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BAR CODES Demystified

Roger Thomas describes the common bar-code format and provides information on how to decode the stripes using a low-cost bar-code wand, PIC microcontroller and software.

IS LINUX FOR YOU?

If you design via CAD running under Windows, the chances are you've been frustrated by operating system crashes. As Rod Cooper points out, Linux is low cost, and it's well worth finding out how your favourite applications will run under it.

CODE-HOPPING REMOTE CONTROL

Pei An has developed a highly secure wireless remote-control system based on Microchip's Keeling code-hopping chips. One control receiver can recognise up to four transmitters, each with four push-buttons.

LETTERS


DESIGN YOUR OWN DSP AUDIO FILTER

Patrick Gaydecki describes how to produce a real-time audio filter based on the simple hardware discussed in the June issue.

NEW PRODUCTS

New product outline, edited by Richard Wilson

SPEAKERS' CORNER

A reader came up with the idea of reducing woofer distortion by using motional feedback derived from pressure changes. "So why is no one using it?" he asks John Watkinson.

DESIGNING RADIO RECEIVERS II

Joe Carr examines receiver design from the ground up. This second article looks at elements of the superheterodyne receiver.

CIRCUIT IDEAS

• Stable go-no-go voltage indicator
• Analog optical isolator
• Emergency light and alarm
• Slow diode as fast spike suppressor

RESTORING BAIRD'S IMAGE

Hugh Mulberry reviews Don McLean's recent book on the work of Baird.

RECEIVING MULTI-BAND PULSED ULTRASONICS

Wideband ultrasonic signals are often processed using a number of band-pass filters with different centre frequencies. Design competition runners up S. Vijayan Pillai and S. Subash have devised a new method for processing such signals using frequency synthesis and Baird's new filtermaker chip.

WEB DIRECTIONS

Useful web addresses for the electronics engineer.

BEGINNERS' CORNER: AN OPTO AUDIO LINK

Ian Hickman describes a simple opto-electronic link with enough bandwidth to carry speech. In its basic form, the link's working distance is limited, but it is easily modified for building-to-building use - or even further.

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Microchip combines PIC microcontroller with DSP

At last Microchip, makers of the popular PICmicro range of microcontrollers, has revealed details of its forthcoming dsPIC DSP-microcontroller combination.

PIC with DSP - performance

The chip

30V/µs
94 instructions
11 addressing modes
up to 4 Mbytes x 24 flash
up to 32 x 16 ram

DSP engine

16-bit by 16-bit multiplier
40-bit adder
two 40-bit saturating accumulators
40-bit bi-directional barrel shifter

Peripherals

fault-tolerant oscillator
up to 8 capture and 8 compare functions
dedicated motor control/power conversion
PWM
Quadrature Encoder Interface
Interfaces for
RS-485, UART, PC, SPI, AC97, CAN, I²S
up to five 16-bit timers
watch/dog timer
up to 80 I/O bi-directional ports
10-bit high-speed simultaneous sampling a-to-d converters
12-bit A/D converters.

It will be a single-instruction stream non-pipelined modified Harvard machine with a 16-bit data RISC core and 16-bit DSP engine.

The instruction set architecture has been designed, "to be highly efficient for C compilers and RTOSs," said Microchip. Towards this vectorised exception processing, supporting eight user-prioritised, fixed latency, interrupts and seven traps, is included. Applications foresee include motor control, Internet-connected appliances, automotive products, power supply management and speech recognition.

Microchip claim dsPIC will be supported by its own tools, application specific libraries and third-party tools. Devices are planned in packages with from 28 to 100 pins and will operate from 2.5 to 5.5V with a variety of power-saving modes.

The company's 0.5um flash process will be used. Beta sampling is planned for the fourth quarter of 2001 with volume production in 2002. An Electronic ink display inventor teams with Philips

E Ink inventor of a display technology that relies on the electrostatic attraction of tiny coloured particles in a liquid, has revealed yet another prototype. This time it is with Philips Components.

The announcement comes only four months after E Ink agreed to develop and commercialise active-matrix electronic ink displays. The prototypes use a 2cm sheet of E Ink's electronic ink with Philips' active matrix backplanes and drivers. The modules can display monochrome and grey-scale images with a resolution of 160x160. The partners intend to be selling high-resolution electronic ink displays for smart hand-held devices in 2003.

Unlike LCDs, E Ink's displays do not need polarisers and have a high contrast ratio and a wide viewing angle. The company already has ties with IBM (Electronics World, July 2001), and has shown a simple coloured prototype.

B² Spice 2000

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Fuel cells deliver up to 3kW and run on any hydrocarbon fuel

Fuel cells developed by German firm NovArs look set to go into pilot production. NovArs’ US technology backer Manhattan Scientifics aims to start pilot production of fuel cells aimed at portable electronics such as power tools, home generators and laptop computers.

The cells are based on a proton exchange membrane (PEM), which can extract hydrogen from almost any hydrocarbon fuel. Power outputs range from 2W to 3kW, the firm said. Energy density is around 115W/l, several times higher than lead acid batteries.

Light-emitting plastics a step closer to production

Cambridge Display Technology (CDT) has signed a deal with Tokki to co-develop production equipment for light-emitting polymer (LEP) displays.

CDT-LEPs are one of the two technologies vying for space in the plastic semiconductor displays market, which has yet to develop.

Many predict that plastic displays will dominate the front of mobile phones and personal organisers in the next few years. Organic light-emitting diodes, or OLEDs, from Kodak and its licensees are the other technology—which seems to be slightly ahead in the race to market at the moment. The CDT-Tokki agreement covers the next generation of Tokki’s volume manufacturing plastic vapour-deposition (PVD) and encapsulation technology.

Development work will include looking for encapsulation techniques to reduce cost and improve display life.

CDT has purchased a 355mm Tokki PVD machine to be installed at its pilot development line, currently under construction in Godmanchester near Cambridge. This facility is expected to come online in early 2002.

Nissei Sangyo will be Tokki’s exclusive distributor for equipment developed in the deal. LEP displays took another step toward production recently when Osram Opto Semiconductors (Osram OS) brought forward production plans for LEP displays.

It was due to start manufacture in 2002, but in a statement it said, “expects to bring a commercial LEP display manufacturing plant in Penang, Malaysia on stream during 2003”.

According to Osram OS, which is a joint venture between Osim (51 per cent) and Infineon, it already has an LEP pilot line in San Jose.

The firm is discussing building a small production line with several companies, it said, which could be based in the US, Europe or Japan.

New package options for smaller circuit boards

Texas Instruments has developed a family of packages for simple logic chips which can cut circuit board footprints by 70 per cent, compared with its previous packaging.

Called NanoStar, the 5- and 8-pin packages are aimed at single and dual logic gates, often used in products such as mobile phones, laptops, MP3 players and other hand-held equipment.

Until now TI has used the 5-pin SC-70 package for single gate logic. NanoStar has a footprint of 1.4 by 0.9mm, or 1.2mm2, which means it uses 70 per cent less board space than SC-70. Its height is 0.5mm.

Connection to the PCB is via eruptive solder balls - the mixture of metals in the balls melt and solidify at the same temperature. Thermal properties are improved compared with the SC-70 packages, TI said.

Bipolar transistor achieves 210GHz

IBM Microelectronics has developed a silicon germanium heterojunction bipolar transistor (HBT) running at 210GHz.

The move marks a big step forward, which could extend silicon’s reach to the 40GHz’s communications market and beyond.

IBM exceeded 200GHz by taking its 0.18µm SiGe process, which runs up to 130GHz, and reducing the vertical thickness of the transistor’s base.

With a cut-off frequency (fT) of 210GHz, IBM’s transistor is not only 75 per cent faster than its own previous devices, it is significantly faster than any other published SiGe transistor.

Hinachi, for example, last year detailed a 0.2µm SiGe HBT with an fT of 76GHz.

Other materials, such as indium phosphide, are being touted for high speed comms applications due to higher performance, but they are more expensive to manufacture. IBM claims its HBT, compared to a similar speed SiGe bipolar device, uses 20 per cent less current — around 1mA.

What’s amazing is that IBM’s process differs little from other companies’ devices. HBTs are built on a 0.18µm SiGe/CMOS process with an emitter area of 0.24µm2.

The major difference comes when the thickness of the base region. Although grown epitaxially like most HBTs, the base has an undichotomised thickness. This reduces the transit time of electrons across the base, which directly affects the cut-off frequency.

Furthermore the amount of germanium in the base is graded, from almost none at the base-emitter junction to between 20 to 30 per cent at the base-collector junction. This brings into question the device’s claim to be an HBT at all.

“There is a small percentage of germanium at the base-emitter junction, so there is a heterojunction effect, seen in an increase of the current gain,” said Shohandi Subbanna, senior engineering manager for analogue and mixed signal at IBM.

“The man heterojunction is at the collector-base junction.”

Subbanna’s engineers expect to have manufactured single circuits based on the HBTs by the end of the year.

In a separate announcement, IBM said it will add "strained silicon" to its CMOS manufacturing within two years, a process it claims will increase switching speeds by 35 per cent.

“The limiting factor for switching speeds is the mobility of electrons and holes,” said Helmuts Schettler from IBM. Strained silicon increases electron mobility by 70 per cent, he said.

Strained silicon is made by growing a silicon layer atop of a lattice with a slightly larger inter-atom spacing. This is often a 7/25 silicon/germanium layer giving a one per cent expansion.

If the top layer of silicon is fairly thin, as it is in a drift channel, then the silicon retains the spacing of the substrate and is said to be strained.

Even a one per cent larger lattice, increases degeneracy of the silicon’s conduction band, trapping electrons and reducing the scattering of free electrons in the lattice. This increases mobility.

IBM has completed some test structures using strained silicon and expects to have it in production by 2003. "It’s a question of getting a reliable process," Schettler said.

Java makes robot clap

TheJavaOne Developers Conference in San Francisco saw the emergence of the “Ultimate Wireless Lego Robot”, or so Motorola claimed.

Together with Flashline, Motorola assembled the robot to demonstrate their wireless data technology.

Users remotely sent commands from a Motorola i50x phone through the Internet to the robot, which will dance, clap its hands, wave its tail, and move around in response.

Both the handset and the application use Java J2ME, one of the smallest versions of Java aimed at portable applications. The Internet connection is ‘always-on’ and the software is booted together from re-usable modules.

This simplified HBT shows its vertical structure. Deep trench isolation protects individual transistors, while a shallow trench separates the base-emitter junction from the collector connection.
First products using Indium phosphate semis available next year

Indium phosphate, one of the new breed of high-performance compound semiconductors, is set to appear next year in a commercial product. TRW, with partner Hitachi, will introduce InP devices into mobile phone handsets in 2002.

InP is an exotic material, until recently confined to laboratories, but its phenomenal speed is tempting manufacturers to bring it into the open.

InP applications—according to TRW
- mobile phone handset power amplifiers
- digital and microwave ICs for satellite payloads
- 40 and 80GHz optical network components
- integrated fibre-optic receivers
- Ku-band to X-band LNAs, VCOS and PAs
- components for "fast route" broadband access
- 60GHz wireless picocells
- 94GHz wireless links.

"TRW's baseline InP HEMT [high electron mobility transistor] process with 63 percent indium in the channel yields devices with an fT of 300GHz and an fmax of 450GHz. InP HEMTs exhibit higher gain than GaAs HEMTs, as well as a lower noise figure and better PAE [power-added efficiency]," claimed the company in a paper last year.

And TRW has made an InP static frequency divider that operates at least 80GHz—way over the head of silicon. In fact, it could have been faster but TRW's test gear ran out of steam.

Direct integration of optical components is another possibility with InP. Devices such as LEDs, lasers, and photodiodes operating in the 1.3-1.55 μm (optical fibre) region may be made alongside HEMTs and HBTs (heterojunction bipolar transistors).

These speed, efficiency and versatility advantages have been more than offset by cost, yield, and reliability problems, as well as lack of high-quality large-diameter InP substrates—which are fragile and brittle when you can get them. According to TRW, InP shares many of these problems with GaAs and the company introduced a high-volume commercial GaAs HBT process in 1993 when others thought it was years away.

Its InP process is modeled on a HMU descendant of its original GaAs process. Steeply transfer included substrate supply (75mm now, 100mm in development), epitaxial (molecular beam), yield and backside processes.

It claims process yields equivalent to those of GaAs HBT processes on its space-qualified 75mm InP process. The 100mm process will be for commercial and space applications.

Reliability is high, says the company, with MTTF (mean-time-to-failure) values of 10¹⁰ to 10¹⁵ hours for devices at 125°C ambient.

Mini mouse is world's smallest

This is the smallest manual input device in the world, claims its maker InControl Systems.

Called Piccolo Point, this is a force sensitive mini-joystick—shown in the picture combined with push-buttons to make a mouse.

It is aimed at wireless and hand-held products and is under 4mm thick with a 14 by 18.5mm footprint—including connector—and with a predicted life of ten million operations.

The company also offers a custom microcontroller that emulates a serial or PS/2 mouse and works with standard mouse drivers, or the user can exploit unused resources in an existing microcontroller to support pointing.

Piccolo Point is available from Diamond Electronics.

Diagonal routing promises faster chips with lower power consumption

A consortium of companies has set up an initiative to promote diagonal routing inside ICs, a technique that could increase speeds, cut power drain and improve yield. Called the X Architecture, the technique rotates the fourth and fifth metal layers through 45°. Standard chips are arranged with metal layers in the so-called Manhattan layout, alternately running horizontally and vertically.

While using diagonal lines is hardly new, the idea of devoting two whole layers to 45° lines is a bold move.

This simple change to the orientation of two metal layers could reduce the length of any single interconnect by up to 30 percent.

An entire cross-section of the industry from EDA firm Simplex, through a number of mask and equipment makers, to semiconductor manufacturers STMicroelectronics and Toshiba are promoting the move.

In fact, Toshiba and Simplex claim to have been working on a production system for over two years.

"As we developed the technology that enables the X Architecture, we worked closely with our partners Toshiba over several years to prove the manufacturability of this new architecture," said Aki Fujimura, president and CEO of Simplex.

On typical chip designs, the firms reckon the total interconnect length is cut by 20 percent. Consequently performance increases by 10 percent and power dissipation drops by a fifth.

Perhaps even more significant is the claim that the process could increase the number of dies per wafer by 30 percent.

"In today's era of five-plus metal-layer designs, the advantages of using diagonal lines are tremendous in terms of chip performance, as well as area," said Dr Kenji Yoshida, v p of engineering at Japan's Semiconductor Technology Academic Research Center.

Using metal layers four and five means that existing library cells and intellectual property blocks are unaffected as they use lower metal layers.
Bar codes demystified

Roger Thomas gives a brief history of bar codes and the organisations that issue bar-code numbers. He details the most common bar-code format used in retailing, and provides information on how to decode the stripes using a low-cost bar-code wand, PIC microcontroller and software.

There are many different bar-coding schemes in operation, but for retail products the EAN-13 system is used. Products that are sold in one store - i.e. own label goods - or require weighting and labelling in-store are not part of this scheme. An EAN-13 bar code allows for unique product identification using thirteen numbers. Bar codes found on food and household products do not include the price or product description. This information is obtained from the computer system that the scanning equipment is connected to.

Bar-code numbering

In the UK, the organisation that allocates company prefix numbers is called eCentre. This is the trading name of the Association for Standards and Practices in Electronic Trade - EAN UK Ltd. It was launched on 7 October 1998 with the merger of the Article Number Association and the Electronic Commerce Association. Article Number Association, or ANA, was the UK authority for company prefix numbers and was established in 1976. The Electronic Commerce Association was formed in 1987, originally as the EDI Association, but in 1995 it broadened its activities to incorporate electronic commerce.

ANA was a founder member of the European Article Numbering, or EAN, Association formed in February 1977 with its headquarters in Brussels. The name was changed in 1992 to EAN International to indicate that its activities are no longer confined to Europe. EAN International is represented in 99 countries by local offices. It was founded to create a compatible bar-

coding system based on the North American bar-coding system known as Universal Product Code, or UPC.

UPC format

The UPC coded bar code was adopted by the North American retail industry in 1973. American Uniform Code Council (UCC) administers the allocation of UPC numbers.

A UPC number is a twelve-digit number with the first digit being a number-system character. The following table shows what each system number represents.

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>UPC retail number</td>
</tr>
<tr>
<td>1</td>
<td>reserved</td>
</tr>
<tr>
<td>2</td>
<td>items that need to be weighed</td>
</tr>
<tr>
<td>3</td>
<td>In-store</td>
</tr>
<tr>
<td>4</td>
<td>drugs and health related</td>
</tr>
<tr>
<td>5</td>
<td>products</td>
</tr>
<tr>
<td>6</td>
<td>used for in-store labelling</td>
</tr>
<tr>
<td>7</td>
<td>coupons</td>
</tr>
<tr>
<td>8</td>
<td>UPC retail number</td>
</tr>
<tr>
<td>9</td>
<td>reserved</td>
</tr>
</tbody>
</table>

After this number, there follows a five-digit manufacturer number - allocated by UCC - and a five-digit product number, assigned by the company. This provides 100,000 companies the ability to number 100,000 products for each system number.

The last digit is a check digit. At present, UPC numbers 1, 8, 9 have not been allocated giving scope for additional 300,000 company-prefix numbers.

