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On the right track?

The thing are looking up for Railtrack. Its train announcements at a local station are computerised, but the computer seems to have feelings. It announces, "I am sorry to tell you that..." or "I am extremely sorry for the delay to your journey," although not "I am pleased to inform you..."

Use of the first person implies that the computer is accepting some responsibility for events. Maybe it is frustrated networking with other computers in distant signal boxes to ensure that future services will run smoothly — what a good idea.

On Tuesdays, the announcements are made by a male voice, whereas on Thursday it is female. Perhaps it has a split personality — one like Marv in the paranoid android would probably be more suited to the post-Hatfield climate.

Could Railtrack be the first to have actually built a caring machine? Could feelings be given to other machines? Perhaps I could argue with the speed camera that's just flashed me.

But seriously. Railtrack and British Rail before it, have benefitted from technology that saves time and money, and possibly even helps to make money too. For example, the move from steam to diesel and electric traction in the 1960s; the introduction of fully blade managed trains which eliminated the need for a guard, unmaned level crossing barriers, the mass signalling schemes of the 1970s and 80s which created signal boxes to cover large areas of track and which replaced many lever-frame boxes; driverless trains on the Docklands Light Railway. Even the infamous Beeching Report, which closed so many railway lines, called for massive new investment.

Technology does have its problems because of the change that it brings. The need to have a "change management plan" with each new scheme is now apparent. It is morally indefensible to throw a lot of people on the job scrap heap without some concern about what they are going to do. Losing a job is like having a rug pulled out from underneath you — it hurts a lot. Big companies now thankfully recognise this and accept the responsibility to organise retraining schemes and outplacement services.

So it's relatively easy to cut costs, but how do you account for railway safety? Is it a bottomless pit into which vast sums of money are thrown to appease nervous passengers?

We seem to hold the railways close to our heart and expect them to be near perfect. It's still a very safe mode of transport, although the recent crashes have been horrendous.

Even more horrendous is the blind spot that we have for road transport. We tolerate over 3000 road fatalities every year at the price for the freedom of the road. Why don't we make more fuss about it? Why shouldn't cars be compulsorily fitted with radar or some linked brakes?

Investment in safety systems is all down to risk management. No system can be 100% perfect, and if you try to make it do so then you can expect to spend as much as the 99.5% in effort. When the railways were split up there was a feeling that the safety regime was too tight and too costly.

Continental Railways, it seemed, worked perfectly well with less regulation. For example, there was more train cab radio control rather than costly signalling, and country stations had more basic facilities.

However, what seems to have been overlooked was the chronic state of the infrastructure in the UK. Railtrack was sold a dummy. Shareholders were blinded by the massive amount of property that Railtrack was about to inherit.

Future advice must be that when Governments sell off the crown jewels they don't throw them away. They are not fakes. Industry is not exempt from this either — look at the sale of Rover to BMW.

Despite the present problems of Railtrack, the railways are going through an unprecedented renaissance. Urban and light rail schemes are being adopted by many cities and towns. Stations that were closed in the 1960s are reopening. The Channel Tunnel Rail Link is being constructed with talk of more high speed lines.

The break up of the railway industry has caused problems, particularly over responsibility for safety. However, it has opened up the network to more passenger and freight trains than ever before.

Technology has an important part to play in speeding up this process and one sincerely hopes that the lessons of Southall, signal SNI09 at Paddington, and Hatfield will be learnt and applied wisely.

Peter Matthews
**UPDATE**

**Chip provides glaucoma warning**

Scientists at the Fraunhofer Institute in Germany have developed a system that measures pressure inside the eye, warning glaucoma sufferers of danger. A chip, pressure sensor and RF coil are inserted into an artificial lens in the eye. The external reading device, integrated in a pair of glasses, powers the circuitry through the RF link. This allows 24 hour measurement. "Until now, measuring methods have virtually neglected fluctuations in pressure during the day and at night," said researcher Gerd von Bojel. A human study of the device is due soon, he said, while commercial devices could be ready in as little as a year.

In its normal form, glaucoma develops slowly and insidiously without pain. Fluid pressure inside the eye increases, reducing blood pressure to the retina. This can permanently damage the optic nerve and lead to blindness.

**Solar-powered plane flies for 18 hours**

NASA has flown Helios, its unmanned solar powered wing, for the first time at a significant altitude. An 18 hour test flight over Hawaii saw Helios reach over 23 000 metres, proving its 35kW of solar cells were up to the task. Helios has a wingspan of 75 metres, yet weighs under 600kg. For the next test flight, NASA's Dryden Flight Research Center hopes to get the wing above 30 000 metres.

By 2003, the team hopes to install hydrogen fuel cells that would enable the wing to continue flying through the night. Such a craft could then be used to provide communications at a much lower cost than satellites.

Flight at 30 000 metres is said to be similar to that on Mars.

BP buys Madrid facility for solar-panel production

BP is buying a semiconductor fab in Madrid from Agera Systems which it will turn over to production of photovoltaic solar panels. By the end of next year, the plant will be one of the largest dedicated solar-cell factories, with a yearly capacity of 60MW of crystalline silicon panels.

"Spain and the rest of Europe represent growing markets for solar power," said Harry Shimp, chief executive of BP Solar. "This project in Madrid will enable us to continue to play a leading role in meeting demand."

The company plans to invest $100m in the factory which will create around 600 jobs.

BP claims to have nearly 20 per cent of the world market in solar panels. Last year its turnover was $200m and it produced over 40MW of photovoltaic equipment.

BP also recently opened a plant in Australia with a yearly capacity of 25MW. The firm calculates this level of production reduces CO2 emissions by 33 000 tons.

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Niobium capacitors replace tantalums

Tantalum shortages are bringing niobium into electronics as NEC announces the first niobium conductive polymer-type solid electrolytic capacitors.

Niobium is one of the alternatives.

Performance non-polymer niobium types.

The company is claiming that its niobium capacitors have the quality and performance equivalent to the conventional tantalum capacitor, and that production yield is better, although it does admit that niobium capacitors will be slightly larger if all else is equal.

NEC anticipates that in the future, niobium capacitors will be used for high-capacity devices — about 1000F — which were too costly to produce using tantalum, and will come to replace aluminium electrolytic capacitors.

Niobium capacitor specification

- Rated voltage: 2.5V
- Capacitance: 220uF
- Size: 7.3 by 4.3 by 2.6mm
- ESR: 55mΩ
- Part number: N8P0DE227M
- Samples: August 2001
- Production: early 2002

Police robot works autonomously

Researchers at Sandia National Laboratories in New Mexico have unveiled a police robot that makes some "how to" decisions on its own.

The idea is to free its operator to make the more critical "what to do next" decisions during bomb disposal and other law enforcement activities.

Even simple operations can be complicated on these robots.

"Sometimes it's like playing a video game with a seven-lever joystick sitting upside down, with one eye closed, and with your boss looking over your shoulder," said researcher Phil Born.

"Operators might say, 'there's something that they're about to bump an object but they're really three feet away. Or they don't know if the robot will be able to fit between two cars or climb a flight of stairs. Often they don't accomplish those difficult tasks on the first try. The pressure can be intense.'"

The Sandia machine is based on a standard Wolverine robot from Remotec in Tennessee, with Sandia's own software — called SMART, an acronym for Sandia modular architecture for robotics and teleoperation.

During a demonstration in March, claims Sandia, the modified Wolverine "shaved minutes off typical bomb responses even with the most skilled FBI robot operators."

Currently SMART automates reusable and costly robot functions such as automatic tool change, tool placement, and bomb-disruptor aiming, as well as teleoperated straight-line movements in all directions.

New behaviours that could be included in future include path planning, machine vision, proximity sensing, obstacle avoidance, visual targeting and 'reachability' analysis.

UK programmable analogue chips break into Japan

UK field programmable analogue array (FPAA) company Anadigm is breaking into the Japanese market through a deal with Omron.

"We are delighted with this alliance, and believe it will substantially accelerate the take-up of this exciting new technology," said Anadigm's CEO Mike Kay. Omron will sell Anadigm chips under the Omron brand.

The Japanese company has experience with the full custom analogue IC business, and sees a demand for FPAA applications in consumer electronics needing under 10,000 units per month, said the company.

"Engineers exercising are seeking to design at higher and higher levels of abstraction, but a universal analogue HDL is not available, due to performance issues associated with analogue IC fabrication," said Kunimori Hamaguchi, CEO of Omron's semiconductor division.

"FPAA's offer a solution to this problem, which massively reduces design time and costs compared with analogous ASICs."

The company will initially market FPAA technology in Japan, where it expects to establish, "a multi-million dollar market within two years."

It also will contribute to the development of FPAA's aimed at specific markets including industrial automation and medical equipment.

Anadigm's FPAA's are based on switched capacitor building blocks and design software from the company allows the chips to be configured on power-up. A wide variety of Analogue functions are available.

New pressure sensor exhibits massive linear resistance change

Research at the University of Durham has yielded an electrically-conducting polymer with linear resistance change under pressure. The composite material contains particles of metal dispersed throughout an elastomer.

Resistance decreases from 10Ω to just 1Ω under fingertip pressure.

"You can go from essentially an insulator to a conductor just under moderate pressure," said Professor David Bloor from the University.

"That's a remarkable range of any physical property, in any material... and under fairly non-extreme conditions."

Physics firm Peratech says it has taken the material and demonstrated it in power tools, in a remote control unit and in a wearable PC interface.

Ported software that runs faster

Running code written for one processor on another normally means interpreting adaptation software and a horrendous loss in speed.

Now a Manchester company is claiming it can port software in real time — with a speed gain.

"Overall we have seen speed-ups of 10, 20 or 30 per cent applications," said Alasdair Rawsthorne, company chief technical officer. Called Dynamic, it is described as "code-morphing" software, running as a kernel around the target processor. At run-time and converting original processor code on-the-fly.

Speed gains, Rawsthorne, come, "simply because of the optimisation of the code. Doing it at run-time means that the behaviour of the software can be observed as it runs and its performance improved."

The company is aiming the product at companies with a lot of existing code needing to be run on a new processor. "You can't buy a decent 68000 now," said Rawsthorne, "and you can only buy 68000 at the cost of 68000 code."

Dynamic has a re-usable core which is adapted for particular processors by attaching a front and back end. "We have adaptors for 68000, Sparc, Alpha, ARM, PowerPC and x86 at the university," said Rawsthorne.

Transitive demonstrated x86 code running on a MIPS processor at the recent Embedded Microprocessor Forum in the US. "We will be delivering a production version of the software at the end of September," he said.

According to Transitive, Dynamic is built upon a well-accepted method called optimising dynamic binary translation. Similar techniques have apparently been lab tested and used intra-commercially by IBM and Hewlett Packard for specific CPU pairs and are also used in Transmeta's Crusoe processor which emulates an Intel x86 processor in a VLIW machine.

Dynamic can be deployed, said Transitive, above the target operating system (OS) in 'multiple binary' mode, executing different binary code streams simultaneously in a single target environment. It can also run under the subject OS interfacing to raw target CPU hardware and processing applications and OS loads of the subject machine transparently to the user.

www.transitive.com

RF identification chip small enough for bank notes

This tiny chip is a radio-frequency identification (RFID) tag developed by Hitachi. The firm reclaims the 'microchip', as it calls it, is small enough at 0.4mm² to be embedded in paper and bank notes. Operating at 2.45GHz, the wireless chip stores an ID in a 128-bit ROM, reducing the chances of tampering.

Memory chips that test themselves

Embedded memory specialist Virage Logic has developed a memory design that includes self-test and repair circuits.

The technique removes the need for testing machines and laser modifications of devices following production, said the firm. It should increase the yield of devices containing embedded memory.

"Today you cannot integrate large amounts of RAM without solving the yield problem, which is a burden for one of the fastest growing segments — communications and networking," said Dr Yervant Zorian, Virage's chief scientist.

Called STAR, the system uses redundancy to provide spare memory bits and a processor dedicated to testing and assigning replacements.

Normally performed at the wafer-sort stage of manufacture, the testing results are stored in an on-chip 'fuse box' which is used to allocate spare bits each time the chip is powered-up.

The firm claims the testing algorithms can pick up 99 per cent of faults.

This, said Zorian, "saves the customer literally millions of dollars by repairing otherwise defective ICs."

Virage has designed three embedded memory products, a 4Mbit, 8Mbit and 16Mbit single-port designs and a 256kbit dual port version.

A licence for the design starts at $170,000 plus royalty fees.
Can i/o via the web be simple?

Set up your own remote monitoring system using Internet protocols, Ethernet and a web server. Can you think of anything more daunting? Read on, you might be surprised how easy and cheap it is — especially if you’ve already dabbled with HTML. Later in the article, Eddy Insam provides a step-by-step guide to help you get the simple hardware described here on line.

Building on my previous articles on Ethernet interfacing, the following shows you how to implement a real web server connected to your PC via a local-area network. This is a very basic design that will allow you to do things like display temperature, control a heater and switch lights remotely from any web browser. Once you’ve grasped how it all comes together though, the opportunities are endless — especially now that fast wireless Ethernet links are becoming readily available.

I live in a very old house; it has a large basement with a large coal bunker where I keep many bits of fine wood that may come in useful some time. I need to keep the place at the right ambient temperature. This means a regular walk down the steps to check the walls for humidity. If there’s a problem, I leave the lights or heating on for a few hours. This is not a job I can delegate to a simple room thermostat; as it would leave the heater on most of the time and use a lot of energy in the process.

Nowadays, I don’t have to go all the way down the steps that often. I go to my PC, fire up my Internet browser and call up a web page. Up comes a screen page displaying the temperature in the room. If I want the lights or the heater on, I just click on a button on the screen.

How is it done? Well, I have an embedded web server in the basement. This server web sits in a small 125 by 125mm box fixed to the wall. It connects to the Ethernet LAN running around the rest of the house, Fig. 1.

Pushing the description to the limit, I could call this a miniature dedicated ‘private internet service provider’. The display containing information from the remote controller unit is not static. Contents of the web pages are changed dynamically by data read by the unit via its I/O ports.

Similarly, I can control the heaters by making page requests from my web browser. I don’t need any special software on my PC. All I need is my standard Internet web browser to give me a two-way simple I/O control.

The trend of using an Internet browser like a ‘program’ is gathering pace. There are certainly advantages to doing things this way — especially as any web-enabled piece of equipment can be used for controlling interfaces. This equipment includes WAP phones and palm-top computers.

So what is inside this box? I have chosen the SitePlayer module (www.siteplayer.com) as the basis for my remote-control system, Fig. 2. This is a good example of current technology, and the kind of ready made product available for this sort of application.

SitePlayer is a 25mm-by-25mm module built as a piggyback board. I have chosen it mainly because it comes with a scripting web language that allows me to relate external events to internally-stored web page displays. There’s more on this later.

Figure 3 shows the block diagram. The SitePlayer module consists of a Realtek RL8019AS Ethernet transceiver chip plus an 8K51 microcontroller. The Ethernet Transceiver chip conditions the Ethernet signals on the line and transfers the packets to the micro.

All the protocols are handled by the microcontroller. It also supports eight general purpose I/O ports plus one serial port. I am only using the parallel part in this design. The micro has 64K of code space, with roughly 16K of program code dedicated for TCP stack and script interpreter code, and 48K of user programmable areas to hold web pages.

The only external components required for this project are an external 10 BaseT line transformer, an R445 socket connector for the LAN, and some external standard circuitry to drive a mains controlled heater, a ceiling lamp and to sense a switch and the temperature sensor. Figure 4 shows the full circuit diagram.

The 4Kbyte web area can include as much text, graphics, etc., as can be fitted in the space available. Web pages can contain special fields that are modified with data read from the I/O ports. Page or click requests will also cause the I/O ports to output different data.

The web page becomes the ‘user interface’ Fig. 5.

Have you wired up your house yet? Externally, a standard CAT 5 network cable is used to connect to the rest of the local network around the house. This can include one or more PCs.

Network cables, connectors and crimping tools are now available from most electronics and computer shops. Many new houses and offices are now being fitted with network connections in every room or standard.

One of the best ways to get started is to buy a network ‘kit’. These will include a couple of network cards for your computer — assuming you have more than one — a four or five port ‘hub’, and a few cables. The instructions supplied with this sort of kit are usually very good and will explain all you need to know about networking in detail.

Note that if you are only using one computer for this project — i.e. you don’t have a hub — you will need to use a special changeover cable or adapter to connect the computer to the module.

