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Volume production has now enabled us to offer this powerful programmer at a very competitive price for a product of such high quality. The Expro-80 has undergone extensive testing and inspection by various major IC manufacturers and has won their professional approval and support. Many do in fact use the Expro-80 for their own use!

The Expro-80 can program E/EPROM, Serial PROM, EPROM, DSP, PLD, EPLD, PEE1, GAL, FPL, MACH, MAX and MPU. It comes with a 42 pin DIP SDIP socket capable of programming devices with 8 to 42 pins. It even supports EPROMs to 16Mbit, the PIC16 series of MPUs and many many more without the need of an adapter. Adding special adaptors, the Expro-80 can program devices up to 84 pins in DIP, PLCC, LCC, QFP, SOP and PGA packages.

The unit can also test digital ICs such as the TTL 74/54 series, CMOS 40/45 series, DRAM (even SIMM/SIP modules) and SRAM. Furthermore it can perform functional vector testing of PLDs using the JEDEC standard test vectors created by PLD compilers such as PALASNI, OPALjr, ABLE, CUPL etc. or by the user. The Expro-80 can even check and identify unmarked devices.

The Expro-80's hardware circuits are composed of 42 set pin-driver circuits each with control of TTL I/O and "active pull up", D/A voltage output, ground, noise filter circuit and OSC crystal frequency.

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The pull-down menus of the software makes the Expro-80 one of the easiest and most user-friendly programmers available. A full library of file conversion utilities is supplied as standard.

Sunshine's team of over 20 engineers are continuously developing the software, enabling the customer to immediately program newly released ICs.

Citadel, a 32 year old company are the UK agents and service centre for the Sunshine range of programmers, testers and in circuit emulators and have a team of engineers trained to give local support in Europe.

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CIRCLE NO. 103 ON REPLY CARD
Matchsticks and magic mushrooms

"We do tend to push the weaker girls towards IT" the headmistress of one of the better girls' schools confided in me, as we discussed the use of computers in education.

So there it is. IT is the Domestic Science of the 90s. Just fit only for cotton-heads that ought to be a bedoot and not a rabbit by the time they're sixteen, and would have been well, their parents' weren't so well-to-do. The sort of girl that's lucky to be leaving school with any sort of qualification. So push 'em towards IT. As for the more academically-minded girls, well - who can blame them if they consider computers and everything to do with them beneath their dignity?

I read in a recent issue of CUE's Newsletter (Computer-Using Educators, Inc., of Alameda, California): "The dilemma in 1990: we had the technology, we could create powerful, well-designed word-processed documents, charts and graphs, we named it. What power to unleash in a classroom. Unfortunately my students and I shared the same secret - all of these skills only counted in the computer classroom." Schandler, writer of the article entitled A Goal Without a Plan is a Dream, goes on to recount how things have changed. "The lab had moved from the place where students were learning skills that had little relevance to their real or academic lives into a studio where tools were made available and creatively used."

Assuming that Ms Schandler is not talking through her sweatband, then by comparison we in the Great Britain of 1995 are stuck in a 1980s timewarp. I didn't say 1990s because in the eighties we were ahead of the curve. Those of us for whom time (and patience) is in short supply refer to the world of the 80s (even if we didn't use them enough to sidestep the mainframe). Chris Abbott, writing in Educational Computing and Technology, November 1994, recounts the experience of visiting teachers who had come to this country to see what had been achieved by the network of LEA centres, that most of them have closed. "The 1993 Education Act suggests that private sector centres will develop overnight, like so many mushrooms, where LEA centres close. No such magical events have taken place." He judges that, "there are only two kinds of purpose at lowest possible cost -

"Both of course have their own agenda. Industry will argue, as its running-dogs have been doing in the correspondence column of Computing, that children must be taught on 'industry standard' software and facebooks. 'Who'd employ somebody trained on an ancient system?' seems to be the mantra as far as they are concerned."

"Of course there were indignant replies pointing out that children being 'trained' now won't be looking for jobs for another ten years - and what price now the industry standards of ten years ago? But the computers, five-inch displays, 80 columns of memory, CISC-COBOL, look as the only way to programme a serious commercial application on a pc. If you were silly enough not to do so, the mainframe."

If people really believed that, when purchasing for the classroom, they would not buy fashionable industry standard systems which "trained", but then proved, time-proof ones which "taught" (Our widespread packages which are supposed to explain as closely as the budget will allow, what is out there in the Real World. I would come modelling media in which the mechanics of a word processor or a financial package (or genetic modelling or an atomic pile) could be modelled, in terms which the pupil (and even the teacher) could grasp. So it boils down to the choice of a goody, cheap durable modelling mylum, one people build models out of matches.

Especially prisoners, who have all the time in the world. Presumably they would use a level programming language to build a software model.

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switch for 500Gbit/s data

Researchers at the Electro Technical Laboratory in Japan have recently developed an ‘Auston’ switch that can produce electrical pulses only 570fs in duration. This very fast electro-optic transducer opens up the prospect of communication at data rates above 500Gbit/s.

The switching element is a gap only 100nm wide between the ends of two titanium strips laid down on the surfaces of a special gallium arsenide substrate. The switch is triggered by a 40fs laser pulse focussed onto the GaAs surface through the gap. The incident energy causes electron hole pairs to be formed in the substrate, briefly connecting the strips together. The narrow gap and the special cold grown substrate, which ensures that residual pairs recombine rapidly, mean that the switch turns off again in less than 600fs.

Actual measurement of the switch closure time is performed using a lithium-tantulate crystal connected to the switch by a transmission line. The electrical pulse from the switch passes under the crystal, changing its refractive index. This change is detected using light pulses from the same laser.

The switch cannot be used as a receiver in current optical communications systems because light from existing optical fibres has insufficient energy (the wave length is too long) to trigger the switch. Development of an effective optical ‘up converter’ is needed before the full potential of the switch can be realised. The only current practical use is as a detector in nuclear accelerators where the electron-hole pairs are formed by particles passing through the substrate.

Steve Bush, Electronics Weekly

Chip growth beats expectations

Chip boom expectations for the third successive year are causing semiconductor industry analysts to revise their market forecasts for 1995 in a hurry.

Motorola has jacked up its capital expenditure plans this year to $4.5bn, compared to $3.3bn last year, forecasting chip market growth between 17 and 21 percent this year.

Jerry Junkins, president of Texas instruments, reckons that the world chip market will grow 21 percent this year to reach $124bn compared to $100bn in 1994.

Mike Glennon of US market analysts Dataquest, which had forecast 14 percent worldwide growth for semiconductors this year said, "My personal opinion is that 14 percent was too low; in Europe we’re looking at a 15 to 20 percent rise and world-wide we could be seeing 20 to 25 percent increase this year."

If the forecasts turn out to be correct, this will be an unprecedented third year in a row for 20 percent plus growth in the semiconductor industry. In 1993 the industry grew 31 percent, says Dataquest, and last year it grew 28 percent.

TI believes the European market will grow 22 percent, the US market 22 percent and the Japanese market 17 percent. But the star of the show will be non-Japanese Asia (‘Asia-Pac’) with growth of 32 percent.

Suppliers pressure BT on high ISDN prices

Supplier equipment suppliers ganged up on BT at last week’s London ISDN user show, forming a pressure group to force reductions in ISDN charges. They are angry at the high price BT charges for installing basic-rate ISDN lines, claiming it is stifling the ISDN market.

Although BT is running a special offer of a £300 installation fee, down from £400, this is still much higher than France’s £80 and Germany’s £50. Some suppliers say Mercury should enter the basic rate market (Mercury only supplies primary rate ISDN) and force BT into a price war.

At the show, suppliers held the inaugural meeting of Agis (Action Group of ISDN suppliers), aiming to pressurise BT and exchanging information to ensure interoperability of equipment. Mark Heath, ISDN marketing manager for Chase Research, said: Our intention is not to be a beat-up BT group, although everyone would like to beat them up."

BT agreed to send a representative to an Agis meeting to answer questions. More queries will no doubt be voiced by Dataflex Design, one of the group’s founding members, which went into liquidation in mid-February but has now been bought out by Amstrad.
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CIRCLE NO. 104 ON REPLY CARD

April 1995  ELECTRONICS WORLD+WIRELESS WORLD  269
SiC grows into power player

Faster power semiconductors, handling substantially higher voltages and temperatures, could be appearing in commercial applications within three years, according to latest Swedish research. The performance breakthrough will come through projected advances in silicon carbide (SiC) technology from which the new devices will be fabricated.

Theoretical advantages of silicon carbide have been known by electronics engineers for some years. But its high melting point and extreme hardness – the very properties that have given it such popularity in the tooling industry – have made practical electronics application difficult.

Now, findings from a joint power semiconductor research programme conducted by ABB, Industrial Microelectronics Centre and Linköping University, predicts that commercial production of simple devices using SiC will be possible within three to five years. Resultant devices should need less space, have much lower power losses and generate fewer harmonic currents than conventional power semiconductors.

The attraction for power specialist ABB is that the technology could be applied to high-voltage ac (hv-ac) and possibly high-voltage dc (hv-dc) power transmission. But SiC could also enable electronics to be used in environments that have previously proved too extreme, such as car engine and automotive applications and melting furnace sensing.

All three research organisations have now moved into the second phase of their development programme, aimed at commercialising the process.

Competition for Intel's P6

Cyris says its MI microprocessor can take on the Intel P6 and win according to its architect, Mark Bluhm. The firm is readying the microprocessor for a June introduction with samples now being delivered to key customers. "The figures being put out by Intel show the P6 has about a 33 percent performance advantage over Pentium, given equal clock rates," said Bluhm. "What we are seeing with the MI is a two times performance increase over the Pentium in some benchmarks and overall a 50 percent advantage."

The current MI samples run at 100MHz and Cyris plans a 133MHz version to be available early next year. By the third quarter this year Cyris anticipates it will be shipping about 100,000 units a month. The majority of those chips will be manufactured by IBM and delivered to about five key customers. "We've got a P6 class machine that will be delivering revenues months before Intel," added a Cyris spokesman. "At least one of the customers we are currently sampling plans to make the MI their high-end microprocessor."

Cyris originally planned to introduce the MI late last year but problems forced it to delay the chip's introduction. The MI is similar to the P6 in that it uses a super- scalar, super-pipelined design.

Cellular battle

Mobile communications suppliers Motorola and Interdigital Communications have begun a court battle which could have significant implications for the whole cellular telephone industry. Motorola is the first to contest Interdigital's patent claim over the tdma channel coding protocol forming the basis of most digital mobile 'phone networks, including GSM.

Interdigital is reported to have asked Motorola for a $200m royalty patent. Motorola claimed the patents were invalid and Interdigital is pressing for increased damages and an injunction to stop Motorola making TDMA phone systems.

AT&T, Siemens and Matsushita have agreed licences with Interdigital, but the world's largest suppliers are awaiting the outcome of Motorola's court case, which is expected to last until April.

Videoconference standard for analogue lines

Telecommunications manufacturers and operators plan to finalise a videoconferencing standard by the end of the year. It will support videophone and data services over existing analogue telephone lines. The ITU standards committee has approved a first draft of the H.324 videoconferencing standard which is the analogue line equivalent of the H.320 ISDN-based standard. The intention is to have a final draft ready by November with the first analogue pc videophone cards expected to appear early in 1996. Effectively this will kill off attempts by BT and AT&T to impose proprietary protocols.

The standard will lean heavily on existing data transmission protocols and silicon. H324 uses the V.34 28.8kbit/s data modem protocol, and the channel is divided into a 5.3 or 6.3kbit/s audio stream using a new audio compression algorithm. This leaves around 22kbit/s for compressed video. Core video compression is the discrete cosine transform based H.261 algorithm used in H.320. To achieve the level of compression needed to squeeze 30 frames/video picture into a 20kbit/s stream, an interpolated motion estimation on P and B frames, similar to that used in the MPEG standard, is implemented.

According to Mike Whybray of BT Research's video group at Martlesham, picture quality is still limited by the 20kbit/s bit rate. "It is better than existing analogue videophones but not as good as two channel ISDN videophones", he added.

UPDATE

Reflective and extreme hardness – the very materials for some years, have been known by electronics engineers for some years.

SiC grows into power player

Faster power semiconductors, handling substantially higher voltages and temperatures, could be appearing in commercial applications within three years, according to latest Swedish research. The performance breakthrough will come through projected advances in silicon carbide (SiC) technology from which the new devices will be fabricated.

Theoretical advantages of silicon carbide have been known by electronics engineers for some years. But its high melting point and extreme hardness – the very properties that have given it such popularity in the tooling industry – have made practical electronics application difficult.

Now, findings from a joint power semiconductor research programme conducted by ABB, Industrial Microelectronics Centre and Linköping University, predicts that commercial production of simple devices using SiC will be possible within three to five years. Resultant devices should need less space, have much lower power losses and generate fewer harmonic currents than conventional power semiconductors.

Cyris says its MI microprocessor can take on the Intel P6 and win according to its architect, Mark Bluhm. The firm is readying the microprocessor for a June introduction with samples now being delivered to key customers. "The figures being put out by Intel show the P6 has about a 33 percent performance advantage over Pentium, given equal clock rates," said Bluhm. "What we are seeing with the MI is a two times performance increase over the Pentium in some benchmarks and overall a 50 percent advantage."

The current MI samples run at 100MHz and Cyris plans a 133MHz version to be available early next year. By the third quarter this year Cyris anticipates it will be shipping about 100,000 units a month. The majority of those chips will be manufactured by IBM and delivered to about five key customers. "We've got a P6 class machine that will be delivering revenues months before Intel," added a Cyris spokesman. "At least one of the customers we are currently sampling plans to make the MI their high-end microprocessor."

Cyris originally planned to introduce the MI late last year but problems forced it to delay the chip's introduction. The MI is similar to the P6 in that it uses a super- scalar, super-pipelined design.
Placing Europe among the leaders in ultra-fast a-to-d converter design, folding interpolating technology uses analogue preprocessing to produce a re-entrant transfer function (above). This reduces the number of comparators needed, which in turn lowers power consumption relative to full flash designs. The re-entrant technique reduces the number of input stages needed since quantisation levels between comparator stages are interpolated. In addition, analogue preprocessing of the input means each comparator detects more than one level of input. UK company Phoenix Design, in collaboration with Thomson, is currently working on a folding interpolating device capable of converting 8 bits to 1GHz. This type of device is needed for example in spectrum-surveillance radar counter measures. The technique is already being used to produce commercially available byte-wide converters operating to 650MHz.

Well off the rails...
Douglas Self’s otherwise excellent article on power amplifier distortion derived from the power supply was marred slightly due to the erroneous replacement of Fig. 12 by a duplicate of Fig. 6. Here is the correct Fig. 12. Apologies to you, the readers, and to Douglas of course - ed.

Building the Tesla coil?
Malcom Wells, author of the article on Like Lightning in the March edition, has sent us these further notes that will be of interest to anyone thinking of constructing Tesla’s coil.

It is interesting to note that the main secondary of Tesla’s very large Colorado Springs coil has a height/diameter ratio of 1.25:1. This, according to a table of values compiled by Medhurst, gives an optimally low value for ‘H’ of 0.46 in the secondary self-capacitance equation of my article. Also, the secondary was mounted well off the ground, which further reduced its capacitance. The very useful formula developed by Medhurst allows a coil to be designed for a predictable resonant frequency, to avoid clashing with radio beacons.

In my article, in the box entitled Essential Equations, there was an error in the equation relating to the minimum height per turn for the primary coil. In addition, the equation should have been separated from the text. The equation should have read,

\[
\text{Minimum height per turn} = \left[ \frac{3V_c}{N_p} + D_{\text{wire}} \right] \text{mm}
\]

where \(V_c\) = peak primary capacitor voltage in kilovolts, \(N_p\) is the number of turns and \(D_{\text{wire}}\) is the diameter of the pipe – which should be as large as possible – used for the primary coil in millimetres. This gives a minimum clearance of 3mm/kV between turns.

The sphere should be mounted 2mm above the secondary, and finally, the toroidal terminal should be mounted \(d_1/2\)mm above the coil.
No-cavity laser

As the laser melts tooth enamel to improve cavity resistance, a computer monitor plots the temperature of the tooth during heating up and cooling. (Picture James Montanus)

Few people, outside the most fanatical of curry eaters, will have wondered what it might be like to have their teeth melted. But if scientists from the University of Rochester and Eastman Dental Center reach their goal we could all one day share in that experience — and have healthier mouths into the bargain.

The trick is, say the researchers, to use a specially-tuned CO2 laser to raise the outermost 5μm of the tooth to 1000°C, instantaneously melting, then fusing, the enamel coating. Enamel that is more chemically resistant to the acids that cause cavities should be the effect, with fewer fillings needed.

The laser is tuned to 9.3 or 9.6μm, rather than the conventional 10.6μm, as at these wavelengths the light is absorbed almost completely by the enamel. This, and using 25 100μs pulses at a time, enables the surface of the tooth to be melted while its core is unaffected. When the enamel fuses after treatment, it is claimed to be 70-85% more resistant to attack — a figure reached by dunking treated teeth in acid for 7h then in a saliva-like solution for 17h to simulate conditions in the mouth.

So far the researchers have used only extracted teeth in the laboratory, and more studies are needed before tooth melting is a useable technique for dentists.

Follow the road to driverless cars

Feets of autonomous vehicles effortlessly steering their way between our towns and cities may be the stuff of science fiction. But work being carried out at the Robotics Institute, Carnegie Mellon University, and the National Institute of Standards and Technology (Nist), is bringing that day ever closer. Nist has already linked together a perception system and steering/control on a robotic vehicle.

Now, using a new algorithm (Henry Schneiderman and Marilyn Nashman, A discriminating feature tracker for vision-based autonomous driving, IEEE Transactions on robotics and Automation, Vol 10, No 6) the vehicle has been kept centred in its lane, under a variety of conditions, at speeds of up to 100km/h. It was even able to keep on track in the rain, at dusk and at night with headlights.

The researchers say that their new algorithm is different because it explicitly addresses the uncertainty concerning how quickly the road changes with time, and also takes into account the uncertainty of the visibility of lane markers in each individual image. As a result the vehicle is able to cope with 7m gaps in lane markers (pavements edges, white lines etc) and momentary loss in their visibility.

Though the system is reported to have performed well, the researchers say they must now develop algorithms of increasing reliability and robustness under all driving conditions.

Dope hope for drams

Large doping concentrations required for some elements of high-density drams make in situ arsenic doping of polycrystalline silicon an attractive option for vias or substrates. With arsenic, autodoping effects on access devices are lower than with phosphorus-doped polycrystalline silicon.

But transferring arsenic doping development technology into manufacturing reality has been difficult because of slow deposition rates and radial non-uniformity across the wafer caused by addition of the dopant gas.

RPS Thakur and C Turner of Micron Semiconductor look to have found a straight-forward solution using conventional low pressure chemical vapour deposition (Appl Phys Lett, Vol 65, (22), pp.2809-2811).

The two researchers have simply used a standard vertical thermal reactor to deposit a stack of doped and undoped layers up to a target thickness. Redistribution of the dopant is then achieved by post-annealing.

The method could be easily integrated for high volume production of thicker polycrystalline silicon films used for dram access memory cell capacitor plates in cmos semiconductor technology.
Splinter in the eye could be a chip

Successful bench-testing of a prototype microchip retina, designed to be surgically implanted in the eye, is being hailed as real advance in development of a bionic vision system. Such a system could help overcome one of the world’s most common forms of blindness.

In a complete system, the ultra-thin microchip will work with a miniature camera and laser fitted on a pair of spectacles. Its purpose is to by-pass defective rods and cones by stimulating healthy nerve cells in the eye directly with tiny electrical currents. If successful, the project could mean a breakthrough for people suffering from retinal diseases where the rod and cone cells – the cells in the eye that receive light – have been destroyed.

Retinitis pigmentosa is the leading inherited form of blindness, affecting about 1.2 million people worldwide. The condition causes a slowly progressive loss that first affects peripheral vision but eventually consumes all vision. Similarly, macular degeneration impairs central vision and removes the ability to read, though peripheral vision is maintained. In both, the healthy retinal nerve cells that would have passed on the visual signals from the rods and cones cannot transmit that information to the brain. Blindness is the result.

Now, in a project led by Professor John L Wyatt of Massachusetts Institute of Technology’s Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics, and by Dr Joseph F Rizzo of the Massachusetts Eye and Ear Infirmary and Harvard Medical School – a wide variety of scientists from different fields is making progress towards a working technology.

So far the team has designed, and successfully bench-tested, a prototype of the microchip, using an external laser. The laser powers the chip via an invisible infrared beam that will also convey the visual information sensed by a tiny electronic camera (the researchers have not yet tested the laser with the camera). Both camera and laser will fit on a pair of spectacles.

As part of the programme, researchers have also developed new techniques for implantation and have completed a number of tests to determine the electrical stimulation thresholds of cells in the eye.

Many challenges still lie ahead, with perhaps the greatest being the potential for damage to delicate retinal tissue at the interface between retina and implant.

But the team’s immediate objective is to refine the method for applying the silicone coating now used on the implant. Tests have revealed tiny leaks in the coating, so a more reliable encapsulation method must be developed, possibly employing new materials. Even the smallest leak of salt from the eye into the implant would destroy the function of the chip.

So far the researchers have successfully recorded signals from the visual part of animal brains following electrical stimulation to an area of the retina roughly as large as the implant will stimulate. The next major goal will be surgical implant of the completed prostheses and verification of the brain’s response to the implant.

Toning up hearing aid control

Clever design of a small, simple and low power wireless receiver promises to make life a little easier for the hard of hearing.

Building the receiver into a hearing aid will allow users to vary their aid volume via simple remote control, while the dual-tone multi-frequency technology exploited is only a small step away from wireless programmes of suit individual ear characteristics.

The volume-control receiver measures 1918μm by 1109μm and is being fabricated in low-threshold-voltage cmos by AMS International of Austria. It has been designed by Alexander Reyes and Edgar Sanchez-Sinencio at Texas A&M University, and J Francisco Duque-Carrillo at the University of Extremadura in Spain (A Wireless Volume Control Receiver for Hearing Aids, IEEE Trans on Circuits and Systems I: Analog and Digital Signal Processing, Vol 42, No 1, 1995). The design has three main blocks: a detector to select the correct incoming dtmf signals; a decoder to process the frequencies and decide if a valid command is present; and a gain stage which changes the volume of the hearing aid to a new value.

Frequency range for most hearing aids is 100Hz to 8kHz, so audio frequencies are used to activate the receiver, with the dtmf control frequencies selected to avoid harmonics and distortion.

Previously, dtmf receivers have called for at least two filters and usually amplitude detectors, digital logic, voltage references, zero crossing detectors etc. Typically they are implemented in a layout at least 2.4 by 3.2mm and consuming 1.25mW.

But high performance of the new receiver – it detects and decodes audio frequencies within 0.41% of their nominal values – has been obtained by squeezing the most out of each of the various sub-circuits. For example the operational transconductance amplifier (ota) yields a high voltage-gain of 87dB, and dissipates only 9.3μW, while the single switched capacitor bandpass filter provides high Q and a variable centre frequency control from minimum capacitance area.

Finally, static flip-flops replace other common memory cells, reducing the space needed to implement the control logic.

Using a similar design to decode and store the configuration for hearing aid signal-processing-unit-equalisers could allow the next generation of programmable units to break free of the physical connections now necessary to customise a hearing aid for individual hearing characteristics.

Small-size and low-power dtmf receiver designed to make life more comfortable for hearing aid users.
**Squeaks of pleasure**

For serious audiophiles already feeling nervously inadequate about how the upper limits of their equipment may be affecting enjoyment (see Ben Duncan’s article this issue, and Letters, passim), there is good news: cds may no longer be limited to their miserably deficient (?) bandwidths. Any technique to increase the bandwidth and dynamic range of cds and dat has the problem that it has to be compatible with current products. Unfortunately, as Mituya Komamura of Pioneer Electronics Corporation reminds us (Wide-band and wide dynamic-range recording and reproduction of digital audio, J Audio Eng Soc, Vol 43, No 1/2, 1995), previous work has shown that high-frequency components in music above 20kHz induce the activation of α-electroencephalograms and can affect the perception of sound quality. He also points to a wide-band dat recorder, able to record frequency bandwidths up to 44kHz, that has been gaining a good reputation with audio engineers.

Komamura’s solution is that input digital-audio data could be organised by 16bits at 96kHz sampling frequency, and band-limited up to 36kHz by a low-pass filter. Low-pass output would be split into two sub-bands (dc to 24kHz and 24-36kHz) by a quadrature mirror filter bank. The 96kHz sampling frequency of the lower band signal could then be divided by two, and the higher one by four, so that the sampling frequencies become 48 and 24kHz.

The higher band signal would then be coded by two-bit adpcm and embedded in the least significant bits of 16bit data slots. Such a system would have a bandwidth 1.5 times that of conventional technology. The lower band, coded by 15bit noise shaping quantisation with subtractive dither, would have a dynamic range wider than that of cd and dat but would be compatible. It makes my α-electroencephalograms syncopate just to think about it.

---

**Satellite tomography maps out ionospheric disturbances**

Joint US and Russian trial of a monitoring method that allows electron densities in the upper atmosphere to be plotted as a ‘map’ has opened the door to better prediction of the ionospheric storms that disturb radio signals and wreak satellites. The technique – ionospheric radio tomography – has been around for some years. But it is only as a result of the US/Russian study, directly comparing satellite radio tomography with conventional approaches, that the technique has been shown to give good results (International Journal of Imaging Systems and Technology, Vol 5, pp 149-159).

