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Leisure Warwick takes a look at the current state-of-the-art in digital still-camera technology.

INTERFACING WITH WAP
Les Hughes explains how you can control equipment remotely from your WAP mobile phone – or any other WAP kit.

PHONO PREAMP FOR THE CD ERA
Norman Thagard’s meticulously designed phono preamplifier features a high-level output compatible with most AV systems and receivers. And it has a noise figure of around 5nV/Hz.

DESIGNING WITH DSP
Patrick Gaydecki describes how to design and program real-time digital signal processing systems from the ground up.

INFRA-SPRINT TIMERS
You might need a precise sprint timer, but Simon Bateson’s microprocessor design provides interesting tips for anyone involved with battery operated infra-red transmitters and receivers.

NEW PRODUCTS
New product outlines, edited by Richard Wilson

LETTERS

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● Better model racing-car controller
● Bipolar voltage stabiliser
● Uses for CMOS switches
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● Versatile flasher
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CURRENT COMPETITORS
II
Giuseppe Perret et al explain how current converters can produce rail-to-rail output voltage swings even when running from a supply as low as 1.2V.

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RANDOM MEMORIES
All A. Particle looks at a down side of the Trans European Trunked Radio system.

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Fernando Garcia explains how you can display a transformer’s hysteresis curve on your digital scope.

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Upwardly mobile?

H ow we hurry mob by tax payers cheered last year when Gordon Brown raised £23bn from the third-generation (3G) mobile licence auction. Here was tax revenue that did not come directly out of our pockets or cheque accounts, but at the petrol pump.

However, it now seems that the mobile phone industry is facing the 3G crunch. On the one hand the mobile operators are desperate to get new high-speed data and wireless Internet services into the market as soon as possible. At the same time, however, they are being told by network infrastructure firms and handset developers that 3G generation (3G) mobile technology will probably take longer than first anticipated to appear in commercial products.

If we go back a couple of years or so, the experts were predicting that 3G mobile handsets would appear by 2002. Whether the operators believed that date or not, they are now facing a very different prospect.

"3G handsets and services could be a long time coming," says Steve Baker, a mobile communications specialist at TTPcom.

The worst case situation being suggested is a launch for 3G services in 2004 or later. On the other hand at least one semiconductor supplier is confident of a launch a lot sooner. "Customers have orders," said Jean-Pierre Demange, director of Texas Instruments' wireless infrastructure business unit. "Our customers are currently in the design phase, with full production expected next year. But we also have orders this year for 3G deployment."

Despite this pessimistic prediction at least one mobile operator has publically questioned the logic of paying big money for a 3G licence. Concerns over the cost and availability of 3G mobile systems based on the UMTS standard are behind Bouygues' decision not to bid for a 3G licence in its key market of France.

Bouygues, which is the third largest mobile operator in France with 5.2 million customers, is the first operator to admit serious doubts over the availability of 3G infrastructure and network information and hence the timescale for the launch of 3G services.

It would seem that the reality of waiting until 2004 at the earliest to launch the mobile multimedia services promised by 3G systems is no longer attractive to Bouygues, and perhaps other operators also.

This is especially the case given that there is an alternative in the GSM upgrade technology, known as GPRS, which is much more close to commercial services. GPRS will be supporting mobile Internet services in the UK and Europe later this year.

"GPRS will be a standard fit on GSM handsets within 18 months," says TTPcom's Baker. That would support data rates of around 100kbit/s to your mobile phone.

That is easily enough to support reasonable quality compressed video (50kbit/s) and significantly better than what is currently possible with GSM.

And when the next enhancement technology known as EDGE comes along in 2003, 200-300kbit/s data rates will be possible.

The late arrival of 3G technology and services is not a possibility being considered by everyone in the mobile phone industry. Semiconductor supplier, Texas Instruments, is confidently portraying a rethink of the first 3G networks in Japan this year and in Europe in 2002.

"There is no delay in 3G deployment as we see it," said Jean-Marc Chevalier, business development manager at TI.

This comment will carry considerable weight in the market particularly as TI has confirmed orders for 3G UMTS wideband-CDMA (WCDMA) developments with six manufacturers including the world's biggest Ericsson, along with Nortel Networks and NEC.

The first volume 3G basestation orders will come from Japan, where operator DoCoMo will launch first commercial services in May. In Europe, Spain will roll-out 3G services this year with other operators, including BT in the UK, following next year, according to TI.

"We are seeing orders for 3G basestation deployment in the second half of 2001 for launches in Spring 2002," added TI's Demange.

The question remains however, is Bouygues is the only operator with concerns about the commercial attractiveness of the 3G mobile concept?

In the UK it is worth noting that five operators have already collectively paid £23bn for their 3G licences.

Building networks will add a potential £10bn to figure to that collective investment before first commercial services are possible.

It could be as long as four years before operations like Vodafone, Orange and BT/Cellnet see any income from their already substantial 3G investments.

New eith Bouygues is playing a very clever political game with the French authorities or it genuinely believes that 3G as currently proposed does not make commercial sense.

If it does not make sense for the French operator, there is a real possibility that it will not be that commercially viable for the UK operators, who are already running up debts in order to finance their long-term commitments to launching 3G services.

It is perhaps too early to say, but within six months we will know for sure whether the French are crying wolf over 3G. If they are not, and there is some logic in what they say, then there may be some very serious fallout in the UK's mobile sector.

Let's hope that Bougyes £23bn figure really does turn out to be a waste price paying.

Richard Wilson

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April 2001 ELECTRONICS WORLD 243
Europe could overtake US in driving chip growth

Europe may become the future engine for world semiconductor market growth rather than the US, according to a report at IPS2001, the annual briefing on the chip industry from Future Horizons.

"One of the problems the US is struggling to come to terms with is its dependency on the PC and computer industries when the rest of the world has moved away from it," said the chairman of Future Horizons, Malcolm Penn. "The US has known no difference in the whole lifetime of the transistor, but computers are now becoming like calculators - they're just a tool." Future Horizons reckons that Europe will become the main driver of high-tech markets because its skills are more converged than in the US. "Europe drives the mobile phone industry and never gave up on consumer - while the US gave up on consumer products," added Penn. "Japan may have the edge in consumer, and the US in computers, but Europe has all three. That makes Europe unique."

The recent downgrading of semiconductor market growth has been led by US analysts, whereas the vice-president for European operations at Datqueshi, Joe D'Egia, reckons that there is not the same pessimism over here. "In my water I feel it's not going to be a bad year for semiconductors - nearer to 20 per cent growth than ten per cent," said D'Egia.

In broadband wireline, the US will fall behind the rest of the world this year with five to six million DSL subscribers compared to the rest of the world's nine to 11 million subscribers, according to newsletter DSLPrime.

Leading world supplier of DSL equipment - Alcatel of France - recently announced 41 per cent growth in telecommunications equipment sales, whereas analysts expect Cisco Systems, US No 1 in communications equipment but currently suffering its worst ever quarter, to achieve between zero and two per cent growth.

Samsung develops 4Gbit/DDR SDRAM

Samsung is announcing the development of a prototype 4Gbit, double data rate, synchronous DRAM at this year's ISSCC.

Manufactured using a 0.10µm process, the chip-scale packaged device measures in at a monstrous 64x52mm² - exactly one square inch. Central to the operation of the circuit is a twisted open bitline architecture.

In a traditional DRAM architecture, such as a folded bitline, the wordline operation generates noise inside and between bitlines. Techniques to counter this are available, but they tend to overly increase chip area.

Twisted open bitline takes the sensing pair of bitlines (the bitline and its inverse) and swaps them over as they pass across the sense amps in the middle of lines of memory cells.

In a conventional folded bitline scheme there is some 17mV of coupling noise, which is reduced to just 3mV in Samsung's twisted scheme. In order to improve the sensing speed of the cells, a pre-sensing scheme uses a linear transconductance amplifier. This can knock a few nanoseconds off the 10ns charge sharing time before the sense amplifier is activated.

Zinc-air cells give instant power

Zinc-air cells have hit the mainstream with Electric Fuel offering batteries for mobile phones and PDAs. Called Instant Power Battery (£9.99), the disposable 3.3Ah devices can power the phone directly or recharge the phone's own battery up to three times through the Instant Power Charger (£19.99), said the company.


Integrated passives built into PCB

Integrated passive components (IPCs) for consumer devices may come out of University of Arkansas research. Scientist Rick D'Elia has been developing thin-film IPCs for military, aerospace and supercomputer applications at the University for nearly a decade. Apart from "some short-term issues" remaining, he sees lack of industry infrastructure as a primary problem for commercial IPC use. His are built into the surface of a circuit board as it is being made rather than older thick-film-on-ceramic construction.

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**Miniature robots “work together in swarms”**

Sandra Labs in the US has “possibly the smallest autonomous unpowered robots ever created”, according to co-developers Doug Adkins and Ed Heller.

It occupies 4cm³ and weighs under 3g. Powered by three watch batteries, it rides on tracked wheels and has an 8kbyte ROM processor, temperature sensor and two drive motors. "They will be able to work together in swarms, like insects. The miniature robots will be able to go into locations too small for their larger relatives," said Sandra.

The mini-robot has already manoeuvred its way through a field of posts at half a metre per minute.

**Colour imaging for 3G mobile phones**

A colour imaging system suitable for 3G mobile phones has been demonstrated by STMicroelectronics at this year’s ISSCC in San Francisco.

Engineers at the firm’s Scottish image sensor division, formerly Vision, combined the 0.5um sensor with a 0.18um co-processor.

The module provides CIF 352 by 288 pixels resolution at 15 frames/s. Power consumption is claimed to be just 50mW.

ST’s camera is interesting in that it uses different technologies for the image sensor and coprocessor. Keeping the coprocessor die size down and having two die seems to be cheaper than integrating everything in a single die.

Both devices are mounted on a ceramic substrate. A plastic lens is also mounted on a cavity in the substrate. The complete device measures 10 by 10 by 7mm and works from a supply of down to 2.6V.

The CMOS image sensor is built using a two-poly, three-metal 0.5um process. The three transistor sensing element and conversion produces 10-bit, progressive scan Bayer pixel data.

This data is fed to the 4.5MHz co-processor which produces a full colour image. Digital anti-aliasing filters are used to remove the stripe patterns and aliasing that affect Bayer patterned images.

Another potential problem for camera is flicker from mains fluorescent lighting, at either 100 or 120Hz, depending on local standards. This can result in unsightly bands sweeping down the image.

To determine the lighting frequency, two column height ‘super-pixels’ detect lighting variations. This can be used to set the exposure controller to coincide with the lighting flicker.

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April 2001 ELECTRONICS WORLD
Engineering employers fail to meet recruitment target

A Government report on skills shortages says that a significant number of engineering employers are experiencing recruitment difficulties.

Skill shortages are especially apparent among professional engineers and the skilled trades, including electronics and IT skills.

The report is the first in a series from the Government dealing with the issue in various industries.

"While the electronics industry is predicted to grow by eight per cent each year for the next five years, more than half of electronics recruiters reported difficulties in meeting their targets," said Lifelong Learning minister Malcolm Wicks.

Researchers from MIT's Lincoln Laboratory have constructed two layer ICs - a technique that can overcome many of the problems associated with large area ICs and multi-level interconnect.

Stacking active devices vertically allows for shorter overall interconnect, reducing capacitance and hence propagation delays.

One test circuit fabricated by the lab is a CMOS active pixel sensor, with parallel analogous-to-digital conversion on the second layer.

Polymer LEDs are "better than conventional"

Polymer LEDs may outstrip the efficiency of conventional types, claims research from the University of Utah.

Physicists previously believed that no more than a quarter of the energy flowing into an LED could be emitted as light, with the rest radiating as heat, and university physics chairman Valy Vardeny explained that the electrons and holes have different spins which prevent all potentially useful recombinations being emissive.

Vardeny's measurement, however, shows that 41 to 63 per cent of the energy can be converted into light either 2.7 or 7.5m deep. At 6m square, the two vials have comparable resistance, around 0.85E6.

The active pixel sensor circuit contains 4096 vials.

Also fabricated using the 3D technique were ring oscillators, in which each inverter in the ring was fabricated in an alternating layer. At 5V, there is no difference in propagation delay between 3D and conventional ICs, under 1ns.

But at lower voltages, down to 1.5V, a difference emerges, with delay per stage of 10ns for the 3D design and over one fs for a planar layout.

Polymer LEDs were used for manufacturing polymer and oligomers under the influence of microwaves.

Vardeny's team, at institutes in the USA and Canada, tested different light-emitting materials in a magnetic field at super-cold temperatures. Lasers (instead of electricity) caused the materials to emit light. Some of the material emitted more light than they would have otherwise.

Vardeny's theory is that the microwaves randomise the spins of the incoming electrical charges so they combine more quickly, boosting the number of recombinations that emit light.

"We succeeded in fooling quantum mechanics," he said. "We did not break any laws of physics. We just fooled them."

The team is now seeking a method of doping microwaves to remove the need for microwaves.

Alan Mapleson, who won a Nobel prize for polymer semiconductor research, praised the Utah study as "nice work".

Steve Bush
Leslie Warwick takes a look at the current state-of-the-art in digital still-camera technology.

DIGITAL CAMERA

A s the digital still-camera market continues to develop apace, some interesting technical developments have come to light. In addition, a few professional features have started working their way down to consumer level products.

One of the notable technical developments is the so-called 'megapixel' sensor - an image sensor with a million or more pixels. In 1998, the 1 Megapixel was the news; 1999 it was the 2 Megapixel. Last year it was 3 Megapixel.

Of course the more pixels there are, the greater the resolution; but the ultimate image quality depends on more than just the quantity of pixels. This is one reason why professional cameras are more expensive. 'Megapixel' is also a slightly misleading term. Virtually all cameras have just the one sensor and require three filtered pixels to make the one full colour element. Additionally, the pixel figure quoted may well include optical black pixels. These are employed to sense variations in black level caused by temperature-induced changes in black (residual) current Fig. 1. This means that a 'megapixel' may not be much more than 300,000 pixels in terms of real resolution.

