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Observing lightning

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• Timer for battery changes
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• Variable over-current trip

Cover photography Mark Swallow

Featured in News on page 9, this electronic tone can detect chemical changes. If development work gets underway again, it could be developed further so that it can recognise classes of chemicals.

Does a capacitor in a hi-fi circuit affect the sound perceived by the listener? There have been many musical and flood claims about capacitor sound, but few authors have attempted quantitative explanations. In the first of this unique set of articles, capacitor guru Cyril Bateman sets out to rectify that. Find out how on page 12.

Joe Carr describes lightning and discusses how to observe its effects in relative safety - page 50.
Reasons to be cheerful...

Work, as the old saying goes, is the curse of the drinking classes. But work has to be done to pay the bar bills, the mortgage and everything else. At least for some the worry these days is finding the work, even whether it'll be granted the privilege of a job. What will the prospects be for designers—and everyone else in the high-tech industries? What will you be doing in eight years' time? Have you any idea? The truth is, you don't know and nor does anyone else, even though our jobs are all at stake.

In fact the future is famously unpredictable. You can never eliminate uncertainty, which has the power to wreck well-honed business plans—as the events of 11 September did for the air travel industry and all its dependents. It's too clear that collapse was never envisaged when ITV Digital was launched.

Unpredictable events can also bring blessings and for firms that can handle such eventualities, they can be highly beneficial. Experts say you cannot plan for unpredictability, but you can at least align your business process to recognise it and then react positively. The trick is to allow for uncertainty without descending into anarchy, so you can turn uncertainty to your commercial advantage.

In other words, the winners will be those who can manage uncertainty the best. That must be encouraging for those working for enlightened employers but will the rest of us still have jobs in 2010? Two reports provide a pointer. A study by BT, "Everyday Life in 2010", predicts that automation will eliminate jobs not dependent on human creativity. Computers will become intelligent personal assistants, greatly boosting the productivity of those with jobs.

Some of today's service industries will no longer exist and firms performing broker or intermediary-type services will be replaced by computer programs providing the same functions for nothing. Only for skilled programmers and computer manufacturers will this be good news.

Big business will not eliminate small companies, however. Some companies may be truly global, with workers on every continent, picked specifically for the task in hand. But their exclusive concentration on core activities will make them more reliant than ever on small and local companies.

Personal motivation will be vital; by 2010 the notion of the job for life will be totally extinct. Most workers will change jobs frequently, working for virtual companies composed of a core of mission-critical project leaders, augmented by skill providers employed on short-term contracts. To avoid the need to move location every time they change job most people will telework but not at home like a few manage today.

Because of the distractions and the fact that most houses are not built with space for a dedicated office, many of us will "go to work" in communal local telewires centres, equipped with all the technology and facilities we need.

People have social needs at work, which these centres will provide, doubling in the evenings as community centres for education and entertainment. It sounds almost utopian—we shall actually work next to our neighbours, strengthening the local community while reducing commuter stress. Fantastical?

More of the same can be found in the report 'Tomorrow's World', written for employment company Kelly Services by Institute of Directors Chief Economist Garee Leach. Looking a decade further at the year 2020, the study predicts major change across the job market, both in structure and in attitudes.

Continued outsourcing will mean a quarter of the workforce will be temporary workers, up from 6% today, with self-employed people accounting for another 20-25% of the workforce. The growth, freelance consultants with high skill levels and experience working for clients or a freelance basis, will be in strong demand. For the remainder of workers, a good recruitment consultant will be as essential a good accountant is now.

In technical professions expertise will figure highly and companies will have greater difficulty retaining their best staff. Performance-related pay and flexible reward packages will increase, with employees able to make up their pay from a wide range of benefits from extra holiday to childcare. Many staff will work a six-day week with flexibility to work earlier or later in the day to suit their lifestyle and family commitments.

Nights, rather than lower, skill sets will be demanded and because knowledge will be obsolete within a few years, short courses and refresher sessions will become part and parcel of normal work. For their part, workers will have to commit to life-long learning if they want to retain pole position in the job market and take maximum advantage of changes on the way.

If this sounds encouraging, then it's extremely happy. On the other hand the forecast could be rather. Either way, it's our job to use uncertainty to our advantage!

Andrew Emmerson
Software automatically designs analogue chips

Firms from Canada and the US have developed software that can automatically generate analogue chip designs.

Canadian firm Analog Design Automation (ADA) calls its own products Creative Genius and Explorer Genius. The creation tool takes a circuit topology including a transistor level net list, test benches, process information and environmental data. Raw circuit data for the tool comes from standard analogue design software such as that from Cadence and Mentor Graphics. The designer inputs the circuit objectives, such as output impedance, slew rate, area and power, and the tool creates multiple circuit solutions that meet the goals.

The software can take account of many variables, such as process variations, temperature ranges, voltages and transistor parameters. "It would take a designer several months to come up with all the circuits Creative Genius can produce in a matter of hours," said Amit Gupta, a co-founder of ADA. "Since our algorithms can handle all the values simultaneously, we can push the limits of the designer's objectives." The Explorer tool is used to sort the output from the Creation tool, examining design trade-offs. Once the final design is selected, component parameters are automatically back-annotated into the schematic.

- Barcelona Design has unveiled a synthesis tool for analogue chip design. Called Prado, the software is a platform for combining analogue circuit engineers, said the firm. Each engine focuses on a specific topology or circuit type, such as phase-locked loops or op-amps.

Prado includes placement and routing of the completed analogue circuit design. "Barcelona provides a radical new alternative for implementing analogue circuits," said Thomas Heydier, CEO of Barcelona Design.

The firm said the software could reduce design time from months to hours, and would be particularly useful when designing mixed signal ICs.

Mitsubishi has already started using the tools at its System LSI division. "It is clear their approach to analogue circuits offers unprecedented speed and flexibility," said Yassyuki Nakamura, engineering manager at Mitsubishi.

Breakthrough in nanotube research

Carbon nanotubes are being touted as future components in next-generation integrated circuits and micromachines.

Unfortunately they are difficult to grow on demand and virtually impossible to grow in a set direction. Now workers at the Rensselaer Polytechnic Institute in the US claim to have achieved controlled nanotube growth, perpendicular to a prepared silica-coated substrate.

"This is the first step toward making complex networks comprised of molecular units. By manipulating the topology of silica blocks, and utilizing the selective and directional growth process, we have been able to force nanotubes to grow in predetermined, multiple directions, with a very high degree of control. No one else has done this," Gauvapathiraman Ramanathbooth, Ramanathbooth, with fellow materials scientists Pulickel Ajayan, have combined formerly disparate areas of research to grow their nanotubes. With the shaped silica surface they use gas phase delivery of a metal catalyst, essential for nanotube growth which, they claim, makes their process more flexible and more easily scalable than conventional methods.

"It's a simple and elegant process that provides unprecedented control over nanotube growth," said Ajayan.

Workers at the Rensselaer Polytechnic Institute in the US claim to have achieved controlled nanotube growth, perpendicular to a prepared silica-coated substrate.

Biotec sensor... US scientists at the Ames Laboratory and the University of Michigan have developed a fluorescence-based chemical sensor that integrates its own organic LED. The compact device could have uses in biomedical and biochemical research, monitoring gases, organic compounds and biological organisms.

Conventional sensors use a laser or inorganic LED as a light source, which makes the resulting device bulky and expensive. The Ames/Michigan combines the organic components in a single device. Integration and miniaturisation of fluorescence-based chemical sensors is highly desirable, as it is the first step towards the development of fluorescence-based sensor arrays that could be used for analysis of living cells and organisms, and biochemical compounds," said Joseph Shinar, a senior physicist at Ames.
New ARM device has audio and video handling instructions

Cambridge-based ARM, whose processors dominate the mobile phone market, has revealed details of its first 64-bit architecture processor, of adds audio and video handling instructions to ARM's CPUs which will suit it to consumer and wireless applications, including videophones, said the company.

Called ARM11, the new processor will yield 350 to 500MHz processors on a 0.13um process, said Dave Corinne, ARM CPU product manager. "0.10um parts should work at over 1GHz."

The company's Jazelle Java instruction decoder and Thumb-16 bit instruction decoder will come as standard with ARM11 as will some DSP capability.

The processor has an eight-stage pipeline and will be available with and without a floating point co-processor.

The pipeline includes dynamic branch prediction. "It is a single-cycle design, so it has simple instruction decoding to keep power consumption well under control," said Corinne. Consumption is projected to be 0.4mW/Hz at 1.13mV/cm and with two 32Kbyte caches, ARM11 will fit into 7mm^2 on a 0.13um process.

It will be available in the last quarter of this year, with high-performance variants from ARM partners out before the end of 2003.

ARM also announced ARM1026EJ-S. Based on v5 architecture, it is the first synthesizable ARM10 and the first ARM10 to include a Jazelle Java instruction decoder.

This processor should operate at between 270 and 325MHz - giving 400 Dhrystone Mips - and occupy around 260,000 gates.

2.4GHz UK wireless network planned for WWW access

BT plans to build a 2.4GHz wireless LAN network with 400 base stations by June next year. Within three years, the firm expects to have 4000 sites in public areas such as hotels, railway stations, airports and bars.

The decision to build the network is conditional on the Radiocommunications Agency allowing communications in the unlicensed 2.4GHz band - a move it is said to be pursuing.

"We intend to build a national network of access points around key public sites... all within reach of business travellers, commuters and other users," said Pierre Donan, CEO of BT Retail.

Anyone within a 1km range of one of BT's "hot-spots" will gain access to the Internet if they have the firm's software on their PC or PDA. Access speeds will be up to 500kbit/s, BT claimed.

"One of the advantages of Wireless LAN is the simplicity of its adoption, requiring no additional cabling and no digging. By only modest investment, we'll achieve a high-speed network and be able to exploit BT's existing and growing broadband network," Danon added.

BT Wholesale has also announced plans to trial high-speed Internet access over satellite.

Aimed at small businesses and residential customers, the service would be attractive to people outside of cable and DSL equipped areas.

"This is not true broadband, but it will give much faster Internet access to many people who could otherwise be denied," said Paul Reynolds, chief executive of BT Wholesale.

A 65cm dish would deliver the service to a 256kbit/s service, with the return path via a slower modem line. Up to 4Mbit/s could be available at higher cost.

US start-up produces 2GHz number cruncher

This is FastMATH - a 2GHz MIPS processor-based number cruncher from a US start-up company called Intrinix.

Aimed at 'adaptive signal processing', it includes a 2GHz matrix/vector processor, 1Mbyte level 2 cache and two 2GHz RaptorIO ports. Performance will be 32Gims - 64Gops - claims Intrinix.

"FastMATH is six times faster than a Texas Instruments C6416 running at 600MHz," said Company v-p marketing Scott Gardner - comparing 1024-point radix-4 FFT times.

To get the speed, Intrinix uses dynamic logic implemented in an 0.13um process and designed using its proprietary Fast14 tools. A 0.10um-400MHz version is planned.

Potential applications include calculation-intensive tasks in mobile communication and signal processing. Gardner takes the example of MUD - multi-user detection in mobile phone masts. "4-user can be supported in two FastMATH chips versus eight desktop processors and an FPGA," he said.

Power dissipation at full speed will be "well under 20W", claimed Gardner. Samples are due in the last quarter of this year with production at the end of next year. Software tools should be out this summer.

Intrinix is also planning FastMIPS, a version of the chip without a matrix processor which should also be out at the end of this year.

Towcester company wins $3m computer contract

Towcester-based VME-based computer maker Radstone Technology has won a $3m contract to supply computers for the Abrams Battle Tank M1A2.

As part of the tank's continuous electronics enhancement program, Radstone is integrating its latest generation rugged COTS (commercial-off-the-shelf) Power PC processor, Called General Purpose Processor (GPP), it supports on-board mezzanines and will allow for improved capabilities in both crew operations and vehicle diagnostics, said Radstone.

This is an initial order covering around 50 tanks. Over 2000 M1A2 tanks are currently in service with the US Army and other nations.

The Abrams is the US Army's main battle tank. The update includes a distributed data and power architecture and a radio interface unit which allows transfer of digital battle situational data.

www.radstone.co.uk

Radstone Technology has won a $3m contract to supply computers for the Abrams Battle Tank M1A2.
Researchers to develop new user interfaces for PCs and PDAs

The UK's Central Research Laboratories (CRL) is running a two-year, H3-4m project to develop new user interfaces for PCs, PDAs and other computing devices. Physical objects will be used to indicate to the computer what information the user is seeking.

"It's about enabling people to use information sources in a more intuitive way," said John Holdren, director of the multimedia group at CRL.

Robot interacts with humans

US company ActivMedia Robotics has designed a robot for interaction with humans. Called PeopleBot, it is a mechanical base on which owners can overlay complex behaviours. ActivMedia sees it being programmed as a waiter, a tour guide, a mobile security camera or an advertising gimmick among other applications.

Various models are sold and features can include a gripper, table-scanning infra-red detectors and a pan-tilt camera. Harry, from its maker ActivMedia Robotics, meets PeopleBot.

Aiwa plant saved from closure

Aiwa Manufacturing Services is the new name for the plant which used to be Aiwa's manufacturing centre in Wales. Trevor Wilkinson, MD of Aiwa's manufacturing facility in Newport, says the closure will help safeguard the jobs at the Newbridge plant and support the continuing development of the Welsh electronics industry.

Government will help to safeguard the jobs at the Newbridge plant and support the continuing development of the Welsh electronics industry," said Andrew Davies, economic development minister for the Welsh Assembly Government.