The ionosphere is a highly variable part of the atmosphere between 100-1000km. In radio tomography, a satellite sends radio signals through the ionosphere to receivers located at intervals on the ground. Analysis of the radio signals once they reach Earth indicates variations in the density of the electrically charged gas that makes up the ionosphere. The variations can be plotted as contour maps that indicate the general structure of the ionosphere, including small-scale phenomena.

Conventionally, the large radar facilities used to produce images of the ionosphere – there are currently six in the world – are expensive to build and operate, precluding a large world-wide network. But radio tomography opens up the real possibility of global maps of the ionosphere because the receivers involved are small and portable, and can be widely distributed.

In the US/Russian experiment, the scientists placed four receivers provided by the Russians in a north-south line along the north-eastern US and eastern Canada. Russian navigation satellites flew over these sites every hour, sending down radio signals to all four receivers simultaneously. The resulting data were then analysed to produce an image of the ionosphere using mathematical algorithms developed by the Russians.

Air Force scientists also placed US receivers at the same four sites and recorded signals from US satellites, analysing the data with their own set of algorithms. Images produced by the US and Russian experimental tomographic techniques were then compared to actual images of the ionosphere made over the same period from the Millstone Hill radar facility in the America.

The result? Both the tomographic images “compared very well to the Millstone Hill results,” according to principal investigator for the work John Foster of the Atmospheric Sciences Group, MIT Haystack Observatory.

A bonus to the experiment is that it coincided with a severe ionospheric storm. The large amount of data on the storm, coupled with the severity of the event itself, means that scientists “will publish many more papers on the geophysics of what took place,” concluded Dr Foster.

---

**Radio tomography plot obtained with the Russian Cicada navigation satellite shows good agreement with the conventional plot from the radar station at Millstone Hill. The plots show the situation shortly after onset of the severe storm.**
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Interference from the mains can degrade performance in sensitive instrumentation. A simple notch filter will not always remove hum due to frequency and component drifts, but Radhakrishna Rao has designed a self-tuning filter that overcomes the usual problems.

Active notch filters have become indispensable in many applications where a signal is corrupted by a dominant, single-frequency interference signal. Such a signal is the 50Hz power supply hum in bio-medical systems.

The analogue front-end proposed here is for cancelling the 50Hz power line interference and its harmonics from ecg-emg signals in bio-medical applications. The configuration uses only operational amplifiers and matched mosfets. It requires no precision components and is based on a simple frequency-correction scheme using both phase and magnitude comparison. The scheme could be implemented as a monolithic device.

Common problems

When the frequency of the interference signal is fixed and known, a symmetrical narrow-band notch filter can be used to remove it. For this, the pole \( \omega_p \) and zero \( \omega_0 \) frequencies of the filter must be made equal to the interference frequency using precision, low-tolerance passive components.

In practice, either there is an uncertainty in the frequency of interference or there is a drift in the values of passive components that determine \( \omega_p \) and \( \omega_0 \). Furthermore, the tolerances of passive components cause \( \omega_p \) to be different from \( \omega_0 \).

The solution to this problem involves a self-tuning notch filter. Here, the filter is automatically tuned to the incoming interference frequency by making both \( \omega_p \) and \( \omega_0 \) voltage-controlled.

Power line interference consists of the dominant 50Hz component and its harmonics at 100Hz and 150Hz. The four op-amp modified Kerwin-Huelsman-Newcomb biquad is used for the basic notch filter owing to its low passive and active parameter sensitivities, especially at low frequencies. For this filter, Fig. 1a, both \( \omega_p \) and \( \omega_0 \) are determined by the same set of passive components. Independent outputs for bandpass, lowpass, highpass and notch are available simultaneously. These are voltages \( V_1, V_2, V_3 \) and \( V_4 \) respectively.

The filter is tuned to the incoming interference frequency by replacing the frequency-determining resistors with voltage-controlled resistors. The control voltage for these is derived by a frequency-correction scheme. As Fig. 1a shows, the frequency-determining resistors, \( R_1 \) and \( R_2 \), have been replaced by voltage-controlled equivalents using matched pairs of linearised CD4007 mosfets. The T-network is used to increase the effective variation in resistance offered by the fet. Since a notch filter needs to be tuned, a scheme for filter zero tuning is more appropriate. This is because zeroes control the significant characteristics for the notch filter. Such a scheme is
shown in the lower half of Fig. 2.

Frequency correction in this method is based on both magnitude and phase comparison using notch and highpass or lowpass outputs for deriving the error signal. The magnitude of this error signal is proportional to the difference between the input frequency and the zero frequency to which the filter is to be tuned and is obtained using the notch output.

The direction of tuning is obtained by detecting the phase difference between notch and highpass outputs. The magnitude of this error signal is then compared with a reference voltage ($V_{ref}$) in order to generate a dc control voltage ($V_0$) which is used for varying the voltage controlled resistances in the filter. The above arrangement, thus, forms a stable negative feedback frequency-correction loop.

The analogue front-end is then developed as shown in Fig. 2. A cascade of three modified KHN biquads with notch frequencies at 50Hz, 100Hz and 150Hz is employed. The first-stage

The voltage-controlled resistor

When mosfets are operated in the non-saturating region with small values of $V_{DS}$ ($V_{DS} \leq V_{GS}-V_T$) the drain-to-source resistance is almost linear and bi-directional. By varying the gate voltage, the drain-to-source resistance can be altered and the device acts as a voltage controlled resistor.

Feeding back half the drain voltage to the gate with two large-value resistors, extends the linear operating range. The advantage of using matched mosfets is that precisely matched resistors can be avoided.

Mos theory demonstrates how the drain-source resistance varies.

In the current saturation region where $V_{DS} \geq V_{GS}-V_T$,

$$I_{DS} = K(V_{DS} - V_T)^2$$

In the non-saturating region where $V_{DS} \leq V_{GS}-V_T$,

$$I_{DS} = 2K \left( \frac{V_{DS} - V_T}{2} \right)^2$$

$$I_{DS} = 2K \left( \frac{V_{DS} - V_T}{2} \right)^2$$

$$I_{DS} = I_{DS1} + I_{DS2}$$

$$V_T = \frac{1}{2K(V_C - V_T)}$$

Part of a 4007 CMOS dual complementary pair is used for its matched mosfets.

External connections are made according to the dotted lines.

The resulting circuit is a pair of linearised matched mosfets which are used as a voltage controlled resistor.
notch filter is self-tuned to the incoming interference frequency - the dominant 50Hz component - using the above scheme.

The second and third stage notch filters are self-tuned to their respective notch frequencies (100Hz and 150Hz, these being the harmonics of the 50Hz component) using the master-slave approach. To this effect, the first-stage filter is taken as the 'master' and the second and third stage filters as the 'slaves'. The frequency determining resistors in the slaves are replaced by voltage controlled resistors of the same value as for the master's. Matched pairs of mosfets are used for this. The control voltage for these resistors is obtained from the same tuning circuit for the master, Fig. 2.

With this mechanism the zeroes of the slave filters, which are filters with notches at 100Hz and 150Hz, are made to track the zeroes of the master, a filter with a notch at 50Hz. Notch frequencies for the slaves are now determined only by the ratios of capacitor values of the slaves to the master's.

Fets rather than multipliers are recommended for voltage controlled resistors. This is because the tuning range obtained using fets can be made just sufficient to cancel the varying frequency components. These are typically 48 to 52Hz for a 50Hz component.

Further applications

The above configuration, therefore, forms an analogue front-end for cancellation of power-line interference in bio-medical systems. The scheme can also be extended to the tuning of other monolithic filters such as the inverse chebyschev and the elliptic. The zeroes of the master, which is a self-tuned notch filter, can be made to tune the zeroes as well as poles of such monolithic filters, which now function as slaves.

As an illustrative example, a fourth-order elliptic lowpass filter using cascaded KHN biquads (for which the pole and zero frequencies can be made different) was used as the slave filter, Fig. 3. The self-tuned modified KHN biquad functioned as the master. The zeroes, $f_{z1}$ and $f_{z2}$ of the slave were made to track the zero frequency $f_0$ of the master over the entire tuning range of the master, as observed in Fig. 4. Tracking accuracy can be deduced from Fig. 5. The slopes of the plots are given by the ratios of zero frequencies, $f_{z1}$ and $f_{z2}$ of the slave to the master zero frequency, $f_0$.

The given configuration is thus shown to be applicable as an analogue front-end as well as for realisation of monolithic filters. The basic filter section employs only single-ended op-amps in inverting mode and all resistor values in it can be made equal. The frequencies of interest are governed only by the ratios of capacitor values. This allows frequency scaling of the filter's response. Tuning of the filter relies on commonly available matched pairs of mosfets. Such an isotopic nature of the filter topology is suitable for its implementation at vlsi level.

Fig. 4. Tuning ranges for the slave filter are shown in this magnitude response plot. The zeroes, $f_{z1}$ and $f_{z2}$ of the slave were made to track the zero frequency $f_0$ of the master over the entire tuning range of the master.

The master tuning range, $TR_m=1.8kHz$

Slave ranges are at $f_{z1}=735.6Hz$ and $f_{z2}=1348.7Hz$

For the band $f_{z1}$ to $f_{z1}$ this gives $f_{z1} = TR_m \times f_{z1}/f_0$ and for $f_{z2}$ to $f_{z2}$, $f_{z2} = TR_m \times f_{z2}/f_0$

Fig. 5. The tracking accuracy can be determined from these plots; the slope given by the ratio between the the zero frequencies of the slave and the master filters.

References

For all your Power Distribution
Olson offer a varied choice
The optical drive

Just as you cannot be too thin or too rich, you can never have too much data storage space. The increasing size of application programs, operating systems, and data files has quickly rendered every generation of hard-drive capacity inadequate.

Furthermore, the trend towards multimedia and image-based files has strained the storage capabilities of hard-disk drives. An alternative to continuously buying new and bigger hard drives is provided by optical disk-drive technology. An optical disk-drive can provide infinite storage capabilities since extra storage space is easily obtained by using additional disk cartridges. These are relatively inexpensive.

Tape is also capable of providing infinite storage in this fashion, but it is far too slow to be a real alternative, especially when the data needs to be accessed randomly.

Optical disks provide the ideal combination of robustness, low cost and performance. The random access capabilities of optical drives are now approaching those of low end magnetic hard drives.

Optical drives are available in four basic types - compact disk (cd) based, magneto-optic based, phase-change based, and ablative-worm based. While these technologies are all different, the drives do share some similarities in their opto-mechanical technology. I will examine in detail a magneto-optical (MO) drive as it is the most complicated. Designs for the other classes of drives are essentially subsets of the magneto-optical drive design. The recording technologies that define the different optical drives will then be explained.

Optical head technology

The purposes of the optical head are to transmit the laser beam to the optical disk, focus the laser beam to a diffraction limited spot, and to transmit readout signal information from the optical disk to the data and servo detectors.

Whether the recording technology is magneto-optic, ablative 'write-once, read-many', or phase change, the laser diode is the key component in optical storage. The first two generations of optical drives used infrared lasers emitting in the 780nm or 830nm wavelengths. The next generation of drives will use red laser wavelengths emitting at around 690nm. Continuous laser output power is typically around 40mW. In order to ensure good wavefront quality, the lasers need to be index guided.

A schematic of the optical head in a magneto-optic drive is shown in Fig. 2. Output of the laser diode is collimated - i.e. made into a plane wave - by a lens and then passed through beam shaping optics. These adjust the elliptic profile and astigmatism of the beam. The beam then passes through a polarising beam splitter, which reflects some 30% of the beam towards a detector and transmits the rest towards the disk.

The light that is reflected is incident on a light detector. This detector is part of a power servo loop designed to keep the laser at a constant power; output of the detector is connected to the laser driver circuitry. This is very important. Without a power servo loop, the laser power will fluctuate as the laser junction heats up, which can adversely affect the read performance.

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The beam transmitted by the beam splitter travels to a turning 90° mirror, called a beam bender, mounted on a movable actuator. During track-seeking operations, this actuator can move radially across the disk. The beam reflected by the turning mirror is incident on an objective lens — also mounted on the actuator — which focuses the light on the disk.

This type of optical head design in which the laser, the detectors, and most of the optical components are stationary while the objective lens and beam bender are movable, is called a split optics design.

In early optical drive designs, the entire optical head was mounted on an actuator and moved during seeking operations. This led to slow seek times of around 200ms because of the mass on the actuator. A split optics design, which is possible because coherent light can be made highly collimated, lowers the mass on the actuator, allowing much faster seek times of around 30ms.

The objective lens also acts as a collector for the light reflected from the disk. This light, used for the servo systems and during reading, contains the readout information. Reflected light follows the incident path up to the fixed optical element. The portion of the light transmitted by the beam splitter is, unfortunately, focused by the collimating lens back into the facet of the laser. Optical feedback affects the laser by causing it to mode-hop randomly, which results in amplitude noise in the laser output beam.

This amplitude noise affects the data signal sufficiently to be considered a major problem. To control the laser noise, injection of high frequency current, also called hfm, into the laser is used in practice. The hfm is usually around 350-500MHz and is of sufficient amplitude to drive the laser below threshold at that frequency. This technique prevents the laser from becoming single mode, because it turns the laser off before it can settle into a single mode. In this way the effects of optical feedback are greatly reduced and the coherence length of the laser is less.

In general, increasing hfm current can decrease the amount of noise. But as a practical matter, the hfm injection current cannot be made too large as it may violate government limits, such as FCC, on allowable electromagnetic radiation from computer accessories.

The light reflected by the first beam-splitter is further split by a second beam-splitter into two components: one for the servo and the other for the data. In this head design, two detectors are shown for data detection. This is specific to magneto-optic read back in which two detectors are needed to implement what is known as differential detection, i.e. the difference in the signals incident on the two detectors is taken.

Phase-change, cd, and WORM drives only need one data detector. Light transmitted through the second beam-splitter is incident onto a special multi-element detector which is used to generate the servo signals. The servo system is discussed in more detail later. It is by no means an overstatement to say that the development of high quality servo systems has played a vital role in making high capacity optical disk drives a reality.

The servo system

The servo system is what enables the focused laser spot to be positioned with accuracy on to any of the tracks on the disk. The extremely high track densities of optical disks — in the region of 18 000 tracks per inch — require that the laser spot position is controlled to within a fraction of a micrometer.

To be able to move across the entire disk surface requires a large actuator. But the larger the actuator, the higher the mass that needs to be adjusted to the rapid changes in the track position — due to run-out in the disk — as the disk spins. Consequently, a compound actuator consisting of a coarse actuator and a fine actuator is used to control the radial position of the laser beam on the disk.

The fine actuator, with its very low mass, can change the spot position rapidly over a limited range. The coarse actuator has a slower response, but has a much wider range of motion and is used for long seek operations. Writable optical disks have a continuous spiral groove, as in a phonograph record, to provide information on the relative track location.

In addition to tracking and seeking, the laser spot in an optical drive must be kept in perfect focus on the disk regardless of the disk’s motion. There can be quite a lot of vertical motion if the disk has tilt or is slightly warped. To achieve focus, the objective lens must be constantly adjusted to correct for the axial motion of the disk surface as the media spins.

Lens position is controlled by a focus servo mechanism. A typical focus actuator consists of an objective lens positioned by a small linear voice coil motor. The coils are preferably mounted with the lens to reduce moving mass, while the permanent magnets are stationary. The lens can be supported by either a bobbin...
on a sliding pin or elastic flexures. Critical factors in the design are range of motion, acceleration, freedom from resonances, and thermal considerations.

As mentioned earlier, the tracking mechanism consists of a coarse and a fine actuator. In high performance drives, the coarse actuator consists of a linear voice coil motor driving a rail mounted carriage while the fine actuator acts to produce small radial displacements of the laser spot on the disk. The compound tracking actuator configuration has advantages over a single actuator not only in track following performance, but also when seeking between tracks.

I have discussed the servo and actuator technology required to ensure proper focus as well as the track following and seeking operations of the laser stylus. The optical head, servo, and actuators cover the essential opto-mechanical part of the drive. Next I will consider the formatting, recording, and reading out of data.

The data channel and SCSI

Most optical drives connect to host computer systems using the Small Computer Systems Interface, or SCSI. A schematic block diagram of the functions in an optical drive, based on the IBM 0632 CHA model. This 1.3Gbyte half-high optical drive is shown in Fig. 3.

The SCSI controller handles the flow of information to and from the host— including commands. It also provides arbitration and disconnect/reconnect functions. Through the logic gate arrays, the drive control microprocessor unit controls all the functions of the optical drive. These include,

- servo control
- spindle motor spin up/down
- actuators
- laser driver
- magnetic bias coil—an electromagnet used in magneto-optical recording
- loading mechanism for disk load/unload
- library interface providing control lines useful in a jukebox environment.

The rom is the control storage for the microprocessor while the ram provides the microprocessor working storage. The optical disk controller, odc, is a key controller of the data path. It transfers commands from the SCSI controller to the microprocessor for interpretation. In addition it provides handshake lines to channel data appropriately through the buffer ram to the write channel, or from the read channel to the SCSI output (through the ram buffer).

Buffer ram varies in size from 1Mbyte to 4Mbyte and provides temporary storage of data read out or data to be written. Used appropriately, the buffer ram can enhance performance of the drive by providing read-ahead cache or segmented write-cache capabilities.

Data input to the drive over the SCSI for recording is first broken up into fixed block sizes of, for example, 512Kbyte or 1024Kbyte length. It is then stored in the data buffer ram.

Fig. 3. Key electrical functions and interfaces of an optical drive. The VFO is the variable-field oscillator used to synchronise data.

Fig. 4. Optical recording techniques compared. The primary difference is the material used. A magneto-optical drive could record on phase-change or WORM media too.
Magneto-optic, phase-change and worm drives can be classified as fixed block architecture technologies in which data blocks are recorded much like in hard drives (Marchant, 1990). Blocks of data can be placed anywhere on the disk in any sequence. The current CD recordable, or CD-R, drive is, on the other hand, an example of a non-fixed block architecture (because its roots are in CD-audio). In current recordable CD drives, input data is recorded sequentially, like a tape player, and can be of any continuous length.

Error correction and control, ECC, bytes are added to each block of data. Optical drives use Reed-Solomon codes which are able to reduce the error rate from 1 in $10^2$ to about 1 in $10^{13}$. Error-correction encoding and decoding is managed by the optical disk controller.

To extract ones and zeros from the noisy analogue signal from the photodetectors, optical drives use a number of techniques such as equalisation which boosts the high frequencies and thus provides greater discrimination between spots. Using an analogue-to-digital converter, the analogue data signal is converted into channel bits. These channel bits are converted back into customer data bytes using basically the reverse of the encoding process.

Clocking of data coming off the disk is provided by the variable field oscillator, or VFO. Data is clocked into the decoder, which removes the modulation code. Remaining special characters are removed from the data which is then fed into the forty-byte ECC alignment buffer to correct any errors. Once data has been read from the disk, it is stored in a RAM buffer and then output to whatever read-out device is hooked by SCSI to the drive.

Having outlined how data is recorded on a spinning disk, I will now turn to specific topics such as recording physics that delineate the various recording technologies, Fig. 4.

**Phase-change recording**

Phase-change recording takes advantage of the fact that certain materials can exist in multiple metastable — i.e. normally stable — crystalline phases. Each of these phases has differing optical properties, such as reflectivity. Thermal energy, as supplied by the focused beam of a high power laser, above some threshold can be used to switch from one metastable state to another.

Energy below the switching threshold should have no effect. In this way a low power focused spot can be used to read out the recorded information without affecting it. In any optical recording system, it is critical to have a sharp threshold for the onset of writing in any recording technology to ensure that readout can be performed without degradation of recorded marks. Figure 5 is an example of the sharp threshold for writing.

To achieve this kind of multiple metastable states, phase change materials typically are a mixture of several elements such as germanium, tellurium and antimony (Ge$_2$Sb$_2$Te$_5$). In an erasable material, recording is affected by melting the material under the focused spot and then cooling it quickly enough to freeze it in an amorphous phase. Rapid cooling is critical, so the design of the heat sinking capability of the material is important. Erasing of phase change material is achieved by an annealing process. This involves heating the material to just below the melting point for a long enough period to recrystallise the material and erase any amorphous marks.

Phase-change drives are simpler than magneto-optical drives. They need less complicated optical heads and do not need a bias magnet. However, most rewritable optical drives are based on magneto-optical technology. This is largely because early phase change disks had very limited number of overwrite cycles, of the order of a thousand, while magneto-optic disks were shown to have a million overwrite cycles.

Phase change technology has come a long way since then, even achieving on the order of 100,000 overwrite cycles.

**WORM technology**

Write-once-read-many technology has a clear place in data storage because it allows permanent archiving capability. Neither magnetic disk storage, nor magnetic tape storage can provide the same write-once capability. There are at least four different types of optical write once technologies that are found in commercial products: ablative, moths-eye, phase-change, and dye-polymer.

Ablative WORM disks consist of tellurium based alloys. Data is written using a high power laser to burn a hole in the material. IBM offers 5.25in drives with current capacities of 1.3Gbyte that use this type of WORM technology.

A second type of WORM material is what is known as textured material, such as in a moth’s eye pattern. The material is usually a platinum film. Writing is accomplished by melting the textured film to a smooth film, which changes the reflectivity.

Phase-change technology provides a third type of WORM technology using materials such as tellurium oxide. In the writing process, amorphous (dark) material is converted to crystalline (light) material by applying heat...
Disk at once (single session)

Lead in

Power calibration area

Lead out

Track at once

Tracks within a single session can also be written in multisession mode. But max number of tracks on disk is 99

Multisession

Session 1

Session 2

Incremental packet recording

Run-out blocks

Single packet

Data

Link block

Run-in blocks

Disk at once (single session)

Multisession

First session

Second session

n th session

Fig. 7. Recording modes available for recordable cd technology. Incremental packet recording increases flexibility of recordable cd and makes it more suitable as a mass storage device for the desk-top. In packet recording, unlike other modes, there is no limit to the number of recordings - provided that there is space on the disk.

not affected by magnetic fields or laser light.

During readout, the recorded ones and zeros are sensed by a low power linearly polarised readout beam and by utilising the polar Kerr effect. In this effect the plane of polarisation of the light beam is rotated by 0.5° or so by the magnetic vector. The direction of rotation, which defines whether the bit is a one or a zero is converted by the polarisation optics into an intensity change which is sensed by the readout detectors and channel.

Although the tiny amount of Kerr rotation results in a very small amount of signal modulation riding on a large dc bias, the technique of differential detection permits acceptable signal-to-noise ratio (snr) to be achieved.

Recordable compact disk - CD-R

The writable - i.e. write once - version of the popular cd-rom is known as CD-R and was introduced about four years ago. A CD-R disk can store about 650Mbyte of data. A recorded disk looks very much like a stamped cd-rom, and is playable in most cd-rom players.

Early CD-R drives were very expensive - of the order of $50,000 each - and were used only by professionals mastering cd-rom disks. Over the next three years, CD-R drive prices fell quickly to around $10,000 in 1993. By the end of 1994, the drive price had fallen to less than $2000, with blank disks costing about $12 per disk in the shops. The OEM price for CD-R drives has already fallen to less than $1000 for small quantities. The dramatic drop in prices, combined with the fact that recordable disks were compatible with cd-rom players has created a great deal of interest in this technology.

A recordable cd is coated with an organic polymer that can change its local reflectivity permanently upon sufficient heating by a laser spot. Structure of a CD-R disk is shown in Fig. 6. When the organic dye polymer is locally heated by the focused spot of a laser beam, polymeric bonds are broken or altered resulting in a change in the complex refractive index within the region. This refractive index change results in a change in the material reflectivity. There are half a dozen organic dye polymers that are commercially being used. Two examples are phthalocyanine and poly-methane cyanine.

Like cd-rom drives, CD-R drives have relatively low performance compared with optical or hard drives. Just as in a cd-rom drive, the seek times are on the order of a few hundred milliseconds while the average access time for a quad-speed drive is about 600Kbyte/s.

Seek time is slow because recordable drives spin the disks in constant linear velocity (clv) mode as defined in the Red Book standards. Constant linear velocity means that the disk rotation speed varies with the radius at which the read head is positioned. There's a way to ensure that the linear velocity is constant with radius. In contrast, constant angular velocity devices like optical WORM disks have seek times on the order of 40ms.

Recording CD-Rs

To understand the attributes and limitations of recordable cd, it is important to understand the various recording modes that it can operate in. For fixed block architecture devices such as magneto-optical drives, the question of recording modes never comes up as there is only one mode, but in recordable cd, there are four modes, as in Fig. 7.

The four recording methods in CD-R drives are: disk-at-once, or single session, track-at-once, multisession, and incremental packet recording. In disk-at-once recording, one recording session is allowed on the disk, whether it fills up the whole disk or just a fraction of the disk. The data area in a single session disk consists of a lead-in track, the data field, and a lead out track. Information such as the table of contents is within the track lead-in.

In single-session writing, once the lead-in and lead-out areas are written, the disk is considered 'finalised'. Even if there are blank areas on the disk, further recording cannot take place. After the disk is finalised - and only then - it can be played back on a cd-rom player, which needs the lead-in and lead-out areas to read the disk.