At the opposite extreme, Olympus has produced a medium-format camera with three 2048×2048 pixel sensors - a total of 12.6 million! At 8-bit full colour depth, this produces a file of about 25MByte per image. The SHD-S1 prototype system consists of a camera body, lenses, computer board and software. There's also a large, pivoted LCD monitor for mounting atop the camera. Liquid-crystal monitors on cameras have become notorious for draining batteries. In an attempt to combat the battery drain problem, Sony has launched the digitalCam 400, which has added solar power.

Virtually all consumer/business cameras have now followed professional practice. They use sensors produced specifically for still imaging, rather than borrowing them from video cameras, whose mass production has made them cheaper. This gives the latest cameras some advantages: square sensor pixels that match the square pixels of computer monitors, rather than rectangular video pixels; and progressive scanning instead of interlace.

Electronic shutter

It is also commonplace for consumer/business cameras to have an electronic shutter in the sensor, rather than a conventional electromechanical type. When the camera's shutter is not for first speeds, the charge-carrying electrons are allowed to drain away from the pixels until the last, say, 1/500 second. They are then integrated for that pre-set time and read out.

An electronic shutter has no moving parts, so shutter times can be very brief indeed - up to 1/20000 second at present. In practice though, more modest speeds are the norm. For slow speeds the charge integration is continuous over the pre-set time.

Because most image sensors have a fairly low sensitivity, equivalent to ISO100-200 films, all consumer and most business cameras have a built-in flash. Cameras have also begun to appear with a flash-synchronisation socket.

Minolta's new Dimage E1500 will have an adapter for external lighting; later this is made possible by its being the first upgradeable camera - which includes the possibility of replacing the 1.5 megapixel CCD. This is because the lens portion of the camera - including CCD - is detachable.

At present, the only alternative is a wide-angle lens unit to replace the zoom one. However, the EX Digital Bus offers a variety of expansion possibilities; as well as the facility to use a 1.5m lens extension cable - a feature first seen on an earlier Minolta model.

In addition, the Digital Operating Environment enables the camera's firmware to be updated from a flash card, to give new functions and additional performance.

CMOS sensors

Until now, all production cameras have used a CCD sensor, but Sony has launched a basic camera with a CMOS device. A unique colour filtering arrangement is used, involving red, green, blue and red (greenish-blue), which is said to improve the tonal separation. This is only one of a few cameras that has a professional 30-bit colour depth instead of the usual 24-bit. The 80000 pixels of the CMOS can be increased to a processed resolution of 3 megapixels by interpolation. Images are normally compressed for storage; generally by the Joint Photographic Experts Group (JPEG) system. Most cameras offer two or more different compression ratios to provide a choice between image quality and quantity. Some are now following professional practice though by also providing a 'no compression' mode. The standard resolution is 640×480 pixels; but many of the latest cameras also provide much higher resolutions.

Until recently, most consumer/business cameras had an internal flash memory while professional models had removable memory - usually PCMCIA hard disk or flash card. Now, most of the former have bowed to user preference and have either a combination of both, or removable memory only - in this case small flash cards.

Sony's cameras though take a normal 3.5in floppy disk. The company has reintroduced the MAVICA name Magnetic Video Camera - originally used in 1981 for the world's first still-camera prototype. This was capable of recording fifty analogue video images on a 2in floppy disk, and inspired the short-lived Still Video format.

For those who need to store large numbers of images in the field, Olympus has developed the 'clam'. This is an interface between the company's cameras and their portable 3.5m magneto-optical drive.

Companies like Peak Development and Premier Electronics have a range of PCMCIA adapters for flash cards, and internal and external card readers for computers not thus equipped.

Many cameras can directly download images to a computer through a parallel or serial interface - even those taking cards. Some of the latest models use the universal serial bus USB, formerly confined to professional cameras. This medium-speed bus allows connection and disconnection while the computer is running.

Cameras have also appeared with an infrared

DEVELOPMENTS

Fig. 1. Arrangement of the optical black pixels around the imaging area of a CCD. These act as a reference to prevent black level varying with temperature.
Olympus pioneered the direct camera-to-printer interface for those who don’t want to mess about with a computer. Note also the flash card slot.

Fuji’s combination camera and printer using instant film. And the mini-printer using the same technology.

Camera-to-printer interface

Olympus has produced cameras capable of interfacing directly with the company’s own printer. Other companies have followed suit, bringing out cameras that interface to their printers. But now, cameras are appearing with a ‘multi-printer link’ facility. This is useful, because the choice of printer can make a considerable difference to the print quality. Printers are also appearing with a flash card slot.

Fuji has taken the idea a step further, showing a prototype that combines the company’s digital camera and instant print technologies. Called the Digital In-Printer camera, this system employs Fuji’s new Instax Mini ISO 800 silver halide instant print film and a vacuum fluorescent print head. The prints are only 5×6.5mm (46×63mm image), but the images are filed on a flash card for other uses.

Fuji has also demonstrated the similarly small and light Digital Instax Mini Printer. This accepts flash cards, and has parallel and infrared interfaces.

It was Fuji, incidentally, that first developed a digital camera – the DS-1P prototype, shown in 1988. The company has recently launched the MX-2700 – the first camera to have a CCD aspect ratio of 3:2. A joint development with Matsushita, this CCD is designed to provide a standard size of colour print from the new ‘digital minilabs’ that produce prints from either computer files or films.

This camera is also one of the new 2+ megapixel types, with a resolution of 1800x1200. It can produce photographic quality prints up to 8×12in.

The CCD actually has 2.3 million pixels, not 2.16, but it is masked so as not to record the noisy pixels at the edges. Matsushita has introduced a model with a 16:9 mode – 1136×640 pixels – under its Panasonic brand.

Digital invert for standard cameras

Image has revived the idea of a digital invert that can replace film in a 35mm single lens reflex (SLR) camera. This allows images to be made electronically or chemically according to need. There are two parts to the EPS-1 prototype – a pod for the main electronics, which fits into the camera’s cassette chamber, and an extension piece. This extension lies in the film path to place the image sensor in the film gate, where it is held in place by a pressure plate.

The image sensor is a 1.3 megapixel CMOS type. Because it is only about half the size of a 35mm frame, the focal length of lenses is effectively doubled. A resolution of 1280×1024 pixels is quoted, with 36-bit colour depth.

Sensitivity of the CMOS sensor is equivalent to ISO 100 film, although it is planned to increase this figure for subsequent products. Exposures can be made at the rate of one every two seconds.

There’s room for up to 24 images in the adaptor’s onboard flash memory. Downloading in the field to a flash card is possible via the an ‘e-port’. An ‘e-port’ provides both a protective housing for the device and a PCCMJ/USB connection for downloading to a computer. Initial production will cater for the Canon EOS 1N and EOS A25, and for the Nikon F5, F3 and N90S/P90.

Digital backs

There have been rumours that the major SLR camera manufacturers are developing digital back add-ons. All the up-market SLR system cameras already allow a data back to be substituted for the standard one so it would make sense from that point of view.

Retro-fittable backs would allow the interchange of information between the back and the camera body, and achieve the precision that could not be guaranteed with a device that simply replaced the film cassette. But, mainly, it would tie users to a particular SLR system.

In the medium and large format markets, the situation is the reverse. Here, virtually all the backs are made by independent companies and adapted to different makes of camera.

Whether the more up-market SLR backs will have a condenser optics system to widen the angle of view has yet to be decided, and it is likely that a 35mm format lens will be used, as Fuji and Nikon have cameras that accept their own SLR lenses.

Figure 3 shows how the optical arrangement relays the image to the smaller CCD. This has the incidental advantage of concentrating the light, allowing a maximum ISO equivalent of 1000.

Some cameras can record a few seconds of digital audio with each image. This is not something that is catching on in the consumer market, but business and professional users are finding it helpful to record details of the subject or its environment. There are also cameras that act as MP3 players.

Sony has created the ‘video clip’, enabling up to 5, 10, 20 or 60 seconds of images with sound to be recorded at 10 or 15 fps depending on the resolution and model of camera. Resolution options are 320×240 and 160×120 pixels, using Motion JPEG compression. There is also a higher quality fast sequential slot mode to record a burst of frames, but without sound.

Two of Sony’s Mavica models record up to 60 seconds of MPEG-1 compressed images. A number of other cameras also offer some sort of burst recording facility. They have a buffer memory to hold the uncompressed images, because the processing times are still in the order of seconds.

Camcorders for stills

Both the Digital Video and new Digital8 camcorder formats have a ‘photo shot’ recording facility in their specifications. Camcorders have already begun to appear with flash memory for single image recording. Camcorders with a single CCD do not have the resolution to compete with the megapixels CCDs of still cameras, despite a growing number that can be switched between interlace and progressive scan. But the results are quite adequate for computer use – and their moving images are at present far superior to the attempts of still cameras.

And finally there is the Sharp Internet ViewCam. This is the first to use MPEG-4 compression to record digital video on a flash card – one hour on 32MbByte. It could well take over from still cameras for some computer uses.
Interfacing with WAP

Les Hughes explains how to start developing software that will allow you to control equipment remotely from your WAP mobile phone – or any other kit designed around the wireless applications protocol.

In my articles on Java1-4 I looked at some of the more exciting developments in Internet technology and how they can be used to interfacing to real world devices. Perhaps the most exciting “development” of all is the convergence of telecoms and mobile computing. Small, personal computers (PDAs) are becoming cheaper, more powerful and more network aware, while mobile phones are starting to appear with the same operating system and features as some PDAs!

Although much progress has been made in the area, things are still quite primitive. Wireless application protocols, or WAP, devices are basic to say the least. Furthermore, with the advent of faster mobile networks later this year – GPRS, iMode, etc., coupled with more powerful devices able to cope with richer content, WAP may prove to be a short lived “standard”.

However, this is all academic. The use of a WAP device for Internet-based control is achievable today.

Behind the scenes

First I’ll examine what happens behind the scenes of a typical WAP session.

In many ways, WAP Internet access is no different from ‘normal’ dial up. You simply make a data call to a service provider. Then, instead of starting Netscape or IE5, you use a WAP browser to request web pages.

Usually, this browser will be integrated into a mobile phone such as the Nokia 7110, but there’s nothing to stop you using a PalmPilot, such as a PalmOS or WinCE device, or even a PC WAP aware browser.

Although some WAP browsers – notably those running as applications on a PC – are sophisticated enough to directly access WAP sites, on the whole you will need to talk to a WAP gateway in order to receive pages. A gateway can be thought of as a proxy. If forwors your WAP requests as a standard HTTP ‘get’ or ‘post’ command to a web server – Apache or the like – and encodes any responses before sending them back to you.

Since this gateway merely acts as a go-between, any web-server-side techniques can be employed in order to generate dynamic content; jpeg, php, servlets, etc., depending on the web server and application.

While the gateway uses HTTP to talk to a normal web server, it doesn’t expect to receive standard HTML pages. Instead, WAP has its own markup language, WML, which is short for wireless mark up language.

WAP mark-up language – WML

WML is an extensible mark-up language implementation. The term extensible mark-up language is usually abbreviated to XML.

Newcomers from an HTML background may find WML’s strict syntax something of an annoyance. HTML browsers often happily accept malformed markup – unordered tags, incorrect nesting, etc. – doing their best to display the page. Extensible mark-up language on the other hand allows validating parsers to reject invalid markup. As a result, authors should always run their code through a validator before publishing.

Wireless mark-up language files are termed ‘decks’. A deck comprises a number of ‘cards’. Each card represents a screen of information.

Because WAP currently runs at 9600 bits, this multi-page-per-file approach reduces the number of times that the browser has to connect back to the server in order to move through a site. But any dynamically generated content based on user input will result in the browser reconnecting to the server anyhow. Also, the device imposes a limit on the amount of information in each deck.

WML supports basic formatting – paragraphs, bold, etc. – and simple monochrome images in the WAP bitmap format WBMP. User input is managed in a similar way to HTML through the use of forms, check boxes and the like, while basic scripting support is provided through WMLScript.

Software/hardware

In order to start experimenting with WAP you’ll need to create a suitable development environment.

Figure 1 illustrates some of the various configurations. As the diagram shows there’s a number of options depending on the hardware, software and Internet/private network connection available. Figure 2 should help you decide which pieces of infrastructure you’ll need.

For those without a physical WAP enabled device, Nokia, Motorola and others provide basic WAP tools. The Nokia SDK includes a WML editor/validator, basic WAP bitmap editor and two WAP phone emulators including the 7110. Since this device requires a gateway, the SDK includes a simple gateway that automatically starts when using the 7110 emulator.

For simple WML development, an SDK is all you really need. However, if you want to really go to town and establish a full-blown development environment for use with a physical WAP enabled device (7110, etc.), you will need a gateway, a web server to generate content and a dial up server and a modem in order to gain access to the system.

In terms of actual products, Apache is now the world’s most deployed web server – freely available for Windows & Linux. Windows RAS or Linux PPP can be used to provide dialup access depending on your favourite operating system. Both of these products are bundled with the OS. A freely available open-source WAP gateway comes in the form of Kannel for Linux, although other free gateways are available for Linux and Windows.

What do I need to get started?

The combinations of real devices, emulators, browsers, protocols (WAP, HTTP) and language (HTML, WML) support makes a definitive answer to this question difficult.

For example, some newer devices have dual HTML/WML browsers than can talk HTTP directly to a webserver, removing the need for a gateway. Some PDA applications can go via a gateway or direct and use either a dialup connection or plug straight into a network.

Broadly speaking, the flow chart in Fig 2 should help you decide what infrastructure you need. The simplest approach is to use an emulator or a PC talking directly to a webserver – Apache for example – on the same PC.

