A lesson in new technology

Many of you will be aware that the numbers of young people leaving school and considering a career in electronics and similar disciplines has been falling for years. Depending on who you listen to, this fall is either worrying or disastrous.

As someone who works with both schools and industry I am aware that many of my industrial colleagues are extremely concerned about future recruitment.

Here in Staffordshire, electronics companies are experiencing a great difficulty in expanding due to the lack of qualified electronics and other manufacturing engineers. As a result, electronics specialists are being appointed from all corners of the globe – but this success is not infinite.

Following the government hope regarding education, education, education, you could be led to believe that a new generation of high calibre students is in the pipeline about to burst out of our schools to revitalize the nation’s manufacturing base. Don’t hold your breath.

Unfortunately, governments have difficulty distinguishing between ‘technology in schools’ and ‘design and technology’ as defined in the National Curriculum.

Several months ago, the government announced that a further £400m would be provided for ‘Technology in schools’. Some took this as being the key to turning a new generation towards electronic design and manufacture.

In those schools where targeted investment has taken place, the experience known to many older readers as ‘Craft’ or ‘CDT’ is now a cutting-edge subject, well matched to the 21st century. In the majority of schools ‘hands-on’ electronic design and manufacture – if undertaken at all – takes place in design and technology lessons.

Unfortunately, I believe that little of this new funding will find its way into design and technology. If it doesn’t, it will have little effect on the nurturing of the future engineers that industry desperately needs.

Although there has been considerable expenditure in general career development for teachers, we have only scratched the surface in updating the skills of specialist teachers in the new technologies – especially electronics. Unlike the wood and metal ages, these new technologies change rapidly, requiring regular career development for staff. Much of this practical career development was provided by local Education Authorities but sadly this has all but disappeared.

I doubt if the new funding will have any effect unless we see directives to equip the country’s design, technology and science facilities with adequate levels of dedicated ‘information and communications technology’ hardware, ICT for short, suitable applications software and manufacturing facilities appropriate to 2001 rather than 1951.

Unfortunately, in many schools this new technology hardware will not be used for designing electronics systems, controlling electrical components via control interfaces, data logging, scientific analysis or allowing young people to design using some of the excellent CAD/CAM software now available.

Only a tiny percentage of schools will allow some of the funds to be spent on the purchase of dedicated design, technology and science computers, CADCAM equipment, PIC systems or ICT controlled manufacturing equipment. Instead the vast majority of this new funding will probably go on supporting ICT in English, business studies, leisure and tourism, geography – and every other subject area.

This of course is no bad thing. Our future engineers need a high quality general education in all subjects. But these areas of the curriculum have little to do with electronic design & manufacture.

The solution – or at least a move in the right direction – would be to set a standard benchmark of minimum ICT requirements for all schools, in design, technology and science departments. If £400m were ring fenced and only given to the country’s high schools, design, technology and science departments, each would receive approximately £50000 each.

You would appreciate that to purchase some small CADCAM manufacturing equipment, software and 20 computers will quickly swallow up this sum. This assumes that the environment is suitable for these modern technology activities – which is unlikely in many schools.

We also have the career development aspect, to teach electronics and integrate all the ICT requirements comprehensively. This requires intensive long-term investment in training. All of this would cost in excess of £20000 per school, minimum.

If science and technology is to be the base of this country’s future economy, as stated by Lord Sainsbury and other government ministers over the past six months, we need some major dedicated funding for these subjects in the nation’s schools, primary and secondary. This is especially important in the secondary sector where the specialist ICT equipment, software and manufacturing equipment for design, technology and science is vital.

John Hindhaugh, Director Staffordshire SATRO
Airship detects battlefield mines

Minesweeper detects battlefield mine.

The technique also applies to bundles of single walled nanotubes, although the process is less straightforward. As the current is passed through the bundle of tubes, each individual tube is destroyed through oxidation, again changing the properties of the bundle.

IBM has shown that this technique, which is not applicable to multi or single walled tubes, can be done on a selective basis.

Arrays of tubes can be left as a sea of metallic elements with a few semiconducting elements making the FETs.

Nanometre-scale tubes could be used to produce FETs.
**Class-D amplifier chip boasts 300W and 0.03% distortion**

Digital reproduction is creeping up the audio chain and has reached the power of many low-cost amplifiers—particularly in those, like answer phones and TVs, where quality is not top of the list. Now Texas Instruments claims to have brought the well-known Class-D attribute of high-power efficiency to a real high-power hi-fi design.

It is to sell an all-digital amplifier subsystem chip that should deliver over 300W with THD+N below 0.03% (20Hz to 20kHz) and a 110dB dynamic range measured at the speaker—when the complete reference design becomes available later this year—claims the company.

It also says that a variable power rail design, which is keeping it on its sleeve, will allow a dynamic range of 130-140dB.

The TA85915 digital modulator is the heart of the amplifier. It is a 24-bit multi-standard, multi-sample-rate (32 to 192kHz) device that processes a digital pulse-code modulated input into a pulse-width modulated output ready for a power output stage.

It has designed a suitable discrete power stage, which will only be available in one form this year, and claims the PWM signal up to the power level required at the amplifier.

The company says it has discovered that the reference design will dissipate less than one-tenth the power of class A and class B designs.

The technology, called equitip, comes through TI’s acquisition of Topcon Technology last year.

**Satellite’s momentum wheel develops 5.2Nms from just 6W**

Surry Satellite Technology (SSTL) has made the momentum wheel which will fly on the Rosetta spacecraft, due to land on comet 46 P/Wirtanen on 25th November 2011.

The wheel will be mounted inside the satellite so that the spin direction is initially fixed, giving the satellite an inherent gyroscopic rigidity. By changing the momentum wheel’s speed over a limited range—less than 10% of the nominal speed of a few thousand revolutions a minute—the satellite can be rotated around the spin direction. In this way, rotational momentum can be exchanged between the wheel disc and the satellite’s body.

This momentum wheel is unique, says SSTL, in that it provides 5.2Nms of momentum with a power dissipation of only 6W.

The device will have to survive a nine year cruise in space before it is fired-up and used to manoeuvre the craft during the final 20 hours of approach and landing on the comet.

Dry laboratory tests and low-friction operation are the keys to long life in a vacuum says SSTL. Details of the Rosetta Mission are available at http://sgrid.esa.int/rosetta/olc/rosetta_en/index.html and www.sstl.co.uk

**LEDS for domestic lighting?**

The domestic light bulb may be a step closer to the history books when Philips in the US has finished its latest development.

It is setting up to weaponize LEDs so that led lighting could have in power efficiency—have to be used in bunches to get sufficient light for illumination.

Unfortunately chip-to-chip variation means that the output can be so patchy and varied from sample to sample that the company is developing ways to optimally mix the light coming out of the LEDs, as well as control algorithms to allow the effective colour of the assemblies to be varied to suit mood and tastes within the home.

One aim is to generate control algorithms that carefully balance the many variations which occur in LEDs, said the company.

Algorithms so far developed also include compensation for device to device light output variations.

The company is working on a chip to throw with current to assembly.

At the moment, some form of initial calibration is required. Eventually an in-sensor room may feed back quantum to information to allow ‘plug-and-play’ swapping of led-based lamps.

**Backlighting of LEDs may be the first application for the new technology, which has been written for Philips’ microcontrollers.**

**Optical fibre survives oil-well drill tip**

New Mexican research centre Sandia Labs has shown that optical fibre is tough enough to survive in an oil-well drill tip without additional armour.

Previously it was thought that the fibre would be too fragile to last long enough to do any useful work within the hollow drill, which also carries abrasive liquid ‘lubricant’. The findings come out of a research project to increase the data rate of low-in-well sensing during drilling operations.

Fibre, protected only by a thin protective plastic coating, survived the few hours needed to make measurements in a 1000m test drill, transmitting information about temperatures, pressures, chemistry, and rock formation at 1Mbit/s. Researchers predict the scheme should be good for 10Mbit/s.

After the fibre is ground up by the drill bit.

Why it survives is not yet known, but it is suspected that it ‘gives’ when brushed by particles in the lubricant and also tends to clip to the inside wall of the drill.

**New unique material focuses microwaves**

A material with a negative refractive index at certain microwave frequencies has been created by physicists from the University of California in San Diego.

Future generations of the material could, the developers say, lead to highly directional antennas and perfect lenses that focus microwaves or light to a point.

“The experiments we report confirm earlier theoretical predictions that a new, unique, class of materials can cause electromagnetic waves, such as radar and microwaves, to bend in a direction opposite to the way they travel through all other materials,” said Sheldon Schultz, professor of physics at UCSD.

The work by Schultz’s team proves an idea put forward by Professor John Pendry, head of the Quantum Physics Research Group at Imperial College.

He suggested that some composite materials with negative permittivity and negative permeability would have bizarre properties such as to make convex lenses behave as concave while flat sheets would focus light to a point.

So-called metamaterials with negative permittivity and negative permeability lead to a negative refractive index, which means the material breaks Snell’s Law. Any EM radiation incident at a boundary will be reflected at an unexpected direction.

A microwave beam incident on Schults’ material refracts in the same side of the normal as the incident ray.

“If these effects turn out to be possible at optical frequencies, this material would have the crazy property that a small flashlight shining on a flat slab would produce a focus at a point on the other side,” said Schultz.

**Audio and video compression system MPEG4 has taken another step closer to full industry acceptance as three key organisations agree on a standard.**

The International Telecommunications Union (ITU), 3G Partnership Project (3GPP) and Internet Engineering Task Force have pledged their support for a format proposed by five Japanese companies.

Their support for any MPEG4 format is said to be critical to delivery of MPEG4 over the Internet.

The five developers of the format are the Matsushita Electric, NEC, NTT, Oki Electric and Toshiba.

Rather than using TCP/IP, the conventional Internet protocol, they have based their standard upon the real-time transport protocol (RTP).

Audio and video are a problem for TCP/IP because of their inherent real-time nature. When data is lost, TCP/IP retransmits, which can cause annoying delays to the service or even out of order sequencing.

On the other hand RTP does not retransmit and adds time stamps to the packet headers in order to keep audio and video synchronised.

Sequence numbers make sure that packet losses doesn’t cause major timing problems.

Designed for lowly media such as mobile phones, MPEG4 is expected to become the main compression standard for telecoms, local-area networks and the Internet.

Video over wired or wireless links can have data rates of between 5 and 64kbit/s, while standard TV is between 2 and 8Mbit/s.

The data, whether audio or video, is split into a series of objects, for example a background, table and a human body. If only the human face moves from one scene to another, only the relevant data is transmitted, reducing bandwidth requirements.

**High-performance Bluetooth**

A Bluetooth radio chip has been developed by STMicroelectronics using intellectual property from Parthus Technologies, the Irish design house.

Aimed at battery operated products such as mobile phones and PDAs, the chip is designed to improve on an intermediate frequency design. ST will use its BICMOS silicon germanium process to manufacture the chip. Current consumption is claimed to be 30mA in receive mode and 30mA when transmitting at maximum power.

"Exploiting ST's Silicon Germanium technology has enabled us to create the highest performing Bluetooth radio on the market," said Kevin Fielding, president of Parthus Technologies.

On the chip the transmits at Bluetooth's Class 2 and 3 levels, good for up to 10m. With the addition of a extra power amplifier, it can manage Class 1 operation, which takes its range up to 100m.

In order to bring Bluetooth products to market quickly, the specifications has very relaxed requirements. Bit error rate, for example, is only required to be 10^-3 at 70dB. The ST/Parthus chip has a claimed BER of 10^-4 at -75dBm.

**E Ink has demonstrated a 12-inch active matrix ‘electronic ink’ display that retains its image power-free.**

The company started off with an active matrix driven by IBM and added the ink, which works through the electrostatic attraction of coloured particles.

The black ink on white background avoids the need for backlighting, claims the company, while brightness is up to six times better than LCD, it said.

E Ink and IBM will deliver a joint paper describing the display at the Society for Information Display Conference in San Jose in June.

E Ink is working with designers such as Mobile Media, who has made a display that fits into a sleep mask and is very small and flexible.
**Solar cell promises 50% efficiency**

Scientists at Vanderbilt University in Tennessee are pursuing a solar cell that converts sunlight at 50 per cent efficiency. Moreover the design will cost just $1 per square centimetre, the researchers claim. Professor Timothy Fisher says his polycrystalline diamond films would be well suited to space applications as they can withstand the high level of cosmic radiation. Efficiency of conventional solar cells can be reduced by a half after ten years in space.

Fisher’s diamond-film structure includes pyramids, about ten million per square centimetre, separated from the cell’s anode by a small gap. The cathode is attached to the back of the film.

Sunlight hits the cathode and heats it to around 1000°C, causing streams of electrons to flow from the pyramid tips to the anode. The resulting large current and small voltage are passed through a DC-to-DC converter at around 90 per cent efficiency, says Fisher.

Costs are kept down as the diamond film can be deposited from methane using chemical vapour deposition.

The goal of current research at the University is to produce a prototype 1cm square cell turning out 10% of power at 1000°C.

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**Steerable solid-state antenna for mobile phones**

Cambridge start-up Antenna has garnered £3m in venture capital funding to develop a steerable solid state antenna.

Launched late last year, Antenna is developing directional and steerable antennas aimed at mobile phones.

By directing the RF, mobile phones can physically split cells and radiation to the user can be reduced.

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**Steerable mirrors at heart of Texas Instruments’ optical comms systems**

Texas Instruments has announced an optical communication system based on steerable mirrors.

It is a point-to-point system which will send 100Mbit/s Ethernet hundreds of metres or up to 50 metres with a class 1 laser.

The steerable side of the design ensures a phone stays in contact with the base station in the user changes position.

By avoiding 360° transmission, power consumption is also reduced, the firm says. And because the antenna is directional, signal processing needs are reduced.

The antenna is formed from three strip-lines on the mobile phone’s PCB. This gives it directional control with a 60° resolution.

First working prototypes are due by the end of this year.

A spin-off from radio frequency location company ActiveRF, Antenna holds licences for technology developed by Sheffield University and Griffith University in Australia. Funding has come from the Cambridge Gateway fund.

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**WAP addresses reduced to a number...**

Typing in WAP addresses using only the 12 keys of a phone keypad is an irritation that may go away with a development from AirClic. In a trial in Sweden the company has replaced WAP addresses with a key-pad-friendly number. The user either types in the number, or scans a special mini bar code into the phone. Apparently, it only takes minutes to register any phone, PC or PDA with the company to use the system.
Elastic capacitors

Electronic engineers understand capacitors but they tend to view colliding bodies as mysteriously - a strange mindset since they are both expressions of the same formulae, as Andrew Robertson explains.

What do collisional bodies and capacitors have in common? Not a lot one might think, apart of course from both being described by the ubiquitous and in integral $\frac{1}{2}m \times v^2$, i.e.,

- \text{momentum} = mv
- \text{kinetic energy} = \frac{1}{2}mv^2

and,

- charge = CV
- charge energy = $\frac{1}{2}CV^2$

Beyond this, few textbooks make more than passing comment of correspondence, but one must bear in mind that formulae only describe - they don't define.

Non-elastic interactions

If a body travelling with a velocity of $v$ collides non-elasticly full face with a stationary body of identical mass, the two bodies unite and move in the same direction as the original moving body but with a velocity of $\frac{v}{2}$. Momentum, being invariant, prevails.

The energy transferred --- $\frac{1}{2}m v^2$ --- is emitted ultimately as heat. Likewise, but with a change of terms, this expression of energy occurs in the classical example of Fig. 1.

With identical capacitors and initially only $C_1$ charged to $V$, closing the switch results in a voltage of $\frac{V}{2}$ in each capacitor. Charge conservation, also invariant, substitutes for momentum. Capacitance for mass and voltage for velocity.

Regardless of the impedances of the physical components, be they large or diminutive, it could, energy wise, be likened to where the collision is concerned. We have therefore in a sense 'elastic' capacitors.

Momentum and charge of the whole universe is by all accounts absolute, and probably zero. In all known interactions, momentum and charge will always be preserved at the expense of system energy. So, regardless of relative masses or capacitances where the second body is initially stationary (or charged), it follows that, for inelastic collisions, combined velocity is,

$$\text{mass} \times \text{velocity} = \text{mass} \times \text{mass}$$

or, for (inelastic) capacitors. combined voltage is,

$$\frac{C_1}{C_1 + C_2} V + \frac{C_2}{C_1 + C_2} V$$

Elastic interactions

Consider now the elastic collision of two identical masses, initially one moving and the other stationary. For simplicity, this is restricted to a flat face collision.

The first body; transfer all its momentum and energy to the second body. This absolute condition is only realised at atomic level but can be approached in the 'real world'.

