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A century of invention?

If you had asked people fifty, or even perhaps ten years ago, what was the Twenty Century’s defining contribution to civilization, most would have unhesitatingly nominated the internal combustion engine. A few brave souls might have proposed the wireless or the telephone, if not discouraged by the difficulty of deciding between them. One or two might have suggested television, risking the criticism that it is only worthless carrying a particular type of information.

Actually, all of those except for technology invented in the last century, though it took this century to develop their full potential. It is fairly obvious now, that – visible and invisible as cars and airplanes are – the thing which has really shrunk distances in the world, and touched and changed all our lives, the achievement which has restored and pervaded every aspect of twentieth century technology, is the computer.

So it seems odd that the most significant contribution to the marking of the millennium thus far devised by the computer and electronics community is an act of collective hero-kits as manmachtates the world ever seize up when asked to roll the year over from 99 to 00.

Admittedly it could be spectacular, and will be if nothing is done. Urban myths are already rich with tales of permanently-condemned canned-beef preserved to be 100 years old, and life insurance customers which the computer can never believe will still be alive in 2005. The image of the party to end all parties gathering to a hall as aeroplanes are grounded, bank accounts mysteriously empty and systems everywhere switch themselves off has a rich, Shavian irony. As a tribute to humanity’s chronic lack of foresight and capacity to cock things up, it could hardly be bettered.

Unfortunately, it probably won’t happen. Even the demented corporation must by now have asked its IT department to look into things and hire some programmers if need be.

So what else can we suggest re the electronic community’s contribution to millennial celebrations? What would make a decent digital equivalent to painting a line of trees along the Greenwich Meridian, or freezing the Thames, or even just dancing in the streets?

The trouble with most forms of electronic communication is that they do not readily lend themselves to large or permanent public monuments. They are either a means to an end, like television, or essentially small-scale and private.

There is no way that visiting a website, however many people do it, can be turned into a grand gesture. Nor is the party to end all parties grinding to a halt as aeroplanes are frozen (if available £2.50.)

The best approach is to let the computer and electronics community enjoy its current fad of celebration listings of information.

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Unfortunately, it probably won’t happen. Even the demented corporation must by now have asked its IT department to look into things and hire some programmers if need be.

What we need is some imaginative idea which will mean something to people, which they can see or be touched by, and which will be inherited in. If you are expecting me to spring a master plan on you that meets those requirements, then I’m afraid you will be disappointed. I simply want to start people thinking, or maybe to hear about thoughts which people have already had.

What can suggest are a few elements which such a project might include. Since the millennium is about time, meaningful, no.

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July 1997 ELECTRONICS WORLD

Peter Willis
A twinkle in the cat's eye

The use of active road studs is a step nearer following the completion of road trials on the A1 and M50. Road studs, of which cat's eyes are the most famous example, are passive reflecting devices. The Doncaster-based company, Astucia, is promoting a version which, in addition to a passive reflector, uses LEDs and a solar charged battery. "Both trials were to test the studs in their passive state for survival and reflectivity, but we fitted the M50 ones with infra-red leds which were still operating at the end, after 12 months on the road," said Tim Lane, a spokesman for Astucia. The studs are self contained and can change behaviour in response to varying conditions. A variety of colours and flashing patterns are available and optional in-built sensors are claimed to allow the studs to respond to the presence of standing water, standing vehicles and vehicles driving too close together. Vehicle distance is measured based on the frequency of the passing headlights. 

Active road testing should begin this autumn, Lane said: "Three sites have been identified in the Wakefield area. Providing there is money in the local budget, they will begin operation in September." The installation to be used in Wakefield provides continuous night time illumination visible from 800m.

FEI optimistic about new government

Conservative optimism is the response of the electronics industry to Labour's sweeping General Election victory. The Federation of the Electronics Industry (FEI) expects the ending of 18 years of Conservative government to result in a renewed emphasis on training and encouragement of small high technology businesses. But it acknowledges the Social Chapter, to which Labour is committed, could reduce competitiveness. Anthony Parish, director general of the FEI, qualified his welcome for many of Labour's industrial objectives by adding: "We are still waiting for them to fill in some of the detail." Parish identifies education and small businesses as two areas where the new government will affect the electronics industry. "They will pursue the education issue with great vigour. They can make a major contribution there," he said. "And they'll have a more co-ordinated approach to the support of small businesses. The [Conservative's] Business Link programme hasn't evolved enough and it is not tied in to other European programmes."

In the area of social policy, Parish warned that the Social Chapter could be detrimental to the UK's competitiveness, but that "the Minimum Wage will not be likely to affect inward investment decisions, provided it is set at a reasonable level". Brian Haken, of the Printed Circuit Interconnection Federation, said: "Industry is looking for a pro-active stance towards Europe. What we don't want is the incoming government to be split down the middle, with Euro-enthusiasts on one side and Euro-sceptics on the other."

If the reaction of Racial Electronics is any indicator, electronics manufacturers have already come to terms with the prospect of a Labour government. "We do business with governments around the world representing the full political spectrum. We've worked with Labour governments in the past and look forward to doing so again," said Racial's spokesman, which has government contracts ranging from defence work to running the Government Data Network.

Wings at the speed of sound... A researcher from the Georgia Institute of Technology holds a prototype microflier, with flapping wings, as part of a programme to develop reconnaissance aircraft with wing spans of less than 13cm. The aim is to make autonomous vehicles that can enter difficult spaces like collapsed buildings. Georgia's specialist area is sensors, and it is currently working on a television camera-radio transmitter system, which it hopes will weigh less than one gramme.
**Micro Video Cameras**

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**Memory module prices fall sharply**

Prices for memory modules has dropped sharply as supply starts to outstrip demand in the pc market.

“We’ve seen evidence of increased spot market activity during April with some off-loading product,” Andrew Mackenzie, director of memory at Datrontech told Electronics World, “We’re selling 16MB and 32MB modules out of the Far East at $67 duty unpaid.”

According to d-ram price-trackers ICIS-LOR, the price of a 16MB module is now $90 from $80 to $71 in late April. In the USA and Asia-Pacific, these prices are even lower. A stop gap to what’s worth of silicon inventory.

A top ten memory supplier told Electronics World that the dip could be due to a move away from mobile phone memories.”

**Mobile phone cancer – more research needed**

The National Radiological Protection Board (NRPB) has called for more research into the carcinogenic effects of mobile phones after an experiment demonstrating the cancer effect of electromagnetic radiation on mice.

The study, performed over 18 months by a team of researchers in Australia involved two sets of cancer-prone mice. One set was subjected for two weeks to low frequency electromagnetic fields similar to those emitted by mobile phones. The other set was subjected for two weeks to high frequency electromagnetic fields.

But funding needs to be earmarked for more research into the effects of high frequency electromagnetic fields.

The NRPB’s Biological Effects Department. “It’s very difficult to relate this kind of research, which uses genetically manipulated mice, to the real world,” he said. The question is: How representative are these tests? It is generally considered by experts that we must do research in the real world.

**Pentium II arrives, as expected**

Intel’s worst kept secret, the Pentium II processor, was officially launched in London during May.

Two processors versions with clock speeds of 233 and 266MHz, priced at $430 and $495 respectively, both are designed for use in desktop pc and are priced at $606 and $775.

Over a dozen desktop systems using the Pentium II from several PC manufacturers have also been announced. Intel’s Pentium II is facing competition from Advanced Micro Devices’ (AMD), K6 and Cyrix’s M2 x86 microprocessors.

AMD’s K6 is much cheaper than the Pentium II – the 233MHz K6 costs $469. However, Intel’s selling price includes a 512KB level two cache.

Cyrix, meanwhile, has yet to launch its M2 device although this is expected later this quarter. The 233MHz clock speed of the K6 is limited by the use of a 0.59µm manufacturing process (Intel uses 0.29µm).

Using benchmarks to compare the two processors directly is difficult since AMD does not quote integer and floating point SPEC figures. However, from preliminary tests, the two devices, similarly clocked, appear to have comparable performance.

The Pentium II fares less well when compared to Cyrix’s M2.

Intel plans to release a 300MHz version of the Pentium II in the second half of the year, which will cost $989. This is believed to be code-named Deschutes, a 0.25µm five layer metal stack of Pentium II.

The current leading workstation processor, Digital’s Alpha 21164, costs under $2000 for a 400MHz part. Intel’s 300MHz Pentium II has a SPECint95 of 1.56, compared to 11.7 for the Alpha. Finding point, however, is a different story, Intel estimates 7.2 for SPECint95, while the Alpha more than doubles that at 15.9.

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Internet via satellite

Peter Willis reports on a newly announced Internet service that should solve the problem of slow data retrieval by using a satellite link.

The convergence of TVs and computers is taking many forms as we enter the digital age. One of the most potentially fruitful is the delivery of Internet by satellite. It was the chief speaking point of the recent Cable & Satellite show in London, in the continuing absence of the long awaited announcement from BSkyB of its digital TV services.

BSkyB seems to have hung up on convergence issues itself, trying to develop an interactive terminal with BT and a banking partner (HSBC) while awaiting the outcome of its BDB consortium application for a digital terrestrial licence.

minal with BT and a banking partner which is creating indigestion. Not that some Satellite show in London, in the continuing absence of the long awaited announcement issues itself, trying to develop the delivery of Internet by satellite. It was the convergence of TV and computers is present is on business or institutional use.

idea, but don't rush to plug your 60cm dish into this is where satellite comes in. With no fixed-wire to slow things down, satellites can it. A cdrom can be downloaded in 11 minutes, Down-load a cd's worth in 11 minutes what is actually required for efficient delivery. The phone network is an antiquated, 19th-century phone network - an antiquated, 19th-century what is actually required for efficient delivery.

Home Networks, subscribers and microcomputer links. Business or institutional use.

Eutelsat is already handling a number of not-multimedia delivery services, including Net on Air, which provides selected bundled pages, and DirecPC operated by Hughes Owlet Telecoms chairman Forthcoming large volume of data for businesses. Others are Telenet, which specializes in financial data, HS-Cast (on-line newspapers).

Future is looking for a service provider partner to further develop the concept. Astra meanwhile has joined with Intel to set up ISM (European Satellite Multimedia Services) and plans to have it working, under the name AstraNet by the end of the year. It too is looking at the corporate market first, concentrating on one-way, point-to-multipoint data broadcasting.

Options for return path data

Internet is of course a two-way concept, and there are two ways of creating the return path or back channel. The expensive way is to add a small transmitter to the satellite dish, as already used by V-at technology. Astra doesn't expect to have the technology for this ready before the end of next year.

The easy way is to use the phone line. For most users this will be quite sufficient since they are typically recipients rather than publishers of Web pages. Their outgoing messages tend to be brief requests for information. One indicator that the technology is eventually destined for consumer application is its commonality with the Net on Air service and the DVB (Digital Video Broadcasting) standard.

Already, the requisite hardware is becoming available. Pace has teamed up with Hinet to develop a satellite pc card, capable of pulling in data, video and audio at up to 38Mbit/s. Based on a modular architecture, it is part of the multimedia delivery system is expected to greatly reduce Internet download time.

The schematic is ready, the board outline is available and all components are imported. The components with a fixed location are plotted on the PCB design depicted below. The PCB design depicted below illustrates the capability of the Wizard, its use to be available on the DVB board and routing algorithms by both the less experienced users and by the experts. This technology applied in the ULTBoard Wizard was used to be available only as options on the more powerful and expensive Workstations. The PCB design depicted below illustrates the capability of the Wizard, its 4-layer version was employed in the ULTBoard Professional Design Contest at the Electronics'95 Exhibition. The same design was executed in a 2-layer version with the ULTBoard Wizard in less than 2 hours.
Room-temperature quantum material is bathed in gold

Gold-cluster molecules, possessing a set of extraordinary quantum properties, could form the building blocks for testing ultra-minimised architectures envisioned by some for 21st-century nanoelectronics, according to researchers at Georgia Tech in Atlanta. Their main fascination is that their conduction electrons are quantised both in their number and in the states they can occupy. Normally, such effects can only be observed and used at very low temperatures such as that of liquid helium, near absolute zero. But the Georgia Tech team reports that the new series of nanocrystals are both sufficiently small that these effects are permanent even at ordinary temperatures, and yet are large enough to have the robust crystalline properties of the bulk metal. In structure, each molecule in the new series has a compact, crystalline gold core - just 1-2nm across - encapsulated within a shell of tightly packed hydrocarbon chains linked to the core via sulphur atoms.

"The surrounding chains can be of any length, and can be modified to confer particular chemical properties, so that they can be incorporated into various solid-state and solution structures," says professor Robert Whetten, head of Physics and Chemistry at Georgia Tech. "Most importantly, each member of the series behaves as a substance composed of infinitely replicated molecules, which can be separated from other members of the series to yield pure substances with precisely defined properties."