Having only the capability of recording a single session can be a quite a limitation for obvious reasons, so the concept of multisession recording was introduced. An early proponent of multisession recording was Kodak which wanted multisession capability for its PhotoCD products. In multisession recording, each session is recorded with its own lead-in and lead-out areas.

Multisession recorded disks can be played...
back in cd-rom drives that are marked multi-
session compatible, assuming that each ses-
sion on the disk has been finalised with lead-in
and lead-out areas. Unfortunately, the lead-in
and lead-out areas for each session take up lots
of overhead; about 150MByte. With this kind of
overhead, the ultimate maximum number of
sessions that can be recorded on a 650MByte
disk is 45 sessions.

Rather than do multisession recording, the
user may opt for track-at-once recording. With
this technique, one or more tracks can be writ-
en in each session. The maximum number of
tracks that can be written on the disk is 99.
However the disk or session must be finalised
before it can be read on a cd-rom drive.

Because of the way input data is encoded
and spread out, it is imperative to maintain a
constant stream of information when record-
ing. If there is an interruption in the data
stream, it affects the whole file being recorded
—not only in magneto-optical or WORM drives.
If the interruption is long enough, it will usually lead to the disk being
rendered useless - a 'golden coaster' as it is
referred to in the industry. For this reason, it is
important to have a fast hard drive capable of
defeeding the data to the drive buffer continuously.

Many of the above problems or inconveni-
cences can be alleviated through a new
recording method just being introduced. Called incremental packet recording, this
method involves breaking the input data up
into packets of specified size, for example
128KBbyte or 1MByte.

Each packet consists of a link block, four
run-in blocks, the data area, and two run-out
blocks. Run-in and run-out blocks help deline-
ate packets and allow some room for 'stitch-
ing' - i.e., providing overlap if perfect synchro-
nisation is not achieved when recording an
adjacent packet in a different recordable cd drive.
Packet recording has several advantages. To
begin with there is no limit to the number of
packets that can be recorded, up to the space
available on the disk of course. In this way,
limitations imposed by track-at-once, multi-
session or drive-at-once can be avoided.

Secondly, if the packet size is smaller than
the drive-buffer size - as is likely to be the
case - a dedicated hard drive is not needed
while recording. Once the packet of informa-
tion has been transferred to the drive buffer,
the computer can do other tasks while the
CD-R drive carries out the recording.

With the advent of packet recording, record-
ad drives technology becomes much more flex-
ible than in the past. As a result, the technol-
y is much more attractive as a general purpose removable data storage device. It can
be used for back up purposes as well as for
storing smaller files.

There is an interchangeability problem with
some cd-rom players as they post a hard error
when they encounter the link block at the
beginning of each packet. To address the
problem of interchange with packet written
disks, the Optical Storage Technology
Association is investigating whether an appro-
priate device-driver utility will enable older
cd-rom drives to accept packet written disks.

An alternative is to use variable sized pack-
ets in which the packet size is equal to the file
size. This technique is attractive because it
reduces the incompatibility with cd-rom
drives, but it also has its own problems - fur-
ther illustrating the point that converting a
recordable cd into a mass storage technology
will require a certain amount of compromise and
reduced expectations.

Cd-rom compatibility issues
One of the key attributes of recordable cd
drives is that in principle the disks they write
can be read by cd-rom drives. Given the phenomen-
nal success of cd-rom and the rapidly
Growing installed base of titles and drives, it is
clearly advantageous for an optical drive to be
cd-rom compatible in some way.

Recordable cd drives can read cd-rom disks,
and write recordable cd disks that can be read
on cd-rom drives. However these disks are
write-once only.

Several companies are working on a new
technology called CD-E or compact-disk-
erasable which is a recordable cd based on
phase-change material. The CD-E drive will
supercede CD-R drives since they will have
not only all the features of the recordable cd
drives but also those of erasable cds. CD-E
drives have the potential to become a mass
storage medium and to replace the floppy
drive on desk top computers.

Recognising the importance of cd-rom com-
patibility, Matsushita Corporation (Panasonic)
recently announced a new rewritable optical
drive called phrasewriter dual or 'PD'. This
drive has the capability to read cd roms. The
phrasewriter-dual drive writes to a phase
change rewritable media. However, unlike
CD-E drives, the disks written by the pd drive
cannot be read back by cd-rom drives, and
thus cannot take advantage of the installed
base of cd-rom drives.

A bewildering array of choice in 1995
How do optical drives available now, or being
introduced in 1995, compare with each other?
There seems to be a bewildering array of
choices for the consumer. Which should the
consumer choose? Of course this depends on
what is important to the user - capacity and
performance or low cost or cd-rom compat-
ility. A comparison of the various technolo-
gies is given in Table 1.

The primary delineators are performance and
cost. Magneto-optical/WORM and phase
change drives offer much higher performance
than recordable cd drives. On the other hand,
recordable cd offers cd-rom compatibility and
has a greater possibility of being low cost
because of the cd-rom base.

Over the next three years, the market will
decide in which application segments each of
these features is most important.

The next generation: HDCD and DVD
The 650MByte capacity of current cd-rom and
recordable cd-R drives has remained
unchanged since the introduction of cd-rom in
1985. However, the growing interest in putting
video on cd is forcing the need to increase the
capacity - video is very storage intensive.

The motivation for developing video cds is
that they will replace the video tape, just as
audio cds replaced the phonograph record and
audio tape in the mid eighties. Furthermore the
high-capacity cd is also needed in computer
applications to replace cd-rom disks.

In december 1994, Philips and Sony pro-
nounced a new compact disk standard called
HDCD, high-density cd, which can hold

<table>
<thead>
<tr>
<th>Table 1. Optical technologies compared.</th>
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<tr>
<td><strong>Multifunction Optical</strong></td>
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<td>Disk diameter</td>
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<td>130 mm</td>
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<tr>
<td>On-line capacity</td>
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<tr>
<td>Function</td>
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<td>Rewritable and</td>
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<tr>
<td>write once</td>
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<tr>
<td><strong>Performance</strong></td>
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<tr>
<td>read data rate</td>
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<td>write data rate</td>
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<tr>
<td>seek time</td>
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<tr>
<td>mean time between failure</td>
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<tr>
<td>disk diameter</td>
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<td>CD-R/CD-E</td>
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<tr>
<td>CD-E</td>
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<td>120 mm</td>
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<tr>
<td>650MByte</td>
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<tr>
<td>Write once but</td>
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<tr>
<td>CD-E will be rewritable</td>
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<td>Phasewriter Dual (PD)</td>
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<td>CD-R</td>
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<td>120 mm</td>
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<td>650MByte</td>
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<td>Can read cd-rom</td>
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<td>Rewritable</td>
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<td>Can read cd-rom</td>
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<td>Not clear</td>
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<td>Not clear</td>
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<td>Not clear</td>
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<tr>
<td>Notes:</td>
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<tr>
<td>1) On-line capacity means capacity available without human intervention - i.e. capacity on a single side.</td>
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<tr>
<td>2) In constant velocity (CAY) drives, linear velocity varies as a function of radius. Thus, data rate varies as a function of the radius of the read/write head because the linear density is constant as a function of radius. The higher data rate is possible when the head is at the outer radius of the disk, while the lower data rate occurs when the head is at the inner radius.</td>
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<td>3) These are projections based on industry consultant forecasts.</td>
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</tbody>
</table>

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3.7Gbyte on a single disk. A second version of the HDCD is likely to have two data layers, as shown in Fig. 8, thus doubling the capacity on a single platter to about 7Gbyte.

A two layer HDCD should cost only marginally more than a single layer HDCD. Not to be outdone, Toshiba and Time Warner with support from Matsushita released an alternative standard for a videoCD in January 1995. Toshiba calls it the DVD or digital video disk but it has also been referred to as SD or super disk. This disk is double sided and can store about 5Gbyte per side. A comparison of the two mutually incompatible standards is given in Table 2.

How will the increases to HDCD or DVD capacity be achieved? In any disk based system the main way of increasing capacity is to make the marks smaller and put them closer together since there is no chance of increasing the size of the disk. To go from current cd-rom capacities to HDCD or DVD capacities - a factor of at least five jump in storage density - requires shorter wavelength lasers, higher numerical aperture lenses, tighter track pitches and higher linear densities.

The laser chosen for the next generation cd's will be a red emitting type operating at 635nm, as opposed to the 780nm of currently used for cd's. However the switch to a red laser leads to a potential problem in compatibility. This is because current dye-polymer media formulations for recordable cd's are not compatible at red laser wavelengths. As a result, the recordable disks you are using today will not be read back by the next generation of higher density compact disk drives. Lack of upward compatibility, though not widely advertised, will not be warmly greeted by any users who are currently archiving data or photos on recordable cd media.

Several US and Japanese media companies are working on recordable cd media that is compatible at both the infra-red laser wavelengths, found in current drives, and the red laser wavelengths. An introduction of such media into the commercial market is imminent and will solve the current upwards-compatibility problem.

The fact that two competing proposals have been introduced for the videoCD standard has caused quite a stir, bringing back memories of the CDV versus Betamax videocassette standard wars. The videoCD standards could well be a replay of the videocassette war unless the two sides get together and compromise on a single standard.

Currently in Toshiba/Time Warner's favour is the fact that several of the Hollywood studios - the 'content providers' - seem to be supporting DVD. Sony and Philips have been lining up the major computer and software makers to support HDCD as the next generation replacement to the immensely popular and widespread cd-rom. Realising the importance of cd rom, Toshiba has agreed to modify its standard so that it will support cd rom, and has begun talks with computer and software companies. Which of the two competing standards the industry will adopt is still up in the air, but hopefully, Sony/Philips and Toshiba can sort out their differences and converge to a single standard.

Optical technology trends

Wherever specific format is adopted, optical drives will continue to see both incremental and radical improvements from a technology perspective. The incremental improvement process will concentrate on the four core technology elements: the laser, the media, the recording channel, and the opto-mechanical actuators for faster seek operations.

The laser will see continual improvements in its operating life and power, which in turn will allow disks to spin faster. Media will see improvements in substrates and active layers. Optics and actuator systems will have improved servo systems to allow faster positioning. In addition there will be reductions in noise, smaller optical components, and lighter actuators for faster seek operations.

The recording channel and electronics will see an increase in the level of electronics integration, a reduction in electronic noise and power consumption, and better signal processing and error correction.

There is a considerable amount of technical growth potential for optical drives, in both performance and capacity. After all, optical drives are a relatively new commercial technology. Remember that the first writable optical drives only started being marketed about six years ago.

Acknowledgments

Thanks to Lee Jesinowski of IBM Tucson for the electronic block diagram of the optical drive, and to Blair Finkelstein of IBM Tucson for the photograph on WORM threshold mark formation.

Probing further

There is a number of excellent books that provide an overview of optical disk systems. A classic is Optical Recording by Alan Marchant (Addison Wesley, Reading, MA, 1990) which provides an overview of the various types of recording as well as the basic functioning of an optical drive. A more detailed study of optical disk drives and their opto-mechanical aspects is provided in Principles of Optical Disc Systems by G. Bouwhuis, J. Bratt, A. Huijser, J. Pasman, G. van Rosmalen, and K. Schouhammer Immink (Adam Hilger Ltd, Bristol 1985).

For recent developments in the field of optical storage, you are advised to attend the meetings of the International Symposium on Optical Memory (ISOM) or the Optical Data Storage (ODS) Conferences (held under the auspices of the IEEE or the Optical Society of America).

<table>
<thead>
<tr>
<th>Number of sides</th>
<th>Sony/Philips HDCD</th>
<th>Toshiba/Panasonic DVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single sided</td>
<td>3.7GB (7.4GB for 2 layer)</td>
<td>50GB/side (10GB total)</td>
</tr>
<tr>
<td>(but up to 2 data layers)</td>
<td>142min/inside</td>
<td>0.725μm</td>
</tr>
<tr>
<td>Disk capacity</td>
<td>135min/layer</td>
<td>635nm</td>
</tr>
<tr>
<td>Playing time</td>
<td>0.84μm</td>
<td>0.6</td>
</tr>
<tr>
<td>Track pitch</td>
<td>635nm</td>
<td>0.52</td>
</tr>
<tr>
<td>Laser Wavelength</td>
<td>Numerical aperture</td>
<td>Plays current</td>
</tr>
<tr>
<td>Numerical aperture</td>
<td>yes</td>
<td>cd-rom titles</td>
</tr>
<tr>
<td>Laser Wavelength</td>
<td>0.6</td>
<td>not clear</td>
</tr>
</tbody>
</table>
Perfect capacitors dissipate no power, but in the real world, many factors combine to reduce efficiency and increase failure rate – as capacitor consultant Cyril Bateman explains.

Capacitors don’t take power. So began my lecturer when introducing the topic of capacitor phase angles. I remembered these words only too clearly some years later when investigating capacitor failures occurring in the line time-base circuit of the first all solid state 110° colour televisions.

My experiences as a capacitor designer and applications engineer have clearly demonstrated that all capacitors have a limited power handling capability, similar to the safe operating area of semiconductors. Directly or indirectly, overstressed capacitors are involved in most circuit failures. Obviously, all components wear out eventually. But overstressed capacitors used with pulse waveforms in power switching circuits can fail very quickly. Worse still, before the capacitor ultimately fails, it can directly contribute to the failure of switching semiconductors, and in doing so, mask the prime failure mechanism.

Manufacturers sometimes determine the power rating of a capacitor by subjecting samples to sine wave stress while monitoring the temperature rise. To confirm long term reliability, this is often supported by stressing at elevated temperature. These results can be related to end-use conditions provided that the capacitor’s rms power level in circuit can be measured or calculated.

Why should capacitors cause such problems used with pulse waveforms? Power dissipated in a capacitor is dependant on $P_{esr}$, alternatively $V/\tan\delta$. While capacitive reactance is inversely proportional to frequency, equivalent series resistance, or $esr$, is not. Depending on frequency and capacitor type, while $esr$ generally reduces with rising frequency, this is not always the case. In some combinations $esr$ can exceed the capacitive reactance, and can also increase with frequency.

Since the $esr$ of a capacitor is frequency dependent, the capacitor’s power dissipation can be measured in circuit only when using sine wave stimulation. Given a mathematically defined waveform, however, power level can be calculated following the classical methods.

This article proposes a method of calculating capacitor power dissipation for any waveform, demonstrated by two recent applications reported in Electronics World – together with a prototype ‘snubber’ circuit. In the first of these applications, an article on Cuk converters, Finnegan found that using a standard electrolytic component for the 3.3µF capacitor of Fig. 1 was unsuitable. Equivalent series resistance caused overheating. In the second article, physically small capacitors are needed for $C_1$ and $C_2$ of Fig. 2. The choice of ceramic type matters here since some exhibit more losses than others and an incorrect type could easily result in overheating.

According to the Fourier theorem, time and frequency domains interrelate and can be transformed with no loss of information – provided complete waves are used and sufficient harmonics are computed. In theory an infinite number of harmonics is required. In practice fifty harmonics have proved to suffice.

Converting from the time domain into the frequency domain for a capacitor

For a capacitor, equivalent series resistance, $esr$, is a single lumped resistive value representing all real losses. This loss comprises three main sources:

- True series resistance, $tsr$, comprising the actual metallic resistances.
- $R_p$ comprising:
  a) Dielectric loss due to molecular and interfacial polarisation.
  b) Leakage resistance, measured at dc volts.

$$esr = tsr + \frac{R_p}{1 + \omega^2 (R_p)^2 C^2}$$

$$esr = \tan\delta \times X_c$$

$$esr = \cos\theta \times |Z|$$

Resistivity in capacitors

Equivalent series resistance tends to reduce with increasing frequency, but by considerably less than the theoretical halving for each doubling of frequency. Ultimately attaining a minimum value when $X_c = X_p$, i.e. at the series resonance of the capacitor as a series $LCR$ system.

In the capacitor equivalent circuit a), true series resistance is caused by actual metallic resistances inherent in the component make-up. Solving this equivalent circuit mathematically into real and imaginary terms results in the series equivalent model b). This is an equivalent series resistance representing all real capacitor losses.
frequency domain for calculations offers many benefits. Not least of these is the ease with which frequency dependent parameters can be accommodated, since all calculations are also simplified. With capacitors subjected to non-sinusoidal waveforms, the resulting capacitor current by harmonic depends on the harmonic amplitude multiplied by the harmonic number. Given an ideal capacitor and ideal square wave, the current resulting from each harmonic equals that of the fundamental frequency. For other waveforms it is possible that harmonic currents can exceed that of the fundamental. Since the equivalent series resistance change by harmonic is always less than ideal, the power contributed by a harmonic can considerably exceed that of the fundamental, Table 1.

Having established the need to avoid early capacitor failures, the sequence for calculating capacitor power dissipation is:

- Fourier transformation of the stimulus waveform observed across the capacitor terminals, into the frequency domain, by amplitude and phase.
- Determination of relative capacitor current and phase for each harmonic frequency.
- Complex multiplication of stimulus waveform harmonic amplitude and phase with capacitor current and phase for each harmonic frequency.
- Reverse Fourier transformation (synthesis) back into time domain.

A closer look
Many suitable fast Fourier calculation routines have recently been published. The essential requirements are sufficient data points for accuracy, say 256 minimum, the provision of \( k(0) \) (mean) data, with sufficient harmonic data by amplitude and phase, such that reverse transformation accurately recovers the original time-domain voltage waveform’s shape and amplitude.

I have successfully used an enhanced version of the Larsen-Dyrik BBC Computer program adapted to run on the Archimedes.

Table 1. These results, derived from the 22nF snubber, show that power loss due to harmonics can exceed that of the fundamental.

<table>
<thead>
<tr>
<th>Harmonic number</th>
<th>Amplitude (V)</th>
<th>Phase (°)</th>
<th>Current (A)</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k(0) ) (mean)</td>
<td>113.13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( k(1) )</td>
<td>118.5</td>
<td>236.9</td>
<td>1.64</td>
<td>3.75</td>
</tr>
<tr>
<td>( k(2) )</td>
<td>89.72</td>
<td>202.5</td>
<td>2.48</td>
<td>4.87</td>
</tr>
<tr>
<td>( k(3) )</td>
<td>53.32</td>
<td>164.5</td>
<td>2.21</td>
<td>2.79</td>
</tr>
<tr>
<td>( k(4) )</td>
<td>21.5</td>
<td>112.7</td>
<td>1.19</td>
<td>0.64</td>
</tr>
<tr>
<td>( k(5) )</td>
<td>9.72</td>
<td>354.3</td>
<td>0.67</td>
<td>0.18</td>
</tr>
<tr>
<td>( k(6) )</td>
<td>14.66</td>
<td>272.4</td>
<td>1.22</td>
<td>0.49</td>
</tr>
<tr>
<td>( k(7) )</td>
<td>14.05</td>
<td>215.1</td>
<td>1.36</td>
<td>0.56</td>
</tr>
<tr>
<td>( k(8) )</td>
<td>10.7</td>
<td>151.2</td>
<td>1.18</td>
<td>0.38</td>
</tr>
<tr>
<td>( k(9) )</td>
<td>8.28</td>
<td>79.05</td>
<td>1.03</td>
<td>0.27</td>
</tr>
<tr>
<td>( k(10) )</td>
<td>6.8</td>
<td>6.96</td>
<td>0.94</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Capacitor performance simulations
The procedure used to generate these results graphs commenced with time domain simulation of the circuit using Pspice. This produced the voltage waveform which would be measured across the capacitor if displayed on an oscilloscope. The 22nF snubber was in fact derived from an oscillogram. This waveform was digitised into 256 X Y co-ordinates and stored on disk using a custom program. The data file became input to calculation programs running on my Archimedes. These are FFT conversion, followed by frequency domain analysis, complex multiply and reverse FFT to restore to time domain.

The results are displayed on screen exactly as shown here. To provide the best resolution, I wrote a dedicated routine to output these curves as a vector datafile in Archimedes Draw format. This permits easy conversion to formats compatible with other machines.

- Calculation of capacitor power by each harmonic and relevant esr, over one period of the fundamental waveform.
- Calculation of rms power dissipated in the capacitor.

Plot 1. Energy transfer for capacitor \( C_3 \) of Cuk converter Fig. 1. This 160V rated component is 3.3μF. A Wima MKS4 metallised polyester gives acceptable power loss for long life.

Plot 2. Experimental snubber using 22nF chip capacitors made from X7R ceramic was unsatisfactory. Capacitor seriously overheated and failed—quickly.
Before any fast Fourier transform can be run, one period of the waveform must be described, mathematically if feasible, or more generally as $X$ and $Y$ co-ordinates, matching the input needs of the chosen FFT calculation. Fundamental to this method is the assignment of esr and capacitance values for each harmonic frequency used. Whenever possible these should be interpolated from the nearest practical measured frequency.

Modern LCR bridges can measure at many frequencies to at least 1MHz. At these higher frequencies the best four-terminal measurement techniques must be used, and preferably with short component lead lengths.

At frequencies greater than are possible with LCR bridges, network analysers measuring by $\text{IZIZO}$ are most appropriate. Since most capacitors of interest will resonate below 10MHz, as an unobservable minimum, a measurement of impedance with frequency can determine the minimal value of equivalent series resistance, at the resonant frequency.

Simulating capacitor performance

Analog circuit simulators are based either on frequency-domain or time-domain simulation methods. Time-domain based simulators can allow for amplitude dependant anomalies that are typical of semiconductor junctions.

At the University of California, Berkeley, a development grant from Sprague Electric in 1970-71 funded the preliminary development of the Cancer program from which Spice, subsequently Spice2, developed. This work was specifically targeted to the needs of the integrated-circuits group at the University. Indeed the word Spice derives from 'Simulation Program with Integrated Circuit Emphasis'.


Spice2-derived simulators comprise small-signal frequency-domain analysis together with time domain transient response and dc transfer functions.

Consequently, although Spice2 based simulators are able to calculate power dissipation, use of the time-domain calculations, inhibits frequency dependency.\footnote{\textsuperscript{11,12}}

While many nodal frequency domain simulators do not support frequency dependency, provided matrix reduction techniques are not used, this enhancement is possible.

With non-sinusoidal waveforms, substantial errors of power result from the capacitor's frequency dependent equivalent series resistance. Eliminate these errors by simulating in the frequency domain and using the appropriate esr values. I have built this capability built into my simulators for the Archimedes.
Provided that the frequency of the highest significant harmonic is below the capacitor self-resonance, current and phase by harmonic relative to unity input stimulus can be calculated by many means including pocket calculator. Should there be any harmonics having significant power above this resonant frequency, a full capacitor model together with simulation software is preferred. This model has to include inductance and equivalent series resistance.

Complex multiplication of each harmonic component of the stimulus waveform with the relative capacitor current and phase provides the final frequency-domain result. These are output when required. Complex multiplication is simplified if data by magnitude and phase angle is used. In this case multiply the respective magnitudes but add the angles.5

Capacitor current in rms can be calculated directly from the above complex multiplication frequency domain results.6 7

The reverse fourier transform or synthesis, provides the time domain capacitor current waveform and the rms power dissipated by the capacitor. Additionally an estimate of the peak and mean power levels throughout the waveform can be deduced. This can be used to reduce power levels by fine tuning the wave-shape. These capacitor power levels should be calculated by harmonic frequency, amplitude, phase and relevant ESR for each of the data points through one waveform.8

This proposed method applies not only to switched mode supply simulation. The above sequence is simple and quick, if performed using dedicated computer routines. I have developed some of these myself.

Preparing X, Y data points defining the stimulus waveform is simplified by using a curve fitting routine. All subsequent data transfers can be automated. For any stimulus waveform, data from the FFT can be stored as a library file, and reused as needed, until a different stimulus is desired.

Given capacitor data-file libraries, the traditional method of choosing capacitors by trial and error becomes obsolete.

References
2. Switched-mode PSU technology runs at 1MHz, EW+WW, January 1993.
3. Intelligent Power ICs Database, Addendum AN9208, Harris Semiconductor, Camberley.
5. Handbook of Line Communications, Vol. 1, HMSO.
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Phasor diagrams and standing waves

Phasor diagrams are extremely useful in combining voltages present at a point on a transmission line from forward and reflected waves. Finding the resulting, measurable voltage at a point is made very much simpler with a phasor parallelogram. This is taken a step further with a novel combined voltage and current diagram which allows currents and impedances to be dealt with.

Power considerations

Once steady state has been reached, power is delivered to the line at a steady rate and dissipated in the load at a steady rate. If the line is loss free, these two rates are equal.

Energy injected into the line before steady state is achieved remains there in the form of the forward and reflected waves. In the steady state, energy stored on the line is continually leaking out at one end and is being continually topped up at the other by the transmitter. The energy returned by the reflected wave helps to maintain the forward wave.

When the generator is switched off, the energy stored on the line will leak rapidly away as the waves echo back and forth.

As both the forward and backward waves are energy carriers, the terms 'forward power' and 'reflected power' are frequently used. Reflected power does not mean wasted power so there is no reason why an ideal line should not transmit energy efficiently even if there is appreciable reflection; a high standing wave ratio. On the other hand, using practical transmission lines, the existence of voltage and currents to be dealt with.

Square

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Square

Providing the line is long enough there will be at least one point where the component voltages are in phase or, strictly speaking, phase by an angle of rotation, (a). Phasors rotate around 360° and cross over as the measuring position on the line moves by more than a full wavelength, (c).

Fig. 1. If the system could be run in slow motion, voltages measured along a transmission line would reveal a follow-the-leader pattern. Travelling along the line to the right, the phase lags that of the previous voltmeter.