So what of a capacitor equivalence? Conventional wisdom conjures up the 'inelastic' situation, but there is a way. In Fig. 2, where only $C_2$ is initially charged and $C_1$, with identical components the entire charge and energy are transferred when the switch is closed. As with collisions, losses cannot be avoided but can be minimised with a high Q inductor and synchronised switch replacing the diode and switch.

At first glance, the inductor's action may appear strangely obliging but the arrangement is simply a tank circuit, with the condition at the instant of switch closure being the voltage crest of an oscillatory cycle. After $180^\circ$, the voltage across the inductor is reversed, current will have fallen to zero and further oscillation and charge exchange is blocked by the diode.

The system energy will be again solely capacitive, having been transferred by way of the inductor intermediary from $C_2$ to $C_1$. Of course for the oscillatory cycle, the two capacitors are affected only once in series, combination, charged to $V$. This is true for both the initial and final conditions since our voltage reference is their junction.

In this simplest case it is zero, as initially is the voltage of the second capacitor. Ergo that capacitor equates to an initial stationary body in our voltage reference frame.

Notably, the voltage $V$ reversing between the top and bottom of the capacitors is analogous to a primary law of elastic collision. Although second nature to the atomic physicist, this may not be so for the electronics engineer. The formulae are not different in terms of momentum and energy equations, but can also be derived from basic electronic principles. Consider Fig. 2 with dissimilar (or identical) capacitors. Series capacitance is,

$$\frac{C_1}{C_1 + C_2} + \frac{C_2}{C_1 + C_2}$$

In the elastic interaction - i.e. $180^\circ$ of an undamped oscillation - the voltage across the capacitors is reversed. which is to say that voltage change across the capacitors is twice $V$. Note that the subscripts and $/ /$ denote the initial and final states before and after switch closure. This means that charge flow is,

$$C_{total} \times \frac{\ddot{V}}{2}$$

Charge in $C_2$ was initially zero so charge flow is equal to charge transferred from $C_1$ to $C_2$. But since $V_2 = 0$, $V_{2-V} = V_1$, and since,

$$V = \frac{2}{C}$$

resultant voltage $V_2$ across $C_2$ is,

$$\frac{C_1}{C_1 + C_2} V + \frac{C_2}{C_1 + C_2} V$$

The derived formula relating to inelastic and elastic collisions between one moving and one stationary object can be augmented to describe interactions between bodies or capacitors with any initial starting condition.

Interaction between two moving bodies equates to both capacitors having an initial charge but the analysis still holds true. One can even incorporate coefficients of restitution and resistance as imperfect components in the mechanical and electrical systems.

There are limits though. In more complex states, such as where the collision is not full face or asymmetry of the bodies impart spin, the elegance of the equivalence becomes strained. An aspect of charge conservation is apparent but not altogether accurate - capacitor charge is perhaps better viewed as charge density.

When a body - a capacitor would do - is thrown into the air, the world moves in the opposite direction. The charge of that capacitor - the complementary effect of momentum - is not quite so absolute.

If, for instance, two identical capacitors are charged in series, then in their charged state reconnected in parallel, the voltage halves but the capacitance quadruples. By manipulation of each capacitor's zero reference, there is a doubling of charge. In the world of momentum, contrary to what, say, advocates of gyroscopic levitation would appear to expose, there is no likely analogy.

So is there benefit from viewing capacitor charging as elastic and inelastic collisions, or vice versa? Certainly, if one's indication is to subjectively feel the physical world. The two environments are merely different in their underlying fundamentals, not formulae coincidence. It is akin to describing electricity in terms of water flow.

The appreciation is not Grand Unification Theory, but such comparison can aid insight and hence possibly improve circuit design. Finally, thanks to Glenn O'Dell for his help in preparing this article.
Pseudo-random bits

Pseudo-random bit sequences have uses in communications, testing, audio and many other areas. Here, Ian Hickman sets out to demystify the topic.

Pseudo-random bit sequences, or PRBSs, are readily generated, either in software, or in hardware using linear-feedback shift registers.

If the output of the last stage of an n-stage shift register is fed back to the input of the first stage, the contents of the register will cycle around indefinitely as the device is clocked. The length of the output sequence will be 2^n bits per repetition. But if the output of the last stage and the content of an earlier stage or stages are combined to give the feedback signal, the length of the repeating output cycle can take various values up to 2^n - 1, depending on how the feedback is arranged.

### Modulo arithmetic

In modulo arithmetic, the result can never exceed some arbitrary maximum number. If the result exceeds this, the number, called the modulus, is repeatedly subtracted until the modulus is not exceeded.

| Table 1 | In GF(2^n), addition of two numbers X and Y follows these rules. X Y Sum
<table>
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<tr>
<td>0 0</td>
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<tr>
<td>0 1</td>
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<td>1 0</td>
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<td>1 1</td>
<td>0</td>
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Ordinary decimal arithmetic uses the ten digits 0 to 9 inclusive, and is capable of representing any number however large. But in modulo-10 arithmetic, the result can never exceed nine. So, for instance, nine plus seven would equal six, not sixteen, and 25 plus 3 equals 8.

A scheme of arithmetic operating with a modulus is called a Galois field. Of particular interest is the modulo-2 arithmetic of just the two digits 0 and 1, known in the trade as the field GF(2). In GF(2), addition of two numbers X and Y follows the rules shown in Table 1.

This is the same as the truth table of an exclusive-or gate, so such a gate performs module 2 addition.

### Polynomials

As the name suggests, these are expressions having several or many terms, involving a variable, usually denoted by x. The general form of an nth degree polynomial is

\[ a_nx^n + a_{n-1}x^{n-1} + \ldots + a_1x + a_0 \]

In the field GF(2), both the variable x and the coefficients are restricted to taking the value 0 or 1. To the electronics engineer, the interest in this apparently arcane branch of mathematics is that polynomials provide the key to designing PRBS generators using linear-feedback shift registers, or LFSRs, of particular interest are LFSRs capable of providing a maximal length sequence 2^n - 1 bits long.

Published tables are available, providing details of such polynomials. One of the earliest and best known references is Appendix C of reference 1, which lists 28 primitive polynomials of degree 9. Some require more exclusive-or gates - i.e. some have more non-zero coefficients of powers of x - while some require fewer than the example "1131" given.

For each of these, there is another arrangement that provides the time-reverse of the sequence, making 56 maximal length sequences in all. For degree sixteen, there are and a half densely-packed sets of them, or higher degrees up to 34, there's just a small subset for each.

The ability to produce a pair of sequences, one the time-reverse of the other, is important in some applications. An example is military communications requiring high security. This application might employ direct-sequence spread spectrum (DSS) communications. Here, the digital data stream of 0s and 1s is to be transmitted is "chipped", before being modulated onto the final RF carrier.

Thus for example, a 100kHz second data stream might be EXORed with a maximal length PRBS of 63 bits, produced by a six-stage LFSR clocked at 6.3MHz. In this way the final output of the transmit mixer occupies 63 times the bandwidth which would have been occupied by the unchipped signal. For a given transmitter power, the power spectral density is 62 times or 18dB lower.

The wider occupied bandwidth makes the signal more difficult to jam, while the lower level means that the signal might escape an enemy's attention entirely.

Ignoring the constant 1 at the end of the expression, the powers of x give the stages of a 9-stage shift register from which modulo-2 feedback should be applied to give a sequence of 0s and 1s, as detailed below.

An LFSR giving a maximal-length sequence

As 1131 is taken from a listing of 'incredible' ninth-degree polynomials, the feedback arrangement mentioned will provide a maximal length sequence of (2^9 - 1) 511 bits, consisting of 256 ones and 255 noughts, arranged in a particular way.

If the input to the nine-stage shift register is obtained by sequentially EXORing the outputs of the ninth stage with the outputs of the sixth, fifth and third stages, as in Fig. 1, the desired maximal length sequence will be obtained. With a nine-stage shift register, the possible number of arrangements of nine binary digits is 2^9 or 512, including all Os, all Is and all other possibilities.

From the first line of Table 1, if the two inputs to an EXOR gate are both noughts, then the output is also a nought. So in Fig. 1, if all the stages of the shift register open as 0s at switch-on, the sequence will consist of an infinite string of Os. But if any other combination of Os and Is appears, even a single 1 in any stage, then the shift register will hold, at various times, all possible combinations of nine binary digits (except nine zeros), and the output will be the maximal length sequence of 511 bits, continually repeating. Thus nine noughts is the only non-allowed state; any other combination of nine digits, 0 or 1, must by definition be one of the (2^9 - 1) 511 valid states.

In some designs, it may be necessary to include arrangements to force a 1 in a stage of the register at switch-on, to prevent any possibility of the degenerate all Os case occurring. Note that you could alternatively use exclusive-or gates, but in that case, the non-allowed degenerate combination is all Is.

At any one time, nine bits of the circulating sequence of 511 bits will appear in the shift register stages. The sequence may be represented by a sequential 'state diagram' of 'bubbles'. Fig. 2. Each state or bubble represents a sequence of nine bits, of which the last eight are the first eight of the previous state. The first bit is the result of the exclusive-or operation on the previous state. As the sequence repeats indefinitely, it is academic which state bubble I refers to. You could define it as whatever arrangement of Os and Is, usually indeterminate, comes up initially in the ninthe shift register stages, just before the first clock pulse arrives.

If the arrangement of exclusive-or gates does not correspond to an irreducible polynomial, the repeating sequence produced will be less than 2^n - 1 bits long. If, at switch-on, the shift register stages come up in one of the states of this shorter sequence, then the state diagram will be similar to Fig. 2, but with fewer than 2^n - 1 bubbles in the ring.

By definition, there must be other states that do not feature in the sequence. I believe that if, at switch-on, the shift register stages come up in one of these, the states will proceed via a 'side arm', as in Fig. 3, until the non-maximal length repeating sequence is entered at some point.

It is possible that a feedback arrangement exists that can generate two different non-maximal length sequences. Which one is generated would be determined by the initial state of the shift register stages as switch-on. I am still investigating this point. No doubt one of you will already have the answer, so please write in.

For LFSRs with more than two stages, there is more than one maximal length sequence, each having a particular series of Os and Is. For an LFSR with three stages, there are only two maximal-length sequences, of seven bits. One is the time-reverse of the other, the same bit sequence but in back-to-front order.

### Many different sequences

As the number of shift register stages increases, the number of different maximal length sequences escalates dramatically. For example, Appendix C of reference 1 lists 28 primitive polynomials of degree 9. Some require more exclusive-or gates - i.e. some have more non-zero coefficients of powers of x - while some require fewer than the example "1131" given.

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The wider occupied bandwidth makes the signal more difficult to jam, while the lower level means that the signal might escape an enemy's attention entirely.
Time-reversed sequences

The arrangement to produce the time reverse of a given sequence can be derived from the polynomial of that sequence, by deriving the "reciprocal polynomial". Given an irreducible polynomial \( f(x) = x^k + \sum_{i=0}^{k-1} a_i x^i \), the reciprocal polynomial is

\[
x^{(k-1) - 1} + \sum_{i=0}^{k-1} a_i x^{(k-1) - i}
\]

Taking the ninth degree example of Fig. 1, where the generating polynomial is \( \sum_{n=0}^{n=8} x^n + 1 \), the reciprocal polynomial is:

\[
x^{8} + x^{7} + x^{6} + x^{5} + x^{4} + x^{3} + x^{2} + x + 1
\]

Multipled out, this gives, \( x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1 \)

So an LFSR with exclusive-or feedback from the ninth, sixth, fifth and third stages will provide the reverse time sequence of one with EXOR feedback from the ninth, sixth, fourth and third stages. Stated more simply, every term \( x^i \) is replaced by a term \( x^{(9-i)} \). Here, \( r \) is less than \( n \).

Convolver systems for spread-spectrum systems

With a chopping rate of 6.3MHz, the spread-spectrum signal needs to be "collapsed" at the receiver, back to the original spread 100kb/s data. This is usually done at a convenient intermediate frequency, the receiver being up to this point a conventional superheterodyne type.

In one arrangement, the IF signal is fed into one transducer port of a convolver consisting of a SAW (surface acoustic wave) device using, typically, lithium-niobate material. The signal proceeds across the device as a surface acoustic wave, passing underneath a collector 'acoustic wave) electrode, forming the device's output. Another input, physically at the opposite end, is fed with a signal at the IF centre frequency, consisting of a CW (continuous wave) signal that has been chipped with the time reverse sequence.

Under the collector, the two surface waves, travelling in opposite directions, interact due to the piezoelectric non-linearity of the material, to provide an output at the original 100kb/s data rate. Thus the spread data is collapsed back to the original data rate. On the other hand, any interference, such as an attempt at jamming with a CW signal, is spread out by the local reverse sequence signal, to a low level.

With the chopping rate at 63 times the data rate, the device provides – ideally – 18dB of "processing gain" to the wanted signal, hopefully raising it above the level of the new spread interference.

Creating a noise source

Since the maximal length sequence for an LFSR with \( n \) stages is \( 2^n - 1 \), there is a component in the output at a frequency of \( f_{max} = 2^n - 1 \), where \( f \) is the clock frequency. There are components also at all harmonics of the minimum frequency \( f_{min} \) up to the clock rate.

The envelope of this spectrum is well known 

\[
x(n) = \begin{cases} 1 & n=0 \\ x(n) & n \neq 0 \end{cases}
\]

The spectrum is shaped by the distribution of different length sequences of \( 0s \) and \( 1s \) in the overall sequence, which is as shown in Table 2. This table is taken from reference 2, which contains much further useful information.

As the longest runs in the overall sequence are \( n \) ones and \( (n-1) \) noughts, if the sequence is low-pass filtered with a cut-off frequency lower than \( f_{max} \), different length sequences of ones and noughts will result in different lengths positive- or negative-going ramps, all of the same slope.

The result is a random noise-like waveform, as illustrated in Fig. 5. This is taken from reference 3, which describes an instrument that did not work exactly as planned. It was supposed to produce audio-frequency noise from a maximal-length sequence, but the article stated that start-up was like Fig. 3, whereas a maximal-length sequence must start up immediately, as in Fig. 2.

The error was promptly pointed out by a reader, it being always open season for short-cuts given authors – a healthy tradition of this journal. The noise source was however used in a more recent article and the operation of the instrument was investigated.

This investigation cleared the original fault, and uncovered an interesting and unexpected fact: a low-pass filtered PRBS does not necessarily provide a Gaussian amplitude distribution. A redesign was therefore incorporated to provide the desired distribution, but that must be a subject of a later article.

Meanwhile, if you want to experiment with LFSR PRBS generators of different lengths, the necessary taps for shift registers with up to 32 stages long are given in reference 5. For most register lengths, there is a "trinomial", a polynomial with just the three terms \( 1 + x^n + x^{2n} \), to some lower power, and unity. These can be implemented with a single EXOR gate.

Reference 6 gives taps for lengths up to 45 stages for those degrees that have a trinomial. This list of trinomials is extended for degrees up to 1000 (1), in reference 7. Reference 6 points out that a pseudo-random binary sequence generator can be made from just a CD4006 18-stage shift register and a CD4070 quad exclusive-or gate – and of course a clock source. The length of the sequence is \( 2^{n-1} \) or 262 143 bits long.

References

5. The Ouroboros, Clive Maxfield, EDN 4 Jan 1996, pp. 135-142 (Note: the left hand column of Fig. 2 is wrong).
6. On the factorization of trinomials over GF(2), S W Golomb, L R Welch and A Hales, Memorandum No 20-189, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, 1959. This article is quoted in Pseudorandom-sequence generation with trinomials, W Freeman, Electronic Product Design 1988, pp. 18 and 19.
7. On primitive polynomials (podd 2), N Zierler and J Brillhart, Information and Control, December 1968, pp. 54-54.
Electronic pollution is all around us. Radio and noise waves impinge on us all of the time. Never has electromagnetic interference (EMI) been so great as it is today. One source defines EMI thus: "Electromagnetic interference is a degradation in performance of an electronic system caused by an electromagnetic disturbance." At worst, EMI can cause a loss of human life, as when it interferes with an aircraft or automobile electronic system. At best, it will pass unnoticed or will interfere with the electronic system on a sub-audible basis.

The European Community has issued regulations pertaining to EMI in all manner of electrical and electronic equipment. Any electrical and electronic product sold in Europe must exhibit that it either emits nor is affected by radiation and conduction of EMI. In other words, it must be electromagnetically compatible (EMC).

Means of EMI Transmission
EMI is transmitted from the source to the victim system in two basic ways: conduction and radiation. The difference is that the EMI travels along a wire in conduction, and travels by air in radiation. In general (but not always), radiation Fig. 1a), occurs at high frequencies above 30MHz, and conduction Fig. 1b), occurs at frequencies less than 30MHz.