The gold-cluster molecules emerge spontaneously during the decomposition of certain gold-thiolate polymers of the type commonly used in decorative gold paints and in gold anti-arthritis drugs. With sufficient control of the decomposition process, this series can be isolated without concurrent production of larger gold crystals. It is then relatively easy to separate the principal members of the series from each other to obtain the necessary homogeneity. Once purified, the molecules spontaneously assemble into crystalline thin films, powders or macrocrypts, while preserving the discrete properties of the individual gold nanocrystal core. Gold is important technically not only for its inertness - once made, the clusters are immune to corrosion even at ordinary temperatures, and to charging, and somewhat less so to temperature - but also for its highly-stable surfaces that find application as junctions in critical microelectronic applications. The electromagnetic and conduction properties of the clusters are extremely sensitive to charging, and somewhat less so to temperature. According to Whetten, this could allow them to be used in proposed electronic circuitry known as "single-electronics."

The new gold-cluster materials are the first to exhibit charge-quantisation in a macroscopically obtained material, for which every cluster behaves identically. First measurements were conducted at Georgia Tech by observing the step-like changes in the current passing from a scanning tunnelling microscope tip to a gold plate through a single gold-cluster molecule as the voltage was increased. The highly regular spacing between these steps, known as "Crabtree staircases," showed that the molecules' gold core is changing like a thermometer in a series of discrete steps by adding or removing single electrons.

Whetten and collaborators at the University of North Carolina-Chapel Hill have reported developing an electrode based on the most massive clusters. This could allow them to be used in a semiconductor that functions as "single-electronics."

Sensor that keeps war going could save lives too

Intensive-care patients in hospitals, in the line of safety personnel in field operations, and of course, the front-lining and construction personnel in hazardous situations could all benefit from a new telesensor being developed by the US military. The chip, designed to be adapted to a whole range of sciences by simply being adapted to different use, could really make wounded soldiers back into battle as quickly as possible. But researchers believe it could be adapted to provide valuable information on the physiological condition of patients in non-military situations. The medical telesensors - application-specific integrated circuits that measure vital signs, process the data and transmit it as radio signals to a remote receiver - are being developed at the Department of Energy's Oak Ridge National Laboratory (ORNL) for military troops in combat zones. Using funding from the Defense Sciences Office of the Defense Advanced Research Projects Agency (DAPA), a group led by ORNL researcher Ron Ferrall has built a 2.3mm temperature sensor. Attached to a finger or ear, the chip can measure body temperature and transmit a reading when queried by a remote receiver.

Military leaders need to know quickly which soldiers have been wounded and what their conditions are," Ferrall says. "Then, medics will be able to decide whether to treat first and where to remove from the battlefield for treatment at hospitals. The first objective is to get the least seriously injured treated so they can return to combat."

The chip contains a temperature sensor that measures absolute temperature using bipolar transistors whose electronic properties are sensitive to temperature. These components are all incorporated on a single chip together with analogue signal processing, transmission electronics and an antenna that sends the data by radio signals (radio frequency transmission) to a monitor when the chip is queried. Each chip, Ferrall says, is planned to have a unique identifier - a characteristic radio signal pattern in which the frequency spectrum changes every few microseconds. Such spread-spectrum transmission allows the monitor to know which soldier needs immediate medical care. In addition, newly-developed thin-film lithium-ion batteries could be used to supply the very low levels of power required by the circuit.

The ORNL group, which also has collaborated with several faculty members from the University of Tennessee, is now developing a pulse oximetry sensor. This device, ultimately to be fabricated on a single chip, will measure pulse rate and blood oxygen level. The group also plans to develop another type of pulse sensor and a blood pressure sensor, in addition to a device that measures electrical conductivity in the skin, on indicator of stress. The pulse oximetry sensor will measure the pulse on the wrist or neck by use of an optical pressure sensor. To measure changes in blood oxygen level, the sensor detects changes in haemoglobin, the iron-containing pigment in red blood cells. When the oxygen level changes, the colour of the haemoglobin is altered. Such a chip will have an infrared light source and detector that can measure changes in the light absorption of the haemoglobin when it is excited by light of specific frequencies. Measurement results will be reported by wireless telemetry.

Sitting on fuel cell technology

Fuel cell technology, able to produce energy from hydrogen and oxygen, offers several advantages as the drive system of the future in terms of cleaner vehicles and reduced reliance on fossil fuels. Unfortunately, up to now, systems have been bulky and only usable in substantially modified vehicles. But Daimler-Benz has announced that its latest experimental vehicle manages to pack all the extra hardware required under the seat of a standard model.

Necar I, Daimler-Benz first experimental vehicle, demonstrated back in 1994 that fuel cell technology technology is a viable proposition. But it was hardly practical then, as the system had such high space requirements that it was more closely related to a mobile laboratory than a vehicle. However, in Necar II, the scientists have reduced the size of the fuel cell system to such an extent that it can now be easily accommodated under the seat of a Mercedes V-class vehicle.

The compaction has been achieved largely by means of a drastic reduction in the thickness, through optimisation of their surface characteristics, of the bipolar plates that ensure an even distribution of the reactant gases to the electrodes. This has allowed the individual cells in Necar II to be grouped much more densely into stacks. Furthermore, a new stack compression strategy has reduced the number of the rods needed, making for considerable space savings. In Necar I the electrical and liquid supply connections were located separately. But in Necar II, the researchers have been able to unite them on the end plates thanks to a special compression technique and the use of new materials. The moisturing units formerly required on each fuel cell stack have also been replaced by a single compact unit, separately located within the cell system. All these individual measures combine to reduce the size of the system to such an extent that the laboratory on wheels of Necar I has now been transformed into the spacious passenger car Necar II, in which all six seats are available for passengers. At present, the gasous hydrogen required for energy production is still stored in tanks under the roof. Daimler-Benz research work is now concentrating on development of a system capable of deriving hydrogen from liquid methanol. This could make it possible to refuel a fuel-cell car using by simply filling procedures not that different to those found in a petrol station of today.
Polymer diode can switch on any colour

Computer screens, televisions, fluorescent lighting and even traffic lights made of low cost LEDs could be just round the corner following announcements of the first plastic device able to emit light of multiple colours. Unlike conventional LEDs, the new devices made out of polyphenylenevinylene and polyquinoline emit colours ranging from red to yellow to green.

And even blue, depending on the voltage applied to them. Normal LEDs, made of materials such as gallium arsenide or gallium nitride, are limited to single colours, making them impractical for the biggest application of all - flat-panel computer and television screens. ‘The holy grail of the whole field of LED design is a flat-panel display for use in future television screens and computer monitors,’ says Samuel Jenkhe, a professor of chemical engineering, chemistry, and materials science at Rochester.

Jenkhe’s multi-colour polymers raise the prospect of replacing today’s bulky screens with much thinner and more efficient arrays of LEDs, and are said to outshine the performance of traditional materials in several ways. Most importantly, just one layer of the device can create full-colour images and, unlike normal LEDs, Jenkhe’s devices can produce efficient greens and blues.

Other advantages include the fact that the plastic LED requires just three volts for start-up and is at least as bright as a current television screen. Since these plastics can be made at room temperature, the LEDs should also be far cheaper to produce than conventional LEDs, which must be made at high temperatures.

Key to the work has been the team’s efficiency in bringing together the electrons and electron holes that combine to produce the light. Jenkhe’s group has been able to construct layers of polymers tens of nanometers thick that position them so that they supply a steady stream of electrons and holes.

Researchers have tried to make such LEDs before – and some have even succeeded in producing a device capable of emitting light. But this has only been of a single colour. The new LEDs emit the full range of colours, depending on the voltage applied to them. By combining the light from several plastic LEDs, Jenkhe has even produced white light that could form the basis for LED-based fluorescent lighting.

Another attractive application being targeted by researchers is in traffic lights. A large, lightweight plastic LED could replace the heavy, inefficient 120V white bulbs that glow behind the coloured glass covers of traffic lights everywhere. Because the LEDs consume so little electricity, this could result in substantial power savings.

Forces that could blow nanochips apart

As the tiny electric wires in computer chips grow ever smaller and the current they carry proportionately greater, the wires’ atomic structure becomes increasingly prone to breakdown, causing gaps that could disable a chip or even an entire computer.

Now a team of materials scientists from Columbia University and IBM has measured the forces created as electric currents dislodge atoms from micro-wires – and found them to be massive.

The phenomenon, known as electromigration, is not expected to cause failure in existing computers, but will undoubtedly present a mounting problem to chip designers and manufacturers, say the researchers – Stade Cargill, professor of materials science at Columbia’s School of Engineering and Applied Science, and I. Noyan, a research staff member with the Materials and Processing Science Group at IBM’s T. J. Watson Research Center.

“We have gone up in current density by an order of magnitude, and that’s the problem,” says Cargill. To measure changes in the atomic structure of a wire as current flows through it, the researchers focused a finely focused X-rays. They showed that one end of the wire, to about 15% of its length, was stripped of metal, and that a build-up of atoms at the other end caused large stresses – of as much as 340MPa – that eventually damaged the wire and its insulation.

The electrons travel along the wire as current and also dislodge atoms of metal from their positions in the wire, carrying them along and depositing them further downstream. Rearranging atoms in this fashion can create gaps where atoms are removed and can also create local pressures where atoms pile up, squeezing metal out of the wire much like toothpaste from a leaking tube.

At the moment, moving a few thousand atoms will not affect wires millions of atoms in diameter. But in microwire electronics, many wires are now less than 1µm in diameter, and moving thousands of atoms around can have far more dramatic effects. Computer failures because of electromigration actually occurred in the 1960s, before hardware engineers were fully aware of the problem. They solved it by using new combinations of metals, by limiting current and the wire’s length, and by encapsulating circuits in rigid insulating materials.

But during the last 30 years, the size of microwire circuits has decreased by almost 40 times, while current in those circuits has decreased less rapidly, from the range of 10 to 50mA to about a tenth of that level now. As a result, current density has increased by a factor of ten.

Once microwires shrink to 0.25µm in diameter and smaller, chip designers will have to discover ways to limit current sent through such wires, or find other ways to counter electromigration.

“These problems can be solved by changing the configuration and metallurgy of the chip,” says Noyan. “However, new solutions will have to be found for each generation of chips, since electromigration is like an allergy. It can be mitigated but never fully cured.”
Leslie Warwick has been investigating how electronics is helping improve today's still-photo cameras.

The introduction of electronics into single lens reflex cameras in the form of through-the-lens exposure metering in the sixties was derided by 'real' photographers. New most 'sirs, including professional models, are completely reliant on electronics - even in manual override mode.

There are now trends interfacing cameras with computers and making it easier for photographers to be integrated into electronic media. A recent illustration of the trend towards interfacing is the Advanced Photo System, or APS. This standard is the first to allow recording of magnetic data and photographic images together on a single film. It was developed by five major photographic companies, namely Canon, Fuji, Kodak, Minolta and Nikon. Over fifty companies have now licensed the technology.

APS uses an all-plastic cartridge that holds not only the unexposed film but the processed film too, so it is never handled by the photographer. The photofinisher supplies an index print showing all exposures and their frame numbers.

Fig. 1. Agfa's Advanced Photo System (240), or APS, and 35mm films compared. The magnetic layer allows recording of camera and photofinishing data. Thinner emulsion layers enhance sharpness by reducing light scattering in a frame size 40% smaller than 35mm. The new PEN base has better mechanical properties, helping to minimise damage when extracting and rewinding film from the cartridge. The film code, 240, indicates the film's width, of 24mm.

Fig. 2. The Advanced Photo System film has both magnetic and optical data tracks. These record the user's choice of print format, together with date and time, and shooting information such as flash and lighting data. Through Information Exchange (IX), this data is automatically read by photofinishing equipment and used for backprinting and optimising image quality.

Technological Advances in Picture Processing

- The cartridge is dropped into the camera, used, then taken to the film processor for developing. There the film is detached and reattached, and finally taken to the photographic laboratory for prints to be made, still in its cartridge.
- Symbols on one end of the cartridge indicate the state of the film inside. There are automatic checks to prevent double-exposure, and the reloading or reprocessing of already processed film. Additionally, the camera can detect the film's ISO speed and number of exposures from the data disc on the opposite end of the cartridge.

Electronic processing can be used to reduce the size of the film, which means changes in storage, transport and handling. The ideal size is that which is currently standard, i.e., 24x36mm. Any changes to this system would result in extra costs, increased weight and reduced image quality. The other disadvantage is that APS film is longer than standard film, and this may result in the film being more difficult to handle in the camera and on the film transport systems.

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Technological System Configuration

- Metering sensor (16-zone SPC + AF)
- Infrared light cut-off filter
- Metering lens

Concentrator lens
- H (Supersensor) screen
- Focus screen
Main mirror
- TTL flash metering lens
- 3-zone TTL flash metering sensor (SPC)
- Multi-Basis

Secondary image formation lens

Fig. 4. The typical optical metering configuration of the Canon EOS-1N. Above the eyepiece and taking light from the pentaprism is the silicon photocell (SPC) exposure meter. In the base of the mirror box are the TTL flash metering SPC and the Multi-Basis (base stored image sensor) for autofocus — both taking light reflected by the sub-mirror.

Fig. 5. Minolta’s 14-segment honeycomb pattern metering. This results in a plus background setting that sensitivity is weighted to the subject. Spot metering is also possible by selecting just the centre segment, giving a reading of 2.7% of the image area (most SLRs offer this facility, and possibly centre weighting).

