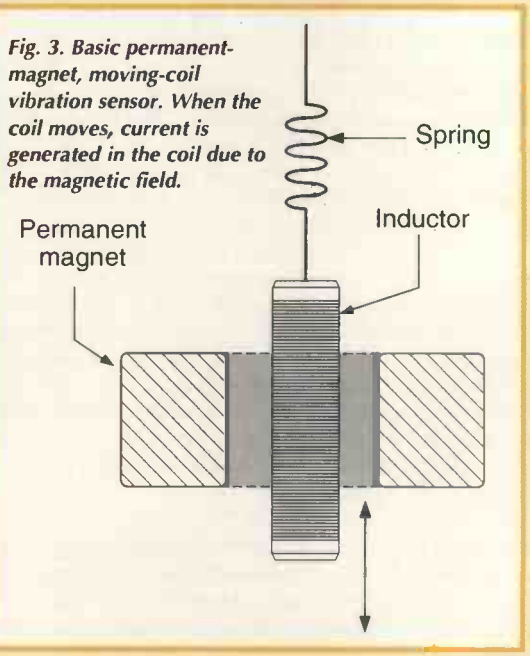

Fig. 3. Basic permanent-magnet, moving-coil vibration sensor. When the coil moves, current is generated in the coil due to the magnetic field.

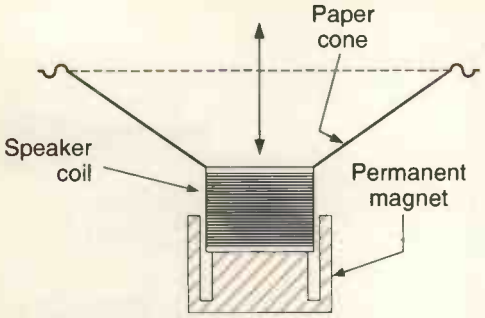

Fig. 4. Another example of a permanent-magnet, moving-coil vibration sensor – the loudspeaker.

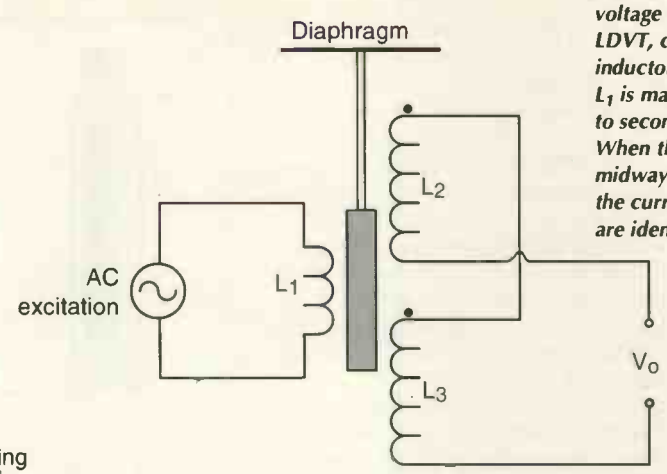

Fig. 5. A linear differential-voltage transformer, or LDVT, consists of three inductors. Excited inductor L_1 is magnetically coupled to secondary coils L_2 and L_3. When the core is exactly midway between L_2 and L_3 the currents flowing in them are identical.

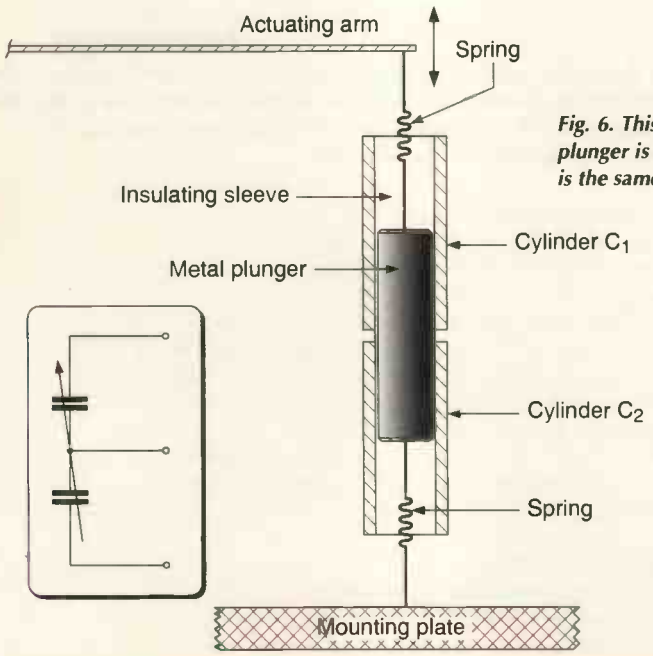

Fig. 6. This vibration sensor relies on capacitance changes. When the plunger is central, i.e. at rest, capacitance at each of the identical cylinders is the same. Moving the plunger causes the capacitances to differ.

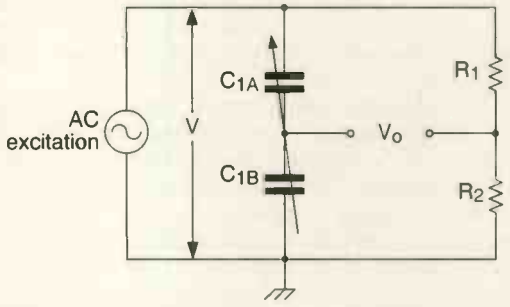

Fig. 7. Circuit for using a differential capacitance sensor of the type shown in Fig. 6. Here, the differential capacitor is connected as two arms of a Wheatstone bridge.

If you were to measure the total capacitance across the two capacitors, then you would find that the net capacitance does not change even though the values of the two capacitor sections do.

Figure 6 shows a vibration sensor that utilises the differential-capacitance phenomenon. The two capacitors are formed by two metal cylinders – C_1 and C_2 – separated by a small dielectric gap of air or other material. These cylinders share a metal plunger that is inside and axially concentric with them.

An insulating sleeve prevents the plunger – the 'common plate' of the differential capacitor – from shorting out against either cylinder. When the plunger is equally inside both cylinders, favouring neither, then their respective capacitances are equal. But if the actuating arm moves, then the plunger will move more deeply into one cylinder and out of the other. As a result, the ratio of the two capacitances changes.

The inset in Fig. 6 shows the equivalent circuit schematic for the differential capacitor vibration/displacement sensor.

A circuit for using a differential capacitance sensor is shown in **Fig. 7**. The differential capacitor – comprising C_{1A} and C_{1B} – is connected as two arms of a Wheatstone bridge. The remaining two arms are resistors R_1 and R_2. It is the nature of this type of bridge circuit that output voltage V_O will be zero when the ratios of the capacitive reactances and resistances are equal:

$$\frac{X_{C1A}}{X_{C1B}} = \frac{R_1}{R_2} \text{ for } V_o = 0 \qquad (1)$$

If R_1 equals R_2, the output voltage will be zero when the differential capacitor is balanced, i.e. C_{1A} is equal to C_{1B}. When vibration or other motion displaces the plunger, however, C_{1A} is no longer equal to C_{1B} so the bridge is unbalanced and V_O is non-zero. The amplitude of V_O depends on the amplitude of the mechanical displacement of the plunger.

Other forms of circuit can be used with a differential capacitive sensor. For example, the two capacitors C_{1A} and C_{1B} can be used to control the frequency of radio frequency oscillators. When C_{1A} is equal to C_{1B}, then the two frequencies would be equal, but a change in that equality will force the frequencies apart. One frequency will rise, while the other will fall.

If the two frequencies are combined in a nonlinear mixer, then the resultant heterodyne beat note will be proportional to the deflection of the plunger. A frequency-to-voltage converter or other form of circuit can be used to produce the analogue waveform.

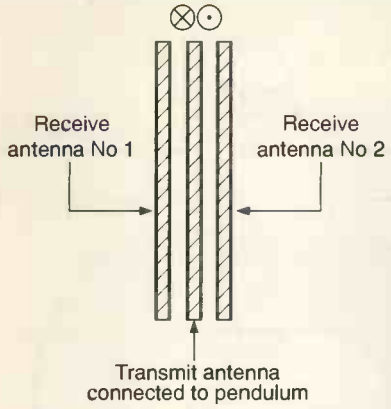

Fig. 8. Sensor derived from the Shackleford-Gunderson seismometer. In this type of sensor circuit the common plate of the capacitor is excited by a 4 to 6MHz RF signal, and the other two are used as 'receive antennas'.

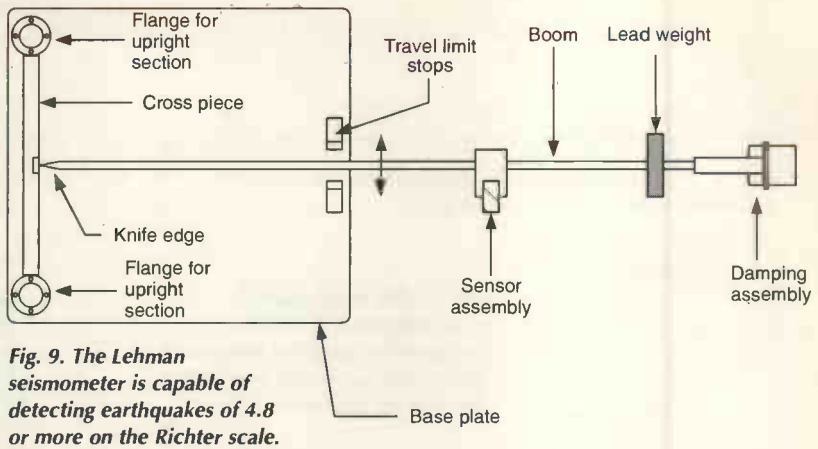

Fig. 9. The Lehman seismometer is capable of detecting earthquakes of 4.8 or more on the Richter scale. This is a plan view of such a seismometer presented in the Amateur Scientist section of Scientific American.

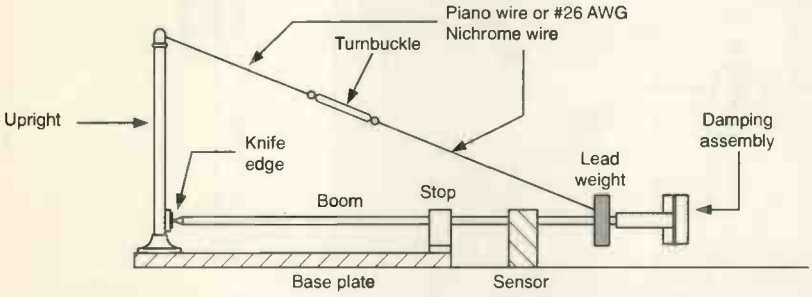

Fig. 10. Side elevation of the Lehman seismometer, showing the arm and its suspension wire.

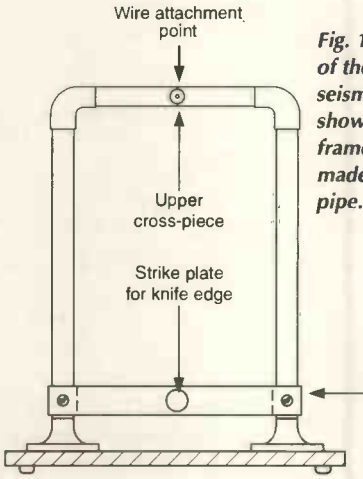

Fig. 11. End elevation of the Lehman seismometer, showing the support frame, which can be made from copper pipe.

Another approach is shown in **Fig. 8**. It is derived from a sensor called the Shackleford-Gunderson seismometer. In this type of sensor circuit the common plate of the capacitor is excited by a 4 to 6MHz RF signal, and the other two are used as 'receive antennas'. When the detected and integrated outputs of these receive antennas are combined the resultant signal is proportional to the vibration.

Still another approach is to charge the capacitors through a high value resistor with a DC source, and then use an electrometer to measure the voltage across the capacitors. The voltage will be proportional to the charge, which in turn is set by the capacitance. The result is that the two DC voltages will vary according to the position of the plunger.

Electrometers are amplifiers with extremely high input impedances, so can be used to measure the charge developed across small value capacitors.

Another form of differential capacitor vibration sensor uses a pendulum to move a metal disc between two sections of a capacitor. The sensor's stator plates, call them C_{1A} and C_{1B}, are made with bits of sheet metal, or blank unetched printed circuit board stock – which might be easier to work.

Two sets of plates are used for each capacitor, and they are connected together. As the pendulum bob swings back and forth it will 'shade' more or less of each set of stator plates depending on the amplitude and direction of the swing. Similar circuit strategies as above will also work for this sensor.

Lehman-type seismometer project

The Lehman seismometer was designed by Dr James D. Lehman of the Department of Physics at James Madison University in Harrisonburg, Virginia. It was the subject of the 'Amateur Scientist' column written by Jearl Walker in *Scientific American* (July 1979, p. 152ff)*. This seismometer is capable of detecting earthquakes of 4.8 or more on the Richter scale in the country where it's used, and 6 or more in other areas of the world.

