Electronics World's renowned news section starts on page 4

ELECTRONICS WORLD

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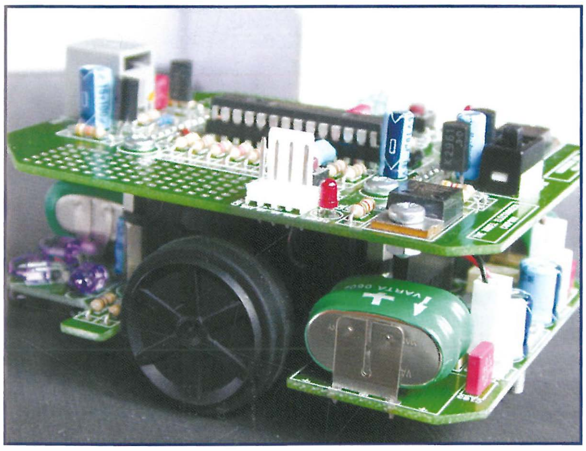
Micromouse wall follower

PART II



Class-A imagineering:

PART II

Boolean castles in the air

The dummies guide to CE marking

Circuit Ideas Special

- Sub-woofer unit
- Decibel meter
- Infrared locator for orientation of the blind
- Serial port controls 16 independent output lines
- Oscillator frequency tuned with power MOSFET
- *and much more ...*

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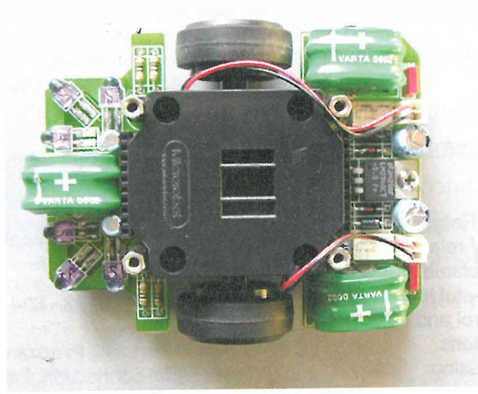

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Industry optimistic

This month is the first time since I took over this venerable tome that I've actually been reading truly optimistic reports from the electronics industry. It would appear that finally the 'digital revolution' is here and has awakened the imagination of consumers, resulting in unprecedented demand for PCs, fast comms products and the software to go with it. This demand coupled with lower manufacturing costs in the Far East, in particular China, certainly looks as though things are on the mend. Even I've noticed a reduction in the price points of technically desirable items like DVD burners, LCD screens and anything WiFi, meaning that my credit card has been put to good use lately!

Entertainment certainly seems to be the driver of this upturn, as my colleagues in the telly programme industry can also testify. It appears that they too are coming out of recession, fuelled not only by more telly channels (courtesy of DVB) and G3 phone services, but also more excitingly High Definition TV, which despite no proper standard ratification in Europe, has started transmitting via satellite. I wonder how long it will be before HD DVDs hit the shops. That is something I've been waiting for. And my credit card is ready.

But for the moment, it's digital TV that's making the high street buzz. Finally after some pretty bad marketing by 'On Digital' and poor retailer advice from the DTG, the DVB-T standard is set to take off. Nothing to do with the fact that the UK government wants to switch off analogue TV and sell the bandwidth – no, of course not. But I still find it a shame that the data rates used on DVB are so low that fast moving things and dissolves break up so badly. And why was the extension to the DVB standard that allowed set top boxes to communicate back to the transmitter (meaning two way high speed data handling from anywhere into the internet) never implemented?

In this month's issue, we can finally find out what CE marks mean and how it affects our industry, courtesy of James Eade. As I said last month, I'm trying to reduce the 'lead time' for Circuit Idea contributors – so there's a bumper crop this month. The Micromouse Robot project concludes and Mr. Maynard continues on his quest to answer some niggling audio questions. And last but not least, the nothing if not controversial Mr. Catt has a look at some computing basics.

Phil Reed

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Topology boost AC to DC efficiency

Lambda has developed an AC to DC power supply topology at its Devon labs, which the firm claims can boost efficiency by five per cent - a significant gain in a market where efficiency is already over 80 per cent.

"Limited levels of efficiency have always meant that AC/DC power supplies come with trade-offs," said Martin Southam, Lambda's European marketing director. With the new design "we have an AC/DC power supply technology that cuts switching losses by 50 per cent to deliver efficiency of up to 90 per cent."

Lambda calls its technology Multi-Resonant-Topology (MRT). It is essentially the use of synchronous rectifiers in a resonant topology with some refinements to allow outputs to run unloaded and to keep operation within a 30 per cent frequency band.

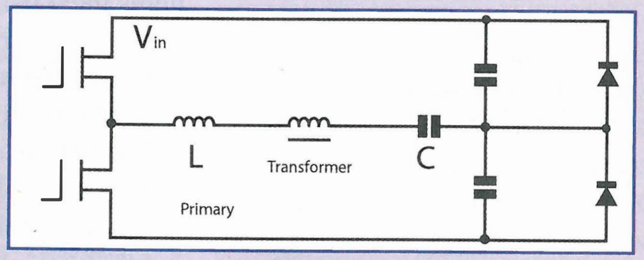
"MRT allows the use of smaller value inductors and wound components. A small output choke reduces losses, as does a ferrite boost choke wound with Litz wire," said Lambda. "Improvements in multilayer ceramic capacitors and functional organic polymer capacitors allows the implementation of much simpler inductorless filter circuits, again lowering losses, increasing efficiency and reducing size."

The power-factor correction circuit in higher-power variants uses a silicon carbide Schottky diode to gain another four per cent of efficiency. A SiC Schottky diode is "as close to an ideal diode as you can get at the moment", said topology inventor Andrew Skinner.

Including an 8-bit Atmel AVR microcontroller to handle housekeeping cut component count in half compared with earlier designs, said the firm.

The first two NV-Power units, as they are called, are the modular NV-350 and the multi-output NV-175, with power densities of 6.6W/in^3 for the 350W unit and 9.36W/in^3 for the 175W design.

How it works



The converter is essentially a resonant half-bridge converter - see the simplified diagram.

Output power is controlled by varying the operating frequency; with maximum power at lower frequency, just above resonance, and minimum power at high frequency.

Under no-load conditions the converter operates at a chosen high frequency with all three capacitors acting as AC shorts. In this state the voltage across the transformer primary is set by the ratio of primary inductance to inductance L.

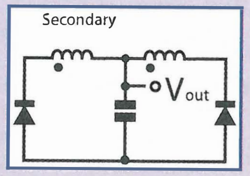
By selecting the inductance ratio and the transformer turns ratio to produce just below the no-load output voltage at a chosen frequency, the converter need never operate above that frequency to stay in regulation at no load.

More traditional resonant converters have to operate at, theoretically, infinite frequency to produce no power. In practice this gives them a very wide frequency range making them difficult to filter and prone to switching losses.

Power demands are greatest operating at high power, during a momentary mains power interruption.

In a simple resonant converter under these conditions, operating frequency can drop below resonant frequency rendering regulator control loop unstable.

The normal way around this, said Lambda's chief engineer Andrew Skinner, is to raise the operating frequency of the converter at all loads, adding to switching losses.



By selecting the ratio of the three capacitors carefully in the Lambda design, Skinner forces the voltage at their junction to swing outside the supply rails just before resonance is reached. This brings the capacitor shorting diodes into conduction, effectively removing the bridge capacitors and reducing resonant frequency - keeping it always below the operating frequency so instability cannot occur as the converter operates through a momentary power loss.

In the real Lambda design, the secondary rectifier diodes are mosfets whose gates are driven by taps on the transformer. "Self-drive is a very nice thing to achieve in a resonant converter. It is difficult to do," said Skinner.

High energy physics saves rare vinyl

A project to preserve rare audio recordings on wax cylinders and acetate is using technology developed to track subatomic particles.

The Lawrence Berkeley National Laboratory project aims to preserve and make available millions of old recordings in the US Library of Congress.

Work to track high energy particles in conditions of high noise at Fermilab and CERN has proven useful: "We developed a way to image the grooves in a recording that is similar to measuring tracks in a particle detector," says Carl Haber, a senior scientist at LBNL.

"We thought these methods, which demand pattern recognition and noise suppression, could also analyse the grooved shapes in mechanical recordings," says Haber.

An optical metrology system mapped grooves in the recordings on shellac phonograph discs. These were then processed to remove hiss and scratches and modelled to see how the stylus would move through the groove. This data was turned into a digital audio file.

LBNL scientist Vitaliy Fadeyev said: "This enabled us to develop a non-contact way to measure delicate samples without the need for much operator intervention. It also has the potential to digitally reassemble broken discs."

Sunlight readable displays

Oxfordshire-based IFM Company has extended its range of sunlight readable displays to include modules with 65mm characters in a 24x7 matrix.

All of IFM's standard product range can be tiled or assembled as character modules. "This new display format enhances our range of standard products by providing a display suitable for single line outdoor messaging systems and signs to be read from one to five metres," said Nick Herring, IFM's sales and marketing manager.

www.theifmcompany.com

Frequency divider circuit exceeds 150GHz

A team led by BAE Systems has built static frequency divider circuits with a clock speed of 152GHz, an industry record for announced devices.

Along with Vitesse Semiconductor and the University of Illinois at Urbana-Champaign, the BAE team built circuits using indium phosphide (InP) heterojunction bipolar transistors (HBTs).

BAE said it will use the technology to "develop the next-generation of miniature digital receivers and exciters that are needed for future strike, surveillance, and electronic attack missions", according to Frank Stroili, BAE Systems technology development manager. "For example, this technology will enable the development of new subsystems such as low cost in-combat programmable electronic warfare jammers, expendable surveillance sensors, and frequency agile software radios for secure communications."

BAE developed the devices as part of a $5.9m US defence research contract.

In 2002 IBM announced it had built silicon germanium transistors with transition frequencies of 350GHz, which it said would result in circuits at 150GHz "within two years".

University of Illinois researchers have created InP HBTs with transition frequencies of more than 380GHz.

Firms promise ten-fold rise in capacitor power

A Japanese consortium of firms has set itself the task of developing and manufacturing supercapacitors with energy densities of 60Wh/kg, ten times that of today's devices.

The group - Omron, Mitsui, Okamura Laboratory and Power Systems - said their electric double layer capacitors would reach 40Wh/kg this year and 60Wh/kg by 2005.

The latter figure is better than most battery technologies can practically achieve, except perhaps for lithium-ion cells.

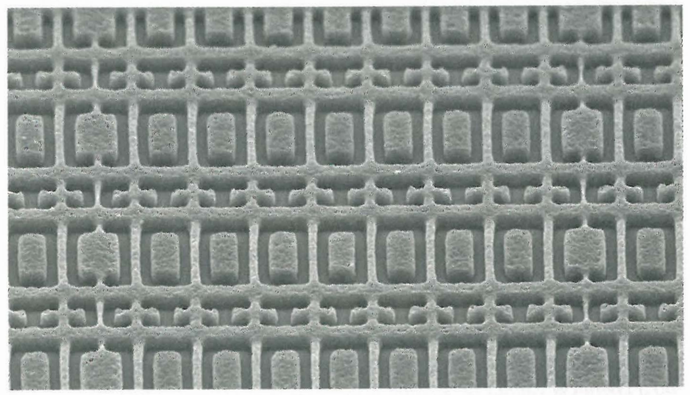
Supercapacitors have the added benefits of almost limitless recycling and they can be charged and discharged in seconds as no chemical to electrical conversion is needed.

They should also be safer and more environmentally friendly than rechargeable batteries.

Meanwhile Maxwell Technologies from San Diego has introduced a D cell-sized supercapacitor rated at 350Farads and 2.5V (see picture). The energy density is claimed to be 21Joules/cm^3, which corresponds to around 6Wh/kg.

By standardising on a battery sized cell, the firm said it reduces costs.

San Diego-based JMAR Technologies has further reduced bugs in its prototype x-ray lithography system, which is capable of producing sub-90nm features with a large depth of field.



In a recent five-day endurance trial, its collimated plasma lithography (CPL) x-ray source and wafer exposure system showed an 80 per cent improvement in availability, 40 per cent reduction in exposure time per field, and a 200 per cent increase in overall productivity compared with a similar trial six months earlier.

JMAR's source consists of copper, hit by pulses from a bank of diode-pumped Nd:yttrium–aluminum–garnet laser amplifiers. The copper is damaged as it produces x-rays, so it is fed as tape from reel-to-reel past the amplifiers. Operation time is limited by tape length.

X-ray source operating time, at 10-12W output, was "several days" said the firm. A second CPL X-ray source under development at San Diego has produced 20W for several hours, converting 10 per cent of input laser energy into x-rays.

The divergent x-rays are collimated into a parallel beam for lithography by a series of close-packed tubes that guide x-rays by grazing incidence reflections inside millions of 20μm tunnels.

Large depth of field is important in lithography as it compensates for variations in wafer flatness and allows 'taller' features to be produced. "CPL is attractive for producing fine contact holes, vias, and chalcogenide-RAM features," said the firm. "These tests confirmed the value of those characteristics and suggested generous process latitude by patterning both dense and sparse contacts within the same field."

Chalcogenide-RAM (C-RAM) is a phase-change, non-volatile semiconductor memory technology with the potential to beat flash memory in write and erase speeds, and cycling endurance.

DVD is paper

Sony and paper company Toppan Printing have developed a next-generation DVD disc based on paper.

Reading and writing of the 25Gbyte disc is by blue laser using the Blu-ray Disc standard - one of several proposed to replace DVD - which allows more than two hours of high-definition program recording.

"Since the Blu-ray Disc does not require laser light to travel through the substrate, we were able to develop this paper disc," said Sony's optical development general manager Masanobu Yamamoto. "By increasing the capacity of the disc we can decrease the amount of raw material used per unit of information."

The paper disc is actually 51 per cent paper.

"Using printing technology on paper allows a high level of artistic label printing on the optical disc. Since a paper disc can be cut by scissors easily, it is simple to preserve data security when disposing of the disc," said Toppan head of R&D Hideaki Kawai.

The worldwide production of optical discs is approximately 20 billion per year, claims Toppan. The combination of paper material and printing technology is also expected reduce the cost per disc.

Credit card goes wireless

Visa has launched a smart-card for debit and credit payments that contains a contactless chip.

Users in Malaysia are testing the card which allows the purchase of goods without signing any slips or entering any PIN numbers. In fact the card does not even need to be removed from a packet or purse.

In order to reduce the chance of fraud, the contact-less operation of the card is limited to low value transactions. A standard contact pad is built into the cards for regular, higher value transactions.

Battery legislation gets European approval

The European Commission's proposed update to the Battery Directive has received tentative approval from the European Parliament, a move which would place the burden of recycling onto manufacturers and local authorities.

However, the Parliament made 87 amendments to the bill, some of which the EC disagrees with, it said.

The Parliament said it would like to extend the ban on mercury in batteries to include lead and cadmium. The Commission said this was unnecessary, as the very nature of a recycling regime would ensure these elements did not disappear into the environment.

"I maintain that our original proposal can achieve the environmental objectives we share with Parliament," said Environment Commissioner Margot Wallström.

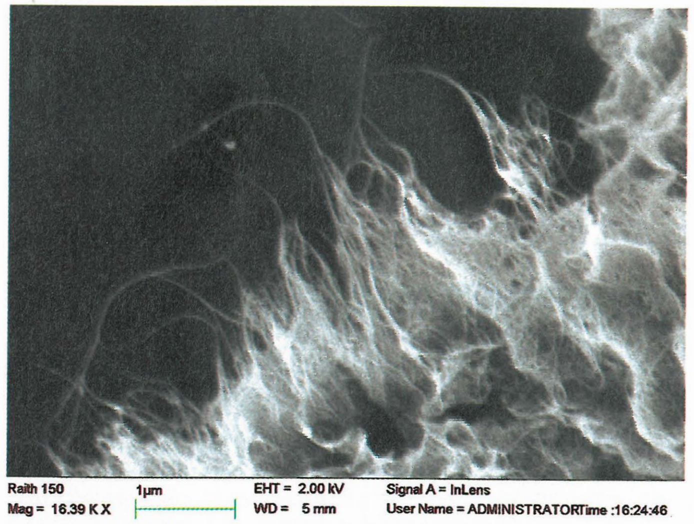
The changes to EU Directive 91/157/EEC are aimed at tackling the environmental impact of 1.15 million tonnes of batteries sold in the EU each year. These should not be dumped into landfill sites or tossed into incinerators, it said.

"Due to the metals they contain, batteries pose environmental concerns when they are incinerated or landfilled," said the EC.

Recycling the metals used should also help to save resources, it said.

The European Commission has estimated that the annual cost of recycling, paid for by producers and local authorities, would be under ¤2 per household per year.

"Consumers will have to contribute to environmental protection by bringing back their spent batteries to collection points," said the EC.



The UK's first commercial manufacturing facility for carbon nanotubes has gone online in Consett, County Durham. Commissioned by chemicals manufacturer Thomas Swan, the plant can produce single walled carbon nanotubes. The firm worked with Cambridge University to adapt and scale up a chemical vapour deposition process. It envisages uses such as lightweight materials for aerospace, conductive plastics, anti-static coatings, electrostatic spray painting and superconductors.

Roll-up, roll-up for flexible displays

Researchers at Paisley University in Scotland have won a £1.4m research grant to develop flexible backplanes for polymer transistors that could lead to robust plastic displays.

Paisley's Thin Film Centre will work with DuPont Teijin Films and Plastic Logic on the project, the first aim of which is to create an A4-sized flexible display.

"When scaled-up this will have enormous applications in intelligent signage for supermarkets, airports, rail and bus stations, road signs and elsewhere," said Professor Frank Placido, director of the centre.

Roll up colour displays are an eventual possibility, he said.

However, Plastic Logic will need to improve its polymer transistors to create the required active matrix backplane.

"If organic transistors can be made fast enough to drive a display then they have a big advantage over silicon in that they can be ink-jet printed," explained Placido.

"Ink-jet printing onto a flexible substrate is the basis for a very cheap transistor. This is still at the research stage so nothing is guaranteed."

The fridge cometh

Taking the Internet fridge concept just a little further, researchers at the University of Florida have made a cooler which comes to you where you order a drink over the web.

Described as "a cross between R2D2 and a vending machine", Koolio, as it is called, is the brainchild of Brian Pietrodangelo and Kevin Phillipson.

Based around a commercial electric cool box, mounted on motorised wheels, the machine is an autonomous robot with a considerable amount of on-board intelligence. Processing power comes from an embedded PC based around PC/104-standard industrial card stack and an Atmel MegaAVR microcontroller.

Koolio resides at a docking station where mains power is used to keep its interior cool. When summoned, it leaves its docking station and navigates using sonar for long distance coverage, infra-red for close obstacle avoidance and shaft encoders for dead reckoning.

On-board cameras allow door numbers to be read.

While travelling, one battery supplies the motors and fridge while another runs the electronics.

"It is completely autonomous and has numerous sensors to accommodate even the trickiest environments," said Pietrodangelo.

www.mil.ufl.edu/~brian/Koolio/Koolio.htm

Lithium cell with no heavy metals

NEC claims to have developed a transition-metal-free lithium-ion battery.

Called 'organic radical battery', "this is a new type of lithium-ion battery which is attractive as an environmentally friendly, high power, high energy density rechargeable battery."

In the battery, polyradicals are used as an active material in cathodes instead of a transition-metal oxide - usually cobalt or manganese oxides.

The polyradical is a nitroxyl polyradical: poly 2,2,6,6-tetramethylpiperidinoxyl-4-yl methacrylate (PTMA).

Both lithium metal and a graphite intercalation compound have been tried as anode active materials with carbonate into which lithium salt is dissolved as the electrolyte solution.

"In the charge-discharge curves, there was an obvious voltage plateau. Average voltage was 3.53V for lithium and 3.44V for graphite, slightly lower than those of normal lithium-ion batteries," said researchers. "The initial specific capacity of the PTMA was 60-100mAh/g."

Cycle life of the PTMA electrode is claimed to be 92 per cent after 1,000 cycles - so anode material limits the cycle life.

A complete prototype cell achieved a discharge of 3.5V and over 1,000 cycles at a capacity of 70Ah/kg, said NEC.

Gyro firm gets cash boost

European Technology For Business (ETB) has secured funding worth £250,000 from an overseas investor to develop its miniature accelerometer.

The Hertfordshire-based firm has developed a three-axis accelerometer by micromachining into a silicon wafer.

ETB uses a mass suspended from a beam, with piezo-electric sensors measuring the strain when the beam is deflected due to an acceleration.

Sensitive charge amplifiers are used to boost the signal from the device.

Machining all three accelerometer proof-masses in the same wafer gives improved alignment, said the firm, a downside to existing designs that often use three independent masses.

ETB is aiming the device at the lower cost automotive markets and measuring potentially damaging vibration from power tools or repetitive strain injuries.

Working prototypes of the device can measure accelerations up to 50g with a sensitivity of 5mV/g. The expected resolution is 0.001g. The device measures just 12x7x5mm.

Correlation adds accuracy to antenna test

Fizzle Technologies from Formby has developed a correlation technique to improve the accuracy of antenna pattern measurements.

The technique, suited to near and far-field measurements, could extend the usefulness of antenna tests in anechoic chambers or open range sites.

Key to the system is the ability to remove multipath fading from antenna measurements, developed with the Signal Theory and Communications Department of the Technical University of Catalonia in Barcelona.

An extra signal is transmitted by the main antenna to the antenna under test. This is then correlated to remove noise and fading.

"Correlation processing effectively finds the component that arrived via the direct path - the wanted component - and removes everything else, including the multipath that causes the distortion. The correlation technique works in real time and does not require measurement data to be processed off-line," said the firm. "This offers significant time-savings over other compensation methods such as lengthy computational algorithms."

Virtual characters remember

.Researchers from Trinity College in Ireland have added memory to a neurobiological model of visual attention in order to generate more realistic animation for virtual reality characters.

The idea is to endow characters with internal characteristics like memory and attention that can guide their movements, said Trinity computer science researcher Christopher Peters. "The memory system provides a means of storage for information about what the character has previously perceived." Characters get synthetic vision modules that provided the sensory input to a long-term, short-term, memory model. The set-up allowed a character to determine whether it had seen an object before. "For example, if something in our environment provokes our interests, we may orient our senses toward that stimulus in order to enhance its processing," he said. If the stimulus proves dangerous, "we may behave so as to avoid it or leave the area."

Laser gets tuned up

A German firm resulting from a European-funded project is building vertical cavity surface emitting lasers (VCSELs) that are tunable over a 30nm range.

This is probably the widest tuning range yet announced for an electrically pumped VCSEL. Such a device could reduce costs in telecoms systems compared with side emitting lasers.

Moreover Two-Chip Photonics has achieved this range at 1,550nm - an ideal frequency for long range optical communications.

The VCSEL uses two ICs, a standard VCSEL made with InGaAs quantum wells and a top mirror micromachined with four vertical support posts.

When the top mirror's legs are heated with a current, the whole device expands, leading to a change in the resonant length of the laser.

Power output is claimed to be 3dBm (0.5mW), with sideband suppression of more than 40dB. The VCSEL is packaged in a TO-5 can.

The collaborators on the project are the Walter-Schottky-Institute of TU München, the High-Frequency Institute at TU Darmstadt, and Vertilas.

FTSE 100 companies failing to report to shareholders on major potential risk

FTS E 100 companies are failing to report on what could be a major business risk, according to a survey conducted by the Component Obsolescence Group (COG).

A review of the FTSE 100 annual reports reveals that the risks associated with component obsolescence are never mentioned. However, according to COG, the issue could incur huge financial and reputational costs for many companies whose operations rely on long lifespan equipment, for example in the utilities, medical, defence, aerospace and rail and automotive transport sectors.

This is because once a component within a piece of equipment has become obsolete, it can be very difficult to get replacement parts quickly or at all. In extreme cases, the equipment may have to be put completely out of service or parts of it may need to be redesigned.

Under the Combined Code of Corporate Governance, listed companies should review all internal controls annually, including financial, operational and compliance controls and risk management systems, and report to shareholders that they have done so.

In addition, draft regulations currently being proposed by Government would mean that from next year, many of the UK's quoted companies will have to carry out an operating and financial review of factors which may affect their performance, including the business risks they face, along with their annual reports.

COG's research indicates that where FTSE 100 companies do mention obsolescence in their annual reports, they only do so in relation to stock valuations.

Comments Michael Trenchard, Chief Executive of COG, "The FTSE 100 is a benchmark for the rest of UK plc. We are concerned that so many leading companies who should be addressing this risk, appear to be paying it so little attention, although clearly, it is not a significant issue for all businesses."

"The ability of the national infrastructure to provide key services adequately, such as utilities, transport or medical care, is already under some scrutiny. Component obsolescence could increasingly become a factor in the equation as the pace of technological change speeds up."

COG says that the problem is likely to get worse because, in the past, components within equipment designed to last for several decades have had high reliability and long life expectancy. Now, however, this equipment is becoming ever more heavily reliant on the same components used in fast-moving consumer goods, which typically have a far shorter lifespan and become obsolete within a few years. According to COG, only 15 per cent of electronic component demand now comes from the industrial market for long lifespan equipment, as opposed to 90 per cent in the 1970s.

Equipment breakdowns

Says Trenchard, "Equipment breakdowns could have a serious knock-on effect on company performance and shareholder value. This is true not just in cases where the equipment is at the core of a company's business, for example in manufacturing or engineering, but also where it is used to support core activities, such as in distribution, or where a company offers after-sales care."

"Companies may feel that component obsolescence is a risk they can afford to manage as and when it occurs, but it may not be as easy as just having to pay several times the original cost of the part once it has become obsolete, although this in itself could involve a major outlay. With some pieces of equipment costing millions of pounds, they have to look at the bigger picture and take a pro-active approach to maintaining their systems for their whole life span."

According to COG, organisations should consider issues such as equipment performance, availability of parts and maintainability as well as cost in their obsolescence management strategies. It also says that they could benefit from working with others in the supply chain and using specifically-designed obsolescence management tools to help them identify problems early and implement solutions.

Government backing for processor firm

A UK firm has been awarded a £427,800 grant by the Department of Trade & Industry to develop a 64-bit parallel processing chip.

ClearSpeed from Bristol has already stunned microprocessor experts worldwide with its 32-bit device, which is capable of processing 25.6 billion floating point operations every second.

"This is great news for ClearSpeed, the South West region and the UK nanotechnology industry as a whole. The 64-bit processor is a tremendous project and is typical of the hi-tech innovation for which the DTI is delighted to provide grant support," said Government Minister Nigel Griffiths.

The Government's Exceptional Research and Development Grant will provide the seed for the 64-bit work. The device will use a 90nm manufacturing process to enable more transistors to be integrated, although the increased size of registers and arithmetic units will counter this somewhat.

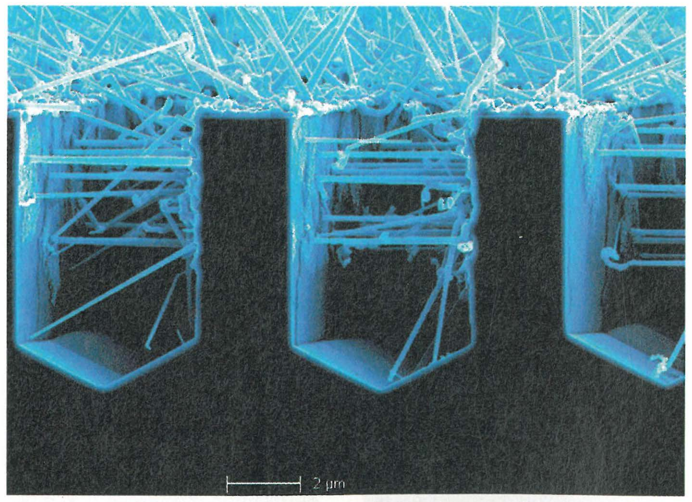
The actual number of processors on the chip is yet to be decided, and could be more or less than the 32-bit device's 64 processor array.

A major aim will be to keep the low power attributes of the existing CS301, which draws just 2W during operation.

Uses for such a chip are varied, but ClearSpeed said it expects supercomputer-type tasks to run on its devices. These include genome research, nanotechnology and atomic physics.

"This product has the potential to make the UK a leading international centre of excellence in this field and will enable sectors that rely on high performance computing, such as biotechnology and the aircraft industry, to take science and technological development to a whole new level," said Griffiths.

Nanowires grow on demand



Hewlett-Packard Lab researchers have grown nanowires to order between electrodes using chemical vapour deposition and a metal catalyst. The wires grow between pair of vertical silicon electrodes, formed on the insides of silicon trenches. Because of the high surface area to volume ratio, the wires could form chemical sensors if coated with suitable receptor molecules, said the lab, although practical devices are five years away.

Micromouse wall follower

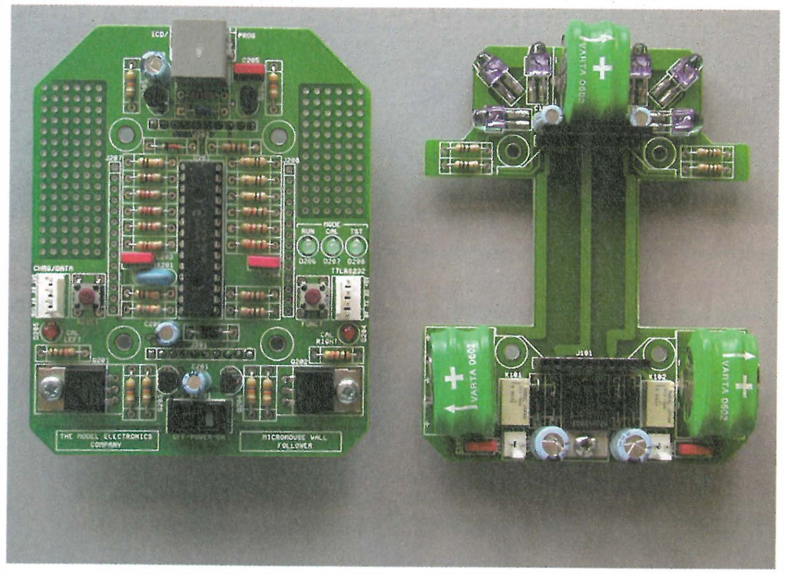
Part II – In last month's article Martin Barratt looked at the design philosophy behind the Wall Follower and described the hardware. This month he examines some of the fundamental aspects of the software and provides details on construction, testing and sensor calibration

In order to make comprehension and modification as easy as possible the software has been written for a dialect of PIC BASIC. The statement syntax conforms to that required by the microEngineeringLabs PIC BASIC Pro compiler at version 2.43 or higher but, with relatively little effort, this may be edited to suit that of another compiler.