Fig. 6. High-Speed Sync (HSS). A conventional flash discharges the entire film in a single moment at once, just after the shutter curtain opens completely. Minolta’s Program Flash 5400HV’s high-speed sync (HSS) flash is a high frequency (US$2400 at that starts before the shutter opens and stops after the shutter close. This ‘flat’ pulse resembles a constant light source, so HSS flash can synchronize with shutter speeds faster than the camera’s x-sync. When the shutter curtain opens the flash fires, and the x-sync time taken for the mirror to flip up and the shutter closing.

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Fig. 11. The Contax AX achieves autofocus by means of Automatic Back Focusing. This employs infra red LEDs in the viewfinder to detect 2mm increments in focus. It also has a fully digital control system covering every aspect of autofocus. "Picture credit: Canon"
Any of you will be familiar with the previous version of Electronics Workbench as a low-cost simulator with a user-friendly graphical interface based on the virtual instruments concept. This traditional version has had a strong bias towards education and was relatively simple. But it was unquestionably attractive to many designers. For those wanting a quick and easy check of basic circuit performance, Electronics Workbench had the virtue of getting away from net list entry and other abstract concepts used by other simulators.

The producer of Workbench, namely BT, is now offering the same package but modified for professional use. It has more features, higher speed and a greatly expanded range of simulations. It also has a much larger component library.

This version recently made its appearance as Electronics Workbench EDA, called here EDA for short. It has no bias towards education, so there is no section devoted to fault injection. The original large selection of sample circuits has been reduced to just a handful, as an introduction.

For this review, I used a 120MHz Pentium with 16Mbyte of RAM and both a 14in and a 20in monitor driven by a 1.4Mbyte Trident 9800 graphics card. Using both Windows 3.1 and 95, it ran well, access redraws being acceptable quickly. The speed of simulation under 3.1 was about the same as under 95.

Typically, the analysis of the first circuit in the monitors panel (Fig. A) ran in 2 to 3 seconds. There appeared to be no speed advantage using Windows 95.

Operator's manuals and help

Four manuals are provided, plus a quick-reference card and installation guide. The user manual is derived from the previous version of Electronics Workbench, but with the references to the dos version removed. This makes it better reading. It consists of an introduction to using EDA and starts from basics, with plenty of explanation and a tutorial, so it is a good introduction for a designer using a simulator for the first time.

If you are used to simulators, you should fly through this book. The second, larger book is a technical reference with explanations of the analyses and component models and is well-written and concise. It assumes to some extent that the reader is familiar with the basics such as Fourier, intermodulation distortion, simulation modeling, etc. For readers who are not, a reading list of a dozen or so publications is provided.

The third manual is a guide to importing and exporting net lists, and includes worked examples. There is no pressing need to look into the composition of net lists unless you absolutely have to, as EDA has schematic capture in many formats, but this is a good reference book if you want to know more.

Hardware and software requirements

This software needs Windows 3.1x, 95 or NT. There is no dos version. It comes on six floppies and installation is simple. Software protection is by personal identification and serial number. The recommended minimum pc is a 486 or better. Under Windows, 12Mbyte of ram is required, under Windows NT, 12Mbyte. In all three cases, the recommendation is 20Mbyte of disk space. Since EDA is essentially a 32-bit program, the 32-bit driver WIN32S is Installed automatically for Windows 3.1 users.
Component libraries
To complement the wider range of simulations, the library of device models has expanded to 8000 types. This is a large library by any standard. I scanned it, looking for gaps but it seemed very comprehensive.

For making up schematics, there are over 100 analogue components and double this number in digital components, and several hybrids.

There is, however, only one schematic component for a terminal, and no library volume of connectors. This is commented on in the main article.

My eye was caught by the non-linear transformer modelling as this component is often not accurately modelled in simulators in this price bracket. If you want a bench-mark, then this is a good component to check against.

The model is much improved over the previous version and there are 16 parameters compared to 5, it is clearly more useful.

Mixed mode feelings
There is much reference to mixed-mode simulation except for a brief summary as to how it is achieved. It is a strong point of Electronics Workbench, which is promoted as ‘true’ mixed-mode in the advertising, one would perhaps have expected more about it, but mixed-mode does not even appear in the index of the books.

Workbench’s mixed mode is clearly regarded as sufficiently easy as not to require a chapter of its own, and this is in fact true. It is simply a multi-mode simulation by adding an analogue buffer amplifier to Fig. 1 and the simulation approximates seamlessly. Like previous versions of Electronics Workbench, EDA uses its own automatically inserted proprietary a-s-w-d interface on digital components to achieve mixed-mode simulations.

There is a fair amount of on-screen help to supplement the user manual. I found needed to use this often at first, as the user manual is quite short. Also, there is a system of prompts for when simulations go wrong, but these are rather tiresome. For example, you see a message saying ‘you must use a short circuit’ but it doesn’t tell you which one. In a circuit of ten or twenty capacitors this is not very helpful – it is still better help than that provided in some computer simulators.

Reading through various computer magazines, technical support for software does not do as well as a hot potato these days, so I checked out the technical support at Coventry – no problem here, a quick and efficient service and no telephone queues.

Drawing schematics
As you can see from Fig. 2, the screen format follows the standard Windows convention. Panning is done with the scroll-bar, and autorelacement is permitted when placing components.

Drawing is done on one very large ‘virtual’ page. Many users will prefer this to having a resizable window, so it is possible to separate sub-circuits and store them as icons. This is quite similar to having a multi-page function. There is no autoraster – a feature which I would definitely like to see added. During the review there was a power cut and, yes, I was caught out.

Many of the present generation of simulators use schematic capture instead of net list entry. Some have been criticised because the drawing system has left a lot to be desired. Usually this has been on the grounds of it being slow to pick, place and specify components. In this area, Electronics Workbench scores well.

Selecting and placing symbols is both intuitive and easy. As in version 4, symbols are taken from a number of parts bins pre-stocked with generic parts. There are 13 of these bins, each loaded with two drop-down symbols each. One extra bin is provided that you can fill with your own preferred choice of symbols. These bins have been re-designed to take up less screen space than the previous versions.

Out of the bin
A bin can be opened with a single mouse click. Opening a second bin automatically makes it possible to open several at once to form a palette, as in graphics programs.

Symbols are placed using drag-and-drop and are easily erased – four mouse clicks and – replaced. Like many Windows programs, you are asked if you really want to erase the selected part, this adds an extra click and is annoying.

Specific information on each symbol is entered at a later stage, from the main library of model types. This system is highly suitable for simulation as experiments can be quickly set up and altered without going into detailed specifications. This contrasts with the slower pch-drafting type of schematic drawing systems using tens components selected in advance from the library and dumped in a single parts bin.

Despite the very large library, searching for specific type of information to attach to the generated schematic seemed very quick. By picking a particular schematic symbol you are automatically placed in the library and a symbol for the component involved do not have to refer to a library index, as you do with some systems. It is clear that a lot of effort has been put into making manipulation as smooth as possible. In general these are a lot of nice touches like this one throughout the program.

Wiring up
Still in pursuit of speed, symbols are connected up using an automatic wiring tool. As this facility has been added, you click on a symbol’s terminal, drag the mouse to another terminal and release. An orthogonal connection is then automatically arranged, using a fully featured node editor. This process is assisted by a snap-to-function, so spot-on accuracy is not required, although a fair amount of manual skill is still needed. There is no adjustment of the symbol spacing as with previous versions.

The automatic wiring works well for small circuits. On large circuits it produces many crossings becoming devious. Like a pch autoraster, the automatic wire-finder finds the going tough when there are many components, or if component spacing is close. In these conditions it does not do as well as a human. If you do not mind the circuit looking a bit untidy, then this does not matter: the simulation will still work – and it is very quick.

I found large, unshaded schematics harder to read than these done by hand. The handbook suggests using white lines with the six-colour option to clarify schematics, and I found this very useful in reducing this effect.

If you space the components out, the automatic wire-finder can give better results, but this takes up more screen space. As a result, you should position your components to suit the circuit. Besides, screen space is always at a premium. But you may have to space the circuit out anyway, because text is always printed at twice screen size. It is therefore necessary to leave the extra space to avoid connections running through text.

If you have to present a good-looking schematic, for a report for example, then it will be necessary to tidy the circuit by editing. This is done by a rubber-band method, except that the connections stay orthogonal. I discovered that sometimes the auto-wire facility wrongly makes a cutting or clipping, especially when previous editing has produced a few tight corners.

Occasionally, on large circuits, I have seen it run wire artily through a resistor, giving some very strange range effects. Also, if you bump into an unidentified resistor, it is possible to create an unintentional mess with rubber bands.

In my view, the automatic wire will be something the purchaser of EDA will hate or love. I would like to see EDA provide an alternative manual schematic wiring program. If it were, everyone would be catered for.

Simulations and virtual instruments
EDA keeps the same range of virtual instruments as before, namely two-beam oscilloscope, bode plotter, autoranging multimeter, voltmeters and ammeters in any amount, function generator, logic analyser, logic converter, and word generator. Some of these have been improved, for example the logic analyser has been up rated to 16-bit.

There is no pulse generator or piecewise function in the virtual instrumentation. If you want these, you have to open the ‘sources’ bin. In this bin, there is an impressive number of extra functions such as an fm signal source, various voltage-controlled oscillators and piecewise and one-shot pulse generators. All of these are set up via a menu system.

In addition to virtual instruments, EDA has a number of analysis tools to supplement the simulations on the virtual instruments. These analyses are; de operating point, ac frequency (phase and amplitude) transient, Fourier, intermodulation, noise, parameter sweep, temperature sweep, pole zero, ac and de transfer function, ac and dc sensitivity, worst case, and Monte Carlo. There is one notable gap in the range of analyses provided – there is no analysis giving a plot of output impedance or input impedance, for example.

The results from these analyses are presented either as a plot or in tabular form, and they are all full-screen. On trying them, I found good continuity of style and technical content, which should enable an operator to go from one to another without any mental gymnastics.

I found the features available in each analysis gave good coverage and scope, and they were particularly easy to use. For example, the ac analysis which provides plots of gain and phase covers the range 1Hz to 1GHz and allows several different scale types for the x and y axes. A typical scale choice provided for this is a logarithmic scale.

Clearly, some of these analyses, like the one just mentioned, overlap with the virtual instruments. The choice is then yours: virtual instruments are easier to set up, gives analysis more detail and flexibility. This is especially true of the bode plotter, which cannot be expanded to an oscilloscope, and has no scaling on x or y axes. The bode plotter is obviously intended just for a snapshot of circuit performance.

Does monitor size matter?
On a 14in monitor the screen space available for drawing is 9 by 4.5in. This is not a lot, but is comparable with other Windows-based simulator programs. However, EDA performs much better with a larger monitor.

On the 14in monitor’s 640 by 480 display, the grid is on a few of the graphs showing slight moving because due to being too closely spaced. This effect, which does not seriously impede moving the graph, is shown in Fig. A. On the 20in 1024 by 768 display, all the simulation graphs appeared excellent as Figs. B, C and D show.

EDA now has a zoom function. This is a very useful addition. On a 14in monitor, and even on a 17in 1024 by 768 display, one used to have to squat at the screen to make them out, but now with five times from 50% to 200%, all is clear.

Fig. A. A plot of 709 op-amp noise (1kHz to 768 pixels).

Fig. B. Typical Fourier analysis, for the 709 op-amp, which can also be presented as a line graph instead of a bar graph (1024 by 768 pixels).

Fig. C. A plot of 709 op-amp noise (1kHz to 768 pixels).

Fig. D. 709 op-amp parameter sweep, showing amplitude and phase at the output when just one resistor in the circuit is changed from 1k to 100k in 20 steps. This is an excellent example of the clarity of the Bode plotter as compared to Fig. A (1024 by 768 pixels).
EDA uses Spice 3c, whereas Electronics Workbench version 4 used Spice 2. All the simulations run much faster than EDA's predecessor, version 4, which was acknowledged to be rather slow. The claimed figure is ten times faster. The increased speed pays this package on par with most other simulators in this class. If you've previously used version 4, the speed increase is conspicuous.

This review is too short to detail every analysis, so I have shown several screens of simulations on a Sallen and Key filter, a 4-16 decoder/deciplexer, and the circuit of the 759 op-amp. This will give a good idea of the style and scope of Workbench EDA.

Schematic capture and pcb layout

When using EDA just for simulations, there is normally no need to delve into net lists. However, if you need to export information to other systems, the package can produce net lists in several formats. These are Spice, Orcad, Percel, Tanjo, Eagle, and Ultimate. The most likely transfer would be to a third-party pcb-layout program, and if this is Windows-based such a transfer is easy.

As I mentioned earlier, there is no library of connectors, such as D15, DIN41612, etc, for schematic drawing so these components would have to be added in. Alternatively, you could draw the schematic in the pcb-producing program and export it to the pcb layout packages, it fits easily into your design flow.

In summary

In its EDA version, Electronic Workbench now has a sufficiently wide range of features to make it very attractive in many fields of activity as a general-purpose simulator. There are still a few areas where things could be improved, but this is true of most programs.

With a price tag of £995, excluding vat, the package is outside the reach of education and amateurs. IT is clearly intended for commercial designers, who will be attracted by the good value for money EDA offers.

