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TALES OF RADIO HORROR – WHAT TO AVOID IN RF DESIGN

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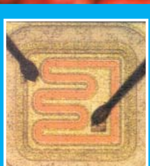

TECHNOLOGY
NEUTRON TESTING HELPS FIGHT IC DAMAGE

INSIGHT
ORGANIC LEDs ARE CATCHING UP WITH HYPE

DISPLAYS
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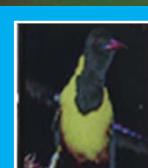

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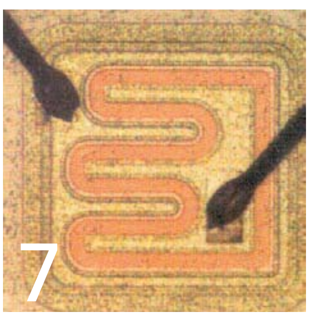

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ELECTRONICS WORLD

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STRIKING 'GOLD' IN A CHANGING CLIMATE

The annual forecast of the Association of Franchised Distributors of Electronic Components (AFDEC) held last month was a sad affair: not because of the association's kind invitation to wine and dine journalists in a prestigious London venue, but because of what was presented.

Year 2007 was one of doom and gloom: world economies are suffering from a credit crunch; oil prices have reached $100 per barrel; the semiconductor cycle is pointing downwards and so are components' average selling prices (ASPs). (Funnily enough, volumes of components shipped are up, fuelled by an ever-widening range of applications for electronics, and are currently on a par with year 2000 levels, but the trouble is that they are selling for a third of the price.)

In the UK, long-term trends are not looking that much better either, as manufacturing and sourcing are moving offshore, which is pushing the market down constantly, year-on-year.

The AFDEC annual forecast gathering is normally accompanied by a member firm, but not this year. As most of them are publicly quoted companies, none want to be seen as delivering a 'depressing' message so close to the new financial year.

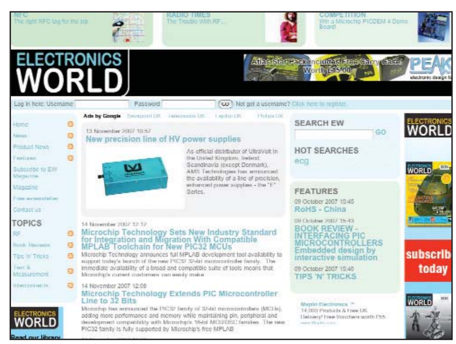
Distributors are a big group of companies which operate efficiently and run a successful business; all of them have a large sales force in place and an infrastructure that cannot lie idle for long. Luckily, the distributors are also showing themselves to be a rather creative kind of crowd too, which may be their saviour.

AFDEC representatives are saying that distributors are putting their investments to good use by beginning to distribute other goods. Many are now looking or have taken up the distribution of items such as batteries, wires, tools, and even plasma and LCD screens. But one of the most interesting items by far is the distribution of embedded software. Each time a new software release comes out, distributors could happily sell it – guaranteeing returns.

This certainly is a good way forward for them, as we are increasingly seeing software as the most differentiating factor in design and development, with many companies beginning to bring out 'platforms' that can be programmed and 'differentiated' through software.

And as software tends to keep 'reinventing' itself at the, more or less, same price (and not suffer from massive price erosions as components tend to – particularly semiconductors and passives); it looks like the distributors will strike gold.

Svetlana Josifovska
Editor



Check out Electronics World's new website by clicking on **www.electronicsworld.co.uk**

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New ADC developed by IMEC offers record performance

A new ultra-low power (700μW), high-speed (50MSamples/s) analogue-to-digital converter (ADC) achieves a figure of merit of only 65fJ per conversion step. This is 2.5 times better than the best ADC of its type previously reported in any research paper and an order of magnitude better than the best commercially available ADC IP blocks in 90nm CMOS. Its details were presented by IMEC.

The novel ADC, based on Successive Approximation Architecture (SAR), is especially suited for nomadic applications in IT. Its power scales linearly with the clock rate over a very wide range, which makes it very well suited for software-defined radio applications. It is implemented in pure digital CMOS technology, making it well suited for scaling to the 45nm CMOS node and below.

Instead of active charge redistribution in the capacitor arrays of a conventional SAR architecture, the low-power architecture of the new ADC uses a passive charge-sharing concept to sample the input signal and perform successive-approximation cycling. Thus the SAR operation is no longer based on voltage comparisons. It operates completely in the charge domain, which enables the record performance to be achieved.

This enables the fundamental power limits of the original SAR architecture to be overcome by doing all of the charge redistribution passively. The only active elements in the SAR ADC are the comparator and digital controller, thus enabling ultra-low power consumption to be achieved. The comparator consumes no power during its inactive mode, so the power consumption of the ADC scales linearly with sampling frequency. This helps to maintain its record figure of merit down to very low conversion rates.

The fully digital implementation of the ADC requires only MOS switches and metal-oxide-metal capacitors which makes the ADC scalable to at least the 45nm node.

Carbon nanotubes can be used as pressure sensors

A new study by researchers at the US-based Rensselaer Polytechnic Institute establishes that blocks of carbon nanotubes can be used to create effective and powerful pressure sensors.

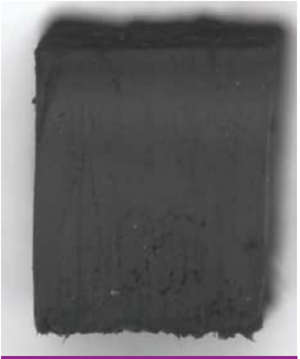
Taking advantage of the material's unique electrical and mechanical properties, researchers repeatedly squeezed a 3mm nanotube block and discovered it could be used as a pressure sensor. No matter how many times or how hard the block was squeezed, it exhibited a constant, linear relationship between how much force was applied and electrical resistance.

"Because of the linear relationship between load and stress, it can be a very good pressure sensor," confirmed Subbalakshmi Sreekala, a postdoctoral researcher at Rensselaer and author of the study.

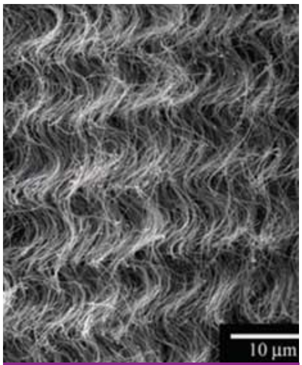
A sensor incorporating the carbon nanotube block would be able to detect very slight weight changes and would be beneficial in any number of practical and industrial applications, Sreekala said. Two potential applications are a pressure gauge to check the air pressure of automobile tires and a microelectromechanical pressure sensor that could be used in semiconductor manufacturing equipment.

Despite extensive research over the past decade into the mechanical properties of carbon nanotube structures, this study is the first to explore and document the material's strain-resistance relationship. Now the team is thinking of ways to boost the nanotubes' strength by mixing them with polymer composites, to make a new material with a longer-lived strain-resistance relationship.

"The challenge will be to choose the correct polymer so we don't lose efficiency, but retain the same response in all directions," added Sreekala.

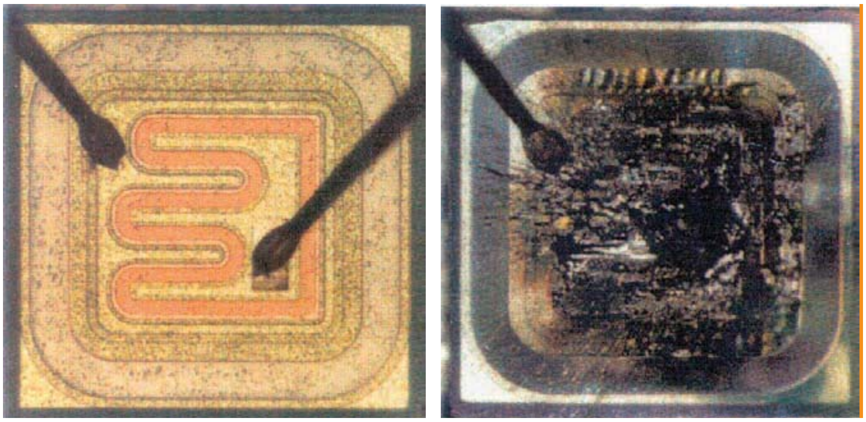


Rensselaer researchers demonstrated that a small carbon nanotube block such as this can be used to create an effective, highly sensitive pressure sensor



When the block is compressed, individual carbon nanotubes start to buckle, which in turn decreases the block's electrical resistance. Researchers can measure this resistance in order to determine precisely how much pressure is being placed on the block

Accelerated neutron testing provides 'Space Rain' umbrella



The effects of cosmic radiation on microelectronic circuits – before and after the irradiation (left to right)

British neutron scientists are tackling the challenge of cosmic radiation and its damaging effects on microchips in the aviation industry. They are using the Oxfordshire-based ISIS facility to replicate the effects of cosmic radiation on the microelectronics of an aircraft.

A flow of fast-moving charged particles from the Sun, known as solar wind, are known to damage microchips. These occurrences are called Single Event Effects (SEEs) and their appearances are 300 times greater at high altitudes, which is of particular concern to the aerospace industry. A microchip in an aircraft can be struck by a neutron every few seconds.

Although SEEs have been recognised as an issue since 2001, the problem is being compounded by the drive for greater RAM density in computers. Smaller electronic circuitry is more vulnerable to this buffeting from neutrons.

The ISIS neutron source now is trying to replicate the experience of thousands of hours of flying time in a very condensed period, which will help scientists and the industry learn how to best deal with SEEs. "At ISIS we have the ability to produce intense beams of neutrons with similar energy ranges to those occurring naturally. This enables accelerated reliability testing of microelectric elements used in the aerospace industry. Once manufacturers understand where the biggest susceptibility problems lie, they can begin to redesign circuitry on a more robust basis," said Dr Chris Frost, head of chip irradiation research at the ISIS.

BAE Systems, Smiths Aerospace and Goodrich Engine Control Systems already belong to a consortium formed in 2003 to look at the problem in detail. The aerospace systems company MBDA heads the team known as SPAESRANE (Solutions for the Preservation of Aerospace Electronic Systems Reliability in the Atmospheric Neutron Environment). Initial tests started at the end of 2006 but a new, £140m 'target station' or neutron source being completed now, includes a dedicated and full time instrument to test the effects of SEEs and chip irradiation.

"ISIS is one of few facilities in the world capable of producing enough very high energy neutrons to perform such accelerated testing. The proposed instrument at the Second Target Station would result in the creation of the best SEE screening facility in the world," said Andrew Chugg, senior technical expert at MBDA.

IN BRIEF

● **RF Engines (RFEL) has announced the availability of the 'Vector Rotation/ Translation' IP core product, which offers a sub-set of the features provided by the traditional CORDIC algorithm.**
CORDIC is a set of algorithms that is frequently used in practical signal processing applications for calculating a wide range of mathematical functions including logarithmic, hyperbolic and trigonometric functions. Typically, the CORDIC implementations that are generally available from mainstream FPGA vendors are heavily biased towards the use of the FPGA's logic resources, compared with the use of the DSP and memory block resources. The new RFEL IP core addresses this issue and allows implementations which otherwise would be impracticable.

● **Innovision Research & Technology is making its Gem Near Field Communication (NFC) IP available under an evaluation licensing programme. This will enable semiconductor companies to develop NFC capability, either for stand-alone solutions or as part of System-on-Chip (SoC) integrated systems. The move to license NFC silicon IP in this way is the first of its kind in the market. It is expected to deliver significant unit cost benefits to implementers of NFC technology, and accelerate mass-market deployment of NFC.**
The IP is fully compliant with NFC standards and includes support for advanced features such as 'battery off'.

● **Cadence introduced the Virtuoso Passive Component Designer, a complete flow for the design, analysis and modelling of inductors, transformers and transmission lines. The new technology puts passive component design into the hands of analogue and RF designers developing fast and complex wireless SoCs and RFICs. Starting from design specifications such as inductance, quality factor and frequency, the Virtuoso Passive Component Designer will help designers to automatically generate the optimum inductive device for their specific application and process technology, resulting in higher performance and smaller area. A built-in accurate 3D full wave solver verifies the generated devices, eliminating the need for a dedicated inductor characterisation run and reducing the design turnaround time.**

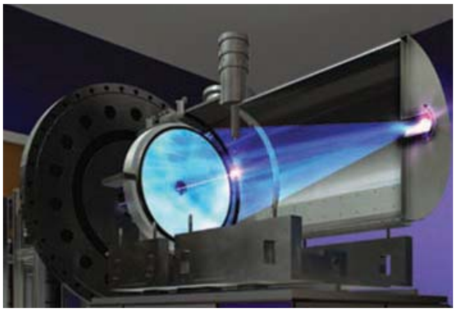
IN BRIEF

Infineon and Advanced Semiconductor Engineering (ASE) announced a partnership to introduce semiconductor packages with a higher integration level of package size, which is offering an almost infinite number of contact elements. The new package form achieves a 30% reduction of dimension compared to conventional (lead-frame laminate) packages.
Although the chip becomes smaller, the need for adequate connection space has imposed physical constraints on package shrinkage. Infineon has now succeeded in extending the benefits of Wafer-Level Ball Grid Array (WLB) to the new embedded WLB (eWLB). All operations are performed at wafer level, signifying concurrent processing of all the chips on the wafer in one step.
The two companies will now promote these advantages through their partnership and a licensing program.

Samsung, NXP Semiconductors and T3G Technologies today announced the world's first high-end TD-SCDMA HSDPA/GSM/GPRS/EDGE multi-mode mobile phone. The device is powered by the world's first software-defined modem capable of achieving data transfer rates of 2.8Mbps. It also features the industry's first soft modem empowered by NXP's Embedded Vector Processor (EVP) to achieve high data transfer and multi-mode capability.
The Samsung SGH-T578H enables about 20 times faster transfers than GPRS, allowing consumers to download several high quality MP3 files in less than a minute.

Synplicity and Lattice Semiconductor have expanded their relationship to include delivery of a highly optimised, non-proprietary ESL synthesis flow for DSP design. Synplicity's Synplify DSP software now supports the LatticeECP2M and LatticeXP2 FPGAs, creating a powerful solution for DSP algorithm implementation in aerospace, wireless, telecom and digital multimedia applications.
The combination of Synplify DSP and Lattice FPGA architectures will help designers capture multi-rate DSP algorithms quickly and easily. Designers can perform architectural exploration across multiple Lattice devices and create algorithmic IP that is highly portable and reusable, so users can easily map their DSP algorithms into any computing platform.

CYMER EUVL SOURCE ACHIEVES 50W AND IS CHOSEN BY ASML



This Cymer EUV source is a laser produced plasma generated by carbon dioxide laser radiation onto a tin droplet target

New advances in Laser Produced Plasma (LPP) technology for Extreme UV Lithography (EUVL) sources has enabled US firm Cymer to double its previously announced source power levels to 50W.

The company intends to double that power level again by the end of this year, but expects to reach the 200-225W level in the fairly near future for the volume manufacturing of chips with ultra fine patterning. The source power currently limits the number of wafers that can be processed per hour. Cymer moved from a discharge produced plasma (DPP) to LPP sources some three years ago, initially using an excimer laser to generate UV radiation with lithium as the target material. It has now changed to a multi-stage carbon dioxide laser and a target comprising droplets of tin, unlike the larger tin surfaces that are more widely employed by other companies.

A particular problem with tin targets is the debris produced. This can greatly reduce the lifetime of the very costly multilayer mirror collector in the optical system, as no lens material can be used at EUV wavelengths. Cymer claims it has reached a collector lifetime of about a year. At the Semicon West 2007 exhibition, Cymer announced that the source it has developed has been adopted by ASML of the Netherlands, for its high volume manufacturing tools. The companies have signed an agreement for multi-units to be produced over some years, with the first unit scheduled for delivery about the end of next year.

Nanostructures printed in Europe

A new nano-print process that could be used in a wide variety of applications, including the printing of nanowires, has been developed by workers at the IBM laboratory in Zürich and the ETH Zürich University. It is claimed that the process offers a resolution three orders of magnitude better than other known printing techniques and is expected to become a promising tool for use in a wide range of fields, including electronics, biomedicine and optical technologies.

It differs from other printing technologies by employing a self-assembly process to control the arrangement of nanoparticles on a printing plate or template. In traditional gravure printing, the ink is scraped into the recessed features of a printing plate in which pigment particles are randomly dispersed, whereas the new technique uses a directed self-assembly process to control the arrangement of nanoparticles. The whole assembly is then printed onto a target surface, whereby the particle positions are precisely retained at a very high resolution.

The researchers were able to print particles as small as 60nm and position them very exactly and in a reproducible way. The printing template geometries explored include lines to produce closely-packed nanowires, which could be used in molecular electronics. They explained that the long-range

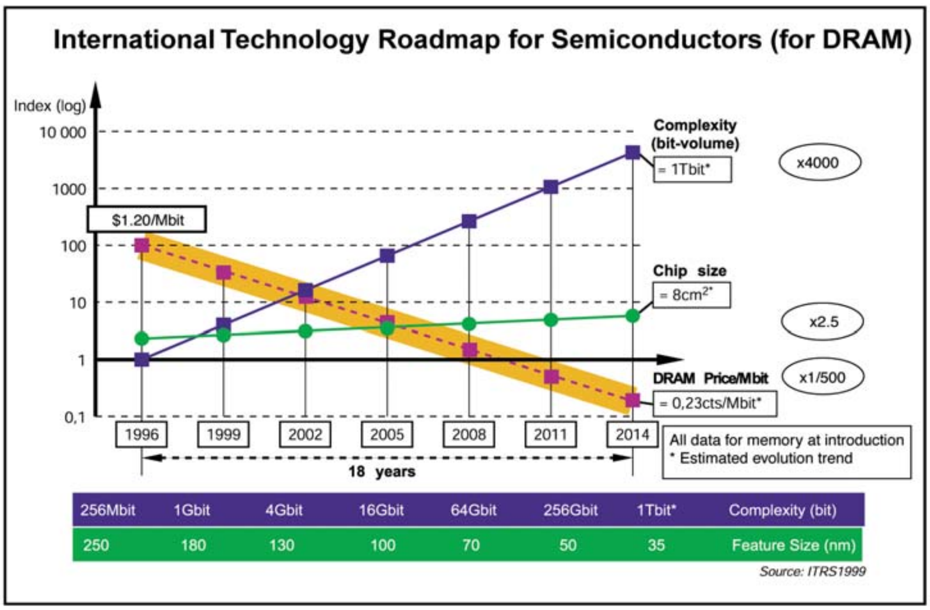
accuracy of the method is similar to that of microcontact printing methods.

Nano-wires are expected to be promising candidates for building post-CMOS nano-transistors. The process could also be used to produce arrays of biofunctional beads that can identify certain cells or markers in the body, such as in tests for cancer tests or to detect heart attack markers.

Nanoparticles interact with light, so the technology could be used in optoelectronic devices. For example, optical materials with new properties could be created, as if the printed structures are as small as the wavelength of the light shining on them, they could form lenses that band light inside future optical chips.

The method is considered to be relatively mature for its optical and biotechnological applications, but for electronics applications the long range accuracy has yet to be optimised before industrial solutions can be realistically considered.