Fig. 2. The relationship between maxima and minima is represented by phasor lengths, (a), and phase by an angle of rotation, (b). Phasors rotate around 360° and cross over as the measuring position on the line moves by more than a full wavelength, (c).
ward-wave voltage component is \( v \) and the reflected component is \( kv \), the resultant voltage will have its greatest possible value of \( v + kv = v(1 + k) \).

Now imagine we move down the line towards the antenna. As the distance increases, the forward wave is delayed an increasing amount while the reflected wave arrives earlier. This means a greater and greater phase difference between the components.

After moving a quarter wavelength, the forward wave will lag on its phase at \( P \) by one quarter of a cycle, while the reflected wave will lead by a similar amount. The result will be that the component voltages are half a cycle out of phase, and the resultant voltage will be \( v(1-k) \). This is the minimum possible value of the voltage.

A further movement of one quarter wavelength will bring the components into phase and yet another quarter of a wavelength is required to bring them into opposition. This stationary pattern will repeat continuously, if the line is long enough, and is termed a 'standing wave'.

All this becomes quite obvious when the component voltages are represented by phasors. Resultant voltage at any point on the line is found by drawing a phasor parallelogram.

**Using phasors**

The two component voltages are represented by phasors drawn like the hands of a clock. The long hand is \( v \) units long and the short hand is \( kv \) units. In practice it is often convenient to assume that \( v=1 \) and that the lengths are \( k \) and \( 1 \) units.

At a point like \( P \), a voltage maximum, the two hands are both pointing in the same direction. Say both point to 12 o'clock. As we move down the line the hands are rotated through equal angles in opposite directions, the angle representing change in phase; for instance a movement of one quarter of a wavelength is represented by rotating each phasor through 90°. This brings the hands pointing to three o'clock and nine o'clock. Phasor lengths must be subtracted to give \( v(1-k) \), a voltage minimum in this case. A further quarter of a wavelength will bring both hands pointing to six o'clock, another voltage maximum. However they are pointing in the opposite direction to when they were at 12 o'clock, so the resultant voltage at the new maximum is in antiphase with the original case, Fig. 2a, b, c.

Further movement down the line causes the phasors to cross over and arrive at another voltage minimum after another quarter wavelength, then arrive at their starting position. After a total movement of one full wavelength down the line, the voltage maximum at this point is in phase with the voltage at \( P \).

**Rotation convention**

In moving down the line towards the antenna the forward wave is delayed, ie lag is introduced, and the reflected wave arrives earlier, ie it leads. Conventionally, lag is represented by a clockwise rotation and lead is represented by an anticlockwise rotation.

Finding resultant voltage at a point

Suppose that the point of interest is one tenth of a wavelength from a voltage maximum. With the clock hands both at 12 o'clock, rotate each hand through one tenth of a cycle, 36°, in opposite directions, Fig. 3a.

Now construct a parallelogram, Fig. 3b, with the clock hands as sides. The resultant voltage is given by a diagonal drawn from the junction of the clock hands. It should be clear that when the components are in phase or in antiphase, the parallelogram collapses into a straight line. When this happens, the figure still works, giving the same answers as obtained by a straightforward addition or subtraction.

The phasor voltage parallelogram (clock hand diagram) shows how the numerical value and phase of the line voltage varies from point to point. Surprisingly enough it can be easily modified to also give current.

**Voltage and current parallelograms**

The currents may also be represented by phasors and it is a fairly simple matter to draw current and voltage phasor diagrams side by side with the correct phase relationships.

One thing which holds for both forward and reflected waves is that at all times and all points in the circuit, voltage/current = \( Z_0 \). Note that this is not true for the resultant values of voltage and current.

First think about the forward wave. As \( V/I = Z_0 \), \( V \) and \( I \) must be in step and peak at the same instant. We therefore draw the forward-wave current and voltage phasors in parallel, ie the phase difference is zero. The length of this current phasor must be equal to \( V/Z_0 \), where \( V \) is the rms voltage.

Now think about the reflected wave. Once again the current must peak at the same instant as the voltage but it has already been pointed out that reversing the direction of the wave reverses the sign of the current relative to the voltage. For the reflected wave, the current phasor must point in the opposite direction to the voltage phasor.

Mathematically speaking, reversing the sign of the current without reversing the sign of the voltage means that \( V/|I| \) is negative, ie the flow of power is reversed, which is of course true for the backward wave.

The length of the reflected wave current phasor is \( kv/Z_0 \). The resultant current is given by the diagonal drawn from the junction of the current phasors, Fig. 4.

"If the current diagram is scaled up by a factor \( Z_0 \), it becomes identical to the voltage parallelogram, except that the other diagonal gives the resultant."**

**Combined voltage-current parallelogram**

The voltage parallelogram and the scaled up current parallelogram may be superimposed to give a combined voltage-current parallelogram, Fig. 5. In this the length of the diagonal drawn from the tip of the short clock hand to the tip of the long clock hand represents the current, scaled up by a factor \( Z_0 \). Angle \( A \), between the diagonals is equal to the phase difference between voltage and current.

The combined diagram is a very powerful tool. It gives a complete description of the voltage and current at any point on the line, and enables this to be compared with the voltage and current at any other. This is illustrated very well when it is applied to a line terminated in a perfect reflector, ie when \( k=1 \).

**Investigating the case when \( k=1 \)**

It is worth while drawing a few diagrams for the case when \( k=1 \), and thinking about what they mean. For instance, as the sides of the parallelogram are always at right angles no matter what size the figure is. Voltage and current are in quadrature.
THEORY

at all points. The phase of the current also remains constant apart from a sudden reversal on passing a current zero: the voltage behaves in a similar way. You will notice that the electrons in neighbouring half wavelength segments are surging back and forth in opposition, causing maximum voltage fluctuation at the points of zero current.

Line impedance, Z
In general, reflection coefficient, k, have any value between zero and unity. The ratio of voltage to current is termed the line impedance, Z, and on an unmatched line Z will vary from point to point. At the output end of the line, reflection must take place so that Z is identical to the terminating impedance. At the transmitter end of the line, Z is the impedance the line presents to the transmitter.

As the diagram allows you to measure the relative magnitudes of line voltage and current and their phase difference, Z may be found at the point in question. ('Line' values of voltage or current means the resultant values). On a matched line, Z=Z0 and does not vary.

Simplifying phasor diagrams
To simplify matters slightly, instead of rotating both clock hands, it is easier if the long hand is kept vertical and the small one is rotated through the double angle. If you do this, the diagrams no longer enable you to compare the phases of voltages and currents at different points on the line. But this is immaterial in finding the line impedance at a given point.

Secondly, the diagram itself may be simplified. Figure 6 shows the voltage and scaled up current parallelograms for a point on the line. They are close together and side by side. Figure 7 shows how unwanted lines can be omitted to give a single diagram. The scale is immaterial. Vector length \( OP=1 \) unit and \( OV=O\) unit. PV represents the resultant voltage while PI represents the resultant current, scaled up by \( Z_0/L \). Angle A gives the phase difference between the line voltage and current. Vector VOI acts as an indicator which can be rotated to reveal conditions at any point on the line.

An arrowhead is placed at \( V \). It is helpful to imagine a clock face behind the indicator with the 12 o'clock and 6 o'clock points marked \( V_{max} \) and \( V_{min} \) respectively. Figure 7 shows the indicator set for a point one tenth of a wavelength from a voltage maximum. This requires a rotation of \( 2\times360/10=72° \) from the 12 o'clock position, Fig. 7. A clockwise rotation is shown in Fig. 7 so the point in question must be on the transmitter side of the voltage maximum. If there is sufficient information to draw the diagram for a given point, then the line impedance, Z at that point can be found.

\[
Z=\text{resultant volts/\text{resultant amps}}
\]

\[
\text{Resultant volts}=PV, \text{Resultant amps}=PI/z_0,
\]

\[
Z=Z_0(PV/PI) \text{ or } (Z/Z_0)=(PV/PI).
\]

Now imagine that the indicator is set at 12 o'clock and then rotated to show the effect of moving along the line. As the indicator is rotated, the diagram changes shape, PV and PI change in length, and the angle between them, A, opens and closes.

Maxima and minima
At 12 o'clock, PV has its maximum length and PI has its minimum length. This point is a voltage maximum and a current minimum. \( PV \) and PI lie one on top of the other, so here angle A is zero. Voltage and current are in phase so Z is purely resistive and at its maximum value which is greater than \( Z_0 \). At 6 o'clock, current is at a maximum and voltage at a minimum, so Z has its minimum value which is less than \( Z_0 \), therefore purely reactive. At all other points A is not zero, voltage and current are not in phase, so Z is complex. Complex values of Z may be represented either by a resistance \( R \), and a reactance \( X \), connected in series, or alternatively by a parallel combination of \( R \) and \( X \).

Standard ac theory gives:

\[
R_0=Z_0\cos A, \quad X_0=Z_0\sin A
\]

Provided a suitable rotation convention is used the diagram also shows whether X is inductive or capacitive. If movement along the line away from the transmitter is represented by an anticlockwise rotation and movement towards the transmitter by a clockwise rotation, X will be capacitive if PV is on the right of IV, and inductive if on the left.

A numerical example
One tenth of a wavelength of 50Ω coax is terminated with a 100Ω resistor. The termination is a pure resistance which is greater than \( Z_0 \), so the termination will be a voltage maximum.

\[
\text{Standing wave ratio}=100/50=2.
\]

k=(2-1)(2+1)=0.33

One tenth of a wavelength is represented by a rotation of \( 2(360/10)=72° \).

The indicator is initially set to 12 o'clock to represent conditions at the termination, and then rotated clockwise through 72°. Figure 7 should be drawn with \( k=0.33 \) and could then be used to solve this problem. Vectors PV and PI and angle A are measured and PV/PI is evaluated. Then,

\[
PV/PI=1.2 \text{ and } A=35°.
\]

\[
Z=Z_0(PV/PI)=50\times1.2=60Ω.
\]

The series components of Z are:

\[
R_p=60/\cos35°=494Ω, \quad X_p=60\sin35°=34Ω.
\]

The equivalent parallel components are:

\[
R_p=60/\cos35°=73Ω, \quad X_p=60/\sin35°=105Ω.
\]

As PV is on the right of PI, X is capacitive.

This applies to both series and parallel cases. Alternatively, using the rotation convention, PI leads PV; the current leads the voltage so 'Z' is capacitive.

At the operating voltage of the line had been a resistance of 25Ω (ie \( Z_0/2 \) instead of \( Z_0 \) 'k' and the swr would have been the same numerically, but the termination would have been a voltage minimum so the initial position of the indicator would have been at six o'clock.

The diagram as a visual aid
The real beauty of the diagram is that it reveals and clarifies so many aspects of transmission line behaviour. You only need a few rough sketches without any maths to get a good idea of how impedance, voltage and current and their relative phase all vary along an unmatched line. Try investigating the result of altering 'k'. It may notice that if the diagram had been drawn upside down with \( P \) vertically above \( O \), giving \( V_{min} \) at 12 o'clock and \( V_{max} \) at six o'clock, the operating rules become similar to those of the Smith chart: 'X' will be inductive when the indicator points to the right, and capacitive when it points to the left. Otherwise the diagram is used exactly as before.

Comparing phases at different points
I have already pointed out that because one of the phasors is kept fixed, the diagram cannot be used to compare the phase of voltage or current at one point with that of another. If you are interested in making such comparisons, go back to the combined voltage-current parallelogram.

The diagram and the Smith chart
Those of you familiar with the Smith chart may notice that if the diagram had been drawn upside down with \( P \) vertically above \( O \), giving \( V_{min} \) at 12 o'clock and \( V_{max} \) at six o'clock, current. Vector VOI acts as an indicator which can be rotated to show the line conditions at any point from generator to antenna.
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SpiceAge competition results

Here are solutions to the competition held in the February 1995 edition of EW+WW.

The two best entries answered all the questions correctly and completed the tie breaker with interesting and viable applications for SpiceAge.

Congratulations to winners, Andrew Pate of Keighley and R. Smedley of London who will each be receiving a copy of SpiceAge for Windows Level 3.

Q1. SpiceAge for Windows is written in which country: USA, Germany, UK, Israel, Australia, Japan?
   A1. In the UK by Graham Baxter.

Q2. In a lossless circuit, resonance is given by \( \omega = \frac{1}{\sqrt{LC}} \). Write down the analogous expression for a mechanical spring + mass system. Please define completely the terms within your expression.
   A2. \( \omega = (\frac{k}{m})^{0.5} \) where \( \omega \) is angular velocity (for example in rad/s), \( k \) is spring stiffness (for example in N/m) and \( m \) is mass (for example in kg). Frequent wrong answers included some dependency on the gravitational constant and hence orientation of the system. (May be that's why upright pianos sound different from grands!)

Q3. Which of the following traces showing current in the terminating resistor is the correct response of a 75Ω transmission line terminated with a 150Ω resistor to which a current of 1A is suddenly applied?
   A3. Working man's answer is that it cannot be trace 2 as that corresponds to a matched terminating resistor. It cannot be trace 1 which is showing no dissipation in the system (the output is in fact short circuited). It must be trace 3.

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| to 20MHz |

Input B, 20MHz-1.3GHz

| Impedance | 50Ω |
| Sensitivity | 10mV rms, 20MHz to 700MHz, 50mV rms to 1.3GHz |

Input A/B limits

| Abs. maximum input voltage | 250V dc, 250V rms |
| 50Hz to 400Hz input A, B, 1V rms >1MHz input A, 1V rms 20MHz to 1.3GHz for input B |

Measurement - range A

| Frequency range | 5-25MHz |
| Resolution | 10⁻¹¹ Hz to 10Hz |
| Accuracy | ±1 digit + timebase error |

Measurement - range B

| Frequency range | 20MHz-1.3GHz |
| Resolution | 1Hz to 1kHz |
| Accuracy | ±1 digit + timebase error |

Period

| Frequency range | 5-25MHz |
| Resolution | 10⁻¹¹ s to 1us |
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Using variable integration, the ACF2101 switched integrator has a wide dynamic range, measuring currents down to a few nanoamps. Douglas Clarkson discusses using the device for detecting currents at photodiode levels.

As the number of applications involving currents generated by sensing devices increases, so also are refinements being sought in measurement circuits. With photodiodes, for example, where the induced current is proportional to received signal levels, current measurement may be over a broad range. It may also vary significantly with time.

Where photodiodes are measuring light levels directly or indirectly in the case of ionising radiation there is often the requirement to measure the total amount of a pulse of light or a pulse of radiation. Manufactured by Burr-Brown, this precision dual integrator can be used to undertake precision integration in a variety of modes to cater for such measurements.

The advantages of such a device are compactness and low droop voltage with time. Such units can be controlled with standard ttl logic levels.

General applications include current to voltage conversion, photodiode signal integration, current measurement, charge measurement, ct scanner front end and general medical, scientific and industrial instrumentation.

Device basics
Figure 1 shows the block diagram of the ACF2101, which is designed to operate on +5V and -15V supplies and draws typically 3mA on the negative supply and 12mA on the positive supply. Control of the device is basically undertaken by means of hold and reset logic pins, shown in Fig. 2. When hold is high and reset low (on condition), input current is

Figure 1. Functional diagram of the ACF2101, precision integrator from Burr-Brown. Features include droop characteristics of 1nV/µs and integrate slew rates of 3V/µs.

Figure 2. Pinout of the ACF2101 dip. The pins are arranged this way to allow for the stray-current guard rings.
integrated and the output voltage falls below 0V. The limit to negative integration voltage is -10V. Logic control is outlined in Fig. 3.

The device has an internal precision 100pF capacitance for each channel selectable using the circuit connections of Fig. 4. Where larger currents need to be integrated, a separate external capacitor can be included in each circuit as shown in Fig. 5.

Using the relationship,

\[ V_{\text{out}} = \frac{I_{\text{in}} \times \Delta t}{C} \]

where \( I_{\text{in}} \) is the input current, \( \Delta t \) is the time of integration and \( C \) is the integrating capacitor, values of \( I_{\text{in}} \Delta t \) and \( C \) can be calculated for a full scale value of \( V_{\text{out}} \) of -10V.

In applications in optical measurement, data can be required to be captured rapidly in micro seconds or over longer time periods, up to several 50Hz cycles. For longer periods, if a signal is being sampled over 50 half cycles at 10ms per half cycle then the sample time is 0.5s. With a typical photodiode current of 5pA the required capacitance will be 0.5pF.

It is important that the capacitance used is of sufficiently good quality. A high performance polypropylene type will minimise leakage losses, for example. Such integrators are valuable for example in measuring levels of light from sources which are varying rapidly, such as fluorescent tubes. The integrator can be switched on for a set period in order to capture an integral number of cycles of visible or ultra-violet light output.

In addition each output amplifier has an output select switch which allows for multiplexing of devices using an instrumentation amplifier as shown in Fig. 6. For all devices unselected, the integrated charge is held in each device and the output is not connected. For selection of a device, the output is communicated to the instrumentation amplifier. In this way a series of channels can be controlled by a common set of logic signals and individual integrated channels can then be selected.

Functional use

Normally the cycle of operation will be: reset - clear residual charge, hold, integrate, hold - maintain final voltage and read value. Data would normally be read at some point during the hold cycle. Voltage droop taking place during the hold cycle is given by

\[ \text{droop} = \frac{200 fA}{C} \]

where \( C \) is integration capacitance in farads and \( fA \) is femto amps.

For a 100pF capacitance and with no additional leakage currents this is equivalent to 2mV/\( \text{s} \) or 2nV/\( \mu \text{s} \).

The logic switching of hold and reset will cause charge transfer to take place. It will be of a sign which is a function of the sign of the transition – positive going or negative going. The magnitude of this switch is typically 0.1pC and this corresponds to a voltage offset of 1mV for a 100pF capacitance. Where this effect becomes significant, its impact can be minimised by ensuring that the reset and hold logic transitions cancel out.

These effects of voltage droop and charge transfer are reduced for larger values of capacitance. Thus for 10,000pF the voltage droop will be 0.2mV/sec and the charge transfer voltage 10µV.

Timing control

Control of the ACF2101's integration time is a key element of successful use of the device. Timing needs to be accurate for a set config-
MEASUREMENT

uration, but options should be available to select various integration times. Thus reproducibility of integration period needs to be good. There are many ways in which such consistency and control of timing can be achieved. Some of them are considered here. Assuming a logic level transition is used to initiate a timing sequence, a device such as the 4538 dual retriggerable monostable multivibrator provides a convenient way of producing an reproducible integrating pulse width, as shown in Fig. 7. With an input low to high transition on pin 4, the inverse output on pin 6 gives the required logic transition for time \( t \) where \( t = 0.7RC \). Table 1 indicates how a range of values of \( t \) can be configured.

Table 1. Value of pulse duration with cmos 4538 monostable.

<table>
<thead>
<tr>
<th>Value R</th>
<th>Value C</th>
<th>Time t</th>
</tr>
</thead>
<tbody>
<tr>
<td>10k</td>
<td>0.1µF</td>
<td>0.7ms</td>
</tr>
<tr>
<td>100k</td>
<td>0.1µF</td>
<td>7ms</td>
</tr>
<tr>
<td>1M</td>
<td>0.1µF</td>
<td>70ms</td>
</tr>
</tbody>
</table>

Assuming a logic level transition is used to initiate a timing sequence, a device such as the 4538 dual retriggerable monostable multivibrator provides a convenient way of producing an reproducible integrating pulse width, as shown in Fig. 7. With an input low to high transition on pin 4, the inverse output on pin 6 gives the required logic transition for time \( t \) where \( t = 0.7RC \). Table 1 indicates how a range of values of \( t \) can be configured.

Fig. 5. Precision capacitances with low leakage current are used externally from the ic to alter the time constant of the integrator.

Fig. 7. An integrating pulse is provided by a simple stand alone retriggerable monostable.

Fig. 8. Guard rings on the DIP package protect the ultra low bias current to the inputs from other currents on the pcb.
In this configuration the timing is a function of the specific values of $R$ and $C$. There is also the short term problem of temperature drift and long term problem of device aging. For a resistor with a temperature coefficient of $+500$ ppm (parts per million) a $10^\circ$ rise in temperature will result in a change of value of $0.5\%$. For a few extra pence per component, resistors with a temperature coefficient of $+50$ ppm can be obtained — reducing the percentage change in value for a $10^\circ$ rise in temperature to $0.05\%$.

Stable capacitors such as polypropylene have a negative coefficient of around $-200$ ppm while types such as polyester have values of around $+300$ ppm. Where possible, temperature coefficients should be of equal magnitude but of opposite sign. Often, however, more control is required over timing — both for accuracy and range of values. The circuit of Fig. 7, can be triggered with a value of $RC$ large enough to complete long pulses of several seconds, but with an external timing transition to reset the output. This output can be, for example, a timing line derived from a crystal of value $32,768$ kHz and divided down by a $4020$ 14-stage binary counter. The positive going start pulse could initialise the counter and set the inverted output of the $4538$ monostable low as a long pulse (several seconds is triggered).

Choice of integration period can be influenced by the nature of the signal being captured. Where, for example visible or ultra violet light levels from fluorescent sources are being measured, then the light output takes the form of rectified sine waves. At $50$ Hz cycles, the period of each positive cycle is $10$ ms. It would be appropriate to use a $250$ ms or $500$ ms integration pulse width with such signals to minimise problems of signal aliasing.

Circuit design using ACF2101 devices

The ultra low operational amplifier bias current of around $100$ nA, requires careful pcb design. Figure 8 indicates how so called guards are required to protect the inputs. Current which could flow from other tracks to the input track is instead trapped at the guard track. Handling boards can also increase voltage droop. Cleaning boards using solvents and de-ionised water minimises this effect.

Summary

The ACF2101 device has wide application in circuits measuring currents over a wide dynamic range. Care is needed with circuit layout in order to prevent leakage currents being picked up by the device as 'current signal'. Obtain a current data sheet on the device and not a preliminary one.

Further reading

AC2101 data sheet, Burr Brown International, 1 Millfield House, Woodshops Meadow, Crayley Centre, Watford, Herts, WD1 8YD.

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Slew rate limits based on Baxandall's 2.2kHz criterion may be true of classical music recorded with dynamic mics, analogue taped and cut onto vinyl with twenty year old technology. But for most music reproduced by power amplifiers today that limit is patently false.

Take live performances: a glance at the spectrum analyser during an Iron Maiden gig — engineered by my colleague Doug Hall — would show the 20kHz led lit almost solidly throughout numerous concerts over the past decade or so. Consistently high hf levels, with amplitudes as large as the loudest bass notes, are unexceptional with certain genres of music. Iron Maiden achieves them with nothing more than traditional (if heavily thumped) percussion instruments.

Low mass modern capacitor microphone capsules and local buffering to reduce hf attenuation and loading dips in stage-to-mixer cabling have boosted the acquisition of percussive edges with quasi-fundamentals of 15kHz and above\(^1\). Live sound and recording consoles have equalisers on every input channel, and most are in use. But I have measured none that does not also increase ultrasonic frequencies when any kind of boost is dialled up on the hf control(s), pushing frequencies above 4kHz. This unadvertised — and not readily avoidable — ultrasonic boosting can at least counter, if not overwhelm, rf filtration and band-limiting in the system. In this way, unexpectedly high level ultrasonic signals can appear at the power amplifiers' inputs.

As for recorded replay in studios and homes, cd and dat can handle full level at 20kHz. While for direct-cut vinyl recordings, the bandwidth above which no additional musically significant cues are heard can range, for some listeners, to 200kHz.

Unfortunately, old data ignores the break-neck development in the past seven years, such as fm synthesis of electronically generated, manipulated and sample-based music. In effect new 'virtual instruments' have been created to add to the family employed by mainstream music, untrammelled by
Many of these new sounds and ‘instruments’ can include or produce full (0dB) levels at 20kHz. Even the breathy sounds of close-miked vocals can become unacceptably sibilant when handled live by some bipolar power amplifiers – a problem widely experienced as disappearing when faster mosfet amplifiers are substituted.

**RF filtration**

Must an amplifier have rf filtration on its input port?

The ideal per-stage bandwidth for high quality music reinforcement, monitoring and reproduction should be at least 100kHz and ideally no more than ~3dB at 200kHz. Above this, input filtration is positively desirable. Without it, whether the incoming program can slew at a rate that taxes the amplifier is not an issue. Radio frequency can (and regularly does) make egress in the cabling preceding most power amplifiers. Self’s design (his Fig. 1 in ref. 2) omits input filtration, yet a 900MHz mobile phone signal need only peak at 100mV to slew at 500V/µs. Just 1mV peak ingress would out-slew even a 50V/µs capability.

Radio frequency filtration does not slow fast edges; it just reduces the amplitude portion of the ‘rate’ or amplitude-frequency product. So input (and other portal) rf filtering (cf interior band-limiting) only protects an amplifier with a marginal slew rate if rf levels are below a certain threshold.

In the real world, the ubiquitous rf debris that is part of urban living may be less obliging. Fast-edged ‘clicks’ caused by dust particles on vinyl striking a stylus can also tax amplifiers harder than the toughest programme.

**Rateable values**

The foregoing shows why higher slew limits than those needed to reproduce a 20kHz – let alone 2kHz – sine wave at 0dB, can be justifiable. For any given degree of hf filtration, more-than-adequate slew limits alone can distance the ears from the very unpleasant and ear-fatiguing distortion that can begin when an amplifiers’ slew limit is approached by a factor of two, or even a ten. At the point where visible slewing begins, when signal slew is equal to the amplifier’s limit, thd is already about 1% and the damage – with grating high harmonics – has already been done.