Of course, we are discussing WAP based control and therefore, at a minimum you will need a TINi and a PC plugged into a network and a WAP browser/emulator. See reference 4 for details of installing TINi.

Fig. 1: There are various ways of developing WAP applications. The one you choose will depend on what hardware, software and networking options are available to you.

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It is quite a lengthy task to establish a professional quality development environment. But it is encouraging that all of the tools required are available for little or no cost and can all run on a single, reasonably powerful PC.

Remote control via WAP
Once you have your environment up and running, you are ready to start experimenting. While basic WAP is interesting enough to experiment with, on its own, remote control of devices over WAP opens a whole new area. Internet monitoring and control of devices can be easily achieved through the use of an embedded web server and some server side technology, such as Java Servlets. Indeed if you’ve been following my earlier articles, you may have already hooked up some devices to the net using an HTML interface. All you need to do is to produce and process WML instead of HTML and suddenly you have a WAP-enabled system. You could even design a servlet that can detect whether it is talking to a WAP browser or HTML browser – or digital TV, etc. – and adjust the produced content accordingly. This is called multi-channel delivery in the business.

WAPFlash – a high-tech ’helloworld’
So, by using a number of components such as the embedded TINi controller and Java servlets, you can now build a simple proof-of-concept application that will enable you to turn an LED on or off via WAP.

In such a system, a WAP device or emulator might talk to TINi via a gateway, depending on your development environment. Whether or not the LED should be lit would be indicated through the use of WML ‘postfields’ – a form element in HTML speak. TINi will process this input and set an LED accordingly.

For this proof-of-concept application is contained within a simple Java servlet. List 1. This servlet has a doGet method that sets or resets an LED on the TINi board depending on the ‘action’ parameter sent by the WAP browser. This servlet produces some WML that reflects the current state of the LED and provides the functionality to control the LED.

The servlet should be compiled into the TINi servlet engine and deployed following the instructions provided with the engine.

At this point you can either use the Nokia tools to talk directly to your TINi from a PC connected via a network or, if you’ve opted for using an actual WAP device, via dialup and a gateway on your network. Your WAP/Servlet should be listening out at:

http://123.456.789.000/servlet/WAPServlet

where 123.456.789.000 is the IP address of your TINi.

Further development
The simple proof-of-concept application shows how easy WAP control can be given the WAP infrastructure. Actual control and monitoring of real world equipment could be achieved by connecting various single-wire devices to TINi’s 1-wire interface. Such a device is Dallas’s DS2440 parallel I/O interface. Alternatively you could use TINi’s CAN and PC buses. As part of my full-time job, I have recently installed a demonstration system using these devices. It is a WAP-controlled soft-drink vending machine incorporating real-time fuzzy-fry radar temperature telemetry.

References

Fig. 2. There are various ways of implementing a WAP-based telemetry system.

What is TINi?
TINi is a tiny controller from Dallas Semiconductor designed for Internet connection. Although very low cost, this controller is a complete computer with Internet, network and serial I/O capability, giving it a huge potential for remote I/O and telemetry applications.

All of the software required to develop applications for TINi is available free of charge from various Internet sites, installing and configuring your environment in order to get TINi up and running consists of a number of tasks.

Bulleau Fournier’s excellent guide at
http://www3.symptica.co/guillaume.fournier/ describes in detail the process that you should follow in order to be able to boot your TINi.
Phono preamp for the CD era

While I have designed and constructed several audio power amplifiers in the past 12 years, I have, until recently, done much preamp work. I have considered attempting to design and construct a preamp for several years, but I find I am usually occupied to begin a project by need, rather than interest. That is true of the phono preamp designer I describe here.

The need arises

Unlike some audio purists, I have been very interested in surround sound since the early seventies. With the incorporation of the sound system into an audio/video system, I replaced my Knoll preamplifier first by an Adcom and then by a Marantz AV tuner/preamplifier. Unfortunately, as with most modern units, neither the Adcom nor the Marantz had a phono input. Lastly, the Knoll has functioned solely as a pre-preamplifier, that is, as an interface between the phono cartridge and a high-level (Tape 1) input on the Adcom. Having a bulky preamplifier in the system was undesirable though, because I had no more room for additional components in the equipment rack. I wanted to replace the Knoll with a dedicated small phono preamp that I could locate behind the equipment rack.

It occurred to me that I was probably not the only one who might need a stand-alone phono preamplifier that would allow updating the system preamp without losing the phono option. So I finally decided to attempt the design of at least one component of a preamp – the phono stage.

The design presented here allows the phono cartridge to appear as a high-level source that you can input into any of the standard, flat-response, high-level inputs on an audio or video/audio preamp or receiver. The few purists left will appreciate the irony of using the CD input, as I do with the Marantz.

The CD input circuitry in my 1985–1987 vintage Knoll PAM-5 manipulates the signal its manner wary – perhaps to compensate for the interchannel time difference in early CD players – so a tape or auxiliary input might be better in some cases.

I specifically designed this preamp for moving-magnet cartridges capable of at least a couple of millivolts output at 1kHz. With some minor changes, you could probably use it with a moving-coil cartridge.

About the author

Five-time astronaut Norman Thagard was the first American to enter space aboard a Russian rocket for a 90-day mission to the space station Mir. With a total of 140 days in space, he became the most experienced US astronaut ever.

In addition to an MS degree in engineering science from Florida State University, he holds a doctorate in medicine from the University of Texas Southwestern Medical School. Dr. Thagard is currently Professor and Director of College Relations at the FAMU-FSU College of Engineering. An avid audiophile, he designs and builds audio amplifiers as a hobby.

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whence output was 20dB less than this. I make no claims for this, however, because I did not examine this possibility.

Equations

The principle of preamplifier design does not differ greatly from those of amplifier design, the major differences being power and noise considerations. The exceptions are for preamps intended for tape heads and phonos cartridges, which requires not only more amplification (because its output is significantly lower, say, a CD player), but also equalisation.

Equalisation involves tapering the frequency response of the preamplifier in a manner that exactly compensates for the frequency response of the signal at the input. The idea is that the overall frequency response will be flat in the sense that the original spectrum of the signal is maintained in reproduction.

The frequency shaping that may take place in the phone preamp is the RIAA curve. This curve has been the subject of several previous articles. I have liberally footnoted this article with references that contain additional information for those of you wanting more details on this topic.

Equalisation is needed because neither the recording nor the cartridge response is flat. To avoid overly wide groove excursions on the record, the low-frequency components are compressed, while to improve signal-to-noise ratio, the high frequencies are emphasised.

On the reproduction side, a magnetic cartridge is a velocityresponding device. If groove amplitude were held constant, electrical output would be proportional to frequency. To compensate for these factors, response is boosted by a factor of about 10 (19 dB) at the low end and attenuated by roughly the same factor at the high end (19 kHz), which is the reference (0 dB) frequency.

Curve-shaping poles

Sufficiently to say that there are two poles, one at 50Hz and the other at 2.12kHz, and a zero at 50Hz that shapes the curve. There are many different ways to produce these poles and the zero, with different designers favouring different circuitry.

The most economical uses negative feedback around only one gain block, with the feedback network making frequency-dependent output impedance, and high open-loop gain are crucial to proper operation of the circuit.

At 1kHz, I receive textbooks for evaluation from time to time. One of these described a one-stage op-amp, realised by using the folded-cascode topology. It could be argued that a cascode, feedback topology is not a very useful technique. However, from the standpoint of audio-frequency performance, a cascode has all the earmarks of a single, albeit complex, stage. It behaves like a 'super' commonsource stage, with lower bandwidth and lower distortion.

I found a predilection for cascode stages ever since reading an article on the subject by Nelson Pass. My very first amplifier design was a 100W Class-A (with 8x12) tube monoblock that featured four identical cascode stages, including the power output stage.

In 1992 I designed and constructed a balanced-input amplifier. It featured a MOSFET-based differential-in, single-ended-out cascode amplifier. A discrete dual-channel phono preamplifier described here. That design permitted a CMRR of over 65dB at 20kHz. Finally, the Thagard/Pass A75, the design of which was completely Nelson's, but with two identical cascode stages, one with the typical features that I had suggested, offered the option of a folded cascode.

Complementary symmetry

In the current application, using a folded cascode in complementary symmetry results in sufficiently high-open-loop gain. This is because the drain of each common-gate device 'sees' the drain of the preamplifier's complementary stage as its load. From the differential-amplifier input to the single-ended output, gain is given by $\frac{V_{out}}{V_{in}} = R_{out}/R_{in}$ where $g_{m}$ is the transconductance and $R_{in}$ is the load resistance.

If $\beta$ is the intrinsic resistance — call it $R_{f}$ — looking into a JFET differential-pair, the transconductance is very high. Within $R_{f}$ range, $R_{f}$ often ranges from 100kΩ to 1MΩ. Of course, the caveat is that the input of the feedback network does not load the output node, and that is not a good assumption here. The $R_{f}$ is a good feedback network. It is a good assumption here, and that is a reasonable assumption here. Apparently, the JFET transconductances are high enough to ensure that the open-loop gain is also sufficiently huge to overcome any parasitic effects.

I began with the intention of using the LM394 BJT 'superbeta' monolithic matched pair in the differential amplifier. Typically, JFETs have a transconductance that is four to eight times larger than that of a BJT in a given application. Also, the source resistance of a moving-magnet phono cartridge is seldom more than about 1 kΩ, so that a low-noise BJT such as the LM394 actually has an advantage from the standpoint of noise.

To lower transconductance of most small-signal JFETs significantly adds to its noise voltage output. The JFETs in this design use devices that have $g_{m}$ closer to these seen in similar BJTs, so the LM394 noise advantage will be lost. Another entry on the negative side is the input voltage-offsets and drifts are higher in JFETs than in BJTs. The interelectrode capacitances are higher in JFETs, too, but the cascode largely obviates this negative aspect of JFETs.

It was Emo Borbely's article describing the 2SK389/2SJ109 high-transconductance complementary monolithic pair JFETs that changed my mind. For one thing, the noise was lower than that of the LM394. For another, input bias of a bipolar transistor is much smaller than that of the JFET, although the LM394's high beta does result in a respectable result.

Thus, this design is mostly a JFET one. It is entirely JFET-based, if you ignore feedback, and any suspicion that the preamplifier isn't really in the signal path. I believe that this is valid, since, ideally, signal currents could pass through these devices.

Noise

I have never given much thought to noise in my power amplifier designs. Indeed, for years, I have been satisfied with getting a gain-of-ten amplifier that requires an input of 1V in order to produce full power output. This is why one of my designs uses MOSFETs in the interface section. I am a good choice for low-noise operation of the MOSFETs that would be used in a power amplifier.

I believe that this is valid, since, ideally, signal currents could pass through these devices.

Since the recommended load conditions for the V15 Type V MR are 47kΩ in parallel with 250pF, I added 100pF in the form of a C. That is because one use an SME 309 Series II arm with 135pF of cable.
JFETs are coupled, other applications. The temperature coefficient of JFETs requires a knowledge of their pinch-off voltages.

Since pinch-off voltage varies from transistor to transistor, it isn’t possible to predict this design on the zero temperature coefficient. Although we’re able to anticipate the differential amp to achieve zero-offset voltage, the drift was excessive.

In the end, I adopted the same DC servo used by many others before me.  

Even a venerable 1D2741 op amp in the servo gave an acceptably low DC-output offset and drift. However, I’ve added to the almost universal use of the LF411 in specifying that part for this application. Certainly, the LF411 is a good choice, since it is sold as a low-offset, low-drift component.

On the breadboard, the LF411 required bypass capacitors near its power-supply pins, even though the supply rails were already bypassed at the point of entry onto the board. That is why there are two bypass capacitors on the supply rails, one at the output of each voltage regulator and another near pins 4 and 7 of the LF411.

You’re welcome to experiment with eliminating the pin-4 and pin-7 capacitors. I included them on the prototype as a conservative measure.

The 1D2741 did not require additional bypassing.

Be aware that the LF411 model showed considerable low-frequency distortion because of the servo. Increasing the integration and low-pass filter time constant corrected this problem in the LF411.

Since there was so much distortion in the breadboard circuit, I left the components at the same 1MΩ/2200pF values that I have used in other designs. However, it is possible to increase its immunity by increasing the value of C to 1.0 or even 2200pF.

Pipisc permits perfect device matching, so the simulated DC-coupled, scrivous circuit had almost no DC-output offset or drift. This made it easy to determine that the apparent problem was with the servo.

JFET self-biasing

As with vacuum tubes, you can use self-biasing with JFETS. That is the function of resistors R1 and R2.

The target drain current was 3mA, meaning that 6mA should flow through those resistors. At 3mA, the JFET characteristic curve I

<table>
<thead>
<tr>
<th>Capacitance</th>
<th>3mA, 6mA should flow through those resistors. At 3mA, the JFET characteristic curve I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observing on a curve tracer suggested that V(DS) = 0.27V was required. With R1 and R2 at 909Ω, about 0.55V source-to-source would be developed.</td>
<td></td>
</tr>
<tr>
<td>Since the DC gate voltages are fixed at ground potential, the desired V(DS) for both n- and p-channel devices is attained. Consequently, the desired V(DS) is met.</td>
<td></td>
</tr>
</tbody>
</table>
Preamplifiers - one channel only

Resistors - 0.25W, 1% metal film unless otherwise specified.

<table>
<thead>
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<th>Resistance Value</th>
<th>Description</th>
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<tr>
<td>10kΩ</td>
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<tr>
<td>47kΩ</td>
<td>47kΩ</td>
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</tbody>
</table>

Capacitors - Panasonic P series 500V polypropylene unless otherwise specified. Four 0.01µF disc ceramics are needed - 1µF input/output bypass, two for AC line filter of power supply.