The source listing is heavily commented and largely self-explanatory, which is one of the benefits of using a high level language, but there are a few aspects of the code that may benefit from further explanation. In the following descriptions, which are best read in conjunction with the source listing, register names, where given, are placed between inverted commas – as in: 'LeftMotorSpeed'.

Default Operating Values

The source code includes a series of DATA statements each causing the listed value to be stored at the specified location in the non-volatile EEPROM area of the PIC16F876 at programming time. The stored values are divided into two sections and their purpose is to provide an initial set of locomotion control parameters and sensor calibration values. Performing the sensor calibration procedure described later overwrites the existing sensor calibration values and, by editing the source code, the programmer may alter the locomotion control parameters to affect the mouse behaviour in the maze. At power-up these values are copied from the EEPROM area to RAM to permit fast and easy access.



Locomotion

The speed of each motor is controlled by a numerical value, ranging from 0-255, written to the 'LeftMotorSpeed' and 'RightMotorSpeed' registers which, when in normal forward motion, is determined by the values of the variables 'LeftFwdSpeed' and 'RightFwdSpeed'. While in the maze the mouse will, at times, need to perform turns or a corrective action to its current heading and a temporary change in motor speeds is needed to accomplish this. This is achieved by applying a 'speed multiplier' to each motor, raising the speed of one and slowing the other, thus effecting a turn. The multiplier values are stored in pairs and scaled by 100 and so a value of 121 will raise motor speed by a factor of 1.21 while numbers less than 100 correspondingly reduce motor speed.

Two pairs of multipliers are provided with one used for 'Heading Correction' and the other for 'Left Turns'. It is the result of calculations made on the sensor readings that determines which of the multiplier pairs is used – more on this later. A further single-value multiplier is provided to control the motor speed when performing a U-turn, or spin, at the end of a blind alley.

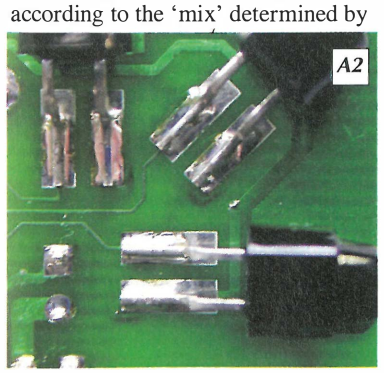
Navigation

Frequent sensor readings are required for successful navigation but they only form part of the equation. The mouse must also be able to determine its location between the walls of a 'corridor' and apply any correction required to maintain an essentially central track. This is important as being equidistant from the sidewalls gives the greatest margin for error while executing a 'manoeuvre'.

For a Wall Follower only two manoeuvres are necessary, a left turn and a right turn. A U-turn, or spin, may be considered as simply an extension of the right turn or, conversely, the right turn can be viewed as a shortened U-turn, as it is in this design. Using this latter method can produce improved turn speeds.

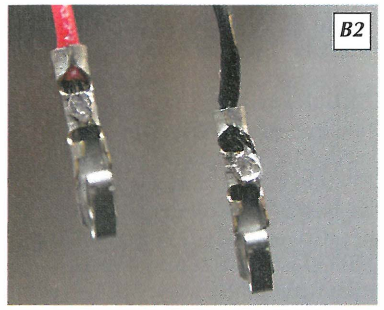
As the mouse travels the maze it uses the sensor readings to ascertain the presence or absence of local walls. As a left-hand wall follower the absence of a wall immediately to its left must cause the mouse to make a left turn in order to re-acquire a left wall and this may need either a 90-degree or a 180-degree turn. If a left wall is present, a check for a wall immediately in front, thus barring further progress, has to be made and, if found, a spin must be initiated. This manoeuvre may be terminated when the front sensors can no longer see any walls and thus caters for both right turns and U-turns.

When not executing either of its manoeuvres the mouse is considered to be travelling 'straight-on' and this is probably the most complicated condition. It requires continual assessment of lateral position along with the application of any heading corrections and is achieved by comparing the current sensor readings with two reference values derived from the '45' degree sensor calibration data. The method employed calculates the reference values, which correspond to two imaginary 'Tracking Lines' running parallel to the walls and offset to the left and right of the central path, according to the 'mix' determined by the values stored in the 'SensorMixCentre' and 'SensorMixEdge' registers – see panel.



Construction

The first step in construction is to separate the various PCBs by carefully sawing along the perforations with a small hacksaw and, once separated, the individual PCBs may be finished to size using a file to remove the remains of the perforations.



Component placement is next and it is generally best to start with the low profile devices, such as resistors and diodes, and work towards those with a high profile such as the connectors. This method allows the PCB to be placed upside down on a stable base for soldering. It is important to observe the correct polarity for a few of the components, most notably the semiconductors and electrolytic capacitors with the 'positive' end (the cathode in the case of diodes) denoted by the square PCB pad.

The I.R. devices are surface mounted and, therefore, require no locating hole but it is important for best performance that they are accurately located. The easiest way to achieve this is to first lightly tin one of the rectangular pads at each device location and, holding the device centrally on its pads with its legs flush against the rear edges, 'reflow' the solder using the iron. This process may be repeated until a satisfactory placement is achieved whereupon the other leg may be soldered. **Photo A2** shows a close-up of the correctly assembled detectors.

The 10-way SIL connectors fitted to each PCB must be mounted absolutely vertically in order to mate easily with the corresponding connectors on the other board. This is best achieved by first soldering one pin, checking for correct alignment and adjusting if necessary, prior to soldering the remaining pins. Note that both J201 and J202 on the Control Board are mounted from the underside.

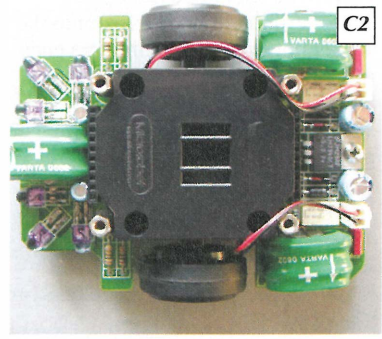
There are two dual-in-line integrated circuits in the design, U201 and U301. These device positions should be fitted with IC sockets, which will allow easy removal for replacement should a failure occur.

Note that the PIC16F876 micro-controller should not be fitted to the Control Board until after successful initial testing.

The three power devices are each mounted to the PCB using an M3 nut and bolt. The best way to fit these is to first bend the legs through 90 degrees such that when placed on the board the mounting hole lines up with the hole in the PCB. Prior to soldering, each device should be tightly bolted to the PCB - using an M3x12 bolt for U101 and M3x6 bolts for Q201 and Q202 - ensuring it fits squarely within the silk-screen outline.

Depending on the choice of programming method either fit J205 for Microchip ICD or J206 for a low-cost programming method. It is not possible to fit both of these plugs.

The Motor Block may be supplied with connectors fitted to the ends of its wires and, if so, these must be removed and replaced. Proceed by cutting the original socket from the motor wires, leaving them as long as possible, and then fit the crimp terminals – see **Photo B2**. Correct insertion of the completed wires into the socket housing is necessary to ensure correct motor direction and is shown in **Photo C2**.



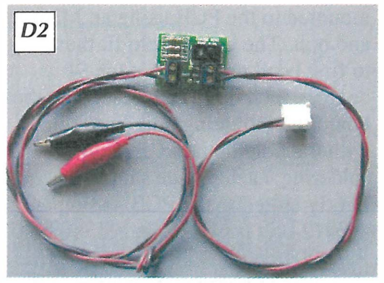
Final Assembly

Before beginning final assembly it is VERY important to visually inspect each PCB for poorly soldered joints and incorrectly placed components and to rectify any problems before proceeding.

Prepare the Motor Block by assembling the hexagonal spacers to each of the four mounting holes, fitting the 14mm threaded spacer below the mounting hole and the 10mm male-to-female spacer above, and tighten using an M3 nut spinner.

The Power Board may then be fitted to the Motor Block using M3x6 bolts by first hand-inserting all four bolts and then tightening them with a screwdriver. Dress the motor wiring and insert the connectors into the PCB mounted plugs, J103 and J104. **Photo C2** shows the Power Board/Motor Block sub-assembly.

Note that the wire length is different for each motor and,

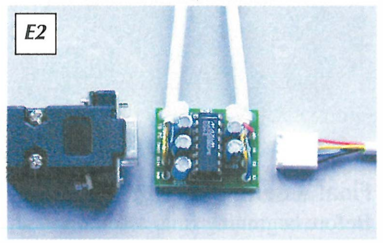

D2

therefore, the orientation of the Power Board should be chosen accordingly.

Ensure that the Power switch is set to the OFF position and fit the Control Board by carefully mating the two 10-way connectors, starting with J201 at the rear, with those on the Power Board and gently pressing the PCB fully home. The four M3x6 bolts may be first hand inserted and then tightened as described above.

Charger Board Wiring

Appropriately coloured crocodile clips should be fitted to lengths of red and black wire and the leads twisted together prior to fitting to the "12V DC IN" side of the Charger Board. Further lengths of red and black wire should be fitted with crimp terminals and inserted into the socket housing prior to the free ends of the leads being twisted together and fitted to the "CHARGE OUT" side. **Photo D2** shows an assembled and wired Charger Board.


E2

PC Interface Board Wiring

The PC Interface Board is wired using lengths of multi-way cable terminated on the mouse side by a 4-way socket housing and on the PC side by a 9-way 'D' socket. **Table 4** –in last month's article - gives connection details. The two cables are dressed so that they sit between the pairs of holes in the PCB and tie-wraps are used to secure them and provide a measure of strain relief. **Photo E2** shows the assembled and wired PC Interface Board.

Initial Testing

In the checks described in this section the two central pins of the CHRG/DATA connector J203 may be used as a 0V reference for the negative lead of a DVM set to 20V FSD. It is also assumed that the micro-controller, when fitted, is pre-programmed with the MOUSEKIT.HEX software.

Prior to purchase, the batteries will probably have been in storage for a while and will not, therefore, be at full capacity. While this means that any build errors are less likely to be catastrophic, it does mean that some of the voltage readings taken may be lower than expected.

Before powering the mouse for the first time, ensure that you have completed a careful visual inspection as described above and also that the PIC16F876 micro-controller is NOT fitted.

Probe the anode of D201 and check for a reading of between 7V and 8V.

Set the Power switch SW201 to the ON position and check for a voltage of about 6V on U201 pin20.

Check that the same voltage reading is present on the tabs of Q201 and Q202.

Check for the same voltage reading on the TTLRS232 connector, J204 pin 4.

If the above tests produced the expected results, then switch off the mouse and fit the PIC16F876 being careful to observe the correct orientation; i.e. pin1 to the front of the mouse.

Switch the mouse on again and note that the RUN LED should start flashing and then illuminate steadily. Repeat tests 2 to 4 above, this time checking for a voltage of 5V ±0.1V.

Check the anode of D202 for a reading of about 5.6V ±0.2V.

Check that the voltage present on U201 pin1 is about 4.25V and that it drops to 0V when the RESET button is pressed.

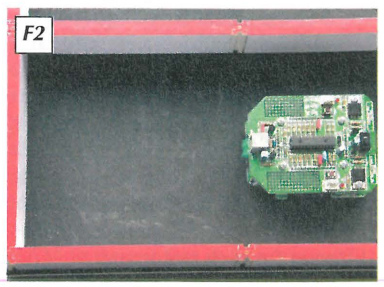
Press the RESET button and, using the FUNC pushbutton, select TEST mode - as indicated by the TEST LED being constantly lit. Place the mouse on a floor with a hard smooth surface, for example linoleum, and press the FUNC button. It should travel forward at a constant speed and in a straight line but, because the two motor systems are likely to have slightly different frictional losses, it is probable that the mouse traverses an arc. Provided the arc has a sufficient radius, at least about 5 metres, then navigation will not be seriously affected but, if necessary, the motor speeds may be adjusted in the MOUSEKIT.BAS source listing as described above. Should the mouse spin on the spot one of the motors has probably been incorrectly wired and this may be rectified by swapping the leads in either J103 or J104 as appropriate.

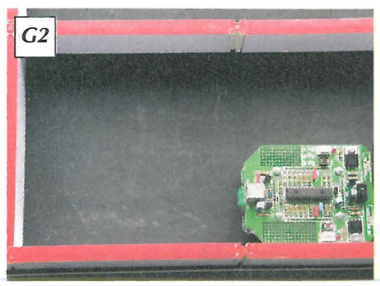
Sensor Calibration

Although a set of default sensor calibration values is included in the mouse software, for optimum performance the infrared sensors may require calibration. The most basic requirement is to establish the signal levels corresponding to the presence of walls at the extremes of distance and this is accomplished by stepping through a calibration sequence. The mouse is placed in a series of specified locations between a known wall pattern, as shown in the photographs, and the sensor readings are recorded at each location. Having established the minimum signals, that is those recorded when the mouse is positioned as far from a particular wall as is possible, any lower level of measured signal may be used to infer the absence of a wall.

In addition to the two extreme-distance (near and far) sensor readings the calibration routine stores sensor readings taken when the mouse is placed in the centre of the lane and these readings are used, in conjunction with those taken at distance extremes, to provide navigation control as described above.

The two Control Board mounted red LEDs, labelled 'CAL LEFT' and 'CAL RIGHT', are illuminated by the calibration software routine both in combination and singly to indicate each step in the calibration sequence. To perform a sensor calibration ensure that the mouse is powered-up and follow these steps:-


F2


G2

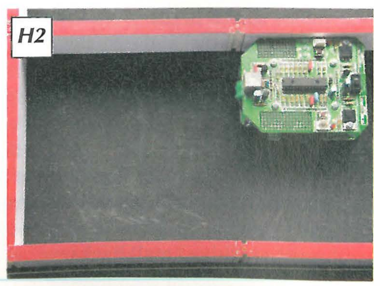

H2

Table 6: Auxilliary processor interface function mapping

Interface Pin	PIC Pin	Signal Name	Comment
J207 / 1	1	NRESET	CPU Reset signal - low when reset button SW202 is pressed
J207 / 2	2	SENS00B	0-5V 00 degree Sensor signal to ADC (Both 00 sensors are paralleled)
J207 / 3	3	SENS45L	0-5V Left-Hand 45 degree Sensor signal to ADC
J207 / 4	4	SENS45R	0-5V Right- Hand 45 degree Sensor signal to ADC
J207 / 5	5	SENS90B	0-5V 90 degree Sensor signal to ADC (Both 90 sensors are paralleled)
J207 / 6	6	COMFUNC	Function push-button signal - low when pressed
J207 / 7	7	VBATMON	Battery voltage monitor – 5V signal corresponds to 12.5V battery
J207 / 8	8 - 19	0VL	0V power supply
J207 / 9	N/A	VBATSW	Switched battery voltage - nominally 7.2V
J207 / 10	N/A	VBATSW	Switched battery voltage - nominally 7.2V
J207 / 11	11	MOTDIRR	Right-Hand Motor Direction control: 0=Forward - 1=Reverse
J207 / 12	12	MOTDRVR	Right-Hand Motor Speed control – active high PWM signal
J207 / 13	13	MOTDRVL	Left-Hand Motor Speed control – active high PWM signal
J207 / 14	14	MOTDIRL	Left-Hand Motor Direction control: 0=Forward - 1=Reverse
J208 / 1	28	PROGDAT	In-Circuit Serial Programming Data signal – for PIC micro-controller
J208 / 2	27	PROGCLK	In-Circuit Serial Programming Clock signal – for PIC micro-controller
J208 / 3	26	LEDDRVR	Right-Hand I.R. Emitter Drive signal: 0 = LEDs Off - 1 = LEDs On
J208 / 4	25	LEDDRVL	Left-Hand I.R. Emitter Drive signal: 0 = LEDs Off - 1 = LEDs On
J208 / 5	24	PROGLVP	Low-Voltage Programming Enable – for PIC micro-controller
J208 / 6	23	MODLEDT	TEST Mode LED drive: 0 = LED Off - 1 = LED On
J208 / 7	22	MODLEDC	CAL Mode LED drive: 0 = LED Off - 1 = LED On
J208 / 8	21	MODLEDR	RUN Mode LED drive: 0 = LED Off - 1 = LED On
J208 / 9	20	P5VL	5V power supply
J208 / 10	8 - 19	0VL	0V power supply
J208 / 11	18	TTL232R	TTL level RS232 Receive signal - from PIC perspective
J208 / 12	17	TTL232T	TTL level RS232 Transmit signal - from PIC perspective
J208 / 13	16	CALLEDL	Calibrate at Left Side LED drive: 0 = LED Off - 1 = LED On
J208 / 14	15	CALLEDR	Calibrate at Right Side LED drive: 0 = LED Off - 1 = LED On

Press the RESET button and use the FUNCT button to select CAL mode and wait until the CAL LED stops flashing indicating that the calibration sequence has begun. Both of the red LEDs illuminate indicating that the first location in the calibration sequence is the 'central' one.

Place the mouse centrally between the left and right walls and with the front in line with the posts, as shown in **Photo F2**. Pressing the FUNCT button records the left and right side looking readings with the mouse centrally located, the forward looking reading for a wall at extreme distance and then moves on to the next step.

The CAL LEFT LED illuminates indicating that the mouse should be placed against the left hand wall as shown in the **Photo G2**. Pressing the FUNCT button records the left and right side looking readings against the left-hand wall and steps on.

The CAL RIGHT LED illuminates indicating that the mouse should be placed against the right hand wall as shown in **Photo H2**. Pressing the FUNCT button records the left and right side looking readings against the right-hand wall and this completes the calibration process.

After the calibration sequence is complete the red CAL LEDs flash alternately. The mouse is now ready to solve the maze and the RESET button may be pressed to allow selection of RUN mode.

Additional Software

Three additional demonstration programs are available, all written in the same dialect of PIC BASIC. Each is briefly described below and further details concerning the usage of these programs are given in the appropriate source listing.

HWARETST.BAS

This test program is designed to exercise the hardware with a view to verifying its correct operation. It re-assigns the normal function of the Mode LEDs as follows:-

RUN Illuminates the CAL LEDs in a binary sequence.

CAL Initially runs both motors in the forward direction and reverses them both at every press of the

FUNCT button.

TST Takes a set of ambient light compensated sensor readings at every press of the FUNCT button and outputs the values as a formatted string, via the PC Interface Board, to a PC running a standard terminal emulator program.

CMDDEMO.BAS

This demonstration program forms the shell of a possible command interpreter that may find use in applications requiring a PC to exercise control over the mouse. The functionality is limited to responding to certain received characters with an appropriate formatted string. It makes use of the PC Interface Board and may be used with a PC running a terminal emulator program.

CHRGDEMO.BAS

This program illustrates a rudimentary battery charge monitoring application. Each minute it takes a battery voltage reading and sends it, along with the elapsed time, as part of a formatted string to a PC running a terminal emulator program. The illumination state of the CAL LEDs is changed every 15 seconds to indicate continued program activity.

Although it is not necessary to power-up the CPU to charge the battery pack the additional signal on J203 pin1 is uncommitted in this design. As such it may be used for any suitable purpose and one possibility is the implementation, in conjunction with a purpose-built external charger unit and a software routine based on the CHRGDEMO.BAS demonstration program, of a CPU controlled fast charge algorithm using this pin to signal the termination of charge.

Alternative Processor Interface

The Alternative Processor Interface has been included to permit users to produce a mouse based on the design described here but not using the specified micro-controller. Two 14-way single-in-line connectors, J207 and J208 mounted on the Control Board, form the interface and are intended to mate with a suitably designed daughter board containing the users choice of micro-controller. **Table 6** lists each pin and provides a brief description of its function.

Note that prior to inserting the Alternative Processor Daughter Board the PIC micro-controller MUST be removed.

Conclusion

Although the design works satisfactorily as presented, the scope of this article goes beyond simply providing a description of the project by offering a limited amount of background information on some of the design problems. It is hoped that the provision of this extra information will increase the level of understanding of the challenges facing the mouse builder and encourage constructors to experiment with possible hardware and/or software modifications to improve performance and functionality.

Calculation of Tracking Lines

For straight line navigation the mouse software compares the current readings from the Left '45' degree sensor with two values representing imaginary Tracking Lines running parallel to the walls and offset to either side of the central path.

The Tracking Line positions are calculated from the '45' degree sensor calibration data according to a formula that is modified by the values stored in the 'SensorMixCentre' and 'SensorMixEdge' registers and thus they may be repositioned if desired.

The basic formulae are:-

TrackingLineValueLeft = (((SensorMixCentre * SensCalL45Mid) + (SensorMixEdge * SensCalL45Near))/16)

TrackingLineValueRight = (((SensorMixCentre * SensCalL45Mid) + (SensorMixEdge * SensCalL45Far))/16)

Taking typical calibration values as an example places the two Tracking Lines as follows:-

TrackingLineValueLeft: (((14 * 92) + (2 * 252))/16) = 112

TrackingLineValueRight: (((14 * 92) + (2 * 39))/16) = 85

From the typical calibration data given a typical '45' degree sensor reading when located in the centre of a corridor is 92 and so, in the example above, the mouse will 'wander' about the central line between '45' degree sensor readings of 85 and 112 – approximately ±5mm.

Note that the two SensorMix values may be altered to affect performance but must total the final divisor which, in this case, is 16.

Readers requiring software, Gerber files and Bill of Materials (XLS format), please contact Caroline Fisher (details on page 3), by email and she will send it out to you. Please use Micromouse in the subject line.

Class-A imagineering: Part 2

Following part one, Graham Maynard shifts from a generalised observation - to more specific circuit observation, this with a view to improving upon and obviating some of the distortion artefacts that are introduced by otherwise supposedly blameless and ultra-low THD amplifier circuit designs

Of course *audio* is forever moving on, and I am not suggesting that anything like the 2x PX4 push-pull chassis in the 78rpm Dynatron radiogram I am lucky enough to own - which is older than me, has had several replacement valves but has never failed, still picks up transatlantic MW when European DRM transmitter pollution is not hissing out the channels, and still amplifies cleanly with external CD input - should be our reference - just that some designers and engineers can suffer from tunnel vision and unwittingly alter everybody's requirements and values as they chase and implement technologically derived 'improvements'.

Those who make themselves responsible for the trend setting equipment we are subsequently obliged to use, have occasionally lost sight of the fundamental sound qualities which once had been taken for granted and been unconsciously appreciated in older designs without any need for explanation; much like the smooth, comfortable, stress free and driver calming ride of pre-1985 designed cars that had oil filled suspension dampers and sensible aspect ratio tyres; also the old and consistently superb low distortion sound broadcasting without gushy automatic dynamic compression with its variable tonality and sibilance, which meant that it once made sense to buy high quality tuners for pleasure listening. Some designer's attentions seemed to have become overly focused on technically correct minutiae or commercial and thermal efficiency, instead of them standing back from their test benches and maintaining that maturely disparate overview of their 'art' which is so essential for maintaining a satisfactory and holistic interface with our unapologetically human senses. In part this could have been due to a new generation of designers and engineers who have come through our modern 'training' system without having been lucky enough to actually live with and experience first hand all of the good qualities that had gone before, prior to them being expected to chase, defend and extoll the manufacturing or production virtues of some progressive development or technique, which subsequently has occasionally, and irreversibly, (because it must continue to rely upon the cost and specification limited technology that was available during its development) altered the overall future for everyone in ways that were not predictable, and which have not always been for the better; as with audio CDs which, whilst having superbly low steady state sine wave distortion specifications, are dynamically impaired by necessary compression and expansion circuitry.

The aspect of listener testing for amplifiers has been repeatedly aired in *WW*, *EW + WW*, and *EW* columns, yet few designers have done other than ever more diligently study their own circuits in an increasingly theoretical way using bench gear and computerised systems. Whatever happened to good old comparison, observation, and trial and error? Theoretical investigations are not a substitute for empirical development; both are as essential a part of competent design and development as to be describable as left and right. There has even been a suggestion that amplifier testing with real loudspeakers would not be practical because of the noise. What? We don't listen to resistors!! And I'll be darned if I listen to sine waves either!! Sinusoidal waveforms are singularly boring. What inspires us is the timely and accurate rendition of change, the presentation of harmonic relationships and asymmetrical transient responses that are not dulled by inadequate amplifier and loudspeaker dynamics. That is why we can still be enthralled by the timing of old performers who struggle to hit their notes, and why listeners with older ears that can no longer hear above say 10kHz, can still be critically discerning of distortions that test equipment is still incapable of quantifying in isolation. The whole point is that amplifiers are supposed to drive loudspeakers with realistically dynamic and representatively loud *audio* waveforms, not steady state sine waves, so those who write such claims about testing show that they have self assumed an unproven right to discount all possibilities for loudspeaker induced amplifier-loudspeaker interface distortion. There should not be any problems auditioning amplifiers, and listening tests should need to be done only once to either prove a design or send it back to the workshop: Suitable arrangements are not impossible to make!

As a result of my early experiences, I learned that you really did need to hear an amplifier running, and if possible, driving your own known loudspeakers before you considered handing over hard earned cash to buy it; in exactly the same way that you would not purchase a car without test driving it first. I also became determined that from then on I would approach audio power amplification from a loudspeaker drive perspective, where almost infinitesimally minute and totally inaudible amplitude distortion residuals close to maximum output would not be deemed more important than maintaining constantly correct drive fundamentals, especially with regard to waveform coherence and the signal plus loudspeaker generated NFB loop error correction propagation delays that arise whilst powering real-world dynamic loudspeakers. Actually, I feel sorry for people who have grown up knowing only solid-state designs, for many modern power amplifiers do not actively drive loudspeakers (as opposed to driving current through a passive resistor) as realistically as the best of what went before.

A designer and owner might know that s/he has one of the lowest THD distortion audio frequency amplifier designs that man can make, without them also realising that there are other significant ways in which an amplifier-loudspeaker interface can induce composite sound waveform distortion. The famous Sheffield Labs in America choose to use tube (valve) equipment throughout their studios - right up to their 24 bit digital mastering process; as a result they produce some of the very finest of CD recordings available. Now it is being reported that the latest valve amplifiers fitted with newly developed low electron reflection mesh anode output triodes, and modern push-pull input, driver and output transformers, can make the majority of real world loudspeakers reproduce sound more realistically than the most thoroughly bench tested solid state designs, so something has been going wrong and it is not a fashion or money thing either. Replacement is not necessarily better than refinement! I can understand why push-pull valves with transformers do not alter the perceived fineties of audio reproduction, but I would not choose to go back to using transformers and although I once contemplated it, I would not want a massive directly coupled tube amplifier either.

Of course there are fundamental differences in the way that inductive loudspeaker voice coils transduce the voltage waveforms from low impedance and NFB loop controlled solid state amplifiers, or the comparatively current generated waveforms from non-NFB hollow state, but even when loudspeaker system impedances have been compensated and linearised, some differences remain. It is then fair to say that we are then not comparing like with like, but we still want to choose a design that reproduces realistically.

Not quite diaphanous

For almost three decades I have become increasingly concerned at seeing one after another of published 'low distortion' class-B amplifier circuits that needed to have a VAS connected dominant pole stabilising filter, sometimes labelled the C.dom or called a Miller capacitor, plus a separate resistor paralleled output choke and often integral input signal filtering which ends up being in series with the audio path yet external to the amplifier itself. So long ago I observed audibly deleterious veiling effects caused by the introduction of these capacitive and inductive signal path elements, and yet they have appeared in recently published circuits, and their usage is still being mentioned, as recently as by Mr. Kevin Aylward in his *EW* Letter, p54, Dec 2003.

At the outset, transistor amplifiers had slow output transistors, less NFB loop gain degeneration, and C.dom capacitors that tended to operate at supersonic frequencies only - but present day amplifiers intentionally have so much internal gain that C.doms now affect a closed loop's ability to error correct throughout the entire audio range, often down to sub-bass rumbles, and this for no other reason than to be able to claim supposedly impressive and ultra-low THD figures. Amplifiers always have unavoidable propagation delays, and input stages must act with a much greater speed than the incident signal waveform to maintain NFB loop controlled accuracy, yet this is exactly where the action of the Miller capacitor type of dominant pole filter and an output choke can impinge upon the load based dynamics of amplifier current flow. Many designers believe that they are making correct use of C.dom and resistor paralleled output choke components and thus they perform open and closed loop examinations with a resistor load to satisfy themselves for bandwidth, distortion and stability. However, because they are catching only the balls that they themselves are linearly throwing vertically upwards, they are not noticing any loudspeaker fired ones that can and do fly at odd phase shifted angles and at unexpected back EMF induced instants through the amplifier-loudspeaker interface, and, because they have followed 'established' rules, they end up plagiarising flawed thinking, and perpetuating design errors.

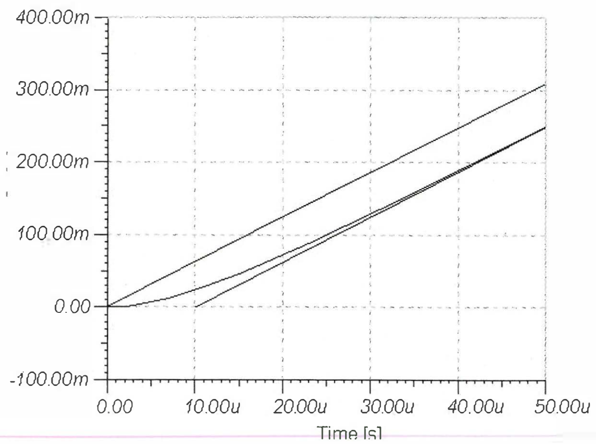
If we examine the action of input filters we see that they introduce a tiny delay at audio frequencies, and this has an increasing effect upon phase coherence at higher audio frequencies. The resultant phase delay increases with frequency and this affects the harmonics of first cycles and sibilants during a first cycle in a way that does not show up when complete sinusoids are examined in steady state isolation. A previously composite waveform can become distorted wrt source before the amplifier actually receives its input, and we can hear the difference because our ears are sensitive to the resulting frequency dependent changes in waveform energy. So, if an input filter must be implemented in order to prevent radio frequency breakthrough or HF feedback, its turnover should be many times higher than audio for first cycle distortion to be kept as low as is normally produced by the following high quality amplifier itself. Also checks should be made to ensure that input filtering does not unnecessarily degrade an amplifier's noise performance, nor its stability at moments of loudspeaker induced overload.