Among Workbench EDA's many new features is the ability to invoke cursors for setting measurement limits.

Using your free Electronics Workbench EDA working demonstration CD

The main software on the CD-Rom is a working demonstration of Electronics Workbench EDA, with sample designs. You can explore the software at your leisure for 30 days before deciding whether to take a free copy of the software. If you choose to upgrade, you'll need a current demo copy of the software. Keeping a copy of the software will be a great benefit when using Workbench EDA's powerful features.

Electronic Workbench Version 5 sets the standard for affordable simulators. Tight integration of its schematic editor, SPICE simulator and on-screen waveforms makes the package easy and instant. The full suite of analyses improves your productivity with insights into the behaviour and reliability of your designs. The SPICE 3 engine simulates analogue, digital and mixed-a/d circuits for exceptional power and accuracy. This incredible model library means you'll have the devices you need.

Since Electronics Workbench can share design files with other simulators and export to PCB layout packages, it fits easily into your design flow. Until 29 August, Electronics Workbench readers can obtain Electronics Workbench EDA for £0.

Features:

- TRUE MIXED ANALOG/DIGITAL
- FULL INTERACTIVE SIMULATION
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- DIGITAL ENGINE
- TEMPERATURE CONTROL
- PRO SCHEMATIC EDITOR
- HIERARCHICAL CIRCUITS
- VIRTUAL INSTRUMENTS
- ONSCREEN GRAPHS
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I/O port for PCs

Pei An's data acquisition and control system interfaces via a PC's RS232 port. Suitable for a variety of data acquisition applications, the interface has two analogue inputs together with seven digital inputs and seven digital outputs.

The PC peripheral is an RS232 serial port data acquisition/control system that could form the hardware core of virtual instrumentation. As the RS232 serial port is a universal feature of all types of computers, this system can be used with any PC. The system has two analogue input channels with 12-bit conversion resolution and an input voltage range of 0 to 5V. There are seven digital input channels and seven digital outputs. Power for the system is derived from either an external 8-15V dc power supply, or by a +9V PP3 battery. A +9V battery or a 9V battery can be used in this mode.

This chip has similar electrical characteristics to that of the industrial standard MAX232CPE, but it consumes much less current. It requires only a single rail +5V power supply. Internally, this power supply is converted to +10V and -10V by a voltage doubler and a voltage inverter. The MAX232CPE converts RTS and DTR of the RS232 port, which are at RS232 voltage levels, into TTL. It also converts two lines from the data acquisition/control board, into RS232 levels and feeds them to CTS and DSR, respectively. The TTL levels are compatible with that required by the on-board components. Further another RS232 output line, TD, is converted to a +5 V TTL voltage level using a simple voltage clamping circuit consisting of a resistor and a zener diode. The voltage level is compatible with that required by the on-board components.

Digising analogue signals

The analogue-to-digital converter is an LTC1288 micropower successive approximation type, Fig. 4. It has 12-bit resolution and requires a 3.7V to 5V supply. Pin 8 and 9 connect to the positive and negative rail of the power supply. Pin 8 also serves as the reference voltage input for the a-to-d converter. Therefore, the supply voltage must be precise, stable and free of noise and ripple.

Typical supply current of the chip is 260µA at a sampling rate of 65K with a 2.7V rail. In standby mode, the supply current drops to several nanometers.

The LTC1288 has two analogue inputs, at pins 2 and 3, which can be configured into two input modes: single-ended and differential input mode. In single-ended mode, an input voltage can be applied to each input with respect to the supply. Two input channels can be used in this mode.

In differential mode, an input voltage is applied across the two inputs. Only one input channel is available in this mode. The analogue input leakage current is typically 1µA. The LTC1288 communicates with other circuits through a four-wire serial interface. These four wires are -CS/SHDN, CLK, Din and Data. Selection of the chip is carried out by taking -CS/SHDN, at pin 1. Low. While the pin is high, the converter is in standby mode. This provides a means of controlling the LTC1288 if a number of the chips are connected in a shared bus.

Clock input, CLK on pin 7, synchronises serial data transfer and determines conversion speed. At the falling edge of CLK, each bit of an n-to-d conversion result (12 bits) is sent out from Data on pin 6. At the rising edge of the clock, the input bit appearing at Din is captured into the IC. Figure 5 shows how data transfer is initiated.

**Fig. 1.** The data logger/controller comprises five elements: RS232/ttl converter unit, a-d converter unit, digital input and output units and parallel printer port.

**Fig. 2.** Circuit diagram of the RS232 data logger/controller.

**Fig. 3.** Pin layout and functions of the RS232 connectors on pc's.

(a) 9-pin male socket viewed from the back of the computer.
Next, a three-bit input word comprising bits 1, 2 and 3, shifts into the IC from the Din input at the following three rising edges of the CLK input. These three bits configure the input mode and the serial data output format.

At the falling edge of the fourth clock, an a-to-d conversion starts. Immediately after this falling edge, a null bit (logic 0) appears on Dout.

At the next 12 falling edge of the clock input, the 12 bits of a-to-d conversion result appear on Dout. During this time the bits appearing on Dout do not have any effects on the converter. Because of this, data bits can be used for driving other units.

Table 1. Functions of the interface's control word. Bits 1 and 2 determine the input mode while bit 3 selects the format of the data output from the a-to-d converter.

<table>
<thead>
<tr>
<th>Bit 1</th>
<th>Bit 2</th>
<th>Channel 1</th>
<th>Channel 2</th>
<th>GND</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Vin+</td>
<td>Vin-</td>
<td>Vin+</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>Vin+</td>
<td>Vin-</td>
<td>Vin+</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Vin+</td>
<td>Vin-</td>
<td>Vin+</td>
</tr>
</tbody>
</table>

Table 2. Pin function of LTC1288. Next, the IC looks for a start bit.

**Digital Design**

1. **Pin-out and internal block diagram of LTC1288.**

2. **Timing sequence of LTC1288.**

3. **Internal block diagram of UCN5810.**

4. **Pin-out and internal block diagram of UCN5801.**

5. **Timing sequence of UCN5810.**

6. **Timing details of the circuit.**

7. **General timing sequence of the data logger/controller.**
The Turbo Pascal 6 program listed here has four basic functions, AD_converter (RS232_address, Mode, inputdata (), Output_byte), which control all the operations of the RS232 data logger/controller. AD_converter (RS232_address, Mode, inputdata (), Output_byte) to the seven outputs. The function returns the analog-to-digital conversion result is shift out from DOUT pin of the UCN58J0 and read into the computer via the RS-232 line. During the period of these 12 clock pulses, the serial bits are shifted in at the low-to-high transition of the positive-going clock pulses and are latched to the output latches at the next read/write cycle when the strate line goes from low to high. The Turbo Pascal 6 program is concerned with the port address of the COM ports installed on your computer. RS232(1) returns the port address of the COM1 port (base address: $400, COM=1). Rs232(2) returns the port address of COM2, etc.

Para-serial shift register. The eighth bit of the input data appears automatically on the RS232 DSR line. This is read into the pc via the RS232 DSR line. After four clock pulses, lines of the input data are read into the computer. These clock pulses also shift data bits into the shift registers of the UCN5801, but these bits are not latched to the output latches. There are 12 more clock pulses following. Each falling edge of these 12 clock pulses, each bit of the analogue-to-digital conversion result is shift out from DOUT pin of the UCN5801 and read into the computer via the RS-232 line. During the period of these 12 clock pulses, the serial bits are shifted in at the low-to-high transition of the positive-going clock pulses and are latched to the output latches at the next read/write cycle when the strate line goes from low to high. 4021 is loaded into the internal shift registers. The eighth bit of the input data is not latched to the output latches. This code reads data from the a/d converter and latches the digital output. Serial bits are read into the pc and read into the RS232 DSR line. At that stage, all the bits of the digital output are read into the pc. These bits are concerned with the port address of the COM ports installed on your computer. RS232(1) returns the port address of the COM1 port (base address: $400, COM=1). Rs232(2) returns the port address of COM2, etc.

Turbo Pascal for controlling data logger

Output digital data inverter in the pc (on dedicated)

Digital Design

Technical support

The turbo system design for this project is available in kit and in assembled forms from the author together with the Visual Basic source code, DLLs and executable files. Please direct your inquiry to Dr Pei An, 13 Sandpipper Driver, Stockport, Manchester SK3 8UL, U.K. Tel: 0161-677-9587.

Garri ngton, Manchester SK3 8UL, U.K.
Prototype your PCBs with the aid of computer software, offering unique benefits when transferring the track layout to copper. One benefit is the ability to produce files for photoplotters and numerically-controlled drill machines.

Most small firms or individual designers using a budget-priced computer-aided design program will not be contemplating making their own PCBs in production quantities, so for many designers, the route to making a PCB will end here when they turn over these files either to a PCB manufacturer or to one of the many Gerber photoplotter bureaux.

Prototyping, on the other hand, is a very different matter. It does not make sense to have your autorouter turn out the artwork for a PCB in a flash if you then have to wait for hours or days for some third party to make up a prototype PCB for you, especially if the original design has to be corrected two or three times due to mistakes or last-minute design changes.

The alternative is to make your own trial boards.

For many, this is not a likely prospect, because the conventional ultraviolet methods that most readers will be familiar with are messy, slow, and give uncertain results, but there are several techniques for making the process more amenable which are discussed here, some of which are specific to PCB-CAD.

It must be emphasised that none of these methods will give results quite as good as those produced by a photoplotter, but for prototyping they can be very acceptable.

Printing versus plotting

The starting point for prototyping is usually a print on paper or a transparency made on the PCB's printer or plotter. This must have a dense,
Examples and results of various ways of applying of etch resist

...
The conventional process of making a contact print using ultra-violet exposure and pre-coated photo-sensitive copper-clad boards, allows you to develop the image in a chemical bath, mess and slow and the results are far from guarantees of quality and eye protection is necessary.

However, the main objection is that the results are so uncertain. Ultra-violet exposure rates vary from batch to batch and between manufacturers of the sensitised boards. As a result, exposure is hit and miss. You can perform a timed test beforehand on a spare piece of laminate each time you buy some material, but this is very time-consuming.

Development is also a randomly variable process so it’s mainly a matter of luck if a board turns out well without prior experimentation. The penalty for incorrect exposure and development times is a wasted board, which can be expensive. You never know for sure if the board is sound until the etch is over. If it isn’t sound, you have to use even more material to make another.

It is not surprising that this part of prototyping pcbs is disliked. Unfortunately, the relatively low cost of the whole process on offer from the major suppliers of materials such as RS and Farrell, but there are viable alternatives.

Alternatives to ultra-violet
A few years ago it was realised that laser printers and copiers had good potential for using laser-plotters for transferring artwork to copper. This is physically possible. I used a parallel plotters can be very time-consuming and it is

The process depends on the fact that toner for laser printers and copiers is usually based on powdered acrylic styrene polymer formulations. These melts at around 120 to 150°C to form a gum with good adhesive properties. The actual melting point depends on the brand.

What to watch out for
There are a few things with this process. First, the photocopy or laser printer has to be in perfect condition. Any fading of the image means that the artwork has been etched where it should not be, and any defects in the photocopy, such as drum scratches, drop-outs and smudges, are faithfully copied onto the artwork. Secondly, ordinary toner is not all that etch-resistant and this property varies considerably between different manufacturers. It has to give a dense black uniform coating to the artwork for etching and the configuration of the toner sticks to 0.01mm on Cameo to 0.005mm on mat. There is no waste of copper board at all.

The best photocopies for this use have no oil at all in their fusing sections. On these machines, the hot roller relies solely on the photo-conductor to prevent sticking. The pressure roller obtained on the average photocopy or laser printer — although scratches on the copper drum etc — will still be acceptable.

Laminating machines are designed for use with thin cardboard, so if you choose this method you will need very thin copper board in order for the sandwich of Photo and Pcb to pass through the machine. With some laminating machines specifically adapted for the purpose, slightly thicker board can be used.

Control of the laminator’s speed and heat is essential to produce the right amount of toner fusion and thus a satisfactory transfer. In the trade, the speed setting is called ‘the dwell time’. Some experimentation will be needed with the settings to get the right dwell time for a particular laminate thickness. If you are using thin copper board, it has to be bonded onto a plain gridded board to make a board of normal thickness, compatible with PCB components and the right for small quantities of copper. For example, fast-setting epoxy adhesive is suitable for this. It is better to increase the board thickness before Armenia and some photocopy service firms.

For better results
A material called PnP gets round some of these problems by using the toner only as a glue for a more substantial etch-resistant overcoat. This material comes in flexible blue plastic sheet the thickness of 80μg/cm² paper, and it is designed to be fed through either a laser printer or photocopier just like paper.

After going through the copier or laser print, the image of the artwork appears in black toner against a blue background. The sheet is then pressed face down onto the copper board via a pouch laminating machine or by careful use of an iron. The application of heat and pressure causes the film to fuse to both copper and the blue PnP coating. When the sheet of PnP is removed by peeling it off, the artwork remains stuck to the copper as a deep blue image.