EUROPE CHOOSES ITS NEXT COLLABORATIVE RESEARCH PROGRAMME



A new program named CATRENE (Cluster for Application and Technology Research in Europe on NanoElectronics) will follow the extremely successful MEDEA+ program, which concludes in 2008. The new program is a public-private partnership whose object is continued development of European expertise in semiconductor technology and applications. It will build on the success of MEDEA+ and earlier programs that lifted the former floundering European industry into a truly global competitive position, by benefiting from international collaboration across Europe. CATRENE will involve collaboration by industrial companies of all sizes with research institutions and universities.

The program will address healthcare provision, energy, transport, entertainment and security by projects directed at these sectors in which microelectronics will play an increasingly important part. It is believed changes such as those due to ageing populations, rising healthcare and energy prices will present both a challenge and an opportunity for the industry to address the new markets.

Jozef Cornu, chairman of MEDEA+ and designated chairman of CATRENE, said: "Nanoelectronics will offer enormous opportunities to those who are the first to master and bring to market new technologies and applications. We believe that CATRENE will play a vital role in helping Europe's microelectronics industry to go from strength to strength."

MEDEA+ and previous programs have been divided into technology and applications sectors, but these are now increasingly converging. CATRENE will therefore focus on large identified application markets, deriving from these a roadmap of the required technologies. Its key technological goals include maintaining and increasing European strength in IP across the whole electronics supply chain and its leadership in lithography and SOI materials. It must also ensure that European companies are among world leaders in advanced semiconductor technologies that allow entire systems to be integrated into a single package and strengthen expertise in applying semiconductor process technology to efficient design.

CATRENE is a 4-year program, starting on 1 January 2008, which is extendable for another 4 years. Resources required will be some 4,000 person-years each year, corresponding to about $8.5bn for the extended program. This may be compared with the 20,000 person-years of the 77 MEDEA+ projects.

The MEDEA+ program (2001–2008) helped the European industry to become a world leader in such sectors as automotive electronics, smart card technology and image sensing and to obtain some 10% of the world markets.

STEERING CLEAR OF HYBRID-TECHNOLOGY BOARDS

By Keith Gurnett and Tom Adams

In the midst of the preparations for the introduction of RoHS regulations in 2006, the notion that the new lead-free solder and traditional leaded solder might both somehow wind up on the same printed circuit board was a relatively new idea. A good many board assemblers encountered the notion first-hand when, as July 1 rapidly approached, they discovered that most, but not quite all, of the components that they are placing on a given board would be available in lead-free versions by the critical date.

These assemblers had no choice but to assemble a hybrid-technology board, one on which a few old-style tin-lead components were mounted onto pads consisting of lead-free solder. This odd and probably harmless arrangement was quietly tolerated for a few months by the National Laboratory of Weights and Measures.

Compatibility, Forward and Backward

There are actually two different types of hybrid boards. When a component whose leads have a tin-lead finish is dropped onto a board that uses lead-free solder, the component is said to be 'forward-compatible', suggesting that the component is being pushed forward into a new manufacturing environment. Conversely, when a component that uses lead-free solder is placed on a board whose pads use conventional tin-lead solder, the component is said to be backward-compatible.

Backward compatibility has become relatively common in the US, where there is no RoHS legislation and where an assembler is free to use either type of solder. An assembler might still be assembling a board using traditional tin-lead solder – something that is in theory still possible if the market for the product is only in the US, but much more common if the market is in military or medical products. Such an assembler will almost certainly face the problem that one or more components are no longer available in tin-lead versions. Since he can purchase only lead-free versions of these components, the assembler is forced into backward compatibility.

Alloy Composition	Liquidus Temp. (°C)	Reflow Temp. (°C)	Melting Range (°C)
Sn-2Ag			221 - 226
Sn-3.5Ag	221	240 - 250	221
Sn-0.7Cu	227	245 - 255	227
Sn-3.0Ag-0.5Cu	220	238 - 248	
Sn-3.2Ag-0.5Cu	218	238 - 248	217 - 218
Sn-3.5Ag-0.75Cu	218	238 - 248	
Sn-3.8Ag-0.7Cu	210	238 - 248	217 - 210
Sn-4.0Ag-0.5Cu			217 - 219
Sn-4.0Ag-1.0Cu	220	238 - 248	217 - 220
Sn-4.7Ag-1.7Cu	244	237 - 247	217 - 220
Sn-5Sb			232 - 240
Sn-0.2Ag-2Cu-0.8Sb	285	246 - 256	226 - 228
Sn-2.5Ag-0.8Cu-0.5Sb	225	233 - 243	
Sn-2Ag-7.5Bi	216	220 - 230	
Sn-3Ag-3Bi	218	233 - 243	
Sn-3Ag-5Bi	216	230 - 240	
Sn-3.4Ag-4.8Bi	215	225 - 235	200 - 216
Sn-3.5Ag-3Bi	217	230 - 240	
Sn-58Bi			138
Sn-3.2Ag-1.1Cu-3Bi	240	230 - 240	
Sn-3.5Ag-3In-0.5Bi	215	230 - 240	
Sn-3Bi-8Zn			189 - 199

Typical physical and mechanical properties of three lead-free alloys and Sn 37Pb (eutectic) [From various quoted sources such as National Institute for Standards & Technology (NIST), National Centre for Manufacturing Sciences (NCMS)]

The SAC Solders

The term "lead-free solder" actually covers a large number of alloys. The two most frequently used probably account for over 90% of the solder in electronics production. They are alloys of tin, silver and copper: Sn96.5Ag3.0Cu0.5 (known as SAC 305) and Sn95.5Ag4.0Cu0.5 (known as SAC 405). These two SAC solders differ in significant ways from traditional tin-lead solder. Their melting point is around 217°C, versus 183°C for tin-lead. When melted, they are less efficient at wetting nearby surfaces. In service they are considerably more brittle than tin-lead solder.

One of the SAC solders can be successfully used on the same board as traditional tin-lead solder if the assembler pays attention to details. Dr Ronald Lasky of Dartmouth College in the US explains how.

"You've got tin-lead solder that melts at 183°C and you've got lead-free solder that melts at 217°C. You need be sure to run the board through at something like 225°C, so that you get complete melting and total reflow of the lead-free solder."

Although the SAC solders are the most frequently used alternatives to conventional tin-lead solder, there are dozens of other lead-free solders, many of which were formulated to meet the needs of specific applications. These alloys contain metals such as Bismuth, Cadmium, Indium, Antimony and Zinc. One reason for the development of these alternative solders is that a joint using a SAC solder can be reworked only once; some of the alternative alloys are more forgiving.

Counterfeit Components

There is another route by which an assembler can produce hybrid-technology boards: the inadvertent use of counterfeit components. Dr Lasky explains that there is a very large market for previously used components. Today, old computers are often recycled rather than melted down. Recycling may mean that the more valuable components are pulled off of the board. The label on the top side of the component is typically ground off, and the component is generally cleaned up and made to appear brand new.

"That kind of stuff is happening because the market for electronic components is a multiple hundred billion dollar market," says Dr Lasky. "You ordered what you thought was lead-free, and it's a big-name company microprocessor, and you got a good price on them. And the microprocessor is real, and it works, but it was made in 2004, and the supplier told you that it was made in 2006. And when it was made in 2004 it had lead in the leads. It functions and everything, but it's not lead-free."

These components – called "pulls" – may give satisfactory performance. They may even last for the list of the system that they are installed in. But the assembler isn't getting what he paid for, and the counterfeit component, simply because of its age, is often not lead-free.

This matters in two ways. First, the difference in melting point and wettability between the two solders may mean that the old tin-lead component does not form good joints. Second, the molding compound of the tin-lead solder was not designed to be reflowed at lead-free temperatures. Tin-lead solders are typically reflowed around 230°C, while lead-free solders require 250°C or even higher. The molding compounds of many components that use tin-lead solder will survive reflow at 250°C, but some will fail through cracks or delaminations or, worse, they will form small, undetectable cracks or delaminations that will eventually turn into field failures.

Detecting Counterfeit Parts

There are however, methods that may detect such counterfeit parts without destroying them. The trick is to "ping" an incoming component with an acoustic microscope.

According to Ray Thomas, manager of the applications laboratory at acoustic microscope maker Sonoscan, "this procedure takes only a minute or so and will tell you whether the molding compound has the same acoustic impedance as the molding compound in the last batch of components".

Acoustic microscopes usually makes images of components, but in this case no image is needed – just a reading of the molding compound's material properties. The transducer on the acoustic microscope pulses a single blast of ultrasound into the top surface of the component and receives the return echoes from the interior. From this pulse, the acoustic microscope calculates and displays a value known as the Acoustic Impedance, which is, technically, the product of a material's density and its acoustic velocity. Acoustic Impedance is expressed in units called MegaRayls.

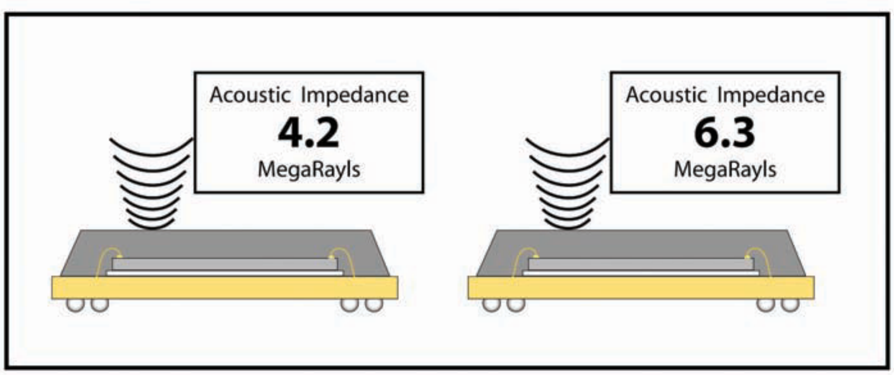
"The Acoustic Impedance of electronic molding compounds for both leaded and lead-free applications ranges from about 3.0 MegaRayls to about 7.0 MegaRayls," says Thomas. "If an engineer knows that component A when bought from supplier X has always had an Acoustic Impedance of 4.2, and if a component taken from the most recent lot also measures 4.2, it is very likely that the component is genuine and not a counterfeit."

The method is not absolute, Thomas points out, because there is a chance that a counterfeit component could use a molding compound whose density and acoustic velocity also have a product of 4.2. But if the engineer finds that the most recent lot shows an Acoustic Impedance of, say 6.3, it is time to start asking questions of the supplier.

THERE ARE METHODS THAT MAY DETECT SUCH COUNTERFEIT PARTS WITHOUT DESTROYING THEM; ONE OF THEM IS TO "PING" AN INCOMING COMPONENT WITH AN ACOUSTIC MICROSCOPE

It may turn out that the component manufacturer has simply changed the molding compound for this component, although the assembler should have been informed of this change. But it may also turn out that the supplier has no good answer to the question. In this case, the assembler may want to investigate further. Making an acoustic image of the component, for example, may show that the design of the lead frame has changed since the last lot was received.

A changed electronic molding could, of course, might have a reasonable explanation. But in many cases the quick measurement of the molding compound's material properties by ultrasound has kept a lot of counterfeit, and probably tin-lead based, parts out of lead-free production. ■



If the molding compound of two supposedly identical components reveals significantly different Acoustic Impedance values when measured by an acoustic microscope, then the molding compounds are different and one component may be counterfeit. [Diagram courtesy Sonoscan, Inc]

by Myk Dormer

TALES OF RADIO HORROR

Previously I've written what I hope have been informative articles, offering application tips and precautionary advice. Now I wish to indulge in a little reminiscence and list for you a few of the more amusing "incidents" that I've witnessed over the years. (Circumstances and names have been obscured to protect the 'guilty').

Short range

A customer reported an extremely short operating range from a wireless module pair, theoretically capable of well over 1km. He insisted that every recommendation of the data sheet had been followed, right down to the specified quarter wavelength wire aerials.

On the eventual site visit I inspected the units: the aerials were indeed correct 16cm quarter wavelengths and the transmitter aerial projected stiffly from the handheld unit. The receiver aerial unfortunately was 'in the way' and so had been neatly coiled up and stuffed underneath the PCB, into a 2mm gap between it and the (steel) chassis.

Low power

A customer phones up complaining that the supplied 100mW transmitter could output no more than 40mW. The unit was re-checked (perfect) and the customer's power meter examined (in calibration). Finally, the cable, coupling the two, was seen: Two meters of the best quality *audio* coax.

Sold short

Another customer complains of lower-than-spec power output. The 500mW transmitter is only outputting 475mW, which is less than -0.3dB low. So, I politely enquire: "Is your power meter in calibration?".

"What power meter?" came the answer. "I'm measuring it by eye, off the screen of my (old) spectrum analyser."

Best of three

A (by now) familiar complaint: The 100mW transmitter is "barely capable of 10mW". No fault can be found on the returned module and the customer's test equipment is functioning normally. Several days of confusion ensue, until a red-faced chief engineer reports the discovery of an inverse pair of diodes added across the RF feed at the last moment "to protect the radio from large signals" by an over-zealous junior.

Less is more

We've supplied small numbers of a 25mW transmitter to a customer for the early stages of a project. The goal posts move (as they are prone to) and he needs significantly more range in the production units.

"No problem," I crow. "We make a 500mW transmitter and it's got the same pin-out." A few days later the confused fellow reports that the new, higher power units have less range than their lower power predecessors. Now I'm confused too, until I re-check the data sheets. The 25mW unit can operate from 3.3-15V, but the 500mW module needs a 5V regulated rail.

What is his power supply? A high-current lithium 'D' cell, supplying 3.7V.

SEVERAL DAYS OF CONFUSION ENSUE, UNTIL A RED-FACED CHIEF ENGINEER REPORTS THE DISCOVERY OF AN INVERSE PAIR OF DIODES ADDED ACROSS THE RF FEED "TO PROTECT THE RADIO FROM LARGE SIGNALS" BY AN OVER-ZEALOUS JUNIOR

Not to spec

An indignant customer complains that a transmitter/receiver pair sold as "capable of 75-150 meters range" is barely able to function over 20m and even then the link reliability varies randomly.

We find the receiver is inside a (metal bodied) lift car, running in a (steel lined) shaft, with the transmitter located in the (steel framed) building lobby.

And the random factor is "lift doors opening..."

Speed kills

A customer evaluates a simple remote control coder chip with a particular transmitter. All goes well until he decides that a faster response time is needed.

He increases the clock speed of the coder until the datastream is as fast as the transmitter's baseband filter will pass, while ignoring our repeated warnings that, as he increases the clock, the time allowed by the simple coder for preamble, start-up and settling times falls proportionally, until it is less than the guaranteed 'on' time of his chosen transmitter.

Guess what happens when he goes to production?

And here are a few little 'gems':

– Lengths of RF coax spliced with mains-type terminal block.

– Long, winding, unmatched PCB track

between the radio and an "RF" connector.

– A customer designed add-on power amplifier with no supply decoupling.

– A customer designed (class C) non-linear power amplifier with no lowpass filter.

– Modules 'potted' with corrosive RTV silicone compound.

– Modules washed in aggressive solvents.

– "I need a range of 100m... underwater".

– An UHF aerial on a VHF transmitter.

– No aerial ("What... I need an *aerial*?")

– "The pins fell out when we de soldered it, so we pushed them back in."

And lastly, here's a classic. A security firm in the 1980s is using the then-popular Motorola MPT700 handheld transceiver and they are getting an unexpectedly high rate of in service failures on one particular site.

Diagnosis of the failed units shows RF power amplifier faults consistent with low frequency oscillation and resulting thermal overload. Nothing similar has been seen with this unit before, so engineers are sent to the customer site to investigate.

None of the expected problems (charger defects, missing or damaged aerials, high power interferers) are found and no solution is in sight, until a technician observes some of the security staff going on-shift:

They take their radios off the charger rack and ***tie the 50cm long flexible whip aerial around the case of the radio*** before putting the unit in their pocket "because the aerial gets in the way".

As a result, there is far more coupling from the output back into the transmitter than the design ever allowed for and the circuitry would sometimes go unstable.

The cure: a more rigid aerial.

Of course, all these examples are purely hypothetical: no real customer could ever have actually made any such errors. If you recognise something, I assure you that I could not possibly be referring to you.

Myk Dormer is Senior RF Design Engineer at Radiometrix Ltd
www.radiometrix.com

OLED DISPLAY MARKET CATCHES UP WITH HYPE

OLED IS FINALLY LIVING UP TO THE HYPE BY DEVELOPING A STRONG POSITION IN A RANGE OF MOBILE APPLICATIONS, SAYS **MYRDDIN JONES**, CEO OF UK-BASED OLED-T

Confidence in the Organic Light Emitting Diode (OLED) display market was initially undermined by hype from OLED manufacturers. During the infancy of the market back in 2000, some analysts predicted that OLED would replace LCD within a period of five years, something that has clearly not happened.

Now, however, OLED is on the way to establishing a strong position in mobile applications where the combination of low power consumption, ultra-fast switching speed and excellent optical performance gives real advantages to consumers.

Improvement in materials is bringing longer lifetimes to OLED devices. The establishment of larger active matrix production lines in Asia is improving product yield, cost and reliability. These factors are contributing to the OLED market becoming a reality.

OLED technology is starting to gain significant market share in the mobile products market in applications such as mobile phones and media players, where its high image performance and low power consumption benefits deliver better performance, in particular when displaying video.

The advantages that OLEDs have over LCD are well documented (see **Table 1**). However, the key distinguishing factors are lower power consumption in video mode with faster switching speeds, a more vibrant colour range, not to mention the fact that they are thinner and lighter.

Given these obvious advantages, why have OLEDs not replaced LCDs? There are many answers to this question. The LCD market has had 30 years to become established with a mature infrastructure and high production yields. The production lines are large, some capable of handling 2-metre by 2-metre substrates, resulting in high production efficiency and low costs.

Whilst excellent progress has been made with OLED lifetimes (now lifetimes in excess of 20,000 hours can be expected even for blue colours), LCD has proven reliability with a thirty-year track record. LCD optical performance is continuously improving and considered "good enough" for many applications.

However, 2007 has seen the emergence of Active Matrix OLEDs enabling higher resolution, large size OLED displays to be manufactured with stunning performance and lower power consumption. The same move from Passive to Active Matrix happened in the LCD market about 10 years ago, which boosted demand for LCD products.

DisplaySearch predicts that Active Matrix OLEDs will achieve an 80% share of the OLED market by 2010, largely being implemented in applications demanding high resolution such as mobile phones, digital cameras, car information systems and mobile music players.

So what's the hype and what's the reality? Despite several high profile announcements of OLED TVs this year, the majority of the market for OLED devices in the next two to three years will be for small-sized displays in high performance mobile applications.

Over the next few years we will see OLED technology continue to develop, concentrating on factors such as production yield, cost control and lifetime that currently restrict its wide implementation. Additionally, vendors will focus on increasing the market share for OLEDs in sectors such as mobile phones, media players and digital cameras, where its high optical performance and lower power consumption benefits are improving product performance.