The plan view is shown in **Fig. 9**, while a side view is shown in **Fig. 10**. A pendulum boom of 75cm or more in length is made of $^5/_{16}$-inch (8mm) stock. It is suspended from an upright section, **Fig. 11**, such that its 'knife-edge' butt end rests against a strike plate on the upright section.

The last 20cm or so of the boom is threaded to accept a $^5/_{16}$-20 or finer hex nut. When side-to-side vibrations characteristic of an earthquake are present the pendulum arm will swing back and forth in the horizontal plane. A pair of stops, **Fig. 12**, are used to prevent over-travel of the pendulum boom arm.

The components of the seismometer are mounted on a flat base plate. This plate can be made of aluminium, wood or plastic, but it must be level and stable. Do not use material thinner than 1.5cm for the base.

The upright segment is made from copper plumbing pipe, right angle-joints, and a pair of universal flanges for mounting to the base plate. The overall height is about 46cm. A lower cross piece holds the strike plate, while the upper cross piece holds a special wire attachment point

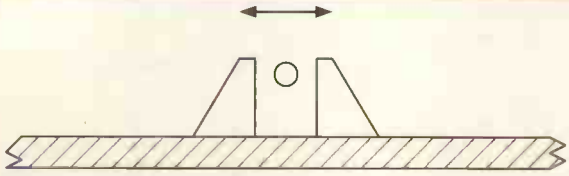

Fig. 12. To prevent damage, the Lehman seismometer's arm movement is restricted by pair of stops.

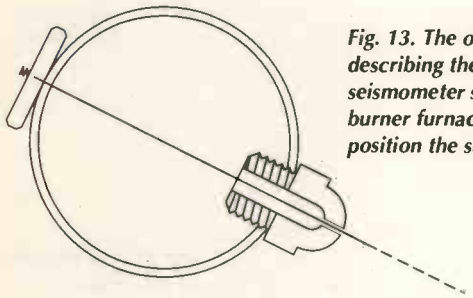

Fig. 13. The original article describing the DIY Lehman seismometer suggested using an oil burner furnace nozzle to precisely position the suspension wire.

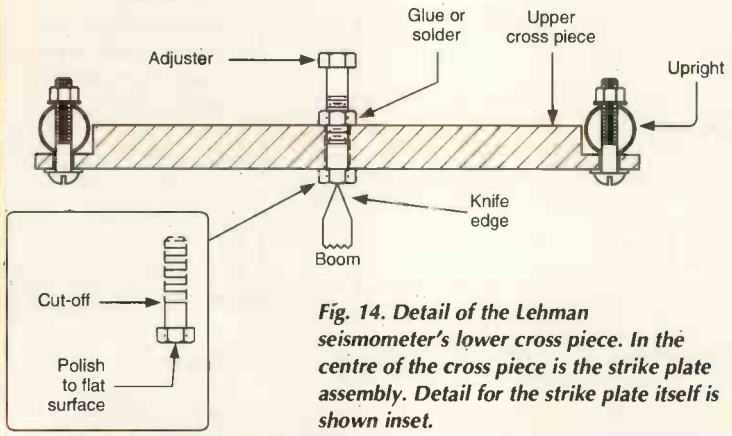

Fig. 14. Detail of the Lehman seismometer's lower cross piece. In the centre of the cross piece is the strike plate assembly. Detail for the strike plate itself is shown inset.

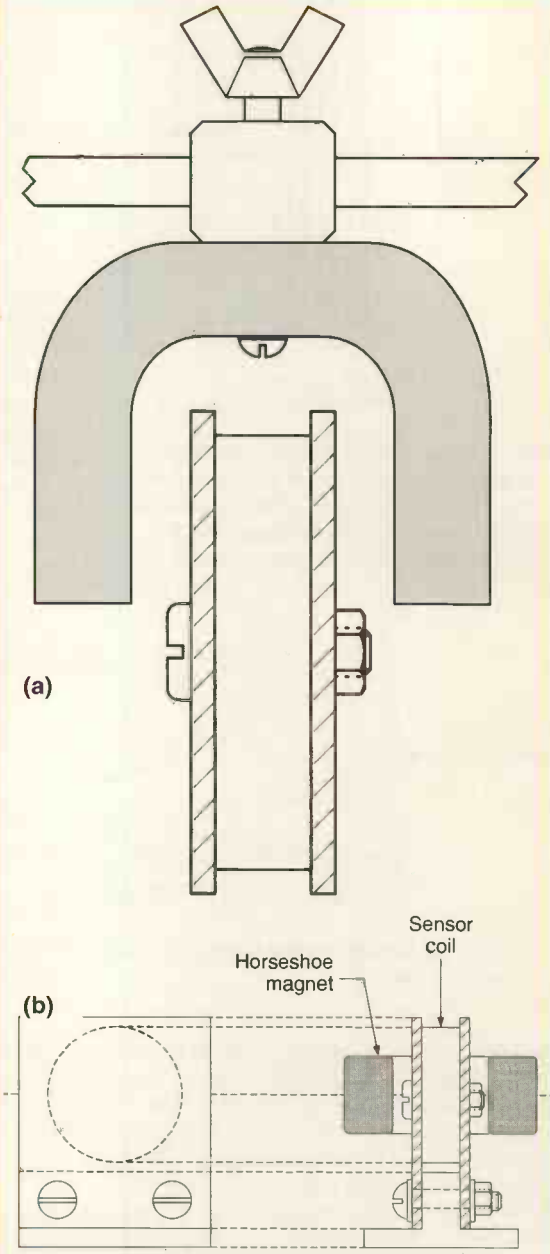

Fig. 15. Detail for the seismometer's sensor assembly In a) is a plan view while b) shows a side view. Here, a magnetic field moves relative to a coil of wire to induce a current.

fixture – about which, more shortly.

In Fig. 11 you will see the side view. The wire suspending the boom is either piano wire or #26 AWG Nichrome wire. A small turnbuckle is used to make the wire taught and level the boom.

The upper end of the suspension wire is tied off to the upper cross piece, **Fig. 13**. The Walker article used an oil burner furnace nozzle to precisely position the suspension wire.

Detail in plan view of the lower cross piece is shown in **Fig. 14**. The cross piece can be machined from a bar of aluminium or brass, although some have made it out of plastic – not recommended, I am told. The ends of the cross piece are bevelled to allow it to be mounted to the vertical upright members.

In the centre of the cross piece is the strike plate assembly. Detail for the strike plate itself is shown inset. A 1/4in (6mm) carriage bolt or other flathead machine bolt is used to make the strike plate. It is cut off from the threaded segment, leaving only the head and the unthreaded portion of the shank. The head is machined flat and polished. This makes a nice, low friction surface for the knife edge end of the pendulum boom.

A hole is drilled through the cross piece just slightly larger than the strike plate. A 1/4-20 (or finer) hexagonal nut is soldered or glued to the backside of the cross piece such that its hole is centred over the hole drilled in the cross piece. A matching hex head bolt is threaded into the nut, so that it sits against the back of the strike plate. When this bolt is adjusted, it will adjust the position of the strike plate.

A sensor assembly is mounted on the boom arm, refer again to Figs. 10 and 11. It is used to detect motion of the boom and translate it into an electrical signal that can be recorded on paper or stored in a computer. Also on the boom arm is a lead weight to make the boom act like a pendulum, and a damping assembly. The damper is needed to damp out oscillations of the pendulum in order to spread out the frequency response. Without the damping assembly the vibrations closest to the pendulum's natural period will cause the greatest response. The frequency response is thus peaked at a specific frequency, rather than being broader.

Detail for the sensor assembly is shown in **Fig. 15**. A

*For interest, there was a radiation detector made out of aluminium foil and a tin can on page 190 of the September 1979 issue. Excellent magazine. Ed.

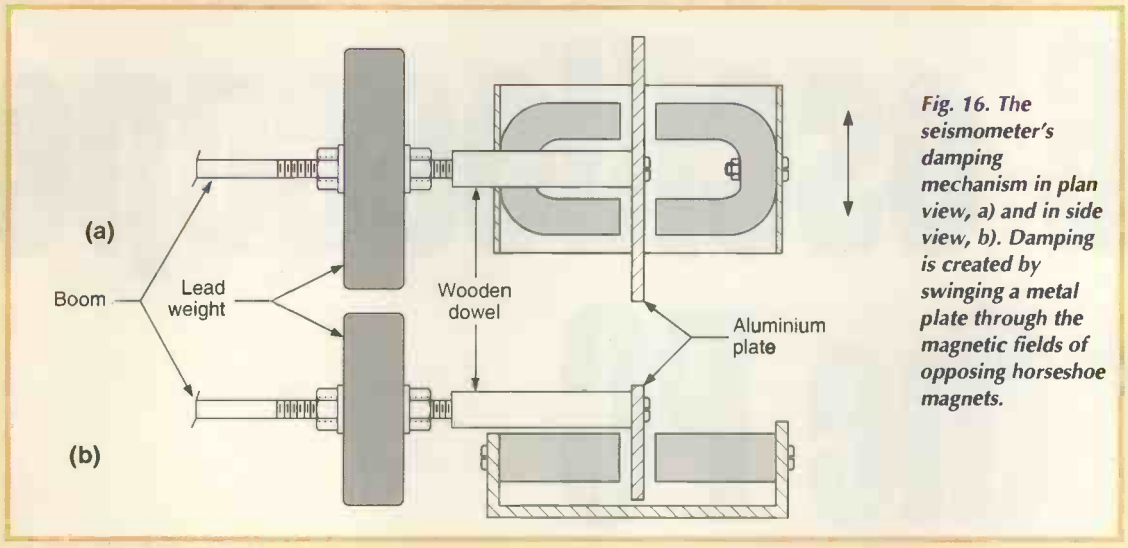

Fig. 16. The seismometer's damping mechanism in plan view, a) and in side view, b). Damping is created by swinging a metal plate through the magnetic fields of opposing horseshoe magnets.

plan view is shown in Fig. **15a)**, and a side view is shown in Fig. **15b)**. The sensor's 'transducible event' results from the fact that a magnetic field moving relative to a coil of wire will induce a current in that wire.

In Fig. 15a) you will see a strong horseshoe magnet mounted on the boom arm of the pendulum. The magnet is fixed with a wing nut connector of the sort used to fasten chemistry and optical apparatus.

Inside the curve of the horseshoe magnet is a coil of wire. The coil should be several centimetres in diameter, and consist of about 8000 to 12000 turns of #36 AWG (or so) enamelled wire. The former for the coil can be constructed of wood or plastic. A slow speed drill is used to scramble wind the wire onto the form.

Winding the coil can be a dangerous operation, and you take your own responsibility if you attempt it. Make sure the drill has a very slow speed (most variable speed drills will do this). Fix the drill and the form in a vice, or other fixture. The wire should be on a dowel mounted offset from the drill and form, but positioned so that it can be unwound without kinking. **Wear protective safety goggles when winding the coil.** Injury to your eyes could occur if the wire breaks, or if you do something wrong.

The mounting of the coil and magnet are shown in side view in Fig. 15b). The mounting assembly can be made from either wood or plastic, or any convenient material.

The damping assembly is shown in both plan and side views in Fig. 16. The lead weight is made of plumber's lead, and is fixed to the threaded end of the boom with a pair of hex nuts. The period of the pendulum can be adjusted by the position of the weight, if needed.

The damping action is created by swinging a metal plate through the magnetic fields of opposing horseshoe magnets. When the pendulum moves eddy currents are set up in the aluminum plate, and these in turn create a magnetic field that is opposite to the polarity of the field that created the current. This is a magnetic version of 'rust on the door hinges' to keep it from swinging for a long time after excited by vibration.

The aluminium plate is fixed to the pendulum by a wooden or plastic dowel. One end of the dowel is threaded to fit the thread on the 8mm boom end. A wood-screw can be used to fasten the aluminium plate to the other end of the dowel.

Seismometers are usually buried below grade. Some people place them in a simple box on a flat rock outcropping, but that is not terribly good practice. Others build a concrete pedestal and box to house the seismometer.