<table>
<thead>
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<td>220µF</td>
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<tr>
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Transformers

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Inductors

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<tbody>
<tr>
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<td>10mH</td>
</tr>
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</table>

Audio Design

ΔVref=60mV is good for a 10:1 ratio. I call these mirrors 'reverse' Widlar mirrors because the more unusual configuration is to have the reference current higher than the programmed current. Here, the left-hand BJT carries the smaller reference current, and the right-hand BJT serves as the current source by 'mirroring' a multiple of the reference current.

Since $I_L$ and $ΔV_C$ are known, Ohm's law dictates that $R_{ref}=V_{ref}/I_L$. $R_{ref}$ serves as the input impedance, and $ΔV_C$ is the output voltage. It is important to note that $ΔV_C$ is the active voltage; $V_{sat}$ is the saturation voltage.

Preamplifiers

The 755 can be used in applications where high input impedance and low noise are required. It is a fixed-gain amplifier with a gain of 30. The 741 is a versatile amplifier that can be used in many applications. It is a fixed-gain amplifier with a gain of 100.

Audio Design

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- 2N3819/2N3819
- 2N7002/2N7002
- 2N5686/2N5686
- 2N3107/2N3107
- 2N7008/2N7008
- 2N7009/2N7009

PPM10 In-vision PPM and Chart Recorder generates a display emulating the well known coastal TWN monitoring systems for stereo audio levels and the necessary data. Also: STEREO TWIN METER BOX comprising a PPM10, featuring inherent stability with a well under 1% deviation, mains powered box frequently used for the first stereo monitoring when working to broadcast standards. Manufactured under licence from the BBC.

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Audio Design

Evaluation from a friend of the author
In spite of pleasantly looking at this evening into the Face-2 input, it sounds great — very quiet and no hum at listening levels.

The gain is definitely less than my JS Audio phone stage.
I'm running the volume control at the 11:00 position, whereas it's normally at 8:00 for phono listening.
I tried to match listening levels between your phone stage and my normal phone setup for a fair A/B comparison.
Using Paul Simper's Groveland album, I noticed a wider and more three-dimensional sound stage, which should perhaps have been a bit lower. I don't recall any significant differences in musical detail, and it was definitely a clear, transparent sound.

Mitch illustrates that the CAD tools are useful — but they also have their limitations.

I am convinced that running the input into one additional gain-of-
four cascade stage that's otherwise identical to the second stage of this preamp will yield a perfectly acceptable signal that could directly drive a power amplifier. In other words, the additional stage would serve as the line-amplifier stage, and the control preamplifier could be omitted if this was a phono-only system. For this, a 50kΩ dual-potentiometer should be inserted between the second stage of this circuit and the new line-amp stage to serve as a volume control.

You could build a complete control panel around this topology if you so desired.

References
2. Rog Williams, "Understanding the RIAA Curve," The Audio Amateur, 24/6, p. 20.
14. ibid., p. 1006
15. ibid., p. 869

Next month, Norman gives full design details of a power supply for the preamplifier, complete with a discussion on grounding.
Designing with DSP

Patrick Gaydecki* describes how to design and program real-time digital signal processing systems from the ground up. This first article gives an overview of DSP using Motorola's DSP56002 as an example.

Digital signal processing, or DSP, is widely considered to be one of the fastest growing application areas in the field of digital computing technology. The range is enormous, with application areas including mobile communications, audio-signal enhancement, biomedical signal analysis, image analysis, signal compression, encryption and satellite telemetry. DSP generally falls into one of two categories. It can be performed off-line, using conventional computers or workstations, or it can be performed in real time. Off-line DSP is applied in circumstances when it is not necessary to synchronise the input and output signals. It is often used for image enhancement, post-recording audio-signal manipulation and data analysis in general. In many situations though, off-line DSP is not an option. Signals involved in live performances, telephony and radio communications for example must be processed in real-time. In these circumstances, conventional PCs may simply be too slow to manage the processing involved.

Where speed is crucial, special microprocessors called digital signal processors are used. These devices have architectures that are optimised to perform at great speed the essentially simple arithmetic that lies at the heart of all DSP algorithms — multiplication, addition and shifting.

In this set of articles on DSP, I will be looking in detail at the Motorola DSP56002, which is a fast, industry standard digital signal processor. Starting with its architecture, I will describe its features, and how you can design and program entire DSP environments based on the device. In addition, I will also be discussing how the device can communicate with a PC so that information and program code can be transferred.

Why DSP?

Signal filtering is a widely used application of DSP, since filters constructed in this way offer many advantages over traditional analogue methods. Most importantly, they are inherently flexible. Changing the characteristics of the filter merely involves changing the program code or filter coefficients; with an analogue filter, physical reconstruction is required.

Filters implemented in DSP are immune to the effects of ageing and environmental conditions, since the filtering process depends on numerical calculations — not the mechanical characteristics of the components. This makes them particularly suited for very low frequency signals.

For the same reason, the performance of digital filters can be specified with extreme precision, in contrast to analogue filters where a 5% figure is considered excellent.

There are some disadvantages associated with this kind of digital solution though. One of the most significant is the investment in terms of the time and intellectual effort needed to develop them.

You have to learn the functions and instruction set of a particular device, construct the system, and write the algorithms. This cycle can take many months. Contrast this with designing and fabricating a second-order analogue filter based on two resistors, two capacitors and one op-amp — a process that might take fifteen minutes.

Typically for digital filtering, the analogue waveform is first digitised by an analogue to digital converter, and the binary values are transmitted to a DSP device that performs a real-time convolution operation in software using either a finite impulse response (FIR) or infinite impulse response (IIR) algorithm.

Processed data are then sent to a digital to analogue converter that produces a filtered analogue signal. In order to meet the requirements of the sampling theorem with respect to the incoming waveform, and to eliminate quantisation noise in the processed signal, an anti-aliasing filter is included before the A/D converter. Similarly, a reconstruction filter is included after the D/ to-a-converter.

How fast does it need to go?

So how fast does a real-time DSP device need to be? Well, it depends on the application, but a very common one is audio-signal processing. For example, say an audio-signal is sampled at 48kHz (DAT standard) and is processed by an FIR filter with 512 coefficients. This means that the processor must be capable of performing 512 multiplications, additions and shifts within one sample period. In this case, that amounts to 24.6 million such operations a second! This is often termed MIPS, millions of instructions per second.

Conventional microprocessors are often not optimised for this kind of work; although they may have access to a large address space, they do not distinguish between memory that holds program code (instructions), and memory that holds data. This is known as von Neumann architecture.

In contrast, DSP devices have access to a much smaller address space since it is assumed that programs that are going to operate in real time will by definition be fairly small. To maximise speed, they have physically separate memories and associated buses for holding instructions and data. This is known as Harvard Architecture.

Finally, they also incorporate hardware multiply-accumulate circuits that enable multiplications, additions and combined multiplication-summations to be performed in a single machine cycle. Hence a filter program implemented on a DSP device costing perhaps £10 will outpace one implemented on a PC by a factor of ten, since PCs have so much processing overhead.

Motorola's DSP56002

The DSP56002 is a general purpose digital signal processor capable of operating at speeds up to 33 MIPS.
It comprises a 24-bit DSP core, program and data memories, various peripherals, and support circuitry. An on-chip program RAM, two independent data RAMs, and two data ROMs containing size, A-law, and µ-law tables feed the processor’s core. Included on the chip are a timer/counters, a serial communication interface (SCI), a synchronous serial interface (SSI), and a parallel host interface (HI).

The device is register-based, in that addressing and loading the contents of control registers with specific bit-patterns configures the internal hardware; these determine the operational modes of the various sub-systems, Fig. 1.

Memory use
There are three memory areas within the DSP56002. These are the program (code or instruction) memory, x-data memory, and y-data memory.

Program memory is sub-divided into 512 words of user programmable RAM, and 64 words of bootstrap ROM. Each word is three bytes (24 bits) wide.

This may not seem like much memory, but remember that the device is hardware oriented. What this means is that operations that traditionally require many instructions to code can be implemented here using a single instruction, since the details are implemented in hardware.

For example, a complete FFT routine using the DSP56002 requires only 60 words, i.e. 120 bytes. In contrast, an FFT routine written on a conventional PC would require several thousand bytes. Many complex DSP routines can thus be held in the device’s internal program memory, with no requirement for external memory circuits.

A bootstrap ROM holds a special program that is automatically invoked when the device is reset. Depending on how it is configured, it ultimately calls or loads a user program that may reside in the device or it may reside externally.

One of the features that makes the DSP56002 so efficient is the sub-classification of the data memory into x and y areas. Each area can hold 256 words of user data. This is an extension of the Harvard Architecture philosophy and a feature not found on most other DSP devices.

The reason this has been done is because many signal-processing algorithms use two distinct signal vectors. For example, FIR filters require memory to hold the incoming signal, and memory to hold the filter coefficients, FFT routines require memory to hold the real and imaginary Fourier components, and so on.

Three of the memory areas has its own data and address bus, and all of these connect to the outside world via bus multiplexers.

Communications
Apart from the memory buses, the DSP56002 has three main methods of communicating with external devices such as other processors, interfaces, a-tod or d-to-a converters, etc.

The synchronous serial interface is mainly used for high-speed serial data transfer involving other processors and a-tod or d-to-a converters. Since the data rate is synchronised to a separate clock signal, very high transfer rates are possible - typically 15 Mbit/s.

The serial communications interface is mainly used for boot loading and asynchronous data transfer, and may be interfaced to such devices as modems, etc. The host interface is a very high-speed parallel interface for direct connection to host computers or external bootloader. It can transfer data at a maximum rate of 12.5 Mbytes/second.

The data arithmetic unit
At the heart of the DSP56002 lies a data arithmetic and logic unit, or ALU, which is responsible for carrying out the mathematical and logical processing of data held in the x and y data memories.

Technically, the device is a 24-bit fixed-point processor, representing numbers using two’s complement fractions in binary. It is really a processor using values between +1. This level of precision - 1 part in 16777216 - is equivalent to 14.4 bit dynamic range. This is slightly unsuitable for fixed-point processors.

In brief, the ALU comprises four 24-bit input registers.

To ensure overflow does not occur during intermediate stages of calculation, the two accumulator registers is 56 bits in length. In other words, they provide 336 bit of internal dynamic range.

The processor also includes a number of other ALU registers - 48 in total. These control the way that data are addressed, and determine the operational status of the DSP core.

Processor ports
The 56002 includes three ports, A, B and C for communicating with external devices such as memory, other processors and interfaces.

Port A is the memory expansion port. It is used when external memory is connected to the processor. It comprises the 24-bit data bus, the 16-bit address bus and a control bus that enable conventional memory access.

Port B is a dual-purpose I/O port that can be configured either as 15 general purpose I/O pins or as an 8-bit bidirectional host interface, as described above.

Port C is a triple-function I/O port. It can act as a general-purpose I/O interface, as an SCI port or as an SSI port (see above). Since port C comprises nine pins, SCI and SSI modes can be made available together.

What are piping and parallelism?

The speed of digital signal processors in general, and the DSP56002 in particular, is enhanced by instruction pipelining and parallelism. Both are consequences of the architecture of the internal systems. Here, the processor controller implements a three-stage pipeline that is essentially transparent to the programmer.

Instruction pipelining allows overlapping of instruction execution so that the fetch-decode-execute operations, which traditionally are performed sequentially, are here performed concurrently. Specifically, while one instruction is executed, the next instruction is being decoded and the one following that is being fetched from program memory. This clearly enhances the speed of the processing considerably.

Furthermore, the ALU, the address generation unit and communication peripherals operate in parallel with one another. This enables the processor to perform in a single instruction cycle (which is two clock cycles), an instruction pre-fetch, a 24-bit x 24-bit multiplication, a 56-bit addition, two data moves and two address pointer updates.

Since the communication peripherals also act in parallel, they may transmit and receive data concurrently with the above operations.

Incidentally, this also means that the power of a processor cannot be determined by the clock speed alone. In fact, the maximum clock rate of the DSP56002 is 66MHz, i.e. it is extremely fast because it performs so many operations in parallel and uses dedicated hardware.

Peripheral control registers

In addition to the ALU registers discussed above, the DSP56002 has 38 separate registers that control the behaviour of the various peripherals. By loading these registers with different control words, it is possible to modify the operation of a peripheral or change its function entirely.

For example, port C has nine pins, which by default are configured for general purpose I/O. By modifying specific control registers associated with this port, it is possible to change the function of the upper six pins to act as the SSI.

Further, the SSI has another set of registers that determine exactly which communication protocol will be used for data transmission and reception.

The processor’s modes of operation

After reset, the DSP56002 can be configured into one of four operating modes, depending on whether it is to be used as a single chip system or with external memory.

These modes are as follows, and are defined by the mode control register in the state control register.

Mode 0: Single-chip mode. All internal memories are enabled, and a hardware reset causes the DSP to jump to internal program memory at 00000 and resume execution.

Mode 1: Special bootstrap mode. This is a special, and frequently used single-chip mode. Following a hardware reset, the DSP downloads a program either from external boot memory, from the serial communications interface or from the host interface — see for example, by a PC. It stores the code in its internal memory, and starts executing the code from address 00000. It then switches to mode 0.

Mode 2: Normal expanded mode. This mode is in fact identical to mode 0, except that the reset vector points to location 00000 (57344 decima), it must be external memory.

Mode 3: Development mode. Similar to mode 2, but all internal memories are disabled.

Mode 1, the special bootstrap mode, is a very useful feature. Effectively, it means that source code can be developed and assembled (or compiled) using PC software commonly available from a number of suppliers including Mentor. It can then be downloaded directly to the device via the serial interface, without the need for any third party hardware. Thus a complete, flexible real-time DSP system can be designed with minimal effort; it might typically appear as shown in Fig. 2.

What's next?

In the second article in this set of four, Patrick will be looking at the hardware issues in more detail, in particular, he will discuss how to clock the device, how to interface it to a PC, and how to connect an A-to-D converter, a D-to-A converter and some external memory.
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Infra-red sprint timer

This system was designed in response to a request from an athletics and sports-science department that wanted to profile the velocity of runners during sprint events. Basically, the timer comprises a series of beam-break detectors distributed along a track, Fig. 1. Each connects to a master unit to indicate a series of time intervals.