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Holographic drives could hold 500Gbyte and transfer at 750Mbit/s

A Cambridge University spin-off is developing holographic data storage techniques that could lead to 500Gbyte discs with read and write speeds of 750Mbit/s.

Polight's first generation product will be called Holodisc and is expected to be available by 2004. In comparison, a DVD offers 4.7Gbyte capacity and read/write speeds of around 360Mbit/s. The memory density will be five times that of conventional magnetic hard disks, said the firm.

"Holographic data storage is the next big step forward for the removable data storage industry," Polight's materials and the company in the unique position of holding a key that will enable holographic data storage to become reality," said Michael Ledzion, Polight's CEO.

The firm's technology derives from research carried out by Professor Stephen Elliott of Cambridge University. His research led to chalcogenide glass materials that are changed both physically and optically when exposed to laser light. Information is stored in the material using optical interference patterns inside the photonegative material.

Furthermore, no processing is required after the laser stage to "fix" the data in the glass.

Each interference pattern stores a hologram, and hence large amounts of data in one go. Ledzion reckons that 1.3byte of data can be stored per hologram. Indeed, it is this that leads to the very high data rates when reading and writing data.

If Polight is successful in bringing products to market, initial applications for the storage medium are expected in archiving and data backup.

FFT cores for demanding filters

If you have a very demanding filter application, look of Wight-based RF Engines may have the answer.

It has released details of its "veetis" family of multi-radar architecture, pipelined, complex fast Fourier transform (FFT) cores. The first family, vectors0082, can continuously process data at up to 200M samples, which the company believes is one of the world's fastest FFT cores of its type.

vectors0082 is a complex 4096-point FFT processor licensable as intellectual property that fits into a one millimetre gate Xilinx Virtex E FPGA.

It is intended for applications including high-speed networking subsystems, VDSL, communication systems, electronic warfare, radar and signals intelligence systems design.

"One of the most important points is that we have a fully implemented design working in silicon, rather than just vapourware," said John Lillington, the company's chief technical officer. "The design uses a high degree of parallelism, the multipliers used are optimised for the target device allowing flexibility to use a mixture of embedded and logic built multipliers. We confidently expect to further refine further the upcoming cores in this family, achieving significantly faster performances, over 800MHz, with higher radix architectures in Virtex II devices."

RF Engines' John Lillington.

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Kit provides eight relay outputs capable of switching up to 250 mA and four optically isolated inputs. Can be used in a variety of control and sensing applications including load switching, external input sensing, output state and external voltage sensing. Programmable via a computer serial port, it is compatible with ANY computer & operating system. After programming, PC can be disconnected. Serial cable can be up to 5m long, allowing remote control. User can easily build battle file programs to control the kit using serial commands. NO special software required - uses any terminal emulator program (built into Windows). Serial terminator connections. All components provided including a plastic case with pre-punched and silk screened front panel to give a professional and attractive finish (see photo).
As a first step in breaking new ground in relation to how capacitors can contribute to the 'sound' of a hi-fi amplifier, Cyril Bateman has designed a spot-frequency oscillator with sub-ppm distortion. Many capacitors introduce distortions onto a pure sine-wave test signal. In some instances this distortion results from the unfavourable loading that the capacitor imposes on its value or semiconductor driver. In others, the capacitor generates the distortion itself. Most properly designed power amplifiers measure less than 0.01% distortion when sine-wave tested at 1kHz. This distortion percentage equals to 100 parts per million. Such small distortions are believed to be inaudible, yet people often claim to hear distortions from these amplifiers when listening to music. 

Many authors claim to have identified differences in sound between different capacitor types. These differences have been ascribed not by measurements though, but by listening tests. This has led to a retrofit upgrade market supplying "better" audio grade capacitors at substantially elevated prices compared to mass market types.

A common subjective claim is that oil-immregnated paper capacitors sound better than film types in valve amplifiers. Others claim that a PET capacitor sounds "tubby" while a polypropylene sounds "bright", and that all ceramics sound awful. Naturally these claims have no supporting measurements. Many writers on this topic even decry measurements, prematurely in case such measurements disprove their subjective claims.

I have regularly received requests for advice about capacitors from readers who have read the many, often conflicting, subjective views about capacitor types. Over the years, these pages have also echoed to disputes between amplifier designers and music enthusiasts regarding capacitor sound distortion. These disputes culminated in a particularly acrimonious debate 9 years ago, during which I offered to perform some comparative measurements.

As a long term capacitor designer and measurement engineer, I believe that any truly audible differences must be both understandable and measurable. Understanding should be in terms of the capacitor constructions. Measurements may even offer a change in measuring techniques.

In order to develop suitable test methods, I have measured large numbers of capacitors of many types. From these measurements, I have determined the distortion differences between capacitor constructions.

What I did not expect to find - and I find this rather disturbing - is that within a small batch of capacitors, some exhibit abnormally higher distortions. These anomalous capacitors typically exhibit some ten times greater distortion than others, taped on the same card strip.

In this, the first of a set of articles, I begin to honour my commitment to quantify capacitor distortion.

What the tests involved

Using a scheme involving a test signal at 1kHz, it is possible to differentiate between capacitor types and between good or bad capacitors within a type, Figs 1, 2. In all performance plots, the 1kHz fundamental has been attenuated some 65dB using a twin-tee notch filter. The test capacitors for this article were each subjected to a three volt test signal, as measured across the capacitor terminals.

Rather than perform measurements using sophisticated equipment, I decided to develop a low-cost method that could be easily replicated by any interested reader. In doing so, I hope to improve understanding of capacitors and reduce the number of capacitor disputes in the letters pages.

Initial investigations

Spectrum analyzers capable of measuring small distortion components are prohibitively expensive for most people. I wanted to make sure that performance measurements could be made using readily available test gear like the Picoscope ADC-100 A to-D converter or a computer sound card with FFT software.

I started by carrying out some initial capacitor intermodulation tests. Experiments involving simple harmonic distortion testing revealed easily interpreted differences when testing less good capacitors. Testing good capacitors however confirmed that my existing signal generators introduced far too much distortion.

A much better signal generator...

Having reviewed past low-distortion oscillator designs, I bread-boarded the more promising ones. Using these I tested a number of capacitors but with only partial success. From these results it became clear that I needed an extremely low distortion 1kHz sine-wave. I had to be able to drive at least 3 volts into a 1000Ω/1pF near perfect, low distortion capacitor load, and do so without this load distorting my test signal, Fig. 3.

To test this near perfect capacitor, measured distortions of my complete equipment needed to be less than 1ppm, or 0.00001%. This is approaching the order of oscillator distortions produced by expensive measuring instruments such as those made by Audio Precision.

So began the design of a suitable test oscillator with a price that would be within the reach of most of you. The design of this oscillator forms the subject of this first article, Fig. 4.

Initial researches

My attention was caught by a remark about "future Wien bridge oscillator design" in John Linsley Hood's 1981 description of a 0.001% Wien bridge oscillator. Most Wien bridge oscillators use a single amplifying stage. John suggested a method spreading the capacitor/resistor elements over two stages. This reduced the drive into his first amplifier and thus reduced its distortion.

I ran some simulations and compared the predicted performance with John's earlier views about lower distortion using this configuration. These simulations also suggested a possible improvement. Usually, the two Wien bridge arms use equal value components. With John's new arrangement this results in his second amplifier having double the voltage output of his first.

I decided to double the capacitance and halve the resistance of the series combination. This would provide equal output.
COMPONENTS

While I used ultra-low distortion, but expensive, AD797 ICs for U3 and U4 when building my final 1kHz oscillator, almost all its circuit development was done using low-cost NE5534A ICs. I found some 6dB difference in distortion between these two IC types in my oscillator.

I have tried other ICs for the oscillator, including the low-distortion OPA34 and OPA4604. To facilitate evaluating ICs I used Harwin turn pin sockets for each position.

When using the AD797 for U3 and U4, it is preferable to fit a 50pF capacitor between pins 6 and 8. If you are using NE5534A ICs, it is preferable to fit a 22pF capacitor instead between pins 5 and 8. Neither capacitor is needed when using OPA34 or OPA4604 ICs.

The oscillator capacitance must be low-distortion types, preferably 1% extended foil with polystyrene, as shown in the photograph. However I have also built satisfactory working prototypes with 1% extended foil with polystyrene and 1% metallised polypropylene, in order of preference.

Obviously a good ceramic capacitor would work almost as well as my first choice of polystyrene, provided the COG capacitor is available selected to 1% tolerance. My PCB provides mountings for a very handy suitable capacitor.

The value of VR1, needed to minimise distortion will vary depending on which type IC and tuning capacitors are used. I found that only the NE5534A IC provided low distortion when used for the output buffer, U5. For this lowvoltage gain component, the 22pF capacitor is essential. Also for its gain control, I found one other sampler compatible variable resistor. That was a Bourns 91 series conductive plastic, obtained as 148-557 from Farnell. Similar types may be OK too, but I have not tried them. Don’t use either cermet or wirewound controls for this position though. I have tried several and they certainly do not work acceptably.

The 50p/22pF capacitors must be low-loss, low-distortion types. Polystyrene types are preferable, but disc ceramics COG only – can be used. Similarly for the remaining picoradial capacitors used. I used COG ceramics for my prototype. The PCB drawing provides for both alternatives.

In each case, my preferred IC choice is the first type listed on the schematic diagram. To produce such a low distortion oscillator it is important to use resistors having a small voltage coefficient of resistance. To ensure as much as a reproducible design, I used only 0.5% Vishay/RCSC metal film resistors in the signal path. These are the black components in the photograph. These are marked at 0.5% on the schematic.

These resistors use plated steel end caps, which I prefer for reliable long term end contact stability. Many subjectivists claim non-magnetic end caps are better. I do not subscribe to that belief.

Undoubtedly, some of the oscillator output distortion is generated inside the three multi-laminate Ceramic trimmers. In these two positions, these trimmers are essential. However the printed board does provide mounting pads for a fixed resistor, which could be substituted for VR5, once its

value has been determined during calibration. So far I have retained use of the trimmer on VR5.

While these RCSC types could be used throughout, I used a standard, inexpensive 1% metal-film resistors, for all other positions.

The VR1, IC3, and IC4 type variable capacitors are used in the gain control circuits. The particularly useful ‘Nital’ types visible in the photograph are available. These are slightly larger Panasonic BP types. Both are IC types, but unfortunately no conventional polypropylene electrostatic capacitors for these positions.

For such a low-distortion oscillator, it is essential to use good quality capacitors to decouple the power supply. For the 0.1μF value, black in the photograph, I used Eves-RIFA SUS, metallised polyethylene-sulfide film. I consider this film produces the best, small, low cost, universal capacitor. They were 10μF types, but unfortunately the company has since stopped supplying them.

Alternatively, a good metallised PET capacitor, such as the Eves-Rifa MMK or BC Components (Philips) 470μF series, should be satisfactory. I used many of both these types, in my tabl meter bars.

For the larger capacitors, I used BC Components twin-tee filters, with 50μF tantalum capacitors, as shown in the photograph, and Rubycon YXF polystyrene electrolytics. Again, other types should be satisfactory, but they have not been tried in this circuit.

However, the oscillator is powered from my laboratory supply, so to output a 18 volt.

results, I designed a simple rectifier and IC control amplifier and tested the composite assembly.

With a 3 volt drive, this set up produced the desired near 0V control voltage to the SS2M018P. Distortion however was far worse than my simulations had suggested. Time for a rethink, Fig. 6.

Accident or design?

I returned once more to my simulations. To approximate the actual ESR losses of the tuning capacitors, I had inserted some inductance in series with each device. As some time during my many simulation runs, I had misseted the entry of this ESR estimate for the shaft feedback capacitor. Instead of 100pF I had input 100Ω. Could this explain my differing results?

Looking back to my breadboard, I inserted a 1kΩ ten-turn variable resistor, set to its minimum value. I adjusted it to replicate my typographical error while measuring the circuit. To my amazement, I increased the distortion value above 100Ω, the distortions rapidly disappeared. Why?

Certain that I had made a mistake, I repeated this adjustment and measurement many times. The results were consistent. Even better, with the variable resistor left above this value, the oscillator could be powered down and restarted, and each time it settled to the new lower distortion output, Fig. 6.

I decided to re-read the data sheet for the AD797 amplifier, which I hoped to use in my final implementations. This IC is claimed to have the lowest distortion figures of all the popular audio op-amps, but I don’t believe it.

After re-reading more carefully, I spotted a paragraph I had previously ignored. This dealt with using a small feedback capacitor C7, in parallel with the feedback resistor R5. “When R5 is greater than 1000Ω and C7 is greater than 33pF, a 100Ω resistor should be in series with C7”.

As one would with many Wien bridge and Sallen and Key filter designs, I was using a much higher feedback resistor of 159kΩ in an parallel with a very high feedback capacitor of 10pF. I examined the data sheets for the NE5534 and several other ICs I had considered using, but did not find the same recommendation. I found that this added resistance worked well in the circuit with my NE5534A. It also worked well with all other ICs I tried in this circuit, virtually eliminating all third harmonic distortions.

Proving the design

Accidents easily happen when bread-boarding and testing prototype circuits. To avoid any expensive mistakes, I used the inexpensive NE5534A devices while developing my printed circuit layout.

To further enhance attainment of my desired low distortion, the circuit would need screening, good earthing between sections and careful supply rail decoupling. Presumably makes a 75 by 75mm PCB board mount screen can with removable lid. It’s available from Farnell. This size could accommodate just the oscillator component. The next size can was much too large. Using the smaller option required leaving my amplitude control components unscreened.

The prototype PCB layout worked extremely well, except for the output amplifier. Driven with 3 volts, my original output was measured badly. Following more breadboard experiments, the board was modified to accept another NE5534A. This was arranged as a variable gain, inverting amplifier, Fig. 7.