Etching can then follow in the normal way. Because the toner acts merely as the adhesive for the etch-resistant overcoat, the etch-resistance of the image is not dependent on toner type or the material configuration of the toner coating to 0.01mm on Cameo to 0.005mm on mat. There is no waste of copper board at all. For prototyping, reasonable results with PnP film, art-grade toner cartridges for laser print, A4, etc, can be expected on your first try.

For production runs, however, the presence of even minute quantities of such a release agent has a big effect on how well the art sticks to the copper laminate.

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Results of ink etch-resistance tests

In the last figure in the panel, I tested three such inks from well-known suppliers. These are labelled a), b) and c). As a control, I plotted the properties of the inks the test artwork was given a fine spacing, a couple of thin tracks and a solid area.

As the results of etching show, none of these inks had good etch-resisting properties. The waterproof Indian ink had no etch resistance at all. In contrast to this, both d) and e) show the test repeated with an ink designed specifically for etch-resistance. The results with this ink were consistently excellent.

One thing a plotter can do which printers and photocopyyers cannot is to rework the artwork several times. Plotters can easily repeat the same artwork very accurately if the copper laminate is kept in exactly the same place on the plate. The first plot could be made in an ink with good adhesive properties on copper, which could be followed when the first ink had cured with an ink that had good etch-resistance, and so on.

For the second pen, careful choice of nib material is needed to avoid damage to the first artwork. A metal pen nib will scrape and tear the first coating, so a softer nib is needed. Control is lost if the pen goes down the track, becomes even more important. Final artwork produced by this method is highly resistant to etching solution. Pen plots have considerable potential for plotting artwork in conductive ink. This could be very useful for prototyping and boards, as Fig. 2 shows. Clearly, pen plotters are sufficiently accurate for surface-mount work, but it certainly helps the plotter if the autorouter has a track-spreading option to avoid closely-spaced continuous tracks. The Spectra autorouter is the only one of those reviewed that could do this.

Components are placed onto the pads with conductive epoxy (RS 496-265 for example). However, I have found no commercially available conductive inks or pens that have been developed for plotter use, although there are conductive inks on the market in press for hand application such as the Circuit Works 2200. Perhaps this will change in the future if there is a demand.

Pen plotters are expensive compared to printers, but they are more versatile and their running costs are low—a little ink goes a long way. You need only one pen, but the bare copper laminate is much cheaper than either photosensitive board or PCB. In my experience, pen plotters are more reliable than laser printers, having fewer moving parts to go wrong, and no need for heat or pressure devices.

As with the PnP method, there is no waste of copper board if you make a mistake—the artwork can be removed with acetone and re-used immediately. On the other hand, as plotting is slow compared to PnP it is unlikely to be useful for a short production run.
threshold is exceeded the potential at the output of \( V_{25} \) falls and \( D_2 \) conducts, removing the forward bias to \( T_2 \). At this point the voltage output falls to whatever value that will maintain the current limit through the external load.

A measure of thermal protection is provided by a LEMSD temperature sensor fitted to the heat sink. The sensor produces an output of 10mV/°C. This is connected to a schmitt trigger set to change state at approximately 60°C.

When the trigger changes state, gate bias to \( T_2 \) is removed via \( D_3 \) until the heat-sink shorts down. Resistor \( R_{19} \) provides a small amount of hysteresis to the trip point, and a flashing overtemperature warning is provided by \( R_{20} \).

My original circuit was prone to oscillation, so some frequency compensation was added in the form of \( C_{25} \) and \( C_{26} \). The series capacitor chain \( C_{25} \) removes the effects of an unwanted pole in the feedback loop formed by \( R_{19} \) and \( R_{20} \).

Previous incarnations of this power supply have used bipolar transistors of the BS50 variety as the series pass transistor. Components \( D_3 \) and \( R_{18} \) were found to kerb an excessive mortality rate when the power supply was accidentally short-circuited in these earlier versions. They were replaced because the current limit did not act fast enough to prevent breakdown.

Protection components \( D_3 \) and \( R_{18} \) may not be necessary with the modern design. I have left them in since the added expense is very small. To date I have had no failures.

A conventional 12V local power supply is taken from two 6.3V filament windings wired in series.

**Component notes**

Main \( T_2 \) or \( T_3 \) can be purchased from RS Components. It is still listed in the latest catalogue but will not be available when present stocks run out. A quick scan through the catalogue has not revealed a direct replacement but there are a few alternatives.

First, Maplin advertises a 600V pnp transistor which would be suitable if your application can tolerate the reduced current rating. However there is no 12V winding so a separate transformer would be needed to power the control circuitry.

Secondly, an isolation transformer could be used. These are available from several suppliers in a range of wattages; a 50VA component would be suitable. This solution requires the high-voltage bridge rectifier to be changed for a voltage doubling arrangement. Again, there is no 12V winding included.

Ratings of the series-pass module, again from RS are 1000V and 5A but not at the same time. There are other transistors of similar ratings available. The following have not been tried but should be satisfactory: 2SKJ135, 2BU132, BU250A, BU251 and BIP635.

Capacitors \( C_{14} \) and \( C_{15} \) are polystyrene types rated at 1000V. Diodes \( D_1 \) and \( D_2 \) are both bandgap references and are easily available. \( D_3 \) could be substituted with a cheaper zener diode with some loss of stability. Transistor \( T_2 \) and \( T_3 \) can be substituted with a high gain p-n-p transistor of the BC870 variety but the use of the p-channel fet usually eliminates the need for a separate power supply.

Some comments are necessary concerning the behaviour of transistors when connected to high voltages. You may wonder why it was necessary to use ten resistors in series for \( R_{11} \). The reason is that physically small resistors with high values tend to age rapidly when connected across a high voltage. This is not because the power dissipation is above the official rating but because the electric field intensity tends to change the composition of the resistive track usually causing the resistor to change value.

Since \( R_{19} \) is the voltage sampling resistor chain, these components need to be stable with temperature changes; the temperature coefficient of metal-oxide resistors is generally high.

### Safety and implementation

It should go without saying that with potentials up to 700V some care is required to ensure that the finished unit is as safe as possible. This is especially true if the unit is to be used by those having little experience of electrical hazards.

I suggest that many of you will have limited high voltage experience, other than wiring up 240V mains, so a few pointers may be in order. Apologies in advance to the old hands.

All of the internal circuitry is isolated from the case and ground thus allowing operation as a floating, positive or negative supply depending on which output terminal is connected to ground at the output terminals. The case should be metal and securely earthed. Should ventilation holes be required then they should be small enough and so located that fingers, screwdrivers, pieces of wire, etc cannot be inserted and touch the dangerous points. This may entail fitting extra perspex covers over transformer connections and group boards. Heatshrink can be fitted over the high voltage connections on the fuseholder, on/off switch and transformer terminals. The heat sink needs some consideration; it is obviously essential to ensure a free air flow around the fins. The easy way to achieve this is to mount it on the outside of the box. If this is done the heatshrink will be earthed and the insulation to \( T_2 \) must be very good. I do not trust a normal insulating mico washer. I managed to obtain a special high voltage thermally conducting one.

If such a washer cannot be found, an alternative arrangement would be to bolt the transformer to the heat sink without a washer. The complete assembly is then mounted on insulating pillars inside the metal case. It will probably be necessary to include ventilation holes and a fan.

A few baffles can now be used to direct the flow of air and also to block access via the holes to the danger points. The output terminals are an obvious source of danger. On the prototype, a small diecast box bolted to the front panel was used to enclose the terminals. Connecting wires to the load are passed through a small hole in the side of the box and screwed to the terminals. The lid is then fitted so there is no possibility of accidentally touching the output.

As it stands my supply offers no protection if the lid is left off. If the design is to be used by students, then it would be wise to add some sort of microswitch arrangement so the supply is disabled the instant that the cover is removed. If you are a printed circuit board, it is wise to leave plenty of clearance around the high voltage tracks; one centimetre is adequate. Veroboard is not recommended. The load is then earthed using a high-grade earth, e.g. stranded wire, etc. You may wonder why it was decided not to include a fuse. The reason is that physically small fuses with high values tend to age very rapidly and so have to be changed fairly regularly. This is not because the power dissipation is above the official rating but because the electric field intensity tends to change the composition of the resistive track usually causing the fuse to blow.

Since \( R_{19} \) is the voltage sampling resistor chain, this component need to be stable with temperature changes; the temperature coefficient of metal-oxide resistors is generally high.
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Ray Herbert recounts events surrounding the first public demonstration of colour television in 1938.

On 4 February 1938, an audience of 3000 people watching a film at the Dominion Theatre in Tottenham Court Road, London had no idea that they were about to witness a piece of television history.

During the interval they were surprised to see live colour television pictures on a 12 by 9 foot screen, transmitted from a small studio at the base of the Crystal Palace South Tower. Advance publicity of the event had been impossible due to the restrictions imposed by the authorities regarding experimental wireless transmissions.

This was a highly significant occasion in two respects; never before had colour television been demonstrated to the public or transmitted by radio link—a double first for John Logie Baird.

Bearing in mind the many months of development work and the high cost of the sophisticated projection equipment, it is remarkable that no further demonstrations took place. A possible explanation is that Baird wanted to start work on a 500-line high definition colour system and this he demonstrated in December 1940 (Wireless World February 1941).

Earlier experiments

It was typical of John Baird’s zeal for immediate progress that he should attempt to produce television pictures in colour during 1928, at a time when improvements in the quality of the existing monochrome images represented the real priority. At that time he was using scanning discs at the sending and receiving end which had 15 holes in three separate spirals, each occupying a third of the circumference and covered sequentially with red, green and blue gelatine colour filters.

The discs span at 6000 revolutions per minute, providing ten images a second. It was a relatively crude arrangement but the highly regarded journal Nature reported enthusiastically, “The colour images we saw in this way were quite vivid. Delphiniums and carnations appeared in their natural colours and a basket of strawberries showed the red fruit very clearly."

Having achieved a notable first, Baird moved on to more prosaic problems of setting up studios and equipment for television broadcasts.

Colour updated

The later colour work carried out by Baird had been at the Dominion Theatre in 1936, an event which he demonstrated his monochrome multi-system. Whether by accident or design.

Supplying power

Power for the 150A arc lamp came from a Hackbridge Hewlett mercury arc rectifier and a frequency changer providing 100Hz for the synchronous motors. A cubic immediately adjacent to the colour projector housed the drive amplifiers and their associated power supplies. The final stage used two high power triodes in a patented, push-pull arrangement to deliver the 20000 volts peak-to-peak, necessary to exercise full control of the Kerr cell from darkness to full white illumination.
HISTORY

Baird's later colour work
Encouraged by what could be achieved using only two colours, John Baird set out to demonstrate high-definition pictures of 600 lines. Spotlights were used in the studio with rotating colour filters and photocells to detect the level of reflected light. At the receiving end, a projection cathode-ray tube produced a black and white picture, colour being added by another rotating colour filter having equal segments of blue-green and red. With this arrangement, a large, bright picture measuring 2 by 2 feet could be obtained.

This unretouched photograph of Paddy Naessens, a visitor to the press demonstration, was taken direct from the screen of Baird's projection colour receiver in December 1943 on Duolux colour film. It subsequently appeared in the April, 1941 issue of Electronics and Television.
Ed Cherry looks at distortion in audio power amplifiers and presents a critique of some of the novel attempts to try to reduce it published in recent years.

Ironing out distortion

There is an experiment on audio power amplifiers in the undergraduate teaching laboratory here at Monash University, in which students routinely observe that distortion, output resistance and slew rate do conform to theoretical predictions. Amplifier design is not a mystery.

1. This article is a sequel to 'Ironing out distortion' in which I set out some of the basis for predicting amplifier distortions. Between the time I submitted the final manuscript and when it was printed in January 1995, Douglas Self published two more articles on audio power amplifiers, and since then there have been other contributions from Self, Giovanni Stochino and Bengt Olsson.

2. Common-emitter output stages

The common-emitter or common-source output stage is my preferred choice. Self refers to my paper with Dr Greg Cambell in the Journal of the Audio Engineering Society. He gives a good account of some of the pros and cons of common-emitter and common-collector stages in the first part of his article.

Notably, he says that output resistance of a common-emitter amplifier with overall negative feedback is equal to that of a common-collector amplifier with overall feedback. Therefore, loudspeaker damping is the same for both. Self did not mention the principal conclusion of the paper, that intermodulation distortion is less for a common-emitter output stage than common-collector.

In my opinion the relation between common-emitter and common-collector stages could have been explained better. Figure 1 here with is Self's Fig. 9 re-drawn as I think it should have been.

Figure 3a is the starting point, a basic complementary common-emitter stage in which the collector currents are combined to load. Notice that the bias and drive for the p-n-p and n-p-n sides must be referenced to the positive and negative supply rails respectively, which is awkward but not impossible. I have built amplifiers of precisely this topology.

The transistor and its power supply on each side of Fig. 3a are in series around a loop with...
The load. As Self points out, the order of series components can be altered without changing the operation in any way. Accordingly the series are supplied as in Fig. 1b. And Figure 1d) is a further re-drawing in which the two input signal generators are combined – again no change to the circuit. Figure 1d) is identical to Fig. 1a).