Thermal insulation surrounding the inner chamber where the seismometer is located is used to keep the temperature stable. It is essential that the seismometer be perfectly level, and not tilted. It may take several days to get the seismometer adjusted properly. ■

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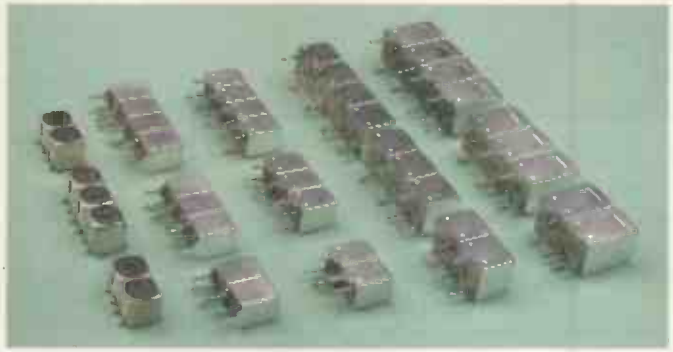

Fo:45~1800Mhz, -3 BW: 2~350Mhz
For Wireless/Cable Modem/Sate.STB/Fiber Filter
1)RF Front-End Filter. Fo=45~1800MHz
2)Sate.STB tuner /BS Tuner /DBS tuner
3)DAB Filter,;(Fo=1472Mhz)
4)Cable Modem:Fo=450~850Mhz/BW=60~300MHz
5)UHF Wireless & Security Home RF Filter.
6)Second IF Fo= 140MHz/BW:2~40M Filter
7)Fiber Filter: Fo=1.2~1.3G/BW=30~300Mhz
8)UHF Transceiver: Fo=66~88Mhz,380~520Mhz
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USB oscilloscope for the PC

Eddy Insam shows how easy it is to make an oscilloscope that plugs into your PC's USB port. Its sampling rate may not be very exciting for RF people, but it can be perfectly acceptable for audio and teaching work.

The author
Dr Eddy Insam is a consultant in innovative applications of telecommunications and specialises in graphics and signal processing. He can be reached on *edinsam@eix.co.uk*.

I covered the basics of USB interfacing using an off-the-shelf module in an article presented in last month's issue. Here I develop the concept by describing a simple virtual instrument that allows you to look at waveforms on your PC.

Figure 1 shows the basic concept. I used a Texas Instruments TLC5510 flash a-to-d converter. You could also use the faster TLC5540 version. These converters are cheap, fast CMOS devices that take very little current. They also require the minimum of interfacing as you will see. As all the chips are surface mount the whole circuit is small enough to fit into a hand held probe-type enclosure.

How the circuit works

The 74HC132 schmitt trigger chain forms a simple relaxation oscillator gated by the TXE 'buffer data available' signal from the USB module. This simple arrangement produces write clock pulses for the module and in slightly delayed form, for the a-to-d converter. The gating ensures clocks are only generated when the USB module is ready to accept them.

When testing, note that the clock will only run if there is a program at the PC end 'reading' the data, otherwise the transmit first-in-first-out buffer fills up and the module just stops taking data. The oscillator frequency sets the a-to-d sampling rate. Because of USB transfer limits, the maximum rate will be about 1MHz. However, the application program in your PC may not be able to accept this data continuously, especially if you have other fast USB peripherals connected such as sound cards or video grabbers.

Figure 2 shows how a two-trace version of the scope could be implemented. I have used two a-to-d converters. It is easier – and possibly cheaper – to do it this way rather than try to arrange for an analogue switch on the input.

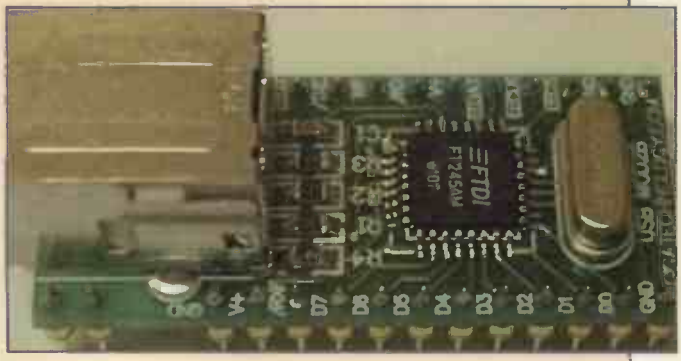
As it is now necessary to take two readings per sample, the overall sampling rate will be halved, reducing the effective bandwidth to 250kHz.

USB interfacing module

This off-the-shelf USB module was the subject of last month's article. It offers an easy route to adding USB to your project. Using it also reduces the PC software to the lowest level of difficulty.

The USB module in question is the FT8U245AM, manufactured by FTDI, (*www.ftdichip.com*). To work, the chip only requires a 6MHz crystal, some passives and the USB socket. It interfaces to an external microprocessor via an 8-bit parallel port and four read/write and control lines.

From the micro's point of view, the FT245 chip looks like a 384-byte first-in-first-out buffer, or FIFO, for transmit, and a 128 byte FIFO buffer on receive. The device works in the USB full speed mode and can transfer data at around a megabyte per second.



This is still good enough for audio work.

The principle can be extended to four or more traces by simply adding more D-type flip-flops. One disadvantage of this method is that the PC does not know which sample corresponds to which input. I cheated by adding a button on the software to switch the traces around.

A similar arrangement can be used to read from higher resolution 12, 14 or 16 bit a-to-d converters, by selecting between the most significant and least significant bytes of a single, wide converter. If the converter has fewer than 16 bits, a spare bit can be used as an external trigger input.

Alternatively, the unused bits can be set to a fixed data pattern. This may enable the PC software to synchronise to the correct byte order by analysing the repetition patterns in the byte pairs received.

Both the a-to-d and the FTDI USB module can operate at up to 10MHz in burst mode. It is therefore possible to run the scope ten times faster by filling the transmit FIFO buffer at higher clock rates, and dumping to the PC at the normal 1MHz transfer rate.

The 384 byte first-in-first-out buffer may not be large enough for some applications. However, it is quite easy to add an external FIFO RAM – such as a 256K TV frame-grabber FIFO. The buffer connects between the a-to-d and the USB. Clocking and gating arrangements are relatively straightforward. This would allow the scope to run at up to 5MHz bandwidth in burst mode.

Such a set-up could also form the basis of a simple USB video frame grabber.

Input circuit

All configurations share the same input circuitry. This is detailed in **Fig. 3**. The TLC5510 has an adjustable analogue input span that is determined by the externally applied voltages at pins REFT and REFB.

The chip includes a number of internal resistors that allow designers to choose a set of gap options without adding external circuitry. The chip was designed mainly for video conversion, and the two main range options are 0.0 to 2.3 volts, and 0.6 to 2.6 volts.

A small problem arises here. The USB cable provides a variable supply voltage between 4.2 and 5.25 volts. As a result, the simple resistor divider inside the chip will not give an accurate reference. It also draws about 10mA quiescent current. As an alternative, I used an external 2.5V reference diode, dispensing with the internal resistors.

The analogue input to the a-to-d converter is internally connected to various capacitor switches, and ideally requires a low-impedance source. Some means of shifting the voltage levels is needed so that the probe input can measure negative voltages. Also, some means of trimming the overall gain and zero points is necessary.

I used two op-amps in the simple configuration shown. You may prefer to use some other arrangement. That doesn't matter as long as it eventually provides an output of 0 to 2.5 volts at low impedance into the a-to-d converter.

The op-amp should be a high-impedance, high-frequency type, enough to give a gain of at least ten at 10MHz. Be aware that some op-amps have limited top saturation voltages. With a positive supply of 5 volts they may clip below the 2.5 volts needed. I used an LF353 for no other reason than I happened to have one available at the time. It seemed to work very well.

All power is derived from the USB wire. The USB interface module, the a-to-d converter and the op-amp all require very little current and can happily work off these voltages at all times, even when the USB interface is inactive.

However, in order to generate the negative supply for the op-amp, I needed to include a DC-to-DC converter, **Fig. 4**,

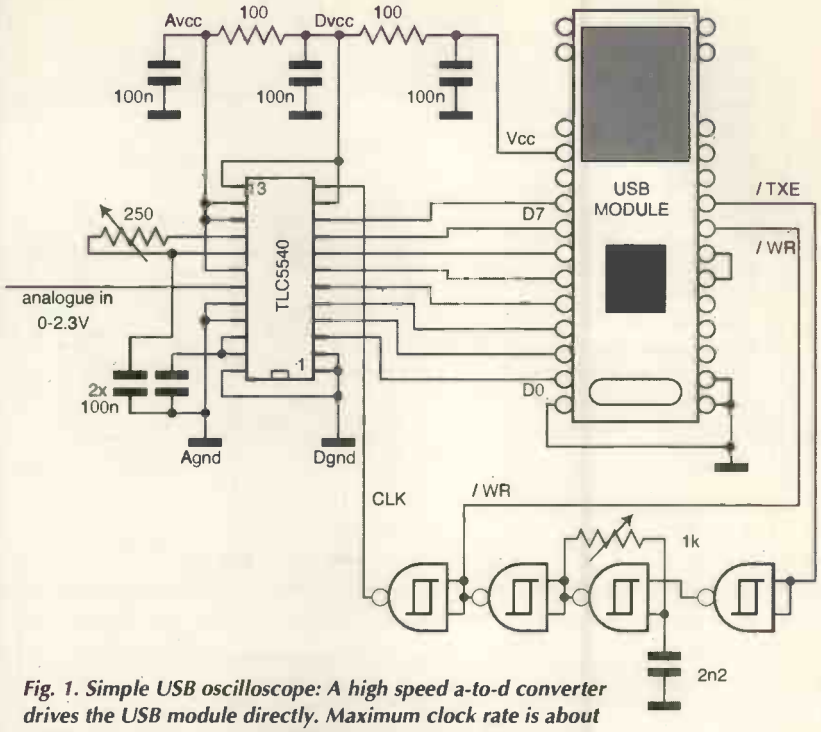


Fig. 1. Simple USB oscilloscope: A high speed a-to-d converter drives the USB module directly. Maximum clock rate is about 1MHz, resulting in a bandwidth limit of about 500kHz. As shown, the input range is from 0 to 2V. Extra analogue input circuitry will be required for voltage level shifting and gain adjustment. Circuit layout is critical as the converter is highly susceptible to spikes and noise. Apart from a PC, the only other thing that you need except for this circuit, is a USB cable.

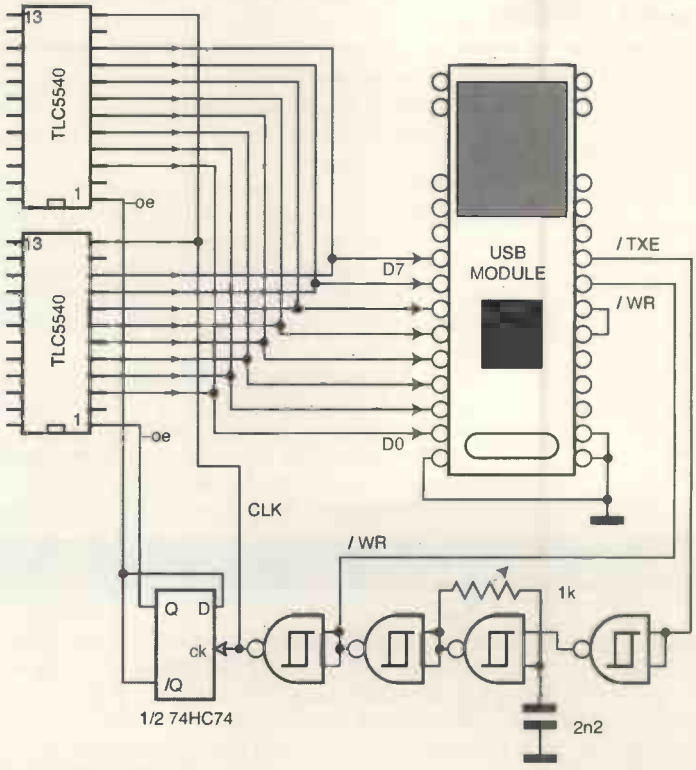


Fig. 2. A multiple-trace version of the scope uses one or more D-type bistable devices to select the relevant output from more than one a-to-d converter, each connected to an analogue trace probe. The same scheme could also be used to read from higher resolution 12 or 16 bit a-to-d converters.