How does it all work? In order to understand the basics, it is easiest to look at how things function from the PC’s point of view.

When you fire up your Internet browser and request a web page, a number of events take place. At the lowest level, a full TCP connection is established between the PC and the remote server.

For the purposes of this article, think of TCP like a telephone call, something that you start by dialling a number, and that results in a fixed connection between the two points until one of the band sets is put down. When the connection is live, bytes are exchanged in a way not too different from a plain RS232 wired link.

A few steps may need to precede this, such as obtaining the numerical address of the remote site. You can’t phone anybody unless you know their telephone number. These numbers, or IP ‘addresses’, are usually stored in local tables, but they can also be found by making a separate call to a ‘directory enquirers’ server on the network, or on the Internet. Of course, everybody connected to the world-wide web has to have a different address. Newcomers must be allocated a unique ‘name and number’. In theory, this should include my basement device. However, as I am running my own local network with no access to the outside world, I can cheat a little. I can allocate almost any numbers or web names I like to my interfaces. As a result, my project is called ‘mybasement.com’ and is associated with the address 192.168.1.250. This happens to be the default IP address of the SitePlayer module.

The TCP link is established, the browser and server can exchange bytes. The protocol used for web

web-page material, which can include text and images. Dynamic scripts are used to replace display fields with values read from the I/O ports. Similarly, request commands from the browser can set data outputs. The module also provides for eight parallel data bits plus one serial port for external control.
access is called HTTP. To request a page, the browser sends a "GET" command string in plain text, usually followed by a file name and maybe a few other parameters, also in plain text. Commands are terminated with double line feeds.

The server simply replies with the contents of the requested file. Web pages are made of plain text, and use a formatting language known as HTML. This language allows for the inclusion of commands such as font and colour changes by the use of predefined "tags" within the text.

If no file name is supplied, a default name such as "Welcome.html" or "Index.html" is substituted instead. When the file has been fully transmitted, the server closes the TCP connection, and that is the end.

To get another page, the browser must open another TCP connection, and send another GET command with the name of the new file.

A typical web site contains many HTML files. There is usually one main file called "Welcome.html" or "Index.html" and various other support files including bitmap images, Java applets, etc.

In a standard page request, the browser will first request -- and display -- the main page. Then it will scan through the contents of this page looking for links to other files. For each link it finds, it will make further GET requests for each, at one a time. Each of these requests involves the opening and closing of a new TCP connection.

As the files arrive, they are presented to the user. If they are bitmaps for example, they are displayed at their correct location on the screen. Text files are very short and can display very quickly. Images, even compressed ones, are bigger and can take more time to download.

The HTTP/HTML scheme allows the various parts of a file to be displayed in any order, and give an impression of speed. Following this logic you can now understand why some web pages can load and display very quickly and why some pages display a blank rectangle while the image that goes with it is still being downloaded.

It should also be clear how straightforward it could be to implement a web server using a low-end microprocessor. The server only needs to wait for GET requests, and then return a string of pre-stored characters. The only limitation is the availability of enough ROM or RAM space to hold all the HTML files and data.

Of course I have simplified the argument a little. I am talking about the simplest of HTTP protocols, but this is all you need to know at this stage.

And now for the clever bit

The SitePlayer module has an internal flash memory big enough to hold up to 4kB of web page data. This can include text, images, sounds, animations and anything else that can fit in that space.

Tools supplied with the module allow you to edit the HTML pages in the normal way on a PC and download them into the module's memory in compiled form.

This is not all, the module has a feature known as scripting. This links fields on its stored web page with internal variables in the microcontroller and also with external events such as 1/0 port data. The module will replace the tags with the actual values that are dynamically updated at display time. In order to do this, some non standard codes need to be added to the standard HTML text.

For example, assume there is a register variable inside the microcontroller that has been given the name port 1 in the script, which happens to contain the decimal value 57. If the original HTML page contained the text: "The value is "port1"", it will be displayed -- i.e sent to the browser -- as "The value is 57"

This scripting can be used in many ways. For example, the source text:

```html
<! image src = "ledn.gif">
```

can be used to display one of a number of pre-stored bitmaps depending on the value of n, i.e led1.gif, led2.gif... This could be used to emulate a seven-segment numeric display for example.

Similarly, codes sent back from the browser can activate outputs in SitePlayer. Clicking on a web page button can cause an I/O output pin to change.

The scripting language is relatively simple, and can be learnt in an hour or so. Figure 5 shows my crude attempts at web design. More can be achieved with the imaginative use of graphics, buttons and Java scripts.

The hardware

Figure 4 shows the full circuit. The parallel port signals are standard 8051 "PORTC" type ports. These can be set as output only or as bi-directional input/outputs.

I have used two pins as outputs to drive two mains controlled devices -- a fan heater and a ceiling lamp. One input pin is used to sense a door latch, and the remaining five bits are used to read the output of an a-to-d converter using an LM335 diode temperature sensor. You can use any combination of input/output in your own designs. All the definitions are done in the software anyhow.

The line connection requires a 10BaseT transformer and RJ45 socket. It may be worth salvaging these from an old Ethernet PC card, as they can be difficult and expensive to obtain in one-offs.

I have used the LFI5022 Lan-Mate combined unit, which consists of a transformer and connector integrated into a single container. Addresses for web sites advertising these parts are given later.
CONTROL & INSTRUMENTATION

Figure 4b shows the a-to-d converter circuit I used to sense local temperature. It incorporates a National AD59010 chip in self-run mode.

A Schmitt trigger inverter—part of a 74HC14—forms a free running oscillator to start a new a-to-d conversion every few seconds or so. Only the five most significant output data bits are used. These connect to the lower five IC pins of the SitePlayer module.

One nice thing about the AD59010 is that you can set the analogue conversion end points to cover almost any two voltage limits. To two (0/2) variable resistors trim the minimum and maximum end points so that the desired temperature range spans the full digital range of 0g to FFh.

The LM35 diode gives a steady 10mV change per °C around its defined output level of 25V volts at 27°. I have set my potentiometers to give a temperature span of 5 to 37°C. This is convenient as it corresponds to a resolution of one degree per bit, making life easy when computing the display assignments on the HTML web page.

Figure 4c shows the circuit used to drive the ceiling lamp and the heater. I opted for ready-made solid-state relays; these can cost a bit more than using separate triac circuits, but they have other advantages such as encapsulation and environment proofing.

The models I used—namely Crydom MP or CX series, available from Farnell and others—take TTL level signals and can switch mains voltages at between 2 and 10 amps depending on model. If you use a different type, ensure they use zero voltage switching.

Note that I have driven the relay modules via the spare hex inverters. This is not strictly necessary, but I added them here just in case something goes wrong. I’d rather have the 74HC14 blow up than my expensive Ethernet board.

Figure 4d shows the remaining input used to read the door latch. I use a simple burglar alarm magnetic Reed switch, also connected via one of the spare hex inverters, again in case something goes wrong.

The whole thing is powered by a 9V battery and 5V supply—not shown. Current consumption is around 60mA.

What’s next?

Once the electronics have been wired up, the rest of the job needs to be done in the software—not at the module end, but at the PC end.

You will need to connect the unit to your network. If you have a hub, connect the unit to the hub via a standard CAT5 network cable. If you connect the module directly to your PC, i.e. if there are no other devices on the network, be sure not to use a crossover LAN cable or adaptor.

The first stage is to get the module to act as a web server only, i.e. without any of the scripting facilities; these can be added later on. This makes it a bit easier to get things running.

You will also need the following files from the SitePlayer CD: 
'sitelinker.exe', 'sitelinker.py' and 
'sitelinkerdemo.html'.

These can be downloaded from the SitePlayer web site. You will also need the various jpeg image files.

I have included detailed step-by-step instructions, as the SitePlayer module manual can be a bit Spartan in places. It may also be useful to go through, or print, the various SitePlayer documentation files supplied as .pdf files.

Creating the control software

The stages involved are as follows:

1. Create a new directory "c:/SitePlayer" (or similar) in your PC. This is where all the program files are going to reside, copy all the above SitePlayer files here. Create a new directory "c:/SitePlayer/web".

2. Design a simple web page using a normal web or plain text editor. Start with something simple, you can always change it later. Feel free to add one or two simple images, but keep them small. If you are using a commercial web editor, remove any unnecessary HTML fields. Many web editors add many extra non-display fields, which are of no use here. Remember that you have a 4KB total limit.

Name your web file "index.htm", and place it in your "web" directory. Ensure all image files you use are also in this same directory.

3. Using a text editor, create a new file named "myproj.spd", place it in your base directory. This will be your Definition file. Copy the text from List 1 to it. If your files are in different directories, ensure the entry named SitePath points to the directory where you keep your web files, and that the other entries point at your base directory. Entry SiteLinkP defines the target IP address to be used for the download from the PC. This must be the same as your SitePlayer module; the default is 192.168.250 unless you have changed it. More on this later.

4. Run 'Sitelinker.exe'. Use the Menu option File/Open to select and open your definition file 'myproj.spd'. Nothing will be shown on the screen.

You have successfully connected to the Basement Web Server!

The door is OPEN
The temperature is degrees
The lights are OFF
The Heater is ON

<table>
<thead>
<tr>
<th>List 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Definition file. Please copy this file to your base directory and name it myproj.spd. Ensure that all paths point to the directories where you keep your own files.</td>
</tr>
<tr>
<td><code>Sample Myproj.spd Definitions file</code></td>
</tr>
<tr>
<td>Lines with a semicolon in first column are comments and ignored by the compiler</td>
</tr>
<tr>
<td>Compile this file with 'Sitelink.exe' which takes this file, and the contents of your web directory, and creates a new compiled file 'myproj.spd' which is then downloaded to the SitePlayer module.</td>
</tr>
</tbody>
</table>
| Sets the name or description of the device 
DeviceName = "Electronics World Demonstration heater controller" |
| Sets SitePlayer to find its IP address from a DHCP server 
If your PC is enabled to do so! SNMP on |
| Sets port for downloading web pages and firmware, don't need any to start with |
| Sets password for downloading web pages and firmware, don't need any to start with |
| Define SitePlayer's IP address to use if no DHCP server is available 
$InitialIP = 192.168.1.255 |
| Define the binary image compiled file name that will be created, enter the full path to $Sitefile 'C:\SitePlayer\myproj.spd' |
| Define the root path were your web pages are 
$SitePath = 'C:\SitePlayer\Web' |

Definitions for SitePlayer standalone direct port 1/0

1. We need these definitions so that they can be viewed with a *objectname replacement *in your web HTML files. They can also be input by making an object of the same name in a form |

4d) `org offs0h` `pl1` `ds 1` ; Port 1 all 8 bits |
400 heter `org offs1` `100` `ds 1` ; Port 1 Bit number 0 |
401 heter `ds 1` ; Port 1 Bit number 1 |
402 heter `ds 1` ; Port 1 Bit number 2 |
403 heter `ds 1` ; Port 1 Bit number 3 |
404 heter `ds 1` ; Port 1 Bit number 4 |
405 heter `ds 1` ; Port 1 Bit number 5 |
406 heter `ds 1` ; Port 1 Bit number 6 |
407 heter `ds 1` ; Port 1 Bit number 7 |
you got a result first time. The first problem you may encounter is compilation errors. These are mainly due to commands in the definition file not pointing at the right directories, so these should be easy to fix. There may also be entries in your HTML web page file that the compiler may not understand. Keep your HTML file simple to start with.

Your next problem will be addressing errors. It may be that your network is not able to access the SitePlayer default address for various reasons – usually subnet masking. One way around this is to change SitePlayer’s IP address to be accepted by the mask in your machine. In my case, the Ethernet address of my machine is 192.168.0.1, and the subnet mask is 255.255.255.0. When I first started using SitePlayer, I could not access it as it had a default address of 192.168.1.250. I had the choice of either changing my own subnet masking to something like 255.255.0.0 – easy to do, but not such a good idea if your PC is also used in other networks – or change SitePlayer’s own IP address to something like 192.168.0.2. You can change SitePlayer’s IP address using the supplied utility, ‘SitePlayerSendDemo.exe’. This program communicates with SitePlayer via the serial port, not via the Ethernet. You will need to add some extra hardware and voltage level conversion circuitry to connect the serial port in the module to the serial port in your PC. See the SitePlayer documentation for more information.

Alternatively, if your PC supports DHCP, it can assign an IP address to SitePlayer automatically. Ensure there is a DHCP on entry in your ‘myproj.spd’ descriptor file.

Adding scripting

Once you have your server operational, you can now add scripting facilities. Try the following steps to enable simple scripting and to allow the browser to read the I/O data pins on the microcontroller:

1. Open a text editor on your web file ‘Index.htm’.

   Somewhere near the bottom of the page, add the line
   <H3>BIT 5 OF PORT1 IS 1</H3>. The H3 is only there to make the text look bigger, ‘05’ is the variable denoting bit 5 of port. You can see that some of these variables have been pre-defined in the descriptor file ‘myproj.spd’.

2. Compile and download the newly generated ‘.jpg’ file to SitePlayer, by repeating items 4 and 5 in the previous section. The browser will now display the extra line of text ‘BIT 5 OF PORT1 IS 1’. Now press the switch connected to pin 5 in Fig. 4A – assuming you have wired one already. Next click on the ‘refresh’ button on your PC browser. The following line of text will now be displayed: ‘BIT 5 OF PORT 1 IS 1’. The web page reflects the change in the micro’s data port.

3. As an extended demonstration of the above, copy bitmap files ‘01.png’ and ‘1.png’ to your web directory. These files contain image bitmaps of seven-segment LED indicators. Now add the following line anywhere in your ‘Index.htm’ web file:

   <img src="01.png" width="40" height="60">
   <img src="1.png" width="40" height="60">

   Repeat step 4 above. The resulting display will now show a seven-segment bitmap choosing either ‘1’ or ‘0’ reflecting the data value on the port. The entry ‘05:15’ returns the first digit of the numeric variable as a single character which defines which of the two jpg files is to be displayed. A full list of commands available and more examples can be found in the SitePlayer manual.

4. The full port can also be read as one byte by using the variable ‘p1’ also defined in the definition file. Ensure that all the ten LED jpg files are in the web directory. Add the following text to our ‘Index.htm’ file:

   <img src="p1.png" width="40" height="60">
   <img src="p0.png" width="40" height="60">

   Recompile and reload as described above. The display will now show a three digit number reflecting the binary data pattern in port, changing from ‘000’ to ‘255’.

So much for reading data from SitePlayer. Sending data to it is a little bit more complex:

1. Create a new text file ‘myprojs.pi’ in the web directory. You may want three text lines in this file. You must ensure the third line contains no text, i.e. the file ends with two new lines.

   HTP/1: 0.302-302
   Location: TinyBox.hc
   <html-

2. Edit the ‘Index.htm’ web file. Add a new line:

   <H3>a href="myproj.pi?io6=Aio6-1">port</H3>

   The command ‘io6=01’ is used to read bit 6, invert it, and place it back (toggle). The reference to myproj.pi causes a link to what is basically another HTML file. This file does nothing but cause a link back to your index page, while at the same time updating the variable, including the I/O port bit on the micro.

3. Compile and download the file as already described. Run the browser and click on the port 6 link. See how the output of this pin toggles on every press using an oscilloscope, or connect a LED to it. Also note how the seven-segment displays change. This is because the full port is read/write.

The above is just a summary of what can be done. Many possibilities exist – especially when the basic software is used in conjunction with more powerful languages like JavaScript, and also when SitePlayer is used with the serial port option.

You don’t need to purchase the SitePlayer device to see all this in action. There is a free simulator for the PC available on the SitePlayer website that you can devise and test your own pages using this simulator.

To end with...

I wonder if the PC of the future is going to be nothing more than a sophisticated web browser, with all computing power done externally across the Internet, or within the peripheral units around it? It will be interesting to see what will happen to all the various operating systems. After all, every browser should work the same way. Maybe it will also mark the end of dedicated, platform-specific software.

Technology is fast catching up. New products such as Bluetooth will remove the need for running wires around the house. A few manufacturers are already working on combined Bluetooth/network appliance interfaces.

More information

See ‘PC Interfacing Via Ethernet’, Eddy Insam, Electronics World, May and June 2001 issues. These articles comprised a description and general introduction to TCP/IP in embedded systems.

Visit www.eix.co.uk/Ethernet for more detailed information on the above.