I could imagine a few theory-based readers having the greatest difficulty in accepting my last paragraph, like those who would choose to remind me about 'group delay'. Yes, of course an audio filter might introduce a relatively constant group delay, such that the time difference between all input and output zero voltage crossovers after the first complete cycle remains the same, whether 20Hz or 20kHz. However, it is seriously wrong to then assume that this fact gives us an ability to treat an audio filter delay as if it were a waveguide delay, because our signal waveform has not been impressed upon any form of propagating carrier. Our audio waveforms are subject to the very same and entirely natural exponential filter input-output settlement characteristics which give rise to this sine wave group delay in the first place, but, and I am obliged to repeat it - we don't listen to sine waves. The sine wave group delay time period is a specifically measurable attribute that does not apply to the leading edge of a first *audio* cycle. The time period for exponential waveform settlement with a newly generated first cycle is actually much longer than is indicated by the steady sine wave figure, and as a result the voltage error introduced by an input filter is close to its maximum at the end of that group delay time period. So, not only is the leading edge of a first cycle audio waveform distorted wrt input after the group time delay time period has elapsed, its initial throughput potential is also at its most distorted wrt to the rest of the ongoing, but delayed, sine wave. How do CD player anti-aliasing filters perform in this regard?

This is why I have included **Figure 2**, which shows a 1kHz-1Vpk signal generator input, the output from a 10kΩ+1nF, R-C filter, and the filter output as it would be if it had the perfect 10µs group delayed output that is so often assumed, but which is of course an electrical impossibility.

It does not matter whether you examine the real output voltage either wrt input, starting at t=0, or wrt output, starting at t=gd (group delay time period), it is distorted wrt to both. An amplifier might be capable of slewing at very high speed but its audio input will still have been distorted before start-up if it is fitted with an input filter that causes audio frequency phase delay at higher frequencies. Input filter phase distortion can be apparent on the first cycles of all audio waves, and its error amplitude increases with frequency as the group time delay becomes a greater proportion of waveform time period, thus its worst effects are noticeable on the reproduction of vocal sibilants and percussive equipment plus other instruments that generate higher frequency harmonics. Gently playing classical string instruments that have been input filtered might sound acceptable as they lose some of their naturally raucous harmonic content, but an impression of 'something missing' could arise on live miked performances and modern pop. What actually is missing is their first quarter cycle (transient) reproduction accuracy - and the cure is blindingly obvious - no filter, no first cycle distortion.

Figure 2: The low pass filter output is dynamically distorted wrt the static group delayed output, as well as wrt input.



Exactly the same first cycle distortion problems arise with series output chokes, only here there is current flow in both directions, so the audible outcome is complicated by two separate first cycle responses that have different time and voltage references, from different amplifier and loudspeaker related starting points. This is why the output waveform of an amplifier with integral output choke will not only be different at the loudspeaker terminals when compared to its output with a linear resistor, but why its output really does change when the loudspeakers are changed, and thus why some loudspeaker types are better partners for specific amplifiers!

C.doms

With regard to C.doms, the activity of say a 100pF capacitor across a VAS stage is not just that of the 100pF component acting alone; the current it dynamically draws from a typical high impedance differential input plus mirror stage is multiplied by the VAS stage gain, which, with a Darlington configuration, can easily be 3000 times. The result is equivalent to three thousand separate 100pF capacitors charging from one leg of an input stage pairing, which often has low value series emitter resistors that instantaneously drop additional differential voltage due to the ninety degree leading current flow through that C.dom. No modern amplifier designer would connect a 0.3uF capacitor directly between the first transistor collector and the signal ground line because of the way in which the input stage must additionally drive capacitor current from NFB loop controlled differential input; the NFB node error potential has to be greater before the VAS transistor can conduct equally, and so the distortion would be increased. Yet from a charging viewpoint this is how a 100pF C.dom reacts when it is connected directly across a Darlington VAS stage, and the VAS input loss it causes gives rise to a zig-zagging error potential at the NFB loop's output node as waveform polarity alternates, either with input, or with loudspeaker generated back EMF.

Charging current is momentarily shunted by what is effectively a 300nF component, when it should have freely gone into the VAS stage to generate speedy and low distortion output stage control. Also the capacitor charges, not just in relation to the slew rate of say a 20kHz input sine wave or a much sharper acting vinyl scratch or noise tick, nor the very much faster NFB loop driven requirement for error correction, but only as fast as the floating differential input stage can balance about its current source due to a given error signal, prior to overall circuit propagation delay allowing the global NFB loop to regain overall input-output control! In other words the momentary NFB loop error signal must be greater when the Miller connected VAS capacitor is used, and this means that the NFB output node error must be greater too.

This capacitive shunting causes additional differential voltage drops at the input pair and across all four input stage emitter resistors, and because this can additionally limit the subsequent VAS driver rate of voltage change, and thus linearity, it can also limit an output stage's ability to error correct. At higher audio frequencies a differential input stage error actually builds up between the input transistor bases before C.dom capacitor charging allows the re-establishment of relatively linear VAS transistor base current flow and thus the separately acting global NFB loop to regain control. By then however, the induced dynamic imbalance has already forced the high gain and mirrored differential input stage into transconductance non-linearity, such that the NFB loop loses 'post-input stage' but 'pre-NFB loop recovery' control, due to the action of that simple, and most certainly not trivial, (say) 100pF C.dom component, and all this in a manner that no amount of global NFB can ever correct because gain cannot overcome time delay. Also, the amplifiers that have the higher value C.doms tend to be the ones that already have the most NFB anyway, the very ones that are supposed to amplify more accurately!

It is bad enough that every discrete and integrated circuit bipolar transistor comes supplied ready made with its own inbuilt Miller capacitance, but to make this effect worse by deliberately adding an external component at a high slew Darlington VAS stage is sheer *audio* thoughtlessness. See especially fig.10a in the 'Audio power amplifier frequency compensation' article written by John Ellis, *EW*, Mar 2003, p10. The NFB loop induced differential input stage spiking imaged during Mr Ellis' closed loop investigations does not reach the output stage due to the subsequent slew rate limiting action of the original Miller connected C.dom itself, so the input induced spike is slew rate limited into a zig-zagging error potential that causes a slight lift in harmonic distortion. This keeps the original amplifier designer happy because the spike itself cannot actually be heard by anyone, but this C.dom activity at audio frequencies is not trivial, because the loss of linearity causes internal and thus output level error shifting at higher audio frequencies until full NFB controlled signal tracking is recovered. Also, and very importantly, there is a similar input stage reaction when dynamically reactive and loudly driven real-world loudspeakers generate opposing currents that momentarily overcome C.dom delayed output stage linearity, such that an output node error potential can build up, and thus a differential input stage error too, before the amplifier can properly counter it. The longer the Miller C.dom induced propagation delay and the higher the amplitude and frequency of loudspeaker system back EMF, then the greater the magnitude of output terminal waveform error potential will become, wrt input waveform, before the propagation (Miller C.dom) delayed NFB loop can fully recover closed loop control. Traditional open and closed loop sine wave testing procedures with a resistor load are no use here because they cannot reveal this design weakness!

The investigation reported in *Loudspeaker undercurrents* by Douglas Self, *EW*, Feb '98, p98 makes essential reading; note especially his illustration of the surprisingly high back EMF currents that were recorded at the amplifier's output terminal. These reverse impinging energies must not be ignored by amplifier designers, and yet normal testing procedures that use sine wave generators and resistor loads are not suitable for simulating and examining amplifier behaviour in such conditions. Clearly any amplified harmonics or treble tones riding the back of a complex bass waveform are at risk of becoming seriously compromised when the bass or mid-bass loudspeaker-cabinet combination causes an amplifier's VAS collector to overdrive the output stage as non-linearly as is illustrated.

Such reverse impinging loudspeaker generated energies cannot be studied via ages old evaluation procedures that rely upon steady sine waves and linearly conducting passive resistor loads which are incapable of invoking real-world-like dynamic loudspeaker induced amplifier behaviour. A measurement of resistor voltage with sine wave drive fails to illustrate the way in which the Miller capacitor C.dom can make a reverse driven amplifier itself behave like an inductor, and thus allow the output terminal to instantaneously develop a tweeter driving error potential before a C.dom delayed NFB loop can re-establish control and minimise both input stage and output terminal error potentials wrt the original input waveform. C.dom induced amplifier inductance was concisely clarified when Peter Blomley introduced his chokeless solid state power amplifier circuit back in Feb 1971, see *WW*, p57. This is beyond normal *EW* back issue resources but his *New Approach to Class-B Amplifier Design* article remains a significant reference.

'C.dev'

The Miller type of C.dom capacitor does exactly what it says on the circuit - it dominates. But if its value is high enough to take a floating, and non-linear rate of change slew charge from the input pair at audio frequencies, then it causes voltage deviation and can no longer be considered a trustworthy master.

C.dom becomes 'C.dev'!

This is due to the input stage current which flows during the charging process being ninety degrees leading wrt to VAS collector voltage change, as this swings through non-linear output stage base (gate) bias and stored charges, plus load varying output stage emitter (source) resistance voltage drops. Thus the capacitor current drawn through the differential input stage by the VAS connected dominant pole component, and thus the voltages dropped by the input stage emitter resistors, are not actually in phase with either input or output node potentials, also, they can additionally be directly affected by phase shifted loudspeaker back EMF currents which cause non-linear shifts in output stage VAS drive voltage due to amplifier-loudspeaker drive that has already occurred but is no longer current. Any number of zeroes between the 'point' and the 'figure' of a 'percentage THD' figure are irrelevant here, because the output terminal error potentials, and thus their effect upon the differential input stage, are no longer directly related to amplifier input!

When I see some class-B amplifier circuits which use emitter resistors within a mirrored differential input stage, and where the Miller implemented C.dom prevents the VAS collector from slewing at high speed through the output stage bias potential range in order to cope with phase shifted load current flow, I can't help comparing the C.dom's quadrature action in audio - to the action of condoms in sex; both are safe - both affect reproduction - both interfere with immediacy, and thus there is a sense of loss of instaneity and the direct perception of reality that is possible when neither are used.

Okay, so I've rattled on a bit here, but so many designers who ensure the unconditional stability of their amplifiers by implementing Miller connected C.doms, fail to realise that they are simultaneously imposing other conditional limits upon their designs, especially with regard to internal phase changes about the VAS transistor, which leaves the entire circuit playing voltage 'catch-up' when its load is not a passive resistor. If an audio frequency acting Miller connected VAS C.dom is essential to maintain stability, then input stage non-linearity can be minimised by:

(i) increasing input stage current flow

(ii) by not using input stage emitter resistors, and

(iii) by choosing an output stage which has a linear transfer characteristic unaffected by supply voltage, temperature and power output changes, and especially one that is capable of coping with high output stage current changes that no longer match signal voltage waveform due to dynamic loudspeaker activity and reactivity

Also with regard to performance, I have yet to see any amplifier designer inform prospective owners that they are inserting between their amplifier's NFB controlled output node and the different output terminal that users are subsequently obliged to connect their loudspeaker cables to, a series inductor having a value that approaches the series inductance of a ribbon tweeter module, or a high quality tweeter voice coil which transduces about a central pole piece that has copper plated induction damping. If you had gone to the trouble of locating a monoblock power amplifier directly behind or beneath the loudspeaker and cable driven it from a low impedance pre-amplifier, as I do, would it make sense to knowingly put an inductor in series with a very expensive loudspeaker and thus its tweeter or the satellite you rely upon for spatial imagery, and thereby permanently impair the manufacturer's intended high frequency characteristics and dynamics? Maybe you already are - and - because these chokes have become integral within so many class-B amplifier designs, such that the amplifier is incapable of running correctly if it is removed - maybe there is nothing you can do about it!!

Maybe that 'highly developed' and resistor tested solid state amplifier that comes with a jaw dropping specification which you were led to believe far exceeds hi-fi requirements, has its performance compromised the moment you connect real-world loudspeakers to its output terminal and you feed it with composite *audio* signals instead of sine waves! There are thousands of 'golden ear' specified (i.e. sine wave-resistor tested) solid state, input filtered/C.dom/choke designs already in existence, but so many of them do not fully satisfy music listeners, and so it is of no surprise to me that those wondrously old, magically photogenic and sonically unobtrusive valves have already made their comeback.

Many amplifier designers appear to assume that a 3-10μH inductor, paralleled with say an 8.2Ω resistor, which is inserted in series with an amplifier's output terminal cannot possibly affect sound reproduction, but how many of them have actually listened for the changes in clarity that are introduced when a series output choke is inserted, and then switch shorted in and out of circuit between different types of directly connected loudspeaker and a good NFB amplifier that does not need to be fitted with a series output choke in the first place? Did they ever take the trouble to properly audition a chokeless design, or have they just assumed that it isn't necessary because it has been 'standard practice' on other class-B designs? I am no Einstein, but I do agree with his words that "The important thing is not to stop questioning". Hence I try hard to not make assumptions, or to guess.

Thoughtless application

When a 6μH//8.2Ω series choke drives an 8Ω test resistor, the audio frequency group delay is constant at an inaudible 750ns. The energy stored and thus the potential developed by the choke during an initial 750ns of waveform slew increases with frequency and current flow, but this is always relinquished and returned during the 750ns following the cessation of amplifier output. However, and as I've already repeated, we don't listen to resistors; also, as previously explained, group delay does not hold good for leading edge first cycle reproduction.

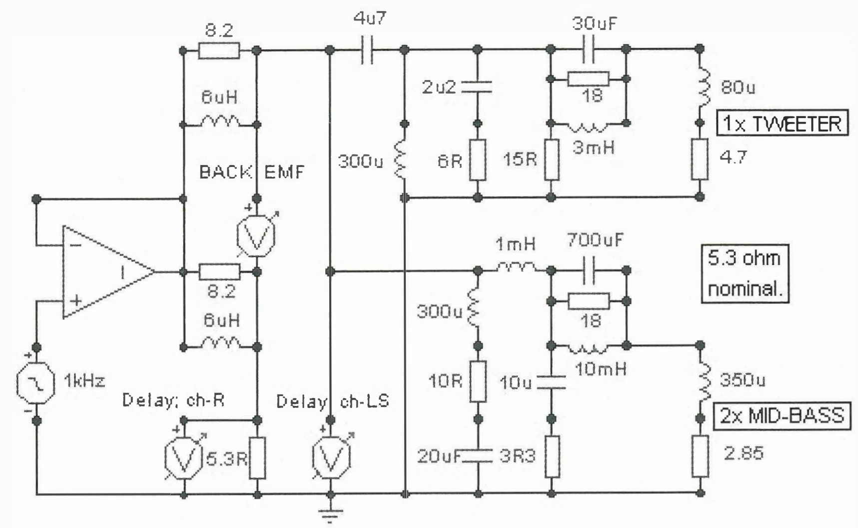


Figure 3: Circuit for comparing choke plus loudspeaker response, against choke plus resistor amplifier response.

Resistors are incapable of presenting an amplifier and its series output choke with load impedance characteristics that vary with frequency, as all dynamic loudspeaker systems do. If we were to vary the load resistance manually we would see the choke delay varying similarly and thus when a loudspeaker system impedance characteristic changes with frequency, so too does the choke delay and the potential it develops, or returns, during that delay period. Thus one portion of a composite musical waveform (an harmonic) can become momentarily more output choke delayed and voltage depleted, or speeded up and voltage advanced, wrt a whole cycle due to entirely natural loudspeaker system impedance variation with frequency.

Resistors are similarly incapable of generating electrically and electro-mechanically induced loudspeaker system back-EMFs that vary with crossover-driver-airspring excitation in a manner that generates choke potential at the real amplifier output terminal, wrt the amplified signal waveform which develops at the real NFB loop controlled output node. Thus one portion of a composite musical waveform appearing at the output terminal can momentarily receive plus or minus potential development modification wrt NFB controlled amplifier output, due not only to a loudspeaker system's dynamic retention and release of audio energy that had been induced by prior driving, but to interacting crossover and impedance compensation circuit elements, both of which mechanisms generate additional back EMFs that are different in frequency to the waveform that energised them, and different to the ongoing amplifier output waveform that might be apparent at any instant.

Resistors therefore cannot be used to indicate how much unpredictable time and voltage, and therefore sound stage stereo image shifting might occur, or how much real and ongoing amplitude distortion any particular amplifier might introduce as its loudspeaker load constantly modifies current flow through its integral series output choke!

Also note that when an audio system has more than one channel, these momentary choke induced aberrations could become differentially significant within the apparent reproduction sound stage, such that relative shimmying not only smears the sound, but also blurs the image position!

I'm only relating facts here - nothing is new, and nor is there is any way of countering the entirely natural audio waveform distortion that arises due to series inductance and parallel capacitance along a signal path, especially when the load is reactive.

I am going to use the test circuit shown in **Figure 3** to illustrate what happens at real-world loudspeaker terminals relative to the proven and resistor examined, ultra-low THD performance we have witnessed on the test bench.

Here I use the normally accepted linear resistor response as a reference, to show that an output terminal's potential is much more seriously affected than is realised when its load becomes the equivalent of one of our real-world loudspeakers.

Figure 4 simulates the induction group delay in microseconds due to separate 6μH chokes that are paralleled with 8.2Ω resistors, one being connected in series with a high quality twin mid-bass plus tweeter loudspeaker, and the other in series with a plain resistor of equivalent nominal value, which is 5.3Ω.

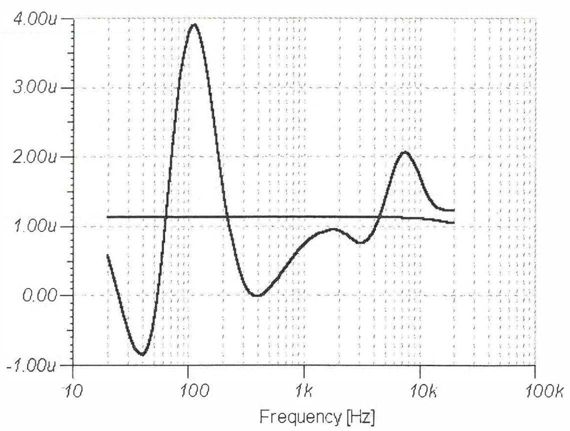


Figure 4: Group delays for a linear resistor, and a reactive loudspeaker

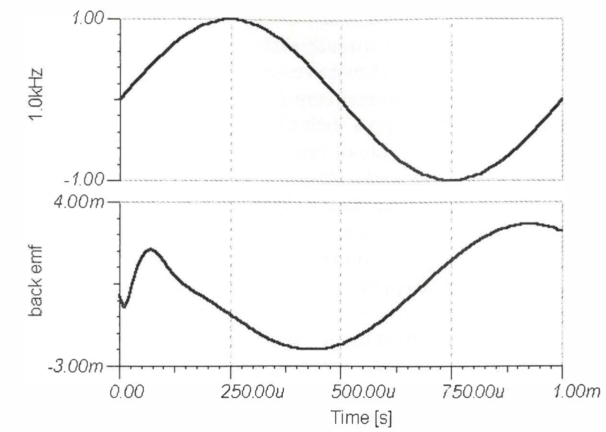


Figure .5: Output terminal voltage difference between the 'reference' resistor, and the simulated loudspeaker

With respect to the near flat 1µs resistor induced delay the imaged characteristic is clearly modified by crossover-driver activity resulting from lagging and leading variation of current flow with frequency through loudspeaker system impedance variation plus electrical and mechanical 'Q'. Obviously some fundamentals and harmonics are going to be affected more than others before a composite waveform actually redevelops at the loudspeaker terminals, and this simulation does not include physically induced characteristics due to air-spring 'Q' and cabinet wave reflections etc. Many loudspeakers generate much worse group delay plots, but I am sticking to this known good design. Also I must mention that whilst approximately ±1µs really is a minute time period, this is the steady state plot which arises for constant sine waves after load dynamics have settled and altered the choke delays for some, but not all, previously related waveform harmonics.

Choke smearing

Figure 5 shows the difference in output terminal potential at 1kHz, between the plain resistor loading and the twin mid-bass plus tweeter loading, for the **Figure 3** 'perfect' virtual amplifier via its integral 6µH//8R2 chokes.

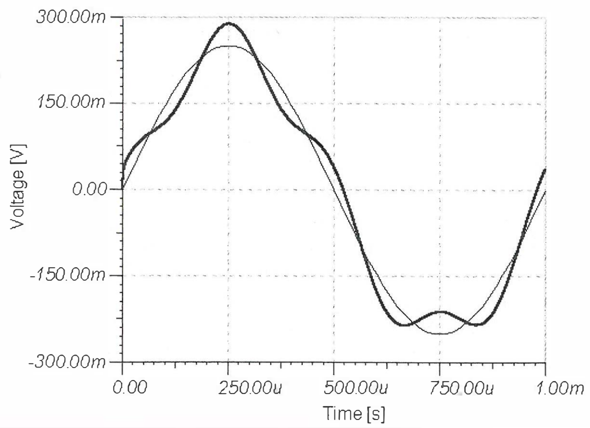
The error due to a first cycle of frequency dependant loudspeaker system induced back EMF impingement upon the 6µH choke is clearly demonstrated, prior to its ongoing error becoming sine wave after 250µs and mixing with original drive to become both inaudible, and immeasurable as THD at the loudspeaker terminal. Obviously though, the first cycle has been distorted, and first cycles are every bit as important as the second, third, and fourth cycles etc., because in *audio* the first cycle of every note is but an ongoing moment within a musical continuum. Our ears hear each and every first cycle as it arises in real time, and we can sense any unnatural intrusion due to this kind of accompanying waveform change. Just because the majority of amplifier designers have not revealed the presence of first cycle distortion does not mean that it does not exist, and such double negativity would not give them the right to denigrate those who report hearing changes that have been introduced by the circuitry of supposedly 'ideal' products. Actually, this is the waveform distortion that the headphone monitoring of a class-B amplifier's output terminals had so clearly revealed to me almost thirty years previously, when its termination was repeatedly switched between resistor and loudspeaker.

If we were to use a loudspeaker as the load on the test bench these differences will not be noticed or measurable because the amplifier's output terminal waveform will normally have already settled into a steady sine wave long before it is examined using standard time delayed and phase compensated single frequency observation methods which null out the ongoing fundamental. What might have happened during a first cycle due to exponential circuit activity, i.e. settlement within capacitors and inductors combined with driver-airspring dynamics, prior to the steady waveform becoming properly developed, is neither observed nor measured, though its effects would have been momentarily audible.

Figure 6 shows the choke induced waveform distortion due to 250mV of 1kHz of amplifier driven choke throughput being modified by 1V of 4kHz of simulated 'back EMF' through a 4Ω resistor which is used to simulate a loudspeaker impedance dip.The bold trace illustrates, albeit on a deliberately low amplitude amplifier output wrt to loudspeaker generation, the instantaneous level and time shifting distortions that the choke's quadrature induced potential and conduction time delay can introduce due to combinations of loudspeaker plus crossover circuitry generating currents wrt the amplifier's NFB loop controlled output node; these end up generating parasitic voltage waveform at the amplifier's choke coupled output terminal. There would be similar parasitic voltage generation due to driver cone/dome, plus mounting, plus air spring resonance effects that I am unable to simulate, as these react and momentarily assist or oppose back EMFs wrt the NFB amplifiers ultra low output impedance. Similar amplitude levels of throughput distortion could occur whether the amplifier is coincidentally generating 25mV or 25V of output at any given instant. Also, it is worth noting that this same kind of error voltage development can separately arise when longer lengths of loudspeaker interconnecting cable feed complex multi-way loudspeaker systems!

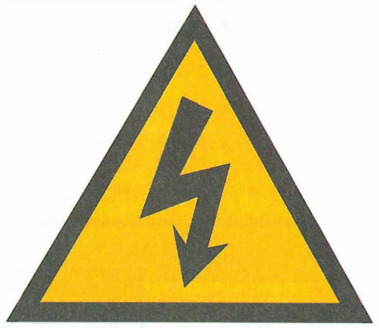
In part three, I shall complete this short and illustrative series of amplifier induced distortion mechanisms, and then describe the first of my low 'first cycle distortion' amplifier circuits.

Figure 6: An illustration of series output choke throughput distortion due to load circuit generated back EMF



The dummies guide to CE marking

"Yeah, it's supposed to be a quality amplifier" said the caller, "it has a CE mark, and that's why I was surprised to find it sounds like an angry wasp in a tin can when I turn it up..." A common misconception unfortunately, particularly amongst the public at large, is that the idea and concept of a CE mark is in some way an indicator of product quality and performance. It is though, anything but. So what is the mark, and where did it emanate? James Eade investigates



Firstly, a little history. Unsurprisingly, being a regulatory control measure, the origins of the CE mark are to be found in Brussels, home of European dictats. Back in 1957, when the Treaty of Rome was being signed by the member states of the fledgling EEC, it meant that (amongst other things) all those members must agree to work towards and promote free trade within the European Community, which is a great idea, but appreciably difficult to implement. In order to affect this, one of the aims was for countries to discard their own regulations and standards in a number of areas from technology to foods, and adopt a set of harmonised European versions instead. 'Wouldn't it be a good idea,' thought Brussels, 'if we harmonise all the laws to do with product safety so that manufacturers can export products within the EU without barriers?'

Such an idea though – while a good one – is a slow and evolving process and one area that received early attention was that of product safety – and by 'products' it means pretty much anything electrical or mechanical and is thus quite broad. And so it came to be, in the early seventies with the issuing of Directives, particularly the Low Voltage and Machinery Directives which required manufacturers to comply with a minimum level of safety. The only problem was that there was no way of promoting the fact that a particular piece of equipment did conform – end customers had no idea whether the manufacturer had taken reasonable steps to ensure that their products were safe or not. And so in the early nineties, the Directives were revamped to become 'New Approach Directives' which made it all better; at least, that's what Brussels hoped.

Along with the New Approach Directives came the concept of an equipment label that would demonstrate a manufacturer had taken all possible steps to ensure that their product met the requirements of the relevant Directive in question. The actual marking is the letters 'CE' which are an abbreviation of the French phrase 'Conformite Europeene'. Initially, the phrase was 'CE Mark', however 'CE Marking' was legislated as its replacement in 1993, which no doubt took a lot of debating time and effort!

Now, those who may manufacture products that don't fall under any of the directives listed will be pleased to know they have not been left out - all other consumer products are subject to the requirements of the General Product Safety Directive 92/59/EC, which does not require the CE-mark. So, CE marking or otherwise, it is difficult to escape the safety directives in their various guises.

Gaining a CE mark

So, how does one go about gaining a coveted CE mark for your product? Theoretically, it's as easy as 1-2-3. In fact, it's even easier; all you (as the importer/manufacturer/authorised representative) have to do is buy some nice sticky CE labels from RS or the like, and slap them on your product. Or, if you're too lazy to go down that road, all you have to do is scribble 'CE' in the appropriate proportions on the packaging or just print it in the manual. And that, unfortunately, is a correctly CE marked device, suitable for sale throughout the EU.

However, such a cowboy attitude will probably end up with you resting on your spurs, and quite rightly too. As soon as you are requested for a copy of said products' 'Certificate of Conformity' by the consumer (an increasingly common occurrence) or an inspector comes knocking to see your 'Technical File' after your 'Widget Amplifier' (mk1) set fire to Jo Bloggs' curtains, then you will find yourself in rather a lot of deep trouble. In the case of the Low Voltage Directive for example, individuals and/or companies can face prosecutions, heavy fines, enforced recall as well as being banned from selling products inside the EU for falsifying or just not bothering to comply with the Directives. It gets more complicated though, as you can face the same for getting your conformity checks wrong, which is a much, much easier - and often very innocent - mistake. It is also worth pointing out that due diligence and reasonable precautions must be carried out, i.e. you should be able to demonstrate that you have gone out of your way to ensure that products are safe and that there are suitable quality control measures in place.

As mentioned, the principle behind the CE mark is compliance with the relevant Directives. This is achieved by complying in turn with the relevant Harmonised Standards that apply to the particular product or product family, as issued by organisations such as the European Committee for Electrical Standardisation or CENELEC (who's mechanical counterpart is CEN, reflecting ISO). CENELEC issue standards in the following forms:

- *European Standard (EN)* – A complete standard that carries national status in member countries.
- *Harmonized Document (HD)* – The preliminary version of an EN, brought out to allow member countries to introduce a corresponding national standard and withdraw conflicting versions.
- *European pre-standard (ENV)* – Prospective standards used in areas of high innovation or where an urgent need for guidance has come about.

When such standards are published, they become adopted by the member states and are published accordingly – for example in the UK they become BS EN and in Germany they are published as DIN EN.

Taking the example of a computer monitor, compliance with standards EN 60950:2000 'Safety of Information Technology Equipment'; EN 50081-1: 'Electromagnetic Compatibility - Generic Emission Standard Part 1, Residential, commercial and light industry'; and EN 50082-1: 'Electromagnetic Compatibility - Generic Immunity Standard Part 1, Residential, commercial and light industry' could be satisfactory for compliance with the Low Voltage Directive (LVD) and Electro-Magnetic Compatibility Directives (EMC). However, if it had a tuner in it as well, for TV reception then EN 55020 'Sound and television broadcast receivers and associated equipment – Immunity characteristics – limits and methods of measurement' may be more appropriate instead.