EAN format

EAN-13 is a thirteen number group structured in a similar way to UPC number. However, there is no system number. This is replaced by a country prefix. Following the country prefix, there is a unique company prefix, product number and a check digit. This check digit ensures that the bar code has been correctly scanned.

The country prefix is the first two or three digits of the bar-code number.

For the UK, the country prefix is 50, Fig. 1. If a bar code starts with 50, this does not necessarily mean that the UK is the country of origin for the product though.

Unlike UPC, the EAN scheme has the company prefix and product numbers of variable length. Varying the length of the company prefix makes for a more efficient use of the numbers. If a company only needs to number 100 products then they are provided with a longer company prefix than a company needing number 1,000,000 products.

Each nine-digit company-prefix number can be used to create up to 1,000 different product numbers. Eight digit prefix numbers can be used to create up to 10,000 numbers and seven digit prefix numbers can be used to create up to 100,000 numbers.

The company allocates the individual product numbers - not the organisation that allocated the company prefix.

Coupon code

Two prefixes have been reserved for use on EAN coded redemption coupons. Prefix 98 is used for a coupon that might cross national boundaries and prefix 99 is reserved for national coupons. For example 99 YYYY NNN VVV comprises YYYY, which is the coupon issuer number, NNN the coupon reference number, VVV the redemption value and C is the check digit.

The redemption value range of the coupon is from 1p (VVV=001) to £99 (VVV=999), the decimal point is fixed. For values greater than £99 the code 999 is used and the redemption value entered at the checkout. Coupons that offer free goods are encoded by VVV=400. Coupon numbers may be re-issued after 36 months has lapsed.

ISBN book codes

The International Standard Book Number (ISBN) is a unique ten-digit number allocated to every book by its publisher. The ISBN system was in use before the EAN-13 numbering system was adopted.

An ISBN code consists of four parts. The first part indicates the language or country of origin and can be a one, two or three digit number. For example, a 0 or 1 number indicates the book is written in the English language. The number 2 is for books in the French language, 3 for books in the German language, 4 for books published in Japanese. The second part indicates the publisher and the third part the book number allocated by the publisher. The size of each field is not fixed and the last digit is the check digit.

ISBN codes are represented in the EAN/UCC-13 coding scheme by adding a 978 prefix. The final digit is the EAN/UCC calculated check digit and not the original ISBN check digit.

Check digits in the ISBN system use a different algorithm. It is possible that the original ISBN book number - and possibly the associated ISBN bar code - will also be printed near the EAN/UCC-13 bar code. If the original ISBN number is printed, the different fields can be separated by hyphens.
CD. Music CDs or games CDs are not included in the 978 numbering scheme and use a normal EAN/UCC-13 number.

ISSN periodical codes

A system used to identify serial publications, such as newspapers and magazines, is called the International Standard Serial Numbering, or ISSN, scheme. An ISSN number is coded in the EAN/UCC-13 scheme with a 977 prefix. These EAN/UCC-13 bar codes can also have a separate two-digit extension code.

For daily publications the number is 977 SSSSSSSS PP CC WW. Here, 977 is the ISSN prefix number and SSSSSSSS the ISSN number. Letter P indicates change of price. It is increased in value by one each time the price rises. The ‘D’ indicates the day of the week—week start.

For weekly publications the number is 977 SSSSSSSS PP CC WW, where 977 is the ISSN prefix number and SSSSSSSS the ISSN number. The ‘P’ indicates change of price. Rising by one for each price increase. Letter C represents the EAN/UCC check digit while WW represents the week number as a separate two-digit symbol.

For monthly publications this additional two-digit bar code indicates the month.

UPC in Europe

Products identified with UPC bar codes have been scanned without any problem in Europe. The twelve-digit UPC number can be processed by preceding the number with 0 to make it EAN-13 compatible.

However, the reverse has not always been true in that some European suppliers have had to obtain UPC numbers if their product was to be sold in North America. The problem is not with the scanner equipment but incompatibility due to many American retail computer database systems not being able to handle the extra digits, or the variable length product and company number.

UPC future

The Uniform Code Council organisation is expected to use all of its company prefix numbers by the year 2005. Consequently, there is an open bar code of bars to space bar code number. Bar code definitions on the left side of the centre guide bar all start with a face terminals.

This date was agreed in May 1997 at a meeting between the UCC and EAN International. UCC acquired country prefixes 10, 11, 12, and 13 EAN International. After the 1 January 2005, thirteen digit EAN-UCC numbers will, for the first time, be allocated by the UCC.

There is no ambiguity between the EAN and UCC numbers. The existing twelve-digit UPC number is not being replaced by EAN-13, but adopting the EAN-13 format allows for expansion and a global numbering system.

UK bar codes

If you look at a typical EAN-UCC bar code number, the first five numbers of the barcode represent the publisher. The first country prefix number is not directly incorporated as bar stripes, but is encoded by the choice of which characters are taken from Fig. 2 or Fig. 3 for a given position. These are often referred to as Table A and Table B.

For example, UK bar code the sequence ‘ABBAB’ to signify the number 5. Fig. 4. The first number must be encoded (0) is taken from Fig. 2. The second and third numbers use Fig. 3, and so on. Similarly the balance ‘ABBAB’ is used to denote the number 9 — used for magazines and books.

Only twelve numbers are actually encoded in the bar-code stripes. The last six numbers are taken from Fig. 5 (i.e. Table C). Definitions in this table are the same as those in Fig. 3.

Each number definition is unique so there are no duplicate patterns.

Bar-code forms

EAN/UCC-13 uses proportional coding with four different widths. When printed, this is more space efficient than coding the number in binary. There are no inter-character gaps—spaces are part of each number definition.

In addition to the bar-coded twelve numbers, there are two guide characters and a start character. These guide bars may be extended below the rest of the bar code.

To increase scanning reliability, not all the possible character permutations are used. The maximum black or white space is four and there are always two sets of bars and two sets of spaces per number. Overall, there is an open bar code of bars to space bar code number. Bar code definitions on the left side of the centre guide bar all start with a space and end with a bar. With bar codes on the right the converse is true starting with a bar and ending with a space. A blank area — referred to as the ‘quiet zone’— must appear before and after the bar code. Bar-code scanners use this zone to determine the exact beginning and end of the bar code.

Bar-code wand

Quality bar-code wands are often manufactured with a metal barrel: cheaper wands tend to be made of plastic. These wands look like a large pen. At one end there will be a small lens and at the other end a lead. The wand must be able to distinguish between the bar-code bars and the gap between the bars. To do this, most hand-held wands use several red light emitting diodes that are used to illuminate the bar code with visible red light and a photocell light detector in the centre of these. The light detector converts the reflected optical signal into a digital signal that is then fed to the microcontroller.

The printed bar should absorb the light, while the blank area reflects the light back to the wand detector, the detector responds to this intensity change. The digital signal above will be threshold will produce a logic 1 and below the threshold will produce a logic 0. Consequently as the wand is moved across the bar code the background produces a logic ‘0’ and a bar is logic ‘1’.

Place the wand to the left of the bar code in the blank area just before the bar code. The wand is held like a pen and a straight line is lightly drawn across the entire bar code. If it does not scan the first time then do not press down harder the second time as this can destroy the wand. Initially it may take a few attempts to scan a bar code before the correct position and speed are found.

Wedge

Having scanned a bar code for data capture, the information needs to be input into application program. This data transfer is often achieved using a keyboard ‘wedge.’

There are two versions of the wedge — hardware and software. With the hardware wedge, the wedge is plugged into the PC keyboard port. The keyboard is then plugged into the wedge plug port. The wedge reads the data from the PC keyboard and sends this data to the wedge. The wedge then sends this data to the wedge, which in turn sends it to the keyboard. A program that exists between this computer and wedge can be used with a suitable wedge without any need for the program to be modified.

Bar-code colours

Bar codes do not have to be printed in black on white but this is usually the case — white and black — and cheaper — and cheapest — print option. Red, yellow, and white are suitable background colours as they will reflect the scanner light. Blue, green, and cyan can also be used for the printed bars as they appear black under the rod scanner light.
Bar code trivia

In 1967 the Association of American Railroad selected a bar-code identification system to keep track of the rolling stock. The first test of the system was in 1961. Each carriage was given a four-digit number to identify which railcar owned it and a six-digit identifier number. These bar-code stripes were placed on the side of the rolling stock using reflective material.

This was the first attempt at an industrial application of bar-code technology. Previous systems have all been associated with retailing. It took until the mid 1970's before the majority of the rolling stock had these bar codes. However, for cost and other reasons the system was abandoned in the late 1970's. Also in 1967, RCA installed one of the first retail scanning systems at a store in Cincinnati. A set of concentric circular bars and spaces of varying widths represented the product number. These bar codes were not pre-printed on the product, but these labels were put on each item by the store. Retail industry recognized the advantages of this technology to speed up the check-out process and for inventory control but this could only be achieved with industry wide standards.

In 1970 the US Supermarket Ad Hoc Committee was formed and the result was the Universal Grocery Products Identification Code. Three years later the UPC (Uniform Product Code) numbering system using linear bar-code symbols was adopted.

On 26th June 1974 at a super-market in Troy, Ohio the first retail product with a UPC bar code was scanned using one of the first bar-code scanners installed. The scanner was manufactured by National Cash Register Company – now known as NCR – and the product was a packet of Wrangler’s chewing gum.

For those that do not have a 16f877 programmer I can supply a programmed PIC for £20, including the Windows software. PIC and MPLAB are registered trademarks of Microchip Technology Incorporated, USA.

Windows 95/98 is a registered trademark of the Microsoft Corporation.

Calculating the check digit

Here is an illustration of how the simple formulas needed for calculating the EAN/U/PIC check digit are used.

Example: calculate the check digit (C) for the EAN/UCC-13 number: 5012345764214

Step one: starting on the left side of the number add together all alternate even numbers:

0+2+4+7+4+1+8 = 25

Multiply the result by three:

25×3=75

Step two: add together the remaining odd numbers:

5+1+3+5+2+2 = 22

Add both results together: 75+22=97

The check digit is the smallest decimal number which, when added to the previous result, produces a number divisible by 10

97+6=103

Both results are therefore not valid.

The full number is 5012345764214

From this example it should be clear that having separate reduces any problems caused by variation in the quality of bar-code printing.

If the timer width of a single width is less than the reference value then the reference width becomes this new value. Whatever number is encoded in the stripes there will always be the two middle single width guide bars for reference. If the width of the reference value is different from a scanned bar, then this new value is divided by 2 and made the new single width reference value.

This ensures that if the speed at which the wand is moving across the bar code changes, then the subsequent measurements will still be accurate. There will be some variation in scanning speed as a constant speed across the whole bar code is very unlikely.

If the bar width time value is less than 150% of the appropriate reference value then bar width is one.

If the timer bar is between 150% and 250% of the reference value then bar width is two. If the timer bar is between 250% and 350% of the reference value then bar width is set to three. If the bar width is greater than 350% of the reference value then bar width is four.

Bar width into binary

The various bar-code widths are measured and converted into a binary sequence according to the bar width. This sequence should begin with '101', which represents black, white, black single width guide bar and is checked by the software. If it is missing then an error message is sent to the software and the result is sent.

Likewise, the software checks that the middle guide bars are also present. If they are not, then the error message is sent. These guide bars are not part of the bar code number and are subsequently ignored by the software.

Converting bar binary into numbers

As already established, each bar-code number is uniquely defined, in effect, a seven-bit binary definition. Each bar-code number binary definition is converted into a number.

The scanned bar code starts off as a binary number and is also converted to its equivalent number. The appropriate table is searched, looking for a numeric match for each sum. For example, if the first bar-code

PC software

I have produced Windows 95/98/ME software that has the ability to check that a EAN/UCC-13 bar-code number is valid. It also determines which country allocated the bar code from the country prefix number. Bar-code numbers can be typed in from the keyboard, as well as being scanned.

The software can also generate EAN/UCC-13 bar codes. The resulting bit maps can be copied to the clipboard and pasted into another application.

The software includes a simple text-based user defined database. If the bar-code number matches a bar code within the database then text information contained in the database is displayed. These demonstrate how bar-code can be used for inventory or asset tracking systems.

If you are interested in this software, please write to me, Roger Thomas, at 24 Slade Hill, Hadkenley, Aylesbury, Buckinghamshire HP17 8AJ. I can also supply a pre-programmed PIC 16F877 for £20. This price includes the Windows software.
sequence number is 13 — which it will be for a UK bar code — then a match is found in table A, Fig. 4, and "Y" is returned. If there is no match, the search is indicating a scanning error.

Depending on whether table A or B produces a match, this also determines the first digit, which is the country prefix. Consequently, all numbers have to be stored so that the first number can be decoded from Fig. 4 and cross-referenced.

If one of the six numbers has not scanned properly then the first number cannot be obtained and an "X" is sent as the first number.

The total number of combinations that can be generated from a 13-digit number, it needs to be verified to see if it has been scanned correctly. This is done by removing the last digit — the check digit — and using all the remaining numbers to generate a check number. If the scanned number includes an "X" then the scanned barcode number will automatically fail. The algorithm to compute this check digit is the same one that was originally used. Both UPC and EAN-13 use the same formula. This calculated number is compared with the scanned check digit. If the numbers are the same then the bar code has been scanned correctly; if not the bar code is rejected and a "check-sum error" message sent to the computer.

Using List 1, programmed into a microcontroller at 19200 baud, 8-bit data and no parity. Although the microcontroller has a built-in serial port, it is necessary to invert the data using a 74LS14 buffer. This also means that when using a serial interface device but as data is flowing one way a serial interface device is not needed.

Terminal software
As the output from the PIC microcontroller is the bar-code number or error messages in plain text (ASCII) then the terminal uses the HyperTerminal software — supplied with Windows — can be used to view this information. Fig. 6. Set the HyperTerminal properties as ‘direct to com’. Set the Port to COM3, 9600 baud, 8 data bits, 1 stop bit, no flow control.

List 1. PIC object code for reading bar codes and conveying the number via RS232 to a PC. When programmed into a flash PIC/16F87, this hexadecimal code allows the decoding of a EAN13 bar code and sends the bar-code number to the PC. This object code is intended for personal use only; any commercial use requires written agreement from the author.

Microchip MPLAB assembler saves the PIC object code in .INHX format. All numbers are in hexadecimal and each line starts with a comment. After the colon each line starts with the number of data bytes followed by the address and the PIC object code, the last byte is the line checksum. Using the object code listed (Note: enter the hex data and save the file in a hex extension (for example barcode.hex)).

If the PIC is not being used in conjunction with the Microchip MPLAB software then select the import (import to memory) option from the File menu. Find the appropriate directory and select the bar code hex file. To view the hex code that will be programmed into the PIC16F87, select from the Windows menu the ‘Program Memory’ option.

When programming the flash PIC, ensure that the PIC configuration options are set to the following: oscillator mode is set to HS (High speed), watchdog timer is off and power up timer is enabled.

If you don’t relish the thought of typing this in, e-mail files@mcall.com.co.uk using the subject header ‘bar codes’.

...
Relatively Unto system cost, vio well your CAD Cooper's worth job, as describe CAD, vantage. ed Internet to Background their get such operating they of Linux computers, you also get to run Linux - neither does it explain how Linux came about. You get all this information on the internet or from a Linux hand-book.

Linux is a product of the Internet, and indeed it would have been impossible for it to reach such a stage of prominence without it. If you have no internet access you will be at a disadvantage. Alternatively though, there is general Linux literature on the market, and Linux magazines are now available.

Background to Linux

When I briefly looked at Linux a few years ago it was a tough, command-line operating system with a well-deserved reputation for being difficult to install. It offered all the disadvantages of DOS with very few redeeming features. The thing that has changed Linux out of all recognition and boosted its popularity is the relatively recent addition of Windows-like GUIs.

Whereas Microsoft is busy trying to transform its DOS origins of Windows 9x, users of Linux are actually encouraged to keep the GUI out and use the command line and generally get involved in the nuts-and-bolts of the Linux system. However, if you want to, you can remain to a large extent inside the cocoon of the Windows-like GUI and ignore this side of things.

Reasons behind a swing to Linux

Although Linux is inexpensive compared to Windows, this alone is not sufficient reason to change over to it. The effort needed in the learning curve, and the time taken to convert machines over to Linux, and the cross-platform compatibility question, should make you examine your reasons for swapping to Linux most carefully. There are possibly many more reasons than those I have listed here, but I can see six main reasons why anyone should want to ditch Windows either partly or wholly, and contemplate taking up Linux. These six are as follows:

1. Reliability. One of the problems with Windows is that every release has been "bypo". The promise has been constantly held out to solve the existing problems in the latest, newest, version, but purchasers have been left with a vague feeling of disappointment with every successive issue. Linux actually gets lots of extra features, which tend to obscure the reality - that the basics, in particular the lack of reliability and security had not been attended to sufficiently.

2. Politics. The political-legal rivalry between the USA's Dept of Justice and Microsoft has left a bad odor in its wake, and the wrangling is still not over. Linux is to all intents and purposes free.