In some cases, both radiation and conduction can occur. In those cases, either radiation occurs first, and then the wave is conducted into the equipment on a line, Fig. 1c), or the radiation occurs after conduction Fig. 1d).

In general, the existence of EMI can occur only if:
- There is a source of energy.
- There is a receiver of that energy, and
- There is a transmission path between the two.

If any of the three does not exist, EMI cannot occur.

What we do about EMI depends on the situation. For example, in the case of some noise sources we can turn it off or otherwise suppress it. In other cases, we might have to live with the effects of EMI as best we can.

Electronic noise
Noise comes in two different types: continuous and transient. By definition, noise has been standardised as 'transient' if it lasts less than a sixth of a second, i.e. 16.67ms, and continuous if it lasts longer.

Continuous noise.
Low-frequency noise sources include fluorescent lights, electric motors, and switching-mode DC power supplies. High-frequency noise is mostly radio-frequency interference, or RFI. It can originate in either radio transmitters, computer clocks or other sources.

In the typical RFI environment, signals levels can be between a few microvolts/metre and 300V/metre. While the latter field strengths are only found close to transmitting antennae for high-power radio and radar stations, anything in excess of 1V/m can cause damage to unprotected circuits.

Test specifications for commercial systems may call for protection to 10V/m, while automotive and medical environments can call for up to 200V/m and military environments up to 300–400V/m.

Analogue circuitry tends to be more influenced by RFI than digital circuitry because it can be interfered with by lower voltage fields.

Transmitting noise. A 'transient' is any temporary over voltage or over power condition that lasts for less than 16.6ms. Transients are either repeatable or random in nature. An example of the repeatable type of transient is the discharge of an inductor or capacitor. Examples of random type transients include electrostatic discharge (ESD), lightning, and the nuclear electromagnetic pulse.

In the case of lightning, Fig. 2 shows the exposure of the US electrical power system to lightning strikes. Clearly, high-voltage lines are struck more frequently than low voltage lines. Unfortunately, that exposure transmits along the lines to your home or business to disrupt electronic circuits.

In fact, the lightning doesn't have to actually strike the line. Coupling via inductance, it can cause disruptive currents to flow in the power system by striking something close!

Counters to EMI
There are two effective ways to counter EMI: shielding and filtering. Fig. 3. Shielding is used to guard against radiation interference, while the filter is used to guard against conduction interference. The filters have the advantage of being bi-directional, so they also prevent interference from flowing out of the system as well as prevent it from flowing in.

Shielding. Shielding is used to attenuate the interfering RF signal before it reaches the protected circuitry. Very frequently, the hidden difference between a higher-priced appliance and a lower-priced one is in the internal shielding that one gets. Consider computer monitors for example. The principal difference between a high-priced model and a cheap one is in the shielding that is provided.

Unfortunately, all shielded enclosures for electronic projects are not created equal. Some enclosures are built fitted, and have dimples or notches to hold the half shells together. As far as I am concerned, the minimum requirement for low-frequency radiation noise is shown in Fig. 4a). Note that the flange of the lower half shell overlaps the upper half shell by at least 4 to 6mm. Four screws, of which only two are shown, hold the assembly together. For high frequencies, even this box is insufficient, but it can be made suitable by adding of more screws, Fig. 4b). The rules are that the screws should be not more than one half wavelength apart, and one-eighth wavelength is better.

Filtering. Filtering can take on different meanings for different situations. In general, most EMI filters are low-pass filters, although high-pass and bandpass filters exist. In some cases of a particular frequency being the cause of interference, a notch filter may be used.

In general, a perfect, ideal single component filter—either a capacitor or inductor—has a theoretical roll-off or gain of −20dB/decade with a practical maximum of something between −60 and −120dB. In fact, real components do not achieve that theoretical goal. Capacitors are more useful in high-impedance circuits, whereas inductors are more useful in lower impedance circuits.

Perhaps the simplest form of single component filter is the feedthrough capacitor, also known as an 'EMI filter.' When combined with good shielding, such a capacitor can be quite sufficient. Figure 5 shows two methods of passing a feedthrough capacitor through a shielded panel. Figure 5a) shows the screw-in variety. The threaded nut is cinched tight against the chassis or panel. Figure 5b) shows the installation of a solder-in type of feedthrough capacitor. A small fillet of solder is used to hold the capacitor against the chassis or panel. This type of capacitor assumes a solderable chassis or panel, thus it eliminates the use of aluminium.

Where greater suppression is needed, a combination of L and C elements is needed. A two-component L-section filter is shown in Fig. 6.)
Fig. 6. Single L-section filters: 
(a) internal capacitor input type. 
(b) external inductor input type.

Fig. 7. Several impedance situations and the filters to implement them.

Fig. 8. Differential signals, a) versus common-mode signals, b).

Fig. 9. Filters for both differential and common-mode signals.

Fig. 10. Metal oxide varistors (MOV) use on AC power mains for clamping spikes.

The second problem is in the application of 500kHz to 2500kHz high powered RF electrolysis units just a few centimetres from the site of the EEG or ECG electrodes. As much as 400 or 500 watts of RF could be applied to the ‘circuit’ only a few centimetres from the pick-up electrodes!

Figure 12 shows the input to a bioelectric amplifier suitable for EEG or ECG use in the presence of high electrical or electromagnetic fields. Both defibrillators and electrolysis units can be accommodated by the filtering shown.

Signals involved in EEG and ECG are below 1kHz, so an RC filter will suffice in this case. The RC filter consists of resistors R1 through R6, and capacitors C1 through C6. This is a low-pass filter.

The defibrillator protection is the zener diodes and series resistors R1, R2, and R3, between the source and amplifier A1. Sometimes, in older machines neon glow lamps like the NE-2 are used instead of the zener diodes. The disadvantage of the neon lamps is they are relatively high power compared to the zener diodes.

Computer EMI

The case of computer EMI is very serious. Just place an AM radio anywhere close to a modern computer, and you will hear lots of hash. In fact, with computer clock speeds reaching several hundred megahertz, the interference to FM radios can be tremendous.

Figure 13 shows a method for connecting a digital connector pin that can carry EMI to a printed wiring board. The ferrite bead acts like little RF chokes, so will eliminate EMI in the VHF/UHF region. Because the filtering is bi-directional, it will attenuate noise going out as well as coming into the computer.

The principal offender with respect to noise from computer systems is the printer. This is because of two factors. First, the deflection circuits tend to operate in frequency ranges under 40kHz – that are below many other systems, and they have lots of harmonics. Second, those deflection circuits tend to be high power.

The answer to the problem is to place shielding around the circuits, and placing a common-mode choke in the signal line.

In summary, EMI protection is often an afterthought in the design of electronic equipment. It should be a first requirement, but unfortunately this isn’t always the case. The methods that I have just discussed will go a long way towards suppressing the RFI or transient conditions on the power lines.
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509
Anologue I/O for the PC

Plugging into a PC's ISA slot, Tarig Iqbal's analogue i/o card provides eight 12-bit resolution inputs and one 8-bit output. A few QuickBasic routines — including one for displaying thermocouple temperature — demonstrate how easy it is to read and write analogue voltages.

A personal computer can be used for applications including data acquisition, signal processing, and control. An ISDN contract is required for most applications. The ISDN contract is a 4-line interface with a 100BaseT connection. Each line can carry up to 480K baud. The ISDN contract is a 4-line interface with a 100BaseT connection. Each line can carry up to 480K baud.

Hardware details

Interfacing of the a-to-d and d-to-a converters to the ISA bus is done using an RS232C parallel interface. The d-to-a converter connects to port A of the PPI. Port B and the upper half of port C are used to interface a d-to-a converter.

Three least-significant bits of port C are used to switch analogue multiplexer. Bit 3 of port C is used for starting a conversion. A detailed circuit diagram is presented in Fig. 2.

Address decoding corresponding to address 792 is achieved by two 74LS255 comparators and a 74LS50 NAND gate. The 74LS255 bus transceiver is meant to provide protection against any bus clash.

The DAC0800 d-to-a converter is interfaced to port A of the R255 PPI. The a-to-d converter is a 12-bit model AD574 from Analog Devices. Lower byte data output of this device is supplied directly to port B of R255, while a nibble of high byte is supplied to the upper nibble of port C.

A start-of-conversion pulse following the sequence high—low—high is generated and supplied to the a-to-d converter by port C, bit 03 of the R255. In this card, the a-to-d converter is configured to measure input voltages in the range ±5V DC.

To increase the number of channels to 8 inputs a 4051B analogue multiplexer is used. The inputs marked CH0—CH4 are directly available on the 25pin connector and they have a signal range of ±5V DC. Two AD595 thermocouple amplifiers and one AD521 instrumentation amplifier are also present on the card. Channels 5 and 6 are reserved for the thermocouple amplifiers. Two K type thermocouples may be directly interfaced with this card.

Channel 7 is reserved for the instrumentation amplifier, whose gain can be selected as 100 or 1000 by a slide switch. The AD521 instrumentation amplifier can be used for interfacing with resistance bridges — e.g. strain gauge — and various other sensors like thermistors and RTDs.

On my prototype, +12V, -12V, +5V and -5V supplies from the PC are also available on the 25 pin D-type connector.

Table 1 provides necessary addresses of I/O card and control word. Table 2 gives the details of I/O available on 25 pin D-type connector.

<table>
<thead>
<tr>
<th>Address</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>795</td>
<td>Control word</td>
</tr>
<tr>
<td>796</td>
<td>Port A</td>
</tr>
<tr>
<td>797</td>
<td>Port B</td>
</tr>
<tr>
<td>798</td>
<td>Port C</td>
</tr>
</tbody>
</table>

Table 2 Signals at I/O card connector

<table>
<thead>
<tr>
<th>P1n</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>+5V</td>
</tr>
<tr>
<td>3</td>
<td>CH0</td>
</tr>
<tr>
<td>4</td>
<td>CH1</td>
</tr>
<tr>
<td>5</td>
<td>CH2</td>
</tr>
<tr>
<td>6</td>
<td>CH3</td>
</tr>
<tr>
<td>7</td>
<td>CH4</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
</tr>
<tr>
<td>9</td>
<td>-5V</td>
</tr>
<tr>
<td>10</td>
<td>CH5</td>
</tr>
<tr>
<td>11</td>
<td>CH6</td>
</tr>
<tr>
<td>12</td>
<td>CH7</td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
</tr>
<tr>
<td>14</td>
<td>IN</td>
</tr>
<tr>
<td>15</td>
<td>IN</td>
</tr>
<tr>
<td>16</td>
<td>GND</td>
</tr>
<tr>
<td>17</td>
<td>Analogue output</td>
</tr>
<tr>
<td>18</td>
<td>NC</td>
</tr>
<tr>
<td>19</td>
<td>NC</td>
</tr>
<tr>
<td>20</td>
<td>NC</td>
</tr>
<tr>
<td>21</td>
<td>NC</td>
</tr>
<tr>
<td>22</td>
<td>-12</td>
</tr>
<tr>
<td>23</td>
<td>+12</td>
</tr>
<tr>
<td>24</td>
<td>-5V</td>
</tr>
<tr>
<td>25</td>
<td>+5V</td>
</tr>
</tbody>
</table>

Programming

Programming of the I/O card is relatively simple using QuickBasic. A routine for reading data from channel 0 is provided in List 1. After a start of conversion, plus a low byte is read and then low nibble of high byte is read.

Output from the a-to-d converter is constructed by combining low and high bytes. Since the input range of converter is ±5V, a simple calibration equation at the end of program is used to transform the converter's output into equivalent voltage.

A program for providing an analogue voltage output is given in List 2. Analogue output is in the range 0 to 10V. Sending 00 to address 792 results a 0V at the output, while sending 255 to the same address results a 10V at the output.

This routine generates a sawtooth waveform at the output. Any desired voltage can be generated at the d-to-a converter's output by using List 3.

A simple program to read K type thermocouple attached to pin 8 and 9 of the D-type connector is in List 4. Output of the thermocouple amplifier AD595 is calibrated at 10mV/°C.

It is useful to assign a corresponding area on the card for building additional interfacing circuits. I have used this card to measure parameters such as blood pressure, motor angular velocity, motor position. Flow rate, resistance rate, load, and water level. This is a multipurpose card and has many applications.

List 1. A routine for reading an analogue voltage applied to channel 0 of the I/O card could be written as follows.

```
OUT 795, 134
OUT 792, NN
GOTO 10
```

List 2. Routine for writing values to the analogue output port to produce a sawtooth waveform.

```
OUT 795, 134
10 FOR N% = 0 TO 255
    OUT 792, NN
NEXT N%
GOTO 10
```

List 3. Routine for producing a specific voltage at the d-to-a converter's output.

```
OUT 795, 134
10 INPUT "VOLTS TO BE OUTPUTTED" As T;
    OUT 792, CINT(T*25.5)
GOTO 10
```

List 4. Single routine for reading and displaying the temperature of a thermocouple.

```
OUT 795, 134
    CONTROL WORD
    CN = 4
    SC% = CN * 8
    OUT 794, SC%, OUT 794, CN = OUT 794, SC%
    LH% = IN793% - HH% = IN794%
    HH% = HH% + 16
    CN = 86% + HH% * 256
    VOLTS = CN / 6096 * 10.14 - 5.07
    TEMP = 100 * VOLTS
    Print "Temperature C% = " : TEMP
```

Fig. 2. Complete circuit of the analogue I/O card, showing the ISA address decoding and data buffering on the left and analogue circuitry on the right.
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4. The Volunteer Organist, Peter Dawson, 1913
5. Dialogue For Three, Flute, Oboe and Clarinet, 1913
6. The Toymaker's Dream, Foxtrot, vocal, B.A. Royle and his orchestra, 1929
7. As I Sat Upon My Dear Old Mother's Knee, Will Oakland, 1913
8. Light As A Feather, Bells solo, Charles Daab with orchestra, 1912
9. On Her Pic-Pic-Piccolo, Billy Williams, 1913
10. Polka Des English's, Artist unknown, 1900
11. Somebody's Coming To My House, Walter Van Brunt, 1913
12. Bonny Scotland Medley, Xylophone solo, Charles Daab with orchestra, 1914
13. Don't Hesitate, Billy Murray, 1929
14. Luce Mia! Francesco Daddi, 1913
15. The Olio Minstrel, 2nd part, 1913
16. Peggy O' My Heart, Walter Van Brunt, 1913
17. Auf Dem Mississippi, Johann Strauss orchestra, 1913
18. I'm Looking For A Sweetheart And I Think You'll Do, Ada Jones & Billy Murray, 1913
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Being able to create two identical but phase-shifted sine waves is useful for testing, but generators capable of producing them are rare. To rectify this, W Q Yang and T Y Ng* have produced a design using two high-performance direct digital synthesis chips to produce two 1V signals at frequencies up to 16MHz. Under the control of an RS232 port, these signals can be used together, with fully adjustable phase shift, or independently.

**Phase-shiftable signal generator**

Many applications in industry and laboratories require the use of signals with certain phase difference or of adjustable phase shift between two signals. Phase-sensitive detection is one example, whose output depends on the phase difference between input signals.

Other examples include signal mixers, vector generators, selective voltmeters, rotational torque induction, etc. All of these applications lead to the demand for highly versatile signal generators that can provide the user with full control over the signal's amplitude, frequency and phase.

The phase of a signal can only be measured and shifted with respect to a reference signal. There are no simple and direct methods to generate phase shifts.

At present, phase differences between signals are produced using dedicated phase-shifting networks and circuits that provide limited and inflexible phase shifts. Although function generators are well established as the most versatile of signal sources, they do not have the capability to change the phase of the signals. This is a major drawback — especially when phase shifting or phase difference between signals is required.

Direct digital synthesis, or DDS for short, has long been recognised as a superior technique for generating highly accurate signals of low distortion over a wide frequency range. With DDS, the amplitude, frequency and phase of the generated signals can be easily and instantaneously controlled.

Using two DDS chips, we have developed a dual synchronous DDS signal generator. It is small, lightweight and has all the advantages of DDS technology in terms of performance and cost.

The generator derives its power through an external 5V power adapter. It can be operated through a PC's RS232 serial port with the developed Visual Basic software and the generated signals are fully user programmable.

Both DDS chips can be operated individually to produce two independent signals, or as a synchronous pair to produce two signals with the same frequency up to 16MHz. But the phase between them can be adjusted. Figure 1 shows the prototype.

In the first part of this article, details of the hardware and the operational principle of the system are given. The second part shows the user interface created using Visual Basic for controlling the signal generator, and lastly test results are given and future developments are suggested.

