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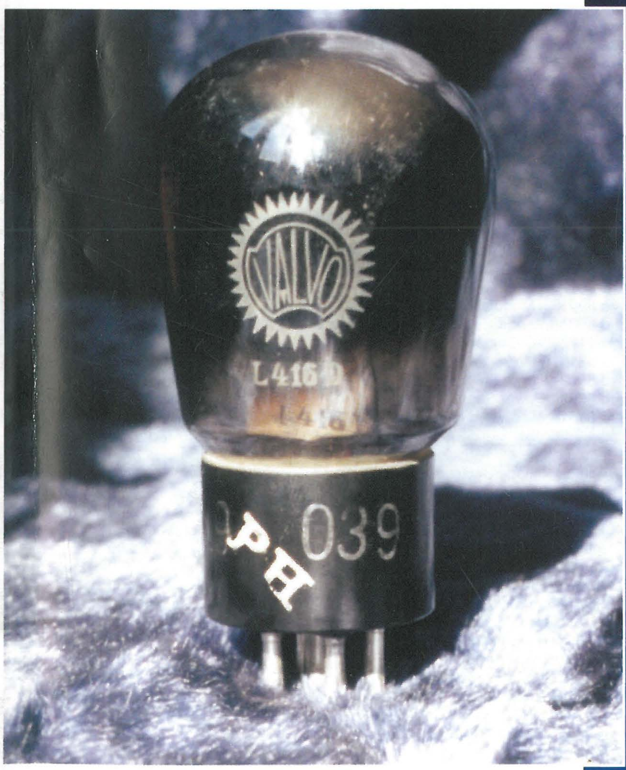
ELECTRONICS WORLD

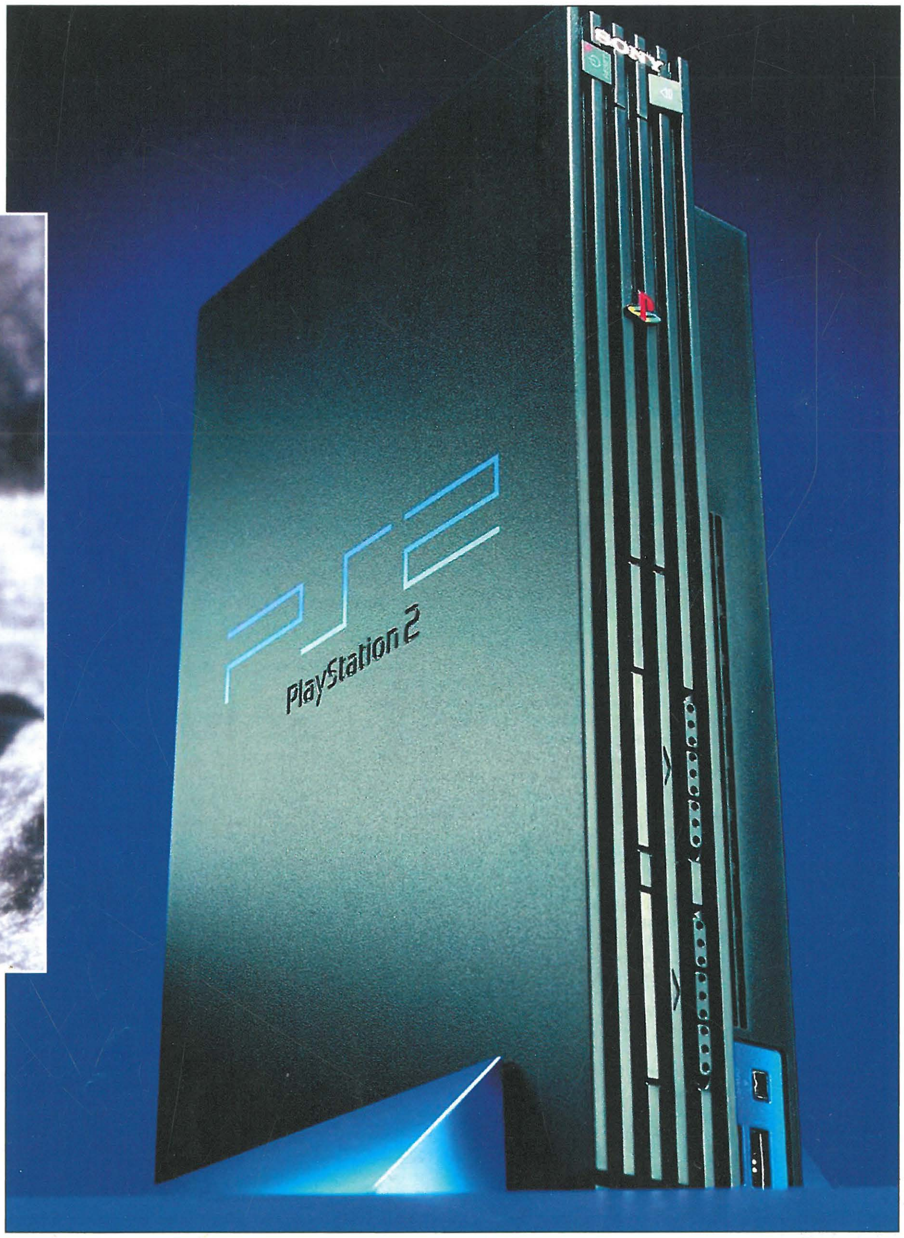
AUGUST 2003 £3.25

Professional SDI video router

Supercomputer from PlayStations

Receivers of the Third Reich





Fundamentals of 802.11

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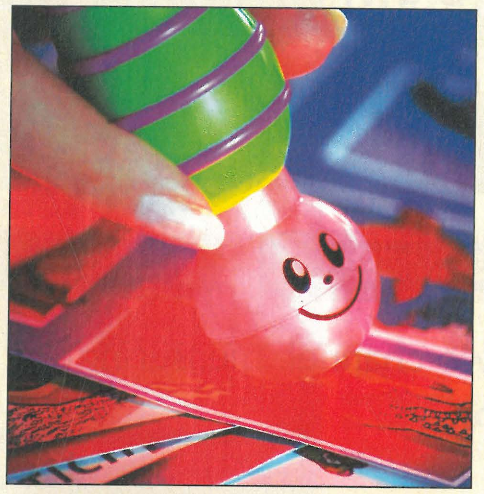

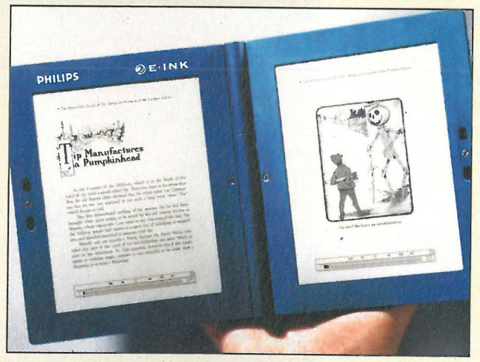

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Throwing Stones in Glasshouses

Authority holds minds, not people. Two years ago, the whole physics department at Essex University closed. The staff moved to mathematics, electronics, and computing. Last year, their mathematics department was under threat. At Gloucestershire University there is no physics taught at all. This is not an isolated case. The problem is that everybody in authority in physics is always right because they can hide behind obfuscation. This is not altogether a healthy environment for students!

I have just finished studying computer programming, multimedia, and marketing courses. The reason? Research is fast becoming a dead end through its own inert authority. T. Theocharis, author of the 1987 Nature paper "Where Science Went Wrong", has recently explained this problem by the following brilliant analogy.

A "theory" is now what a mouse makes up to decide whether to turn right or left in a maze. It is therefore a physicist, guessing which options to pursue without proof. It continually hopes for eventual confirmation that "it was right all along" if it finally - after many blunders - arrives at a small piece of cheese. This absurdity is true.

Take the Catt Anomaly. We know the speed of electricity, and we know the speed of electrons. We know that for a typical 1 amp current, the electron drift speed is 1 mm/second, and conduction electrons account for less than 0.1% of the mass of any substance. Kinetic energy is given by $E = 1/2\ mv^2$, so electron drift delivers less than $0.5x0.001mx(0.001)^2 = 0.0000000005$ Joules per kilogram of wire. "Gibberish, I don't understand physics, I am just plain wrong." Unfortunately, not correct.

Faced with evidence of a problem, a group of idiots have a choice between ignoring it, which is a short-term option only, or trying to discredit it by foul means. The idea of a third choice, of proper discussion, or fear-of-all-fears, of actually making progress in science by bringing clarity to bear on an important problem, would be admitting ignorance. Hence, every point raised is seen to be a danger to a fragile subject that it must be guarded against the slightest inspection. An anomaly must be ignored or ridiculed. Progress would be a threat to the authority of those who fear revolutionary progress. So they would prefer to shoot themselves in the foot in the long-term, by opting for speculations instead of provable facts. They can still hope that the short-term cover-up will sweep away a problem for long enough for it to literally die.

Now we have the electric current used in science to deliver the energy we actually use. Authoritative geniuses will respond with "there is no anomaly", giving no proven explanation. (As Ivor Catt says, "if you have anything new it will first be ignored, then ridiculed, and then finally those same people will claim that they discovered it first!")

Two diametrically opposed views of this anomaly exist among those with a few more brain cells. One is that the electrons are in effect "touching" each other, and thereby transmit energy, like a line of ball bearings pushed from one end. This is wrong, because not only is the kinetic energy delivered thousands of billions times too small (see the calculation above), but the reason why the electric speed is that of light in the medium between the two wires remains disingenuously unexplained. Electrons do drift, so the mechanism does exist. I do not discredit electron motion, I just point out the drift mechanism does not explain the electricity in terms of energy! The alternative view is that electromagnetic energy, which carries the actual energy, causes the electric drift current. Since it travels at light speed, it is more reasonable.

The point of the Catt Anomaly has, says Ivor, nothing to do with his theory. It is an anomaly between rival textbooks and professors. They will answer his polite query in their condescending authoritative manner until they are told that their "explanation" is the exact opposite of that taken by other authors and professors. Then they cannot be induced to communicate with one another to resolve the problem. They use the term "fearful heresy" where more rational beings use "discussion". However, since the Catt Anomaly and Theocharis' work appeared, both originally in *Wireless World*, everyone is at least subconsciously aware that there is something fishy going on!

Physics has gained a reputation for gobbledegook. It is losing its gloss, not gaining respect, by hanging on the last word of gentlemen popularising without proof multiple-universes, 26 dimensions in space, etc. Anyone who points out a contradiction or gives a mathematical proof for a simpler, less obscure mechanism is (1) ignored, (2) becomes a target for a repeat of the gobbledegook they are replacing, or (3) gets a dose of good old political propaganda in response from the establishment spokesperson (misquoting the argument in an effort to claim that the person who is defending science against gobbledegook is actually attacking science).

Nigel Cook

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UPDATE

Government targets UK electronics

The British Government has turned its eye on the electronics industry, with the setting up of an 'Electronics Innovation and Growth Team'. The aim is to boost the UK's electronics industry in the coming 10 to 15 years.

Industry executives and senior Government officials from the Department of Trade and Industry will come together to discuss the industry's needs.

"We need to understand the key issues that will shape the future of this important sector and to ensure that the UK can best respond to the competitive challenges it will face," said DTI minister Stephen Timms MP. "The UK has some great strengths in electronics but we cannot rest on our laurels – competitors are learning quickly and implementing fast."

The team will address the challenges for the whole product life cycle, from design to manufacturing, with the aim of increasing employment and exports.

A steering group will be led by David Kynaston, formerly European head of Solectron and v-p for electronics at trade body Intellect, which is supporting the initiative.

Electronics is not the first port of call for the DTI and its innovation and growth teams. It previously created teams for the aerospace, automotive, chemicals and environmental industries.

Transistors switch 10kW

Toshiba has developed a possible successor to the IGBT with its injection enhancement gate transistor (IEGT) that, in module form, can switch voltages up to 4.5kV at currents of 2.1kA.

The IEGT combines a trench gate semiconductor structure with thin wafers, said the firm. Each individual transistor can handle 1.2kV and 40A. By combining IEGTs the firm can make high power switches.

Compared to conventional non-punch through devices, the IEGT has 23 per cent lower saturation voltage and 400A latch up capability at 125°C.

The device retains the positive temperature coefficient of NPTs, enabling the parallel connection needed for making high power switches.

The firm's 4.5kV and 3.3kV modules are suitable for high-end motor drives, uninterruptible power supplies (UPS), power transmission schemes, HVDC designs and transportation systems, it said.

The 3.3kV module comprises 24 IEGT chips and 12 diode chips and handles currents up to 1.2kA.

The new 4.5kV device has a package diameter of 125mm while the 3.3kV module has a footprint of 140 x 190mm.

Samsung leapfrogs a generation in LCD displays

Large panel liquid crystal displays could tumble in price over the next few years as manufacturers accelerate moves to larger glass substrates.

Within two years Samsung, one of the top two makers of LCDs, will be producing 2.2 x 1.87m panels from its Korean factories.

This marks a jump from today's fifth generation substrates directly to the seventh generation, and will give glass able to yield twelve 32-inch or eight 40-inch displays.

According to Samsung, each new generation cuts manufacturing costs by 20 to 30 per cent. The 40in. screens will be cheaper than similar sized plasma panels, the firm claimed.

LG.Philips LCD, Samsung's main competitor in the market, has already announced plans for a sixth generation (1.5 x 1.85m glass) plant by 2005.

However, Samsung claims the sixth generation size is inefficient for making 40-inch panels, hence the jump direct to the seventh generation.

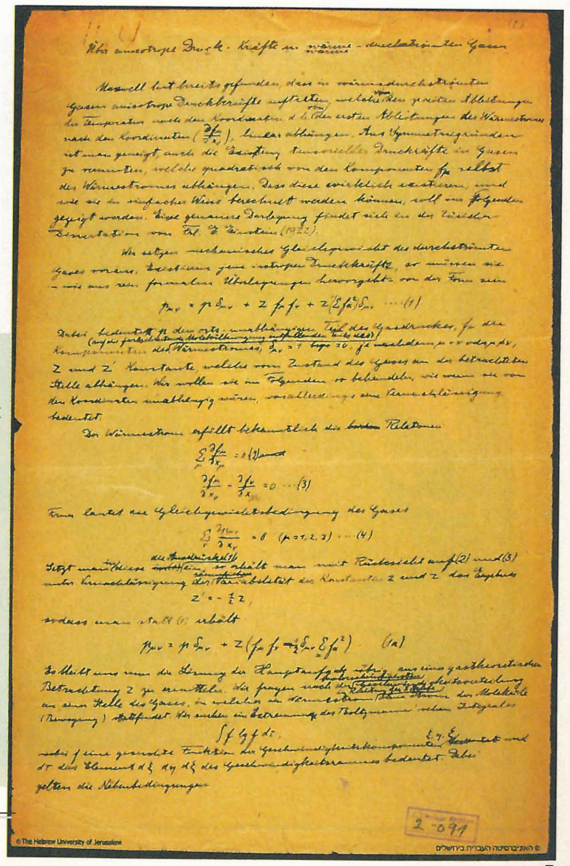
The fifth generation substrates in production today by several firms measure 1.1 x 1.25m.

A Website devoted to the writings and papers of Albert Einstein has gone live at www.alberteinstein.info.

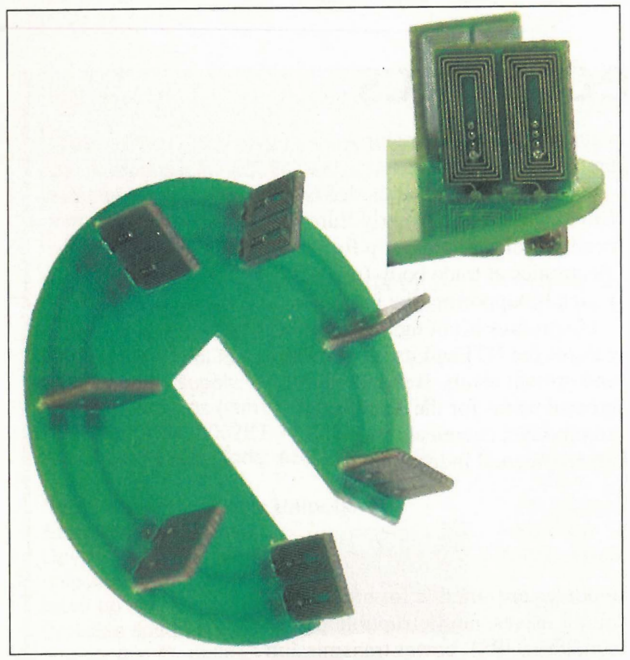
With over 3,000 digitised images and an archive with access to over 43,000 related documents, the site gives the first major public access to Einstein's work.

The online work includes scientific papers, his diaries, correspondence and notebooks.

The website is a joint collaboration between the California Institute of Technology and the Hebrew University of Jerusalem.



Century-old measuring technique gets a face lift



In a move to cut the cost of ac current sensing using the Rogowski technique, Swiss sensor maker LEM has developed a novel variation on the Rogowski coil.

Invented in 1912, Rogowski coils are air-cored toroidal windings which, when wrapped around a current-carrying conductor, produce a voltage proportional to the differential of the current flowing in the conductor.

Having no magnetic core bandwidth is wide, as is dynamic range because there are no saturation effects.

The coils are made virtually immune to external magnetic fields by returning one end of the coil along the centre of the solenoid, making the coil an incomplete turn to interfering signals.

Turns are traditionally evenly spaced around the toroid and careful design means output voltage is largely independent of distortions in the shape of the toroid. This last feature means flexible wrap-around Rogowski coils can be quickly attached to unbroken conductors.

Winding has to be precise, and therefore non-trivial, to maintain accuracy while shrugging off external fields.

In its patented development, LEM has move away from distributed toroidal windings to use a series of discrete fixed coils arranged in two concentric circles around the conductor being measured.

By careful choice of geometry and winding, the two-coil arrangement can like the traditional coil be made almost immune from external fields and remain sensitive to current in the conductor-under-test.

However LEM's method has the added advantages of reducing a complex winding to a PCB, controlling the physical juxtaposition of the various turns, and allowing the conductor-under-test to be introduced through the gaps between coils.

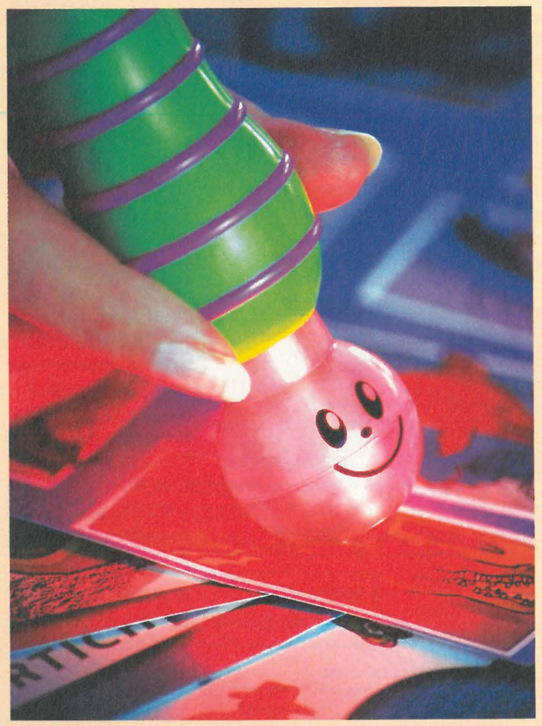
In LEM's case, cost is further reduced because the precision discrete coils are themselves small eight-layer PCBs soldered into the main board.

As output current is proportional to the differential of current-under-test, all Rogowski coils need an integrator on their outputs to create a voltage proportional to current. In the LEM case, this is built into the units, of which there are two ranges: AP with a rectified average current output, and APR for true-RMS work.

Both families have 12 devices covering 10A to 400A.

In-built electronics with 0-5, 0-10V(external 24V supply), or loop-powered 4-20mA output are available. With all, errors are better than 0.8 per cent, bandwidth is 10Hz to 1kHz and temperature range is –20 to 60°C.

www.lem.com



Toy worm uses advanced British technology

Wokingham's Innovision R&T has teamed up with UK research organisation QinetiQ to develop a system which can identify the presence of specialist inks in minute dilutions.

The technology combines an optical filter and synchronous light detector at a price which makes it suitable for toys.

"The simple detector system uses low voltage, performs well in high levels of ambient light and can be easily incorporated into assembly line production," claimed Innovision.

In its first application - an educational game for young children called Contactor - the reader detects inks printed so faintly they are invisible to humans. Fitted in a model glow-worm, it provides visible and audible feedback to multiple choice questions on brightly coloured quiz sheets.

"Our mission is to bridge the gap between the lab-bench and the commercial market place," said Marc Borrett, managing director of Innovision. "In this instance QinetiQ helped Innovision in the development of a filter suitable for the application and will have a share in the royalties from sales of the product."

Further products and collaborations are planned. "We are now exploring a range of potential applications in other sectors including low-cost security and brand protection," said Borrett, "Innovision and QinetiQ continue to work together on new developments, and further announcements are expected in due course."

Where there's a heart

A remote video link for heart transplant experts is being developed by Xiomed, a startup firm from Cambridge.

With the help of a £45,000 Smart Award, the firm hopes its system will help with the assessment of potential donor hearts by experts at Harefield Hospital.

"The problem Harefield has got is that when a donor becomes available there's limited time to assess the heart," said Gerard Wimpenny, co-founder and director of Xiomed.

Often the only tests that can be carried out are checking blood type and age, giving rise to broad judgements on the heart's suitability for transplant. Some suitable organs might be wrongly rejected, while others might be selected only to be found unsuitable at a later stage.

More in-depth checks on blood flow and heart valve operation give better results, but this requires the use of a Doppler echocardiograph while the donor is still on life support.

"But people who can do this are few and far between," explained Winpenny. "What is needed is a means of connecting together the specialist and echocardiograph machine."

Xiomed's system will do just this, giving video, audio and text links between the surgeon and machine operator.

"We're developing a system that will run over the NHS net, an IP system," Wimpenny said.

Video data will be multiplexed with other instrumentation data and the verbal guidance from the specialist.

Data rate could be as low as 50kbit/s, said Wimpenny. It will use object based encoding to get resolution where it is needed.

Digital system verifies passports

The Generics Group claims to have invented a cheap digital identity verification system for use with documents such as passports.

The technique uses an analogue source, such as the photo on a passport, to generate a large number.

Generics has found a way to repeatably generate the same number from the photo - critical to the scheme's success. The firm describes the number as "highly reliable and discriminatory".

The number can be stored on the passport alongside the photo, perhaps encrypted using public key cryptography into a bar-code.

"Any attempt to modify the photograph or any other element of the documentation would be uncovered as soon as the bar code was scanned," said the firm.

The system also ensures privacy, as the biometric data does not need to be stored in a central system.

IEE merger looks likely

Talks are ongoing between the IEE, the Institute of Incorporated Engineers (IIE) and Institution of Mechanical Engineers (IMechE) with a view to merging the three professional bodies.

Following a recent meeting, the president of the IEE, Professor Mike Sterling, said: "Most of the comment and questions concentrated on how to proceed rather than whether we should."

All three organisations are carrying out consultation with members. IEE members can give their views at www.iee.org. A final vote on the proposed merger will be carried out in the autumn.

"We are increasingly persuaded of the need for a strong, multi-disciplinary professional body covering all sections of the professional register," said Sterling. "Both members and their employers would find such a body more relevant to the first decade of the 21st century."

Between them, the three UK bodies have around a quarter of a million members.

Walls have selective hearing

Culham Electromagnetics and Lighting has won a year-long contract from the Radiocommunications Agency to lead research into frequency selective surfaces (FSS).

The work could lead to more efficient use of radio spectrum inside buildings, said the Abingdon-based firm.

Arup Communications, the National Physical Laboratory, and Warwick University will join Culham in the programme.

FSS are structures that can be transmissive at some frequencies and reflective at others.

The concept could be applied to screens and partition walls that would block wireless LAN frequencies inside buildings, thereby avoiding interference and improving network capacity.

Both fixed and tuneable FSS will be developed as part of the work.

Bye bye paper, hello e-paper

Electronic paper developer E Ink has joined up with Philips Electronics to create working prototypes of electronic books.

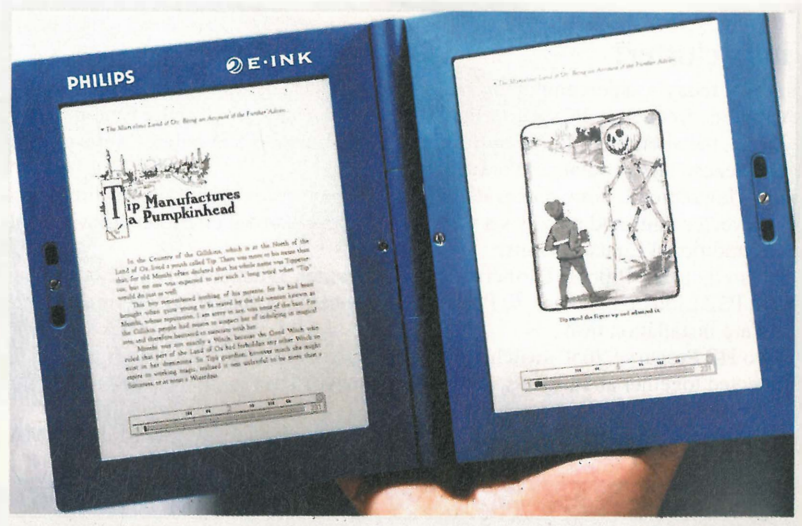
The designs are engineering samples for a customer, not just technology demonstrators, said the firms, and use commercial grade components.

The book pictured has a resolution of 160dots/inch.

This is higher than previously shown, and combines the E Ink material with Philips' thin-film transistor backplane.

The firms expect their customer to go into full scale production sometime next year.

E Ink has also demonstrated a display on a steel foil substrate less than 0.3mm thick. It can be bent to a radius



A supercomputer built from PlayStations

Researchers at the US National Center for Supercomputing Applications (NCSA) in Champaign, Illinois are building a supercomputer from PlayStation2s (PS2s).

"This is literally a hand-made supercomputer assembled by a creative group of researchers who are constantly pushing the limits of our field," said Dan Reed, director of NCSA. "Many people have talked about the possibilities of the PlayStation's graphic processors, but to our knowledge, no one else has attempted to make these machines perform as a large, integrated Linux cluster. We have shown it is possible, and the long-term result could be another low-cost computing alternative for the scientific community."

PlayStation has two fast 'vector units' (VUs) designed to mathematically manipulate polygons for game displays.

"There are 65 compute nodes [PS2s] in the cluster," NCSA scientist Craig Steffen told Electronics World. "Each PS2 has two VUs, and each VU has four floating-point multiply-accumulators [FMACs]. Each FMAC does two floating-point operations per clock, and the clock runs at 300 MHz."

This means, flat-out, each machine can do 2x4x2x300million=4.8 billion FMAC operations per second - written as 4.8GF.

With 65 PS2s, "that's 312GF as an upper bound to the speed of this cluster", said Steffen. "Keep in mind that getting 75 per cent of the theoretical peak is very good, and we're not anywhere near that."

At the moment, having connected the PS2s together, the team is writing basic software. "Right now we're working on the low-level libraries to use the vector units. This is at the proof-of-concept stage at the moment," said Steffen, "When we get a little farther, and we can use the vector units as efficient computational engines, then we'll start thinking about serious benchmarks."

What will finally limit cluster performance, processors or interconnection, can be guessed at said Steffen: "That's going to vary by application. Until we get the VU's under control, it's limited by CPU. Once the VUs are running fast, some apps will be network limited, some will probably still be CPU limited. Unfortunately, a lot of apps will be precluded from running at all due to the non-expandable 32 Mbyte of main RAM."

So far, the project has proved commodity game hardware can be used for scientific work and now the team is working out if the cluster can do it well.

If it can, "then we hope that the time we've spent working on the PS2 will let us hit the ground running with the PS3," said Steffen.

www.ncsa.uiuc.edu/.
http://arrakis.ncsa.uiuc.edu/ps2/cluster.php

PlayStation2 plus announced

Sony remains silent on anything to do with the PlayStation3, but recently announced details of what could be described as PS2+.

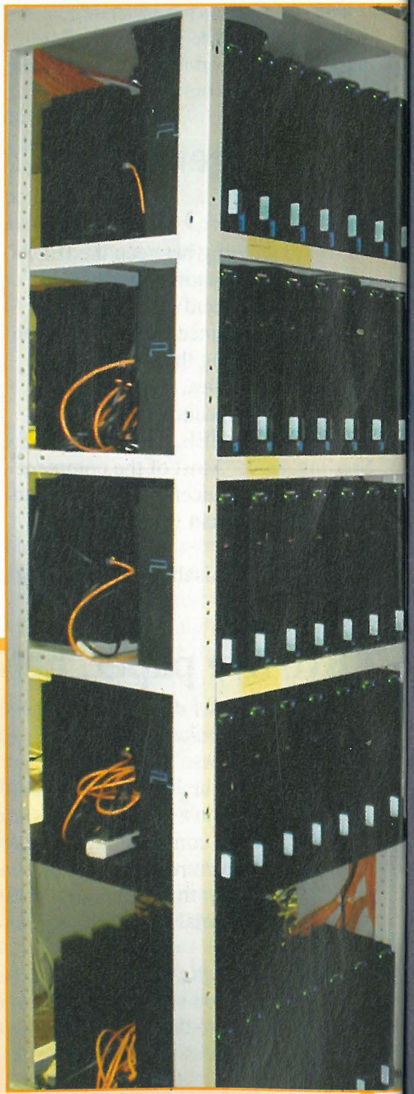
To be called PSX, the up-market machine will retain the Emotion Engine and graphics synthesiser chips from PS2, which means it will still play PS and PS2 games as well as DVDs, but it will look like a piece of hi-fi and do a whole lot more.

Inside Sony plans a looking slot-type DVD recorder as well as a 120Gbyte hard drive, with a built-in TV tuner to record programmes on either.

On the back is Ethernet, USB 2.0 and a Memory Stick slot.

PSX "will be launching in Japan in this fiscal year and in other territories in the next fiscal year, which means we may see the PSX in Europe in 2004 or 2005", said Sony.

Sony has also announced a portable 60mm optical disc-based PlayStation, called PSP.



Linux cluster?

Many of today's supercomputers are so-called clusters. These are shelves or racks of simple computers, frequently PCs, connected together by a network, usually Ethernet.

Linux, the alternative PC operating system to Microsoft's Windows, suits cluster applications well because it is good at networking and is free.

For PlayStation2, Sony makes its Linux Kit which gives programmers direct access to the PS2's vector units and provides a working and development environment with tools found on more traditional Linux systems.

It also includes 100baseT Ethernet hardware which attaches to the PS2 box.

The PS2 Linux cluster has 70 PS2s: 65 for processing, four as user terminals and one for software installation tests.

Two HP Procurve 2650 switches each network roughly half the cluster and the two switches are connected together at 1Gbyte/s, and to the firewall/fileserver at the same speed.

"http://arrakis.ncsa.uiuc.edu/ps2/ps2_network_diagram.jpg" * MERGEFORMATINET

Energy saving output driver

Cambridge company Adiabatic Logic has invented an output driver that can cut power consumption in the I/O of integrated circuits by up to 75 per cent.