Figure 1d) is a true common-emitter output stage. The emitters are grounded (neglecting the base and emitter, and the full output signal (plus quiescent voltage) appears between each collector and emitter. It beleeves that this arrangement of a common-emitter output stage is originalized when

1) published in 1968, although it has appeared several times since, in reference 5 for example, without ever really catching on.

Benefits of common emitter

The arrangement of a common-emitter output stage (in Fig. 1a) has an enormous practical advantage over any common-collector output stage: the input signal amplitude is just a few volts peak-to-peak. Therefore, the only transistors in the common-collector amplifier which need to withstand high voltages are the output transistors. Everything else – including the drivers – can operate from low supplies of, say, 15V.

A high-voltage transistor must be tightly doped in order to achieve a wide collector depletion layer and reduce the electric field. It is a given collector voltage. Initially this reduces the saturation voltage. Compared with any common-collector amplifier, a much better transistors can be used in all the low-voltage level-and driver sections of an amplifier (based on Fig. 1d). Non-dominant poles can therefore be moved further down, making it easier to stabilise the feedback loop. Higher quiescent and peak currents can be used in order to achieve high slew rate, without running into either power-dissipation or secondary-breakdown limits.

The only disadvantage of Fig. 1a) is that the main VCC supplies, feedback loops. Therefore, there would be no need for each channel of a stereo amplifier. But then, many high-gain amplifiers use separate power supplies anyway. Figure 2 explains the relationship between common-emitter and common-collector output stages. Figure 2a) is identical to Fig. 1d) except that the ground point has been moved: the VCC supplies are grounded but now the input signal source must float on top of the output voltage. This is a thoroughly impracticable arrangement, but circuit operation is not changed. The amplifier is still actually common-emitter: the full input signal swings between base and emitter, and not just base-emitter; and the output signal voltage appears between collector and emitter.

Figure 2b) shows the conversion from common-emitter to common-collector. The plates end of the signal source is simply grounded. Now the signal voltage between base and emitter. The intrinsic output noise of a common-emitter stage is high, but this is reduced in Fig. 3a) by the addition of a second-stage compensating capacitor. By comparison, the intrinsic output resistance of a common-collector stage is low, so this low resistance is attributable to the local feedback, and in Fig. 3b) is further reduced by the overall feedback. However, the voltage gain of a common-emitter stage is large whereas the gain of a common-emitter stage is small. Therefore the overall loop gain around the common-emitter amplifier is much larger than around the common-collector amplifier. It turns out that the extra overall feedback around the common-collector stage compensates exactly for its higher intrinsic output resistance. It also turns out – but is much more difficult to prove – that the stability of the common-collector amplifier is the same, higher loop gain not withstanding.

Output resistance – a new method

You might be interested in a new, generally applicable method for finding the input and output resistances of a feedback amplifier. In the same paper an approximation is given to the feedback, which clearly is much less exact, merely an estimation of the same order of accuracy as the required output resistance. The method is, write down the loop gain. The expression for the output resistance of a feedback amplifier is equal to the inverse of the loop gain expressed in types of formula.

Equate this loop gain to unity, and solve for the output resistance. If the feedback which reduces/increases the first-stage current source might have had a high output resistance, it also has a high shunt capacitance: recall that a capacitor-draws a spike of current when the voltage across it changes rapidly. This spike is in the direction which subtracts from the peak current, not to the right-hand side of the compensating capacitor.

Current source analyses

Function (Fig. 5a) is an n-p-n current source, the "figure of merit" of a current source. It is a measure of the transistor's current gain; or, in other words, the output resistance of a feedback amplifier is equal to the load resistance that would reduce the loop gain to unity. The method is easy, because it requires only the loop gain and not the output resistance without feedback. It works for all feedback amplifiers. It works for all feedback amplifiers. It works for all feedback amplifiers. It works for all feedback amplifiers. It works for all feedback amplifiers.

The similarity of Figs 6a and 6b) is apparent. The current source is Ck.

The similarity of Figs 6a and 6b) is apparent. The current source is Ck.

Slew rate

Self's discussion of slew rate is correct, but it falls into the category of analysing a bad circuit rather than recommending a good one.

Slew rate is set in amplifiers of the basic common-collector-output topology by the circuit's ability to charge and discharge the second-stage compensating capacitor, Fig. 4. The current source at both sides of this capacitor, and the slew rate is restricted by whichever side first reaches the available current limit. On the left-hand side of the compensating capacitor the available charging current is near enough to the output from the first stage and, if this stage is a long-tailed pair with current mirror, the positive and negative limiting values are symmetrical and equal to the tail current. On the right-hand side the signal is more complicated: the current available to the capacitor is the left-overs from the algebraic sum of the second-stage collector current, its source current load, and the input base currents of the third-stage transistors.

Self noticed that the 'current source' in his amplifier (Vbc in Fig. 1 on p. 761 of September 1994 issue) did not supply constant current when its voltage across it changed rapidly. He observed a 'spike' of current. It turns out that the feedback which decreases/increases the first-stage current source might have had a high output resistance, it also has a high shunt capacitance: recall that a capacitor-draws a spike of current when the voltage across it changes rapidly. This spike is in the direction which subtracts from the peak current, not to the right-hand side of the compensating capacitor.

The ratio of Rs to R1 is not critical, except that Rs should be as large as possible consistent with Rf>>RDCQ.

Time constant RfCQ should be chosen having regard to the lower 3dB cut-off frequency of the amplifier: alpha=RCQ(1+R1/Rf).

Shifting compensated amplifier

There is a corresponding method for finding the compensating capacitor as shown grey in Fig. 6 has many advantages; I have described how to design one in a previous article (Ref. 1). It has the advantage of an effective output current source. It is very effective in reducing cross-over distortion – the major residual distortion in Self's 'nameless' amplifier. It also helps with slew asymmetry, because the loading effect of the capacitor is transferred from the second-stage collector, where the available current is milliamps, to the output, where the current is microamps.

Until now there has been no reaction from readers to this recommendation in my article, or from readers to this recommendation in my article, or from readers to this recommendation in my article, or from readers to this recommendation in my article, or from readers to this recommendation in my article. I would like to put it on record that a complementary common-emitter or common-collector amplifier with feedback supplies as in Fig. 1d) provides an elegant solution to driving the gates of isolated-gate bipolar transistors, or gates. When the drive power supply is modulated and increased, the application of the gate must be driven between about +15V and -10V in a few nanoseconds; transient current in the gate capacitance during switching amounts to several milliamperes.
(If any reader has taken care of all three matters, then the stage distortion for the lag-compensating capacitor is shifted, I would be pleased to make contact. But I do urge you to shift the capacitor. It effectively reduces the very remarkable reduction in cross-over distortion.

Load-stabilising Zobel networks

Load-stabilising networks are used to ensure that the amplifier proper is presented with a load equal to something like its normal load resistance at high frequencies. This is the case even if the load impedance at low frequencies is very much lower. Secondly, they are used to prevent rf interference, picked up by the loadpeakers acting as antennae, from finding its way back into the first stage via the feedback network. Since submitting the final manuscript of Ref. 1, I have realised that there are in fact two families of load-stabilising networks – not just the two networks which Thiele proposed.

Figure 7 shows the general models for both circuits. In both circuits the inductance and capacitance should satisfy

\[ \frac{1}{R_0} = \frac{1}{R_1} + \frac{1}{R_2} \]

where \( R_n \) is the nominal loadpeak resistance, probably 8Ω and \( \alpha_{\infty} \) is the network cut-off frequency. In addition, for Figs. 7a and 7b respectively,

\[ R_1 = R_2 = R_0 \]

\[ R_1 = \frac{1}{\alpha_{\infty}} \]

Note the sign change in the denominator. In Fig. 7a, if \( \alpha_n \) is infinity, i.e. the capacitor branch is open-circuited, then equation (a) above reduces to \( \frac{1}{R_0} = \frac{1}{R_1} + \frac{1}{R_2} \), i.e. the circuit reduces to Thiele's original. Again there is a continuum of allowed resistance values between these extremes. Thiele's original with \( R_2 = \infty \) gives the greatest isolation between amplifier and load, and the extinguished attenuation of rf interference. But the circuit does ring badly if the external load is made pure capacitance.

Whether a pure capacitive load is realistic of anything practical is a moot point, and in any case the ringing is a simply a resonance between the inductance and this capacitance – not an indication of approaching instability in the amplifier.

If anyone is worried by the ringing, however, then damping can be increased by using some finite \( R_2 \) and the corresponding \( R_1 \). The price, of course, is reduced isolation and reduced rf attenuation. Thiele has made me aware of (or my modification of it in Ref. 1) is still my preferred choice.

Similarly, if in Fig. 7b you choose \( R_2 = R_0 \) and \( R_1 = \infty \), the whole network disappears. If you choose \( R_1 = R_2 = R_0 \), on the other hand, the circuit reduces to Thiele's original. Again there is a continuum of allowed resistance values between these extremes. Thiele's original with \( R_1 = \infty \) gives the greatest isolation between amplifier and load, and the extinguished attenuation of rf interference. But the circuit does ring badly if the external load is made pure capacitance.

**Distortion of the supply rails**

Self's cascode-like first stage is an ingenious arrangement for coping with the supply rails entering the circuit via the lag-compensating capacitor. Congratulations! My preferred choice is the common-emitter output stage as described above. Here there is no significant signal on the low-voltage supply. If you try to Fig. 8b – crazy-looking or not.

Even if the circuit reduces to Thiele's original. Again there is a continuum of allowed resistance values between these extremes. Thiele's original with \( R_2 = \infty \) gives the greatest isolation between amplifier and load, and the extinguished attenuation of rf interference. But the circuit does ring badly if the external load is made pure capacitance.

Field-effect transistors exhibit a corresponding dependence of differential gain on drain voltage. They too can generate second-order-like distortion via a-translmemoauence (see the notes where he has explained this process of how the feedback network, and transistor base current, and ultimately modulated at the signal voltage required for full operation, this is one of the reasons why I prefer the 300V typical of old-style vacuum-tube amplifiers, to today's more usual 0.7÷0.3 V. If a hardware solution is required, I use the bootstrapped cascode arrangements shown in Fig. 8.

Power mosfets versus bipolar devices

I agree with everything Self says about the relative nonlinearity of mosfets and mosfets in output stages. However, I have omitted one important consideration: gain-bandwidth product. I also agree with his comment that the experimentally measured crossover distortion when there is the simple fix of shifting the lag-compensating capacitor as in Fig. 6.

Comparison anomalies

In August 1993 John Lindsey-Hood's published a comparison between joints and mosfets. In this comparison, the common-emitter cascode in his Fig. 1 is marked "value for some circuits, etc.". The comparison of mosfets, joints and mosfets was not made on a level playing field.
The fact that measured distortion for the mosfets was about half that for the bjts is of itself meaningless; we must also be told the ratio of the compensating capacitors in the two experiments.

My guess is that the compensating capacitor was smaller in the case of the mosfets as compared with the bjts. As explained above, Bode’s work shows that much more feedback can be applied to mosfets at high frequencies without approaching instability, because their transit time is shorter; mosfets require less compensation than bjts.

If the mosfet compensating capacitor was half the bjt capacitor, then Linsley-Hood’s experiment shows that the open-loop distortion can be applied to mosfets at high frequencies itself meaningless; we must also be told the ratio of the compensating capacitors in the two experiments. As explained above, my preference for mosfets. Their open-loop distortion may be somewhat greater than for bjts, but mosfet capacitor was smaller than half the bjt capacitor, the open-loop bjts are better than the mosfets — as Self claims.

In the end, however, it is closed-loop distortion that matters, not open-loop, and Linsley-Hood’s experiment confirms my preference for mosfets. Their open-loop distortion may be somewhat greater than for bjts, but mosfet capacitor was smaller than half the bjt capacitor, the open-loop bjts are better than the mosfets — as Self claims.

References


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MINICOMTRANSCEIVER INCORPORATING BIM TRANSMITTERS/DATA LINKS
Make your own fluxmeter

You can't see or feel them but a body of opinion says that they can harm you. Frank Ogden describes an instrument to measure low frequency flux fields.

W have never heard so much lately about low frequency magnetic fields from power lines and mains equipment and their alleged connection with health risks. I hold a personal view that the various Government inspired studies, none of which indicate significant linkage between disease and exposure, have not looked for correlation between disease and magnetic field in likely locations; they did not survey retrospectively location addresses of actual illness.

Most researchers suggesting disease linkage suspect sustained medium level exposure in the range 300 to 1000nT as being significant. Short, intense bursts such as those received when operating a hair dryer or other electrical equipment are not considered important. In short, LF radiation is probably of no concern unless you live or work under - or above - a power line, or within the path of a piece of electrical equipment in continuous operation.

The simple instrument described here will deliver an AC flux measurement accuracy within 10% without any form of calibration. This requires the 215-turn sensor coil to be wound accurately, that it should intercept about 78cm of flux, and that the instrument housing does not distort the incident flux.

Such a coil will deliver 0.5 microvolt EMF at 50Hz for each nanoTesla of incident flux. Thus, when coupled to an amplifier with a gain of 2000, a 1000nT 50Hz sinusoidal flux will generate 1V rms at the amplifier output. This can be measured with a calibrated precision rectifier, DMM or other measuring instrument connected to the output terminals.