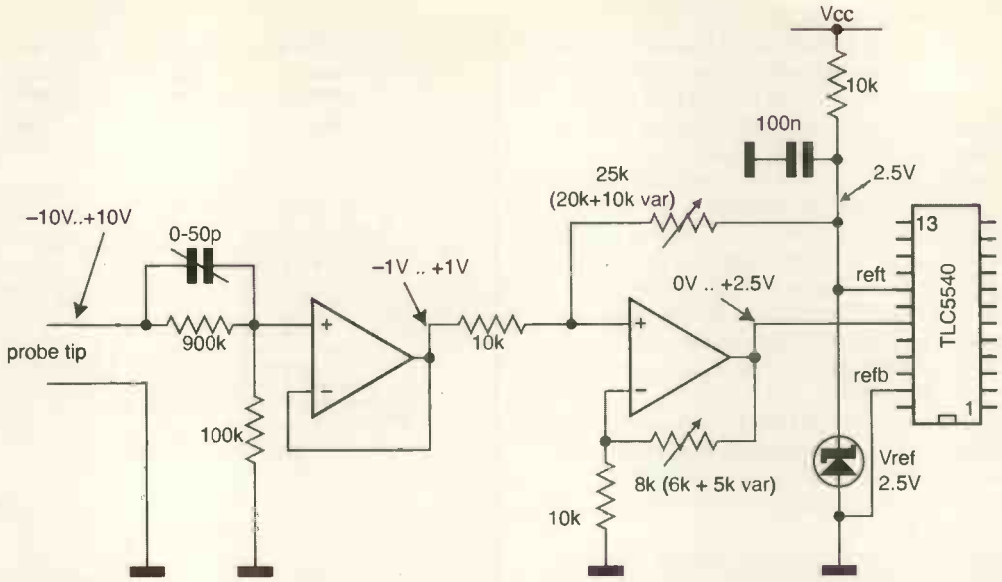


Fig. 3. A possible analogue input signal conditioner. The input range is –10 to +10V with an input impedance of about 1MΩ. The second op-amp performs a bit of level shifting and gain to provide the 0-2.5V required by the a-to-d converter from the probe's input range of –10 to +10 volts. The two potentiometers are used to trim zero level and final gain.

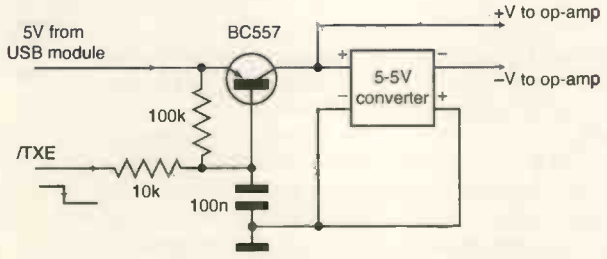


Fig. 4. A circuit to provide the negative supply required by the op-amp. The transistor is used to switch power only when the USB module is active. This is derived from the TXE signal.

which robbed nearly 15mA from the 5-volt supply. I found myself adding a simple circuit using a p-n-p transistor to remove power to the DC converter and to the op-amp when the USB is inactive.

The USB module does not provide a specific 'power down' output, so I crudely derived this from the TXE signal. If you use a more efficient low-power DC-to-DC converter, you may not need this part of the circuit. It may be possible to derive the negative supply from the clock. I assume it should work as the op-amp takes little power. I have not tried this.

The TLC5510 chip is incredibly sensitive to noise and supply glitches. This shows as bumps and spikes on the displayed waveforms, especially during 0111111_2 to 100000_2 type transitions. The application notes suggest using separate connections for digital and analogue supplies. You *do* need these if you want a clean output.

Obtaining the parts

The Texas a-to-d converter is available from Farnell at about £4 each in small quantities. The USB module is available from FTDI in the UK for £23.50, which includes VAT and shipping. The company has local agents in the US and Australia. Check the company's web site *www.ftdichip.co.uk* for more up to date details on pricing and availability.

An alternative device FT232, provides a serial output instead of a parallel one. This could be used as a direct replacement for systems using legacy RS232 interfaces. All information is available from the FTDI web site.

If you are creating your own PCB layout, make sure you download the data sheets from the Texas web site including all application notes. They contain very useful recommendations on noise suppression.

For my prototype, I used air-to-air wiring for all pin connections on the Texas chip. This at least guaranteed that no PCB cross-talk noise would be present.

I might have spent ten minutes getting the USB module to work but I am not saying how much time I spent trying to minimise analogue noise problems.

PC application software

On the PC, you only need to install the FTDI comms emulation driver (VCP). All the relevant drivers are downloadable from the manufacturer's web site. These are available for all relevant versions of Windows, Mac and Unix/Linux.

Detailed installation instructions are also available from the web site. They are very simple, and you may not want to read them – especially if you, like me, are one of those people who only read the documentation when things don't work.

After installation, you will notice that an extra COM port has been added to the existing list in your control panel. Note that this COM port is only enabled when the USB module is active. So, if you want to change the number for example, ensure the USB module is plugged in.

Writing software for the PC is reasonably simple. Many of you will be conversant with software programming, whether in Basic, Borland or Microsoft tools. If you have written software for the serial port, read no further! The only thing you will need to know is that the USB module looks in all respects like a COM port. The only relevant difference is that speed parameters are ignored. The chip runs at full speed.

For those of you using Basic, there are a number of plug-in ActiveX and DLL component modules you can get for driving the serial port. I have not tried any of these, but considering the high data rates involved, I would not be surprised if some of these are not able to keep up with the incoming stream from the USB module.

However, there is an alternative. The USB module's manufacturer, FTDI, also supplies a set of drivers that will allow you faster and more direct access to the chip resources. Known as D2XXX, these drivers are provided in the form of separate DLL files that present a relatively simple interface to VB, VC++, C+ Builder, Delphi etc.,

Listing. Software in C for communicating with the USB oscilloscope.

```
//**    User Entry points:
int     com_Init    (int port, int bsize);
int     com_Exit    ();
//**    Local variables, user does not need to access these
HANDLE  com_handle= NULL;      // comms port handle
int     com_thrstop=0;         // flag to order thread to stop
int     com_bmask=  0;         // max buffer size mask, i.e. 0x3FFF
int     com_bsize=  0;         // circular buffer size = bmask+1
int     com_bindx=  0;         // circular index to last written data
PBYTE   com_bdata=  NULL;      // ptr to rx data buffer
char    com_zerror  [256];     // stores error messages
//** The main running thread. This is called by the Init function, and
// made to stop by the Exit function. User does not call this.
// Uses NON_OVERLAPPED mode with simple sleep delay for simplicity
static DWORD WINAPI com_Thr(LPVOID p)
{    COMSTAT comstat; DWORD errmask;
//** Initialise and validate...
     com_thrstop=0;
     com_bindx=  0;
//** Do the forever loop.(till "stop" flag is set externally)...
     while ( (com_thrstop==0) && (com_handle!=NULL) &&(pDlg!=NULL) )
     { //** Add any extra operations here,
       //
       //* Get nr of bytes in rx queue to read
       ClearCommError(com_handle,&errmask,&comstat);
       int ntr=comstat.cbInQue;          // this gives the Q size
       if (ntr>0)
       { //* align for wraparound in circular buffer
         if ( (ntr + com_bindx)>com_bsize) ntr=com_bsize-com_bindx;
         PBYTE ptr = com_bdata + com_bindx;
         //* Read the bytes to our buffer
         DWORD nrd;
         int ne=ReadFile(com_handle,ptr,ntr,&nrd,NULL);
         //* Handle errors, if any...
         if (ne==0)
            { ClearCommError(com_handle,&errmask,&comstat);
              //pDlg->CommErrorCB(errmask); //could call user error CB
            }
//* if RX data is valid, call user call-back with buffer data
        if ( (ne!=0) && (nrd!=0) )
        { // Any relevant low level signal processing could go here..
          //
// Call a function in the user application. Pass: buffer start, index
// to last block written, and number of bytes (circular buffer)
// pDlg is a pointer to the user application Object (assuming c++)
// Alternatively, just call a normal user function without reference.
           int ee=pDlg->CommReadCB(com_bdata,com_bindx,nrd);
           if(ee!=0) com_thrstop=1;   //If <>0, user wants to abort
           com_bindx += nrd;
           com_bindx &= com_bmask;    //align index on circular buffer
        }
      }
//* If nothing read from line, block thread to allow buffer to fill.
      else
      {  Sleep(10);          // could add extra user operations here
      }
    }
//** End of thread...
     com_thrstop=0;
     return 0;
}
//*********************************************************************
//** Initialise. Call this once at the start of your program
// 'port'  is the wanted port number, e.g. 3
// 'bsize' is the wanted buffer size, must be a power of 2, e.g. 32768
int  com_Init(int port, int bufsize)
{    int e;
//** Validate.....................................................
     if(com_handle!=0) return 0;    // If already open, ignore call
     com_bsize=bufsize;             // save buffersize, must be 2^n
     com_bmask=bufsize-1;           // set mask e.g. 0x7FFF
     com_zerror[0]=0;               // clear global error message
//** Open the comms port.....................................
     char zp[8]; sprintf(zp,"COM%d",port);
     com_handle=CreateFile( zp,                              // "COMn"
                            GENERIC_READ|GENERIC_WRITE,     //
// no share (only option)
                            0,
// Security attribs
                            NULL,
// must be this for comms:
                            OPEN_EXISTING,
// non FLAG_OVERLAPPED
                            0,
// must be NULL for comms
                            NULL
                          );
// cannot open com port?
     if (com_handle==INVALID_HANDLE_VALUE)
        { int ee=GetLastError();
          sprintf (com_zerror,"COM%d error %d",port,ee);
          com_handle=NULL;
          return -1;
        }
//** Allocate a dynamic byte buffer for storing incoming data.....
     com_bdata= new BYTE[com_bsize];
// error, cannot allocate memory
     if(com_bdata==NULL) { com_Exit(); return -1; }
//** Allocate internal buffer sizes within the comms driver .......
     e=SetupComm (com_handle,com_bsize,1024);
//** Default DCB to some initial values.............................
     DCB  Dcb;                        // Holds a dcb structure
// fills DCB with current settings   0=fail
     e=GetCommState(com_handle,&Dcb);
     Dcb.DCBlength=           sizeof(DCB);
     Dcb.BaudRate=            115200;       // Ignored by FT driver
     Dcb.fAbortOnError=       FALSE;        // Stop tx rx if error rx
     Dcb.fBinary=             TRUE;         // Binary mode, noEOF check
     Dcb.fParity=             0;            // 0=disable parity
// 1=enable CTS for outgoing flow control
     Dcb.fOutxCtsFlow=        0;
// 1=enable DSR for outgoing flow control
     Dcb.fOutxDsrFlow=        0;
// set DTR to on    (DTR_CONTROL_HANDSHAKE)
     Dcb.fDtrControl=         DTR_CONTROL_ENABLE;
// if true, enable rx when DSR=1
     Dcb.fDsrSensitivity=     0;
// if TRUE, XON/XOFF enabled for outgoing
     Dcb.fOutX=               0;
// if TRUE, XON/XOFF enabled for ingoing
     Dcb.fInX=                0;
// Error char replacement when parity detected
     Dcb.fErrorChar=          0;
// if TRUE, discard NULL bytes on rx
     Dcb.fNull=               0;
// leave rts on always  (RTS_CONTROL_HANDSHAKE)
     Dcb.fRtsControl=         RTS_CONTROL_ENABLE;
     Dcb.fAbortOnError=       0;
     Dcb.ByteSize=            8;            // nr of bytes
     Dcb.Parity=              NOPARITY;     // NOPARITY;
// 0,1,2; 1,1.5,2  ONESTOPBIT;
     Dcb.StopBits=            ONESTOPBIT;
     Dcb.ErrorChar=           0x00;
     e=SetCommState(com_handle,&m_Dcb);     // set DCB   0=fail
//** Set Timeouts ..........................................
     COMMTIMEOUTS  Cto;              // Comms Timeout structure
     Cto.ReadIntervalTimeout=         MAXDWORD;
     Cto.ReadTotalTimeoutMultiplier=  0;
     Cto.ReadTotalTimeoutConstant=    0;
     Cto.WriteTotalTimeoutMultiplier= 0;
     Cto.WriteTotalTimeoutConstant=   0;
     e=SetCommTimeouts(com_handle,&Cto);
//** Open thread now.....................................
     DWORD tid;
     HANDLE
hThr=CreateThread(0,0,(LPTHREAD_START_ROUTINE)com_Thr,0,0,&tid);
     if(hThr==NULL) { int ee=GetLastError();
                      sprintf (com_zerror,"Cannot create thread");
                      com_Exit();
                      return -1;
                    }
//=.....................................................................
     com_thrstop=0;
     return 0;
}
//=====================================================================
//**    Call this once at the end of your program
int  com_Exit()
{
//** If already closed, ignore the call.....................
     if(com_handle==0)  return 0;

//** If thread is running, attempt to close it (& wait till its done
it)....
     com_thrstop=1;
     Sleep(100);
//** Close Comms handle ....................................
     CloseHandle(com_handle);
     com_handle=NULL;

//** Delete our receive buffer .....................
     if(com_bdata!=NULL) delete [] com_bdata;
     com_bdata=NULL;
     return 0;
}
```

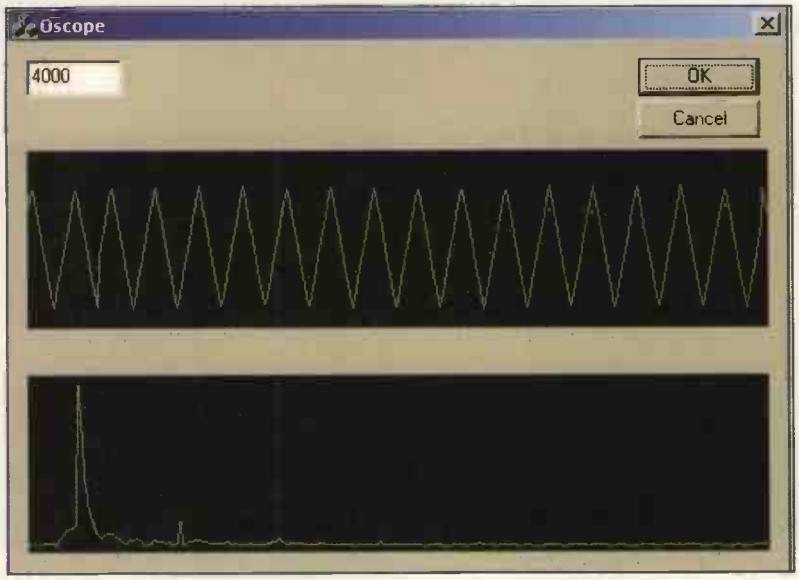


Fig. 5. Screen dump produced using a simple oscilloscope PC display program. The bottom line shows a real-time FFT display of the top trace.