A block diagram of the generator is shown in Fig. 2. and Fig. 3 shows its detailed circuit. The system is made up of four parts: power supply, serial-to-parallel interface, data latching circuit and DDS chips and clock.

A 9V power adapter forms an external power source and a 78L05-voltage regulator provides the on-board power supply. The generator employs two AD7008 chips as a pair of signal generating sources controlled serially via the PC's RS232 port.

---

*Dr Yang is with UMIST, as was his co-author Mr Ng at the time of writing.

---

**Fig. 1. Prototype of the dual synchronous DDS signal generator.**

**Fig. 2. Block diagram of dual synchronous DDS signal generator.**

**Fig. 3. Simplified circuit of the dual synchronous DDS signal generator.**
TEST & MEASUREMENT

The FESELECT pin is then used to select the register for generating the signal.

Even though the phase of the output signal can be offset using the 12-bit phase register, accurate phase shift cannot be produced due to the limited phase resolution provided by the register. Quadrature amplitude modulation is performed using IQMOD to generate the desired signal phase shift instead.

The 20-bit IQMOD register is used to control the amplitude of the cosine (I) and sine (Q) signal components generated from the ROM. Its first 10 bits, bits 0 to 9, define the I amplitude. The next 10 bits, bit 10 to 19, define the Q amplitude.

Using IQMOD, quadrature amplitude modulation can be performed. The I and Q components are summed together before entering the DAC and the sum is given by:

$$\text{Reconponent} \cdot \text{Quartnponent} = A \cos \theta + B \sin \theta$$

where:

$$R = \sqrt{A^2 + B^2}$$
$$\cos \theta = \frac{A}{R}$$

Equation 3 shows that by summing the I and Q components together, a signal of amplitude R and phase angle $\theta$ is produced. The values of R and $\theta$ depend on two amplitudes, A and B. Conversely, given the desired signal amplitude R and phase angle $\theta$, the required amplitudes of the I and Q components can be determined by equations 4 and 5:

$$A = R \cos \theta$$
$$B = R \sin \theta$$

Here, 0.5 Vpk-pk and 0° or 180°. By loading the determined A and B values into IQMOD, the generated signal will have the desired amplitude and phase shift.

Fig. 4 shows that RS232 port has only three output pins: Data, RTS, and DTR. These are not enough for sending data to and controlling the AD7008 chip.

Therefore, a serial-to-parallel interface is used to produce a 16-bit data bus and a 5-line control bus to both AD7008s. The AD7008 chips are configured to operate in the 16-bit parallel loading mode. Serial signals sent from the AD7008 port to the generator are converted into parallel form for use as control signals or as data to be loaded into the chip's registers.

Data control signals RTS and DTR are first converted from RS-232 level into TTL using a MAX3232ACE low power RS-232 transceiver. The transmit-data pin TD is converted into -0.6V to +5.1V using a voltage clamping circuit consisting of a resistor and a zener diode, Fig. 3.

The UC5818AF chip is a 32-bit serial-to-parallel converter chip that forms the heart of the serial-to-parallel interface. It is basically a 32-bit shift register with parallel latched outputs as shown in Fig. 4. RTS is used for sending serial data to the converter. DTR is used as clock signal (Clock 1) to shift the data in the TD and RTS is used as a data strobe to internally latch the data stored in the shift register to the chip's output.

Referring to Fig. 7, serial data presented by RTS at the AD7008AF's input is shifted into the shift registers bit by bit towards the serial data output at the positive transition of each Clock 1 (DTR) pulse. Data stored in the shift registers are then internally latched to their respective outputs in parallel when the STROBE signal (TD) is high. The internal latches continue to accept new data as long as STROBE (TD) is high.

Data in 32-bit serial form sent from the PC to the signal generator are converted into parallel form for use as 16-bit direct digital synthesis data or five control signals to both AD7008 chips by the UC5818AF chip.

Serial data is in one of two forms. These are control and DDS data, as shown in Fig. 8. This data is shifted into UC5818AF starting from the most significant bit (MSB).

Bit 8, also called the DLAB/CH bit, distinguishes the two formats. Serial format DDS data is represented by a high DLAB bit and control data is indicated by a low DLAB bit.

Corresponding to the serial data format, UC5818AF's parallel outputs are classified into corresponding control and DDS data lines, Tables 1 and 2. Output OUT 10 to OUT 25 of the serial-to-parallel chip are used for 16-bit DDS data while OUT 1 to OUT 5 are used for control signals.

The DDS data has to be present when control signals are sent to the AD7008 chip. Therefore, the UC5818AF's outputs can only be used for sending DDS data or control signals at any one time. This is accomplished by using an external data latching circuit.

Output OUT 9 corresponds to the DLAB bit of the serial data. It is used for enabling the data latching circuit each time DDS data are sent and disabling it whenever control signals are sent. Once the DDS data is latched by the data latching circuit, the UC5818AF outputs are then used for sending control signals to either one or both AD7008.

Data latching details

Two 74HC125 8-bit latches combine to form the 16-bit data latch. The latches are enabled only when OUT 9 (DLATCH) is high and DDS data will be latched for every subsequent clock pulse produced by DTR.

Serial interface line DTR is also used as Clock 1 for shifting serial data into UC5818AF. For every clock pulse, a new serial data bit is
shifted into UCN5818AF but will not be sent to its parallel output until STROBE (TD) is high. At the same time, if OUT 9 is high, data will be latched into the 16-bit data latch.

All DDS data are sent serially to UCN5818AF with a high DLATCH bit. Once converted to parallel, the DDS data is presented to the 16-bit latch through OUT10 to OUT25 with OUT9 high. The data is then latched when control serial data is next shifted into UCN5818AF.

As control serial data is associated with a low DLATCH bit, the parallel form disables the latch and control signals are sent to AD7008 chips without affecting the data.

With this arrangement, the UCN5818A’s parallel outputs are used for sending data to and controlling the AD7008 chips independently at any time.

Implementing the DDS chips
Control signals from OUT1 to OUT5 require that control serial data be sent twice. The required control signals are activated by first sending serial data with the corresponding control bits set high. A second set of serial data is then sent with all bits set to low to deactivate the signals. Each AD7008 has its own WRITE and LOAD lines, but they share the same RESET signal.

Loading DDS data to the registers of AD7008 requires two operations. The data is first written into the chip’s parallel register and then loaded to the selected register. Since the DDS data is latched to both AD7008s, it can be loaded to an individual chip or both chips simultaneously, depending on the settings of control bits in the control serial data sent. To load the data into a particular chip, only that chip’s control signals are activated. If both chips are to be loaded at once, their control signals are activated simultaneously.

On the synthesizer chips, TC2 to TC5 represent the transfer control address bus connected to D12 to D15 of the 16-bit latch respectively. The transfer control address is sent in the same way as DDS data. Only the four most-significant bits contain the address of the destination register into which the written data is to be loaded. This address has to be present before a load can be executed.

Both WRITE and LOAD operations are similar. The exception is that the DDS data sent in a LOAD operation is used as a transfer control.

<p>| Table 1 |
|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Serial data bit</th>
<th>Parallel output</th>
<th>Control lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (LSB)</td>
<td>OUT 1</td>
<td>RESET</td>
</tr>
<tr>
<td>1</td>
<td>OUT 2</td>
<td>WRITE</td>
</tr>
<tr>
<td>2</td>
<td>OUT 3</td>
<td>LOAD 1</td>
</tr>
<tr>
<td>3</td>
<td>OUT 4</td>
<td>WRITE 2</td>
</tr>
<tr>
<td>4</td>
<td>OUT 5</td>
<td>LOAD 2</td>
</tr>
<tr>
<td>5</td>
<td>OUT 6</td>
<td>Spare</td>
</tr>
<tr>
<td>6</td>
<td>OUT 7</td>
<td>Spare</td>
</tr>
<tr>
<td>7</td>
<td>OUT 8</td>
<td>Spare</td>
</tr>
<tr>
<td>8</td>
<td>OUT 9</td>
<td>DLATCH</td>
</tr>
</tbody>
</table>

Functions
- RESET: data latching circuit & both DDSs
- WRITE: latching DDS 1
- LOAD 1: Load to DDS 1
- WRITE 2: latching DDS 2
- LOAD 2: Load to DDS 2
- Spare: not used
- DLATCH: Enable data latching circuit

Fig. 10. This user interface has been developed by the authors to help get the design up and running.

Fig. 11. Signals generated in “Dual” mode with fixed amplitude and phase of 1V pk-pk and 0° respectively, and varying frequency of 50kHz, left, and 1MHz, right.

Fig. 12. Signals 1 and 2 were first generated identically and in-phase, top left, in “Dual” mode with amplitude, frequency and phase of 1V pk-pk, 16kHz and 0° respectively. Next, the DDS2 signal was phase shifted relative to DDS1 for 90° phase values, 90°, bottom left, and 180°, bottom right.
In 'individual mode', DDS data are loaded into the selected AD7008 and only the respective output signal is affected. In 'dual synchronous DDS mode', the data is loaded into both AD7008 synchronously and both output signals are affected in similar times at the same time.

Signal frequency is determined by the value loaded into FREQ2 register. Both amplitude and phase are determined by that loaded into the I/QMOD register.

The key feature of this signal generator is its capability to shift the generated signals in the range of 0° to 360°. Two identical signals of zero phase difference are generated in dual mode, and the desired phase difference is then set by phase shifting either signal in individual DDS mode. This allows the phase of either signal to be shifted accurately with reference to the other as desired.

User interfacing

We have developed a user interface and control program using Visual Basic 6. It allows the user to operate the generator from a PC. The developed user interface is shown in Fig. 10.

There's a numerical keypad in the graphical display. The user can enter the values for the signal's frequency, amplitude and phase and the unit automatically changes to 'Hz', 'Vpk' or 'Deg' respectively, depending on which component is selected.

The 'DDS Select' allows the user to select which AD7008 chips the values are entered to: DDS1, DDS2 or both. By selecting 'Dual', the entered values are loaded to both AD7008s synchronously to generate two identical and in-phase signals. One signal's phase then be shifted with respect to the other by entering the phase value for either DDS1 or DDS2. Each time a frequency, amplitude or phase value is entered, the affected AD7008 chip status is updated respectively.

From frequency, amplitude and phase information entered by the user, the control program uses equation 2 to calculate the ΔPhase value to be loaded into AD7008's FREQ2 register. It also uses equations 4 and 5 to determine the A and B values to be loaded into I/QMOD register. The values are then converted into DDS data and loaded into the respective registers of the select AD7008 to generate the desired signal.

Test results

We have tested the generator using the software just mentioned for different values of frequency, amplitude and phase in various 'DDS Select' modes. The generated signals were examined using an oscilloscope. Figs. 11, 12, 13 and 14. Signal 1 was generated by DDS1 and signal 2 by DDS2.

The results show that the signals are generated accurately in amplitude, frequency and phase in relation to the values entered. With this generator, it is now possible to produce fully-adjustable signals in terms of frequency, amplitude and phase.

Future developments

The signal-generator prototype was developed for use with a PC. By replacing the PC with a microcontroller, the generator could be turned into a stand-alone instrument.

In addition, amplifiers and filters could be incorporated to increase the amplitude range of the signals and to remove high frequency harmonics.

Software availability

While developing this signal generator, the authors produced rudimentary Visual Basic software that provides an interface between the PC and generator. To obtain a copy of the software file of charge, e-mail jlove@cumulusmedia.co.uk.

Table 3

<table>
<thead>
<tr>
<th>Command register bits</th>
<th>Configuration</th>
<th>Setting</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>data bit</td>
<td></td>
<td>16-bit parallel loading enabled</td>
</tr>
<tr>
<td>D1</td>
<td></td>
<td>0</td>
<td>Normal operation</td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td>1</td>
<td>Amplitude modulation enabled</td>
</tr>
<tr>
<td>D3</td>
<td></td>
<td>0</td>
<td>Synchroniser logic enabled</td>
</tr>
</tbody>
</table>

Fig. 13. Top dual 38MHz, 1V pk-pk signals with DDS2 signal shifted 130°. Bottom dual 15MHz signals, 0.5V pk-pk signals with DDS1 shifted by 80°.
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Fig. 13. Top: dual 30kHz, 1V pk-pk signals with DDS2 signal shifted 130°. Bottom: dual 150kHz signals, 0.5V pk-pk signals with DDS1 shifted by 80°.

Software availability
While developing this signal generator, the authors produced rudimentary Visual Basic software that provides an interface between the PC and generator. To obtain a copy of the software free of charge, e-mail J.Love@cumulusmedia.co.uk.

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Designing with DSP

Having covered the hardware needed to implement a simple DSP system in last month’s article, Patrick Gaydecki now explains how to produce the software. “The idea that DSP chips are more difficult to program than the average microprocessor is a myth,” he argues.

In this third article explaining how to implement digital signal processors, or DSPs, I will be discussing the DSP56000’s language. This language is used by all members of the family including the DSP56020. I will also explain the steps involved in coding, simulating and executing programs for this DSP device.

To give the subject a hands-on flavour, I will be presenting a very simple program to emphasise the link between the language and the hardware sub-systems of the DSP56002. Finally, I will be exploring the way in which system interrupts are implemented, as attempts are crucial to the way the device operates in many environments.

Knowing the language set enables the system described in last month’s article to perform some truly impressive real-time processing of live audio signals. Before you begin though, it is worth bearing in mind three points.

Firstly, the results obtained from certain operations in this language might initially appear surprising and counter-intuitive in comparison to those from general-purpose microprocessors. This is because the language involves fixed-point, fractional arithmetic.

Secondly, in common with other modern DSP devices of its kind, this processor has an extraordinarily wide-ranging syntax. There is only enough space to cover part of its functionality here.

Thirdly, it is a myth that the DSP device is difficult to program; it is quite straightforward, and the basics given below provide a good springboard to explore the full breadth of this device’s capability.

The arithmetic and logic unit

The ALU has ten data registers. Data input register X is subdivided into X0 and X1 while data input register Y is subdivided into Y0 and Y1. In addition, the data accumulator register A is subdivided into A0, A1 and A2 while the data accumulator register B is subdivided into B0, B1 and B2, making ten registers in all.

The X and Y registers are each 48 bits wide. Hence X0, X1, Y0 and Y1 are each 24 bits wide. Both X0 and Y0 can be addressed as 48 or 24 bits registers. Both A0 and B registers are each 56 bits wide. Registers A0, A1, B0 and B1 are each 24 bits wide while registers A2 and B2 are each 8 bits wide. Both A and B can be addressed as a whole or according to their subdivisions, as in the case for X0 and Y0.

The DSP56000 family represents its data using two’s complement fractional format, in which only numbers (operands) within the range ±1 can be represented. The resolution depends on the word length.

If the operand is represented as a word, it has 24-bit resolution – or one part in 16777216. If it is represented as a long word, it has 48-bit resolution.

Table 1 shows how the DSP56002 uses 2’s complement arithmetic to represent words. The same scheme may be applied to long words.

From the Table 1, you can see that positive numbers from 0 to 1–2–23 are represented in hexadecimal from 0 to 7FFFFFFF and negative numbers from –1 to –1–2–23 are represented from B0000000 to FFFFFFFF, respectively. Note that in word format, six hexadecimal symbols are required, since each symbol represents 4 bits and a word is 24 bits wide.

Single-statement syntax

In common with other DSP languages, the DSP56000 assembly code allows certain multiple statements to be included within a single instruction. Due to the nature of its architecture, it can execute these in parallel.

In this section, I will deal only with single-statement instructions. These follow the general syntax,

```
<opcode> SOURCE OPERAND DESTINATION OPERAND ); comment
```

A space is required between the opcode – i.e. the instruction – and source operand, but no space operand are allowed between operands. Comments are preceded by a semicolon.

Within the instruction, a ‘$’ symbol preceding a number (operand) implies that it is a literal value. If this is omitted, the number is a memory reference. A ‘$’ symbol preceding a number means that it is expressed in hexadecimal form. If it is omitted, it is formatted in decimal.

It is very important to remember that since the processor uses fractional arithmetic, it loads literal values into its arithmetic and logic unit registers with left justification. Hence the command,

```
MOVE #20,H
```

places the value 20000000 into X0, not 20000000. The best way of thinking about this is to assume a decimal point to the left of the register. If you want to force a number to be right justified, you use the right-shift case:

```
MOVE $20, H
```

This would load X0 with 000000020. One of the nice things about DSP56000 assembly language is that you can use decimal numbers directly. This is due to the fact that

```
MOVE 20, H
```

achieves exactly the same result as

```
MOVE $20000000, H
```

These of who are new to this language may well consider a processor that can only handle numbers less than or equal to 21 to be extraordinarily limited. In fact, nothing could be further from the truth; it is simply a question of scaling. Its all-important properties are the resolution and speed at which it can conduct multiplications, additions and shifts.