The circuit is almost too simple to warrant description. The sensor coil couples directly to a two-stage differential amplifier with a gain of 2000. Thus, when used with the coil as specified, an input 50Hz, 1mT flux generates one volt rms output at the coupling capacitor to the precision rectifier. The rectifier/meter circuit is pre-calibrated against a decent voltmeter or known voltage source.

Alasdair's original piece, which advocated a simple instrument similar to the one given here is unconditionally stable at unity gain. However, it reveals hotspots around the home: risks, the instrument provides a fascinating insight into the nature of magnetic fields and what they do from a 1000nT flux produces 1V rms at the output to the precision rectifier.

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Simple fet audio preamplifier

A simple fet audio preamplifier, with a tendency towards elaboration in power supply and driving a 1kHz load, output voltage before clipping is 5.7Vrms.

Considerably simpler than many fet preamplifiers, this one gives a smooth signal, particularly at higher frequencies, where some bipolar transistor preamplifiers have a tendency to sound harsher and more "aggressive".

Smps inrush tester

Inrush current, that taken by a switched-mode power supply at switch-on, the reservoir capacitors being uncharged, is large and short-term. It is necessary to examine this characteristic on any design.

With the addition of a duo, this is a repeatable method of measuring the inrush current of a switched-mode power supply.
Soft-starting bedside lamps

Turning on a bedside lamp at 3-o'clock in the morning is not often a pleasant experience, depending on what one was doing the night before. This circuit switches the lamp on at reduced power and brings it on fully after a few seconds. It also makes lamps last a very long time.

For sensitive souls who find switching on a lamp in the middle of the night as much of a shock as being tipped out of bed, this driver brings light in gently, coming to full brightness in about four seconds.

Audio phase indicator

A hi-colour led glows green for L and red for phase-sensitive, red for out of phase and remains off when no signal is present. Left input signal is amplified and clipped, the pin 6 output driving the comparator IC2, whose output controls the analogue switch IC1, pin 5, to switch the rectifier in and out of phase, its output therefore following the relative phase of the two signals and being integrated at IC1 pin 1. This output is positive or negative with respect to ground, depending on whether the inputs are in or out of phase. The integrator samples and holds for no signal at D1, to minimize detection of incorrect phase information.

If there is no signal or only one signal present, there is no input to one or both of the analogue switches at IC1, pin 1 and 8 and the led stays off. Otherwise, the led responds to a negative or positive integrator output. Mike Law

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CIRCUIT IDEAS

led glow

Soft-starting bedside lamps

At the instant the switch is closed, there is no voltage on C1 and the TC7206 tric is not conducting (the titric is cheaper than a thyristor and has the same function here). Diode D2, half-wave rectifies the live line and, during the half cycles when D1 is not conducting, C1 charges through R1 and D3. When this voltage gets to about 15V, the zener begins to conduct and carry current to the gate of the triac, which conducts; in this condition, the voltage across C1 does not exceed its rating. On switch-off, C1 discharges through R1.

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Yongning Xia
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Divide one of the LCD outputs from a five-function digital watch to get any clock signal with a period between half a second and 512 seconds.

**IC phase-splitter for valve audio output**

In Electronics World for November, 1996, Wim de Jager described a hybrid transistor-valve amplifier: this circuit replaces the transistors with integrated circuits.

Phase-splitter A1 produces gains of 10.1 and -10.1 and feeds the driver stages A2a, A2b, and A2c. Level shifting is provided by the 78W5 regulator and Rv1, which produce an adjustable reference of +5V to drive an offset current through Rv3, shifting the output level to -10V to -50V. Diodes D1, D2 avoid the op-amps becoming saturated. Since the phase-splitter gain is around 100, the op-amp A1 needs only unity gain, R1 providing this to avoid over-correction.

To fine-tune matching/load-sharing in the valve output stage, replace R4b with circuit A, which will correct balance at zero load. For full-load trim, insert circuit B in series with R4b. Settings of these two adjustments are slightly interactive. To increase the error and therefore assist in adjustment, temporarily short R4.

Sajit Lledale
New Delhi
India

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**Reference**


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Reducing voltage reference noise

Conventional voltage reference circuits, which take the form of a low-pass RC circuit followed by a buffer, as in Fig. 1, have their disadvantages: the errors come from leakage through the capacitor and noise generated in the buffer is added to that from the reference.

To reduce the effect of capacitor leakage to an insignificant level, the RC low-pass circuit goes after the buffer, but within its feedback loop, as shown in Fig. 2, so that errors caused by the leakage are reduced by the buffer loop gain. Leakage errors caused by C₁ are small, since it is in the feedback loop. In addition, having a fairly large value capacitor at the output allows the driving of capacitive loads without instability, the low output impedance being of advantage at high frequencies.

Analysis points to an important result. Overall noise is inversely proportional to the square root of the number of voltage references: 

\[ E_{\text{total}} = E_{\text{ref}} \sqrt{n} \]

where \( E_{\text{ref}} \) is the individual noise of a reference.

Using the Burr-Brown REF 10 with \( E_{\text{ref}} = 10 \mu \text{V pk-pk} \) in the circuit of Fig. 2 gives an overall noise of less than 7 \( \mu \text{V pk-pk} \).

Kamil Kraus

Rokycany

Czech Republic

Fig. 1. Commonly used voltage reference circuit. Problems with this layout are capacitor leakage and buffer noise.

Fig. 2. Modified circuit with the leakage inside the feedback loop and noise reduced by two references.

Loop aerial cuts through the noise

To allow the reception of long and medium waves in an environment polluted with computers and television receivers, this loop aerial and its amplifier, working with a 1m square maximum loop, reduce noise to the background level of the bands.

The business end of the circuit is formed by the input transformer and fet source follower, at long- and medium-wave frequencies, fets show low noise figures at 10kΩ source impedance. Transistor Tr₁ bootstraps out the gate/drain capacitance of Tr₁, the gate-source capacitance being low due to the follower configuration.

Maximising input transformer ratio while keeping shunt capacitance low results from the use of a toroid (Cirkit 55-40001 or Fair-Rite 26-43540001) with two primary turns of audio screened cable with the screen grounded at one end, and 40 on the secondary. The op-amps form a low-noise amplifier driving a 50Ω cable and the other components form a phantom power supply, although a local supply could be used, in the 25-40V range.

J.A. Burnell

Camberley

Surrey

WINNER TTI PROGRAMMABLE BENCH MULTIMETER

Power systems to keep you in touch
Ian Hickman's simple sound generator incorporates an erasable eprom-based waveform generator whose output signal is determined via a Basic routine running on the pc. Ian demonstrates how to use the generator to produce realistic bottom-end wind-oragne notes.

With a sound card in your pc, experimenting with synthetic sounds is straightforward. But there are still benefits in terms of versatility from a small stand-alone circuit, that can be hooked onto - or even into - something else. Here I describe a simple system for generating synthetic sound waveforms.

The circuit was to be minimal and preferably use only common ICs. The arrangement, Fig. 1, was made up on an odd piece of 0.1in matrix prototyping board. It consists of a

erasable eprom, containing data defining the waveform of the sound, reading out its contents sequentially to a d-to-a converter, which reconstitutes the intended sound.

How it works

The eprom address is simply obtained directly from a ripple counter, with one minor modification. The three-inverter oscillator drives the clock input of a CD4040 twelve-stage ripple counter, the twelve outputs of which drive the A0-11 address lines of the prom.

When the normally open push-button S1 is pressed, counting starts from all zeros. The twelfth, most significant, bit toggles the CD4041 D-type bistable IC, via an inverter, on its falling edge. Therefore, A11, the thirteenth address line to the prom, stays high until the button is released.

The result is that the prom initially reads out the data starting at location 0000, through location 0FFF, after which it repeats reading out the data in locations 10000H to 1FFFFH, as long as S1 remains closed. When S1 opens, ICs 2 and 3 are reset, and all address lines return to logic zero. That is at least what happens if S2 and S3 are both closed. In fact, the prom is a 273256D device with a 256K by 8-bit capacity. Switches S2 and S3 control address bits A13 and A14, effectively partitioning the prom into four segments of 8Kbyte each. Thus the prom is capable of storing four different sounds, any one of which may be called up, according to the settings of S2 and S3. With component values shown, the clock oscillator runs at 16kHz.

Many sounds have a characteristic starting transient, and this is stored in the first 4Kbyte half of a segment, the steady-state sound being held in the second half. Thus each sound is reproduced with its own characteristic start-up. The data input to the d-to-a converter is converted to a series of dc levels, each lasting for one period of the clock. The d-to-a converter reference current IREF is defined by R4, the minimum value of IREF at pin 4 being zero, and the maximum being 1.65μA/255. Its completion, first at pin 2, is not used, being spilted to ground.

Current IREF flows through R6 to the output voltage being therefore in the range +5V down to nearly zero. It should therefore be ac-coupled when applied to an amplifier, but when viewed on an oscilloscope, the expected dc-coupled average voltage is of course +2.5V.

Using the sound generator

The circuit can be used to reproduce a sustained sound, created with the characteristic starting transient, or, by storing sound in just the first 4K of a segment, a short transient may be obtained.

In the latter case, all locations in the unused second 4K of a segment should be loaded with the value 7Fh, i.e. 127 decimal. The 127 value represents the mean level of the waveform, allowing a peak output of ±127 least-significant bit relative to this.

A falling minor third

A further example of a non-recurring sound would be the call of the cuckoo, a falling minor third. Each note is about a third of a second long, separated by a similar interval.

Played back over a loudspeaker in a tree at an improbably early date in spring might bring a claim to hearing it first in the local paper. However, my interest was in a more specific application, and I have written a program in TurboBasic to generate the necessary eprom data.

I was interested in trying to simulate the tone of an open flute pipe, as found in an organ in one of our cathedrals or large churches. As with most musical instruments, this has a characteristic start-up. In the case of a flute pipe, this is known as 'chuff'.

In fact most musical instruments are recognised principally by their initial transient, if you come in after the sound has started, it is often difficult to identify which instrument it is.

With an open-flute pipe, the initial transient consists of three separately identifiable parts. When a key is pressed, opening the pallet which admits air to the pipe, the first sound to appear is the noise of escaping wind. Then the pipe starts to sound, but typically it initially tends to 'overflow', producing the second harmonic. These two components are the 'chuff', which then subsides, to a greater or lesser degree, as the sound of the fundamental builds up to the steady state volume.

Unit 1 is the latest version of a program (which is still subject to further development) to produce a waveform sounding like a typical flute pipe. To keep the listing short, all the normal standard features have been removed, and some lines telescoped - hence the gaps in the line numbers sequence.

Basic produces organ data

The program consists of two parts: line 100 to 440, and 1000 to the end. The GOTO at line 136 means that normally, only the second part executes. This draws a picture of the waveform that will be generated, on the screen.

Line 130 defines an amplitude envelope EI, for the fundamental. This builds up linearly to a maximum amplitude of 40 - or such other value as set by parameter F - over points 0 to 190, i.e. the left hand half of the screen, thereafter remaining at that amplitude. The next line defines a sawwave E1 (the fundamental) with thirty two steps per cycle and multiplies it by EI, to give the enveloped fundamental F. Given the 16kHz clock frequency and thirty-two steps per cycle, the frequency of the fundamental is 500Hz.

Lines 180, 1000 do the same for the second harmonic H, except that the envelope builds up linearly to value Y over the first quarter of the screen, and then dies away linearly by half way across, a 'diamond-shaped' envelope.

Lines 110 to 1200 are concerned with the wind noise element of the sound. This is the part that proved most problematic, and is responsible for the program being at version 6 - not counting some unrecorded intermediate versions.

But the original wind noise envelope E3 has basically remained unchanged throughout. It consists of a diamond shape like the second harmonic envelope, but occupying only the first quarter of the screen, rather than the first half, and reaching a maximum amplitude of only 172.

The first attempt at wind noise simply called up 'diamond' enveloped random numbers, but it was soon obvious that this was not quite realistic. So it was low pass filtered by taking a running average of successive random values, initially over 16 points. This was also a failure and I suspected that the noise should be band-pass limited by a formant introduced by the pipe itself.

The noise was therefore band limited to a much lower low-pass filter cut-off, by averaging over 128 samples, equivalent to four complete cycles of the fundamental. The DIM M(128) instruction in line 120 makes an array of 128 numbers. The loop then fills it with 128 random values each in the range -1 to +1.
The circuit is clearly easily modified for other purposes. If only a single type of sound is required, S1 and S2 may be omitted, and a 64Kbit prom used. Alternatively, extra address counter stages could be added, enabling the whole contents of the 256Kbyte prom to be loaded into and played back. The prom would provide the raw waveform for display on the screen, whereas the actual second harmonic, noise was totally unrealistic, and after erasing the prom the waveform had been recorded earlier, the version with white noise included was in binary format, other options include load ram from prom, display options include load ram from prom, display and edit prom, etc. The prom was then fitted in the mix in the zero-insertion-force socket, which gives a useful precaution, as on an older machine (I was using a Compaq Deskpro 586) with the first part of the program is distinctly taut.