With modern ICs such as microcontrollers and Asics burning half their power in the I/O, the firm's design could have dramatic effects on power consumption.

"This came out of some work on adiabatic clocking on chips," said Geoff Harvey, chief technology officer at the firm.

The intelligent output driver (IOD) makes use of reflection along a transmission line, a textbook phenomenon.

To shift a chip's output from a zero to a one, the IOD first raises the output voltage to half the rail voltage. This uses charge stored in an on-chip capacitor, passed through a three-pole switch. The reflection from the receiver chip will double the voltage to the rail. When this happens the switch automatically takes the output up to the rail voltage.

When moving from a one to a zero on the output, the charge returned to the driver is stored in the capacitor ready for the next low to high transition.

"In theory you can save 100 per cent of the charge, but we're limited to 75 per cent because of real-world losses," said Harvey.

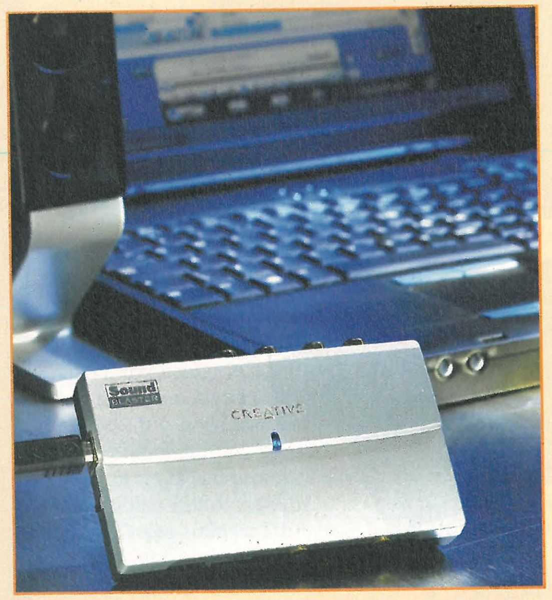
The system will also save cost, said Harvey, as it does away with the need for serial termination resistors. "And with IOD you already have an inductor in the PCB tracking."

The extra capacitor needed in the IOD for driving outputs high should not take up too much room. "We typically need five to seven times the load capacitance for the reservoir capacitance, so we're talking about $0.1mm^2$. That's about the same as the bond pad," Harvey said. A single capacitor can be shared between multiple I/O pins.

Several companies are said to be interested in licensing the IOD for use in ICs.

www.adiabaticlogic.com

Consultancy firm The Technology Partnership (TTP) has developed a module for transmitting video over the Internet. The unit is aimed at delivering video-on-demand in systems such as in-flight entertainment or around the home to multiple TVs. Adding a hard disk drive, said the firm, would turn the unit into a personal video recorder. Multiple units could be used, connected via Internet to a central set-top box or gateway. IBM's PowerPC processor runs the Linux operating system and can handle MHEG, MHP and Java. The unit decodes an MPEG-2 stream running over Cat-5 or coaxial cabling. TTP is working on a wireless LAN version.



As a way to get reasonable quality audio into PCs and laptops without pulling them apart, Creative has introduced Sound Blaster MP3+. The 16-bit 48kHz external sound card plugs into a USB port and includes analogue and digital inputs and outputs as well as a software bundle.

In Brief

Hard drive company Seagate is trying to persuade IT equipment makers to switch to 2.5 inch hard disks for professional storage - so called 'enterprise' - applications.

"Systems built around these small enterprise-class disc drives will provide data centres with unparalleled levels of input/outputs per second performance in a smaller system space compared to what's being delivered today" said the company.

Compared with traditional 3.5-inch drives, Seagate is claiming: lower power consumption, smaller size, faster I/O and quieter operation.

"The performance density offered by these new systems will create storage solutions that are 33 to 200 per cent smaller than today's systems," it said.

Seagate's 2.5-inch drives for IT use will be produced for the current versions of Fibre Channel and Ultra320 SCSI, as well as Serial Attached SCSI.

Systems based on these disks should appear in 2004.

Fundamentals of 802.11

Wireless networking is all the rage and could just be what is needed to connect together entertainment devices in a domestic environment, let alone its business potential. Ian Poole explains how it works

Wireless networking is one of the new growth areas in electronics with many chip and circuit card manufacturers poised to take advantage of the new markets. Previously wired connections were always required to enable PCs to connect to networks and to other peripherals. Now this can all be accomplished far more conveniently using wire-less technology. It can now be said that Wireless Local Area Networks (WLANs) have made the transition from being a relatively niche market to a mainstream technology. Manufacture of chipsets quadrupled between 2001 and 2002, and this growth is set to continue as people take up the advantages of this new technology.

There are a number of standards that are used for wireless connectivity. 802.11, Bluetooth, and hiperLAN are but three. Each operates in a slightly different way and they are used in different areas. For computer peripheral interconnections the 802.11 family of specifications is becoming widely used.

802.11, rather than specifying a single standard actually covers a family of similar standards. Some of these are ratified and can be implemented whereas others are not yet. In fact the 802.11 working group is just one of the 16 groups that exist under the IEEE LMSC (LAN / MAN Standards Committee). (The IEEE is the Institute of Electrical and Electronics Engineers that is based in the USA)

The reason for the large number of different standards is that since the first proposals were finalised and launched the industry has moved forward and it has been possible to introduce new features and update the specifications as a result of industry feedback. Issues such as throughput rate, operating range, security, robustness and ease of operation have all featured high on these lists. As a result of the success and widespread use of the system it has been possible to introduce further variations of the standard to encompass these issues, whilst still retaining the earlier versions to enable manufacturers to continue with their existing products.

Basic specifications

The first of the 802.11 standards to be launched onto the market was developed to support roaming within an office environment or where wired connections are not convenient. As a result WLAN cards for computers use this standard and enable people to hot desk and the like. They may also be used for large conferences where delegates need to use their laptop computers to access data dynamically.

The performance of this 802.11b standard is comparable with many wired systems, supporting data rates of up to 11Mbps. It uses direct sequence spread spectrum techniques with a total of 52 carrier centre frequencies. Like many other applications such as Bluetooth, 802.11b uses the 2.4GHz ISM (Industrial, Scientific and Medical) band allocation. Not only do other data services use the band, but many industrial and heating applications such as microwave ovens also use this band. It therefore has to be very resilient to interference.

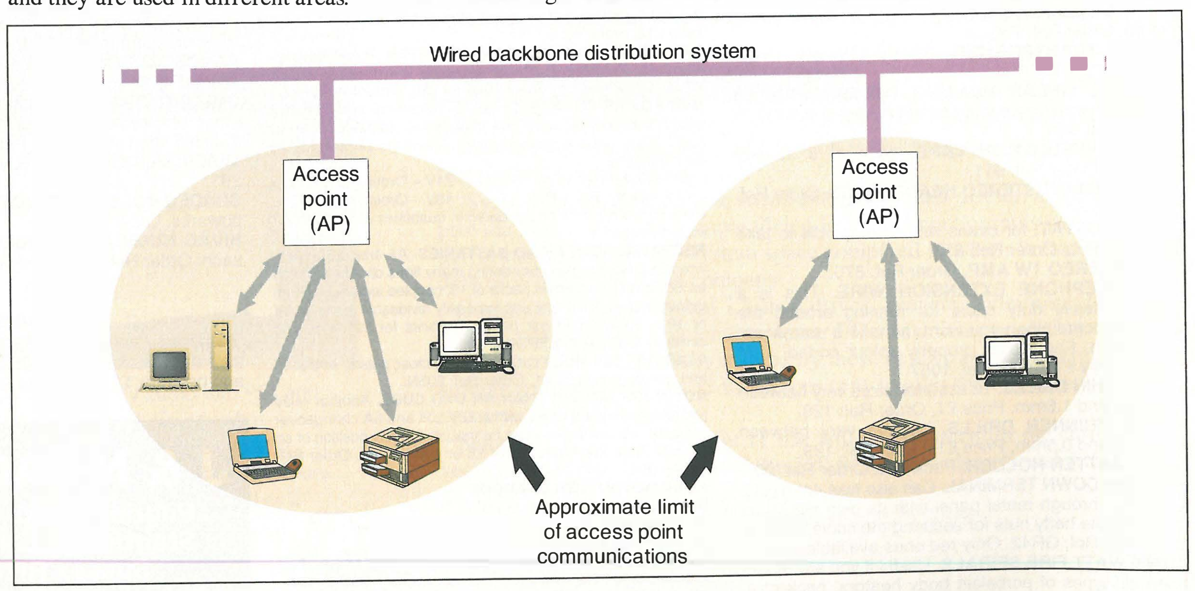


Fig. 1. IEEE 802.11 system as used to provide connectivity for a large network system

The 802.11a specification is a higher performance specification. It uses the 5GHz ISM band which is expected to be less congested. This specification can achieve data rates of up to 54Mb/s and employs orthogonal frequency division multiplex (OFDM). It is not as popular as 802.11b, because manufacturers have now established their production lines for the standard and using a higher frequency costs will be slightly higher. However for the future it is anticipated that it will gain considerable acceptance in some areas.

As if this was not enough, a further specification, 802.11g is being introduced. Due for ratification in June 2003, chipsets were available at the beginning of 2003, anticipating its success. Offering data rates of 54Mb/s and using the 2.4GHz ISM band it is backward compatible with 802.11b, thereby enabling the new standard to work seamlessly with existing 802.11b cards. It achieves its higher speed by employing OFDM for the higher data transfer rates and the enhanced protocol enables the backward compatibility.

Networks

By using a wireless network it is not necessary to install a wired network. Despite the cost of the additional wireless hardware, the wireless solution can be considerably cheaper than the wired solution. This results from the fact that wired networks are very costly to install and maintain, especially if they need to be modified to take account of a new office plan. Whilst it may be argued that WLAN cards are required in each computer, ordinary LAN cards are needed anyway for a wired version. Accordingly the costs for the hardware tend to roughly balance out.

Apart from the cost the WLAN provides significant advantages in terms of flexibility, enabling mobile office working far more easily.

Using the 802.11 system there are two types of network that can be formed. These are termed infrastructure networks and ad-hoc networks. The infrastructure systems require a hard wired backbone. This backbone is connected to a server and uses the wireless link to enable connection to the full computer network and other local services such as printers. The wireless network is then split up into a number of cells, each serviced by a base station or Access Point (AP) which provides access to the backbone of the full system. This Access Point may have a range of between 30 and 300 metres dependent upon the environment. Although involving some wired connections, the wires to the access points are not constrained in the same way that fully wired networks are, and they are therefore much easier to install.

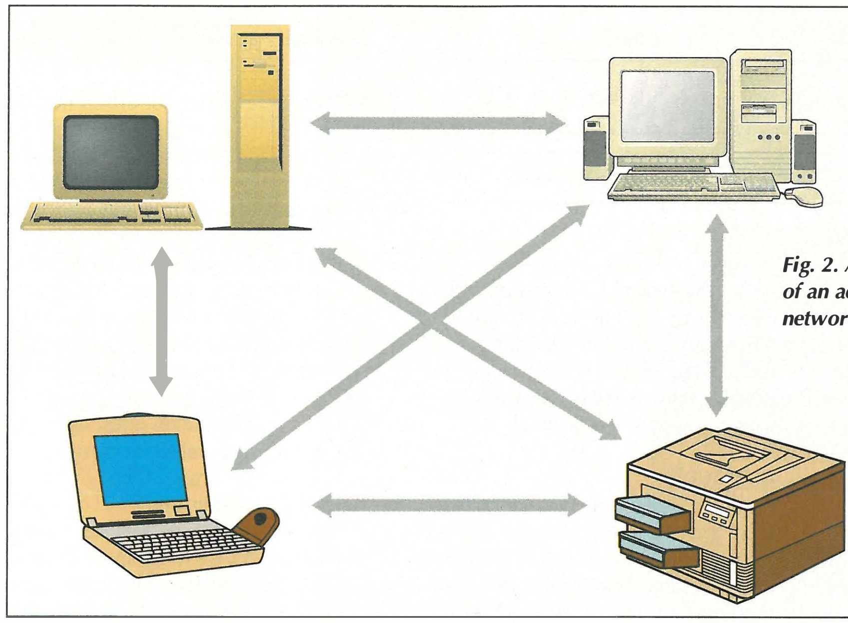


Fig. 2. An example of an ad-hoc network.

The other type of network that may be used is termed an ad-hoc network. This type of network is formed when a number of computers and peripherals are brought together to communicate with one another. One of these networks may be required when several people come together and need to share data between their computers or if they need to access a printer without the need for having to use wire connections. In this situation they only communicate with each other and not with a larger wired network and there is no controlling Access Point. For this type of operation, special algorithms have been generated to enable the system to operate with one of the peripherals taking the role of master to control the network and the others acting as slaves.

Modulation scheme and data structure

802.11b uses a technique known as direct sequence spread spectrum (DSSS). It spreads the signal out over a wide bandwidth and as a result it enables the system to operate in an environment where there are other users and levels of interference may be high. A variety of different types of modulation can be used and they are chosen dependent upon the rate at which data is to be transmitted. Systems running at 1Mb/s use BPSK (Binary Phase Shift Keying) modulation, and those running at 2Mb/s QPSK (Quaternary Phase Shift Keying) modulation. For higher data rates, systems running at 5.5Mb/ps and 11Mb/s use CCK (Complementary Code Keying) and QPSK modulation. CCK involves 64 unique code sequences, each of which supports 6 bits per code word. The CCK code word is then modulated onto the RF carrier using QPSK, and this allows another two bits to be encoded for each 6-bit symbol. In this way each 6-bit symbol contains 8 bits, i.e. 1 byte.

The same both ways

802.11 cards are all designed so that they are symmetrical, with all stations having the same output power capability. This must be the case, especially when the stations are to operate in an ad-hoc mode as any of the stations may be called upon to act as the master. Around the world there are different power limits, but in most cases the maximum limit is 100mW EIRP. The two main exceptions to this are for the USA where the limit is 1000mW and in Japan where the limit is specified differently as 10mW/MHz. A minimum power limit of 1mW is used as this generally accepted to be the minimum level required for communication, even over a very short distance.

Within the allowable maximum, and the minimum levels, the power is

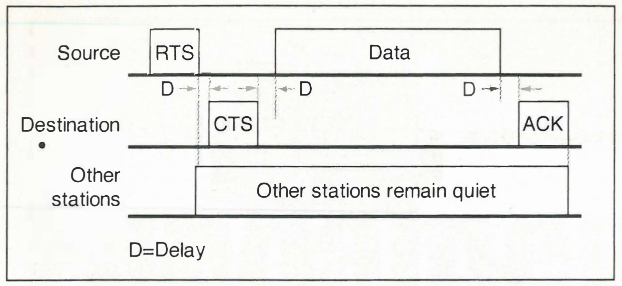


Fig. 3. Transactions between stations transmitting data to each other.

set by the system. This ensures that excessively high powers are not used when they are not needed. This reduces the levels of interference to other nearby cells and ensures battery usage is kept to a minimum.

Protocols

As with any system of this nature there are operating protocols that are set up to ensure the correct operation of the system. When a station wants to join a cell, it must first synchronise with the other stations in the cell. This may be gained in two ways. The first is passive scanning. The station waits to receive what is termed a beacon frame from the access point or another station in an ad-hoc network. This frame is a periodic frame of data that is sent out with synchronisation information on it. This enables new stations to synchronise, and also ensures existing stations maintain their synchronisation. The alternative method is for the station entering a network to send out a 'probe' transmission and then wait for a response.

Once the new station has the synchronisation information it can then request access to the cell. It does this by going through an authentication process. Only when this has been completed can the station enter the cell and exchange data. The process includes exchanging passwords to ensure that the new station should be in the cell.

Collision avoidance

One of the problems that could occur with a wireless system of this nature is that two devices try to transmit at the same time. This possibility is accounted for in the software layer known as the MAC (Media Access Controller) by a system known as CSMA/CA (Collision Sense Multiple Access with Collision Avoidance). This is very similar to the CSMA/CD (Collision Sense Multiple Access with Collision Detection) system that is used in 802.3 for Ethernet. A different system is required for a wireless network because on a wired network all nodes will be able to hear each other, whereas on a wireless network it is possible that one station may not be able to hear all the others.

When a station wants to transmit, it checks the frequency to ensure no other stations are transmitting. If the channel is occupied the station delays sending its message for a random amount of time. When all is clear it sends its message. As there is a possibility another station could perform the same operation at the same time, an acknowledgement is sent to the station from whom the message is received. If the station sending the message does not receive its acknowledgement then it resends its message.

The first message that is sent is what is termed a request to send (RTS). This is done in case there are other stations that cannot be heard. This RTS message defines the length of the message to be sent and the destination. If this is acceptable a clear to send (CTS) message is sent.

Information sent across the system is split into frames. There are three types of frame: data frames that are used to send actual data from one station to another; control frames that are used to control the way in which data is sent. Examples of these are the RTS, CTS and ACK frames that are sent. Finally there are the management frames. These are sent across the system in the same way as the data frames and they are used to control or manage the cell, but the data is not visible to the user.

Summary

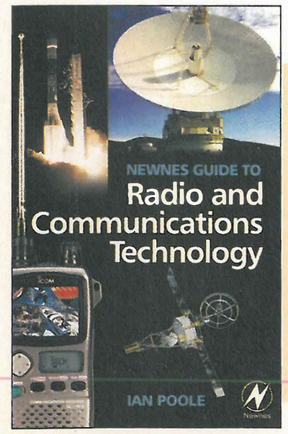
The use of WLAN technology is seen as one of the major growth areas for the electronics industry. Whilst the cellular telecommunications industry may be in recession at the moment, there is no sign of this for WLANs. Intel recently announced that it has set aside $150 million to promote its adoption and it is obvious that it intends to play a very dominant role in this market. Intel's support alone would signal the success of the market, but there are many other players, large and small that are already producing large amounts of product. The question is not whether the market will be successful, but how successful and which players come out on top. ■

What's on in 802

There are a variety of different specifications that result from the IEEE LAN /MAN (Local area network/metropolitan area network) committee. Set up over 22 years ago, this committee has undertaken a vast amount of work that has shaped much of the networking in the computer and data communications industry.

There are a total of 16 working groups that operate under the guidance of the committee and of these the most well known is possibly 802.3, the Ethernet group. Ethernet has become a very well known standard used for a vast number of computer networks. However, with wireless communications rapidly growing in importance, the WLAN working group, 802.11 is seeing its work rise in importance.

802.1	High level interface
802.2	Logical link control
802.3	Ethernet CSMA / CD
802.4	Token Bus
802.5	Token ring access method and physical layer specification
802.6	MAN (metropolitan are a network)
802.7	Broadband technical advisory
802.8	Fibre optic technical advisory
802.9	Isochronous LAN
802.10	Standards for interoperable LAN / MAN security
802.11	Wireless LAN (WLAN)
802.12	Demand priority
802.13	Not used!
802.14	Cable TV based broadband communications network
802.15	Wireless personal area network (WPAN)
802.16	Broadband wireless access (WMAN)
802.17	Resilient packet ring study group



For more information about radio and electronics technology visit www.radio-electronics.com Also, Ian Poole's book *Newnes Guide to Radio and Communications Technology* (published July 2003) gives more information about WLAN technology and many other new wireless or radio technologies as well as the basic radio principles.

German propaganda receivers of the Third Reich

Comparing a valve radio receiver from the 40s to something from the present day, you could be forgiven for wondering how on earth it worked at all. The designers in those days were a lot more innovative than you might think. Jeremy Stevens explains

When as a child I first started dabbling in electronics during the 1960s, valves were ubiquitous in television sets and in the process of being displaced in radio receiver applications. Undoubtedly I broke up a number of potential antiques as valve radio receivers had virtually no value at that time.

I have more recently started collecting interesting examples of radio history and restoring them for daily use – much to the chagrin of my wife. Dealing with valves again instead of microprocessors can be therapeutic: the technology is stable and there is nothing new to learn other than to refresh one's memory of some of electronics' first principles.

I first became aware of the German People's Radio (Volksempfänger) when an old friend of mine contacted me, he having been given a DKE38 to repair. The owner, a former soldier, brought it back to England after the war and I subsequently carried out some research on the subject for my friend and as a result developed an interest in these receivers. It was on a visit to the Techno-Classica exhibition in Essen, Germany, where I was browsing for classic car spares that I came across a pair of Volksempfänger for sale on one of the memorabilia stalls. Volksempfänger are particularly conspicuous when on sale in Germany because the German eagle and swastika emblem is always covered (as dictated by law); this, paradoxically, draws attention to these receivers. Somewhat rashly, I decided to make an offer for a VE301 and after some negotiation I became its owner.

Historical Background

In January 1933 Hitler assumed the office of Chancellor of Germany. By March 1933 the first propaganda broadcasts had commenced having been organised by the Minister of Interior, Frick and SA member Hadamowsky. (After the war Frick was found guilty of war crimes at the Nüremburg trials and subsequently hanged). In April 1933 engineers from the Heinrich Herz Institute under Prof. Leithäuser commenced mapping the field strength of the main transmitters throughout Germany. This work established that reception of national stations could be achieved using a simple TRF receiver. Thus the concept of the Volksempfänger, a mass-produced cheap radio receiver for the reception of German State propaganda, was born. In keeping with the limited sensitivity necessary to make reception of stations outside Germany difficult, the TRF design comprised just two stages, a first stage detector with reaction followed by an audio output stage as shown in **Fig. 1.**

The electrical circuit design of the receiver was by Otto Griesing. Walter Maria Kersting (1889-1970) designed an emblem for the receiver (*20th Century Design* [2]) comprising a silhouette of an eagle's head superimposed over five concentric rings, like ripples in a pool of water. The pace of development of this project was astonishingly fast, the VE301 was announced at the Berlin Radio Fair held in late August 1933. With typical German attention to detail the model number had a special significance as it commemorated the date that Hitler became Chancellor, 30 January 1933. A pre-production run of 100,000 units was prepared for sale at the exhibition, priced at RM76 and all the receivers were rapidly sold. Over the next few years and up to the outbreak of war, the price was to fall further. The sets were made in vast numbers and several variants were produced by a number of different manufacturers from 1933 to 1945. When war started in 1939 the larger radio manufacturers ceased domestic radio production, manufacturing military equipment instead. Limited production of Volksempfänger continued only in small companies. At this time it also became illegal to listen to foreign stations. This heinous crime was categorised as "moral self mutilation" and, if convicted, the minimum term in imprisonment was 5 years. The maximum penalty was death! (*The Past is Myself* [5]).

AC and AC/DC sets were only available with Bakelite cases. Battery and DC only sets were supplied in wooden cases. The stark rectangular lines of the Bakelite case in particular reflected the architecture of the time, as **Figs. 2** and **3** illustrate.

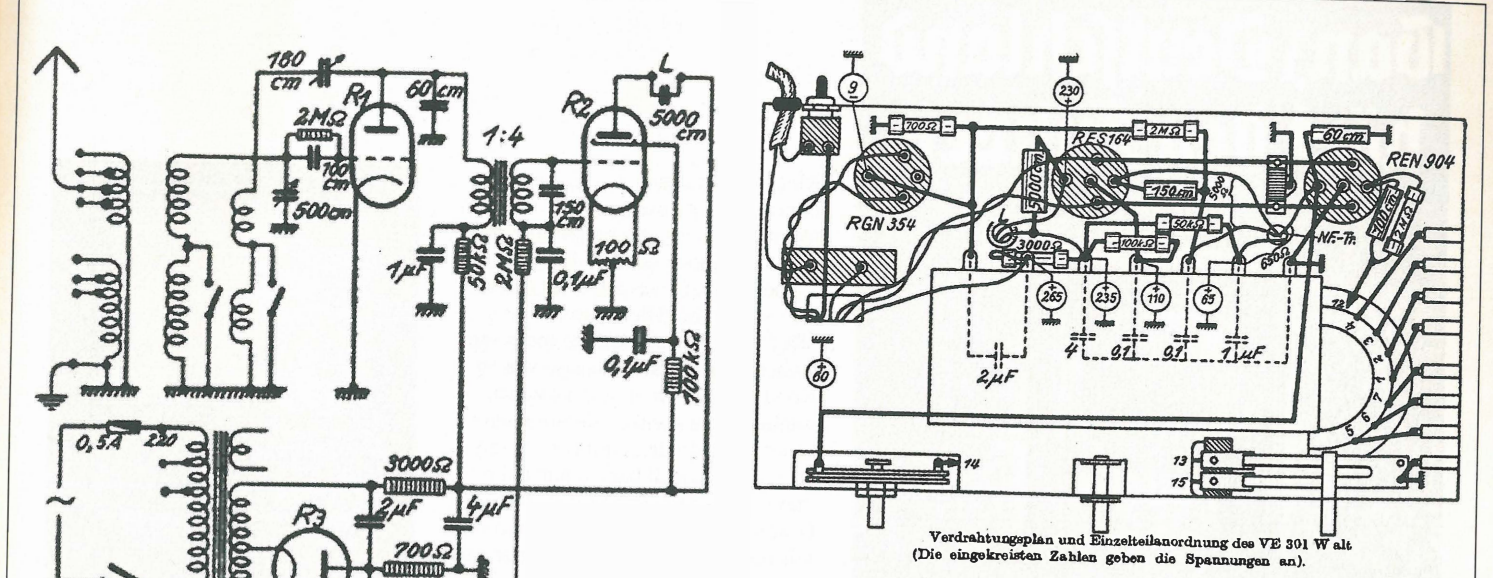


Fig. 1. VE 301 circuit diagram and layout.

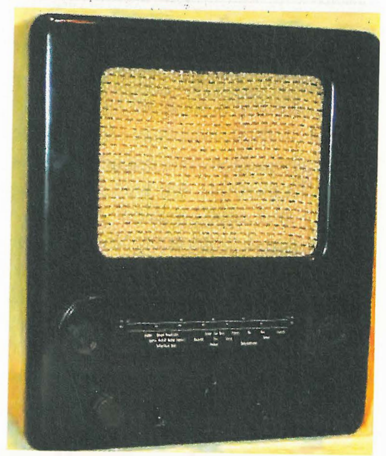
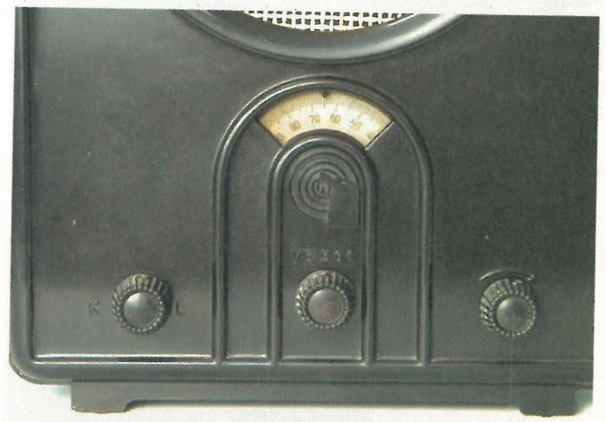


Fig. 2. VE 301 Bakelite case.

The original VE301W was an AC only set (suffix "W" stands for "Wechselstrom" i.e. "AC") and was produced up to about 1938. It had a distinctive round speaker aperture, centrally placed arched feature with a sector cut out to reveal a linearly engraved tuning scale (**Fig. 4**) and multiple aerial sockets on the left side of the case (**Fig. 5**). Kersting's eagle emblem took pride of place in the centre of the arch. This receiver featured on a poster with the caption: "Ganz Deutschland hört den Führer mit dem Volksempfänger" (**Fig. 6**) – "All Germany hears the Leader with the people's radio". In 1938 the "Reichsadler" replaced the eagle emblem. The Reichsadler was an eagle with outstretched wings and talons grasping a swastika, that familiar symbol of the Third Reich and ultimate evil as shown in **Fig. 7**.

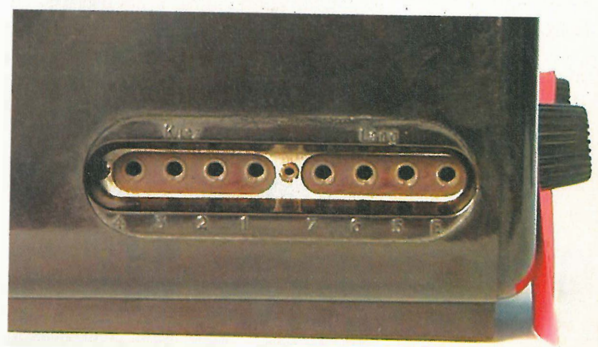
Griesing's design used a triode first stage detector (REN904) and transformer coupling to the output valve (RES164). A RGN354 half wave rectifier provided the HT supply. Its anode was returned to chassis via a 700Ω resistor in order to provide back-bias for the directly heated output valve. The loudspeaker was a high impedance balanced-armature type directly driven from the output valve anode, thus negating the need for an output transformer. There were a number of aerial sockets connected to taps on the coupling coil; three for long wave and four for medium wave plus earth. The desired tap was selected in combination with adjustments to the tuning and reaction controls facilitating optimum coupling in line with the desired listening level and selectivity. The use of Litz wire in the

Fig. 3. VE 301 wooden case.



(Photo Radio Museum Rottenburg)

Fig. 4. Linearly engraved tuning scale.



(Photo Radio Museum Rottenburg)

Fig. 5. Multiple aerial sockets on the left side of the case.

Fig. 6. Advertising poster.

Fig. 7. The Reichsadler.

Fig. 8. AF7 pentode.

RF coils was deemed sufficiently important to be mentioned in the technical description on the first page of the handbook of the VE301.

The VE301G was a DC set (suffix "G" stands for "Gleichstrom" i.e. "DC"), whilst this retained the central arched tuning scale, the case was in wood with the front vertical edges rounded. The speaker aperture was square and divided with two closely spaced horizontal bars to leave the major part of the aperture at the bottom. The primary difference on this receiver was that the rectifier and mains transformer had been dispensed with. The valves were indirectly heated types REN1821 and RENS1823d. The heaters were wired in series with a dropper resistor and drew 180mA.

The two versions of the battery receiver, VE301B & VE301B2, also used the wooden case. The former used two RE034 triodes and a RES174d output valve. The latter used different valves (two KC1 triodes for detector and first stage audio amplifier and a KL1 pentode output valve. In both cases the 2V heaters were powered from an external lead-acid accumulator). Both sets were introduced in 1933 and the "B2" version lasted until 1938 but the "B" version was discontinued in 1934.

In 1935 the AC/DC version, VE301GW was launched. The mains transformer was replaced by a dropper resistor and the valve line up changed to VC1, VL1 and VY1. These valves had 55V, 50mA heaters.

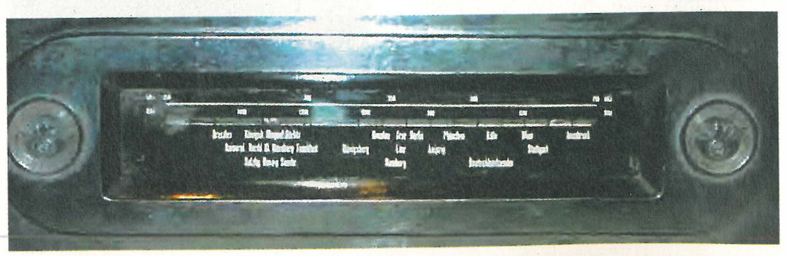
In 1937 the VE301Wn was launched. The suffix "n" stood for neu or new. A front panel control to vary the aerial coupling and bandwidth was introduced to accompany the reaction control. This replaced the multiple aerial sockets employed for the same purpose in earlier models. The first stage detector valve was changed from a triode to an AF7 pentode **(Fig. 8)** and

Fig. 9. VE301Dyn.

the transformer coupling to the output valve replaced by a simple RC network.