Unfortunately there is no definitive list anywhere that says precisely what standards apply to particular equipment – indeed, the person who develops a web based database where for a nominal fee users can type in esoteric names such as 'DI box' or 'audio compressor' and be returned a list of appropriate harmonised standards would be in line for a considerable chunk of cash. This is probably the hardest aspect of compliance, and the easiest area to make a mistake.

The starting point is a document called the 'Official Journal of the European Communities', otherwise known as the OJ. In this is a complete list of current harmonised standards that can be trawled through to find those relevant to the product in question. If you find a product specific standard that covers your widget, all well and good, because compliance with that standard will assume compliance with the relevant directives. However, life is never that simple and it can be hard to find product specific standards – particularly in the entertainment industry for example. There is a fairly tried and tested route to achieving compliance, as follows:

- Ascertain what directive applies to your product (e.g. LVD, EMC, Machinery)
- Search the OJ for a product specific standard, or use a generic one if appropriate (there are several 'catch-all' standards that may apply, such as EN 60950 – Safety requirements for information technology equipment including electrical business equipment). Note also that standards often have 'similar' product coverage e.g. EN 60335 is aimed at domestic appliances such as vacuums or washing machines, but under the 'similar' category covers commercial catering and vending machines.
- If there isn't one that fits the bill, use an International (IEC) standard or failing that a relevant national standard
- Compare your product's performance against the criteria set out in the standard(s).

When the last point is achieved satisfactorily, the hard work is nearly over. Each and every product though must have a 'Technical File', which describes and documents the product. Its purpose is to demonstrate that a product does indeed comply with the relevant Directive, and what steps have been taken to get there. Where an EN standard has not been used, this document will also contain the extra detailed information of tests and inspections that have been carried out in the process of compliance with a Directive. It will also contain information such as conceptual designs, drawings, test reports, instruction and service manuals, lists and explanations of safety critical components, and so on. Unsurprisingly, such a document will run to a good few lever arch files of paper.

The final piece of paper in the Technical File will be the coveted Declaration of Conformity. This document is quite straight forward and simply gives the manufacturers details (or representatives), a description of the product and a list of relevant standards that the product complies with. It also has some poor mug's signature at the bottom, and should it all go pear shaped, that individual is personally liable and could face a prison sentence. Once that is all complete, the manufacturer can safely stick a CE mark on the product.

Farm it out

While this article gives a very brief overview of the process (and is not to be used as a manual!) it can be seen that it is quite an involved job complying with the Directives. Those responsible for CE marking a product should seek assistance where they are unsure – many trade associations have departments specifically to help their members in such matters. There are of course 'National Certification Bodies' such as the British Standards Institute (BSI), VDE in Germany or the British Electrotechnical Approvals Board (BEAB) that will perform all the relevant tests for you at a fee, and is the preferred option owing to their skill and knowledge in these areas. Testing by such bodies also allows a manufacturer to affix other relevant marks to the product, such as the BSI kite mark.

There are also independent UKAS (United Kingdom Accreditation Service) inspected labs that can offer the service, such as ETL, ERA or TÜV. They will perform the tests to the appropriate Harmonized Standards and the issued test report is used for inclusion in the Technical File. Or, if a manufacturer is particularly large, they can perform testing in-house using calibrated test equipment and trained personnel.

If external testing is chosen though, it is worth bearing in mind that some of the more esoteric pieces of equipment encountered may be confusing to a test house – in the realms of theatrical lighting one can't expect them to know what a Big Ben is for, or a gobo rotator for example. Accordingly, it is definitely worth reading up on the subject and doing one's own research to ensure that products are not tested under the wrong banner – which has happened before now. The buck stops with the manufacturer, not the test house.

A list of relevant Directives based on the principles of the New Approach and which provide for CE marking are below. The list is not exhaustive (there are about 20 in total), but some concerned with other areas such as medical and pressure vessels have been left out.

- Council Directive 73/23/EEC of 19 February 1973 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits 73/23/EEC (Amendment 93/68/EEC). **(The Low Voltage Directive)**
- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products 89/106/EEC (Amendments 93/68/EEC) **(The Construction Directive)**
- Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility 89/336/EEC (Amendments 92/31/EEC and 93/68/EEC) **(The EMC Directive)**
- Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery 98/37/EC (Amendments 98/79/EC) **(The Machinery Directive)**
- Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity 1999/5/EC **(The RTTE Directive)**

More information on CE marking can be gained from the website **www.newapproach.org** and the Official Journal can be found at **http://europa.eu.int/eur-lex/en/oj/**

Boolean castles in the air

IBM 'stretch'

"...In next month's *EW* I hope the editor will let me tell you more..."

Ivor Catt, *Letter to the Editor, EW* June 2004, p56 – he has

First I will give a cameo to illustrate how difficult innovation is, in an attempt to get back to the kind of ambience that would have existed during earlier eras, leading to today's multiple dysfunction in high technology.

Cameo

Sir Clive Sinclair set up a company, Anamartic, to develop my Wafer Scale Integration invention, 'Catt Spiral'. It had previously been developed by UNISYS in Scotland, whose chief engineer told me he used hijacked money without the permission of UNISYS HQ in the USA. Then he moved to do the same work for Sinclair. Even though he had been a maverick, he thought it important that I should not be well informed as to the detail of the work being done to develop my invention. One day I gave him the slip, and came across a machine which could do "stitch bonding" across the face of a wafer. The engineer told me about its yield (reliability). This led later to my next invention, Kernel, which obsoleted Catt Spiral. The company, which had fired me, hired me back because of Kernel. This shows how important they thought it was.

Without reliable enough stitch, it was impossible to deliver both the electrical current needed for distributed processing across a wafer, and the global 100Mb serial data streams needed. The electrical resistance of the conventional Al conductors on a chip surface was too great. Decades before bonding, I had solved the obverse problem of heat extraction using on-chip liquid cooling.

We can map this separation onto the situation in Bletchley and later Manchester, where there was an apartheid between mathematicians and engineers. This would have made it impossible for cryptographers like Turin, however brilliant, to contribute to the development of the general purpose computer, which was engineering hardware. The article by Lee Sallows, *A curious new result in switching theory* in *EW* May 2004, p32, prompted me to expostulate about logic design, the field that earned me my salary for decades. My article in *EW* in June 2003 is a cry over the unwarranted limit placed on computing power by allowing only one processor per machine. Now, in the case of Sallows, we can see a restriction at a much more basic level, similarly due to temporary historical engineering tradeoffs which were thought to have permanent significance.

In 1959, when I graduated in Engineering from Cambridge University, the head-hunters from Ferranti encouraged me to try working in the new digital computer industry. I joined the late Gordon Scarrott's labs in Ferranti Manchester, which was tied to Manchester University. The other important computer place was Elliot Bros., Borehamwood, which was tied to Cambridge University. Nowhere else mattered.

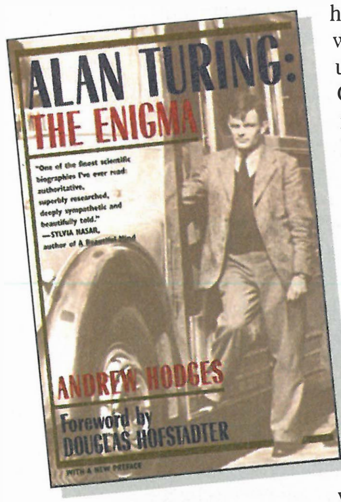
The Ferranti/Manchester team beat Cambridge, because the structure of their linkage between industry and university was better than the Cambridge structure. Apparently, in the Cambridge case, the university remained too much in control, which stunted them. The Ferranti/Manchester Atlas computer sold for a couple of million pounds, and competed with the big fast IBM machine, which was officially called 'Stretch'. Its name boasted that all its technologies had been stretched to their limit. When it failed to function, we called it 'Twang', and the world market came to our Atlas.

I did not hear the name 'Turing' until decades later, yet I now read that Alan Turing worked at Ferranti/Manchester University until he killed himself in 1954. His name was not on any of the documents I read and used, even though I did some of the design for the Ferranti Atlas. Why was there never any mention of Turing if, as we now persistently read, Turing was the genius who made massive contribution to our work designing and building computers? We did have a 'resident genius', but his nickname was 'Yanto', E T Warburton, not Turing. I never even heard of the 'Turing Machine' until decades later, though I worked in the Ferranti labs for three years. This is a useful sidelight on the bizarre schism down the middle of the subject called 'logic', or 'logic design'.

When you do a Google search for Turing + logic, you end up reading about Oxford Logic, about which more later. If Turing was the brains behind my work, but I find Oxford logicians name-dropping him, did Turing have a foot in both camps? The answer is probably that he had a foot in neither, but, like my hero T E Lawrence, his history has to be falsely rewritten now for PC reasons which will be obvious to you.

Alan Turing

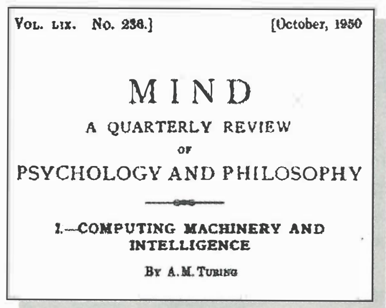
The last paragraph is explained by my journey into the past while writing this article. In a letter dated 26 October 1948 the Ministry of Supply placed an order with Ferranti Ltd. "to construct an electronic calculating machine to the instructions of Professor F. C. Williams." The line between "mathematicians" and "engineers" was demarcated very clearly, and if not quite an Iron Curtain, it was a barrier as awkward as the MacMahon Act. This would never be Alan Turing's machine. This explains both why I never heard of Turing the mathematician, and also why we can ignore Turing when tracing the history of the development of logic gates. He had no access to those who were developing computer logic design. This also explains something I never before understood, which is why, when I arrived from Cambridge, I was met with such hostility by the engineers. By ignoring the fact that my degree was in engineering, and that the Cambridge physicist Ken Johnson was already there out-performing them, they would have feared that I was yet another unpractical Cambridge mathematician like Turing trying to do engineering design. It also explains why they reversed the deflection plates on Ken Johnson's oscilloscope, and were gleeful when it took him a week to find out what was wrong. The autumn of 1949 saw Alan's only titbit of hardware design for a Ferranti machine. His own electronic knowledge stopped short of the necessary practical detail.



In 1959, when I started doing logic design for the Ferranti Sirius Computer, I asked my boss, the late Charlie Portman, what books I should read. He replied that there were none. He said we were doing something totally new. So much for the influence of 'Oxford Logic', an academic discipline which had a pedigree of centuries. Stargazers tell me that Sirius is a dog's leg. Our Sirius was the size and shape of an upright piano. Total main memory was 40,000 bits, so software was minimal. This article's text would just about fill our memory. We had an assembler from Machine Code into Assembler, which would then be printed onto punched tape, to be used as input when the programme was run. We had no (real time) interpreter. A cabinet with three times more add-on memory cost what I would earn in ten years. One logic gate cost £5, half a week's pay. I did some of the logic design, including the 'Divide' instruction, which we added to entice the reluctant customer to our £25,000 machine. Start with Dividend and Divider, and end with Quotient and Remainder. I did 'divide' by successive subtraction. Take the divider away again and again until what is left of the Dividend changes sign. Add one Divider back, and subtract one from the count of how many times, which becomes the Quotient. What is then left of the Dividend is the Remainder. You might think it sad that, correctly, nobody told me to look into what I call 'Oxford Logic'. I have never, ever, found useful overlap between Oxford Logic and my decades of salaried work doing logic design of digital systems.

All oranges are purple. It is purple. Therefore it is an orange. True of false?

When I do a Google search for Logic + implication , which latter is the only "function" that I remember from their world, I find hits for Turing! When I do a Google search for Turing + Boole, I get the book, *The Universal Computer: The Road from Leibniz to Turing* by Martin Davis.



Vol. lix. No. 236.] [October, 1950

MIND

A QUARTERLY REVIEW OF PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

What is "The Universal Computer"? Is it our kind of computer, or some confection of Oxford Logic? Mark Johnson, reviewing the book, writes:

"The first major advance came when George Boole developed an algebra of logic. His system was able to capture a fair amount of what might be called everyday reasoning, but it still had limitations. Gottlob Frege was able to address these limitations, and in so doing, created essentially the system of first-order logic which we use today."

I have never heard of "first-order logic", although I designed computer systems for decades. "First-order logic which we use today"! Who uses it? So Turing is behind first order logic etc., and Turing is the genius behind the digital computers I helped to design. And I never heard of Turing until years later, and I never heard of "first order logic" until today.

Mark Johnson ends:

"Read this book. Have your friends read it. And remember both the logicians and the engineers the next time you boot up your universal computer."

Does he mean logic designers like me who designed your computer, or the Oxford logicians who bend the brains of their students?

I outline the nature of Oxford Logic as follows:

All oranges are purple.
It is purple.
Therefore it is an orange.
True of false?

Since I usually earned my living doing logic design, or teaching it to students, my mind resists going through more than half a page of their stuff. Do the students who get sucked into their logic then run away, and become pinstripes in the City earning fat salary trading currencies? Or do they go on to teach younger victims about purple oranges? Arnold Lynch says that Colossus was not a computer, and it lacked memory. He also says that Turing was involved with a simpler machine and had nothing to do with Colossus.

I have concluded that since even in my time there was virtually no software in our computers because of the cost of memory, it followed that up until then, although mathematicians might have done brilliant work using their primitive computers, they would not have been able to influence computer hardware. In much the same way, however brilliant I proved in my use of a hand calculator in 1980, I would not have had much influence on its design, particularly if I had little knowledge of its engineering. Last week, Arnold Lynch said that in the case of cracking German codes with Colossus, 80 or 90% of the challenge was in the hardware design and construction. Turing, who Arnold says was probably the best mathematician at Bletchley, could only have influenced the other 10 or 20%, that is, developing procedures to solve problems using any available computing machines. Colossus was specified by Max Newman, who had Turing as a student in Cambridge. Arnold says that Bletchley rejected Colossus because of their lack of technical knowledge about valve reliability, and it was built by Flowers at Dollis Hill after its rejection by Bletchley. Here we see that lack of technical knowledge caused mathematician/cryptographers to obstruct architectural advance even towards special purpose computer systems dedicated to their own problem. As with stitch bonding, state of the art technical knowledge is indispensable, even for apparently special purpose machines, let alone general purpose.

When writing his article in *EW* May 2004, Sallows enters a murky world where political correctness has encouraged much rewriting of history, aided by the heavy secrecy surrounding Bletchley Park. However, even without the present urge to erase any achievements by white heterosexual males from history, he would have been misled. Sallows' "remarkably simple, highly intriguing, probably useless, but undeniably fundamental new result in switching theory" is to get two inverters, aided by numerous other Boolean logic gates, to perform the function of three inverters. Perhaps this challenge derives from the era when the transistor inverted, and the transistor was expensive. In contrast, I am concerned about very useful but suppressed aspects of logic design which Sallows tends to obscure even more. The reason is that Boolean functions are not fundamental, as I showed in my article published in February 1968, see **www.ivorcatt.com/47.htm**, where I prove that the basic set of logic functions with one or two inputs totals four, the Inverter, the AND, the OR and the Exclusive-OR. Starting with a gate with one input, we find that one type only, the Inverter, is possible. Moving on to gates with two inputs where the inputs are treated the same, I show that the three basic gates are AND, OR and Exclusive-OR. All other possibilities are the inverse of my three, plus output stuck at 0 and output stuck at 1.

Lacking the Exclusive-OR, nothing which builds on Boole can be fundamental. This is not the fault of Boole, who intellectualised about his kind of logic in 1850, not about the basics of the digital electronic computer in 1950 and 2000. Even in his own period he was at fault for missing the Exclusive OR, but not seriously so considering his objective, to clarify reasoning. In stark contrast, our billion-dollar industry wants to serve humankind without subjecting them to intellectual activity. The computer designer wants to get the hole in the wall to deliver cash to you aided by minimal thought and action from you, and without your having to consider the nature of Truth, which is irrelevant.

Truth as a semantic concept. I should like to propose the name "the semantic conception of truth" for the conception of truth which has just been discussed.

Computer science did not emerge into view as a separate discipline from a cluster of related topics. Logic design emerged as part of digital hardware design when engineers strove to build practical machines. They came to think that short-term engineering convenience was based on fundamentals which for a time happened to reinforce the gap in Boole's set of logic functions.

I have checked back to find that circuitry was so expensive and small in number that machines like Colossus had virtually no logic design content. A few years later on, mechanical relays could most easily implement AND, OR and INVERT. The next generation of logic, using resistors and very expensive triodes, later expensive transistors, could most economically implement AND, OR, INVERT. The Exclusive OR remained more expensive to build.

Although I went on a training course to programme the last machine to use triodes, the Ferranti Pegasus, I did virtually no logic design with valves, beyond a three bit counter. My main logic design began with discrete diodes and transistors. A transistor cost £2, about a day's pay, while a diode was much cheaper at seven shillings. The ruling logic gate used a bank of diodes for AND or OR, and a restandardising transistor which insisted on inverting while doing so. This series of accidents caused the incompleteness of Boole's set to be overlooked. The Exclusive OR required two transistors, and so was ruled it out of the set for reasons of cost.

By 1965, the cost of transistors had fallen enough to justify building the exclusive OR, but virtually nobody did. Its design relied on the fact that in order to conduct, a transistor's emitter and base must be at different voltages. One transistor would conduct for A and NOT B, while the other transistor would conduct for B and NOT A. Collector OR-ing gave the complete Exclusive OR. Only one person, the logic board designer in Data Products Corp., Culver City, noticed the engineering opportunity. I found it very useful, and this helped me to escape from the conceptual trap everyone had fallen into, starting with Boole and deepening because of short-term engineering tradeoffs with relays and valves.

Oxford Logic

I went to see my co-author Dr Arnold Lynch this week and audiotaped him for two hours on his design work on the Bletchley Park Colossus, which Lynch said was not a computer and had no memory. Ninety years old on June 2, 2004, he is one of only two survivors from those who helped to design and build the machine, see Electronics World, June 2004, page 16. There were "need to know" secrecy barriers within the design team, but after the war, Lynch heard a lecture by the key designer, Thomas H. Flowers. Flowers said there was no mathematical symbolism in the matter of the machine's logic, whereupon Lynch suggested to him that he read Tarski, not knowing that Tarski was "Oxford Logic" (purple oranges). A single quote from Tarski will suffice:

Truth as a semantic concept.
I should like to propose the name "the semantic conception of truth" for the conception of truth which has just been discussed.

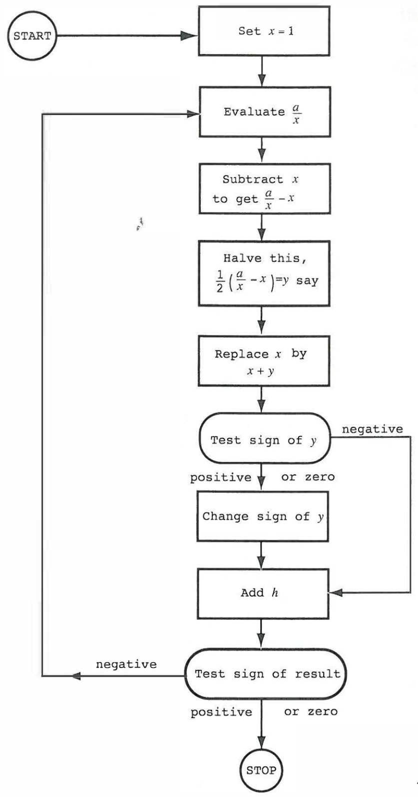
As my web pages show, my colleague Theocharis and I are very concerned about Truth, as his article in Nature proves. Our concerns do not map onto Oxford Logic. Further, both are orthogonal to my decades of work designing computers, where true and false are given, and never questioned. Tarski and Oxford Logic, and also my own concerns about Truth, have no place in digital computer hardware as it developed, and as it is today. My own suppressed article on Truth, and also Theocharis, can be found on my websites.

In your local bookstore, you can pay £40 for a book on Oxford Logic written by an Oxford Professor in 2002, presumably used as text in college courses on "Logic" to unsuspecting student victims. This will not give them access to the multi-billion dollar industry, digital hardware, that my culture spawned, but which has admittedly now been driven abroad. After reading half a page of Oxford Logic, my head is spinning, and I stop. Oxford students must be chastened, deeply impressed by the Tarski tribe standing between them and their degree.

When I was Principal Lecturer in West Herts College and a member of the County Syllabus Committee, I tried hard to get rid of magnetic core memory from our Computer Hardware courses because I knew it had been obsolete for a quarter of a century. I failed, because all the other lecturers, although junior to me in status, succeeded in stopping me from removing what little they knew from the syllabus.

Oxford Logic has no relevance to the hardware behaving the way you want when you dialogue for money with a hole in the wall. My co-author David Walton, who later specialised in problems with large, complex arrays of software, may argue that it then has relevance, but that came much later when the cost of memory had fallen and made complex software possible.

Sources for this article can be found at www.ivorcatt.com/47.htm



A process for evaluating √a (x is the result) from the Ferranti Pegasus programming manual 1962

NEW PRODUCTS

Please quote *Electronics World* when seeking further information

New family of Pentium M processor boards

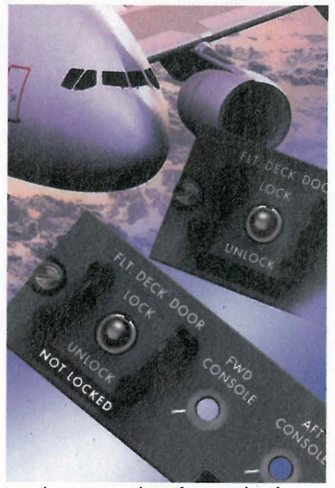
Concurrent Technologies and Thales Computers have undertaken joint development of a new family of Pentium M based VME processor boards available in commercial, extended-temperature and rugged versions. Under the agreement, concurrent Technologies will be responsible of the design and manufacture of the commercial product lines, and Thales Computers will be responsible for the design and manufacture of the extended and rugged products. Both companies will sell all versions under a cross-distribution agreement. This brings to the market a product family that will meet the needs of customers whether they are involved in commercial or defense oriented products. Customers will be able to start development with commercial versions and progress to the rugged versions, safe in the knowledge that their software can transfer seamlessly from one version to the other.

the first commercial products are due for release during Q2, 2004, and the rugged products will be available later this year.

Concurrent Technologies
www.gocct.com
Thales Computers
www.thalescomputers.com

New flight-deck security panel

A range of flight-deck security panels incorporating an integral sunlight-readable annunciator ensures flight crews are always able to see when a cockpit door is unlocked regardless of the prevailing lighting conditions Designed as a front end for flight-deck access control systems in commercial aircraft, the new panel utilises high-brightness LEDs for illuminating the annunciator and conventional filament lamps for the rest of the panel legends. The annunciator's 'secret till lit' legend remains hidden until illuminated by the LEDs, and at night the panel's integral auto-dimming sensor reduces the light output from the LEDs to an appropriate level. The annunciator remains operational even in the unlikely event of an LED failure.



Paramount Panels (UK)
www.paramountpanels.com

Amalgamation of established component manufacturers

Microponents Ltd and Micro Metallic Ltd, well established manufacturers of high precision components for automotive, communications, aerospace and high tech engineering applications have amalgamated to become Precision Micro Ltd. This new company has a comprehensive portfolio of manufacturing capabilities, providing photo etching, laser cutting, EDM, electroforming, precision stamping, forming and finishing and will meet customers' entire requirements for finished components from a single source.

the combination of manufacturing technologies enables Precision Micro to work with a selection of materials including ferrous and non-ferrous metals and alloys, plastics, composites and even wood in 10μ to 16mm thickness and to tolerances measured in microns.

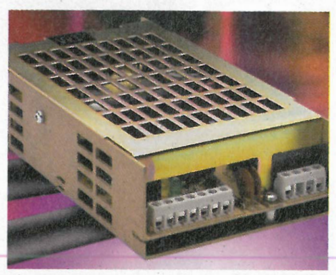
Precision Micro Ltd
www.precisionmicro.com

Gedae software development chosen by Lockhead Martin

Gedae, a software development productivity tool has been chosen by Lockheed martin for the Non Line-of-sight – Launch system (NLOS-LS) program. After the system software functionality has been developed and verified on a workstation, Gedae implements the application by generating an application targeted to specific embedded multiprocessor and embedded hardware. Gedae applies over 100 logarithms to achieve the implementation. the result rivals hand-coded efficiency and quality but with dramatically less development effort. the versatility of the tool makes it available for all aspects of development including signal and data processing, application control and integration with other systems. Gedae addresses the complete problem ad so avoids complex and costly interfaces between tools and the inefficiencies o mixed development methodologies. it improves productivity by more that 5x greatly reducing schedules and development and life cycle costs.

Gedae Inc
www.gedae.com

New entry-level 45W battery-charger PSU



Lincoln based manufacturer VxI Power has launched an entry-level 45W switch-mode power supply unit, ideal for use as a battery charger in cost-sensitive fire-panel applications. Known as Oracle II-45, this PSU satisfies the minimum requirements of the EN54-4 standard for local power supplies used in fire-detection and alarm systems. Operating from a universal 90 to 260V AC input, the power supply comes in 12V and 24V versions, providing one main output and one battery-charge output. For maximum flexibility, the total output current can be apportioned between the two outputs to suit individual requirements. Oracle II-45 features temperature-compensated charging to ensure maximum battery capacity at low temperatures and maximum battery life at high temperatures. Independent current-limited charging protects the system against faulty batteries and ensures that the main output can function immediately on reconnection of the mains supply after a failure, regardless of the state of charge of the battery. As well as being EN54-4 compliant, the power supply also meets the requirements of the EN60950 safety standard and all relevant European EMC standards.

VxI Power Ltd,
www.vxipower.com

Please quote *Electronics World* when seeking further information

Electronic enclosures range

Electronic enclosures available from HellermannTyton now range from panel instrument cases through small cases suitable for bench top use and wall mounting cabinets for Local Area Networking applications to a comprehensive range of floor mounting 19inch rack systems.

The range of bench cases provide an aesthetically modem yet functional housing with a number of innovative design features. Force ventilated and RFI shielded versions are also available.

A recently launched wall mounting cabinet, the 'VARI 2000' is available in 3U, 4U, 6U and 12U sizes featuring 19 inch mountings in the vertical plane to give a space saving design. A two piece combination door on the larger sizes means that the cabinet can be mounted in a recess or in the comer of a room yet still provide full access for cabling and maintenance. The floor mounting enclosure range fulfils all installation requirements from single stand alone units to multiple cubicle suites.

Details are given in the company's 180 page catalogue available on request, or on its website.

HellermannTyton
www.hellermanntyton.co.uk

Handheld base station tester to support EDGE

NetTek Base analyser is the only base station to offer a toolbox feature set. This addition enables Global Systems for Mobile Communication (GSM) operators to meet the new measurement requirements presented on deployed EDGE (Enhanced Data Rates for Global Evaluation) networks. EDGE does not require a 3G license, and utilises the existing frame structures and carrier bandwidths from GSM networks. Once the EDGE network is deployed operators must ensure tat is is successfully maintained in order o retain and increase mobile subscribers and achieve return on investment. Tektronix has added EDGE support to its proven handheld NetTek analyser's portfolio of daily maintenance measurement capabilities. Tektronix is the first manufacturer to offer EDGE measurements in a handheld toolbox form factor. the instrument's window based user interface simplifies operation and minimises training needs. the compact battery-powered tool, which weighs just over 4kg is lightweight ad rugged for transport to remote sites.

Tektronix Inc
www.tektronix.com

New gentic algorithm and direct search toobox for MATLAB

Engineers and scientists are constantly looking for approaches to find optimal solutions, perform trade-off analysis, balance multiple design alternatives and quickly incorporate optimization methods in their algorithms and models. the Gentick Algorithm and Direct Search toolbox helps them achieve their goals by making optimization technology more accessible through graphical user interfaces and structured command line tools.

The MathWorks continues to expand the range of problems MATLAB can address. The toolbox serves as a central access point for the tools required to use genetic and direct search algorithms. Users can learn from and build customised optimization routines as needed.

The Genetic algorithm and direct Search toolbox requires MATLAB and the Optimization Toolbox and is available immediately for Windows, UNIX/Linux and Macintosh systems.

MathWorks
www.mathworks.com

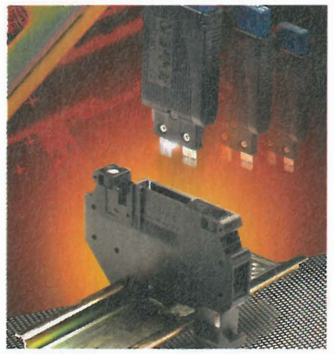
Handheld oscilloscopes gain enhanced analysis power

Fluke has announced new enhancements to its dual-input ScopeMeter 190 Series of hand-held oscilloscopes increasing their power to analyse signals. Idal for engineers working n service and engineering applications they now offer increased waveform resolution providing even greter signal detail to help uncover anomalies and also include Frequency Spectrum Analysis using Fast Fourier Transformation (FFT) analysis as a standard fe ture. With safety c ertifica ion to 1,00V CAT II and 600V CAT III users can safely solve virtually all electronics mea urement problems encountered out in the field. The battery-powered oscilloscope offers up to 200MHz bandwidth and 2.5GS/s real time sampling rates, the speed, performance and analysis power usually found only on high-end bench oscilloscopes. Bandwidths st at 60MHz for the entry level 2B. The waveform me ies on all models have increased by 150% allowi many as 3000 samples per channel to be acquired. The high-resolution can be transferred to a PC running optional FlukeView ScopeMeter software for dicumenting, archiving and analysis. All ScopeMeter models have a large 320x240 pixel display, a fast display update rate, up to 1000V independently floating isolated inputs, a facility for measurement of effective output voltaages of variable speed motor drives and frequency inverters and a 5000 counts true-rms multimeter function. A free Fluke Scope Training CD contains self-paced oscilloscope training modules, one set based on general oscilloscope theory, the second eplains best practice in the use of Fluke ScopeMeters.