While the specific application is unlikely to be common, a number of design ideas emerged during development that should have wider appeal. Most of these are to do with low-power design.

Infra-red beam detectors

Infra-red transmitter-receiver systems are widely used in TV remote controls. They are now found in a high-speed bi-directional form in interfaces such as the IRDA link for PCs and peripherals.

Typically, an infra-red emitting diode, or IRED, is modulated with data directly, or through modulation of a high-frequency subcarrier, often 38kHz.

High-frequency modulation can largely overcome the extreme levels of background IR due to sunlight and domestic heating sources. However, the first stage preamplifier and photodiode load need careful design to prevent DC or LF saturation occurring. Some infra-red control receivers fail to respond to their transmitters in bright light: this is due to first-stage overload.

The need to pick up low levels of modulated IR in the presence of high levels of interference has led to the availability of application-specific ICs, such as the TBA2800, and complete IR photodiode/amplifier modules, notably those made by Sharp and HP.

However most receivers are integrated into fixed or mains-powered devices, so the battery saving measures all seem to have been concentrated at the transmitter end. There are no micropower receiver chips; all consume at least one - and sometimes several - milliwatts.

Power consumption issues were addressed in a previous short article in the October 1994 issue of E&W&WW. The circuit described there forms part of this system.

Reflection or transmission?

One early design question was whether to use a combined transmitter/receiver combined with a remote reflector, or two separate modules. The material cost of an additional box and battery, minus the reflector, was not great.

Separate boxes were eventually favoured because they are easier to set up. Aiming is straightforward, as shown later.

Having separate modules doubles the useful range, and it must be admitted, shunting between a circuit delivering 2A current pulses, and a circuit detecting microwatt signals, is always easier when they are several metres apart.

Finally, this had to be a high-reliability system. In an evaluation prototype using combined transmitter and receiver, some white clothes acted as reflectors and would not always trigger the detector. A transmission beam is always unequivocally broken.

Having said that, there is no reason why the system should not operate in a reflective mode for other applications.

Transmitter circuit

As shown in Fig. 2, the transmitter is a conventional design using a TLC 555 low-power timer as the pulse source.

To maximise the efficiency of the system, the pulse duty cycle must be minimal. Against this was the fact that the pulse repetition frequency had to be high - more than 1kHz to satisfy the 1ms timing resolution of the system.

If the duty cycle was too low, the pulses would be very short and the receiver would need a very wide frequency response. This would increase noise and current consumption. Eventually, the pulses were set at 3.6μs at a pulse repetition frequency of 1.3kHz. At an IR emitter peak current of 2A, mean battery drain was about 5mA. This ensured a full day's operation with a nickel-cadmium PPS-sized battery.

A simple battery voltage indicator was included for testing purposes. When the unit is switched off, the battery can be charged with an ordinary NiCd trickle charger through an external socket. The diode renders the connector short-circuit proof. Although supply line disturbances and pulse shape in a stand-alone transmitter are not terribly important, I originally developed the transmitter in the same case as the receiver, with the intention of sharing supplies with sensitive circuitry. I therefore spent a while on the choice of driver transistor, local reservoir capacitor and board layout to maximise the available current for the IREDS, while minimising power line disturbances.

Of those tried, all the commonly available 'low ESR' capacitors specified for switch-mode power supplies gave good current delivery. On the other hand, most general-purpose electrolytics caused various degrees of ringing on the supply rails.

Despite its small size, the ZT750 transistor can drive high currents, and seems ideally suited for this application. It is important to minimise the area of the capacitor/transmission line high current loop on the PCB. Use thick tracks and keep them close together.

Since the average current is low, the circuit can be effectively decoupled with 10μF capacitors in both the supply and ground lines if a common supply is to be used.

Infra-red receiver circuit

Photodiodes are often required to detect relatively low-powered pulses in the presence of intense continuous sunlight or 100Hz illumination.

Commonly, the diode is used in reverse leakage mode - i.e., as a current source into the inverting input of an op-amp, or directly into a resistive load. However, in the presence of sunlight or incandescent lighting, these circuits saturate. It is possible to use an inductor or transistor gatry circuit but there are still two problems. Firstly, although the gatry exhibits high AC impedance, there is no actual power gain from the transistor. Secondly, the considerable photocurrents induced in sunlight - several milliamps must come from the power supply, and will drain batteries.

In Figure 3, the photodiode operates in photovoltaic mode. Transistor Q1 saturates at a very low current and the collector sits around 0.3V. Its base is AC grounded. As a result, to signals with a fast rise time such as those generated by remote

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You might not have a need for a precise sprint timer, but Simon Bateson's micropower design should provide some interesting tips for anyone involved with infra-red transmitters/receivers that need to be able to run from batteries.
control transistors, $Q_1$ emitter appears as a low impedance and the photodiode current is diverted into it. Thus, $Q_1$ acts as a common-base amplifier and the collector current cuts-off rapidly. Even at low collector currents, the response is fast because of the lack of Miller and storage effects. At low frequencies and in constant light, all the photodiode current passes through the 1kΩ resistor rather than through the supply so there is no battery drain.

The following amplifier is a series-feedback pair operated at a low-current. It has a good gain-bandwidth product considering its power consumption, but it can suffer from overload. Consequently, it can be slow to switch-off when heavily overloaded, for instance, when the IR transmitter is brought in contact with the photodiode.

To overcome the overload problem, the output is fed to a comparator through a bias/threshold network. Network $R_1$ and $C_3$ provide an automatic bias that tracks LF shifts and saturation in the op-amp, while $R_5$ and $R_6$ set the comparator threshold. This measure was found to preserve pulse width very well. In data or alarm applications, direct PCM signals can be passed to decoder chips without error.

The TLC393 is a dual micropower comparator with open-drain output stages. Resistor $R_1$ charges $C_1$ from the supply, but every time an IR pulse is received, $C_1$ is discharged through the comparator. Rather like in a 'watchdog' circuit, a loss of signal will trigger the second comparator, switching on the indicator LED.

Note the diode and rather large reservoir capacitor in the supply; these ensure that the circuit is undisturbed by the relatively large LED current. In the presence of IR pulses, the circuit consumes about 60µA when tripped, it consumes only 10mA to light the LED. This change in current is the signal to the master unit that the beam is broken, so a single coaxial cable carries both power and signal - a simple current loop system.

The receivers are easy to set up; the transmitter is pointed roughly at the receiver. Next the receiver aimed either side of the transmitter until the LED comes on, then fixed mid-way between these two cut-off points.

Master unit - analogue circuitry

Figure 4 shows the analogue side of the master unit. This was built on a board along with a rechargeable PP3 sized battery.

Connections to the outside world are as multi-purpose as possible. Power is supplied to all the receiver units, which are simply chained together like an Ethernet using BNC adapters and leads. There are no 50Ω terminators, of course!

Current drain is monitored by $R_1$. Potentiometer $R_1$, is trimmed so that the op-amp, connected as a comparator, switches when the current draw exceeds about 7mA. Obviously, since the drain of a single receiver is only 60µA, many receivers can be chained together if necessary.

The arrangement of $Q_1$, $C_2$ of Fig. 4 and the LED,$R_4$, load in Fig. 5 as a battery condition indicator and signal indicator. It also acts as a short time constant to prevent potential multiple triggering - not that this ever actually occurred.

A regulated power supply is provided by the second op-amp. The op-amp is arranged in a self-biasing configuration discussed in Howitz & Hill's book "The Art of Electronics". This gives a very stable low-voltage supply to the digital side of the system at a minimal power drain, which is not possible at the required voltage with three-terminal regulators.

When the unit is switched off, the battery can be charged through the external terminals via $D_9$. The test button simply draws about 9mA when pressed to verify master unit function and battery condition.

When designing circuitry to be used - literally - in the field, protection against interference, wrong connections, etc., must be considered. Here, the master unit and all the receivers are protected against anything short of lightning strike or EMP by $D_1$ and a fuse. This diode is a "Transil" or high-speed transient suppressor. It will pass 36A, clamping at 21V, within 10µs.

Master unit - counters

For this application, three successive periods were measured, requiring three counters and four IR beams. I considered using a microprocessor, but turned the idea down on the grounds of development time, current consumption and the need for three displays.

The displays were miniature 6-digit LCD counter modules (RS type 343-442) that consume just 10µA. They are fed from a 1kHz signal to count milliseconds. A Harris device specifically designed as a low-power oscillator.
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279

High-speed digital recorder for graphics, video and audio

Celtion Microsystems has introduced the DGs digital image recorder, which uses Firewire (IEEE 1394) bandwidth to capture, compress, store and replay video signals. This includes computers, radar and other digital image data. The system, developed by RGB Spectrum, provides up to four input channels with PAL or NTSC options. Images from two selected channels can be output to separate monitors, or one monitor can display up to four-quarter-size representations of the recorded images. It supports outputs of 25 framerates at 640 x 480 pixel resolution or 60 framerates at 1280 x 1024. Two audio input channels are available for digitised audio recorded with the video data, enabling stereo audio playback. The system supports event marking using SMPTE time codes. This is done manually from the front panel control or via serial commands over an RS232 interface. Event marking supports the random access feature, where the operator can start playback from any point in the recording. Compression comply with IEEE Blue Book standard, and lets up to three hours of digital video be recorded.

Celtion Microsystems
Tel: 0181 977 6161
electronics@creolon.com
include a C671300 SDRAM controller and an LCD controller with 4Mbyte SDRAM and a maximum resolution of 160 x 120, up to four 10/100BaseT Ethernet ports, front or rear panel UDO, up to 350Mbyte flash drive and a board-based management controller providing the IPMI architecture. It is also available with an optional extended temperature range from -40 to +70 °C.

SSR Technologies
Tel: 00 49 821 5034-0
www.ssr.com

Ocelt Mac-phy chip handles 4.8Gbit/s
LSI Logic has available a Fast Ethernet ocelt Mac-phy combination chip. The L88800 integrates eight physical layer devices (phy) and eight media access controllers (Mac) on a chip. The device is for networking applications (including Ethernet switches), backbones, network convergence and network processors. Integrating the phy reduces pin count and eliminates the associated simultaneous switching outputs because the high-speed interface is internal, boosting performance and reducing EMI. The flexible bus interface is programmable for 64, 32 or 16-bit bidirectional or split bus. It can simultaneously transmit and receive from two ports. Working at full capacity, the chip can handle up to 4.8Gbit/s data from all eight ports at the same time, letting it support 24 full-duplex ports be configured on the one bus.

LSI Logic
Tel: 01344 412009
www.licoLogic.com

DC/DC converter controllers
The XC9301 and XC9302 step-up and down DC/DC converter controller ICs have been introduced by Torex for battery-powered handheld equipment, such as mobile phones, PDAs, palmtop computers and portable audio equipment. Input voltage is 2 to 10V and output is selectable in 0.1V steps from 2.4 to 6V. Switching frequency is set at 1MHz (±5% per cent) and output is more than 250mA. They step up and down without using a linear voltage regulator. Efficiency is typically 81% per cent at 5V and 78% per cent at 3.3V. Soft-start time is internally set to 10ms to protect against瞬间 currents when power is switched on and against voltage overshoot. During standby operation, current can be reduced to 0.5μA. They are SOT25 packages and operate from -40 to +85°C. The XC9301 switches from PWM control during large output currents to PFM for light load operation.

Torex Semiconductor
Tel: 0030 211992
www.torex.com

Dual polar UMTS antenna has 16dBi gain
European Antennas has launched a dual polar UMTS basestation antenna that provides 16dB gain on both polarisations (+/-5°). It can be used for most traditional macro sites as well as high density micro-cells. Measuring 910mm high, 135mm wide and 72mm deep, the antenna can be installed alongside existing GSM antennas without significant effects on wind-loading, claims the company. Downwards facing 716 connectors allow for access and installation. The antenna elements are housed in an aluminium chassis fitted with dielectric to stop the build-up of moisture near the PCB.

European Antennas
Tel: 01638 731888

IR transceiver complies with IrDA version 1.3
Agilent Technologies has announced an infra-red transceiver that complies with IrDA version 1.3. The NSD43210 is 2.5mm high and is for PDAs, phones and mobile phones. It is a 64bit/s to 1.125Mbit/s transceiver that operates with logic levels down to 1.8V and from power sources down to 2.7V. Footprint is 8.0 by 3.0mm and it is IECE0823-1 class one eye safe. Typically, it draws 10μA in shutdown mode and 200μA in standby mode.

Agilent Technologies
Tel: 07004 60606
www.agilent.com

Coaxial connector for 3G mobile telecoms
A coaxial multiple connector has been developed by Haring for 3G mobile telecoms applications. The Mini Conax has adjusted levels of impedances for all inner sections of the connector and allows signal transmission from the daughter and the backplane at frequencies up to 4GHz. Soldable surface mount technology is used on the inner conductors.

Haring
Tel: 00 49 5772 470
www.haring.com

Digital power meter tests motor efficiency
The PE4000 digital power meter from Yokogawa comes with a plug-in module to test the efficiency of electric motors. The two-channel unit has inputs for measuring torque and speed, as well as a pulse output for calculating the electrical power consumption and relating it to the torque and speed. The instrument makes it possible to calculate and analyse the overall efficiency of the motor. Values can be measured and displayed online. The instrument is suitable for inverter-driven motors for domestic appliances such as washing machines, refrigerators and air-conditioners as well as in electric vehicles. The instrument is a digital wattmeter with frequency capability up to 2MHz. It has a menu-driven TFT screen that will display instantaneous values, integrated values and voltage, current and power waveforms. Sampling is up to 512msec/s, voltage ranging up to 1kV and DC input up to 20A. Higher values are possible with external current sensors.