The future is certainly bright. In 2006, the worldwide flat panel display market was worth $70bn, forecast to grow to $100bn by 2010, according to display analysts. Within this, OLED is the fastest growing non-LCD display technology. Within three years the OLED display market is expected to be worth $2.5bn. ■

- Lower power consumption due to the high energy efficiency of the display and the absence of an inefficient backlighting system
- Thin and lightweight due to the simple monolithic structure (no backlight system)
- Wide viewing angle with no colour shift, contrast shift or brightness shift from any direction
- Ultra-fast switching response, providing excellent moving image performance
- A large colour gamut. This means that the primary colours, red, green and blue are very intense and saturated. As a result, the colours on an OLED are very vivid
- Very high contrast of > 1000:1, resulting in a vibrant display image with excellent grey scale performance

Table 1: OLED benefits

The majority of the market for OLED devices in the next two to three years will be for small-sized displays in high performance mobile applications

Gary Nevison is chairman of the AFDEC RoHS team, and Customer Support Manager, Legislation and Environmental Affairs at Premier Farnell. As such he is our industry expert who will try and answer any questions that you might have relating to the issues of RoHS, WEEE and REACH. Your questions will be published together with Gary's answers in the following issues of Electronics World.

DIGGING DEEPER

AFTER GIVING A BASIC OVERVIEW OF REACH IN A PREVIOUS COLUMN, THIS MONTH WE TAKE A CLOSER LOOK AT SOME OF THE MAIN QUESTIONS ABOUT THE REGULATIONS THAT COULD HAVE A GREATER IMPACT ON THE ELECTRONICS INDUSTRY THAN ROHS.

REACH IS A REGULATION MEANING IT IS SOMETHING THAT EVERYONE WITHIN THE EU MUST COMPLY WITH. THERE IS NO MEMBER STATE LEGISLATION EXCEPT TO DEFINE ENFORCEMENT AND PENALTIES. REACH WAS INTRODUCED BECAUSE MANY THOUSANDS OF CHEMICALS ARE USED IN THE EU, SOME IN VERY LARGE QUANTITIES, BUT THE RISKS TO HUMAN HEALTH AND TO THE ENVIRONMENT FROM MOST ARE NOT KNOWN.

REACH INTENDS TO ADDRESS THIS BY MAKING MANUFACTURERS AND IMPORTERS OF CHEMICALS RESPONSIBLE FOR PRODUCING DATA TO DEFINE THE HAZARDS AND RISKS FROM AROUND 30,000 SUBSTANCES THAT ARE USED IN QUANTITIES OF MORE THAN 1 TONNE PER YEAR IN THE EU

Q: Who is affected by REACH?

A: REACH is very far-reaching and applies to manufacturers, importers and distributors of chemicals, and manufacturers and importers of 'articles'. 'Articles' are defined as products such as electrical equipment, sub-assemblies, components – items having a "special shape, surface or design which dictates their function to a greater degree than their chemical composition". REACH also affects downstream users of chemicals and preparations.

Q: Who is responsible for the registration of chemicals?

A: All manufacturers and importers of chemicals, chemicals in preparations (mixtures of solutions and substances) and substances in 'articles' that are 'released' in use.

Q: What is the definition of a 'released' chemical?

A: This is still a topic of debate but some examples will illustrate this issue:

– Solvent in an aerosol can is not a released chemical but is a preparation (the solvent) within an article (the can).

– Ink in an inkjet printer cartridge is intentionally released and the authorities have decided that this is a preparation (the ink) in an article (the cartridge).

– Electrolyte in a battery (e.g. lead acid or zinc carbon) is a released substance. Although release is not intended, it is foreseeable (due to a leak) and so is included as a released preparation.

– Metals are recovered from electrical equipment at end-of-life by recycling. This is intended and foreseeable and so probably should be regarded as a release. However, clarification from ECHA is awaited.

Q: Are all chemicals treated in the same way?

A: No, the data required for registration depends on the quantity produced or imported. A lot more technical data is required for usage of 1000 tonnes per year than is required for 1 tonne per year. The deadlines for registration of the larger quantities are also much shorter than for smaller quantities. The most hazardous chemicals are considered differently and will be classified as "Substances of Very High Concern" (SVHCs). These include those that are toxic, carcinogenic, mutagenic, reproductive toxins and harmful to the environment. Chemicals falling into these categories must be authorised before they can be used. Authorisation will not be given if there are considered to be safer alternatives or if the substance cannot be safely controlled.

Q: Which materials might contain SVHCs?

A: One of the European Chemicals Agency's (ECHA) jobs is to list SVHCs but this is not yet complete. They are likely however to include a variety of materials that are present in electrical equipment such as lead (used in solders, some glasses and various electronic components), cadmium (present in plating, pigments, switch contacts), hexavalent chromium (found in passivation coatings), beryllium and arsenic.

The ECHA is also likely to include many quite common chemicals that are present in widely used materials such as polyurethane paints and resins, various types of adhesives, sealants, plating chemicals and solvent cleaners.

Metals may also contain SVHCs if they contain lead, arsenic or cadmium. It is recommended that users check manufacturer's safety data sheets as these will list all hazardous ingredients. If any are category 1 or 2 carcinogens, mutagens or reproductive toxins, then these will be SVHCs.

Q: Are plastics included in REACH regulations?

A: No, polymers are excluded from REACH but any residual monomer and any additives are included in the scope.

Q: What action should 'downstream users' of chemicals take?

A: As all commercial users of chemicals will be affected by REACH, it is recommended that a strategy is defined and followed. This should start now.
Most manufacturers use chemicals and preparations. These should be audited to answer the following questions:
– Do you import any materials directly from outside the EU in quantities of more than 1 tonne of an individual substance per year?
– Do you import equipment, sub-assemblies or components from outside the EU and do these, on an annual basis, contain more than 1 tonne of a 'released' substance or more than one tonne of a substance likely to be a SVHC at a concentration of > 0.1%?

Please email your questions to:
svetlana.josifovska@stjohnpatrick.com
marking them as RoHS or WEEE.

Watching the chemicals

The number of incidents of allergies, asthma, certain types of cancer and re-productive disorders are on the increase in Europe and chemicals are considered as possible causes. If REACH succeeds in reducing chemical related diseases by only 10%, the health benefits are estimated at €50bn over 30 years.
100,106 chemicals were reported to be on the market in 1981, the only time that chemicals have been listed in the EU. The chemicals sector is the third largest manufacturing industry in the EU, encompassing 31,000 companies and 1.9 million people. Internationally, the EU is the leading chemicals producing area, its €580bn representing 33% of global sales.
For 99% of chemicals (by volume), information on properties, uses and risks are sketchy. Chemicals produced in high volumes (above 1000 tonnes per year) have been managed more closely. Still, there is no data for about 21% of those, and another 65% come with insufficient data.
The costs of registration, including the necessary testing, are estimated at €2.3bn over the 11 years that that it will take to register all the substances covered by REACH. The total costs, including those to downstream users, are estimated at €2.8bn to €5.2bn, depending on the extent to which registration costs will increase prices of chemicals and the costs of substituting chemicals that will be withdrawn.

DIRECT DIGITAL SYNTHESIS (DDS) IS A COMMONLY USED TECHNIQUE AND IN THIS ARTICLE **CARLOS VERDONCK** DESCRIBES THE DESIGN AND CONSTRUCTION OF A COMPLETE SYSTEM, WHICH IS GOVERNED BY A PC/LAPTOP OVER A USB PORT

USB 20MHz DDS SYSTEM

DDS stands for Direct Digital Synthesis and is a digital way of generating a sine wave where a counter, an accumulator and a look-up table generate digital sample points. These sample points become a pure sine wave after appropriate low pass filtering.

Everything is based on the fact that a sine wave is determined by minimal two sample points and with the increased speed of digital electronics over the last few years you can find DDS techniques almost everywhere. Digital radios, tuners, RF equipment and links, transmitters, receivers, HAM gear and so on have a high chance to hold a DDS technique to generate and lock their frequency.

In this way, the intelligence to program the DDS is separated and isolated on a PC and the hardware is minimised for the DDS unit. There is a GUI accompanying the DDS unit, which is written in Visual Basic to control the system, and source code is also available. You can even adapt it to your own needs. All source/design files are downloadable to construct your own DDS unit. As a service to the reader, there is an option available to buy a complete working and tested unit, so you can directly start testing and using this clock/signal source.

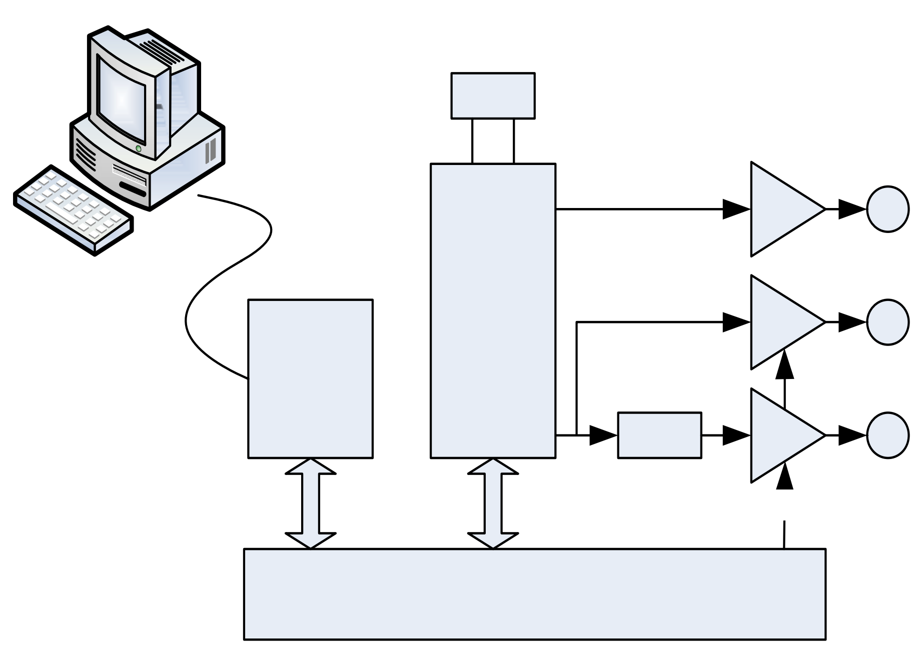


Figure 1: *Block diagram of the DDS unit*

Specifications

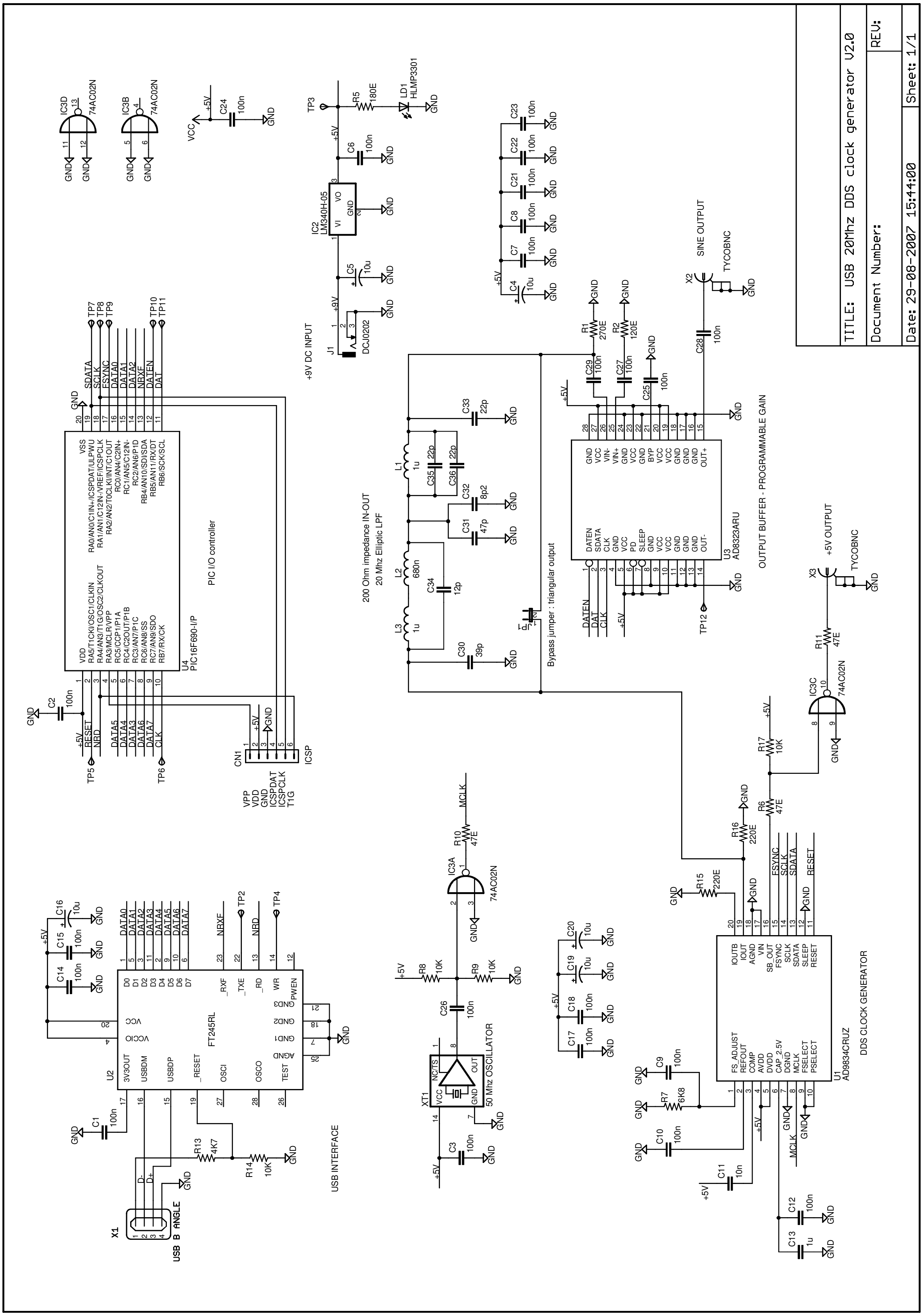
- Output frequency programmable from 0Hz to 20MHz, in steps of 1Hz
- XTAL controlled, 100ppm
- Three outputs available:
  - o Sine wave, amplitude +/-2Vpp, with a software programmable output level
  - o Triangular wave, amplitude +/-2Vpp, with a software programmable output level
  - o CMOS 5V output (clock)
- USB V1.1 interface to set frequency and amplitude of the outputs
- Visual Basic driver program to control the DDS (GUI)
- Compact design: 8 x 10cm
- Aluminium housing optional
- Powering using separate +9V wall plug

WORKING PRINCIPLES

The DDS unit itself has main blocks:

- The USB interface, which connects to a PC/laptop
- A PIC microprocessor controlling and programming the DDS
- The DDS itself, including the filtering and buffering

Access to the USB port is done via a USB I/O interface chip from FTDI, the FT245RL. This chip controls the complete USB interface and comes with all the necessary drivers for most of the programming languages. Using this technology, you don't have to bother about the USB interface, enumeration, HID or other things. It allows you to quickly create USB connectivity to your application and it was the easiest choice for this DDS system. The FT245RL is in fact a FIFO interface where on one side the data you send from your PC is dropped in a data buffer and on the other side the application can read out the data from this buffer.



04-09-2007 10:55:05 f=0.71 C:\My Documents\Eagle\USB 20Mhz DDS clock generator V2.0\USB 20Mhz DDS clock gener

***Figure 2**: Schematics USB 20MHz DDS system*

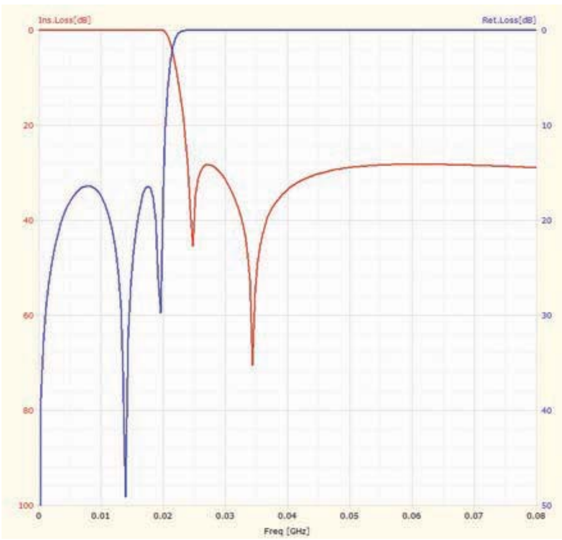


***Figure 3:** Frequency characteristic of the elliptic filter*

The PIC microcontroller is the heart of the DDS generator and has three main functions:
1) Initialising the DDS at start-up;
2) Interfacing between the USB FTDI chip and the DDS to update the frequency;
3) Set the desired attenuation for the sine/triangular output buffer stage.

Once the generator is initialised the PIC controller waits for data to come from the PC and it updates the DDS accordingly (frequency, wave shape and output stage). The DDS chip AD9834 gets its frequency control from the PIC controller and creates the correct frequency tuning control word. The clock frequency of the DDS runs at 50MHz, leaving some roll-off (5MHz) for the (elliptic) low-pass filter, creating a frequency window from 0Hz to 20MHz. On this DDS chip, there's an on-board high-speed comparator, generating a clean square wave, CMOS 5V.

SCHEMATICS

On the schematic, you can find the three main blocks as depicted on the block diagram. The USB chip is configured as self-powered, meaning that the USB bus doesn't power the board. All electronics on board is powered at 5V. Powering is done via a wall-plug adaptor of 9V, where a stable 5V voltage is derived from.

The PIC micro (U1) reads 8-bit data from the FT245 (U2) FIFO interface, which contains the frequency control words, the desired wave shape and the attenuation info for the output stage. Once a valid data packet is received, the PIC updates the DDS via the two serial control interfaces: SDATA/SCLK/FSYNC (for the DDS) and DAT/CLK/DATEN (for the programmable attenuator).

The DDS gets its clock from a 50MHz XTAL oscillator, which is the maximum clock frequency for the AD9834BRU version. The footprint for the oscillator is a 14 pins DIL universal footprint. Standard, the oscillator is a 100ppm version. The clock output is buffered and shaped for 50% duty-cycle which gives optimal results for the DDS. Optionally, the user can generate an own clock for improved frequency tolerance.

On the DDS, two outputs are generated: the sine and triangular wave are combined on one output and the square wave comes on a separate output. There are also two BNCs as such to connect the kit to the outside world. One BNC holds the sine/triangular wave and the other one the square wave.

The output of the DDS is current driven into 220-ohm output resistors and first passes an elliptic low-pass filter. This elliptic filter has a stop band attenuation of minimal 30dB, which is enough to filter out the mirror and sideband components from the DDS. Input and output impedances are around 200 ohms, which is the best value for the DDS according the datasheet. The frequency characteristic of the elliptic filter can be found in **Figure 3.**

The triangular wave is generated inside the DDS chip by bypassing the SIN ROM table. In this case, the accumulator (step function) is directly output on the DDS and no low pass filtering is needed. In this case, the low pass filter needs to be bypassed by inserting jumper on JP1. The amplitude of the triangular wave can still be programmed by the output stage.