Fluke
www.fluke.co.uk

Please quote *Electronics World* when seeking further information

New circuit breakers improve reliability



Aerco is now stocking the ETA range of DIN rail circuit breakers. The ETA 1180 series is designed to plug into industry standard terminal blocks and replace glass fuses commonly used in DIN rail terminal-block applications with the advantages that circuit breakers eliminate replacement time and do not experience age degradation. They are 'hot-swoppable' and can also be used as an off/on switch to provide safe shutdown during equipment maintenance. The 1180 series avoids nuisance tripping during harmless short-term surges such as in-rush current associated with motor start-up, therefore a fuse can be replaced by a 1180 circuit breaker of lower current rating thus increasing the level of overload protection for devices that control factory equipment such as assembly line, robots, heaters and machine presses. Designed for voltages up to 250V AC or 65V DC the ETA 1180 series is available in current ratings ranging from 0.1A to 10A.

Aerco
www.aerco.co.uk

D-Sub filtered connector range supported by adaptor kit

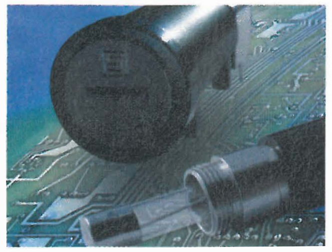
Harting has upgraded its range of D-Sub filtered connectors and has introduced an evaluation kit that allows users to select the optimum filter to meet their RFI suppression requirements. the

kit includes 32 adaptors providing a range of filter characteristics to cover most scenarios. Selecting thee optimum filter is simply a matter of plugging in various adaptors and viewing the filtered and unfiltered signals on an oscilloscope. Internal surface-mount circuitry is used to provide a variety of functions. The connector design allows segregation of the filtering for each contact and enables filters of different types to be incorporated to provide an optimum solution.

The D-sub filer connector family includes standard male/female, soldercup/straight/right-angle devices with 9, 15, 25, or 37 pins, plus a large range of accessories.

Harting Ltd
www.harting.com

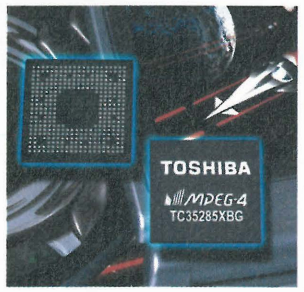
Safety across the board



For equipment designers seeking to optimise safety and reliability, Schurter has announced an extension to the FUP series of fuseholders aimed at applications including primary circuit protection of household appliances and telecomms equipment. Its high current capability makes the FUP fuseholder suitable for use in industrial power electronics equipment including programmable controllers, heating and air conditioning systems and explosion proof equipment.

Schurter Electronics Equipment
www.schurter.com

New MPEG-4 chip integrates 3D Graphics



Toshiba has announced te launch of a powerful MPEG-4 encoder and decoder LSI that brings video-game-grade 3D graphics to cellular phones. the latest addition to Toshiba's T series , T4G (part no. TC35285XBG) supports fast rendering of graphics including advanced shading, texture mapping, and special effects enabling high resolution 3D graphics for mobile phones, matching those of current game consoles. The T4, predecessor to T4G is already in use in the latest phone on the Japanese market. the launch of T4G with its 3D graphics processor goes even further meeting requirements for high level performance in compact design.

Toshiba electronics europe
www.toshiba-europe.com

A low-cost special requirement test cable, Sta-Put features an armour jacket that retains its shape after bending enabling engineers to position the device under test (DUT) where it is most convenient. Two or more cables can be used to suspend the DUT in air, making it ideal for bench setups and field support. Designed to provide near zero force connector loading on the test bed, the cable can be bent and reshaped an unlimited number of times. Shielding is specified at greater than 60dB.

Smiths Interconnect – Florida RF Labs
www.rflabs.com

A new website from Sensortechnics details a contact page which lists all of SensorTechnics technical contacts worldwide.
www.sensortechnics.com

CD from National Instruments

Engineers can now use the new National Instruments Measurement and Control Designer 2004 CD to quickly select the best software and hardware for test, measurement and industrial control applications, saving time and resources in configuring and developing systems. The CD includes hundreds of resources and tools to reduce setup time and costs.

National Instruments
www.ni.com/uk

CIRCUIT IDEAS

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

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

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

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

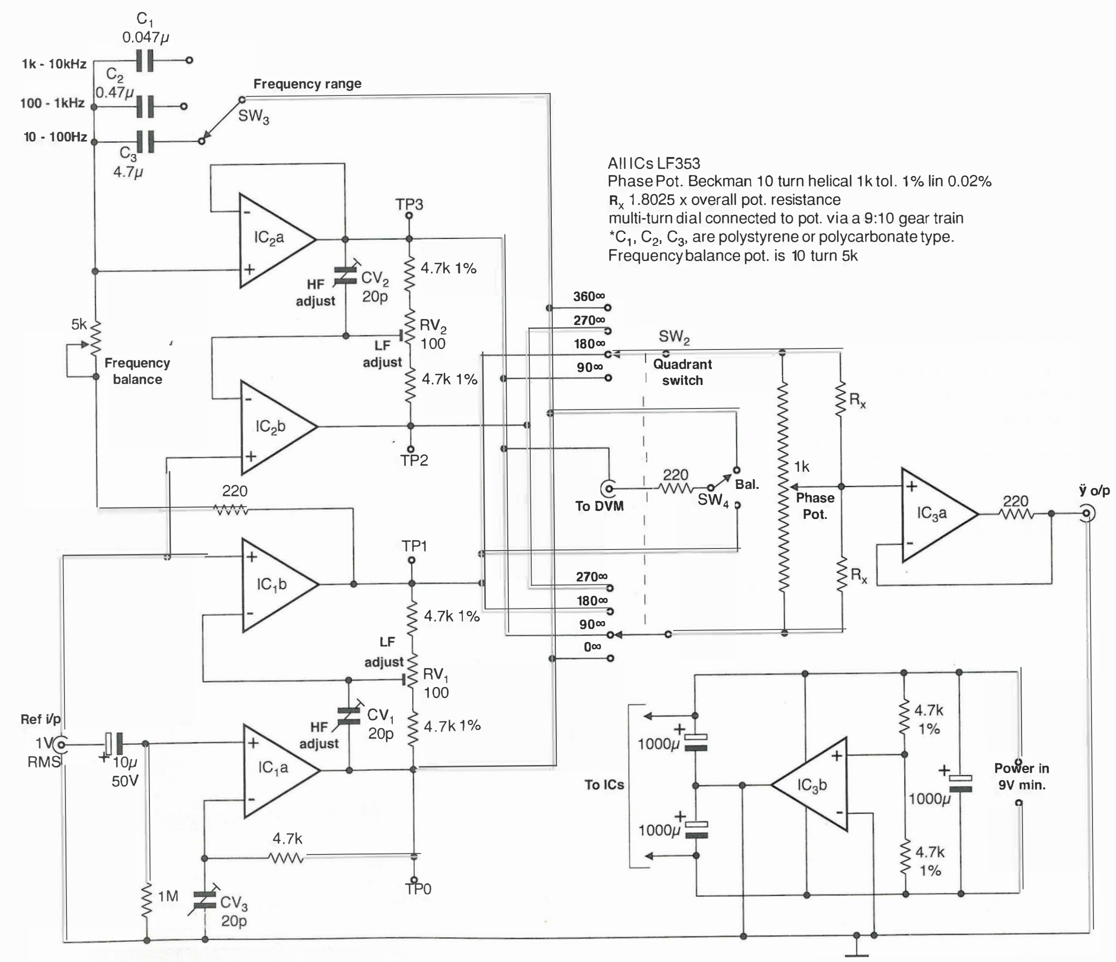
Clear hand-written notes on paper are a minimum requirement: disks with separate drawing and text files in a popular form are best – but please label the disk clearly. Where software or files are available from us, please email Caroline Fisher with the circuit idea name as the subject.

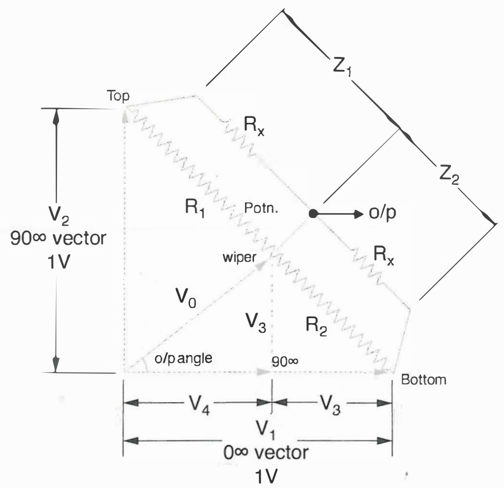
Send your ideas to: Phil Reed, Highbury Business Communications, Nexus House, Azalea Drive, Swanley, Kent, BR8 8HU *email ewcircuit@highburybiz.com*

A collection of non-inverting logic translators

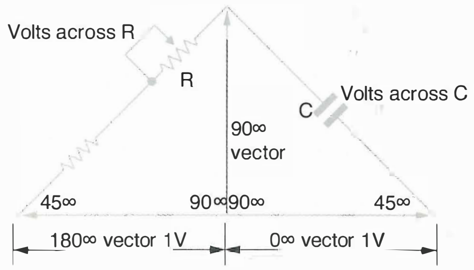
Many designers seem to be unaware of the possibility to build voltage translators using only a single-stage. You only have to look at the schematic of a VCR for instance, to realise that whenever such a function is needed, as in the Vacuum Fluorescent Display drive section for example, two common-emitter stages are generally cascaded. Although this may be justified in some cases, when a high source-current is required, it is most of the time totally superfluous.

The key to avoiding this wasteful double-inversion is to use a common-base (or gate) configuration. Of course, the current gain is reduced to unity, but in most cases, low-voltage





Linear phase shifter potentiometer assembly read in conjunction with calculation of phase



90∞ generation

logic families, such as TTL, tend to have a healthy low-level output capability and do not need current boosting.

How is it done in practice? **Figure 1a** shows the basic configuration: the signal to be translated drives the emitter of a general-purpose transistor whose base is held at mid-supply by means of the divider formed by R_1 and R_2; on the collector side, a resistor pulls up the potential to the higher voltage supply. The component values shown are typical and are suitable for general-purpose applications. If VHi exceeds 50V, other types of transistor can be used: the 2N5551 withstands 160V and the BF422, 250V.

In its basic form, this circuit is relatively slow; adding a small capacitor between base and ground can reduce the switching times, and if maximum speed is needed, substitute a HF type for the transistor: a BF494 for example. Note that even with these modifications, the rise time will depend essentially on the load capacitance; if it cannot be reduced, the only way to increase the speed is to decrease R_1, at the expense of the current consumption.

The logic low output voltage of this level shifter will be that of the low-voltage gate plus the saturation voltage of the transistor; in the case of a TTL IC, this amounts to about 600mV. The logic high output voltage is essentially equal to VHi (unloaded of course).

In practice, R_2 can often be omitted; it is certainly the case with CMOS families, thanks to their rail-to-rail swing, but despite their theoretical high level output voltage of only 3V, TTL families also seem to operate satisfactorily under those conditions.

When operation at really high voltages is required, it is preferable to use the circuit of **Figure 1 (b)** rather than simply choose a transistor having a higher breakdown voltage. This circuit has rigidly controlled operating conditions, which provide increased protection against breakdowns; in addition an active load is used instead of a simple resistor: this increases both the speed and the output current with no power penalty.

For applications requiring the lowest low-level output, a Schottky diode must be used between the base and emitter of the upper BUX87; in other cases, a 1N4148 is perfectly adequate. This circuit operates at up to 450V and down to DC and 1000V under pulsed conditions; it is therefore suitable for off-line converters, frequency variators etc.

If a small MOS transistor is substituted for the bipolar type, the base resistors can be eliminated **Figure 1(c)**. The main drawback of this circuit is the relatively large drain capacitance of the MOS leading to slow rise-times as compared with the bipolar version. You also have to make sure that the threshold voltage of the transistor is lower than the supply voltage VLo. This is not likely to be a problem in 5V, but at 3.3V and below, this may be a concern.

The highest performance version is that of **Figure 1d:** not only are the bias resistors unnecessary, but the circuit also benefits from the low capacitance and high speed of the jFET. Interestingly, this circuit is not referenced to the logic supply, but relies on the depletion mode of action of the transistor.

For proper operation, you simply have to ensure that the transistor has a Vp smaller than the supply VLo (at lower supply voltages, you may substitute a BF245A).

Finally, why would you bother to reinvent the wheel? After all, logic translators exist in integrated form and come in many variants. Here are some reasons:

Integrated translators come in packs of 4 or 6; very often, you only need one or two. Even when you can use up the whole package, it may not be practical because the four operators will be needed at the four corners of the board, making the routing of the PCB terribly awkward.

With home-brew translators, you can tailor the circuit to your application: if you change the resistance values from kΩ to MΩ in **Figure 1a**, the circuit operates as before, but at micropower levels. And finally when you have to operate at hundreds of Volts, discretes are the only option.

Louis Vlemincq
Auderghem
Belgium

Simple infrared remote control extender

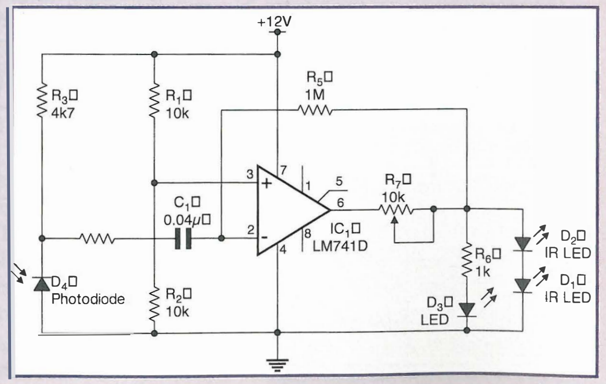
Many electronic equipment like TVs, CDs, etc. use an infrared remote control. Since the range is limited, sometimes the range of the remote control needs to be extended. A circuit diagram presented here is for that purpose.

A photodiode is connected to the inverting input of an op-amp through a resistor R4 and a capacitor C1. The other non-inverting input of an op-amp through a resistor R4 and a capacitor C1. The other non-inverting input is connected between the two resistors R2 and R3 which provides the reference voltage.

The output terminal pin no.6 is connected to the two infrared LEDs through a preset of value 10k. An led is also connected to the output of the op-amp, through a voltage dropping resistor R.5(1k). This LED indicates if the unit is working or not.

VR1 is uses for setting the maximum current output.

Raj K. Gorkhali
Kathmandu
Nepal



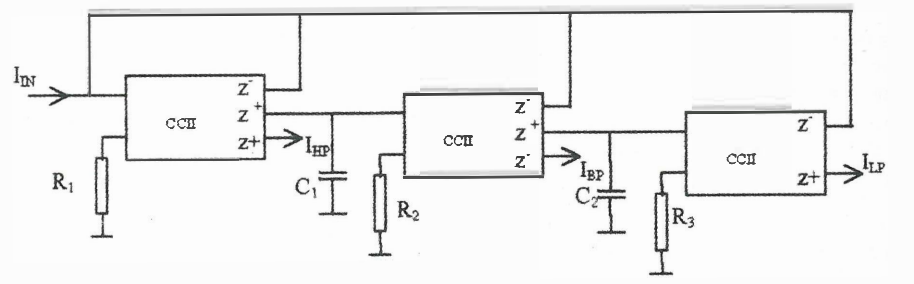
A new current-mode universal filter based on CCIIs

The fad that a second generation Current Conveyor CCII is treated as the standard building block for the construction of continuous-time circuits is attributed to its advantages of having higher signal bandwidth, greater linearity and larger dynamic range than the conventional OTAs and OAs[1]. These novelties have attracted the attention of circuit designers and quite a large number of circuits employing CCIIs have been reported. These circuits use either excessive components or need to change circuit topology to realise additional filtering signals[2,3]. Also in the recently reported architecture[4,5], the capacitor at the x-terminal of the CCII realising the BP filtering function has limited the performance of the filter at high frequencies. It is worth noting that the multiple output active devices are being overwhelmingly used to simulate analogue filters and other structures for their facility of current output sources.

Here we are proposing a canonical Current-Mode universal filter using two CCIIs with three outputs[6], a single DO-CCII, two grounded capacitors and three grounded resistors. The circuit implements all the five generic filtering functions and can implement three basic filtering functions viz. LP, HP, and BP simultaneously. The other responses, namely AP and Notch, can be realised simply by connecting appropriate nodes and for their implementation no change in circuit topology is required as no additional components are needed.

The architecture of the proposed circuit is integrable as it uses grounded capacitors, which are ideal for integration. The grounded resistors can be replaced by OTAs configured as resistors, lending electronic tunability to filter parameters besides making the configuration resistorless, which is highly desirable in IC technology. The sensitivity performance of the circuit is very low which has improved its performance. The circuit offers economy in chip area as it has only one input and three outputs. The proposed circuit, besides overcoming the problems encountered in the circuits, also negotiates most of the advantages of IC construction.

A routine analysis of the circuit in the figure, yields the following current transfer functions:



Proposed CM Universal filter

$$T_{HP} = I_1/I_{IN} = s^2/D(s) \quad (1)$$

$$T_{BP} = I2/I_{IN} = s/C_1R_2/D(s) \quad (2)$$

$$T_{LP} = I3/I_{IN} = 1/C_1C_2R_2R_3/D(s) \quad (3)$$

$$\text{Where. } D(s) = s^2 + s/C_1R_2 + 1/C_1C_2R_2R_3$$

The all-pass response can be obtained by adding the output currents I_1, I_2, and I_3 and is given by

$$T_{AP} = (s_2 - s/C_1R_2 + 1/C_1C_2R_2R_3)/D(s)(4)$$

From equation (4) it is clear that to realise all-pass there is no need of imposing constraints on the elemental values. The notch response is realisable by summing I_1 and I_3 and is given by

$$T_N = (s^2 + 1/C_1C_2R_2R_3)/D(s) \quad (5)$$

The filter performance factors ω_0 and ω_0/Q are given as under

$$\omega_0 = v1/C_1C_2R_2R_3 \quad (6)$$

$$\omega_0/Q = 1/C_1R_2 \quad (7)$$

An inspection of equations (6) and (7) reveals that ω_0/Q can be adjusted by R_2, and can be controlled through R_3 without disturbing ω_0/Q, thereby providing non-interactive tuning feature of filter parameters.

Sensitivities: The active and passive sensitivities are as

$$-S^{\omega 0}{}_{C1,C2,R2,R3} = 0.5; \quad -S^{\omega 0/Q}{}_{CI,R2} = 1$$

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Srinagar India

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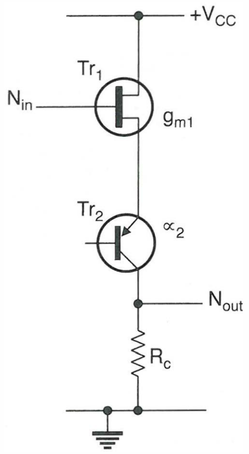
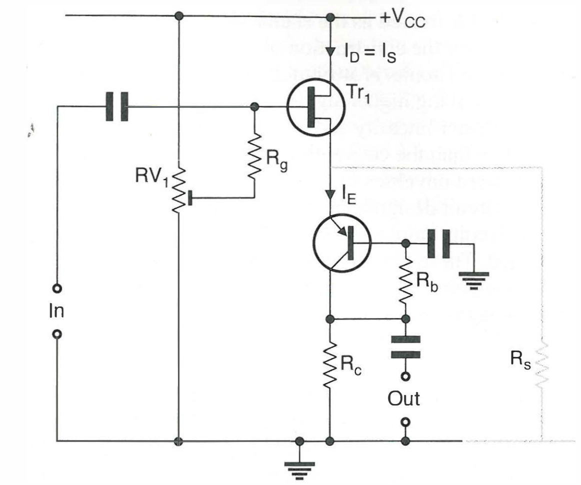
5. Shahram Minaei and Sait Turkoz New current-mode, current controlled universal filter with single-input and three outputs Int. J. Electronics Vol.88, no. 3, pp. 334-337, 2001.
6. Erik Bruun, A combined first- and second-generation current conveyor structure Int. J. Electronics. Vol. 78, no. 5, pp. 911-923, 1995

Complementary Cascode

The circuit shown in **Figure 1a** uses a FET to provide high input impedance and a bipolar transistor to provide gain. With typical devices the output impedance of the FET (=l/gm) is much greater than the input impedance of the bipolar, which here functions in the low-impedance common-base connection. Thus the FET acts as a source of input current for the bipolar. The latter has a current gain of unity, very nearly. Hence the combined stage gain approaches $gm1.R_c$. Both devices function in wide-band modes.

Since the output is in phase with the input, the circuit can be turned into an oscillator by coupling Rc to the gate of the FET. If Rc is replaced by a tuned circuit this sets the frequency. No coil taps or secondary windings are needed and one side of the tuned circuit is earthed. If a resistive load (Rc) is coupled to the gate by a capacitance the result is a relaxation oscillator. In this form the circuit has a long history. In the fifties it appeared in an ancestral form in which the FET was a triode valve and Tr_2 a point-contact transistor.





D.C. conditions

One way of setting-up **Figure 1b** uses a preset potentiometer RV_1 to adjust the gate bias. For the bipolar, R_b (typical value hFE.Rc) is chosen to set the emitter-collector voltage. If Trl is a type whose gate cut-off voltage is a sizable fraction of Vcc it may be possible to dispense with RV_1 return R_g directly to the earth line. Tr_2 then acts like a source bias resistance and R_b sets up the working points for both transistors.

Gain and bandwidth

With practical FETs and supply voltages the bandwidth is large but with resistance loads the voltage gain is modest. An attractive feature is that intermodulation can be kept low by choosing a suitable operating current for Tr_1. Since the bipolar is virtually current-driven its nonlinearity is swamped. Even if Tr_2 operated at a considerably lower current (I_E) than Tr_1 (I_S) this would still be true. Thus if some of Tr_1's source current is bled off via a bypass resistance (R_s) the resulting reduced collector current enables R_c to be increased, so increasing the voltage gain. Bandwidth is reduced by capacitive loading across R_c, but in many practical cases is still adequate. Instead of wasting current, in R_s it can be used **Figure 2** to supply an emitter-follower Tr_3. To minimise bleeding off of signal current from Tr_1, R_d should be several times the input resistance of Tr_2. C_d prevents signal feedback to Tr_1. This three-transistor circuit, which might be called a complementary cascode follower, has the desirable qualities of high input impedance, low output impedance and useful gain. With the circuit values shown V_{cc} = 15V the gain was 26, 3dB down at 700kHz. At the point of clipping output was 10V p-p.

Bipolar complementary cascode

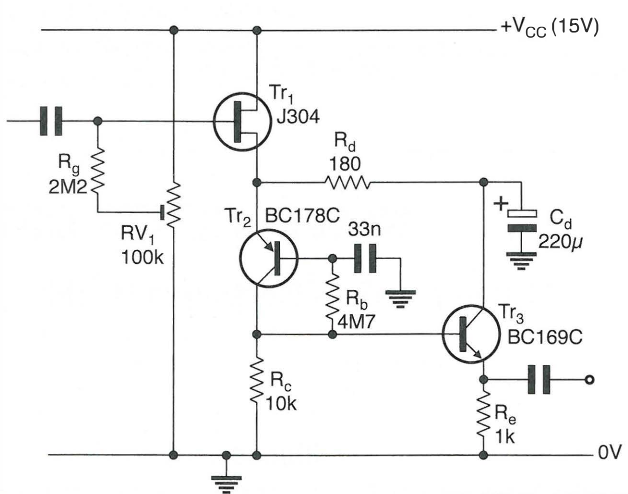
The FET can be replaced by a (suitably biased) NPN transistor. The input resistance is then comparatively low but internal feedback is reduced. The effective mutual conductance is half that of Trl. Connecting a resistance R_{ee} between emitters raises input resistance to roughly hfe1. R_{ee} and reduces the effective mutual conductance to about $1/R_{ee}$. When connected as an LC oscillator **Figure 3** the condition for oscillation is that R_{ee} should be less than the dynamic resistance rd of the LC. By setting R_{ee} just low enough for oscillation R_{ee} is very nearly the same as rd and the circuit can be used to get a reasonably accurate measure of rd. Since rd = ωLQ this enables the circuit Q to be calculated.

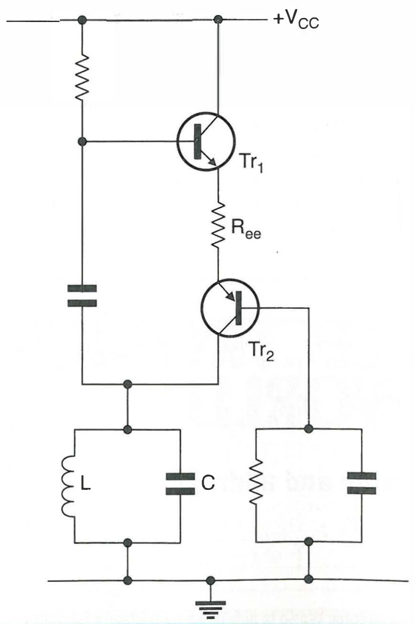
George Short
West Sussex
UK

Figure. 1: Basic cascode follower. Output is in phase with input and gain = gml.R_c.
Practical circuit.

Figure.2: Gain can be increased by reducing the current in Tr_2 and increasing R_c. The surplus source current supplies emitter-follower Tr_3.

Figure.3: Bipolar cascode makes a convenient two-terminal oscillator.





Serial port controls 16 independent output lines

The circuit in **Figure 1** allows a PC to control 16 binary output lines through its RS-232 serial port. A listed Visual Basic program provides a graphic control panel with 16 toggle switch buttons plus a clear button. The user can use a mouse to click any toggle switch button to turn on and off that channel. When a channel turns on, the corresponding button changes colour from grey to red. Click the same button again, the channel turns off and the button colour changes back to grey. 16 buttons work independently. If the clear button is clicked, all channels will turn off at once. **Figure 2** shows all channels off. In **Figure 3**, channel 5 and 12 are on and the others are off.

The RS-232 port has 9 pins. For control point of view, they are defined as in **Table 1**.

The status on pin 1, 6, 8 and 9 can be read directly. For pin 4 and 7, the outputs can be written directly. Pins 3 and 2 are used to send and receive serial communication signals and are therefore not directly controllable. However, pin 3 can send pulses if the corresponding registers are set up properly. The minimum voltage on output pins is between -5V and +5V, normally is between –8 -12V and +8 +12V. Every output can provide at least several mA driving current. The input level is most likely RS-232 and TTL compatible. For example, a common RS-232 driver/receiver (MAX232) uses +1.4V as logic threshold with 0.5V hysteresis to handle slow signals. For this application, only output pins are used.

IC_1 and IC_2 (74HC595) are 8-bit serial-in parallel-out shift registers with output latches. They are connected as a 16-bit shift register. Three signals are required to drive this 16-bit shifter register:

(a) 1-bit serial data signal.
(b) Shift clock and
(c) Latch clock. 16 shift clocks will move data into the register serially.

After that, a latch clock sends all 16-bits to 16 channel output registers simultaneously. When a button on the screen is clicked, the program will update the status of all 16 outputs, send the 16 outputs to IC_1 and IC_2 in serial and then latch them into the parallel outputs of IC_1 and IC_2.

The Visual Basic 6 program uses TX line (pin 3) to generate a latch pulse. RTS line (pin 7) sends out shift clock. The DTR line (pin 4) has two usages. It provides power to IC_1 and IC_2 through D_6, C_1 and C_2, so most of the time it stays high. It is also used to send out 1-bit serial data through D_5. Zener diodes D_1, D_2 and D_5 are used for limit the RS-232 output voltage to +5V.

Since the RS-232 serial output port has limited output current, no current limiting resistors are required.

Yongping Xia
Torrance
California
U.S.A

For the listings mentioned above, please email Caroline Fisher (details page 3) with 'CI 170' in the subject, and she'll send them to you.

Table 1

Pin no	Name	Input/output	Control
1	CD	Input	Direct
2	RX	Input	Indirect
3	TX	Output	Indirect
4	DTR	Output	Direct
5	Ground	-	-
6	DSR	Input	Direct
7	RTS	Output	Direct
8	CTS	Input	Direct
9	RI	Input	Direct

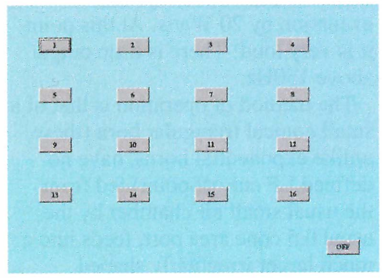


Figure 1

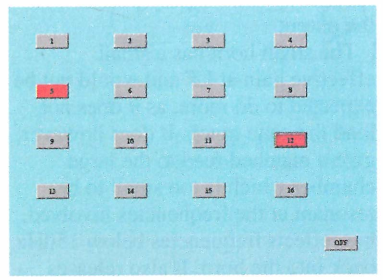
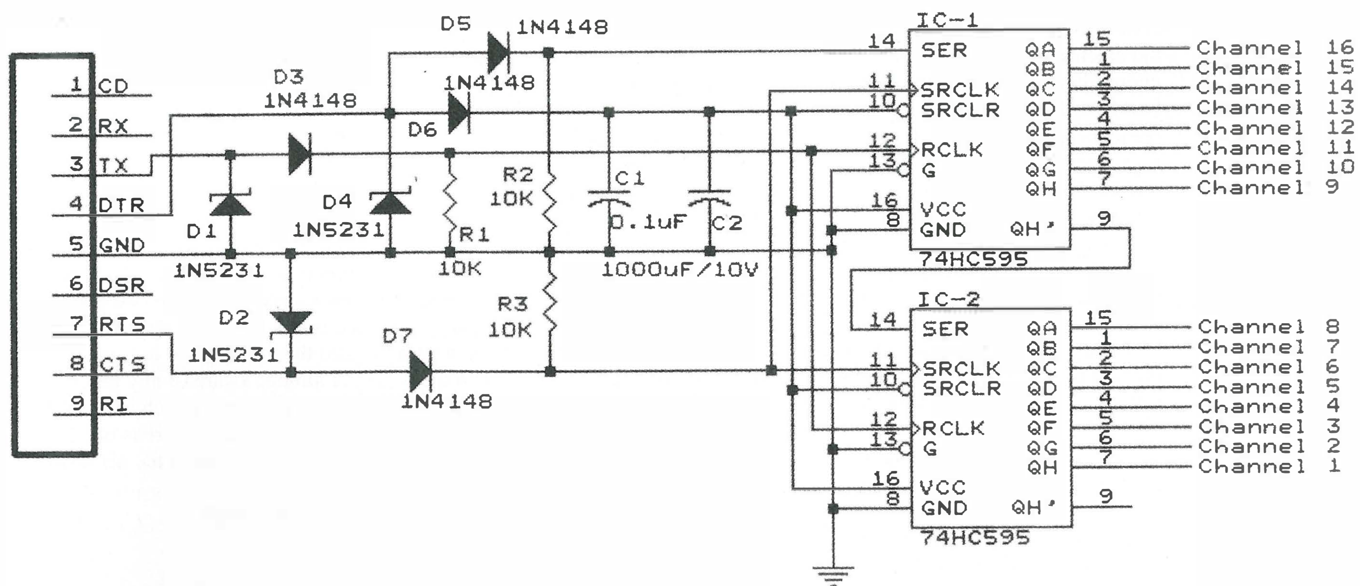


Figure 2



Sub-woofer unit

This unit was designed as a free-standing corner sub-woofer to augment the low frequency response of a commercial domestic 'Hi-Fi' system which was equipped with a subwoofer output at line level which had a 3dB point of 400Hz, but no sub-woofer. It was intended to sit behind a bookcase which was angled across the corner.