Choosing a gain-control pot

Choice of the gain control potentiometer was crucial. I evaluated four types, wirewound, ceramic and two different conductive plastic types.

Wirewound alternatives generated intolerable distortion;
between pins 5 and 8. The revised circuit board provides for both options. Note that it is crucial to use only close tolerance and low-distortion capacitors for both these positions. Preferred types are 1% foil/polyester or COG disc ceramic.

**Final testing**

To permit accurate measurements of this oscillator's distortion and facilitate calibration using either the ADC-100 or a sound card, a pre-notch filter is essential. The ADC-100 in its spectrum-analyser mode provides selectable peak input levels up to 20 volts. Its OdB reference is fixed nominally at ±1 volt.

Having a 12-bit resolution, the ADC-100's dynamic range is limited to just 90dB. Most sound card's 44.1kHz converters inputs are limited to 2 volts peak or less, but having 16 or more bits, they can provide more dynamic range.

To measure down to ~130dB below 3 volts with either of the above, the fundamental should first be reduced by some 60 to 65dB. To minimise the influence of ambient interfering noise and attain a more readily measured signal, this reduced fundamental and the harmonic voltages must be pre-amplified by some 40dB.

Using a 3 volts test signal, this amplified fundamental and distortions results in a measurement voltage of around 0.3 volts RMS. To minimise wideband noise and extraneous pickup from AC mains or your PC, the signal should also be band-pass filtered.

**Making measurements**

I have designed a second printed circuit board that houses a low-distortion, passive pre-notch filter. To permit matching the notch frequency to that of the oscillator output, the notch is tunable by some ±10% from its nominal frequency. Nominal input impedance of the filter is 10kΩ. A high impedance unity gain, low noise pre-amp can be switched into circuit, should this passive notch loading be excessive.

Four stages of low-noise, low-distortion, amplification and bandpass filtering follow the notch filter. All measurements shown in this article were made using this pre-notch filter/pre-amplifier as the input into my ADC-100 converter.

**Other measuring methods**

Early carbon film resistors were trimmed to their final value by grinding a spiral groove into a resistive element coating on a ceramic former. Resistor noise and non-linearity was significantly reduced, compared to the older composition resistor. Incomplete or badly ground spirals frequently resulted in component failures under load.

In the sixties, engineers at Ericsson believed that non-linearities in capacitors and resistors could be detected. They measured the level of third-harmonic distortion generated in a component subjected to a very pure sinewave test signal. Non-linearities were believed to result from badly ground resistor spirals, poor electrical contacts and the use of non-linear materials.

The engineers' original non-linearity detector design produced low-distortion test signals at 10kHz and 50kHz. Third harmonic distortion generated by the component under test was passed through bandpass filters for measurement. Subsequently the 50kHz test frequency was dropped and a commercial instrument—the CL11 component linearity tester—was produced by Radiometer of Denmark.

To accommodate the range of capacitor impedances and test voltages needed, a low-distortion output transformer was used. Having seven adjustable tappings, it was used to tightly couple the instrument to the component under test. Component impedances from 3Ω to 300kΩ could be measured.

Today, an updated version can be obtained from Danbridge A/S, Denmark—a specialist manufacturer of capacitor test instruments. Using such equipment makes testing resistors quick and easy, however the extremely low impedance of many capacitors at 10kHz requires using extremely small test voltages. Blind and oxidised connections can be discovered. From my work though, I find detection of certain capacitor distortion effects—especially with electrolytic types—requires a much increased test voltage.

These capacitor distortions cannot be measured at very low voltages. To avoid overloading the test capacitor or the equipment, this increased voltage test must be performed at lower frequencies. Extremely tight coupling between the test capacitor and the linearity tester is implicit in the CL11 equipment design. From my early work measuring capacitors, I found it necessary to loosen this coupling in order to clearly reveal anomalies found in modern capacitors. Fig 1

Using trial and error when measuring known good and bad capacitors at 1kHz, I found that 100kHz is a series with a 4.7μF capacitor provided the best compromise between measuring current and capacitor voltage. This resistance value needs to be adjusted according to the capacitor's impedance at the test frequency used.

**Jung-Cal test**

Some twenty years ago, a simple capacitor test method used an inverter/amplifier to compare the differences between a test and reference capacitor. These capacitors were connected in series with each of the instrumentation amplifier inputs, then subjected to a rectangular test wave.

**Fig. A**

The circuit formed a traditional Wheatstone bridge.

Using a sinewave stimulus, a test capacitor was compared with a known reference capacitor. When a rectangular wave test signal is used though, interpretation of the output waveform was impracticable, unless both capacitors were of similar value, dielectric and construction.

For most capacitor constructions, capacitance does vary with test frequency and test voltage. For all capacitors, using dielectrics other than air or vacuum, equivalence at any one test frequency is difficult. In my tests, ESR reduces with frequency, reaching a minimum at the capacitor's series self-resonant frequency.

Differing dielectrics and constructions thus result in small differences in ESR and impedance with test voltage and frequency. The differences simply cannot be adequately resistively nullled. This imbalance led to a variety of unsatisfactory explanations and interpretations, often involving dielectric absorption.

Having tried and failed to reconcile the output waveforms when using previously characterised capacitors, my advice is to use this circuit only with a sinewave test signal, as a resistance or capacitance bridge.
COMPONENTS

Calibration

Calibrating this oscillator requires a suitable spectrum analyser, distortion meter or preferably my low cost pre- notch filter/Attenuator preamplifier. This is shown in Fig. 10 and will be detailed in my next article.

Prior to inserting the SSM2015, trimmer VR1 should be set to its mid value. Similarly, prior to inserting U1 and U2, trimmers VR2 and VR3 should be set to their starting values shown on the diagram. These values give a good starting point and should ensure the oscillator starts reliably. Output at the test point adjacent to VR3 should be around 3 volts.

Monitor test point adjacent to C31 using a DC millivoltmeter. Adjust VR5 only to attain near zero volts. With the scope-screen cover fitted in place, allow the circuit to fully warm up for at least 20 minutes.

Observing the output spectrum at the test point adjacent to VR3, using the high impedance preamplifier, you will probably see significant distortion products, Fig. 5.

Slowly increase the resistance of VR5 and simultaneously adjust trimmer VR1 to zero volts on the test point adjacent to C31. This will help reduce the third and higher odd harmonic components.

Adjusting VR5 and VR1 will also slightly change the oscillator frequency. If you are using a pre-notch filter, re-adjust this filter tuning to maximise notch depth. Distortion products should suddenly reduce as you approach the optimum resistance value for VR5, Fig. 6.

Reconnect your test probe to the test point adjacent to VR3 and adjust VR3 to minimise the second harmonic component only. This adjustment has little effect on the higher harmonics which should be ignored.

Return to monitoring the test point adjacent to VR3 and slowly adjust all three trimmers as above to minimise distortion. This completes the oscillator calibration, Fig. 8.

Test or select U3. Attach a 600Ω resistor load to the 'out' test point and adjust the conductive plastic potentiometer to give a 3 volt output. Monitor the distortion spectrum at this 'out' test point, and compare with that previously attained at the test point adjacent to VR3. Both should be almost identical. If not replace U3 and retest.

While monitoring the 'out' test point, you may be able to slightly reduce the overall output distortion by making small adjustments of the three variable trimmers, as above. Distortion with 3 volts output with 60Ω load, should be considerably less than 1ppm, Fig. 8.

By varying the output potentiometer, the output voltage should range from less than 0.2V to more than 4V. 'Adjust on test' resistor positions have been provided for R3A and R10 to ensure attaining this output voltage range.

References

1. CLT Component Linearity Test Equipment data sheet, RED Instrument AS, Copenhagen.

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es the associated hair cells to emit pulses of electricity into nerve fibres that are joined to it. These nerve fibres are part of the auditory nerve, which leads to the brain.

The other set of hair cells, the outer hair cells, mostly have attached to them nerves coming from the brain. The attached hairs appear to alter the shape and mechanical properties of the tectorial membrane in such a way as to alter the sensitivity of the inner hair cells.

It is very likely that this is a feedback system and is responsible for the logarithmic response of the ear to sound pressures: the ratio of the loudest to the quietest sound powers that we can (safely) hear is some $10^4$, or $10^{14}$. In fact, it is useful to look at the whole ear and brain system in electronic terms.

We have an acoustic filter (the pinna) followed by a transmission line (the ear canal), which leads to an acousto-mechanical transducer, the ear drum. This is part of a variable transformer (the ear-drum, bones and oval window), and the oval window re-converts the signal to the acoustic form but in a liquid, not air.

The basilar membrane and the inner hair cells then act as a frequency analyser and an analogue-to-digital converter, feeding a massively parallel - some 3500 bits wide - interface (part of the auditory nerve) with the brain computer. This computer feeds signals back through an even wider parallel interface to the outer hair cells, which control the nerve impulses into analogue mechanical movement, forming an amplitude compression and automatic gain control system.

If, like Nature, you had to make a filter, a microphone, an amplifier and an analog/digital compressor, out of bone and jelly, could you do better?

**Not hearing so well**

There’s a number of ways in which the hearing system can be faulty from birth, or become faulty later. The proper terms are hard of hearing, meaning that you can’t hear so well as other people, deaf, meaning that you have great difficulty in hearing, and Deaf, with a capital “D”, meaning that you can’t hear almost, or completely, nothing.

The human ear has quite a lot to reserve; most hard of hearing people do not notice a problem until they have more than 20dB loss of sensitivity compared to that of the average young person (not deformed by pop-concerts) over a substantial part of the audio spectrum, usually the high end.

There are two broad categories of fault. One is conductive deafness, which is usually due to the mechanical system being clogged up with the after-effects of an infection, resulting in a loss of sensitivity which is often quite uniform over most of the audio frequency range. The other is sensori-neural deafness, which is due to degeneration of the basilar membrane system and usually exhibits a dramatic loss of sensitivity to high frequencies.

The accepted method of combating hearing loss is to provide electronic amplification, with a frequency response tailored so as to compensate for the loss. It might be thought that ‘shouting louder’ would cause further loss of hearing, similar to that experienced by exposure to high sound levels in the workplace.

In fact, any such effect is at worst tolerable, and there is no other real alternative, unless (intra-ear) corrective surgery can alleviate conductive loss. No such remedy is at present available to alleviate sensori-neural loss.

**Electronic help**

The use of headphones to listen to radio and television eliminates the need to have the sound volume in the room annoyingly high for other listeners. In addition, using headphones is often more satisfactory than listening with a hearing aid. This is because the omnidirectional microphone of the aid picks up room reverberation and extraneous noises.

**John Woodgate** has devised a very simple circuit that enhances the listening experience of people with impaired hearing when using headphones.

---

*S. John Woodgate, B.Sc (Eng) C. Eng. MIEE FAEs FirstGCE*
Figure 5 shows the circuit diagram. The (assumed) 120Ω source impedance of the headphone output of the signal source, the 39Ω resistor and the d.c. resistance of the inductor (78Ω) form an approximately 8.1 voltage attenuator (18dB) at low frequencies. This circuit is intended to work between a preamplifier or power amplifier headphone output, which has a source impedance of 1200Ω approximately, and an amplifier or IR or radio transmitter input with an impedance of more than 5kΩ.

The tuned circuit resonates at 2kHz, with a Q of just under 0.7. The frequency response is shown in Fig. 6. Note that the vertical scale is very different from that of Fig. 2.

The input connector is a three-contact 3.5mm jack, wired for mono, as is now conventional. For a stereo system, you need two of these circuits, of course, one for each channel. The output is conveniently provided with a flying lead terminated in a three-contact 3.5mm jack plug for connection to the headphone amplifier, IR or radio transmitter.

The whole thing can be built on a piece of stripboard, or a real printed board if you wish, that will fit inside a 35mm

have the ears of an 85 year old, and they are at the sides of my head, not in a jar in the fridge.) Figure 3 shows an aid’s sound pressure levels and Fig. 4 the test set up used for the measurements.

This frequency response doesn’t look very dramatic until you realise that the rise above 400Hz achieves a slope of well over 40dB/decade, which corresponds to the very steep loss of response of the ear. This is achieved in the hearing aid by a succession of three overlapping low-Q mechanical resonances in the microphone and earphone, each causing a peak in the response.

We could reproduce this electronically with three active band-pass filters using op-amps, which in turn require a power supply. But we can do it quite well with a single, low-Q LC tuned circuit, which has the considerable advantage of needing no power supply. This is possible, in spite of the insertion losses of this passive circuit, because most infra-red and radio headphone systems have a considerable reserve of gain which is not normally used.

Circuits using inductors have traditionally been unpopular, because off-the-shelf components in standard values, like those of resistors and capacitors, were not available. You had to design, and quite possibly make, your own. This is no longer the case, although the range of components is still less than those of other resistors or capacitors. Luckily, components suitable for our application can be obtained from Farnell, and probably other sources.

The circuit design

The following parts list refers to parts from Farnell Electronic Components, which will accept credit card orders for small quantities. Rapid Electronics is another good source of parts at attractive prices and will also accept credit card orders. Unfortunately, the 68μH inductor offered by Rapid is not so good, because it has about 200Ω resistance instead of the 7Ω of the Farnell part. You could try increasing the 39Ω resistor to 1.2kΩ, but the Q will increase. This may not be disastrous, though: the application is very tolerant.

Farnell: www.farnell.com.uk, 08701200 200
Rapid: www.rapidelectronics.co.uk, 01206 751166

Parts details

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Farnell: www.farnell.com.uk, 08701200 200
Rapid: www.rapidelectronics.co.uk, 01206 751166

Film can. But is it so simple that 'a bird's nest' is also possible.