3. Immunize from viruses. If you have been the victim of a virus attack via Windows, things may never quite be the same again, especially if it was you who exposed your company and colleagues to such things as the Love Bug disaster. Linux is a lot more difficult to get involved in the nuts-and-bolts of the Linux system. However, if you want to, you can remain to a large extent inside the cocoon of the Windows-like GUI and ignore this side of things.

Running Windows applications under Linux

Using a virtual machine to run Windows is for some old idea but it works well. It was used in IBM's OS2 Warp operating system. A copy of Windows 3.1 - called naturally enough Win-3OS2 - was included with OS2 to cater for those who wanted to continue to use their existing Windows 3x applications, but who also wanted to use OS2. With OS2, a virtual DOS machine was created by OS2 on which Windows 3 ran. This version of Windows included the V32s extension for running 16-bit applications.

There were considerable drawbacks to doing things this way. IBM claimed that OS2 could run Windows applications better than itself - and it did. Stability was improved, and there was some cost. There are commercial products that do the same for Linux and are better. The two most well-known are VMware and Win4Lin.

To use a virtual machine - or VM - you need a copy of Windows to install after you have installed the VM. You can now install Linux in each VM and run Windows inside the Linux VM.

VMWare can handle Windows 9x, NT and 2000 and costs £299.

Win4Lin is tailored for Windows 95 and 98 and costs £49.

Using an emulator

The doppelgenger approach has the potential to be the best system of all. But unfortunately it is not fully developed yet.

The idea behind Wine is that an alternative Linux-based set of APIs - or Application Protocol Interfaces - was presented to a Windows application instead of the regular Microsoft APIs, then it could be fooled into accepting Linux as Windows.

As far as an application is concerned, an API making a call on Linux is just as good as an API making a similar call on Windows. This is a variation on the old saying that a rod is as good as a wick to a blind horse. For this technique to work, a full set of Linux APIs is required. Here is the snag: the developers have only done around 90% of the equivalent Windows APIs. If an application needs one of the missing APIs, it is not possible to run it successfully. Although I would not recommend the current Wine for complete beginners, it only needs a basic grasp or Linux to have a go at it.

Wine is truly the key to the future popularity of Linux. It solves the dilemma under discussion completely. And because it's a non-commercial program, it's free.

6. Fewer chores. I personally don't like backing up frequently, or defragmenting the hard drive. Defragmenting a HDD may seem to be a relatively unimportant chore which only needs to be done once in a while, but as drives get larger and sofware bloats out to match, it becomes an ever more time-consuming process.

However, there are some PC activities in Windows that demand frequent defragmentation so you just can't get away from it. Writing CDs with a CD-burner is one example. Here, it is advisable to defragment before writing to an audio CD in order to get a clean recording, especially if you want to avoid the dreaded buffer under-run. The important thing to note here that Linux fragments very well, being essentially self-defragmenting, so needs very little attention in this respect.

Potential snags to Linux

I should emphasise before you read this section that pointing out some of the snags of Linux is not an attempt at deni...
Mandrake Linux 7

Produced by the French company MandrakeSoft, Mandrake is a well-regarded distribution. Despite being on just one CD, this version was a complete fully functional Linux system with large number of applications and utilities. Mandrake Linux is one of the versions you can get for £23.50 from The Linux Emporium, and it's an ideal system for driving out a Linux system without committing yourself to the full distribution.

Version 7.0 is well worth consideration if you have a machine with 32 MB of RAM and do not wish to upgrade with more RAM. It is a compact and useful Linux distribution.

Version 7.2 – the current version – is much enlarged, occupying seven CDs. It exhibits many small but significant incremental improvements typical of Linux development – in contrast to Windows.

For the beginner the main advantage of version 7.2 is provision of the large pool of applications. You will not have to supplement your installation by chasing all over the Internet for what you want – it's right there for you to pack. And if you want to try out voice operation then the availability of VoiVoice and StarOffice will certainly be of interest.

SuSE Linux

SuSE Linux has won several awards for the high quality of its distribution. It also has much more printed documentation than is usual, in the form of an installation guide etc.

There are two versions, Personal at £25.99 and Professional at £44.99. The Pro version comes on six CDs and includes a huge amount of software covering everything you would want to do with a PC.

It can create a minimum 8 GB of hard disk space if you install all this. More software than most people will ever need, but some programs overlap, and some are mutually exclusive, so installing all of it will be impossible even if you have a huge enough hard disk.

A DVD is included in the pack as an alternative installation medium. SuSE being a first Linux brand to use this format. A floppy boot disk is also useful, which is most useful if you find you can't boot from the CD-ROM.

A version includes software tools for developers and servers, video-conferencing, Java 2. By providing such a vast array, there will be many programs that you won't be interested in, but on the other hand there is bound to be something for everyone.

The Personal edition comes on just two CDs. Both Personal and Pro include the excellent StarOffice suite.

SuSE Linux has an easy installation system, extensive documentation and a very large collection of Linux applications in its CDs. However, having a huge number of applications would not be good for the newcomer if he could not sort them all out, and it is here that SuSE excels with its install/uninstall and indexing system. The RAM requirements for running the graphical installer YAST2 may seem high, but even entry-level PCs now come with more than is needed, so this is no longer such an issue.

The overall impression is that SuSE Linux is a well-presented, designed and useable OS, and has the best selection of Linux applications.

Compaq Vibe

The Compaq Vibe is a Linux based system. Users are able to access all applications and even bootable CDs. It is an easy and efficient system to use, with a wide range of applications available. The installation process is also straightforward, and users are able to customize their system to suit their needs. Overall, the Compaq Vibe is a good choice for those looking for a powerful and efficient Linux based system.
Corel Linux version 1.2

Corel Linux is easier to install and slightly more Windows-like than its rivals, and for these reasons is popular with newcomers to Linux.

Early releases of Corel-Linux came in for some criticism from reviewers because there were a few bugs and some errors of judgement about the interface. I am happy to say that these appear to have been put right in the second edition of Corel Linux.

The OS installed smoothly and ran well on both test machines.

It must be pointed out that Corel-Linux is a lean distribution compared to SuSE and Mandrake. A typical Corel installation takes up about 600MB, mainly because there are nowhere near as many applications provided with this distribution which consists of just one CD. Compare this with the six or seven CDs of SuSE and Mandrake. On the other hand, Corel Linux does not cost as much as these two.

This does not mean to say Corel have skimped on the basic implications needed for smooth running of your system. There are still plenty of utilities and even a few games.

Although the two other Linux distributions mentioned in this article have GUI's that look uncannily like the Windows desktop layout at first glance, Corel has gone step further to make Linux just a little more Windows-like.

One thing acting in Corel's favour is the porting of its well-known and acclaimed Windows programs like Corel PhotoPaint, WordPerfect and CorelDraw over to Linux. This is a big advantage to those who already use these programs, because they can slip from Windows to Linux almost effortlessly.

Incidentally, Corel's PhotoPaint is of offered free.

Setting up the resolution and refresh rate for large monitors for CAD can sometimes be tricky, but this window from Corel Linux shows how clear and simple it is with Corel Linux.

If you are already a Windows user, you might look at Penfold's "Linux for Windows Users" but this is only a slim volume. If you like a graphical approach, and want a more substantial book then look at Bellomo's "Linux" from IKE. Although this is Red Hat based and therefore GNOME-oriented, much of it is applicable to other systems.

Summing up

Linux at present is not quite as intuitive, user-friendly or as GUI-oriented as Windows, but is not far behind and is making rapid progress.

I would hesitate to recommend it to all members of the ownhing public as a complete replacement for Windows just yet. Those of you who use your PC mainly as a games machine will be waiting your time; but those who use it to surf the Net will benefit from its security; engineers will benefit from its stability; scalability; flexibility; and everyone will benefit from Linux being nearly free.

If you are fully conversant with the PC and Windows and appreciate what Linux has to offer, and are prepared to re-learn a certain amount, I think the advantages far outweigh the disadvantages.

If you are serious about finding an alternative to Windows, there is some significant process to pronounce on adopting Linux. Whether you can swap over partially or in full is to some extent dependent on what you do with your PC.

Windows may not disappear, but it would be most unlikely not to wane in the face of the Linux onslaught. This is not just because Linux is free and Windows expensive, but because you can in fact run Windows applications on Linux, effectively making Windows redundant.

There are various ways you can recycle your present collection of Windows applications in a Linux system using a virtual machine or a Windows emulator like Wine. There is no way to find out is through experimentation. Try using a caddy system for your hard drives and have a separate drive with Linux installed on it. An alternative is dual booting, but this can be confusing.

Useful web addresses

http://www.linux.org
http://www.linux.org
http://www.linuxenpower.co.uk
http://www.winehq.com
http://www.codeweavers.com
http://www.freshmeat.net

For more information on Easy-PC Easy-SPICE or for a demo copy call Number One Systems on +44 (0)1684 733662 fax +44 (0)1684 737664 or E-mail info@numberone.com or you can download demo copies from www.numberone.com because of copyright restrictions and so much more.

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ELECTRONICS WORLD September 2001

COMPUTING
Pei An has developed a highly secure wireless remote-control system based on Microchip's Keeloq code-hopping chips. One control receiver can recognise up to four transmitters, each with four push-buttons.

Remote control via RF is widely used in applications such as remote key entry systems, alarm systems, gate and garage door openers and burglar detection systems. Conventional remote control systems offer limited security due to two shortcomings: a) the combination of possible code combinations is relatively small. Using code grabbing and scanning techniques, an unauthorised person can easily override the security measures. Microchip's Keeloq hopping code system has two outstanding features. The first one is that a 66-bit transmission code is used. There are 7.3x10^49 combinations. This makes code scanning impossible to apply. Scanning at a rate of 8 times per second, it would take 2.3x10^24 years to break the code.

The second feature is that during its working life, the receiver will probably never respond to the same code twice. If the remote control is used eight times a day, 22 years will pass before the receiver responds to the same code again. This renders a code grabber useless.

The present design uses a hopping-code encoder and decoder pair, namely the HCS301 and HCS312. In a system, up to four transmitters can be acknowledged by one receiver. For transmitting and receiving data, a UHF FM radio link from Radiometrics is used.

The system has a communication distance of 150 metres over open ground and 50 meters in building. Figure 1 illustrates the Keeloq remote control system.

Hopping encoder
The HCS301, Fig. 2, has four inputs, labelled S0 to S3. Output PWM provides pulse-width modulation and the -LED line connects to the cathode of a LED. When the HCS301 is activated, the LED illuminates. Pin functions are given in Table 1.

Table 1
<table>
<thead>
<tr>
<th>Pin</th>
<th>Pin name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0</td>
<td>Switch input 0</td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>Switch input 1</td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>Switch input 2</td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td>Switch input 3</td>
<td></td>
</tr>
<tr>
<td>VDD</td>
<td>Positive supply voltage (3.5V to 13V)</td>
<td></td>
</tr>
</tbody>
</table>

Once there is a change in status in S0 to S3 from logic 0 to 1, the HCS301 produces a 32-bit hopping code — i.e. encrypted data — generated by an encryption algorithm. It combines this with a 28-bit serial number, a 4-bit press code and 2 status bits to create a 66-bit data stream. The last 34 bits can be either unencrypted or encrypted depending on user's setup. The serial data stream appears at the PWM pin, Fig. 3.

An 12- by 16-bit EEPROM inside the HCS301 holds an encryption key, device serial number, synchronisation counter and a configuration word. They are used by the encoder to create the 66-bit serial data.

Contents of the EEPROM are programmed by a Keeloq programmer. The contents are read-protected Programmer software, which runs on a PC, asks users to input a 64-bit manufacturer's code and a 28-bit serial number. The two codes are then processed by a key generation algorithm to create the 64-bit encoder key.

The encoder key and the serial number are programmed into the EEPROM, in Fig. 4.

Changes in the transmitted code for each transmission are based on a 16-bit synchronisation counter. The value in the counter is updated each time a button is pressed.

When the logic status of S0 to S3 lines change from 0 to 1, the encoder creates an output as shown in Fig. 5. The encoder key and synchronisation counter are processed by a Keeloq encryption algorithm to generate the 32-bit hopping code (encrypted data). Because of the complexity of the code-encryption algorithm, a change in one bit of the synchronisation value will result in a large change in the hopping code.

The data stream can be transmitted out in four speeds. Using a basic pulse width of 400s, representing the slow speed, a code transmission period is 108ms and the data transmission rate is 833bits/s. If the basic pulse width is 100s — the fastest speed — a complete code transmission takes 27ms.

Flow of the encoder's operation is shown in Fig. 6.

Decoder details
The Microchip HCS312, Fig. 7, is a code-hopping decoder that is compatible with the HCS301 encoder. Table 2 shows its pin functions.

Before a transmitter can be used with a receiver, it must 'learn' the receiver. During learning, the serial
Table 2

<table>
<thead>
<tr>
<th>Pin</th>
<th>Pin name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-LRNIN</td>
<td>Learn input, to initiate learning, 10kΩ pull-up</td>
</tr>
<tr>
<td>2</td>
<td>LRNOUT</td>
<td>Learn output to indicate learning in progress</td>
</tr>
<tr>
<td>3</td>
<td>NC</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>MCLR</td>
<td>Master clear</td>
</tr>
<tr>
<td>5</td>
<td>Ground</td>
<td>Ground</td>
</tr>
<tr>
<td>6</td>
<td>S0</td>
<td>Switch input 0, Source 20mA and drain 26mA</td>
</tr>
<tr>
<td>7</td>
<td>S1</td>
<td>Switch input 1, Source 20mA and drain 25mA</td>
</tr>
<tr>
<td>8</td>
<td>S2</td>
<td>Switch input 2, Source 20mA and drain 25mA</td>
</tr>
<tr>
<td>9</td>
<td>S3</td>
<td>Switch input 3, Source 20mA and drain 25mA</td>
</tr>
<tr>
<td>10</td>
<td>VLOW</td>
<td>Transmitter battery low indication output</td>
</tr>
<tr>
<td>11</td>
<td>SLEEP</td>
<td>Connected to RFIN to allow wake-up from sleep</td>
</tr>
<tr>
<td>12</td>
<td>CLK</td>
<td>Clock in programming mode and in synchronous mode</td>
</tr>
<tr>
<td>13</td>
<td>DATA</td>
<td>Data in programming mode and in synchronous mode</td>
</tr>
<tr>
<td>14</td>
<td>VDD</td>
<td>Positive supply voltage (3.5V to 13V)</td>
</tr>
<tr>
<td>15</td>
<td>OSCOUT</td>
<td>Oscillator out</td>
</tr>
<tr>
<td>16</td>
<td>OSCIN</td>
<td>Oscillator in (4MHz), R=10kΩ and C=10pF</td>
</tr>
<tr>
<td>17</td>
<td>NC</td>
<td>Ground</td>
</tr>
<tr>
<td>18</td>
<td>RFIN</td>
<td>Serial data input from receiver</td>
</tr>
</tbody>
</table>

If a decoder receives a message whose format is valid, the serial number is checked. If it is from a transmitter that has already been "taught", the message is decrypted and the decrypted synchronisation counter is checked against what is stored for that transmitter. If the counter value is verified, the button status is loaded and status appears at S0 to S3, Fig. 8. The decoder features a complex synchronisation technique to add security. If the stored counter value for a transmitter and the counter value that was just decrypted are within 16 of each other, the counter is stored and the command is executed. If the counter value was not within 16, but is within 16000, the synchronisation value is stored in a temporary location, and the system waits for another transmission. When the next valid transmission is received, it checks the new value with the one in the temporary storage. If the two values are sequential, a new synchronisation starts up.

If the counter value was outside 16000, the transmitter will not work and must be re-taught.

Fig. 6. Flowchart of the operation of the encoder.

Fig. 7. Pin-out of HCS512 4-channel keeloq encoder and its internal function blocks.

Fig. 8. The 32-bit encrypted data is decoded by the Keeloq decryption engine to reproduce a counter value. The decoder will check if the serial number matches.
The time between a data transition is from 0.07 ms to 150 ns (A version). If an equal mark and space square wave is transmitted from the transmitter to the receiver, the frequency of the signal should be within 6 Hz to 7 kHz (A version).

The antenna of the transmitter can have three versions: the helical type, the loop type and the whip type. Fig. 11. The helical option is the smallest. It needs to be optimised for the exact wavelength in use. The loop antenna consists of a loop of PCB track, which is tuned by a variable capacitor. The whip-type antenna is a wire, rod, PCB track or combinations. How the three types of antennas are constructed and a comparison of their performances are given in the diagram.

Circuit of transmitter

Figure 12 is the circuit diagram of the transmitter. Four press-to-make switches are connected to S0 to S1 of the HCS301. Output –LLED connects to the ON/OFF pin of a +5V LK115D50 regulator. During a code transmission, the -LLED pin goes low, enabling the regulator to output +5V DC to the TX2 transmitter module.

Two CR2016 3V button cells are used to power up the system. The LK115D50 has a dropout voltage of 0.17V with a sleep mode current of 0.1uA and an operating current of 230mA.

A 16-way DIL pin header is used to connect to a KeeLoq programmer via a ribbon cable. The antenna in the design is a whip-type.

The complete circuit can be constructed on a single-sided PCB and housed in a slim box with four buttons, Fig. 13.

Receiver circuitry

The circuit of the receiver is shown in Fig. 14. Six LEDs indicate the logic states of S0 to S3, learning mode and low voltage on the transmitter. Switch SW1 is used to set the encoder to enter learning mode. The MCP890 supervisory IC generates a reset signal for the HCS312.