SitePlayer’s web site is www.SitePlayer.com. Demonstration programs can be downloaded from here.


List 2

A minimal sample web page. Copy this file to your web directory. Ensure that all the named image files are also present in the same directory.

<html>
<head>
    <html-podcolor=‘#CC0000’>
    </head>
    <body>
        <H1>You have successfully connected to the Basement Web server!</H1>
        <H3>BIT 6 OF PORT1 IS 1</H3>
        <H3>BIT 7 OF PORT1 IS 1</H3>
        <H3>BIT 6 OF PORT1 IS 1</H3>
        <H3>BIT 7 OF PORT1 IS 1</H3>
        <H3>BIT 6 OF PORT1 IS 1</H3>
        <H3>BIT 7 OF PORT1 IS 1</H3>
    <html>
</body>
Improving valved test gear

You can pick up valve-based surplus test equipment very cheaply, but the valves within will no doubt have deteriorated due to their age. Wim de Ruyter explains how to get round this problem.

Inspired by Dave Mien who produced a MOSFET-based 6V6 equivalent recently, I tried to synthesise a 6AL5G pentode. This will not work with one MOSFET alone. The mega-ohm impedances needed can only be achieved via cascode circuits, as they are in transistorised oscilloscopes. In the solution described here, the bottom element of the cascode is a ‘superfet’ circuit. It comprises a junction fet and a p-n-p bipolar transistor. The resulting transconductance is the reciprocal of the unbypassed source resistor. Any desired transconductance can be realised. The strong negative feedback action of this source resistor makes the input circuit ultra linear. When the unbypassed resistor is a metal film type, the long term stability is much better than could ever have been achieved using valves.

Adjusting the circuit to suit the valve
By selecting the right junction fet pinch off voltage, you can adapt the circuit to the valve it has to replace. The gate voltage of the mosfet is stabilised by a 12V zener as shown. With DC-coupled amplifiers this must be higher. A service manual for the instrument in question is indispensable. The maximum drain voltage of the BSS125 is 600V. Gate-source capacitance is 160pF, and the dissipation 1 watt. This will suffer in most oscilloscope amplifiers. Only the junction fet needs to be matched in balanced oscilloscope amplifiers. Often, stabilised power supplies use cathode-follower circuits. Here, the valve can be replaced by a mosfet without needing any peripheral components. Such circuits are always negative feedback loops. Of course an appropriately rated heat sink must be added in this case.

Often, the price difference between valves and semiconductors is small, but in many cases, valves cost considerably more. I have been unable to synthesise a pentode circuit in which the suppressor grid is essential. Also the remote cut-off pentode is still a problem. Fortunately such pentode circuits are seldom used in measuring equipment.

Implementing the idea
So far so good, but how do you connect the semiconductors and associated components to valve sockets? Very simple, when the circuit is mounted on an inverted valve socket. You can then use lengths of stainless-steel wire to plug the inverted socket into the original valve socket. Suitable stainless wire is available as welding rod. It is a millimetre in diameter. The length of the ‘double male’ connector pins is half an inch, in accordance with the accepted standard. A small circuit board can easily be fastened to the central tube of the valve socket by soldering. I used double-sided un-etched circuit board, with one side forming a screen between input and output. The bottom element of the cascode is mounted on one side, the top element on the other. Strip board may be easier to use, but you lose the screening properties of the double-sided board.

Remember that electrically contacting materials must maintain their connection integrity in humid conditions, so materials other than stainless steel are not advisable. Valve pins are of brass steel. This is an alloy of steel with 36 percent nickel and hence inherently stainless.

I would advise deburring, and perhaps rounding, the ends of the steel wire so as not to scrape any coating off the socket of the original equipment. You might consider trying solder-coated copper wire. It's very easy to tin this wire with the aid of plumber's flux, but remember to clean it thoroughly afterwards with meths or soapy water. Also, if you replace some valves in a piece of equipment with a lot of valves, it might be worth checking the effects of the reduced heater-winding load - Ed.
In applications like home cinema, numerous power amplifiers need to be packed together as compactly as possible. Do their output coils interact? And if so, does it matter? Doug Self investigates.

When designing a stereo power amplifier, the issue of interchannel crosstalk is always a concern. Now that amplifiers with up to seven channels for home theatre are becoming more common, the crosstalk issue is that much more important, if only because the amplifier channels are likely to be more closely packed.

But here I deal with only one important aspect of it. Almost all power amplifiers have output coils to stabilise them against capacitive reactances. A question often raised is whether inductive coupling between the two is likely to degrade crosstalk. It is sometimes suggested that the coils—which are usually in solenoid form, with length and diameter of the same order—should be mounted with their axes at right angles rather than parallel, to minimise coupling. But does this really work?

I think I'm pretty safe in saying there is no published work on this, so it was time to produce some. The magnetic coil coupling could not doubt be calculated—though not, without a good deal of work, by me—but as is so often true in the glorious pursuit of electronics, it was quicker to measure it.

The coils I used were both 14 turns of 1mm diameter copper wire, overall length 22mm and diameter 20mm. This has an inductance of about 2mH, and is pretty much an 'average' output coil. It is suitable for stabilising amplifiers of various kinds up to about 150W/8Ω. Above that, you might need to look at the wire diameter.

Different coils will naturally give somewhat different results, but extrapolation to whatever component you are using should be straightforward; for example, twice the turns on both coils means four times the coupling. Coil diameter should be considered, and so on.

Figure 1 shows the situation in a stereo power amplifier. The field radiated due to the current in Coil A is picked up by Coil B and a crosstalk voltage is added to the output signal at B.

Figure 2 shows the experimental setup. Coil A is driven from a signal generator with a source impedance of 50Ω, set to 5V rms. Virtually all of this is dropped across the source resistance, so Coil A is effectively

---

**Figure 1a.** Magnetic coupling of output coils in a stereo power amplifier, a), and the experimental circuit for coaxial coils, b). The 'transmitting' coil A is driven with an effectively constant current, and the voltage across the 'receiving' coil B measured.

**Figure 1b.** Typical crosstalk voltage.
driven with a constant current of 100mA rms. Figure 3 shows the first result, taken with the coils co-axial and their ends touching. This proved, as expected, to be the worst case for coupling. The crosstalk rises at 6dB/octave, because the voltage induced in Coil B is proportional to the rate of change of flux, and the magnitude of peak flux is fixed. Capacitive crosstalk can be neglected because of the very low impedance of the receiving circuit. The 6dB/octave rise shows that this is clearly not the same as conventional transformer action, where the frequency response is essentially flat. In a transformer, the primary inductance is much greater than the circuit series impedance. As a result, the magnetic flux that couples with the secondary halves when the input frequency doubles. The voltage induced in the secondary remains the same.

The worst-case crosstalk – co-axial coils touching – at 20kHz was taken as the 0dB reference, referred to as CAL on the plots. This represented 2.4mV rms induced across Coil B. Now 100mA rms of current flowing in Coil A corresponds to 800mV rms across its associated R load, so this gives a total crosstalk figure from channel to channel of ~54dB at 20kHz in the worst case. Crosstalk curves on deteriorating above 20kHz but no-one can hear it, so I for one don’t care. All crosstalk figures given below are at 20kHz. I do appreciate that the ear is a good deal more sensitive at 1kHz, but given the 20kHz figure, the crosstalk can be worked out for any desired frequency using the 6dB/octave characteristic.

The load resistance of the receiving – i.e., crosstalk to – channel has very little effect as the voltage induced in the coil is at a very low impedance indeed. It is essentially the impedance of the coil. I then separated the coils by 10mm at a time. With each increment, the crosstalk dropped by 10dB, as you can see from Fig. 3. At 110mm spacing, which is quite practical for most amplifier designs, the crosstalk had fallen by 47dB from the reference case, giving an overall crosstalk of 54 47 = 101dB total. This is a very low level, and only occurs at the very top of the audio band.

At 1kHz, where the ear is much more sensitive, the crosstalk will be some 25dB less. This brings it down to ~160dB total, which I can say with some confidence is not going to be a problem. This is obtained with what looks like the least favourable orientation of coils. Coil-to-coil coupling is ~32dB at 50mm, and the figure at this spacing will be used to compare the configurations.

The next configuration tested was that of Fig. 4. Here, the coils have parallel axes but are displaced to the side. The results are in Fig. 5; the crosstalk is now ~38dB at 50mm. With each 10mm spacing increment the crosstalk dropped by 7dB. This setup is worse than the crossed-axis version but better than the coaxial one.

The final configurations had the axes of the coils at 90°, the crossed-axis condition. The base position is with the corners of the coils touching. Figure 6. When the coil is the mid position, still touching, crosstalk almost vanishes as there is a cancellation null. With the coils so close, this is a very sharp null and exploding it in quantity production is quite impractical. The slightest deformation of either coil ruins the effect.

Moving Coil A away from B again gives the results in Fig. 7. The crosstalk is now ~43dB at 50mm, only an improvement of 1dB over the crossed case: turning coils around is clearly not as effective as you might suppose. This time, with each 10mm spacing increment the crosstalk dropped by 8dB rather than 10dB.

The obvious next step is to try combining distance with cancellation. 2mm error has worsened crosstalk by 20dB at 20kHz. Obviously in practice the coil PCB mounting hole won’t move – but it is very possible that coils will be bent slightly sideways in production.

Figure 10 gives the same results for a 50mm spacing, which can usually managed in a stereo design. The null position once more just gives the noise floor across the band, and a 2mm misalignment now only worsens things by about 5dB. This is definitely the best arrangement if the spacing is limited.

When there are coupling problems, there is always screening as a possibility. Pieces of metal cost money, so this should be a last resort, not least because they appear to be relatively ineffective. Metal screens are 100% effective at eliminating capacitive crosstalk, but the situation with magnetic coupling is very different. I spent some time doing informal experiments with bits of steel and aluminium, and they proved relatively ineffective, improving things by only a few decibels.

In summary
Coil orientation can indeed help, but only if applied intelligently. Simply turning one coil through ninety degrees gives an improvement of only 1dB. If it is carefully aligned to cancel out the coupling though, there

---

**Fig. 2. Physical coil configuration for the measurement of co-axial coils.**

**Fig. 3. Crosstalk versus spacing for co-axial coils.**

**Fig. 4. Coil configuration for non-co-axial parallel-axis coils**

**Fig. 5. Crosstalk versus spacing for parallel-axis coils.**

**Fig. 6. Coax configuration for crossed-axis measurements.**

**Fig. 7. Crosstalk versus spacing for crossed-axis coils.**

**Fig. 8. Coax configuration for crossed-axis with cancellation.**
is a big improvement; see how -36dB in Fig. 5 becomes -61dB in Fig. 10 at 20kHz. The alignment needs to be accurate to plus or minus half a millimetre, but this should be no problem with normal PCB layout techniques.

On a typical stereo amplifier PCB, the output coils are likely to be parallel—probably just for the sake of appearance. However, their spacing is unlikely to be less than 50mm unless the output components have been deliberately grouped together for some reason—and I can't think of a good one. As with capacitive crosstalk, physical distance is cheaper than anything else, and if the results are not good enough, use more of it. In this case the overall crosstalk at 20kHz will be 54.38-92dB total, which is probably already well below other forms of interchannel crosstalk. A quick turn-of-the-cd improves this to at least -114dB at 20kHz. At 1kHz it will be even lower. It should do.

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<tr>
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<td>Vinivv.ralfe-electronics.co.uk</td>
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<tr>
<td>T20</td>
<td>30880 data acquisition unit, memory options (£2600)</td>
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HISTORY

Morse Code
the first communications revolution

Ian Poole looks at communications technology from the days before wireless was capable of carrying voice - Morse code.

Today, the internet and mobile phones are looked upon as being a telecommunications revolution. New generations of mobile phone are about to hit the market, and the internet has become an accepted part of everyday life. But over a hundred years ago an equally important communications revolution took place with the introduction of the Morse telegraph system. This linked towns and cities that had previously relied on messages carried by riders on horseback. Even countries and continents were linked by this new technology changing society for ever.

An unlikely person

The inventor of the new system was a most unlikely person. Although the name of Morse is well known, few people realize that he was an artist of some renown — in fact today he is judged to be one of the finest artists to come from North America.

Born in 1791 to Jedidiah Morse, a distinguished geographer and preacher, Samuel Findley Breeze Morse was an indifferent scholar, although he took an interest in the lectures on electricity and he enjoyed painting. Finally he managed to graduate from Yale in 1810 after which he became a clerk in a book publisher in Boston Massachusetts. However he was unhappy in this career and he became an itinerant artist. His portraits are judged to be some of the finest ever painted by a North American artist.

To improve his style Morse made some trips to Europe and in particular to England. On returning from one trip in 1832, shortly after the electromagnet had been discovered, he entered several conversations about electricity and communications with fellow passengers. Out of this exchange of ideas, a telegraph system began to develop.

The first telegraph system

It took some time for Morse to develop his system because most of his time was taken with his painting. However, to speed progress, he enlisted the help of others, including a man named Alfred Vail who was a gifted mechanic. Progress became much faster and a system using dots and dashes to represent letters was developed by 1838.

The next stage was to secure funding for a trial system, but this proved to be very difficult. Undeterred by the lack of interest, Morse continued with most of his other projects, finally securing funding for a 65km line between Washington and Baltimore.

Accordingly, on 24 May 1844 Morse sent the first message, “What hath God wrought!” The content of this message was chosen from the Bible (Numbers Chapter 23, verse 23) by Annie Elsworth, the young daughter of a good friend.

With the successful opening of the first line, people and organisations quickly saw the benefit it could bring. Accordingly its use spread very rapidly. Within a year many new companies came into being to run lines to all parts of America.

New lines were installed, often alongside railroad tracks. Towns that were previously isolated now had communications links with the outside world. Previously communications relied on stagecoaches or the Pony Express, requiring days or weeks to cross the whole of the USA. In fact so successful was the Morse telegraph that only 19 months after the Pony Express was started it had to be discontinued.

Not only was the Morse system used in the USA: Europe and the rest of the world used it because of its effectiveness and simplicity. The first European line was set up between Hamburg and Cuxhaven in 1847, and many others quickly followed suit.

Soon the need to link countries across seas and oceans was realised and in 1866 a submarine cable link was established between Britain and the USA, and by 1871 a link to Australia was established.

As a result of the vast use the telegraph, stations were set up in towns, and in many remote areas repeater stations were required. Often, new towns arose as a result of these. One famous example is Alice Springs in the Middle of Australia. A line was required from Adelaide in the South to Darwin in the North from where messages could be sent to London and a repeater was needed in the middle of the desert. Alice Springs was chosen because of its location near a suitable pass in the McDonnell range of mountains.

Morse keys

Since the very first keys were produced an enormous variety have been manufactured. The first key used by Vail when he was preparing for the telegraph demonstrations in 1844 was very simple device, as you can see from the diagram. However it suffered from many problems.

Further developments were made, but around 1848 a key known as the 'camelback' was introduced. A spring was added into the same style was retained for many years.

Key styles changed and straight levers became more common. In the US, James H Bunnell patented what he called a 'steel lever key', which first appeared in 1881. Keys like this were used for very many years and can still be bought today. In the UK though, keys tended to be much heavier like the ones used by the Post Office.

Fig. 2. Circuit diagram of the transmitter used for the transatlantic transmission

As time went on, electronics technology progressed and eventually fully automatic keyers capable of sending dots and dashes were designed. The first ones used valves designed to take place. With many operators spending many hours operating, many suffered from a complaint known as 'glass arm' or 'telegraphers paralysis'. To overcome this, people started to investigate the possibility of mechanical semi-automatic keys. The first successful variety was known as the Vibroplex.

By pressing the 'paddle' to the right, a series of dots were made.

Dashes were made manually by pressing the paddle to the left. This greatly reduced the level of movement required to send Morse Code and successfully reduced the occurrence of glass arm.

As time went on, electronics technology progressed and eventually fully automatic keyers capable of sending dots and dashes were designed. The first ones used valves

A steel lever key. This particular example was manufactured in the USA around 1920.

A key used by the British Post Office. Note the heavy brass construction. This key was manufactured around 1900.
and were introduced around the early 1940s, although the introduction of transistors and then integrated circuits enabled them to be built more easily as well as allowing greater amounts of flexibility. Now it is possible to use computers to generate and read Morse. However most people still enjoy using a key to send Morse. Besides, computers are not as adept as the human mind at receiving Morse — especially when there is any interference.