A quite small and fairly cheap 6.5 inch polypropylene woofer is the driver.

The slightly unexpected result has a response which goes below the limit of human hearing although it will produce audible harmonics when driven at 15Hz.

Construction is simple and it can be driven to the limit of speaker excursion by 20 Watts. At this point it is very loud! There is little output above 150Hz.

The method of operation is that of a small conical triangular horn (these, unlike exponential horns, have no defined LF cut-off point) fed from the usual small air chamber by the usual 0.5 cone area port, feeds into a much larger irregularly shaped chamber, which in turn feeds the outside through a 0.5 throat area port. The direct sound from the back of the speaker appears to play little role in the output

The small horn has a small effective gain at LF and would not be expected to do more, as it does not load the cone much. It does however, give a matched feed to the large chamber which is too small to be resonant at the frequencies involved, but reflects frequencies below 150Hz back into the horn. It also releases some to the outside. The pressure wave reflected back into the horn (without phase reversal) loads the cone which in turn converts more of the electrical drive into acoustic energy in real time and the process builds without involving any true resonance. This reduces the cone movement to some extent and reduces the sound output to the speaker rear.

At about 300Hz the output of the cone is out of phase with the reflected wave and a null results which effectively eliminates the output up to and above the crossover point. This subwoofer will sound truly horrible if fed with a full band signal.

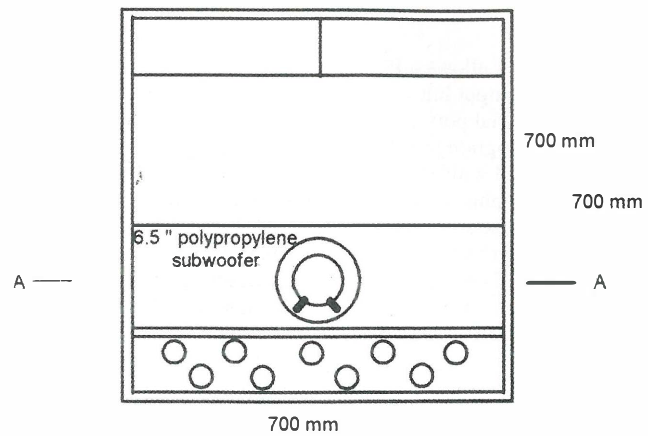
The transient response sounds very good although I do not have the resources to fully explore this at the frequencies involved. A bass drum sounds like a live bass drum, which is not the case with a number of systems I have listened to. Some of the low notes in the 'Bladerunner' audio CD can send a shiver up the spine, something normally reserved for large cinemas.

Although the corner placement is ideal, the unit does not really need it and a rectangular version could easily be built by making the top and bottom covers rectangular and covering the sides.

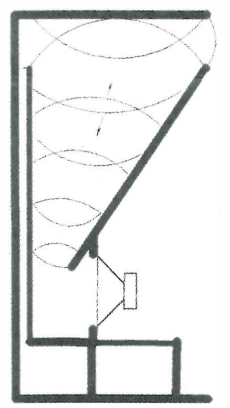
Construction is straightforward. All joints which could provide a path from the front of the speaker to the back should be sealed. The amplifier box can be deleted, reducing the height. If this is done, then the box can be inverted so that the floor of the room acts as a continuation of the unit. The amplifier used in the prototype has a quiescent dissipation of only 6 Watts so an automatic off function was not required. The triangular vent at the corner acts as a chimney for warm air drawing air into the vents at the bottom.

I am not aware of any other speaker cabinet which uses the same principles and if there is one out there I apologise to the originator thereof.

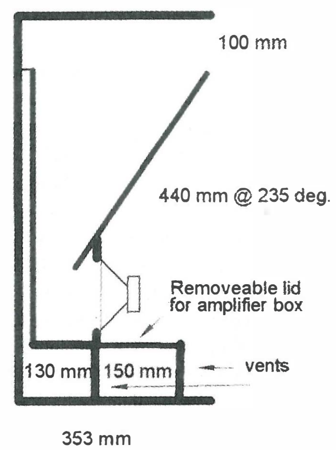
R.M. Catchpoole
Queensland
Australia



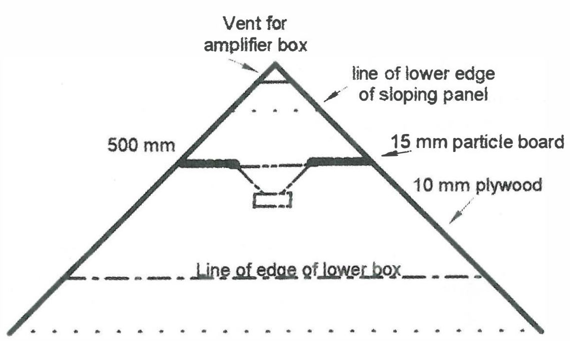
Front elevation



Method of operation

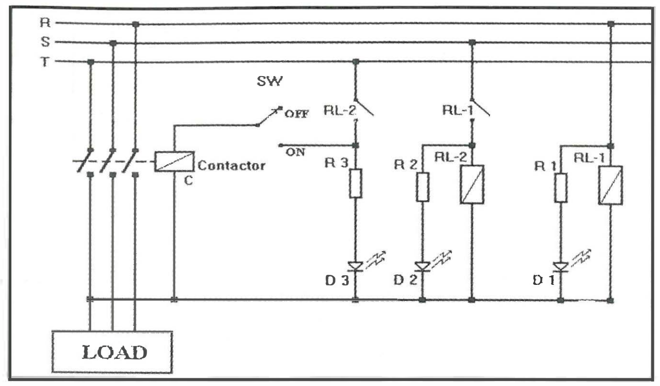


Side elevation



Section A-A

Phase failure protection for three phase



Three phase electrical equipment must be protected against failure of any phase. This simple and inexpensive circuit provides this protection. When Phase R is present Relay RL-1 latches and LED, DF glows and indicates the presence of Phase R. The normally open contact of RL-F is in series with the coil of RL-T. If Phase Y is present, then relay RL-2 latches and LED, M glows and represents the presence of Phase S. Similarly the NO contact of RL-2 is in series with the coil of the three phase connector C. If phase T is present and the switch SW is ON then three phase contactor latches and the three-phase supply is connected to the load. Failure of any phase is indicated by the OFF state of the LED and the load is also switched OFF. When all the three phases are present three LEDs D1, D2, D3 are ON and the load is connected to the three-phase supply.

R1, R2, R3 = 120KΩ, 0.5W
D1, D2, D3 = Red LED.

RL-1, RL-2 = SPCO Relay, Coil Voltage 220Vac, Contact Rating 1A ac = Three phase contactor, coil voltage 220Vac

Contact rating depends upon the load.

Muhammad Naheem
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Pakistan

Decibel meter

The decibel meter of **Figure 1** comprises two log amplifiers A1 A2 of an LM 324. The outputs of A1 and A2 are given to a differential amplifier A3 and its output forms input to a non-inverting gain amplifier A4 of amplifiers SLM 324. The gain of this amplifier is adjusted with a positive temperature coefficient thermistor and resistance to give directly the dB output. The thermistor compensates the variation in emitter saturation current IS with temperature. The standard 0 dB is taken as 0.77 v equal to dissipation of 1mW power in 600 ohms resistor. The voltage of 0dB of 0.775V forms the Vref input of amplifier A2. The voltage to be compared forms V1 of amplifier A1. The amplifier outputs are as shown in the sample with example. The advantage of the circuit is that with a single chip of LM 324 decibel meter can be obtained.

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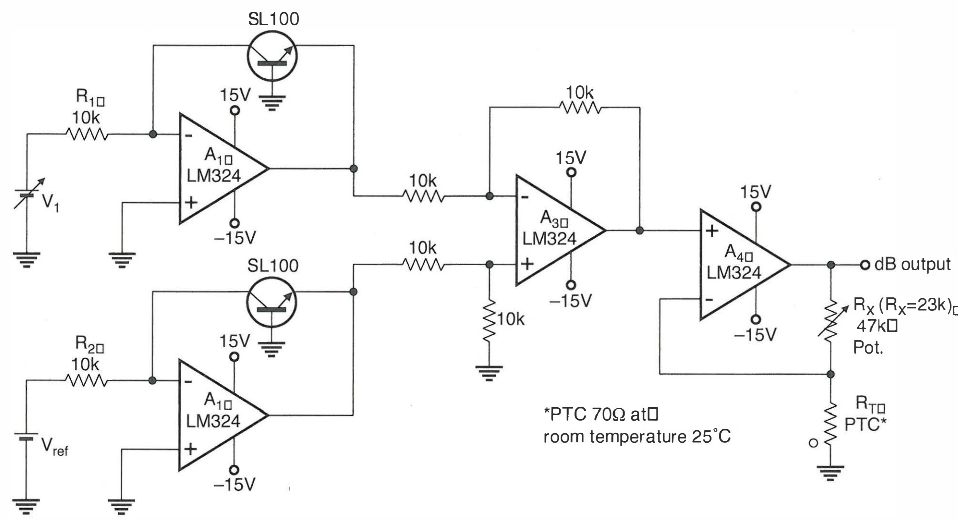
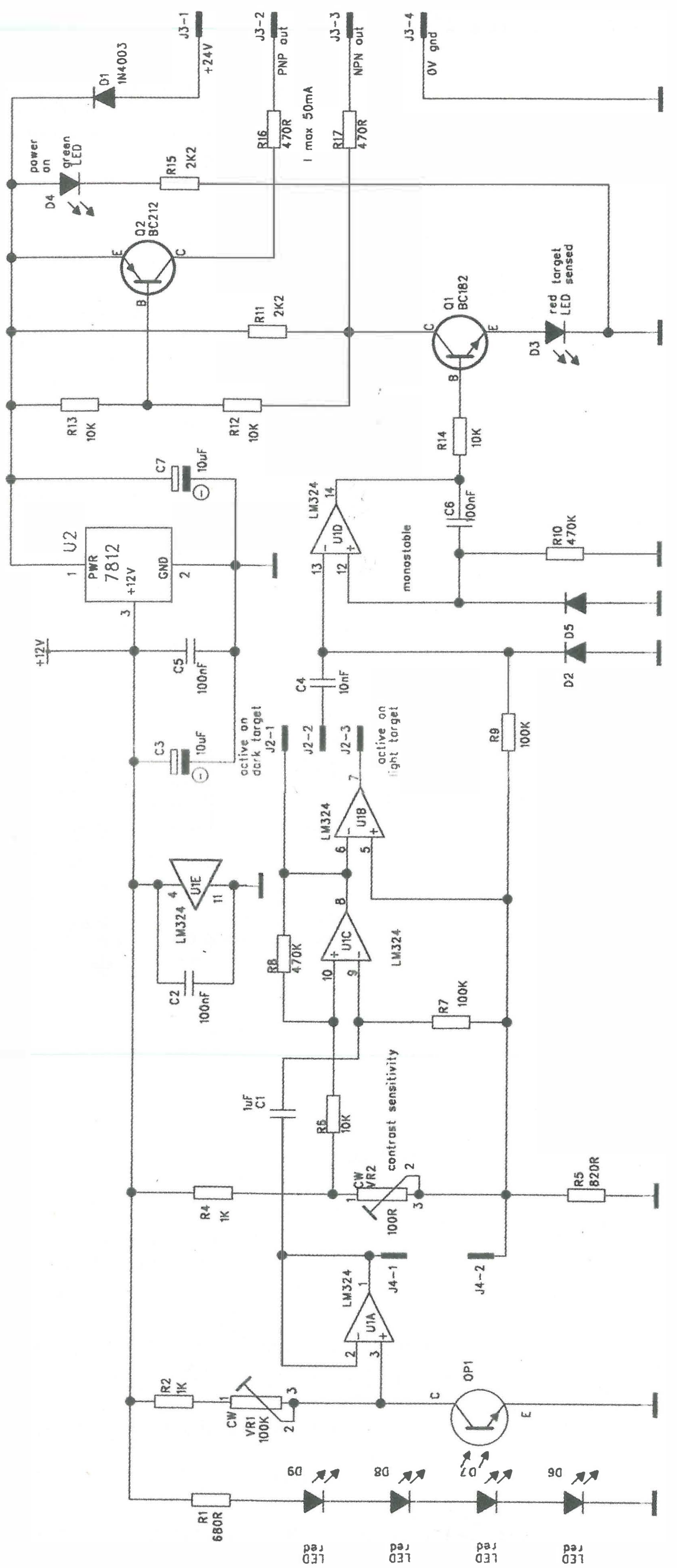
India



Calculations:
Theoretical examples:

Amplifier A1 output = $- KT / q\ .1n\ (V_1 / R_1\ I_S)$
Amp. A2 output = $- KT / q\ .1n\ (V_{ref}/R_1 I_S)$
Amp. A3 output = $KT/q\ .1n\ (V_1/V_{ref})$
Where K=Boltzmann's constant, q = Electronic charge, T = absolute temperature ^0K; I_s = Emitter saturation current = 10^{-13} A.
The value of KT / q at room temperature of 300^0K is 0.026V.
Therefore $R_1 I_S = 10K.10^{-13}{}_A = 10^{-9}V$
Amp. A_1 output = -0.026 x 1n $(2.06/10^{-9})$ = -0.56V
Amp. A_2 output = -0.026 x 1n $(0.77/10^{-9})$ = -0.53V
Differential output of amp.A_3 = 0.03V
Amp. A_4output = Differential output $x(1+R_X/R_T)$
= 0.03 (1+23K/70Ω)
= 9.9 dB

Practical values:
Amp.A_1 output = -0.55V
Amp.A_2 output = -0.52V
Differential amp. A_3 output = 0.03V
Amp. A4 output =0.03 (1+23K/70W)ª10dB
Amplifier A_4's gain is adjusted by the constants = (20x0.4343/0.026) =334
The constants are obtained from the following standard relations.
Power in dB = 10x $\log_{10} (P_2/P_1)$
Ie: dB=20 x $\log_{10} (V_1/V_{ref})$ (Power in terms of voltage ratio).
Log_{10} x = 0.4343 1n x
KT/q = 0.026V
Thus practical value of dB is in agreement with the calculated theoretical value of dB.



Dynamic mark detector

Reflective optical sensors are often used in industry to detect marks on packages and documents. Where the mark is textual a camera is needed, with neural-net software and a powerful processor. If a simple bar or block is to be detected, a reflective opto-switch will suffice. The catalogues are full of such devices but they can be tricky to set up and maintain if the mark is weak or the environment is dusty or grimy.

The solution offered here uses target motion to allow small changes in reflectivity to be sensed reliably, even when the optical contrast is poor or when the target is small. The signal, which may be very brief if the target moves rapidly, is stretched beyond 10ms to ensure capture by an industry-standard PLC. Separate PNP ('source') and NPN ('sink') outputs are provided, active dark or active light.

The amplifier is AC-coupled and can cope with gradual degradation of the optics, but it is sensitive to the 100 (120) Hz flicker of fluorescent lighting. Mount the detector within a short matte black tube to limit its angle of view. Shield the target from ambient lighting and flood it with continuous close illumination from two or more high-brightness LEDs. Choose the emission wavelength for maximum contrast (e.g. orange if the target is blue). The phototransistor will probably have peak sensitivity at 650…900nm but can still 'see' at 500nm.

To calibrate the emitter and detector levels, use background material as target and adjust VR1 for a null ±1.0V across the two test pins marked J4. If a null cannot be achieved, increase the lighting on the target.

Put a jumper on J2 to select active dark or active light. R16 and R17 protect the outputs against overcurrent but some PLCs may protest.

VR2 sets the sensitivity to marks. Since the system is capable of detecting very faint marks, setting the sensitivity too finely may output a signal from a smudge, a crease or a sudden change in ambient illumination. Set VR2 fully clockwise (its most sensitive position) and set the target material in motion. While turning VR2 anticlockwise, note the position at which LED D3 begins to flash consistently as the target passes the sensing head. Then note where the flashes are no longer consistent and set VR2 halfway between these positions.

Jonathan Reynolds

Gerber and Excellon files exist for a single-sided PCB – jonathan@valrey.clara.co.uk

Measuring magnetic fields

Alternating magnetic fields can disturb scientific apparatus as well as audio/video equipment. A rapid way of 'surveying' an area is with a search-coil connected to an oscilloscope, but a better method includes a pre-amp that compensates for the d¢/dt effect of the coil: otherwise the lower frequencies are under-estimated compared with the higher ones. (This is because the coil senses the rate-of-change of flux rather than the flux itself.)

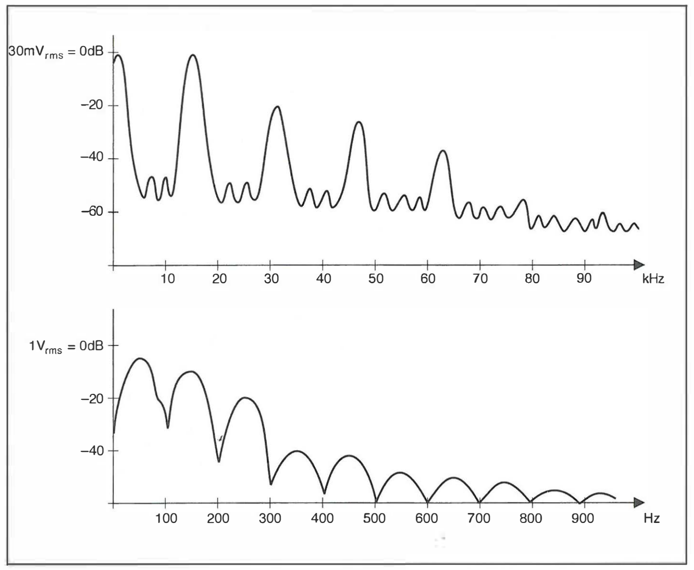
The circuit shown in Figure 1 achieves the requisite frequency-compensation quite simply in fact A2 acts as an integrator, and A1 a buffer with additional (suitably calibrated) gain. Thus for a coil wound on a wooden former and having sufficient diameter and turns to be equivalent to five square metres, the pre-amp delivers an output of 100mV per milliGauss. A fairly 'quiet' room typically has 50Hz fields of around one milliGauss (measured RMS), and the intricacies of the waveform would be difficult to observe without this pre-amp. As a matter of interest, the coil alone yields a mere mV for such a field, largely swamped by ~3mV of hash at around 50kHz, which is this particular search-coil's natural resonance frequency.

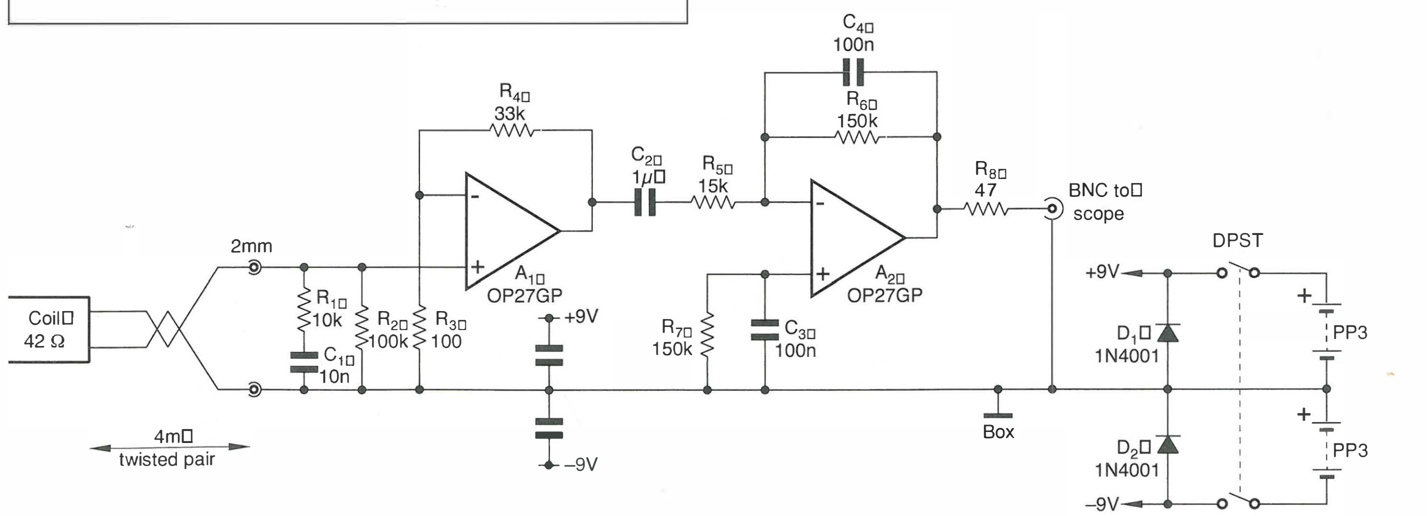
The pre-amp was checked by removing the coil and feeding-in a sinewave from a 50-ohm source. The frequency was swept from 10Hz to 100kHz, and the integration was seen to be 'true' over almost three decades, in fact 3dB down at 20Hz and 20kHz. Since the output of the integrator ideally fails by a factor of ten for each increasing decade of frequency, the sig-gen was started at 150μVrms for 10Hz and stepped up to 1.5mV rms at 100Hz, then 15mV rms at 1kHz; it was kept at this level for testing at 10kHz in order to prevent slew-rate limiting of the output. The residual noise with the input shorted was about 0.2mV rms at the output. With the coil reconnected, the ambient field gave an output signal of ~100mV rms; placing the coil in a steel safe, the output was reduced to about 1mV rms, about as good magnetic screening as one can get without resorting to mumetal. A proper screen must be in the form of a complete box or shell, with more than one layer if necessary. Non-ferrous screens are effective for higher frequencies only, but for 50Hz one needs iron or its alloys. The purpose of R1C1 across the input terminals is to restrain. All if the coil is unplugged. Of some concern is the effect of strong RF fields, particularly from mobile 'phones, which might overload the input stage. For most applications this does not seem to be a problem, since the coil appears lossy at RF, but R1 may be reduced towards 10 ohms if need be.

When monitoring the ambient alternating fields in a laboratory, with the coil's axis vertical, the dominant 50Hz signal can vary by a factor of two up or down (i.e. x4 overall) throughout the day. This is in the absence of any local sources such as transformers. What seems to be happening is a series of step changes in waveform shape and amplitude in response to varying loads being drawn from heavy distribution cables that may be >10 metres away. Another insidious contributor is the dreaded ring-main: if the clamp-screws are not equally tight on L and N terminals of 15A sockets, it is quite possible for the majority of the current to arrive at a load via one half of the ring and return via the other. The result is a current-loop enclosing a large area - an ideal candidate for creating strong and extensive hum fields. It is very difficult to reduce these, short of converting the wiring to a star or spur network.

Modern digital 'scopes often offer a Fast Fourier Transform function, which is a convenient means of extracting and displaying the spectrum of frequencies in the waveform picked up. Some examples are shown in Fig.2. In 2a, the detected field was in the vicinity of a 100VA laminated transformer feeding a rectifier, capacitor and load. Note the harmonics of 50Hz. In 2b, the coil was placed above a 14-inch colour TV set; this time, observe the line-scan frequency of 15.6kHz and its harmonics, in addition to the field-scan which is at 50Hz but not synchronised to the mains. If you do not own a fancy 'scope, there are now available economical ADC-gadgets which connect to a PC, and then the FFT can be performed with a commercial or shareware software package.

CJD Catto
Cambridge
UK





A novel circuit to energise latching relays

Latching relays would have more applications, especially in battery supplied equipment, if they didn't need direct and reverse currents to be set on and off. This heaviness is somewhat overcome using two coil devices and some more or less sophisticated circuits have been published here or there to make them more serviceable. Dedicated circuits are even available (for example the VS5-24V, Conrad ref 177 555-17) but they are quite expensive.

The idea here proposed relies on the fact that a latching relay needs only a few milliseconds pulse to be set or reset. So if you just insert a large electrolytic capacitor in the circuit, as in **Figure 1**, it works. I could have verified this, with all the relays of this species I had to hand. So two coils are no longer needed and you can drive these relays from logic circuits with totem pole outputs. The monolithic drivers for power MOSFET are peculiarly well suited for this purpose as they have logic level inputs and high current outputs. **Figure 2** shows how to drive two latching relays with the Harris ICL7667. Inputs are TTL and the Vcc voltage can vary from 4.5 to 15 volts, in accordance with the relays to be energised. The consumption is 4mW with inputs low, 20mW with inputs high and the output resistance is 7Ω.

Needing higher voltages you can adopt the International Rectifier IR2110 double driver, up to 24 volts **Figure 3**. For this device the static consumption on Vdd is 200mA typical and the output resistance is 7Ω.

You can also drive a 48 volt relay with 24 volt supply using the IR2110 as shown **Figure 4**.

Lastly, a very cost effective solution: National Semiconductor buffers CD4050UBC, CD4050BC, CD4049BC and CD4049BM can sink 40mA and output 12mA when supplied with 15 volts. Each gate can therefore drive through his 470µF capacitor a 12 volts 960Ω latching relay with 2 Amperes DPDT (Conrad reference 0504 840-30) . So a package can drive 6 relays but ... s possible to wire two or more gates in parallel to dri... ore powerful relays.

Jea... rc Brassart

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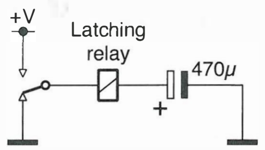

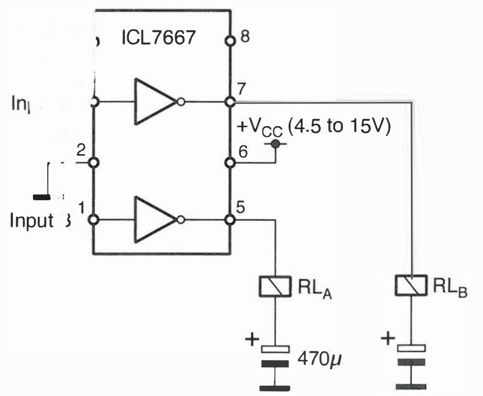

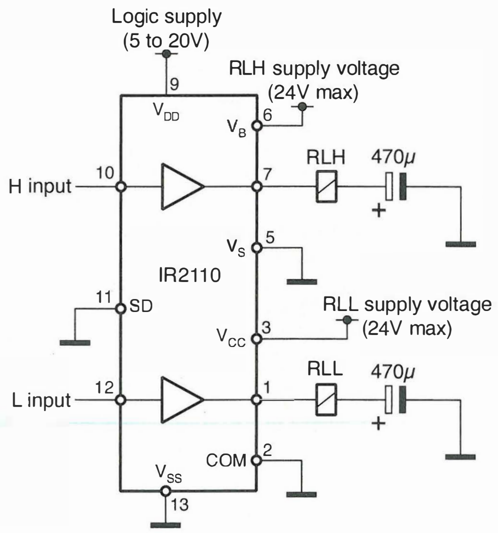

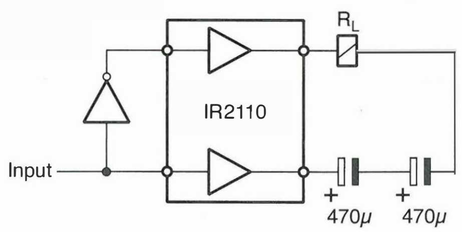

Oscillator frequency tuned with power MOSFET

This Hartley audio frequency oscillator uses a 32mH ferrite core inductor or transformer in parallel with the capacitance of a MOSFET as the resonator tank. Power mosfets such as the L3705N from www.irf.com have a Coss capacitance that varies from say 3500pF to about 700pF when a Vds is applied from 1 volt to 40 volts respectively. This oscillator's frequency is thereby controlled from about 15kHz up to 30kHz with the output amplitude staying between 1.8 and 2V peak to peak.

The output voltage is controllable from 0 to 5 Vpp with the potentiometer. By varying the voltage on gate 2 of the dual gate N-ch depletion mosfet (type ECG 222) the output voltage is kept reasonably constant. Single gate n-ch depletion junction fets such as the 2N4303 also work quite well. Sine wave distortion is a concern of course especially when the Vds of the power mosfet approaches 0V and with larger oscillator output voltage swings. Be sure to use a low leakage capacitor to connect the drain of the power mosfet to the inductor. Ceramic capacitors gave complications. Distortion can be improved by making the N1:N2 turns ratio greater (say 3:1) and using a higher valued resistor to bias the drain voltage of the power mosfet. Adjusting the source resistor of the small signal fet also affects output voltage swing.