Using the clarifier

The insertion of the clarifier into an infra-red or radio headphone system will naturally result initially in a reduction of sound level from the headphones.

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Spectrum pricing comes of age

June 2002 marks the twentieth birthday of spectrum pricing. This article traces at first hand its history over those years: how it came to be conceived and got its name but was then discarded, how it was revived 13 years later, but also how governments and their economic advisers failed to understand its underlying principles.

That failure brought part of the radio communication industry to the brink of disaster in 2000, as will be relayed in next month's issue. But it is evident from the latest review of spectrum management[1] that little has been learned from that episode, as will also be recounted next month.

Spectrum pricing was first conceived in 1982 in response to a shortage of spectrum in some bands, which had begun to appear in the 1970s. The first service to be hit by the shortage in Britain was civil land mobile radio (CLR/M), as it was then known. Applicants were having to wait for years for licences and many of the best users were not been grasped by the Government or its economic advisers. David Rudd reports.

The Home Secretary commissioned an independent review under the chairmanship of Dr J. H. Merriman. The report was published in 1982. It was held up as an interim measure—the withdrawal of Bands I and III from broadcasting use and the accelerated closure of the 405-line television service in favour of CLR/M.

The Government accepted those recommendations, but Merriman's final report in July 1983[2] made it clear that he expected shortages would recur and persist across wide swathes of spectrum unless the regulatory procedures, which he said were "arcane" and "detached from the realities of service and manufacturing industry," were reformed.

In Merriman's view, the procedures would, "have to include some capability for the making of value judgements, since demand may often exceed supply."

But he did not know how to go about it.

The Department of Transport was concerned about the shortage of spectrum for land transport applications and its Transport Science Policy Unit (TSPU) submitted a proposal to that review for "A Renting System for Radio Spectrum." It was included in the final report alongside papers from the Home Office, the Office of Regulatory (RRD) and some economists in the DTI[3].

Charging rents to reflect scarcity value

I conceived and wrote that submission. As far as I know it was the first published proposal in the world—it was certainly the first in Britain—for charging spectrum users at rates to reflect its scarcity value ("opportunity cost" in the economic jargon). It had three main principles:

- G r a d u a l l y to introduce a system of charging for spectrum at rates that would reduce the demand for spectrum in any band and geographical location until it no longer exceeded the availability of spectrum there.

- N o t to try and maximize the revenue, indeed to charge no more than enough to provide that any applicant could get an allocation or assignment in any band at the going rent without undue delay, and to charge no more than the bare administration cost in any band where the demand was less than the long-term supply (larger charges would discourage the best use of spectrum).

- T o have full regard for international obligations and for users competing against foreign users receiving free assignments from foreign administrations, but gradually to bring the established British users, principally the broadcasters, the Department of Defence and the emergency services, into the charging scheme.

The proposal was intended as a long-term solution to be put in place before more shortages developed. It would effectively guide future applicants for licenses into making the most economical—not necessarily the most efficient—use of their allocations or assignments.

A set of parameters was put forward in the proposal for calculating the rents to be charged to users (see panel 1) and the options they would have to avoid or reduce their charges and so release spectrum in the congested bands (panel 2), I gave a lecture on the proposal at the Institution of Electrical Engineers (IEE) in 1985 and it was published in 1986[4].

The proposal not to exempt even the emergency services was instinctively opposed by nearly everybody. It is often still the case nowadays that although the arguments have been published several times. They are therefore repeated in panel 3 for readers who still have that instinct.

The RRD's Technical Director had proposed a "pricing" as "likely to be ineffective and contentious."

The DTI economics optimized charging an economic rent for spectrum would not be an acceptable solution unless the allocation could be deregulated and made subject to competition. And the economists concerned with subsequent reviews (including the last) seem still to be imbued with those opinions.

Feasibility study recommended

Merriman made no formal recommendation on "spectrum pricing"—as he and the RRD preferred to call the proposal—but inclined to the view that "it may well be impracticable." However he suggested that if the Government thought spectrum pricing should be pursued it should commission a feasibility study.

The term "pricing" has been universally substituted for "renting" ever since, probably because "renting" retains unwarmed connotations of "the unacceptable face of capitalism" and so on in the public mind, but the charge contributed to the subsequent confusion.

Two years after the Merriman report, the DTI, which had taken over spectrum management, commissioned a study from CSP International, which reported in March 1987[5]. But CSP departed radically from the Department of Transport's proposal. In first excluding defence and television broadcasting (by far the largest users) from the scope of the study and then allowing revenue maximization to become the guiding principle instead of matching the demand to the supply.

CSP's literature review cut out the relevant part of the Merriman report and did not mention the IEE lecture, both of which had been absent from the reports of subsequent reviewers. I criticized that study in Electronics and Wireless World later that year[6].

References

5. CSP International, "Deregulation of the radio spectrum in the U.K.", March 1987, HMSO.
7. HMSO Cm 3252, 1996.
In his second article on analysing signals using a PC and some low-cost software, Richard Black discusses Fourier transforms.

A lot of the time in electronics, simply being able to visualise a waveform is all one needs. In that case, going to all the trouble of capturing the waveform to a PC is often redundant - use an oscilloscope!

Still, there are situations where the high dynamic range of the 16-bit digital audio format is useful. Suppose you want to look at the decay of a damped oscillation. The initial amplitude may be quite high, but on most analogue or digital scopes it may prove tricky to capture both the waveform at the start and the final disappearance into noise.

Use a digital audio recorder as your digitiser, though, and you can subsequently zoom in as much as you want on the PC's screen and even perform functions like filtering and averaging after the fact to improve resolution further.

But spectral analysis is where PC-based test and measurement scores. Using the combined power of modern hardware and intelligent software, you can look at the spectrum of a waveform in detail and learn a lot about it.

The key to all of course is the famous fast Fourier transform, or FFT. A numerical version of the analytical Fourier transform, it effectively transforms a description of a signal in the amplitude domain to one in the frequency domain. Used correctly, it is a powerful tool, but if used without proper understanding it can create more problems than it solves.

The FFT takes a handful of samples and computes the spectrum that those samples represent. The handful is generally a number which is a factor of 2. The output consists of N/2 + 1 complex numbers, each representing the amplitude and phase at a discrete frequency.

If you use a mathematical package such as Mathcad to do your FFT, you will have access to real and imaginary parts, but Cool Edit does not offer such programmes (and most data analysis programmes I've seen) return only the amplitude (magnitude).

FFTs and "bins"

An essential feature of the FFT is that the frequency "bins" into which the signal is sorted are equally spaced. In audio terms a 1024-point FFT returns 513 bins each about 43Hz wide (for a total bandwidth of 22.05kHz when sampling at 44.1kHz). This can be a problem especially when working at low frequencies, and longer FFTs have distinct advantages.

Cool Edit handles up to 64k points, and Mathcad up to 1M points.

Simply selecting 1024 - or however many - data points is not enough, because the sharp discontinuity at the ends of the selection will produce unwanted artefacts in the FFT. The data must be "windowed" - multiplied by a function which, ideally, has value zero at the start and end points, value 1 in the middle and an FFT which shows a flat frequency response.

Cool Edit offers a selection of windowing functions, including the near-ideal triangular and the very well-behaved Blackman-Harris, which is in most instances the best. Just occasionally another window such as Blackman or

Hamming will give more useful frequency resolution at the expense of ultimate noise floor. With Mathcad you must "roll your own" window - for details of functions see any reference work on digital signal processing.

There will come a time when even a 64k-point FFT in Cool Edit has insufficient resolution for your needs. This can be either because you actually need to examine spectral lines that are very closely spaced or because the graphical display lacks resolution. It is ladybird by the size of your screen: you can't actually display 32768 points in logarithmic display mode though, there are several pixels per bin at LF.

In this case, three functions in Cool Edit will help. First, there are two ways of changing frequency: the stretch/compress function and modulation by another signal. Stretching works just like slowing down an analogue tape recording (there are options to change pitch or speed independently but it doesn't actually work). Averaging the frequency of the entire waveform by a factor of up to 20. You'll lose something, either in the band down - the very lowest frequencies fall into the "DC" bin which is not displayed - or in the treble (when speeding up - CE is smart enough to filter frequencies that would be above the Nyquist limit, avoiding aliasing) but signs of interest can be moved so that their spectral display is more informative.

Using modulation

Modulation is a powerful feature, but must be used with care. Under the "Generate" menu is the option to generate a waveform which is used to modulate the existing audio. Just as in RF modulation, this multiplication of one sinusoid by another results in two output frequencies, the sum and difference of the inputs.

Suppose you want to examine a series of spectral spikes centred on a 3kHz tone closely. Modulating by a nearby frequency - maybe 2800Hz - will produce a transposed series of spikes centred on 3000Hz, another centred on 5000Hz. There's no gain in resolution on an FFT, but on a logarithmic display effective resolution is much increased. If you wish, you can then speed the section up by a factor of ten or so to increase the true FFT resolution.

But the modulation is generally necessary to limit the spectrum to avoid aliasing. The third useful CE function is the "FFT filter". Technically, this is an FFT implementation of a finite-

Fig 1. Advantages of a long FFT. In 1a), the signal looks like something in the region of 55kHz when analysed with a 4k-point FFT, but in 1b) it is clearly seen to be two sinusoids at 50Hz and 66Hz thanks to a 64k-point analysis.

Fig 2. The 'Generate Tone' window in Cool Edit, set up to modulate by a sinusoid.

Fig 3. Various views of a spectrum. In 3a), the entire spectrum is viewed with a linear frequency axis, while 3b) shows the increased LF resolution of a logarithmic frequency axis. In 3c), a narrow range around 190kHz has been selected using the FFT Filter' function, and in 3d) it has been further processed by modulating by 531Hz. In 3e), after low-pass filtering, the signal has been compressed by a factor of 10, driving all frequencies upwards and making close-in sidebands clearer to see (at 10 times the offset frequency from the fundamental, itself hardly restored to 550kHz thanks to the choice of modulating frequency and frequency scaling).
impulse-response filter. It can give incredibly sharp cut-off in low-pass, high-pass or band-pass form, with no phase shift or other distortion in the passband.

This feature has options for FFT length and window: normally set window length to 512 points (=maximum and window in Blackman-Harris. I've tested this filter every way I can think of and its behaviour seems to suit all intents and purposes perfectly.

Combining these three functions, it is possible to zoom in to very high resolution on an FFT display. Bear in mind that you need a fairly long section of data to work on: A 44.1kHz FFT requires about 1.3 seconds if you are going to zoom in (compress) the signal first by a factor of 10 you need at least about 13 seconds. In fact, even more power is needed. In Cool Edit's main FFT options, there's one that allows you to 'Scan' a selected portion of audio and display an average FFT over the selection. This doesn't actually increase resolutions, but it does give a newer display and it gives the operator greater confidence that he or she is looking at real spectral peaks.

Add-ons for Cool Edit

Other Cool Edit functions can occasionally come in handy: for instance, as an optional extra ($49) you can buy a 'Pro EQ' extension pack which adds various filter options to the FFT and 'Track' filters supplied with the standard CE. Included among these is a set of 'Scientific Filters' which mimic - in both amplitude and phase - the basic Bessel, Butterworth and Chebyshev filters of various orders and configurations.

These filters aren't perfect because their performance starts to deviate from ideal above about one-third of the Nyquist frequency. They can be used though, for instance, to integrate (low-pass) filter or differentiate (high-pass) signals.

Mention of that high frequency departure from ideal behaviour brings up the possibility of converting to a different sample rate. Cool Edit can change the binary sample rates up to 2MHz - though you won't be able to play such files back through any sound card known to man.

On occasions, it is worth the time to transpose and then process data. In particular, if you want to compare non-symmetrical waveforms side by side, you can transpose to a very high rate (but use a small amount of data) and time-shift. This is only done in whole sample periods, to line them up. The 'Quality' slider controls can be set to around 400.

Another option under 'Convert sample type' (itself found under the 'Edit' menu) is to change the word length of data.

Anything read in off a CD will be in 16-bit format, as will data recorded over a sound card. For processing though, it can be useful to work in 32-bit mode.

The 32-bit mode uses floating-point storage and processing to give resolution of 14.4 (24-bit mantissa) and overall dynamic range of about 140dB in the worst, and some intermediate stage in the processing, involves much reduced signal levels. Note that 'noise' is not quantisation distortion: it is of paramount importance to ensure that the 'filter transform results' box is checked (under 'Options/Settings/Data'). A quick summary of what all this means is that all is about is presented in a separate panel.

When dealing with frequencies near the Nyquist limit it can be difficult to see what's going on as the data are shown as points joined by straight lines. Cool Edit has a visible answer.

At very high zoom levels, individual samples can be clearly seen. Instead of joining them by straight lines, CE calculates a linear interpolated curve, just like any normal CD player. This works well up to about 19kHz. To look really close to the Nyquist limit, just unzoom, or filter and modulate downwards.

As I mentioned at the start of this article, sometimes visualising the waveform itself is very useful. In this case, one may wish to employ Cool Edit's various filtering functions to home in on the desired portion of a noisy or distorted waveform.

You can for instance view the distortion residual of a waveform simply by filtering out the functional using either the FFT filter or the notch filter. Either of these will let you filter out several fundamentals so you can view the distortion residual of a multi-tone stimulus. You can also alter the level of that residual and listen to it... and so on. The possibilities are endless.

In summary, I should say that there are certainly many programmes other than Cool Edit that can accomplish most or all of what I have discussed. The principles remain the same: Cool Edit is very cheap though. To an audio-based person like me, it offers plenty of other attractions. For instance, it is one of the fastest and most versatile MP3 encoders I've seen. And if you've ever tried any audio editing at all in an Analogue domain, but never in the digital, I can guarantee you'll be hooked in minutes.