These events may happen rarely in many systems and situations, and in others not at all. But no-one should not dismiss the validity of higher-than-expected slew rates as being beneficial to sonic quality because a difference could not be heard with casual listening. No-one would remove the rear fog lamps from a car on the grounds that other vehicles had never run into it.

Walt Jung’s original and in-depth work on slewing covered this ground 18 years ago and should be compulsory reading for anyone writing on this topic.

Slewing can trigger prolonged indigestion in amplifiers. Even when it doesn’t, as little as 1-2s of gross distortion due to slew-limitation during a performance can effect listener enjoyment for several minutes afterwards – an effect analogous to gross video corruption when watching a spell-binding film.

The upshot is that prudent minimum slew limits for quality audio should be at the limits of wood and metal.
least Walt Jung’s 18 year old recommendation of 0.5V/µs per peak output volt (pk $V_o$). This allows an 80kHz power bandwidth (referred to 1% distortion) and remains almost safe for a great deal of reproduced sound: by a factor of four for CD and DAT, and at least five for live BBC (vhf, fm) broadcasts.

Fig. 4. Simulation circuit used for Fig. 3 precisely follows Self’s own Fig. 11 schematic. British semiconductor models are used for the small signal BJT; Zetex (ex-Ferranti) is the only general semiconductor maker in the world so far to issue Level 3 (Gummel-Poon) BJT data. Output devices are modern, fast (20M1A), TO3P. Models were created with extra data supplied by the Japanese maker. This was entered into MicroCap’s refined parametric extraction program (PEP), to derive the Level 3 parameters. The sister circuits used to plot Figs. 1 and 2 differ as follows:

In Fig. 1, all the current source circuitry is replaced by ideal, independent sources. In Fig. 2, current source circuitry connections are as shown in Self’s Fig. 1.

In all three circuits, differentiator RC values have been scaled to permit accurate results up to 500V/µs.
Virtual spectrum analysis

Using MicroCap IV as a spectrum analyser is straightforward, requiring just the Harm operator (Harm[v/nn]) where nn is usually the output) an analysis period that is an integer of the stimulus period, and adequate memory. Here, just over 1MB (of 4MB system memory) was free for use. A 486-DX with Dos-6 is a sensible minimum. Even with MicroCap IV – the fastest pc software simulator – each high-accuracy run will offer you a minute or two to spare.

Fig. 7. Testing the high speed topology with a 485V/µs step yields about +315, -405V/µs. The mild asymmetry is academic, with nearly 2V/µs/V0 pk available for 160V swings (800W into 16Ω). Speed is readily increased further. Physical (as opposed to simulated) slew testing of this order needs care, as aside from the usual high speed traps [7] the low resistance differentiator networks shown dissipate heavily.

Fig. 8. The DVT has simpler drive circuitry than Self’s, coupled to complementary power mosfets. The drive IC is a macro of a fast op-amp built from discrete components (DT). For fair comparison with Figs 1-3, the 8Ω load, gain and differentiator values (100 and 100pF) are identical. Switch resistors 'rsw' allow 3/4 of the output mosfets to be disconnected to view the performance of one mosfet pair.

Fig. 9. Simulated harmonics in Self’s Fig. 1 circuit, 0.5dB below clip. The top left marker tells us that the 1kHz fundamental is at 44V (discovered by using MicroCap’s cursor function). So the ugly ninth harmonic, at 115pV, is about 0.0003%. This is audibly more significant than it appears.

Fig. 10. With the input stage current unbalanced ‘by uninspired guesswork’, here increasing R, to 3.9kΩ, the harmonic structure changes. Here, the evens are strengthened over Fig. 9, but not enough.
amplifier, even modified to ±50V/µs, is just about acceptable. But it is certainly unsuited for the higher swings often required into inefficient speakers that are the domestic norm. And also for today's weight- and volume-challenged live music monitoring and reinforcement amplification.

In practice, with advanced hf drive units (both dome tweeters and compression drivers) used in professional live music monitoring and reinforcement amplification, even modified to ±50V/µs, is just about acceptable. But it is certainly unsuited for the higher swings often required into inefficient speakers that are the domestic norm. And also for today's weight- and volume-challenged live music monitoring and reinforcement amplification.

Like a powerful car in experienced hands, the headroom is demonstrably safer for drive units and ears alike - no matter how counter-intuitive this seems. The present record of about 160Vo pk output per channel is set by one of my own designs - made by a UK company - and two similarly rated units from US competitors. Their associated differences which will not greatly affect the predictions. All transistor parameters are perfectly matched between identically named individuals. Protection diode D1 and the input dc blocking cap C1 are excluded, and electrolytic capacitors C2 and C3 are modelled as ideal non-polar components. All the small signal bipolar transistors are Level 3 (Gummel-Poon) models. All simulations were carried out at 27°C, the default temperature. Stepping over more realistic operating temperatures - up to 80°C in some cases - is straightforward but requires individual graphs for clarity.

Simulated differences
The circuitry entered in MicroCap IV to produce Figs. 1 - 3 differs from Self's explicit circuit in only minor respects which will not greatly affect the predictions. The supply comprises perfect dc from 50V batteries, albeit with 30mA series resistance, so the rails do drop slightly when loaded.

All transistor parameters are perfectly matched between identically named individuals. Protection diode D1 and the input dc blocking cap C1 are excluded, and electrolytic capacitors C2 and C3 are modelled as ideal non-polar components. All the small signal bipolar transistors are Level 3 (Gummel-Poon) models. All simulations were carried out at 27°C, the default temperature. Stepping over more realistic operating temperatures - up to 80°C in some cases - is straightforward but requires individual graphs for clarity.
The output referred 100V/μs test signal would be well above the scale maximum of 50V/μs. Multiplication by 492 rather than 1000 – the factor needed to get the differentiator outputs converted so each volt = 1V/μs – brings it into visibility.

According to the model, the topology used by Self is slewing at +37V/μs in the main flatish region, though peak slew is +45V/μs. Negative slew rate has no flat region, but peaks at over –50V/μs, and asymptotes about –37V/μs.

Only one exception to a full, frank simulation was used to achieve these results: ideal current sources were used in place of Tr1,6 and Tr14 and surrounding parts (see Simulated differences panel).

In Fig. 2 the current-sources were re-entered exactly as in Self’s circuit. Here, the flat portion of the positive slew limit reduces to +18V/μs, and the peak to about +32V/μs.

Negative slew (V0-) peaks at –35V/μs, and if there were a flat region, it would be about –30V/μs.

After rewiring with Self’s Fig. 7 current-source improvements (Figs. 3 and 4) we are back to +36V/μs or a peak of +42V/μs, and as much as –45V/μs. This is not quite the ±50V/μs claimed by Self, but it is near enough, and follows the right pattern. The feedthrough ‘braking’ effect on positive slewing is real and undisputed.

What is disputed is the ability of other designs to outpace the Lin topology employed by Self, which dates back forty years. Quality-conscious designers have long ago moved on, having discovered that as soon as one aspect of this cantankerous topology is perfected, another collapses into disorder or asymmetry.

Figure 5 shows the slewing of the DVT250s 400W/4Ω channel professional mosfet amplifier, Fig. 6, first produced in 1984 by Rauch Precision, a company founded by Jerry Mead.

When launched, its slew performance was exceptional, though the circuitry was fairly conventional. In the later version simulated here it employs six transistors – excepting the output mosfets, current source and mirror. Distortion is higher than Self’s. But it still meets the essential raw criterion of well below 0.1% thd into any rated load at any level below clip, at any audio frequency.

The plots confirm that the DVT’s slew rate is about +85 and –70V/μs in the flat portion, i.e. at least 0.88V/μs per pk Vp for the 62V peak swing. Peak slew is 120V/μs.

Tellingly, second-hand samples are much sought after today and reach high resale prices. An oft cited reason is the effortless ability to handle distortion free. Though not being trusted, they are not experiencing in more recent amplifiers.

In the past decade, leading designers charged with creating quality high-power amplifiers for music have had to develop topologies to ease provision of the higher slew rates needed for high swings, above 90V.

Figure 7 demonstrates graceful and only mildly asymmetrical slewing in excess of ±300V/μs, in response to the 485V/μs test signal – a performance achieved with my 160Peak-capable design as well as Fig. 8. Speed can readily be pushed higher, yet percentage thd is not being traded: at over 1300W into 8Ω, it can be as good as 0.02% at 20kHz.

In all cases, mosfets are used. Bipolar junction devices would be vapoourised without added anti-saturation circuitry. When amplifiers with such a high swing and high slew are bare-tested with rf filtration removed, even heavy-gauge pvc cabling made for 50Hz mains can melt, demonstrating the gross energy abstraction of pvc as dielectric. Naturally, this does not occur with ‘audiophile’ cables of ptf construction.

Harmonic argument: Self rebuttal

In Distortion in Power Amplifiers6, Self describes the thd-reducing effect of perfectly balancing the collector currents in the input differential pair transistors. He makes no mention of a classic EW+WW article7 on this topic however. Instead, he infers that some practices in this area are ‘misguided’: for example when the collector resistor (i.e. R2 in his Fig. 7a) is set for pair current imbalance. But simulation can demonstrate that there is method in the apparently wayward combinations.

The amplifier being driven does have a 0.5dB below true clip, with a near perfect pure dc power supply (batteries), and a 1kHz stimulus, into an 8Ω load. This is one of the most benign conditions a real power amplifier can expect.

The amplifier does indeed demonstrate low harmonics in this static domain. But notice that while the second is the greatest, the next largest are the scarcely benign fifth and the positively metallic sounding seventh harmonics.

Even harmonics are depressed by comparison, and the second is not good at masking this. Worse, the real order – to our ears – greatly emphasises the high harmonics, including some distinctly grating components above the tenth, not plotted here for clarity. While small, these are not necessarily masked by much higher, but paradoxically less audible lower order distortions created by loudspeakers.

Harmonic argument: Bessel-Kolmogorov

As a result of the earlier work of Bessel and Kolmogorov, it is known that a single stage with a current source in the input differential pair transistors will achieve less than 0.1% thd at any audio frequency. This is why amplifiers with a single stage are designed to achieve this result.

The amplifier being driven does have a 0.5dB below true clip, with a near perfect pure dc power supply (batteries), and a 1kHz stimulus, into an 8Ω load. This is one of the most benign conditions a real power amplifier can expect.

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In Fig.10, the current mirror (Fig. 11a) used to enforce close current balancing has been removed and replaced with Self's original arrangement, a single \( R_c \) in the forward leg. Here (Fig.11b) it is 3.9k\( \Omega \), which causes a major imbalance. The upper plot shows how the forward leg current \( (\sqrt[2]{10}) \) seen lowermost, is about 250\( \mu \)A, starving the voltage amplification stage of current drive.

Although this has increased (try summing the heights of the triangles) the sonic qualities will be different and, to many ears, more pleasant and more rounded. The reason is that the odd and even harmonics are almost evenly paired, with the exception of the recessed sixth and tenth. These same considerations have been used for centuries by musical instrument makers to adjust timbre.

Lastly, Fig. 12 shows what happens when \( R_c \) is readjusted for near perfect balance without the current mirror. Note how the much-magnified current plots in the upper panel show how the current waveforms, while dc matched, are dissimilar in amplitude and harmonic content, making a nonsense of perfect quiescent matching.

Once again, the harmonics are different. The seventh is below the noise floor, the tenth is nearly masked, while the second is recessed. Overall, a hard, nasal sound would be predicted by the harmonically conversant.

So much for balancing.

Douglas Self's series on amplifiers provides a lucid insight into the nth degree static linearity of low frequency amplifiers for industrial loads, test equipment satisfaction and low common denominator 'consumer audio'.

But in the context of true high fidelity audio and what analogue electronics can offer to the unfettered reproduction of all kinds of music, it falls far short.

References

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ELECTRONIC COMPONENTS BOUGHT FOR CASH

310 ELECTRONICS WORLD + WIRELESS WORLD April 1995
The demand for data traffic in today's high technology world has fuelled an incredible growth in the requirement for data-communications equipment, which includes fax, telex, X25 packet switching, lans and modems.

Data communication requires either its own separate digital network or modems that convert digital information for transmission over analogue telephone lines. Modems give access via the world-wide telephone network, but are slow and inefficient. Separate digital networks are more efficient but expensive to install. In addition they are generally proprietary offering little or no equipment portability.

Digitization of the telephone network began in the 1960s on the trunk lines between public exchange switches. Around a decade later the first digital telephone exchanges appeared. Currently, the only part of the network remaining exclusively analogue is the subscriber line connecting the telephone to the public or private telephone exchange. The majority of today's telephone lines are still analogue, optimized for transmission in the voice spectrum of 300Hz to 3.4kHz, but this is changing.

The digital future
Tomorrow's telephone network, available now, will be digitized from end to end. It will provide integration of voice and data communications giving an efficient and compatible world wide network. Transmission rates will increase dramatically while errors decrease to a negligible level, making communications faster and more efficient.

More than one signal may be sent simultaneously on a single telephone line. Both voice and a wide variety of data services will be available to users over one network with standard interfaces and recognised set-up procedures without the expense of additional or special lines. Ultimately this will bring cheaper equipment and a wider range of services. This network is called ISDN.

Standards for inter-connectability
The international telegraph and telephone consultative committee, CCITT - a United Nations organization began working on standards for ISDN in 1978. It published a series of recommendations that have become a world-wide industry standard. Fundamentals of the ISDN structure are specified

Integrated services digital network - ISDN - makes it possible for anyone with a telephone line to communicate digitised speech and data world-wide at up to 144kbit/s. Mike Button explains how.
Isdn architecture according to CCITT
In order that users may have a common language to express and define their requirements the CCITT has a set of definitions which all users can ‘understand’. The hardware is divided into several segments called ‘termination equipment’ and the functionality of the network is defined by ‘reference points’. Isdn configuration does not depend on whether the basic or primary rate is employed.

Figure 1 shows the topography of the network identifying specific classes of equipment at CCITT defined reference points. The isdn equipment, listed below, is classified by its function and location within the network.

Termination equipment. The exchange termination is the interface between the telephone switching network and other parts of the exchange. This includes the interface to the line termination and to other parts of the switching network. The line termination is located at the telephone exchange and performs OSI physical layer functions for the ‘B’ and ‘D’ channels plus the ois layer two and three for the ‘D’ channel. See panel below for details on the OSI reference model.

Network termination, NT, is divided into two types, type NT1 performs such functions as line length extension and two-to-four wire conversion (U to S interface).

Termination NT1 deals only with layer one of the OSI model and as such has no intelligent logic. NT2 types are intelligent devices that actively participate in call routing and control functions. They can be connected, simultaneously, to multiple isdn line types. Network terminations often form the boundary between

Isdn services
Basic rate. The basic rate runs at 144kbit/s and provides two 64kbit/s bearer channels for either voice or data and one 16kbit/s data channel for signalling or data. This ‘2B plus D’ arrangement is the standard service provided to the user. This basic rate service is now available from BT as ‘Isdn 2’.

Primary rate. Europe. The primary rate runs at 2.048Mbit/s and provides 30 bearer channels, one data channel and one synchronization/control channel – all at 64kbit/s. This ‘30B plus D’ arrangement is provided when more traffic or data handling capacity is required. In North America and Japan the primary rate runs at 1.544Mbit/s and is configured as ‘23B plus D’. The primary rate is used to connect private branch exchanges to public exchanges or to interconnect basic rate services within and between exchanges. Private branch exchanges can be interconnected via telephone networks. Local area networks have been developed using the primary rate to interface with other lans. This primary rate service is now available from BT as ‘Isdn 30’.

The open system interconnect (OSI) model for networks
In the early 1970s data communications had no recognised standard and hence there was no compatibility between vendor products. It soon became apparent, as the market for data communications grew, that it was in everyone’s interest to have the capability to interconnect equipment from different manufacturers. In 1978 the International Standards Organization (ISO) commenced work on the ‘open system interconnect’ reference model to provide the framework for orderly communication across different data networks. The work of this committee was supported by the CCITT in their recommendation, X.200.

The model chosen by the ISO is a seven layer structure in which each layer provides particular logic services that belong to each other.

1. The physical layer, the lowest layer in the 2777 X.200 architecture, provides mechanical and electrical functions and procedures for the installation and maintenance of power supply, hardware clock and timing, provision of connectors and so on.
2. The data link layer resides immediately above the physical layer provides for the transfer of units of information between the two ends of the physical link such as framing, flow control and error detection. In isdn the CCITT Q.921, ldp (link access procedure d), is the key layer 2 protocol for signalling on the D channel. Examples of data link layer protocols are - bisynchronous, and synchronous data link control (sd1c) of IBM’s sna, digital communications message protocol (dcmp) of DEC’s Decnet, Ethernet’s local area network (lan) IEEE standard, ISO’s high level data link control (hl1c), a subset of which is known as lapb (link access procedure balance).
3. The network layer is responsible for addressing, switching and routing functions that are needed to set up a path for transparent transmission.
4. The transport layer is responsible for providing the required performance at a minimum cost based on the current state of the network.
5. The session layer co-ordinates the interaction of the application processes at each end. It controls session establishment, management and release together with error reporting.
6. The presentation layer provides for code conversion data between different types of termination.
7. The application layer is the layer that is application specific and communicates directly with its opposite number.

The main objective of the OSI definitions is to simplify the communication between different layers. Each layer is defined to provide services to the next higher OSI layer. Adjacent layers interact with predetermined requests and responses called primitives. At each layer there is a ‘peer’ protocol to govern the layer interaction.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Provides mechanical and electrical functions for the installation and maintenance of power supply, hardware clock and timing, provision of connectors and so on.</td>
</tr>
<tr>
<td>Data Link</td>
<td>Provides physical link functions such as framing, flow control and error detection.</td>
</tr>
<tr>
<td>Network</td>
<td>Provides addressing, switching and routing functions.</td>
</tr>
<tr>
<td>Transport</td>
<td>Provides transparent transmission.</td>
</tr>
<tr>
<td>Session</td>
<td>Co-ordinates the interaction of the application processes.</td>
</tr>
<tr>
<td>Presentation</td>
<td>Provides code conversion data between different types of termination.</td>
</tr>
<tr>
<td>Application</td>
<td>Communicates directly with its opposite number.</td>
</tr>
</tbody>
</table>

The open system interconnect (OSI) model only communicates with the layers directly above and below it. Despite this, the system behaves transparently as if the layers are connected directly to their counterpart at the receiving end, shown here by the dotted lines.

Each layer of the open systems integration (OSI) model only communicates with the layers directly above and below it. This transparency is achieved by the layers being connected directly to their counterpart at the receiving end, shown here by the dotted lines.
### Oscilloscopes

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the subscriber equipment and public exchange. Terminal equipment can be telephone instruments, computers and faxes that are directly compatible with isdn. Terminal adapters are provided to connect non isdn compatible equipment to the network. They convert the communications protocol used by non isdn equipment to either the basic or primary rate. The DP2000 isdn telephone, available from BT, is piece of terminal equipment with a combined terminal adapter for additional data or voice equipment.

Reference Points

Reference points identify the connection points between equipment classes only. They do not specify any implementation or protocol of this inter-connection. Reference point 'R' is the boundary between non isdn compatible equipment and the network. Reference point 'S' is the boundary between the NT2 equipment and the terminal equipment/adapter. If there is no NT2 equipment then the reference point 'S' will not exist. Reference point 'T' is the boundary between the NT2 equipment and either the NT1 or terminal equipment. Reference point 'U' is the boundary between line termination and network termination. Reference point 'V' is the boundary between the exchange switch and the line termination (LT). The 'R' reference point is defined as an interface between the isdn and a non isdn world. Various standard data interfaces are possible at the 'R' point, for example RS232, X.25 and X.21. A non-isdn subscriber terminal needs a terminal adapter (TA) to connect to the isdn world. The S-interface is the user interface into the isdn network.

Termination of the public network, NT1, ensures the conversion between the U and the T interfaces. These functions are bit rate conversion, clock and frame re-synchronization, frame conversion and power supply. NT2 is an intelligent module which carries out the conversions between the T-interface and the S-user interface. It also provides the interconnection between the subscriber terminals both at the physical layer and the software level. When the S and T interface correspond to the same port, NT2 is not needed. NT1 and NT2 may also be combined to ensure a direct conversion from the public network (U-interface) to the user interface (S-interface).

Integrated circuits for isdn

There is a host of integrated circuits available from different manufacturers. To give a list and function summary of all types is beyond the scope of this article. For more information, interested parties should contact either the manufacturer direct or one of the many distributors. Mitel, AMD, Philips and GEC have

---

**Fig. 2. Timing and control signals are fed down the line with the data.**

**Fig. 2a. Two speech channels and one data channel can be fed down a twisted pair using an isdn chipset and a few digital ics. The block diagram, Fig. 2, shows how this 'master' circuit fits into the isdn structure.**
data books on their range of ISDN integrated circuits and I have found the distributor, Electronics 2000, very helpful. The more common circuits are given below.

Coder decoder. A codec provides the conversion between the voice-band analogue signals from the telephone instrument and the digital signals required by a PCM (pulse code modulation) signal as used by ISDN. It is manufactured as a single integrated circuit incorporating digital to analogue and analogue to digital converters operating at a sample rate of 8kHz to accommodate the 300Hz to 3.4kHz audio bandwidth. Codecs from different manufacturers vary slightly in function but they all have the following features in common:

- Operation at basic and/or primary rate.
- Analogue input with corresponding digital output.
- Digital input with corresponding analogue output.
- Chip select or synchronization input.
- A non-linear analogue to digital companding, A-law or p-law.

In order to maintain an acceptable dynamic range the analogue signal is converted to or from an eight-bit digital signal, made up of a sign bit, (S), three cord bits, (C) and four step bits (D).

### Table 1. European and North American codec companding laws convert the analogue signal to an eight-bit digital signal, made up of a sign bit, (S), three cord bits, (C) and four step bits (D).

<table>
<thead>
<tr>
<th>Chord Value</th>
<th>Step Value</th>
<th>Chord Value</th>
<th>Step Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mV)</td>
<td>(mV)</td>
<td>(mV)</td>
<td>(mV)</td>
</tr>
<tr>
<td>0 0 0 0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.613</td>
</tr>
<tr>
<td>0 0 1 1</td>
<td>20.1</td>
<td>10.1</td>
<td>1.226</td>
</tr>
<tr>
<td>0 1 1 1</td>
<td>80.6</td>
<td>70.8</td>
<td>4.90</td>
</tr>
<tr>
<td>1 0 0 0</td>
<td>161.1</td>
<td>151.7</td>
<td>9.81</td>
</tr>
<tr>
<td>1 0 1 1</td>
<td>332.0</td>
<td>313.0</td>
<td>19.61</td>
</tr>
<tr>
<td>1 1 0 1</td>
<td>645.0</td>
<td>637.0</td>
<td>39.2</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>1289.0</td>
<td>1284.0</td>
<td>78.4</td>
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</table>

**Examples**

<table>
<thead>
<tr>
<th>Cord = 3</th>
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<tbody>
<tr>
<td>+ 3 4</td>
</tr>
<tr>
<td>0 1 1 0 0 1 0 0 0</td>
</tr>
<tr>
<td>1 0 1 1 0 1 0 0 0</td>
</tr>
</tbody>
</table>

**Examples**

<table>
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<tr>
<th>Cord = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 2 7</td>
</tr>
<tr>
<td>0 0 1 0 0 1 1 1</td>
</tr>
</tbody>
</table>

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**Companded digital signal**

**European A-law**

<table>
<thead>
<tr>
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<th>Step Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mV)</td>
<td>(mV)</td>
</tr>
<tr>
<td>80.6</td>
<td>70.8</td>
</tr>
<tr>
<td>100.12mV</td>
<td>90.4mV</td>
</tr>
<tr>
<td>30.3</td>
<td>19.61</td>
</tr>
<tr>
<td>637.0</td>
<td>39.2</td>
</tr>
<tr>
<td>1284.0</td>
<td>78.4</td>
</tr>
</tbody>
</table>

**North American p-law**

<table>
<thead>
<tr>
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<td>90.4mV</td>
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<td>19.61</td>
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<tr>
<td>637.0</td>
<td>39.2</td>
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<td>1284.0</td>
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**Examples**

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<th>Cord = 3</th>
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<tr>
<td>+ 3 4</td>
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<td>0 1 1 0 0 1 0 0 0</td>
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<tr>
<td>1 0 1 1 0 1 0 0 0</td>
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**Examples**

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<th>Cord = 2</th>
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<tbody>
<tr>
<td>- 2 7</td>
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<tr>
<td>0 0 1 0 0 1 1 1</td>
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In order to maintain an acceptable dynamic range the analogue signal is converted to or from an eight-bit digital signal in a non linear manner. There are two companding (conversion) laws presently en vogue. Generally the A-law is used in Europe and the p-law in North America, Table 1.

### Subscriber line interface circuit, slic

This device, normally a hybrid circuit, provides all the 'borsch' functions (battery feed,
Racal/Dana counters - 9904 - 9905 - 9906 - 9915 - 9916 - 9917 - 9921 - 50Mc/s - 3G Hz - £100-
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Marconi distortion meter type TF2331 - £150. TF2331A- 200.
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Scalar network analyser type 527E + rubidium standard type 9475- £2750.