Need more information

Tony Wong 'Understanding USB' Electronics World, November 1999. A very good article describing the inner workings of USB.
http://www.usb.org – the web site of the USB organisation.
http://www.ftdichip.com – for more information on the USB chip and module.
http://www.Farnell.co.uk
http://focus.ti.com/docs/analog/analoghomepage.jhtml Texas Instruments data sheets on a-to-d converters and application notes.
J Hyde 'USB Design by Example' Wiley, NY 1999. http://www.usb-by-example.com
J Axelson 'USB Complete' Lakeview Research 1999. http://www.lvr.com

The last two references are good reference books on USB. They contain many examples and background information.

You just link it to your software project.

For those of you using C or C++, you can use any of the many Windows API functions. The **Listing** shows some very simple plain vanilla code that you can include in your application when using the FTDI serial emulator interface. The only two functions required are *com_Init()* and *com_Exit()*. These are used to initialise and terminate the comms service. These should be called once at the beginning of the program and once at the end.

The initialisation program starts a 'thread'. This is a section of code that runs transparently in parallel with the main user program. The thread keeps a watch on incoming serial-port bytes, and calls a function in the main user program whenever there is a quantity of bytes to transfer. This is known as a 'call-back' function. In this way, the main program does not need to spend time reading the COM port – usually a cause for hangs and clumsy behaviour in some Windows programs.

I have made the code in the thread very simple, and have not resorted to advanced methods such as events or overlapped functions. I wanted to make it easily readable and understood by those not fully conversant with advanced programming topics.

The thread consists of an infinite loop, which is only terminated when an error occurs or when a global flag is set. This follows the normal practice that threads should terminate themselves.

First, the loop within the thread calls a comms API to find out how many bytes there are in the comms buffer. This has the seemingly inappropriate name of *ClearCommError()*. In our case, this function will nominally return either 4K or zero. The 4K is the default transfer size for the FT driver as specified in the INF file.

If there are bytes to read, the *ReadFile()* function is called to move these into a circular buffer, and then call a function in the user program. I have called this function *CommReadCB()*.

If there are no bytes to transfer, I put the thread to sleep for 10ms. The *Sleep()* API Function is a simple and efficient way of blocking a thread for a fixed time, as it manages the multi-tasking using very few CPU cycles. This blocking ensures the thread does not run continuously and hog large chunks of the CPU time.

In my version of the program, I have extra code within the thread for interpolation of arrays, and for detecting a 'trigger' point to emulate a triggered scope. These are written around the 'Read' and 'Sleep' function to maximise usage of spare time. I have not shown these as they may reduce readability of the relevant sections of code.

The call-back function in the main program is used to process the incoming array. For example, rearranging data arrays for display bitmaps, performing filtering and processing, etc.

One important point for software developers: you must avoid calling certain Windows API functions – especially graphics functions – from within the thread or the user call-back. If you do call them, you may cause very odd effects including crashes. Windows provides the *PostMessage* function for this.

The FTDI driver defaults to 4Kbyte transfers. There can be up to 250 calls to the call-back routine in the main program every second. Some PCs can handle this rate quite happily.

With my simple demo program, my 300MHz PC had enough time to display each array received on oscilloscope-like graphics, and also compute and display the same data as a 1024 point FFT – including integer to float interpolation.

I am not much of an artist when it comes to designing front panels; Fig. 5. shows my crude attempts at displaying the scope output on a PC. I am sure you will be able to come up with much more attractive designs.

Taking it further

If you intend to commercialise your product using USB you must register your own VID and PID with the USB organisation (www.usb.org). Becoming a member of this Forum costs $2500 a year, although you can obtain an ID number without joining the organisation for $1500. Check their web site for more details.

Alternatively, you could use the default VID and PID of the FT245 device. This has the disadvantage that connecting multiple FT devices to the same computer may confuse the drivers. However, FTDI maintains a book of unique PIDs that can be uniquely allocated to you at no cost. Please e-mail *fred.dart@ftdchip.com* for more details.

The only downside of going this route is that you cannot apply for USB certification for your products, or use the new trademarked USB logo on your packaging. To do so, you must apply for your own VID.

You may be wondering how the PID is stored within the FT chip. The FTDI device contains its own hard-wired VID (0403_{16}) and PID codes (0601_{16}). When adding your own, you store these in a separate 93C46 EEPROM chip that connects directly to the FT245 chip. This is the little box shown in Fig. 3 of last month's article. ■

Electronics World 2002 reader survey

Your chance to have a say, and a chance to win a free subscription to Electronics World*...

To help us to make sure that Electronics World continues to be useful to you, we would greatly appreciate it if you would take a few minutes to fill in our reader survey. We have endeavoured to make the questions as easy as possible to answer, but if there are any that don't accommodate your circumstances, simply insert a question mark by, or near, the question concerned.

Do you use CAD to design circuits? **Regularly** ❑ **Often** ❑ **Sometimes** ❑ **Rarely** ❑ **Never** ❑

If so, what proportion of time do you spend using CAD relative to building circuits?
Almost all ❑ **More than half** ❑ **Less than half** ❑ **Hardly ever** ❑

Are you involved with microprocessors and microcontrollers? **Yes** ❑ **No** ❑

Are you using high level programming languages? **Yes** ❑ **No** ❑

Do you use a PC at work? **Yes** ❑ **No** ❑

If you use a PC, does it have Internet access? **Yes** ❑ **No** ❑

Do you perceive Electronics World as an enthusiast's magazine, or a journal for professionals?
Hobbyist ❑ **Professional** ❑

Do you believe that Electronics World's direction has changed over the past five years? If so, has it changed for the better or for the worse? **Better** ❑ **No change** ❑ **Worse** ❑

Would you describe yourself as an electronics professional, or are you purely an enthusiast?
Enthusiast ❑ **Professional** ❑

Do you work in electronics? **Yes** ❑ **No** ❑

Does Electronics World have too many equations? **Way too many** ❑ **Too many** ❑ **About right** ❑ **Not enough** ❑

How often do you buy Electronics World? **Every month** ❑ **Regularly** ❑ **A few times a year** ❑ **Rarely** ❑

*Details at the end of the form

Do you have difficulty buying Electronics World through your newsagent?

Rare ❑ **Sometime** ❑ **A lot** ❑ **Terrible** ❑

Does a gift on the cover make a difference as to whether you buy the magazine or not?

None ❑ **Sometimes** ❑ **Often** ❑ **Nearly always** ❑

Do you appreciate the special offers that we negotiate for you?

No ❑ **A little** ❑ **Often** ❑ **Nearly always** ❑

If you subscribe, are you happy with our subscription service? If you are not, please let us have brief details in the comments area at the end of the survey.

Happy ❑ **Neutral** ❑ **Disappointed** ❑ **Frustrated** ❑

How many people does your company employ?

1-10 ❑ **10-50** ❑ **50-200** ❑ **>200** ❑

Do you own the company?

Yes ❑ **No** ❑

Roughly, on average, how much do you spend on components each month at work?

£50 ❑ **£50-200** ❑ **£200-£1000** ❑ **>£1000** ❑

Roughly, on average, how much do you spend on components each month at home?

£10 ❑ **£10-50** ❑ **>£50** ❑

Would you describe the components that you buy as primarily analogue, primarily digital or mixed?

Analogue ❑ **Digital** ❑ **Mixed** ❑

Do you buy test gear?

Yes ❑ **No** ❑

If you buy test gear, do you buy it largely for home or for work?

Home ❑ **Work** ❑ **Both** ❑

If you buy test gear, approximately how much a year do you spend?

£500 ❑ **£500-1000** ❑ **£1000-10000** ❑ **>£10000** ❑

Is the majority of test gear you buy new, or second hand?

Mostly new ❑ **Bit of both** ❑ **Mostly second hand** ❑

What earnings bracket are you in? Note that we will only use this information for statistical purposes, and strictly in accordance with the law.

Up to £12k ❑ **£12-22k** ❑ **More than £22k** ❑

Are there other magazines in the same field that you enjoy/value more than Electronics World?

Yes ❑ **No** ❑

If so, what's your favourite?_____

If you don't subscribe, to Electronics World, what stands in the way of you subscribing?

_____

_____

What is you favourite section in the magazine? (i.e. circuit ideas, news, new products, RF design...)

_____

What additional topics, if any, would you like to see in the magazine?

Which three suppliers do you use most, regardless of whether they are component or equipment suppliers?

1 _____

2 _____

3 _____

Which single supplier do you spend most with?

_____

If you work in electronics and buy components and equipment, which three prodcut areas do you spend most on? (e.g. T&M, passives, digital ICs)

_____

What is your job title?

_____

PRIZE DRAW

Many thanks for spending the time to fill in our survey. Please mail it back (no stamp needed) to

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FREEPOST SEA11435
Sutton
SM3 8BR

or fax it on 01792 878233.

Senders of all entries returned by 11 March 02 will be eligible to win one of five, one-year subscriptions to *Electronics World*. This applies to overseas readers too. Winners will be drawn from a hat and notified by post as soon as possible after the closing date. The prize is not negotiable, and no correspondence will be entered into regarding it. Please provide your details in the coupon on the right.

Name_____

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Real-time digital filter

RTDF – a unique, integrated hardware and software system for designing, downloading and running very high performance filters in real time. Available only from *Electronics World*.

The RTDF 1.5 is a unique real-time audio-bandwidth digital filter with infinitely adjustable characteristics – all available at the click of a button. Filter design and execution is accomplished in two easy steps. In fact, you can have a no-compromise filter up and running within seconds.

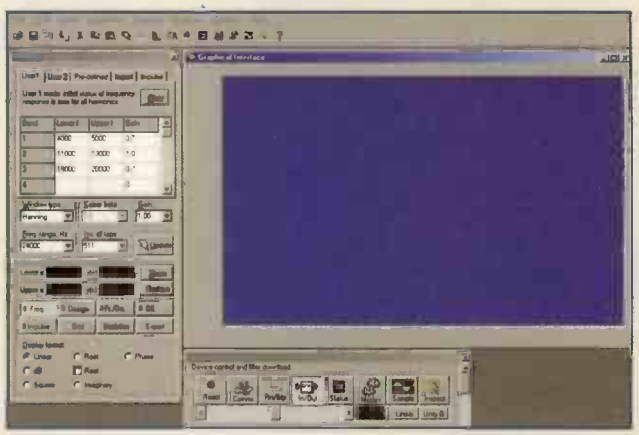
If you want to change the filter completely – low-pass, band-pass, high-pass or arbitrary – just repeat the two steps.

The RTDF filter system includes hardware based on an advanced digital signal processor, low-level firmware that implements the filtering operations, and a high-level PC-based software interface that designs the filter according to your requirements. Once a filter is designed, the software interface is used to download the filter to the hardware system via a serial link, where it is executed on demand.