Famous times
In its life, the Morse code has been used to carry many historic messages. It was used to carry information about the end of the American Civil War. After General Grant accepted the surrender of General Lee on 9 April 1865, he sent the message: "General Lee surrendered the army of Northern Virginia this afternoon on terms proposed by myself the accompanying additional correspondence will show the conditions fully".

The Morse code was widely used for wireless transmissions, especially in the very early days when it was not easy to modulate a signal to carry sound. As a result many historic transmissions were made using Morse code. One was the first transatlantic radio transmission made by Marconi in 1901.

Transmitting across the Atlantic
Marconi had been developing his wireless system for several years and had been installing his equipment on ships. For them to be of particular use they needed to be able to communicate over large distances.

Marconi felt that it would be possible to send signals across the Atlantic and accordingly he set about proving whether this was possible. He set up two stations, one at Poldhu in Cornwall, and the other in Newfoundland. The Poldhu station sent out the letter "L". This letter was chosen for two reasons. The first was that it was easy to recognise. The second was probably more important: the transmitter was a very new design and it could not be trusted to transmit dashes without the risk of a breakdown. Finally on 12 December 1901, Marconi was convinced that he could hear the weak set of dots through the static. Later he was able to send messages across the Atlantic using the system, and created headline news on both sides of the Atlantic.

Distress signals
Another incident of major importance occurred in 1912 during the maiden voyage of the Titanic. In order to cut the time of the crossing the liner steered a northerly course to shorten the distance travelled. Unfortunately she struck an iceberg on the night of 14 April and although she had been described unsinkable, the great liner took on water and slipped to the bottom of the seabed. The two wireless officers, Jack Phillips and Harold Bride stayed at their posts until the last moments of the ship. Sending out the distress signals CQD and SOS. CQD was the recognised maritime distress signal, and SOS was due to replace it.

The distress signals were heard on both sides of the Atlantic as well as by the SS Carpathia that was about 93km away. As a result Carpathia steamed towards the stricken liner only to reach it an hour and twenty minutes after it sank to rescue some 700 survivors. Nevertheless over 1500 people died in the tragedy.

Finale
With new and more sophisticated forms of communication now available, the use of Morse has declined considerably in recent years. Many years ago the use of radio began the decline of landline Morse systems. This was compounded by the introduction of the teleprinter that used a keyboard to enter messages and provided a printed copy at the far end. In Britain the Post Office discontinued the use of landline Morse in 1932, although its use continued until the 1960s in both the USA and Australia.

The use of Morse continued for many years after this particularly for ships, although teleprinters and then computers combined with the growing use of satellite communications spelled the end. Finally from midnight on 31 January 1999, international regulations no longer required ships at sea to be able to make distress calls in Morse. Despite this some ships — especially those from the third world — still use it as a low cost alternative to the more expensive satellite systems. Radio amateurs still use it widely because it offers advantages in terms of the simplicity of the equipment and being able to make contact under conditions where other forms of communication would not be able to get through. As a result it will continue for many years to come, continuing a tradition that is over 150 years old.

\[ \text{B. P.} \quad \text{E. C.} \quad \text{G. H.} \quad \text{A. K.} \quad \text{L. M.} \quad \text{N. O.} \quad \text{P. R.} \quad \text{S. T.} \quad \text{U. V.} \quad \text{W. X.} \quad \text{Y. Z.} \]

![Fig. 3. The Oner—circuit diagram of a simple low-power Morse transmitter that can occupy less than an inch cubed. It can be built in an evening yet is still capable of providing contacts over distances of several thousand miles. This circuit is reproduced with kind permission from George Burt GM0XX.](image)
Many refrigerators still use rudimentary electromechanical control systems. But with microcontroller alternatives becoming so cheap, and energy consumption becoming such an important issue, the arguments for resisting change are weakening. Here, William Mackay of Motorola explains the benefits of using a low-cost microcontroller.

The digital fridge

As most of today's domestic appliances are high technology, there are many opportunities to replace dated mechanical parts, improve and standardise inflexible manufacturing methods and develop economic appliance control using a microcontroller solution.

Complemented with new flash technology, the MC68HC08 microcontroller family provides a convenient development environment and manufacturing flexibility for low-cost appliance embedded solutions. This article discusses a low cost solution for a domestic refrigeration appliance.

Compressor control

Basic conventional fridge control typically uses a bi-metallic thermostat to control the fridge temperature. The thermostat simply applies power to the compressor based on a coarse mechanical temperature setting. This method has been used in the past for some time and is now rapidly becoming dated, due mainly to the increasing demand for more efficient control of the appliance and for an increase in the number of functions that the appliance can perform.

Temperature is more accurately controlled using negative temperature-coefficient thermistors – NTCs for short – with the microcontroller analogue-to-digital converter module. Figure 1 shows conventional compressor control and a microcontroller solution.

In contrast to conventional compressor control, a more efficient and long-term cost-effective solution can be implemented using the microcontroller to control the compressor motor using a triac and a relay. The PTC thermistor connected in series with the start winding is no longer required and the sequence of events required to start the induction motor is now under software control.

The relay is energised and closes the contact to apply line voltage to the start and run windings simultaneously. The triac is fired on the first zero-crossing point of the line voltage, and every successive zero-cross detected for a period of approximately 40ms. In normal operation, after this time the compressor will have started and the triac will be in the non-conducting state until another start sequence is invoked. The compressor remains powered and running while the relay remains energised. When the PTC thermistor out of the circuit, considerable cost and a few watts of power can be saved.

Refrigeration system

An MC68HC08KX8 microcontroller forms the heart of the refrigerator system, providing an adaptable platform for a range of functions suitable for low to high-end appliances.

Using the microcontroller in a refrigeration appliance can provide various possibilities for developing improved operational efficiency and versatility. As the system is under software control there is better scope for improving system efficiency with more accurate electronic temperature measurement and compressor control. This is complemented by additional functionality provided from the device feature set. A schematic of a typical implementation is shown in Fig. 2.

Functional overview

The temperature of the system is primarily dependent on inputs from two NTC thermistors, and a potentiometer. One thermistor detects the fridge ambient air temperature and the other detects the evaporator temperature. The potentiometer is used to select the desired ambient air temperature of the fridge.

Other application features included are an audible alarm, used to alert the user of a 'door-open' condition or over and undershoot.
temperature conditions. A door switch determines the status of the door as either open or closed. There are three system status LEDs: one indicates power on, another indicates when the compression is powered, and the third LED is a visual indication of a 'door open,' 'over temperature,' or 'under temperature' alarm condition.

Stall and rotation detection
Compressor motors in today's refrigeration appliances are thermally protected by a bimetallic contact embedded in the motor windings. This contact is in series with the AC line supply to the motor and will open and remove power to the motor when overheating occurs. This can be caused by various sources, for example, by electrical start-up failure that can result in a motor stalls.

If the motor is stalled, overheating occurs fairly rapidly and may cause permanent damage to the motor. Mechanical failure of the compressor pump is another potential problem source. This may impair the rotation of the motor and again result in a stall condition.

Detection of a motor stall condition can be achieved efficiently and economically using the input capture features of the device. This has the added advantage of monitoring the rotation of the motor during the normal run condition, Fig. 3.

After start-up and during normal running conditions, the continuous rotational motion of the motor and magnetic field induces a voltage in the now redundant start winding. In this condition there is a measurable phase difference between the start and run windings.

If the motor is not rotating, that is, stalled, then there is no measurable phase difference between the start and run windings. This is illustrated in Fig. 4a) and 4b).

The zero-cross detect circuit conditions the above waveforms into usable digital signals forming a series of pulses switched between OV and VDD at half the period of the AC line frequency. In this case, that's every 10ms.

Digital signals derived from the zero-crossing points of the run and start windings are conveyed to the microcontroller input capture pins. A sample of the waveforms applied to the input capture pins is shown in Fig. 4c).

In summary
The refrigerator is an appliance that in the past was controlled primarily by mechanical parts. It provided the user with little controllability and no operational information.

Today's consumers are demanding better efficiency and more intelligent appliances. Using the HC08KX8 flash microcontroller, the system design can benefit from a flexible development life cycle.

Using a microcontroller can also provide attractive appliance features, and from a manufacturing point of view, a range of appliances can be accommodated using the microcontroller as a standard hardware platform.

Printed circuit boards can be standardised for anything from low end to high-end appliances, and application software versions can be implemented with ease using the programmability and re-programmability of the 8K flash. This minimises development time and reduces manufacturing costs while improving time-to-market.

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Faraday’s homopolar generator

The homopolar generator was discovered 170 years ago, yet no theory is available to give a convincing explanation of the results of the experiments described here, argues Dom Di Mario. You can replicate these experiments with magnets and a few pieces of copper.

It is unlikely that you will find the description of the Faraday homopolar generator in any university textbook on electromagnetism. The closest you will come across is the plain homopolar generator. The fundamental difference between the two adaptations of the homopolar generator is that in Faraday’s device, the magnet generating the field moves or rotates together with the conductor in which the voltage is supposed to be generated.

Faraday first reported its operation in 1833. Figure 1 shows a practical implementation of the discovery. A ring magnet together with a copper disc that is three or four times the diameter of the magnet are involved.

The disc is glued to the magnet and the combination is rotated while the voltage is measured between two sliding contacts. One contact is placed at the centre of the assembly, the other allowed to slide from the centre up to the edge of the copper disc.

The maximum reading takes place when contact A is at, or just beyond, the radius of the magnet. Actually, you will read almost the same voltage regardless of whether the contacts are between the centre and the radius of the magnet or between the radius of the magnet and the outer edge of the disc. Obviously the first solution is a more practicable implementation.

As a generator, this set-up seems to have only drawbacks: the output voltage is generally rather low, just more than 2mV with my set up using a 4V DC electric motor rotating between 20 and 40revs and a ring magnet of 36mm diameter. Other experimenters have reached hundreds of millivolts or more with powerful magnets and motors.

This is a DC machine. The presence of sliding contacts introduces a voltage drop that could make the generator totally useless, given the high current that it takes.

Yet, there are some rather puzzling aspects concerning this generator: as the magnet is moving together with the copper disc, you would expect that no voltage would be generated. In fact, the voltage is definitely there. It is the same as you would have with a stationary magnet and a rotating disc.

With a stationary magnet, the voltage can be explained using existing laws of induction. It is also possible to imagine that when the disc and the magnet rotate together, a voltage is generated in the wire connected to the brush; this happens regardless of its orientation, its size, whether it is reduced to a needle – even with the wire magnetically shielded, except for the contact point.

However, the real issue surfaces when you consider the set-up’s operation as an electric motor: you should expect to see rotation of the disc/magnet combination after a certain voltage is applied across the sliding contacts. From a practical point of view, it will be quite difficult to send, say, hundreds of amps through the sliding contacts, but it is the theoretical implication that remains without a proper answer: against what is the magnet/moving?

The only solid material available is the sliding contacts, but the direction of the current is such that the disc appears to exert no force on them for a certain orientation, or if they are shielded. Are the disc and magnet moving without a counter force?

Conversely, if you use the device as a generator and apply a load, you are unable to see where the back-torque is exerted. The generator seems to generate electricity without a corresponding input loading, except for friction losses.

Because of the implications, you would expect a rush of experiments, but there is little activity in this area. Most contributions towards the implementation of a Faraday homopolar generator came from a series of experiments carried out by the late Bruce dePalma with his N-machine.

Despite the fact that the device showed no apparent increase of input power when a load was applied, there was no further development. This was probably because the results were not so clear cut and certain assumptions had to be made in order to compute the power losses.

Also Stefan Marinov[1] has been busy with the theory and construction of machines based on the same principle: his Modrlo and Soviet Collo motors were two ingenious implementations, but he was largely ignored by his fellow academics.

Contributions also came from P. Tewari with his 'Drive space generator’[2] and L. Menchera[3] who tried to demonstrate that the magnetic field should be considered stationary outside a magnet even when, in motion, an hypothesis put forward by Faraday himself.

A basic experiment

From an experimental point of view, there are other configurations that should be explored, with the hope of finding a clue that will provide a better understanding of the underlying mechanism.

If you use a common cylindrical metal magnet, you can dispense with the copper disc. There is a voltage between either of the magnetic poles and the centre point of the magnet. The exact position and shape of sliding contact B at the magnetic pole is not critical, although you get a higher voltage when the contact is placed off axis or right on the edge.

The voltage will decrease if contact A is moved away from its centre position between the poles until you will have no voltage when the contact reaches either end of the magnet. The maximum reading was 4mV using the same electric motor as in the previous experiment, with a magnet 20mm long and 15mm diameter.

With this configuration, you could make the same assumptions about counter torque as you would for an electric motor, but doing so would yield the same set of unanswered questions. The major difficulty in generating a usable amount of energy is to have a very low resistance for the sliding contacts.

Resistance of the contacts must be close to zero. If it isn’t, the voltage drop across the contacts could easily be equal to the generated voltage, leaving nothing to drive an external load. This can be achieved only with the use of sliding contacts lubricated with mercury, as in the N-machine.

Even with the contacts lubricated in this way, the resistance of mercury could be too high if there is too much of it. This means that the brushes, or whatever mechanical solution is devised, must be machined with very close tolerances.

An interesting consequence of this experiment is that the Earth, a rotating magnet, should have similar properties.

Fig. 2. The easiest way to verify Faraday’s discovery is with a plain metal magnet. Its rotation will generate a voltage between either end and the centre of the magnet. Maybe the Earth behaves in the same manner.

Fig. 3. At least double the voltage is available if two magnets are assembled with like poles facing each other. The distance between the poles is critical and some adjustment is necessary to find the best positioning.

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October 2001 ELECTRONICS WORLD
Two ring magnets of the same type used in the first experiment were assembled so that like magnetic poles face each other. The distance was about 20mm and a copper sleeve was placed in such a way as to slightly overlap the like poles of the two magnets.

Voltage output was taken right at the edge of the sleeve as shown in Fig. 3. Using this setup you will measure twice the voltage that you measured before. The additional benefit of this solution is that both sliding contacts are mechanically the same: this could be an advantage from a mechanical point of view as there is no need to connect electrically

to a centre point.

In all the above experiments, I observed no decrease or variation of the voltage in spite of the magnetic screening. This screening comprised a 1mm thick tubing, which was applied to the wires connecting the brushes.

In order to avoid eddy currents, the brushes were reduced in size until they were of two needles. Doing this resulted in no change in the output voltage.

An AC generator

The fact that the Parady homopolar generator is a DC machine is an inconvenience that limits its flexibility. Figure 4, is a suggestion of a machine generating an alternating current.

A square magnet, with north and south poles on the sides, is rotated and the voltage is taken with the collector brushes placed at the edge of the disc. If one of the brushes is placed in the centre you will have half the voltage. One major problem with this generator is that there is also an induced voltage on the collector wires. This means that if you want to measure the homopolar voltage, you should try to get rid of the induced voltage.

I found getting rid of the induced voltage rather difficult. Screening the collector wires with ferrite tubing helped, but it didn’t solve the problem fully. I was not able to totally eliminate the induced signal that was interfering with the signal generated with the homopolar effect.

There seems to be a 90° phase difference between the two signals but further investigations proved difficult due to the low level of the signal and the precarious mechanical set up I was using.

I tried a variation of the above AC generator using the rotor of a bicycle dynamo with an eight-pole magnet. Its outer circumference was covered with a layer of copper. The brushes were placed at an angle of 45°, or odd multiples of one, from the other, this is the same angle as one magnetic pole relative to the other.

The unwanted signal from the induced voltage is even more difficult to control with this arrangement. Careful magnetic screening and positioning of the collector wires was necessary in order to detect the homopolar voltage.

As expected, the output voltage depends on the speed of the rotor and the intensity of the magnetic field. What was not expected was the fact that the largest voltage is present when one of the brushes is placed where the magnetic field is most inhomogeneous while the other brush is located where the field is mostly homogeneous or absent.

A special case is the machine of Fig. 3, where both brushes are placed within an inhomogeneous field but they both refer to a zero potential, which is a point in the middle between the two brushes. Actually I found that there is an ideal distance between the magnets of Fig. 3 where the voltage is at its highest. It is likely that the magnetic lines are more or less deformed, hence the resulting field is more or less homogeneous.

A non-uniform field is necessary

The results of all the above experiments seem to obey the law whereby a conductor generates a voltage across it when it moves in a non-uniform magnetic field, Fig. 5b.