In 1938 the VE301WnDyn was launched and represented the end of development as the model continued unchanged in production until 1944. There was also an AC/DC version (VE301dynGW) that used the same V series valves as in earlier models. The Bakelite case was changed substantially as it now incorporated a rectangular loudspeaker aperture **(Fig 9)** with traditional illuminated glass tuning scale as shown in **Fig. 10.** The scale was calibrated in kHz for both MW & LW bands. A conventional moving coil loudspeaker with energised field replaced the balanced armature unit. The output transformer and ballast resistor (28kΩ) were also carried on the loudspeaker frame. The rectifier was changed to a double diode (RGN1064), but was still used in half wave configuration with both anodes wired in parallel. None of the front panel controls were identified on this model (in common with the earlier wooden cased DC/battery versions). The three aerial coupling taps and earth connections were at the

Fig. 10. VE301 tuning scale.



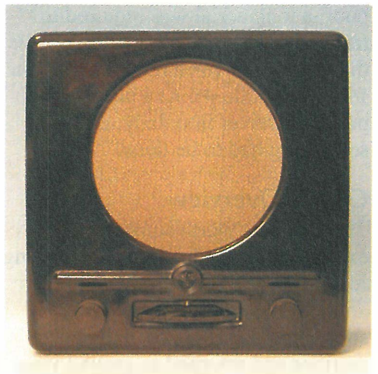


Fig. 11. Braun version of the DKE 38.

Fig. 12. The Deutsche Olympia portable.

rear of the set. Kersting's single eagle emblem was replaced by a pair of Third Reich eagles moulded in the case at each end of the tuning scale. In March 1938 German troops were welcomed into Austria as the two countries united under The Anschluss and the names of Austrian stations joined the exclusively German Reich stations on the tuning scale.

Also in 1938 a smaller, cheaper, receiver was introduced, the DKE38, shown in **Fig. 11.** The DKE38 model name is short for "Deutsche Klein Empfänger (19)38". This receiver was available in AC/DC and battery variants. Also available in a Bakelite or wooden case, it was cheaper than the VE301 and featured a high impedance balanced armature loudspeaker and simple Bakelite tuning knob with engraved linear scale acting directly on the tuning capacitor. Capable of receiving MW and LW stations, an ingenious band switching method was employed, activated when the circular tuning dial was rotated past its 180° end position. The scale engraving was repeated in two colours, white for MW and red for LW. Volume and selectivity adjustment was by means of a front panel adjustable aerial coupling control as in the VE301Dyn. The version of the DKE38 for mains operation had just two valves with 55V heaters, a rectifier type VY2 and triode-pentode, typeVCL11. It was nicknamed "Goebbels-Schnauze" – literally "Goebbels Snout or Mouthpiece" thus underlining the receivers' intended use as a propaganda instrument of the Third Reich. Small changes to the circuit design, primarily in the power supply, were made to the DKE38 in 1940 and 1944.

There were two more propaganda receivers; a portable known as the "Deutsche Olympia" **(Fig 12)** and a workplace set without an internal loudspeaker. The Olympia had the model designation DO36 & DO37 indicating the model years of 1936 & 1937 respectively. The Deutsche Arbeitsfront Empfänger had the model designation DAF1011 and dated from 1935. As with the VE301, the model number had a special significance as it commemorated 10 November 1933 when an address by Hitler to workers in a Siemens factory was broadcast. Although a TRF design, the DAF1011 had both a RF stage and extra audio amplification to provide sufficient power for driving multiple external loudspeakers.

Photographs of the VE301W, VE301Dyn, DKE38 and DAF1011 are published in *Bakelite Radios*[1].

Initial Examination

At the time of purchase I was only able to ascertain that my VE301 receiver was complete, that the case was undamaged and that the manufacturer was Philips. Although clean, everything appeared original including the valves, mains lead and plug. The rubber wiring to the loudspeaker and loudspeaker mounted scale lamp was in a terminal state of decay.

The valve line-up was as follows: Rectifier RGN1064, Output pentode (directly heated) RES164, (L416D) shown in **Fig. 13,** and RF detector pentode AF7. The valves were all made by Valvo and had 4V heaters. All the valves carried a warning that they were only to be used in a VE301 receiver!

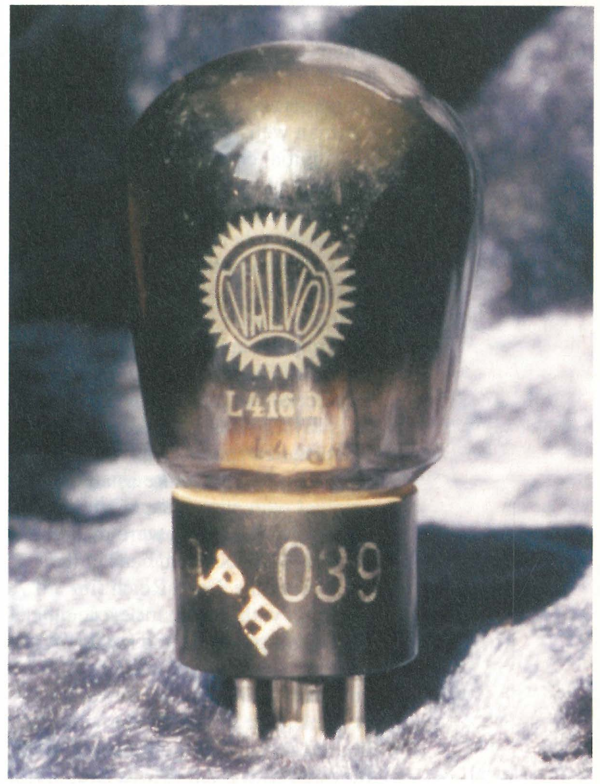


Fig. 13. L416D output valve.

Removal of the chassis was a little difficult because the control knob grub-screws had seized. They were freed by a judicious application of easing-oil. On AC/DC sets these screws are a potential source of electric shock as they can become live if the mains connections are reversed. The same can be true of the AC only sets if there is a fault in the insulation of the mains circuit.

When the chassis was eventually removed the set's excellent overall condition was confirmed, only one repair was evident and that was the replacement of a smoothing capacitor. The replacement (dated 1946) has clearly failed as the pitch encapsulation had run out of the case.

Before proceeding further I decided

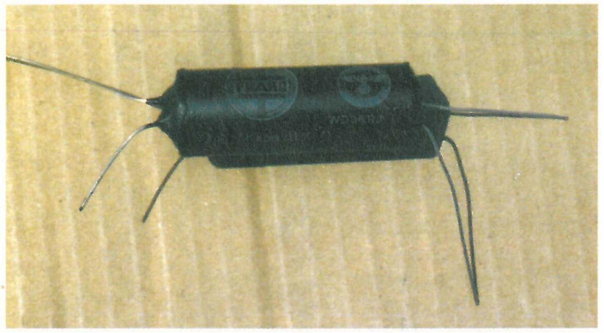


Fig. 14. Restored multi-capacitor.

to draw out the circuit diagram. I could have saved myself the trouble as I later discovered that circuit diagrams are available on specialist German websites.

An initial check of all the passive components revealed that as might be expected all the resistors measured higher than their claimed values but not sufficiently high to warrant replacement. However, it was a different matter with the foil and electrolytic capacitors: all were leaky. I had assumed that as Philips made my receiver it dated from post 1940, possibly 1942. However, the electrolytic capacitors gave a clue to the date of manufacture as all the original parts were dated October 1938. The capacitors were made by NSF and FRAKO and carried the emblem of the Third Reich (in common with just about every other major component in the receiver). Luckily, they were of a type of construction that rendered restoration possible. The capacitor element was housed in a cardboard tube sealed at the ends with pitch. It was a relatively easy matter to remove the complete element by placing the capacitor in an oven at 70°C for about half an hour to soften the pitch and then pushing on the end. Modern components are almost invariably smaller and can be placed inside the original case and sealed in place with the original pitch.

One of the capacitors was a multiple foil type, something I was not expecting to find. The single wound element was tapped giving values of 0.1µF+0.1µF+0.2µF with respect to a common ground terminal. It was slightly more challenging to squeeze modern replacements into this item. The restored component is shown in **Fig. 14.**

Another surprise was the unit of capacitance printed on some of the smaller values manufactured by NSF, namely "cm". Some research revealed that "cm" was once used as the unit of capacitance! According to the Bosch Automotive Handbook[4] $1\mu F = 0.9 \times 10^6$cm and originates from now defunct CGS units system for electrostatic units where the Farad is defined as 9×10^{11}cm. In other words a capacitor of value 1cm is equivalent to 1.11pF. This apparent anomaly results from the attempt to define all units in terms of mass length and time only in the CGS system.

Switching on for the first time

The new capacitors having been fitted and the insulation of the mains wiring checked I switched on and eagerly awaited the results as the valves warmed up. I was disappointed to be greeted with a faint hum and nothing else. Prodding the control grid of the output valve indicated that at least this was working, but there was absolutely no response from the top cap grid of the AF7. At this point I noticed the absence of a reassuring glow from the heater. Unfortunately the valve proved to be soft. This temporary setback was soon overcome when I discovered Jan Wüsten's web site. I was able to purchase a brand new AF7 and Jan supplied me with the data for all the valves used in my receiver. I therefore had no need to initiate my back-up plan of installing an SP4, the nearest equivalent English valve, on to a side contact base.

It took a week to obtain the replacement AF7 and on fitting it the VE301 finally showed some slight signs of life. The audio quality was acceptable, certainly helped by the large loudspeaker. True to its designer's brief the sensitivity was poor; a long aerial was required to receive anything at all. On long wave there was not even a hint of signal on 198kHz (Radio 4). As I intended to put the receiver into daily use something had to be done!

Circuit Overview

The circuit is worth some detailed examination as it has some interesting features. The power supply employs an RGN1064 with both anodes strapped in parallel as a half-wave rectifier and returned to ground via a 450Ω resistor. In this way a negative bias voltage is developed for the directly heated RES164 output valve. A bleed resistor of 28kΩ increases the overall current draw on the HT supply to boost the field current of the loudspeaker. (This component started to increase in value at an alarming rate when the set was once more put into use and on replacement was found to have reached a value of 43kΩ.) This resistor also has a swamping effect on variation of the speaker's field current as a result of changes in the anode current of the output valve. The back bias circuit develops around –12V with respect to the receiver's chassis. It has a residual 50Hz component that is not well filtered by the following 200kΩ and 0.1µF capacitor with the result that approximately 0.8Vp-p ripple appears on the output valve's control grid. The presence of a 'humdinger' potentiometer allows for cancellation of injected hum from the AC energised, directly heated, cathode of the output valve. It is a pretty fundamental requirement in this design as any particular valve's emission will not be even along the length of its filament. The pot enables the hum to be nulled for all reasonable valve spreads and may well help to achieve an 'aggregate null' taking in account the hum injected by the grid bias supply, but with obvious limitations due to phase shifts, waveform distortion, etc.

The RES164 output valve is specified for an anode current of 12mA at 250V and under these conditions has a mutual conductance (g^m) of 1.4mA/V. The screen grid current draw is about 1mA. Keeping comfortably away from saturation, an anode current swing of about 18mA p-p with a corresponding voltage swing of 300V p-p will develop an audio output power of about 0.9W RMS at the output valve's anode: 720mW at the loudspeaker, allowing for an output transformer efficiency of 80%. This implies that the anode load resistance is about 16kΩ. With this in mind the anode filter capacitor (5000cm, 5500pF) results in a HF roll off (–3dB) in the output stage of 1.8kHz. Thinking this too low I disconnected the capacitor but found the receiver broke into oscillation! I had forgotten that this capacitor also had the job of filtering residual RF from demodulated signal. It had, however, gone significantly high, it measured 7500pF on my bridge, so was replaced. Output stage voltage gain can be calculated by multiplying the mutual conductance by the anode load resistance i.e. 16kΩ x 1.4mA/V = 22.4. One can deduce, for full audio output, that a p-p grid voltage of approximately 300V/22.4 = 13.4V p-p or 4.7V RMS is required.

The output from the AF7 Demodulator stage ('Audion') is capacitively coupled to the output stage's control grid with no attenuation other than an RF filter. There is no conventional volume control in this receiver. Volume (and to some extent selectivity) is controlled by adjusting the aerial input coupling, affected by rotating the input coil through 90°. This has the advantage that the possibility of overloading the AF7 on strong signals is minimised. In addition, not having a conventional potentiometer volume control means that gain adjustment does not suffer from crackling and noise.

So how does the detector work? The incoming RF is AC coupled to the AF7 grid by a high pass network, physically realised as a single component, with a cut-off frequency of about 700Hz. The RF signal is DC restored by diode action between the control grid and cathode of the AF7. A negative bias is therefore developed on the control grid, proportional to the amplitude of the RF envelope. The tuned circuit is only lightly loaded because, in the steady state, the grid current only flows at the most positive excursion of the RF input. The cut-off frequency of the input coupling network is such that grid voltage follows the modulation envelope of the RF carrier. As a larger RF input voltage develops a more negative grid voltage, the output at the AF7 becomes more positive, thus the output is in phase with the incoming RF envelope. The detector stage therefore not only demodulates the incoming RF waveform but also provides some useful audio gain as well.

As the output is positive going, the AF7 operating conditions must be chosen for a relatively low quiescent anode voltage and this has been achieved in this design by limiting the screen grid voltage. As the earthy side of the tuned circuit is grounded the cathode must also be returned directly to ground to avoid negative biasing of the detector diode formed by the grid and cathode of the AF7. This approach also saves an additional resistor and capacitor in the cathode circuit

From the voltage drops in the circuit it can be deduced that the anode and screen grid currents are approximately 400µA and 130µA respectively rather than the valve's rated currents of 8mA and 1mA respectively. By running the valve at a low anode current a high value anode load resistor may be used in order to maximise the voltage gain ($A = g^m \times RL$). The rated g^m for an AF7 is 2.1mA/V, even if this is reduced to 1.5mA/V by operation at reduced screen grid potential, a respectable voltage gain of about 750 may be expected before applying reaction. Allowing for a DVM resistance of 10MΩ, the screen grid runs at about 24V and the anode at about 70V with no signal. On a strong local signal in London the audio signal on the AF7 anode was approximately 50V p-p, grossly overdriving the output stage.

It will be noticed from the circuit diagram that the screen decoupling

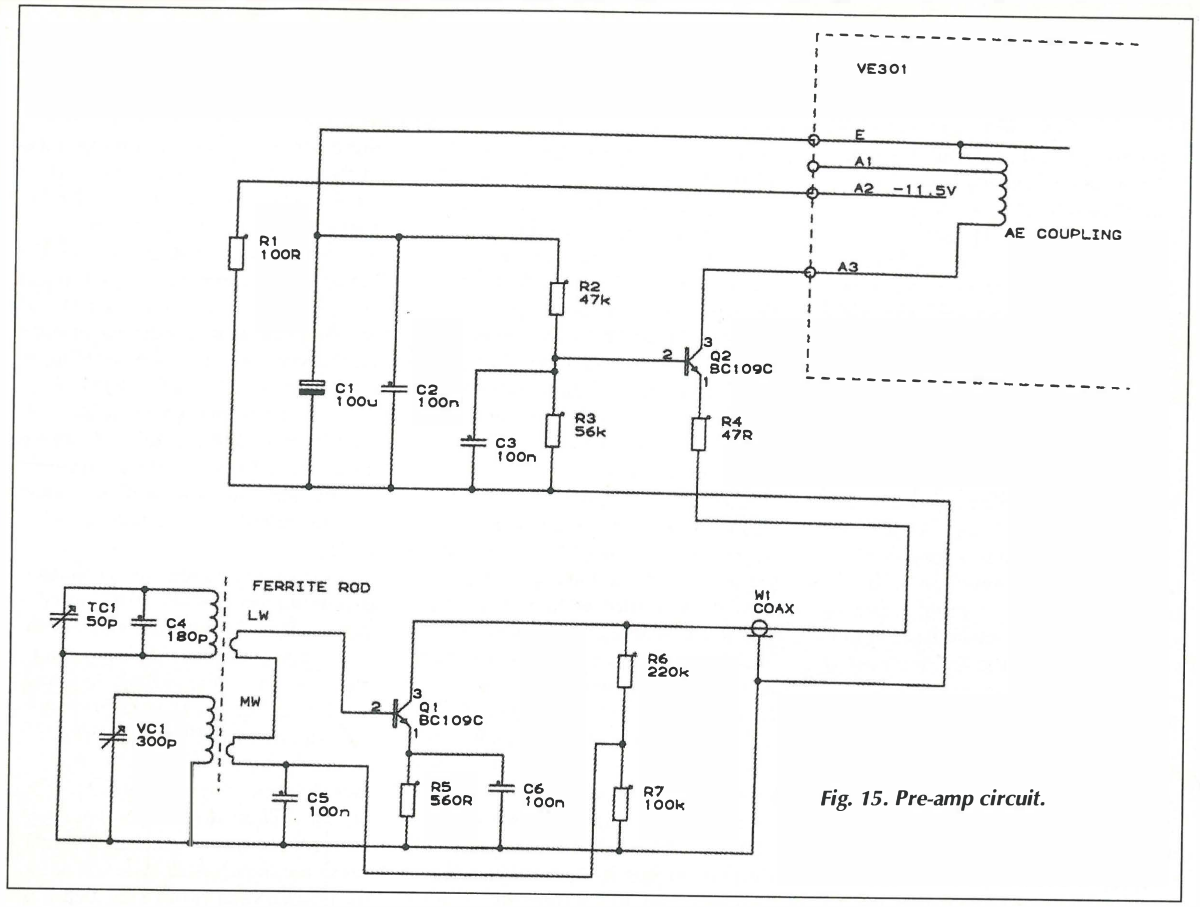


Fig. 15. Pre-amp circuit.

Web sites:

Jan Philipp Wüsten Electronic:	www.fragjanzuerst.de
VE301 restoration:	www.geocities.com/radioflier.geo/ve301res.htm
Wumpus' Old Radio World	www.oldradioworld.de/volks.htm
Joachin Herzig's web site	www.ve301.de
Radiomuseum Rottenburg	www.rolaa.de/sehensw/radio/radiomus.htm

capacitor is 0.2μF, a seemingly large value for RF frequencies. It must be remembered that the valve is amplifying the detected audio frequencies and the screen grid must be at a good AC ground. It was found that a 0.047μF de-coupler produced noticeably less gain than the specified 0.2μF.

Gain and selectivity can be boosted in this type of circuit by applying a controlled amount of positive feedback (reaction). Residual RF at the anode of the AF7 is fed back to the input tuned circuit via a variable capacitor. The medium wave coil comprises two bank wound coils sandwiching a single turn reaction winding. On long wave, the reaction winding occupies the bottom layer or so of the coil. The two reaction windings are wired in series.

Taking into account the gains of both stages, for full output power without reaction, a RF envelope of about 19mV p-p is required at the AF7 grid.

Finally we reach the receiver's interface to the outside world, the aerial coupling coil. This has two taps and in conjunction with a 300cm capacitor, provides three possible aerial connection options facilitating matching to different aerials over the wide operating frequency range of the set (150kHz to 1.5MHz). In order to determine the inductance of the two sections of the coupling coil they were tuned with a 47nF capacitor and a resonant search performed. Thus the inductance for each of the two sections was found to be 33μH and 800μH.

Improving Performance

The biggest irritation with this receiver is the need for a long wire aerial. I decided to carry out a few experiments with separate ferrite rod aerial (removed from an old transistor radio) and pre-amplifier circuit. The pre-amplifier's supply could be borrowed from the –12V bias supply provided the current draw was less than 2mA. By adopting this approach, only one easily reversed modification to the VE301 was necessary. As well as improving the receiver's sensitivity a tuned pre-amplifier would also improve adjacent channel interference – often a problem with TRF sets. The final circuit is shown in **Fig. 15.**

In order to prevent the possibility of RF instability caused by the proximity of the ferrite rod to the receiver, it was decided to mount it remotely, using a 75Ω coaxial line for coupling. Remote mounting would also facilitate rotation of the ferrite rod to suit the direction of the received signal. The next decision was what configuration of pre-amplifier to use? It had to be simple, match reasonably well to a coaxial line and interface to the available input and output coils; namely the aerial coils of the VE301 and ferrite rod antenna.

After some thought and consultation of the Mullard and Siemens data books [6 & 7], I decided to opt for a split cascode pair using bipolar transistors. With a maximum of 2mA available at 12V, the old-faithful BC109C or BC548C looked like good candidates at the frequencies of interest, both devices giving near identical performance. The best noise performance depends on source impedance and collector current and is generally at a lower collector current than that required for maximising the current gain. It is also necessary to consider the dependence of transition frequency on collector current as this falls with falling collector current. A good compromise between these conflicting requirements could be achieved at an operating current of 2mA and a collector-emitter voltage of about 5V on each transistor.

A cascode pair consists of a common emitter input stage driving a common base output stage. The input and output impedance of a common base stage are highly interdependent, in general the input impedance is very low and the output impedance moderately high. The 800μH aerial coil of the VE301 presents a load impedance to the pre-amplifier of about 1kΩ at 198kHz and 7.5kΩ at 1500kHz. This is sufficiently low not to increase the input impedance of the common base stage much above 20Ω over the frequency range of interest. Thus the coaxial line can be fairly well terminated by simply adding an appropriate resistor in series with the common base stage's emitter. The common emitter half of the cascode pair is mounted remotely along with the ferrite rod antenna and its collector is arranged to drive the coaxial line directly. As the coaxial line presents a low impedance, the voltage swing at the collector and hence the reverse coupling is minimised. In effect this stage provides current gain only. Under these conditions the input impedance of the transistor approximates to h_{ie} (about 9kΩ when operating at 2mA) correctly loading the ferrite rod antenna, thus ensuring the "Q" and hence bandwidth are right. A pre-set trimmer was used to tune the LW coil to 198kHz with a variable capacitor on the MW coil. The two coupling coils were wired in series thus eliminating the need for a band-switch on the pre-amplifier. To avoid an additional wire for the power supply, the base bias for the common emitter stage is derived from the collector.

Some consideration was given to delivering more power to the aerial input coil of the VE301 by the use of transformer coupling. The common base stage has a fairly high output impedance, necessitating a large turns ratio in order to achieve an optimum power match and hence a large inductance on the transformer primary. There is a danger that the inherent collector capacitance might cause the transformer to resonate in the desired pass-band. This idea was therefore dropped. Although the output of the cascode stage is not optimally matched from a gain point of view, in practice the circuit works very well, is stable and meets its objective of eliminating the need for an external long wire aerial.

I have only outlined the design process for the pre-amplifier, as this could easily be the subject of another article. In the process of development I discovered the value of older books where the theory is dealt with in fundamental detail. I also found that the results from SPICE programs although useful should not be relied upon unless one understands the approximations within the library models. ■

References

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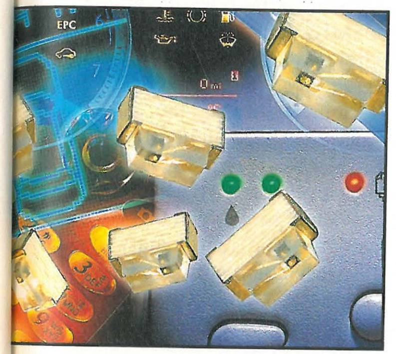
2. Catherine McDermott, *20th Century Design,* ISBN 1-85868-710-0
3. *ARRL Radio Amateurs' Handbook* (1968 edition)
4. *Bosch Automotive Handbook* (1952 German edition)
5. Christabel Bielenberg, *The Past is Myself,* ISBN 0-552-99065-5
6. Mullard, *Reference manual of Transistor Circuits,* 2nd Edition 1961
7. Siemens Transistor Data Book (1981)

NEWPRODUCTS

Please quote *Electronics World* when seeking further information

LEDs have built-in reflectors

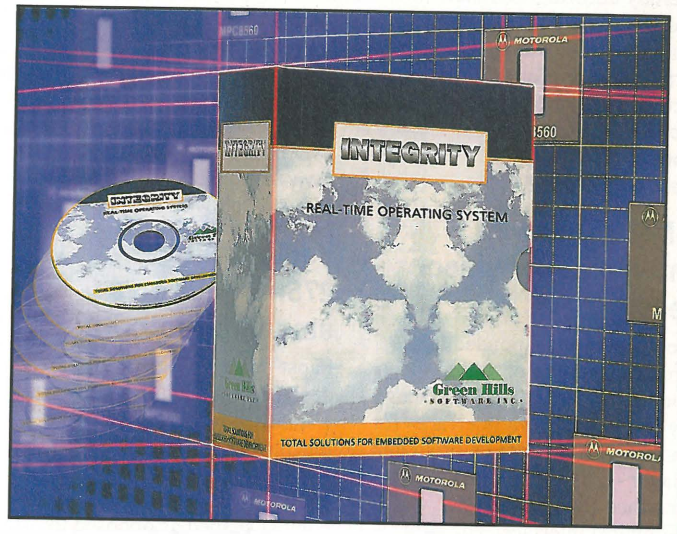
Rohm has introduced a series of side-emitting LEDs that use built-in reflectors and lenses to optimise intensity with respect to physical size and power. Available in red, orange, yellow, green, and blue, the SML-A12 devices measure 0.55mm high with a footprint of 1.15mm. The blue LEDs use InGaN on SiC semiconductor technology while the other colours are AlGaInP



on GaAs devices. All are packaged with a reflector with a white diffused epoxy lens. Typical luminous intensity for the red, orange and yellow devices is rated at 63mcd with forward current (If) = 20mA with the green device rated at 40mcd. The blue LED has typical luminous intensity of 11.5mcd and forward voltage of just 3.0V at forward current of 5mA. Maximum recommended forward current is 25mA in each case, while peak forward current is rated at 60mA. The maximum power dissipation of all devices is just 62mW.

ROHM
www.rohm.co.uk
Tel: +44(0) 1908 282666

IP adds billions of unique addresses



Green Hills Software has two dual-mode IPv4/v6 Internet Protocol (IP) stacks for its integrity real-time operating system (RTOS), IPNET and IPLITE. Developed by Green Hills Software's technology partner Interpeak AB, the protocol stacks provide backward compatibility with current IPv4 requirements while overcoming 32-bit address limitations and security shortcomings. This makes it possible to securely connect IP devices to the Internet. According to the company, the design challenge is that many systems now need to be connected to the Internet and as a result require unique IP addresses. The current 32-bit standard, IPv4 provides approximately four billion unique IP addresses. The 128-bit technology used by IPv6 by contrast, provides nearly 600 quadrillion IP addresses. Green Hills Software has also said it plans to support Motorola's PowerQUICC 111 family of processors with its Integrity RTOS. Green Hills Software already provides PowerQUICC 111 support through its MULTI IDE and C/C++ optimising compilers.

Green Hills Software
www.ghs.com
Tel: +44(0) 1844 267950

RTC goes in small places

Ricoh's latest real-time clock is designed for small spaces on the PCB. The R2043k, with an oscillator frequency of 32.768kHz comes in a FFP 12 package that measures 2 x 2 x 0.85mm. According to the supplier, PCB area is further reduced as the device can be used in combination with a small crystal having a crystal CL range of 6 to 9pF. Its time keeping voltage is typically 0.66V and power consumption is typically 0.45μA. It comes with a time trimming function for oscillator adjustment.

Ricoh
www.ricoh-semiconductor.com
Tel +31 2054 74310

PCI adds I/O for boundary scan access

JTAG Technologies has I/O products to support test access of boundary-scan designs with PCI interfaces. Two are for testing PCI slots on motherboards and backplanes, and for testing PCI card interfaces. These are plug-in cards, compatible with standard 32-bit and 64-bit PCI slots and supporting 3.3V and 5V PCI busses. The third I/O module, for general use, is a DIMM carrier that provides boundary-scan access to up to 256 customer-configurable test points designed for mounting when no test fixture is available. This carrier can contain one or two of the firm's DIMM DIOS modules. All I/O products can be used in combination with JTAG Technologies' boundary-scan controllers. They can be configured in separate boundary scan chains or can be incorporated in any other chain already available in the design.