Robert Bliek

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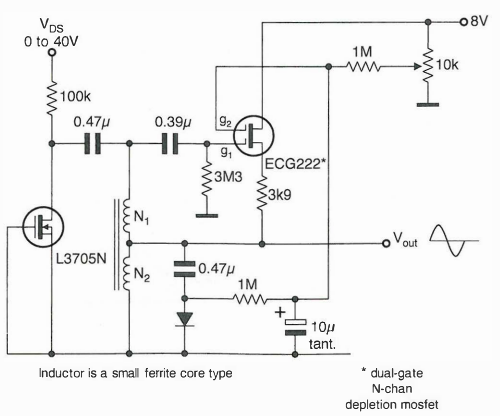

Vehicular traffic control based on traffic density

In a traffic junction of n roads (four roads taken in this example, **Fig. 1**) the traffic is being controlled by sequentially opening the traffic from one side to the other in cyclic manner with the time of opening the traffic in each side determined by the vehicular density originated in its side. **Fig. 2** shows its circuit (block) diagram.

In each side of the junction (**Fig. 1**) two vehicle sensors (electromechanical or optoelectronic) are kept at the far end and near end of the junction at a suitable span to detect the vehicle entering into the road and the vehicle leaving the road. The sensor produces a pulse whenever a vehicle passes by it. The present density of the traffic in each road is recorded in respective UP/DOWN counter in which the far end sensor would increment its count and the near end sensor would decrement it.

At the time of opening the traffic in one side the counter data is latched and given to PWM (Pulse Width Modulator) to produce a pulse whose time duration is proportional to the counter data. From this pulse the durations of glowing the green lamp, yellow lamp and red lamp are derived in the switching system and the lamps are lit up accordingly.

Fig.3 shows the details of the PWM circuit. The PWM pulse is produced from a flip-flop FF by controlling the asynchronous inputs -R and CLR. The U/D counter data from the latch is checked with another 4-bit counter run by 1/4Hz clock. When they are the same the CLR input of the FF is activated to mark the end of the pulse. The negative edge of the PWM is detected and is used to start the PWM of the next side by activating the PR input of the flip-flop.

The switching starts always with the north side. The manually operated switch SW1 presets the FF of the north PWM and clears the others. **Fig.4** shows the details of the switching system. For the sake of simplicity, only the north side is shown. The monostable multivibrator set for two second period generates the pulse YN to switch on the yellow lamp of the north side by operating the relay YNR. The remaining period of the PWM of the north side is used to derive the signal GN to switch on the green lamp of the north side through the relay GNR. The contacts of the relay GNR (GNRI), YNR(YNRI) and RNR(RNRI) close the power supply to the respective lamps for lighting them up. **Fig.5** shows the timing diagram of various switching signals.

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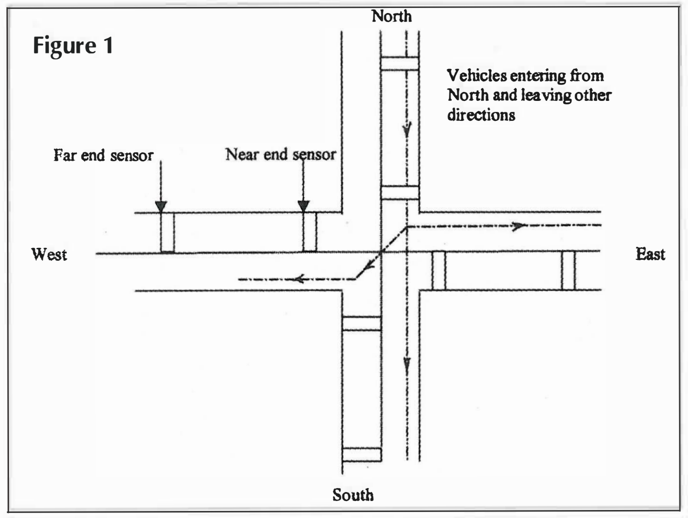

Figure 1

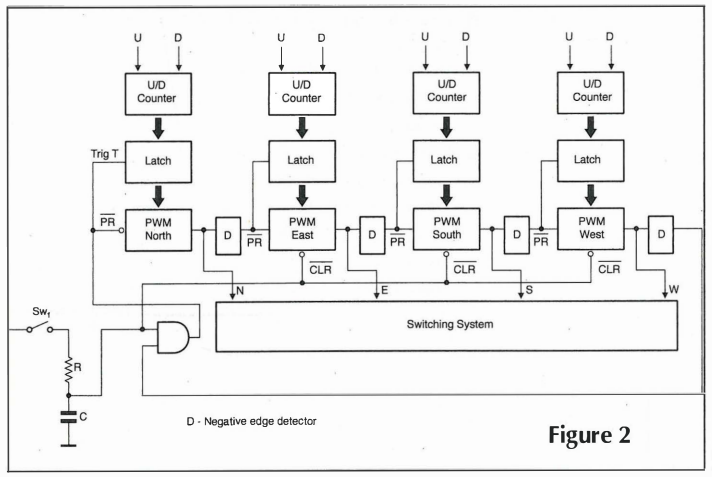

Figure 2

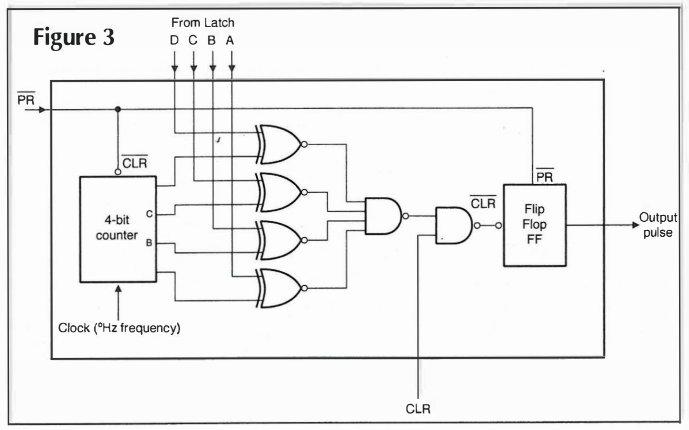

Figure 3

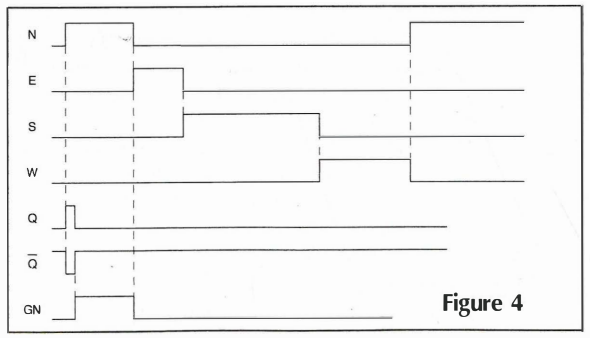

Figure 4

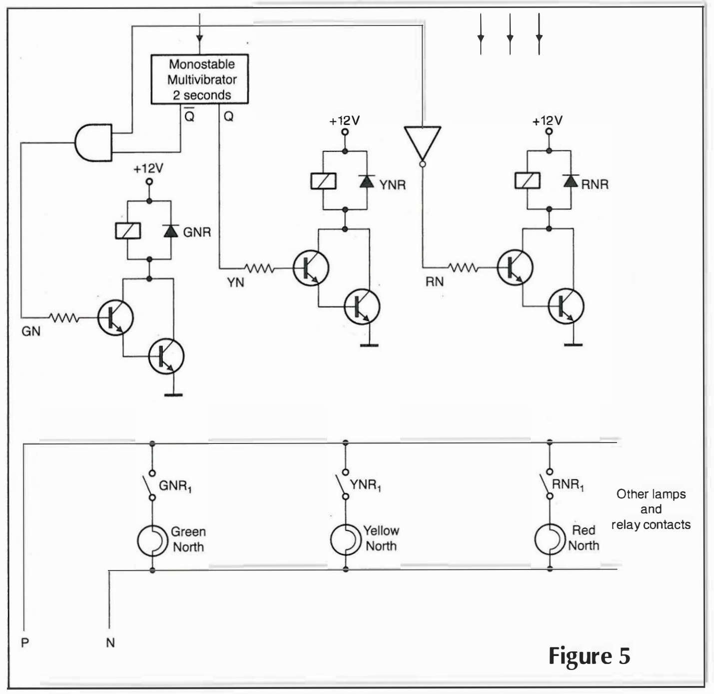

Figure 5

Infrared locator for orientation of the blind

The electronic circuit of the locator is represented at **Fig. 1**. The device generates packets of infrared light impulses. The length of each packet is 20ms and pauses between them are approx. 0.5 secs long. Each impulse has the length 60ms and frequency of their generation is 2.8kHz.

Reflected from an obstacle, the light reaches the receiver's photodiode. Electrical signals from it are amplified and they reach a transistor-based simple threshold amplifier. The receiver is tuned to 2.8kHz. The bandwidth at level ±? is 1kHz. The blind person evaluates the distance from an object by the volume of sound in a headphone.

The locator has following advantages over other devices:

- one battery, low voltage feeding
- low current consumed (approx. 4mA)
- increased level of noise-cancelling (for example from filament lamp radiation)
- low dependence of the device's sensitivity on batteries' voltage when discharged.

Another man represented an obstacle during the tests. At distance of more than 2.5m the signal is below the hearing threshold. With reducing distance the volume of sound rapidly increases. At distance of approx. 1m its volume reaches the pain threshold.

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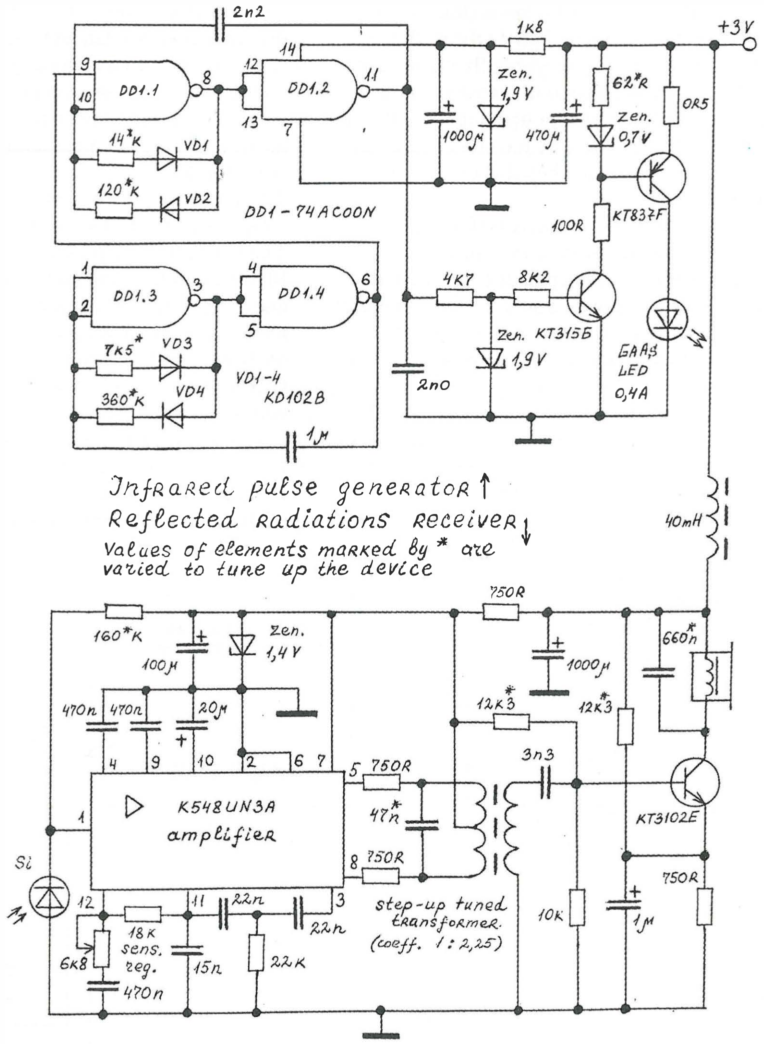
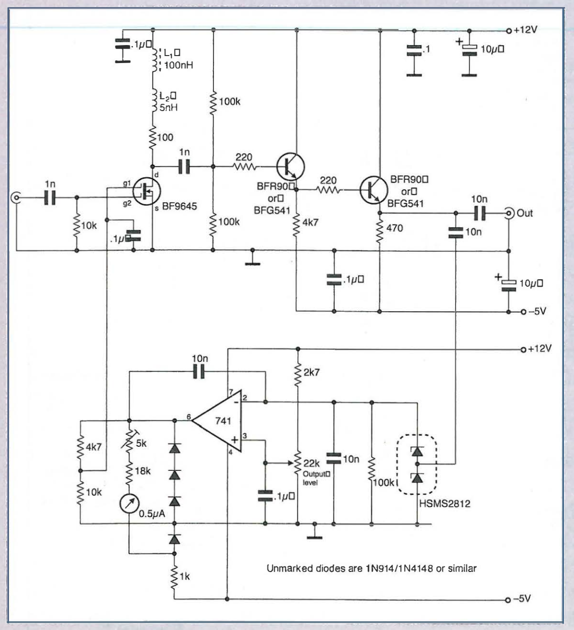
Estonia



RF constant level device



I designed this circuit to overcome the inconsistent amplitude of the output from my cheap old VHF signal generator. I needed a constant level for sweeping through the response of high frequency amplifiers.

The circuit is based around a dual gate MOSFET (a much under-used device, in my opinion) to provide voltage controlled gain. The output amplitude is measured using a dual Shottky diode to rectify the RF and produce a DC level that is a bit less than the peak-peak amplitude. This HP diode is available from Farnell (549-710) but, at a pinch, a pair of IN916 diodes could be used. RF Shottky diodes are preferable because the low volt drop allows smaller output levels to be controlled. Silicon devices mean that you will not be able to get much less than 1V peak-peak.

The level control is performed by a 741 that is heavily slugged to keep the closed loop stable. A 0.5mA meter is added to indicate if the MOSFET is working within a linear range (typically Vg2 between 0V and +5V).

The two inductors in the source of the MOSFET are intentional. To obtain a bandwidth of 10MHz to 200MHz+ a single coil would not suffice. Using two means that when L1 goes past its self-resonant frequency, L2 continues to provide an inductive load. L1 is 100 turns on a 5mm former with a dust core. L2 is 10 turns on a 5mm former with an air core. Most RF dual-gate MOSFETs will work. I used 3SK88 and BF964S because they were in my junk box. Likewise the double emitter-follower buffer transistors are not critical, they just need very high fT.

The output level is adjustable from 0.3V p-p to 8V p-p but the higher outputs are not available across the full bandwidth.

Of course, the circuit could be adapted to a number of other uses such as audio companders or audio oscillators.

Mike Arnold
Sale, Cheshire
UK

Simple voltage monitor/alarm

A colleague was having trouble with his car. Every now and then the battery would go flat, usually with no warning and within minutes. He had already checked the current drain and found it to be an acceptable 100mA. Hardly enough to be a potential threat!

The fault could happen several times a day, or once a month. A new alternator, battery and full wiring check revealed no problem, so the following circuit was evolved to monitor the voltage at the battery terminals, but of course could find many other applications where under or over-voltage could be a problem. This enabled him at least to know when the problem was occurring.

The unit was built on Veroboard as it is quite a simple circuit. The wiring was soldered on, and the unit fixed to a convenient place. It was coated with lacquer before exposing it to the elements and enclosed in a plastic housing. It functions as follows:

The battery is connected to V_{BATT}. The IC supplies are derived from a 7808 or 7809 regulator to give some headroom for noisy supplies.

A reference voltage is taken from the 8V rail (V_{DD}) by R_4 and stabilised by D_3 a 6.2V zener. This was chosen as it is on the border between PTC zener and NTC zeners. This is used to set the voltage on the –ve input of the comparator. For stability reasons, part 2 of the IC is connected as a buffer.

The monitored line is taken directly from V_{BATT}, and applied to the +ve input of the comparator, via the resistor chain R_3, R_1, R_2. R_1 is a multi-turn device and its slider is applied to the IC via R_7, R_7 & C_1 acting as a low-pass filter to take any spikes away.

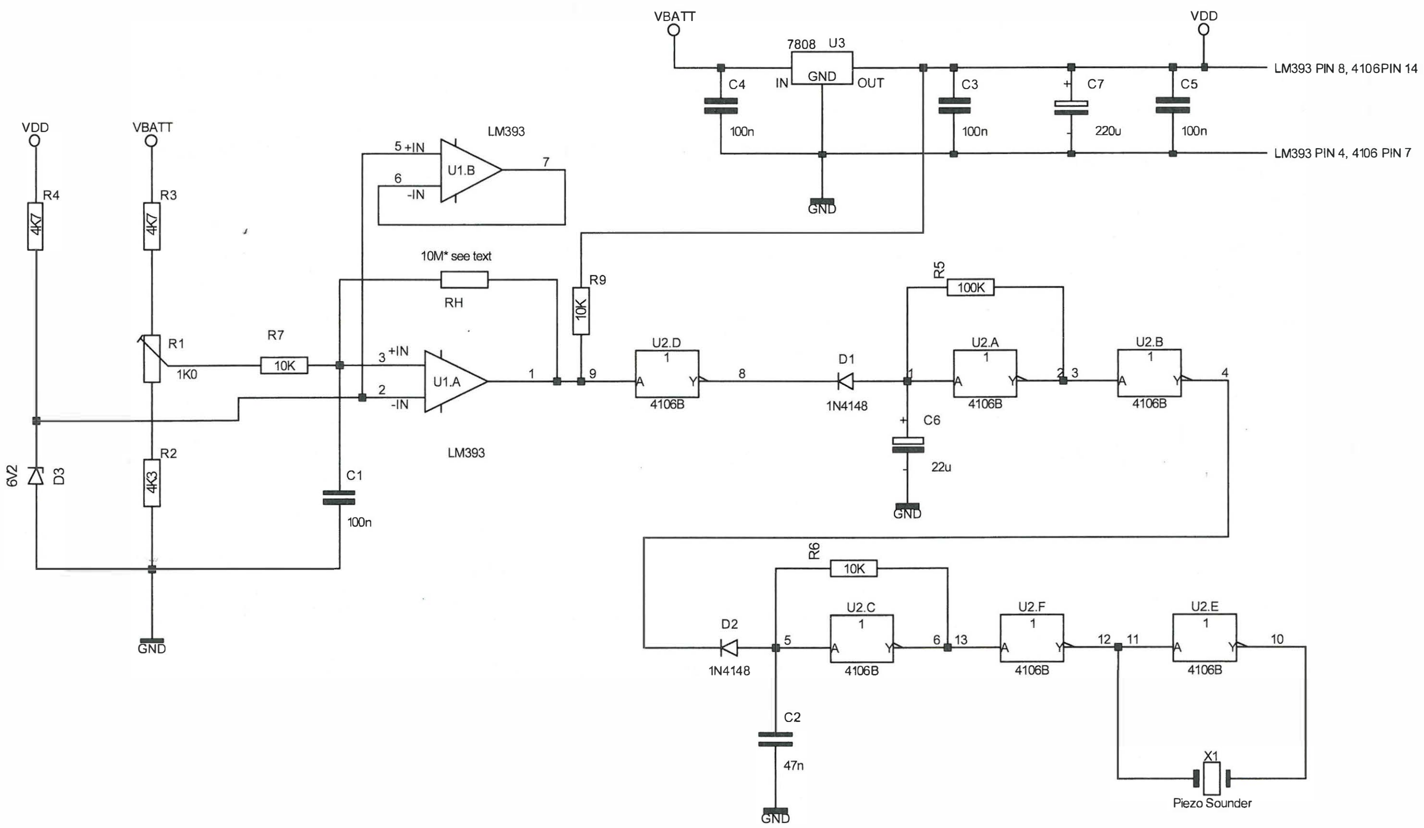
As the voltage on pin 3 of U_1a falls below the reference voltage on pin 2, the output on pin 1 switches low. U_{2d} inverts this and enables U_{2a}, a Schmitt oscillator with a frequency of about 1Hz. Similar reasoning applies to U_{2b} and U_{2c}, but the latter section oscillates at about 2kHz. U_{2e} & f act as a buffer giving a bridged drive into the piezo sounder. Alternatively, a 12V Buzzer or alarm could be connected from VDD to U_{2a} pin2. This point could also be used to drive an LED were it more convenient.

It should be remembered that the zener will have some temperature co-efficient and so will drift slightly. As the input is divided by 2 (roughly), the error from the zener will appear to be magnified by a similar amount, thus 0.1V drift on the zener will upset the monitor accuracy by about 0.2V.

Set up is easy. Connect a variable PSU set to more than 13V. Check the zener voltage then reduce the supply to the required trip level (I used 12.4V) then set R_1 to give about 10mV more on pin 3 than pin 2. A drop of about 20mV will then sound the alarm. The unit will reset automatically when the voltage rises again.

Hysteresis may be added, if required, by connecting a 10M resistor from pins 1 to 3 on the LM 393. This will upset the switching levels slightly, and will cause a window effect, i.e. the alarm may sound at (say) 12.0V but not go off again until (say) 12.6V is exceeded. The actual window can be varied by the ratio of R_H to R_7.

Michael Fallon-Williams
By email



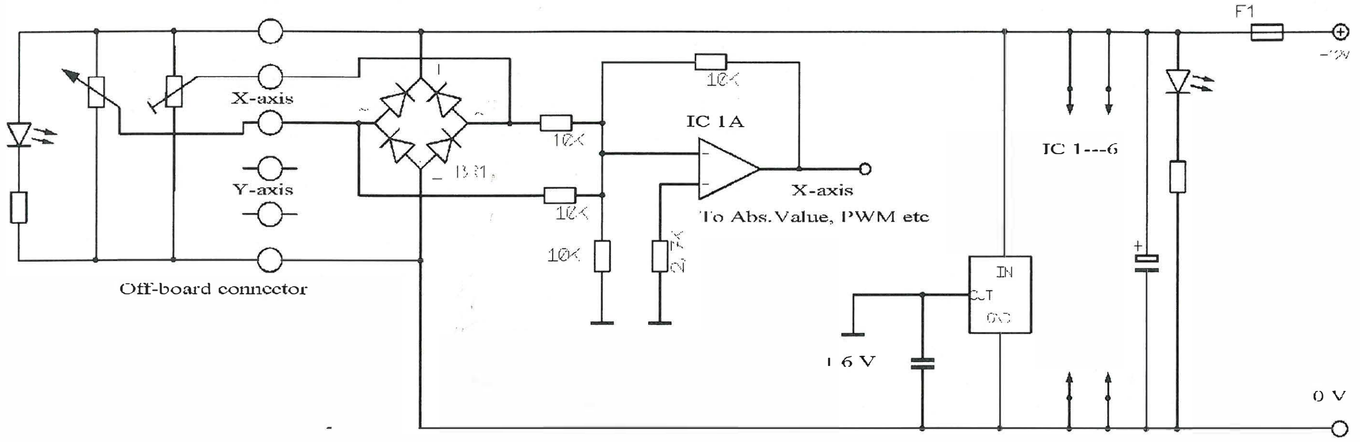
Bridge rectifier protects two op-amp inputs

A 5k analogue joystick and two preset potentiometers feed generic summing /scaling J-FET op-amps through 10k resistors. Additional 10k 'pull-to-ground' nulls input if controls are unplugged.

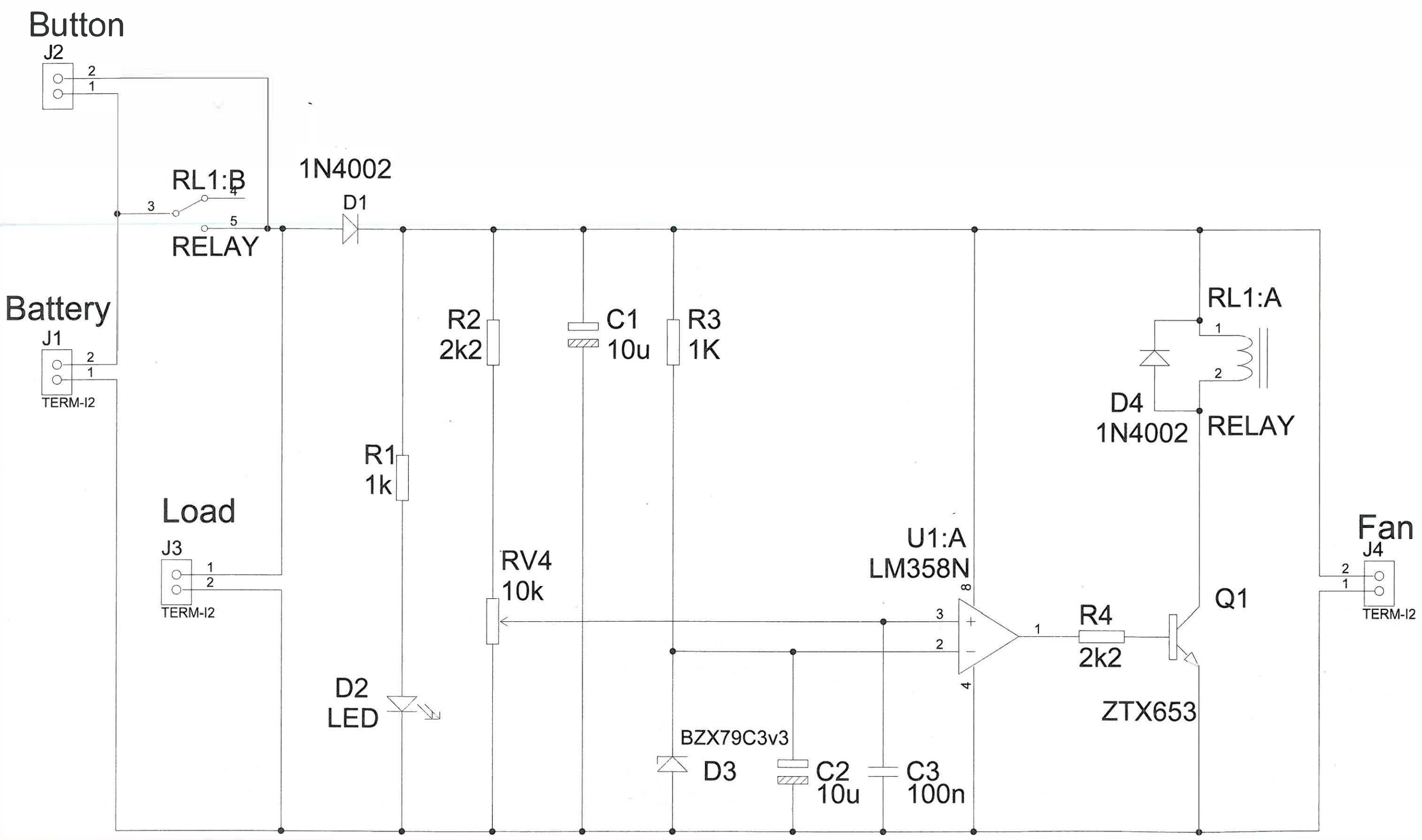
The simplest way to guard each off-board line was 'reversed diodes to the rails' ahead of a limiting resistance. I realised I could keep the 10k resistors 'on-board' as limiters, but still had to find space ahead of them for two diodes per line, eight total.

I used two small bridge rectifiers, wired +rail, -rail, ~per line: even W005 (50 V, 1.5A) claims 10 micro-Amp maximum leakage, much less than the parallel ~2 mA current through each potentiometer arm. The rating also ensures they can 'crow-bar' the 12 Volt battery fuse.

Nik Kelly
Liverpool
UK



Correction: In March, we ran a Circuit Idea from Allan Patrick for a battery discharger. When the diagram got printed it was pretty illegible, as many readers pointed out. Here is Allan's redrawn circuit, which I hope you can now read!



LETTERS to the editor

Letters to "Electronics World" Highbury Business, Media House,
Azalea Drive, Swanley, Kent, BR8 8HU
e-mail EWletters@highburybiz.com using subject heading 'Letters'.

Catt flap I

Ivor Catt's flap about transmission lines has been rattling on for over 20 years now, and what a great source of amusement it has turned out to be! The crux of his renamed 'Catt Question' is this assertion: when a wavefront travels in a transmission line, electric charge appearing at the wavefront cannot come from behind it because the charge would have to travel at the speed of light to do so.

That argument only holds water if it is assumed the excess charge appearing on one of the two conductors is the only mobile charge within it. But even at high electric field strengths the charge surfeit or deficit on its surface is only a very small proportion of the total number of mobile electrons available, the vast majority of them being neutralised by immobile positive nuclear charges.

If it really were true that the electrons have to move at the speed of light to provide the necessary charge, what happens if the amplitude of the voltage step is reduced? Given that the number of mobile electrons is unchanged, it seems pretty obvious that their drift speed reduces in proportion. This being the case, Catt's argument only applies at one particular voltage, which would be an extremely high one indeed, vastly greater than any practical real-world transmission line insulation could possibly tolerate.

Catt is wrong about what conventional theory tells us. What it really says is that the electron drift speed behind the wavefront is the speed of light multiplied by the ratio between the tiny excess charge and the enormous mobile charge available. On that correct reading of conventional theory, the 'Catt Question' vanishes. In practice the picture is complicated by skin effect, which reduces the number of mobile electrons available at high frequencies, but my basic argument still holds.

If Mr. Catt wants the rest of us to take his question seriously he must present his case more convincingly, which means he must establish – rather than merely assert - his central argument that the charge cannot have come from behind the wavefront. To do that he must effectively counter my argument that the drift velocity need not be anywhere near as high as the speed of light. If he is unable to do that he has no case to answer, and is hardly in a position to complain about being ignored.

In the past Catt has claimed that those 'disciplined in the art' are 'unable to grasp' his crucial assertion. I can only speak for myself. Being one who is to a limited extent a member of this club, I can do without that insult. Catt's claim to have shown conventional theory to be false is a misrepresentation, since he is challenging not the theory, but his own misinterpretation of it. Funny, that - it's just what I'm doing too. So we both agree, then? Hardly!

Alan Robinson
Holgate
York

Current thinking

Ivor Catt has come back with another diatribe on "The New Scholasticism" in the April edition of *EW*. This starts with a scathing criticism of Maxwell's invention of 'displacement current'.