I repeated the basic Parady experiment, Fig. 5b, but this time with one cylindrical magnet providing a magnetic field that does not extend over the whole disc. Note that two magnets are shown in order to have a mechanically balanced system.

The sliding contact is next to the magnet. Rotation of the disc will give the same voltage as in Fig. 1. Rotation of the disc and the magnets however does not give the same voltage but a pushing unidirectional voltage—once you manage to remove the induced signal.

It is now the wire connected to the sliding contact that is immersed in a non-uniform magnetic field that generates the homopolar voltage.

The original Parady experiment, Fig. 1, with the disc and the magnet moving together, is a very special case. It could lead you to think that is it the sliding contact that is actually moving in an inhomogeneous magnetic field and becomes the source of a continuous voltage, because the field is always present.

In Fig. 5b you could move the conductor and the magnet originating the field together, but you would still have a DC voltage. This is the same as having a stationary conductor/magnet and the sliding contacts moving in a non-uniform magnetic field.

It is now clear where the voltage is generated. Any magnetic shielding of the wire will still preserve the non-uniformity at the contact point, so it will make no difference. Surely it will make a difference when the mechanical forces acting on the various parts are considered! But as yet we have no satisfactory answers. Further experimentation is necessary.

The Parady homopolar generator could be a useful alternative to generators currently in use. However, any serious implementation would require superconducting magnets and specially designed brushes. Until then, the machine is bound to remain a laboratory curiosity or, possibly, something to be totally ignored because of its apparently inexplicable features.

References

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Quasar has launched the first miniature FM radio transmitter and receiver modules to offer communication rates of 128kbps at distances of up to 400m. The new QPM53-434 transmitter and QPMR5-434 receiver modules simplify the implementation and reduce the component count of one-to-one and multi-node wireless links and provide 'drop-in' replacement of lower speed modules. Applications include building security and car alarms, remote industrial process monitoring, computer networking and electric gate operators, with small size and low power consumption making the modules ideal for battery-powered, portable designs. Supplied in a fully shielded miniature SMD package, the QPM53-434 transmitter features no adjustable components, offers high resistance to shock and vibration and delivers a temperature-compensated RF output from -20°C to 55°C. The QPMR5-434 high-sensitivity receiver is based on a single conversion FM Super-heterodyne design with double-RF filtering that includes a SAW front end for maximum sensitivity. Analogue and digital outputs allow for direct connection to a microprocessor or additional processing circuitry, while a received signal strength indicator (RSSI) provides a DC output voltage that is proportional to the RF input signal.
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Oscilloscope sends e-mail
Yokogawa’s DL1740 SignalExplorer is a compact 4-channel digital oscilloscope combining a sample rate of 12GS/s, an analogue bandwidth of 500MHz and a memory length of 1Mword. Despite its high-range performance, the instrument is small enough to occupy an A size footprint on a test bench and weighs only 5.3kg.
A 500MHz bandwidth is achieved via a dedicated single-chip input amplifier. The fast screen update rate of 30 times a second – even at 1Mword record length – results from using a dedicated high-speed data-processor set known as the Data Stream Engine. The combined effect of these new circuits is a reduction in component count, very low power consumption and minimal heat sink requirements.
The DL1740 uses a 6-4-inch TFT display. The repetition frequency of waveform data can be determined by using brightness, thus emulating analogue oscilloscopes. The instrument is equipped with USB compliant interface as standard, allowing keyboards and USB printers to be connected. The ability to use a keyboard has improved the instrument’s ease of use and screen images from the colour display can be easily output to a colour printer. The Waveform Viewer software provided allows the user to exchange waveform data and screen images between the oscilloscope and a PC.
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DC voltages from 3 to 170V in chip sizes from 0603 to 2220 with maximum single-pulse (30/300µs) surge currents up to 1200 A; the ZVEI Series for ESD protection applications. Offering a number of contacts from 2 to 8, 12 and 14, the connectors feature a metal threaded or bayonet coupling and offer complete EMI shielding in the fully mated and locked position. TTI: Tel: 01494 460000

One piece and high density interfaces
Samtec has introduced the FSI and SFI one-piece MSB and CSB high density interfaces. The one-piece interfaces are on 1mm pitch with up to 100 contacts and a mated board spacing of 3mm (FSI) or up to 30 contacts for a mated board spaced of 1.5mm (SFI). These interfaces have phosphor bronze contacts and are for MCM interfaces, high shock and vibration applications. The high density interfaces have up to 500 contacts on 1.27mm pitch with profiles down to 3mm between mating boards. Tiger-eye hermaphrodite copper contacts are used. Solderable attachments are available. Samtec: Tel: 01253 738292 www.samtec.com

Computing platform for customised and embedded systems
Sun Microsystems has announced a processor board to complement the Netra family of servers. The Netra AX110-500 PCI board hosts embeds the Ultraspars 11e processor and the Solaris operating environment into applications with a traditional server cannot be used due to environmental or space requirements. The board is for commercial and industrial products and systems. It supports telecoms, aerospace, medical imaging and banking applications. It deploys a 1MHz performance in a profile that can support 1U, 2U or ATX chassis designs. The motherboard is a standard ATX form factor board, powered by the 64-bit Ultraspars 11e processor. The board also supports Wind River’s real time OS VxWorks for embedded systems. Sun Microsystems: Tel: 0276 416379 www.sun.com

Audio analysing DMM
Keithley Instruments has announced the Model 2015-P audio quality testing in telecoms applications in the 300 to 40GHz high dielectric constant materials. It can characterise a signal spectrum without a separate computer or analysis software, can report frequency and amplitude of the highest value within a specified frequency band, and can identify additional peaks in descending order of magnitude. A peak frequency is identified, it can give the magnitude and frequency maximum components above and below the peak value. If desired, the instrument can also report the magnitude of a specified set of frequency components or determine the difference in amplitude between two spectral components. Audio measurements include total harmonic distortion, THD, noise, signal-to-noise plus distortion and frequency spectrum analyser. Filter types include CTCT weighted, CMA, weighted, CCIR and CCR audio shaping. Selectable high and low-pass filters can be combined to form a band-pass filter. It also provides a dual output 20Hz to 20kHz sine wave generator. The second inverts the output for testing different input circuits for common mode or noise cancellation, or it can be used as a pulse train for synchronisation of other instruments with the model’s source output. Keithley Instruments: Tel: 01429 889750 www.keithley.com

ADSL line-driver hybrid
Advanex’s Data Line Components (APC) has released an ADSL line interface hybrid component for high-density and CDI line card applications. Developed specifically for use with Alcatel Microelectronics’ 2405 Quad ADSL Central Office chipset, APC78147 is a dual channel device containing all of the analogue components required between the AFE chip line driver and the line connective. The device is suitable for use with both voice and data or data and voice and permits a significant reduction in the per square inch PCB area required per port, increasing the number of channels possible per socket performance has been validated across the full industrial temperature range from -40 to +85°C. ESD suppression is now available for sampling from April 2001. APC: Tel: 01634 290588 www.apc-pc.co.uk

Quartz device for UMTS and CDMA
Epson has introduced the TG-2820C temperature compensated crystal oscillator for CDMA and UMTS applications. Frequency stability is ±5 x 10^-6 over a temperature range of ±30°C to +80°C. Available in frequencies between 12 and 19 MHz, it has 1.5mA maximum consumption at a supply level of 2.8V. Footprint is 3.2 by 2.5mm and height 1.5mm. It comes in an SMD ceramic package. Epson Electronic Devices: Tel: 0049 089 14000277 www.epson-electronics.de

Pan and tilt surveillance camera kit
A range of mini dome cameras with automatic pan and tilt are available from Stech Electronics. The PTZ range of surveillance cameras comes in a variety of camera options and is ideal for internal use such as retail store monitoring or where close commercial surveillance might be required. Once installed, the controller enables a full 360° panning action and a 90° tilt from the horizontal. Stech Electronics: Tel: 01297 419913

Power supplies for embedded systems
Diamond Systems has introduced two Jupiter-MM dc-to-dc power supply modules for PCI/104 embedded systems in air and ground vehicle applications. The supplies accept input voltages from 8 to 30V DC, making them suitable for 12 and 24V systems. Output power is provided directly onto the PCI bus connectors, as well as on an auxiliary jumper for external tapping. The MM-LP-XT has a 45 output and maximum power output of 25W. The MM-SO-XT has ±5 and ±12V outputs plus ±5V. Maximum output power is 50W. This version has up to 10A that can be provided on the ±5V or ±12V or the total power of the power can be distributed across the four outputs. The board is jumper configurable to support RS232, RS422 and RS485. Efficiency is 92% peak. Diamond Systems: Tel: 0151 581 486700 www.diamondsystems.com

Quad LVDS line driver with flow-through pin connection
The ADV-Q5200G has a short-circuit function to protect sensitive equipment, such as modems, telecoms and measurement instruments, from high current loads. When the load exceed current specifications, it goes into an open state and cuts off the input current within 50µs. Because there is almost no

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110W quad output AC/DC power supply
Artex’s Technologies has launched a compact quad-output ac-to-dc power supply that is ideal for low-power applications involving peak current demands. The new NLS110-902 power has a power capability of 80 watts – which can be boosted to 110 watts with 200% boost capability – and is corrected to comply with the EN61000-3-2 standard for harmonic current content. The unit provides +5V, +24V, +12V and -12V power and meets electromagnetic noise continuous ratings of 10A, 4.5A, 5A and 1A respectively. However, the power supply is also capable of dealing with higher peak current requirements. The NLS110-902 is an open-frame, profile, design, with a small 7 by 4.5 inch footprint. The power supply features a universal input that accommodates any voltage in the range 90 to 264V AC at any frequency from 47 to 440Hz. The output is equipped with overvoltage protection, and all four outputs are comprehensively protected against short-circuit conditions, with full auto-recovery. An optional Power Fail Detect signal is available. Artex’s NLS110-902 power supplies fully comply with the rigorous EN55022-A200 radiation test levels, and meet all applicable immunity standards, including EN61660-2-3, 5, 4 and 6 levels 3. Artex’s Technologies: Tel: 253 24 25527 www.artexsys.com

Short-circuit protection for relay
The AQP1205K Photomos relay from Matsushita Electric Industrial Company has a short-circuit function to protect sensitive equipment, such as modems, telecoms and measurement instruments, from high current loads. When the load exceed current specifications, it goes into an open state and cuts off the input current within 50µs. Because there is almost no

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32-bit RISC microcontroller

The 32-bit RISC microcontroller is based on a SH3 CPU core and features an 160Kbyte of on-chip, full speed Flash memory. The SH7018F offers a compact peripheral set and modern 0.35µm manufacturing processes. It is suitable for consumer, industrial, office-automation and PC peripheral applications and is also targeted throughout the distribution network. The SH7018F'S SH2 CPU offers sixteen 32-bit wide general registers, an on-chip multiplier and a five-stage pipeline, which enables it to achieve 20MIPS Dhrystone performance at an operating frequency of 20MHz (500 MHz instruction cycle time). With 160Kbyte of on-chip, high speed and single voltage Flash memory, the CPU is able to execute instructions with no wait states. The peripheral set comprises of a three channel 16-bit timer unit (MTU), an additional 16-bit free running counter (CMF), an 8-bit interval timer (TIM2), a watchdog, one USART and an analogue-to-digital converter (ADC). There are also a maximum of 62 I/O pins plus 8 input-only pins, some of which provide external external interrupt capability. Seventeen of the I/O pins can be programmed as reset or run at 3.3V, while the logic and other I/O pins run at 5V. 

MATSUSHITA
Tel 01898 321555
www.matsushita.co.uk

Cold-cathode quad lamp inverter

Taiyo Yuden has announced an inverter to drive four cold-cathode fluorescent tubes for LCD backlighting. The LT680 is 10mm high, 160mm long and 34mm wide and provides an input range of 10.8 to 13.2V DC and a total output of 16W. With a built-in brightness control, the module provides dimming capability by PWM or DC voltage. It uses entirely surface-mounted components. Taiyo Yuden Tel 01494 464642 www.yuden.co.uk

Rail-to-rail i/o op-amps

The LT1672, LT1673 and LT1674 are Linear Technology’s single, dual and quad rail-to-rail input and output, precision operational amplifiers that draw 1.5 and 2uA maximum supply current. These uncompensated amplifiers have a 125kHz gain bandwidth product and 4V p-p input voltage noise from 0 to 1kHz. They do not stress the supply or introduce excessive current under no load conditions. These features make them an excellent choice for power, noise-limited applications in low-end signal processing and industrial control systems.

CMOS SRAM with low data retention voltage of 1.5V

NEC's latest 1Mb Static RAM (SRAM) is designed using full CMOS process memory allowing it to operate with supply currents as low as 25mA (max) and with supply voltage 1.8 - 3.6V, data is retained at voltages as low as 1.5V. Offering high-speed access times down to 70ns and operating in an extended, -25 to +85 degrees C temperature range, the CMOS SRAM is an ideal memory for a wide variety of industrial applications and mobile phones. Designed using a 0.32-micron rule, in a 128K-word by 8-bit organisation, the SRAM is available in 3 varieties (B, C and D versions) to suit a variety of industrial applications. B offers the fastest access times of 70ns with supply voltages from 2.7V; C offers access times down to 100ns and supply voltages down to 2.2V, D offers the lowest supply voltage of 1.8V with access times down to 120ns. C and D versions retain data with a supply voltage as low as 1.5V.

The CMOS SRAM is available in a 32-pin chip (LT1672, LT1673) and 64-pin chip (LT1674) package. 

Comparing to DRAM, SRAM offers faster access times and does not require refresh circuitry but previously has been relatively to power hungry - limiting the applications of SRAM in telecoms circuits which rely on the circuit’s residual power.

NEC Electronics Tel 01950 911100

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correctly when one or both are above the positive supply, making them suitable for high side current sensing applications. They let a low voltage system sense a higher voltage supply. Maximum input offset voltage is 375uV, offset voltage drift 0.4 to 2uV/°C, open loop gain 215mV/mV, CMRR and PSRR 90dB minimum and input offset and bias current 20 and 250pA respectively.