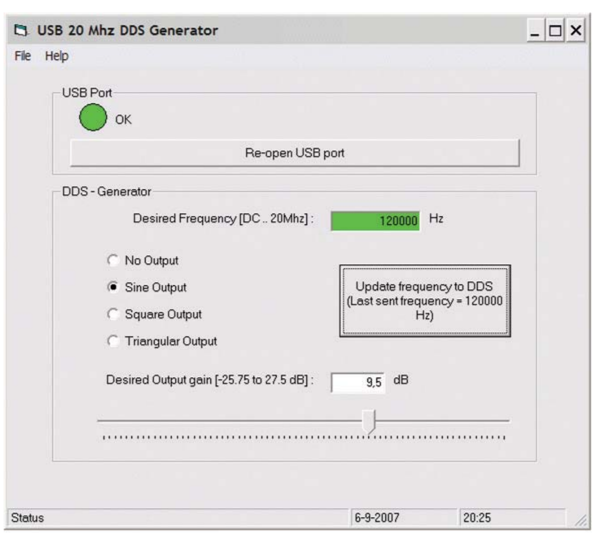


***Figure 4:** GUI screenshot*

Ordering and downloading extra material

This design is made available to you, via the company LV Kits, which distributes and also sells it own electronic kits and modules. Ordering can be done via their website: www.lvkits.be/EW/index.htm or via e-mail: info@lvkits.be

There are several options: as a completed and tested unit or as a do-it-yourself kit, where all components and PCB are separate.

On the website, you can download the following files:

- Reference [1]: A Technical Tutorial on Digital Signal Synthesis (.pdf)
- Schematics (.pdf)
- PCB Gerbers (.pdf)
- HEX file to program the PIC16F690 (.hex)
- Visual Basic project package (source + executable) (.zip)

Qty	Value	Device	Parts	SMD?
1		HDR-1X6-SIP-100	CN1	
1		JP1E	JP1	
1	1u	C-EUC1206	C13	X
2	1u	L-USL3225M	L1, L3	X
1	4K7	R-US_0207/10	R13	
1	6K8	R-US_0207/10	R7	
1	8p2	C-EU050-025X075	C32	
4	10K	R-US_0207/10	R8, R9, R14, R17	
1	10n	C-EU050-025X075	C11	
5	10u	CPOL-USE2.5-6	C4, C5, C16, C19, C20	
1	12p	C-EU050-025X075	C34	
3	22p	C-EU050-025X075	C33, C35, C36	
1	39p	C-EU050-025X075	C30	
3	47E	R-US_0207/10	R6, R10, R11	
1	47p	C-EU050-025X075	C31	
1	50MHz OSCILLATOR	XO-14	XT1	
1	74AC02N	74AC02N	IC3	
20	100n	C-EU050-025X075	C1, C2, C3, C6, C7, C8, C9, C10, C12, C14, C15, C21, C22, C23, C24, C25, C26, C27, C28, C29	
2	100n	C-EUC1206	C17, C18	X
1	120E	R-US_0207/10	R2	
1	180E	R-US_0207/10	R5	
2	220E	R-US_0207/10	R15, R16	
1	270E	R-US_0207/10	R1	
1	680n	L-USL3225M	L2	X
1	AD8323ARU	AD8323ARU	U3	X
1	AD9834CRUZ	AD9834CRUZ	U1	X
1	DCJ0202	DCJ0202	J1	
1	FT245RL	FT245RL	U2	X
1	LED GREEN	HLMP3301	LD1	
1	LM340H-05	LM340H-05	IC2	
1	PIC16F690-I/P	PIC16F690-I/P	U4	
2	TYCOBNC	TYCOBNC	X2, X3	
1	USB B ANGLE	MINI-USB_4P-85-32004-10X	X1	
1	DIL20	SOCKET	Socket for U4	

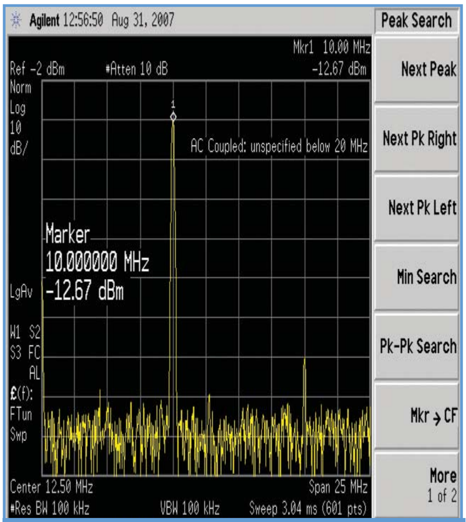


Figure 5: *Sine output spectrum*

After the low pass filter, the sine/triangular wave is going through a variable gain buffer, the AD8323 from Analog Devices. This 5V line driver features a programmable gain in steps of 0.75dB over a 54dB range, giving the DDS an enhanced output power control. Gain is set via the PIC controller, directed by the GUI. The DDS and the programmable line driver are programmed via a 3-wire SPI interface (enable, clock and data). There are two SPI interfaces: one for the DDS (FSYNC, SCLK, SDATA) and one for the programmable attenuator (DATEN, DAT, CLK).

Remaining is the square output, which is explained here. One of the characteristics of the AD9834 is the sign bit. This feature is used to generate a square clock signal out of the DDS. The MSB of the DAC output of the DDS is fed through an internal comparator and is available as a square wave with the same frequency as the sine output. A CMOS output buffer (IC3) is used for isolation.

BOARD LAYOUT AND SOFTWARE

As the DDS unit is completely controlled via PC, there is no user interface available like buttons, an LCD etc, so the number of components is very limited and board space is minimised. Everything is put on half a Euro card format (8 x 10cm), in a two-layer setup. Care is taken on ground layers and routing around the DDS. Gerber files can be downloaded from the author's website, but you can order the PCB as well.

The software is written in Visual Basic and the program contains only one main screen. On the GUI, you can set the following items:

- The frequency can be set from 0Hz to 20MHz;
- The gain control for the sine/triangular output can be set in steps on 0.75dB;
- The desired output wave shape can be selected (no output, sine, square, triangular). When selecting no output, the DDS is switched off and both BNC have a DC signal.

The source code is available for adaptation to your own needs. The project contains one main basic file and a main form. Most of the source code is the embedding of the FTDI drivers and initialisation of the DDS. Further details about the software can be found in the source code.

CONSTRUCTION HINTS AND TESTING

In case you want to construct this kit yourself, here are some guidelines:

- There are three TSSOP components on board, namely U1 (DDS AD9834), U2 (FT245) and U3 (AD8323), which are critical to solder by hand.
- Start with the AD9834 chip and use solder flux, as this is a high density TSSOP20 package. Watch the orientation of pin 1. Once positioned and soldered, remove flux with a flux cleaner and check this part for shorts, as this is the highest risk part. Repeat this action for the FT245 and AD8323 chips.
- Mount the remainder SMD components: C13, C17, C18 and L1, L2, L3
- Solder the rest of the components, according the BOM.
- There is one programmed part, the PIC controller, which goes on a 20-pin IC socket, in order to get the part updated or replaced. Be careful to mount the socket first. Watch the orientation of pin 1.
- Watch the orientation of the elcos and XTAL oscillator!
- The elliptic filter consists of several ceramic capacitors and chokes. Make sure that each component is inserted in the right place here.

References

[1]: A Technical Tutorial on Digital Signal Synthesis: http://www.ieee.li/pdf/essay_dds.pdf

[2]: All design files and links for ordering: www.lvkits.be/EW/index.htm

- Once completed, double check and verify your artwork. Check for possible shorts and excess of solder tin.

Once constructed, before switching on the power supply, first check the power supplies with a multimeter: measure the impedance of +5V (TP3) with an ohmmeter. No short may be noticed here. Now, you are ready to get the DDS up and running.

Insert a 9V wall plug, connect the USB cable and start the software (see also download section). At start-up, no frequency is set and the DDS awaits a valid frequency and output power control packet from the PC. Upon first installation, the FTDI drivers need to be installed as well. Connecting the USB cable to the kit, the PC will ask for the appropriate drivers for the FTDI chip. This process happens twice: once for the chip and once for the virtual FIFO port.

Using the DDS GUI, you are able to set the desired frequency, wave shape and attenuation of the output buffer. Press the 'Update to DDS' button to get the DDS system programmed. Once connected, the GUI will detect the module (you'll get a 'green' light) and the frequency can be set. The frequency range can be set from 0Hz to 20MHz, in steps of 1Hz. The GUI displays the last downloaded and programmed frequency (see **Figure 4**: the GUI screenshot). Upon each change on amplitude, frequency or wave shape: don't forget to push the 'Update to DDS' button.

SINE OUTPUT

Depending on the desired frequency setting, the signal to noise ratio will vary. In **Figure 5** you can see the sine output measured on a spectrum analyser over a band from DC to 25MHz. The output is set at 10MHz, giving an SNR of 60dB. ■

GIJS WERNER, GLOBAL MARKET MANAGER AT FCI, ANALYSES THE FUNCTIONAL AND FINANCIAL NEEDS FOR CONNECTORS IN THE LATEST GENERATION OF MEDICAL EQUIPMENT AND DEVICES

HEALTHY COMPONENTS

Many high-tech industries now require increasing levels of functionality and flexibility. This is most true of the medical industry, where applications are critical to the successful care and safety of the patients.

Continuous improvements in the medical imaging segment, in particular, are due to the availability of more accurate and easier-to-use technologies that benefit an aging population, both in hospitals and at home.

The increasing demands on new medical imaging equipment are driven mainly by investments in scanning systems by hospitals, replacement of older outpatient facilities, replacement of conventional analogue machines by digital x-ray systems, growth in diagnostic ultrasound equipment (see **Figure 1**) and the trend to combine different technologies within the same equipment, like Computer Tomography (CT) and MRI.

Figure 1: *An MRI ultrasound system*

Reliable Components

As medical testing and procedures become more advanced, the electronic components designed into the equipment must be more than just reliable in critical applications. Connectors utilised in today's medical applications must function at higher speeds, provide higher density, require smaller footprints and lower profiles, and comply with ever-stricter industry standards.

These trends are most evident in medical imaging applications, but they are just as prevalent in data storage devices, communication systems, image archiving and online manipulation of images in the medical industry.

Higher speed requirements are a result of the desire for real-time diagnoses, increased accuracy and faster imaging (to ensure patient safety and to make diagnostics more effective). There is also a need for improved functionality for machines that combine previously separate systems, such as Positron Emission Tomography (PET) and CT, imaging techniques which when combined allow doctors to more readily identify and diagnose cancer, heart problems and brain disorders. And in ultrasound systems, new diagnostic imaging technology enables systems to move from 2D to generally preferred real-time 3D/4D imaging, thus requiring higher speeds to display all information.

Speed is a fundamental design parameter that has system-wide implications, from board-level to PCI bus. It is important that OEMs choose component suppliers that understand these end-product requirements because choosing the right connector can save time during the design and testing process that can be spent on other aspects of the system. Also, components that provide increased performance, such as connectors that are ideal for high-speed applications, can help bring down the overall cost of medical imaging systems (like an ultrasound machine) every single year, as the performance of an individual connector increases, fewer are required for the overall design.

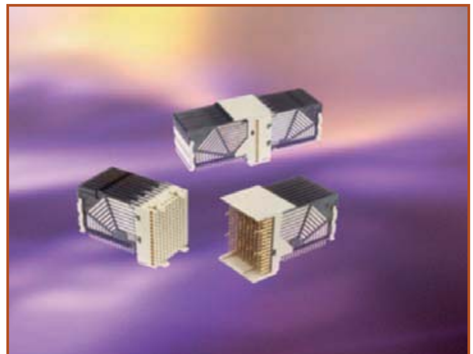


Figure 2: *AirMax VS*

Part of this drop in end-product prices is due to the shrinking of overall system size, and to meet that need connector manufacturers have significantly increased the density of their products, packing more speed and performance into less space. Product engineers try to prevent complete system redesigns by making system upgradeable to keep pace with market trends, making scalability an important feature, not just in systems but in the electronic components as well.

For example, FCI's AirMax VS (see **Figure 2**) high-speed backplane connectors offer design versatility because signal connectors can be scaled by varying the number of columns of contacts, the number of contacts per column and the column spacing. AirMax VS connectors also allow for mixed pin assignments (differential or single-ended signals or power), to provide additional flexibility to system designers. Data rates can scale from 2.5Gb/s to beyond 12Gb/s without requiring re-design of a basic platform. Medical equipment continually requires more performance but it helps if the architectural design remains intact.

Driving Forces

The miniaturisation of connectors in the medical industry is being driven by equipment such as mobile monitoring stations and handheld equipment such as field-operable CT scans or laptop-sized portable ultrasound systems, as well as a trend toward outpatient treatment over in-hospital stays, which requires components with lower profiles in addition to smaller footprints.

One of the best connector solutions for these machines are flex cable connectors, but in the past utilisation of these connectors may have meant a lower level of electrical performance. But, connector manufacturers have developed more advanced solutions now, such as FCI's MEG-Array on flex foil or BergStak/Conan on flex foil for less demanding applications.

The MEG-Array Mezzanine (**Figure 3**) provides the features needed for MRI, CT and other imaging applications to achieve real-time, higher resolution imaging. Used to connect the photo diode within the scanner, MEG-Array's higher density allows a greater number of slices, resulting in more accurate imaging. Additionally, MEG-Array delivers outstanding mechanical and electrical performance, achieving data rates of up to 10Gb/s.

Finally, more than ever, new industry standards (such as USB, PCI, RJ45, DVI, MicroTCA and PCI Express) are being incorporated and are required for new equipment designs. Today, leading connector manufacturers, including FCI who was first to market with a PCIe surface mount connector, are developing products specifically for these markets. The growing implementation of such standards can be attributed to their facilitation of shorter design cycles and faster system introductions, and the fact that open standards technology offers ready-made solutions to expanding connectivity requirements, all of which can give OEMs an edge in a competitive marketplace. OEMs are often pushed to "experiment" with new architectural options, which can make even the latest electronic components quickly obsolete.

Because of this, OEMs prefer to avoid proprietary systems because they result in higher costs and longer development cycles (typically up to 5-7 years for a new generation of MRI scan to be introduced, for example). Components that do not readily work with a specified architecture can create additional lag time and affect overall design.

How can component suppliers like FCI help? It is crucial to make the right choice of connector: interconnects are an essential element of overall system reliability and, thus, in the successful care of patients. It is imperative that OEMs use suppliers with a proven history in the design and manufacture of the components they need and the parts should be known to be reliable for demanding applications.

***Figure 3**: MEG-Array Mezzanine*

***Figure 4**: PCI Express*

Functional Needs

The product lifetime of medical equipment is relatively long so the ability to scale up and upgrade via open standards, as well as a high level of reliability, are essential elements of the equipment's performance, especially for complex and expensive combined-modality systems (like MRI), which require constant use to provide proper payback. If the interconnectivity selection has been carefully made with an eye on open standards and future product road maps, increasing functional and financial needs of medical equipment will be met.

A good example of this was the introduction of PCI Express (**Figure 4**), now the connector standard of choice for PC-based systems, which has gradually found its way into medical equipment as well. Where we used to see many propriety systems, the open PCIe standard is being applied more and more, especially in ultrasound systems. To respond to medical customers' needs, FCI has extended the vertical PCI Express card-edge connectors family with surface mount technology to accommodate the market need for surface mount connectors for the use of high-speed, serial PCI Express architecture.

Traditionally, ultrasound system have used standards-based architectures like CompactPCI bus or VMEbus, but with the backplane performance hitting the limitations of standard architectures, there is a clear need for connector technologies that offer higher performance and higher reliability at a reasonable cost.

Card-edge technology, in addition, is a logical choice for these backplane connections, combining high-speed performance and reliability at low applied cost. The use of surface mount PCIe Express card-edge connectors is not limited to backplane connections, but is also being used by ultrasound manufacturers to improve manufacturing yields for board-to-board connections.

According to Bharat Book Bureau, an aggregator of global business intelligence with an on-demand collection of published market researches (**www.bharatbook.com**), demand for medical imaging products will expand 3.9% annually to $15bn in 2010. Equipment will make up $10.4bn of this total, with the balance posted by consumables and accessories. CT scanners will generate the largest demand among medical imaging equipment through 2010 and beyond.

To meet this growing demand, OEMs will need to find reliable component suppliers that can meet the needs of highly advanced, high-speed, small-sized, portable medical diagnostics equipment. Connector manufacturers who develop products specifically for imaging and other medical applications (such as patient monitoring, ultrasound equipment and defibrillators) that incorporate open standards, provide reliable and durable connections, yet still offer high-speed and top-quality electrical performance, will be the leaders in this industry due to their ability to facilitate the evolution of end-product development. ■

DESIGNING REMOTELY-CONNECTED MEDICAL DEVICES

THERE IS A MOVE TOWARDS INCREASING THE USE OF REMOTELY LINKED MEDICAL MONITORING SYSTEMS WITHIN HEALTH SERVICES WORLDWIDE. THIS PRESENTS A NUMBER OF DESIGN CHALLENGES, EXPLAINS **JONATHAN BEARFIELD**, END-EQUIPMENT MARKETING ENGINEER AT TEXAS INSTRUMENTS

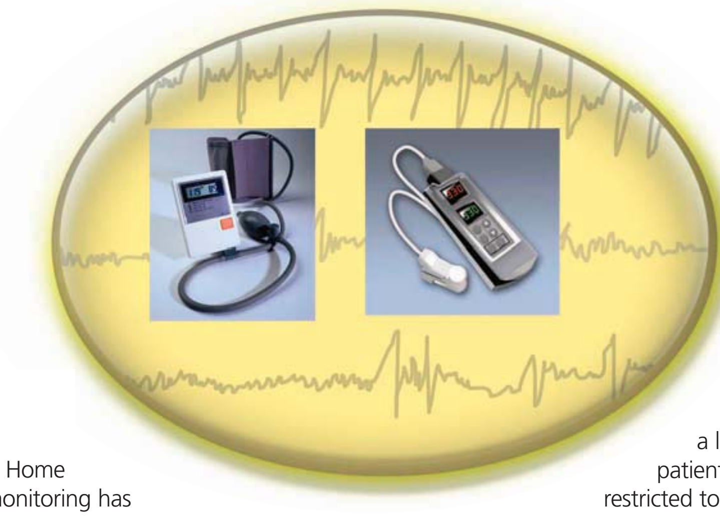


Figure 1: *Portable/ remote medical monitoring systems*

Healthcare delivery is set to change dramatically with the widespread deployment of wireless technology. The growing numbers of patients with chronic conditions, including heart disease, diabetes and asthma, requiring more frequent clinic visits, are driving the development of remote medical monitoring devices. In addition, healthcare policies aimed at reducing the amount of time patients are treated in hospitals and clinics in favour of treatment at home is also helping to shift heathcare delivery towards remote monitoring/telemedicine.

Remote medical monitoring devices record vital medical readings, such as electrocardiograms (ECG), blood glucose and respiratory function (**Figure 1**). Data is then transmitted to a central computer within a hospital or GP practice to be monitored and stored within the patient records. Data can be transmitted as scheduled i.e. daily, weekly or continuously, depending on the disease, or on demand, if the patient feels unwell. The implementation of systems that ensure the accuracy and security of individual patient data is of paramount importance.

Home monitoring has a number of advantages including fewer hospital/clinic visits, reduced healthcare costs, greater convenience for the patient and physician, and improved patient quality of life. It is of particular benefit for patients who live in rural areas without easy access to a specialist physician. In addition to regular monitoring, these devices can also alert physicians of any significant changes in the disease/medication requirements, or of device malfunctions.

Inevitably, future developments in remote medical device technology will include two-way communication that will allow physicians to make remote treatment adjustments in response to the data received. Clearly, wireless technology is on the verge of having a tremendous impact on the way patient care is provided.

There are a number of challenges facing the designers of remote medical devices. These devices must be portable, often wearable, and able to transmit wireless data that is both accurate and secure. This article discusses the main design considerations when developing remote medical monitoring systems (**Figure 2**).