The final article in this set will employ all the tricks mentioned above in a Sherlock Holmes-like search for evidence of 'audio cable sound'.

References


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Fundamental limits: Nyquist's criterion and dither

The basic maths behind digital audio - indeed any sampled-data system - is fairly simple but not entirely intuitive. It is based on mathematical results dating back to Newton's time, but the first complete statement of sampling theory, as we know it was given by Claude Shannon in 1949.

It is Nyquist, however, who is honoured in everyday parlance, marking his realisation that by sampling N times a second one could capture a faithfully a sinusoidal waveform of less than (not equal to) 1/N of the original.

Despite many hand-waving attempts to debunk this, particularly in the audio press (and yes, I once made some myself, to my shame), it holds good.

Band-limit a signal to a less than half the sampling frequency and sampling works as claimed. Improper band-limiting leads to 'aliasing', where a signal at N/2 + x Hz will appear instead at (N/2-x)Hz and so on. On reconstruction, further band-limiting is required to prevent aliasing signals at (N/2-x)Hz which would otherwise appear at (N/2+x), (3N/2+x), etc., Hz.

Quantisation, the representation of samples by a numeric value, is in fact a separate issue. Because the number has finite precision (1 part in 65536 in 16-bit CD-format digital audio) there is inevitably distortion generated when quantisation occurs. This distortion can be very unpleasant, but the situation is entirely saved by the seemingly magical properties of property applied either. Adding a small amount of noise, with defined statistical properties, can be mathematically shown to essentially remove the distortion component of the signal, turning it into a relative harmless noise.

This means that it is legitimate to analyse signals by simply looking at the noise floor. In fact the rule of thumb, that signals below the noise floor are good as gone, is completely wrong. Dithered 16-bit audio has a maximum signal-to-noise ratio of about 93dB. Perform a 65536-point FFT, though, and that noise is divided into 32768 bins, giving a signal-to-noise ratio of 93.8dB in each bin of move like 118dB relative to a full-scale sinusoid.

For many analytical purposes, then, dithered 16-bit digital signals have a dynamic range effectively well in excess of 120dB. Undithered, that drops to more like 85dB.

Any hard copy of a CD will be in 16-bit format, as will data recorded over a sound card. For processing though, it can be useful to work in 32-bit mode.

The 32-bit mode uses floating-point storage and processing to give resolution of 14.4 (24-bit mantissa) and overall dynamic range of about 140dB in the worst, and some intermediate stage in the processing, involves much reduced signal levels. Note that 'noise' is not quantisation distortion: it is of paramount importance to ensure that the 'filter transform results' box is checked (under 'Options/Settings/Data'). A quick summary of what all this means is that all is about is presented in a separate panel.

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References


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Whether as a PC data base or as hard copy, SofCopy can supply a complete index of Electronics World articles going back over the past nine years.

The computerised index of Electronics World magazine covers the nine years from 1988 to 1996, volumes 94 to 102 inclusive and is available now. It contains almost 2000 references to articles, circuit ideas and applications - including a synopsis for each.

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More and more...

The field of engineering in general, and electronics in particular, continues to expand at an exponential rate. It is long since an electronics engineer could expect to cover the whole subject, it being necessary to specialize in digital or analogue techniques.

Each of these areas has subsequently splintered into a whole gamut of specializations, and this is mirrored in the plethora of "Freebies" or contest circulation magazines supported entirely by advertising revenue. One that I have been receiving more or less since its first appearance, is RF innovations – a publication devoted entirely to the techniques and applications of RFID – electronic tags for identifying and tracking all sorts of goods from clothing to livestock, by radio frequencies, induction loops or whatever.

The publication has carried an interesting article on Bluetooth entitled "Application processors". But despite all the press interest on Bluetooth, the general manager of Intel's Comms Group says the system is a dead duck, having lost out to IEEE 802.11. Odd, as Intel was a founder member of the Bluetooth SIG (Special Interest Group).

Another more recently launched controlled-circulation magazine is Wireless Europe, covering longer range wireless systems than those of RFID, such as GSM, 3G, GPRS, wireless WLANs (wide area networks) etc. All these magazines just seem to start arriving unannounced and unrequested, so much so for the Audi floating to livestock, which is supposed to ensure that the circulation list of a controlled circulation magazine only includes readers who have specifically requested it.

In practice, circulation lists are widely traded between magazines, inflating the lists and misleading advertisers into thinking that their adverts reach a larger number of potential customers than is actually the case. I even started getting a magazine all about paperwork, hydraulic actuators and such: interesting, but really not my field. The result is ever more wase paper and destruction of forests. Ah well, gripe for today!

Conundrum

Hot Electron always reads with interest a chat page, rather like this, that regularly appears in one of the better known American freebies. It is written by that famous guru of analogue electronics, and enthusiastic climber of Nepalese mountains, Bob Pease of National Semiconductor. We have corresponded more or less, but he won't recognise me under this particular pen name.

In one of Bob's recent pages, he included a nice little teaser, which I am sure he won't mind my retelling here. The diagram shows a weight W supported by two coil springs P and Q, interlinked together by string X. Strings Y and Z are slack, but only just. The question is, what happens when string X is cut? Does the weight go up, go down or stay put?

Bob's original article also included an electronic analog of the problem involving resisters and zener diodes, and also not involving wide and narrow roads. This was in aid of his contention that a proposed relief road, in his home state of California, would probably end up making traffic worse rather than better.

The nerve of it!

A new branch of electronics will surely exist soon, if it does not do so already. I refer to biosensor and some bizarre reports are surfacing about some of its stranger manifestations.

One report concerns the bacterium known as pseudomonas syringa. It occasionally somehow gets into semiconductor wafers via water used in the manufacturing process, even though the water is ultra pure.

Ozone, UV light and all other measures fail to eliminate it completely, and it chews its way into the surface of the semiconductor.

Apparently it feels at home in both silicon and germanium, and sits in a little protective ring of the material. Researchers at Buffalo, USA, have shown that electrons can cross it, and some bacterium are so sensitive to light that the current flowing in the semiconducter may be controlled by the pigment of the bacterium, which can act as an active transistor.

Meanwhile, other researchers at the Max Planck Institute in Munich have grown conducting nerve cells from cells on the surface of a silicon chip, anchoring them in place with microscopic polyimide pads. The cells then grow interconnections, with each to the other.

A stimulator electrode on the chip can send impulses through the nerves and back to other points on the chip, though exactly what end the researchers have in view is not clear at this stage.

Nerve cells are comparatively slow, compared with gigabyte clock rate microprocessors, the human brain only achieving its remarkable results by virtue of its massively parallel processing architecture.
CIRCUIT IDEAS

Fact: most circuit ideas sent to Electronics World get published

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

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

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

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

Send your ideas to: Jackie Lowe, Highbury Business Communications, Anne Bolyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8BZ

Timer for battery chargers

Many devices with NiCd or other types of rechargeable cell specify a time for charging. This is usually several hours and it is very easy to put a battery on charge and then forget about it.

This circuit was developed at the request of my son, who was given a rechargeable stencher that required a charge time of eight hours.

On operation of the "On/Start" switch, the output is live for a preset period of from 2 to 12 hours, after which it is off. Timing is reset by switching "On/Start" off and then on again.

The delay is determined by the ICM724 timer/counter chip, which is connected as a monostable and triggered by switch on. The timer drives a TLP3063 optically-isolated triac with zero crossing turn-on. A BC212L p-n-p transistor buffers the output of the timer as its maximum sink current is 3mA and the optical isolator needs about 5mA. The optical isolator, in turn, controls the gate of a TIC 226M triac.

Maximum current for the TLP3063 is 100mA. This current is possibly sufficient for battery chargers up to about 30 watts, but having a larger triac makes the unit more versatile. For example it could be used to switch a light off in the house when unattended.

A jumper allows timing and switching functions to be tested over a short interval of 20 seconds to 2 minutes. By simply changing the value of the 470pF capacitor, the delay range may be altered.

I mounted the low-voltage components on one pcb and the two triacs on another, with only the led drive connecting the two. The output connector is a panel-mounting 13A socket (RS part number 647-455), with the "running" neon indicating when that socket is live. The unit is housed in a J50 by 90 by 55mm box.

The timer chip, optical isolator and triac are available from RS (parts nos 261-795, 261-0211 and 494-403) and their Application Notes may be downloaded from the RS website.

Other components are from Maglin Tony Meacock Norwich

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1405 Fifth Street, Suite D, Davis, CA 95616 USA
Push-button controlled power supply

Two push buttons set the output of this power supply. These buttons allow one of 256 voltage levels to be set. Each push of the up button increments the output by about 70mV and vice versa for the down button. If the up button is held down, the voltage increments more rapidly. Output from the controllers passes through an R-2R ladder to provide the reference voltage to a standard linear variable power supply. The supply always powers up at 0V due to the reset circuitry. If both buttons are pressed, the current count is held. Ripple is 3mV pk-pk at 1A loading.

Gregory Freeman
Mt Barker
Australia

The Balance Box

Microphone or line level amplifier for balanced or unbalanced signal lines

Professional portable units operating from an internal PP3 battery or external mains adaptor

- Precision true floating transfer lines balanced input and output at microphone or line level
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The Phantom Power Box – The Headphone Amplifier Box

- OneStep DIN rail mounting radio frequency interference filter and voltage transient protector for voltage and current loop process signal lines

Conford Electronics
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Information Line 01428 751469 Fax 751223
E-mail contact@confordlec.co.uk
Web: www.confordlec.co.uk
Capacitance meter for 1pF to 100nF:

In this capacitance meter, covering the range 1pF to 100nF, a monostable device a potentiometer sets the width of the timing pulse, \( t \). The counter is fed with the oscillator and monostable outputs and determines the interval, \( t \), between the falling edges of the A and B inputs. The counter's LED display is calibrated to display the unknown capacitor with \( R_c \).

Turkey

Simple capacitance meter based on measuring the interval of a pulse whose width is determined by the unknown capacitance.

Electronic fuses as liquid level sensors

There's a lack of cheap electric sensors for detecting liquid levels. Wet electrodes are often used, as in the circuit ideas section of the April and July 1999 issues, to replace mechanical switches. They can suffer from electrolysis and oxidation though.

Electronic fuses, like the Polyswitch from Raychem and the Polyfuse from Bourns, show a heavy positive temperature coefficient. They turn off almost immediately if heated by a current that exceeds their nominal value. Afterwards, they stay off, remaining hot with the leakage current. When they cool, or as the supply is removed, they return to their original state. For further details see www.raychem.com or www.bourns.com.

The cooling effect could be provided by a liquid, opening up the possibility for novel liquid sensing applications. I experimented with the REXE10 Polyswitch from Raychem. It looks a little like a ceramic capacitor and has nominal current of 100mA. It is guaranteed to switch off at 200mA. Its resistance is 4.5kΩ.

Using the usual two sensors to turn a liquid pump on and off, you can realise the cost-effective circuit shown here. Assuming that the capacitor to be sensed is empty, the relay cannot remain on because the fuses are open due to excessive current. As long as there's no liquid in the container, the current consumption is low.

When the liquid reaches the upper sensor, the relay turns on. The pump turns on and continues to run until the lower sensor is dry.

Resistors \( R_1 \) and \( R_2 \) are chosen to ensure 200mA in the sensors. With the 6V Finder 55 Series relay, whose coil is 40Ω, \( R_1 \) will be 30Ω, 2W and \( R_2 \) will be 12Ω, 0.5W. This particular relay has enough contacts to switch a three-phase motor.

One more sensor could be added to drive an alarm if the liquid exceeds the maximum level. There is no electrolytic effect with these sensors because the on voltage is too weak. Nevertheless, it is worth insulating the connections of the sensors with epoxy glue for example to prevent oxidation.

Jean-Marc Brassart
Saint-Laurent Du Var
France

Active antenna with noise suppression

This circuit is an active antenna with noise suppression properties. The superhet source follower circuit has strong negative feedback. This means that the self-generated noise of the transistors is applied in antiphase to the input, resulting in active noise suppression.

You might think that instability is not possible in such a circuit because the amplification never exceeds one, but parasitic capacities make a capacitive divider from gate to source to ground. This makes the circuit a Colpits oscillator. But by manipulating this regenerative effect you can use the effect to advantage.

The best way to make adjustable damping is series connection of a 2.7kΩ resistor and a 5pF trimmer. You can make this a front-panel adjustment if you like.

For lower frequencies, the parasitic capacities are not large enough, so some additional capacitance may need to be added. Note that both capacitive adjustments interact, but capacitive regeneration adjustment exudes noise, unlike a potentialometer.

Output impedance of the superhet follower is only a few ohms, so a terminated 75Ω coax output is not a problem. Of course due to the outstanding linearity, the third-order intercept properties are good too.

This same idea can be modified for ranges other than 14 to 30MHz by the way.

A yellow Amidon 9.5mm core is a good choice. The tap at three turns was found by trial and error. Note that fractional turns are not possible. The p-p-p transistor must definitely be a BF-type. Audio types in the BC range have much larger capacities, despite their high transition frequency.