The above rule for left justification does not apply when performing register-to-register moves, where data position is preserved. Neither is it the case for moving literals to peripheral (control) registers as opposed to ALU registers. This is because these registers perform control rather than arithmetic functions.

In addition to the data registers, the address-generation unit (AGU) has 24 16-bit address registers that are used to hold the addresses of data referred to in the instructions. These are:

```
Rr, rm=6,...15 (address) Nr, nm=0,...7 (offset) Mr, nm=0,...7 (modifier)
```

Each R register is associated with an N and M register according to its subscript. Register R is used to locate operands in memory, while N provides an offset to an R address and M specifies the kind of addressing that is being performed.

Three types of addressing are possible: linear (default), reverse carry (for FFP) and modulo, for accessing circular buffers. Modulo addressing is used extensively for real-time filtering operations.

Addressing modes

A DSP56000 instruction, or op-code, consists of one or two 24-bit words. There are fourteen addressing modes possible, and some of the more important ones are summarised in Tables 2 and 3.

A number of points concerning Table 2 is worth noting. First, with simple immediate addressing (nm=0), only the sub-register specified, in this example A0, will have its contents changed. Secondly, with immediate to 56-bit (nm=7), the data are left just as discussed above. Furthermore, in this case a negative number has been used. This is because it is greater than

Table 2. Summary of key DSP56000 “register-direct” addressing modes.

<table>
<thead>
<tr>
<th>Sub-type</th>
<th>Instruction</th>
<th>Operand before</th>
<th>Operand after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>MOVE X1,A0</td>
<td>X1=0000123</td>
<td>X1=0000123</td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X56181A0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X56181A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X561A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X561A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X5200AO</td>
<td>X20=0123456</td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X52A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X52A</td>
<td></td>
<td></td>
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<tr>
<td>Immediate</td>
<td>MOVE X52A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>MOVE X52A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Summary of key “register indirect” addressing modes for the DSP56000.

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Instruction</th>
<th>Operand before</th>
<th>Operand after</th>
</tr>
</thead>
<tbody>
<tr>
<td>No offset</td>
<td>MOVE B1,Y(0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post increment by 1</td>
<td>MOVE B1,Y(R3)+3</td>
<td>B0=0123456</td>
<td>R3=1200</td>
</tr>
<tr>
<td>Post decrement by 1</td>
<td>MOVE B0,Y(R3)-3</td>
<td>B0=0123456</td>
<td>R3=1200</td>
</tr>
<tr>
<td>Post increment by offset register</td>
<td>MOVE B0,Y(R3)+N3</td>
<td>B0=0123456</td>
<td>R3=N3</td>
</tr>
<tr>
<td>Post decrement by offset register</td>
<td>MOVE B0,Y(R3)-N3</td>
<td>B0=0123456</td>
<td>R3=N3</td>
</tr>
</tbody>
</table>

Table 1. Fractional format data representation in DSP56000 language.

<table>
<thead>
<tr>
<th>Number range</th>
<th>Decimal value</th>
<th>Hex number</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>±2–24</td>
<td>±1–2–23</td>
<td>80000000</td>
<td>FFFFFF</td>
</tr>
<tr>
<td>±2–23</td>
<td>±1–2–23</td>
<td>80000000</td>
<td>FFFFFF</td>
</tr>
</tbody>
</table>

Dr Patrick Gaydecki is a Senior Lecturer with the Department of Instrumentation and Analytical Science at UMIST in Manchester.
Dealing with DSP56002

Instructions and parallel operations

There are 62 instructions in the DSP56000's language. These are divided into the following groups: move, arithmetic, logical, bit manipulation, and program control.

I have already mentioned single statement instructions. However, there are thirty instructions that can specify one or two parallel data moves in one instruction cycle in parallel with the opcode.

An instruction with the same source transforming to several destinations is permitted. However, an instruction with several sources transferring to the same destination is not. Table 4 below shows examples of the former and how to do it, which does not provide details on some of the more frequently used instructions.

For further information, take a look at the DSP56000's user manuals, details of which are given later.

The really impressive thing about these instructions is that they can be run in a single instruction cycle. Look, for instance, at the following instruction, i.e.

MAC 2,3,4 2 (32), 3 1.00

This is performing a multiplication, accumulation, two data moves and two register updates. For a DSP56002 clocked at 60MHz, this entire list of actions takes a mere 33ns.

Developing a program

Once you have written a DSP56000 routine using any standard text editor, it may be assembled using an assembler program supplied by Motorola. Typically, the instruction might be:

asm56000 -e -d1 -1 myprog

where the -e option specifies the code is to be generated using absolute addresses, the -d1 option specifies the generation of a.C/E Motorola object file, and the -1 option specifies that the assembler is to generate an assembled program listing.

If the assembled program contains no syntax errors, it may then be downloaded to the target processor and run. However, just because a program assembles correctly, it does not mean that it has been assembled correctly. Hence it is often a good idea to look at the program into a DSP56002 simulator to jump to the address at which the interrupt service routine (ISR) starts. This jumps to the ISR, executes it, and then returns to the point from which the ISR was invoked.

Table 4: Some key multiple-statement instructions in the DSP56000 language set.

Table 4 shows the syntax of the DSP56000 language set. It includes multiple-statement instructions such as

Instruction
Add B to 0 and move $81 to B in parallel, unsigned
Add A to B and move $81 to B in parallel, signed
Add A to B and move $81 to B in parallel, unsigned
Add B to A and move $81 to B in parallel
Add A to B and update R1 in parallel
Add A to B and move A to memory in parallel
Multiply Y1 and X1, place result in A and move X0 to Y0 in parallel
Multiply-accumulate X0 & Y0 to A, place content of X(R0) into X0, update R0, place content of Y(R1) into Y0 and update R1, all in parallel

The syntax of the DSP56000 language set is shown in Table 4. It includes multiple-statement instructions such as

Instruction
ADD B A, $81.0 B
ADD A B, $81.0 B
ADD A B, $81.0 B
ADD B A, R1 + W
ADD A B, A, X $1000
ADD A B, A, X $1000
MPY Y1, X1, A, X0, Y0
MAC X0, Y0, A
XO = $0010000000
Y0 = $00000000
A = $0000000000
X0 = $0013456
X1 = $00000000
Y0 = $00000000
R0 = $00000000
R1 = $00000000
R2 = $00000000
R3 = $00000000
R4 = $00000000
XO = $0013456
Y0 = $00000000
R0 = $00000000
R1 = $00000000
R2 = $00000000
R3 = $00000000
R4 = $00000000
XO = $0013456
Y0 = $00000000
R0 = $00000000
R1 = $00000000
R2 = $00000000
R3 = $00000000
R4 = $00000000
XO = $0013456
Y0 = $00000000
R0 = $00000000
R1 = $00000000
R2 = $00000000
R3 = $00000000
R4 = $00000000
XO = $0013456
Y0 = $00000000
R0 = $00000000
R1 = $00000000
R2 = $00000000
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XO = $0013456
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XO = $0013456
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R3 = $00000000
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R1 = $00000000
R2 = $00000000
R3 = $00000000
R4 = $00000000
XO = $0013456
Y0 = $00000000
R0 = $00000000
R1 = $00000000
R2 = $00000000
R3 = $00000000
R4 = $00000000

Further reading

Fig. 2. Sequence of events involved in an interrupt.

Instruction
JSR MYSUB

Instruction 1
Instruction 2
Instruction 3
Instruction 4

Interrupt Vector Space

RTI

Interrupt Service Routine

Fig. 2. Sequence of events involved in an interrupt.
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IP software is compatible with third party EDA and debug tools

An IP module library and compatibility with third party EDA and debug tools are provided by Tricendi's Fastchip software. Windows based, it manages the configurable system-on-chip (SoC) design process for the firm's 8-bit E5 and 32-bit AT products. The library of pre-licensed, pre-verified drag-and-drop IP software modules includes a two-wire serial PIC-compliant interface, a quad VGA LCD controller and a triple DES controller. The modules can be parameterised to meet application needs. The basis to the IPMI protocol, the PIC module is for enclosure management applications, operating in multi-master, slave only or master-only modes. By adjusting settings, the QVCA LCD controller module supports various single drive STN panels and colour and monochrome displays. The triple DES controller module is for POS terminal work. It also supports the Symplify logic simulation tool from Symplify. Operability with Wind River's Visuprobe II design tool and Visiclock source level debugger has been changed so logic designers can access and control the entire SoC. Tricendi Ltd Tel: 01273 570200 www.tricendi.com

July 2001 ELECTRONICS WORLD 527
They are almost pin-compatible with the H8S/2357P, 2350 and 2352. Each device has the same peripheral set including a DMA controller with four channels and a data transfer controller. A bus state controller divides the 16-byte memory into eight areas. Parameters can be programmed into each to allow glitchless access to external memories and peripherals. A six-channel 16-bit timer provides 16 input capture and output compare registers. The chips also have two 8-bit timers, which provide a reduced time functionality during low activity. A programmable pulse generator has 16 real-time outputs that drive data patterns onto the pins under timer control. This eliminates the jitter that would normally be associated with interrupt-driven operation. Three serial ports provide asynchronous, synchronous and multi-master operation, as well as support for a subset of ISO7816-3, while an eight-channel 10-bit ADC provides results within 700µs at 20MHz. The ADC is complemented by a two-channel 8-bit DAC.

Hitech Europe
Tel: 01628 585163
www.hitech-eu.com

Microwave analyser from 10MHz to 46GHz

DF has announced a 46GHz microwave system analyser. The 6845 MSA is a 10MHz to 46GHz frequency analyser with a full bandwidth, independently controlled tracking generator. It includes a synthesised source and three-channel scalar analyser, and is used for the manufacture, installation and maintenance of radio links, satellite links and microwave systems. It includes a 46GHz tracking generator, which acts as transmitter and receiver when receiving up and down links. The instrument is aimed at manufacturers, installation and maintenance of point-to-point and point-to-multi-point radars and satellite communications equipment.

National Semiconductor unveiled several low voltage differential signalling (LVDS) data transmission products at DesignCon 2001. They include devices with on-chip test capability for telecoms and datacoms systems, mobile phone base-stations and Internet infrastructure equipment. LVDS technology is suitable for point-to-point and multipoint data transfer. Also on show were IEEE 166 and JTAG compliant LVDS devices with boundary scan test access to the microprocessor. One of the projects in which HP is working with the company to improve fault coverage is using test access to the boundaries of a chip, enabling structural and connector test capability. IEEE 166 defines a four-wire digital interface to a standard test access port on each compliant device. The DS92LV16 is a single-chip 16:1 LVDS serializer and 1:16 deserializer. The 125MHz design can be used to construct 16 bidirectional point-to-point links across two pairs between two of the pairs. The clocking scheme allows a variable input rate from 30 to 80MHz with a ±5 per cent clocking frequency between chips. Built-in local and loop back modes facilitate seg-regation of pre-specified parts of the system by the replication of signals back to the board (local) or back to the cable or backplane (line).

National Semiconductor
Tel: 00 49 8141 38149
www.crydom.com

LVDS transmits at high speed
in locks, security equipment and textiles machinery. They can be driven electrically in either direction, so a spring is not required to act in the return direction. Devices can have a profile of less than 1mm and their action is the same as that used in cylindrical actuators.

 DENISON Control Systems Tel: 01959 624000 www.denison.com

Embedded PGA cores for Asics and ASSPs
Actel has introduced its VersaCore embedded PGA IP cores for Asic and application specific standard product systems on a chip. The unit is based on technology from Prosys Technology and Gainfield, which Actel bought last year. These blocks have been designed using 0.18µm CMOS BRAM technology. Additional cores are being developed for smaller process geometries.

Actel Tel: 020 7673 2376 www.actel.com

JTAG emulators for config processors
Arc Cores has announced two JTAG emulators that provide development and test capabilities for configurable processors. The emulators from Corelis use Arc’s on-chip debug capabilities to support any processor clock speed at which the target system runs. The Scanice and Netice emulators use the JTAG port on Arc’s Target processor to provide access to its on-chip debug facilities. Both include the Matisso Windows 95, 98, NT and 2000 compatible Sercos source-level debugger. For JTAG emulation access, the Scanice uses an XPC bus JTAG controller that is installed in a PC and the Netice a LAN-based Ethernet JTAG controller. On-chip debug capabilities provide non-intrusive memory access and multi-core debug, and do not need debug firmware. To support rapid development, the on-chip logic lets the user examine memory locations without stopping the processor. Debug operations can be achieved with no resident code running on the CPU. Programs and data can be downloaded to any port of the system RAM through the JTAG port without a resident loader program or a JROM emulator.

ARC Cores Tel: 0080 208 2800 www.arc-cores.com

Digital pressure sensor weighs 30g
The UZU3 digital pressure sensor from Matsushita weighs 30g and is for robots or automated manufacturing systems. A panel-mounting bracket lets multiple sensors be mounted directly on top of each other without an space between adjacent sensors. The device has a two-colour (red and green) display that changes colour if the detected pressure exceeds the user-defined set point. This lets the operator confirm output status at a glance. The display can also be changed from digital to analogue, indicated as a bar display. Response time is 2ms. A chatter prevention function lets the response time be adjusted to insignificant pressure fluctuations can be ignored. There are four output modes - hysteresis, window comparator, automatic sensitivity setting and forced output. Vacuum, positive and compound pressure types are available. The compound type serves pressure requirements between 100Pa and 1000Pa.

Matsushita Tel: 01908 390070 www.matsushita.co.uk

Rad hardened mosfet at 1000V
International Rectifier has introduced a 1000V radiation-hardened (rad-hard) power Mosfet. The IRF7373G-000V device is a significant rating improvement on previously available 600V rad-hard Mosfets, said the company. As a result, said the company, it can be used to replace less efficient bipolar transistors in high-voltage applications and also enables designers to accommodate safe DC-rating conditions without losing functionality. Typical applications include travelling wave tube amplifiers, which are used to amplify microwave signals in satellite communications systems. The 100VW Model is an enhancement-mode n-channel device, made with IR’s proprietary radiation-hardened gate- and field-oxidation process to achieve single-event upset and total ionising dose hardness requirements. The device is single event upset hardened with linear energy transfer of 37MeV·mg/cm² and retains virtually identical electrical performance up to 100Krad (Si) total dose, said the firm.

International Rectifier Tel: 020 8045 8000 www.irf.com

TiePieScope HS801 PORTABLE MOST

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

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

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

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

- Measured signals and instrument settings can be saved on disk. This enables the creation of a library of measuring settings. New settings can be added to a signal, for special comments. The (colour) print outs can be supplied with the corresponding read outs (e.g. company info) on three lines with measurement specific information.

- The HS801 has an 8 bit resolution and a maximum sampling speed of 100 MHz. The input range is 0.1 vol full scale to 80 volt full scale. The record length is 32Kx84K samples. The AWG has a 10 bit resolution and a sample speed of 25 MHz. The HS801 is connected to the parallel printer port of a computer.

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

- TiePie engineering (UK), 28 Stephenson Road, Industrial Estate, Sl. Ives, Cambridgeshire, PE17 4WU, UK. Tel: 01480-460028, Fax: 01480-460340

- TiePie engineering (NL), Koperslagerstraat 37, 8601 WL SNEEK The Netherlands Tel: +31 515 415 416; Fax: +31 515 418 819 Web: http://www.tiepie.nl

Honda has launched a range of low-profile slot connectors for use with the latest secure digital (SD) solid-state, removable memory cards. Designed for use in telephones and datacards applications as well as hand-held devices, the connectors incorporate a card retention mechanism for additional security. The connectors accept standard SD memory card sizes and feature a patented "push-pull" eject mechanism, which provides a reliable alternative to snap in/snap outs, said the supplier. The SD card is inserted into and ejected out of the connector body by a simple tactile push action. SD memory cards provide removable storage for up to 4GB (bytes) of encrypted data and feature mechanical card detection and write protect. Incorporating a three-step sequential contact design, the series accepts standard 7-position multi-media cards as well as the thicker, 9-position SD cards. An optional card detect feature is also available and SM terminations are housed beneath the connector body to reduce overall size. Furthermore, the low profile design meets published MMC and SD specifications.