JTAG Technologies
www.jtag.com
Tel +44(0) 1234 272226

FPGAs programmer runs on a laptop in the field

Actel has available a FlashPro Lite programmer for use with the company's flash-based ProASIC Plus family of FPGAs. Designed to allow customers to program devices using a laptop computer the programmer supports the Standard Test and Programming Language (STAPL), making the device

independent of any specific programming algorithms. The algorithm is embedded into the programming file, independent of the FlashPro software, enabling the same programming file to be used with other STAPL-compliant programmers. The programmer draws power

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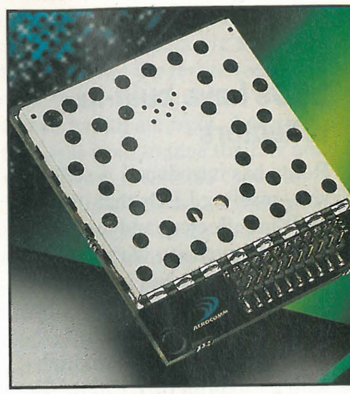
from the target board rather than an external power brick. It also implements a 26-pin header to connect to the target board, thereby allowing designers to program a board built for FlashPro Lite using either the firm's FlashPro or Silicon Sculpter programmers.
Actel
www.actel.com
Tel +44(0) 7823 3224

SMPTE/Firewire interfaces for video test system

Tektronix has responded to the growing number of digital video formats and standard interfaces by introducing two interfaces for its MTX100 MPEG recorder and player - a SMPTE 310M interface and IEEE1394 (Firewire) interface. The firm has also added an HD-SDI stress test module for its TG2000 Multi-format Video Signal Generator Platform. The MTX100, with the SMPTE 310M synchronous serial interface, now supports 19.39Mbit/s for 8-VSB terrestrial broadcasting. It also includes an ASI interface, allowing for the acquisition or play out of transport stream data in ASI format. The SMPTE 310M provides for the stimulus of DTV devices under ATSC standards.
Tektronix
www.tektronix.com
Tel +44(0) 1344 392000

Venturi fan blows 275m³/hour on a standard footprint

Papst's latest range of fans are designed to increase airflow on a standard footprint. The mechanical design of the DV4112 incorporates an air channelling venturi which is conical shaped as opposed to cylindrical, with the fan blades following the same profile which according to the company increases the air pressure characteristics at the exhaust side of the fan. The fan is designed to achieve a maximum flow rate of $275m^3/h$, approximately twice the performance level attainable from a similarly sized axial fan, and able to operate against static pressures of up to 300Pa, said the supplier. Built on the VarioPro programmable control platform, the fan can be factory customised to meet the airflow requirements specified by the customer. The DV4112 series operate from 12V DC and consume 23W of power running at a nominal speed of 6,000rpm.
Papst
www.papstpic.com
Tel +44(0) 1264 333388

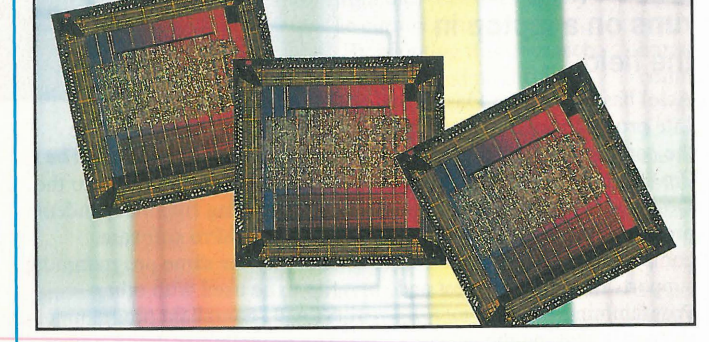


868MHz wireless module for Europe

Aerocomm has released an 868MHz spread spectrum wireless module designed for the European market. Designated the AC4486, the transceiver module interfaces with OEM's designs via a serial TTL level connection and will provide bi-directional links using the firm's proprietary RF-232 transparent protocol. It provides two channels - one operating at 5mW and 100 per

Asics on a budget get a makeover

The options for custom SoC design on a budget of less than £50k have increased with the latest cost-reduced applications specific device platforms from Fujitsu and Chip Express. Gate array supplier, Chip Express has pushed the gate count of its devices to 1.8 million usable gates with its 0.18µm CX5000 family. This brings the gate array company into direct competition with Asic company Fujitsu Microelectronic which is addressing a similar cost-reduced custom device market with a range of higher clock speed devices that it claims can reduce costs for 500,000 plus gates Asics by 80 per cent. The Chip Express system slice is designed as a platform gate array offering eight size and on-chip memory options. At the low end, the 189-pad CX50041 delivers 44k gates and 64kbit of SRAM/ROM. The largest device, the 1089-pad CX51761, has 1.8 million gates and 2.6Mbit of SRAM/ROM as well as PLL and DLL macros. There are also four versions with added memory and are available with between 1.0 and 4.5Mbit of memory with a memory to logic gate ratio of over 500 per cent. The gate arrays are intended to sit in cost/performance terms between high NRE cost Asics and high end FPGAs. Design NREs range from £20k ($35k) to 65k ($100k) depending on the level of design. Although the company claims that the limiting factor on speed is power consumption, not gate delay, and it argues that constrained logic areas will run faster. The CX5000 system slice preliminary libraries are available for download from the company website for customers targeting system slice design handoffs from this month, with production silicon in September 2003. The company will begin accepting the extended memory version, called Memory Pig, design handoffs in September. Last year another Asic supplier, LSI Logic made a similar move to cut up-front Asic costs with its RapidChip product which combines standard cell Asic design with up to eight million uncommitted logic gates. This is based on 0.13µm process technology and pre-defined hardware circuit elements, which the firm is aiming at medium volume applications in that middle ground between FPGAs and full custom Ascis. In comparison Fujitsu's Accel Array is built on 0.11µm process technology. Customer designs will be implemented using three metal mask layers and there will be pre-defined circuits such as high-speed interface I/O and incorporates pre-designed global clock trees and 24 flexible peripheral local clocks. There is also built-in logic scan, JTAG and RAM BIST. The first pre-fabricated platforms include SRAMs, flip flops and Asic logic.
Fujitsu
www.fujitsu.com
www.chipexpress.com



cent duty cycle for short range applications, the other at 500mW and and 10 per cent duty cycling for longer range deployment. Dual frequency bands are provided covering 902-928MHz, and 868-870MHz. Intended for applications such as vending machines, automated meter reading, lighting control and security, the transceivers will operate over the industrial temperature range of –40 to 80°C and are agency approved for use in portable, mobile and fixed applications in Europe. Various antenna options are available including integrated, external or solder pads, and the modules feature adjustable receiver sensitivity from –85dB to 102dB depending on data throughput. The modules operate from a 3.3V supply and measure a compact 48 x 42 x 5mm.

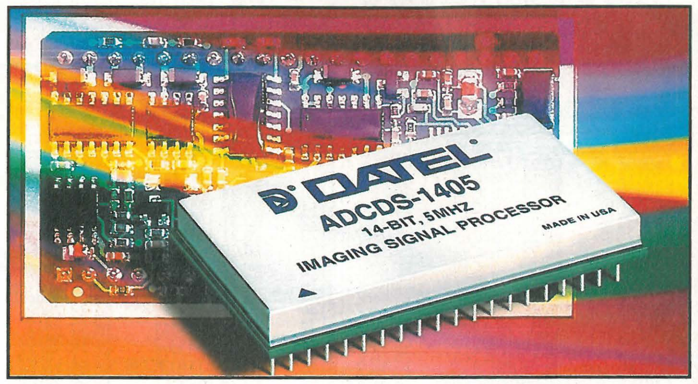
Aerocomm
www.aerocomm.com
Tel: +44(0) 1908 326342

Windows CE.net gets debug support

Lauterbach is providing kernel support for the Windows CE.net operating system. The firm's TRACE32 debugger is capable of visualising the OS resources (such as process tables) and allows debugging of kernel, drivers, processes and DLLs. If the user adds the optional trace module, they can then execute real-time performance analysis at the threads level. This functionality is free for all new users of TRACE32 and existing users can upgrade free if they are in the software maintenance period of their contract. The family consists of three main categories of hardware debuggers: JTAG debug systems, JTAG debuggers with trace (where supported by the microprocessor) and full blown In-Circuit Emulators.

Lauterbach
www.lauterbach.com
Tel: +44(0) 1256 333690

Image digitiser has configurable amplifier



Datel's latest image digitiser designed for direct connection to high performance CCDs (charge coupled devices) contains a user-configurable input amplifier, a critically important correlated double sampling (CDS) function, and a high speed (5MHz), 14-bit A/D converter in a 40-pin TDIP package. The ADCDS-1405 has a sampling rate of 5Megapixel/s, noise of 50µV –145µVrms and signal-to-noise ratio of 73dB min. Dynamic range is 16,384 to 1 and differential nonlinearity is +0.9LSB max. Additionally, users can vary the bandwidth of the 1405's input stage to trade off noise against sampling rate. The 145µV rms noise specified at 5MPPS can be reduced to 50µV (approximately 1/3 of an LSB) at lower conversion rates.

Datel
www.datel-europe.com
Tel: +44(0) 1256 880444

Power modules push down thermal resistance

Toshhiba's latest 600V and 1200V intelligent power modules feature thermal resistance (Rth) ratings up to 50 per cent lower than previous technologies, claims the supplier. Suitable for general-purpose inverters and motor drives, the C-IPM modules integrate up to seven IGBTs, drive and protection circuitry in a single package. Rth values as low as 0.033°C/W are achieved by using silicon nitrite (SIN) rather than aluminium oxide (A1203) as an insulation sub-strate, and by reducing isolation plate thickness by 50 per cent to just 0.32mm. These changes

mean that the IGBTs used in the 600V, 100A device for example, have an Rth of 0.21°C/W. The modules are available with current ratings of 50A, 75A, 100A, 150A, 200A, 300A and 400A. The 600V versions also offer a 600A option. The device can be supplied with a variety of configurations.

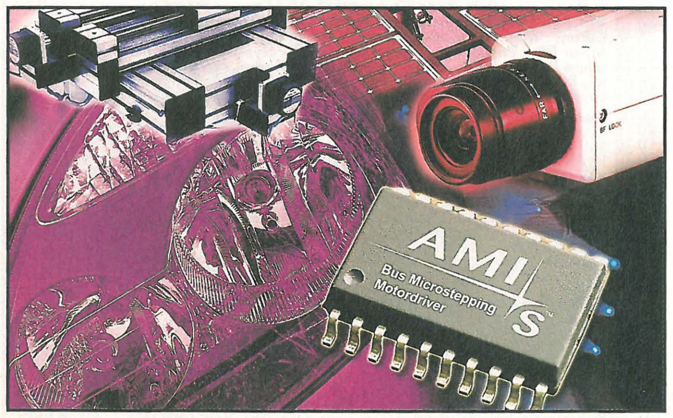
Toshiba
www.toshiba-europe.com
Tel: 49 211 5296 254

Schottkys are tailored for output rectification

International Rectifier has introduced 15V and 20V Schottky diodes for server and telecoms power systems that are tailored for output rectification and output ORing circuits. The 80CPTN015 diode is rated at 15V, and housed in the TO-247

Driver micro-steps in remote and multiple axes applications

AMI Semiconductor has a family of micro-stepping motor driver products for remote and multiple axes positioning applications. The device integrates bus connection, positioning electronics and a motor driver in a single SOP20 package. The AMIS-3062x family consists of two products; one has a LIN bus interface and the other a serial bus interface. Both versions are designed for small-positioning automotive applications such as headlamp levelling and swivelling, cruise control and idle control. The device can also be used in a range of industry applications such as XYZ tables, robots, climate control and process control. The 30261 with LIN interface is suited to remote, single or multiple axes positioning applications



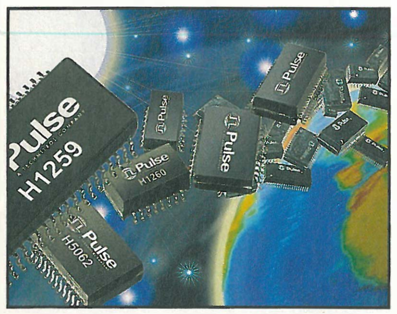
AMI Semiconductor
www.amis.com
Tel: 32 5533 2211

Please quote *Electronics World* when seeking further information

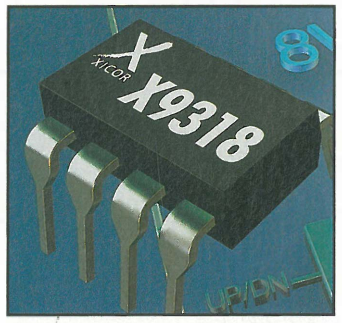
package. An improved barrier material is designed to support a maximum junction temperature of 150°C. Maximum forward voltage drop is 340mV, 40A at 125°C. This allows 10 per cent reduction of power dissipation, said the supplier. The 80CPT015 is also rated at 15V, and has a typical forward voltage drop of 270mV at 125°C. The 60CTT015 and the 60CTTN015 are 15V devices in the TO-220 package, with a typical voltage drop of 0.28V at 30A and 0.33V at 30A, respectively. The 60 CTT015 is targeted towards ORing applications and has a Tj(max) of 125°C. 60CTTN015 has a max junction temperature of 150°C. The leakage current of the 60CTTN015 is a very low 250mA at 125°C, making it suitable for operation up to a maximum junction temperature of 150°C, without any fear of thermal runaway.
International Rectifer
www.irf.com
Tel: +44(0) 20 8645 8003

Putting surface mount magnetics into the network

Pulse has introduced a range of surface-mount discrete magnetic components, the Star Magnetics



range, for applications which include PCMCIA (H0055/56), single-port fast-Ethernet network interface cards (H1260, H1265 and H1278), gigabit-Ethernet multi-port 1N and 2N applications (H1259 and H1266). The range offers frequencies in the range 1MHz to 1000MHz.
Pulse
www.pulseeng.com
Tel: +44(0) 1483 401700



Digital potentiometer operates up to 8V

Xicor has introduced the X9318 family of 100-tap, non-volatile digitally programmable potentiometers which can operate at up to 8V. Operation at 8V across the potentiometer is allowed while the digital control operates between 0V and 5V. The device features a 10-tap wiper with 99 segmented resistors and an R(total) of 10kΩ. According to the supplier, using the UP/DOWN interface, the system designer can adjust the wiper position to the appropriate setting. This setting can then be stored in the internal EEPROM memory. The aim, said the company, is to eliminate the need for an on-board microcontroller. Target applications include process controls requiring retention parameters, data acquisition systems requiring pre-configured voltage reference levels and signal conditioning circuits requiring zero offset and span correction in various sensors (such as temperature, pressure, IR, strain gauge, etc.). Other applications include power amplifier biasing for RF, audio and amplifiers that require gain or phase control. Production samples are available in 8-lead SOIC and DIP packaging.
Xicor
www.xicor.com
Tel: +44(0) 1993 700544

DC power converter for 12V bus

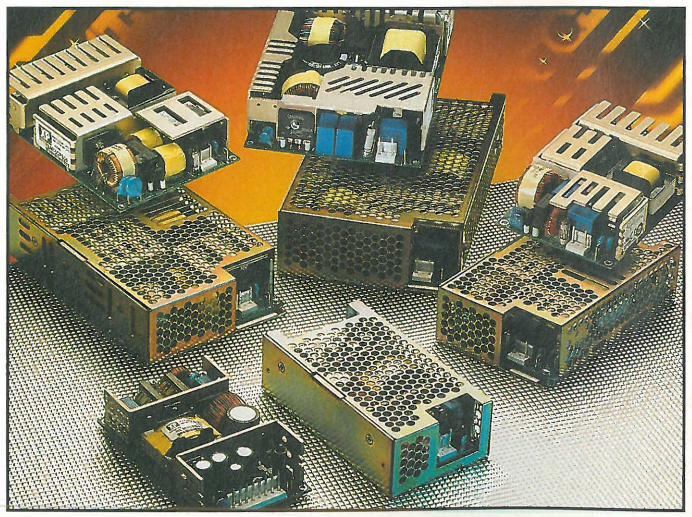
Vicor has stepped up its DC-DC converter offering for distributed power designs based on a 12V intermediate bus. It has introduced a family of bus converter modules (BCM) which take a 48V input to derive an isolated 12V output. The company is presenting the step-down converter as an alternative to traditional quarter brick converters in a significantly smaller surface mount package. Available in a BGA surface mount package, called the VIC, the 200W BCM B048K120T20 requires less than a third of the board area of intermediate bus converters in quarter-brick style packages, said the supplier. Available in two mounting styles, it has an above-the-board height of 4mm (in-board mounting) or 6mm (on-board mounting). Power density is 800W/in^3.
Vicor
www.vicor.com

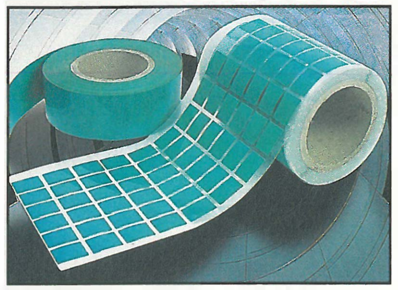
70-185W AC/DC supply has four custom outputs

Power firm XP is offering a 70-185W AC/DC power supply with up to 4 standard and customisable output voltages. Suitable for applications that require multiple voltage rails such as instrumentation, broadcast, medical and analytical equipment, it can source both standard and non-standard DC voltages from a single unit. Called the RLM, it can deliver at least 2A on all outputs making it suitable for driving both logic and linear loads. Less than 1U high, the power supply offers a power-fall signal and comprehensive overload protection as standard. Options include isolated outputs, remote on/off, screw terminals and metal covers. Remote sensing is available on both single and multiple output models. The RLM product range features a universal 85-256V AC input, standard output voltages of 3.3 to 48V DC and typically efficiency of 82 per cent at full load. With an operating temperature range of 0°C to +70°C, the RLM is approved to all major international safety and EMI/RFI specifications.
XP
www.xpplc.com
Tel: +44(0) 118 984 5515

Thermal insulator is "easy-to-handle"

An electrically insulating phase change material is designed to simplify the implementation of thermal managements by providing an easy-to-handle thermally conductive and electrically isolated interface between electronic power devices and heatsinks. Available from Bergquist, Hi-Flow 300 is an electrically insulating material consisting of a thermally conductive phase change compound coated on two sides of a thermally conductive polyimide film. According to the supplier, the polyimide reinforcement means that the material is easier to handle than conventional interface





alternatives - including grease - while a phase change temperature of 55°C minimises shipping and storage problems. with a thermal conductivity of 1.6W/m-K and a dielectric breakdown voltage of 5000V, the material is suitable for both discrete power semiconductors and modules and is available with standard film thickness of 0.25mm, 0.38mm and 0.51mm. It is available in roll form, sheet form or as die-cut parts depending on application requirements. The material is flame-retardant in accordance with UL94 V-0.

Bergquist
www.bergquistcompany.com
Tel: +44(0) 1908 263663

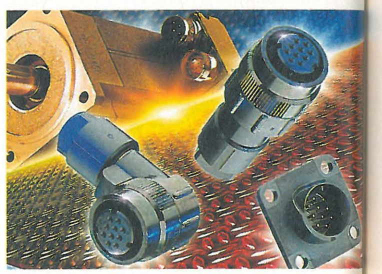
Four wideband-CDMA carriers on one DAC

Texas Instruments (TI) has a programmable dual digital-to-analogue converter (DAC) supporting up to four wide-band-CDMA (WCDMA) carriers. Offering three modes of operation as well as three separate clock modes, the DAC allows for a low input data rate with a programmable interpolation rate of 2x - 16x up to an output rate of 500Msample/s. The DAC is designed to be used with four additional devices to simplify the design time required for the wireless transceiver system of the basestation. The 12-bit, 80Msample/s ADS5410 analogue-to-digital converter, the THS4271 high-speed operational amplifier, the CDC7005 clock synthesiser and a single-chip digital down-converter and up-converter, the GC5016. For single-carrier WCDMA signals, the DAC5686 has demonstrated ACPR better than 68dBc at frequencies up to 122.88MHz. For dual carrier WCDMA signals, ACPR better than 71dBc is possible up to 61.44MHz, said the supplier. The three clock modes are: PLL mode, DAC clock mode and Data/DAC clock mode.

Texas Instruments
www.ti.com
Tel: 49 8161 80 3311

Waterproof connector locks in one move

A range of all-plastic waterproof connectors from JAE Europe incorporate a one-touch lock mechanism and are designed to fit into small electronic devices including servometers. The push-and-twist type one-touch mechanism featured in the JN1 and JN2 miniature circular connector series is designed to simplify mating with a device profile down to 30.3mm. The receptacles are available in both thru-hole and crimp versions that can be mounted directly on the board, while the plug is a reliable crimp connection type with simple wiring and assembly. The all-plastic body of the new range contributes to a low weight of 11g for the JN1 devices and 30.5g for the JN2



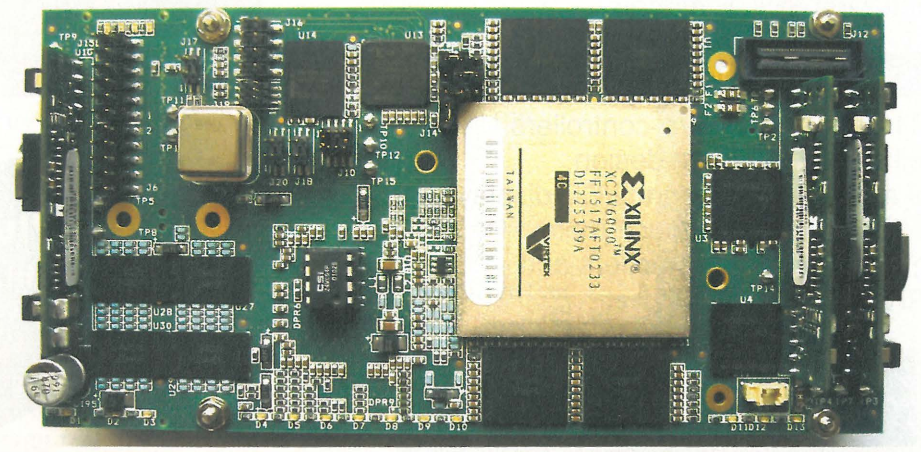
parts. Features include environmental protection such as water proofing and dust proofing conforming to IP67 specifications, as well as safeguards against vibration and oil.

JAE Europe
www.jae.uk
Tel: +44(0) 1276 404000

PCI Mezzanine card with 500Mbytes/s bandwidth

Orange Tree Technologies has announced a PCI Mezzanine Card (PMC) based on a Xilinx Virtex-11 FPGA with 64-bit data paths from the FPGA to each memory bank and the PCI controller. With enough processing power for applications such as radar, sonar, software radio, image processing, and digital signal processing, the 64-bit data paths in the Zest 100 are suited to high precision arithmetic but can also equally be used for low precision arithmetic with very high memory and I/O bandwidths, said the firm. According to the UK company, the PCI controller addresses the issue of I/O bottleneck by achieving a sustained bandwidth of 500Mbyte/s. The 64-bit data paths to multiple double data rate (DDR) memory banks enable multiple 128-bit words to be accessed in every clock cycle. There are six memory banks, each with an independent 64-bit data path. Four banks connected to the FPGA are double data rate (DDR) SRAM with 4Mbyte each. One further bank connected to the FPGA is 32Mbyte of DDR SDRAM. The remaining bank is 128Mbyte of SDRAM connected to the PCI controller and accessible from both the FPGA and the PCI bus. There is also 16Mbyte of flash. Four programmable clocks generate frequencies from 400kHz to 500MHz. They can be used on their own or with the Virtex-11 on-chip Digital Clock Managers to enable applications to be run at their optimum frequency and with different clock domains. Full software support for Windows and VxWorks operating systems is provided, together with example logic cores for all the FPGA interfaces.

Orange Tree Technologies
www.orangetreetech.com
Tel: +44(0) 1235 511020



8051 core comes with free evaluation kit

The embedded e8051 core available from Huntone runs at over 100Mips in FPGAs and 200-300Mips in Asics. A free evaluation version is intended to enable small test programs to be run at full speed in the user's own target hardware. According to the supplier, the e8051 block can be dropped into the design, and programs developed using standard software tools. ■

Huntone
www.e8051.com
Tel: +44(0) 1202 849078

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

The best circuit ideas are ones that save time or money, or stimulate the thought process. This includes the odd solution looking for a problem – provided it has a degree of ingenuity. Your submissions are judged mainly on their originality and usefulness. Interesting modifications to existing circuits are strong contenders too – provided that you clearly acknowledge the circuit you have modified. Never send us anything that you believe has been published before though.

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

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

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

Lead Acid Battery Conditioner

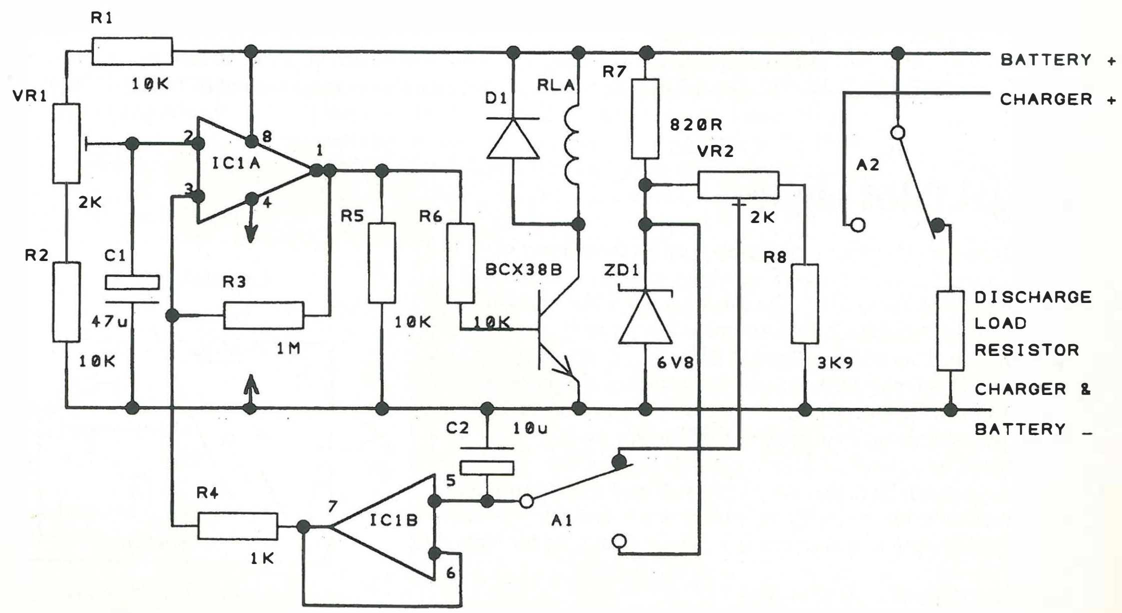
I recently began using a sealed 12 volt lead acid battery, which had not been used for some six months, but had been stored in a fully charged condition.

I was surprised how quickly the terminal voltage fell even with a light load. After several recharges the battery again performed as I would have expected. I remembered reading at sometime that lead acid batteries thrive on work and this gave rise to the accompanying circuit that will condition the battery automatically by automatically cycling from charging to discharging conditions. It will not recover a battery that has been stored in a discharged condition and allowed to sulphate and become open circuit, if only! The conditioner requires to work in conjunction with an external current limited power supply.

When a partly charged battery is connected to the conditioner, the relay RLA will energise and it will go into the charge mode. IC1A is half of an LM358 op-amp and is used as a comparator. Resistors R1, R2 and VR1 provide a sample of the battery voltage which is compared with a 6.8 volt reference provided by ZD1 and buffered by IC1B, the other half of the LM358. C2 provides a temporary store of the reference voltage, whilst the relay contacts are in mid flight. At the maximum charge voltage set by VR1, about 14.5 volts, the comparator output falls, turning the BCX38B Darlington off, thus de-energising the relay and switching the unit into discharge mode. Also at this time the reference voltage is switched by contact A1. This voltage will govern the point at which discharging will cease and is set by VR2 to be about 10 volts. At this time the comparator output the goes positive, energising the relay, and the charge cycle starts again. Resistors R4 and R3 provide some positive feedback around the comparator to provide clean switching for the relay. C1 provides some filtering for the sampled battery voltage and also prevents a noisy relay switch over.

The relay should be chosen such that it will energise at the discharged voltage of the battery, a nominal 12 volt relay will normally be OK. The load resistor may be chosen to suit the ampere-hour capacity of the battery. A chart recorder could also be connected to the battery to record the battery's recovery progress.

R.A. Joyce
Luton
Bedfordshire
UK



Relay economiser

Current required by the coil of a relay to hold it closed is normally much less than that for its initial actuation. This is because the gap in the magnetic circuit falls to a minimum.

For example, the Schrack 12V relay shown in **Fig. 1** needs typically 8V at 130mA to swing it from open to closed, but very much less to hold it there: the actual drop-out voltage translates into 7 or 8mA, and to keep the contacts properly closed and also survive moderate vibration it is reasonable to assume a figure of around 15mA. So there is considerable scope for power-saving available to the initiated. It is certainly extravagant to feed the coil with the full 12V at 44mA – which corresponds to more than half a watt.

Although it might be possible in theory to make use of the change in inductance between the open and closed states, this method was found to be unreliable. Instead, the CMOS IC shown in Fig. 1 provides a guaranteed turn-on pulse of 20ms when enabled, then a train of shorter pulses for holding the relay closed.

The duty-cycle of these pulses is determined by the supply rail, i.e. 31% at 15V, 34.5% at 12V and 38% at 9V, so that the 'hold' current is sustained at more than 10mA regardless of supply voltage. This pulse-width modulation is achieved with the aid of the internal clamping diodes in the MC14011 and bias resistor R_5.

As **Table 1** indicates, the correction is not perfect, but is very simple. The overall frequency is set at approximately 2kHz, which is a compromise between two principles. Firstly it avoids mechanical chatter and hence wear of the contacts. Secondly, it reduces switching losses in the core, coil and the switching transistor.

Also, to minimise RF emission and associated EMC problems, the value of the gate resistor R_6 is chosen such that the rise and fall times at the drain are fairly slow, around 1ms. The value of the bias resistor R_5 may need to be more than 1MΩ, depending on the threshold of the IC.

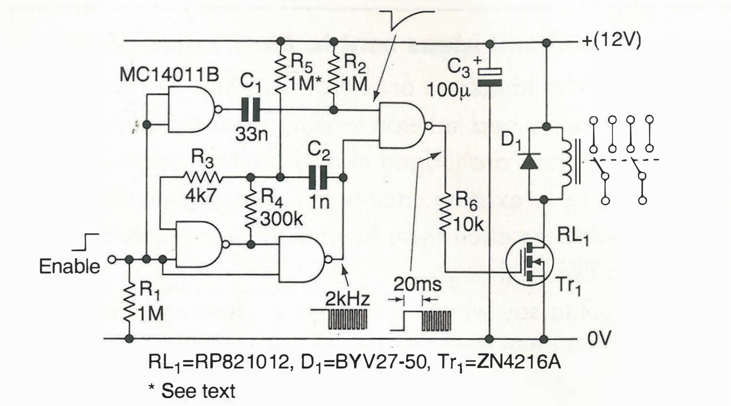
Consumption of the oscillator circuit itself is only 0.4mA so most of the supply-current goes usefully to the relay. In fact, the situation is even better than this, since the combination of RL_1 with the MOSFET and the recirculating diode D_1 behaves like a switch-mode power supply, trading voltage for current. Thus, at 12V, to maintain an average current of 14mA through the coil, the actual supply current – including that for the IC – is a mere 6.4mA. This means the saving in power, compared with traditional driving of around 530mW, is considerable: the consumption is 77mW, so the saving is no less than 453mW or 85%!

This economy can be put to good use where the only available power is from a capacitive 'mains dropper[1]', but C_3 should be increased to 470μF in order to feed the initial surge current of 20ms duration.

The lowest supply voltage at which the circuit will always turn RL_1 'on' is 7.5V. However, once 'on', the relay will stay 'on' till the supply fails below 5.0V – assuming of course the 'enable' signal has not been removed already.

C J D Catto
Cambridge
UK

* Catto, C J D, 'Op-amp supply direct from mains', *Electronics World*, May 1997, p.378.



Using a switching signal, this relay drive circuit saves a significant amount of power. It also self-adjusts, maintaining its efficiency over a range of supply voltages.

Table 1. On and off times against supply voltage and current.

V_s V	On-time μs	Off-time μs	Coil current mA	Supply current mA
15	162	362	16.4	7.4
12	180	343	14	6.4
9	192	318	11.5	5.4
7.5	203	307	10	4.9

Frugal Pilot Light

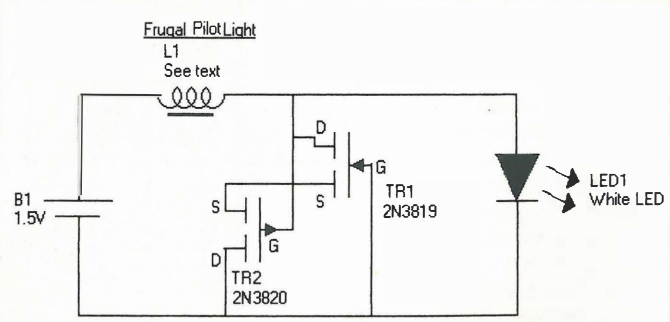
This circuit uses the negative resistance effect from a pair of JFETs to voltage double a 1.5V supply in order to light an LED. The output voltage is 2.9V with a 1.5V supply. The unusual feature of this oscillator is the extremely low power consumption. This was measured at 250μA.

If the LED is removed the circuit draws 60μA. If a piezo transducer is added across L1, it will produce a tone dependent on the series resonant frequency of the inductor used.