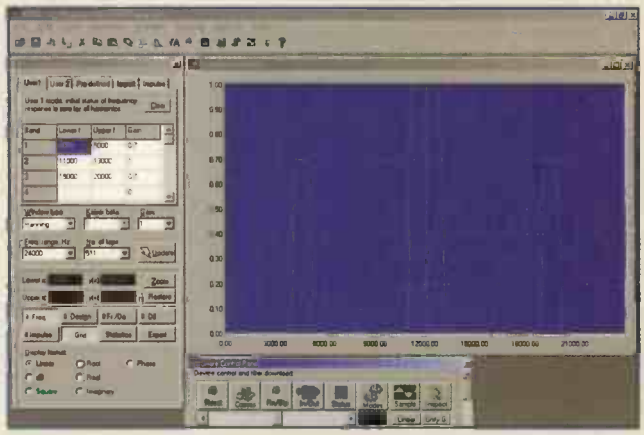
You don't need to know about digital signal processing theory or the mathematics associated with digital-filter design. But if you're a filter expert, you won't find yourself restricted by

RTDF - key features

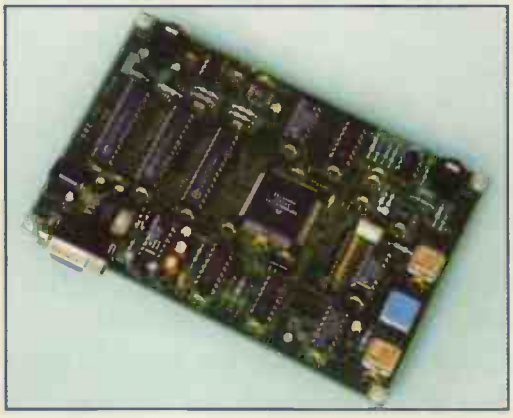
- Runs under Windows 95, 98 or ME
- Generates FIR filters with a maximum of 1024 coefficients.
- Multiple pass, stop or arbitrary filters.
- Lower –3dB frequency 3.7Hz at 48kHz sample rate and 1.2Hz at 12kHz sample rate.
- Filter operates in single or dual channel modes.
- Import mode – ASCII import of any frequency response.
- Hardware module holds up to 16 filters, instantly selectable with one mouse click.
- Zero-phase distortion in the pass, transition and stop bands, ignoring input and output coupling.
- Choice of rectangular, Bartlett, Hamming, Hanning, Blackman or Kaiser Windows.
- Virtual control panel allowing run-time changes to filter gain and sampling rate.
- Includes frequency and time domain plots of filter performance.
- Frequency response plotted as linear, dB, square, root, real, imaginary or phase.
- Impulse, frequency and phase response exportable in a variety of formats (dB, power etc) as ASCII files for incorporation into standard spreadsheets.
- 18-bit resolution in single, 16-bit in dual-channel mode.
- Normal or turbo speed, software selectable.
- User selectable sample rates of 48kHz, 24kHz, 16kHz, 12kHz, 9.6kHz, 8kHz, 6kHz, 4.8kHz, 4kHz, 3.2kHz or 3kHz.
- Maximum input and output level 4V pk-pk



Step 1 – Enter the characteristics of your filter, such as cut-off points and sharpness, in the Filter Design Interface Window on the left of the display.



Step 2 – Click on the Update button to view your result in graphical form, download it to the hardware module and run the filter from the hardware control panel – done!



Filter hardware: a DSP56002 board with RAM and 16/18bit oversampling analogue converters for stereo i/o at up to 48kHz sampling.

the easy-to-use interface. If you want to do it the hard way, you can even design your filter in long-hand then download the filter's frequency response as an ASCII file to the RTDF's control program!

The RTDF is a total filter solution. Due to its flexibility, it is particularly well suited to processing audio signals in real time. High-quality analogue signal conditioning and a dual-channel 16/18-bit resolution analogue-to-digital converter and digital-to-analogue converter provide a resolution sufficient for the most demanding applications.

In short, the RTDF brings the power of digital signal processing to any audio-bandwidth domain that requires high-performance electronic signal filtering. Applications include sensor linearisation, audio signal processing, signal analysis, vibration analysis, education and research in electrical, electronic and other physical sciences.

Low-pass, high-pass, multiple band-stop / band-pass filters may be combined to produce very complex filters for frequencies up to 24kHz.

The software can accept measured responses to define a filter template. This can be used for measurement equalisation or to search out signal signatures in noisy environments.

Since the filters are implemented using a symmetrical finite impulse response (FIR) method, no phase distortion occurs in the filtered signal – no matter how sharp the filter is. Because the processing module is so fast, it is possible to design filters with responses far beyond what is possible with traditional analogue techniques.

Windows software

The control program runs under Windows and provides a user-friendly filter-design tool that de-mystifies the process of specifying the filter. The filter design process simply becomes one of describing the desired frequency response.

The design package indicates the response that will be produced and any deviations from that specified. User designs may be stored for re-use and actual responses may be entered from measurements for simulation or equalisation purposes. Once designed, filters are calculated and downloaded to the hardware within seconds.

The software designs the filter according to the user's specifications. The filter is expressed as a set of FIR, zero-phase distortion coefficients or taps. Collectively, the coefficients of a filter are known as the *impulse response*.

The system's gain and sampling rate can be adjusted while the filter is running and you can switch instantaneously between a filtered or non-filtered signal.

Most importantly, the software includes a flexible filter design section. A window displays the frequency or impulse response of the realised filter in various formats. A hardware control section downloads a filter and provides for general communication with the filter module.

The DSP module

The hardware DSP module connects to the PC via a standard COM port using the cable supplied.

The 16/18-bit over-sampling dual-channel sigma-delta a-to-d and d-to-a conversion system can easily be set to any one of eleven sample rates, ranging from 48kHz down to 3kHz.

So how fast can the filter operate, and how many filter coefficients can it practically employ? The maximum number of taps at the highest frequency range of 24kHz, in single channel mode, is 527. At this range, the system is sampling at 48kHz. This represents a very sharp filter indeed.

Using a frequency range of 12kHz – sample rate of 24kHz – in single-channel mode, the system can operate a filter with a maximum of 937 taps. At any range below this, it can operate a filter with a maximum of 1024 taps. The performance of a 1024-tap filter is so extremely sharp that it is quite unlikely that you would ever need to use it.

In dual-channel mode, the maximum number of taps permissable at the highest frequency range of 24kHz is 191. With a frequency range of 12kHz , it is 397. Full details concerning tap numbers, frequency ranges and operating modes are provided with the on-line documentation. ■

Minimum system requirements

100 MHz PC running Windows' 95, 98 orME
SVGA display (800X600 pixels) or higher
CD ROM drive
10 Mbytes of free hard disc space
Serial port, capable of 19200 bit/s

System includes:

- Filter DSP board
- Windows filter design software on CD plus demonstration-filters
- Fully-worked help files – featuring tutorial
- Installation instructions
- Analogue i/o cables
- RS232 COM port download cable
- Power supply

Use this coupon to order your RTDF filter

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Make cheques payable to Electronics World.

Reader offer – buy the VIOM for £33.60 excluding VAT and save 20%.

VIOM control module

For a limited period, Phaedrus is offering its new VIOM i/o control module to Electronics World readers at a special offer price of £33.60+VAT (£39.48 total). Carriage is free for the duration of this special offer. Its normal ex-VAT price is £42 excluding VAT.

VIOM is a versatile input/output control module. Each of its 16 outputs may be controlled locally by its own inputs, timers and counters or remotely via the module's RS232 serial port.

In local mode the outputs can be controlled by an AND/OR combination of any of the inputs. In addition delays can be inserted before the output becomes active and then on and off periods can be defined to allow for cyclic operation.

Active high or active low operation can be individually selected on each output. Outputs may be controlled from a host via the serial port either individually or collectively. The host may also interrogate the module for the current status of the outputs.

Timer/counter registers can be controlled from the inputs or the serial port. Thresholds can be defined which can be used to trigger outputs. Values of the registers can be read via the serial port.

Inputs can be interfaced with clean contacts or CMOS/TTL outputs and can be defined as active high or active low. They can be programmed to report to a host via the serial port either periodically or on a change of state. Alternatively the host can interrogate the module and request the status of all inputs.

Optional dedicated 8 way display and relay modules can be connected directly to the module via ribbon cable.

Software

Any PC application that can be used to generate ASCII characters and send them out through the RS232 COM port can be used to program the module. Hyperterminal, supplied free with Windows, is among these applications.

There are 95 ASCII-based commands for controlling the module.

PC based applications can be downloaded from the web address given here, free of charge. These include a tutorial and a data logger plus applications for monitoring and controlling I/O pins together with the eight counter/timers. More applications will follow during 2002.

Several projects for using VIOM in stand alone mode are supplied with kit. These include a combination lock, a quiz box, chasing lights and a logic demonstrator.

How do I order?

The offer price includes the i/o module plus its manual in PDF form, and the example projects mentioned above. Offer ends 31 May 2002 and is limited to one item per reader. A special web address has been set up exclusively for EW readers wanting to order by credit card. Visit:

www.phaedrusltd.co.uk/pages/html/ewoffer.html

for details. Alternatively, send a cheque or postal order to Phaedrus Ltd, Unit 1 Darwin Enterprise Centre, Railway Road. Darwen BB3 3EH.
Please make cheques payable to Phaedrus Ltd.
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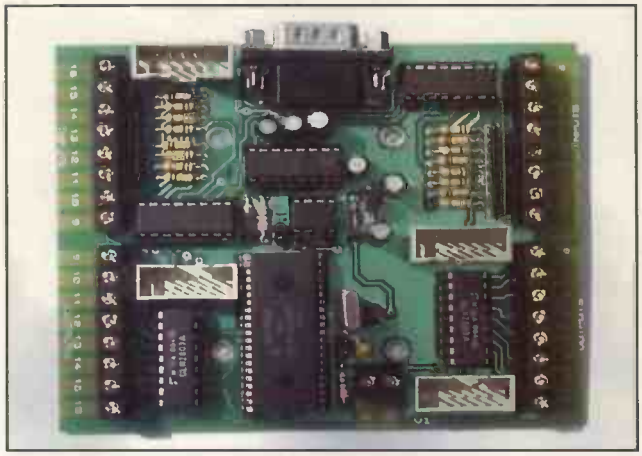

Specification

- Number of Inputs: 16
- Number of outputs: 16
- Inputs: CMOS, 10kΩ loading
- Output type: open collector
- Max output current: 100mA
- Number of internal (virtual) I/O ports: 16
- Number of timer/counters: 8
- Size of timer/counters: 32 bit
- Time resolution: 10ms
- RS232 serial port
- 95 ASCII based commands
- Supply voltage: 9-16V DC
- Supply current: 40mA
- Dedicated display and relay modules available

Programming the module

The following VIOM code could be sent to VIOM as a text file via its RS232 port. The lines starting with '<' are comments. The code makes output 2 oscillate at a rate of 1 second on and 1 second off when inputs 1 and 2 are both active. The first line, 'FDL', tells the VIOM module that the following file is a download:

```
FDL
<AND inputs on output 2
WO2J0
<Set On time for output 2 to 1 second
WO2C10
WO2D2
<Set Off time for output 2 to 1 second
WO2E10
WO2F2
<Allocate Inputs 1 and 2 to Output 2
WO2L1
WO2L2
```

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Connector types

- Power: screw terminals
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TEK CT-5 High Current Transformer Probe - £250.
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HP Network Analyser type 8407A + 8412A + 8601A - 100Kc/s - 110Mc/s - £500 - £1000.
HP 8410-A-B-C Network Analyser 110Mc/s to 12 GHz or 18 GHz - plus most other units and displays used in this set-up - 8411a-8412-8413-8414-8418-8740-8741-8742-8743-8746-8650. From £1k.
Racal/Dana 9301A-9302 RF millivolt meter - 1.5-2GHz - qty in stock £250-£400.
Racal/Dana Modulation Meter Type 9009-9808 - 5Mc/s - 1.5GHz - £150/£250 – 9009A £350.
Marconi Microwave 6600A 1 sweep osc , mainframe with 6650PI - 18-26.5 GHz or 6651 PI - 26.5-40GHz-£750 of PI only £600. MF only £250.
Gould J3B test oscillator + manual - £150.
Barr & Stroud Variable filter EF3 0.1Hz-100Kc/s + high pass + low pass - £1[illegible] other makes in stock.
Racal/Dana 9300 RMS voltmeter - £250.
HP 8750A storage normalizer - £400 with lead + S.A. or N.
Marconi mod meters type TF2304 - £250 – TF2305 - £1,000.
Racal/Dana counters-99904-9905-9906-9915-9916-9917-9921-50Mc/s-3GHz - £100 - £400 - all fitted with FX standards.
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HP86290A+B Sweep PI-2 - 18GHz - £1000 - £1250.
HP8620C Mainframe - £250. IEEE £350.
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HP5335A Universal counter - 200Mc/s-£1000.
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Dummy Loads & Power att up to 2.5 kilowatts FX up to 18GHz - microwave parts new and ex equipt - relays - attenuators - switches - waveguides - Yigs - SMA - APC7 plugs - adaptors etc. qty. in stock.
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HP8405A Vector voltmeter - late colour - £400.
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+ MG912B (LD 1.35) Light Source + MG92B (LD 0.85) Light Source £350.
Anritsu MZ118A O/E Converter.
+MH922A 0.8 O/E unit + MH923 A1.3 O/E unit £350.
Anritsu ML96B Power Meter & Charger £450.