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Tektronix 3336A or B syn level generator - £1500.
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Tektronix 3336A or B syn level generator - £1500.
Tektronix 3325A syn function generator - £1500.
overvoltage protection, ringing feed, line supervision and 2 to 4 wire conversion) needed to connect a telephone instrument to a telephone line. It receives the audio signals from the codec and is controlled by the ‘D’ channel.

Subscriber line audio circuit, slac
This device, normally a hybrid circuit, is called a central office interface by the Americans. It provides a complete audio and signalling link between a telephone exchange line circuit and a telephone line. It looks and behaves like a telephone instrument providing loop seize and ringing detector circuits. It takes and receives the audio signals from the codec and is controlled by the ‘D’ channel.

Digital network line circuits (dnic, dsic, dsc, isac-s)
The connection between the telephone exchange and an isdn terminal is normally a twisted pair line. To transmit isdn data over this medium some form of electrical conversion is needed to enable both data detection and synchronization. A number of interface circuits have been devised to provide a variety of signalling codes over both two-wire and four-wire circuits. Some of the more common signalling codes used by these devices are described below.

2B1Q – Two binary to one quaternary. This takes two bits of isdn code and converts them to a four level signal. It halves the transmitted baud rate.

4B4T – Four binary to three ternary. This takes four bits of isdn code and converts to a three level signal. It reduces the transmitted baud rate by three quarters.

Biphase. Converts the isdn signal into level transitions. (Binary ‘0’= falling edge and binary ‘1’= rising edge, similar to ‘Manchester code’). It does not reduce the transmitted baud rate but does have the feature of concentrating the power spectrum in a relatively narrow bandwidth.

Data rate adapters. These provide the means whereby low speed signals such as RS232 can be converted to the basic rate. They have similar functions to a codec except that they handle serial/parallel data signals instead of analogue signals.

Digital Switches. Within a telephone exchange digital switches are used to cross connect basic and primary rate signals.

Circuit example
Most integrated circuit manufacturers now produce chip sets to provide isdn facilities. It is now relatively easy to use this technology to produce equipment to access isdn.

The circuit example given in Figs 2(a) and 2(b), taken from an existing design, show how a single twisted pair line can be used to carry two speech channels and one data channel at distances up to one kilometre. Figure 2 gives details of how this circuit fits into the isdn scheme. Figures 2(a) and 2(b) give actual circuit details. This circuit pair could be used, for example, to enhance the facilities of a field telephone at fêtes and galas. For simplicity, circuits for the termination equipment are not given. The analogue signal inputs and outputs could be connected to buffer amplifiers to drive operator’s headsets or two sic standard telephone instruments may be connected at each end.

The data inputs and outputs may be connected, via suitable buffers, to a key and lamp unit or directly to a sic control input.

Integrated circuits used to provide isdn facilities.
ities are supplied by Mitel; a brief description of these circuits is given below. Full details of the dnic and codec are available in data sheets of the devices, available from Mitel or their distributors.

Digital network interface circuit, dnic
The MT8971B device is intended for use as an interface for the integrated services digital network. It may be used in practically any application requiring high speed basic rate duplex data transmission over two wires. It is a multi-function device capable of providing transfer of speech or data over a distance of a kilometre or more.

With the more expensive MT8972B and a loop extender circuit distances of up to seven kilometres can be achieved. An adaptive echoing technique is used by the on-circuit digital signal processor to transfer data in a ‘2B’ + ‘D’ format.

Several modes of operation are available. In this example, modes two and six are used for transferring speech and data in master and slave mode. In order to provide framing and control signals, extra bits are added to the serial data steam and the data plus synchronisation signals are transmitted at 160kbit/s.

The MT8965 coder decoder
This device provides the conversion interface between the voiceband analogue signals and the digital signals required in a digital pcm-switching system. An 'A-law' encoding and decoding is provided to CCITT specifications.

Line signalling
The line signalling 'D' channel is controlled by two universal shift registers IC5 and IC6.

Output Y0 from IC6 performs the following functions.

The tri-state buffer is enabled which presents the output of IC13A to the DI bus.

IC5 is changed from the parallel load mode to the 'shift right' mode.

Next, IC5 is changed from the 'hold' mode to the 'shift left' mode.

At the rising edge of output Q of IC12A (which occurs at the start of each bit period) data from IC5 is clocked into the 'd-type latch' IC13A (7474), the output of which is then presented to the DI bus via the enabled tri-state buffer IC14A.

At the rising edge of Q of IC12A which occurs three quarters through each bit period, IC5, IC6 are clocked and the data present is shifted left once. This process continues during the period that output Y0 from IC6 is active (OV).

Availability
BT is currently offering an isdn service to its customers. Both basic rate and primary rate services are available, together with compatible terminal equipment. Akin with the early days of the Post Office telephone service, the installation and rental charges will prohibit installation of isdn to all those but the most affluent or those with a real need.

The installation charge for a single line basic rate service is £400 with a quarterly rental of £84. The provision of a primary rate service starts at an installation charge of £594 with a quarterly rental of £508. A telephone type terminal suitable for these services is £699.

All these charges are excluding vat. Full information is available from BT on their freephone number 0800 181514.

Prospective users with a high volume of data traffic will see savings on call connection charges as data can be sent at a much higher rate than currently available from modems. This, of course, assumes the distant end also has the isdn service connected.

Mike Button is a consultant design engineer with TDR Ltd. He can be contacted on 01666 577 464.

Further reading
Products Data Book, SGS Telecommunications.
ICs for Communications Handbook, Siemens Telecom.
AMD Isdn Data Book.

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April 1995 ELECTRONICS WORLD+WIRELESS WORLD

319
A number of circuit arrangements have been proposed to allow the magnitude of an audio signal to be controlled by an externally applied dc voltage. Most of them, however, introduce a relatively high level of harmonic distortion into the signal being controlled.

A typical layout, using a junction fet as a voltage controlled resistor in one limb of a resistive attenuator, is shown in Fig. 1. Unfortunately the channel resistance is modulated by changes in the gate-drain potential. This leads to substantial signal distortion.

The classic method of minimising this is by introducing some negative feedback from the drain circuit. A typical layout for this, from Siliconix application note AN73-1, is shown in Fig. 2. The resistor ratio suggested by Siliconix is \( R_2 = R_3 \times (10 \times \text{I} / \text{I}_{\text{max}}) / R_L \). This reduces the distortion at 1V rms and 1kHz from 10-15% to 1-1.5%. Although this value decreases as the signal level is reduced, it is not good enough for hi-fi applications, where ideally a thd figure of less than 0.01% is sought.

Figure 3, from Precision Monolithics application note AN-105, is a much better arrangement. In this design, input signal voltage is caused to modulate the stage current of two matched long-tailed pairs comprising a matched quad-transistor array. Even-order harmonic distortion, caused by the curvature of the transistor \( V/I \) characteristics, is minimised by driving the two halves of the circuit in push-pull.

A thd of less than 0.03% is claimed, at an unspecified signal level or operating frequency. Experimentation indicates that achieving this performance demands a very high degree of matching of all four transistors.

Using two separate monolithic matched pairs is not satisfactory. The Precision Monolithics circuit philosophy is also applied, in simplified form, in the Motorola MC3340. At one time, this device was widely used as the basis for remote volume controls in televisions. It was claimed that the IC had a thd figure of 0.6% at less than 0.5V rms. Unfortunately, this performance is only achievable at low attenuation levels. At 50dB attenuation the quoted thd has worsened to greater than 3%.

A better and more modern circuit is the National Semiconductors LM1040 for which a thd figure, at 300mV and 1kHz, of 0.06-0.03% is claimed. This device is intended for use as a voltage controlled gain, tone and balance sys-

**Low distortion attenuator for hi-fi**

With a distortion figure of just 0.005% over most of the audio range, this switch-mode attenuator designed by John Linsley Hood removes the transistor matching problems normally associated with high-performance attenuators.
Fig. 3. Offering a significant improvement over the simple fet attenuator, this arrangement involves two matched long-tail pairs whose stage current is modulated by the input.

A rectangular-wave signal with adjustable mark-to-space ratio can be generated by a hex inverter IC. Figure 5 shows a configuration with a CD4066 hex inverter running from a +12V supply line. In this example, IC1 and IC3 form a bistable latch. This latch is caused to flip backwards and forwards between its two stable modes when the phase-inverted triangular waveform generated by IC3 overrides the voltage derived from IC2 via R1.

The resulting triangular voltage waveform and an input dc control voltage are summed at the input of a chain of inverters, IC4_6. This produces a rectangular waveform output whose mark-to-space ratio can be made to lie within the range 5%-95% to 95%-5% depending on the dc input voltage and the relative values of R4 and R5. Output waveform is then fed to a switching fet, such as the NS J111, to give the final voltage controlled attenuator layout shown schematically in Fig. 6.

At 1V rms, over the range 100Hz to 10kHz, the thd was of the order of 0.005%, and not greatly increased at higher attenuation levels. The effect of the circuit on a 1kHz square wave input was only that to be expected from the pre- and post-chopping low-pass filtration. In the prototype, this was provided by a cascaded pair of third order unity-gain Sallen and Key low-pass filters with an f0 of 23kHz.

Fig. 4. The switch-mode attenuator offers high performance without the need for matched components.
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LETTERS

Letters to “Electronics World + Wireless World” Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Statistically significant

In his reply to my letter (February, EW + WW) Douglas Self questioned the "statistical evidence" that mosfets in general have lower distortion than bipolar, in reference to audio circuitry. I thought he'd never ask.

Take first the Hitachi power mosfet data book I-15a in which two 80W amplifiers are described, one of hybrid design, the other, all fet.

The hybrid offers 0.01% distortion at 1kHz but within the audio range offers 0.002% at 1kHz, and 0.003% at 20kHz.

The all fet version offers 0.01% distortion at 50kHz and within the audio band falls to under 0.002% at 1kHz and about 0.0035% at 20kHz. But these distortion figures are largely unchanged at full power, at the rated output of the amplifiers: 100W, 8Ω load.

There is also the series of amplifiers by P R Pimmer, formerly of Pantechnic. These used Hitachi type circuitry but with selected transistors in the driver stage in which the overall distortion was slightly better than the Hitachi version. Results were 0.002% at 1kHz and better than 0.005% anywhere in the audio band (20kHz - 20kHz) and any power up to 150W for the PA7200 version.

A confirmation of this kind of performance was given in a review by Gordon J King (ETI, June 1978) of the Hitachi commercial amplifier HMA7500 (80W/channel). It was severely tested by King using 15kHz/1kHz tones into 5Ω modules of impedance and 60° phase shift at 1kHz (modulation tests). The two tone signal at the output of the amplifier had a peak value of 28V across the coils load.

Second order product of the difference frequency (1kHz) was -78dB or 0.01%, while distortion measured under normal testing was typically lower distortion figures at 80W.

Moving on to the ET15500 design by Dave Tilbrook (ETI, June 1982), distortion is almost non-existent at 0.0007% at 1kHz and 100W and 0.003% at 10kHz and 100W.

John Lindsey Hood's mosfet design (ETI, July, 1984) showed a distortion of 80W (full power) of -94dB at 1kHz, about 0.002%, and at 10kHz 0.021% at 80W. Hood's amplifier had a greater input sensitivity than others quoted and would probably give better distortion figures, gain for gain. Also, the description implies that the low levels of distortion were mainly from the signal source itself.

Excellent linearity was demonstrated by the David Hafler DH200, DH220, DH500 series of amplifiers. The oldest, DH200, offered 0.0015% at 1kHz, 0.005% at 10kHz and 0.01% at 20kHz, 100W, 8Ω load. The design is now some 20 years old, and figures would be improved with a more substantial power supply.

The American Company, Musical Design - where circuits bore a remarkable similarity to the David Hafler, except for fet (low-impedance) amplifiers, were exceptional at 0.0002%, 1kHz and rated power.

Of course some designs have given power output numbers, but I have not been able to confirm them. However, the statistical evidence is overwhelmingly in favour of the lower distortion variety.

Distortion in bipolar amplifiers is much more markedly distinguished with increased power and frequency. One amplifier that should be considered is that by Edward Cherry whose 60W nested differential feedback loop amplifier (ETI, May, 1983) produced 0.002% at rated output and 1kHz, falling to 0.015%, 2nd and 3rd harmonic at 4kHz. But the circuit was complicated and bipolar types in a graph (or similar arrangements on the board. By contrast the simple Hitachi mosfet configuration must be a clear winner in every respect, barring the cost of mosfet devices.

All the circuits I have described, except the Sage modules, have used Hitachi mosfets and as such have been set for 100mA bias current per pair of output devices. The Hafler circuits used slightly more quiescent at 275mA for two pairs. In my earlier letter I suggested that the low 45mA quiescent value in Self's mosfet circuit would be significantly contributing to the crossover distortion artefacts observed.

I also can not agree with Self's comment regarding the independence of slew-rate limit and bandwidth. In absolute terms it is difficult to separate one from the other. Any amplifying device fed with a signal of changing rate will suffer from an upper limit at which it can reproduce that rate of change, thus encompassing both bandwidth and slew-rate. There is surely no mystery in mosfet amplifiers having vastly superior slew rates simply because they can be used at much higher frequencies (implying wider bandwidths).

Returning to distortion and early rate of roll off of frequency in bipolar amplifiers, the major source of distortion comes from the relationship between current gain and collector current. In power amplifiers this is a graph shaped like the parabola - ie very non-linear, showing the gain varying according to the collector current. Variation is marked, offering quite a gain spread, with the lowest at low and high currents and highest at intermediate currents. Added to this is the relationship between gain and frequency in which the power bipolar rapidly loses gain as the frequency increases. Using typical figures of $F_r = 2MHz$ and gain of 100 this device will only offer a gain of 1 at 20,000Hz. Clearly, as the frequency rises the normal overall feedback decreases, and so distortion rises.

The situation is quite different with mosfets. Here the $V_{on}$ characteristic is very linear and since the devices are much faster they have less trouble coping with high frequencies – provided they are driven by low impedances.

Distortion tends to fall as the drain current ($I_D$) increases (run at 100mA+ please). Bipolars also suffer 'notch' distortion due to storage of minority charge carriers.

I have said before that in my experience, going back 25 years of reading test reports from most of the major journals, I have found with few exceptions that amplifiers containing bipolar output devices regularly roll off at around 15kHz at full power, many starting before this frequency. This experience is a matter of public record and the evidence is there for anyone who cares to sift through all of the reports in the same way I have done.

The reasons for this behaviour are, as I have shown, that output devices are being selected which are simply too slow: that is also a statistical factor. Faster devices are less rugged and more expensive.

I have most of the articles and literature referred to for mosfet amplifiers if further doubt is expressed.

V J Hawtin
Middlesex

Defence or attack

If it were true, as Colin Long (Letters, January) seems to imply, that high military spending makes good economic sense then we might reasonably expect to see the major industrialised military economies outperforming their non-military counterparts.

In fact we see the reverse, because such activity is bad for any economy, whether an autocratic command system of the (old) USSR or the democratic demand economy of the USA. Even with rich oil and mineral reserves, they are so obviously outperformed by Germany and Japan, as indeed is the UK.

Mr Long questions why the MoD has come in for such criticism. It is because it has compounded the
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problem through damaging interference. Using a variety of devices, including its "massive purchasing power", the MoD has taken a vigorous and broad-based purchasing power", the MoD has immediately brought up memories the lead" (January, p.12). But the "Voltage follower that gives Research Notes has always received democratic progress". to a critical dependence on the tax- payer. armament manufacture. I want to see our industry competing in foreign markets, with its domestic market is now reduced competing in foreign markets, with its domestic market is now reduced, by the military - its domestic market is now reduced, by the military - tax -payers' money on more armament manufacture. Of a similar circuit, titled "Feed - forward floating power supply (High-response-speed equalizer circuit)" by Eiichi Funasaka and Hikaru Kondou, Journal of the Audio Engineering Society, Vol 30, No.5, May 1982, p.324-329. With due respect to the remarkable work of Mr. Lidgeber, it is surprising not to see the early reference mentioned. Erik Morgan Slovenia Percentage player As a fascinated bystander in the debate on audio amplifier distortion, may I request a stronger distinction between harmonic and non-harmonic distortions? Most musical sounds, including the voice, are generated by physical mechanisms which produce a harmonic series, the relative amplitudes of which determine the characteristic "sound" of the instrument. A variation of a few percent in the absolute level of these harmonics is generally perceived (if at all) as a subtle change in timbre or brightness, of the kind also produced by a great many non-electronic effects including room acoustic. So provided that an amplifier produces harmonic distortions which drop sufficiently quickly with increasing order n to avoid masking the genuine harmonics of typical signal sources, can we not virtually ignore its thd figure? In my experience the overall 'sound' of a good amplifier is far more affected by slight frequency response deviations from flatness than purely harmonic distortions - or, for that matter, phase distortions. In contrast, non-harmonic distortions are audible even in very small amounts. Intermodulation distortion in particular multiples with the complexity of the musical signal to produce a thick muddy or tinny background which obscures musical detail and can make listening quite unpleasant. If, as I would suggest, the non-harmonic distortion of an amplifier is much more audible than the harmonic, then it follows that the prominence of your result contributors with harmonic distortion is misplaced, even if an entirely (harmonically) distortionless amplifier would in principle produce no intermodulation distortion. Furthermore, should not distortions produced by non-linearity be directly dependent on signal level (as in rf mixers), and percentage distortion figures therefore strictly meaningless? Perhaps we should abandon the increasingly irrelevant % thd figure and standardise on one of the various multiple-tone intermodulation measures available, preferably with a graph of measured signal to noise-distortion ratio, in decibels, versus signal level? A New Bristol Cables and cars I was interested to read in Barry Gillebrard's article, "Interfacing piezoelectric cable", January, pp. 21-23, that the type of cable we used some 40 years ago in an application for traffic speed measurement, has now become a fully fledged product. My colleague Joop van der Kam had discovered that if insulated wire is squeezed in a vice, a voltage is generated between its core and the metal of the vice. In fact any cable insulated with modern plastic materials generates electric noise when flexed1 and special measures have to be taken to get rid of unwanted flexural noise in cables used for low-level electrical signal sources, such as microphones, etc. Cause of the noise is separation of electrical charge that takes place when two different materials are brought in close contact. This can easily be demonstrated by pressing a coin onto a plastic bag. When the coin is removed, the deposited electrical charge can be made visible by dusting the plastic with fine particles (flour, pencil lead filings, etc), revealing the coin's features. The discovery led to development of a traffic speed measuring apparatus in 19572. It became rather popular because its cost was only some 10% of the competing radar device (in the era of the radio valve and klystron) and the prosecuting authorities liked the easy proof of whodunit? because of the direct physical contact between car and cables. A radar device relies of course on an invisible beam and unless the conditions were ideal, you could never be completely sure whether the return signal had been influenced by it reflecting off buildings or other traffic participants. Today I would design the traffic speed meter with digital electronics, but in 1957 we did it as depicted in the figure. This traffic speed measuring circuit exploiting piezo-electric cable was designed some 40 years ago. Two, toughened coaxial cables
Bye-bidirectional I^2C
Jean-Paul Broder (Letters, February) is incorrect in stating that the SCL line in an I^2C system needs to be bidirectional to handshake properly. I^2C handshaking is done via acknowledge bits on the SDA line. The only time a bidirectional SCL line is needed is in a multistation system, which also calls for additional hardware for arbitration.

Correction: in editing my Circuit Idea the word programmed was left out of the following phrase: "...writes 01 to a location programmed as 00 in the eprom...".

Mike Harrison
White Ving Logic
Essex

Figured out

In Fig. 6 of the article 'Analogue design with a 5V supply' (February, EW+WW, pp.162-165) by Walt Jung and James Wong the equations should read:

For G=100, \( (R_5+R_6)/R_4 = (R_1+R_2)/R_3 = 9 \)
For G=10, \( (R_5+R_6)/R_4 = (R_1+R_2)/R_3 = 9 \)

These respective resistor ratios should match to 0.01\% or better.

Laurence Marchini
Oxon

Cathode ray conundrum

I am intrigued by the possibility that a cathode ray tube is capable of generating a reactionless force.

Consider what happens in an oscilloscope when the trace is deflected upwards by a magnetic field. The electrons then will have a small upwards momentum which is balanced by a downwards force on the deflector plates in accordance with Newton's equations of motion.

It occurs to me that what happens next is unusual and we cannot safely use our experience of mechanical systems to predict the possible effects. The beam of electrons is accelerated forwards towards the screen through a high potential, usually over 10,000V. Such voltages are sufficient to impart a velocity to the electrons which is a significant proportion of the velocity of light, c. According to Relativity theory, the electrons will undergo an increase in mass. Assuming their upwards velocity is not affected by this sideways acceleration, they will have acquired increased upwards momentum without any increase in the downwards reaction force. This will be realised as a net reactionless upwards force on the entire device when they hit the cathode.

I understand that when this particular problem is considered in text books, the answer given is that the vertical velocity of the electrons is somehow reduced (in the absence of any downwards force and contrary to Newton's second law) so that Newton's third law should be preserved in some form. This is an answer I had already considered and rejected. The trouble is that the amount that the vertical velocity of the electrons would have to change is a function of the vertical velocity of the reference frame from which the problem is considered - even when that velocity is an insignificant proportion of c. This would be absurd. I may have made a mistake but I am unaware that the conventional view has been tested by experiment, and unlike some other ideas that have been put forward on these pages, this idea is definitely testable. In any case, I don’t see why Newton's second law should be so readily discarded to save his third law.

I do not suggest it might be possible to measure this force in an oscilloscope. I calculate that for a typical oscilloscope (Tektronix 2235), the magnitude of the reactionless force (if it existed) would be sufficient to produce an apparent weight reduction of only 0.3\% for 1mA of anode current. I have made enquiries about getting a purpose-designed thermionic device built where the level of predicted weight loss would rise to milligrams and so unambiguous measurements could be made. Building of a suitable device to do this seems to be possible, but it is unfortunately beyond my resources.

Has the idea been experimentally tested before or would anyone be interested in helping test it?

Interestingly, one of the few other places where this force might be expected to arise is in a force precessed gyroscope, although once again the level would only amount to a weight change less than one \( \mu g \) for any practical system, and it would not be practical even to attempt to measure it this way.

The possibility of this force has nothing to do with precession, which is in fact a nuisance.

Unfortunately, even if this force exists, I do not see many practical applications for it. However, if it were implemented, the amount of kinetic energy that would have to be stored in a device in order for it to be able to lift its own weight would be enormous and certainly beyond any technologies we have at present. Nevertheless, it has a certain theoretical interest.

R Lerwill
Clwyd

References
1. R A Rasmussen. "Flexural noise in cables", Bell Lab Rec, 37, 8, p.305, August 1959
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Until recently, designing viable active filters with cut-off frequencies at 1MHz or greater was difficult because voltage feedback amplifiers with sufficient gain-bandwidth products and short propagation delays were simply too expensive.

The emergence of current feedback or transimpedance amplifiers has significantly changed this picture. Using these amplifiers, together with a conscientious design and PCB layout, you can design active filters that operate at high frequencies. Active-filter applications are no longer restricted to the audio-frequency range.

Active RC filters have many advantages over passive filters, these becoming increasingly important as frequency increases. For example, there is no insertion-loss penalty and you can even have power gain if needed.

A doubly-terminated passive filter would attenuate the signal by at least 50%. The elimination of inductors is the biggest advantage offered by active filters. This advantage doesn't involve size considerations alone. Passive inductors are only linear for low power levels, much like transistors with no negative feedback. As you pump more current through the inductor, the magnetic core material begins to saturate and the inductor generates its own harmonic-distortion terms. The filter's transfer response will not necessarily suppress these signals. In an active RC filter, the amplifier quality and design sophistication set the dynamic range. Theoretically, designers have a good deal of control over both of these parameters.

As a case study, consider three situations - a low-pass antialiasing filter, a band-pass filter, and a high-Q notch filter - in which active filters that incorporate current-feedback amplifiers provide a viable alternative to passive filters. All three filters will be designed around the Burr-Brown OPA603.

You could implement the three designs using carefully selected, video-speed conventional op-amps. However, current feedback amplifiers more readily satisfy the low transit time and large bandwidth at high gain requirements for the example circuits. Let's start with the design of an antialiasing filter, Fig. 1, to drive the input of an ADC603 - a 12-bit, 10MHz a-to-d converter.

When dealing with a-to-d converters in filter work, the Nyquist theorem states that if any converter input harmonic frequency is greater than half the sampling rate, those frequencies must alias, or fold back, into the passband. Normally, this condition is not desirable. To skirt the issue, you must suppress any input frequencies that exceed the Nyquist rate before the converter sees them.

The result of this manoeuvre is that the required attenuation becomes a function of converter resolution. It is also important for the filter to roll off as fast as possible. An elliptic response is the best choice because the addition of transmission zeros in the stop band creates the sharpest roll-off theoretically possible for a particular number of poles without having to rely on mutual inductance.

The first step in designing the filter is calculating the attenuation requirements. You can do so by estimating the theoretical signal-to-noise ratio, $\text{SNR}$, using the expression

$$\text{SNR} = 6.02N + 1.8\text{dB},$$

where $N$ is the number of bits. For the ADC603, the expression yields

$$\text{SNR} = 6.02 \times 12 + 1.8 = 74.04\text{dB}.$$
You can now form the filter by cascading two second-order sections and one first-order section, Fig. 1b. The essential equations for the second-order sections are,

\[ T(s) = \frac{H(s^2 + b_0)}{s^2 + a_1s + a_0} \]

\[ p = \frac{1}{\sqrt{b_0}} \]

\[ q = \frac{(b_0 / a_0) - 1}{2\sqrt{b_0}} \]

\[ K = 2 + \frac{(b_0 / a_0) - 1}{2} - a_1 \sqrt{b_0} \]

The essential equations for the first-order section are,

\[ T(s)=\frac{a_0s+a_0}{s} \]

\[ a_0 = 1/RC. \]

The task is to design a fifth-order elliptic antialiasing filter Fig. 1a with a guaranteed stop-band attenuation of 75dB and no more than 3dB of passband ripple. In addition, the maximum attenuation should begin at 5MHz, which is half the sampling rate.