Transmitting Data

The key to the success of remote medical monitoring devices is the ability to consistently transmit accurate data. This data may be collected and transmitted either via a landline (wired or wireless) or a mobile telephone network to an Internet-based database or centralised computer centre before being sent to the necessary medical staff. The main drawback of using a landline is that patient monitoring is restricted to the home.

Currently, most monitoring devices utilise landline connections. Wireless interfaces such as Bluetooth and ZigBee, as well as other very low power wireless solutions such as Chipcon products (Texas Instruments) SmartRF technologies that are already networking homes and businesses, can be considered.

Within the medical device, the data interface connects to wired and wireless Ethernet connections and near-field and longer range wireless connections. Newer interfaces allow all equipment within a hospital to be networked, as well as those in patients' homes.

Using a wireless sensor pack, patients at home could be remotely linked to a hospital or clinic via a broadband connection, allowing constant monitoring.

When selecting a wireless interface for medical monitoring devices, data rate and range are important considerations. Implementing a 2.4GHz solution is usually appropriate as it provides a high data rate and duty cycle as well as multiple channels. This provides maximal data transmission rate, which is useful when performing multi-sensor monitoring that generates large amounts of data. The range, however, could be limited, which may not be a drawback as the patient is likely to be confined to a bed in these situations. In ambulatory patients with few sensors, transmission range is more important than data rate so it may be appropriate to use a lower frequency solution in order to increase signal range. Obviously, the choice of solution employed will be influenced by the type of monitoring and overall system power budget.

Patient-Friendly Screens
The monitoring device display must be patient-friendly. The parameters being monitored, such as blood pressure or temperature, must be easily accessed and read by the patient. Making the display readable will involve incorporating a suitable backlighting solution.

A backlighting solution with a wide input voltage range should be used in battery-powered monitoring devices as there is less need for additional regulation in the system. Greater design flexibility can be achieved using boost or buck/boost solutions as this allows a range of battery types to be selected. A high degree of integration and advanced packaging will be more efficient and cost effective, and will be influenced by solution size and overall power efficiency.

The introduction of touch screen control (TSC) has allowed medical devices to become significantly smaller. Furthermore, the menu driven functions make it much easier for patients and physicians to use these devices. One critical aspect of implementing TSC is the electrostatic discharge (ESD) handling capability of the solution selected. To prevent damage to the central microcontroller/DSP, the TSC circuit must be able to dissipate energy from an ESD strike. Resolution, screen size, conversion type and speed, and overall power consumption must also be taken into account when using TSC.

Monitoring Biometric Parameters
Applying the appropriate signal chain is essential when using biometric sensors to record medical parameters. The first step in the signal chain is an instrumentation amplifier (Figure 2) such as Texas Instruments's INA326, a micro-power amplifier with low input offset, low drift and great DC accuracy with AC performance. The aim here is to use an amplifier that allows a microvolt level signal within milivolts of noise, and can operate effectively when a high-pass filtering scheme is required. System compensation requirements can be reduced by introducing an auto-zero or auto-cal feature.

A low power operational amplifier, such as Texas Instruments's OPA376, with wide bandwidth, rail-to-rail input and output (RRIO) and excellent precision, usually forms the next stage in the signal chain (Figure 2). Signals with linear offsets over the entire input common mode range are generated with this amplifier as a result of zero-crossover. Consequently, supplementary DSP algorithms are not required to compensate for shifts/offsets.

The third stage in the signal chain is an effective delta-sigma or successive approximation analogue-to-digital converter (ADC) (Figure 2). Including single-cycle filter settling and convert-on-command not only optimises conversion speeds and allows greater source impedances, but also makes the ADC design more straightforward. In systems that require comparison of multipoint signal sources within the same clocking cycles, global synchronisation can provide consistent signal gathering.

Data Processing and Storage
Large amounts of data are collected by medical monitoring devices. This requires rapid data storage and processing. The microcontroller must be able to perform diagnostic algorithms, link to larger systems and recognise changes/feedback. These processing functions, however, must be balanced against the power consumption limitations. It is now possible to utilise a low-power microcontroller (such as the MSP430) by adding the latest DSP technology and power supply topologies, without compromising functionality.

Adding a DSP allows some of the processing bandwidth to be used to manage power consumption.

System management is divided between the DSP, which drives overall system performance and the MSP430-type controller, which manages the standby mode and sleep and wake-up transitions. The result is that average system power consumption remains low, with peaks only when the DSP is processing.

Super-caps or other energy storage devices can be used to minimise brown-outs and improve system runtime during DSP power surges. Controllers such as the MSP430FG461x offer real-time processing using very low power.

Ensuring Sufficient Battery Power
For portability, most medical monitoring devices will need to be battery-powered. In low-powered, simple systems disposable batteries may be cost-effective. More complicated systems with a high power-draw will require rechargeable batteries.

A method of battery authentification, i.e. an encrypted device ID that ensures the batteries inserted meet the manufacturer's specification, should be included as the consequences of power failure may be life-threatening. In medical monitoring devices it is important to accurately know the run time that is left. This is best achieved using impedance tracking, which allows the remaining run-time to be calculated within one percent error over the entire battery life. This enables longer run-time by allowing the system to access all of the usable energy in the battery. Simple voltage tracking or Coulomb counting does not give a true reading of battery life. These devices may be needed in an emergency so it is essential that they operate immediately when plugged into the mains i.e. independently of the battery charging path. This can be achieved using dynamic power path management.

Virtual Future
Recent advances in medical monitoring device technology have meant that the 'virtual doctor' is closer to becoming a reality. Even today, patients can be conveniently and cost-effectively monitored at home, and some operations can be overseen from a remote location by means of a video link. Conceivably, future innovations may make it possible to consult a 'virtual doctor' anywhere in the world via a video link and a home body scanner.

To achieve further advances and help medical device manufactures optimise overall design, it is important that suppliers of semiconductors understand the requirements of portable medical products (i.e. the space and power budget limitations) and define performance specifications for each type of device. ■

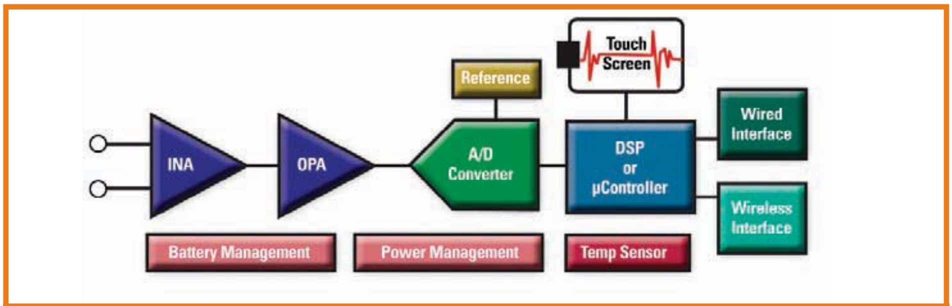


Figure 2: *The main design considerations in the development of remote medical monitoring devices*

GARETH BECKETT, SENIOR MEDICAL ACCOUNT MANAGER AT AXIOM MANUFACTURING SERVICES, EXAMINES THE CHALLENGE POSED BY THE GROWING DEMAND FOR MORE USER-FRIENDLY MEDICAL DEVICES THAT CAN BE APPLIED IN THE HOME, IN DAY CLINICS AND ON HOSPITAL WARDS.

DESIGN IS CRUCIAL IN SPREAD OF TELEHEALTHCARE PRODUCTS

Technological advances and pressure for cost reductions have made telehealthcare increasingly attractive to policymakers. This has created growing demand for more user-friendly medical devices that can be applied in the home, in day clinics and on hospital wards.

Until recent years the delivery of healthcare was a relatively straightforward split between primary, secondary and social care. In other words, receiving care involved a visit to the GP, a stay in hospital or visits to one's home by a health professional.

The advent of telehealthcare, or eHealth, has been blurring these lines of demarcation and changing the scenario radically.

The emergence of this phenomenon is being influenced by two key factors, both of which appear to be gathering momentum.

On one hand there have been continuous advancements in information and communications technology, which make it possible to transmit and receive complex medical data in various formats across long distances between patients and medical or nursing staff and between different health professionals who play complementary roles in a patient's care regime. The availability of broadband connections and wireless technology in most areas has further fuelled this development.

SMT lines like this one at Axiom are of increasingly used for medical systems

At the same time, decision-makers within the NHS and, indeed, private healthcare, are seeing the potential savings that could be made through wider and more effective use of various telemetry or ambulatory products, particularly by patients in their own homes. In addition with the problems of MRSA and Clostridium difficile there is a greater need for products which reduce hospital admissions, the length of stay or the possibility of cross-bed contamination.

For example, some studies suggest that using remote monitoring equipment could help reduce the number of hospital admissions for patients with heart problems by as much as 85%. Given that up to 20% of the population aged over

65 suffer from such complaints the potential for savings is enormous. Similar savings could be made in respect of other chronic conditions such as asthma and diabetes which also afflict a large proportion of the population.

Demand for Smaller Devices

Demand is also increasing for in-hospital devices which are smaller and easier to use, as the popularity of telehealthcare has grown among medical and nursing professionals themselves.

In fact, it is the evolution of more user-friendly in-hospital devices that facilitate remote monitoring from either the ward office or some other location that has inspired the development of more products which can now be used in the home to allow for better and more frequent communication between patient and clinician.

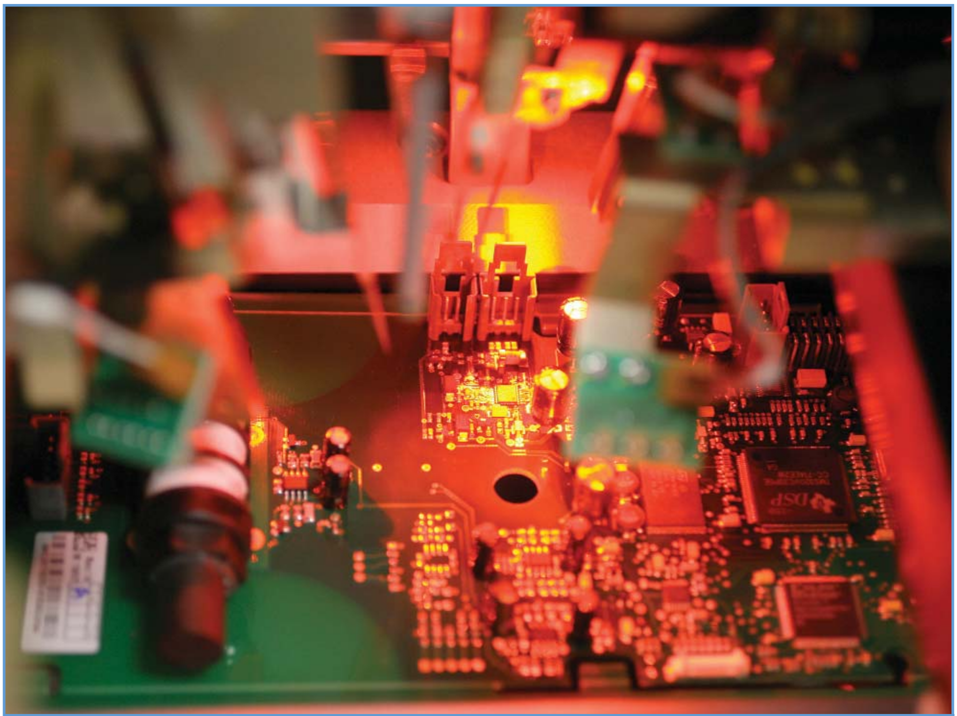
It is essential for safety purposes that these products are easy to use and hard to mis-use as well as being aesthetically pleasing.

As this trend continues to unfold and the number of such devices on the market increases dramatically, there will be greater emphasis on superior cost-effective product design. This in turn will lead to greater collaboration between designers and manufacturers to create the next generation of easy-to-use, safe and reliable in home or mobile patient devices.

It should be remembered that most of the cost of a product is determined by the design and, in so many cases, the best place to find large cost savings is through improving the design and getting that design right first time from a manufacturing, procurement and test point of view. This is infinitely better than trying to overcome in-built design problems and barriers later in the process.

In the case of medical products, design is changing rapidly. Where practicality and functionality once dominated the development stage, the former traditional, heavy industrial appearance of these products is being replaced by more patient-friendly and attractive designs.

Such changes are increasingly dictating the process through which designers and electronic manufacturing service (EMS) providers engage, consult and develop electronic medical devices. In particular this has led to a need for greater collaboration earlier in the design phase of the process.



Internal technical image of the Flying Probe (Fixtureless) Test System, also used in medical systems

The Polar Extremes

Modern-day design and manufacture for the medical sector does not focus solely on the development of high-level technology and industrial-looking systems. In fact, product development that we encounter can be found at both ends of the electronic design spectrum.

At the more traditional end, the focus clearly remains on technological product development. For example, the design and manufacture of high-voltage, highly-functional products such as RF plasma generators, which use high-powered pulsed bipolar energy that enables surgeons to perform highly complex procedures, such as keyhole surgery and, increasingly, cosmetic surgery, results in an entirely functional form-factor for the generator unit, which is often not even situated in the operating theatre.

In these cases, size, appearance and intuitive operation are less of an issue for product designers. In terms of manufacture it follows the SMT/through-hole hybrid approach where you still find proliferation of traditional electronic through-hole components such as wire wound resistors, torroidal coils and ferrites, inserted in to heavily copper clad PCBs using both reflow and wave soldering processes.

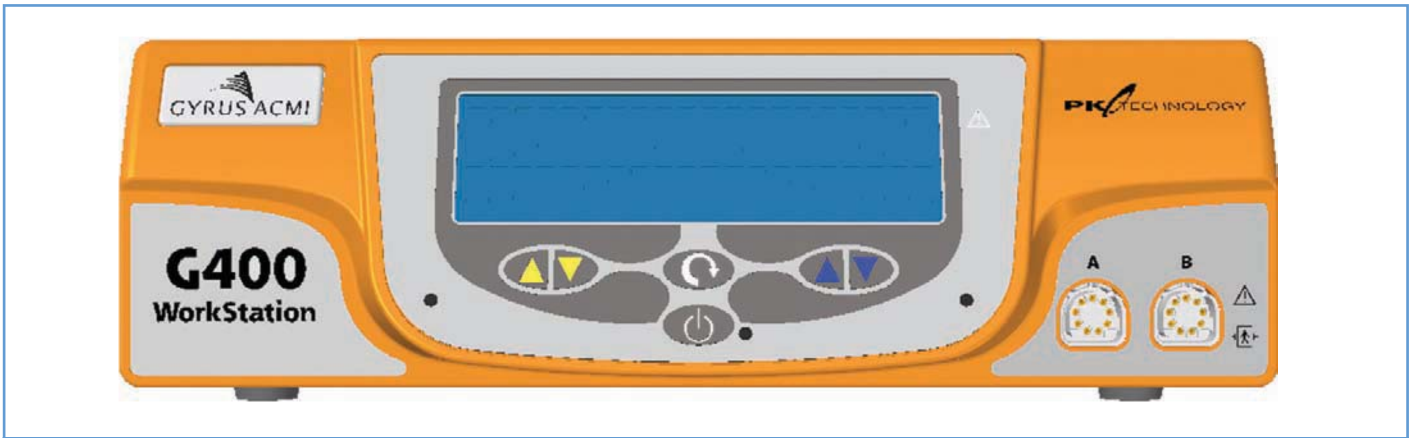
However, with the need for increasingly "intelligent" ward-based products, and with telehealthcare driving new product design and development, medical devices are becoming smaller. In addition there is greater attention to accessibility, safety, fail-safe operation and ease-of-use. All of this demands more innovative approaches to design, assembly and test.

As an example, let us focus on the intravenous pump driver. This highly complex product needs to be user-friendly, compact, lightweight, reliable and robust while, at the same time, also carrying a battery-powered function to allow for it to operate with complete mobility in and around hospital wards and in patients' own homes.

Accepting Other Technologies

Although legacy solutions have tended to rely on serial communications, there are increasing moves to accept other technologies such as wireless, which offer mobility and connectivity for fast data updates and patient peace of mind.

As form factors reduce and require a more aesthetically pleasing high-tech look and functionality, which is easier to use and more difficult to misuse, the whole design structure and process changes and demands a more complex design for the circuit board. In fact, this often means the use of several supporting boards. In the



The Gyrus G400 RF plasma generator from Axiom

case of a complex intravenous pump driver, the PCB will require the use of high-density SMT components because of the limited 'real estate' (or space) on the board.

Along with the demands for high functionality comes the need for more memory, and increasing use of ball grid arrays (BGAs) and tiny 0402 passives help to facilitate this. BGAs allow for smaller footprints enabling higher-density interconnecting designs to be employed.

Despite the potential benefits of miniaturisation in the design process, circuit board design poses challenges during assembly and particularly test. This has led to test solutions which leverage for example the new JTAG technology.

Design and Manufacture – Greater Synergy

As developments progress, we have seen and will continue to see older industrial style medical products replaced with modern more aesthetically pleasing designed equipment. The aim, as with any other electronic product, is of course to achieve the highest customer and user satisfaction at the lowest possible production cost.

Changes in the telehealthcare market are lifting the bar on electronic design and assembly technology, requiring that both functions accommodate the limited space available within the product's external casing in which to mount PCBs, motors and encoders for example, and/or the necessary electro-mechanical parts, whilst also leaving room to accommodate the all important user friendly display.

Introducing design for test, design for procurement and design for manufacture early on in the design phase is vital and will confirm that the processes and components are valid and will reduce risk of early market failure.

Such issues may not naturally occur to designers. With due respect to these professionals, their designs are often created without a thorough understanding of the processes they need to go through to get to the end user.

The issues include not just cost, physical practicality of manufacture and test, and procurement lead times but also environmental considerations and conformity with various regulations, for example rules on electromagnetic compatibility. Admittedly many large firms are able to create the cross-functional teams that can consider both design and manufacture simultaneously but they often lack the time needed to bring new products to market due to other constraints.

On the other hand, small and medium sized companies – which in many cases typify the originators of medical equipment – are unable to consider design, manufacture and test together because they simply do not have the necessary resources in-house to create integrated teams.

In both scenarios there is wisdom in considering an early partnership with a suitable Electronics Manufacturing Services (EMS) provider who shares the culture and values of the OEM.

Benefits of Early Engaging with an EMS

Involving the EMS provider at an early stage in the design process, or by outsourcing design to these providers, gives the OEM the opportunity of early warning on whether or not a particular design approach will or won't work during the production stage. Added to that is the EMS provider's ability to give an early costing and to build an effective supply chain for the product.

If left unaddressed, problems created by inappropriate design could lead to late time-to-market, due to difficulty of manufacture or long product lead times. Worse still, this could result in unreliable products for this highly life-critical sector.

While medical design and manufacture cannot – and indeed need not – have the same degree of aesthetic appeal associated with high-volume consumer goods such as MP3 players or mobile phones, product end-users are nevertheless calling for intuitive, accessible, attractive and reliable products.

This is particularly important given that many of the users of such devices are likely to fall into the older age groups who tend to have lower exposure to consumer and business-related IT products and are therefore looking for simplicity not complexity.

Designers and manufacturers will increasingly face challenges to produce such products and that pressure demands that they embrace a Design for Excellence approach. Such an approach integrates the principles of design for manufacturing, test, procurement and environment from the outset.