Honda Connectors
Tel: 01792 532388
www.hondacollectors.com

Connector for secure digital memory cards

ABRITARY WAVEFORM GENERATOR- STORAGE OSCILLOSCOPE- SPECTRUM ANALYZER- MULTIMETER- TRANSIENT RECORDER
FR-V chip based on VLIW architecture

Fujitsu is releasing its Leo FR-V VLIW chip designed around the company’s FR-V core for the European navigation market. The 32-bit, four-way VLIW has media and graphics enhancements, and is software compatible with the firm’s MB93501. It is modular and expandable, with the memory management unit being ARM compatible with Windows CE support. Internal frequency is 266MHz, and the chip has an external flexible 32-bit system bus operating at 66MHz, 1.8V, and a set of generic and automotive specific peripherals. The architecture can execute parallel instructions. The compiler rather than the processor is responsible for guaranteeing simultaneous issuing of each packet. There are six execution units on the processor – two integer units, two floating point units and two media execution units, all running in parallel. Its compiler decides which unit is going to carry out a command using VLIW. The CPU core provides a peak performance of 106MIPS, 1.06Gflops and 425Mflops at 266MHz, integer operation, floating-point and media.

Fujitsu Microelectronics
Tel:01628 504600
www.fujitsu-mfe.com

Miniature coaxial connectors on the edge

Developed for those PCI applications where space is at a premium, Radial launches its MC-Cart can be used in either edge card or board applications (i.e. PCMCIA or ISA cards). The connector operates from DC to 8GHz with an impedance of 500. Specified for sizes 500µm to 5000µm, it features snap-on mating for safety of the connection. A switch version is available and various interface lengths can be produced to allow any length to mate with the standard connector, in conformance to requirement 15.205 of the standard requirements. Radial Tel:020 8997 8880
www.radial.co.uk

SM electronics are hot hat devices

Available from Nichicon (Europe) is the UN series of tantalum electrolytic capacitors. Available in diameters: 12.5, 16,18 and 20mm, the capacitors operate across a temperature of -55 to 105°C. Suitable for automatic insertion using carrier tape and tray the series has a working voltage of 6.3 to 100V and capacitance 22 to 3300µF at 20 percent tolerance. Load life of the SM electrolytic capacitors is 64000 hours at 55°C. Allowable ripple is 5% at 75°C. 50µF (25°C) depending on capacitance and working voltage, size range is 1.25D by 13.5L (mm) by 20 by 21.5mm. Nichicon Tel:01276 685533
www.nichicon.co.uk

32-bit Risc MCU with on-chip mask ROM

Epson has developed a 32-bit Risc MCU integrating peripheral circuits with built-in ROM based on its own EDOC3229. Two models, the EDOC3364 and the EDOC3212, include a built-in high-speed MAC (multiplication & accumulation) instruction, a multiplexed A/D converter, DMA, DMAHA, 4 channels, SIO and various timers. These functions make them suitable for classic DSP applications especially for software codecs and signal processing (voice recognition and text-to-speech), said the company.

Epson Electronics Tel:00 49 89 14005 227
Programmable caps to replace inductors

Maxim Integrated Products has introduced first electronically programmable capacitor with high self-resonant frequency and 32 discrete capacitance steps. Housed in an 80PGA package (2.2mm x 2.4mm), the MAX1974 is designed to replace mechanical inductors in common tuning circuits. It can be set to any one of 32 discrete capacitance steps ranging from 6.26pF to 12.74pF in 0.2pF increments. Application circuits can be used to increase the capacitance range, increase capacitance steps, or to multiply the Q-value to fit a particular application. Because the capacitors are actually implemented in silicon, there is virtually no drift over time, said the firm and the temperature drift coefficient is less than 3ppm/°C. A Q of 50 is possible. Two pins are used to program the MAX1974. Capacitance values are selected by raising the enable pin and sending the device a discrete number of pulses corresponding to the desired capacitance value. It does not require a clock and will retain the programmed capacitance value for as long as power is supplied. If the system requires a change in the capacitance value it can be changed any time by simply raising the enable pin and sending the desired number of pulses to a pin.

Applications include post-trim of low-cost regenerative stages,
tunable RF stages, garage door openers, keyless entry, industrial wireless control, and precision trimming of capacitive-based sensors.
Maxim
Tel: 0118 930 3388
www.maxim.com

Frequency converters have variable outputs
Magnus Power has launched the redesigned LP series of frequency converters, which is offered with either single or three phase output. The single phase range consists of the LP500, 600 and 1000 and is rated at 300, 600 and 1kVA respectively. Each model has an output frequency that is variable from 50Hz to 60Hz. Output voltage varies from zero to minimum in two ranges, usually 0-135V, and 0-270V. Output current capability is doubled on the lower range.
Magnus Power
Tel: 0116 2672856
www.magnus-sales@kvaener.com

TFT-LCD module with A/D conversion board
Customised versions are available on request.
Sencon is offering a 15in TFT-LCD module that incorporates the A/D conversion board. Eliminating the need for a discrete A/D circuit and the associated interfaces to the LCD module, Hyundai's HM15X31 and HM15X12 LCD modules support XGA resolution, 16.7 million colours and a refresh rate of up to 75Hz, without external frame memory. Features also include automatic detection of changes in input display mode and frame rate and power management capabilities that meet DPMS and VESA requirements. The CCFL backlight delivers a typical brightness of 200cd/m² (at 6.0mA), whilst an option allows brightness to vary according to the ambient brightness.
Sencon
Tel: 01279 422224
www.secon.co.uk

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NEW PRODUCTS

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USB 2.0 controller with serial interface engine

Cypress Semiconductor has added to its recent USB 2.0 controller announcement with a serial interface engine that provides a 480Mbps/Usb 2.0 connection to a peripheral containing a microcontroller. It does this without draining the controller's resources. The EZ-USB SX2 integrates a USB 2.0 transceiver, a PLL, an SPI, a 48kbyte FIFO, and a local bus interface. The integrated SIE takes care of USB housekeeping chores, so the microcontroller can spend its resources on the peripheral application.

Cypress Semiconductor
Tel: 01707 378700
www.cypress.com

10-bit Gunnin logic transceiver

Fairchild Semiconductor has added the GTLFI01250 to its range of Gunnin logic transistor (GTL) products. It is a 10-bit universal bus transceiver, with separate LVTL inputs and LVTL outputs. It provides an easy transition to that bus signal level translation. High-speed backplane operation is a direct result of GTL's reduced output swing, high drive, reduced input threshold levels, and output edge rate controls. The GTLFI is the firm's derivative of the Gunnin logic family, similar to the JEDEC standard JESD3-1. All devices are process, voltage, and temperature compensated. While many transceiver technologies are designed and specified for lumped-load environments, this device is optimised for distributed-load environments that characterise backplane applications. Designed using BICMOS process technology, the GTLFI devices operate over 3.3V and provide 30mA drive for backplane environments.

Fairchild Semiconductor
Tel: 001 608 522 5372

Development environment for Motorola MSC8101 DSP

Green Hills Software has introduced the Multi 2000 integrated development environment (IDE) for Motorola's MSC8101 DSP based on the Starcore SC140 core. The IDE has a C+ and C optimising compiler for the Starcore SC140 EFR benchmarks and provides editing, debugging, profiling and project management capabilities. It automates software development. The source-level debugger, with incremental debug capability that supports process and system-level debug, is RTOS aware, which lets designers debug and tune applications at a task level. An instruction set simulator lets programmers develop and test code on a PC or workstation without the target hardware. The compiler automatically purges C programs for execution on the DSP's, Mac, ALU and BU processor. It also provides more than 100 optimisations to boost performance and code efficiency. The compiler increases parallelism by reordering operations within loops, and reduces loop overhead by supporting zero-overhead hardware looping for loops that are nested up to four deep. It collects frequently used data and places it in the lowest bit of the address space. This lets the data be accessed using 32-bit instructions, thereby improving VLSI packing efficiency.

Green Hills Software
Tel: 01444 429936
www.ghs.com

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In the first article describing this professional audio-visual router, I looked at the hardware side of the design. Many of the router's functions are carried out in software by code in the router microcontroller's on-chip PROM. The program that forms the user interface to the PC can be used to add features.

Software, and router configurations used in a typical studio environment, are the subjects this second article.

Software for the router's microcontroller

It is not possible to publish the whole firmware assembler code for the VRS-8x4 video switcher, the ARS-8x2 audio switcher and the PVRS-1 keyboard, due to the limited amount of space available. However, the source code can be obtained via e-mail, as can the object code, which is available free of charge.

Object code for those of you who want to use it without any modifications is given in Listings 1-3, presented later in the article.

Code for the video and audio switches has to be burned into a standard 27256-type 32K PROM. The code for Atmel's 89C2051 micro can be programmed into the controller's onboard flash with a parallel port programmer. You can buy such a programmer or build one yourself using the documentation provided on Atmel's website (http://www.atmel.com).

Configuration commands

Usually, the user will control the complete routing system through its own keyboard or via a PC serial link. If you want to build your own interface or control the system through a terminal emulation program (set to 9600/8/1/1) you need to know the serial commands that the firmware can understand. These are listed in Table 1.

All commands are ASCII strings. Each command ends with a carriage return - not with a carriage return plus line feed. It is worth mentioning how the keyboard retrieves the active configurations after power is applied. Imagine you have a valid start-up configuration, or you have set up the connecting paths through a PC interface and you change the control method from PC to keyboard on the fly. This is possible by the way.

The corresponding LEDs on the video router have to be lit and that the internal configuration registers of the keyboard software need to know the current configuration. This is done as follows.

After power is applied the keyboard, the microcontroller waits 100ms and then issues the ‘GetConf’ command. The router acknowledges this command by returning the active configuration in an 'Out1InNOut2InX' format. This format is a command for the video router and is used by the 89C2051 code to set up the internal registers and to light the appropriate LEDs. An interesting situation arises if you control the R by 4 video matrix using an 8 by 2 keyboard. You will not be making full use of the crosspoint switch in this case, but if you do not need the capacity, there is little point in implementing the full keyboard.

From the keyboard, you can specify connections only for two outputs - outputs 1 and 2 in this case. However, the keyboard subsystem is designed so that it also configures output 3 to mirror output 1 and output 4 to mirror output 2. These additional outputs can be used for monitoring purposes.

Typical configurations

This section outlines some typical configurations of the routing system that you might find useful in studio applications.

Audio follows video router, PC control. In the configuration shown in Fig. 1, the whole system is controlled via a host PC using appropriate software. My PC graphical user interface software supports up to four stacked pairs of audio and video routers. Using this software, Fig. 2, the 'Audio' check box in the control window of the PC interface (details later) has to be checked for correct operation.

In this configuration the user can control up to four audio and video switcher pairs completely independently. Each device pair responds only to serial commands from the PC that are designated for it. You don't need four serial ports or four PCs to control the four switchers in your studio - you have only one single interface.
Audio follows video router, keyboard control. In the situation depicted in Fig. 3, control over the switchers is achieved with a VRS-1 keyboard. More than one pair of video and audio devices will need to be stacked in this case, unless identical operation of all switches is necessary. This is a typical situation for a small studio.

Independent video or audio stacks, mostly PC control. In this case, Fig. 4, all devices in the stack are of the same type. They are either VRS-8x4 video routing systems or ARS-8x2 audio routing systems. Control is usually performed via a host PC.

As in the case of the keyboard control, all devices will be loaded with the same configuration. Up to four devices can be controlled through the GUI application software that I developed. The 'Audio' check box in the Windows interface is not checked in the depicted configuration — even if you have four video stacks on the same board. This check box is only meaningful when you are using the audio-follows-video configuration.

Creating a graphical user interface

My interface, Fig. 2, is compiled to run in Windows 95/98 environment. It has the following menus:

- Menu 'Communications' — the user can select the COM port of the PC, connected to the system. The software supports COM1 to COM4.
- Menu 'Lock' — the application software is locked and unlocked with this menu. When locked, the user can change the connection patterns of all stacked devices, but cannot download the selected configuration to the target device. In this way, accidental transmission of possible errors and program drops are prevented. This function is the same as the hardware lock switch on the VPRS-1 keyboard.
- Menu 'Language' — the application software supports two languages — English and native language Bulgarian. The source code for the GUI interface can be obtained, details later, so if another language, is desired, the modifications can be easily done.

Menu 'SysTray' — the application is minimized as an icon in the system tray and can be activated every time the need arises. This feature is especially useful if the host PC is used for controlling other equipment at the same time. In this case, the operator does not want to be distracted by too many virtual control panels. The software for this menu is written by E. Spencer (ellow@sync.demon.co.uk) and is public domain.

Menu 'About' — gives information about the current version of the software.

The software also has the following ancillary control functions:

- 'AVRS8x4_1, AVRS8x4_2, AVRS8x4_3, AVRS8x4_4' tab strip — this strip gives the configuration area the same look as the dividers in a notebook. So multiple configuration planes, one for each stacked AV system pair, are defined in the same area of the window. The maximum number of stacked systems is four, and each stack has four tab strips.
- 'Crosspoint Router 1, 2, 3, 4' frames — the frames for the stacked devices (matrix) numerical order are switched by the tab strip controls. In every frame, a virtual representation of the 8x4 connection matrix is given. For the audio router, only rows 1 and 2 have meaning. Rows 3 and 4 can be specified as connections, but will not have any effect on the audio router, since it has only two outputs. A valid connection can be performed by clicking on the connection circle. The active circle is highlighted in red. Clicking on the red circle again will disable the activated connection. The selected configuration pattern(s) becomes active after the corresponding "Load Configuration" buttons are pressed. So the operator has first to specify the configuration pattern and then to load it into the system.
- 'Disable check box' — this box is used to disable the corresponding output of the matrix.
- 'Output'. Input select boxes — these controls, the user

Software availability

Object code contained in Listings 1-3 is available for free of charge. The code together with the author's Prolt PCB layout and Windows 95/98 GUI is available for $15. Source code for the design is also available direct from the author. Its price will depend on whether your application is for commercial or domestic use. E-mail to Jackie Love at jlove@cumulimedia.co.uk with your requirements.
can specify a custom name or label for each target. Input signal from every of stacked devices in the corresponding frames. The information is stored in the Windows registry, so it is preserved after the application is quit. This feature gives the user the possibility to work with numbers, but with all the useful sources and destinations labels like 'Studio 1', 'Camera 1', 'Room 3', and so on.

*An Audio...* check box - this control is used to specify an audio-follow-video stack.

The AVS-8x4 audio and video routing system with keyboard.

Listing 2. Audio switcher firmware.

<table>
<thead>
<tr>
<th>Device</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x1000</td>
<td>Device 1</td>
<td>0x20</td>
</tr>
<tr>
<td>0x1001</td>
<td>Device 2</td>
<td>0x30</td>
</tr>
<tr>
<td>0x1002</td>
<td>Device 3</td>
<td>0x40</td>
</tr>
<tr>
<td>0x1003</td>
<td>Device 4</td>
<td>0x50</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Key</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select 1</td>
</tr>
<tr>
<td>2</td>
<td>Select 2</td>
</tr>
<tr>
<td>3</td>
<td>Select 3</td>
</tr>
<tr>
<td>4</td>
<td>Select 4</td>
</tr>
</tbody>
</table>

The AVS-8x4 audio and video routing system with keyboard.

**Back panel view of the video switcher.**

- Frame 'Stacked Devices' button 'Load Configuration' - the function of this control is to transfer the specified connection patterns to the target devices. The connection pattern for each group of routers has to be specified. If you have only two AV router systems connected to your PC, you don't need to specify all four patterns of course. You should do it only for the first two router pairs.
- Frame 'Stacked Devices' button 'Save StartUp' - this button is used to transfer the start-up configuration patterns to the target devices. Active configurations on the target devices are not affected by this operation. The control is used for stacked audio and video routers. A connection pattern for every router has to be specified.

In summary, the AVS-8x4 audio and video routing system has been designed for studio environments, where the requirements for reliable 24 hours a day, 7 days a week operation are essential. As a result, the firmware has been designed extremely reliably with strict safety margins, so that every single channel is protected.

The system has the advantage that it uses no special cabling for realising the necessary frame configuration. Standard serial cables can be used to connect between audio and video switchers, or stacks. Having the opportunity to organise large stacks of switches can prove to be extremely useful when expanding a current studio configuration, or building a large television production facility.

The system described in this article is currently in use in the Sofia and Plovdiv studios of ERV/COM - the largest cable TV provider in Bulgaria. According to the staff operating the equipment, it is a pleasure to work with, because it is robust and the interface is intuitive and easy to use.

**References**

July 2001 ELECTRONICS WORLD
Glitch detector and delay

Retraction of supply after a power cut or switching of heavy duty equipment can cause power glitches that may be detrimental to some types of equipment.

One example is the ubiquitous PIR security light. In some cases a slight glitch can re-energise the manual switching mode initiating a permanently on condition. If left, this is wasteful of power, causes unwanted light pollution and in a lengthy absence of the occupant can indicate empty premises to a potential burglar.