Yokogawa
Tel: 01845 252920
www.yokogawa.co.uk

Rectifier is efficient to 86 per cent
International Rectifier has introduced the IR11176 application-specific synchronous rectification IC (SRIC) for isolated DC-to-DC converters with voltage output down to 1.5V, powering telecoms and broadband network servers. Used with the firm's DC-to-DC converter-specific Hexlets, the IC provides 1.5 and 1.8V converters at 40A, with in-circuit efficiencies of 85% and 86% respectively for 1.5V output circuits with 48V input. It controls gate drive circuits to reduce losses in secondary-side, isolated DC-DC converter synchronous rectification Mosfets. It uses a modified PLL to lock the switching frequency to the secondary-side rectification Mosfets to the primary-side switching action. This lets the Mosfets be pre-fired with programmable delay to reduce turn on transition time, as well as the dead time and overlap between gate drive signals. Pre-firing the Mosfets eliminates parasitic diode conduction and all output current is conducted through the active Mosfet channels.

International Rectifier
Tel: 0208 645 8001
www.irf.com

Power converters handle 7A
EMI has introduced the Ernst EPM power converter modules. Available from Radiation, they mate with UPM universal power modules and transfer power from the backplane to the daughtercard. Male connectors are available in three pin heights to enable sequential pin mating. All modules have press fit contact terminals, using flat neck and pin clamping procedures. This is combined with a closed entry female receptacle on the backplane and a right angle male header on the daughter card. The male and female connectors operate from -55 to +125°C, with the power shared across four press fit terminals to increase heat dissipation. Current capability is up to 7A and the connectors meet IEC150 finger probe safety requirements, carry UL1410, immiutability testing and meet IEC61008-1-101.

Radiation
Tel:01784 439393
www.blieic.com

Analysers measure WDM to 1620nm
Arctis has introduced the MS5101C optical spectrum analyser with option 15 to 15 measurements be made on wavelength division multiplexer systems at wavelengths up to 1620nm. WDM systems can have 48 channels with 100GHz (0.8nm) spacing with future systems having 200 channels with 50GHz (0.4nm) spacing, carrying more than 1Tbit/s over a 76nm spectrum with 100GHz modulation. These will require wavelength amplification into L-band at up to 1620nm. The
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**Baseband processor and MAC IC**

Intersil has announced a wireless single-chip baseband processor and media access controller for developing Internet appliances that will give customers first access to data, video and voice-over-IP. It supports wireless Ethernet (IEEE802.11) bus based systems and sits at the heart of the four-chip Prism 2.5 WLAN product.

Tel: 01344 350290

www.intersil.com

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**Future Electronics World April 2001**

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**SM trimmers are auto-adjustable**

Easby Electronic's SM03165 tapped surface-mount trimmer from Meggitt. The single turn potentiometer has a power rating of 0.17W at 70°C. It incorporates a stable cermet element and in-line terminations. Supplied on tape and reel, its footprint is 4.5 by 4mm and height 2.2mm. The range goes from 100 to 1MΩ and operating temperature from -25 to +85°C.

Easby Electronics
Tel: 0171 850 5555
www.easby.co.uk

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**Chip-in-glass displays have seven outputs**

Iron has introduced a chip-in-glass display comprising a 96-bit VIP drive IC with a multi-level I/O structure.

There are seven output pins. Single and dual line 5 x 7 dot formats are available that are 16, 20 and 40 characters long. Graphic displays include 128x18, 128x32, 128x64, 192x16, 256x32 and 256x64 dot formats. Over 30 CIG displays are available. Operating temperature range is -40 to +85°C.

Iron
Tel: 0845 6039552
www.iron.co.uk

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**DC-DC converters isolated to 4.2kV DC**

Acal has 3W DC-DC converters providing galvanic isolation to 4.2kV DC. Made by Ikeb Electronic, the units in the VIP3 family have IO isolation and coupling distances of at least 2mm to meet EN6950 and UL1950 safety standards.

Acal
Tel: 01344 350290

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**Internal filtering and the EMC design let them meet EN50022 level B without external components. They are surface-mounting. Standard units have input ranges of 930 to 18 or 128 and 15V DC and are for battery-powered applications. Output voltage options are 5, 12, 15, 5x12 and 15V DC. They come in two ambient temperature ranges: -25 to +71°C and -40 to +85°C. Acal Power Solutions
Tel: 01292 856858
www.acalelec.co.uk

**PCB connectors use IDC technology**

Weddsmiller has introduced the BLIDCH 3.5 bus connector and BLIDC 3.5 socket block for standard PCB connections in industrial applications. The connectors use IDC technology.

It is no need to strip wires for connection to either solid or flexible conductors and no need for special tools. Both types allow access for standard test probes of 1mm diameter. The bus connector allows multiple connections, in several orientations, without interruption to the bus if the plug is disconnected. It is available in two to eight poles and is stackable.

Weddsmiller
Tel: 01625 434343
www.weddsmiller.co.uk

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Plug relay provides 16 isolated relay outputs

Amplicon has introduced its PC1263, a 16-channel relay output board for PCI bus. The device is a plug in board providing 16 isolated relay contact outputs, and can be used with any PC supporting PCI bus versions 1.1 and 2.1. The board is back-to-back compatible with the PC1263 for ISA bus, and makes use of the PCI-ISA interface chip - the PLX8802 - to reduce cost. The board features independently controlled single pole, single throw, dry reed relays, each of these associated with standard LED in order to show its output status, and with every pair isolated. The relays are capable of switching 200V DC at 15W in 0.5ms (max). Also included is device drive software compatible with Windows NT, 95, 98 and 2000, and IntelliVDE, Delpth and Visual Basic example software. It operates in the temperature range 0°C to 60°C.

Amplicon Tel: 01773 570200
www.amplicon.co.uk

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100MHz. Onboard attributes include a 10/100BaseT Intel 82559 fast Ethernet controller with wake-on-LAN and optional alert-on-LAN. It also has an AGP2x LCD and CRT VGA controller and secondary IDE connector for disk-on-module flash disk expansion. AMC Tel: 01753 856860 www.amcuk.com

19in enclosures for cable management
Olson Electronics has introduced standard 19in wall mounted and floor standing enclosures for cable management in commercial and industrial IT-based, voice and data communications installations. The Vero Interak rack-mounting steel cases and cabinets are purpose-designed to provide a centralised, secure, controlled environment for electronic equipment, cables and accessories. Using an all-steel construction with a lockable glass front panel, wall mounted cases are supplied in kit form in a choice of 7, 12 and 17U heights. For assembly and installation by one person, the cases have a load rating of 40kg. Olson Electronics Tel: 020 8905 7273 www.olson.co.uk

PCL radar scan off the shelf
Primigraphics has introduced a commercial-off-the-shelf 2k by 2k PCL radar scan converter for large screens in air traffic control and vessel traffic systems. The Advantage 2k PCL card works with the Raptor PCL 2k by 2k graphics processors from TechSource to provide primary radar video direct onto a 24HS x 2048 display. The Advantage converter accepts rho-theta format data from up to three independent radars via the PCL bus and converts each to raster format. The card can also accept decompressed data, transferred via a LAN or other link, letting each operator generate a view at any scale or off-centre distance. It uses reverse scan conversion technology implemented on Motorola's Coldfire 90MHz MCF5307 processor. Features include up to 3Mpixels/s conversion rate, variable persistence, multiple radar windows, image rotation is 0.18° steps, 360° rho-theta stores and a 4Mbyte onboard frame store. Primigraphics Tel: 01763 850222 www.primigraphics.co.uk

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NEW PRODUCTS
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LCD mounting range gets extensive

Marlton Instruments has added chip-on-board, chip-on-glass, chip-on-film and tape automated bonding LCD mounting technologies to its custom modules. They are made in an ISO90001 accredited environment. Applications range from low-volume specialist units for B.Ae flight simulators to 100,000 plus quantities for cable TV.

Marlton Instruments
Tel: 01207 900269
www.marltoninstruments.com

Modules feed 350mA on standard LAN cabling

Pulse has launched 10/100BaseTX LAN magnetic modules to eliminate the AC power requirements for IP telephones and other Ethernet devices. Capable of feeding up to 350mA on standard LAN cabling, the H2005A and H2006A dual-port modules allow for enough power to drive different applications over LAN cabling. These include IP phones, remote sensors, building thermometers and wireless LAN access points.

Pulse
Tel: 01482 401700
www.pulseeng.com

Low-pass filter meets digital testing needs

The Audio Precision S2- AESS1LP filter from Thubry Thander Instruments meets the requirements for digital audio testing laid down by the Audio Engineering Society. The standard specifies, in section 4.2.1, the use of a standard low-pass filter that has a sharp roll-off above the audio upper band (20kHz). It meets this with a stopband attenuation of 60dB or better above 24kHz. The filter must be inserted early in the measurement path to remove the out-of-band noise before the measurement notch filter and its subsequent gain. This will ensure that the noise part of the THD+N parameter contains only the in-band noise and distortion. Without the filter, the automatic gain ranging that normally follows the THD+N notch filter can behave incorrectly and the resulting measurement will be in error.

Thubry Thander
Tel: 01480 412451
www.thtun.co.uk

Connector is no push over

The JAE SH3 push-push connector is for use with multimedia cards in portable data storage applications, such as PDAs, voice recorders, digital imaging equipment and electronic books. It has a push once to insert, push again to release operation. It meets Micromedia Card Association (MMDA) electrical and physical specifications. The surface mount connector provides seven contacts configured to allow hot insertion as pins three and four contact to card pads first, as required by the MMDA specification. Contact resistance is 100mΩ and rated current 100mA. Durability is typically one million.

JAE Europe
Tel: 01278 404000
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Differences in degradation are not so obvious, but with printed Circuit boards, they can be significant, and some are not. Let's see how much difference a high bandwidth amplifier would make to these common problems. To this end, I have tested the performance of a high bandwidth amplifier in the context of a single colour television receiver, and found that there is a significant improvement in the TV signal, particularly in the middle frequencies, where the signal is weakest.

In conclusion, the use of a high bandwidth amplifier is recommended in the context of single colour television receivers, particularly those with a high bandwidth of 10kHz, as it provides a significant improvement in the TV signal.

REFERENCE

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This 2-way or 3-way crossover offers the possibility of listening to the same speaker system with either constant-voltage or constant-phase or with constant-power response. Each loudspeaker is driven by its own power amplifier. A state-variable filter is used because high-pass, low-pass and band-pass outputs are simultaneously available and, since the denominators in their transfer function are identical, no additional adjustment is necessary.

In the first position, with switch 5A open, the crossover acts as a constant-power filter. Only two drivers are active, the woofer and the tweeter. The crossover frequency was chosen such that the two speakers work well within their operational limits. Total output power, which is the sum of the high-pass and low-pass power, is frequency independent.

\[ P_{\text{total}} = P_{\text{high-pass}} + P_{\text{low-pass}} = \text{constant} \]

The second position, with switch 5A closed, the crossover acts as a linear-phase filter. All drivers, including the midrange, are now active. The sum of the three output voltages is frequency independent.

\[ U_{\text{total}} = U_{\text{high-pass}} + U_{\text{mid-range}} + U_{\text{low-pass}} = \text{constant} \]

This concept, well known as filter-driver loudspeaker, assumes that the three driver units have a linear behaviour, a constant phase shift and similar group delays. These can be achieved with all-pass filters inside the power amplifiers and a staggered positioning on the front panel.

Experience shows that the constant-voltage crossover is superior to the constant-power crossover if the listener is within the direct radiation field, i.e. inside the hall-radius. Outside the hall-radius, in the diffuse field, the constant-power crossover is superior. This makes the switchable crossover an interesting alternative for loudspeaker boxes used in studio and home applications.

Dr Cerd Schmidt
Frankfurt
Germany

D7

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www.softcopy.co.uk
Wide-range VFO for RF uses only one IC

This RF VFO has a wide range around 2.5 to 25MHz with values shown. It is built around a standard 74HC123 monostable and needs just two fixed resistors - a 500kΩ variable one, and the chip itself. Since there are two such circuits in the package, the other half could be used in the same way for another such oscillator.

By replacing the variable with a fixed resistor of around 39kΩ and connecting a crystal where the timing capacitor is normally connected, it can be used as a crystal oscillator in the range 10-20MHz. Such an oscillator could be the basis for a mixertype BFO.

Better model racing-car controller

A common problem with commercial model racing-cars that run in a slotted track is that the rheostats controllers are so abysmal. Starting a motor with a variable series resistor does not give a smooth take-off, and the car tends to over-rev once initial friction is overcome. What you need is a true variable voltage supply - but even this can have difficulties with dirt on the brushes, oxide on the track, etc. A better method is to apply full-voltage pulses but of variable width: this way, power can be smoothly varied - and any contact-resistance is duly overcome.

In the circuit shown, a 555 timer produces pulses at a rate of 6.3kHz maximum, with a fixed off-time of about 150µs. The on time is less than 5µs in the quiescent state, but this rises to 45µs for starting, and approximately 2ms flat-out. Thus the duty-cycle increases from 3% through 23% to about 92%, in a steady and repeatable manner.

Existing Scalextric Micro hand-held rheostats have a resistance of about 600Ω variable down to less than an ohm for maximum speed.

However, there is an off-position when they become open-circuit. By using the current-source built around R1 and D1 it is possible to achieve the desired range of pulse-width control without modifying the rheostat. The idea is that R5 plus C5 gives the desired 150µs off-time, but R1 and the diode D3 allow as much - or as little - charging current as necessary into C1 during the on-time.

Thus, when the controller P1 is open-circuit, R2, R3, and R4 cause a collector current of 11mA to flow, and the on-time is minimal.