Linear Technology
Tel: 01276 677676
www.linear-tech.com

Clock generators suit embedded communications
AMI Semiconductor has introduced a family of one- and two-phase lock loop clock ICs. They are for fixed-frequency systems such as digital cameras, computer peripherals, printers, LAN hubs and Gigabit Ethernet hubs. Several are derived from common platforms. The platforms can be customised for frequencies, pin outs and features in the final processing layers, similar to a gate array. Each device uses an on-board crystal oscillator to generate a
reference frequency, which is used by the PLLs to generate precise output frequency ratios (ratioing or oversampling). The crystal oscillator is suitable for any fundamental-mode crystal in the 5 to 30MHz range. For video systems, which cannot tolerate unpredictable artifacts, dual-PLL models are available that generate three output clocks from a single crystal reference by driving the frequency through an array of phase-division. These three outputs are locked to reduce phase noise, jitter and EMI from harmonic stacking.
AMI Semiconductor
Tel: 0049 3513 152233
www.amis.com

Various voltages from one package
AVX has improved its Bexcap electrochemical capacitor to provide various voltage options from one package. The standard ranges of 3.5, 4.5 and 5.5V with custom ranges from 1.5 to 10V are available. Capacitors are between 50 and 500mF, ESR frequencies from 25 to 230MHz and maximum leakage current 5 to 40uA depending on size.
Package options are 28 by 17 by 17 (2.9 to 6.0mm) and 48 by 30 by 30 (2.9 to 6.0mm) with moulding wall construction down to 0.7mm.
AVX
Tel: 01252 770000
www.avxcorp.com

Push-button switch with integral lamp
Ontron has introduced a split screen lighted push-button switch for process control applications. The A3PN IP40-rated switch is available in rectangular and square models, measuring 32mm deep. The DPDT switch, which uses an LED, is available in seven solid colours including red, white, blue and pure white. Options include a horizontal split screen and an indicator only version (M2PN series). Rated voltage is 5, 12 or 24V DC. A 110V DC model with voltage-reduction circuitry is also available. Operating range is -10 to +40°C. Options include switch guard, seal cover and character plate.
Ontron
Tel: 020 8450 4646
www.ontron.com

Blade and beam down to 0.4mm pitch
Connectors from Deltron Roxburgh for board stacking systems have pitches down to 0.4mm on a blade-and-beam construction. The Samtec BST headers and BHS sockets have

Eight-slot test system for function test
WK Test has introduced the 5908 Compact tester, an eight-slot member of its 5900 family of functional and combinatorial test systems for high-volume contract manufacture and consumer applications. It accepts all of the firm’s modular test systems, so it can be configured for other test requirements. A Windows NT interface provides a multi-tasking environment. Features include network integration and data-log- ing. Remote control over the LAN, WAN or Internet is possible using optional utilities. The system supports up to two variable and four fixed power supplies. Each variable supply provides up to 400W. The eight identical system slots can accommodate any of the firm’s more than 40 modular test instruments, which provide functions such as analogue and digital measurements, analogue waveform simulation, digital simulation, data acquisition, microprocessor and ROM emulation and communications simulation. Custom modules are also available. It comes in free-standing or rack mount versions. The free-standing unit measures 400 by 600 by 300mm.
WK Test
Tel: 01243 825511
www.uktest.com

Electronic Industries Association

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up to 80 I/Os and a mated height of 5mm. For 0.5mm pitch there is a choice of high-density BTH and BSH versions or low-profile LTH and LSH models, with a 2.3mm mated height. The BTH and BSH have up to 366 I/Os in a board area of 7.40 by 9.34mm. The low-profile versions provide up to 100 I/Os in 6.73 by 28.07mm PCB footprint. On 0.635mm pitch, the BTH and BSH have two lead styles, providing 5 or 8mm mated height for up to 300 I/Os. The 8mm BTH and BSE have mated heights of 4.27 to 10.26mm for standard or elevated applications up to 240 I/Os. The minimum density connector requires 4.79 by 101.35mm on the PCB. Deltron Redruth Tel: 01724 281200 www.deltron.ranel.co.uk

**PLL clock drivers target high-speed applications**

Two low-voltage PLL clock drivers for high-speed memory clocking applications are available from Fairchild Semiconductor. Operating at up to 175MHz, these parts are for high clock fan-out and where matching parameters for skew and jitter are critical. Applications include registered DIMMs and wherever common clock timing is critical in system clock distribution. The FM57900 and FM57951 are direct replacements for the Motorola MPC950 and MPC951. The FM57900 operates from a crystal or oscillator input with clock multiplier. The FM57951 accepts a PECCL clock input and has zero delay and clock multiplication capability. Both provide nine configurables CMOS outputs with less than 250ps of output-to-output skew and less than 300ps of cycle-to-cycle jitter. They come in 32-lead LQFPs and are rated for 0 to 70°C operation. Fairchild Semiconductor Tel: 01793 866866 www.fairchildsemi.com

**Lithium-cell monitor IC**

Texas Instruments has announced a battery monitor IC for Li-ion- and Li-polymer-based applications in mobile handsets, Internet audio appliances and digital cameras powered by a single lithium cell. The device measures critical parameters in a battery pack, such as charge, discharge, self-discharge and temperature and employs an auto-calibrating VPC (voltage-to-frequency converter) for continuous charge/discharge integration. With information from the measurement IC, a host system can calculate remaining battery capacity and predict remaining system run or standby times. The bq2032 battery monitor communicates measurement information to the host controller using the SDQ serial interface, a single wire command-based protocol compatible with the Dallas Semiconductor 1-Wire. The part also includes 224 bytes of flash memory and a 64-bit ID ROM register. The non-volatile memory integration allows a system designer to add a fuel gauge to a system while replacing serial EEPROMs or IC chips, which are currently used in battery packs to store battery pack characteristics or identification and addressing codes. It is packaged in an 8-pin TSSOP. With a 25mV sense resistor, the resolution of the converter is better than 0.12mA.

**SM shielded-drum core inductors**

Available from Ultimate Renaissance are two SMT shielded drum core power inductors claimed to give an EMI performance comparable with a toroidal core. Applications are in switching power supplies and 40-lead converters. The Pulse P1172 and P1173 have inductances from 2.7 to 47uH and DC rating from 2.5 to 10.0A. Package outline is 12.0mm square footprint and 8.0mm height. Weight is 4.5g. They are available on tape and reel. Ultimate Renaissance Tel: 01793 438910 www.ur-home.com

**8050-profile SMT LED for PCBs**

Ledtronics has introduced the Surfled 8050-profile SMT LED for LED applications. It is 2.12mm, comes in six colours and several related hues, is available on EIA standard footprint on 2.1mm rows, and has a viewing angle of 140°. It operates from 20mA. When used with the firm's Optiled light pipes, it simplifies the spatial relationship between the PCB and remove indicator illumination points by channelling all the LED-generated light to where the light is required. There are two versions - high efficiency and super bright. Applications include back lighting computer panels, hand-held instruments, and datacoms and telecoms status indicators.

Ledtronics Tel: 011 310 534 1505 www.ledtronics.com

**NEW PRODUCTS**

**TiePieScope HS801 PORTABLE MOST**

- The HS801: the first 100 Mega samples per second measuring instrument that consists of a MOST (Multimeter, Oscilloscope, Spectrum analyzer and Transient recorder) and an AWG (arbitrary waveform generator). This new MOST portable and compact measuring instrument can solve almost every measurement problem. With the integrated AWG you can generate every signal you want.
- The versatile software has a user-defined toolbar with which over 50 instrument settings quick and easy can be accessed. An intelligent auto setup allows the inexperienced user to perform measurements immediately. Through the use of a setting file, the user has the possibility to save an instrument setup and recall it at a later moment. The setup time of the instrument is hereby reduced to a minimum.
- When a quick indication of the input signal is required, a simple click on the auto setup button will immediately give a good overview of the signal. The auto setup function ensures a proper setup of the time base, the trigger levels and the input sensitivities.

**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.
- 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 text 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 volt full scale to 50 volt full scale. The record length is 32Kx64K samples. The AWG has a 10 bit resolution and a sample speed of 25 MHz. The HS801 is connected to the parallel printer port of a computer.
- The minimum system requirement is a PC with a 486 processor and 8 MbYTE RAM available. The software runs in Windows 3.x or 95 / 98 or Windows NT and DOS 3.3 or higher.
- TiePie engineering (UK), 28 Stephenson Road, Industrial Estate, St. Ives, Cambridgeshire, PE17 4WU, UK Tel: 01480-460026; Fax: 01480-460340
- TiePie engineering (NL), Kopperslagerstraat 37, 8601 W, SNEEK The Netherlands Tel: +31 515 415 415; Fax: +31 515 418 819
- Web: http://www.tiepie.nl

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**NEW PRODUCTS**

Please quote Electronics World when seeking further information.
High-impedance RF probe

Having completed his 50Ω true-RMS-reading RF millivoltmeter, Cyril Bateman went on to design this add-on probe to provide a high-impedance, low-capacitance input.

When measuring in-circuit signal voltages, it is essential that the method used presents a high impedance, low capacitance load to the circuit under test. Measuring in-circuit direct voltages presents little difficulty. Making AC in-circuit measurements is quite a different matter—especially at high frequencies.

If you examine the techniques used to measure alternating voltages, you will find that most methods have limited frequency range. Average-responding millivoltmeters involving rectifying techniques can be used up to perhaps 10MHz. Most RMS-responding meters though, based on I.C.s using the ‘implic’ solution method, are limited to 1 or 2MHz. There’s more on this in the panel entitled ‘RMS’.

Because of frequency-range restrictions, many designers are forced to rely on their oscilloscope to measure AC voltages. Many oscilloscopes measure to at least 100MHz. Because of capacitive loading though, most test probes inhibit measurements of low-level signals at high frequencies.

My Collins M125W oscilloscope probe has a bandwidth of 250MHz and 1:4ms rise time. When set to divide by ten, it applies 10pF loading to the circuit. Set to times one, it applies 60pF to the test circuit. The probe’s bandwidth reduces to just 10MHz and rise time increases to 35ns. By 10MHz, square-wave signals are visibly distorted.

While at low frequency this probe exhibits greater than 1MHz of impedance, by 10MHz this reduces to 800Ω when set to divide by ten, and 26Ω for divide by one.

Many scope probes impose much heavier loading. An HP11000 probe for example, set to times one, applies a 150pF load to the circuit under test.

Measuring signal levels less than 500mV, you may be forced to set the probe to divide by one in order to obtain an adequate display. Many modern I.C.s become unstable or decidedly peaky when loaded with such capacitance. At best the probe’s capacitive load attenuates the measured signal.

In order to measure low-level signals the probe’s capacitance to ground must be reduced. In practice this means using either a 50Ω measurement system, or a low-capacitance active probe.

In the August 2001 issue I described a simple but accurate circuit with a 50Ω input impedance. It is able to measure RMS voltage to 100MHz. Equipped with a suitable high-impedance, low-capacitance ‘front end’, this design will solve many measurement problems, Fig. 1.

Commercially-available active probes can be very expensive, so I decided to investigate the design of a suitable ‘front end’ impedance-converting, probe.

High-Z probe

Much modern circuit design uses supply voltages of ±5V or less, resulting in maximum peak signal levels of around ±2.5V. A target input voltage of 2V RMS would suit most circuits and maximise the dynamic range of my AD8361 based true RMS I.C.3

Having reviewed a number of design alternatives, including discrete FET followers and high impedance I.C.s, I decided to use the AD8361. For ease of use, this would need to be able to drive a metre-long coaxial cable, connecting the probe to my RMS meter. To match my RF RMS voltmeter design’s performance, I wanted a flat response to 100MHz.

Choosing the I.C.s

Following a review of I.C.s available from mainline distributors, I decided to base my probe design on the Maxim4 MAX4005. This is a unity-gain, very high-frequency, JFET input I.C. with an internal 75Ω precision thin-film output resistor.

This chip provides a ±0.1dB gain flatness of 60MHz and ±0.2dB from 80MHz to 800MHz, a 35pΩ rise time and 950MHz bandwidth. Its 10pA input bias current and 2.2pF input capacitance are ideal for use in a high-input-impedance, low-capacitance probe.

An alternative cost- and space-saving approach would be to use the MAX4002 in a two-stage version and use a 75Ω Input attenuator to divide the input signal, and then use the MAX4005 to amplify the attenuated signal. This would provide the required 650mV maximum input to my AD8361 RMS meter.5 This level ensures that its optimum dynamic range is achieved.

Measuring RMS voltage

Following a number of circuit simulations, as described in my last article,6 I decided to base my probe design on the Maxim4 MAX4005. This is a unity-gain, very high-frequency, JFET input I.C. with an internal 75Ω precision thin-film output resistor.

This chip provides a ±0.1dB gain flatness of 60MHz and ±0.2dB from 80MHz to 800MHz, a 35pΩ rise time and 950MHz bandwidth. Its 10pA input bias current and 2.2pF input capacitance are ideal for use in a high-input-impedance, low-capacitance probe.

The 75Ω input to the MAX4005 and using a correctly-terminated 75Ω coaxial cable, would provide the required 650mV maximum input to my AD8361 RMS meter.5 This level ensures that its optimum dynamic range is achieved.

Fig. 1. Using the AD8361 to accurately measure true RMS from 10MHz to 100MHz in a 75Ω system. This is a double-sided printed board originally designed for my 50Ω meter. It provides an excellent match to 75Ω with R1, R2 to 0Ω and R3 to 120Ω.

Fig. 2. The final schematic for my 75Ω true RMS meter printed board. The IN4133 in-amp is used to correct no-signals offsets and as output buffer. This version needs a ±5V supply.

Fig. 3. Layout of the complete printed board, size 8.5 x 7 inches, adapted for 75Ω RF RMS measurement. Accepting a maximum 650mV input, this circuit is a moderate-cost, low-level RF technology.

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1. The probe dielectric is 0.002" thick, the sheath is 0.050" thick, and the overall probe length is 38mm.

2. This is an exact number.

3. Ten, 250MHz I.C.s are available, all are excellent.

4. Higher-frequency I.C.s are available, all are excellent.

5. A 75Ω coaxial cable is a moderate-cost, low-level RF technology.
Measuring true RMS

The AD361, the first low-cost IC to provide accurate RMS measurements, was designed by Barrie Gilbert more than twenty years ago. Using the 'impedance' solution of the RMS equation, feedback is used to perform the square root calculation. This IC provided a 60dB dynamic range at low frequencies and a 1% accuracy with a 7.1V current limit.

Now he has provided another unique RMS measuring IC, but this time based on the 'direct' solution. The AD8361 provides extremely wide bandwidth, measuring from audio to 2.5GHz and up to 300GHz dynamic range. This new technique can measure high crest factor waveforms, with an accuracy similar to a thermal detector.

The AD8361 "TrueRMS" detector is an RMS-to-DC converter that provides true RMS-measuring responses for complex waveforms with a nominal conversion gain of 7.5. It has a claimed dynamic range of 30dB and ±0.25% linearity response up to 2.5GHz. It can measure from very low frequencies but not DC, up to 2.5GHz. The device includes two identical squaring cells whose outputs are balanced by the action of a high-gain error amplifier. It calculates the conversion from RMS to DC automatically, by first squaring the input signal in the input cell. This input cell has a nominal low frequency input impedance of 225Ω. The input signal is biased to 0V to the input signal must be DC blocked by an external capacitor.

The current output from this squaring cell is averaged using an internal resistor and 2μF capacitor. It performs waveforms with a nominal conversion gain of 7.5. This averaged voltage is applied to one input of the error amplifier.

The second squaring cell is used to close a negative feedback loop around the error amplifier. This second cell is driven by a fraction of the quasi-DC output of the AD8361. When the voltage at the input of this second squaring cell is equal to the RMS value of the input signal, the loop is stable and the AD8361 output represents the RMS value of the input.

Scaling errors in both squaring cells cancel and they track with temperature changes in stable measurements over the temperature range.

With a 45V supply, the AD8361 is linear with inputs up to 600V, which with a nominal conversion gain of 7.5 results in a DC output of 4.5V. In practice, at 100MHz, this conversion gain is limited to between 6.5 and 8.5 times.

To allow for AD8361 offset errors, if the maximum possible linear input signal is used it is advisable to slightly increase the power supply voltage, by 100 or 200mV to avoid input compression, taking care not to exceed its maximum permitted supply of 5V.
Calibrating the probe

The high-impedance probe PCB, loaded with a temporary 75Ω terminating resistor, should be adjusted as a stand-alone probe before you connect it to the true-RMS meter PCB.

This is necessary because the input VSWR of the 75Ω RMS board rises slightly due to the impedance of its 1pF capacitor as frequency is reduced below 1kHz. The bias reference voltage where the trimmer capacitor setting has little or no effect must be taken at 1kHz or lower frequency. The probe's uncorrected flat frequency response extends down to 100Hz.

Two methods can be used to determine the correct setting for the trimmer capacitor. The best method is to use a precise known sine wave at two frequencies, 1kHz and 1MHz. However this is only possible if you have a good AC voltmeter available to set and measure the probe input and output voltages.

Attach a short length of 75Ω coaxial cable to the high-impedance probe output then to the voltmeter high impedance input via a 75Ω through termination located on the meter's input socket. Note the probe's output voltage at 1kHz then using exactly the same input voltage, adjust Cprobe to obtain this reading at 1MHz. A practical alternative, is to use a good 1kHz square wave available as the calibrator on your oscilloscope front panel.

Attach a short length of 75Ω coax to the output of the high-impedance probe then to the oscilloscope input via a 75Ω through termination located on the oscilloscope input socket. Apply the high-impedance probe test probes to this calibrator and while monitoring the high-impedance probe's output on your oscilloscope, adjust Cprobe for the best possible square wave.

Combined assembly

For accuracy, a 50Ω signal generator and 50Ω connecting cables as needed, should be terminated with a 50Ω through load. Voltage at the output of the 50Ω through-terminating load is monitored using a known voltmeter and adjusted to the required 500mV.

Attach the high-impedance probe input probe and the known voltmeter to this 50Ω through load using a "T" connector. Do not adjust Cprobe, which has already been set for the correct response.

Measure the DC voltage V1 at the junction of U7 and R3 then adjust the attenuator value by adding resistors R6 and R5 as appropriate. The required total value R5, which is the net sum of R5, R6, and R4, can be easily calculated:

\[ R_5 = 0.5 \times 1\,\text{k} \Omega \] in ohms.

Typical net values for R4 and R5 for AD8361 at nominal and maximum gains are:

- AD8361 gain-7.5: R4 = 398kΩ, R5 = 900kΩ
- AD8361 gain-8.5: R4 = 38kΩ, R5 = 220Ω

Apply signal voltages of ±0.5 and 1.0 and verify attenuator output accuracy at these voltages.