A low-power, low-dropout +5V voltage regulator, namely a TCS5RPS002, is used to produce the +5V supply. Connector TP, is a 16-way DIL header for connecting the receiver to a KeeLoq programmer via a ribbon cable.

In the prototype, the antenna for the receiver is a whip-type. The complete circuit can be constructed on a single-sided PCB, Fig. 13.

Programming the encoder/decoder

For my design, I used the programmer supplied with the KeeLoq evaluation kit. This kit is designed to give the user the opportunity to evaluate the KeeLoq encoding and decoding technique quickly and easily without having to make a large capital investment. All the hardware and software necessary to implement a fully functional remote control system is contained in the evaluation kit. This kit also demonstrates all of the operating modes of the HCS301 and HCS501 and other chips.

Windows-based software included can be used to program encoders and decoders. The software requires you to input some information. Encoder key configuration information and other user-selectable information are automatically programmed into the encoder's and decoder's EEPROM.

The programmer can be used for programming the HCS chips in-circuit. During programming, the current encoder boards and decoder boards should be connected to the programmer via a ribbon cable, Fig. 15. Note that the power supply to the decoder board should be disconnected before programming. For the transmitter, there is no need to remove batteries before programming.

Using the system

A full system consists of a receiver and four remote-control key fobs. The HCS301 encoder and HCS512 decoder must be programmed first by the KeeLoq programmer. Note that during encoder programming, a slow data rate is selected. Before a remote control system can fully operate, all key fobs must be ‘taught’ by the receiver one by one.

If a remote control is recognised by the receiver, the ‘Learn’ LED flashes. The output status of S0 to S3 does not change.

Technical support

A designer's kit is available from the author. The kit includes PCBs and components. Please direct your enquiry to Dr Pei An by e-mail: pan@intec-group.co.uk or send a stamped s.a.e. to 'KeeLoq', Electronics World, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 9NZ.

During learning, the 'Learn' process, the switch on the receiver is pressed first. The 'Learn' LED should illuminate. Next press any button on the remote-control key fob. The 'Learn' LED turns off. Now press any button on the key fob again. The 'Learn' LED flashes for four seconds or so then turns off. This indicates that this particular key fob is properly 'taught'. If a button is pressed again, the status of S0 to S3 will change. If the 'Learn' switch is pressed and held for more than eight seconds the receiver clears all the records in its memory. In this case, the 'Learn' LED illuminates and after eight seconds, it turns off. All remote control key fobs must be 'taught' again.
Phono preamp for the CD era

I am happy that there has been such interest in my circuit. I am somewhat surprised however that it is in 2001 and digital audio technology has overshadowed analogue audio.

Regarding the issue in question, the letters from Mr Hall and Mr Tutt were greatly appreciated. There seems to be an unfortunate decline in the public discourse. It should be possible to be critical without being offensive. While it is disappointing to receive criticisms of one's work such as Mr Self offered, it would discourage me only if the criticisms reflected real design problems.

The phono preamplifier had already been in constant use in my system for almost one year when the article was published so I felt pretty confident that it was reliable as well as subjectively pleasing.

Mr Walt Jung gives a good example of how to cut a critical response without engendering offence. He also is absolutely correct. I erred when I stated that the design is entirely JFET.

I am astonished that I made this error since I covered this very topic before the article was written and had specifically presented the course textbook material from page 320 of "Microwave Circuits" by Muhammad H. Rashid. There, clearly indicates that one-half of the differential gain comes from the left-hand side of the differential amplifier through the current mirror. This information can be found in many textbooks on op amp design, some of which I had read prior to the design of this preamp.

However, my error in explaining how the circuit operates in no way affects actual circuit operation. Like Walt, I have no problem with signals passing through BJTs in properly designed circuits. There is, however, a cult following for all-JFET or all-MOSFET circuitry and it had been my intent to have no signal pass through a BJT. This can be accomplished, by the way, in several different ways while maintaining the folded-cascode single-stage op-amp topology. I have played around successfully with such modifications on breadboards. I did not pursue them because they did not significantly improve the objective performance of the circuit.

In the same issue, I do not know how Mr Schiek could conclude from my reply to Mr Self that I did not understand AN-346. My reply was based not only on my understanding of AN-346 but also of AN-104, aptly entitled "Noise Spec Confusion," which specifically addresses noise in a phone preamp. It uses the model for the Shure V15, Type III cartridge. It is similar, although not identical, to the V15XMR.

Furthermore, William Chater in his article "A Mostly MOS Preamp." The Audio Amateur, 1990 lists the important noise sources that would have either the Type III or eMK cartridge resistance, itself, as the greatest single contributor to broadband noise. It was that article that prompted my statement that the cartridge was the biggest contributor to noise, a statement that apparently prompted this whole, largely unfounded flurry of comments and counter-comments.

However, it should be allowed by anyone discussing this subject that the input transistors, the cartridge resistor, or the 7457 resistor can be the biggest contributor. This depends upon whether or not one wants to factor in weighting curves based on hearing characteristics, cartridges with greater lower impedance and or resistance, particular BJT or FET input devices, etc. It also depends on whether one is talking about signal noise or broadband noise, and if broadband noise the specific band.

In any event, the title of my master's thesis was "A Method for the Determination of the High-Frequency Noise Spectrum of a Radio-Frequency Plasma." I probably did not need a tutorial on the subject of noise from either Mr Self or Mr Schiek.

Perhaps my statement about Phonic inspired Mr Schiek's comments. I was trying to moderate. I own five books on PSpice and have used it extensively for the last five years. There is nothing magical about PSpice, it does the same sort of circuit and network analysis that the human would do if the human could solve the often-intractable equations. While PSpice does occasionally fail to converge on a solution, I have found this to be unusual.

Also, I have never seen PSpice do anything "strange or unusual." In the case of the noise analysis that I did using PSpice, it showed the same increasing contribution of the 47k resistor with frequency due to increasing reactance of the cartridge inductance that the analysis in AN-104 showed to be true for Mr Self's assertion.

While the program failed to predict the low-amplitude, high-frequency oscillation in the real second stage, a second look at PSpice simulation results showed a "peaking" in the response at that frequency. The very same value of capacitance that caused the oscillation above is the one that PSpice simulation showed to be required to eliminate the peaking.

Although I designed three successful power amplifiers, a friend of access to PSpice, I would no longer go directly to PSpice.
Input filter distortion
It was with interest that I read Dave Kimble’s article on how to design a second filter stage in the Circuit Diagrams issue on page 83 of the August 2001 issue. I refer to power amplifier designers and engineers. It is not clear to me what is the disadvantage of the second filter stage. G. Chris Martin

Earth leakage issues
In response to Chris Miller’s letter in the July 2001 edition, entitled “Tracking down earth leakage,” many items of electronic equipment do incorporate suppression systems that link earth to earth – typically by using a separate earth conductor connected to L & N and N & E. The earth leakage is limited by equipment safety standards, typically to 0.3A. Obviously, a number of such devices used on a group of circuits protected by a 30mA RCD will cause the RCD to trip. David Holland

I understand that some designers consider that, for example, an external lead could be used to supply equipment outdoors from any single socket, therefore all downstream fixtures in a house should be protected by RCDs, but the pieces are not connected to L & N. This has been considered in the context of the issue of the circuits has not been fully considered. RCD protection is not always required by BS7671 for fixed socket-outlet circuits within a domestic dwelling. In many cases, it may be better to provide specific RCD-protected sockets for outdoor use rather than compromise the usefulness of the installation as a whole. Brian Mant

Back-booster regulator
Regarding my circuit idea, “back-booster regulator” on page 62 of the August 2001 issue, the two tanta- lum capacitors are printed as 47uF, which could be misinterpreted. It must be noted that the 47uF capacitors use a diode rectifier. The 35VZ diode used, which is a silicon diode. Henry Midmest

For the UK, please note that RCDs are not required by BS7671 for fixed socket-outlet circuits within a domestic dwelling. In many cases, it may be better to provide specific RCD-protected sockets for outdoor use rather than compromise the usefulness of the installation as a whole. Brian Mant

Johns Radio, Whitewall Works, 84 Whitewall Road East, Birkenhead, Wirral CH5 2ER. Tel (0151) 684007. Fax: 651160
Earth leakage issues

The full range of Earth leakage issues and how to respond to them is fully covered in this article.

BS EN 61008-1:2010 requires the installation designer to consider the risk of a fault and to take steps to prevent it. This includes the installation of RCDs and testing the installation. RCDs are devices that monitor the current flowing through a circuit and trip if the current is not the same on both sides.

However, typical considerations for the selection of an RCD are:

- The current rating of the circuit
- The maximum load current
- The sensitivity of the RCD
- The protection required

In some cases, it is also necessary to consider the possibility of a fault on the power supply. This can be achieved by using a double-pole RCD or by installing an additional RCD on the power supply circuit.

RCDs are used to protect people from electrical shock and to prevent fires caused by electrical faults.

The selection of an RCD should be based on the following:

- The maximum load current of the circuit
- The sensitivity of the RCD
- The protection required
- The type of installation (e.g., domestic, commercial, industrial)

In addition to the RCD, it is also necessary to consider the protective earthing conductor. This should be sized according to the relevant regulations and the current flowing through the conductor should not exceed the permitted value.

BS EN 61008-1:2010 requires the installation designer to ensure that the protective earthing conductor is adequate to carry the maximum fault current without overheating.

In conclusion, the selection of an RCD and protective earthing conductor is important to ensure the safety of the installation.

Finally, it is important to note that RCDs should be regularly tested to ensure they are functioning correctly. This can be achieved by using a test set or by testing the installation with a test button.

References


Designing with DSP

Design your own DSP audio filter

In this fourth and final article on implementing and programming real-time digital-signal-processing systems, Patrick Gaydecki describes how to produce a real-time audio filter based on the simple hardware discussed in the June issue.

For those of you who haven't seen my previous articles, I have been using the DSP56002 to help explain how to design using DSP chips in general.

In this final article dealing with designing and programming DSP systems, I will be discussing how to configure the DSP56002. In particular, I will show how to initialise the phase-locked loop, the bus-control register - which controls memory access timing - the synchronous serial interface (SSI) for a-to-d and d-to-a converter communications and the serial communications interface (SCI) for communicating with a PC.

I will also look at how the simple system designed in the second article can be programmed to respond to interrupts, and how you can write software for real-time filtering of audio signals.

As discussed earlier, the DSP56002 has a register-based architecture, in common with most other processors of this type. Thus, to enable certain functions or configure the various sub-systems to operate in a particular way, appropriate words (bit patterns) must be loaded into the associated control registers.

All of the control registers are mapped into a "x-data" memory space, residing between locations X:SFDE and X:SFFF.

Configuring the phase-locked loop

In the design covered in the second article, a control pin termed PIN1 was tied low. This means that after reset, the PLL is disabled and the DSP56002 operates at the externally applied clock frequency. Hence if the clock frequency is 10MHz, the device operates at 5 MIPS, since each instruction requires two clock cycles.

In order to take advantage of a higher MIPS rate, it is necessary to multiply the applied clock frequency; this is done by activating the internal PLL.

The PLL control register (PCTL) is a 24-bit register located at address X:SFPP. The bits are arranged as shown in Table 1.

Bits M0-MF11 are loaded with a bit pattern that determines the multiplication factor (MF) applied to the clock frequency. A value of 0 specifies an MF of 1, a value of 1 gives an MF of 2, a value of 2 gives an MF of 3 and so on up to FFF, which gives an MF of 4096. In Motorola parlance, the hexadecimal number FFFF would be written as SFPP.

Similarly, bits DFO-D53 determine the division factor (DF). A value of 0 specifies a DF of 2, a value of 1 gives a DF of 3 and so on up to FFO, which yields a DF of 21.

The XTLD bit controls the on-chip oscillator output, XTAL. If the internal oscillator is not used, as in the design in question, the bit should be set, disabling the XTAL output. This minimises RF noise.

The PSTP bit determines whether or not the PLL and the on-chip oscillator operate when the DSP56002 is in a STOP processing state - i.e. suspended. This is normally cleared.

The PEN bit enables or disables the PLL. During reset, the logic level present on the PIN1 pin is loaded into the PEN bit. After reset, the PIN1 pin is ignored. Hence in this system, which is typical, the PLL is initially deactivated, and must be activated by setting PEN to 1.

Bits COD0-COD1 enable or disable the CKOUT pin, which is synchronised to the internal clock when the PLL is enabled. It is recommended that if this pin is not used, as in this case, it should be disabled by setting both bits to 1.

The value held in the CSRC bit determines whether the clock signal for the core is taken from the output of the voltage-controlled oscillator, in which case it is logic 1, or the divider within the PLL, which is represented by logic 0. Here it is set to 0.

The value held in the CKOS bit determines the source of the clock signal for the CKOUT pin. When CKOS is logic 1, the clock source is the output of the voltage-controlled oscillator. If CKOS is logic 0, the clock source is the divider within the PLL. If this is the case, it is again set to 0.

As an example, if the externally applied clock frequency is 10MHz and you want an internal clock of 60MHz, i.e. an MF of 6 and a DF of 4, the bit pattern in Table 2 needs to be set.

In hexadecimal, the value in the table is 17005. The instruction MOV D510005,D3:SFPD achieves the desired result of multiplying the internal clock frequency six times, yielding a processing speed of 30MIPS. For more details on the PLL, see reference 1.

Access speed of the external memory bus

The DSP56002 can be configured to operate with memory chips of various speeds by inserting wait states during the access cycle of the external memory bus. If the WT pin is deasserted - i.e. tied to logic high, as in this case - then the number of wait states inserted is equal to the value held in the bus control register (BRCR), located at X:SFPF.

Since the system in question has been designed with high-speed RAM with an access time of 10ns in accordance with the full-speed access cycle, no wait states are necessary. Thus the command:

MOV W 40,X:SFPP

ensures the external memory bus is suitably accessed.

Table 1: Bit functions of the DSP chip's PLL control register.

<table>
<thead>
<tr>
<th>Bits</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-11</td>
<td>M0-MF11</td>
<td>Multiplication factor bits</td>
</tr>
<tr>
<td>12-15</td>
<td>DFO-D53</td>
<td>Division factor bits</td>
</tr>
<tr>
<td>16</td>
<td>XTLD</td>
<td>XTAL bit, disable XTAL output</td>
</tr>
<tr>
<td>17</td>
<td>PSTP</td>
<td>Enable PLL and on-chip oscillator</td>
</tr>
<tr>
<td>18-19</td>
<td>COD0-COD1</td>
<td>Enable or disable CKOUT pin</td>
</tr>
<tr>
<td>20</td>
<td>COD2</td>
<td>Enable or disable the external clock source</td>
</tr>
<tr>
<td>21</td>
<td>CSRC</td>
<td>Select clock source for PLL</td>
</tr>
<tr>
<td>22-23</td>
<td>COD3-COD4</td>
<td>Source of clock signal for CKOUT</td>
</tr>
<tr>
<td>24-25</td>
<td>CKOS</td>
<td>Source of clock signal for CKOUT</td>
</tr>
</tbody>
</table>

Table 2: Bit pattern in the PCTL register to obtain a 60MHz internal clock from a 10MHz external clock.

<table>
<thead>
<tr>
<th>Bits</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>00000</td>
</tr>
<tr>
<td>3-5</td>
<td>00000</td>
</tr>
<tr>
<td>6-7</td>
<td>00000</td>
</tr>
<tr>
<td>8-9</td>
<td>00000</td>
</tr>
<tr>
<td>10-11</td>
<td>00000</td>
</tr>
<tr>
<td>12-13</td>
<td>00000</td>
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<tr>
<td>14-15</td>
<td>00000</td>
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<tr>
<td>16</td>
<td>00000</td>
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<td>17</td>
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<td>18</td>
<td>00000</td>
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<td>23</td>
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<td>24</td>
<td>00000</td>
</tr>
<tr>
<td>25</td>
<td>00000</td>
</tr>
</tbody>
</table>
operating at full speed. For more details on bus wait states, see reference 2.

Synchronous serial interface

As discussed in the second article, the a-to-d and d-to-a converters normally connect to the SSI of the DSP65002.

Two modes of communication are possible, namely 'normal' and 'network'. In normal mode, one datum word is sent by the a-to-d converter to the DSP per frame, or to the d-to-a converter from the DSP.

This is the case for a single-channel mode.

For a stereo or surround sound system, multiple words are sent within a frame. Each word within a frame occupies what is termed a time slot. Figure 1 shows the signals required for normal and network mode operation.

Assume for the time being that the

power removed.

By enabling the SCIE receive interrupt, it is possible to communicate with the device through the serial port while it is running the program. You might want to do this if, for example, the program was performing some additional processing and you wanted to change the gain of output data on the fly by sending commands through the SCIE.

Principles of SCI interrupts were outlined at the end of my third article. In order to enable the SCI interrupt, you need to do three things. First, set the SCI control register (SCR) to generate an interrupt if a character is received. Also make sure it is set up for a standard protocol (e.g. 8 data bits, 1 start and stop bits). The SCR is located at X:SFFFG.