Anritsu MN95B Variable Att. 1300 £100.
Photo Dyne 1950 XR Continuous Att. 1300 - 1500 £100.
Photo Dyne 1800 FA. Att £100.
Cossor-Raytheon 108L Optical Cable Fault Locator 0-1000M 0-10kM £200.
TEK P6701 Optical Converter 700 MC/S-850 £250.
TEK OF150 Fibre Optic TDR – £750.
HP81512A Head 150MC/S 950-1700 £250.
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HP8158B ATT OPT 002+011 1300-1550 £300.
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STC OFSK15 Machine jointing + eye magnifier – £250.

MISCELLANEOUS ITEMS

HP 4261 LCR meter – £650.
HP 4274 FX LCR meter – £1,400.
HP 3488 Switch Control Unit + PI cards – £[illegible].
HP 75000 VXI Bus Controllers + E1326B-DVM-quantity.
HP 83220A GSM DCS/PCS 1805-1990MC/S convertor for use with 8922A – £2,000.
HP 1630-1631-1650 Logic ANZ's in stock.
HP 8754A Network ANZ 4-1300MC/S + 8502A + cables – £1,500.
HP 8754A Network ANZ H28 4-2600MC/S + 8502A + Cables – £2,000.
HP 8350A Sweeper MF + 83540A PI 2-8.4GHz + 83545A PI 5.9-12.4GHz all 3 – £3,500.
HP MICROWAVE TWT AMPLIFIER 489A 1-2GHz-30DB – £400.
HP PREAMPLIFIER 8447A 0.1-400MC/S – £250. Dual – £300.
HP PREAMPLIFIER 8447D 0.01-1.3GHz – £400.
HP POWER AMPLIFIER 8447E 0.01-1.3GHz – £400.
HP PRE + POWER AMPLIFIER 8447F 0.01-1.3GHz – £500.
HP 3574 Gain-Phase Meter 1Hz-13MC/S OPT 001-Dual – £400.
MARCONI 2305 Modulation Meter 50kHz-2.3 GHz – £1,000.
MARCONI 2610 True RMS Meter – £450.
MARCONI 893B AF Power Meter (opt Sinad filter) – £250-£350.
MARCONI 6950-6960B Power Meters + Heads – £400-£900.
MARCONI SIGNAL SOURCE-6055-6056-6057-6058[illegible]9 - FX Range 4-18GHz - £250-£400.
RACAL 1792 COMMUNICATION RX – £500 early – £1,000 late model with backlighting and byte test.
RACAL 1772 COMMUNICATION RX – £400-£500.
TEK MODULE MAINFRAMES – TM501-502-503-504-506-TM5003-5006.
TEK PI 5010-M1 – Prog Multi Interface – £250. FG Prog 20MC/S Function Gen – £400 – S1 Prog Scanner – £[illegible] – DM Prog DMM – £400.
TEK 7000 OSCILLOSCOPE MAINFRAMES – 7603-7623-7633-7834-7854-7904-7904A-7104 – £150-£1,000.
TEK 7000 PI's – 7A11-7A12-7A13-7A18-7A19-7A22-7A24-7A26-7A29-7A42-7B10-7B11-7B50-7B53-7B85-7B92A-7D15-7D20.
TEK 7000 – 7S11-7S12-7S14-7T11-S1-S2-S3A-S4-S5-S6-S51-S53-S54.
HP POWER SUPPLIES – 6621A-6623A-6624A-6632A-6652A. Qtys available. Also 6000 types £POA.

WE KEEP IN STOCK HP and other makes of RF Frequency doublers which when fitted to the RF output socket of a S/Generator doubles the output frequency - E.G.50-1300MC/S to 50-2600MC/S price from £250 – £450 each.

SPECTRUM ANALYZERS

HP 3580A 5Hz-50kHz – £750.
HP 3582A Dual 0.2Hz-25.5kHz – £1,500.
HP 3585A 20Hz-40MC/S – £3,500.
HP 3588A 10Hz-150MC/S – £7,500.
HP 8568A 100Hz-1.5GHz – £3,000.
HP 8568B 100Hz-1.5GHz – £4,500.
HP 8590B 9KC/S-1.8GHz – £4,500.
HP 8569B 10MC/S (0.01-22GHz) – £3,500.
HP 3561A Signal Analyzer 15Hz-50kHz – £1,000.
TEK492 50kHz-21GHz OPT 2 – £2,500.
TEK492P 50kHz-21GHz OPT 1-2-3 – £3,500.
TEK492AP 50kHz-21GHz OPT 1-2-3 – £4,000.
TEK492BP 50kHz-21GHz – £3,000-£4,000.
TEK495 100kHz-1.8GHz – £2,000.
HP 8557A 0.01MC/S-350MC/S – £500 + MF180T or 180C – £150 – 182T – £500.
HP 8558B 0.01-1500MC/S – £750 – MF180T or 180C – £150 – 182T – £500.
HP 8559A 0.01-21GHz – £1,000 – MF180T or 180C – £150 – 182T – £500.
HP 8901A AM FM Modulation ANZ Meter – £800.
HP 8901B AM FM Modulation ANZ Meter – £1,750.
HP 8903A Audio Analyzer – £1,000.
HP 8903B Audio Analyzer – £1,500.

MARCONI 2370 SPECTRUM ANALYZERS – HIGH QUALITY – DIGITAL STORAGE – 30Hz-110MC/S Large qty to clear as received from Gov – all sold as is from pile complete or add £100 for basic testing and adjustment – callers preferred – pick your own from over sixty units – discount on qtys of five.
A EARLY MODEL GREY – horizontal alloy cooling fins – £200.
B LATE MODEL GREY – vertical alloy cooling fins – £300.
C LATE MODEL BROWN – as above (few only) – £500.

OSCILLOSCOPES

TEK 465-465B 100MC/S + 2 probes – £250-£300.
TEK 466 100MC/S storage + 2 probes – £200.
TEK 475-475A 200MC/S-250MC/S + 2 probes – £300-£350.
TEK 2213-2213A-2215-2215A-2224-2225-2235-2236-2245-60-100MC/S – £250-£400.
TEK 2445 4ch 150MC/S + 2 probes – £450.
TEK 2445A 4ch 150MC/S + 2 probes – £600.
TEK 2445B 4ch 150MC/S + 2 probes – £750.
TEK 468 D.S.O. 100MC/S + 2 probes – £500.
TEK 485 350MC/S + 2 probes – £550.
TEK 2465 4ch-300MC/S – £1,150.
TEK 2465A 4ch-350MC/S – £1,550.
TEK D.S.O. 2430A -150MC/S + 2 probes – £1,750.
TEK D.S.O. 2440 -300MC/S + 2 probes – £2,000.
TEK TAS 475-485 -100MC/S-20MC/S-4 ch + 2 probes – £900-£1.1K.
HP1740A – 100MC/S + 2 probes – £250.
HP1741A – 100MC/S storage + 2 probes – £200.
HP1720A – 1722A - 1725A - 275MC/S + 2 probes – £300-£400.
HP1744A - 100MC/S storage - large screen – £250.
HP1745A - 1746A - 100MC/S - large screen – £350.
HP54100A – 1GHz digitizing – £500.
HP54200A – 50MC/S digitizing – £500.
HP54501A – 100MC/S digitizing – £500.
HP54100D – 1GHz digitizing – £1,000.

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EIP 351D Autohet 20Hz-18GHz – £750.
EIP 371 Micro Source Locking – 20Hz-18GHz – £850.
EIP 451 Micro Pulse Counter – 300MC/S-18GHz – £700.
EIP 545 Microwave Frequency Counter – 10Hz-18GHz – £1.5k.
EIP 548A Microwave Frequency Counter – 10Hz-26.5GHz – £1.5k.
EIP 575 Microwave Source Locking – 10Hz-18GHz – £1.2K.
EIP 585 Microwave Pulse Counter – 300MC/S-26.5GHz – £1.4K.
SD 6054B Micro Counter 20Hz-24GHz – SMA Socket – £800.
SD 6054B Micro Counter 20Hz-18GHz – N Socket – £700.
SD 6054D Micro Counter 800MC/S-18GHz – £600.
SD 6246A Micro Counter 20Hz-26GHz – £1.2K.
SD 6244A Micro Counter 20Hz-4.5GHz – £400.
HP5352B Micro Counter OPT 010-005-46GHz – new in box – £5k.
HP5340A Micro Counter 10Hz-18GHz – Nixey – £500.
HP5342A Micro Counter 10Hz-18-24GHz – £800-£1K – OPTS 001-002-003-005-011 available.
HP5342A + 5343S Source Synchronizer – £1.5K.
HP5345A 500MC/S 11 Digit LED Readout – £400.
HP5345A + 5354A Plugin – 4GHz – £700.
HP5345A + 5355A Plugin with 5356A 18GHz Head – £1K.
HP5385A 1GHz 5386A-5386A 3GHz Counter – £1K-£2K.
Racal/Dana Counter 1991-160MC/S – £200.
Racal/Dana Counter 1992-1.3GHz – £600.
Racal/Dana Counter 9921-3GHz – £350.

SIGNAL GENERATORS

HP8640A – AM-FM 0.5-512-1024MC/S – £200-£400.
HP8640B – Phase locked – AM-FM-0.5-512-1024MC/S – £500-£1.2K. Opts 1-2-3 available.
HP8654A – B AM-FM 10MC/S-520MC/S – £300.
HP8656A SYN AM-FM 0.1-990MC/S – £900.
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HP8657A SYN AM-FM 0.1-1040MC/S – £2K.
HP8660C SYN AM-FM-PM-0.01-1300MC/S-2600MC/S – £2K.
HP8660D SYN AM-FM-PM-0.01-1300MC/S-2600MC/S – £3K.
HP8673D SYN AM-FM-PM-0.01-26.5 GHz – £12K.
HP3312A Function Generator AM-FM 13MC/S-Dual – £300.
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HP3336A-B-C SYN Func/Level Gen 21MC/S – £400-£300-£500.
Racal/Dana 9081 SYN S/G AM-FM-PH-5-520MC/S – £300.
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MARCONI 2383 S.ANZ 100Hz – 4.2 GHz. £2K
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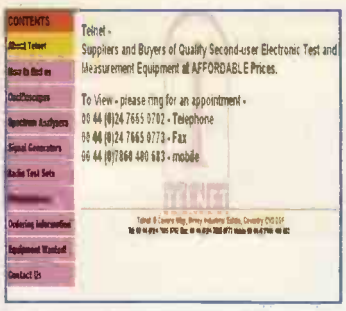

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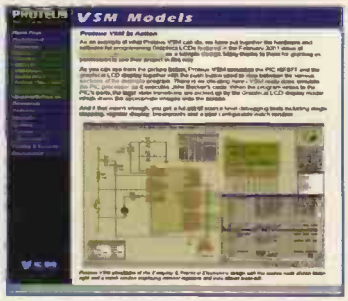

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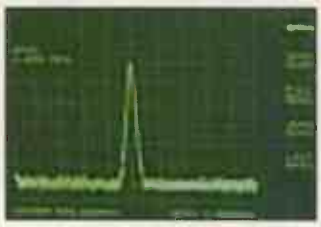

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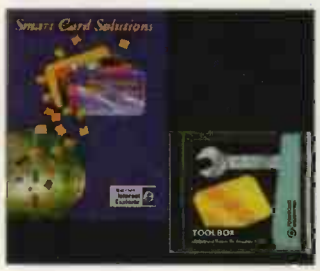

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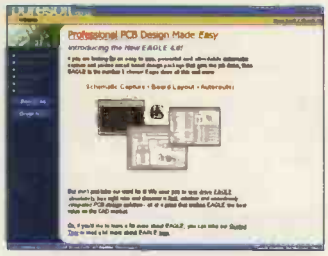

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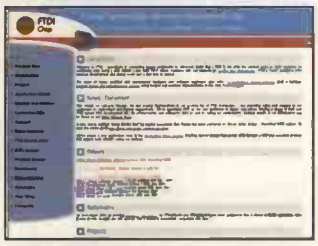

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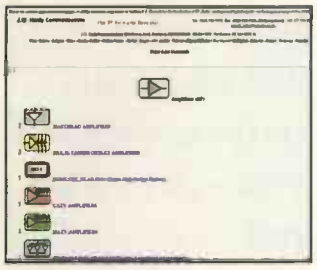

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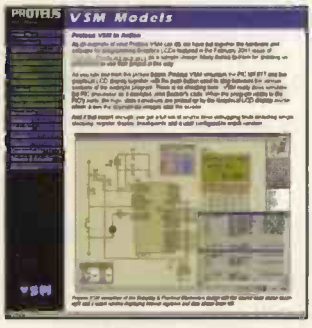

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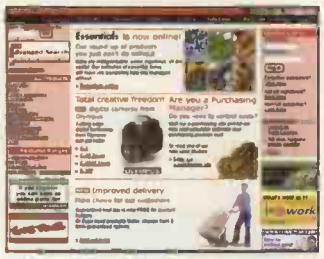

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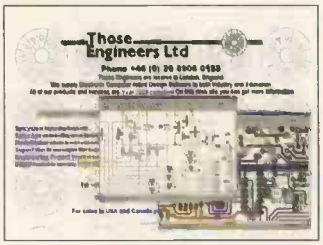

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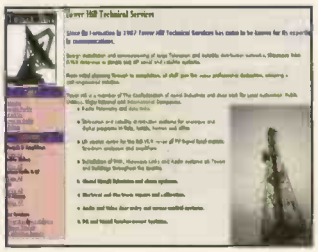

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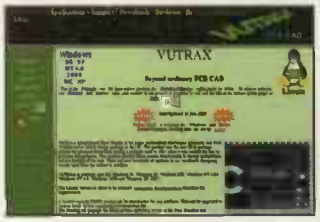

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http://www.egroups.com/list/uktvrepair

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

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Specifications

Switch position 1

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

Switch position 2

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

Switch position 'Ref'

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

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PIEZO ELECTRIC SOUNDER, also operates efficiently as a microphone. Approximately 30mm diameter, easily mountable, 2 for £1. Order Ref: 1084.