Correctly-terminated 50Ω system

I monitored sine wave input and output voltages using my HP331A below 1MHz and my HP4350A vector voltmeter for higher frequencies. Square wave input and output voltages were measured using a pair of carefully-matched and adjusted Coline M125V oscilloscope probes, both set to divide by ten.

Using a 1kHz square wave, trimmer Cprobe was first adjusted for optimum square wave response by observing both the probe input and output voltages simultaneously on my dual-beam oscilloscope.

Increasing this square wave input to 5MHz revealed identical input and output probe traces, indicating this probe's response was at least as good as my matched pair of Coline M125V scope probes at this frequency.

Sine wave measurements from 100Hz to 100kHz using the HP331A and HP4350A instruments showed a near flat response to 100MHz for this probe on its own, when terminated in 75Ω, Fig. 8.

Coaxial input probe

In order to measure in-circuit voltages, I wanted my probe to accept the probe and adaptors provided for my Coline M125V probes. The Coline probe body terminates in a 4.8mm diameter barrel and 0.7mm probe tip.

This 4.8mm barrel was no problem. I already possessed some lengths of thin wall 4mm ID brass tubing obtained from a local aeronautical supplier. Incidentally 'Paper Mate' ball pen refills are also almost exactly the required external diameter

My wife's sewing box provided two needles of suitable length and diameter. Together with two PTFE insulators from insulating stand-offs, I had the required parts.

To accept the Coline spring hook adaptors, I needed a probe body at least 30mm long. A few calculations suggested that a coaxial probe of this length, assembled using these parts, would exhibit some 1.65pF of capacitance.

In the event, to ensure a sufficiently tight fit of the PTFE into my tube I had to insert a 5mm length of 1.4mm outside-diameter tubing into the central hole of each PTFE insulator. This would slightly increase the calculated capacitance.

When assembled, my finalised test probe measured 1.6pF. Added to the probe PCB capacitance of 1.5pF this would result in a total probe input capacitance of some 4pF.

Final tests

This probe was attached to my prototype probe PCB and the above sine wave and square wave tests repeated. I was satisfied with the results. To facilitate a secure test probe mounting, I increased the PCB length to 44mm. I then assembled and calibrated the final probe. Fig. 9.

The final probe was attached to my 75Ω true-RMS measuring PCB using RG179 B/U coaxial cable, ready for full tests of the completed assembly. This PTFE insulated coaxial cable, which is available in cut lengths, is easily soldered directly to a PCB without damaging the cable.

Testing with 500mV sine waves, I found performance from 5kHz to 100kHz was better than ±0.25dB. At 20MHz it was nearly ±0.5dB and better than ±3dB at 500MHz.

Using a 500mV reference, dynamic range measured at 1MHz was better than ±0.25dB to 1.9V. Measured at 10MHz with a 500mV reference, it was ±0.28dB at 250V, better than ±2.0dB to 100mV and better than ±4dB at 50mV.

The particular AD8361 IC used exhibited a no-signal offset of 10mV. This was corrected to 3.4mV using an INA131 instrumentation op-amp. I would expect to...
input capacitance is high and its capacitance very low. For the amplitude results, I used an HP331A vector voltmeter up to 1MHz and an HP8405A vector voltmeter for higher frequencies. For the above tests, the AD8361 output offset of 110.5mV was reset to ±3.4mV by adjusting the input impedance.

Table 1

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>DC out (mV)</th>
<th>Relative (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1k</td>
<td>386</td>
<td>-2.25</td>
</tr>
<tr>
<td>5k</td>
<td>486</td>
<td>-0.25</td>
</tr>
<tr>
<td>10k</td>
<td>496</td>
<td>-0.07</td>
</tr>
<tr>
<td>50k</td>
<td>497</td>
<td>0.0</td>
</tr>
<tr>
<td>50k ref</td>
<td>500</td>
<td>0.0</td>
</tr>
<tr>
<td>1M</td>
<td>499</td>
<td>-0.01</td>
</tr>
<tr>
<td>5M</td>
<td>501</td>
<td>0.02</td>
</tr>
<tr>
<td>10M</td>
<td>502</td>
<td>0.0</td>
</tr>
<tr>
<td>25M</td>
<td>500</td>
<td>0.0</td>
</tr>
<tr>
<td>50M</td>
<td>504</td>
<td>-0.12</td>
</tr>
<tr>
<td>75M</td>
<td>508</td>
<td>-0.18</td>
</tr>
<tr>
<td>100M</td>
<td>512</td>
<td>-0.206</td>
</tr>
<tr>
<td>150M</td>
<td>500</td>
<td>-0.104</td>
</tr>
<tr>
<td>200M</td>
<td>473</td>
<td>-0.48</td>
</tr>
<tr>
<td>250M</td>
<td>428</td>
<td>-1.35</td>
</tr>
<tr>
<td>300M</td>
<td>361</td>
<td>-2.39</td>
</tr>
<tr>
<td>350M</td>
<td>335</td>
<td>-3.48</td>
</tr>
<tr>
<td>400M</td>
<td>291</td>
<td>-4.7</td>
</tr>
</tbody>
</table>

Note: 0dB input was set to 500mV

Dynamic range performance of the probe

<table>
<thead>
<tr>
<th>Input at 10kHz</th>
<th>Output DC</th>
<th>Error (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1V</td>
<td>1.521V</td>
<td>±0.12</td>
</tr>
<tr>
<td>5V</td>
<td>7.611V</td>
<td>±0.17</td>
</tr>
<tr>
<td>10V</td>
<td>15.22V</td>
<td>±0.26</td>
</tr>
</tbody>
</table>

References
2. RMS to DC converters ease measurement tasks. http://www.analog.com
4. 4.95 section FET-Input Buffer with 75Ω output, http://www.maxim-ic.com
5. 'Revolutionary RF IC Performs RMS-DC Conversion', Microwaves and RF, September 1999.

Received reference voltage.

The 10MHz input voltage for each measurement was monitored using an HP8405A vector voltmeter, while at 1MHz an HP331A voltmeter was used. My next article will detail how this high-impedance, low-capacitance probe design can be used to provide a unity-gain, high-impedance, low-capacitance, oscilloscope probe, usable from 100Hz to 100MHz.

141133 reference voltage.

For the above tests, the AD8361 no signal output offset of 110.5mV was reset to ±3.4mV by adjusting the input impedance of high and its capacitance very low. For the amplitude results, I used an HP331A vector voltmeter up to 1MHz and an HP8405A vector voltmeter for higher frequencies. For the above tests, the AD8361 no signal output offset of 110.5mV was reset to ±3.4mV by adjusting the input impedance.
**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.

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Send your ideas to: Jackie Lowe, Cumulus Business Media, Anne Boleyn House, V-13 Ewell Road, Cheam, Surrey SM3 8BZ

---

**Increasing the Signal Level Handling of a Digital Potentiometer**

While building a stereo amplifier I decided to make use of two DS1804 digital potentiometers from Dallas Semiconductor. The idea was to prevent the routing of low-level analogue signals from the rear phone connector panel to the volume control on the front of the box, so minimising the noise that could be picked up and reinsert to the amplifier inputs.

The voltage restriction on the potentiometer means that the signal on any of the analogue terminals H, L, or W cannot go more than 0.5V below ground (pin 0) or 0.5V above the supply (pin 8).

Even after dividing down the line-level signals from my CD and tuner, I experienced a problem characterised by a low-level buzzing coming through the speakers with the wiper in position 0, i.e. at ground potential, in response to peaks in the music level. Rather than try to DC bias the analogue terminals above ground and run the risk of signal degradation, I used two diodes to drop the supply and create an artificial ground for the DS1804, giving an extra 0.6V or so of signal handling (0V and the analogue ground on L are tied together at the power supply).

To prevent overdriving of the INC and UP/DPIN inputs, I used two more diodes. The resistors are needed on these lines to ensure the device sees correct logic-low levels. Encoder output is deboUNCd by a 74HC123 dual monostable, set to around 0.5s pulse width.

An extra feature of the circuit shown is the driving of the CS input, pin 7. When the AC supply is active, this line is pulled low by the BC337 and the potentiometer reacts to the states of the control lines.

When the unit is powered down, CS goes high because the 0.47µF capacitor discharges before the 5V supply drops. The current wiper position is transferred to a non-volatile store on-chip. This is automatically retrieved at next power-up, so restoring the last setting of the volume.

John Avery
Ashwood
Surrey

---

**Stepper Motor Sequencer**

There is no shortage of imaginative circuity or dedicated stepper motor drivers, but for basic 4 pole, unipolar 2 phase excitation, a 4018 is perhaps cheap and easy as it gets. A glance at a data book index would not suggest suitability but it is a slightly unusual counter, as the circuit configuration timing diagram illustrates.

Although not used in this simple circuit, initial starting conditions can be better set with the jam inputs. For operational characteristics the reset has been shown in the timing diagram, with all the jams low. Outputs can be gated for reversal but in such applications a dedicated driver might be more appropriate.

Andy S. Robertson
Circon
Aprhure
FS2

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**Ten Year Index: New Update**

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**Attenuators using common resistors**

Using testing of sensitive amplifiers, it is sometimes useful to insert an extra 20 dB or 40 dB attenuation of the signal coming from the source. In case you do not have a handy-made cascode attenuator, the pads shown in Fig. 1 can be rapidly constructed and fitted in a tin box.

For a 50Ω system, with no added attenuation, the source and load are both 50Ω, and hence there is an automatic drop of 50% of the source EMF at the load. The power in the load is one half or 3dB relative to the total power supplied by the source.

For an additional loss of 20dB, the values in Fig. 1a) preserve an accurate 50Ω impedance on the input and output sides, and give the correct additional attenuation: thus there is an overall loss of 20 in source EMF. Alternatively, the end resisters can be replaced with single 62Ω and the link a single 240Ω. The impedance is then 0.7% high, but the attenuation error is rather larger: the signal ends up almost 4% high. Similarly, the 40dB pad of Fig. 1b) provides an accurate 50Ω impedances, and is an overall loss of 20 in source EMF. With the values shown, the errors are less than 0.05%, though tolerances of common resistors will tend to swamp this.

Bear in mind that the front-end resistor may have to dissipate appreciable power. Use Philips MR325 type with 0.6W rating, allowing 5.5V rms across 51Ω.

At high frequencies, stray capacitance and serial coupling from input to output become a limiting factor: e.g. 1pF at 1KHz contributes a shunting effect of -10dBK. Hence trying to make a 60dB pad all in one go, with a 153Ω+10Ω goes cross-link is not very successful except at moderate frequencies.

A rapid form of construction is to splice the components into a 50Ω BNC-BNC cable, or use a BNC plug-cable plus a BNC socket. With a little care and insulating tape, a fairly well screened result can be achieved by adding strips of braid all around.

C J D Catto
Cambridge

**Cascode driver improves SMPS**

Using a cascode power stage for the power supplies operating from high supply voltages - direct from the mains for example - offers potential advantages. Faster switching is achieved. This is because the limited current capacity of the controller chip has to drive the Miller capacitance of the lower MOSFET transistor (see circuit diagram) through a collector voltage swing of only about 15V rather than the 40V of a single-transistor circuit. This reduces switching losses.

Additionally, the Miller capacitance of a 50V-rated transistor will generally be less than that of a similarly rated 500V device. A clamp circuit is necessary to minimise the turn-off drain voltage swing at this point and this may conveniently be arranged to provide power for the controller chip.

Feeding only the gate bias circuit of the upper transistor of the cascode pair from the start-up resistors gives a fast turn-on during power up, even though a relatively large capacitor is provided to maintain supply to the control chip between supply cycles. Also, there is the capability to supply auxiliary circuits like slope compensation amplifiers with a moderate parasitic drain.

The start-up resistors have low power ratings in that they may be small and inexpensive. Note that two resistors are used, not for dissipation reasons, but safety. Small resistors are not rated to stand off mains - be sure the resistors used have an adequate voltage rating.

The circuit operates as follows. On start-up, R1 and R2 pull up C1 and C2 acts as a voltage follower to provide the few milliamperes required to charge C1-C2 to the start up volts of the controller chip. Most controller chips of this type incorporate an internal zener function. The current into this chip is limited by R4, which clamps the gate voltages at R6 if the current it detects 0.7V or so across R5. In operation R5 is pulled up, as required by the controller chip. In addition to driving the output via R3 when on, it clamps the gate voltage at R6 to about 10V via D1 and D2.

When it turns off, the rise in volts on the drain of R3 charges C6 via the drain/source capacitance of R6 and D6. This is a fast rise with a high transient current rating, but only about 10V. This charge supplies operating current to the controller chip via R1, which keeps fast current out of the controller chip. If R6 has a large source/drain capacitance and the design features a high switching rate it may be necessary to limit the current flowing into the controller chip by adding a zener of say 15V across C6 and increasing R1 to keep the current within the chip makers specifications.

**Valve-based, time-aligned, active loudspeaker crossover filter**

A recent article described a perfectly time-aligned active crossover filter system for audio. The main characteristic of the system was the ability to control any input signal to be faithfully reproduced at the output.

The circuit described here is based on the same principle but implemented using valves, which have enjoyed resurgence in recent years. The complete circuit excluding the power supply is shown in Fig. 1.

The buffered input signal is fed to a high-pass filter, which is a simple second-order RC-RC filter. The low-pass filter is built from a difference amplifier with inputs from the buffered input signal and the output from the high-pass filter. Note that other high-pass filters may be used without adjustment. A volume pot is fitted within the low-pass section to cater for any difference in amplifier and/or speaker sensitivity. The 1kΩ variable resistor VR5 is used to balance any mismatch between the two halves of the 12AU7. Gain of the low-pass section is approximately 4. Both simulation and experimental results agree with the description given in the reference.

**Reference**

Intelligent power switching

This circuit lets the power for an instrument be controlled by a push button. The operator simply turns the instrument on by pressing the power button on the keyboard. When the instrument is on, the user again presses the power button, the host DSP system or controller has the power of the circuit. This ensures that whatever the DSP is doing can be ended and that the DSP will turn the instrument off.

Power button control. The functions of this circuit are explained under the following conditions:

1. There is no battery connected to the instrument.
2. The battery is connected to the instrument.
3. The power button is pressed the first time.
4. The power button is pressed the second time.

1. When no battery is connected, all signals are at zero volts, i.e., low.
2. When the battery is connected, it is essential to have the two D-type flip-flops set into correct states from start. Flip-Flop USO-A is set by U49-A because of the RC circuit at its input. This ensures that its output and $Q_1$ is high for around 50ms before it goes low. When USO-A is set, the Q output of USO-A is high and the Q output of USO-A is low. As a result, USO-A's D input is also low. This puts transistor Q92-B into its off state.

The second flip-flop, USO-B, is reset by U49-B through diode D16. This ensures that its R input is high for approximately 7ms. Once it is reset Q of USO-B is low and $Q_1$ is high, leaving USO-B's D input high also.

Now both flip flops are in known states. The signal DSP, which is an I/O signal from the DSP, is kept low during this process through R13 since the +3.3V is off.

3. When the power button is activated the first time the signal PWK will be shorted to GND while the switch is closed. This causes the signal of the output of U49-B to go high for that period. Then USO-A is clocked at its C input. This causes the outputs of USO-A to invert and transistor Q19-B turns on, resulting in the +5V supply going on. This +5V supply is connected at VBATOUT. The +3.3V supply also turns on.

When the +5V rail has come up, then Q92 turns on, ensuring that the signal path from U49-B to the C input of USO-A can not be altered by the user. This prevents the user from activating USO-A again.

The I/O line PBO5 on the DSP is automatically configured as an input when the device starts up, after the +3.3V is running. To allow the user presses the power button, this signal will be low since Q19-A is on. The DSP will not continue its program before the user has released the power button and PBO5 goes high. Though USO-B will be reset once again, this will not alter its output. The system is running.

4. When the power button is pressed again, PBO5 goes low again resulting in a GPIO inhibit. This eventually causes the DSP to initiate a shutdown. This activation will of course also toggle the C input of USO-B, but its output will not change. The user releases the power button and now the DSP can start the shutdown process. First the DSP has to ensure that any vital processes are ended and then store any critical data in nonvolatile memory. Then it programs PBO5 as output and sets it low. This causes the C input of the USO-B to invert the output, which both will toggle the C input of USO-A and invert its output, shutting down the system. But at the same time Q15-A and U49-C will cause a pulse to reset USO-B again, leaving the circuit in the same state as before the user pressed the power button the first time.