A greater emphasis on collaboration between OEM and EMS to achieve such integration throughout the process can boost efficiency, reduce time-to-market and achieve significant cost-savings across the board. ■

MATT TAPPING, UK BUSINESS DEVELOPMENT MANAGER AT HITACHI DISPLAY PRODUCTS GROUP (DPG), EXAMINES HOW THE UPTAKE OF NEXT GENERATION APPLICATIONS ARE FORCING MANUFACTURERS TO REVOLUTIONISE THE CLARITY OF DISPLAY IMAGES

A PICTURE PAINTS A THOUSAND WORDS

Throughout history consumers have been fascinated with new technology and how it can be miniaturised for use on the move. Take the mobile phone market for example: Dr Martin Cooper, a former general manager for the systems division at Motorola, is considered the inventor of the first modern portable handset. Cooper made the first call on a portable cell phone to his rival, Joel Engel, head of research at Bell Laboratories in the early 1970s, but it took another decade for the technology to take off. Since these first steps, the mobile phone has become a must-have item and, over the years, has evolved from a brick-like device to one that can be as small as a credit card.

However, the mobile phone (in its current form) is dying in well established markets like Europe, and in its place a new, more dynamic breed is evolving – video is going to herald a new wave of mobile usage, but only if users can get the quality they demand.

IPS display can be viewed clearly from various angles

Mobile video has had a slow start though take-up has been steady, but recent figures show this is finally growing. By 2010, market research house iSuppli expects mobile video will attract more than 100 million subscribers and more than 300 million handsets will ship with mobile TV chips.

If the mobile phone is to become a proper medium for watching video or TV, then users will need to be able to watch it as clearly as they would a normal television. This puts immense pressure on handset manufacturers to develop screen technology that can keep up with demand.

It is not just the mobile entertainment industry where dramatic advances in display technology are demanded. Automotive manufacturers are keeping pace with their peers in the mobile telephony space, and the burgeoning automotive LCD-display industry has also meant that the requirement of exceptional display technology is necessary to sustain the growth. Analogue dials are fast becoming ancient history and designers are looking at LCD display technology to deliver critical information and enhance the driving experience – some high-end manufacturers are installing fully digital instrument binnacles, for example. New vehicles are being introduced with Head-Up Displays (HUDs) and the European obsession with satnav devices means that in-car display technology is a key concern for manufacturers.

Consumer demand for more dynamic displays is driving electronic innovation and while this is good for the consumer, the manufacturing industry is facing a number of tough challenges.

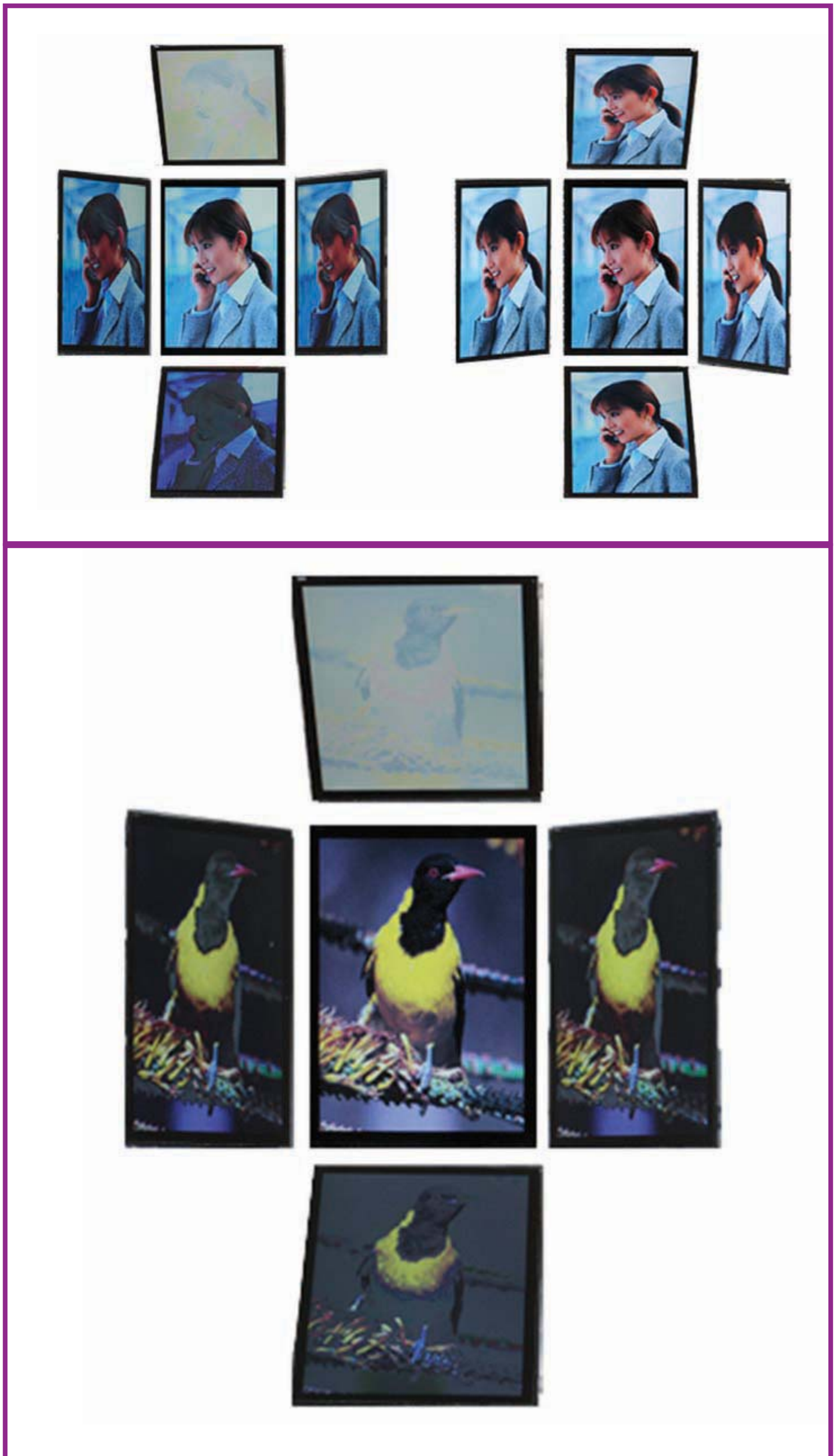
The Trials and Tribulations

Analysts support the suggestion that these markets are set to grow even further and that, to fully exploit them, advances need to be made in how to deliver dynamic user content:

The satnav market in Europe is rapidly expanding; it is growing from just under €1bn in 1999 to over €8bn by 2005 alone. Europe is also currently preparing to launch Galileo, the €3.4bn satnav system, which it hopes to deploy by 2010. With such growth predicted, manufacturers will need to investigate different ways to differentiate themselves from the competition.

ABI Research revealed that the global mobile marketing and advertising market is expected to reach £1.5bn by the end of 2007 while Telephia estimated that revenues from mobile video subscriptions in the US totalled $148m in Q4 2006, up 188% from the start of the year. More recently, analysts predict that mobile social networking will soon hit the mass-market, with revenues topping $2.8bn by 2012. This shows that the consumer appetite will not abate, so it is critical that the handset industry adapts and ensures that devices are available to meet this demand.

What options do manufacturers have, and how can they leverage current innovation to cater to consumer needs? Unfortunately, within both the mobile telephony and automotive industries traditional display technology is limited. Viewing angles impair the user's experience as the content appears distorted and grainy, which can be potentially life-threatening in the



Traditional display (LCD, for example) and the screen clarity – or lack of - from a range of angles automotive environment. What users, operators, designers and manufacturers demand is a display technology that offers consistent viewing quality whatever the viewing angle or external conditions and one that does not consume too much power. While this is a utopian shopping list, a new breed of display technologies are entering the market that offer a dynamic user experience – In-Plane Switching (IPS).

The Future's Bright

Traditionally, active matrix LCD (AMLCD) technology has been *de rigueur* in mobile and automotive displays, but it has its limitations. Response time, viewing angle, colour shifting and resolution are some of the biggest inhibitors, but due to LCD's widespread availability these have been somewhat overlooked in favour of the technology's low-price, relatively small power footprint and flexibility.

As user demands have changed, so too have the attitudes of device designers. Designers are now looking to next generation display technologies and IPS is becoming a more attractive proposition thanks mainly to its application flexibility.

An LCD structure which aligns the liquid crystal cells in a horizontal direction, IPS technology was originally developed in the mid 1990s. In this method, the electrical field is applied through each end of the crystal, unlike most other TFT display technologies. Thanks to its unique pixel alignment, IPS was originally deployed in desktop PC TFT monitors as it delivered a comparable contrast ratio and clearer image than CRT displays coupled with a suitably wide viewing angle. In the last few years, the technology has undergone four development generations which were IPS, Super-IPS (S-IPS), Advanced Super-IPS (AS-IPS) and lastly IPS-Provectus (IPS-Pro), each aimed at improving specific characteristics such as transmission or contrast ratio. These are generically referred to as IPS technology and have advanced display performance considerably which is why it is now seen as the best choice for mobile and automotive displays. But why?

Increased Safety

Within the automotive industry, safety is paramount. The dashboard display is a critical part of the cockpit and with more and more drivers now relying on satnav devices, the need for clear, crisp images is imperative. IPS's unique selling points are response time and image viewing angle, with the associated colour stability inherent through IPS technology. Recent innovations also mean that these benefits can now be offered at a competitive cost level.

IPS response rates are typically 17ms vs 32ms for a generic TFT AMLCD. In a driving scenario, this flatter, faster response is critical in reducing the time to deliver information to the driver such as eliminating blurring of a moving map as it rotates to follow the direction of travel. While this is important, the viewing angle offered by IPS is the key factor behind IPS uptake within the automotive industry.

In a typical IPS display the liquid crystal revolves in parallel with the glass substrates which realises the wide viewing angle of the display. Changes of colour tone due to the viewing angle are so slight that a natural picture can be seen from any angle vertically or horizontally. The AS-IPS technology modified for mobile phone and automotive applications has an improved aperture ratio of around 30% compared with conventional products to produce higher brightness. It also features improved colour reproduction. When considered in a satnav scenario, this means that the driver and passenger will both see the same image, neither will see an image where dark colours become inverted or whites can be confused with yellows. This reduces the risk of an accident as the driver can remain focused on the road. IPS won't necessarily reduce road accidents, but it is going to help.

Revenue Generation

While safety is key in the automotive environment, revenue generation and the user experience are important to the mobile operator. For operators to truly capture the potential of new video content they must ensure that users can experience high-quality images on the move, without removing any of the phone's 'normal' functionality, i.e. battery life, call quality etc. IPS achieves this on all counts, thereby providing a compelling alternative to other types of LCD displays.

One outstanding feature of IPS here is the image quality for power consumption and cost balance. For example it is now possible to achieve a 2.2" display of QVGA resolution (240 x 320 pixels) which provides 300Cd/m2 brightness and 1000:1 contrast ratio which is also transflective, meaning it can be read in any situation from a dark room to full sunlight. This display can also include on-board adaptive content and backlight controls to reduce the power consumption by 30% (on average). End users of a device using this kind of display will see a definite increase in battery lifetime vs a similar device without these features and with better video and still image quality as well. With this functionality people are more likely to spend longer mobile browsing or watching video clips which should lead to increased revenue opportunities for operators.

Some manufacturers have already developed 2.9-inch wide, high definition WVGA (480 x 800 pixels) IPS liquid crystal (LC) modules for mobile phones to provide high definition in addition to a wide viewing angle (effectively 360º) and high image quality, while reducing overall power consumption. This enables mobile phones to display images of a higher quality and definition. Employing a screen with VGA resolution or higher in a mobile phone, will enable users to see the entire width of websites or mobile videos without having to scroll laterally.

IPS's rapid response rate and increased colour gamut means that the mobile market is now able to realise the potential of video on the move. Users will finally be able to enjoy the benefits of high definition mobile video, without compromising handset functionality and, in turn, operators will be able to increase potential revenues. IPS could prove to be the catalyst for mass-market uptake.

What Next?

Display technology does not stand still for long, if at all and there are several other TFT complimentary and competitive technologies being developed by all companies in the industry, e.g. adaptive brightness and content technologies, OLED and 3D displays just to name a few. Charles F. Kettering, a US electrical engineer and inventor (1876-1958) could almost have been predicting display technology when he said: "Our imagination is the only limit to what we can hope to have in the future".

With such limitless scope for future developments, it is safe to predict that designers and manufacturers will be able to cater for consumer demand and help drive the evolution of both in-car and mobile multimedia applications. ■

SUNIL HEART, SENIOR LECTURER AT THE GRIFFITH SCHOOL OF ENGINEERING AT GRIFFITH UNIVERSITY IN AUSTRALIA GIVES AN OVERVIEW OF HOW AUSTRALIA DEALS WITH THE EMERGING ISSUE OF ELECTRONIC WASTE AND INVESTIGATES THE CURRENT INITIATIVES UNDERTAKEN TO SOLVE THE PROBLEM

AUSTRALIA'S EVER GROWING E-WASTE MOUNTAIN

The world is experiencing a boom in the uptake of information technology. Coupled with this and the availability of new design and technology in the electronics sector at a rapid rate is causing an early obsolescence of many electronic items used around the world today. For example the average lifespan of a new model computer has decreased from 4.5 years in 1992 to an estimated two years in 2005 and is further decreasing. Studies have revealed that around 500 million computers will become obsolete in the United States alone between 1997 and 2007. The same scenario applies to mobile phones and other handheld electronic items used in the present society. Each year over 130 million mobile phones in the US and over 105 million mobile phones in Europe reach their end-of-life and are thrown away.

As a result used electronic and electrical items, commonly known as e-waste, have become a serious social problem and an environmental threat to many countries worldwide. United Nations estimate that collectively the world generates 20 to 50 million tonnes of e-waste every year. This is one of the fastest growing waste streams around the world today growing a rate of 3-5% per annum or approximately three times faster than normal municipal solid waste.

***Figure 1**: E-waste collection day in Brisbane*

What about Australia

Australians are technology loving people and there is always that tendency and constant drive to get hold of the newest and latest electronic products. Hence, Australia is no different to other nations who contribute the global mountain of e-waste.

The information and communication technology (ICT) industry in Australia, which includes businesses related to computer hardware and software services, telecommunications, and communication cable and Internet providers, is the twelfth largest ICT industry in world. Australia also had the fourth highest ICT contribution to GDP growth in the world **(www.aiia.com.au)**.

The Australian computer industry is considered to be the backbone of ICT and consists of a number of major manufacturers as well as several minor players the likes of computer assemblers. Large global computer manufacturers such as Hewlett Packard, Dell, Acer, IBM, Toshiba and Apple dominate the Australian computer market, but they only account to between 50% and 60% of the total market. The remainder is dominated by 'non-brand' or 'white box' computers which are assembled from imported generic parts. Apart from this type of assembly there is no significant computer manufacturing industry in Australia.

During the past few years Australian businesses and households have experienced

Figure 2*: Scrap computers from an e-waste recycling event*

a significant growth in the use of computers and Internet access. According to the Australian Bureau of Statistics (ABS), during 2003, 85% of all businesses in Australia have indicated use of a computer while 71% of them have reported having access to the Internet; some 25% of all businesses have a web presence.

As for the household use, a survey conducted by ABS has revealed that in 2005-06, 60% of all the Australian households had home Internet access and 70% of all households had access to a computer at home. This is a significant growth from 1998 data where only 16% of all the households had access to the Internet and 44% had access to a home computer.

This data confirm the fact that the need to access the Internet from home is fuelling the purchase of home computers in Australia. Research house IDC Australia estimates that over three million desktop and laptop computers are sold in Australia each year out of which laptops account for over 1.2 million. It can be conservatively estimated that there are at least 14 million computers in use within Australia today. These computers will contribute to Australia's e-waste mountain at some stage of their life span.

There is no accurate data on the amount of computers discarded each year but one estimate made in 2001 stated that in 2006 there will be around 1.6 million computers disposed of in landfill, 1.8 million put in storage (in addition to the 5.3 million already gathering dust in garages and other storage areas) and 0.5 million recycled in this country.

Addressing the Problems

In general, computer equipment is a complicated assembly of significant number of different materials, many of which are highly toxic. The production of semiconductors, printed circuit boards (PCBs), disk drives and monitors used in computer manufacture utilises many hazardous chemicals. Printer inks and toners often contain toxic materials such as carbon black and cadmium. Computer CPUs contain the heavy metals cadmium, lead and mercury. PCBs contain the heavy metals antimony, silver, chromium, zinc, lead, tin and copper.

Regulations and policies related to e-waste management have been developed in many countries worldwide. European Union leads the way through its well known Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) Directives. This is closely followed by countries such as Japan, Taiwan and Korea and few states in the US.

Australia is still to reach these levels as no national regulations or policies dealing with e-waste are in place at present. Australian state and federal governments are currently working together to impose regulation directed towards extended producer responsibility upon computer manufacturers and retailers with a view to managing this huge and growing waste stream.

Currently there are efforts towards a co-regulatory framework for product stewardship, a federal and state government and industry cooperative push for industry to take primary responsibility for computer related products. Co-regulation for product stewardship is a process where some form of government regulatory intervention is used in conjunction with specific industry product stewardship schemes.

Although the Australian federal government has not yet developed regulations and policies dealing directly with e-waste, it has developed a number of other environmental initiatives which will have some impact on e-waste generated in Australia. The guidelines developed for export and import of used electronic equipment through its Hazardous Waste (Regulations of Export and Imports) Act 1989 is one of the examples. This act regulates the export and import of hazardous waste within and outside Australia as required under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

The act regulates export and import of hazardous wastes, including waste electrical and electronic assemblies. In 2004 it became apparent that large quantities of used ICT equipment were being exported from Australia for re-use or recycling in developing countries. As a result, in 2005 the criteria for identifying electronic scrap were revised and new ***'Criteria for the Export and Import of Used Electronic Equipment'*** was published to simplify the process of determining whether or not a particular waste is hazardous or not. Most computer waste is assumed to contain hazardous materials and, therefore, assumed to be hazardous unless proven otherwise.

Own Initiatives

In the absence of federal regulations many states around Australia have developed or in the process of developing their own initiatives to deal with the issue. Queensland government's Environmental Protection Authority (EPA) recently announced its e-waste program to recycle its entire fleet of computer systems and replace them with monitors, hard drives, keyboards and mice that meet the world's highest environmental standards. This would be the first government agency in Queensland to do so.

In March 2007, EPA handed over 2,300 computers to a recycling company preventing over 50 tonnes of e-waste going into a landfill and replaced with new equipment using 60% less power than the previous fleet **(www.epa.qld.gov.au)**. It also announced that a Japanese company specialising in e-waste management and recycling has approached the EPA expressing interest in exploring opportunities to recycle Queensland's waste.

The New South Wales (NSW) state government, through its Department of Environment and Conservation (DEC), is leading the country on the development of Extended Producer Responsibility (EPR) policies aiming at producers taking the physical or financial responsibility for the environmental impacts of their products' life-cycle.

As part of its sustainability path, NSW is also developing cohesive partnerships between government, business and the community to strengthen sustainability initiatives and adopt innovative approaches to environmental protection and restoration. Known as Sustainability Compact, the DEC and its private sector partners make a public commitment to sustainability leadership.