LIQUID CRYSTAL DISPLAY on p.c.b. with i.c.s etc. to drive it to give 2 rows of 8 figures or letters with data. Order Ref: 1085.

30A PANEL MOUNTING TOGGLE SWITCH. Double-pole. Order Ref: 166.

SUB MIN TOGGLE SWITCHES. Pack of 3. Order Ref: 214.

HIGH POWER 3in. SPEAKER (11W 8ohm). Order Ref: 246.

MEDIUM WAVE PERMEABILITY TUNER. It's almost a complete radio with circuit. Order Ref: 247.

HEATING ELEMENT, mains voltage 100W, brass encased. Order Ref: 8.

MAINS MOTOR with gearbox giving 1 rev per 24 hours. Order Ref: 89.

ROUND POINTER KNOBS for flatted ¼in. spindles. Pack of 10. Order Ref: 295.

REVERSING SWITCH. 20A double-pole or 40A single pole. Order Ref: 343.

LUMINOUS PUSH-ON PUSH-OFF SWITCHES. Pack of 3. Order Ref: 373.

SLIDE SWITCHES. Single pole changeover. Pack of 10. Order Ref: 1053.

PAXOLIN PANEL. Approximately 12in. x 12in. Order Ref: 1033.

CLOCKWORK MOTOR. Suitable for up to 6 hours. Order Ref: 1038.

TRANSISTOR DRIVER TRANSFORMER. Maker's ref. no. LT44, impedance ratio 20k ohm to 1k ohm; centre tapped, 50p. Order Ref: 1/23R4.

HIGH CURRENT RELAY, 12V d.c. or 24V a.c., operates changeover contacts. Order Ref: 1026.

3-CONTACT MICROSWITCHES, operated with slightest touch, pack of 2. Order Ref: 861.

HIVAC NUMICATOR TUBE, Hivac ref XN3. Order Ref: 865 or XN11 Order Ref: 866.

2IN. ROUND LOUDSPEAKERS. 50Ω coil. Pack of 2. Order Ref: 908.

5K POT, standard size with DP switch, good length ¼in. spindle, pack of 2. Order Ref: 11R24.

13A PLUG, fully legal with insulated legs, pack of 3. Order Ref: GR19.

OPTO-SWITCH on p.c.b., size 2in. x 1in., pack of 2. Order Ref: GR21.

COMPONENT MOUNTING PANEL, heavy paxolin 10in. x 2in., 32 pairs of brass pillars for soldering binding components. Order Ref: 7RC26.

HIGH AMP THYRISTOR, normal 2 contacts from top, heavy threaded fixing underneath, think amperage to be at least 25A, pack of 2. Order Ref: 7FC43.

BRIDGE RECTIFIER, ideal for 12V to 24V charger at 5A, pack of 2. Order Ref: 1070.

TEST PRODS FOR MULTIMETER with 4mm sockets. Good length flexible lead. Order Ref: D86.

LUMINOUS ROCKER SWITCH, approximately 30mm square, pack of 2. Order Ref: D64.

MES LAMPHOLDERS slide on to ¼in. tag, pack of 10. Order Ref: 1054.

HALL EFFECT DEVICES, mounted on small heatsink, pack of 2. Order Ref: 1022.

12V POLARISED RELAY, 2 changeover contacts. Order Ref: 1032.

PROJECT CASE, 95mm x 66mm x 23mm with removable lid held by 4 screws, pack of 2. Order Ref: 876.

LARGE MICROSWITCHES, 20mm x 6mm x 10mm, changeover contacts, pack of 2. Order Ref: 826.

COPPER CLAD PANELS, size 7in. x 4in., pack of 2. Order Ref: 973.

100M COIL OF CONNECTING WIRE. Order Ref: 685.

WHITE PROJECT BOX, 78mm x 115mm x 35mm. Order Ref: 106.

LEVER-OPERATED MICROSWITCHES, ex-equipment, batch tested, any faulty would be replaced, pack of 10. Order Ref: 755.

MAINS TRANSFORMER, 12V-0V-12V, 6W. Order Ref: 811.

QUARTZ LINEAR HEATING TUBES, 306W but 110V so would have to be joined in series, pack of 2. Order Ref: 907.

REELS INSULATION TAPE, pack of 5, several colours. Order Ref: 911.

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MINI STEREO 1W AMP. Order Ref: 870.

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IT IS A DIGITAL MULTITESTER, complete with backrest to stand it and hands-free test prod holder. This tester measures d.c. volts up to 1,000 and a.c. volts up to 750; d.c. current up to 10A and resistance up to 2 megs. Also tests transistors and diodes and has an internal buzzer for continuity tests. Comes complete with test prods, battery and instructions. Price £6.99. Order Ref: 7P29.

INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges: AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. These instruments are ex-British Telecom but in very good condition, tested and guaranteed OK, probably cost at least £50 each, yours for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P4.

REPAIRABLE METERS. We have some of the above testers but slightly faulty, not working on all ranges, should be repairable, we supply diagram, £3. Order Ref: 3P176.

PHILIPS 9in. MONITOR. Not cased, but it is in a frame for rack mounting. It is high resolution and was made to work with the IBM 'One per disk' computer. price £15. Order Ref: 15P1.

METAL CASE FOR 9in. MONITOR. Supplied as a flat pack, price £12. Order Ref: 12P3.

ANOTHER PROJECT CASE. Should be very suitable for a non-recognisable bug or similar hand-held device. It is 150mm long, 36mm wide and 15mm thick. Originally these were TV remote controls, price 2 for £1. Order Ref: 1068.

A MUCH LARGER PROJECT BOX, Size 216mm x 130mm x 85mm with lid and 4 screws. This is an ABS box which normally retails at around £6. All brand new, price £2.50. Order Ref: 2.5P28.

BT TELEPHONE EXTENSION WIRE. This is proper heavy duty cable for running around the skirting board when you want to make a permanent extension. Four cores properly colour coded, 25m length only £1. Order Ref: 1067.

HEAVY DUTY POT. Rated at 25W, this is 20 ohm resistance so it could be just right for speed controlling a d.c. motor or device or to contraol the output of a high current. Price £1. Order Ref: 1/33L1.

1mA PANEL METER. Approximately 80mm x 55mm, front engraved 0-100. Price £1.50 each. Order Ref: 1/16R2.

VERY THIN DRILLS. 12 assorted sizes vary between 0·6mm and 1·6mm. Price £1. Order Ref: 128.

EVEN THINNER DRILLS. 12 that vary between 0·1mm and 0·5mm. Price £1. Order Ref:129.

D.C. MOTOR WITH GEARBOX. Size 60mm long, 30mm diameter. Very powerful, operates off any voltage between 6V and 24V D.C. Speed at 6V is 200 rpm, speed controller available. Special price £3 each. Order Ref: 3P108.

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HIGH AMP THYRISTOR. Normal two contacts from the top and heavy threaded fixing underneath. We don't know the amperage of this but think it to be at least 25A. Price 50p each. Order Ref: 1/7RC43.

THREE LEVEL PRESSURE SWITCH. All 3 are low pressures and the switch could be blow-operated. With a suitable tubing these switches could control the level of liquid, etc., price £1. Order Ref: 67.

BREAKDOWN UNIT, Order Ref: BM41001. This is probably the most valuable breakdown unit that you have ever been offered. It contains the items specified below, just 2 of which are currently selling at £3.50 each. Other contents are:

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2 *NPN* power transistors ref. BUV47, currently listed by Maplins at £3.50 each, a power thyristor, Mullard ref. BTW69 or equivalent, listed at £3.

All the above parts are very easy to remove. 100s of other parts not so easy to remove, all this is yours for £5. Order Ref: 1/11R8.

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Coil Voltage	Contacts	Price	Order Ref:
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24V DC	4-pole changeover	£2.00	FR13
240V AC	1-pole changeover	£1.50	FR14
240V AC	4-pole changeover	£2.00	FR15

Prices include base

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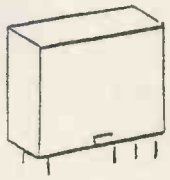

6V Order Ref: FR17
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24V Order Ref: FR19
48V Order Ref: FR20

Price £1 each less 10% if ordered in quantities of 10, same or mixed values.

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BIG POWER RELAY. These are open type fixed by screws into the threaded base. Made by Omron, their ref: MM4. These have 4 sets of 25A changeover contacts. The coil is operated by 50V AC or 24V DC, price £6. Order Ref: 6P.

SIMILAR RELAY but smaller and with only 2 sets of 25A changeover contacts. Coil voltage 24V DC, 50V AC, £4. Order Ref: 4P.

BIG POWER LATCHING RELAY. Again by Omron, their ref: MM2K. This looks like a double relay, one on top of the other. The bottom one has double-pole 20A changeover contacts. The top one has no contacts but when energised it will lock the lower relay either on or off depending on how it is set. Price £6. Order Ref: 6P.

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3-OCTAVE KEYBOARDS with piano size keys, brand new, previous price £9.50, now 2 for the price of one. Order Ref: 9.5P5.

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ADVERTISERS' INDEX

BETA 43
CONFORD ELECTRONICS 31
CRICKLEWOOD ELECTRONICS. . . . 35
CROWNHILL. . . . . IBC
E. A. SOWTER 31
J. K. MICROSYSTEMS. 37
J&N FACTORS 70
JOHNS RADIO 65
JPG ELECTRONICS. 35
LABCENTER ELECTRONICS . . . . OBC
LAPLACE INSTRUMENTS 37
MILFORD INSTRUMENTS 35
NUMBER ONE SYSTEMS 29
OLSON ELECTRONICS 8
PICO 31
QUASAR ELECTRONICS. 33
QUICKROUTE 2
RD RESEARCH 4
SPACE ELECTRONICS 43
STEWART OF READING 43
TELNET. . . . . IFC
TEMWELL CORPORATION 53
TIE PIE 45

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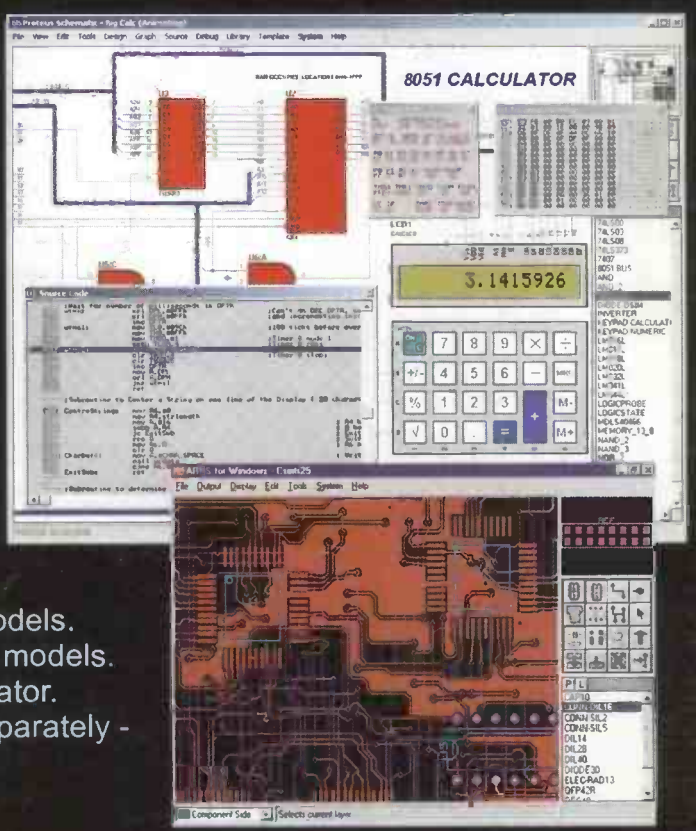

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*E.g. PROTEUS VSM can simulate an 8051 clocked at 12MHz on a 300MHz Pentium II.

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