Next, set the interrupt priority level in the interrupt priority register (EPR) located at X:SFFFE. This waits for the interrupt to be enabled. Using the mask register for this task, interrupt the SCI using the SCI module (MR).

Without getting bogged down in too much detail, the first three instructions in the code fragment in Listing 2 accomplish these three tasks respectively. After this, you have the code to read and write a-to-d and d-to-a converter data as above. If an SCI interrupt occurs, the program counter needs to know where to look for the interrupt service routine, so remember that you also need a JSR or equivalent instruction located at P:S14. Look back at the third article for more details on this. After the main code, we have a label that indicates the start of the interrupt service routine. This must also be a JSR instruction. Code for this is in listing 2.

Putting it all together — simple filtering

One of the most common applications of DSP devices is signal filtering. They are ideal for this, as digital filters really just involve a large number of multiplications, additions and shifts — operations they are very good at doing quickly.

Although the mathematics behind digital filters is beyond the scope of these articles, I can give a brief outline of the method by which these algorithms are implemented.

Real-time digital filters generally come in two flavours: finite-impulse response (FIR) and infinite-impulse response (IIR). Let's consider the first type. With FIR filters, the incoming signal points are multiplied by a set of numbers — called taps or coefficients — and added together to produce one new, filtered value. This process is repeated each time a new signal point is acquired.

The number of coefficients in the filter kernel varies widely — anywhere between 3 and 1023 is common, depending on the filter required. For example, a simple five-point running mean filter would comprise five taps, each 0.2. This process is formally termed 'convolution'. Many textbooks have been dedicated to this subject — in particular, how to choose the values of the taps to generate a particular frequency response.
The conversion expression is given in mathematical terms as,
\[ y[n] = \sum_{k=-\infty}^{\infty} h[k] x[n-k] \]
where \( x[n] \) represents the input signal, \( y[n] \) represents the output signal, \( h[k] \) represents the filter kernel and \( n \) is the number of taps.

Digital signal processors perform one multiplication, addition and shift in one instruction. Hence simple arithmetic shows that if 30 MIPS, an audio signal sampled at 44.1kHz could be filtered using a kernel comprising up to 680 taps. A filter with this many taps can be designed with a sharpness far beyond what is normally possible with analogue types.

To implement filters using the DSP56002, a special kind of addressing termed modulo addressing is used. There’s more on this in my third article. Code shown in Listing 3 implements a simple nine-point running mean filter. It also sets up the PLL, the external memory bus and the SCI interrupt, in the manner discussed above.

For more information on filtering using the DSP56002, see reference 3.

Commercial DSP Filters
There is a huge range of DSP products on the market, intended both for the professional engineer and the amateur enthusiast. One such system is supplied by Kerno Ltd, called the KDF, specifically aimed at audio band offering.

This product incorporates a Windows-based software system for designing the filter, and a DSP hardware module that executes the filter in real-time. No knowledge of mathematics is required. Once the user is happy with the design, it can be sent to the hardware from the same package with the click of a button.

Figure 2 shows the design interface. The nice thing about the system is that completely arbitrary filter shapes can be specified, either using its design facility or by importing ASCII text files representing the frequency response.

In summary
We hope that this series of articles on DSP system design and programming has been a useful introduction to the subject. DSP is a truly enormous branch of learning, and one of the fastest growing and most important technologies of our time.

Although the learning curve is a little steep to start with, the rewards, in terms of intellectual satisfaction, are well worth the effort. Happy experimenting!

References

The Phantom Power Box
48 volt microphone phantom powering unit
Professional portable units operating from an internal PP3 battery or external mains adaptor

* Suitable for converting any microphone amplifier to 48 standard phantom power * High efficiency DC to DC converter for extended battery life * Accurate line balance for high common mode rejection * Low noise and distortion * Extensive RFI protection

The Balance Box (mic/line amplifier) - The Headphone Amplifier Box - The OneStop DIN rail mounting radio frequency interference filter and voltage transient protector for voltage and current loop process signal lines

Conford Electronics
Conford Liphook Ranks GU5 9XW
Information line: 01428 751340
Fax: 751223
E-mail: contact@confordcde.co.uk
Web: http://www.confordcde.co.uk

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NEWPRODUCTS

Please quote Electronics World when seeking further information.

Connector enables 5.0Gbit/s's connection

Teradyne has announced a six-row version of its VHDM high-speed differential connector. It will support point-to-point transmission distances up to 5.0Gbit/s. Applications include Sonet OC-48, OC-192 and OC-768 systems, 10Gbit/s Ethernet, terabit routers, optical networking equipment, servers and data storage systems. The connector uses an orthogonal in-line grid rather than a staggered grid, allowing for traces up to 15mm wide and let-ting traces run through the connector without jogs.

Tel: 01344 426899
www.teradyne.com

Analogue output photocoupler

NEC Electronics' PS601 eight-pin photocoupler provides a maximum supply voltage of 35V, response of 0.8us and isolation voltage of 3kV rms. The single chip photocoupler contains a GaAlAs LED on the input side and a p-n photodiode and amplifier transistor on the output side. Applications include interface circuits for instrumentation, control equipment, computer and peripheral manufacturing and electrical isolation of TV video terminals. Allowing voltage peaks up to 8kV, it has an operating temperature range from -55 to +100°C. It is available in two packages – plastic DIP or the PS601H, in a lead bending Gull-wing type for surface mount.

Tel: 01908 691133
www.euk.nec.co.uk

Gigabit Ethernet core

LSI Logic has introduced a Gigabit Ethernet core for use in copper and fibre networks. The E110 core is a 10Gbps 1000BaseT Ethernet media access controller. It can support applications from 10 to 1000Mbit/s on one platform and suits embedded applications including switches, routers, servers and desktop computers. A programmable 10, 100 and 1000Mbit/s data rate option supports data transfer of Jumbo frames up to 10000bytes. LSI Logic Tel: 0148 432 8000
www.lisologic.com

IR receiver resists the light

An infra-red receiver module with an internal automatic gain control to increase immunity against light disturbances caused by energy-saving lamps has been announced by Vishay Intertechnology. The Telefunken TSOP1790 combines a photodetector and preamplifier in one package. It has a 45MHz carrier frequency and is for use in multimedia applications and products, including interactive TV, video conferencing systems, game controllers, interactive toys, wireless keyboards, wireless mice and remote controls. The receiver can handle up to 20kHz at a bitstream distance of up to 20m. With an internal band-pass filter, it is for PCM frequencies and provides TTL and CMOS compatibility. Power consumption is 10mA and it can operate from supply voltages between 2.7 to 5.5V. Rated for temperatures between -25 and +85°C, the device provides an output power of 5mA, with a demodulated output signal that can be directly decoded by a microprocessor. It measures 6 x 8.25 x 5.6mm. Receiver start-up time is 50μs and receiver data delay time 18μs. Vishay
Tel: 01 610 644 1300
www.vishay.com

SBC for embedded multimedia

Diamond Point has launched the Inside Technology 786LCD3.5 single board computer in 8.9cm format. Incorporating an integrated SIS 630 chip set with hardware accelerated MPEG-2 and DVD decoding to support high-end multimedia applications in embedded systems, the board Integrates Intel's Pocket 730mm processors and a 12-bit and 3D hardware accelerated graphics controller with up to 64Mbyte of shared video memory. The controller can drive flat panel plasma, TFT LCD and CRT displays at a resolution of 1920 by 120 in 16 million colours. Optional graphics modules, including Panelink, LVDS, 5-pin LCDConnect and DVI TV-out are available. A Soundblaster Pro 16 compatible virtual AC-3 surround sound SPDIF 4Mbit/s I/O and infrared communications facilities. For PC/104 and ISA bus access, the board is powered by an onboard lithium battery. Connection for an external battery is also provided. A 10Mbps Fast Ethernet port, two 16/56Mbps RIS232 serial ports with 16byte FIFO buffer, National Centronics port offering ECP or EPP mode and five-channel USB port are provided. Diamond Point
Tel: 01634 200390
www.dpsp.com

Audio-d-to-a converter for CD players

Wolfson's stereo digital-analogue converter technology is at the heart of two CD players from Rega Research. Sound devices based on the W8716 multibit, 192kHz stereo d-to-a converter using a sigma-delta conversion technique to improve signal-noise performance and reduce clock jitter effects.
Tel: 0131 6763386
www.wolfson.com

Smartcard connector avoids PCB redesign

By encapsulating its LS28 smartcard connector in a metal casing and adding a flexible printed circuit board, FCI has introduced a panel mounted smartcard connector that lets OEMs upgrade equipment facias without modifying PCB layouts. With its one piece construction, the 200 connector comes with a choice of flexible printed circuit cables between 58 and 155mm long. Two connector bodies are available, handling card penetration depths of 25 and 35mm from card edge to panel surface. Card detection is via an internal normally closed, self-cleaning, wiping blade switch. Providing a choice of eight or 16 sliding contacts, the connector meets ISO7816 and Afnor LTE90421 standards. With the option of in-line capacitors, the flexible printed circuit cable comes with Europe Master Visa recommendations on signal integrity. The cable termination pitch can be either 1.25mm.

Power
Tel: 01722 430000
www.greshampower.com

Multijet RJ-45 connectors

Pulse has announced the PulseJet Harmonica family of multiple connectors with integral magnets. Developed with Tyco Electronics, the two-tier-stacked eight, 12 and 16-port connectors provide isolation and EMI suppression for 100BaseTX computer and telecom networks. The two-by-four eight-port 1208H3A, two-by-six 12-port 12045SHB and two-by-eight 16-port 2009H3C connectors all meet EN50081-2 standards that reduces the stress of human handling of subcomponents such as leads, cables and connecting wires.
Tel: 01483 401700
www.pulseeng.com

Linear address range to 16Mbyte

Philips Semiconductors has announced the 80C151M2 microcontroller family including an 8-bit 80C151 supporting up to 16Mbyte of on-chip linear addressable memory for communications and consumer markets. The microcontroller is based on the firm's 51Mx core, created to accommodate an increase in on-chip program and data memory with high-level C language performance. Binary object code compatibility is maintained, so engineers can reuse existing 80C51 codes. The 51Mx's 23-bit linear address supports up to 16Mbyte of on or off-chip program and data memory. The program counter is extended to 23-bits and the stack pointer to 16-bits. A 23-bit extended data pointer, with two 24-bit universal pointers utilizing existing general purpose registers, creates a 16byte linear address range for data memory. The 80C151M2 comes with 96byte of OTP memory and 3kbyte of RAM and the 80C151ME2 with 64byte of OTP and 2kbyte of RAM. Both operate with supply voltages from 2.7 to 5.5V and run at up to 24MHz (5V) with a typical instruction cycle time of 200ns.
Philips Semiconductors
Tel: 0131 40 272 891
www.semiconductors.philips.com

Modular DSPs use FPGA

Hunt Engineering has extended its Heron range of modular products for DSP with versions that use Xilinx FPGAs for DSP processing and flexible I/O. They let digital radio users remove an IF stage from their system by digitising directly at 100MHz and performing digital down conversion in the FPGA. When fitted to a Heron module chassis such as the HEC88 PCB carrier card, they can have their program downloaded from the PC over the serial bus. This lets users program and reprogram them as they would with the DSP elements of the system. There are three modules with FPGAs, each 10.16 by 6.35cm. The FPGA1 covers Virtex gate counts between 50k and 200k gates and the FPGA2 Virtex devices between 40k and one million gates. The 101 combines a Spartan II FPGA with 200k gates with two channels of 105MS/s 12-bit A/D. Each input has a separately controllable programmable gain stage. The Spartan II FPGA module allows the size of Xilinx Webpack development tools. The modules that use the Virtex family of FPGAs can be reconfigured to meet the requirements of different terminals or future requirements. For more information on the module, contact the Philips Semiconductors sales office.

Philips Semiconductors
Tel: 0131 6763386
www.wolfson.com

NEWPRODUCTS

Please quote Electronics World when seeking further information.
and Verilog Ic FPGA's have more gate densities and features, but require more test time. Foundation IEEE or Xilinx Simulink System Generator, which can be used from Xilinx. In the licensed software, Xilinx includes IP cores for DSP for creating FPGAs, digital data synthesis, correlators and filters.

Hunt Engineering
Tel: 01278 760188
www.hunting.com

TFT LCD industrial panel PC
Advanced Modular Computers has launched the AMC-5030, a 38cm TFT LCD panel mounted PC with a maximum resolution of 1280x768. Its aluminium front panel meets Nema 4 or IP65 standards. It can handle temperatures up to 50C and non-condensing humidity levels up to 85% RH. The model comes with a 90W power supply, three drive bays and the P-566 Socketseven card with processing speeds up to 100MHz. Onboard features include VGA, 2MB IEEE EDOM, audio, 10/100Base Ethernet controller, digital I/O, and one disk on chip socket. Dimensions are 392 by 277 by 141.2mm. A DIN rail style touch screen is an option, relying on a separate keyboard.

All Computers
Tel: 01753 680960
www.allc.com

PWM motor controller
Toshiba Electronics has introduced a PWM three-phase brushless motor controller IC with an external power FET module to produce a sinusoidal motor control waveform. With reducing electrical and acoustic noise. Using low-pass regulators, the T8659/F,F8672 skeletal module can generate the sine wave output and simulate an external microcontroller. The device also has built-in dead time function, which allows safe operation of the power FETs in push-pull configuration.

Toshiba Electronics
Tel: 08 211 8269
www.toshiba-europe.com

Multilayer ceramic capacitors
Multilayer ceramic capacitors have been announced by Vishay Intertechnology. The Vitaros VJ0210 capacitor will be used for high-frequency decoupling and bypass in laptop and desktop computers. Its VTOP housing lets designers place the capacitors underneath ICs. The VJ9101, VJ9710, VJ9740 and VJ9740 each measure 0.16 by 0.32cm, with maximum thicknesses of 0.051, 0.096, 0.071 and 0.076cm respectively. The chips can reduce AC noise in multi-chip modules. The VJ0210 has an inductance of 0.15H. Vishay
Tel: 01 617 644 1300
www.vishay.com

Serial EEPROM supporting ACR
A serial EEPROM from Unique Memec supports the advanced communications receiver (ACR) special interest group specification. Microchip's 24LC00 EEPROM provides the emumination memory for next-generation PC, audio and video systems. The chips feature a standard plug-and-play configuration, each chip provides intelligent digital, audio and network capabilities. The system bus of an ACR-compatible PC can communicate with the receiver card, making it transparent to the computer's operating system.

Unique Memec
Tel: 01 296 93796
www.unique.memec.com

VCO has differential buffered output
Maxim Integrated Products has introduced the MAX3453 2.4GHz monolithic VCO with differential output. It integrates
the oscillator, tank circuit and a matched output buffer in an eight-pin MUX package. The VCO is compatible with integrated transceiver ICs with a low IF architecture, which typically require an off-chip VCO and a differential interface to reduce spurious noise.

Application examples include cordless phones, HomeRF, Bluetooth and other proprietary systems running in the 2.4GHz ISM band. Oscillator frequency tuning is factory-adjusted to guarantee limits from 2400 to 2500MHz with a +0.4 to +2.4V tuning voltage input range. The oscillator signal is buffered by a differential amplifier/lowpass stage to provide 2.7Vp output power. This buffer stage also isolates the oscillator from load impedance variations.

Oscillator phase noise is typically −138dBc/Hz at 3MHz offset. The VCO operates from a +2.7 to +5.5V supply. Internal regulation of the oscillator supply voltage eliminates the need for a dedicated external low dropout regulator. The VCO consumes 8mA of current. In shutdown mode, the current is reduced to 0.2mA. An evaluation kit is available.

Maxim
Tel: 01862 202388
www.maxim-ic.com

Signal Integrity test suits optical systems
Ansoft has released version 3.7 of its PCB/MCM signal integrity tool for PCB designers needs in optical networks, memory interfaces and multi-gigabit transmission systems. The 3D extraction engine lets designers address problems such as power and ground bounce, crosstalk and simultaneous switching output noise and parasitic extraction (R, L, C) for any 3D structure on the PCB. It has interfaces that let it automatically and real-time in and characterise an entire PCB or MCM design in Cadence’s Allegro or Mentor Graphics BoardStation. During the analysis, the designer can choose whether to analyse particular structures and nets in full 3D or a mix of 2D and 3D. Any type of non-ideal power or ground plane (partial plane, split plane, random hole or meshed plane) can be analysed. It can also analyse single-chip, few chip or multi-chip (system-level) designs from Cadence’s Advanced Package Designer. The software uses the partial element equivalent circuit method to produce a distributed 3D model. This method lets the tool create accurate models of high-speed systems such as differential pairs and source/sink synchronous data lines. The distributed nature of the model allows the effect of each individual interconnect structure in the circuit on the non-ideal ground planes – on signal or plane in Spice.

Ansoft
Tel: 020 8891 6166

Auctions & Sales

PHILIPS 4095A (PSPICE) 4-Ch 10MHz Osc with Cal, £450
PHILIPS 3294A (PSPICE) 4-Ch 40MHz Osc with Cal, £800
RIGOL RPS3042N 20MHz Osc with Cal, £325
RIGOL RPS3042N 20MHz, £350
TEKTRONIX TDS3014C 100MHz Osc with Cal, £450
VICTOR 1520A 100MHz Osc with Cal, £400

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NENPRODUCTS

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The NEWPRODUCTS section in Electronics World is dedicated to showcasing the latest technological advancements and innovations. It covers a wide range of topics including but not limited to electronics, technology, and innovation. This section is essential for readers interested in staying updated with the latest developments in the field.