The Sustainability Compact developed between the DEC and Hewlett-Packard Company (HP) is one example of the above. In Victoria, Sustainability Victoria is the government agency responsible for waste minimisation in that state. Together with Hewlett Packard it is financing and sponsoring the current "Byteback" pilot programme in inner Melbourne, with the end product being taken by the recycling company Sims E-Recycling.

Environment Victoria is also instrumental in the formation of an alliance of electronic recycling companies, environmental groups and local councils with the aim of accelerating government action on computer recycling. The coalition calling itself 'Lets do IT! Alliance' is requesting the federal and state governments to introduce mandatory extended producer responsibility schemes as soon as possible to stem the number of computers now being dumped in landfills instead of recycling.

In South Australia (SA), the government is currently in the process of replacing its computers with a major part of the business being held by HP. The Government has begun an equity programme with Zero Waste SA (**www.zerowaste.sa.gov.au**) co-managing a refurbishing and donation scheme for the community. The Australian Capital Territory (ACT) is the only state in Australia where there is a ban on landfill disposal of e-waste. An e-waste collection and processing system is coordinated by the landfill contractor

The Sleeping Giant

To date, Australia has not recycled much of its computers mainly due to lack of infrastructure which has not been put together as not enough incentives are being created to invest in reprocessing facilities. However, within the last two years there has been a significant interest from major international companies to set up businesses in Australia.

Sims E-Recycling (Sims-E) and MRI are just two major companies currently operating in Australia. Sims E is the recycler appointed to support the Sustainability Victoria and HP pilot collection programme in Melbourne. MRI (Australia) is the second major recycler here. MRI is the recycler for the national mobile phone take-back scheme and holds the recycling contract for Dell's Australian computer take-back scheme.

E-waste in Australia is growing at an alarming rate given its liking for information technology products. Widely known as the sleeping giant in solid waste sector, Australia's e-waste rate is set to climb to even higher levels compared to most other countries around the world. However, a sustainable solution to the problem in Australia seems to be far away. Given its unique market structure and the uncertainty of the historical waste issue, any duplication of policies and regulations adopted in other countries around the world may not provide a sustainable solution to the problem in Australia. It needs to conduct thorough research into the local conditions and develop its own policies. ■

Let There Be Light

I expect I am not alone among readers of *Electronics World* in having been aware for some time of the dichotomy now revealed by your article and Svetlana's editorial in the same just-published issue [December 2007, *'Power on the menu'* on page 5 and *'Let there be light'* on page 40]. On the one hand we are being exhorted to go digital and on the other to save energy.

In this context I have two very elderly household radios, one that is even AM only, that use a fraction of the power that a DAB radio would consume. I have no plans to change them because, after some 30 and 40 years respectively, they both still work fine, yet in a few years I shall be forced to buy a power-hungry DAB radio and to consign my Hacker and Roberts to landfill, thereby poisoning the environment into the bargain.

To return to your article and to the subject of lighting, I think it's true that, among the engineering community, approximations to the figures you quote are well-known, if not as facts, then certainly by intuition. As you suggested, you can easily burn your fingers when changing a light bulb. Yet, is this surplus energy really wasted? In our 'temperate' climate it can get pretty cold in winter, when we mostly need electric light, so the extra heat is actually useful. After all, if it were not being generated, our central heating thermostats would simply ensure that our boilers fired up more frequently.

Other 'facts' that are rarely mentioned when energy saving possibilities are quoted are the extra energy needed to manufacture and transport compact fluorescent lamps (CFLs) and their component parts, or, as you mentioned, to remove and treat their contained mercury. Then again there is the small matter that CFLs cannot be used with some types of light fitting, such as enclosed ceiling units that have inadequate ventilation, or in housings that are simply too small for them. I wonder how long it will be before we hear of house fires started by CFLs.

Possibly you know of the website article whose link I have included below, within which the sentiments expressed I find myself largely in agreement. I'd be interested to hear your views on it. In common with its author, I certainly have no objection to CFLs being used appropriately, and I already do so myself, but I do object most strongly to being told continually how to live my life by targets-mad and hopelessly non-technical politicians. In common with others I have read about, very soon I shall be starting to stockpile incandescent light bulbs for use in certain of my household fittings.

The story goes that, towards the end of the 1930s, Hitler frequently asked for updates on the numbers of bomber aircraft being built and he always urged for yet more. The only way production could be increased, however, presumably because of the lack of engines, was to cease production of 4-engined bombers and to concentrate solely on smaller 2-engined types, which they did; but they didn't tell Hitler that. Mmmm... Could the exclusive use of CFLs also be an example of 'more is less'? Or do I mean 'less is more'?

www.sound.westhost.com/articles/incandescent.htm
www.sound.westhost.com/articles/incandescent.htm

Mike Hall
UK

Chris Williams from the UK Displays & Lighting Knowledge Transfer Network replies:

Thanks for your comments about my article. As you correctly detected, I am extremely anxious to make sure that any change in technology is "fit for purpose", and to promote the adoption of "if it ain't broke, don't fix it!". Through UKDL we evangelise to today's engineering students and SME companies the need to be innovative, which can include looking at recent history and seeing how technology started. The success of "retro" designs in volume production is a frequent reminder that simple can be very good, effective and profitable.

I have a big Georgian pile here in Hampshire, with a right mix of incandescents, fluorescents and CFLs throughout. It allows me to comment from a practical point – I am fed up of buying CFLs that die after less than 10 hours, and I don't understand why the incandescent bulb in one room of my house still works even though it must be more than 50 years old!

For your info, we are getting involved with Defra to start the "after the event" education process, and to try and get the words "mercury free" added to their stated intent for UK households to use high efficiency lighting.

By the way, your comment about fire risk of CFLs also applies to LED assemblies. They are low voltage, high current and, when mounted in enclosed, poor thermal efficiency luminaires, unpleasant things do happen. Again, part of our campaign is to try and stop Joe Public dashing off to the DIY sheds and buying Chinese LED assemblies without understanding something about what they are doing.

I'll be updating the lighting matter during the next few months, so, keep reading and commenting.

FLAT PANEL DISPLAYS ARE GOOD FOR YOU – YES OR NO?

By Chris Williams, UKDL

This month's column is a collection of facts and figures that have emerged during the first day of an international UK-Korea workshop being held in London.

An historic indicator of the predicted size of the Flat Panel Displays (FPDs) market is shown in **Figure 1**.

This prediction has followed through in fact, and the state of the FPD market at the exit 2007 has the different major display technologies summarised below.

Technology	Market Share %
Liquid Crystal Display (LCD)	90%
Plasma Display Panel (PDP)	5%
Organic Light Emitting Diode (OLED)	0.5%
All others added together	4.5%
TOTAL	100%

The only "new" display technologies that are expected to make any penetration in the next 5-10 years are flexible displays and 3D displays, both of which in turn may use various electro-optic effects. Therefore, LCD is King of the "displays" castle and is expected to stay there for a long time. Good if you are on the inside of this technology, tough if you are fighting on the outside with any type of alternative technology.

There is a school of thought that says this cosy domination by the LCD makers may not last as long as the market researchers expect or manufacturers want. To remain market-competitive in the LCD field today, a manufacturer must now invest huge sums of money in new manufacturing plants. To build a new TFT LCD manufacturing plant capable of handling substrate sizes of Generation 8 requires an investment of more than $4bn. Not many companies can even consider making that size of investment. A pictorial description of why this is needed is shown in **Figure 2**, where the relative sizes of the different generations of glass are shown in comparison to each other.

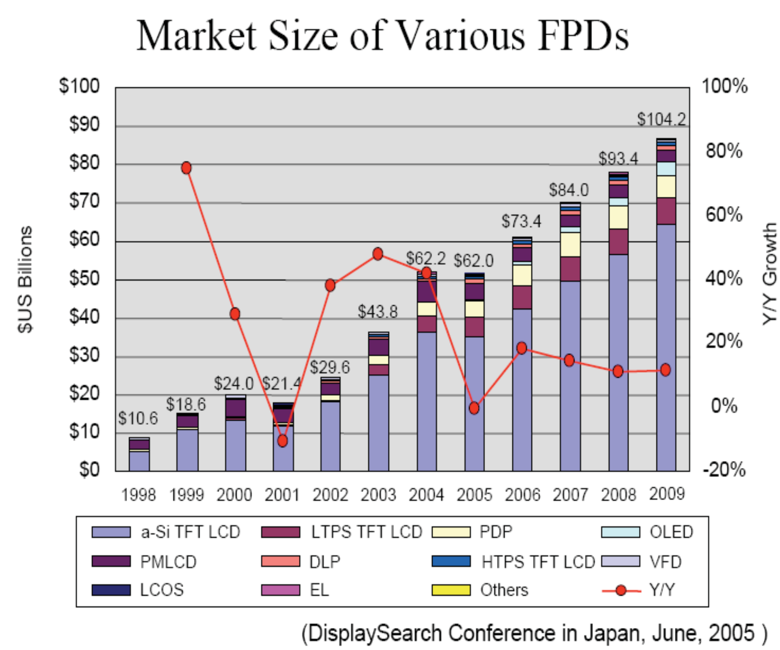


Figure 1: Historic indicator of the predicted size of the Flat Panel Displays (FPDs) market

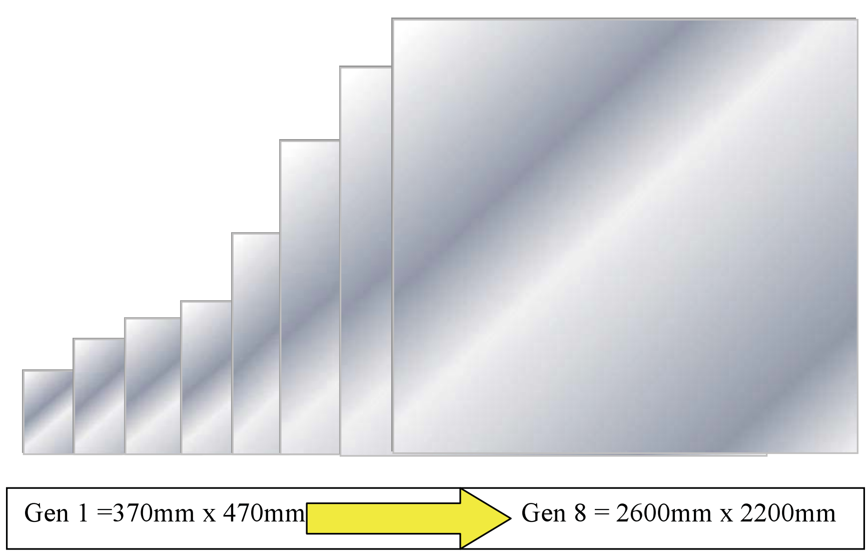


Figure 2: Comparison of different generations of glass substrate from G1 to G8

It doesn't need much imagination to understand why the cost of the manufacturing equipment has increased so much when you see that chart. Why so big?

So that the manufacturers can make the displays we want in our LCD TVs. When the TV screen itself is a wide format 50-70 inch monster, the display maker has to manufacture several screens at once for the process to be reasonably economically viable. Our thirst for big screens is driving this investment – if we all stopped buying large screens tomorrow, the manufacturers would stop investing.

The growth in size of our TV screens and the rush to move over from CRTs to LCDs is creating a paradox. At present there is a politically supported rush to implement change in the lighting market. "Ban the bulb" is now a regular chant against the incandescent bulb, because it exhibits low efficiency in converting electricity to light – with only 5% of the input energy being converted to light and 95% expended as heat.

I HAVEN'T HEARD ANY SIREN CALLS FOR LCD TVs TO BE BANNED BECAUSE OF THEIR VERY POOR ENERGY EFFICIENCY

In the UK, the major retailers have rushed to join this bandwagon, with public declarations of support and systematic "clearing of the shelves" and avowals not to stock incandescent bulbs from now on.

Laudable? Perhaps – but wait a minute.

The liquid crystal colour active matrix display is itself a miserably poor performer in optical efficiency terms. Typically, only 5% of the light that hits the back of the display will eventually emerge from the front. Some 95% of the light will be absorbed within the display itself as heat. With the efficiency of the backlight itself being much less than 100% (cold cathode fluorescent tubes about 20%, similar to best in class LEDs), the overall illumination performance of an LCD TV is probably about 2-3% at most, but I haven't heard *any* siren calls for LCD TVs to be banned because of their very poor energy efficiency. How about that for hypocrisy!

Technology is continually throwing up these conundrums and paradoxes. That's what makes it a great field to be working in. The closing thought this month is: when you are watching the programmes on your LCD TV, just think about the fact that the whole device is less efficient than an incandescent light bulb.

Chris Williams is Network Director at the UK Display & Lighting Knowledge Transfer Network (UKDL KTN)

AUDIO INVERTING AMPLIFIER

The first sketches of this circuit appeared about twenty years ago, when I started to develop an all-discrete audio preamplifier. I had a good example of building such things: Doug Self's preamplifier described in *Wireless World* (June 1979). Its basic amplifying stage contained some improvements in comparison with a classic one, as a result, the preamplifier's characteristics were notably better than typical at that time.

Doug Self soon switched over to using the NE5534 op-amp, whose high performance in audio applications seems unsurpassed even now, twenty years after (I confidently measure its distortion not exceeding 0.0002% in the whole audio range, with a 2V output signal applied to a 2kΩ load).

In the meantime, I was experimenting with my audio inverting amplifier until reaching (in the early 90s) the ultimate in its characteristics, simplicity and sounding. The amplifier's sounding alone advantageously distinguishes it from the ones built on op-amps. I, however, didn't mention this feature when describing the configuration as a circuit idea in *Electronics World* (September 1992), the represented there were only its objective measurement characteristics.

I have versatile measurement data obtained both with the help of my VK-1,2 instruments and when simulating the circuit with the Multisim 9 software, the data being practically the same, confirming their high reliability. Of course, the audio inverting amplifier deserves detailed ventilation and, further, I would like to give its analysis. Employing a minimum of components (four transistors, four resistors and three capacitors) this discrete amplifying block has a transparent and rational structure that ensures a very small degradation of the audio signal passing through it. It contains the only one stage of voltage amplification, a cascode on Q1, Q2, while its output stage (the emitter follower Q3 fed with the current source Q4) performs subsequent current amplification (see **Figure 1**).

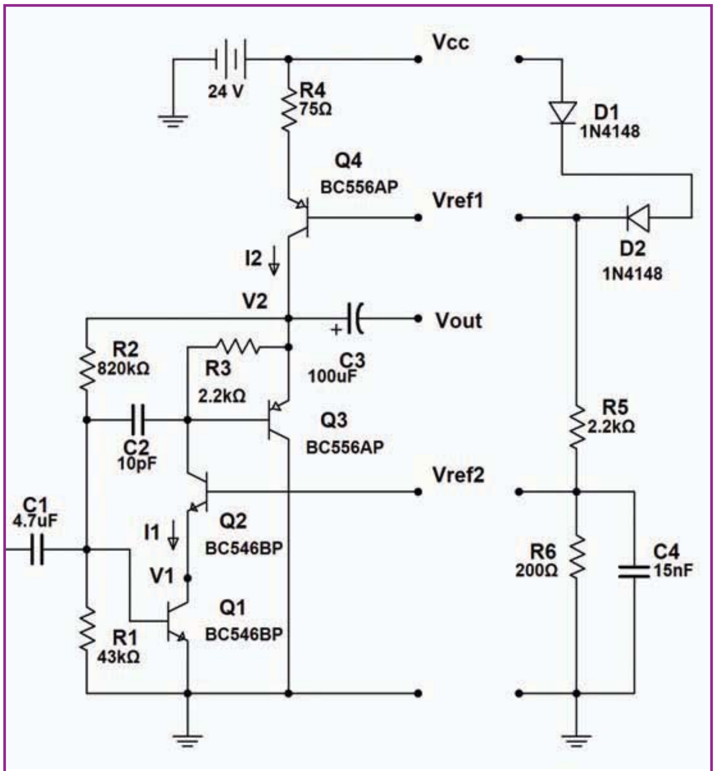


Figure 1: *Basic inverting amplifier configuration*

To make the circuit to operate correctly when handling audio AC signals, proper DC conditions must be provided. Quiescent currents I_1, I_2 of the input and output stages and DC voltages V_1, V_2 at their critical points (the collector of Q1 and the emitter of Q3) are easily and almost independently set with the help of four resistors (R1-R4) and two reference voltages V_{REF1}, V_{REF2} derived from a simple network (D1, D2, R5, R6). These references can be common for several such amplifying blocks.

Given that in normal operation conditions the emitter-base potential of a transistor lies within 0.6-0.65V, being slightly affected by its collector current, and that the base current is negligible in comparison with the collector current ($I_C/I_B = B > 200$ for BC546, BC556), the main DC relationships for the circuit are fairly straightforward.

With the chosen in Figure 1 resistor values, they yield:

$$I_1 = \frac{V_{BE3}}{R3} = \frac{0{,}65}{2{,}2} = 0{,}3\text{mA} \qquad \text{All resistors – in k}\Omega$$

$$I_2 = \frac{2V_D - V_{BE4}}{R4} = \frac{2\times 0{,}65 - 0{,}65}{0{,}075} = 8{,}7\text{mA}$$

$$V_1 = V_{REF2} - V_{BE2} = (V_{CC} - 2V_D)\frac{R6}{R5 + R6} - V_{BE2} = 22{,}7\frac{0{,}2}{2{,}2 + 0{,}2} - 0{,}6 = 1{,}3\text{V}$$

$$V_2 = V_{BE1}\frac{R2 + R1}{R1} = 0{,}6\frac{820 + 43}{43} = 12\text{V}$$

The calculated values are close to the measured ones; they are optimal for the circuit's best AC performance – minimum noise and distortion and maximum slew rate of the output. To reduce limitations in achieving a maximum possible signal swing at this output, V_1 is lowered to 1.3V without any detriment to an audio AC signal at this point because the signals at the collector and the base of Q1 are practically the same and don't exceed some millivolts.

The temperature stability of the chosen quiescent currents and voltages depends mostly on the emitter-base potential of the involved transistors or V_D of diodes. A 1^0C rise of temperature causes a 2.1mV decrease of this potential, so for the assumed, say, 20^0C temperature variation, the instability of V_{BE} will be 42mV or 7% relative to 0.6V. Such percent drift of the circuit's DC conditions is quite tolerable.