This circuit produces a delay on initially switching on and then monitors the supply to detect such glitches, introducing a delay and isolating the power supply. In my case this is to several security lights but the circuit may be of use to protect other types of equipment where sudden surges may cause a fault, damage or mis-operation.

A two-diode full wave rectifier circuit produces a waveform which is shaped to produce narrow negative pulses at 10ms intervals. These are applied to a MC14528B triggerable monostable with a time constant slightly longer than 10ms. A missing pulse such as that caused by a mains glitch or drop-out will fail to extend the monostable period just before the end of its natural period. It therefore times out and the edge triggers a second monostable with a time constant of around 15s.

Divide LEDs is illuminated indicating that the power supply to external equipment is switched off. A positive level is available from pin 10 or a negative level from pin 9 of the MC14528B to suit any switching requirement. Mechanical relays, solid-state relays and triacs can be accommodated.

In my case, a small 12V relay switches other with higher contact ratings, and manual switching is added to control the security lights. The delay remains until such time as normal 10ms pulses return and both monostables return to their initial state. Apart from any desired changes to the final delay period, the only adjustment is that of the 100k resistor preset VR1. This should be adjusted until LED1 just turns off, or pin 7 may be observed on a scope until the 10ms pulses disappear. If other than an 18V transformer is used, it may be necessary to adjust the value of the bottom left 4.7k resistor, just under point a, to produce suitable 10ms pulses.

A normally-closed push-button switch in one leg of the rectifier circuit is used to test the system, changing the rectified output waveform from 10ms to 20ms.

L N Smith

Stoke-on-Trent

Staffordshire

F3

Unity-gain phase-shifter

Aval operational transconductance amplifier - OTA for short - is at the heart of this phase shifter.

The relationship between $e_p$ and $e_i$ can be derived by using the formulae below. If $e_p$ and $e_i$ are the voltages at the negative and positive inputs of the OTA respectively, and assuming $e_i > e_p$ and that the gain of the output buffer is unity, then:

$$e_p = e_i$$

$$i = (e_i - e_p) R_i R_e$$

$$e_i = e_i - e_p (1 + j w C R_i)$$

Since (1) and (2) then:

$$e_i = e_i - e_p (1 + j w C R_i)$$

The absolute value of $A$ is 1; the phase-shift is found to be:

$$\sin \phi = -2 A e_p R_e$$

In practice, with the components shown in the diagram and a source frequency of 100kHz, the phase can be shifted between 210° and 330°. The 1nF capacitor can be scaled as required for other frequency ranges.

W. Dijkmans

Waalre

Netherlands

E98

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A versatile interface for a narrow frequency sweep display

Frequency-sweeping signal generators—or sweepers—can be used with an oscilloscope to display frequency response characteristics of a device under test. Often they have a provision for an external drive to the frequency sweep circuitry. If a ramp output from the sweeper is available to feed an X-amplifier of the oscilloscope, the scan may not be enough to display accurately a steep-sided narrow bandwidth waveform, such as that of a crystal filter. In such cases, a separate variable frequency ramp generator has to be used for the sweeper's external input. If an oscilloscope has an X-sweep output (ramp output) is used with the sweeper, then this ramp can drive the external input of the sweeper, thus controlling the scan rate from the scope. However, it is likely that a direct connection of the ramp output to the sweeper's external input would be unsatisfactory—for example, possibly even catastrophic.

Some form of signal conditioning/buffering between sweater and scope is essential. This could provide a suitable polarity and amplitude of ramp voltage from a low source impedance to drive the sweeper for a linear frequency-X-sweep display on the oscilloscope. An inverting/non-inverting amplifier, having a gain continuously variable between +1 and —1 has been derived previously in Circuit Ideas. An adaptation of this circuit could form an interface unit between the sweater and scope, to provide flexibility of ramp output amplitude and polarity.

In a conventional sweep display, frequency increases left-to-right along the X-scan. A ramp having either a positive or negative slope will be required. According to the sweeper's external input characteristics of frequency versus voltage. This polarity selection, together with control of ramp output from the interface, is provided by the continuously variable +1 to —1 feature. Ramp output voltage can be made to have nominally equal excursions either side of zero. An additional control offsetting the zero allows you to centre the display on the scope screen.

A similar shift of the display by a pre-determined fixed amount, as and when required, can be derived from a stabilised voltage source in the interface. This gives a frequency calibration in terms of displayed frequency sweep, i.e. kilohertz per division on the scope screen. If, at any particular sweep width. This facility is useful if no frequency markers are available or they are too widely spaced to cater for narrow frequency sweeps.

The circuit shown is of a battery-powered interface for a specific application, using a Marcon TF2008 sweep signal generator and a Gould OS5250 oscilloscope. The oscilloscope ramp output is 0 to +10V from a nominal 18kΩ source. The sweeper external input is 35kΩ per volt on the particular RF frequency range in use.

Calibration voltage, derived from a 1.23V band-gap reference IC2, is set by choice of R2 to produce a 100kHz shift of the display when the pushbutton switch is operated. A ramp output of +2.5V is obtained with the value of R, shown, but this can be adjusted to suit other source resistances and voltages of a scope ramp output. The time-constant of CxR must be large enough to pass without distortion lowest sweep frequencies used. In the application described, this was 5Hz.

The polarity of Cx must suit the oscilloscope's ramp polarity. If a greater output than +2.5V is required, then a higher rail voltage and/or an IC, capable of a peak-to-peak output swing closer to the rail voltages than that provided by the MC1458 will be needed to avoid limiting.

The interface provides smooth control of sweep width between maximum and zero, so very narrow sweeps are easily set up. These, in conjunction with an 80kHz dynamic range log-amp detector feeding the scope-Y-amp, enable crystal filter response characteristics to be displayed over a large portion of the scope screen, making it easy to measure bandwidths and shape factors.

Rouss Maddell
Worcestershire

E78

Reference

Simple stepper-motor drive

This stepper motor control circuit—or "translator"—comprises a shift register and clock source, Fig. 1. Outputs Q1 to Q6 are gated so that for any one is high, a zero is clocked into the first stage output Q1. When the first three stages all hold zeros, a one appears at the right-shift input. On subsequent clock pulses this is gated into Q3, and so on, to pass through the other stages. Thus a continuous circulating wave drive sequence is obtained.

The outputs Q7 to Q12 drive four power amplifiers, each as in Fig. 2. The wave drive sequence can be gated with NOR gates as in Fig. 3, to provide a two-phase drive sequence. In order to change the direction of the stepper motor, inputs at S1 and S2 are set high or low with switch SW1. R1 resets the translator.

The advantage of this circuit is its immunity to noise. If a noise pulse disrupts any of the Q5 outputs, the sequence is automatically re-established by succeeding clock cycles. R1 is a reset for the clock circuit.

V Gopalakrishnan
Bangalore

India

E79

Table: Wave drive sequences without the modification in Fig. 3, and two-phase drive, as obtained with the modification.

<table>
<thead>
<tr>
<th>Wave drive sequence</th>
<th>Two-phase drive sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1      Q2      Q3      Q4      Q5      Q6</td>
<td>Q1       Q2       Q3       Q4       Q5       Q6</td>
</tr>
<tr>
<td>0       0       0       0       1       1</td>
<td>0         0         0         1         0         0</td>
</tr>
<tr>
<td>0       1       0       0       0       1</td>
<td>0         0         1         0         1         0</td>
</tr>
<tr>
<td>0       0       0       1       1       0</td>
<td>0         1         0         1         1         0</td>
</tr>
</tbody>
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A microcurrent amplifying stage

A common-source amplifying stage using a single field-effect transistor can ensure enormous low voltage gain, if the effect of the device's drain current is very small. An example circuit is shown in Fig. 6. A similar arrangement was used in the days of valves, with a pentode used in the "stave" mode. In both cases, the large gain is bought at the expense of limited bandwidth. S Checheyev

Transistors

Moldova F6

A maximum possible value of the voltage gain factor depends on the drain-source and drain-gate leakage currents of the field-effect transistor and can be very large.

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Fig. 1. Stepper motor controller using a shift register.

Fig. 2. Power drive for one stepping coil.

Fig. 3. Gating to convert the controller output from wave drive to two-phase drive.
Three-phase sequence indicator

Phase rotation or phase sequence is an important parameter of a three-phase supply, as the direction of rotation of induction motors will depend on it. In some cases, serious damage to machinery may result if the driving motor is reversed. In such cases, local protection against phase reversal is essential.

The circuit given here is probably the simplest and the lowest cost solution possible for providing an indication of the direction of phase rotation. It is readily adapted to provide an interlock, to prevent operation with the wrong phase sequence.

The circuit makes use of the fact that in a three-phase system, the voltage vectors of two phase terminals with respect to the third phase have a phase difference of 60°. Whichever voltage leads the other is an indication of phase sequence.

If the phase A leads phase B, the transistor Tr1 receives base current first and only LED1 will light in the same manner. Therefore, LED1 and LED2 will indicate clockwise and anti-clockwise phase sequences of the supply respectively.

If one of the LEDs is replaced with an opto-coupler, the signal can be transmitted at a potential close to the load level. This may be used to interlock the motor starting switch so that the motor will not operate in the reverse direction.

C Padhavavada
Dhivahala
Sri Lanka

Important note

- All the components of the circuit will be live at phase voltage, so the circuit is potentially lethal.
- The circuit can be used on supplies up to 400 V phase-to-phase voltage.

Keyboard has serial interface

This circuit is based on the UC5833 IC, which is a 32-bit serial-input latched driver with 32 open-collector outputs. Control pins are clock, serial data in, serial data out and strobe, i.e. output enable. The keyboard is controlled by a microprocessor or microcontroller using three output pins and two input pins. The software should implement the following steps.

At power on, the software should disable the output enable line and zero all 32 output registers during clocking in zeros until the serial data out line reads zeros continuously. Then, the serial data in line is taken high for one clock cycle, and this then circulated through the shift registers on subsequent clock pulses. When the clocking high bit reaches the last open-collector transistor of the latch conducts and the controller is informed of the key closure by the op-amp output "key sense" signal.

This information is stored along with the clock pulse count — which is reset every 32 counts. The same key is then repeatedly sensed for key release when corresponding clock period is reached. Once the key release is detected, the program can jump to the appropriate action routine.

Note that the clock frequency should be chosen to ensure that there are several samples of any key pressed. Precedences should be included to deal with two key rolls-over, a detected second key-press being ignored until the first key release is sensed.

Jayan Kathie
Mumbai
India

£75 winner

Three-Phase Power Supply

The circuit is suitable for testing three-phase supply using a three-phase transformer. It consists of a three-phase switch which is controlled by the output of a microcontroller. The output of the switch is fed into a three-phase motor.

The motor operates on the three-phase supply and the output is fed into a three-phase safety relay which is used to protect the motor.

Circuit diagram

- Input: Three-phase supply
- Output: Three-phase motor

Microcontroller

The microcontroller is used to control the three-phase switch. It is connected to the three-phase input and output.

Three-phase motor

The three-phase motor is connected to the output of the switch.

Three-phase safety relay

The safety relay protects the motor from overloads and short circuits.

Note: This circuit is not suitable for commercial use. It is for educational and testing purposes only.
Letters to the editor

Letters to “Electronics World” Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS
e-mail jackie.lowe@rbi.co.uk using subject heading ‘Letters’

Input-filter distortion

I thank Graham Maynard (Ew Jan 2001) for taking the time to reply to my letter.

Unfortunately, he has failed to explain the quantum of distortion claimed and the analysis of the cause is specious.

As all apparatus is designed technically, correctly, and rationally, please allow me to explain, and hopefully promote a more accurate understanding of the relevant issues.

To the best of my knowledge and understanding, linear distortion is measured in terms of amplitude, phase, and power, with the units being centimeters or decibels (or power, dBm, radians) and seconds).

I have yet to see explained how it might be expressed as a percentage like non-linear distortion, as Graham does. He gives me no formula or other clue as to how this might be done.

My understanding of linear fundamentals appears not to be the same as Graham’s. For audio it is impossible to consider the effects of a circuit as unimportant by the workplace of determining the extent of any linear distortion.

Graham is correct in that the filter introduces a ‘tiny delay’, but he is incorrect in expressing that “it’s a linear filter with frequency”, certainly within the range of human hearing.

What in fact happens is that the filter introduces a pretty uniform 2.2ms delay over the audio band, with a maximum variation of less than 150ns. This is nearly identical to the effect that would be produced by sending the signal down a perfect transmission line of 2.2ms.

This would be inaudible since the same time delay is forced on all signal components.

I have no reliable evidence that the effects above 20kHz are audible. I reject any and all claims not backed by properly conducted research.

This can be easily demonstrated with a very simple PSFICE simulation.

1) RC circuit for group delay
2) RFE

By running PROBE and plotting dB(2), you will get a plot of the group delay through the circuit. The delay at 100Hz is 2.2us and the delay at 20kHz is just under 2us.

Over the range of human hearing the variation is small. Put this in some perspective, if you moved your head back a couple of inches a millisecond you would get pretty much the same audible effect — virtually inaudible, and nothing anyone is likely to think is important.

When one considers common listening

Tracking down mains earth leakage

A while ago, I suffered from my regular tripping of my domestic mains earth-leakage circuit.

The trips occurred about every month or two — but sometimes two or three times in a 24 hour period, and the problem had been on my radar since there was no evidence of any light fitting circuits or six mains.

Almost invariably the breaker would have clicked on after a trip, and frequently, nobody had been turning anything on or off in the house.

I concluded, therefore, that there was earth leakage current running all the time, but that random fluctuations were causing it to just reach the trip threshold. In order to measure this, I tried loading a few components in series with line and neutral feeds to the fuse box, and connecting a millimeter on AC volts. Not sensitive enough.

After further head scratching, I remembered that I had an old line-out transmitter and receiver, and was able to demounting the clamp and re-assembling the receiver box to the mains, the EHT winding produced an output of about 45mV with the house fully powered up — which was enough to trip all the breakers.

By turning off all the trips, the voltage reduced to virtually zero, suggesting that I was now indeed measuring the residual current.

For my results, I measured the residual current at 1mA. While not insignificant, it could have been worse but it was a problem.

I unplugged all the earthed appliances, judging that a device with two earthed mains leads could not possibly leak to earth. Wrong. It turned out that a television was leaking out to its aerial lead, not measured at about 5mA or 0.5mA.

Interestingly, I had noticed on trips that seemed to occur more in cold weather, and I suspect this has something to do with the conductivity of the chimneys on which the aerial is mounted.

But there remained the puzzle of why the earth currents were so low with each circuit. Surely they couldn’t all be faults on the line? To find out, I replaced the multimeter with an oscilloscope.

I had the waveform coming out of the EHT winding, and plotted the field of long grass — the supposed source of leakage. I was expecting a moment’s thought then tell me that any resistance to earth would provide a low impedance path to the mains on the incoming mains.

My first question, then, is whether or not this would contribute to ICRB trips? Deciding that I was more interested in noise-resistant — than anything else, I now added a simple RC-filter of 10k330fF to allow me to see the 50Hz component. I was rewarded with a slightly rougher sound.

Using the second channel of the ‘scope to monitor the mains, I could see that there was a phase lead. This confirmed my suspicion that it was capacitance between the line and neutral that accounted for most current measured.

I should mention that my household is fitted with kit with switch-mode PSUs — e.g. computers, TVS etc. — which all have no filter capacitors down to ground in an attempt to clean up the resultant noise.

So here is my next question: Is it true that mains cabling capacitance and filters in AC PSUs inputs will permit a certain amount of standing leakage? By this I mean the in-phase current is such that leakage is required to tip the breaker is considerably less than the 30mA rating on the breaker?

Chris Miller
Via e-mail
Just producing profile drag. The contemporary Citroën DS19 had a Cd of 0.31.

Incidentally, the XJ8 which followed the E-type was wind tunnel tested and put all this right. There is a spoiler and a large smooth underbody at the front, and the famous ‘flying buttresses’ at the rear follow the path of the vortex structure leaving small eddies on each side.

The sharp inner lip of the buttresses and the end of the rear roof produce a defined separation point and I wouldn’t part with mine.

A VW concept van based on the old 1950s Fi-split screen van — dabbled the Microbus and hailed as the bus of the future.

Graham replies... What a real shame it is that Mr Dennis did not follow my suggestion and try these values for himself, for they might well be audible on a system that is not already filtered. No amount of theorising or self-opinionation can alter the facts.

Mr Dennis’ footforth 2.2μa group delay explains why he firmly belives the filter cannot affect audio dynamics.

Unfortunately, he has incorrectly assumed that an electrical RC filter behaves as if it is a propagational transmission line.