LDC driver-IC tester

Advantest’s LDC driver test system is designed for the testing of 12 devices such as thin film transistor (TFT) LCDs, and 12-chips that contain a controller and LDC driver. The D6371 can simultaneously test a maximum of 8-chips, or 2-chips simultaneously, and can be used to perform visual measurements of drivers with a maximum of 128 pins and capable of digital testing up to 125MHz. For testing multiple-pin ICs, the unit can measure LDCs that have a maximum of 1.280 pins. The system also employs a per-pin comparator architecture, which enables the user to perform high-speed function testing. The system’s testing station can simultaneously measure up to four LDC devices.

Advantest
Tel: 0049 (0)930 3700 312129
www.advantest.de

Oscillator requires one resistor

The Linear Technology LTC779 is a 80723 packaged oscillator IC that generates an oscillator frequency from 1kHz to 30MHz. The function of the resistor must be determined by adding a 1% per resistor or ±16.6% per with a 0.1% per resistor. There is no need for a crystal, ceramic resonator, capacitor, or external reference clock. Accuracy is maintained over all supply and temperature variations, defined by less than 0.004 per cent / °C and 0.05 per cent per volt.

Maximum supply current at 5V for 10MHz output is 2.4mA from 5V to 40Hz. Applications include localised clocks, synchronising of switching power supplies and driving switched capacitive filters.

Linear Technology
Tel: 01276 677676
www.lineartech.com

Materials absorb microwave

Two flexible, absorbent EMI materials are now available from Mura Technologies. The EA100 prevents abnormal oscillation in high frequency microwaves and

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CRICKLEWOOD ELECTRONICS 40-62 Cricklewood Broadway, London NW2 8TN
Tel: 020 8328 3344 Fax: 020 8328 3345
http://www.cricklewoodelectronics.co.uk
E-mail: sales@cricklewoodelectronics.co.uk

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subsequent interference between circuits. The EA20 has high- 
high-loss characteristics for suppression over a wide band in 
digital products. Both 
microwave absorbers cover 0.1 
to 20GHz and can be introduced 
at any stage in the sequence 
form design to delivery. The 
silicon-based materials 
flexible and can be held in place 
with adhesive tape. Thicknesses 
available are from 0.2 to 
2.7mm. The thickness depends 
on the frequency to be 
suppressed. Custom sizes can be 
 supplied.

Phone: 01252 811666
www.murata.co.uk

Connector with 
0.6mm pitch
Harwin’s latest range of surface mount ultra fine pitch 
connectors, called the MM9 connector series is a 0.6mm 
pitch board mounting connector 
provide stacking heights of 
3mm, 4mm and 5mm between boards. 
They are available with up to 
100 contact positions, 
polarised to prevent mis-mating 
and equipped with locating 
gauges for accurate PCB placement.

Metal latching clips are 
available upon request of 
additional strain relief 
required. The housings are 
manufactured from glass filled 
LCP and have a UL94V-0 
flammability rating.

The housing has a minimum 
insulation resistance of 100MΩ 
and a tolerance withstand 
voltage of 200V AC.

Standard packaging is tape and reel

Press-fit connectors for D-sub and 2mm
Northern Connectors offers press-fit connectors including 
the Harting DIN41612 and the Harbus 64 range. In 
addition, the distributor will provide press-fit products for both: D-Sub straight and right angle IDC boxed headers, 
hard metric 25 pin connectors, and SC21 as well as BNC 
connectors.

To achieve the packing densities required, back-panel PC 
boards are in the form of multi-layer boards which use 
press-fit terminations. The press-fit pins are inserted 
and adapted to the hole within the PC board. Electrical contact is 
made solely by pressure and cold-welding of contact 
surfaces within the insertion zones.

Northern Connectors
Tel: 01744 272000
www.northernconnectors.com

512bit flash with 
random read
STMicroelectronics has announced a 512bit flash 
memory device with sequential 
and random read operations, 
page mode programming, sector 
and bulk erase modes, and a 
20MHz SPI-compatible serial 
bus.

Like its 1Mb predecessor, the 
non-volatile field-
programmable 512bit (64k 
by 8bit) M25P05 is targeted 
at applications for the storing of 
code and blocks of data in 
industrial, consumer and 
telecoms products, says the 
supplier. The flash chip 
handles two sectors of 256 
pages each. Because one page 
is 128bytes wide, the entire 
memory can be viewed as 512 
pages or 65536 bytes.

The memory’s page program 
instruction writes one to 128 
bytes at a time. The memory 
can be erased at once using 
a bulk erase instruction.

Alternatively, one sector 
at a time can be erased using 
a sector erase instruction. There 
is a 2ms full memory read 
operation at 2.7V, 3ms (typical) 
for 128-byte page 
programming; and 256byte.
NEW PRODUCTS
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sector and 512byte erase operations of 1s and 2s (typical), respectively. Allowing either random or sequential read operations, the serial memory reduces the number of instructions needed compared to a parallel architecture, simplifying development. The four-wire SPI-compatible serial interface clocks at a top rate of 20MHz.

www.st.com

DC-to-DC current uses headers with Maxi, half interfaces are reflowed, the modules are inserted into the sockets. Vicor Tel: 01276 678222 www.vicor-europe.com

Surface-mount DC-to-DC converters for 100A
Vicor has introduced a surface mount interface accessory, called SurfMate, which is designed for use with pin-compatible 2nd generation DC-to-DC converters and accessory modules. According to the supplier this will allow designers and assemblers to surface mount high-density DC-to-DC converters with current ratings up to 100A. It uses a pair of surface mounted headers that contain sockets to accept the input and output pins of the converter module. The header assembly is compatible with any thickness PCB, does not increase the module mounting height above the board, and is available for all three standard module sizes—Maxi, Mini, and Micro (full, half and quarter brick DC-to-DC converters). The interfaces are packaged in standard reusable JEDEC trays for use with automated pick and place equipment and are compatible with standard reflow solder operations. After

One-phase 'green' fan
The Green Motor fan range from Sunon has been awarded ISO14001. The range includes axial fans from 17 by 17 by 8mm frame size to 120 by 120 by 38mm, and microblowers from 35 by 35 by 4.8mm to 45 by 45 by 9mm. They use a one phase full-wave winding mechanism to reduce material waste, increase torque and reduce failure rate during production. The motor bobbin, which protects the coil, is produced from a high-temperature resistant, non-flammable and insulating engineering thermoplastic. This lets the fan motor be operated at an ambient temperature up to 90°C.
Sunon Tel: 0031 1461 54515 www.sunon.fr

Power switch IC supports USB wake-up
USB power switch ICs offering advanced configuration and power interface (ACPI) wake-up capabilities are available from Micrel Semiconductor. Micropower modules are packaged in dual-channel protected MOSFET switches optimised for universal serial bus (USB) wake-up capabilities supported by ACPI for desktop PCs. When the PC is active, these devices will guarantee 500mA continuous output current per channel as required by USB. When the PC is placed in the ACPI S3 sleep state, the outputs are switched to the 5V standby supply available in ATX style power supplies. In this state, the continuous output current is reduced to 100mA, or to a user-adjustable value. This reduction protects the smaller current capacity of the standby supply in case of short-circuit faults. When the PC is returned to the active S0 state, the outputs are switched to the 5V main supply. The four devices include the MIC2010, MIC2012, MIC2070 and MIC2072. The MIC2080 offers adjustable auxiliary current limiting for more precise control, whereas the MIC2012 has preset current limits for the auxiliary mode. The MIC2070 and MIC2072 provide a circuit breaker function that latches the output(s) off when an over current condition is detected, reducing power consumption during a fault.
Micrel Semiconductor Tel: 00 71 80 2000 www.micrel.com

Modular compact PCI backplane
Schoeff has introduced a modular CompactPCI backplane with a power supply interface for industrial and telecoms users. The various modules can be combined into a system whose flexibility allows the construction of prototypes and short-production-run models. The backplane consists of modular backplanes, power piggybacks and one or more power backplanes. The modular backplanes comply with revision 3.0 of the CompactPCI core specification. Models with three to eight slots are available in 3U or 6U formats. The five and seven-slot versions are bridgeable. All can be switched without losing a slot width. The piggyback board, which is plugged directly into the rear of the backplane, is used for connecting each power supply. This board contains an ATX connector, various universal supply terminals for M4 eyelets (power bus) and three drive connectors. The board both enables power to be fed to the backplane from various sources, and serves as a central node for power distribution in the system.
Micrel Semiconductor Tel: 00 71 80 2000 www.micrel.com

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

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

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

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

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

- The HS801 has an 8 bit resolution and a maximum sampling speed of 100 MHz. The input range is 0.1 to 100000 Volt full scale to 1000 V full scale. The record length is 32Kx64K samples. The AVG has a 10 bit resolution and a sample speed of 25 MHz. The HS801 is connected to the parallel printer port of a computer.

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

- TiePie engineering (UK), 28 Stephenson Road, Industrial Estate, St. Ives, Cambridge, PE17 4WJ, UK Tel: 01480-46028; Fax: 01480-460340

- TiePie engineering (NL), Kopperslagersstraat 37, 8601 Wl SNEEK The Netherlands Tel: +31515415416; Fax:+31515418819 Web: http://www.tiepie.nl

Reliability

| CIRCLE NO. | 1/2 ON APPLY CARD |

TiePieScope HS801 PORTABLE MOST

ABRITARY WAVEFORM GENERATOR-
STORAGE OSCILLOSCOPE-
SPECTRUM ANALYZER-
MULTIMETER-
TRANSIENT RECORDER-

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

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- TiePie engineering (NL), Kopperslagersstraat 37, 8601 Wl SNEEK The Netherlands Tel: +31515415416; Fax:+31515418819 Web: http://www.tiepie.nl
A reader came up with the idea of reducing woofer distortion by using motional feedback derived from pressure changes inside the cabinet, as opposed to voice-coil position. "So why is no one using it?" he asks John Watkinson...

**BASS PERFECTION?**

Regular Speakers’ Corner reader John Cole, from Devon, recently wrote in with a suggestion for improving bass response. John wondered why the idea wasn’t used in practice. He wrote as follows:

"At 100Hz, the wavelength is three metres, at 50Hz six, so to a reasonable approximation, a normal sized speaker is a point source that simply sucks and blows air. The material of the speaker head is a constant volume, so where is the change of volume to accommodate this? Clearly it’s the change in volume of the air being compressed and rarefied in the box. That must be true even for a vented enclosure, as long as the vent and the driver are close together in wavelength terms. Inside the box there essentially a single pressure, since again the space is small compared to a wavelength, and in a good approximation its change is proportional to the change in volume, being a fraction of atmospheric pressure.

The next step is obvious. Mount a pressure-sensitive microphone or – in these days when piezo-electric devices are commonplace – a fast acting pressure sensor within the box and use feedback to constrain its output to follow the signal input at bass frequencies. Unlike normal feedback, that measures the coil position, this scheme uses a readily available linear transducer and doesn’t require the cone to remain rigid as it strays against the internal pressure. Tell me please, why isn’t it used?

I like questions like this because to answer properly requires a wide range of technologies to be considered. Let’s start with the acoustics.

It is absolutely true that the average-sized speaker can be considered a point source that sucks and blows at low frequencies. The radiation is proportional to the volume velocity of the diaphragm.

However, the pressure in the box isn’t, unless the box has infinite volume. Figure 1 shows a finite box with a moving diaphragm. It assumed that the diaphragm is ideal, such that it moves an equal amount inwards and outwards due to a sinusoidal drive signal. However, this does not result in a sinusoid pressure waveform in the box. Figure 1 shows why.

If it is assumed that the diaphragm displacement is 10 percent of the static volume of the box, then when the diaphragm moves in, the volume falls to 0.9 of the static volume, so that the pressure goes up to 1/0.9 = 1.1111 times static. However, when the diaphragm moves out, the volume increases to 1.1 times static, so the pressure falls to 0.9 = 0.9 times static.

Figure 1b) shows that in the resultant pressure waveform is distorted. The positive peak would be 11 percent bigger than static, whereas the negative peak would be 9 percent smaller than static. Figure 1c) shows the pressure change. Feedback wølln’t fix it

The other point worth making in regard to this query is that it is all too easy to suggest ‘fixing’ a problem by putting feedback around something. In the same way that most speaker designers have a fixation with frequency response, it seems that most electro-

- electronics engineers have a fixation with negative feedback as a universal solution. Unfortunately it’s not that simple.

When considering a loudspeaker drive unit in a box, Fig. 2 shows that it is a resonant system having a fundamental frequency within the audio band. The phase response below this resonance is 180° out from the phase response above.

The question then is do we want negative feedback above the resonance frequency, which becomes positive feedback below, or vice versa? Of course neither of these approaches would work; they would be unstable. In order to use negative feedback around a loudspeaker, it is necessary to construct a compensating circuit that has the inverse phase characteristic to the drive unit and incorporate it in the feedback loop. Doing this is not a trivial matter.

The other problem with negative feedback is that it only works when there is some loop gain left. This means that the operating bandwidth and power output of negative feedback systems must be significantly less than the open loop characteristics.

A very precise donkey Feedback may linearise and extend bandwidth at small amplitudes, but as amplitude increases, the system may just go open loop.

You can’t make a ratchett by putting feedback round a donkey. Instead you get a slower but very precise donkey.

These restrictions do not apply so much to feedback because there is no requirement for loop gain – because there is no loop. In such a way we have arrived at another reason why Mr Cole’s idea and other active technologies are seen so infrequently: the number of loudspeaker designers who can coherently explain the difference between feedback and feedforward is very small indeed.

You don’t generally need those skills to take commodity drive units from Taiwan and fit an MDF box around them. Worrying about phase linearity would cut into the time taken polishing the veneer.

---

**Valve Radio and Audio Repair**

* A practical manual for collectors, owners, dealers and service engineers * Essential Information for all radio and audio enthusiasts *

This book is not only an essential read for every professional working with antique radio and gramophone equipment, but also dealers, collectors and valve technology enthusiasts the world over. The emphasis is firmly on the practicalities of repairing and restoring, so technical content is kept to a minimum, and always explained in a way that can be followed by readers with no background in electronics. Those who have a good grounding in electronics, but wish to learn more about the practical aspects, will benefit from the emphasis given to hands-on repair work, covering mechanical as well as electrical aspects of servicing. Repair techniques are also illustrated throughout.

This book is an expanded and updated version of Chas Miller's classic Practical Handbook of Valve Radio Repair. Full coverage of valve amplifiers will add to its appeal to all audio enthusiasts who appreciate the sound quality of valve equipment.
Designing radio receivers II

Joe Carr discusses receiver design from the ground up. This second article looks at elements of the superheterodyne.

In the first article of this set I looked at the various receiver architectures on the market, ending with the superheterodyne. This month I will be covering the various circuits within the superheterodyne receiver, starting a discussion of receiver performance parameters.

Front-end circuits

The principal task of the front-end and frequency-translation sections of the receiver in Fig. 1 is to select the signal and convert it to the intermediate frequency. In many radio receivers though, there may be additional functions. In some cases - but not all - an RF amplifier will be used ahead of the mixer. Typically, these amplifiers have a gain of 3 to 10dB, with 5 to 6dB being very common. The tuning for the RF amplifier is sometimes a broad bandwidth fixed frequency filter that admits an entire band. In other cases, it is a narrow band, but variable frequency, tuned circuit.

Intermediate-frequency amplifier

The IF amplifier is responsible for providing most of the gain in the receiver, as well as the narrowband-pass filtering. It is a high gain, often multi-staged, tuned-radio-frequency amplifier with a single frequency. For example, one IF shortwave receiver block diagram lists 120dB of gain from antenna terminals to audio output. Of these, 85dB come from the 8.83MHz IF amplifier chain.

In the example of Fig. 1, the receiver is a single conversion design, so there is only one IF amplifier section.

Detector stage

The detector demodulates the RF signal, and recovers whatever audio - or other information - is to be heard by the listener.

In a straight AM receiver, the detector will be an ordinary half-wave rectifier and ripple filter. In this case it is called an envelope detector.

In other detectors - notably double sideband suppressed carrier (DSBSC), single-sideband suppressed carrier (SSBSC or SSB), or continuous-wave (CW or Morse telegraphy), a second local oscillator is heterodyned with the IF signal. This is usually called a beat frequency oscillator (BFO) and it operates near the intermediate frequency.

The resultant difference signal is the recovered audio. That type of detector is called a product detector. Many AM receivers today have a sophisticated synchronous detector, rather than the simple envelope detector.

Amplifying the audio signal

Audio amplifiers are used to finish the signal processing. They boost the output of the detector to a usable level to drive a loudspeaker or set of earphones.

Audio amplifiers are sometimes used to provide additional filtering. It is quite common to find narrow band filters to restrict audio bandwidth, or notch filters to eliminate interfering signals that make it through the IF amplifiers intact.

Double and triple-conversion receivers

Double and triple-conversion receivers are designed to take advantage of two aspects of radio design. The first is the fact that a high intermediate frequency will yield superior image performance, and the second is that it is easier to get high gain and bandwidth limiting filter characteristics at low frequencies.