I personally acknowledge the action of someone with genius (Maxwell). When faced with a subtle anomaly in some complex mathematics, he sorted the problem. The resulting set of equations have been used to analyse practical problems over many decades, and no-one has disproved them.

I have seen the so-called 'proofs' emanating from the Catt camp. These start with equations picked out from transmission line theory, and end up with other equations developed by transmission line theory. The reasoning is entirely circular.

However, the problem with Ivor is that he does not stick to writing nonsense.

He waxes enthusiastic about the Transverse Electromagnetic (TEM) wave and the Heaviside Step Function. He identifies the need to explain in physical terms how a logic step travels from one gate to another. This is an approach with which I can concur.

If he had thought about this problem a little longer, he would have realised that 'current' is not actually a movement of electrons. It is related to these movements in the same way that a wave appears to travel down a row of dominoes as they topple over. The difference between the movement of electrons and dominoes is that the electrons never touch each other. Each one is affected by the field emanating from its neighbours.

If 'current' is thought of as a moving force field, it is possible to visualise it as something which exists both inside and outside the conductor. This field at the surface of the conductor matches the propagation of the TEM wave in the space outside the conductor. The concept of the TEM wave in a transmission line is fundamental to the formulation of the transmission line equations. These equations effectively define how the surface charge density propagates along the conductors.

The website www.designemc.info covers this topic in more detail. Just go to the 'contents' page and select 'Twin-T model' at section 6-2.

The analogy of dominoes toppling over remains highly significant. In one conductor, the 'dominoes' are toppling forward. In the other conductor, they are toppling backwards.

This picture is entirely in line with the teachings of electromagnetic theory. In fact, when it is applied to the propagation of energy by three parallel conductors, it provides a means of analysing that other bugbear which troubles Ivor - electromagnetic compatibility.

Ian Darney
Kingswood
Bristol. U.K.

Catt flap II

I would like to point out to Mr. Catt and your readers that the subject of inrush currents and their effect on mains supplies is dealt with in the EMC standard IEC/EN/BS EN 61000-3-3.

The subject of immunity to mains supply transients is dealt with in relevant product standards in the CISPR xx and EN/BS EN 550xx EMC standards. Also see IEC/EN/BS EN 61000-4-11.

It would be gratifying if Mr. Catt could see his way to present his own work (some of which is undoubtedly very valuable) without insulting his professional colleagues.

John Woodgate
By email

Watts wrong?

After reading the *EW* May 04 Letter by Leslie Green C Eng MIEE, I ask that the Editor does not implement checks which will automatically change an author's intended text on grounds of technical correctness alone.

I am sure that Mr Green knew exactly what Jeff Macaulay meant us to understand when he wrote about his '80W RMS' Hybrid Amplifier. I did; and it is most likely that everybody else did too, which was of course the intention when communicating information relating to the powering capabilities of his audio amplifier design.

The suggestion to automatically insert 'W.mean' in place of 'W.RMS' does not automatically imply the zero phase resistor loaded sinewave examination that we have all come to understand as being a modern way of measuring amplifier output. Actually the term 'mean' could be used to misrepresent in exactly the same way that 'instantaneous' 'music' and peak' ratings already do; whereas 'W.RMS' cannot!

Maybe I could be more TC in my own right by writing 'W.sine', but I have already, quite deliberately, and knowingly incorrectly from a fundamental standpoint, chosen to continue using the term 'W.RMS', because it simultaneously represents the method of measurement used when bench testing a designed-for specification.

In the valve era, when audio Watts were sinewave Watts, you knew exactly what you would get in the way of power. However, much more than amplifiers have changed since the 1960's, including - by their 'common' usage - terms and dictionary definitions.

Thus I don't think it right that Phil be expected to automatically 'correct' and thus possibly alter the intended meaning of any author's text. The words must remain those of the author, and not those of the Editor who is instrumental in offering us the chance to read them.

I also believe that our Editor was most concerned to discover that software had changed 'micro' and 'omega' symbols to 'm' and 'W' after he had made a final check of the text, then clicked for Save, Send to and Print. Indeed any computer using Wordpad could do the same as it re-filed after a final Save. Considering all of the company, staff, relocation and equipment upheavals Phil has managed to steer our magazine through, this was an understandable glitch. Actually he deserves our arms around his shoulders, not additional chiding.

Graham Maynard
Newtownabbey
N. Ireland

No smoke without fire

I would like to add a snippet of information to Ian Hickman's pseudo-sinewave inverter article.

He states correctly that some modification to a square wave is necessary for the creation of adequate peak voltages in a mains inverter. There is another issue that older equipment cannot always face when presented with the squarer waveform coming out of Ian's or other similar modified sinewave commercial inverters, a fact I found out associated with a burning smell and the relics of a spray of electrolyte.

That is that the ripple current in the switchmode power supply contained within some equipment equipment may actually be high enough to boil the electrolytic mains smoothing capacitor fitted, even if the peak voltage did not exceed the 339 volts of mains.

This was on an old 1970's Philips scope which decided to not quite catch fire.

The near fire was caused by the fact that the electrolyte seems still to conduct when dried out. Current flow through the electrolyte then heats plastic components to the point where they char and then the heating increases, leading to more charring and either the surface of the PCB or a connector becomes a glowing mess until the mains fuse blows !

I have also experienced this effect when I knocked one of the capacitors on an ATX PC motherboard, which was 'soft-off' which meant there was still 12 volts on some connectors. The electrolyte dribbled in the inevitable direction and the PC started smoking. The plume of smoke rose neatly to the ceiling approximately 1 metre away from the smoke detector but did not trigger it before someone switched it off.

Mike James
Hamble
Hants

Re: capacitance meter measuring drift

I just read the interesting article *Capacitance meter* in the March 2004 issue. It is indeed a well-designed project, but by looking at the circuit diagram, I was surprised to see the low resistance values used in the "X oscillator" for the microfarad range.

The Author says the total value is around 280 ohm. Even taking into account the "on" resistance of the 4052 analog multiplexer (around 100 ohm at 12V), the current demanded to the first 40106 inverter is too high. Consider the high-to-low output transition: if the Cx capacitor was left at 4 V by the previous half cycle, initial charging current is:

(12 V - 4V)/(280 ohm + 100 ohm) = 21 mA.

At 12V, a 40106 inverter can usually supply less than 7 mA before the output starts "dropping".

So, the oscillator frequency is heavily dependent on the output sink and source current of the inverter.

Unfortunately, this current capability is in turn dependent on the chip temperature (-0.3% per degree centigrade).

If the inverter output stage were not overloaded, that would not be a problem, but in this case, it is.

So, I believe the initial drift the Author sees in the microfarad range (which he attributes to the "reconditioning" of electrolytics), is caused instead by the "warm-up" of the 40106 chip.

A simple improvement would be to use the spare 40106 inverters to "invert twice" and buffer the 280 ohm branch of the oscillator (I think the picofarad range is best left alone with just one inverter in the path, to avoid excessive propagation delay, which would add to the "zero reading").

This would still leave the 4052 "on" resistance (which is also temperature dependent) as a drift factor.

This last problem cannot be easily corrected without adding more chips (for example, using a separate, high-

power oscillator for the microfarad range, and a simple but fast oscillator for the other ranges), or making the measure time for high value capacitors too long.
Paolo Palazzi
Cervignano
ITALY

Electron mysteries

David Potter's excellent discussion of electron diffraction (*EW*, April) brings out the central paradox of wave-particle duality in electronics far better than any previous article. It is well researched and entertaining. I was unaware of many of the original problems of suppression"... Born and friends conducted a satiric seminar, making fun of de Broglie's idea... Schroedinger's ... wave mechanics alarmed his wife... she feared for his sanity."

Heisenberg did not help by deriving the "uncertainty" principle using a bogus treatment of an optical gamma ray microscope, which is impossible. We see on the internet a great welter of attacks on Modern Physics, all of which seem to be pointing out interpretation problems, like Poppers. Sir Karl Popper, in his work "The Logic of Scientific Discovery" claimed that Heisenberg's uncertainty principle was a statistical scatter relationship, when in fact it is really a "variation principle", since it describes the possible variation ranges of a pair of parameters (either momentum and distance, or energy and time; since the product of each pair is equivalent).

Popper and his acolytes created the quagmire by defining a scientific discovery as a speculative theory or a "falsifiable proposition". Archimedes' proofs of the criteria for buoyancy, derived by a combination of clearly stated facts and straightforward mathematical arguments, would be denied by Popper's idea, as well as every mathematical theorem. Archimedes' recently restored lost work, "The Method", confirms that he first speculated, then used the hypothesis as a scaffolding for constructing a rigorous proof. Today's Modern Physics teacher attempts to block the construction of a rigorous proof, claiming that anyone who claims to do so is a charlatan, while having the hypocrisy to pretend to "know" that the reason why apples fall is a "law" of Newton or Einstein which states that it falls. By analogy, a car goes because it is a convenient "law" that the accelerator pedal makes it move, end of story. (End of science!)

In addition to Potter's cameo, the same issue contains Tony Callegari's evidence for ELF signals with wavelengths corresponding to astronomical distances to the Moon and Mars. The frequencies of his measured signals are fractions of a cycle per second. Much conventional wisdom is that nothing below 100 MHz can get through the Earth's ionosphere. In fact, the electromagnetic forces result from continuous energy exchange by spinning particles like electrons (*EW*, Feb 04, letters).

This exchange of energy carries momentum and therefore causes accelerations and forces. Direct exchange causes repulsion; blocking of momentum exchanges from a given direction causes attraction (the oppositely charged plates of a capacitor partly block energy exchange inbetween them causing attraction by the momentum hitting them from outside). The resulting equation gives the correct force strengths more accurately than QED, which is too high by a factor of 137. It also requires "virtual" particles to be massless, with no momentum to cause force, because if they had any mass-energy they would have a limited range on account of being able to exist for the limited Heisenberg time! (See *EW* April 03 "Electronic Universe part 2".)

Callegari's experimental observations appear to be the effect of the Moon and nearby planets on blocking the continuous exchange of energy from different directions, while the Earth orbits the sun at 30 km/second. These slight variations penetrate the ionosphere because they are variations in the background electromagnetic field strength (normally unmeasured because there is equal positive and negative charge around us). I am also very impressed with Ivor Catt's latest letter (*EW*, Feb) where he directly and clearly explains, for the first time, what is wrong with the conventional treatment of capacitors!

It is curious that these developments are being ridiculed by teachers/professors/government science funding committees paid by taxpayers to be objective. University Faculty science regularly employs political solutions to tackle scientific problems (like shooting the messenger).
Nigel Cook
By email

Ghost in the loft

With regard to Ian Hickman's leader article, I've got another ghost for him. Until very recently I was using the Practical Wireless 'Purbeck' oscilloscope that he designed in 1978. I built it when I was 16, using the Watford Electronics kit, and apart from one or two minor repairs it has been working well for the past 25 years. Unfortunately the custom mains transformer went open-circuit in the high voltage secondary, and I have decided to buy a commercial scope with much better performance. I don't think I can bear to bin it though - it will probably sit in the loft for the next 25 years!
Jonathan Wellingham
Broadcast Technology Engineer
Bristol
UK

John Ellis

Referring to the letter by John Ellis in the April issue the correct derivation is that given below.

Capacitor voltage V is correctly given by

$$\frac{dV}{dt} = \frac{(V0 - V)}{RC}$$

$$\frac{dV}{(V0 - V)} = \frac{t}{RC}$$

Integrating

$$-\log_e (V_0 - V) = \frac{t}{RC} + k$$

(Note the appearance of the negative sign)

$$(V_0 - V) = e - \frac{t}{RC} \quad e^{-k}$$

Now, when t = 0, V = 0

$$V_0 = e^{-k}$$

$$(V0 - V) = V_0 e - \frac{t}{RC}$$

Transposing

$$V = V_0[1 - e - \frac{t}{RC}]$$

Bryan Hart
Leigh-on-Sea
Essex,
UK

Circuit ideas

If Mr Diestlin (Letters April 2004) is unhappy with the quality of the circuit ideas then the solution is in his own hands, he can submit some ideas that meet his standards of quality and refinement and allow then to be assessed by the rest of the readers.

Although many readers will be employed within the electrical and electronic professions, he must remember that many of the circuit ideas will be submitted by people acting in a private capacity and will not, therefore, have been subjected to the normal peer assessment within a design team.

It might be useful to readers generally if the circuit ideas could be rated by their designers and the rating published. I suggest that three ratings would be adequate.

1. This is a purely "paper" design that looks as if it will work.
2. The design has been made to work on a "breadboard" but needs further development.
3. The idea has been built and is working successfully in the system for which it was designed.

My own submission (not yet published) was intended to be used in a motor vehicle. As this is a quite harsh environment for electronic circuitry it seemed sensible to fully test on the vehicle before making the circuit public. However, the title "Circuit Ideas" puts no pressure on any contributor to build or test anything.
C G Gardiner
Chelmsford,
Uk

"Puzzle" in April issue

I came across the same problem a few years ago. Surely, the circuit of fig 1 only relates to a "cube" of resistors all of the same value. The method of shorting all points of the same value is a useful concept, but limited to the one situation where the values are all equal. Ray D. Smith mentioned the idea of simplifying a circuit to enable it to be solved. This is what I used to stress to my students when lecturing on electrical theory. The better way to simplify the general problem of a "wire cube" of unequal value resistors is to use the "Star to Delta" and "Delta to Star" transforms. This then enables resistors in parallel and resistors in series to be solved step by step.

As a side issue, I have never seen it stated in any book or article, that there can be a voltage without a current flow (practically) but there cannot be a current without a voltage. This comes from work I am involved with concerning so called "induced current" I feel that the statement "Induced current" is incorrect. It should be "Induced emf" and the current that results is limited by the equivalent resistance of the material in which the emf is induced.
Ivan Eamus (G3KLT)
By email

In praise of Alan Bate

I think I bought my first edition of *Wireless World* (as it then was) back in 1968. I was still in school and to be honest I didn't understand half its content. The thing that grabbed me was the technical discussions and explanations of circuit operation. It was so much better than the other publications of the day like *Practical Electronics* and *Practical Wireless*. They offered interesting designs but were presented with only the briefest explanation of how things worked.

I particularly remember a series of articles on the design of an oscilloscope written by the editor at the time. They were beautifully written, in a style that informed you of not only of how the circuit worked, but also included some of the calculations of how he got there. It gave such an insight to his thinking.

The article on *Precision Rectifier Circuits* by Alan Bate took me back to those early years. I have no intention of building his design (no offence but I have no need of it) but the insight into his thinking was pure magic. We are often presented with the final design but seldom see how the author got there or any of his reasoning. Thank you Alan and please mister editor - can we have some more?

While I'm on my trip down memory lane, I also remember a publication called 'Radio Constructor' and the antics of Smithy. It was always the first thing to be read. I loved the way it taught the reader some of the concepts of electronics in a style not unlike Mr. Crabtree Goes Fishing, without the pictures. Ahhh, happy days.
Graham Johnston
By email

Precision rectifier circuits

May I congratulate your contributor, Alan Bate, for the above-mentioned article. It is most interesting. My own application of it will be as a precision AM rectifier for use in vintage communications receivers (such as my RA 17), extracting the RF from the IF output.

The grave disappointment with the piece was the abysmal quality of the circuit diagrams. Parts of them are almost impossible to read, even when expanded on the office photocopier. The quality contrasts vividly with that of the reproduction of the ancient circuit of the harmonic distortion meter in Ian Hickman's excellent piece on the late Linsley Hood. I well remember (and still have) the original article and what a model of clarity the circuit is. I appreciate that you were probably reproducing the author's own artwork. Dependency on a diagram largely assembled by a PC program, however, is no substitute for a diagram drawn by and old-fashioned human draftsman. Was it not possible to transform the author's circuit into you usual clearer format? Most other journals and magazines do this.

Could I also ask you to proof read such articles with greater care. I am intrigued as to a measurement of input impedance expressed as being 'over 50kW' (see pg 29). In my youth 'kW' was thought to be a measure of power, and a great deal of it!
Michael O'Beirne
Long Ditton
Surrey, UK

JLH – too late

As a 78 year old contemporary of J Linsey Hood, my first, and never forgotten, introduction to music reproduction was from the pre-war *WW* Quality Class A amplifier, feeding into a home made Voight Tractorial Corner Horn. The one with an 8 sq ft flare opening!

Decca had introduced their new FFSS LPs and when played with a moving-coil pick-up, the sound (in my opinion) has yet to surpassed. With my finances and prospects in those days, virtually nil, the very thought of owning such a magic became a far-off dream. Time moved on. Service in the R.N. gave basic training as a Radio Mechanic and later I also worked at Windscale. In 1969 with a family and the Ceng achieved, the old hankering for 'the sound' arose once more. I built various transistor horrors and longed for the good old days.

Then *WW* to the rescue. There it was... The Linsey Hood PP Class A design. Minimal distortion, a power bandwidth up to 100kHz, enough to satisfy the bats and then in the following month's *WW*, an apology, due to test gear limitation and a remarkable new figure of 2.5MHz. Never mind the bats, watch out for low flying aircraft! OK so it gets hot, buy (as the saying goes) 'if you can't stand the heat'. Etc.

To try do it justice, I made up two speaker cabinets using the new KEF flat piston drive units, based on the idea proposed by Prof. Barlow using expanded polystyrene foam covered with aluminum foil giving low distortion with no flapping cone break-up.

That set-up has been in continuous use ever since. Its only limitation is the signals fed into it. My wife and I have enjoyed fine music over the years from our elderly (nostalgic) records the FM radio, TV Nicam stereo, and latterly (with some reservations) CDs.

Strangely enough I have recently thought I would like to make some mark of thanks for the years of pleasure we have had from this superb amplifier.

Thus it was a shock to see the cover of this months *EW*. Therefore, I am glad of this chance to show my sense of gratitude..... even if it is too late!

Ron Stephenson MIEE
Sculthorpe
Norfolk, UK

Build 'em or print 'em

I read, with a somewhat intellectually perturbed sense of moderate amusement, the amateur projects section in the recent May edition of *Electronics World*, which our local library seems to have received ahead of time. I was wondering if you have a competition with a prize for the best critique, since my only claim to engineering training is that of having spent years listening to my father and uncle in techie conversation - the latter stomping around the room on one leg amid clouds of smoke, explaining the novel particularities of circuits and components that don't always work.

The three diagrams published, unfortunately, one could see at a glance, were ones that don't work. D. Kepple's low battery warning device diagram was incomplete - no point 'B' to stabilise a 5 volt supply chip. Perhaps an error in printing or photocopying, but the Traffic lights simulator was a clever spoof - not so challenging when you find that LEDs will not pass sufficient current to light when in series, especially on the microchip output, and I would not have used a 74HC4017 as neighbourly alternative to seasons greetings feedback. The Long delay timer using only one 555 chip seemed fine except that it would not time anything at all! If the guy that sent the latter diagram wants to pay for a longer delay timer circuit, one that does not suffer from stalled threshold phenomenon, and in which the 555 chip itself lasts longer, he need only check out my website and email me (note the email address if not a Yahoo or Hotmail user).

I hope you don't find this just too embarrassing to print - otherwise the *EW* clear editorial style makes interesting reading. Having spent a few years gaining experience in various forms of business, I'd be ready to work as admin for an electronics professional - but any diagrams that I offer as useful electronics gadgetry will be of value for their accuracy and workability in solving problems of our time.

Martin J. Marsh, B.A.
London, UK

No offence

My original missive was intended to be facetious but with a small barb; "less errors" made me smile.
I took no offence at your comment and it amused both my wife and my colleagues..

I seem to have struck something of a chord though and clarity of communication is important.
Paul :-).

p.s. Shouldn't that have been " letter writers' " rather than " letter writer's " given the absence of the indefinite article?
Another five minutes wasted....

Paul Bartlett
By email

CD-R failure

Last year I completed the very lengthy task of transferring all of the music from my L.P. and cassette collection onto CD-R. I had already transferred most of the data I was holding on floppy disks, SmartMedia cards and various hard disk drives onto CD-R, in the belief that this medium was good for at least 20 years.

At about this time, I was disturbed to learn that the Dutch magazine PC-Activ had published test results on 30 different brands of CD-R showing that some had deteriorated in just 20 months. A year later, after checking my own pile of 70 CD-R's, I have discovered that about 30% have deteriorated. In my case, one make in particular, made by Swiss-based Vivastar was prone to this type of slow progressive failure.

From various comments on the internet it seems many users of CD-R are having the same problems, some having DC-R failure in months rather than years. Perhaps one could expect the cheaper makes of CD-R to fail earlier, but it seems the problem is not confined to them.

Several theories have been put forward for the cause of this decay. The upper side of the CD-R seems to be its Achilles heel. One theory is that permeability of the upper surface of the CD-R allows atmospheric attack of the metal layer. Another supposition is that the glue used in some labels leads to slow contamination via the same route, yet another blames the use of some types of pen used to write on this side. I would have thought that it is unlikely that the dye is a fault, but curiously in my case the older Cyanine-based CD-Rs appeared to be relatively unaffected.

It would be interesting to hear if any EW readers have had similar experiences and can throw some technical light on the problem.

Simon Wright
By email

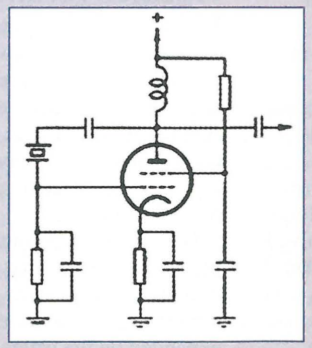
Old hat

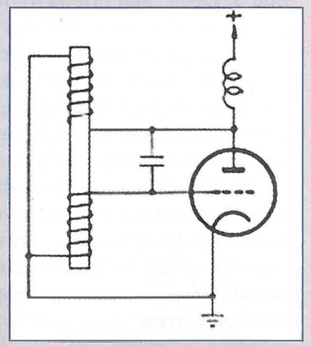
The "Floating Transducer Buffer and Amplifier" presented by Andrew S Robertson in March 2004 *EW* is interesting and useful, but hardly new – in fact very 'old hat'. Sorry Andrew, we've seen this circuit before!

As an early example, I quote the work of George W Pierce, who patented his famous oscillator with the same connection arrangement in 1923. I attach two examples of his work which can be found at http://www.geocities.com/neveyaakov/electro_science/pierce.html

The first is his oscillator: and the second a magnetostriction amplifier with the same familiar circuitry.

Murray Greenman ZL1BPU
Karaka, South Auckland,
New Zealand





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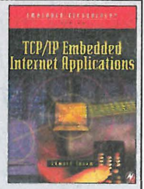

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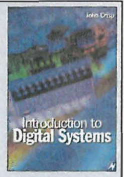

John Crisp

This self-study text introduces digital electronics from first principles, before going on to cover all the main areas of knowledge and expertise. It covers the practicalities of designing and building circuits, including fault-finding and the use of test equipment.

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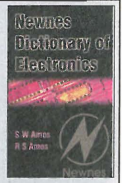

S W Amos; R S Amos

Aimed at engineers, technicians and students working in the field of electronics, this dictionary provides clear and concise definitions, including TV, radio and computing terms, with illustrations and circuit diagrams.

4th edition ▲ Mar 2002 ▲ 394 pages
100 illustrations ▲ PB ▲ Published in UK
Code 0-7506-5642-5 **£12.99**

NEWNES GUIDE TO TELEVISION & VIDEO TECHNOLOGY

Eugene Trundle

An exploration of television and video technology. It covers the fundamentals of digital television (satellite, cable and terrestrial) and digital video, as well as providing a grounding in analogue systems.

3rd edition ▲ Feb 2001 ▲ 432 pages ▲ Index
PB ▲ Published in UK
Code0-7506-4810-4 **£17.99**

NEWNES GUIDE TO DIGITAL TV

Richard Brice

Covering all aspects of digital television, this text encompasses the electronics of the equipment, data compression, television production, servicing and the different transition methods - terrestrial, satellite and cable. The text has been updated with developments since the 2000 edition.

2nd edition ▲ Oct 2002 ▲ 304 pages ▲ Index
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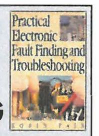

Robin Pain (Design Engineer, Cotag International Ltd)

A text using simple circuit examples to illustrate principles and concepts fundamental to the process of analog and digital fault finding. It aims to help the reader tackle any job, from fixing a TV to improving the sound of a hi-fi. A digital multimeter and oscilloscope are needed for these jobs.

Apr 1996 ▲ 284 pages ▲ Index
50 line illustrations ▲ PB ▲ Published in UK
Code 0-7506-2461-2 **£21.99**

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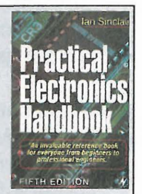

Ian Sinclair

A collection of all the key data, facts, practical guidance and circuit design basics needed by a spectrum of students, electronics enthusiasts, technicians and circuit designers. It provides explanations and practical guidance, and includes new sections on SHF techniques and intruder alarms.

5th edition ▲ Feb 2000 ▲ 571 pages
Illustrations ▲ PB ▲ Published in UK
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Radio Society of Great Britain

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Mac E Van Valkenburg; Edited by Wendy Middleton

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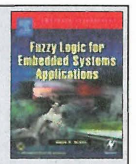

Dr Ahmad Ibrahim

Written by a recognised expert in the field, this covers all the basic theory relevant to electronics design, with particular emphasis on embedded systems. It shows how the techniques can be applied to shorten design cycles and handle logic problems that are tough to solve using conventional linear techniques. All the latest advances in the field are discussed, and practical circuit design examples presented.

Oct 2003 ▲ 312 pages ▲ PB
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Farid Dowla (Lawrence Livermore National Laboratory, University of California-Davis, USA)

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November 2003 ▲ 720 pages ▲ HB
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John Watkinson, Francis Rumsey

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Edited by Peter Marlow

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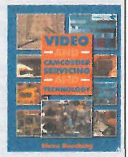

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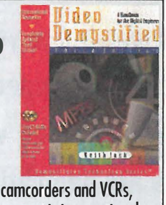

Keith Jack

This edition has been updated to include information on digital television, datacasting, interactive video, digital camcorders and VCRs, and video interfacing. Coverage is international, including European, Asian and North/South American video standards, methods and techniques.

3rd edition ▲ Jul 2001 ▲ 784 pages & CD-Rom
References ▲ Glossary ▲ Index ▲ PB
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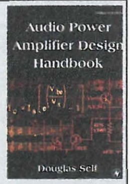

Douglas Self

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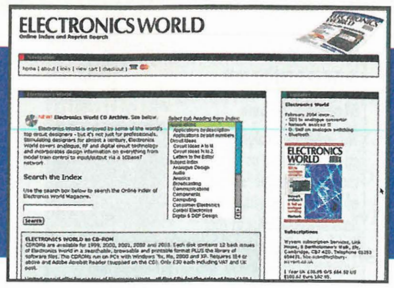

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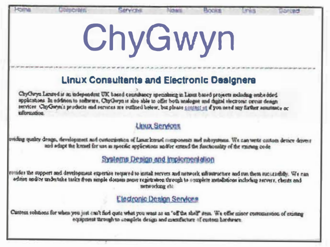

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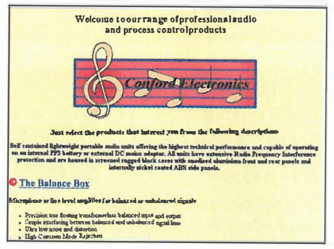

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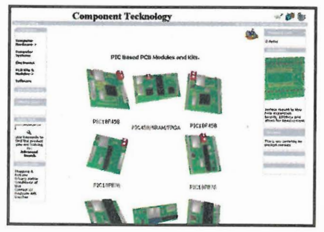

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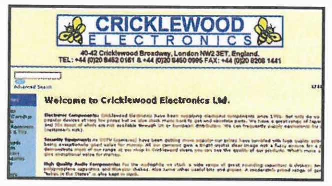

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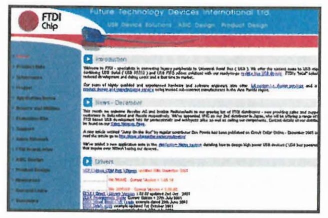

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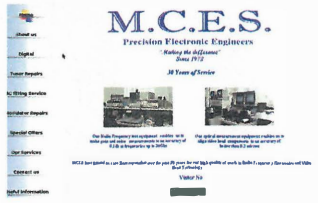

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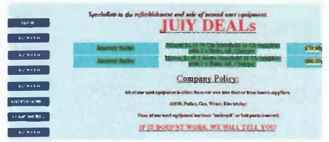

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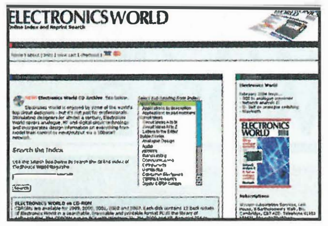

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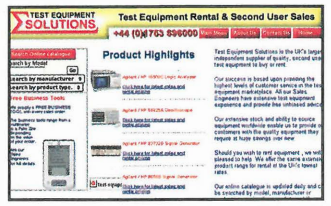

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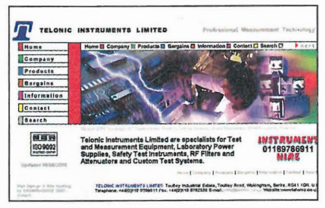

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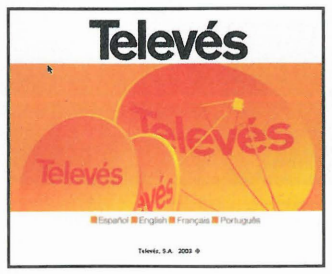

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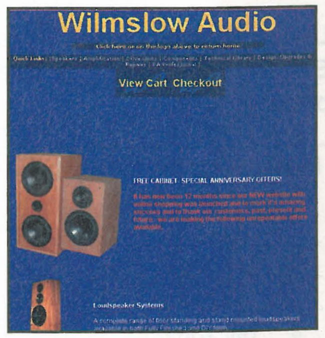

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