As I wrote, these filters do not distort LF, but they do reduce clarity by having a HF effect. This effect is initially asymmetrical and lasts for longer than the spot frequency ‘group delay’ period. This is especially so at frequencies where the phase-lag ‘delay’ is no longer insignificant.

The RC phase lag, the greater the initial asymmetry and wavefront distortion, which becomes severe on sharp leading edges. See the 20kHz simulation, Fig. 1, for clarification, at LF there is similar delay but minute and quite insignificant error.

At the end of a delay line my input-output difference curve won’t be symmetrical. The return to zero has a negative maximum at 2.04μs. See the 43.5mV difference too small, when compared to the normal positive (group delay) peak, and thus within a 40μs time frame — most significant when compared with the 1.2V 50kHz original — but then I never did want to ‘fix’ this much as Mr Dennis has already accused me.

No filter. No real-life effect. Thus I’ll leave Mr Dennis to ponder what happens to leading edges of waveforms transients when they pass through his delay line. We cannot have one examination for LF and another for more dynamic signals.

Incidentally, the filter proposed by Mr Ellis (it is not mine as Dennis writes) limits view in a 50V, 8Ω amplifier to 17V in 2μs. This is slow by today’s standards, and I’m sure that Mr Dennis is as able as I am to see the error that I would suggest to be 10μs and the perceived lack of transmission line delay. He probably has already PSpicked this aspect in the normal course of his work, but not yet thought it this far weird.

Also, I have changed both my letters and thus Mr Dennis must have misted me to misconstrue. It is he who writes ‘delay’ where I wrote of “...phase shift” that increases sharply with frequency...

He infers human bias and imagination where I have actually taken the trouble to check these filters in isolation for their additional input-l.f. impact on amplifier input circuitry. I have no reason to make false report about my real-life findings of the 1970s and 1980s, which computers are now able to examine.

He also intimates that I was talking about linear distortion. That was not clever.

**What does ‘engineer’ mean?**

The shortage of engineers in Britain is primarily due to the fact that the title, ‘engineer’ has no meaning in Britain, and also to the low salary levels offered to well qualified engineers. If you look at the number of engineering graduates who actually take up engineering careers, you will probably discover that it is less than 50%.

The shortage of engineers with a hands-on approach is primarily due to the decline in manufacturing, research and production that has occurred in recent years in Britain. This decline has meant that these people have also taken jobs in more secure occupations.

The various training schemes, that have been introduced have not yet solved this problem. For the most part they do not meet the needs of the electronics industry, as the course content is theoretical and often several years out of date. The Society of Engineers, which is Britain’s third oldest professional engineering body, realised this problem. It has restructured its examinations to meet the requirements of modern electrical and electronic engineering.

The design and project papers are completed by the candidate at home over a specified period of time. These provide the candidate with the opportunity to demonstrate that he or she has a practical approach to engineering as well as a theoretical knowledge. The design also means that the candidate has to find out more about the Society of Engineers and its examinations, telephone 01206 263323 or sending letters and email secretary@soe-engineers.org.uk. David Parnell Via email.
that Mr Maynard dismissed in referring to his Fig. 3 in fact Mr Maynard's circuit will make the bass transient response worse, not improve it. The simple circuits, with a well-damped loudspeaker system, can do all the necessary compensation. Readers will be far better advised to use simple bass-boost circuits and, if necessary, put some good acoustic damping material into their loudspeaker cabinets. Dare I suggest long-fibre wool?

Arthur R Bailey PhD MSc FIEE

Ilkley

W. Yorkshire

Graham replies...

I thank Arthur Bailey for his letter in response to my sub-bass equaliser article. Mr Bailey has many decades of audio experience and I much respect his work, but my article approaches sub-bass reproduction from an historically unconventional starting point. I too have done my work carefully, and thus I trust that he will understand differences which at first sight are not clear, for my equaliser does exactly as he suggests. It compensates for what is actually happening, theoretically as well as practically.

"E-bass" is not a phase-altering bass boost system. It is a phase-linear and adjustable sub-bass equaliser that has been specifically designed for use with strongly constructed bass drivers. Because these drivers are driven only at frequencies below their deliberately raised cabinet resonance, they transcend with much less phase error than when mounted in our conventional cabinets.

I agree with Mr Bailey that we do not want any phase advance with reducing frequency. Nor do we want even the changes that occur due to loudspeaker resonance. But cabinet damping alone cannot prevent these. Long-fibre wool might reduce system 'Q' and the sharpness of the resonant phase change, but the phase change still occurs. In conventional cabinets the effects are always audible at sub-bass frequencies.

I say that we have allowed ourselves to become used to, because of the difficulties presented in overcoming the problem! Bass boost cannot help either; for it only adds to the overall phase distortion; it might improve some sounds at some frequencies, but it is deleterious to others.

Unfortunately, Mr Bailey has introduced theoretical representations that are not always properly understood. These place me in a position where I must respond.

I agree that his Fig. 1(e) circuit will equalise his Fig. 1(b) characteristics. I also agree that his Fig. 1(a) is a fair representation; but where has the driver-cabinet combination gone in Fig. 1(b)?

Applying C=22µf and R=100Ω to Fig. 1(b) leads to a -12dB roll-off below a ~38Hz turnover at 80Hz. But the real-life cabinet resonances that produce a peak and tightens the phase change about its frequency of occurrence is missing!

Sampling 'scope memories

Firstly, one issue without an article by Ian Hickman is bad enough, but two issues without is a disaster!

Secondly, in the March 2000 issue, we were presented with a most interesting insight into sampling techniques — sufficient to divert my attention from trying to improve the performance of a TDA8703-a chip.

Not having such a well-filled circuit box, I used a B6F69A1 with BAT83 diodes. Coupled with a P1C16792 and a bit of programming this reproduced a 50MHz square wave quite well on the computer. Unfortunately it had to be driven from a low impedance as the suggested active probe (May 1996) using a MAX4005 converted square waves above some 20MHz to fairly good sine waves!

However, with the original article we were admonished to "Watch this space..." Well I have but to no avail. Is it not about time that the recent gaps were filled with the promised follow up article?

John Kanaar

Via e-mail

Ian replies...

John, I am afraid that readers have been "watching this space" for far longer than I intended. The missing part of the design is the trigger and incremental delay processing, to reconstruct the sampled waveform. I had in fact done quite a lot of work on this part of the design before developing and publishing the sampling circuitry. But for various reasons, it has languished on the back burner.

As the moment, apart from my many non-electronic activities, I have a new edition of one of my books to complete by late summer, but after that, I intend to return to and finish the sampling 'scope design.

Yes, his Fig. 1(b) does create a leading characteristic. In real life though, the compact sub-bass loudspeaker is electrically connected such that it runs properly in phase at sub-bass frequencies. It actually develops a fairly small, at low frequencies close to the deliberately raised resonance, which is not driven.

Also, with a steep-cut electronic crossover having phase changes of its own that can never be properly avoided, as with all crossovers — the amplifier is then able to directly exert a high degree of linear output control all frequencies. This means that it will electrically dampen loudspeaker system induced, resonant frequency results where they have not been fundamentally energised. Such results are unavoidable within all loudspeakers.

Thus I have not been labouring under a misapprehension. I have actually tried my Fig. 1, which is Mr Bailey's Fig. 1(e). In real life it sounds atrocious when applied to a phase linear sub-bass reproducer.

I sought other 'ears' to confirm whether my own observations were correct. It took me ages to get my head around what was actually happening; also to get beyond conventional 'ears'.

My real-life findings appear to conflict with what I had read through the decades. But I could not be so brash as to say 'if the theory does not fit, then change the theory'. My findings could not be disputed either. It was my own interpretation and application that had to be re-evaluated.

In common with other integrator circuits, Mr Bailey's Fig. 1(e) network shifts the entire sub-bass spectrum into what is virtually a lagging quadrature. This would then mix with bass harmonics plus other mid and treble signals that have been simultaneously amplified.

There is a distinct 25ms delay at 20Hz. Overall reproduction literally falls apart because a reflexively-operating sub-bass loudspeaker cannot be made to compensate by transducing electrical waveforms before they arrive.

I wrote that I used a dual-beam oscilloscope to observe and measure these time differences, and I worked away until they were minimised by a circuit that would not overdrive at infra-sound frequencies. My own hands-on work was completed without the aid of computers, but these were later used to confirm measurements and then to draw up the article.

My equaliser circuit offers an alternative possibility for level and flat phased sub-bass reproduction. I implore that anyone who might feel a need to comment to please audition what is possible before putting pen to paper.

Just because I prefer compact sub-bass does not mean that I advise readers not to construct heavy and large conventional cabinets that leave drivers at risk of over excursion and introduce a hideous phase change at sub-bass frequencies. When it

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John Woodgase's letter in the May 2001 edition of Electronic Letters, regarding EMC and the DIY PC, raises some important points. The requirements have changed in the past few years, and it is important to note that CE certification is required for an individually built PC. While it is true that the European EMC Directive applies to all electronic equipment, whether 'placed on the market' or 'brought into service' (without being first placed on the market), the requirement for CE marking, and hence declaration and subsequent testing, is necessary for any product displayed in public. Other words, your PC is built at home is subject to the regulations but you are not required to demonstrate that is does.

In effect the Directive enforces the 'Power that be' so that if you are causing a problem - you need to fix it at your own cost. Otherwise, it only requires you to not knowingly cause a problem.

John comments that he has had PC suppliers respond to his querying PC EMC performance by saying that 'all the parts were CE marked'. It is important to understand that this is not a defensible position on behalf of the manufacturers. At the very least they should be able to demonstrate 'Declaration of Conformity' from the manufacturer of the component, and to the Declarations which CE marking represents actually covers the requirements that the PC manufacturer needs to verify.

The classic example for this is the power supply module. Within the context of the EMC Directives this is treated as a component, not a product. As a component, it is exempt from the EMC Directive, but in some cases the 'Low Voltage Directive' (think of that as the safety directive).

The power supply has to have CE marking affixed to it (however, compliance with the safety requirements, but this says nothing about its EMC performance). The onus is on the PC manufacturer to place a CE marking on the power supply module that the power supply should be designed so that when the PC manufacturer affixes CE marking to the PC that the EMC requirements will be met.

Let's break down the scenario in more detail.

In the May issue, Robert Atkinson rightly picked me up on a statement I had made concerning the EMC requirements for home-built PCs. I had said "I built my" meaning that I built my own as an enthusiast, building as my hobby. However, the comment was made about all PC builders, so it is important to note that CE marking is only applicable to CE marked parts. It is not the case that all parts are CE marked.

In the Masterclass column, I mentioned the use of riser cards, which are often used to connect PCI cards to the motherboard. I made a comment that these cards are generally unshielded, and this is not correct. Some riser cards are shielded, and these should be used in place of unshielded riser cards.

About valve substitutes

In the May issue's letters column, Ralph Poole asks anyone interested in commercial solid-state valve substitutes when he was an engineer and is now a manager, in 1977, to contact him. He then notes that the diode finds its way to the left terminal of the power supply, to the negative pole of the Li-ion battery.

In the May issue of Electronic Letters, the column "High-voltage amplifier" was written by Arni Ingars's letter in the May issue regarding the high-voltage transistor power amplifier to drive loudspeakers using field-effect transistors. However, if you want to run a 25 VHT line then you would require a special output stage, which is designed specifically for this purpose. These transistors are designed to operate at this voltage, and they are not suitable for use in the output stage of a power amplifier.

The current solution involves using a commercial high-voltage amplifier, such as the one designed by Arni Ingars, which is capable of driving the loudspeakers at the required voltage without overstressing the transistors.

Get in Linux

Regarding John Jameson's letter in the April issue, I can understand being in the midst of a programming project myself. But there is an alternative that may please your readers, regardless of their current projects. There are two related projects, Wine on Linux and Odin on OS/2, that are API redirecters/replacements. These allow Win32 programs to run on their respective host systems.

While their drivers are available in progress, they still require Wine 9.7.3 and/or Windows 98/2000/XP/MNT programs to run.

I have Mr Jameson's Protos electronics design running on a preview version of eComStation these are the upcoming versions of OS/2 - with a daily build of Odin. Is it perfect? No. I have to manually refresh sometimes, as it is not updated automatically, and panning by moving the mouse while holding down the shift key doesn't work. It's a bit hit-and-miss, but it's something.

Some new motherboard cards, hard drives, ram, processors, etc., to a Pentium III. Only the monitor and sound card are really original in fact! At least I had enough inside knowledge to buy a new case with decent EMI protection. However, what about poor Joe Public? (Joe is not required to produce a certificate of compatibility to build a pc, and yet can buy all the boxes to do so. The only unambiguous path if Joe Public wants to have a safe, reliable, low-threat system is to buy a case and power supply that have been approved by a recognized testing house. Joe Public needs to know that he can be prosecuted for buying non-C markable relevant equipment? Do you not think it is a waste of time and effort to produce the 'Declaration of Conformity'? I hope you do.

Many people are using these machines for their own computers. I hope you do not think it is a waste of time and effort to produce the 'Declaration of Conformity' that is how safe you are connected to the cathode.

Peter Roberts

Mysterious EMC

I would like to commend Ian Darsney on his attempt to demystify EMC in the May 2001 edition of Electronic Letters. The idea that the Maltese Cross is a symbol of evil seems untenable. It can be heard by creating leakage currents to flow. If a piece of metal is touched to the solder securing the voltage holder, the print to melt. The only option was to replace the Fig. 7.

The solid-state replacement modules were supposed to be cooler running, and used a 982 JFET module. The module was initially built on a 82A plug and intended to be quite an efficient plug-in replacement.

Unfortunately, describing his high-

voltage transistor power amplifier to drive loudspeakers, using field-effect transistors. However, if you want to run a 25 VHT line then you would require a special output stage, which is designed specifically for this purpose. These transistors are designed to operate at this voltage, and they are not suitable for use in the output stage of a power amplifier.

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At every point on the image conductor a potential exactly opposite to that on its real counterpart and a current equal in magnitude and flowing on the opposite direction is visualised. If you now consider the electric field that exists between this image conductor and the real conductor, it will be at a potential of zero midway between the conductors throughout their length. This confirms that there is no potential difference across the ground plane.

Indeed it is actually the need to fulfil the requirement that there be no potential across the ground plane that leads to the development of the image representation. It is also incorrect to assign the image inductance and resistance values to the current flowing in the ground plane. They do have to be assigned to the image conductor, but only along with assigning an image voltage source and load resistance hence maintaining the resultant current flow in the real conductor to the same as it would be if there were a short circuit between the ground plane end of the load impedance and the ground plane end of the conductor.

is in fact saying that the return current flowing in the ground plane is restricted to an area immediately beneath the conductor — at high frequency only. This would suggest some inductance associated with this flow, but not equal to that of the forward conductor. It may well be that Ian has experienced voltage drops between points designated as ground. If so this represents an inadequacy of the ground plane and in these circumstances the image representation would break down.

A particularly important property of the ground plane is that it should be continuous under the forward conductor’s path. Any break in the ground plane continuity will force the return current to take a path other than directly under the forward conductor this can greatly increase the area enclosed by the forward conductor currents and hence compromise the EMC performance.

At first I was surprised to read Ian’s recommendation that the situation with a conductor over a ground-plane be improved by connecting a ground return wire in parallel with the ground plane. In my mind’s eye I visualised a conductor running, say, 4in (200mm) over a ground plane with source and load connected. I then envisaged laying a conductor from ground plane end of the load across the face of the ground plane to the ground plane end of the source. I am pretty sure that a negligible current would flow in this wire. It would be easy enough to check this with a suitable set up including an A current probe if someone wanted to try it.

It then occurred to me that Ian probably intended that the return conductor be run immediately adjacent to the original conductor and not along the ground plane. The effect of this is indeed interesting. This second conductor now forms a short circuited secondary of a transformer in which the original conductor is the primary. As a result a current will be induced in this conductor opposite to that in the original conductor hence generating an opposing radiated field and reducing emissions (and by reciprocity improving immunity).

The effect will be limited by the effectiveness of the coupling between the two conductors. If perfect there would now be no current flowing in the ground plane at all. Indeed the effectiveness would be improved by connecting the ground plane at the load (or source) end and so forcing all the return current through the second conductor. A further improvement can then be achieved by wiring the two conductors together.

Could I appeal to Ian to consider writing a further article—or the editor to refer an excellent article on such exists—dealing with the importance of the areas being enclosed by the loops formed by forward and reverse connections from source to load? Visualising these can be of great help in understanding what reduces emissions and improves immunity.

Philips Williams BSc:CEng.
Harlow
Essex
Via e-mail

Self on Audio

Douglas Self

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