Figure 2 shows a basic double-conversion receiver.

It first converts the IF to a high intermediate frequency, and then down converts it to a lower IF.

The particular frequencies selected for the first and second IF depend on the application. In high-frequency shortwave receivers, the first IF will be in the order of 50MHz to gain the advantages of a high intermediate frequency - namely better image response. The second IF will be 10.7 MHz, 95MHz, 8.83MHz or 455kHz depending on the design. In the VHF/UHF bands the high IF may be 10.7MHz, 50MHz or 70MHz, whereas the second IF will be 10.75MHz or 455kHz, depending on the design.

Direct-conversion receivers

The direct conversion receiver (DCR) is a sub-set of the superheterodyne in which the intermediate frequency is equal to the baseband frequencies. It converts radio signals directly to audio, rather than to an IF.

The local oscillator on the direct-conversion receiver is tuned to either the RF signal, or to a certain offset that depends on the tone that you wish to listen to in CW reception. The result is direct audio conversion in the DCR receivers.

Receiver performance factors

There are three basic areas of receiver performance that must be considered. Although interrelated, they are sufficiently different to merit individual consideration: noise, static attributes and dynamic attributes. I will look at all of these areas. But first let's look at the units of measure that we will use.

Input signal voltage: Input signal level, when specified as a voltage, is typically stated in either microvolts (\(\mu V\)) or nanovolts (\(nV\)). The volt is simply too large a unit for practical use on radio receivers. Signal input voltage - or sometimes power level - is often used as part of the sensitivity specification, or as a test condition for measuring certain other performance parameters.

There are two forms of signal voltage that are used for input voltage specification: source voltage \(V_{\text{Ref}}\) and potential difference \(V_{\text{Ref}}\). As illustrated in Fig. 3.

The source voltage \(V_{\text{Ref}}\) is the open-terminal, i.e. no load, voltage of the signal generator or source. Potential difference, \(V_{\text{Ref}}\), is the voltage that appears across the receiver antenna terminals with the load connected. The load is the receiver antenna input impedance, \(R_{\text{in}}\).

Fig. 2. Basic double-conversion receiver. It first converts the IF to a high intermediate frequency, and then down converts it to a lower intermediate frequency.

![Fig. 2. Basic double-conversion receiver.](image)

Fig. 3. Two forms of signal voltage are used for input voltage specification, namely source voltage \(V_{\text{Ref}}\) and potential difference \(V_{\text{Ref}}\).

![Fig. 3. Two forms of signal voltage.](image)

When \(R_{\text{in}}=R_{\text{L}}\), the preferred 'matched impedances' case in radio receiver systems, the value of \(V_{\text{Ref}}\) is one-half \(V_{\text{Ref}}\). This can be seen in Fig. 3 by noting that \(R_{\text{in}}\) and \(R_{\text{L}}\) form a voltage divider network driven by \(V_{\text{Ref}}\), with \(V_{\text{Ref}}\) as the output. This is,

\[
V_{\text{Ref}} = \frac{V_{\text{Ref}}}{R_{\text{in}}} R_{\text{L}}
\]

(1)

It requires only a little algebra to convert signal levels from one unit of measure to another. See the end of the panel entitled 'Special units'. This job is sometimes necessary when a receiver manufacturer mixes methods in the same specifications sheet. In the case of millivolts and \(\mu V\), \(\mu V\) is \(\mu V\) \(V_{\text{Ref}}\), or \(V_{\text{Ref}}\) of 0.5\(\mu V\) applied across 50k\(\Omega\), so the power dissipated is 50\(\mu\)W, or \(-1\)dBm.

Noise considerations

A radio receiver must detect signals in the presence of noise. The signal-to-noise ratio, or SNR, is the key here.

![RF Design](image)
because a signal must be above the noise level before it can be successfully detected and used.

Noise comes in a number of different guises, but for sake of this discussion we can divide them into two classes: sources external to the receiver and sources internal to the receiver. There is little one can do about the external noise sources, for they consist of natural and man-made electro-magnetic signals that fall within the pass-band of the receiver. Figure 4a) shows an approximation of the external noise situation from the middle of the AM broadcast band to the low end of the VHF region. A somewhat different view, which captures the severe noise situation seen by receivers, is shown in 4b).

One must select a receiver that can cope with external noise sources – especially if the noise sources are strong. Some natural external noise sources are extraterrestrial. For example, if you aim a Yagi beam antenna at the eastern horizon prior to sunrise, a distinct rise of noise level occurs as the Sun slips above the horizon. This is especially so in the VHF region – the 150-152MHz band is used to measure solar flux. The reverse occurs in the west at sunset, but it is less dramatic because atmospheric ionisation decays much slower than it is generated.

The receiver’s internal noise sources are determined by the design of the receiver. Ideal receivers produce no noise of their own. Output from the ideal receiver would contain only the noise that was present at the input along with the radio signal. But real receiver circuits produce a certain level of internal noise of their own.

Even a simple fixed-value resistor is noisy. Figure 5a) shows the equivalent circuit for an ideal, noise-free resistor, while 5b) shows a practical real-world resistor. The noise in the real-world resistor is represented in Fig. 5b) by a noise voltage source, $V_n$, in series with the ideal, noise-free resistance, $R_i$. At any temperature above absolute zero – i.e. OK or about -73°C – electrons in any material are in constant random motion. Because of the inherent randomness of that motion, however, there is no detectable current in any one direction. In other words, electron drift in any single direction is cancelled over even short time periods by equal drift in the opposite direction.

Electron motions are therefore statistically de-correlated. There is, however, a continuous series of random current pulses generated in the material, and these pulses are seen by the outside world as noise signals. If a perfectly shielded 50Ω resistor is connected across the antenna input terminals of a radio receiver, the noise level at the receiver output will increase by a predictable amount over the input noise level. Noise signals of this type are called by several names: thermal agitation noise, thermal noise, or Johnson noise. This type of noise is also called ‘white noise’ because it has a very broadband – nearly Gaussian – spectral density. The thermal noise spectrum is dominated by mid-frequencies – of $10^5$ to $10^6$Hz – and is essentially flat. The term ‘white noise’ is a metaphor developed from white light, which is composed of all visible colour frequencies. The expression for such noise is:

$$V_n = -4kTR$$

Here, $V_n$ is the noise potential in volts, $k$ is Boltzmann’s constant ($1.3808 	imes 10^{-23}$ J/K) and $T$ is the temperature in kelvins, normally set to 290 or 300K by convention. Also, $R$ is the resistance in ohms and $B$ is the bandwidth in hertz.

Table 1. Noise values for a 50Ω resistor at various frequencies.

<table>
<thead>
<tr>
<th>BW (Hz)</th>
<th>Noise voltage $x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>E-08</td>
</tr>
<tr>
<td>1000</td>
<td>1.41</td>
</tr>
<tr>
<td>1500</td>
<td>1.73</td>
</tr>
<tr>
<td>2000</td>
<td>2.00</td>
</tr>
<tr>
<td>2500</td>
<td>2.24</td>
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<tr>
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</tr>
<tr>
<td>3500</td>
<td>2.65</td>
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<tr>
<td>4000</td>
<td>2.83</td>
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<tr>
<td>4500</td>
<td>3.00</td>
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<tr>
<td>5000</td>
<td>3.16</td>
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<td>6000</td>
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<td>7000</td>
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<tr>
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<tr>
<td>8500</td>
<td>4.12</td>
</tr>
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<td>4.24</td>
</tr>
<tr>
<td>9500</td>
<td>4.36</td>
</tr>
<tr>
<td>10000</td>
<td>4.47</td>
</tr>
</tbody>
</table>

With equation 5, you can find the noise voltage for any particular bandwidth by taking its square root and multiplying it by the equation. This equation is essentially the solution of the previous equation normalised for a 1Hz bandwidth.

**Signal-to-noise ratio**

Receivers are evaluated for quality on the basis of signal-to-noise ratio, also known as $S/N$ or $SNR$, and sometimes denoted $S$.

The goal of the designer is to enhance the SNR as much as possible. Ultimately, the minimum signal level detectable at the output of an amplifier or radio receiver is that level which appears just above the noise floor level. Therefore, to lower the system noise floor, the smaller the minimum allowable signal.

**Noise factor, noise figure and noise temperature**

The noise performance of a receiver or amplifier can be defined in three different, but related, ways: noise factor ($F$), noise figure ($NF$) and equivalent noise temperature ($T_e$). These properties are definable as a simple ratio, decibel ratio or Kelvin temperature, respectively:

Equation 6.

$$F = \frac{P_{in}}{P_{out}}$$

Here, $F$ is the input signal-to-noise ratio and $P_{out}$ is the output signal-to-noise ratio.

**Noise figure** ($NF$). The noise figure is frequently used to measure the receiver’s ‘goodness,’ i.e. its departure from ‘ideality.’ Thus, it is a figure of merit. The noise figure is the noise factor converted to decibel notation:

$$NF = 10 \log(F)$$

Here, $NF$ is the noise figure in decibels, $F$ is the noise factor and log refers to base-10 logarithm.

**Noise temperature ($T_e$).** The noise temperature is a means for specifying noise in terms of an equivalent noise temperature. That is, the noise level that would be produced by a matching resistor – 50Ω for example – at that temperature, expressed in kelvins. Evaluating the noise equations shows that the noise power is directly proportional to temperature in kelvins. It also shows that noise power collapses to zero at the temperature of absolute zero (OK).

Note that the equivalent noise temperature $T_e$ is not the physical temperature of the amplifier, but rather a theoretical construct that is an equivalent temperature that produces that amount of noise power in a resistor. The noise temperature is related to the noise factor by:

$$T_e = (F+1)T_0$$

In order to make comparisons easier the noise factor is usually measured at the standard temperature $T_0$ of 290K – standardised room temperature – although in some countries 299K or 300K are commonly used. The differences are negligible.

It is also possible to define noise factor $F_n$ in terms of the output and input signal-to-noise ratios:

$$F_n = \frac{P_{in}}{P_{out}}$$

Figure 7. Each stage in the cascade chain amplifies both signals and noise from previous stages, and also contributes some additional noise of its own.
RF DESIGN

and to noise figure by,

\[ T = K \log \left( \frac{N/P}{10} \right) \]

(10)

Noise temperature is often specified for receivers and amplifiers in combination with, or in lieu of the noise figure.

Noise in cascade amplifiers

A noise signal is seen by any amplifier following the noise source as a valid input signal.

Each stage in the cascade chain, Fig. 7, amplifies both signals and noise from previous stages, and also contributes some additional noise of its own. Thus, in a cascade amplifier the final stage sees an input signal that consists of the original signal and noise amplified by each successive stage plus the noise contributed by earlier stages.

The overall noise factor for a cascade amplifier can be calculated from Frits' noise equation,

\[ F_N = F_1 \left( \frac{F_2 - 1}{G_1} \right) + \cdots + \frac{F_N - 1}{G_{N-1}} \]

Here, \( F_N \) is the overall noise factor of \( N \) stages in cascade, \( F_1 \) is the noise factor of stage 1, \( F_2 \) is the noise factor of stage 2, \( F_N \) is the noise factor of the nth stage, \( G_i \) is the gain of stage 1, \( G_j \) is the gain of stage 2 and \( G_{N-1} \) is the gain of stage \( (N-1) \).

As you can see from Frits' equation, the noise factor of the entire cascade chain is dominated by the noise contribution of the first or two. High-gain, multi-stage RF amplifiers typically use a low-noise amplifier, or LNA, circuit for the first stage or two in the cascade chain. Thus, you will find an LNA at the feed point of a satellite receiver's dish antenna, and possibly another one at the input of the receiver module itself. Other amplifiers in the chain might be more modest without harming system performance.

The matter of signal-to-noise ratio (S/N) is sometimes treated in ways that each attempt to crank some reality into the process. The signal plus noise-to-noise ratio \((S+N)/N\) is found quite often. As the ratios get higher, the S/N and \((S+N)/N\) converge (only about 0.5% difference at ratios as large as 100dB). Still another variant is the SINAD (signal plus noise plus distortion-to-noise) ratio.

The SINAD measurement takes into account most of the factors that can deteriorate reception.

The next article in this set will look at the receiver noise floor and the static measures of receiver importance, such as sensitivity and selectivity.
CIRCUIT IDEAS

Fact: most circuit ideas sent to Electronics World get published

The best circuit ideas are ones that save time or money, or stimulate the thought process. This includes the odd solution looking for a problem — provided it has a degree of ingenuity.

Your submissions are judged mainly on their originality and usefulness. Interesting modifications to existing circuits are strong contenders too — provided that you clearly acknowledge the circuit you have modified. Never send us anything that you believe has been published before though.

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

Clear handwritten notes on paper are a minimum requirement: disks with separate drawing and text files in a popular form are best — but please label the disk clearly.

Send your ideas to: Jackie Lowe, Camulus Business Media, Anne Boleyn House, 9-13 Ewell Road, Chess, Surrey SM3 0BZ

Stable go/no-go voltage indicator

The following circuit gives instant indication if a voltage is between two pre-set limits values or if it falls outside the limits. It has a temperature-stable internal voltage reference and so its accuracy is essentially determined by the stability of the external resistors R1, R2, R3, and R4.

At the core of the circuit is the TL4301, which behaves like a switch with an elevated trigger threshold. A simplified circuit below depicts the behaviour. When the trigger voltage is above 2.5V, the device is on. When the trigger voltage is below 2.5V, it is off.

In the basic circuit, the trigger voltage presented to pin 3 is determined by the ratio of R1/R2 and R3/R4.

When the measured voltage is below the lower limit determined by the values of R1, R2, T1 and the LED will be off. When voltage V is above the lower limit but smaller than the upper limit, T2 will be on and the LED will light. The voltage is within the limit conditions. When V is above both limits, T3 is also on and the LED is extinguished. Accuracy of the circuit is independent of supply voltage.

For go/no-go measurements on low-impedance voltages — for example a check on power supply rail voltages, etc. — the LED can be powered from the voltage being measured. The only inaccuracy this will introduce is any drop in the voltage under test due to supplying the current for the LED. If the impedance is low and there is sufficient current available, this should be negligible.

The value of R1+R2, etc., can be calculated to set a particular threshold voltage by:

\[ V_{\text{lower limit}} = \frac{2.5V(R + R_1)}{R_1} \]

\[ V_{\text{upper limit}} = \frac{2.5V(R + R_2)}{R_2} \]

The table gives some useful values for common voltages.

<table>
<thead>
<tr>
<th>Voltage limit</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7V, 1.9V</td>
<td>5k</td>
<td>47k</td>
<td>5k</td>
<td>60k</td>
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<tr>
<td>1.425, 1.75V</td>
<td>5k</td>
<td>47k</td>
<td>5k</td>
<td>60k</td>
</tr>
<tr>
<td>1.25, 1.4V</td>
<td>40k</td>
<td>5k</td>
<td>40k</td>
<td>6k</td>
</tr>
<tr>
<td>11.4, 12.6V</td>
<td>35k</td>
<td>5k</td>
<td>35k</td>
<td>6k</td>
</tr>
<tr>
<td>9.5, 12V</td>
<td>28k</td>
<td>5k</td>
<td>28k</td>
<td>6k</td>
</tr>
<tr>
<td>4.75, 5.25V</td>
<td>11k</td>
<td>40k</td>
<td>9k</td>
<td>11k</td>
</tr>
<tr>
<td>4.5, 7.0V</td>
<td>18k</td>
<td>6k</td>
<td>18k</td>
<td>6k</td>
</tr>
</tbody>
</table>

An optical audio isolator

A challenge recently arose to transfer audio across a high-voltage boundary without using transformers or capacitors, or RF of any kind. Initial tests with photovoltaic isolators, such as the PV15100 indicated that audio transfer was just about possible, but signals heard on common low-impedance headphones were very weak and distorted. So I developed the active circuit shown in Fig. 1.

It makes use of a matched pair of MCT2E1 single-transistor opto-couplers, which have a current-transfer ratio of approximately 100%. The output side is powered from a pair of 1.5V cells. On the input side, it is essential to bias the LEDs in the couplers with a 1V, provided by Rg, D1, D2 and R1 and D2, D3. These are fed from another pair of 1.5V cells.

Resistors R1 and R2 are chosen so that a standing current of about 600mA flows through the output transistors, thus eliminating crossover distortion.

When a signal is applied via R1, a linear transfer is obtained, and the frequency response extends from below 100Hz to above 10kHz. Note that the circuit is essentially current-driven, and R1 may need to be altered to suit your hi-fi amplifier.

To power-down, it is necessary to disconnect the cells on the input side only, since the output ones then suffer less than 10mA transistor leakage current only.

For stereo, the batteries are shared between the two channels. In certain airliners, the audio to headphones is literally 'piped', but transfer through air was outside the scope of this wager.

CJ D Catt
Cambridge F46

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Hard copy Electronics World Indexes on paper for volumes 100, 101, and 102 are available at £2 each, excluding postage.

CIRCUIT IDEAS

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Emergency light and alarm

This emergency light and alarm is powered by two AA Ni-Cd batteries and features four switchable options. The circuit is permanently plugged into a mains socket and Ni-Cd batteries are trickle-charged. When a power outage occurs, the lamp automatically illuminates. Instead of illuminating a lamp, an alarm sounder can be chosen.