For the same reason, line 410 is included as a precautionary, as on an older machine it was using a Compaq Deskpro 586 with the first part of the program is distinctly taut. When a version of the waveform had been produced and downloaded to the machine, it was then loaded into the appropriate pin of the prom, with the trailing edge of the most significant bit of the prom, a red led on the zero-insertion-force socket flashes and a warning message appears on the screen. The program had been recorded earlier, the version with white noise was used, the prom was blank, which also prompts a test for correct connection. This machine does not require the mix to be centred at a higher frequency than 64Hz, the mix is found to be definitely wrong. When a version of the waveform had been produced and downloaded to the machine, it was then loaded into the ram locations 1000 and 2000, etc, would be used if another version of the waveform had been produced and downloaded to the machine, it was then loaded into the prom. When a version of the waveform had been produced and downloaded to the machine, it was then loaded into the prom.

As far as the program is concerned, a few of your mistakes in each of the various versions - yes, loading the data into the appropriate pin of D, defining the first half the program is distinctly taut. The sound of this is rather like blowing across the top of a milk bottle, without actually getting to sound a note - nursery bars of limited white noise. The sound of this is rather like blowing across the top of a milk bottle, without actually getting to sound a note - nursery bars of limited white noise. The sound of this is rather like blowing across the top of a milk bottle, without actually getting to sound a note - nursery bars of limited white noise.

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Schroff UK Ltd. Tel., 01442 240471; fax, 01442 240472. The Deluxe series is 175pF/m and resistance is 50Ω per contact, allowing up to 400 contacts to be connected. The force contacts is 50g per contact, allowing up to 400 contacts to be connected. Insertion force using special low-profile contacts is 0.1N. They meet the relevant Directive 2000/14/EC and comply with MIL-STD-2000.

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Components. Electropower offers its 1997 catalogue, which includes the latest developments in the industry. It is available in a variety of formats, including printed-circuit board and DVD. They are available with analogue output cards and RS232 and RS485 cards per port. Electropower, Tel., 01234 645845, fax, 01234 610282.

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Scientists at BT’s research laboratories believe that artificial muscle will be around next year, but we will have to wait another 30 years for artificial legs. Peter Willis reports on these – and a host more – predictions.

Whatever next?

The good news is that artificial brains will be along by around 2035. But we may not need them – learning will have been superseded by transparent interfaces to smart computers about ten years previously.

Also, by 2025, robots will outnumber people in developed countries and the commercial production of antimatter will have begun. Between now and then, we can look forward to electronic cash displacing paper and coins by 2005, space tourism by 2002, 3D video conferencing and holographic displays by 2015, and full voice interaction with machines by 2007.

Thought control of computer games will be here next year, and wristwatch telephones should be in the shops any time now.

These are just a selection from a list of about 300 planned or expected developments collected from around the world by the techno-seers at BT's Martlesham Heath research laboratories, and published as the 1997 Technology Calendar.

This is no ordinary calendar, although it is designed so you could hang it on the wall. It sorts these breakthroughs into a dozen categories, including telecommunications, devices and machine interfaces, and lists them in order of anticipated first commercial application.

The list starts from this year and ends at 2040, when global environmental management corporations will be inducing artificial precipitation and using nuclear fusion as a power source.

CDs on a roll?
The range of this predictive thinking is both wide and highly detailed. A rice through the future at millennium, 2000, finds “evolving field-programmable gate arrays” and “3D very large scale integration with at least ten layers of devices” alongside “Lethal flat screens 100 times sharper than 1977 tvs but cheaper”, and CDs made on rolls 200 times faster at 3p a disk. Interactive vehicle highway systems will have arrived, and solar cells will be in common use for residential power supply.

The listings are necessarily brief, not to say cryptic at times. I feel I should know what “light detection sensitivity exceeding shot noise limit” is. By 2011, when it’s due, it might well. Likewise TeraFLOPS and PetaFLOPS, both supercomputer speeds, the first due this year, the second in 2003.

On the other hand, “desktop fabrication units” and “active contact lenses” seem self-evident – or do they?

Biotechnology looks like making people obsolete. Before those artificial brains arrive, there will be artificial muscle and artificial pancreas, both next year, and artificial blood and ears in 2000. This will be followed by artificial heart, lungs, kidneys, liver, peripheral nerves and in 2030, fully-functional artificial eyes.

Artificial legs are not due until 2030. Before then, in 2020, artificial insects and small animals with artificial brains will have been developed. No doubt some of these will be programmed to bite robotic mail delivery automata, due about the same time – always assuming anything as old-fashioned as mail remains to be delivered.

And the bad news?
Not all the news is good. Only next year, it says, “viruses based on artificial intelligence will evolve and adapt”, and by 2003, “various forms of electronic addiction will be a big problem.”

The calendar also contains an addendum of various things, such as natural or human social upheavals which could, at any time, throw progress off course. They range from an asteroid hitting earth or the melting of polar icecaps (oceans rise 100 feet) to mega-revolutions and terrorism, international financial collapse, the end of intergenerational solidarity or the collapse of the sperm count.

More ambiguous developments such as the growth of religious environmentalism and “new age attitudes” blossoming with the millenniums, are also listed.

However, provided we survive these, and from about 2010, technology will give us the means to predict natural disasters, there is much to look forward to in the wonder-age of technology. Robotic pens in 2010 for instance, or on-line voting in 2007 and electronic referenda by 2010.

Only next year, we will be able to enjoy “many people sharing a visual virtual space...” I can hardly wait.

But it will not be until 2018 that the ultimate blessing of the electronic age – a video recorder capable of being programmed by adults – is delivered.

Scientists at BT’s research laboratories believe that artificial muscle will be around next year, but we will have to wait another 30 years for artificial legs. Peter Willis reports on these – and a host more – predictions.

Whatever next?

Whatever next?

Whatever next?

Whatever next?

Whatever next?

Whatever next?

Whatever next?
can be calculated. A relatively simple controller may lose track five times a year and have an average mean time between failures of 30,000 hours — more than five years. This adds up to a loss of about 80 minutes of traffic a year, which may sound trivial.

A more sophisticated device, which can be expected to lose track less than once in two years and has a mean-time between failures of 120,000 hours, will not lose track for more than ten minutes a year.

The difference in traffic lost by the two systems over a ten year life will be more than 700 minutes. The value of transatlantic traffic on a big antenna can be $1500 per minute; thus, the more consistent and reliable controller will be worth more than $150,000.

In conclusion, external data inputs can help to correct wind deflections in the antenna and mechanical imperfections in its drives. It also makes it possible to maintain pointing accuracy even though the antenna is always under closed-loop feedback control.

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Microelectronic Switched-Capacitor Filters

Switched-capacitor filters and associated MOS integrated circuits are now an established technology finding applications in the telecommunications and instrumentation fields. With unrivalled breadth of coverage, this book surveys the design techniques of an important class of analogue signal processing systems. An accompanying diskette containing a comprehensive computer-aided design package (IDACAP) enables readers to gain a greater depth of understanding of the described techniques. Containing both source code and actual designs from the basic concepts, this book also provides a solid background in designing basic circuits, advanced circuits and systems techniques.

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High-Frequency Analog Circuit Design

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Introduction to High-Speed Electronics and Optoelectronics

Lasers, fibres, optics and high-speed optical systems share many concepts with microwave devices. Furthermore, microwave-based optoelectronics and microelectronic integrated circuits share evolving principles and technologies. It is only natural, therefore, that students of optoelectronics should be introduced to high-speed concepts in a unified manner. This highly practical introductory textbook for optoelectrical and microwave engineers, applied physicists, and students to develop and identify tools for understanding, analysis, design, and characterisation of high-speed components. Broad in scope, this unique text/reference examines the, complementary nature of electronics and optics and emphasizes high-speed techniques in which the two fields are less differentiated. Beginning with an overview that develops a perspective for the application of analog high-speed technology in general, the book goes on to deserve and circuits used at microwave and millimeter-wave frequencies, optical components, and optoelectronic integrated circuits and subsystems. Particular attention is paid to applications in the area of high levels of interest, and because many of the concepts are applicable in other fields. The book concludes with contributions of the often-overlooked area of measurement and characterization of high-speed devices. Fully referenced and supplemented with hundreds of helpful illustrations.

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Not so perfect CDs
Regarding the news story 'Doubles on digital recording quality' in the March issue, digitally mastered recording is unquestionable, and leads to the almost perfect reproduction of sound. However, in the 15 years I was involved in the development of cd players, saw a considerable decrease in quality.

- Compact discs are pressed by companies who are not aware about the parameters that have an influence on reproduction quality. Reading IEC-1-10 would be a good start.
- Reduced-quality optical systems decrease the optical signal-to-noise ratio, which results in a higher error rate. Although error correction has improved things, this can lead to an audible distortion.
- In the past, the digital and analogue circuits were separate. Today, digital filtering, the d-to-a convertor and the first analogue amplifier are often combined within one IC. This results at least in a higher noise rate, increased distortion and much more crosstalk.
- And do not forget mechanical instability. The maximum allowed tracking error is expressed in thousands of a millimetre. At this size, all component surfaces are rough and imperfect. Moving parts excite everything else – even fixed mounting plates.

The 'experts' should blame the digital recording, but the decay in quality and know-how at compact disc and player production points.

M. Vanderfeestes
Ghent, Belgium

Light reflections
Professor Donald Knuth's theory of the electron as a dynamic, continuously changing object will certainly seem odd to those who are familiar with traditional electronics (EW, May, p366).

In fact, the dynamic model of the electron was first proposed in Berkeley World by Carl, Davidson and Watson in December 1979. They argued simply that logic pulse moves at the velocity of light and is strongest down by the time needed to accelerate electrons. Then, electrons must have an internal motion of light speed, so that their motion is strongly deflected by the pulse.

Another argument is the velocity of light itself. Why is it constant regardless of the energy of the electronic entities? The answer is that the internal motions of the electrons add up to light speed.

When an electron is moved along, at say half light velocity, then the internal speed (say electron spin on internal motion) is reduced from light speed to half that.

Vigel Cool
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Old glue news
It is a pity that you spent one and a half pages on a solution known for more than 30 years.

In 1966, we used a dual component bag from the manufacturer 3M. With a gentle pull in the middle of the bag the internal separation joint could be opened so that the upper and lower contents could be mixed without dirty hands or tools. This viscous mixture was used to fill isolation moulds at joints of high voltage cables.

Hv Vanderfeestes
Ghent, Belgium

I wonder who supplied 3M SB.

Had I node beforehand
Readers interested in circuit simulation software - specifically Spectrum Software's MicroCAD IV evaluation version - may welcome this comparison note.

For anyone wishing to simulate small analogue circuits, MICROCAD looks an attractive proposition. Within a limit of 25 nodes it offers the full modelling and simulation capabilities of MICROCAD and costs only £59. Having been impressed by Spectrum's free demonstration of MICROCAD, I purchased a copy of MICROCAD believing it would meet my immediate needs.

But the stated node limit is misleading. Despite the software itself identifying 25 or fewer nodes in a circuit, the analysis may nonetheless refuse to run because of nodes hidden within certain circuit components. A decade has one hidden node, for example, a bipolar transistor two. As a result, circuits you might reasonably expect to be analysable are not.

Simpler phase quadrature
There is a much simpler procedure for designing phase quadrature circuits (first described by Professor Regel in the last issue of EW). The underlying principle relies on modulo four arithmetic for expressing the geometrical quadrant of any rotary oscillations in which at least two cycles are completed in order to comply with the requirements for sampling at the Nyquist frequency.

The initial step is to construct a square with one of its vertices located at the origin of a Cartesian graph system and two of its sides aligned over the X and Y axes, respectively. The four edges are then regarded as the ratio arms of a Wransen's bridge and the principal diagonal from the origin as the nulling meter connection.

Differential quadrature phase shift over a restricted range of frequencies can then be calculated in terms of modulo (poly)arithmetic by interpolative projection of an appropriate series of Y values among a second series of appropriate X valued pairs that define the finite Fourier transform governed by modulo four arithmetical (see diagram). The procedure can be extended to second order processing and automatic signing of complex signal patterns by rotating the initial circle around the origin into the remaining three quadrants of the initial Cartesian graph system taken as reference phase. The methodology is essentially a generalisation of the concept of "least squares" used in statistical practices.

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Initial contract period is normally for three years but shorter periods can be negotiated. Other benefits include a gratuity of 50% in the first year, 55% in the second year and 40% in the third year at 50%, support for approved research; appointment and reparation fees, leave fares for staff member, spouse and two authorised dependants after 18 months of service, settling-in and settling-out allowances; six weeks' paid leave per year, education fares and assistance towards school fees for two approved dependants, free housing. Salary protection plan and medical benefit schemes are available. Staff members are also permitted to earn from consultancy up to 50% of earnings annually. Salary is subject to CPI increases. Exchange rate stabilisation on the international component of salary and on gratuity payments is payable.

Detailed applications (two copies) with curriculum vitae, including certified copies of qualifications obtained and names, addresses and telephone numbers of three referees and an indication of the current availability to take up the appointment should be received by: The Registrar, PNG University of Technology, Private Mail Bag, Lae, Papua New Guinea by 28 June 1997. Applicants resident in the United Kingdom should also send one copy to the Personnel Office, University of York, Heslington, York YO1 5DD. Please quote the reference number from whom further information may be obtained.

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