Wim de Ruyter
Gouda
The Netherlands
### Self on Audio

**Douglas Self**

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- Precision preamp MRP10
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- Balanced line inputs and outputs, part 1; Balanced line inputs and outputs, part 2
- Power Amplifiers: FETs less linear than BJTs; Distortion in power amplifiers 1-8; Distortion residuals; Triomodal part 1, 2
- Load-invariant power amp
- INVAR DOC
- Common-emitter amps; Two-stage amplifiers; SPEAKERS: Excess speaker currents; Class distinction (amp classification); Relay control
- Power partition diagrams; Audio power analysis

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**EMI gasket material in place**

Chomerics has introduced a corrosion-resistant, form-in-place EMI shielding gasket material for dispensing on bare metal electronics housings, such as base-station PCB covers and other electronic equipment with required long service life. Called Cho-form 5541, the material is a single component, electrically conductive silicone elastomer containing nickel-plated graphite particles. Gaskets are dispensed by robot onto customer enclosures or castings and heated in 30 minutes. The gaskets provide shielding effectiveness above 70dB from 200MHz to 10GHz, and meet UL 94V-0 flammability requirements. It is provided in boxes (180cc) cartridges containing 350g of compound.

Chomerics
Tel: 01628 604500
www.chomerics.com

**Chip fuses that are good for the environment**

Bussmann Chip fuses from Cooper Electronics Technologies are bonded to a ceramic substrate and are encapsulated in glass to improve reliability and according to the supplier will not burn or char in high temperature environments. Designed to be more reliable than traditional soldered fixing elements which often degrade when subjected to cycling, the fuses use both thick and thin film technology in a solder-free design that improves temperature and pulse cycling capabilities, without causing degradation to the fuse element, said the company. They also comply with demands for board level lead-free components by specifying the lead free plating option, as the fuses withstand high IR reflow temperatures when using lead free solder pastes due to their high temperature capability.

Cooper Electronics Technologies
Tel: 001 561 742 1178
www.cooperet.com

**3mm yellow LED with lens**

Optosource is stocking a range of 3mm yellow LEDs, Manufactured by Global Light of Germany, the GLLE3011-YY14 series has an elliptical lens, offering a viewing angle of 65 degrees in the horizontal plane and 40 degrees in the vertical, GL! colour grade the LEDs into four separate bins of 1.5mm bandwidth ensuring that there is no colour variation when used in multi-LED arrays, said the supplier. Light intensity is 500mcd at 20mA. The Al-In-Ga chip allows users to drive the LED with a high 50mA maximum forward continuous current, or 150mA peak power pulse current. When driven at these levels, light output reaches 1000mcd

**Detect switches have snap action**

ITT Cannon has launched a series of C&X snap acting, detect switches which measure 8.2 x 2.7mm with heights of...
8-mm for the vertical mount version and 8-mm for the right-angle version, including, however, the MDS switches feature a snap-action, tactile feel with a total travel of 2.0 mm. Designed to detect the presence of a mechanical device in medical consumer electronics, the switches are available in vertical or right-angle and mounting styles. Typical voltage applications include security equipment, consumer electronics, medical devices, and communications equipment. The MDS range has a contact rating of 0.3 A at 6 V DC. Mechanical and electrical life is 10,000 operations, and operating temperature range is 10 to +50°C. ITT Cannon Tel: 01273 406061

www.ittcannon.com

Tri-band embedded GPRS module

TDC is offering next generation GPRS mobile phone developers a GSM tri-band module supporting voice and data transmission via GPRS Class 10. Measuring 34 x 33 x 3.5 mm, the Siemens MC45 module is a triband GSM module that has voice, data, fix and SMS abilities. It supports GSM networks in the frequency ranges 900, 1800 and 1900 MHz. There is an audio interface, which allows the user to activate an integrated microphoner/loudspeaker unit in notebooks and hand-helds, and so use it as a hands-free system for telephone calls. It also allows for simultaneous transmission of data and control of device functions via a standardised AT command set. The MC45 is approved for international RF, TTC, CCF and PTCRB standards. TDC Tel: 01256 332000 www.tdc.co.uk

3.5Gbit/s telecoms bit error-rate system

Agilent Technologies has extended its RS232/RS422/RS485 error rate test platform by adding modules to include 3.5Gbit/s electrical, optical and electronic converter modules and components. Intended for 10Gbit Ethernet testing, characterising cross-point switches and transmission systems, the system performs multiplexer and demultiplexer testing for telecommunications; system area network IC, multiplexer and receiver testing in manufacturing; and forward-error correction device testing. Also, the fast eye-mask measurement can perform a quick pass/fail test capability for manufacturing. Agilent

Tel: 07084 666666
www.agilent.com

64-bit Mips processor clocks at 600MHz

PMC-Sierra has introduced the fourth generation of its RM7000 64-bit Mips-based processor with maximum production clock speeds of 600MHz. The RM7000C and RM7665C use 0.13um, copper-interconnect technology process, and offer a power consumption of 2.5W at 600MHz. The RM7000C is available at a rate of 533MHz. Mips Technology

Tel: 0944 292600
www.mips.com

Fast analyser probes slash input capacitance

Tektronix has introduced frequency connectors probing for its TLA7000 logic analyser modules that offers an 8GHz timing acquisition rate. The aim has been to reduce lead capacitance by eliminating the need for connectors. Total input capacitance is specified at 0.7pf. It is possible to make analogue and digital measurements (both timing and state) through a single probe. The P6860 high-density probe for single-ended signals and the P8860 high-density probe for differential signals is designed to eliminate multiple analyser and

IR transmitter and receiver chipset for stereo wireless

Toshiba Electronics is offering an infrared transmitter and receiver chipset designed to simplify implementation of automotive and domestic wireless audio applications. The Toshiba TA2061AF infrared linear audio signal transmitter IC and the TA2056FP 1.5V cordless receiver IC enable stereo transmission of linear audio signals to local loudspeakers and headphones. It is suitable for in-car and home entertainment systems. When used with an appropriate infrared LED such as the firm's TLM225, the chip set enables designers to implement a complete wireless stereo audio system with the minimum of additional discrete components. Featuring two crystal VCO channels, it offers infrared audio signal transmission at typical frequencies of 2.3 and 2.8MHz. It combines two FM receivers for stereo reception at 2.3 and 2.8MHz with two RF amplifiers and operates from a supply of between 0.95 and 2.2V. The device is housed in a 16-pin SSOP package. Toshiba

Tel: 01276 694730
www.toshiba-europe.com

Scope connections to the system under test

Tel: 01944 292600
www.tektronix.com

Step-down regulator for single-cell Li-Ion

Linear Technology is offering a synthesised, fixed frequency down regulator that can deliver up to 1.5A at 95.5% efficiency. The LTC185's input voltage range of 2.65V to 6V makes it suitable for single-cell Li-Ion, or multi-cell alkaline/NiMH battery powered applications. It can provide output voltages down to 0.8V to support the latest DSP and microcontroller operating voltages. Linear Technology

Tel: 01276 677676
www.linear-tech.com

Hall-effect switch for battery-powered applications

The A3212 Hall-effect sensor IC available from Allegro Microsystems is a pole-independent microswitch power with a latched digital output. It includes a Hall-voltage generator, small-signal amplifier, chopper stabilisation circuitry, a latch and Mosfet output. The BCMS10 device's 2.5-3.5V operation, coupled with a Schokking, reduces its average operating power requirement to less than 15W with a 2.75V supply. The device's output can be turned on by either a north or south pole of sufficient strength, in the absence of a magnetic field, the output is off. It uses chopper stabilisation to provide dynamic stability, which reduces the residual output voltage normally caused by device overmodulating temperature dependancies, and thermal stress. The device also offers electrostatic discharge

AC-to-DC converter with insulated transformer

The latest AC-to-DC converter from Rohm Electronics delivers a DC output of 12V and 350mA and can handle an input voltage range of 85V AC to 115V AC. A built-in transformer is designed to reduce component count and board space, while insulation on both primary and secondary windings ensures safe operation and device protection. The BP5710 offers a maximum withstand voltage between transformer primary and secondary windings of 180V rms for 2s. Rohm Electronics

Tel: 01908 282666
www.rohm.co.uk

NEWPRODUCTS

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R&Dtest gets full 3G capability

Rohde & Schwarz has added 3G mobile functionality to the UMTS standard WCDMA to its radio communication tester (SMT-1200). Intended for the development and production of 3G, an option allows a WCDMA downlink signal to be generated for synchronisation of the mobile phone under test, thus making bit error rate measurement possible, said the company. The platform retains its capability to support various standards like GSM, GPRS, TDMA, CDMA, (3GPP99/3G). Bluetooth as well as WCDMA. The test performs transmitter measurements on terminals for the UMTS standard WCDMA (3GPP/3G).

The RM7000C and RM7665C use 0.13um, copper-interconnect technology process, and offer a power consumption of 2.5W at 600MHz. The RM7000C is available at a rate of 533MHz. Mips Technology

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Tektronix has introduced frequency connectors probing for its TLA7000 logic analyser modules that offers an 8GHz timing acquisition rate. The aim has been to reduce lead capacitance by eliminating the need for connectors. Total input capacitance is specified at 0.7pf. It is possible to make analogue and digital measurements (both timing and state) through a single probe. The P6860 high-density probe for single-ended signals and the P8860 high-density probe for differential signals is designed to eliminate multiple analyser and

IR transmitter and receiver chipset for stereo wireless

Toshiba Electronics is offering an infrared transmitter and receiver chipset designed to simplify implementation of automotive and domestic wireless audio applications. The Toshiba TA2061AF infrared linear audio signal transmitter IC and the TA2056FP 1.5V cordless receiver IC enable stereo transmission of linear audio signals to local loudspeakers and headphones. It is suitable for in-car and home entertainment systems. When used with an appropriate infrared LED such as the firm's TLM225, the chip set enables designers to implement a complete wireless stereo audio system with the minimum of additional discrete components. Featuring two crystal VCO channels, it offers infrared audio signal transmission at typical frequencies of 2.3 and 2.8MHz. It combines two FM receivers for stereo reception at 2.3 and 2.8MHz with two RF amplifiers and operates from a supply of between 0.95 and 2.2V. The device is housed in a 16-pin SSOP package. Toshiba

Tel: 01276 694730
www.toshiba-europe.com
SPI/ASI interface converter for DVB

Yokogawa Matron has introduced a parallel/serial interface converter, the Model 7095/65, to assist in test equipment conversion requirements in the development of DVB systems. According to the supplier, broadcasting systems are increasingly using serial-based interfaces for the transmission of MPEG streams, leading to the need for parallel/serial interface conversion units such as the 7095/6. It carries out SPI/ASI conversion in either direction and is available in portable or rack mount form. In addition to serial/parallel conversion, it enables the data to be changed by inserting null packets into the transport stream. The packet length can be changed between 188, 204 or 208 bytes. The signal specification complies with ISO/IEC 3181, and the data rate is from 10kHz to 800kHz.

Yokogawa Matron
Tel: 01494 495000
www.matron.com

RF meter for 433MHz licence exempt applications

An RF meter from RF Solutions is a hand-held unit designed for validating the signal strength of radio transmitters on installation. It is also able to determine the presence of other RF signals that may cause interference. The licence-exempt meter detects RF carrier signals at 433MHz. Signal strength is indicated by a ten LED display with one peak bold function to simplify the reading of measurements. The unit operates from a single 9V PP3 battery and features one-minute auto-shut-off and battery low indication. The unit has an RF sensitivity of 110dBm and an RF bandwidth of 60kHz.

RF Solutions
Tel: 01727 406611
www.rfsolutions.com

NEW PRODUCTS

Please quote Electronics World when seeking further information.

protection to SkY. It is available in versions for operation over temperature ranges of -40 to 80°C and ±10°C. Allegro Microsystems
Tel: 01903 259383
www.allegromicro.com

Switches get tactile jogger

Omnos is introducing a small form factor jog lever switch that is designed to provide a tactile feel. Type B63 switches, which are designed for applications in consumer electronics, mobile phones, PDAs and voice recorders, provides tactile feedback in up, down and sidesways (clockwise/anti-clockwise) directions. Measuring 10mm wide and 2.9mm in height, the switch has a capacity of 5V with a 10mA DC resistive load, and offers contact resistance of 1.5% rated at 5V DC, 1mA. Operating forces are 3.3 newtons in the push direction and 1.2 newtons in the lever direction.

Omnos
Tel: 020 8450 6646
www.omnos.com

Test probes designed for a long life

Readon is stocking the ranges of long life test probes and sockets from QA Technology. QA's patented rolled design probes incorporate a probe tube and head design that reduces radial push play at the probe tube opening. The clearance between the tube and the plunger has been reduced by forming the tube around the plunger itself. According to the supplier, this feature reduces play from side to side and improves pointing accuracy. The locking force causes a well defined wiping action between the plunger and the inner surface of the probe tube to provide improved electrical contact.

Readon
Tel: 01460 62620

Flexi-connector locks

Incorporating a cable lock option, the 62674 series of 0.5mm pitch vertical connectors from FC1 is designed to provide cable retention for flexible printed circuits. Prehistoric by the connector's slider mechanism, cables are inserted in a zero insertion force operation, said the supplier. The cable lock option is also designed to provide cable strain relief and prevents unintentional cable release in applications susceptible to vibration. The connector has a 29.5mm bright profile and is available with 12, 20, 24, 25, 30, or 33 phosphor bronze, tin alloy plated contacts, with different pin counts available on request.

FC1
Tel: 020 8294 3902
www.fc1connect.com

Battery to mains converter costs £49

Merlin Equipment's latest range of inverters will convert 12V DC battery power to 230V AC mains power. Called Purewavez, the range includes five models with a number of power ratings from 150W to 1500W. All units feature full overload, overheat and short-circuit protection. According to the supplier, the two stage inverters are over 90% efficient. Pricing starts at £49.