L1 should be as large a value as possible to get a low frequency output. Note that this circuit will also detect shorted turns in an inductor as it will not work if one is present.

One possible use of this circuit is a fishing float light for night fishing.

André de Guérin *Vale Guernsey*



Very sensitive microphone

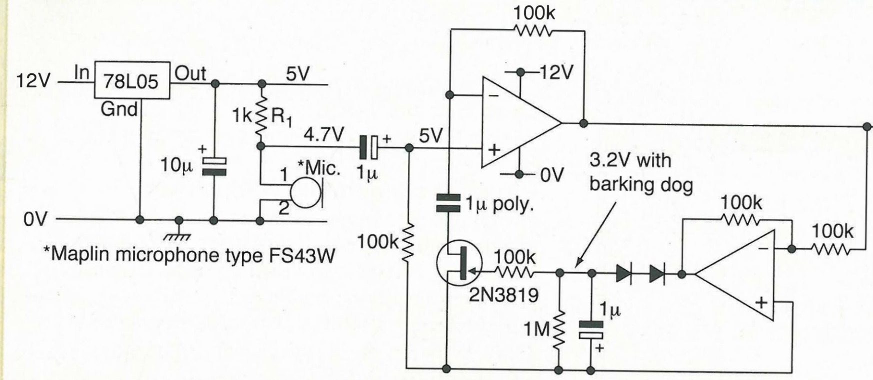
This microphone and AGC amplifier circuit is very sensitive but definitely not high fidelity. Recordings of distant birds sound realistic. My barking dog 2m away though sounds distorted, but not much louder than the birds.

The circuit is based on John Hey's circuit idea in the August 1998 issue of *Electronics World*. The extra diode in the feedback loop delays the point at which the amplified microphone signal is attenuated.

The Maplin catalogue recommends that 4.5V is an optimal supply voltage for the microphone, whose part number is FS43W. There is very little background hiss from this cheap microphone capsule.

Don't use part of an LM324 as a voltage splitter as there is internal crosstalk – a 5V regulator works fine.

Mike Belford
Cooraclare
County Clare
Ireland



Although not hi-fi, this microphone amplifier circuit is very sensitive and includes AGC.

Active amplitude modulator

Amplitude modulation is one of the most powerful techniques used in the field of telecommunications. Typical amplitude modulators involve inductors and capacitors to achieve the desired modulated output.

The circuit presented here uses active elements to modulate the cainer signal according to the information signal. Because only active elements are used, the technique lends itself to IC fabrication.

Amplitude modulation is achieved by changing the amplitude of the carrier in accordance with the amplitude of the modulating signal. The theory of this circuit is to change the voltage gain of the amplifier in accordance with the amplitude of modulating signal.

Carrier is applied to the inverting terminal of an op-amp and the voltage gain of the op-amp is changed in accordance with the amplitude of the modulating signal.

A typical equation for an AM signal is:

$$V_{(t)} = V_{c(max)}\cos\omega_c t + \frac{m}{2}V_{c(max)}\cos(\omega_c + \omega_m)t + \frac{m}{2}V_{c(max)}\cos(\omega_c - \omega_m)t$$

Here, ω_c is the angular frequency of the carrier, ω_m is the is the angular frequency of the modulating signal $V_{c(max)}$ is the maximum carrier amplitude and m is the modulation index.

The above equation contains three frequency components: upper sideband, lower sideband and the carrier.

In **Fig. 1**, the op-amp is used in inverting mode. Carrier is applied to its inverting input. Any change in drain resistance of the FET changes the gain of the amplifier. A change in draing resistance is caused when the FET's negative gate voltage is varied.

A fixed negative voltage, V_{GS} is applied to the gate in addition to the modulating signal. The gate voltage must always remain negative to avoid distortion so:

$$|V_{GS}| = V_{m(max)}$$

The fixed negative voltage must be greater than the maximum value of the modulating signal in order to maintain the gate of the JFET at a negative value. "It is important to keep in mind that the drain curves of a JFET can be assumed linear near the origin. So, a change in the drain resistance of the JFET can be assumed linear for a

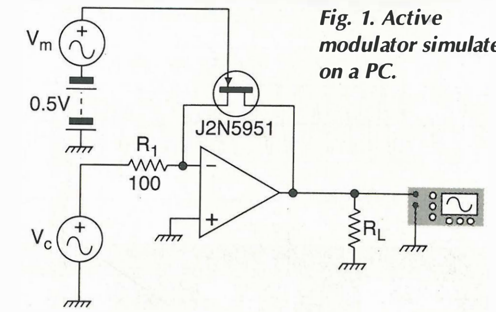


Fig. 1. Active modulator simulated on a PC.

V_c is the carrier at 200mV, 10kHz and 0°
V_m is the modulating signal at 200mV, 1kHz and 0°

small value of drain-to-source voltage (around 100mV)" said Albert Paul Malvino in the tenth edition of 'Electronic Principles' on page 449.

An expression for the drain resistance of a JFET is:

$$r_{ds} = \mathrm{k}|v_{gs}| + r_{ds0}$$

Here, r_{ds0} is the AC drain resistance with zero gate-to-source voltage, k is a constant and v_{gs} is AC gate to source voltage.

An equation for the output voltage of the op-amp is:

$$v_o = -Av_{in}$$

$$v_o = -\left(\frac{r_{ds}}{R_1}\right)v_{in}$$

Here, r_{ds}=(k$|v_{gs}|$+r_{ds0}).

$$v_o = \pm(v_c)\left(\mathrm{k}|v_{gs}| + r_{dso}\right)/R_1$$

Here, v_{gs}=$|V_{GS}|$+v_m, modulating signal v_m=$V_{m(max)}\cos(\omega_m)t$ and carrier signal v_c=$V_{c(max)}\cos(\omega_c)t$.

$$v_o = \pm(v_c)\left[\mathrm{k}\left(v_m + |V_{GS}|\right) + r_{dso}\right]/R_1$$

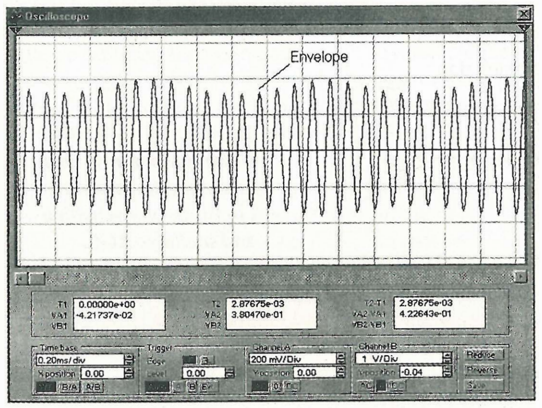


Fig. 2. Output from the active modulator circuit shown in Fig. 1.

$$v_o = \pm\left[\mathrm{k}(v_c)(v_m)/R_1 + (v_c)\mathrm{k}|V_{GS}|/R_1 + (v_c)r_{dso}/R_1\right]$$

$$v_o = \pm\mathrm{k}(v_c)(v_m)/R_1 - \left(\mathrm{k}|V_{GS}| + r_{dso}\right)(v_c)/R_1$$

$$v_o = \frac{\pm\mathrm{k}}{2R_1}\cos(\omega_c + \omega_m)t - \frac{\mathrm{k}}{2R_1}\cos(\omega_c - \omega_m)t - \left(\mathrm{k}|V_{GS}| + r_{dso}\right)(v_c)/R_1 \qquad (2)$$

Output voltage of the op-amp contains three frequency components. They are the upper sideband:

$$\frac{\pm\mathrm{k}}{2R_1}\cos(\omega_c + \omega_m)t$$

the lower sideband:

$$\frac{\pm\mathrm{k}}{2R_1}\cos(\omega_c - \omega_m)t$$

and the carrier:

$$-\left(\mathrm{k}|V_{GS}| + r_{dso}\right)(v_c)/R_1$$

Therefore the above equation can be regarded as an equation of AM signal.

Output of the circuit of Fig. 1 is shown in **Fig. 2**.

Circuit for generating DSB carrier

Double-sideband suppressed carrier, or DSBSC, modulation is preferred as it saves transmitter power. Generating DSBSC can be achieved by eliminating the carrier term from the equation 2.

If a summing amplifier is cascaded as a second stage added to that of Fig. 1, the carrier can be eliminated to provide double-sideband suppressed-carrier output, **Fig. 3**.

Let v_{o1} be the output of the first stage and v_{o2} the output of the summing amplifier shown in Fig. 3. Now:

$$v_o = -v_{o1}(A_1) - v_c(A_2)$$

$$v_o = -(v_{o1})\left(\mathrm{k}|v_{gs}| + r_{ds0}\right)/\left(\mathrm{k}|v_{gs}| + r_{ds0}\right) - v_c\left(\mathrm{k}|v_{gs}| + r_{ds0}\right)/R_1$$

$$v_o = -v_{o1} - v_c\left(\mathrm{k}|v_{gs}| + r_{ds0}\right)/R_1$$

$$v_o = -\left[-v_m v_c \mathrm{k}/R_1 - v_c\left(\mathrm{k}|v_{gs}| + r_{ds0}\right)/R_1\right] - v_c\left(\mathrm{k}|v_{gs}| + r_{ds0}\right)/R_1$$

$$v_o = v_m v_c \mathrm{k}/R_1$$

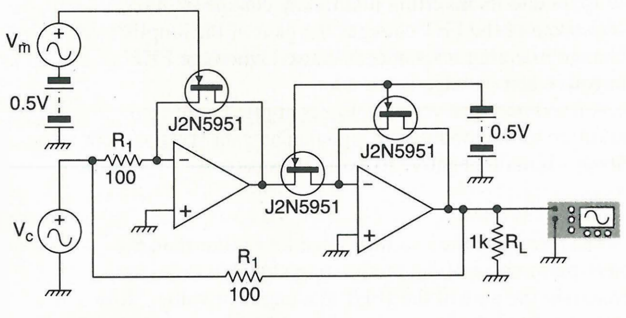


Fig. 3. Adding a summing amplifier to the circuit of Fig. 1 allows the carrier to be eliminated, providing double-sideband suppressed-carrier output.

Here, the modulating signal v_m=$V_{m(max)}\cos(\omega_m)t$ and the carrier v_c is $V_{c(max)}\cos(\omega_c)t$.

Figure 4 shows a simulation of the circuit's output. Both circuits were designed and simulated using Electronics Workbench EDA.

Again, v_o contains two components: They are the upper sideband:

$$\frac{\pm\mathrm{k}}{2R_1}\cos(\omega_c + \omega_m)t$$

the lower sideband:

$$\frac{\pm\mathrm{k}}{2R_1}\cos(\omega_c - \omega_m)t$$

and the carrier:

$$-\left(\mathrm{k}|V_{GS}| + r_{dso}\right)(v_c)/R_1$$

No carrier is present in the modulated signal so DSBSC is achieved.

Tahir Farooq *Gujranwala Pakistan*

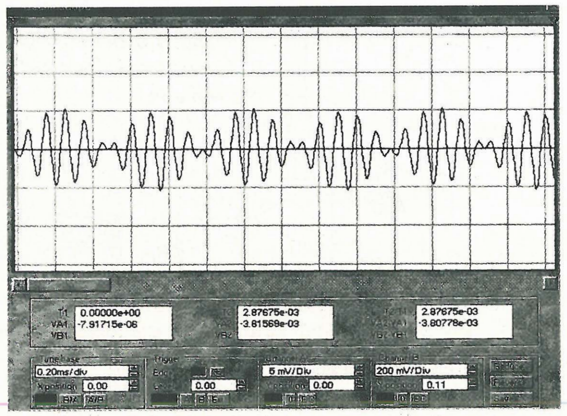


Fig. 4. Simulation of output from the double-sideband suppressed-carrier circuit Fig. 3.

Professional SDI router

Known commercially as the 'DVRS-8x8', Emil Vladkov's stackable serial digital interface router uses National's dedicated CLC chip set to provide eight inputs and outputs for digital video signals running at up to 400Mbit/s.

Developments in the field of advanced semiconductor design have made it possible to construct and implement a powerful and relatively low-cost routeing system for the uncompressed serial digital video transport standard SDI.

The subject of this article is an eight-input, eight-output cross-point router with equalising and reclocking capabilities. It makes extensive use of National Semiconductor's SDI chip-set comprising the CLC006, CLC014, CLC016 and CLC018[1].

An industry-standard 80C51 micro-controller and supporting hardware is at the heart of the system. There are two ways of operating the router. One is to use a dedicated keypad, described later. The second method is to connect the router to a PC and issue commands from the PC's keyboard using a graphical interface that I have developed.

Chip overview

CLC006. This is a serial digital cable driver with adjustable outputs[2]: it is especially designed to drive 75Ω digital transmission lines (Belden 8281) at data rates up to 400Mbit/s.

Output voltage swing – typically 1.65V – is adjustable from 0.7V pk-pk to 2V pk-pk using external resistors. The output stage of the driver is class AB, which consumes less power than similar designs.

Typical controlled rise and fall times of 650ps minimise transmission induced jitter. The CLC006 can drive both coaxial transmission lines – as in the case in this design – and twisted pairs. I find it an excellent choice for digital routers, serial digital interfaces for the broadcast industry and SDH/SONET and ATM drivers.

CLC014 – The function of the CLC014 monolithic cable equaliser[3] is to compensate for signal losses in any media with dispersive loss characteristics. The chip automatically equalises up to more than 300m of Belden 8281 cable. At this length, the spectral component of the signal at 200MHz is usually attenuated by more than 40dB.

The CLC014 is capable of both single-ended and balanced operation. In the design described here, single-ended mode is used. A carrier detect output, labelled CD, indicates the presence of a signal at the input. A mute pin, when tied to the CD-output, disables the output of the equaliser when no signal is present.

Pathological patterns are defined in the standards for the serial digital interface. These are specific data patterns with low transitions count or high DC-content. The CLC014 is insensitive to these patterns.

CLC016 – a data-retiming PLL with automatic data rate selection[4]. This chip is designed for high-speed serial data and clock recovery. Being highly integrated, this chip simplifies design.

Auto-rate select circuitry is incorporated. The device selects up to four different data rates between 40 and 400Mbit/s. Data rates are user selectable with a single resistor! If the auto-rate select circuitry finds a rate that matches the user-selected rate, it automatically provides data and clock recovery with low jitter specifications of just 130ps pk-pk.

The CLC016 has improved performance relative to its predecessors when handling the pathological data patterns inherent in the SMPTE 259M video industry standard. Pathological data patterns are worst-case patterns designed to stress, i.e. test, the PLL and equaliser.

Carrier-detect and output-mute functions are provided. These prevent random transitions at the outputs when no signal is present at the inputs.

The retimer/reclock is suitable for recovering the following standard data rates: NTSC/PAL serial digital composite signals (143 and 177Mbit/s), 4:2:2 serial digital component signals (270Mbit/s) and wide screen digital video signals (360Mbit/s).

These are the data rates that the DVRS-8x8 serial digital-video router can recover and process. I should mention here though that the same chip is universal and can be used in data recovery in SDH/SONET and ATM networks.

Main features of the router

- 8x8 digital cross-point switch capable of operating at data rates exceeding 360Mbit/s per channel;
- Non-blocking architecture;
- Low channel-to-channel crosstalk;
- Channel jitter 200ps pk-pk typ.;
- Fast output edge speed: 650ps typ.;
- Input type: 800mV, 75Ω, BNC;
- Output type: 800mV, 75Ω, BNC (Belden 8281 or equivalent transmission lines);
- Conforms to SMPTE 259M serial digital interfaces: NTSC/PAL, 4:2:2 component, 360Mbit/s wide screen, also 540Mbit/s 4:4:4:4 (optional);
- Clock and data recovery at all channels at fixed data rates: 143, 177, 270 and 360Mbit/s. The data rate of the reclocked signal is displayed at the front panel;
- Carrier detection and output mute for all input channels. The carrier detected signal is displayed at the front panel;
- Automatic equalisation of all input channels: up to 300 metres of Belden 8281 cable;
- Control via button panel (with indication) or Windows 95/98 graphical user interface;
- Visual indication on the local front panel of the routeing system (64 channel cross-point LEDs plus 8 input CD LEDs plus data rate indicators for output channels 1-8);
- Lock control preventing accidental switching;
- Stackable using standard RS-232 cables – up to four devices can be independently controlled via the PC user interface;
- Start-up configuration selectable by user;
- Mains powered.

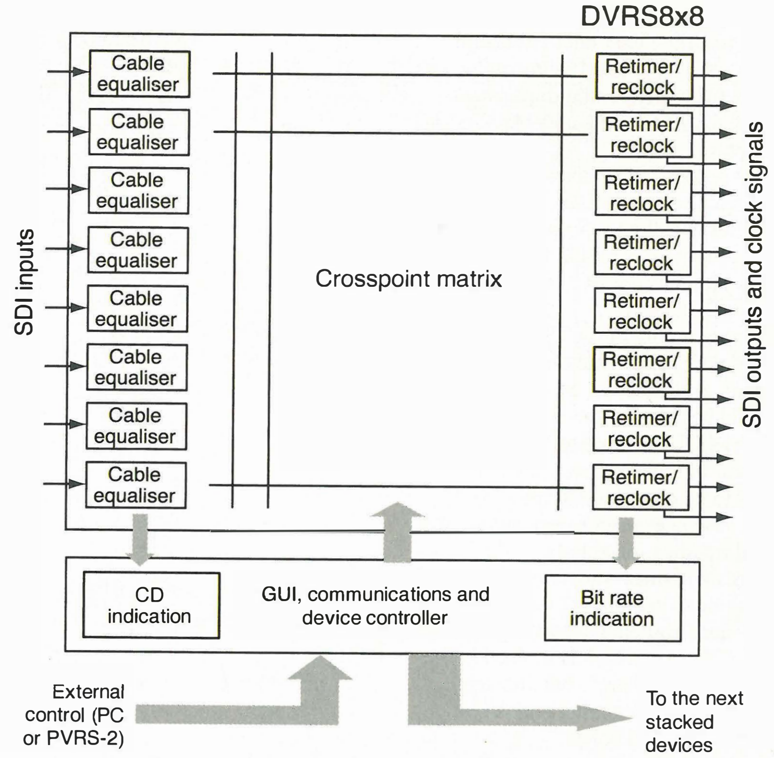


Fig. 1. At the heart of the serial digital interface router is an eight-by-eight cross-point matrix.

DVRS-8x8 specifications

Video specifications – DVRS-8x8

Serial inputs	
Sampling	4:2:2 or 4fsc, 10 bit
Line/field rate	525/60 and 625/50
Bit-serial	To ANSI/SMPTE 259M and EBU Tech.3267-E
Data Rate	143, 177, 270 & 360Mbit/s
Cable equalisation	Automatic up to 300m (Belden 8281)
Impedance	75Ω internally terminated
Return loss	>15dB, 5-270MHz
Number of inputs	8
Level	800mV pk-pk nominal
Serial data output (SDI 1)	
Bit-serial	To ANSI/SMPTE 259M and EBU Tech.3267-E
Data Rate	143, 177, 270 & 360Mbit/s
Cable drive	Up to 300m (Belden 8281)
Impedance	75Ω
Return loss	>15dB, 5-270MHz
Level	800mVp-p nominal (terminated)
Rise and fall times	650ps
Data jitter	±200ps
Number of outputs	8 (additional 8 outputs at SDI 2)
Serial clock output (if SDI 2 is not configured)	
Impedance	75Ω
Number of outputs	8
Clock jitter	130ps @ 270Mbit/s
Duty cycle	44/56
Rise and fall times	230ps
Level	800 mV pk-pk nominal (unloaded)
Serial data output 2 (SDI 2, in place of the Serial Clock Output)	
Bit-serial	To ANSI/SMPTE 259M and EBU Tech.3267-E
Data Rate	143, 177, 270 & 360Mbit/s
Cable drive	Up to 300m (Belden 8281)
Impedance	75Ω
Return loss	>15dB, 5-270MHz
Level	800mV pk-pk nominal (terminated)
Rise and fall times	650ps
Data jitter	±200ps
Number of outputs	8 mirror SDI 1 outputs

Router control system

Local control	
Display:	8 rows x 8 LEDs matrix configuration 8 LEDs for input carrier detect (CD) 8 x 2 LEDs for output data rate
Output data rate	LED1 LED2 Data rate (Mbit/s) On On 360 On Off 270 Off On 177 Off Off 143
Configuration:	Indication only
Keyboard control:	PVRS-2 device, connected to the serial port of the first device in the stack with the power plug inserted
PC control	
Type:	GUI-application, running under Windows 95 or 98
Configuration:	Full control, stackable
Interface:	Serial RS-232, 9600bit/s

Mechanical & climatic

Height	44mm (1RU, 1.75in)
Width	483mm (19.00in)
Depth	235mm (9.00in)
Weight	3.5kg
Temperature	+5°C to +35°C
Humidity	96% maximum

CLC018 – an 8-by-8 digital cross-point switch[5] handling data rates exceeding 1.4Gbit/s. This National Semiconductor chip is a fully-differential digital cross-point switch featuring a non-blocking architecture.

Every output can be connected to every input or disabled (tri-stated). The device has excellent jitter performance, not exceeding 50ps pk-pk. Inputs and outputs support both ECL and PECL (positive ECL) levels.

Reprogramming of the CLC018 can occur in the background during normal operation as the device has double row latch architecture for the control signals.

The CLC018 has two reset modes. A so-called 'broadcast' reset forces all outputs to be connected to input port DI0. A 'tri-state' reset forces all outputs in the third state (disabled).

The main application areas of this cross-point switch are not only the serial digital video routeing according to SMPTE 259M – which is utilised in the design described here – but also telecoms/datacoms switching and ATM SONET/SDH backbones.

Circuit details

The heart of the SDI routeing system – the cross-point matrix – is presented in **Fig. 1**. This matrix is configured by a microcontroller.

All inputs are equalised through cable equalisers prior to entering the matrix. Every cable equaliser indicates, via its CD pin and a LED, if there is a signal at the corresponding input.

All outputs from the matrix are retimed/reclocked to remove excessive jitter from the signal. The retimer/reclock chips also generate a data clock. This clock is normally not used as external clock in broadcast equipment, but I have provided it as an extra feature.

The PLL of every retimer locks at the signal data rate and provides an indication – via LEDs – of the signal data rate. The device controller is also responsible for communications with the host PC or user keypad and for supplying the next following devices in the stack with commands.

This is an original concept, I have used it in many analogue video routers that have been the subject of previous articles in this magazine[6,7].

Table 1. Output combinations of the LEDs and how they reflect the valid data rate.

Data rate (Mbit/s)	LED-RD1	LDE-RD0
143	Off	Off
177	Off	On
270	On	Off
360	On	On

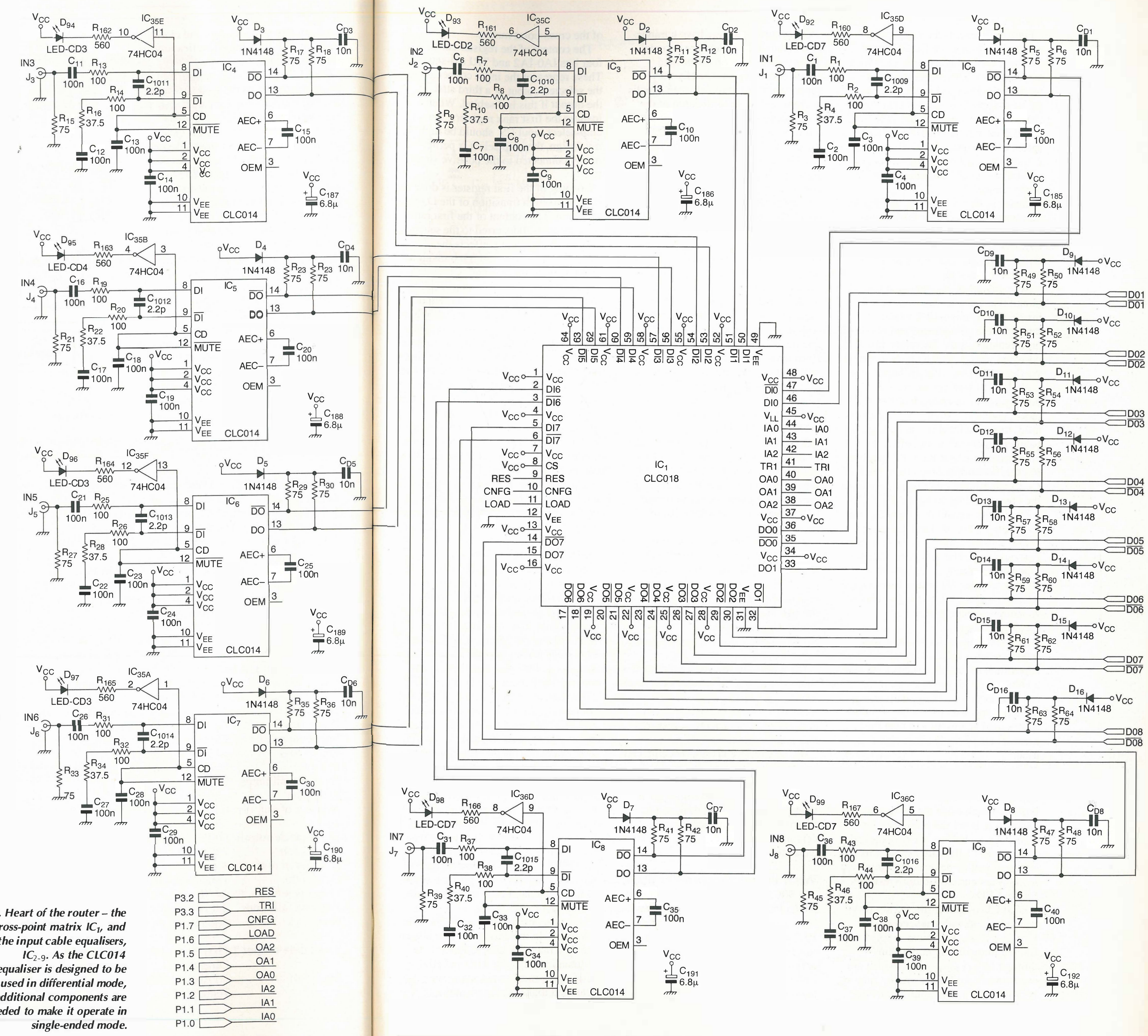


Fig. 2. Heart of the router – the cross-point matrix IC_1, and the input cable equalisers, IC_{2-9}. As the CLC014 equaliser is designed to be used in differential mode, additional components are needed to make it operate in single-ended mode.

Figure 2 presents the cross-point matrix IC_1, which is a CLC018, and the input cable equalisers IC_{2-9}, which are CLC014s. The cable equalisers work in single-ended mode and the signal is applied at input connectors J_{1-8}. You can use conventional 75Ω BNC connectors, but the high-frequency nature of the signal – typically 270Mbit/s – makes the use of dedicated SDI or digital BNC connectors a better choice.

Resistors $R_{3,9,15,21,27,33,39}$ and R_{45} are terminating resistors for the input signal. The signal is AC-coupled to the CLC014 through capacitors $C_{1,6,11,16,21,26,31,36}$. The inputs of the chip are self-biasing.

Note that all components are surface-mount types. At the high frequencies involved, it is impossible to use through-hole components and universal prototyping boards. Therefore I have designed a PCB, which can be ordered via this magazine – details later.

As the CLC014 equalisers are designed to be operated in differential mode, and here a single-ended input is used, there is a need for an additional balancing network to minimise the effects of noise. For the first equaliser IC_2 this network consists from the R_2-C_2-R_4 and for the other equalisers from the corresponding components.

The inputs are isolated from the input terminating network through serial resistors, which are R_1 and R_2 for the first equaliser. The equaliser adaptive-loop time constant is set through a single capacitor connected between the AEC-pins of the CLC014. The corresponding capacitors are $C_{5,10,15,20,25,30,35,40}$.

Although the device manufacturer recommends a value of 100pF for these capacitors, I found in experiments that a value of 100nF provides more reliable operation. The equaliser tries to reconstruct every noise at its inputs if no signal is present and the time constant is too small when 100pF is used.

The carrier-detect output of every equaliser, CD, connects to the mute pin, but also to the 74HC04 inverting buffers, which drive the corresponding LEDs to indicate the presence of a signal. These buffers are IC_{35A-D} and IC_{36C-D}. The LEDs are D_{92-99}, which are 3mm yellow devices. Resistors $R_{160-167}$ are current-limiting resistors for the LEDs.

Each CD output is filtered at every equaliser chip with capacitors $C_{3,8,13,18,23,28,33,38}$. Power supply is filtered immediately at the chips through $C_{4,9,14,19,24,29,34,39}$, which are each 100nF. Additional supply filtering is provided with tantalum capacitors $C_{185-C192}$.

Capacitors $C_{1009-1016}$ have a minuscule value of 2.2pF and are optional. Their use depends on the printed circuit board design. Usually they suppress the crosstalk between equaliser chips and the amplification of the noise component. If you have problems with too large an input sensitivity and the CLC014's CD output indicates a valid input signal when there is no such signal present, then these additional components will be necessary.

Outputs DO and DO\ of every equaliser are connected to the inputs of the cross-point matrix CLC018 DIx and DIx\. Note that all of the signal processing internal to the DVRS-8x8 device is carried out in differential and not single-ended mode.

Care should be taken when designing the printed circuit board so that the lengths of the tracks for the signal DO and the inverted signal DO\ are equal. Even small differences in track length will lead to phase differences between the signals in the differential signal pair, which at the high frequencies involved will produce bit errors.

The CLC014 does not produce true ECL – or more strictly speaking PECL or positive ECL – signals. The cross-point matrix expects ECL levels at its inputs. For this reason, the outputs of the equaliser chips are set to correct ECL levels using an additional matching network.

For the first input equaliser this matching network consists of diode D_1, resistors $R_{5,6}$ and the filtering capacitor C_{D1}. The same function for the other equaliser chips is accomplished through the following components: diodes D_{2-8}, resistors $R_{11,12,17,18,23,24,29,30,35,36,41,42,47,48}$ and capacitors CD_{2-8}.

The outputs of the cross-point matrix should be also set at correct ECL levels before entering the inputs of the retiming/reclocking circuits. This is done using of diodes D_{9-16}, resistors R_{49-64} and capacitors CD_{9-16}.

As the CLC018 cross-point chip can operate with data rates in excess of 1.4Gbit/s, proper supply filtering as close as possible to the chip body is vital for the successful design. The filtering is accomplished through ceramic capacitors C_{41-44} and tantalum capacitors $C_{183,184}$.

What the microcontroller does

The 80C51 microcontroller configures the CLC018 matrix through port P1 and two signals from port P3, namely P3.2 and P3.3[8]. The configuration logic of the switch is double-register architecture. A particular register in the first rank is selected through a valid address at the OA0-OA2 address pins. This register corresponds to an output of the cross-point matrix.

The content of the register consists of four bits IA0-IA2 and TRI (tri-state). These represent the input connected to the selected output or a third state of the output if this is disabled. When loading the first rank registers, the chip-select input CS should be high. In my design, the chip-select is permanently connected to the positive supply rail.

Loading of the first register is done at the low-to-high transition of the LOAD input pin. The content of the first rank of registers is transferred to the second rank – which actually affects the outputs – at the low-to-high transition of the CNFG input signal.