When power is restored, the lamp or the alarm is switched off. A switch provides a "latch-up" function, in order to extend lamp or alarm operation even when power is restored. Circuit operation is as follows. Mains voltage is reduced to about 12V DC at the 10µF capacitor's terminals, by means of the reactance of the 330μF 400V capacitor and the diode bridge. This prevents the use of a mains transformer. Trickle-charging current for the battery is provided by the series 390Ω resistor, diode and the green LED that also monitors the presence of mains supply and correct battery charging.

Slow diode as fast spike suppressor

One of the most accommodating features of "flyback" - also known as "boost" - switch mode is that the primary-to-secondary flyback voltage is proportional to the turns ratio under any load condition. Voltage is therefore easily regulated by sensing the primary voltage. One upset though is that spikes rise to the clamp or snubber voltage due in the main to stray inductance. The solution is generally to sample after a slight delay to let things settle down. This works well, especially with dedicated management hardware, but is not ideal for minimalist designs. Disregarding the turns, "don't let slow diodes anywhere near switches", if the feedback is via a 1N4000 series or similar slow diode, spikes are blocked, an effect delaying sampling. A nominal resistance load is of course required but this is high and may by default be that of the input resistance of the control elements.

Maximum switching speed is not specified for such devices, but a slow diode can be relied on to be slow. Inhibiting of spikes and fast transients is pretty efficient. This "haste" has been found to be reliable, accurate, repeatable and economical. Sometimes it pays to think laterally, and application is of course not limited to this example. One could envisage a cheaper - and perhaps more effective - alternative to, say, data line filters.

Andy Robertson
Girvan
Ayrshire
F51

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Track
1 Washington Post March, Band, 1909
2 Good Old Summertime, The American Quartet 1904
3 Marriage Bells, Bells & xylophone duet, Burckhardt & Daub with orchestra 1913
4. The Volunteer Organist, Peter Dawson, 1913
5. Dialogue For Three, Flute, Oboe and Clarinet, 1913
6. The Toymaker's Dream, Foxstol, vocal, B.A. Rolfe and his orchestra, 1929
7. As I Sit Upon My Dear Old Mother's Knee, Will Oakland, 1913
8. Light As A Feather, Bells solo, Charles Daub with orchestra, 1912
9. On Her Pic-Pic-Piccolo, Billy Williams, 1913
10. Polka Des English's, Artist unknown, 1900
11. Somebody's Coming To My House, Walter Van Brunt, 1913
12. Sunny Scotland Medley, Xylophone solo, Charles Daub with orchestra, 1914
13. Doin' the Raccoon, Billy Murray, 1929
14. Luce Mail Francesco Daddi, 1913
15. The Ohio Minstrel, 2nd part, 1913
16. Peg O' My Heart, Walter Van Brunt, 1913
17. Auf Dem Mississipp, Johann Strauss orchestra, 1913
18. I'm Looking For A Sweet Heart And I Think You'll Do, Ada Jones & Billy Murray, 1913
19. Intermezzo, Violin solo, Stroud Haxton, 1910
20. A Juanita, Abrego and Picasso, 1913
21. All Alone, Ada Jones, 1911

Total playing time 72.09

21 tracks - 72 minutes of music
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12V DC motor controller outputs PWM

This PWM controller provides speed control from zero to maximum angular velocity for any motor up to 250W. It provides a smooth, progressive control, for drills, kiddie cars, golf trolleys, models, robots, etc.

Below 741 of control potentiometer resistance, Tr2 and Tr4 conduct, turning the Tr4 constant current sink and IC, 'on'. A small potential across C2 causes Schmitt trigger IC2 to oscillate with a very short 'on' period. Transistor Tr3 is bias in this foggled about its emitter potential, and its collector current is amplified by Darlington Tr4 to drive two 25A output transistors. The control potentiometer track may be physically cut at 30° below maximum resistance to guarantee an electronically 'off' setting.

As the potentiometer resistance is further reduced, the voltage across C5 and thus the IC1 conduction period increases. At maximum resistance, IC11, and thus the output transistors, tactfully 'on'. An antilogarithmic potentiometer has produced very smooth and gradual clockwise power control, although ordinary 10kΩ log pots suit direct twist grip or pedal control.

All components fit in a 100 by 75 by 30mm alloy box, clip the power resistors and transistors to it. Fix additional output devices in parallel to increase power drive. A 20:1 motor gearbox ratio with golf trolley sized wheels should keep speed on the footpath legal. A 24Ah battery and 180W motor easily does the round on hefty golf courses.

Graham Maynard
Newtownabbey
Northern Ireland
F49

Minimal audio oscillators

These two oscillators took inspiration from the circuit ideas in the August 2000 issue. One was a telephone earpiece oscillator by D. M. Bridgen and the other a ceramic oscillator by C. J. D. Cutt. Using reverse biased n-p-n transistors it is possible to design basic oscillators with just three components. The earpiece oscillator operates between 8 and 16V with a frequency of 1800Hz at 12V. The ceramic oscillator exploits its intrinsic capacitance and operates between 9.3 and 20V with a frequency of 1000Hz. This latter oscillator draws very little power despite a sound level comparable to the earpiece oscillator.

You may try other n-p-n transistors, although I found that not all of them would oscillate. The base lead is normally left unconnected but it could be used to modulate the generated sound.

Dave Di Mario
Milan
Italy
F44
Hugh Mobberley reviews Don McLean's recent book on the work of Baird.

Donald F McLean

Restoring Baird's image

November this year will mark the 63rd anniversary of what is commonly regarded as the start of BBC Television in 1936. However, most of us are unaware that BBC Television started with regular scheduled broadcasting over four years before - in August 1932 - on the 30-line television system developed by John Logie Baird in the late 1920s.

Why is this so rarely mentioned? Part of it may be to do with the sheer complexity of television's development - the story has been oversimplified to maintain the general public's attention. Part of it may also be to do with Baird's reputation, which steadily declined into the 1960s. Most likely though, it has to do with the sheer scale of the technological development of high definition television overshadowing all the earlier pioneering work.

So says a new book by Donald McLean, 'Restoring Baird's Image,' published by the Institution of Electrical Engineers. This book makes an authoritative case for changing our thinking on early television in Britain, from the work of Baird all the way to the start of the 1936 high-definition service.

The author's credentials come from his unique restoration of several contemporary videotape recordings made of 30-line television. These discs, covering the years 1927 to 1935, provide new reference points for the pioneering achievements of Baird and the quality of television programming in those early days. No images from these discs have previously been seen, with the later recordings of BBC TV entirely unknown until the late-1990s.

The author's work of restoring these discs forms the core of the book. Written in a conversational style, the book opens up this complex period in television's early history. The book goes a long way to help the reader appreciate the significance of these recordings and the era in which they were made.

It starts by taking us on an objective introduction to television's early history, identifying mechanically scanned television as another valid form of imaging that is of far more use today than it has ever been. A chapter on the development of videotape and videodisc recording - a rare sight in any television history book - describes how the 30-line recordings happen to be made 25 years before videotape and nearly 50 years before the videodisc player.

The achievements in the 30-line TV broadcast period before 1936 are quite a revelation. After sixty years of believing that no video recording of 30-line BBC TV exists, several discs turned up around five years ago. These video recordings were made on domestic aluminium disc audio recorders from 'off-air' broadcasts.

Akin to finding the proverbial needle in a haystack, the author has identified one of the discs as being a television special - the world's first television review - transmitted by the BBC on 21st April 1933. Together with the other recordings, the book convincingly presents the evidence that 30-line BBC TV was in no way amateur, but was very professional and professionally produced as the later 405-line service became.

The book closes with a critical eye turned to the historians and documentary makers who have needlessly neglected all television over the years. What separates this book from others covering the same period is its uniqueness and originality - it has both a new story to tell and illustrates an old story in a new and entirely authoritative way. Support from the leading experts on Baird, Ray Herbert and on videotape recording Martin Salter, assures the book's historical accuracy.

There are some 150 figures in the book, including 60 previously unpublished historic photographs and over 120 30-line images - the largest collection in any one publication. This is a TV historian's delight providing a refreshing 'new book' history in both words and pictures. The book's well-kept coverage of the first decade of television.

Written in a conversational style, the book opens up this complex period in television's early history. The book goes a long way to help the reader appreciate the significance of these recordings and the era in which they were made.

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One of the book's hidden secrets: not content with restoring the early videotapes, the author also restored all the historical photographs in the book.

Restoring Baird's Image

A visit to the author's website at http://www.dfm.direcon.co.uk reveals many of the restored video clips from the videotapes which it was not possible to include in his book.

secret is that the author has painstakingly cleaned up the historic photographs, removing crease marks, scratches, dust specks and moiré. The rarity of many of these pictures together with the high quality of restoration and reproduction makes this, for just the photographs alone, an attractive book to buy.

To quote from the Foreword, John Trescothick of the National Museum of Photography, Film and Television, describes the author's work as "an outstanding example of industrial archeology."
Receiving multi-band pulsed ultrasonics

When receiving ultrasonic signals, band limiting helps reduce noise problems. With a wideband receiver, multiple bands are normally used, ramping up the number of components needed. £100 Farnell voucher winners S. Vijayan Pillai and S. Subash have devised a method for reducing the number of components using the mixer and oscillator features of the ZXF36L01 at the front-end of an ultrasonic receiver.

In an ultrasonic system, where a pulsed transmission of narrow band signal is involved, band-limiting the received signal reduces noise problems. Normally, band limiting is achieved by splitting the band right from the hydrophone level. This involves more hardware and sensors.

Wide-band hydrophones with built-in amplifiers are available covering 2 to 80kHz. One example is a wide-band ultrasonic sonar system whose useful range extends from 2 to 80kHz.

In the scheme described here, a ZXF36L01 does the band sampling. As a result, only one sensor and one A-to-D conversion are necessary.

Output from this system is in band-serial, bit-parallel form. The expected signal has a minimum pulse duration of 5ms. Band processing in time is done for 2 to 85kHz, as shown in the Table.

Band sampling is done at every 0.5ms. The first 1.5ms is used for the lowest band and is separately processed. Since the converted band is limited to 19kHz, the sampling frequency of 64kHz is sufficient. A multi-channel processing scheme can be applied to the digital signal, Fig. 1.

Both mixer and band-pass filter can be realised using one ZXF36L01. An outline of the implementation is shown in Fig. 2.

For:

\[ F_p = 14kHz, R = 10k\Omega, C = 1000\mu F \]

select \( R_1 \) and \( R_2 \) for a Q of 1.4. These components are

Launched this year, the ZXF36L01 is a versatile high-Q band-pass 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.

A designer's kit is available from Farnell and you can find full data on the device on Zetex's web site http://www.zetex.com/pdf/ics/zxf36101.pdf.
The PROM is a W57C191B. This is a standard 24-pin DIP slim package manufactured by Waferscale Integration, Inc. It is used as a frequency synthesiser. An address is fed to the PROM once per microsecond and the three interlinked 74163 counters are cleared at every 1000μs. They cycle from 0 to 1000, addressing 1000 unique locations in the PROM.

If, for example, 1kHz at pin 9 of the PROM is needed, logic zero is stored in the first 100000 = 500

locations and logic one in the next 500 locations at the LSB (output O1) bit position of the PROM. Other frequencies can be created at outputs O2 to O7 of the PROM in the same way. At the O7 bit position, the frequency to be generated is 64kHz, which is given as a sampling clock to the a-to-d converter.

Similarly if 1kHz is needed at pin 10, store logic zero for the first, 100000 = 45

2 x 1000

locations, logic one in the next 46 locations, logic zero in the next 45 locations, logic one in the next 46 locations, and so on until 1000 locations are filled at the O1 output bit position of the PROM.

To use the PROM as a frequency synthesiser, the address is fed to the PROM once per microsecond and the three interlinked 74163 counters are cleared at every 1000μs. They cycle from 0 to 1000, addressing 1000 unique locations in the PROM.

If, for example, 1kHz at pin 9 of the PROM is needed, logic zero is stored in the first 100000 = 500

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Other frequencies can be created at outputs O2 to O7 of the PROM in the same way. At the O7 bit position, the frequency to be generated is 64kHz, which is given as a sampling clock to the a-to-d converter.

Similarly if 1kHz is needed at pin 10, store logic zero for the first.

**Table. Band processing time for 2 to 80kHz.**

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<tr>
<th>Time (ms)</th>
<th>Band (MHz)</th>
<th>Filter Qn</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.5</td>
<td>2-10</td>
<td>X</td>
</tr>
<tr>
<td>0.5-1</td>
<td>10-20</td>
<td>1</td>
</tr>
<tr>
<td>1.5-2</td>
<td>20-30</td>
<td>11</td>
</tr>
<tr>
<td>2.5-3</td>
<td>30-40</td>
<td>31</td>
</tr>
<tr>
<td>3.5-4</td>
<td>40-50</td>
<td>41</td>
</tr>
<tr>
<td>4.5-5</td>
<td>50-60</td>
<td>51</td>
</tr>
<tr>
<td>5.5-6</td>
<td>60-70</td>
<td>61</td>
</tr>
<tr>
<td>6.5-7</td>
<td>70-80</td>
<td>71</td>
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</tbody>
</table>

Fig. 3. Circuit of the multi-band receiver. Clocks by the 2MHz TTL output, one a value of 1kHz for R2000. Choose R2000 depending on the signal input.

**PROM frequency synthesiser.**

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September 2001 ELECTRONICS WORLD
Ian Hickman describes a simple opto-electronic link with enough bandwidth to carry speech. It was designed so that a group of students could make it up in a couple of hours. In its basic form, the link's working distance is limited, but it is easily modified for building-to-building use - even further.

An optical speech link

T
his simple all analogue opto-electronic link conveys speech from a transmitter station, via a pulse modulated light beam, to a receiver, as in Fig. 1.

At the transmitter, the output of a microphone is amplified, and then applied to a pulse generator arranged as a modulator. The pulse train output of the modulator carries the speech signal as variation in output voltage that modulates the light beam. At the receive end, a photodiode detects the light pulses and produces a corresponding output - audio only. This is amplified by an op-amp, and then further amplified by a second inverting op-amp stage. Output from the second amplifier is applied to a low-pass filter. This filter acts as a demodulator, thus recovering the original speech signal. For convenience, the output was monitored on an existing laboratory amplifier or "speakout box" - one of those endlessly useful pieces of kit that's a must in any electronics laboratory.

The transmitter circuit

To feed the transmitter, Fig. 2, issued a very ordinary moving-coil microphone with an output resistance of 200Ω. It was connected directly to the non-inverting input of an op-amp, one section of a TL084 quad op-amp. A single op-amp would of course have sufficed. However, a quantity of quadruple op-amps had been made available for the students to experiment with under the RPEE scheme, described in an earlier article. With a 10ΩMΩ feedback resistor, the voltage gain of the op-amp was 1000000:1 (with 1000Ω input and 100Ω output). This is quite adequate for the purpose, and it also served as a convenient mode of operation.

The output signal, a sawtooth waveform, was then applied to a preamp and further amplified by a second inverting op-amp stage. Output from the second amplifier is applied to a low-pass filter. This filter acts as a demodulator, thus recovering the original speech signal. For convenience, the output was monitored on an existing laboratory amplifier or "speakout box" - one of those endlessly useful pieces of kit that's a must in any electronics laboratory.

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affects both the pulse-repetition frequency, or prf, and the mark-space ratio. When the voltage rises, the prf increases and the mark-space ratio decreases. When it falls, the prf decreases and the mark-space ratio increases. The change in frequency is immaterial, as far as operation of the link is concerned, the useful information being carried by the mark-space ratio.

The modulated pulse train is applied to another section of the CD40106. This device is used as a buffer to drive the light-emitting diode (LED), the current being limited by series resistor R8.

At the receiving end

At the receiver, Fig. 3, the photodiode D3 is aligned with the transmitter's light-emitting diode (LED) so as to detect the light pulses. These are amplified by op-amp ICP. This amplification is achieved by the photo-current generated by the diode. The output of the amplifier is balanced by the current fed back to the inverting input via Rb. The circuit is designed to work. Adding an R3 to complete the transmitter circuit. The output is fed into the output amplifier. The output amplifier can be inserted at point X.

Similarly, at the receiver, ICP and the photodiode were connected, and the current flowing through the photodiode was amplified. The current flowing through the photodiode was amplified and used to control the output of the amplifier.

Finally, with the amplifier connected, the operation of the system overall was checked. The signal was sent from the transmitter to the receiver, and the received signal was checked.

Increasing the range

Various steps are available for increasing the range. The most obvious is to increase the drive to the LED, by reducing the value of R8. This is possible, if the other unused inverters in the CD40106 are connected in parallel with ICP. Brighter LEDs than those used are now available. The new way of increasing range is to arrange that the LED falls on the active area of the photodiode, as described below.

When a wireless communication system, the range is determined by the available 'effective radiated power' at the transmitter, the sensitivity at the receiver, and the atmosphere in between.

At UHF and VHF frequencies, the output power of the transmitter can be increased, in the desired direction of communication and at the expense of other directions. This can be done using a transmitting antenna with directional gain. This will, however, require an improvement in the sensitivity and the desired intelligence is unaffected.

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