Frans Raven Hansen

Horlev

Denmark

F60
Inverting current conveyor from an OPA1662

An OPA2662 operational transconductance amplifier can be used as a non-inverting current conveyor, or CCII(+), without any modification. In this case, $Y = R$, $X = Z$, and $Z = C$, where $X$, $Y$, and $Z$ denote terminals of the current conveyor and $R$ is the gain of the amplifier, Fig. 1a.

In many applications, an inverting current conveyor, or CCII(-), is also required. To construct one, we used both parts of an OPA2662 dual integrated circuit, Fig. 1b.

Relationships between currents $I_2$ and $I_1$, and voltage $U_2$, where $R_1$ and $R_2$ were 100Ω are shown in Fig. 2a for CCII(+) and in Fig. 2b for CCII(-). The following coefficients can be determined from these curves:

$I_2 = 3.1I_1$ for CCII(+) and $I_2 = 2.9I_1$ for CCII(-).

Both current conveyors were used in the circuit realising a frequency-dependent negative conductance, as shown in Fig. 3. This circuit was described in Electronics World, May 2001.

$I = \frac{2C}{CR}(2-3k)$

Here, $C$ is capacitance, $R$ is $(R_2 + R_1)$, $k$ is ESR of capacitor and factor $k$ is.

Lech Tomaszewski, Robert Gabrek, Sebastian Ofel
University of Silesia
Institute of Physics
Katowice
Poland

Reference
L. L. Tomaszewski, M. Mafika, M. Slavonic,
"FDNC using current conveyors.,"

Simple circuit for measuring capacitor ESR or low resistance

An unconventional but simple circuit using a 555 timer IC and five other components, plus a +5V DC supply and a frequency counter, enables approximate comparison measurement of capacitor ESR values. Such low values cannot be measured by most capacitance bridges or meters.

The circuit consists of a CMOS version 555 astable oscillator with 50:50 duty cycle output. It is modified by the addition of $R_2$ and $r$. Small variations in the value of $r$ — for example the ESR of the timing capacitor — provide a large change in output frequency.

Output frequency of the oscillator is given by:

$f = \frac{2Cr(2-3k)}{R}$

Here, $C$ is capacitance, $R$ is $(R_2 + R_1)$, $k$ is ESR of capacitor and factor $k$ is.

For correct functioning, the factor $k$ must not exceed 0.33. If it does, the 555 circuit will oscillate at a very high frequency, governed mainly by the 555 IC propagation delay.

As the value of $k$ increases through the range from zero to 0.31, the oscillator frequency increases exponentially, by a factor of $x10$. A further increase in the value of $k$ from 0.31 to 0.331 gives a further $x10$ increase in output frequency.

Using $R_1 = 4.7k$ and $R_2 = 2.2k$, then for $ESR = 0$, $R$ is nominally equal to 0.318.

If the $ESR$, now increases to say 100k, $R$ increases by around 3% to 0.328. The circuit now has an output frequency that is approximately three times the value of the frequency when $ESR = 0$.

Note that an increase in resistance, $r$ (ESR) gives an exponential increase in output frequency.

Test method. Calibrate the circuit by using a known low-ESR capacitor of the same capacitance value as the device under test, plus a low value resistance box. Alternatively, use a selection of 1 to 150Ω 1% tolerance resistors.

Plot the calibration graph of output frequency versus $r$ value, over the range zero to 150Ω. Connect the capacitor under test into the circuit and determine the ESR value from the output frequency measured, by means of the graph.

In order to give good resolution for low values of ESR, of say, <1Ω, and to overcome the effect of frequency variations due to C value variations, add a fixed resistor in the range 10 to 100Ω to $ESR = 0$, ±1% tolerance, in series with the capacitor under test.

To determine the value of $r$ as above, then subtract the additional resistance value, to determine the internal capacitor ESR value.

Precautions. Use a well-regulated DC supply and decoupling capacitors, to avoid frequency instability.

Remember that capacitor ESR is both frequency and temperature dependent.

Other uses.
1. High resolution milli-ohm low resistance measurement. Use a fixed, high grade, low-ESR capacitor e.g. polysilicon or polypropylene dielectric and connect resistor under test close to the oscillator circuit.

Alternate pulse router

Originally devised to facilitate the calibration of mechanical speed tapers, this simple circuit has proved useful in several other applications such as in driving pulse transformers.

The circuit routes alternate pulses to a second output. The 4049 inverter at the input can be replaced with another type of inverter, for example, a transistor circuit.

Similarly, other devices can replace the 4027 bistable device and the 4049.

D M Townsend
Pretoria
South Africa
FSO

£75 winner}

2. Oscillator with grounded frequency control.
3. Oscillator where increase in resistance is to give increase in frequency, e.g. PTC thermistor measurement, control or temperature compensation.
4. High resolution temperature measurement, with 1ΩΩΩΩ PRT sensors up to +100°C.

Typical results
With $C=0.1\mu F$, $R_1=4.7kΩ$, $R_2=2.2kΩ$.

$R (\Omega)$ $k$ factor $f$ (kHz)
0 0.3186 16.37
10 0.3196 17.56
20 0.3206 18.8
50 0.3237 24.3
100 0.3265 47.1
110 0.3285 68.2
120 0.3305 75.3
130 0.3314 108
140 0.3324 173
150 (max) 0.3333 230

Note — with $r$ greater than 100Ω, a resolution of better than 1ΩΩ can be obtained.

S H Dolding
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Australia
FS8
Designing radio receivers III

Joe Carr explains what the noise floor is, and reveals how you can interpret the various ways that receiver makers express static measurements of performance. This is the third in a set of four articles that cover designing receivers from the ground up.

Fig. 1. Some receiver makers specify sensitivity only at lower bandwidths to make the set's performance look better than it is.

radiofrequency or 200 to 500Hz for CW.

Indeed, one of the places where 'creative specification writing' takes place for commercial receivers is in advertisements. Some will enthusiastically cite the sensitivity for a narrow bandwidth mode - CW for example - while the other specifications are cited for a more commonly used bandwidth mode such as SSB.

In one particularly egregious example, an advertisement claimed a sensitivity number that was applicable to the 270kHz CW mode only, yet the 270kHz-CW filter was an expensive option that had to be specially ordered separately!

The amount of sensitivity improvement is seen by evaluating some simple numbers. Recall that a claim of "x-µV" sensitivity refers to some standard such as 'x-µV to produce a 10dB signal-to-noise ratio in y Hz bandwidth.'

Consider the case where the main mode for a high frequency (HF) shortwave receiver is AM for international broadcasting. The sensitivity is 1.9µV for 10dB SNR, and the bandwidth is 5kHz.

If the bandwidth was reduced to 2.8kHz for SSB, then the sensitivity improves by the square root of the ratio, or \( \sqrt{5/2.8} \). If the bandwidth is further reduced to 270kHz - i.e. 0.27kHz - for CW, then the sensitivity for 10dB SNR is \( \sqrt{2.8/0.27} \).

The 1.9µV AM sensitivity therefore translates to 1.4µV for SSB and 0.4µV for CW. If only the CW version is given, then the receiver might be made to look a whole lot better than it is, even though the typical user may never use the CW mode. Note the differences in Fig. 1.

The sensitivity differences also explain why weak SSB signals can be heard under conditions when AM signals of similar strength have disappeared into the noise, or why the CW mode has as much as 20dB advantage over SSB, ceteris paribus.

In some receivers, the difference in mode - AM, SSB, RTTY, CW, etc. - can conceivably result in sensitivity differences that are more than the differences in the bandwidths associated with the various modes. The reason is that there is sometimes a 'processing gain' associated with demodulation of a waveform that increases the signal at the output of the IF amplifier.

A simple AM envelope detector is lossy because it conserves power, not signal. An RC filter, which is a passive circuit without amplification. Other detectors, including product detectors for SSB and synchronous detection for FM, appear to their own signal gain. As a result, they may produce better sensitivity numbers than the bandwidth suggests.

Another indication of sensitivity is minimum detectable signal, or MDS, which is usually specified in dBm. This signal level is the signal power at the antenna input terminal of the receiver required to produce some standard 5+N/N ratio, such as 3dB or 10dB. Fig. 2.

In radar receivers, the MDS is usually described in terms of a single pulse return and a specified 5+N/N ratio.

Also, in radar receivers, the sensitivity can be improved by integrating multiple pulses. If m return pulses are integrated, then the sensitivity is improved by a factor of \( m \) if coherent detection is used, and \( \sqrt{m} \) if non-coherent detection is used.

Modulated signals represent a special case. For these sensitivities, it is common to specify the conditions under which the measurement is made. For example, in AM receivers the sensitivity to achieve 10dB SNR is measured with the input signal modulated 30 percent by a 400 or 1000Hz sinusoidal tone.

An alternate method is sometimes used for AM sensitivity measurements, especially in consumer radio receivers. Here, SNR may be a little hard to measure with the equipment usually available to technicians who work on those radios. This is the 'standard output conditions' method.

Some manuals will specify the audio signal power or audio signal voltage at some critical point, when the 30% modulated CW receiver is present. In one automobile radio receiver, the sensitivity was specified as 'x-µV to produce 400mV across the loudspeaker when the signal generator is modulated 30% with a 400Hz audio tone.'

The cryptic note on the schematic showed an output sine wave across the loudspeaker with the label "400mV in R3 for a 2.5W +0.5dB RF". What's missing is mention of the level of total harmonic distortion, or THD, that is permitted.

The sensitivity is sometimes measured in essentially the same way. However, the signal levels will specify the voltage level that will appear at the top of the voltmeter control, or output of the detector/filter, when the standard signal is applied. Thus, there are two ways seen for specifying AM sensitivity: 10dB SNR and standard output conditions.

There are also two ways to specify FM receiver sensitivity. The first is the 10dB SNR method discussed above. In other words, this is the number of microvolts of signal at the input terminals required to produce a 10dB SNR when the carrier is modulated by a standard amount.

The second way to measure FM sensitivity is the level of signal required to reduce the no-signal level by 20dB. This is the 20dB quieting sensitivity of the receiver.

If you tune between signals on an FM receiver, you will hear a loud 'hisst' signal - especially in the VHF/UV bands.

October 2001 ELECTRONICS WORLD
Some of that noise is externally generated, while some is internally generated. When an FM signal appears in the passband, that hiss is suppressed, even if the FM carrier is unmodulated. The quieting sensitivity of an FM receiver is a statement of the number of microvolts required to produce some standard quieting level, usually ±2dB.

Pulse receivers, such as sideband and pulse communications units, often use the tangential sensitivity as the measure of performance. This is the amplitude of pulse signal required to raise the noise level by its own RMS amplitude.

Fig. 3. Pulse receivers, such as those found in radar systems, often use tangential sensitivity as a measure of performance. This is the amplitude of pulse signal needed to raise the signal above the noise level by its own RMS amplitude.

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Fig. 3. Pulse receivers, such as those found in radar systems, often use tangential sensitivity as a measure of performance. This is the amplitude of pulse signal needed to raise the signal above the noise level by its own RMS amplitude.
For example, an AM broadcast-band radio signal has audio components out to 5kHz, so the signal occupies up to 10kHz of spectrum space (F±5kHz). If a 2kHz+SSB IF filter is selected, then it will tend to sound ‘mushy’ and distorted.

\[ \text{IF passband shape factor} \]

The shape factor is a measure of the steepness of the receiver's IF passband. It is taken by measuring the ratio of the bandwidth at -6dB down from the peak to the band with -40dB down, Fig 7a. The general rule is that the closer these numbers are to each other, the better the receiver.

Anything in the 1.1:1 to 1.9:1 region can be considered high quality, while anything worse than 1.3 is not worth looking at for ‘serious’ receiver uses. If the numbers are between 1.1:1 and 1.3, then the receiver could be regarded as being middling, but useful.

The importance of shape factor is that it modifies the notion of bandwidth. The cited bandwidth - 2.8kHz for SSB for example - does not take into account the effects of strong signals that are just beyond those limits. Such signals can easily ‘punch through’ the IF selection if the IF passband ‘skirt’ are not steep. After all, the steeper they are, the closer a strong signal can be without messing up the receiver's operation.

The situation is illustrated in Fig 7b. This curve inverts Fig 7a by plotting attenuation versus frequency. Assume that equal amplitude signals close to \( f_p \) are received, Fig 7c, the relative post-filtering amplitudes will match Fig 7d. Thus, selecting a receiver with a shape factor as close to the 1:1 ideal as possible will result in a more usable radio.

**Ultimate rejection**

A receiver's distance-frequency or ‘ultimate’ rejection specification tells you something about the receiver’s ability to reject very strong signals that are located well outside the receiver’s IF passband. This number is stated in negative decades, and the higher the number the better.

An excellent receiver will have values in the -60 to -40dB range, a middling receiver will see numbers in the -45 to -60dB range, and a terrible receiver will be -44 or worse.

### Stability

The stability specification measures how much the receiver frequency drifts as temperature changes.

Local-oscillator drift sets the overall stability of the receiver. This specification is usually given in terms of short-term drift and long-term drift - for example from local-oscillator crystal aging. Short term drift is important in daily operation, while the long term drift ultimately affects general dial calibration.

If the receiver is controlled by a variable-frequency oscillator, or VFO, or it uses partial frequency synthesis, which combines VFO with crystal oscillators, then the stability is dominated by the VFO stability. In fully synthesised receivers, the stability is governed by the master-reference crystal oscillator.

If either an oven-controlled crystal oscillator (OCXO), or a temperature compensated crystal oscillator (TCXO), is used for the master reference, then stability on the order of 1 ppb in 1 hour is achievable.

For most users, short-term stability is most important - especially when tuning SSB, ECSS or RTTY signals. A common specification value for a good receiver will be 50Hz/hour after a three hour warm-up, or 10Hz/hour after a 1.5 minute warm-up. The smaller the drift the better the receiver.

The foundation of good stability is at design time. The local oscillator, or VFO, or a portion of a synthesiser, must be operated in a cool, temperature stable, location within the equipment, and must have the correct type of components. Capacitor temperature coefficients are selected in order to cancel out temperature-related drift in inductance values.

Post-design time changes can also help, but these are less likely to be possible today than in the past. The chief cause of drift problems is heat. In the days of vacuum-tube oscillators, the heat of the internal heating filament produced lots of heat that in turn caused drift.

A related phenomenon seen on low-cost receivers, or certain home-brewed receivers of doubtful merit, is mechanical frequency shifts. Although not seen on most modern receivers - even some very cheap designs - it was once a serious problem on less costly models. This problem is usually seen on VFO-controlled receivers in which vibration to the receiver cabinet imparts movement to either the inductors, \( L \), or capacitors, \( C \), element as LCVFO.

Mechanically stabilising these components will work wonders.

### AGC range and threshold

Modern communications receivers must be able to handle signal strengths over a dynamic range of about 10000:1. Tuning across a band occupied by signals of wildly varying strength is hard on the ears and hard on the receiver’s performance. As a result, modern receivers have an automatic gain control (AGC) circuit that smooths out these changes.

Automatic gain control will reduce gain for strong signals, and increase it for weak signals. It can also be turned off on most HF and VHF/UHF communications receivers.

The AGC range is the change of input signal in \( \pm 1 \) dBV from some reference level, such as 1 V EMF, to the input level that produces a 20dB change in output level. Ranges of 90 to 100 dB are common.

The AGC threshold is the signal level at which the AGC begins to operate. If set too low, then the receiver gain will respond to noise, and irritate the user. If set too high, then the user will experience irritating shifts of output level as the band is tuned.

AGC thresholds of 0.7 to 2.5μV are common on decent receivers, with the better receivers being in the 0.7 to 1μV range.

Another AGC specification sometimes seen deals with the speed of the AGC. Although sometimes specified in milliseconds, it is also frequently specified in subjective terms like ‘fast’ and ‘slow’.

This specification refers to how fast the AGC responds to changes in signal strength. If set too fast, then rapidly keyed signals like on/off CW, or noise transients will cause unhelpful levels at receiver gain. If set too slow, then the receiver might as well have no AGC.

Many receivers provide two or more selections in order to accommodate different types of signals.

Joe's fourth and final article on receiver design looks at measuring of performance under dynamic conditions.

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