Merlin
Tel: 01529 697987
www.them Merlin group.com

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8-bit microcontroller with dot LCD driver

NIC's latest 0PD99835 microcontrollers include an on-chip dot LCD driver that can drive a panel of up to 2304 dots. Aiming at the battery-powered applications, the devices feature an operating supply voltage of 1.8 to 3.6V (typical) while driving an LCD at 3V on a 37.5kHz square wave clock. The integration on one chip of LCD display and system control functions such as a booster circuit that can boost the voltage up to 5V for LCD, a freely configurable 16-lead volume 3-octave scale audio/sound generator, A/D converter, serial interface, and large capacity internal memory up to 60kByte of ROM and 32kByte of RAM).

Right-angle M12 connector for rapid termination

A range of right-angle M12 circular connectors for rapid termination has been introduced by Harting. Designed for use in industrial sensor systems to M12 standards, the connectors are intended for applications where pre-assembled cable would previously have been used. With the design, cable can be terminated quickly, according to the supplier, eliminating the need for fixed-length pre-assembled cable. Called Haren, it uses axial insertion displacement technology to reduce installation, which involves removing the outer insulation of the cable, attaching the connector assembly, and tightening a screw cap. The finished joint offers strain relief as well as sealing to IP67. The right-angled M12 circular connector is available in 3- and 4-pin male and female versions, with maximum voltage and current ratings of 32V and 3A, respectively.

Hardware/software co-design support for ARM

Colosio has announced the new version of its Handel-C hardware design suite. DK11 includes features for system-level HW/SW co-design, co-simulation support for arm and PowerPC embedded processors, interface modeling, enhancement area and delay analysis, improved VHDL output, 100 times faster simulation, and support for Altice, Altera, Bitwise, and Xilinx V+H1 Pro devices, said the firm. The design suite supports the development, verification, and refinement and implementation of complex algorithms in hardware. It includes built-in design entry, simulation, and synthesis - all driven by Handel-C. Handel-C is based on ANSI-C extended with concurrent timing, concurrently, flexibly, with variable and resource allocation, and complex algorithm efficiency in hardware.

Digital audio amps

STM's stm32coelectronics has introduced a family of digital audio amplifier chips based on Direct Digital Amplification (DDA) technology licensed from US firm Apogee Technologies. Parts available today include the ST304A controller plus two power amplifier types: the ST3500 and ST3505. The ST304A converts two serial digital inputs in 18 or 24-bit format into five channels of digital drive for multi-channel power amplifiers. It performs sound surround processing plus volume and control functions can be added by embedding additional software.

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NEWDISCS

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Phase noise and frequency synthesisers

Ian Poole explains how phase noise affects a synthesiser's performance, and offers tips on how to minimise it.

Frequency synthesisers are an widespread use in areas from hi-fi fidelity tuners to car radios and cellular telephones. They have become an everyday part of radio frequency design because of their flexibility, stability and frequency setting.

Without frequency synthesisers, many of the facilities that are required for today's communications would be far more difficult to achieve. This would severely impact areas such as cellular telecommunications as well as wireless technologies such as Bluetooth and the like. This makes frequency synthesisers critical to today's electronics and radio technology.

There is a number of types of frequency synthesisers, but the type that is in most widespread use today is based on the phase locked loop. It is sometimes referred to as an indirec synthesiser. Such synthesisers offer a considerable amount of flexibility and there are plenty of ICs that are available around which these circuits can be designed.

In another technique, called direct digital synthesis, the waveform is generated completely digitally. Such synthesisers are more expensive to implement. Also, they are not quite as widely used, although their use is increasing as costs fall.

Despite the fact that indirect synthesis has many advantages, it has some disadvantages too. The main one concerns the phase noise that can be generated. Synthesisers have to be carefully designed to ensure that the levels of phase noise fall within the design requirements, otherwise system performance can be degraded.

Basic synthesisers

Before investigating phase noise any further, I'll present a brief overview of indirect synthesis.

The basic building block is a phase-locked loop as already mentioned. This consists of three main blocks: the phase detector, the loop filter and the voltage controlled oscillator (VCO). A reference signal, from a crystal oscillator or other source enters one input to the phase detector while the other input receives a signal from the voltage controlled oscillator.

The phase detector generates an error voltage proportional to the phase difference between the two input signals. This is passed through the loop which serves a number of functions, one of which is to remove the high frequency signals, and especially the one at the comparison frequency that would give rise to sidebands on the output of the synthesiser.

Having passed through the loop filter, the error voltage is applied to the control input of the VCO. It has the effect of trying to reduce the phase difference and hence the frequency difference between the two signals entering the phase detector.

Eventually a point is reached where a steady phase difference exists between the two signals. As the phase difference is constant this means that the signal from the VCO and the reference are on exactly the same frequency. This basic circuit enables the VCO to produce a signal on the same frequency as the reference, Fig. 1.

A frequency synthesiser is required to produce a signal on a variety of frequencies. To achieve this further circuitry is required in the phase-locked loop. A programmable divider is placed in the loop between the VCO and the phase detector as shown in Fig. 2. In this way, the VCO frequency is divided down by the ratio of the divider.

Now the loop will fight to reduce the phase difference for the two signals at its input. Hence the frequency of the two signals at the input to the phase detector will be the same. With a divider set to a division ratio of N, this means that the VCO must operate at a frequency N times the phase comparison frequency, i.e. at N times the reference frequency. By changing the division ratio of the VCO frequency can be changed.

The synthesiser steps in frequency increments equal to the phase comparator frequency. To have small steps, a low phase comparison frequency is required. This can result in very high division ratios being required - especially if the synthesiser is operating in the VHF or even UHF portion of the radio spectrum.

This is a basic form of synthesiser. More complicated systems using several loops some containing mixers can be devised to keep the division ratios low, and to provide higher levels of performance. However one of the major drawbacks of synthesisers based around phase locked loops is that they can generate large levels of phase noise if they are not designed to avoid this.

What is phase noise?

Some phase noise appears on all signals to a greater or lesser degree. Crystal oscillators are very good in this respect, generating the lowest levels.

Variable frequency oscillators are not as good. They are not as stable as crystal oscillators or synthesizers. Nevertheless, their performance is acceptable for most applications. A poorly designed frequency synthesiser can be very bad. Some designs do manage to achieve very low levels of phase noise though, but this is often at the price of possibly using several loops and the associated additional cost.

Phase noise can be considered as short-term fluctuations in the phase of a signal: in view of this it is sometimes called phase jitter. It manifests itself as noise modulation on the signal and accordingly it results in sidebands spreading out from the carrier of the signal.

In most cases the noise falls away as the frequency offsets from the carrier increases as shown in Fig. 3. However for synthesers based on phase locked loops the situation is a little more complicated as we shall see later.

Quantifying phase noise

It is necessary to be able to quantify the level of phase noise on a carrier. Unlike a carrier that occupies a single frequency, noise spreads out over a wide band of frequencies. In order to measure noise a certain bandwidth has to be specified.

In addition to this its position has to be specified as well. If the noise varies with frequency. In the case of phase noise it is generally specified in 1 Hz bandwidth and at a certain offset from the carrier. For example set a level of noise may be quoted as being 90dB down on the carrier in a 1Hz bandwidth at -10kHz offset or -90dBc/Hz at 1kHz.

Phase noise can degrade the performance of both receivers and transmitters. In a receiver, an affection known as reciprocal mixing is a cause of degradation. Here the phase noise from the local oscillator can mix with a strong off-channel signal to give rise to a signal that can fall within the passband of the IF.

For transmitters the effect of phase noise can be to spread noise either side of the transmission. Phase noise naturally have a particular effect on phase modulated transmission where it will introduce error, degrading the bit error rate when data is transmitted. In view of all these effects it is of paramount importance to ensure that the levels of phase noise are kept to the minimum when designing a syntheser.

The loop and phase noise

In order to keep the level of phase noise to a minimum, it is necessary to know how the different elements of the loop generate noise and how the action of the loop affects this. For example, phase noise generated by the VCO contributes to the overall phase noise contour in a different way from that generated by the phase detector.

It is necessary to ensure that the noise from each element in the loop is minimised. However the loop filter has the most effect on the final performance because it determines the break frequencies where noise from different parts of the circuit start to affect the output, Fig. 4.

To see how this happens, take the example of noise from the VCO. Noise from the oscillator will be divided by the divider chain and will appear at the phase detector. Here it will appear as small perturbations in the phase of the signal and will emerge at the output of the phase detector.

![Fig. 1. A basic phase-locked loop.](image1)

![Fig. 2. A basic frequency synthesiser using a programmable divider in the loop.](image2)

![Fig. 3. Phase noise characteristic of a free running oscillator.](image3)

![Fig. 4. Noise profile of a typical single loop synthesiser.](image4)
Fig. 1 is to increase the low frequency feedback in the oscillator. This is easily effected by introducing a small unbalanced input at a bipolar transistor circuit. Using a FET rather than a bipolar transistor is also supposed to help.

While these precautions are focused on the voltage controlled oscillators, most of them are equally applicable to the reference oscillator as well. In this way, one of the contributing components to the noise inside the loop filter can be reduced. The other main contributor to this is the phase detector.

Today, most phase detectors are included within a specially designed synthesizer chip. Optimizing the phase noise performance of synthesizers using these chips is difficult because there is no access to the critical areas of the circuit.

Where a phase detector is made from individual chips then it is possible to take a number of steps to improve the performance. A typical circuit arrangement is shown in Fig. 6. It is based on two D-type bistable devices.

Circuit layout is very important. Crosstalk between the two inputs can have a significant effect and therefore input lines should be separated. Also supplies to the ICs should be decoupled right on the IC itself. Some people use D-types in different packages to reduce the crosstalk.

Another problem occurs in what is termed the drift zone. When the loop is in lock, the pulses emanating from the Q and Q' outputs tend to zero, giving the detector zero gain. Accordingly the loop tends to wander slightly, producing noise. To overcome this a small amount of leaky can be added into the loop by placing a high value resistor from the tuned line to ground.

In summary, Designing a synthesizer is by no means easy. Difficult compromises need to be made. Cost, agility, noise profiles, sideband levels, and many more conflicting requirements, all have to be carefully balanced to give an acceptable overall performance. However by having a good understanding of the major contributions to the noise and how they contribute to the overall noise profile, it is easier to make sound judgments.

Further information about all aspects of radio and electronics can be found at www.radio-electronics.com

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**Fig. 5: A typical VCO circuit.**

When it comes to the loop filter, only those frequencies that are below its cut-off point will appear at the control terminal of the VCO to correct or eliminate the noise. From this it can be seen that VCO noise which is within the loop bandwidth will be attenuated, but that which is outside the loop bandwidth is left unchanged.

The situation is slightly different for noise generated by the reference. This enters the phase detector and again passes through to the loop filter where the components below the cut-off frequency are allowed through and appear on the control terminal of the VCO. Here they add to the noise to the output signal. It can be seen that noise from the reference is added to the output signal within the loop bandwidth but is attenuated outside this.

**Similar arguments can be applied to all the other circuit blocks within the loop.** In practice, the other block that normally has any major effect is the phase detector. Its noise affects the loop in exactly the same way as noise from the reference. The frequency divider creates some, but often the noise which is present will be combined with that from the phase detector.

Fortunately, noise from the reference and phase detector is generally very low when they are considered on their own. Unfortunately their contribution is often critical in the overall performance requirements, as the loop multiplies the frequency of the reference signal.

Also, the level of phase noise is multiplied. In fact, the amount by which it is multiplied is simply 20 log N, where N is the ratio of the filter. So a loop that has a divider set to 2, and has a multiplication factor of 2, will multiply the noise of the reference and phase detector by 6dB. As multiplication factors increase, so does the noise.
lightning did not even break the skin, but traveled the wet surface of their body to ground. The skin was said to be severely burned, after the manner of scalding.

It is estimated that Earth is struck by lightning 20 million times per year. And if you believe the old myth about "lightning never strikes the same place twice" then consider the fact that the Empire State Building in New York City takes about twelve strikes per year.

Radio and television antenna towers are also struck frequently. I haven't taken the time to add that they do not "attract" lightning, that would not have come anyway. They tend to act as lightning rods.

The lightning is generated under about 15,000,000 volts of electrical potential. According to one source there is normally an atmospheric potential cloud-to-ground of 200,000 to 500,000 volts, and a constant but minute current of 10^-4 amperes.

Inside the lightning bolt, the temperature is 15,000 to 60,000 degrees centigrade. This is several times the temperature on the Sun. The lightning bolt travels at speeds up to 100,000,000 feet per second.

A lightning bolt is actually a series of strokes, averaging about four. Duration varies from a few nanoseconds upward, but about thirty microseconds is said to be average. The average peak power per stroke is 10^8 watts.

Many people struck by lightning were in unsafe situations. For example, on an open beach or in an open field such as a golf course. It is also not smart to be in a boat on the water. Standing next to a tree or other tall object, such as a radio tower, is also rather dangerous, as the lightning may easily be attracted to that tree.

In one case, a group of golfers was struck when lightning struck a nearby tree and travelled underground, to a covered pavilion where they had taken refuge from the storm. Carrying an umbrella with a metal tip above the covercry has caused lightning injuries, presumably because it looks to the lightning like a lightning rod, and you look like a ground wire! As a general rule, one should not be within 100 feet of a metal tower at any time.

Other types of lightning may or may not be lighted before it strikes, depending on what you consult. One of the latest schools of lightning is "air to ground lightning," and "lightning interception." Of the "lightning" hitting the ground, the fact that it is not often hit by lightning is a generalization.

Lightning hits trees, buildings, and people. Lightning usually travels at speeds of about 100,000 feet per second. At a distance of 300 miles, it has traveled at the speed of light. Lightning is usually followed by a series of "thunderclaps" that are heard many miles away. These are produced by the sound waves that are generated by the lightning flash. The sound of thunder is produced at the rate of about 10 miles per second.