Transfer coefficients' for this case are

\[ p_1=0.309021 \]
\[ q_1=1.557592 \]

\[ K_1=6.875982 \]

\[ p_2=0.480652 \]

\[ q_2=2.272930 \]

\[ K_2=6.011362 \]

\[ R=1 \]

\[ C=5.232999. \]

This filter prototype has an \( f_3 \) bandwidth of 0.15912 (1rad/s), and its maximum attenuation begins at a stop-band frequency of 0.3171. In this case, you have to scale the frequency to the stop-band frequency, rather than to \( f_3 \). In addition, you can arbitrarily scale the impedance to 1kΩ. Multiply each resistor by this impedance value; divide every capacitor value (\( p, q \) and \( C \)) by the frequency-impedance scaling factor, \( K_f \).

\[ K_f=\frac{1kΩ}{5\times10^6Hz}=1.577\times10^{-1}. \]

Final component values, rounded to three significant figures, are,

\[ p_a=19.6pF \]
\[ q_a=114.4pF \]

\[ K_a=6.88 \]

\[ p_b=30.5pF \]

\[ q_b=64.5pF \]

\[ K_b=6.01 \]

\[ C=332pF. \]

Using a feedback resistance of 499Ω you can choose the closest 1% values for gain resistors, \( R_{G1}=84.5Ω \) and \( R_{G2}=100Ω \).

High-Q bandpass filters have many uses. One is isolating a particular harmonic of a distorted sine wave before amplifying the signal to more easily measure the magnitude. Many common active filter configurations run into problems in such applications because the value of \( Q \) is highly sensitive to changes in the gain – and thus the frequency response – of the amplifier. One of the best filter topologies in this situation is an extension of the basic Sallen-Key circuit Fig. 2a. Adding a second amplifier can raise the potential value of \( Q \) by two orders of magnitude.

For stable operation, \( K_1 \) should be greater than zero and \( K_2 \) should be less than zero. The transfer function is,

\[ T(s)=K_1x_1(2s101-KIK2)s2+(4-1C1)s+2. \]

From this expression, you can determine that,

\[ Q=\frac{2(1-K_1K_2)}{4-K_1} \]

\[ \omega_0=\frac{2}{\sqrt{1-K_1K_2}} \]

Sensitivities of most concern involve the variations of \( Q \) when the gain of either amplifier changes. Analysis shows that,

\[ S_{K1}Q=K_1(1-K_{21})(4-K_{21})Q(1-K_{21})Q(1-K_{21})Q \]

\[ S_{K2}Q=K_2K_2/1-K_1K_2. \]

You can neglect \( S_{K1}Q \) because it is approximately equal to 1 and is not a serious limitation. Although its probably not obvious, there’s a tradeoff between \( K_2 \) and \( S_{K2}Q \). The higher the gain of \( K_2 \), the lower the value of \( S_{K2}Q \). In a voltage type op-amp, higher gain inherently means lower bandwidth. However, a transimpedance amplifier has the ability to maintain its bandwidth at high gain. This characteristic gives current feedback amplifiers a clear advantage in this situation.
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Choosing a bandpass filter with a centre frequency of 1MHz and a ~3dB bandwidth of 40kHz, the sensitivity to variations in gain should be no greater than 9.

First, the required value of Q is,\[ Q = \frac{f_0}{BW_{3dB}} = \frac{1MHz}{40kHz} = 25. \]

Simultaneously solving the equations for \( Q \) and \( \frac{KQ}{2} \) gives \( K_1 = 3.556357 \) and \( K_2 = -17.01347 \). The corresponding centre frequency for this prototype is \( f_0 = 0.287996 \). The new transfer function is now,\[ T(s) = \frac{s^2 + \alpha_1 s + \alpha_2}{s^2 + 4\alpha_2 s + \alpha_2^2} \]
and the Q value is now a function of \( K \),\[ Q = \frac{1}{4(1-K)}. \]

As \( K \) approaches 1 from below, Q increases in an unlimited fashion. If \( K \) is greater than 1, however, the circuit is unstable. Although wide bandwidth at high gain is not as important here as it was in example Fig. 2, the comparatively lower transit time of a current-feedback amplifier should yield superior performance in this application.

A specific example will prove the point. The result of designing a 1.5MHz notch filter that has a ~3dB bandwidth of 225kHz. The first step is to calculate Q using the expression,\[ Q = \frac{f_0}{BW_{3dB}} = \frac{1.5MHz}{225kHz} = 6.66. \]

You can use this value to calculate,\[ K = 1 - (1/(4Q)) = 0.9625. \]

If \( R_1 \) is set equal to 1k\( \Omega \) then,\[ C = 2\pi f_0 R_1. \]

If you let \( R_2 \) also equal 1k\( \Omega \) then \((1-K)R_2 = 37.5 \) and \( K_2 = 962.5 \). Figure 3b shows the final notch filter design. Both amplifiers are configured as unity gain buffers, and the feedback resistance is set at 4990. The actual response, Fig. 3c shows a slight excess attenuation beyond the notch frequency, but the performance is still good.

Making the case for current feedback

Don’t get the idea that something is inherently wrong with voltage feedback, even at high speed. In fact, voltage-feedback amplifiers generally have a lower noise-floor specification than current feedback amplifiers. However, when comparing voltage and current feedback amplifiers, you must take the application into consideration. Current feedback, or transimpedance, amplifiers have some distinct performance advantages as waveform speed gets higher and higher. These advantages can translate into higher-performance active filters.

The most striking difference between voltage feedback and transimpedance op-amps is that with a fixed feedback resistor, the current feedback amplifier has very low gain bandwidth tradeoff. Transimpedance amplifiers maintain bandwidth at high gain settings—an advantage in active filter topologies because a large gain is needed to minimise sensitivity.

In addition, transimpedance amplifiers have very high slew rates compared with those of conventional voltage op-amps. A typical slew rate for a video-speed voltage feedback amplifier is in the 200 to 300V/\( \mu \)s range. A comparable current feedback amplifier might slew as fast as 2500V/\( \mu \)s. This slew-rate disparity is easy to explain. In a conventional amplifier, the slew rate is the ratio of the bias current flowing through the slewing node to the capacitance that can be referred back to that node. In a transimpedance amplifier, the feedback current mirrors and adds to the bias current flowing through the slewing node to the capacitance.

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One final factor that favours the transimpedance amplifier is settling time. Designers often choose a filter transfer function for best time-domain response. Therefore, ensuring that the amplifier settles to the required level substantially faster than the filter has to settle is crucial. High speed amplifiers are complicated devices and acceptable ac response does not necessarily ensure an acceptable settling time. Many conventional voltage feedback op-amps use internal pole-zero cancellation to increase their bandwidths. Analysis shows that a small mismatch in the pole-zero cancellation has a negligible effect on frequency response, but the scheme can dramatically boost settling time. This effect is small, but it can often extend the 0.01% settling time to several microseconds.

References

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Electronics World + Wireless World
April 1995
Do you have an original circuit idea for publication? We are giving £100 cash for the month’s top design. Additional authors will receive £25 cash for each circuit idea published. We are looking for ingenuity in the use of modern components.

Power supply preregulator with no moving parts

Using no relays, this circuit switches the ac input to a series of full-wave bridge rectifiers, providing smoothed and regulated dc output.

At switch-on, the op-amp outputs are both high and SCR1,2 fire alternately to form a full-wave bridge driven from the 42.5V transformer tap. When V_out increases above about 48V, IC1b output goes low, allowing SCR3,4 to fire alternately, the 85V tap now driving the bridge. Similarly, as V_out reaches 96V, both op-amp outputs are low and SCR5,6 fire to form a bridge driven by the 127.5V tap. Optocouplers MOC3041 enable zero crossing triggering of the SCR.

If the output is short-circuited, only SCR1,2 fire to minimize dissipation.

Gregory Freeman
Nairne
South Australia

Series of SCR bridges replaces relays on a tapped transformer secondary.

Polarity-dependent switch

Depending on the polarity of the input voltage, this low-loss mosfet connects or disconnects the supply to the load; it is used as a polarity discriminator or simply as a self-synchronising switch.

With a positive input, the parasitic diode across the mosfet conducts, the positive feedback causing the mosfet to saturate to an R_on of 30mΩ. When the input is negative, no current flows and Vgs remains at zero, the input voltage possibly reaching the mosfet rated breakdown, in the case of the MTP50P03HDL 30V.

Do not allow the positive excursion of input voltage to exceed the 10V gate/source voltage of the mosfet.

Kristen Ellegard
Oslo, Norway
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Testing sampling rate

For correct sampling of a sinusoid, samples must be taken at least twice per cycle - the Nyquist rate. This circuit gives a positive indication as to whether this is taking place.

Transistor Tr1 behaves as an emitter follower when Tr2 is off and as a diode when Tr2 is on, it being controlled by Vs in Fig. 2c, itself derived from the sampling voltage.

When a sampling pulse arrives during a negative half-cycle, Tr2 is off and Vin appears at Vp, which is shown in Fig. 2d for a correctly sampled wave and at Fig. 2e for an incorrect one.

Voltage Vp goes to comparators OA1,2, D1,2, clamping the negative outputs to ground; OA1 output is high during positive half-cycles, but OA2 goes high only when a negative-going pulse appears. Bistable device FF1 is reset at the start of each half-cycle and set at the first negative pulse. Bistable FF2 is set by OA3,4 at the start of negative half-cycles.

Since FF2 depends for its reset pulse on the setting of FF1, which itself is set by the appearance of a negative pulse, Q2 will remain high and Vout low if the pulse does not arrive, indicating that incorrect sampling is taking place.

If sampling rate equals input frequency exactly, the circuit fails since the negative half-cycle may be sampled each time.

K N Sunil Kumar
Visakhapatnam
India

If sampling rate of a sinusoid is below Nyquist rate (2f_n), this arrangement, below and right, provides a constant low at the output.
Noise source from an optocoupler

Output from this photoelectric noise source is typically 12µV, which is about 28dB above thermal noise; some samples of 4N26 opto-isolators give a much greater output. Noise output was measured over a 10kHz bandwidth, in which 1/f or flicker noise is likely to be large.

Connected as shown, the led controls the transistor working point accurately. Output impedance is $1/(20/e)$ or about 1.4kΩ in this case and the output can be matched to loads of 50-600Ω or more. Grounding pin 3 reduces hum pickup.

W Gray
Farnborough
Hampshire

Noise source, after Hickman (EW+WW, November 1993) uses opto-isolator which also controls transistor working point.

High-speed buffer features low input-capacitance

An input capacitance of 1.2pF or 2.7pF, depending on devices, and a bandwidth of 50MHz with 10mV offset come from the use of a bootstrapped fet input buffer, as described by Horowitz and Hill.

Both the OPA620 or the EL2070 op-amps have been tried as bootstrap driver, with no discernible difference in performance, although the EL2070 is a current-feedback type and needs at least 220Ω in the feedback path to ensure stability. Since the OPA620 is a voltage-feedback op-amp, the feedback resistor could be shorted.

Output impedance is 50Ω in the circuit shown, but the RC output circuit could be dispensed with to avoid the 6dB loss in gain due to the resistor and to obtain a dc response; at dc, resistor $R_4$ should be adjustable to maintain a reasonable input offset. No output snubbing is needed to stop oscillation with a reactive load if load impedance is 50-200Ω and resistive, otherwise the resistance should be over 20Ω.

Both U402 and U440 dual fets work well in the circuit. Using the U402, bandwidth is more than 50MHz and input capacitance with $R_5$ at 10kΩ is 2.7pF. The U440 gave an input C of 1.3pF, but with a greater input offset.

Phil Denniss
University of Sydney
NSW
Australia

Reference
Safe NiCd battery-pack discharger

Although nickel-cadmium batteries need regular charge/discharge cycles, the discharge must be limited to avoid reverse charging of weak or partially discharged cells in the pack. This circuit limits the discharge of an eight-cell pack to a 1V terminal voltage per cell.

Connecting the battery takes pin 6 to the 5.6V zener voltage, the transistor conducts and the led indicates discharge. When battery voltage reaches 1.5V, pin 3 goes low, the transistor turns off and battery discharge stops: the led turns off.

To take any number of cells up to a maximum of 12, the zener voltage should be \( \frac{2}{3} \) the final terminal voltage and zener current adjusted by \( R_2 \) to 0.5A.

Bill Hume
Newmilns
Ayrshire

PCBs for Douglas Self's power amplifier series

Circuit boards for Douglas Self's high-performance power amplifier are now available via EW+WW.

Detailed on page 139 of the February 1994 issue, Douglas Self's state-of-the-art power amplifier is the culmination of ideas from one of the most detailed studies of power amplifier design ever published in a monthly magazine. Capable of delivering up to 100W into 8Ω, the amplifier features a distortion of 0.0015% at 50W and follows a new design methodology.

Designed by Douglas himself, the fibreglass boards have silk-screened component IDs and solder masking to minimise the possibility of shorts. Sold in pairs, the boards are supplied with additional detailed constructional notes.

Each board pair costs £45, which includes VAT and postage, UK and overseas. Credit card orders can be placed 24 hours on 0181-652 3614. Alternatively, send a postal order or cheque made payable to Reed Business Publishing to EW+WW, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
**APPLICATIONS**

*Please mention Electronics World + Wireless World when seeking further information.*

**Power from the 'phone**

This power supply, from Maxim's `Engineering Journal`, volume 17, is useful in portable systems that connect to domestic telephone lines. Such systems are modern and telephone test sets. For apparatus needing 150mW or less, the circuit eliminates the need for batteries and mains adapters. It draws power from the telephone jack without affecting voice signals. Built into peripheral equipment such as pcmcia modems cards, it can spare the battery in a host computer. Line current available to a telephone in the off-hook state is limited not by regulations or code, but by the sum of impedances in the central office battery and intervening phone lines. These line impedances vary greatly in proportion to distance from the central office, so the customary practice of matching impedances for maximum power transfer is impractical. But, the zener-clamp termination, D1, works well for line impedances to 1kΩ and for worst-case conditions. It also meets the one condition imposed on line current by the phone system: off-hook current must exceed 20mA to ensure activation of a network-access relay in the central office.

5V isolated supply

Diode D1 provides approximately 6.8V to the center tap of T1, and 5V to the Vcc terminal of IC1. A 400kHz oscillator driving a flip-flop, inside IC1, generates two push-pull, 50% duty-cycle, 200kHz square waves that drive internal, ground-referenced switches, in turn, these connect to the primary of T1. Isolated power on the secondary side is first rectified by schottky diodes, D2 and D3, and then regulated to 5V by the low-dropout linear regulator IC2. Transformer, T1 has a center-tapped winding whose ET product (a voltage-time product of 25μs) is sufficient to prevent noise from closed magnetic paths.

For example, an embedded control system may have to compensate for variances in a mechanical actuator performance or loading. The basic program can be programmed and tested in design. The final program and control constants can be easily added later in the production phase without removing the microcontroller from the circuit. Automatic software and performance upgrades can also be implemented via in-system programming. Upon receiving new system software via disk or modem, a control processor with the included programming code could perform an in circuit reprogramming of other microcontrollers in the system. This programmer can load program code, part configuration, and eeprom data into the PIC16C84. In read back mode, it can verify all data entries.

In-circuit programmer from LPT1

**W**ith the capability of programming a PIC16C84 microcontroller without removing the device from the target circuit, this low-cost serial programmer is controlled using a pc parallel port. Microchip’s application note AN589 describes a circuit which can also read back internal PIC data. This feature is very useful where changes in program code or constants are necessary to compensate for other system features.

For isolated 5V outputs, the ideal turns ratio is 1.2:1.0 ct (ct is center tapped). The transformer should be wound on Magnetics Incorporated “W”, Fair-Rite “76” or other high-permeability magnetic material. To minimize radiated noise, choose a pot core, regulator to maintain a regulated 5V supply. Transistors Q1, Q2, and the associated resistors assure a low-power shutdown mode for IC1 until its supply voltage can sustain a full power-up. IC1’s supply current is fairly constant, so light filtering, provided by L1 and C3, is sufficient to prevent noise from entering the hybrid transformer.

Maxim Integrated Products Ltd.

21C Horseshoe Park, Pangbourne, Reading RG8 7JW.

Tel 01734 845 255, fax 01734 843 863.

**From an off-hook telephone line, isolated power can be taken whilst still maintaining normal voice or data communication. Low power shutdown is provided to ensure proper functioning of the MAX253.**

340

ELECTRONICS WORLD + WIRELESS WORLD April 1995
into the device. A high-to-low transition on RB6, the clock input, qualifies each bit of the data applied on RB7. The first six bits form the command field and the last 16 bits form the data field. The latter is composed of one zero starting bit, 14 data bits, and one zero stop bit. The incremental address command is the command field only.

The read mode is similar to programming mode except that the data direction of RB7 is reversed after the six bit command to allow the requested data to be returned to the programmer. After the read command is issued, the programmer tri-states its buffer to allow the device to serially shift its internal data back to the programmer. The rising edge of clock input RB6 controls data flow by sequentially shifting previously programmed data bits from the part. The programmer qualifies this data on the falling edge of RB6. Note that 16 clock cycles are needed to shift out 14 data bits.

Accidental in-circuit reprogramming is prevented during normal operation by the MCLR voltage which should never exceed the maximum circuit supply voltage of 6Vdc and the logic levels of port bits RB7,8. If MCLR is not forced by the target circuit, reset is then removed and the program or verify voltage is applied by a logic high on D3 and a logic low on D4. This turns off Q3 and turns on Q2 and Q1. Simultaneous reset and program mode is prevented by connecting the emitter of Q2 to latch bit D4. Data and clock are connected to the device via a tri-state buffer U3. Parallel port interface bit D0 is used for data and port bit, D1 is used for clocking.

During programming mode both clock and data buffers are enabled by port bits D2 and D3. During read mode, the data buffer is tri-state activated via D2 and D3.

Resistors: 1/4 watt, 5%
```c
#define PROGRAM_MODE #define RUN #define PIC_PROC_ERROR -1 #define PROGMR_ERROR -2 #define PTR 0

int ser_pic16c84(int cmd, int data)
{
    int i, s_cmd;
    if(cmd <= MAX_PIC_CMD)
    {
        biosprint(0, 8, PTR);
        s_cmd = cmd;
        for (i=0; i<6; i++)
        {
            biosprint(0, (s_cmd&0x01) +2+8, PTR);
            biosprint(0, (s_cmd&0x01) +8, PTR);
            s_cmd >>=1;
        }
        if (cmd == INC_ADDR) // command only, no data cycle
            return 0;
        else if (cmd == BEGIN_PROG) // program command only, no data cycle
            
    }
    else if (cmd == LOAD_DATA) // output 14 bits of data
    {
        for (i=200; i>0; i--)
            biosprint(0, 2+4+8, PTR);
        biosprint(0, 4+8, PTR);
        for (i=0; i<14; i++)
        {
            biosprint(0, (data&0x01) +2+8, PTR);
            biosprint(0, (data&0x01) +8, PTR);
            data >>=1;
        }
        biosprint(0, 2+8, PTR);
        biosprint(0, 4, PTR);
        return 0;
    }
    else if (cmd == READ_DATA) // read 14 bits from part, lsb first
    {
        biosprint(0, 4+8, PTR);
        for (i=200; i>0; i--)
            biosprint(0, 2+4+8, PTR);
        biosprint(0, 4+8, PTR);
        for (i=0; i<14; i++)
        {
            biosprint(0, 2+4+8, PTR);
            biosprint(0, 4+8, PTR);
            if(!((biosprint(2,0,0)&0x40))) data += 0x2000;
        }
        biosprint(0, 2+4+8, PTR);
        biosprint(0, 4+8, PTR);
        return data;
    }
    else if (cmd == RESET) // reset device
    {
        biosprint(0, 32+16+4, PTR);
        delay(1);
        biosprint(0, 32 +4, PTR);
        return 0;
    }
    else if (cmd == PROGRAM_MODE) // enter program mode
    {
        biosprint(0, 32+16+4, PTR);
        delay(10);
        biosprint(0, 8, PTR);
        delay(10);
        return 0;
    }
    else if (cmd == RUN) // disconnects programmer from device
    {
        biosprint(0, 32+4, PTR);
        return 0;
    }
    else return PROGMR_ERROR; // command error
}
```
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Three more winning power control circuits representing the best of many excellent entries submitted for the International Rectifier design competition, featured in the October 1994 issue.

Fourth prize - 50Hz/60Hz inverter uses a single IC

A rugged and efficient square-wave inverter for use in automobiles and boats can be constructed around the IR2151 self-oscillating half-bridge driver. This inverter works on a 12V automobile battery and provides an output of 200W at 50Hz or 60Hz with a 220V or 110V output.

This inverter makes use of the following features of the IC:

- Complementary square waves at HO and LO outputs
- Frequency of square waves immune to supply voltage variations.
- Square waves with 50% duty cycle.
- Under-voltage lockout.

Lockout in the event of low battery voltage is a very important feature. Without it, under low battery voltage conditions, the power mosfets would not conduct fully and would dissipate power. This in turn reduces inverter efficiency and could result in damage. When battery voltage falls below 8V, both power mosfets are switched off. Although the dead time of about 1μs generated by the IC is sufficient to prevent the cross conduction of the mosfets, it is not sufficient to allow the transformer ringing signals to be dissipated in the appropriate snubber circuits. Fortunately, dead time can be increased to the desired value by adding a few inexpensive.

Power inverter delivers up to 200W using a single IC. Most of the complexity is in the discrete transistor circuitry needed to extend the IR2151's dead time.
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Tel 0181-906 0155, FAX 0181-906 0969.

*upgrade price from GESECA; £295 + VAT new*
components to the basic inverter circuit. Supply voltages \( V_a \) and \( V_b \), and hence the outputs \( HO \) and \( LO \), are limited to 9.1V by components \( R_1 \), \( C_1 \) and \( D_i \). Oscillator frequency is set by components \( R_2 \) and \( C_2 \). When high side output \( HO \) goes high, transistor \( T_1 \) holds the gate of power mosfet \( T_3 \) low for a dead period of about 300\( \mu \)s, determined by components \( R_3 \) and \( C_3 \). Diode \( D_2 \) discharges the gate capacitance of \( T_3 \) instantaneously when the \( HO \) output goes low. Although the turn-on time of \( T_1 \) with this arrangement increases to about 30\( \mu \)s, it is a very small part of the period of this inverter output.

Components \( T_2 \), \( C_4 \), \( D_5 \), \( R_4 \) and \( R_6 \) provide an equal dead period to the low side output \( LO \). Components \( R_5 \), \( C_5 \), \( D_6 \) and \( C_6 \) provide the snubber action for \( T_{1,2} \). This circuit configuration is not just limited to 50/60Hz inverter. High-frequency inverters with ferrite-core transformers, and having proper dead times, could form elements of electronic ignition systems and dc-to-dc converters. By changing \( R_1 \), the inverter can be powered by batteries of other voltages.

M. S. Nagaraj
ISRO Satellite Centre
Bangalore

**Fifth prize**

**Electroluminescent lamp driver for automobiles**

This driver for electroluminescent displays incorporates all the features normally needed for automotive electronic circuits. Diode \( D_1 \) serves as protection against reverse polarity. In the event of an overload on the output transformer, \( T_1 \) robs \( V_a \) of voltage and disables the circuit. Capacitor \( C_1 \) takes care of radio-frequency interference. Values quoted for \( CT \) and \( RT \) cause astable operation at 400Hz, which is suitable for this type of lamp. Over-voltage protection is taken care of by the IR2151's internal zener diode.

Clyve J. Caines
Nairobi
Kenya

Generating the high voltage needed for an electroluminescent display is easy using the IR2151 and a pair of medium-power mosfets. This circuit, intended for the automotive environment, has additional features such as over-voltage, over-load and reverse-polarity protection.

**Sixth prize**

**1-to-3 phase converter**

Rotary speed of a three-phase motor depends on the frequency of the applied voltage. The motor is linked to the converter by six power transistors contained in a type MP6750 module from Toshiba, a third of which is shown bottom right in the diagram. Inductance of the motor windings acts as an integrator that converts the pulses of varying widths into a sinusoidal signal. The converter is based on three IR2151 timer circuits. Each voltage supplied to the three pairs of power transistors is phase shifted by 120°. This is done by reducing the timing capacitors of each IR2151 progressively by a third, i.e. \( C_1, \frac{2}{3}C_1, \frac{1}{3}C_1 \).

Frequency of the timing circuit, and hence the speed of the motor, is set to a desired value by altering the resistance of three equal resistors, \( R \), only. This method of converting single-phase mains to three-phase can be used to control small three-phase motors up to approximately 700W, irrespective of whether they are synchronous or asynchronous types.