The whole cross-point matrix can be placed in an initial state of all outputs connected to input 0 or disabled. When TRI is held low and a high-going pulse is applied to the RES input, the outputs become active. When TRI is held high and a high-going pulse is applied to the RES input, the outputs are disabled.

The whole process of configuring the cross-point switch, which at first glance may look a little bit confusing, is done by the firmware residing in the controller. The data bus of the CLC018 can be either +5V or ECL-levels compatible, depending on the state of the logic-level power supply pin V_{LL}. In this case normal CMOS level compatibility is used.

Data and clock recovery

Figure 3 presents the data/clock recovering circuit for the first output channel which comprises CLC016, labelled IC_{10}, and accompanying components. The four data rates 143, 177, 270 and 360Mbit/s at which the PLL locks are set through resistors $R_{67,68,69,70}$. I suggest that these resistors are 1% tolerance or better.

The frequency detector output FD connects to the VCO control lines VC and VC\ through the loop filter consisting of components R_{66} and $C_{50,51}$. The loop filter controls the PLL dynamics and acquisition time.

Capacitor C_{45} determines the period of scrolling through the different data rates until the chip finds a suitable one. Filtering network R_{65}/C_{46} connects the loop-unlocked output SER to the data rate scrolling-oscillator enable pin ACQ/WR. The AUTO control line of the chip connects to the positive supply rail, which enables the automatic rate selection, or ARS.

It is also possible to operate the chip manually. In this mode, the user selects the data rate with pins RD0/RD1. In automatic mode, the RD0 and RD1 lines act as outputs reflecting the searched/locked data rate at the moment. They are used in the proposed

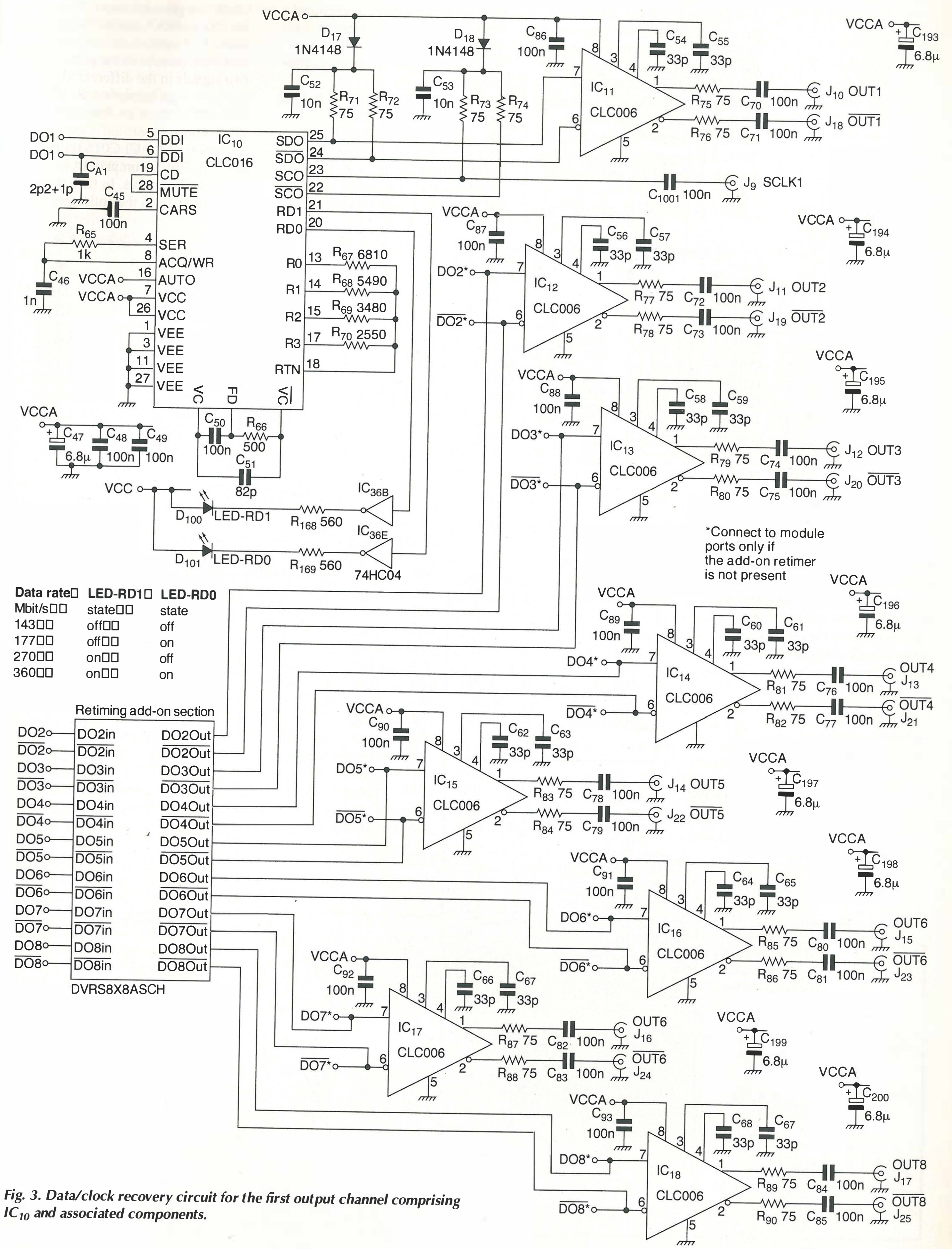


Fig. 3. Data/clock recovery circuit for the first output channel comprising IC_{10} and associated components.

design to indicate the data rate of the output signal at the front panel of the DVRS-8x8. For this purpose, the RD0/RD1 signals are inverted and buffered via the 74HC04 buffers $IC_{36B,E}$. These drive yellow LEDs $D_{100,101}$ through current-limiting resistors R_{168} and R_{169}. Table 1 presents the output combinations of the LEDs and how they reflect the valid data rate.

The CD and MUTE pins of the chip are tied together, preventing random output oscillation when no input signal is present. Capacitors $C_{47\text{-}49}$ are for power supply decoupling.

Special attention needs to be paid to the optional capacitor CA_1 – in this case 2.2pF+1pF SMD. It is situated at one of the differential input lines to the retimer chip and compensates for eventual bit errors arising from signal track differences and parasitic capacitance at the DO and DO\ complementary lines. As I mentioned earlier, even small differences in the phase of the two signals in the differential pair can have high impact on the bit error rate at the high data rates involved.

Outputs of the CLC016 retimer are ECL/PECL compatible, but not native ECL outputs. In fact, they are outputs from the collectors of

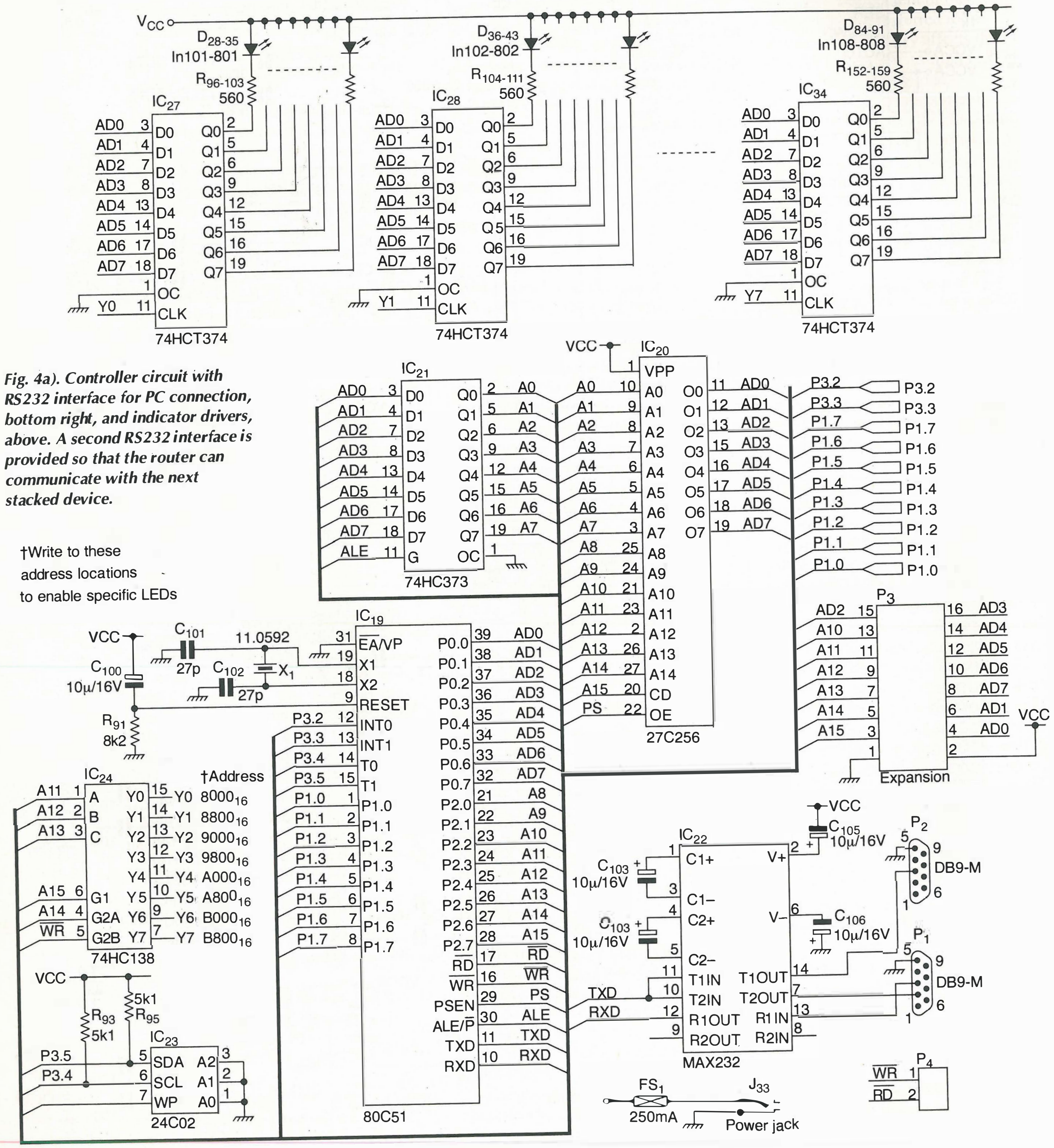


Fig. 4a). Controller circuit with RS232 interface for PC connection, bottom right, and indicator drivers, above. A second RS232 interface is provided so that the router can communicate with the next stacked device.

†Write to these address locations to enable specific LEDs

the output transistors. To provide correct ECL/PECL levels, networks consisting of diodes $D_{17,18}$, capacitors $C_{52,53}$ and resistors $R_{71\text{-}74}$ are used.

Clock signal details

A clock signal is extracted from the serial data. This clock output is taken from the SCO output and is AC coupled to BNC-connector J_9 through capacitor C_{1001}. Note that terminating the clock-output with a 75Ω tap will result in 6dB signal decrease, which may be not suitable for every application.

As I mentioned earlier the provision of a clock output is an extra design feature and is usually not implemented on most commercial designs. Depending on your needs, the clock outputs can be configured as second SDI outputs (SDI 2), mirroring the corresponding SDI 1 outputs.

The same data reclocking circuits are implemented for the other output channels too. They are contained in the circuit hierarchical block entitled 'Retiming add-on section' in Fig. 3. Details on this section next month.

Outputs from the data/clock recovery circuits are fed into cable drivers $IC_{11\text{-}18}$. As the adjustable gain feature of the cable drivers is not used in this design and the preset output levels are accepted the gain-setting pins 3 and 4 of the drivers should be left unconnected. To provide greater noise immunity the capacitors $C_{54\text{-}69}$ are connected to these pins.

As the CLC006 has dual complementary outputs, these can easily be used to effectively double the number of outputs of the serial digital router from 8 to 16. The polarity of the signal has no effect on how it is interpreted as the SMPTE 259M proposes an NRZI-code for the serial digital interface.

The non-inverting outputs are tied to BNC-connectors $J_{10\text{-}17}$ and the inverting outputs to $J_{18\text{-}25}$. Resistors $R_{75\text{-}90}$ are the 75Ω line interfacing and impedance matching resistors. Capacitors $C_{70\text{-}85}$ are the DC-blocking capacitors. Power supply filtering is achieved through $C_{86\text{-}93}$.

Figure 4 shows the device controller. It is built around an 80C51 microcontroller, IC_{19}, and associated components[8]. The microcontroller is clocked at 11.0592MHz using X_1 with $C_{101,102}$ and is automatically reset at power-on via R_{91} and C_{100}.

Firmware for the microcontroller – the object code for which is presented later, resides on the 27C256 EPROM, IC_{20}. Latch IC_{21} provides address/data demultiplexing of the ports of the microcontroller.

The start-up configuration – which is user selectable and is loaded when the device is powered on – is stored in the 24C02 serial EEPROM[9], IC_{23}. Serial communication is integrated in the 80C51 microcontroller, but the correct RS232 levels are obtained through the use of the interface driver IC_{22} and capacitors $C_{103\text{-}106}$. It should be mentioned that there are two RS232 interface ports associated with this driver – one for connection with the PC master, labelled P_1, and one for the connection with the next stacked device slave, P_2.

Communication with the 'master', which can be either a PC or a keyboard, is bidirectional, so that the controlling device can retrieve information from the router.

Status display

Visual indication of the active configuration is achieved with 64 red 3mm LEDs, arranged in eight rows (outputs), consisting of 8 columns (inputs) each.

Each row consists of LEDs connected to an output from one of the latches $IC_{27\text{-}34}$. The latches are loaded with the data from data port P0 of the microcontroller. Data is clocked into each latch by clock signals obtained at the output of the address decoder U_{24}. This device decodes part of the address space of the microcontroller – addresses 8000_{16} to $B800_{16}$ – and is enabled by the write pulse at pin WR\ of the micro.

A write pulse appears each time that the controller tries to access external data address space and is transferred to the appropriate latch by the address decoder. So the LED-rows are visible to the microcontroller as cells in its address space.

The LEDs are $D_{28\text{-}91}$ and the

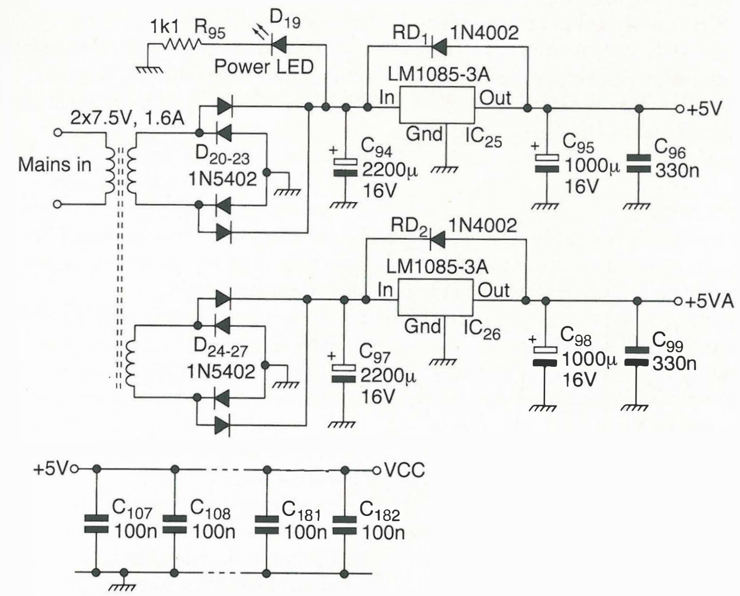
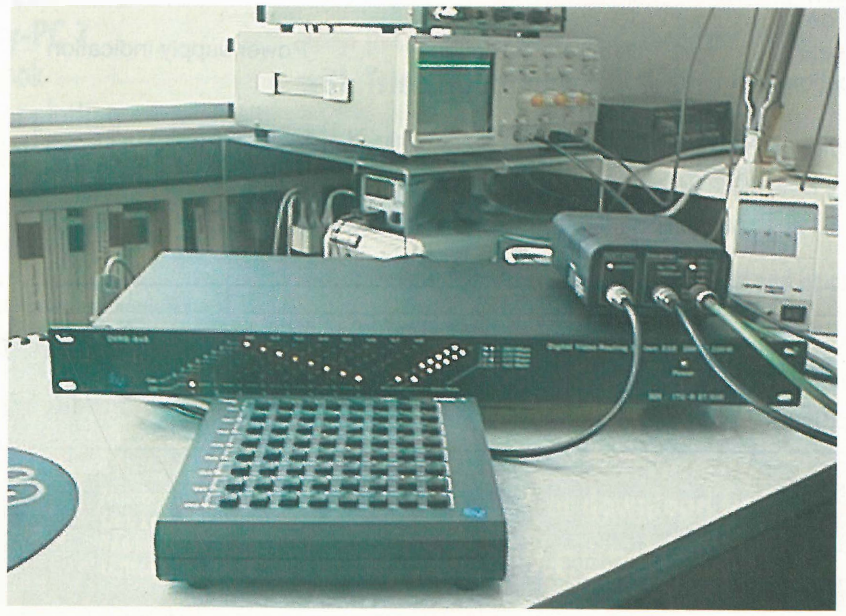


Fig. 4b). Power supply and regulators. Also shown are the decoupling capacitors, which are distributed around the system.



current limiting resistors are R_{96-159}. The PCB is designed to be expanded in future with other features or more cross-points, so expansion ports $P_{3,4}$ are provided. Power supply filtering is accomplished with $C_{107-116}$ and $C_{180-182}$.

Power supply

Because there's a great number of components in the design, current consumption is high. Fortunately all components share a common supply voltage of +5V DC.

I had two choices when designing the power supply section. One was to use a power transformer and a linear regulator. The other was to use a 220V switch-mode power supply. My choice was the linear power supply, which provides significant less noise, both radiated and fed into the power line. I considered that the whole digital router was noisy enough – I had to screen the whole 1RU-high module – without adding yet more noise sources.

Current consumption of the circuit is more than 3A. I have used 5V, 5A linear regulators from National Semiconductor. I had a problem in that power transformers that can provide more than 3A at their secondary, are usually bulky and don't even fit into 3U modules let alone the 1RU used here. So I have found a way of using a transformer with two equally rated secondary windings (7.5V at 1.6A – ANG part), which means splitting the power supply into two sections.

Voltages at the secondary windings are rectified independently through power diodes D_{20-27} and capacitors $C_{94,97}$. The regulators are LM1085 types from National Semiconductor – $IC_{25,26}$. Output filtering is accomplished by $C_{95,96,98,99}$. Reverse biased diodes $RD_{1,2}$ provide additional protection. The regulators are mounted on large heat sinks.

The two power supply rails are +5V and +5VA. The +5V supply supplies the device controller and all associated components, the cross-point matrix and the input equalisers. The +5VA rail supplies the retimer/reclocks and the output cable drivers.

I experienced no problems as the two supplies start simultaneously. Raw input to the first regulator section is used to provide the DC-supply for the external keyboard through the power jack socket J_{33} and the short circuit protective fuse F_1. A value of 250mA is marginal; you may want to use a greater value to prevent false alarms.

The same raw input lights the power-on LED D_{19} through current-limiting resistor R_{95}. ■

In his next article, Emil discusses the keyboard and retiming add-ons and also details the firmware for the microcontroller. Details of PCB and software availability will also be announced.

Further reading

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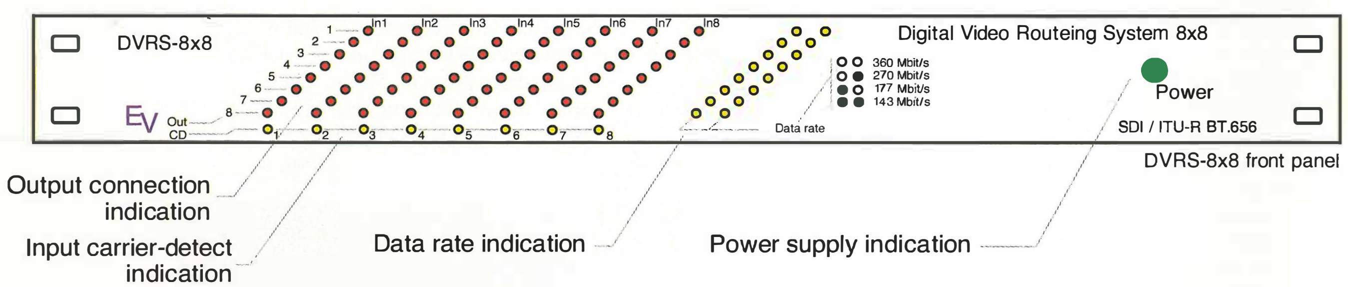
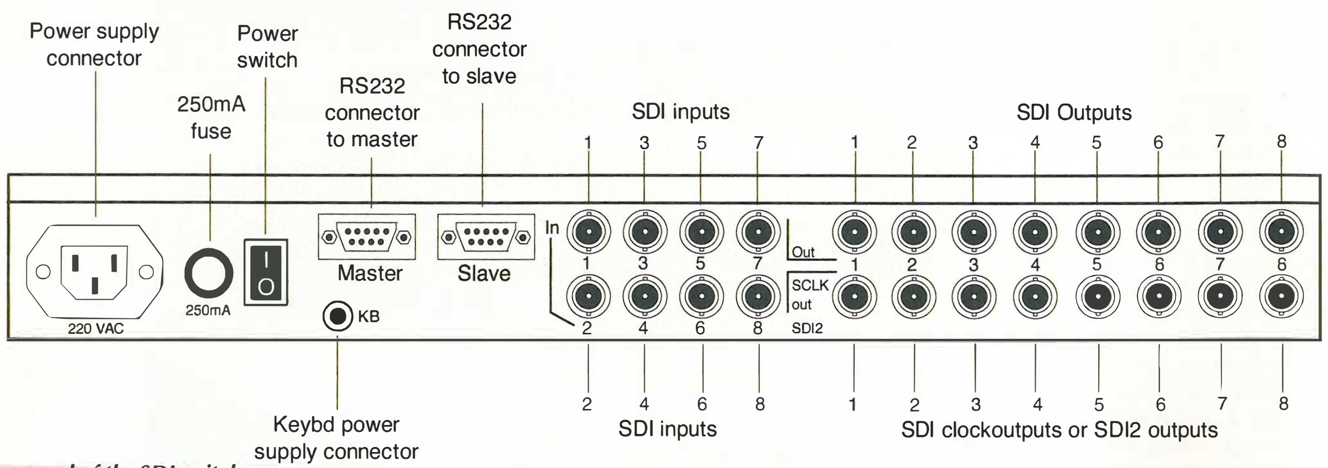
Front panel of the SDI switch.





Rear panel of the SDI switch.

Capacitor Sounds II

Distortion v Time v Bias

Cyril Bateman shows how dielectric absorption with DC bias determines capacitor sounds' second harmonic distortions

My last article described the design and construction of a low cost, real time distortion analysis hardware system, able to measure second and third harmonic distortions from 60dB to 120dB below a 1 volt test signal. Distortion levels are displayed using two alternative methods, a rapid response tree of twenty LEDs, showing distortion change in 3dB steps, as well as two low cost DMM panel ameters able to display 0.1dB changes, better accuracy and resolution but slow response while the displays settle.

This equipment complements my very low distortion test generator and notch filter/preamplifier assemblies, originally used with a soundcard and FFT software as described in my original *EW* Capacitor Sounds series of articles. With this I was able to measure distortions imposed onto the test signal by many capacitor types found in high quality audio systems. This test system uniquely provided the facility to measure additional distortions found with most capacitors when subjected to a DC polarising voltage[1]. This DC blocking or polarised usage is a fundamental reason for many and perhaps most, capacitor applications.

To reliably measure distortions produced by the better quality capacitors requires a measurement system producing less than 1ppm distortion, together with a noise floor better than -120dB below a 1 volt test signal. Such equipment, although optimised for measurement of capacitor distortions, is equally suited to measuring and identifying pre-amplifier and power amplifier harmonic distortions.

To prove this new hardware method, I measured large numbers of capacitors, comparing the new equipment results with those found using the soundcard/FFT software method. I found excellent agreement between the two methods, but soon noticed that distortions from some capacitors seemed to take a significant time to settle. This was especially noticeable watching the two LED columns, when with some but not all capacitors, the second harmonic display in particular 'ran' up and down the LED column for several seconds after charging or discharging the DC bias voltage. **Fig. 1.**

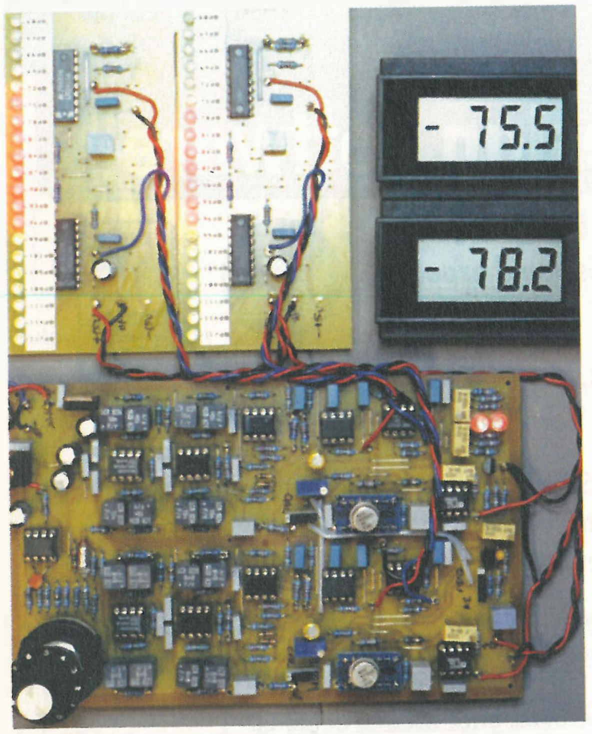


Fig. 1. This real time hardware system replaces the soundcard and software used for my earlier series. Monitoring the second harmonic distortion amplitude at C27 and DC bias across the test capacitor using my Pico ADC100 digitiser, produced the plots for this article. The upper DMM displays the stabilised second harmonic, the lower the third, testing the 0.1μF X7R ceramic capacitor with DC bias, as figure 1 my last article.

Equipment or capacitor behaviour?

Careful comparison measurements made using this prototype with those for the computer and soundcard software method confirmed an excellent correlation when measuring good, low distortion capacitors. Both methods can produce stable distortion measurements with and without DC bias.

Comparing poorer capacitors, especially using DC bias, highlighted capacitor distortion anomalies as the capacitor charges or discharges. These were instantly visible watching the LED trees but were masked using the soundcard and software method or the DMM displays, because of the trace averaging time or while the DMM displays settled. However, all methods produced almost identical results when the capacitor finally stabilised.

Investigations since made into these anomalies have revealed additional insights into how dielectric absorption really does dominate capacitor sound second harmonic distortion and why the distortion continues to change after the figure 2 capacitor has become fully charged or discharged. **Figs. 2, 3.**

Capacitor Anomalies

In production, every capacitor is tested for conformity against four specific departures from the ideal capacitor.

Capacitance value and tanδ at 1kHz (small values test at 1MHz, large values 100Hz).
Insulation resistance.
Voltage withstand test.

Voltage withstand is always performed using substantially elevated voltages relative to the capacitor's rated voltage. Considered as potentially damaging if repeated, it is defined as a 'once only' test. Multilayer ceramic capacitors will typically be tested using 250% rated voltage for 5 seconds with charging current limited to 50mA, foil and film capacitors using twice rated voltage for 2 seconds and aluminium electrolytics at their surge voltage rating, usually 120% rated voltage.

Metallised film capacitors are different, typically testing at 160% rated voltage for 2 seconds. One other significant difference results from their use of thin dielectric and 'metallised' electrodes, is that small fault areas in the plastic film dielectric can be 'cleared'. An excess voltage in production evaporates away or 'clears' the metallised electrode surrounding any localised fault areas in the dielectric. If excessive, this clearing could result in non-ohmic electrode areas, increasing third harmonic distortion and dielectric absorption[2].

Insulation resistance, usually performed at a much lower voltage, is extremely time consuming, so to reduce test times makers usually specify relatively 'easy' limits. These two capacitor voltage tests, apart from any metallised film 'clearing' effects, can have little impact if any on sound distortions generated by a capacitor.

The need to test for capacitance value is obvious, but why measure tanδ? In fact what is tanδ? The theoretically perfect capacitor does not exist, but some construction methods do provide near ideal capacitor behaviour. However all 'solid' dielectric capacitors must exhibit dielectric losses which appear as loss resistances in series and in shunt with the capacitor element, together with small but inevitable series resistances introduced by the metallic electrodes, leadout wires and connections.

In effect each capacitor incorporates a high value shunt and low value series resistor. As a result the phase angle difference measured between the capacitor through current and capacitor voltage for every practical capacitor will always be less than the 90° expected for a perfect capacitor.

Whenever a capacitor is subjected to an AC through current, these dielectric losses and the metallic resistances dissipate some power according to I^2R and the capacitor internal temperature rises above ambient. Except at DC these series resistances dominate capacitor behaviour, so for ease of calculation, all resistive losses are lumped together, resulting in an 'equivalent series' loss resistance or ESR, calculated from the capacitor's measured phase angle.

Because the capacitor has only two terminals, we cannot easily identify these individual loss resistances, we can only measure the capacitor's impedance and its voltage/current phase angle, or more usually its two vectors of resistance 'r' and reactance 'x'. The 'r' or resistive vector (ESR) is measured in phase with the capacitor through current, the 'x' or reactance X_c vector 90° later.

Tanδ is simply the result of dividing the magnitude of this 'r' vector by the 'x' vector. Similarly

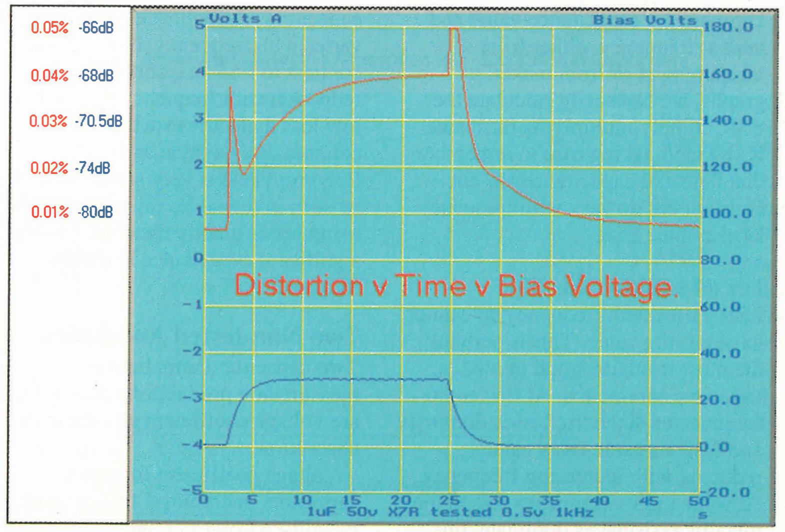


Fig. 2. The top plot, left scale, of a 1μF 50V X7R multilayer ceramic shows second harmonic distortion increasing and reducing prior to a prolonged settling period, in a capacitor with large dielectric absorption (1.76%) and a non-linear voltage coefficient, using a 0.5V test signal. This anomalous behaviour was hidden using the soundcard and software method. Bottom trace, right scale, shows DC bias voltage measured across the capacitor.