On the other hand, when P1 is squeezed to near its minimum resistance, the base of TR1 is pulled up towards the +12V rail. Therefore the collector current is only 250µA or so, yielding the maximum on-time. When P1 is just engaged - i.e. at 60Ω - the collector current is roughly 1.2mA, which gives around 45µs. Output from the timer conveniently drives the enhancement-mode MOSFET TR2, with a gate resistor R6 to slow the edges of the output waveform. A catching diode, D6, allows for inductive effects in the track and motor.

There is some electromagnetic emission, but this falls off rapidly with distance, and the interference on LW/W is comparable to that from 'electronic' transformers for 12V tungsten-halogen spot-lights.

Since two cars and hence two controllers are normally required, it is better to have separate circuits for each, with various their own wiring from the transformer-rectifier and their own dedicated reservoir capacitors. But the jack-sockets for the rheostats tend to be on a common busbar. A compromise is to take the positive rail at Z2 for both, and increase C1 and C2 to 100µF. Resistors R2 and R3 may need adjusting to suit the supply. The quiescent 6.3kHz causes a faint audible note from the car's motor; the frequency could be raised by reducing C1 to say 3.3µF if desired - though losses may start to be significant.

Uses for CMOS switches

CMOS switches can be used as intermediate elements in various switching devices for control applications.

Figure 1 shows a CMOS switch circuit using a CD4066. In the initial state, a low level voltage is present at the switch control input, pin 13. The switch channel is open and no current flows through the load.

Capacitor C1 charges through the closed contact of the switch S1 up to the device supply voltage. Pressing button S2 momentarily, connects capacitor C1 to the control electrode (pin 13) of the IC, switching the channel on.

Resistor R3 keeps the control electrode voltage high, keeping the switch in its on state. If the button S2 is kept pressed longer, capacitor C1 discharges through resistor R2, and the load resistance R1. Voltage on the control electrode falls and the switch turns off.

The switching process is shown in Fig. 2. The circuit of Fig. 1 can also be used to produce pulses of a predetermined length. Figure 3 shows a double-pole, two-way CMOS switch. Here, control of the CMOS switch S1 can be carried out either by switch S2 or by CMOS, as shown, or by a transistor switch as in Figs 4 & 5. Control signals from the outputs of the transistor switches connect to Fig. 3 at the points marked 'x' .

A push-button CMOS switch is shown in Fig. 6. Whether the device is switched on or off depends on how long the push-button is depressed.

A switch based on similar principle, but using normally open control button, is shown in Fig. 7. Michael A Shustov

Bipolar voltage stabiliser

To stabilise a voltage of either polarity, low current symmetrical zener 1 diodes are usually used, Fig. 1. A bipolar voltage stabiliser, Fig. 2, has a high loading capacity and good stability of the output voltage.

Symmetrical zener diode D3 is still used but voltage across the zener now feeds the bases of high-powered transistors TR1 and TR2. Diodes D1 and D2 supply an n-p-n or p-p-n transistor, according to the polarity of the applied voltage.

Loading characteristic of this bipolar voltage stabiliser is shown in Fig. 3.

Michael Shustov

Russia

Syntemal zener diodes can be used to stabilise an supply voltage regardless of its polarity, as in Fig. 1. Figures 2 and 3 show that adding buffer transistors makes significant difference to the performance of such a stabiliser.

Figure 1 is a pushbutton-controlled CMOS switch. Its state depends on how long the button is pressed. Figure 2 is Fig. 1's timing diagram while Fig. 3 is a double-pole changeover switch whose control inputs can be produced using Figs 4 & 5. Further normally-closed and normally-open push-button operated switches are shown in Figs 6 & 7 respectively.

April 2001 ELECTRONICS WORLD
Antennas and propagation for wireless communication systems

This will be a vital source of information on the basic concepts and specific applications of antennas and propagation to wireless systems, covering terrestrial and satellite radio systems in both mobile and fixed contexts. Antennas and propagation are the key factors influencing the robustness and quality of the wireless communication channel and this book includes:

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CIRCUITS IDEAS

Push-button thyristor operation

Thyristors are often used to switch loads, like filament lamps, relays and motors, on and off. Two buttons are normally used to switch the thyristor off and on. Push-button thyristor control circuits like this are less well known.

Referring to Fig. 1, in the initial state, the normally-closed push-button contacts bypass the thyristor control circuit. The thyristor resistance is maximum; current does not flow through the load. Operation of Fig. 1 is explained in Figs 2 & 3.

To switch the thyristor on, button SB1 is pressed. In this case the load is connected to the power supply through the normally-open contact of SB1, but the capacitor C1 charges through the resistance R1 from the power supply.

The product of R1 and C1, Fig. 2, defines the speed of capacitor charge. After the button is released, capacitor C1 discharges into the thyristor control electrode.

Versatile flasher circuit

When creating a circuit for a blinking indicator light, one uses a 555 timer. But in an attempt to create something different, I found circuit shown here better. Output current of a 555 is limited to 200mA. By changing the output transistor of this circuit to handle the extra current, it is possible to use the circuit to generate a greater output current.

The oscillator starts when power is applied to it. It generates a squarewave voltage across the load connected to the output. Timing is set to 10s by C2 and R2. When power is applied to it, C2 starts charging through R3 and the load. When the capacitor reaches the level of Vcc by R3 and R2, Transistor T1 starts conducting. As T1 conducts it drives T2, which creates a short-circuit.

If the capacitor voltage is equal or more than the thyristor switch-on voltage, the thyristor latches on. Load switch-off is by a momentary pressure on the button SB1.

As the button contacts shunt the thyristor's anode and cathode, the thyristor switches off. On release, the thyristor does not fire, as capacitor C2 has not had time to charge.

In Fig. 4, series connected diodes D1, D2 limit the maximum charge voltage of the capacitor.

Michael Shustov
Tomsk
Russia
ES5

Whether the thyristor in Fig. 1. is on or off depends on how long the push button is depressed for. Timing details are shown in Figs 2 & 3 while Fig. 4 shows a variant of the circuit with gate-drive limiting diodes.

For inductive loads D1 must be included for protection. As the circuit does not have any short-circuit protection, it is necessary to use a power supply containing short-circuit protection. The power-supply level doesn't influence the frequency, but with the transistors used, the level should be limited to 45V DC.

It is possible to connect the circuit to the load in two ways. In the first the load is connected to the Vcc of the 744 timer, while in the second configuration the load is connected to the -Vcc terminal. In both cases the configuration does not affect the performance of the circuit.

B Van den Abeele
Evergem
Belgium
D75

Don't use the electric light for the person's light!

Simple flasher for insertion in the positive or negative side of a load.
Now, C1 discharges through R1 and T2 until it can no longer sustain the base current of T2. Transistor T2 also drives the load when C1 is discharging. With a BCS47, the circuit can drive up to 200mA.

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Michael Shustov
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Current conveyors II

Giuseppe Ferri et al describe how current conveyors can be made to produce rail-to-rail output voltage swings even when running from a supply as low as 1.2V.

Recently, designers have been putting much effort into reducing the supply voltage and power consumption of digital, analogue and mixed-signal ICs and systems. The trend towards lower operating voltages is mainly due to the following:

- In IC design, increasing the number of components in a given chip area also increases power dissipation, making power consumption an important issue.
- Tighter chip geometries lead to lower breakdown voltages, limiting the supply voltage.
- Increasing use of battery-operated portable electronics and wireless systems - including cellular phones, portable PCs and wireless terminals. Such devices demand low power consumption, as well as small size and low weight.
- Increasing use of low power solutions in other application areas such as fibres, audio signal processing, RML and EMC compliant systems, and non-invasive sensors, integrated into silicon.
- The cultural scientific interest in exploring the technological and physical limits of integrated devices.

Current conveyors lend themselves to low voltage operation. In this second article we will be discussing some low voltage current-conveyor implementations and presenting their simplified schematics.

Table 1. Main performance features of the current conveyor shown in Fig. 1, powered by a 1.2V supply.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>0.94</td>
</tr>
<tr>
<td>β</td>
<td>0.98</td>
</tr>
<tr>
<td>Rα</td>
<td>12kΩ</td>
</tr>
<tr>
<td>Rβ</td>
<td>11.5kΩ</td>
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<tr>
<td>CV</td>
<td>15F</td>
</tr>
<tr>
<td>Bandwidth</td>
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</tr>
</tbody>
</table>

Table 2. Main performance of the CCII- of Fig. 3, determined using a 1.5V supply.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
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</tr>
<tr>
<td>β</td>
<td>0.958</td>
</tr>
<tr>
<td>Rα</td>
<td>20kΩ</td>
</tr>
<tr>
<td>Rβ</td>
<td>20Ω</td>
</tr>
<tr>
<td>CV</td>
<td>910F</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>30MHz</td>
</tr>
</tbody>
</table>

Table 3. Electrical characteristics of the CCII shown in Fig. 4.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>1.5V</td>
</tr>
<tr>
<td>k1</td>
<td>0.1mA</td>
</tr>
<tr>
<td>k0</td>
<td>1mA</td>
</tr>
<tr>
<td>M1, M2, M3</td>
<td>150V/μm</td>
</tr>
<tr>
<td>M4</td>
<td>100V/μm</td>
</tr>
<tr>
<td>M5, M6</td>
<td>11V/μm</td>
</tr>
<tr>
<td>M7, M8, M9</td>
<td>10V/μm</td>
</tr>
<tr>
<td>M10</td>
<td>1V/μm</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>63MHz</td>
</tr>
</tbody>
</table>

Table 4. Main performance of the CCII, determined at a 1.2V supply.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>0.975</td>
</tr>
<tr>
<td>β</td>
<td>0.958</td>
</tr>
<tr>
<td>Rα</td>
<td>20kΩ</td>
</tr>
<tr>
<td>Rβ</td>
<td>20Ω</td>
</tr>
<tr>
<td>CV</td>
<td>910F</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>30MHz</td>
</tr>
</tbody>
</table>

Table 5. Main performance of the current conveyor in Fig. 6 running from a 1.2V supply.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>0.97</td>
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<tr>
<td>β</td>
<td>0.98</td>
</tr>
<tr>
<td>RP</td>
<td>35kΩ</td>
</tr>
<tr>
<td>R1</td>
<td>100MΩ</td>
</tr>
<tr>
<td>C1</td>
<td>200F</td>
</tr>
<tr>
<td>CV</td>
<td>150F</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>63MHz</td>
</tr>
</tbody>
</table>

Figure 1 shows a simplified second-generation current-conveyor, or CCII. Its main characteristics are given in Table 1, where α is the voltage gain (V1/V2) and β is the current gain (I1/I2).

An improved topology is shown in Fig. 2. Here, a positive second-generation current conveyor (CCII+) is shown. Voltage V3 controls the biasing current, while transistor M5 performs the voltage buffering operation. From Fig. 2's topology it is possible to obtain a CCII- by simply adding a current mirror, as in Fig. 3. Its main characteristics are listed in Table 2.

Figure 4 shows a modified CCII-current conveyor that has been adopted for IC design. This circuit exhibits a current gain of k=αxβ and will run from a 1.5V supply. Its electrical characteristics are shown in Table 3 and its performance figures in Table 4.

Introducing transistor M6 in Fig. 4 allows the minimum operating supply voltage to be reduced to 1.2V. But the dynamic range for the conveyor is consequently reduced to about 70%, as shown in Fig. 5.

In this graph, the voltage at node X results if a sweep of the Y-node voltage from 0 to 1.2V is performed with typical biasing currents (IB) of 600nA.

Figure 6 shows a modification of the previous current conveyor. Transistor M5 of Fig. 4 has been replaced by a pMOS transistor, MP5, so that the circuit will operate better at lower supply voltages.

In this case the circuit works with a full dynamic range, but only if the output stage is considered. Table 5 outlines Fig. 6's performance.

Wide dynamic range conveyor

In Fig. 7, you will find the simplified schematic of a complete wide dynamic range CCII.

A low-voltage rail-to-rail op-amp performs the voltage-following action between Y and X with good accuracy. Output current at the high impedance

Fig. 1. Simplified second-generation current-conveyor, or CCII, suitable for low-voltage operation.

Fig. 2. Improved current-conveyor topology. This is a positive CCII- with its abbreviation is CCII+. Voltage V3 is bias and transistor M6 is a voltage buffer.

Fig. 3. Further improved CCII topology. Here, a current mirror is added the the conveyor of Fig. 2, turning the CCII+ into a negative conveyor, or CCII-.

Fig. 4. Schematic of a CCII configuration adopted for IC designs. This topology will run from a 1.2V supply.

Fig. 5. Dynamic range of the CCII of Fig. 4.

Fig. 6. Low-voltage implementation of Fig. 4. Transistor M5 of has been replaced by a pMOS transistor (MP5), to make the circuit operate better at lower supply voltages.

Fig. 7. Simplified schematic of a complete wide dynamic range CCII.
node is produced by a copy of the output stage of the op-amp. The op-amp has complete rail-to-rail dynamic range. This is ensured by a traditional constant-$I_c$ input stage working in weak-inversion (one-to-one current-mirror switch). This stage is followed by a typical low-voltage AB biased output stage.

Impedance on input node X is kept sufficiently low by the feedback of the op-amp, which has an open-loop gain of around 80DB. Unfortunately, this impedance reduction takes place as long as the feedback is effective. As it is only effective at low frequencies this technique does not lend itself to high frequency designs. It is also worth mentioning that this circuit architecture requires a supply voltage higher than $2(V_{CC} - V_{SAT})$.

References
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Now you can record measurements together with readings of environmental conditions — temperature, humidity, light level and even sound pressure — using just one meter, the DT21. This 3.5-digit multi-tester even checks transistors.

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Visit http://www.farrell.co.uk for details of the ZXF36101 development kit or http://www.zetex.com/pdf/ics/zxf36101.pdf for more data on the filter chip.

Design competition

Devise a useful and/or ingenious application for the ZXF36101 versatile high-Q bandpass filter with integral mixer and you could win a £500 voucher to spend with Farrell.

There's two runner up prizes of £100 vouchers too.