Lightning is often heard at first, and then the railroad, telephone, or radio towers. These are probably the most common places where lightning is heard. Lightning is often heard at night, and usually heard at dawn.

Lightning is often heard at night, and usually heard at dawn. Lightning is often heard at night, and usually heard at dawn. Lightning is often heard at night, and usually heard at dawn.
The Space Shuttle and satellites are also being used for lightning research. Some hauntingly beautiful video footage of space shuttle lightning is available from NASA's web site. High-altitude aircraft lightning research revealed newly discovered phenomena called sprites and jets.

**Storm scope**

Lightning research can be terribly dangerous, especially if it puts you out in the open or if you are foolish enough to mimic professional methods such as ground wire tethered rockets. There are, however, some instruments that are easily build and relatively safe to use. The storm scope is one such instrument. Figure 2 shows the basic configuration. This project was originally published by Thomas P. Leary in the June 1964 QST magazine. His implementation used vacuum tube amplifiers though.

The storm scope consists of a pair of orthogonal small loop antennas, one oriented north-south (N-S loop) and the other east-west (E-W loop). Keep in mind that a small loop antenna—less than 0.18A wavelengths in size—for example—an eight-foot grid with nulls broadside to the loop plane, and maxima off the ends. Align the ends of the loop (maximum sensitivity direction) in E-W and N-S directions. A compass will make the accuracy better.

The loops are fed through differential amplifiers, with gains in the 20 to 80dB range, to the vertical and horizontal plates of the oscilloscope. The reason for the wide gain scale is that oscilloscopes vary.

The original project connected the amplifier outputs directly to the oscilloscope deflection plates. Modern two-channel oscilloscopes can be used in the X-Y to form a vectorcope, of which the storm scope is a variation on the theme. Although any two-channel scope with an X-Y mode is usable, a directional ambiguity exists unless the instrument also has a Z-axis input. This is often present, but hidden on the rear panel of the scope. The Z-axis us used to modulate the intensity of the trace with a signal from a sense whip or vertical antenna near the two-X loop. It may be necessary to amplify the Z-axis input signal, but in that case a single-ended rather than differential amplifier is used.

**Fig. 5** shows the loop and amplifier configuration. The loop consists of about fifty turns of small-gauge insulated wire in a three-foot loop. Either square or circular loops can be used, although I find that the square is easier to construct. The loop is untethered. The output of the loop is applied to the input terminals of the differential or push-pull amplifier.

It is critical to shield the loop. Wrap either copper foil or aluminum foil (or tape) over the entire loop except for a small quarter inch or so gap along the top edge. This prevents the shield from acting like a single-turn shorted loop itself.

The shielded loop will be less prone to pattern distortions from capacitive coupling. In addition, it responds largely to the magnetic component of the lightning electromagnetic field. It is less sensitive to electrical fields, so will not pick up as much locally generated power line noise and appliance noise. I recommend a loop pair using 0.75in by 4in by 36in lumber. Although my own woodworking skills leave something to be desired—polish for "arata"—others are able to make a better job of the method shown in Fig. 4. A notch, Fig. 4A, is cut at the centre of the loop and bottom members of each loop. The depth of the notch is the thickness of the lumber, while the width is sufficient to snug the other piece of wood in it, Fig. 4B.

The square loop will tend to "trapezoid" out of shape if left to its own devices. As a result, some or all of the methods of Fig. 5 are used at the four corners of each loop. In
cloud-to-cloud pattern co-exist. I was not able to confirm these patterns, but that might be the particular thunderstorm I observed several years ago when I was active in building loops while researching a book (Joe Carr's Loop Antenna Handbook, Universal Radio Research, 6300 American Parkway, Reynoldsburg, OH, 43068, USA).

**Electric-field measurement**

Figure 8 shows a partial schematic of a sensor used to measure the electrical field at or near ground level produced by thunderstorms. I do not recommend building this project unless you are a professional researcher. And if you do build it, stay a good distance away from it when thunderstorm activity is nearby.

Electrical fields are measured in terms of volts per meter (V/m), or kilovolts per meter. The sensor shown in Fig. 8 uses a pair of 10cm copper electrodes on a centimeter diameter insulated rod, spaced a meter apart. A pair of resistors is used as a voltage divider to reduce the voltage (thunderstorm fields of 0kV/m are easily observed). The professional sensor was used with a high-voltage meter for the upper resistor in the voltage divider (i.e. the type of resistor used inside a high voltage probe for an oscilloscope or voltmeter).

Output from the voltage divider is fed to a high voltage isolation amplifier, and then to a fiber-optic transmitter. Safety dictates that the sensor be far away from humans and the instruments used to record the burst. Fiber optic cable is used to prevent the electromagnetic pulse from inducing a high voltage spike into the wiring.

I saw a primitive variant on this theme at a friend's house in Texas in the early 1980s. My friend was an antenna guru and something of a technical mentor for me. He owned a 43-arcute tract of farmland near Austin, mostly for the purpose of erecting antennas at will (but partly so I could get away from other people — he was semi-bemis). He had a 1400-foot long wire antenna mounted on telephone poles, trees and whatever else could be commandeered. At the receiver end of the antenna he had a small box, Fig. 9, with a series connected stack of ten M4 carbon resistors. The box, and the bottom end of the resistor chain was grounded.

When I first saw the rig, I noticed that the little light on the box blinking erratically, so I asked what it was. He explained to me that he had to do occasional receiver repairs before he realised that so many burned out RF front-ends could not be due to faulty design. He figured that it was atmospheric elec}

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Equality?

Regarding my leader in the March issue, while I cannot claim to be a huge fan of the medical profession in general, I most emphatically did not treat the profession, as detailed by Dr Wilkins, with any disrespect. I described the behaviour of one of the organizations that claim to represent his profession.

There was an item presented in R4, prior to the ultimatum issued by the BMA. I wrote to the editor of the programme, contrasting the lives and salaries of GPs with those of engineers working in manufacturing industry - as I have done all my working life.

This has included, in my own case, two redundancies.

Several days later, I received a most thoughtful and detailed reply from this presenter. He described in his letter that the criticism of doctors had to be such that I 'had to tone down these 'in order to elucidate the doctors' side of the case.' He also made it very clear that he had sympathy with my views.

I was reading the Financial Times monthly or usually two or three days behind to read a small article that pointed out that agreement was now close between the BMA and the government in respect of the annual assessment of GPs competence. I had assumed, post-Shipman, that this was now mandatory.

How many years is it since Thomson, three or four? I'm head of an R&D group and have just carried out the annual assessment of my group; equally my own performance has been assessed. I have undergone this procedure every working year of my life since graduation - as probably have most other.

Electronics World readers who work in the commercial sector. So what is the medical profession different?

Mr (Dr) Brian Judd made reference to the Boeing 747. Has he ever considered why the 747 actually stays airborne? The reason is, of course, because quite a few talented engineers - which will include many Ph.D. - have devoted a significant proportion of their lives to ensuring a competent design. What use would the medical doctor be of a 747 were it to exceed an uncontrollable speed, with a possibility of crashing? The Ph.D. engineer might just save the day.

I did not rehearse this leader as implied by Dr Judd. It was written as a response to Dr Ken Smith's letter and it took approximately one hour to type. I do not have any chips on my shoulder: facts are facts.

I am, however, delighted that Electronics World chose to publish it. These gentlemen's letters have, quite simply, polarised my views about the medical profession even further. If readers want to know about the real income of GPs, then I recommend the reference detailed below.

Lawrence Jone
Via e-mail.

Stuck in a winter warp...

In Update in the April 2000 issue I read that universities and colleges are failing to produce enough electronics graduates to satisfy the demand by industry and that the number of applications for electronics and engineering courses decreases year upon year with students preferring to take media studies or humanities instead.

The real reason for this situation is due to the lack of coverage of science and technology in the secondary school curriculum. The present situation, in terms of amount of science and technology in the secondary school curriculum has been cut back on making way for a more liberal arts and humanities education.

After GCSEs replaced O Levels the science and mathematics courses have become trivialised, dumbed down and stripped out. In fact the contents of the AS and A Levels in mathematics and physics courses today are almost identical to that of the O Level courses in the mid 1980s and the intermediate grade GCSE - which now allows students to achieve a grade B rather than a grade C as originally intended - science and mathematics courses contain less subject material than the old CSE courses had in them.

As well as a decline in standards in science and maths, the quality of the technology course leaves much to be desired. For a start, apart from the basic concept of using light or an infra-red or a laser printer for this purpose.

Jonathan Wells
Saxby
Lincoln

Further to Cyril Barman's article on making double sided PCBs, could I offer a method which we have used with great success for many years? It was suggested by a friend, Mike Fielding, and is almost foolproof.

Assuming that the two pieces of artwork have been printed, the blank PCB is placed on the lower artwork in the correct position. Now superglue two pieces of scrap PCB strip to the artwork to form a corner next to the blank PCB.

When this has set, remove the PCB, locate the top artwork and align accurately. Make sure that it doesn't move out of position. Lift the corner and

Superglue it to the top of the strips. To expose the PCB, remove the protective cover, slide it back into the corner and expose one side. Turn over the PCB and artwork, make sure that the PCB is still located in the corner of the strips and expose the other side. Develop, etch and drill and there's it!

Dave Beath
Snr. Elec. Eng., Dennis Ferranti
Meters Ltd

Shocking hazard reduced?

Referring to a letter in the previous issue, Susan is correct to point out the dangers of her circuit, but is misinformed about the dangers of Tesla.

The shock hazard depends on the current which, in turn depends on the voltage, source impedance and contact resistance. A milliam is actually perfectly safe and at approximately the shock threshold feeling. It takes tens of hundreds of milliam to get a shock and 1A plus to interfere with heart operation. Residual-current devices, or RCDs, to protect people are usually set to 30mA which is considered as adequately safe.

Common high-voltage sources such as vehicle ignition and CRT acceleration are low current high impedance so the voltage collapses under the load of being touched. In the case of mains shocks the current is usually limited by the contact resistance. This is greatly reduced by having wet hands, which is why the danger is so much greater when water is around.

Static energy in capacitors complicates the picture but again is usually safe enough in 100 to 1000 VQCE encountered in CRT and electronic circuits.

Paul Bennett
Via e-mail.
Real-time digital filter

Signal Wizard is a unique and integrated hardware/software system for designing, downloading and running filters in real-time. Low-pass, high-pass, band-pass, band-stop, comb or any arbitrary shape you like can be designed in seconds. Once a filter is designed, the software interface is used to download the filter to the hardware system via a serial link, where it is executed on demand. You don't need to know about digital signal processing theory or the maths associated with digital-filter design. But if you're a filter expert, you won't find yourself restricted by the easy-to-use interface. If you want to do it the hard way, you can even design your filter in long-hand then download the filter's frequency response as an ASCII file to the Signal Wizard's control program! Signal Wizard is a total filter solution. Due to its flexibility, it is ideal for processing audio-bandwidth signals in real time. High-quality analogue signal conditioning and a dual-channel 16/18-bit resolution analogue-to-digital converter and digital-to-analogue converter provide a resolution sufficient for the most demanding applications.

In short, the Signal Wizard brings the power of digital signal processing to any audio-bandwidth domain that requires high-performance electronic signal filtering. Applications include sensor linearisation, audio signal processing, signal analysis, vibration analysis, education and research in electrical, electronic and other physical sciences.

System requirements:
- 100 MHz PC running Windows 95, 98 or ME
- SVGA display (800x600 pixels) or higher
- CD ROM drive
- 10 Mbytes of free hard disc space
- Serial port, capable of 19200 bits

Signal Wizard - key features
- Runs under Windows 95, 98 or ME
- Generates FIR filters with a maximum of 1024 coefficients.
- Multiple pass, stop or arbitrary filters.
- Lower -3db frequency 3.7Hz at 48kHz sample rate and 1.2Hz at 12kHz sample rate.
- Filter operates in single or dual channel modes.
- Import mode – ASCL import of any frequency response.
- Hardware module holds up to 16 filters, instantly selectable with one mouse click.
- Zero-phase distortion in the pass, transition and stop bands, ignoring input and output coupling.
- Choice of rectangular, Bartlett, Hamming, Hanning, Blackman or Kaiser windows.
- Virtual control panel allowing run-time changes to filter gain and sampling rate.
- Includes frequency and time domain plots of filter performance.
- Frequency response plotted as linear, db, square, root, real, imaginary or phase.
- Impulse, frequency and phase response exportable in a variety of formats (dB, power etc.) as ASCII files for incorporation into standard spreadsheets.
- 18-bit resolution in single, 16-bit in dual-channel mode.
- Normal or turbo speed, software selectable.
- User selectable sample rates of 48kHz, 24kHz, 16kHz, 12kHz, 9.6kHz, 8kHz, 6kHz, 4.8kHz, 4kHz, 3kHz or 2kHz.

For more information, visit: http://www.umist.ac.uk/dias/pag/signalwizard.htm
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July 2002 ELECTRONICS WORLD
The HS801: the first 100 Mega samples per second measuring instrument that consists of a MOST (Multimeter, Oscilloscope, Spectrum analyzer and Transient recorder) and an AWG (Arbitrary Waveform Generator). This new MOST portable and compact measuring instrument can solve almost every measurement problem. With the integrated AWG you can generate every signal you want.

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

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

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

- Measured signals and instrument settings can be saved on disk. This enables the creation of a library of 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) and 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 80 volt full scale. The record length is 32K/64K 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.xx / 95 / 98 or Windows NT / 2000 / XP and DOS 3.3 or higher.

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