Kamil Kraus
Rokycany
Czech Republic

This 1-to-3-phase mains converter is suitable for driving small motors up to 700W, regardless of whether they are synchronous or asynchronous.
Versatile lamp-ballast IC

The 1R2151 is a fluorescent lamp ballast but, as you can see from the three designs presented here and those shown last month, the device has many potential uses. As the top diagram illustrates, the 2151 is essentially a 555 timer with integral level shifting and power mosfet drive circuitry. A typical application circuit is shown in the lower diagram.

Features of the device are,
- Floating channel bootstrappable
- Operates to 600V
- Tolerant to negative transients
- Undervoltage lockout
- Programmable oscillator frequency
- Operates to 600V
- Low-side in phase with RT pin

Typical connections for the 1R2151 in self-oscillating mode show that the device needs few external components. Power for the high-side switch gate comes from a 1Tp bootstrap transistor. This is charged to around 14V whenever Vg is pulled low during low-side power switch conduction. The fast-recovery bootstrap diode blocks DC bus voltage when the high-side switch conducts.

At the front end of the 1R2151 is a timing circuit that is very similar to the established 555. Two timing pins are available externally, opening up the possibility for numerous applications other than lamp ballasting. Dead-time generators are incorporated to ensure that the two power mosfets being driven by the device do not conduct simultaneously.
**SEETRAX CAE - RANGER - PCB DESIGN**

### Ranger 1 £100

- Schematic capture linked to PCB and wiring list entry
- Outlining (raster) library editor
- Manual board layout
- Full design rule checker
- Back annotation (linked to schematic)
- Power, memory and signal autorouter - £50

### Ranger 2 £599

- All the features of Ranger 1 plus
  - Gate & pin cross-posting (linked to schematic)
  - Back annotation (linked to schematic)
  - Auto track necking
  - Copper flood fill
  - Power planes (heat-relief & anti-pad)
  - Chip up & relief autorouter

### Ranger 3 £3500

- All the features of Ranger 3 plus
  - UNIX or DOS versions
  - 1 Meg resolution and angles to 1/10th degree
  - Hierarchical or flat schematic
  - Unlimited design size
  - Any shaped pad
  - Split power planes
  - Optional on-line DRC
  - 100% report & output, push & shove autorouter

### Outputs to:

- 8 inch 2400 dpi dot-matrix printer
- HP DeskJet LaserJet printers (including DeskJet 850C)
- HP-GL Houston Instruments plotters
- Gerber photoplotters
- NC Drill Excellon, Sieb & Meyer
- AutoCAD DXF

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**CIRCLE NO. 140 ON REPLY CARD**
**ACTIVE**

**A-to-d and d-to-a converters** 10MHz sampling a-to-d. Date's AD5-110 is a 12-bit, 10MHz sampling converter with guaranteed no missing codes over the military range of temperatures. Signal-to-noise is 68dB and thd -66dB, both around 68 better than other devices available. It is used in many industrial areas and contains a sample/hold amplifier, control and timing logic and error correction. Date (UK) Ltd. Tel. 01256 880444; fax 01256 860706.

**Discrete active devices** Power rectifiers. Surface-mounted bridge rectifiers by Steindenger handle reverse voltage up to 800V. Si1 types are contained within a 5.9 by 2.6mm footprint, 3mm thick, and are believed to be the smallest and lightest available. Somewhat larger and 30% cheaper are the SIN series.

**DSP modules** First in LS's new range of digital signal-processing modules based on the Texas TMS320C44 are the MDC44T and MDC44S. LS's hardware provides more functions on the single-width TMM-40 standard, so that the C44 is used to the full. Both modules possess increased memory - in the case of the MDC44S, 8Mbyte of ram and can be programmed in C for which a set of development tools is provided. An interface in the host pc is also used for initial program loading. Oros. Tel. (France), 00 33 76 90 62 36; fax 00 33 76 90 51 37.

**Logic** Caller ID chip. Mital has introduced the MT8742 caller line identification circuit, intended for the caller line display service announced by BT and for similar services elsewhere. It provides all alerting tone detection required by BT and in caller line ID on call-waiting services. Guard time is programmable and the device meets BT's requirement for loop-reversal detection, which is used in applications other than BT's caller ID to provide a ringing detector. Miltel Semiconductor. Tel., 01291 430000; fax 01291 430400.

**Memory chips** 'Densest' serial memory. At 128Kbit, Xicor's X25128 is claimed to be the world's densest serial seeprom. It is meant to support the Serial Peripheral Interface and has a 24MHz bus frequency, 2.7-5.5V working and a correct requirement of less than 1µA. Memory can be partitioned into blocks, with a feature called block lock, with levels of write protection, so that access is allowed to some portions while data in others is protected. Micro Call Ltd. Tel., 01844 261939; fax 01844 261676.

**NEW PRODUCTS**

Please quote "Electronics World + Wireless World" when seeking further information

**Thin sam. EDI has a number of 4Mbit static rams in the Thinpack ceramic package, which is only 1.9mm high, for use in military or high-reliability applications. Leads of the package are trimmed and formed and compatible with the plastic TSOP Type II pack. Micro Call Ltd. Tel., 01844 261939; fax 01844 261676.

**Mixed-signal ICs** Battery capacity monitor. Meeting the requirements of the Intel/Duralcell System Management Bus and Smart Battery Data, Benchmark's bq2040 capacity monitor is for use with NiCd, NiMh and lithium-ion batteries. Sending information on mAH capacity on the SMBus or indicating capacity directly by leds. The device is in a 16-pin SOIC. Sequoia Technology Ltd. Tel., 01734 256000; fax 01734 256020.

**Programmable logic arrays** 135MHz PLDs. Lattice Semiconductor's LPL3F and LPL5 232 are 32-macrocell ECLCMOS, high-density programmable logic arrays, the 'isp' meaning in-system programmability. They are both 80MHz, 110MHz or 135MHz, 7.5ns devices, supporting the Pontium and Power PC processors. Each has 32 registers and universal ios, two dedicated inputs, three dedicated clock inputs and a dedicated global output enable, all being connected by a global routing pool. Micro Call Ltd. Tel., 01844 261939; fax 01844 261676.

**Single-chip solutions** RF receiver. Integrating all the components of a receiver's rf strip, the AD607 and AD609 from Analogue Devices feature a ultra-low-power architecture. The two ICs are designed for wireless systems using a minimum supply voltage of just 2.7V down to -25°C and consume less than 25mW. They are suitable for applications using protocols such as GSM, cdma or tdma.

The AD607 has a linear IF amplifier with 100dB range whereas the AD609 has a logarithmic amplifier with 90dB of RSSI range and limited output. Both devices have low noise mixers a with 500MHz bandwidth as the first stage with an internal preamplifier which requires only ~168m of LO drive. The mixer output will drive an industry standard 10.7MHz 330Q filter. Am, fm, cw and sb are all demodulated by the AD607 with the AD609 providing fm and pm demodulation capability. Analogue Devices. Tel 01932 222222

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PASSIVE

Passive components

Modem transformer. Integrity Technology introduces the T14Z telephone line-matching transformer, for a transmission speed to 28.8Kbps in V.34. Using an EI, 14mm alloy core and a phenolic bobbin, the transformer is contained in a package about 0.5in cube with hard copper pins. It is designed to connect directly to 600Ω lines with zero bias. Primary winding is rated at 80mA continuous and 125mA in the ringing cycle. Integrity Technology Corporation. Tel., (USA) 00 408 252-8640; fax 00 408 262-1680.

Pulse transformer. Occupying a mere 0.625in square of board space, this transformer is the same as an earlier single type, DDC's dual pulse transformer is meant for use in MIL-STD-1553 dual redundant data bus systems. It is in dually phthalate encapsulation and is available in through-hole, surface-mount or flat-pack versions. All types have centre-tapped primaries and multiple taps on secondaries to cope with existing systems. Data Device Corporation. Tel. 01635 40158; fax 01635 32264.

Metal-film chip resistors. Gothic Crellon has a series of precision metal-film resistors that offer good pulse stability in single pulses up to 200W for 1μs. Resistance range is 100Ω-100kΩ at ±10%, in the E24 or E96 series of values. Temperature coefficient is less than 2.5×10⁻⁵K, power dissipation 0.125W maximum, voltage rating 100V dc or rms maximum and thermal resistance 170K/W. Gothic Crellon Ltd. Tel. 01734 788876; fax 01734 776095.

Connectors and cabling

SM wire-to-board connector. Claimed to be the smallest available, the Molex 53261 connector has a mounted height of 8.5mm on a 1.25mm pitch, with a 250Ω, 1.2A rating per contact. Connectors are supplied in tapes and reels and there is a cable assembly service on offer. Flint Distribution. Tel., 01530 510333; fax 01530 510275.

Network outlets. MOD-TAP's range of very low profile wall and floor outlets are for use in boxes of 16mm depth and are compatible with Euromod andModsnap accessories. They can be floor-mounted to either flat metal or plastic facades with an 18mm clearance. MOD-TAP Ltd. Tel., 01703 701919; fax 01703 704063.

Pcb terminals. Pcb terminals pitched at 3.5mm and 3.81mm from Wieland come in standard and pluggable versions, with the standard type as a vertical or horizontal connection, this having a fixing cam. Pluggable units are of pin-strip or edge-card connection and plug-and-socket. Ratings cover 6A/125V to 12A/125V. Wieland Electric Ltd. Tel., 01483 31213; fax 01483 505029.

Static control connectors. For establishing connection between different connector types, 4mm and 10mm for example, in static control applications, TBA has a range of kits. Where no ground point is present, a hand tool enables the user to fit studs to make the connection to accept 4, 7 or 10mm studs and banana plugs. TBA Industrial Products Ltd. Tel., 01706 474422; fax 01706 46170.

DIN 41612 connectors. Apfel DIN 41612 connectors in the U/L range are now obtainable from Westfield. Types available include B, C, Q and R (including half types), pc-board mounting, solder, wire-wrap, press-fit and idc ribbon models in 16-96 ways. Connectors are of the dual-beam type in a number of forms. Westfield Distribution Ltd. Tel., 01488 685183; fax 01488 685430.

Sensors

Thermocouples. A package that includes the PicoLog data logging software. Pico's TC-08 is a thermocouple to pc interface. The unit requires no power supply and connects to the pc via the serial port. Eight different thermocouples can be accommodated (B, E, J, K, R, S A and T types) and the software allows samples as fast as once a second and as slow as one per hour. Advanced temperature processing functions include filtering, min/max detection and alarm setting. A real time display is available in either graphical or text format. Pico Technology Ltd. Tel. 01954 211716.

Displays

Contrasty LCDs. Hitachi's LGM7380 graphic/alphanumeric liquid-crystal display has a contrast ratio of 16:1, a six-times improvement over the earlier LGM6380, achieved by the use of a film-relation layer and a fluorescent backlight. Size is 160 by 68 by 11mm. Other units in the range include the LGM738X/UCG-OOT VGA display and the LM620RPDC 320 by 240 colour and ic controller. Eiger Technologies Ltd. Tel., 01928 579009; fax 01928 579123.

Filters

Piezo IF filter. Narrow-passband filters from Murata, the SFE10.7MV5 and SFE10.7MV7 for fm radio and am up-conversion, use the second overtone vibration mode to achieve ±13kHz bandwidth and ±35dB spurious response suppression. Murata Electronics (UK) Ltd. Tel., 01252 811666; fax 01252 811777.

SAW filters. Surface transversal acoustic wave filters by GPS are on quartz and offer a ±0.15°C to 80°C temperature range, compared with the 0-40°C range in other materials; group delay is less than 150ns. First available is the DW9249, intended for use in the IF in DECT digital cordless telephones, operating at a centre frequency of 112.32MHz with a ±3dB passband of 1.152MHz. Adjacent-channel rejection is 20dB. GEC Plessey Semiconductors Ltd. Tel., 01793 518510; fax 01793 518582.

Personal DSOs. Tektronix has produced a range of digitising storage oscilloscopes at a price low enough that they can be considered personal instruments while retaining lab. instrument accuracy and performance. The range of TDS 400A instruments encompasses bandwidths from 200MHz to 400MHz with sampling to 100Msamples and offers, when coupled with a range of accessories, an array of features for all kinds of electrophysical measurement. Both new models have a graphical user interface and offer automatic measurement of 25 parameters; there is also an FFT and a 3.5in floppy drive to allow results to be saved and imported to Windows and Macintosh applications. One of the accessories is the P2500 high-quality digitising storage probe, which allows the 'floating' measurement of voltages up to 1300V when no ground point is available, the P2500 converting the floating voltage to a ground-refered one with no capacitance penalty.

Record length is 120K to allow a complete sight of a long signal while retaining the ability to see detail. Tektronix Uk Ltd. Tel., 01628 486000; fax 01628 474759.

Intrumentation

Sound-intensity probe. Improvements to Bruel & Kjaer's sound intensity probes increase physical robustness and extend screw holes. Options include the i series with a recessed top for a membrane keypad, the standard type with a flat top and a slanted model for wall mounting, all with pcb mounting pillars. OKW Enclosures Ltd. Tel., 01489 535358; fax 01489 536363.

Snap-in bezels. RMF bezel/filter assemblies snap into a suitable panel aperture without the need for screws or fasteners of any kind. The ABS bezels are available in a range of sizes to match most types of display, black being standard and colours available to order. Combined coloured filters have a non-glare surface and come in red and clear for leds and idols, colour again being available to order. Panel thickness is required to be 0.040-0.125in. and the range of sizes is from 1.343 by 1.906in to 1.656 by 8.531in. UV-Tec Ltd. Tel., 01483 505029; fax 01483 505031.
NEW PRODUCTS CLASSIFIED

Please quote "Electronics World + Wireless World" when seeking further information.

4 databook. As well as performance figures, there are details of the special features of flat-tam design. Harris Semiconductor UK Tel. 01276 686866; fax 01276 682333.

Connector catalogues. Four catalogues from Robinson Nugent describe interconnection products. There is a giga socket brochure on sockets for the Pentium; a catalogue on 5 and 8K smt fine-pitch board-to-board connectors; a third on MEMPAX PCMCIA connectors; and one on 2mm products. Robinson Nugent Ltd, UK Tel. 0331 4990 7575; fax 0331 4990 7115.

Noise suppression. Panasonic offers a catalogue of noise suppression and filtering components for power line, signal line and surge pulse protection. Components described include line filters, ceramic-disc and chip capacitors, chokes, emi filters and bead cores and inductors. There is also an Introduction to the law and regulations on noise and the principles of its suppression. Panasonic Industrial (Europe) Ltd. Tel. 01344 853827; fax 01344 853863.

Gas plasma displays. A colour brochure from Cherry describes the company's latest range of gas plasma displays, including the Plasmadot family of full-field dot-matrix types and a series of interface controllers and dc-to-dc converters. Technical details and some application information are included. Cherry Electrical Products Ltd. Tel. 01582 763100; fax 01582 768893.

Light measurement. Instruments for light measurement, applications and the basics of radiometry and photometry are all described in a new catalogue from International Light of Massachusetts, which also includes tutorial information. International Light Inc. Tel. (USA), 00508 465 9293; fax 00508 462 0759.

Flexible circuit material. Rogers Corporation offers a colour brochure describing the company's latest flexible printed circuit substrates: its capabilities in the manufacture of flexible pcb substrates in polyimide-based films, fr4 glass-epoxy, rigid metal and material and adhesive types in acrylic, butyl phenolic and epoxy. Copper.
NEW PRODUCTS CLASSIFIED

Energy management controller. Microchip says its new 47E1121 IC, developed in partnership with EPAM Energy Management, will reduce power consumption in consumer and industrial equipment using 32-bit microprocessors. It runs at up to 320mW, has a 1.8 volt power supply, and can perform functions such as detecting overcurrent, undercurrent, and overtemperature.

Sensors. The Sensor Technology Sourcebook lists and describes companies and organizations involved with sensors of all kinds by application and alphabetically, with names and telephone/fax numbers, lists databases, technology transfer specialists and commercial products. Technical Insights Inc. (USA). Tel. (USA), 00 203 774 9605; fax 00 203 774 9630.

Materials

EMI/RF seals. At prices not much more than those for ordinary dust and moisture seals, James Walker's Shieldseal 107 conductive elastomer in standard or custom profiles provides double arcing chambers; line feed is increased by up to 30% by the use of the company's PIC16F846-bit, line-driven unit or the microcontroller used. Each key can be programmed to generate a macro of up to 16 characters on one level or on each of four concurrent levels.

Transducers and sensors

Piezoelectric film sensors. Strain sensors from Pro-Wave, based on polyvinylidene fluoride film, offer improved sensitivity over ceramic types. A two-pin, pcb-mounted unit, the FS-2513P, measures 13 by 25mm, is encased in a moisture-resistant coating and has a sensitivity of 0.5mV/g with a 25-70Hz frequency range. Capacitance and output impedance at 1kHz are 1.5pF and 100kΩ. Quarterline Ltd. Tel. 01933 705415.

Electret microphones. Future Components handles the complete range of Panasonic's electret capacitor microphone cartridges in the WM-034 and WM-54 series, intended for use in both industrial and consumer application. WM-548 is a new, 4.5mm deep model with a choice of sensitivity in the -46dB to -40dB ±2dB or ±3dB range. WM-546B is a 4.5mm deep model. WM-034B/C is commonly used types operating at 4.5V with -46dB to -38dB ±3dB sensitivity, while WM-034D/C is a 1.5-10V model and WM-034F with a 1.5V range working with high and low frequency roll-off for telephone use. Future Components Ltd. Tel. 01279 756999; fax 01279 757676.

Data communications

Plug-and-play IEEE 488.2 controller. National Instrument's IEEE 488.2 controller is now available in a ready-to-wear, jumperless version. AT-GPIB7/7XY(P) plug-in slots and is designed for true plug-and-play operation in compatible systems, in which hardware settings are automatically in place at switch-on. In a non-compatible system, the

100, 160 or 260g range. Height from the board is between 13mm and 1.6mm and overall size is 5.7 by 4mm to 10 by 6mm. A dust-proof type, the JTP-1200, is available from Nedeka Ltd. Tel. 01462 422433; fax 01462 422233.

Cashpoint keyboards. Programmable keyboards for shops, made by DED are protected by liquid filling and a membrane type with feel. POS-Page 854/865 have 120 keys, covered by a transparent sheet which forms a menu page to indicate each key's function, the page being produced using software supplied and the keyboard itself or simply marked up by pen. Each key can be programmed to generate a macro of up to 16 characters on one level or on each of four concurrent levels.

Several options for interfacing to computers, scales and printers are provided. DED Ltd. Tel. 01797 320636; fax 01797 320273.

COMPUTER

Computers

Power supplies

Fixed-±amps. Using fixed-frequency switching to meet EN50022 level B EMC limits, XP's NFN 25 and 40 universal-input units are available in 25W and 40W versions and various output voltages including 5, 12, 15 and 24V singles and 5V with ±12V, 5V with 12V and ±5V, and 5V with ±15V. Universal input handles 85- 264V, 47-440Hz. XP plc. Tel. 01734 845515; fax 01734 643423.

PCMCIA power controllers. Micrel's range of controllers now includes the Micrel 2561, a low-cost device in 14 or 16-pin SOIC packaging. It will switch between the three VIN voltages off, ±3V and ±5V of the five VIN voltages off, ±3V, ±5V and 12V, selection being by means of two

digital inputs for each output. Output current is up to 750mA for VIN and 200mA for VCC. There is full protection for equipment and power supply. Hawke Components Ltd. Tel. 01256 880800; fax 01256 880325.

'Smallest' Ito regulator. Described by National Semiconductor as the smallest and highest-performing dropout regulator family, the 50mA LP3969 is one of the company's TinyPack series in the 8.2 mm² SOT-23 package. Dropout voltage is 120mV at 50mA and 7mV at 1mA; quiescent current 375μA. Input voltage is -0.3V to 16V and output voltage, 3.3V or 5V, accurate to within ±0.5%. National Semiconductor GmbH. Tel. 01049 81410382; fax 01049 81410351.

Efficient regulator. Having a 4.40V operating range, Linear's LTC1159 high-frequency, synchronous, switching regulator is 99% efficient with loads in the 0.02-2A range while providing 5V from a 10V input. Two external mosfets are driven at frequencies to 250kHz, the unit automatically switching between continuous and burst operation for higher efficiency. Quiescent current is 250μA and 25μA when shut down and dropout is 200mV at 1A and 100% duty cycle. Micro Call Ltd. Tel. 01844 261935; fax 01844 261678.

Radio communications products

Satellite receiver. R L Drake of Ohio has introduced the ESR410, a satellite receiver using synthesised tuning and block conversion. Frequency range is 950-2050MHz and the unit is meant for equipment and power supply. Littelfuse Ltd. Tel. 01797 320636; fax 01797 320273.

Network for smart noses. Windows-based network by NCS, the NeuRun, is in use by the French firm AlphaMOS to add automatic decision making to the Fox 2000 electronic nose, little effort having been needed to embed artificial intelligence in Fox's LabView-based software. NeuRun is compatible with pc and windows dos software and hardware, so that it can be used to construct and upgrade applications in a modular manner without the need to program or redesign existing software. In this case, NeuRun is embedded as a background task behind LabView, and samples are being analysed by NeuRun, a decision on the sample made and the decision transferred back for display in less than one second. Neurolab Ltd. Tel. 01703 687775; fax 01703 63730.
board provides configuration by means of the NI-488.2 software configuration interface that is supplied with the board, in addition to dos and Windows drivers. It is compatible with LabVIEW, LabWindows/CVI and LabWindows applications packages. National Instruments UK. Tel. 01635 523545; fax 01635 523154.

RS232 voltages from transceiver. Linear's LTC1348 RS232 transceiver IC delivers true RS232 voltages from one 3.3V supply. It is a three-driver, five-receiver DTE unit drawing 500mA and needing only three small capacitors for the RS232 voltages. It has four current-saving modes of operation, including a 10mA "receive-keep-alive" mode and full protection from esd and overvoltage. LTC1348 supports data rates up to 120kbps. Linear Technology (UK) Ltd. Tel. 01276 677676; fax 01276 64851.

Development and evaluation

8051 emulator. TX91 is a low-cost emulator supporting all rom-less variants of the 8051, including the Dallas DS82520, up to an oscillator frequency of 30MHz and can be configured for 3V working. The single-chip ROM/256RAM can be supplied for the unit. HTOP development environment is used, in which one can debug code in C, PLM or Pascal

at source level, and view and modify variables while the program runs. On offer is a free information pack and demo disk. Hitex (UK) Ltd. Tel. 01203 692066; fax 01203 692131.

Programming hardware

Dual processor. SMS Sprint Dual is a twin programmer for both development and production, its most popular version being capable of handling 48-pin dip PDLCs up to 84 pins and a JTAG connector for in-circuit programming. For production, the instrument will program devices in parallel, speed of operation being enhanced by the use of the host pc's cpu and ram. Concentrated Programming Ltd. Tel. 01279 600313; fax 01279 600322.

Software

Windows XRAY Monitor. Microtec offers a Windows version of the XRAY Monitor debugger for the Motorola 68000 family, using all the short-cut facilities of windows for speed, including a button bar for common commands and icon dropdown. Assembler and high-level source code is visible together and there is context-sensitive help. Configuration to target hardware is easy and the faster target processors run at full speed. Microtec Research Ltd. Tel. 01256 575571; fax 01256 575523.

Mixed-mode circuit simulation. Windows-based IsSpidey by Intuos is an advance on Spice 3 in that it will now simulate both analogue and digital circuitry in the same EKE. The event-driven IsSpidey algorithm supports 12-state digital data, and also real, integer and user-defined data, so that it is capable of simulating, say, disp functions and sampled data filters in an analogue environment. Real data is handled by the event-driven simulator, so that the sampled-data filter can be simulated quicker than in an analogue model. Intuosoft. Tel. (USA) 010 310 833-0710; fax 010 310 833-9658.

Graphics. Numerical Algorithms Group now distributes template Graphics Software packages, from two-dimensional presentations to high-level three-dimensional visualisation. FlGraph, a 2D/3D charting system for Fortran and C generates line, bar, pie and contour graphs on graphics terminals, IBM mainframes and the X Window system. FIGARD/ANSI is for graphics in cad/cam on workstations, mainframes and Windows NT. TUGS is a free copy of the OpenGL software interface for 3D applications, and Open Inventor, a C++ authoring system based on OpenGL. These products complement NAG's IRIS Explorer. Numerical Algorithms Group. Tel. 01865 511245; fax 01865 310139.

MEJDAF Europe Ltd

INTRODUCE

* 'ENGINEER' brand professional tools from Futaba Tool Manufacturing Co. Ltd. Japan for Electrical/Electronic Engineering Industry.

* 'GOOT' brand soldering equipment from Taiyo Electric Industrial Co. Ltd. Japan.

We offer competitive prices for these exceptionally high quality products.

For descriptive literature please contact:

MEJDAF EUROPE LIMITED
196 Preston Road, Wembley, Middlesex
Tel: 0181 904 9671
Fax: 0181 904 9546

April 1995 ELECTRONICS WORLD + WIRELESS WORLD
# Smart Kit Electronics

**HIGH QUALITY ELECTRONIC KITS**

We feel that most readers will know these kits but if you want more information about them, then we have the official Smart catalogue available. This gives circuit diagrams and illustrations. The price is £1 or free if you order kits to the value of £20 or more, the prices include VAT. You can send a cheque or postal order or ring and quote your credit card number and please add £3 service charge if the order is under £25.

<table>
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<td>VU meter with led display</td>
<td>4.60</td>
<td>1070</td>
<td>Hi-fi preamplifier</td>
<td>7.47</td>
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