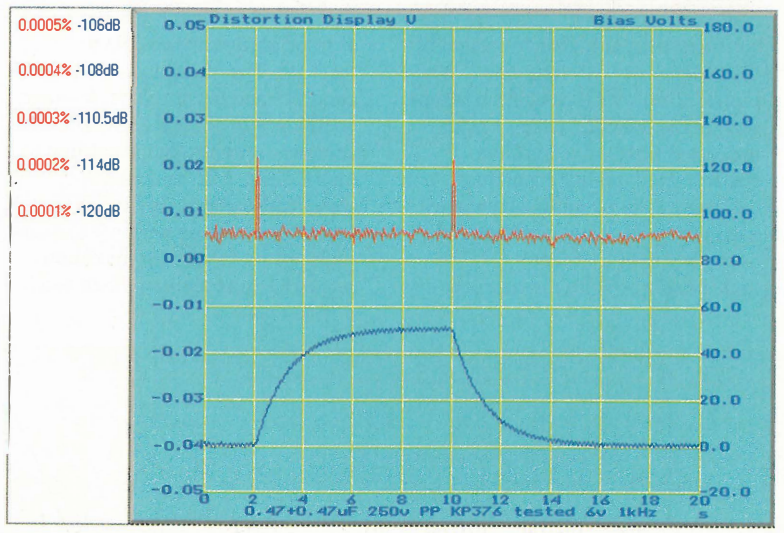
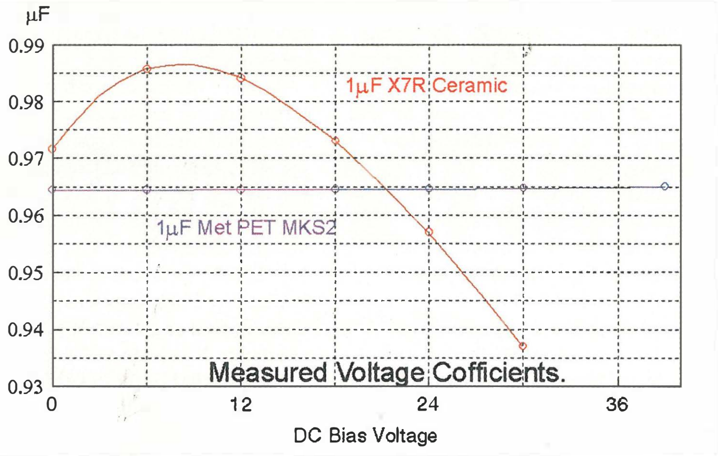


Fig. 3. Distortion plot of my 0.47+0.47μF KP376 foil and PP near perfect reference capacitor, scaled 100 times more sensitive than figure 2, using a 12 times bigger test signal and 50% more bias voltage, during the same test session. This 'normal' behaviour shows a near ideal capacitor having no measurable VC and little dielectric absorption (0.04%). The two brief switching transients result from operation of the bias charge discharge switch.

Fig. 4. The large and non-linear voltage coefficient of the figure 2 high 'K' X7R multilayer ceramic compared with the tiny VC of the MKS2 metallised PET capacitor. This MKS2 VC, the largest of the film capacitors I measured, was absolutely linear from 6V to 24V bias increasing by just 0.031%.



knowing the capacitance value and tanδ at frequency, either from measurement or from maker's graphs, we can easily calculate the ESR. Simply multiply its reactance X_c by tanδ, taking care to remember that tanδ and capacitance are not constant but do vary with frequency as also must ESR.

Let us explore this ESR

ESR varies with frequency so cannot have a finite value. This is perhaps the most misunderstood of all capacitor parameters. At low audio frequencies dielectric losses dominate and ESR measures as a value reducing with increasing frequency. At some higher frequency, when the metallic resistances dominate, this ESR reduction slows becoming near constant, then at higher frequencies ESR increases with frequency. When plotted it follows the 'bathtub' shape seen in the attached table of actual measured ESR values, for two typical, good quality capacitors.

Clearly even at audio frequencies, capacitor ESR is not constant and does vary with frequency, increasingly so with the best low loss capacitors. Capacitance value also varies with frequency, however in contrast to ESR, capacitance reduction with frequency for the best low loss dielectrics such as COG ceramic, Polystyrene and Polypropylene is very small. As can be seen in the table, capacitors made using lesser quality dielectrics loose significant capacitance at audible frequencies.

Two Non-tested Anomalies

Two capacitor anomalies not measured on production capacitors, are voltage coefficient and dielectric absorption.

Voltage coefficient for most capacitors, including COG ceramic, metallised Polyester and Polypropylene film types is so small as to be almost impossible to measure. The exceptions are high 'k' ceramics and electrolytics. Voltage coefficient or VC for high 'k' ceramics is controlled according to their CECC, MIL and EIA classifications, e.g. BX or 2X1 grade capacitors must lie within +15% and –25% of nominal with maximum rated DC volts applied. Each batch of these capacitors will be QA sample tested to ensure compliance.

Dielectric Absorption or DA is another matter, I know of no similar classification which monitors DA for any type of capacitor. Two common methods exist for measuring DA and both are essentially slow DC methods, having no direct correlation to AC usage. The most common being to charge the capacitor to a known voltage for a long time, briefly discharge through a low value resistor for a few seconds then allow to recover for some time before measuring the 'recovered' voltage using a very high impedance voltmeter. The alternative method performs the opposite test by measuring capacitor charging current over a long time.

The problem with both tests is deciding on the charging voltage to use. Generally the capacitor rated voltage is used, but most capacitors in transistor equipment are used with much smaller DC polarising voltages, even with little or no DC bias voltage.

Tests performed for this article

To investigate the anomalies illustrated between **figures 2 and 3,** I needed to explore the affects change in voltage coefficient, tanδ and DA have on second harmonic distortion. Ideally I needed to find and measure capacitors having no measurable VC or DA, no measurable VC but large DA, large VC and no DA and some exhibiting both anomalies.

Apart from allowing sufficient time for the capacitor to stabilise, measuring capacitance and tanδ with bias voltage is easily performed. The DC bias adapter used with my 100Hz distortion test equipment also attaches to my 0.1% Wayne Kerr bridge. Assembled using 450 volt AC rated, series wound, metallised Polypropylene capacitors with no measurable VC, this bias adaptor has been proved free from distortion to 100V DC and was used for all measurements, with and without bias voltage.

The voltage coefficient of film capacitors is so small as to be in practice un-measurable, so unusual measures were needed to derive some figures for this investigation. In addition to the obvious need to maintain a constant room temperature I found it essential to shield the smaller capacitors from normal room air movement and low temperature infra-red. An inverted, black plastic, empty 35 mm film canister was placed over the capacitor which was allowed to stabilise for some 10 minutes following each bias voltage increment.

Table 1

Capacitor Type.	100Hz	300Hz	1kHz	3kHz	10kHz	30kHz
100nF metPET - ESR	38.5Ω	19.2Ω	8.6Ω	4.3Ω	1.8Ω	0.75Ω
Measured tanδ	0.0025	0.0037	0.0054	0.0083	0.0115	0.0144
Measured Capacitance	102.4nF	102.1nF	101.9nF	101.3nF	100.6nF	99.7nF
Measured lZl	15.6kΩ	5.19kΩ	1.56kΩ	523.4Ω	158.2Ω	53.2Ω
100 µF 50v Polar - ESR	507.8mΩ	292.6mΩ	224.5mΩ	203.6mΩ	191.3mΩ	179.4mΩ
Measured tanδ	0.0322	0.0548	0.1384	0.3687	1.095	2.725
Measured Capacitance	100.7µF	99.4µF	98.0µF	96.2µF	91.2µF	80.6µF
Measured lZl	15.8Ω	5.35Ω	1.64Ω	587mΩ	258mΩ	192mΩ

Dielectric absorption is even more time consuming and considerably more difficult to measure accurately. Most 'standard' test circuits require the use of an exceptionally high input impedance voltmeter with 15 minutes charge and recovery times[3]. The usual 10MΩ DVM discharges recovering 1µF capacitors before a reading can be taken, so conventional instruments simply will not do. I considered using a very high input impedance FET opamp buffer, but the best type I had to hand exhibited a 50pA bias current, sufficient to charge or discharge many capacitors.

I also had a matched pair of low cost PM128 panel meters, these claim a high input impedance as supplied set to measure 200mV full scale. Their voltage readings were almost unchanged when a 100MΩ resistor was added in series, confirming they did have an exceptionally high input impedance. I decided to use these to measure two capacitors at one time. With the expected 0.5% DA typical for PET, a capacitor charged to 30 volts would require some 150mV recovery voltage to be measured, well within the PM128 meter's 200mV range. Any larger DA would be measured using a 100MΩ divider.

A very high voltage, 40mm diameter porcelain two gang four way rotary wafer switch facilitated switching from charge to discharge, to recovery then to measure, the two co-tested capacitors. In this way the PM128 meters would only load the capacitors for a few seconds while noting the readings. Following a few trials this method worked well with good repeatability, provided I used a stopwatch to time the discharge period. For this I choose to use ten seconds, discharging the capacitors into a 56 Ohm resistor.

After many measurements I managed to locate a number of suitable test capacitors matching three of my four target VC and DA grades. The problem being that all attempts to identify a capacitor with high VC and no DA had failed. On reflection it is almost certain that this particular combination does not exist in production capacitors. I managed to find several good examples showing little or no VC and DA, but only one showing almost no VC and large DA and many samples showing various levels of both anomalies.

In the end and to restrict the number of figures for this article, I selected three 1µF capacitors of roughly similar size and 200-250 volt DC rating, also three same case size 1µF 63V rated metallised PET and one metallised Polyphenylene Sulphide type.

Test Capacitors

Measuring the voltage coefficient of the X7R dielectric ceramic capacitor of figure 2 revealed a large and non-linear effect. Initially the capacitance increased with DC bias, but from 12V to 39V it reduced more than 5%. This high 'k' X7R ceramic type also exhibited measurable change of tanδ with DC bias voltage, 0.0119 at 0V, 0.0149 at 12V and 0.0139 with 30V DC bias. **Fig. 4.**

Even larger changes were found measuring Z5U type capacitors, but COG ceramic types, whether multilayer or single layer discs, are quite different in every respect. They have no measurable voltage or tanδ coefficients and their ±30ppm temperature coefficient cannot be

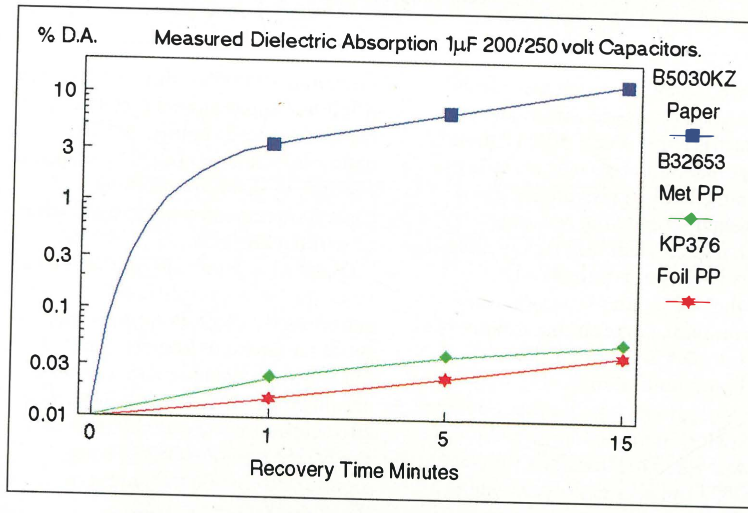


Fig. 5. Dielectric absorption recovery voltages, comparing the 12.74% DA of the 1µF 200V rated impregnated paper type B5030KZ of figure 6 with the 0.04% of my near ideal 0.47+0.47µF 250V type KP376 foil and Polypropylene reference capacitor of figure 3 and a good MPP capacitor.

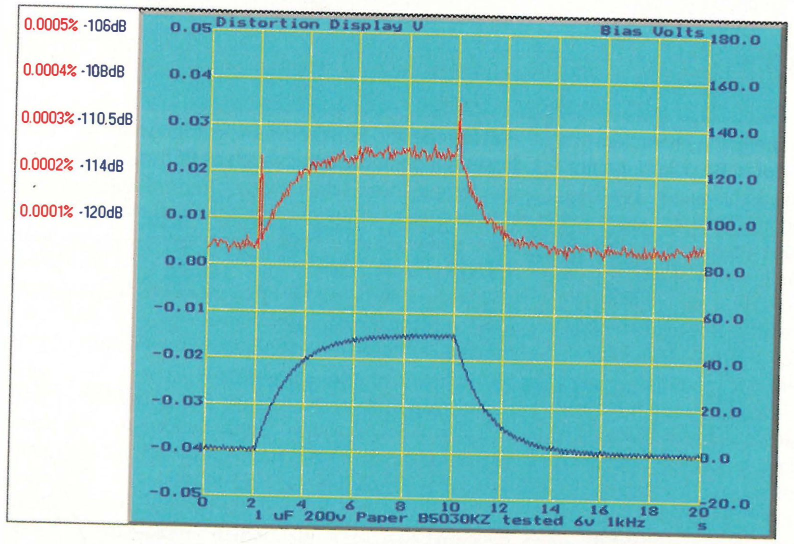
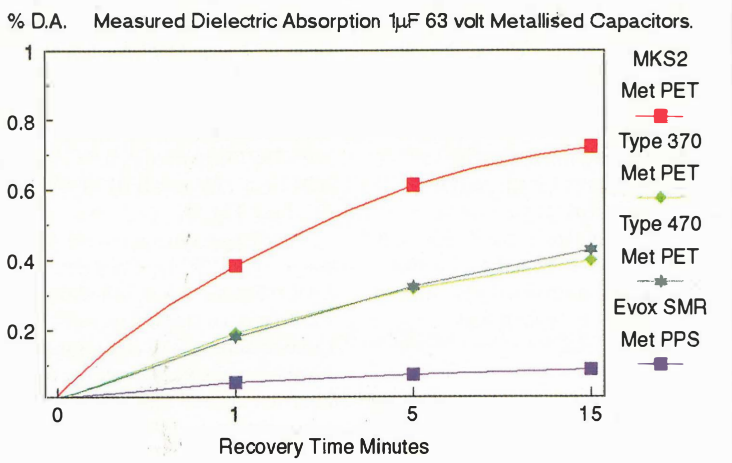


Fig. 6. This 1µF 200V impregnated paper type B5030KZ capacitor with a negligibly small 0.03% voltage coefficient but very large 12.74% dielectric absorption, clearly shows how dielectric absorption and DC bias voltage dominate second harmonic generated by the capacitor. With no bias both this and the figure 3 capacitor measured almost identical second harmonic distortions, -127.3 and -127.5dB respectively.

Fig. 7. Recovery voltage comparing three different 1µF 63V rated, same case size, metallised PET capacitors with a slightly larger case metallised Polyphenylene Sulphide capacitor. While the two BC Components types, 370 and 470 show similar DA the Wima MKS2 measured almost double and produced the worst distortion of these four capacitors.



bettered, they are much more stable than Mica or plastic film capacitors. Measuring the 100nF 50V COG types featured in my earlier articles, even the fifth significant figure of capacitance and tanδ remained unchanged, when bias was increased in 6V steps from 0 to 30V DC.

Other capacitors I measured fell within these two extremes. With 48V bias my 0.47+0.47µF 250V KP376 FKP aluminium foil and Polypropylene, near perfect reference capacitor, increased in value by only +0.0053%. The 1µF 250V Epcos B32653 metallised Polypropylene measured +0.005% while a 1µF 200V B5030KZ impregnated metallised paper measured slightly more, a barely measurable +0.03% voltage coefficient. Tanδ for all three capacitors remained unchanged with or without DC bias.

Dielectric absorption for these three capacitors however differed substantially. Both Polypropylene types measured extremely small DA but the impregnated paper capacitor exhibited an enormous 12.74%. The FKP capacitor measured 0.04% and the B32653 MPP 0.052%. More significantly while the recovery voltage for both PP types builds steadily and slowly with time, that for the paper capacitor increased almost instantly to a very high value, reaching 3.38% in just 1 minute, almost one hundred times larger than the PP capacitors fifteen minute value. **Fig. 5**

These DA differences clearly show in the distortion with time as well as the conventional FFT soundcard plots. With no DC bias, both the paper and FKP capacitors measured almost identical second harmonics at -127.3 and -127.5dB respectively, the B32653 MPP -126.8dB. With 48V DC bias, the second harmonic of the FKP increased just 1dB, the B32653 MPP type increased by 6.3dB, but the second harmonic for the metallised paper capacitor increased by 13dB. More significantly, the FKP distortion time plot appears unchanged with or without bias or time. In contrast the plot for the paper capacitor clearly shows second harmonic distortion continuing to build slowly, increasing and decreasing over many seconds. **Figs. 3, 6.**

Rather surprisingly, I also measured significant differences of VC and DA between the three same case size, 1µF 63V rated, metallised PET capacitors. While the two BC Components capacitors, 370 and 470 types, show closely similar DA recovery voltages, the Wima MKS2 type shows much increased DA, at 0.724% - almost double that of the other two metallised PET capacitors.

As expected, the Evox metallised Polyphenylene Sulphide capacitor, which performed so well in my earlier tests, measured 0% VC and only 0.087% DA when co-measured with the 470 style capacitor, to make a direct comparison with that style's 0.4% DA. **Fig. 7.**

Three of these four quite similar capacitors also measured very small and linear VC when tested using 0 to 30V DC bias, ranging from 0% for the Evox to a negligible 0.0049% for the 470 and 0.024% for the 370 style. The MKS2 style measured the worst with 0.031% at 30V and 0.062% by 39V. Its VC was ruler straight from 6V to 24V bias, with a small dip from 0V to 6V and increasing deviation above 30V bias. see Fig 4.

The distortion with time plot for this MKS2 capacitor shows a noticeable dip then increase in second harmonic as the capacitor discharges and another small dip, not seen in other capacitor plots, as it charges. With such a range of measured distortions, I had no choice but change scales. The Evox SMR also BC Components type 470 were measured using the 0.05 volts for -106dB full scale display, but for the type 370 and the MKS2 capacitors I had to use the 0.5 volt, -86dB full scale display. **Figs. 8, 9, 10, 11.**

Most notable of all is that even with no DC bias the MKS2 measured some 10dB more second harmonic distortion than the other two metallised PET types. Due to its large DA of 0.724% it also displayed the largest increase of second harmonic, more than +26dB with 39V bias despite starting from a higher unbiased level (-115dB) than the others. This behaviour was not unique to this particular specimen but found in others of the same style.

Conclusions - VC or DA?

As preparation for this article I carefully measured more than one hundred capacitors. As can be seen in figure 2, a large dielectric absorption combined with a large non-linear voltage coefficient does seriously affect the level of second harmonic distortion produced by a capacitor. However such large and non-linear voltage coefficients simply do not exist in COG ceramics, foil and film

Dielectric Absorption

In essence two major dielectric characteristics exist - polar and non-polar. By polar I am not referring to an electrolytic capacitor, but the way a dielectric responds to voltage stress. This stress is the voltage gradient across the dielectric and not simply the applied voltage. It is stress in volts per micron, which matters.

Vacuum and air are little affected by voltage stress. Solid dielectrics which behave in a similar fashion are termed 'non-polar'. Most solid dielectrics and insulators are affected to some extent, increasing roughly in line with their dielectric constant or 'k' value.

When a dielectric is subject to voltage stress, electrons are attracted towards the positive electrode. The electron spin orbits become distorted creating stress and a so-called 'space charge' within the dielectric. This stress produces a heat rise in the dielectric, resulting in dielectric loss.

Non-polar dielectrics such as COG ceramic, Polystyrene and Polypropylene, exhibit small losses but polar dielectrics such as PET are much more lossy. Once charged to a voltage, it takes longer for the electron spin orbits in a polar dielectric to return to their original uncharged state.

Dielectric absorption is often measured by fully charging the capacitor for several minutes, followed by a rapid discharge into a low value resistor for a few seconds. The capacitor is then left to rest for some time after which any 'recovered' voltage is measured. The ratio of recovered voltage to charge voltage, is called dielectric absorption.

Various writers have used this method to develop capacitor models which simulate the effect DA has on capacitance value with increasing frequency. For that purpose such models can work well.

In the past I had tried without success however to use these published models with conventional 'Spice' simulators, attempting to model the effects of DA on harmonic distortion of capacitors, but none of the published capacitor models proved successful. A particular difficulty being the long simulation times needed to ensure stability and the care needed when choosing the final 'FFT' calculation window.

Armed now with the careful capacitor measurements needed for this investigation I was able to refine my models. Using a harmonic balance simulator, developed to calculate distortion in RF circuits, produced usable simulation results, supporting the effects which DA with bias voltage has on distortion.

So how does dielectric absorption affect the distortion produced by a capacitor? The main difference I found is the increasing magnitude of the second harmonic, with increasing bias voltage.

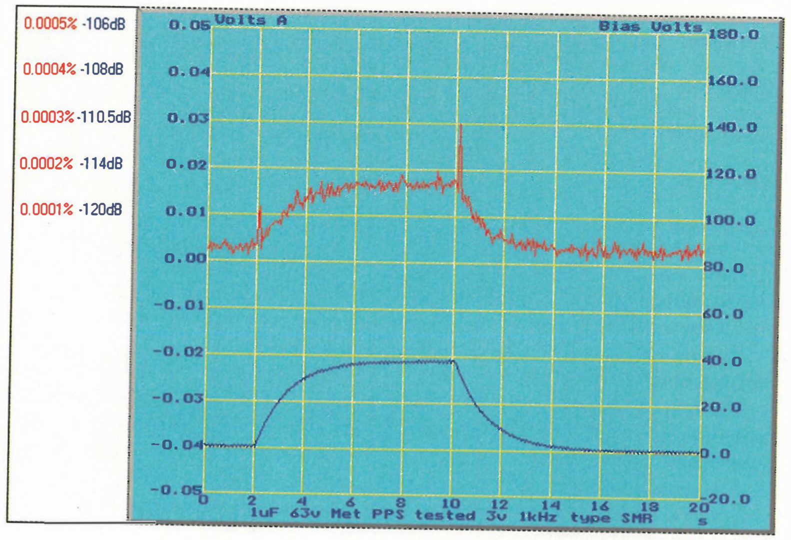


Fig. 8. This Evox SMR 1µF 63V capacitor size 12.5 x 6mm, with 0% VC and 0.087% DA, shows a 10dB increase in second harmonic with DC bias, half that measured with the best metallised PET capacitor tested, figure 9 and compares well with the 6dB increase of the 26 x 10mm B32653 MPP type.

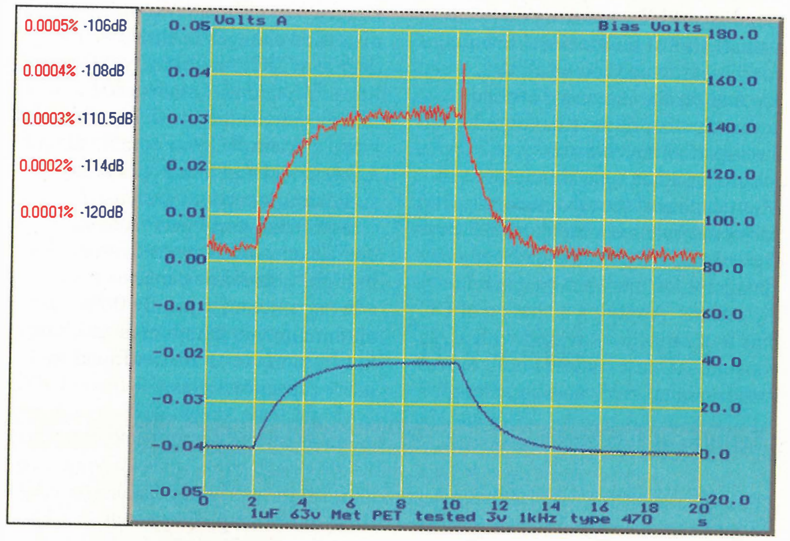


Fig. 9. BC Components type 470, 1µF 63V metallised PET capacitors consistently measure a small second harmonic without DC bias and negligible 0.0049% VC. However with 0.4% DA, second harmonic increases by 19.9dB with bias.

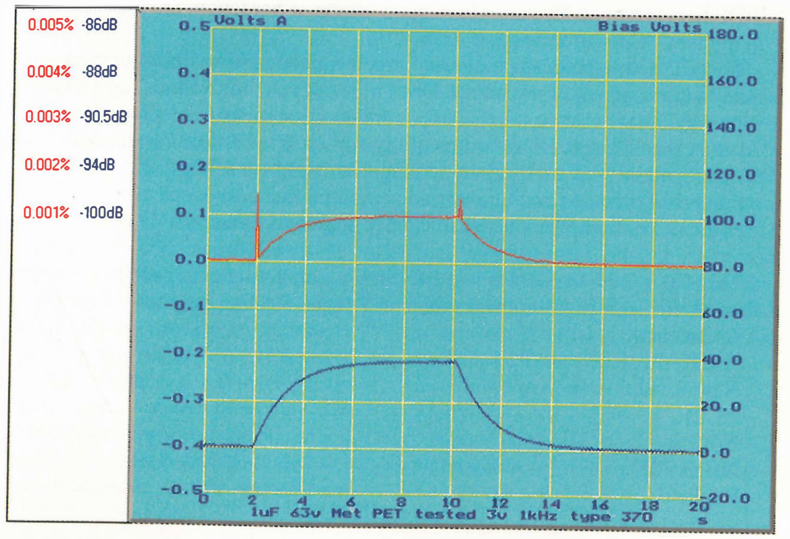


Fig. 10. The same makers 370 type shows 4dB more second harmonic with no bias and 25.3dB increase with bias, tested under the same conditions, enforcing use of a less sensitive display scale.

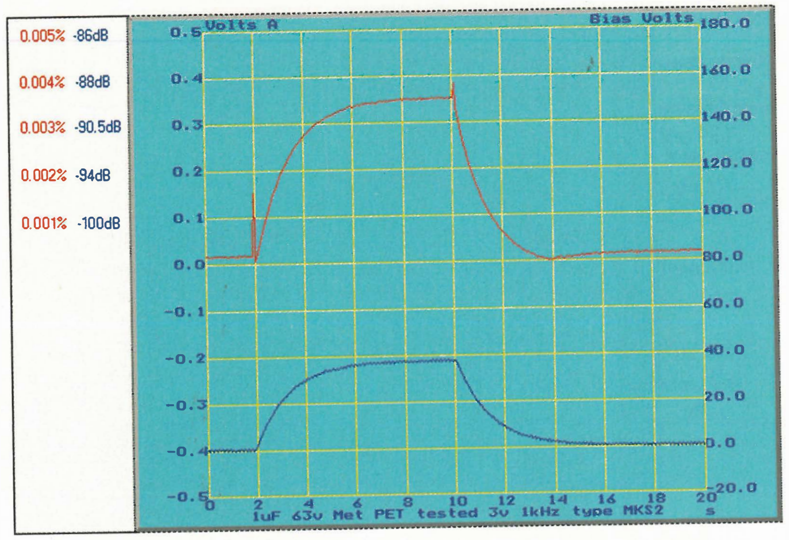


Fig. 11. With and without DC bias voltage the same case size Wima MKS2 shows much more distortion than the other capacitors. While discharging, its no bias second harmonic distortion overshoots then slowly rebuilds to -115dB, 10dB worse than the others. With bias its second harmonic distortion at -88.5dB, is ten times larger than type 470 and twenty times the Evox SMR capacitor.

or metallised film capacitors. Some metallised PET capacitors do exhibit a small almost un-measurable voltage coefficient, much too small to account for the increased second harmonic distortions I measured with the capacitor DC biased.

Using a Spice type simulator, Microcap6 and the advanced harmonic balance simulator in Aplac7.62, I explored the effect a change of DC bias has on capacitor distortions. Applying a change of DC bias to a capacitor stressed with a constant AC test signal simply moves the test signal zero crossing, along the voltage coefficient plot. With no DA and a non-linear VC plot, distortion changes in-line with the degree of VC non-linearity. Given a linear VC and no DA distortion remains unchanged with bias, but when a linear VC was combined with a DA model and bias applied, my simulated distortions increased.

Significant non-linear voltage coefficients will inevitably be found in high 'k' ceramic capacitors and to a lesser amount, typically 0.2%, in aluminium and tantalum electrolytics, but from my tests are not found in other capacitor styles.

Technical support

Full details of this new hardware test method and my original Capacitor Sounds series 1ppm low distortion oscillator, buffer amplifier, notch filter/preamplifier and DC bias assemblies, together with parts lists, assembly manuals and full size printed circuit board drawings, all as .PDF files arranged for easy viewing on screen or hardcopy, are provided in my new "Capacitor Sounds" CD ROM.

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VC

Voltage coefficient is in practise so small as to be in practice un-measurable for COG ceramic and the better film dielectrics such as Polystyrene, Polypropylene and Polyphenylene Sulphide. Metallised PET capacitors do exhibit a small near linear VC, but not usually of sufficient level to visibly affect distortion measurements.

DA

The better dielectrics such as COG ceramic, Polystyrene, Polypropylene and Polyphenylene Sulphide do exhibit a small but measurable dielectric absorption, usually less than 0.1% which has little effect on second harmonic distortion even when DC biased. However, as has also been clearly demonstrated, less than 0.5% DA, found in many perhaps most, metallised PET capacitors, does result in substantial increases in second harmonic distortion with increasing DC bias. From these tests, dielectric absorption is shown to be the dominant second harmonic distortion mechanism for COG ceramic and plastic film capacitors, especially when DC biased.

These test results reinforce my earlier recommendation that metallised PET capacitors should either be individually distortion tested before use, or simply not used in any quality audio system[4].

In my next article I explain how my real time second and third harmonic analyser described in the July issue, together with my 1ppm low distortion 1kHz generator, buffer amplifier and notch filter preamplifier[1] can be assembled into a low cost case, as a self contained free-standing distortion analyser which can be used testing both amplifiers or capacitors. ■

References.

1. Capacitor Sounds. C. Bateman. *Electronics World*, July, September, October 2002.
2. Understand Capacitor - Film. C. Bateman. *Electronics World*, May 1998.
3. Technical Spotlight, Wima Capacitors. http://www.wima.de/spotlight/spotlight.htm
4. Capacitor Sounds. C. Bateman. *Electronics World* p.40, November 2002.

LETTERS to the editor

Letters to "Electronics World" Highbury Business Communications,
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e-mail j.lowe@highburybiz.com using subject heading 'Letters'.

Smug editor

I'd promised myself that I would not waste time and mental energy in responding to Ivor Catt's tirade against EMC (*EWW*, March 2003). Indeed, I deliberately filed away the (notably slender) issue earlier than usual, in an attempt to ensure this. However, the rather smug "job-well-done" tone in your April 2003 editorial ("Catt's Whiskers") has, alas, forced my hand.