Rules

- Electronics World reserves the right to publish submitted entries. All designs published will be attributed to their designers. A minimum payment of £50 will be made for each design published.
- Submission of an entry does not remove your right to exploit your design, but it does give Zetex the right to use the entry as an application note, or as the basis thereof, effectively making the design public domain.
- Winners will be chosen jointly by technical experts from Zetex, Farrell and the editor of Electronics World. The judges' choice will be final and no corresponding will be entered into regarding the choice of winner.
- No employee of Reed Business Information, Zetex and Farrell, or any of their associated companies, may enter this competition, nor may members of their families.
- No entry will win more than one prize, but multiple entries may be submitted.
- Prizes are as stated here and are not negotiable.
- Entries arriving after the closing date will be void.
- No purchase in necessary to enter this competition.
- Winners will be notified by post, and the results may be published.
- For a list of winning entries, send an SAE to the editor's address.
- Submitting an entry for the competition implies acceptance of these rules.

Launches this year, the ZXF36101 is a versatile high-Q bandpass filter requiring a minimum of external components. In addition to the variable-Q analogue filter, there is also a mixer block, making the device suitable for a wide range of applications.

All you have to do is enter the competition is send a design idea incorporating the ZXF36101 to the address below. Entries will be judged on ingenuity, originality and usefulness. All entries are subject to the rules set out below.

A designer's kit is available from Farrell and you can find full data on the device on Zetex's web site http://www.zetex.com/pdf/ic/zxf36101.pdf.

It is not necessary to prove your design, and buying the kit is not a condition of entry into the competition. The design you submit has to work in practice but you will not be penalised for not having built a prototype.

If you do submit a design that meets the competition criteria and you have bought the kit, then you will receive a Farrell voucher for £15, courtesy of Zetex.

Send your entry to Filter Design, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AZ.

Note that it is not necessary to send your prototype! Simply send the circuit diagram and a clear, concise description of the circuit. It will help if you describe why you think that your circuit should be among the winners. You can also e-mail your entry to jackie.lowther@farnell.co.uk, but unless the e-mail has a subject heading that reads "Filter Design" it will not be eligible. Please attach diagrams and text separately and include a daytime phone number with your entry if possible.

The closing date for the competition is 30 April.
Personal voice communications without a licence over a two mile radius for £75, exclusive.

Reader offer

A pair of two-way PMR radios for just £75*

RS 446 personal mobile radio...

To celebrate its launch, new test and instrumentation company Tecstar is offering Electronics World readers two RS446 personal mobile radios for just £75 excluding VAT and carriage.

Capable of transmitting and receiving voice over a distance of up to two miles, depending on terrain, the PMR 446 needs no licence. It offers eight channels, scanning — and with CTSS up to 304 channel combinations.

A backlit liquid crystal display shows volume, sub-channel number, battery level and transmit/receive or channel busy. A unique call feature enables the user to alert the person they wish to contact.

Transmission distance is up to 2 miles. The radio has an accessory socket for an external headphone, earpiece or vox-microphone/headphone combination. A keypad lock and battery save feature are also standard.

The unit measures only 120 by 50 by 22mm and weighs less than 150 grams — including batteries. It is supplied complete with instructions and belt/clip mounting clip.

Compact, lightweight and low cost, the RS446 wireless personal—communications hand set has a wide range of applications. These include fêtes, events and rallies. Builders on building sites benefit from these radios, as could exhibitors at exhibitions and staff at warehouses, winter activities, sports events, maintenance departments, schools and care homes. Of course you can also use the RS446 just to keep contact with someone locally. The uses are almost limitless.

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What is CTSS

CTSS — or 'continuous-tone controlled squelch system' — allows sub-channels of the main channels to be used. There are 38 sub-channels to each main channel. Using sub-channels decreases the likelihood that someone else will be using the same frequency.

Random memories

by Alf A. Partile

In the world of low-power radio, there's considerable concern at the moment about new frequency allocations likely to cause interference to existing systems.

A particular case in point is the possible UK allocation for licence-free low-power devices, which is under threat from TETRA. Many existing licence-free low-power devices use up to 250W effective radiated power at 148MHz. Although no new applications should use this band, numerous 418MHz modules are still in use. Supposedly they will all be phased out around 2001.

TETRA — the Trans-European Trunked Radio system — is currently being rolled out. It is being used by emergency services and some private users such as fleet vehicles. Portable operate in the range 410-415MHz at up to 1W effective radiated power and base stations in the range 420-425MHz with currently a 6W effective radiated power limit.

I connected a Band III aerial to my spectrum analyser, and sure enough, there were some signals at around 425MHz, at a whopping -78dBm. Presumably these were TETRA base stations.

Now, though, portables will have 410-430MHz, and the base stations 420-430MHz, with a 25W effective radiated power limit. Current users of 418MHz should also be concerned if the proposed European allocation of 433MHz, but the regulations for this band itself are up in the air at the moment. Furthermore, this is a shared band and some users are experiencing interference from radio amateurs.

In the mean time, there is concern that existing 418MHz users may experience interference from TETRA. Well designed units — PM superhet receivers with SAW filter front ends — should be OK, except perhaps in the immediate vicinity of a TETRA transmission. But cheap low-tech super-regenerative receivers — 'hedgehogs' — are likely to be in trouble.

Any of you wanting more information on this topic should visit the web site of the Low Power Radio Association at www.lpra.org, or e-mail the Association at info@lpra.org.

The super-regenerative receiver relies on periodically self-quenching oscillations, due to positive feedback, to obtain great sensitivity with a very few components, at the expense of very poor selectivity.

So apart from being vulnerable to adjacent band transmissions, the 'receiver' also makes a low power transmitter in its own right — or own wrong, some would say. Its output, viewed on a spectrum analyser, shows a peak of spectral lines spaced at a quartz frequency, and looking rather like the raised spines of a hedgehog, hence the nick name.

Any oscillator may 'squeal', that is, it may operate in distinct bursts at a supersonic frequency, like a super-regenerative, if the time constant of the bias circuitry is too long. While this phenomenon is used to good effect in the super-regenerative receiver, squeeging is usually an undesired result of poor circuit design. Apart from some types of radar transponders — known as squitters — the only other 'useful' application of super-regenerative circuits is in the design of the 'transmit-only' power source for a 'radio' that is used only as a responder, to be used in a variety of cases that require a weak signal to be located.

Be warned, these are do-it-yourselfers, and to be avoided at all costs. They may cause interference to others, especially if they are built at home. You are warned. But there is no great harm, and they are a good way of understanding the world of radios.

April 2001 ELECTRONICS WORLD

307
View hysteresis curves

Fernando Garcia explains how you can display a transformer's hysteresis curve on your digital scope.

A hysteresis curve is a useful graphical display of a transformer's magnetic characteristics. It allows you to view several parameters at a glance, and to determine the presence of manufacturing defects like air gaps, missing laminations, relative quality of the magnetic steel properties, etc.

Unfortunately the equipment needed for displaying a hysteresis curve is expensive. As a result, such equipment is usually only found in specialised laboratories.

If don't need to view a calibrated hysteresis curve though, but rather a relative curve shape, the very simple circuit described here will suffice. You will need a dual channel oscilloscope, but apart from that, only a handful of passive components.

The relative shape is helpful in comparing unknown units against a known good unit. This is particularly useful, for instance, when evaluating the steel lamination from different vendors.

Fortunately, with the newer digital oscilloscopes that incorporate mathematical functions, even that simple circuit is no longer required. The curve may be fully obtained by processing the waveforms with the scope's internal functions. The basis for the operation lies in the relationships:

\[ B = K_x \times I \]
\[ H = K_1 \times I \]

where \( K_x \) is a constant for the turns, \( K_1 \) mean magnetic length and \( I \) is the magnetising current.

Both \( K_x \) and \( K_1 \) are assumed constant if you are only computing a known-good reference device against an identical device whose magnetic properties we are concerned about.

Lastly, the curve's characteristic shape is given by the change of permeability with the rate of change for the flux density and magnetising force. Thus,

\[ \Delta H = \Delta B \]

For a few words of caution. Always use an isolated variable transformer. Always fuse your circuit. Before plugging or unplugging the device under test, set the variable transformer all the way to zero volts and ramp up the voltage slowly. Finally, ensure that all secondary windings are open and suitably insulated.

Reference

The trick is to apply the voltage developed through a sampling resistor by the magnetising current to the scope's horizontal X channel. The sampling resistor should be calculated such that at the device-under-test's rated magnetising current, about 100 to 200 mV pk-pk are dropped across the resistor. Likewise, the applied primary voltage is fed to the scope's vertical Y channel, Fig. 1.

The procedure
With the scope still in the volt-time format, adjust the variable transformer's output to match the device under test's maximum rated primary voltage, as read on the digital multimeter. At this stage, adjust the scope's time base to obtain at least a full waveform cycle. Adjust the vertical gain controls such that the maximum waveform amplitude fits within the vertical. Now find the scope's mathematical functions and apply integration to channel Y. You should have now a display similar to what is shown in Fig. 2a). Now remove the Y trace leaving only the integration and horizontal traces.

The last step is to change the scope format to X-Y mode. You should now have a waveform like the one in Fig. 2b). The position controls may require fine adjustment to centre the hysteresis plot to the centre of the graph. If the curve appears mirror-image, apply the invert function to the X channel.

Remove the known-good device and replace it with a suspect device. You'll be amazed at the amount of information that may be obtained with a simple inspection of the curve.

A few words of caution. Always use an isolated variable transformer. Always fuse your circuit. Before plugging or unplugging the device under test, set the variable transformer all the way to zero volts and ramp up the voltage slowly. Finally, ensure that all secondary windings are open and suitably insulated.

Reference
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A valve substitute

Unable to find a replacement 6V6 audio power valve for his radio, Dave Allen set about making a MOSFET substitute which, he says, works better than the valve it replaced. Here's how he did it...

A anyone giving me many years of good service, my faithful mufly wireless recently fell silent. This was due to a failed 6V6 audio output valve.

The faucet's demise was caused by the coupling capacitor feeding its input grid on pin 5 going short circuit. This resulted in a positive voltage being applied to the valve’s grid, which in turn caused excessive current between the anode and cathode.

Apart from the dead valve and capacitor, the rest of the radio was in good order. Replacing the 0.1µF/400V cou-

Substituting valves that are part of a series-connected heater chain

Removing a valve from a series-connected heater from a circuit disables all other valves in the same heater circuit. If you want to replace a valve with a series-connected heater using a MOSFET substitute, the missing heater will need to be substituted too using a resistor that simulates the heater.

A ZOP3 valve is used here to illustrate how to determine the compensation resistor needed for the heater chain. This valve requires a heater voltage of 20V at a current of 200mA. Since R=E/L, the heater replacement resistor is 1000Ω.

The power rating of the resistor is 6W, hence 20×0.3, which is 4W. For this example, a resistor with a 5% tolerance rated at 100Ω and capable of handling 2W would be a good choice.

As this resistor is replacing a valve’s heating element, it will get hot, so it is advisable to place it where it will have sufficient ventilation and electrical insulation from the metal chassis.

Table 1. Pin connections for the 6V6 cathode

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No connection. This pin may be connected to the suppressor grid, g2, on certain pentode valves and can be ignored.</td>
</tr>
<tr>
<td>2</td>
<td>Heater</td>
</tr>
<tr>
<td>3</td>
<td>Anode</td>
</tr>
<tr>
<td>4</td>
<td>Screen grid (g3)</td>
</tr>
<tr>
<td>5</td>
<td>Input grid (g1)</td>
</tr>
<tr>
<td>6</td>
<td>No connection</td>
</tr>
<tr>
<td>7</td>
<td>Heater</td>
</tr>
<tr>
<td>8</td>
<td>Cathode</td>
</tr>
</tbody>
</table>

Implementing the valve substitute

A good starting point is the preparation of the valve base. Wearing safety goggles and gloves to protect you against cuts from broken glass is a good idea when reclamining the valve base.

The best way to break the glass envelope is to place the dual valve in a thick plastic bag and tap the glass with a small hammer. Then carefully remove the shattered remnants from the base.

Remnants of wire in the valve base pins can now be unscrewed.

A piece of 0.1m thin wire stripboard with 11 strips by 32 holes is required for mounting the MOSFET, heat sink, and the few passive components.

After completion of the component board, three short flying leads can be connected to the board and taken to the relevant pins on the valve base and soldered. The board can then be held in place using epoxy resin adhesive.

Setting up

With the plug-in module completed, rotate the wiper of VR1 so it is at the anode end of D1. This will ensure there is no positive bias voltage on the gate of the FET when you first switch on your receiver.

Now insert the plug-in module into its socket and connect a meter switched to its 20V DC range across R1. Switch on your receiver and let it warm up for about ten minutes.

Slowly rotate VR1 until the MOSFET springs to life. This will happen quite suddenly. Finally adjust VR1 for a drop of 2V across R1. This corresponds to a current of 20mA flowing through the output stage, which works well with my particular receiver.

Power dissipation considerations

As the MOSFET in this case is biased in class-A, it is constantly dissipating

<table>
<thead>
<tr>
<th>Main components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
</tr>
<tr>
<td>R1</td>
</tr>
<tr>
<td>R2</td>
</tr>
<tr>
<td>VR1</td>
</tr>
</tbody>
</table>

Capacitors

C1, C2: 100Ω, 63V metallized polyester film, 5mm spacing

Semiconductors

IRF300 MOSFET (Farnell). This version of the MOSFET has no insulated tab so the heat sink will not be at HT potential.

Diode

D1 is an 18V/400mW zener diode.

Fig. 1. Original feedback to earlier stages

Fig. 2. Using a 6V6 substitute, the heater and screen grid connections become redundant, so only three pins on the valve base are used.

Fig. 3. MOSFET substitute for the 6V6 valve. Only three pins are needed on the valve base, to replace the valve’s anode, cathode and grid.
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