It is tempting to respond at length to Catt's wearisome and paranoid rant on a point-by-point basis, and I'm confident that others will rightly do so. Suffice it instead to say that whatever Catt may think, EMC, and its associated statutory regulation, is not some sort of conspiracy perpetrated against him by outdated and ignorant veterans of the defence sector. Rather, it is simply a necessity driven by very real and modern technical issues, such as the prevelance of high-speed digital signals, switched-mode power supplies, electronic motor controls and personal RF communications. If Mr. Catt truly wishes to consign us all to an anarchy in which the radio spectrum is rendered unusable by noise and in which, for example, it is unsafe to use industrial machinery in case someone operates a mobile phone nearby, then frankly I think we have cause to be very grateful to the international regulators for protecting us from his kind.

I was annoyed by the Catt article on two counts. Firstly, I found its unscientific, opinionated and self-indulgent nature insulting to *EWW*'s readers, and in my opinion unworthy of publication in what was once an intellectually demanding journal. Secondly - and perhaps more worryingly - it appears to have been commissioned in order to be deliberately provocative, rather than because it had a positive contribution to make to the subject in hand. Such a low-brow approach may indeed provoke correspondence like mine, but I would have thought that a much better way to increase the thickness of the journal, and readers' interest in it, would be through quality articles and papers. Controversy for its own sake is a poor substitute.

I recently came very close to allowing my *EWW* subscription to lapse, but relented at the last minute on the grounds that I have valued your journal highly in the past, and that I might yet miss the occasional gem. The sort of drivel exemplified by Catt is not, I hope, an indication that I have wasted my money.

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UK

Fourier and Catt

I was intrigued by Leslie Green's article (*EW* March page 48), but after some playing with MathCAD myself, I have concluded that he was claiming more than he should. The MathCAD results are artificial in that the time axis has been quantised to increments of one unit. The absurdity of this is revealed by removing the 0.5 unit offset in the two formulae, whereupon the unmodified series with Fn = 1/n actually never overshoots at all. In contrast, if you apply much finer time sampling, say t := -2, -1.9 .. 6, you get the expected overshoots and ringing.

This then does indeed reveal that the revised coefficients give both less overshoot and less ringing, and a bit of experimentation suggests that the value for K is about optimal, even though Mr. Green did not justify it, but the overshoot is reduced from 8.9% not to 0.3% as claimed on the last page, but to about 2.9%. I suspect an error in decimal place, like the 112 in place of 11.2 in two other expressions.

As regards EMC - I was highly entertained by Ivor Catt's article (*EW* March 2003, page 44). I entirely agree that the European EMC regulations were prepared with far too little consideration of the real world; this is not surprising given that a lot of those involved were academics, not practising engineers working in design and manufacturing. Furthermore, I have grave doubts about the morality of imposing standards for susceptibility to interference; that is a matter that ought to be left to the market place, except of course when safety is an issue (where in general different and tighter limits apply). I am however surprised that Mr. Catt did not point out that a spur to devising such awkward standards was the hope that they would protect European industry against foreign competition; some of the limits could never be justified on technical grounds.

However Mr. Catt is quite mistaken (or perhaps a decade or more out of date) when he talks about a separation between those designing the insides of equipment and those trying to stop emissions or susceptibility after the fact. It is now acknowledged that EMC considerations must be taken into account at every stage of design, and particularly on internal printed circuit boards, and in my field at least (professional audio) we have had to throw out decades of inherited 'wisdom' (e.g. on earthing practice) and go back to first principles. The result is that new items of equipment meet the EMC limits, both emissions and susceptibility, with no performance impairment and at little financial cost. In other words, in audio at least, the EMC regulations, infuriating and irrational though they were and are, have

DTV quality

With reference to A Cox's letter on 'Quality reduction between TV and VCR'

(*EW* April 2003). Relating to my own experience of digital set top boxes,

I myself have had problems.

I recently purchased a Grundig Freeview box and after connecting it and setting it up I was a little disappointed. I found that viewing through or recording on the VCR, I got a terrible picture, the picture cycled between light and dark and the sound came and went.

A quick phone call to the manufacturer revealed the answer. The problem was that the broadcasters had inadvertently left the MACRO copy protection switched on. This, I was advised, was going to be switched off on the 10th of March and this would cure the problem. Low and behold, on the evening of the 10th, I tried it again through the VCR, perfect.

As for the peripheral services, i.e. PDC, I have discovered something else that is missing. All broadcasters (with the exception of C5) send the programme title on analogue, i.e 'Watchdog' or 'Tomorrows World', not on digital though. This is something I intend to pursue as my VCR has a built in library system which automatically registers the title against the recorded programme.

Alan Jones.
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actually led to improved products.

So yes, the EMC standards are seriously flawed, but the requirement to meet them has imposed a needed discipline on designers that was lacking before.

Kenneth Gundry
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California
USA

More Catt, please

I laughed out loud at the brilliant article by Ivor Catt, in the March issue of *Electronics World*, on the subject of our ludicrous EMC regulations. Thank God someone with such impeccable credentials has had the nerve to speak out about the farcical shambles of this sorry piece of 'Eurocracy'.

As an electrical engineer who dabbles around the edges of electronics, I have seen many projects stumble and fall in the face of the extortionate expense of pointless testing for problems that do not exist.

Several years ago, I designed a novel and accurate, general-purpose electronic timer that was so robust it even survived (with not so much as a squeak) when I inadvertently blew the end off my screwdriver whilst messing about with the prototype. It had a component count and cost of about a third that of comparable designs and was, to the best of my available test methods, totally interference free. Sadly, it's still on a shelf in my workshop because I couldn't justify the cost of the ridiculous test requirements for CE/EMC approval. Is it any wonder we no longer have a proper manufacturing base in the UK?

And to cap it all, many domestic products that are supposedly CE/EMC approved cannot possibly have been tested in any sort of rigorous manner, yet are freely available from manufacturers who presumably have the resources to pay for approval. For example: the commonplace electronic water descalers, which many people have on their domestic water systems, are a major interference source on both commercial long wave and other amateur bands. Hardly surprising when you consider they operate by inducing a variable radio frequency signal onto the copper pipe-work, which then acts as a ruddy great aerial that broadcasts the signal far and wide. Couldn't possibly have been properly tested but widely available with CE/EMC approval. Furthermore, ever noticed how your mobile phone interferes with VHF radio when it dials up? CE approved of course.

Ivor is absolutely right. This is an important issue and I'm with him every step of the way – he sounds like my kind of a guy so let's hope we can hear some more of his entertaining revelations.

Chris Griffiths.
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Somerset
UK

Amplifier compensation

Further to the excellent article by John Ellis (*EW* 3/03) regarding amplifier compensation. A PSpice simulation of the Fig.12 amplifier, for Vo/p = 28V, Iq=72mA, shows THD = .02% at 20kHz dropping to .0015% at 1kHz and a slew rate of 10V/µs. The 20kHz feedback is 18dB,which is close to the Fig 13 value of 16dB.

Doug Self/Blameless uses 30dB at 20kHz,so that we need four times more gain to obtain the Self results. Using C2 = .25nf and C4 = 25pf gives a 20kHz THD of .005% and .0013% at 1kHz, and a slew rate of 40V/µs.

It would be interesting to know if the practical amplifier is still stable at the reduced capacitor values, a PSpice step input suggests that this amplifier is stable. It is agreed that the differential input signal problems exists, see Fig.10, but is this important in practice for Miller compensated amplifiers, having the same THD and slew rates as the PLIL amplifier, especially when many successful Miller amplifiers have been produced and utilised.

What further overall system tests are required to highlight differences between the two types of compensated amplifiers, other than the less satisfactory aural subjective tests?

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Back to basics

Spurred by a letter stating that my (3 year) subscription is about to expire, I have some misgivings about renewing. This is new, as it was never a question before. I am a long-standing subscriber, my first *WW* dating back to the early 70's.

Like many of your readers, I pursue an engineering career in electronics, as well as a personal interest in electronics for audio and music. I am a member of the AES. A long row of eminently talented contributors to the magazine has kept it at the forefront of audio and made it a major source of knowledge and inspiration within this field. Many of those articles remain valid decades later and are often referred to by contributors in current literature.

Reiterating the list of those authors and their accomplishments through the last 35 years should be unnecessary, except to a newcomer in this field, which I would direct to the 12 year index CDs from this magazine. The magazine has thrived as a forum for these luminaries, and *EW* should be proud to provide it, as well as be grateful for the articles, often founded on invaluable research done in commercial establishments, and generously published for a token writers fee. I assume that writing for this magazine in the past was considered an honour. Maybe this has changed. I doubt it was ever well paid.

By no means should this be taken as a plea for more audio, other subjects can be equally interesting if selected for originality, current relevance and quality. My misgivings are further fuelled by the March 03 issue. The article by Mr. Ellis B.sc., Ph.d. does deal with audio, spending a full eight pages on guesstimations and rather undramatic results from simulations, concluding in some vague handwaving about unproven, possible advantages from the PLIL compensation method – I'm sorry to say, but this is not good enough. The article contains little or nothing new. At most, the matter deserves a few, but clearly written pages.

Mr. editor, I expect you to separate the wheat from the chaff. Repeating a mail from Richard Black must be a mistake? However, this, and a letter from Mr. Bateman leads me to ask you bluntly: Are you going to bring more articles by C.B. and similar authors, drawing on their many years of experience and in-depth knowledge, handing us a lifetime of insights in an immediately useful form? Or should these insights just go to waste? I find one of these articles worth any ten Ph.d.s.

I am also concerned with the Catt article. His statement sums up what many engineers feel about the EMC legislation and practise. However I fear it will fill up your letters pages with more heated arguments from people with little else to do than mudslinging and self promotion. They are free to argue, but please let them take it somewhere else, OK? This does not make good reading.

I would request the editor of *EW* to strongly discourage any inter-personal comments in the letters pages, and suggest to letters contributors that they stay firmly on the subject of electronics, learning more from those who know, and less from those so opinionated. It does fill up *EW* pages for free, but I do not like paying for it. I'd even prefer a few more advertisements instead, to help finance the magazine.

I will consider my subscription for a while now, and for the first time, the offer of 3years and 33% reduction seems less tempting - will the magazine survive that long, what with the price going up, and the contents going iffy?

With the best wishes for the EW.

Michael Edinger
Denmark

I will try my best to accommodate some of your comments – Ed.

Shot in the Foot, continued

I missed A.C. Bloomfield's letter in the February *EW*, but for the sake of completeness, it's 'kai su teknon'. Not 'technon' or 'tekhnon'.

As you no doubt appreciate, these are Julius Caesar's dying words ('Even you, my son') to Brutus, according to Caesar's biographer. No, he didn't say 'Et tu Brute': being a very well educated Roman, he spoke Greek. Brutus was rumoured to be Caesar's natural son.

A. Pedant, aka Richard Pickvance
London
UK

USB pre-amp

I refer to the article "USB-powered high-precision hi-fi phono preamp" which was published in *EW* Jan.2003,p.38.

I've been reading *EW/WW* for more than 30 years and I've never seen in it such a ridiculous headline for an electronic design - a design which is far away from the above mentioned claim for accuracy. In the past years *WW/EW* had published a broad range of expert's reports by people like H. P. Walker, D. R. G. Self and many others who discussed in depth all aspects of RIAA-amplification, esp. noise, overloading, precision of response curve etc. They always had been - and some of them still are - on top of the amp-evolution by trying to take things forward. None of these aspects is covered in a "high-precision" nor in a satisfactory way by Mr. Baumbach's design. I wonder why you publish such a "step back"? On the other hand I think it's a good idea to tackle such a USB -RIAA-problem and that's why I would like to add the following remarks to Mr. Baumbach's proposal:

In my eyes "high-precision" should only be called something which is near the optimum (e.g. a +1 - 0.1 -0.25dB) tolerance of the response curve could be tolerated under precision aspects for RIAA designs only, a landing airplane would have a great chance to crash at the landing point if its altitude meter would be calibrated with such a tolerance) and this can easily be reached by using the approach given in the application note AN-346 of National Semiconductor. It should not be forgotten to mention that the MAX4478 also has a significant output impedance at 75µs (approx. 30R - 40R at 2120Hz and Av = +3) which should also be taken into account when calculating any resistor/capacitor network following such op-amps (see data sheet)!

The overload problem cannot be wiped out in general because of the low 3.3V supply voltage proposed - but it could be improved drastically by (among other things) one of the following measures or all together:

a) move the 75µs-filter from the output of OP2 to its input
b) use of low-output MM cartridges (< 2,0mVeff) or high-output MC cartridges (> 1 mVeff) only
c) reduction of the overall amplification factor at 1kHz and 0dB (e.g. 5mVeff) input level to an output level with a minimum of approx. 17.7dB margin before clipping (=150mVeff)
d) replacement of the proposed voltage regulator with a low-drop type to gain a higher supply voltage of + 4.5V and thus higher output swing capabilities which will create an additional 2.1dB margin before clipping.

Total amplifier generated noise can also be reduced by redesigning the feedback networks with the use of very much lower resistor values (e.g. change from 4k7 to 475R etc.) and higher capacitor values than shown (a calculation with the method presented by Nat. Sem's application note AN 102 gives an improvement of min. 2.2 dB noise reduction).

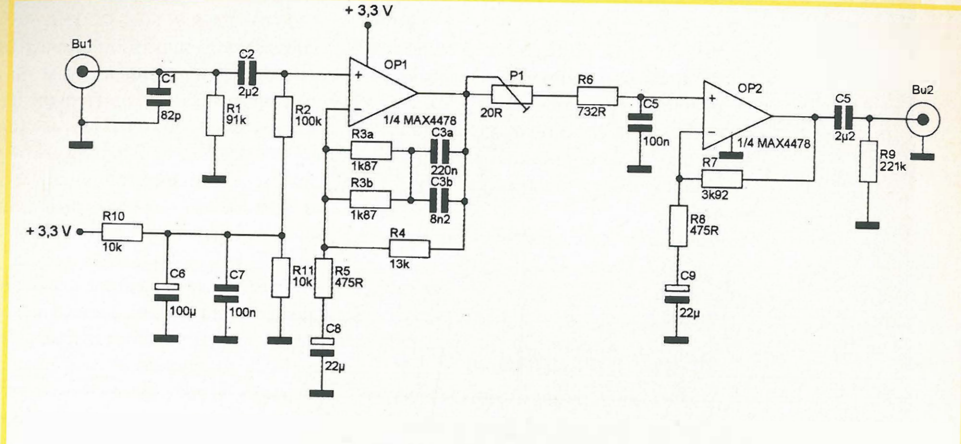


Abb. 2: RIAA-Entzerrer-Verstärker mit MAX4478 - NEU

Fig. 1 sums up the above-mentioned ideas.

Although I think that people working on the whole USB field should be supported by publications like *EW* your magazine must carefully check the balance between the high level demands - which were deeply reflected in many (thankfully) published letters of your readers not long ago - and the need to "fill the pages" with apparently interesting articles.

Kant once said: "less is more!" This - and the level of quality *WW/EW* had been producing during the past years - should be the red rope for your (our!!!) magazine.

Burkhard Vogel
Stuttgart
Germany

Firstly, apologies to Burkhard who's email got lost in our server crash. Secondly – as we don't actually build and/or test circuits published in EW – I have to take them on face value. A USB phono pre-amp seemed like a jolly good idea for those of us who like transferring our old vinyl music collection to CD. – Ed.

DIY audio

Reading Eric Lamarque's letter in the April 2003 issue, I wonder if *EW* is starting a new career in the 'people' press, as we call it in France. As a regular reader of *WW*, then *EWWW*, and now *EW* since 1978, this is the first letter I read with so many comments about family life. How wonderful that whatever M. Lamarque does - girls or modifications of electronic circuits - it 'sounds better'! His story is good for the internet chats, but not at their place at all in *EW*. Here are two personal experiences which may contradict those provided by the 'audio DIY-fi' amateurs like him : - I once replaced a JCR4558 (I think) with a NE5532 in a highly rated Onkyo tuner. I never found it sounded better at all. I once looked at the inside of an old professional _ inch tape recorder that sounds lovely - it was full of antique 741s!

The John Linsley Hood class A amplifier seems to have established itself, with a little help of its author, as a legend. The reason is probably that it was one of the first published class A projects. My references say it was in the April 1969 issue of *WW*. It was preceded by one project by D.H. Reed published in *Hi-Fi News*, April 1968, and followed by another one by L. Nelson-Jones in *Wireless World* in March 1970. These details partly come from Geoff Moss's Class-A amplifier site. In those times, there were only two commercial (British) class A units available, one by Richard Allan and the other by Sugden. The better specification of JLH's class A amplifier was its extended HF bandwidth which needed to be tamed to avoid oscillations. Open loop distortion, output impedance and power supply rejection were rather poor. With only four transistors, it was not so simple as it needs an electronic smoothing power supply with heat sink. I've built this amplifier three times in 1971, 1973 and 1988. I am not very fond of subjective comments but I may say that, in 1988, there were far better sounding amps for me. For example, JLH's 1980 *Hi-Fi News* class B 30 watt amp. John published a revised version of the class A project in *EW* September 1996: directly coupled, with regulated power supplies and better control of the standing current. Using Darlingtons in the output stage would give better specifications but "for the sake of historical fidelity", this modification was not adopted. To me, this is an unjustified and very disappointing nostalgia of the same kind as the myths for tube amps: not very scientific. With an ear listening to the sirens of the subjectivist camp, some of John's approaches have not always been very rigorous, I am sorry to say. Despite the above negative comments, I nevertheless enjoyed reading many of his articles.

Sébastien Veyrin-Forrer
Saint Chartres
France

Praise for audio

While I generally agree with the letter from Ray Lee BSc "On the demise of Electronics magazines" (*EW* Letters, May), I must take issue with one point - the statement that designs like Linsley Hood's amplifiers are no longer relevant.

Audio amplifiers are one area where it is still quite possible for the home constructor to outperform commercial manufacturers on both price and performance. So designs from the likes of Linsley Hood and Doug Self, as examples of how this may be achieved, are of great relevance. The same applies, in varying degree, to other non-mechanical items of audio equipment - preamps, tuners, mixing desks, effects units.

There is also the point that audio is perhaps the area of electronics most beset by ignorance, misinformation and outright bullshit. Articles and discussion in *Wireless World*, especially those involving the above two authors, stand out like jewels in a sea of mud.

So it was good to be treated of another of Doug Self's articles on subtle behaviour in audio amplifiers with cures/alleviations achieved by ingenuity and maybe 10p-worth of parts.

With thanks for scientific audio articles past and future,

Pigeon
By email

Wheatstone revisited

My criticism is about the accuracy estimation of the bridge measurement calculated in the article (*EW* April). In the "Determining the error" box in p.20, it is assumed that the ratio of A resistance branch to B resistance branch is (100+x)/100 or 100/(100+x) and then some manipulation is done to these ratios. This manipulation has no meaning and so its result is meaningless. If the ratio of A to B is something like (100+x)/100 then the ratio of D to C has to be identical in order to null the meter reading. If D (the switch selected resistor) has absolute accuracy to the knob's markings and C has absolute accuracy, then the D value selected will have the same x percent error as the A to B ratio error.

There is no way to minimise the measurement error caused by the resistor ratios used in the bridge. Another problem is using 0.1% accuracy resistors in a 4-decade series connected resistors (branch D). The finest decade values are within the error value of the other higher three decades, so its selection is meaningless.

Victor Koren
Tel Aviv
Israel

Wheatstone

In his interesting article 'Wheatstone Revisited' (*EW* April) David Ponting presents, on page 16, a little bit of calculus to find the minimum value of $y = n + 2 + (\frac{1}{n})$

He obtains the correct answer, of course, but there is a simple algebraic rule well worth remembering that avoids the use of calculus in this case and a number of other problems in electronics, notably those involving impedance matching for maximum power transfer and the choice of signal source resistance for noise minimisation in amplifier design. Substituting x for n, for generality, the rule states that if $y = x + (\frac{a}{x})$ then y(min) occurs for $x = \sqrt{a}$ and has a value $2\sqrt{a}$

If $y = n + 2 + (\frac{1}{n})$ then 'a' = 1 so y(min) = 4.

Bryan Hart
Leigh-on-sea
Essex
UK

The Question

In response to Orde Solomons letter last month (*EW* July p54) traditionally, when a TEM step (i.e. logic transition from low to high) travels through a vacuum from left to right, guided by two conductors (the signal line and the 0v line), (http://www.ivorcatt.com/1_1.htm) Figure 5, there are four factors which make up the wave;

- electric current in the conductors
- magnetic field, or flux, surrounding the conductors
- electric charge on the surface of the conductors
- electric field, or flux, in the vacuum terminating on the charge.

The key to grasping the anomaly is to concentrate on the electric charge on the bottom conductor. During the next 1 nanosecond, the step advances one foot to the right. During this time, extra negative charge appears on the surface of the bottom conductor in the next one foot length, to terminate the lines (tubes) of electric flux which now exist between the top (signal) conductor and the bottom conductor.

Where does this new charge come from? Not from the upper conductor, because by definition, displacement current is not the flow of real charge. Not from somewhere to the left, because such charge would have to travel at the speed of light in a vacuum. (This last sentence is what those "disciplined in the art" cannot grasp, although paradoxically it is obvious to the untutored mind.) A central feature of conventional theory is that the drift velocity of electric current is slower than the speed of light. [Published in Electronics & Wireless World sep84, reprinted sep87. For further information on the Catt Anomaly, see letters in the following issues of Wireless World; aug82, dec82, aug83, oct83, dec83, nov84, dec84, jan85, feb85, may85, june85, jul85, aug85.]

Ivor Catt
St. Albans
Hertfordshire
UK

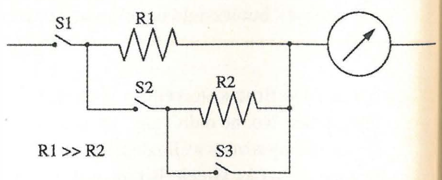
A full response to Ivor's critics will be published next month and then we will draw a line under the EMC debate – Ed.

Kirchhoff's Laws and how (not) to destroy a galvanometer.

Revisiting Wheatstone, David Ponting writes that "Kirchhoff's ... so-called Laws don't go much beyond common sense and a restatement of Ohm's [law] ... ". (*EW* April 2003, p.12). Actually, the first and second of Kirchhoff's laws express the conservation of charge (the node law) and the conservation of energy (the mesh law), applied to electrical circuits. I feel they are fundamental enough among the law of physics.

The so-called Ohm's law, instead, is not a law of physics at all. Rather, it is a definition of a class of conductors, the "ohmic" conductors, namely those conductors for which the I-V relationship is linear.

Regarding the compromise between



ultra-sensitivity and roughness for a galvanometer, the "triple switch" was devised to address the problem (fig. 1): press in sequence S1, then S1 and S2, then S1 and S2 and S3, each time zeroing the bridge at its best. S1, S2 and S3 are spring-loaded switches that open on release. If the procedure is started the wrong way, that is starting with S3 (highest sensitivity to current and to damage) nothing can happen, as S1 and S2 are still open. If you want really to destroy the galvanometer, you must deliberately start with a fully unbalanced bridge and firstly press S1, S2 and S3 together.

Marcello Carla
Florence
Italy

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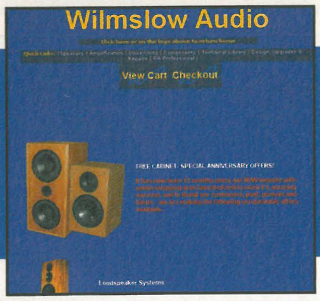

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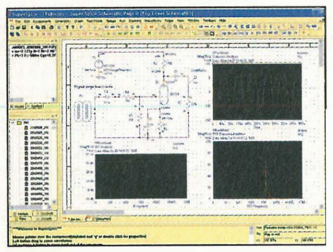

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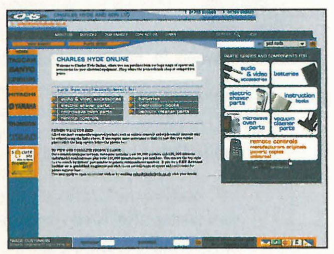

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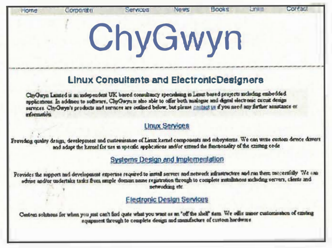

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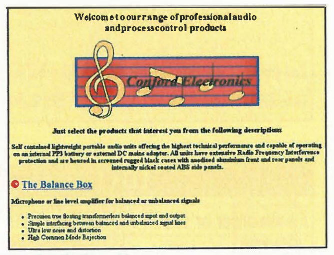

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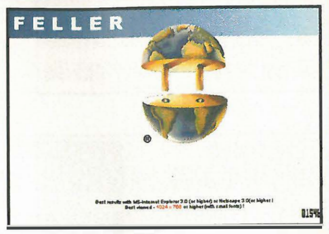

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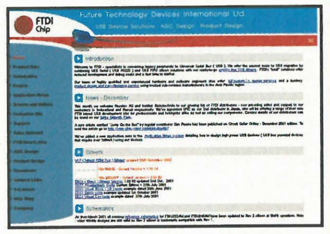

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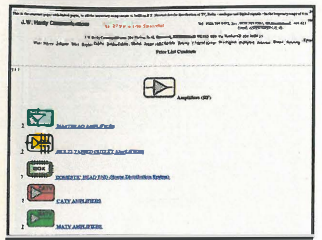

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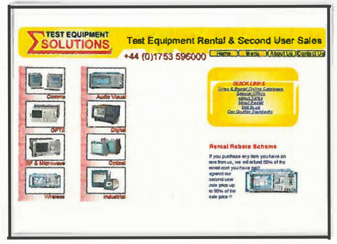

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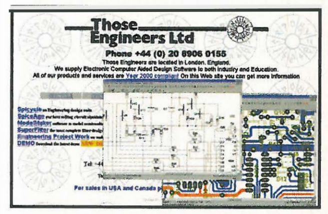

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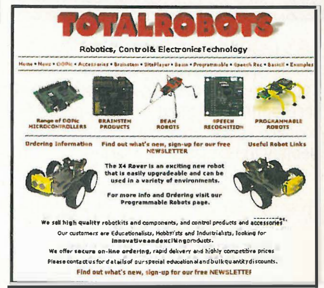

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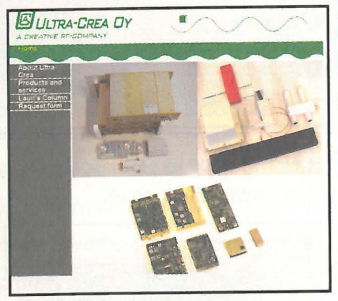

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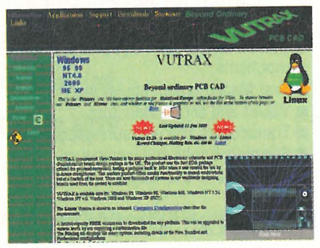

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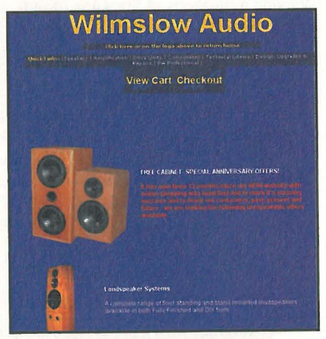

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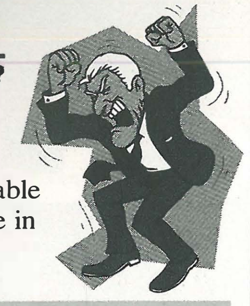

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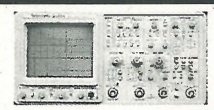

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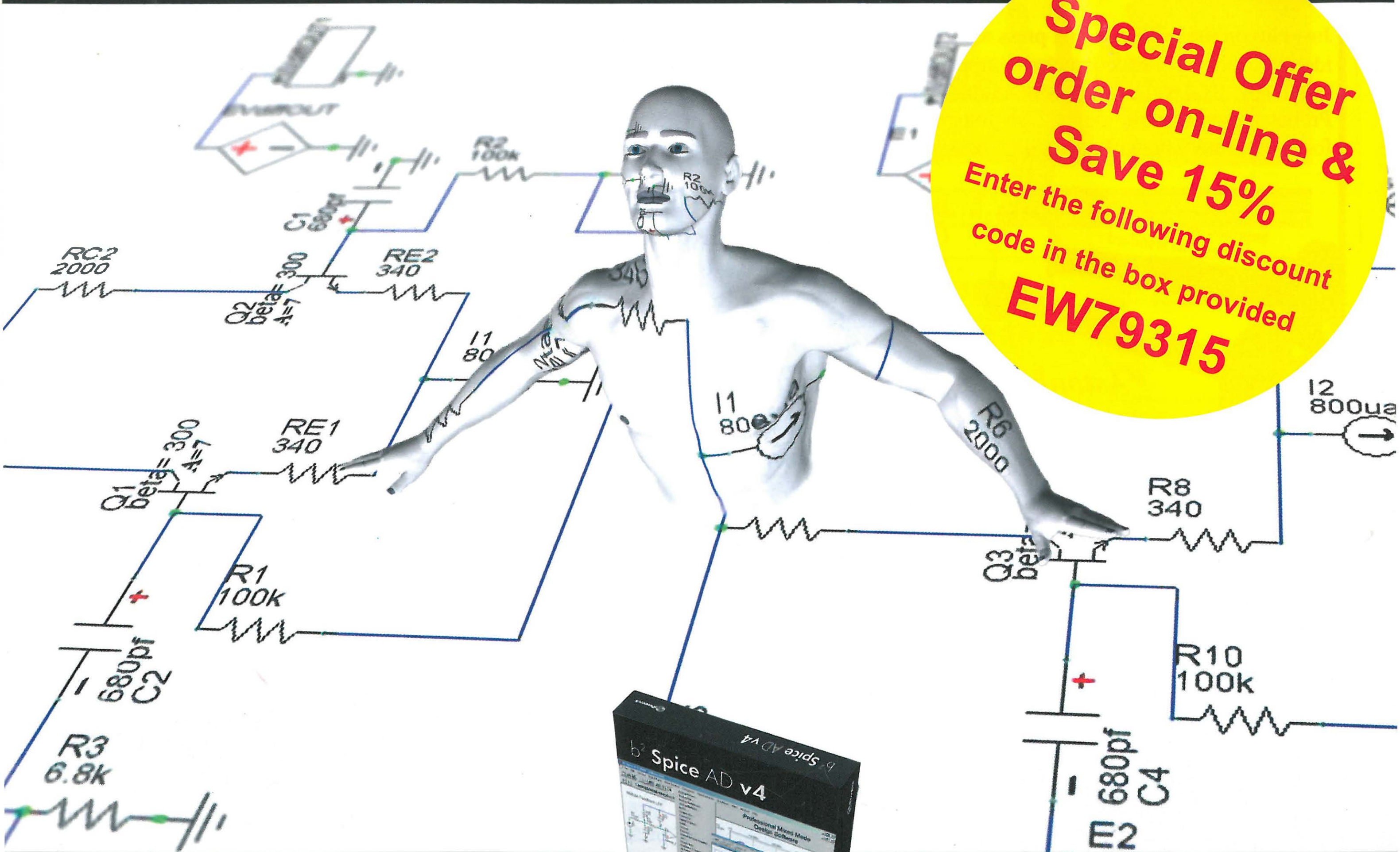

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