To make the circuit work as a linear amplifier with a fixed gain, two additional resistors R_{IN} and R_{FB} should be introduced (see **Figure 2**). They form the shunt negative feedback which determines the circuit's main AC characteristics – input resistance R_{IN} and closed-loop gain $A = - R_{FB}/R_{IN}$, where " - " means that the amplifier inverts the input

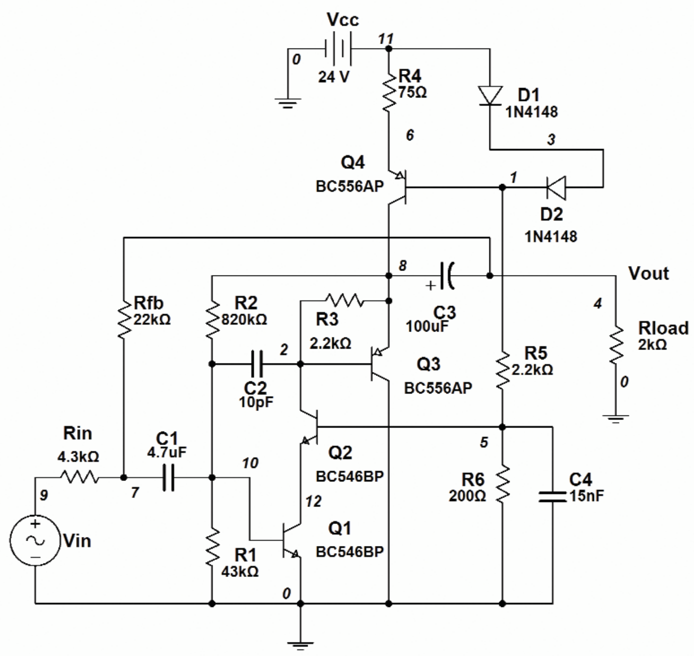


Figure 2: *Inverting amplifier with feedback*

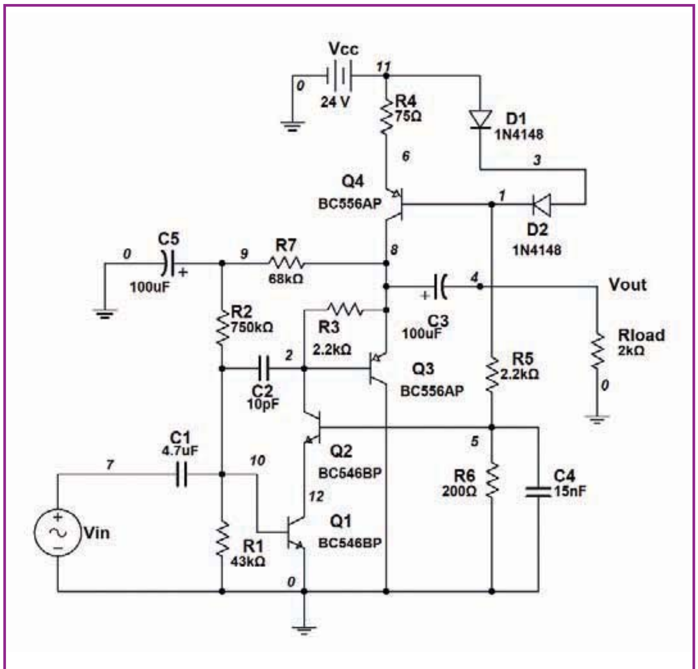


Figure 5: *Inverting amplifier without feedback*

signal's phase. The chosen values in Figure 2 give R_{IN}= 4.3kOhm and A = -22/4.3= -5. The measured DC voltages at all operating points of the circuit are listed in **Table 1**.

DC Operating Point Voltage (V)

4	0.00000
6	23.35603
2	12.78413
3	23.32658
7	0.00000
11	24.00000
9	0.00000
5	1.88752
8	13.48451
10	0.61179
1	22.65316
12	1.27907

Table 1: DC operating points of the inverting amplifier

The base of Q1 is the point of comparing the input and output (feedback) signals applied to it via R_{IN} and R_{FB} correspondingly. The resulting AC signal at this point of the so-called virtual earth is very small:

$V_{IN0} = V_{OUT}/A_0$, here A_0 is the open-loop gain.

This signal doesn't exceed 1-2mV; it modulates the emitter-base potential which is high enough (0.6-0.65V) to cause any notable non-linearity. The explanation of that circuit fragment is depicted in **Figure 3**.

In a typical differential amplifier with the series negative feedback, the input and feedback signals are applied to different points: to the bases of a long-tail pair Q1, Q2 (see **Figure 4**).

The comparison of these signals isn't so accurate here as in the inverting amplifier, and just non-ideal matching of the two emitter-base potentials seems to be responsible for the audio signal's degradation. The more sensitive this amplifier, the more serious the signal's degradation and more subjectively preferable for its handling appears to be the inverting amplifier which gives more natural feel to the output signal and, hence, to the sound we hear. This conclusion is rather intuitive because it isn't confirmed by the

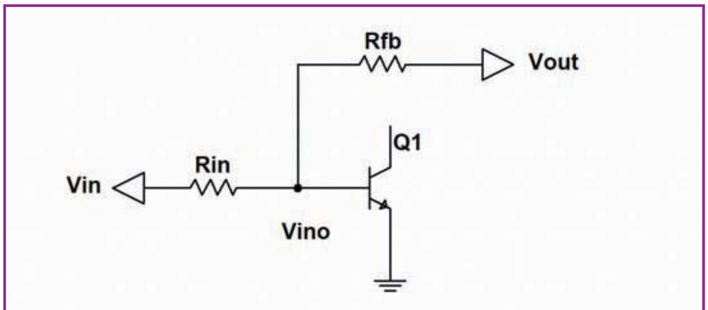


Figure 3: *AC equivalent input circuitry of the inverting amplifier*

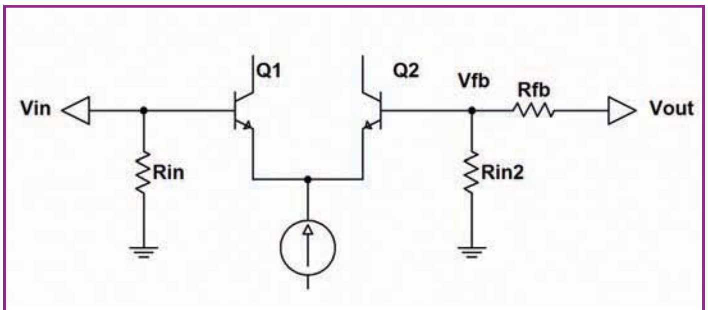


Figure 4: *AC equivalent input circuitry of the differential amplifier*

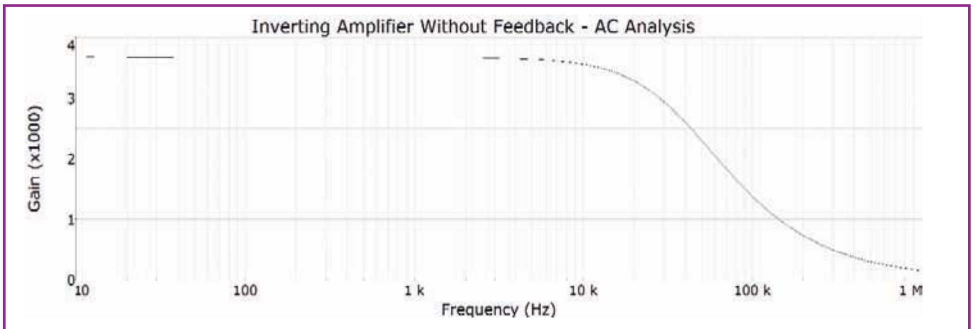


Figure 6: *Inverting amplifier's open-loop gain*

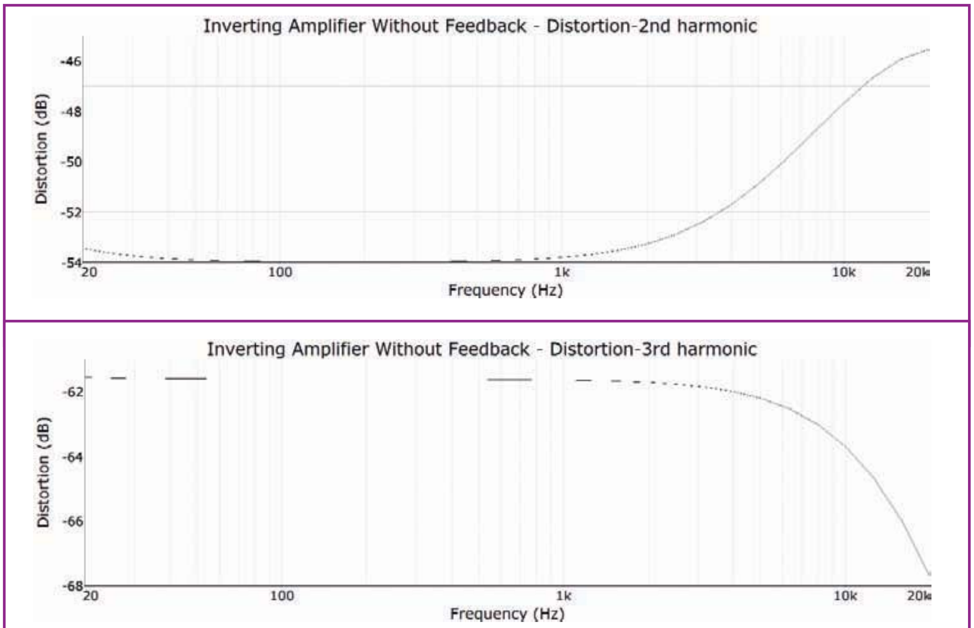


Figure 7-8: *Inverting amplifier's distortion*

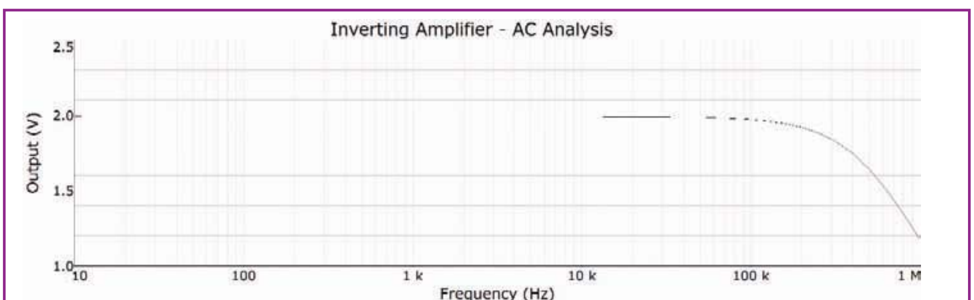


Figure 9: *AC analysis of the inverting amplifier with feedback*

most sensitive distortion measurements with the help of stationary test signals; however, it can be easily confirmed when subjectively testing the inverting and differential amplifiers with the help of our ears.

The two circuits' comparison is most demonstrative when using them in the MM-head preamplifier necessary for vinyl disc reproduction. The signal this preamplifier copes with is small in magnitude (about 5mV) but rich of the so-called live contents, just what we all dream to enjoy. For a clean experiment, all the measurement characteristics of the inverting and differential preamplifiers should be maintained equal (gain, frequency responses) and exemplary (ultra-low distortion and high output slew rate).

After such preparation, the following listening evaluation doesn't require much time to convince everybody in the inverting amplifier's capability to reproduce all that has been recorded – sounds and even silence, both being just live sounds and live silence. This impression doesn't become less strong in the presence of a slightly higher noise inherent to this preamplifier.

In general, my audio inverting amplifier should be used in all the stages of audio amplification, correction and conversion to ensure the output signal isn't spoiled by any casual circuitry. The only exception may be done for a power amplifier, particularly if using my own VK-5 70W-amplifier. Such stages as preamplifiers with a fixed gain, mixers and tone controls are widely used in audio just in the inverting amplifier topology and, here, I wasn't so original, building them on my discrete inverting amplifier.

To use the circuit in my noise reducer and low-voltage power amplifier was a puzzling task indeed, which required novel design solutions in the realisation of low-pass filters and bridged amplifiers.

The above words about audio capabilities of the equipment built on the inverting amplifier may seem similar to those pretentious reviews which praise the appearing on the market fashionable audio components. The target of the subjective reviews is to convince people to buy these expensive (thousands of dollars) components.

Their specially selected, most advantageous but not full specifications serve this purpose too. Since I have no fiscal interest, the inverting amplifier's objective and subjective characteristics presented here are a true description and I would like to give as much technical data as possible.

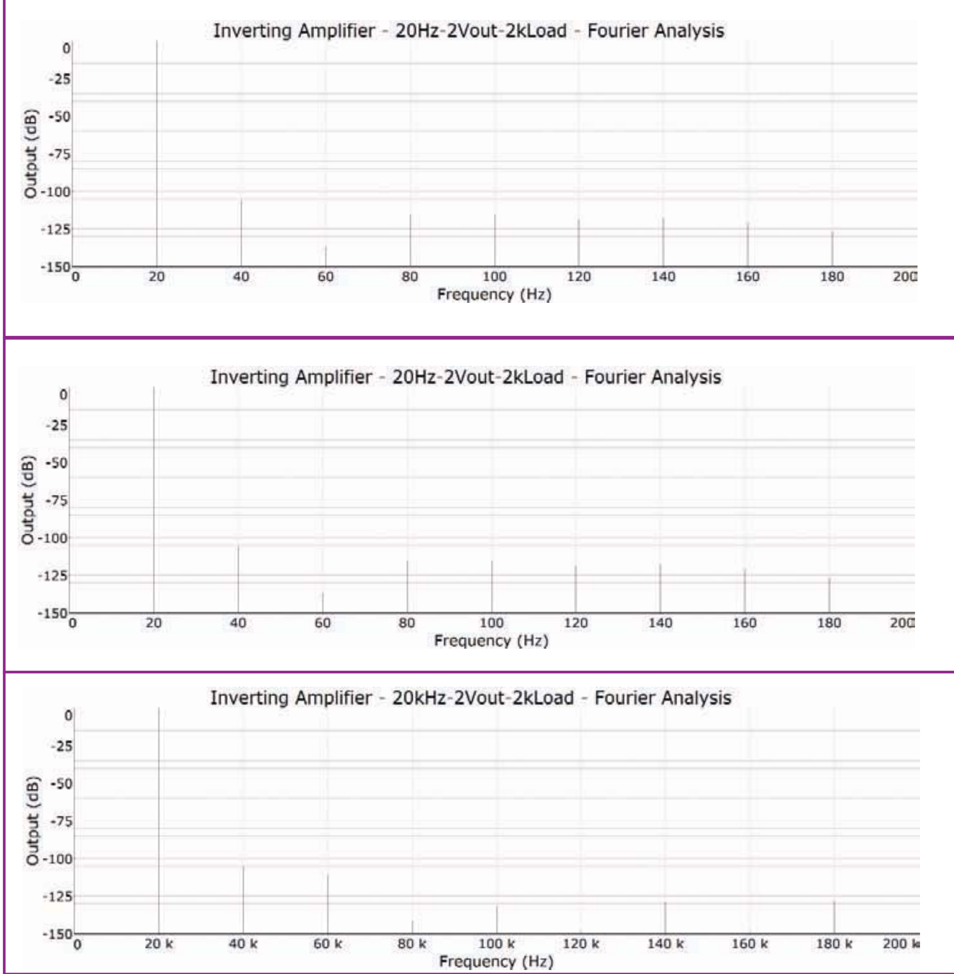
The amplifier is excellently simulated by the Multisim 9 software which offers a powerful set of tools and virtual instruments for all conceivable kinds of circuit analysis. It's reasonable to start testing with the basic inverting configuration. The scheme to be entered to the program is shown in **Figure 5**.

Here, the biasing resistor to the base of Q1 is split into R2 and R7, their common point being AC grounded via C5 to prevent the AC negative feedback. The main characteristics of the circuit are an open-loop gain A_0 (see **Figure 6**) and open-loop distortion measured on a 2kOhm load (**Figures 7-8**).

According to the above, the inverting amplifier features an open-loop gain of more than 3000 in the whole audio 20Hz-20kHz range (still 160 at 1MHz), its 2V output signal, applied to a 2kOhm load, has open-loop total harmonic distortion (THD_0) within -(54-46)dB or 0.2-0.5%. This 2V signal is a maximum operational output of the majority of audio preamplifiers and I usually set it when making the circuit's analysis. However, the amplifier's headroom allows to produce at its output up to 7V, this signal being on the verge of clipping and having THD of about 1.5% (with the same load).

Testing of the inverting amplifier with feedback is performed on the example of the circuit Figure 2. After entering it to the simulation program, an input signal of 0.4V should be chosen to give the desired 2V output; the set closed-loop gain A= -5 is typical for most audio applications. The obtained amplitude-frequency response is shown in **Figure 9**. Note that the circuit's closed-loop bandwidth extends up to 700kHz (at the level of -3dB) and the amplifier remains absolutely high-frequency (HF) stable not only in this case, but always, and with any amount of the applied negative feedback; the correction capacitor C2 = 10pF guarantees that.

The amplifier's closed-loop distortion can be obtained from its open-loop distortion by reducing the latter in A_0/A times. This parameter is called the feedback amount and in our case it exceeds 3000/5 = 600 in the whole audio frequency range. The calculated closed-loop distortion is: THD = THD_0/600 = (0.2-0.5)/600 = 0.0004-0.0008%. To get corresponding experimental data, the simulation program should be run again and it will perform spectrum analysis of the inverting amplifier's output at the lowest, mid and highest frequencies of the audio range. The result is produced in two forms, one of them being tabular (see **Table 2**).



***Figures 10-12:** Fourier analysis of the inverting amplifier with feedback*

———————————————————————————

Inverting Amplifier - 20Hz-2Vout-2kLoad - Fourier Analysis

———————————————————————————

Fourier analysis for point 4:
DC component: 0.00096019
No. Harmonics: 9, THD: 0.000606194%, Gridsize: 256, Interpolation Degree: 1

Harmonic Frequency Magnitude Phase Norm. Mag Norm. Phase

——————————————————————————— 1

20 2.83423 -179.22 1 0 2 40 1.46528e-005 66.9097 5.16995e-006 246.13 3 60 4.02943e-007 111.967 1.4217e-007 291.188 4 80 4.97682e-006 -1.7748 1.75597e-006 177.446 5 100 4.69966e-006 0.175405 1.65817e-006 179.396 6 120 3.31164e-006 3.58998 1.16844e-006 182.81 7 140 3.81943e-006 -1.7331 1.34761e-006 177.487 8 160 2.48622e-006 4.94929 8.77211e-007 184.17 9 180 1.31362e-006 23.1385 4.63482e-007 202.359 ——————

———————————————————————————

Inverting Amplifier - 1kHz-2Vout-2kLoad - Fourier Analysis

———————————————————————————

Fourier analysis for point 4:
DC component: 0.000875411
No. Harmonics: 9, THD: 0.000536896%, Gridsize: 256, Interpolation Degree: 1

Harmonic Frequency Magnitude Phase Norm. Mag Norm. Phase

——————————————————————————— 1

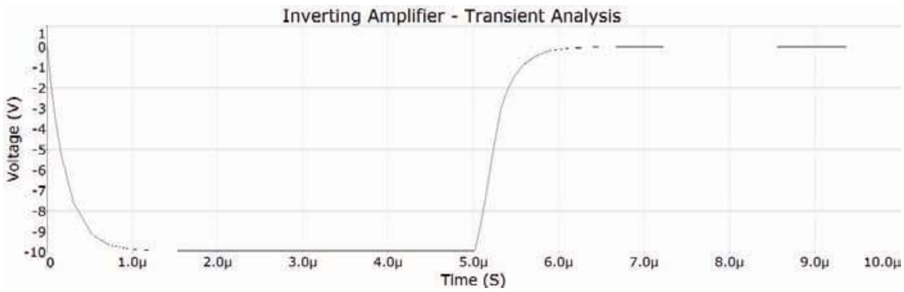
1000 2.833 179.935 1 0 2 2000 1.34127e-005 94.6933 4.73445e-006 -85.242 3 3000 6.98556e-006 179.63 2.46578e-006 -0.30578 4 4000 3.50262e-007 -119.9 1.23636e-007 -299.83 5 5000 6.1371e-007 -15.364 2.16629e-007 -195.3 6 6000 1.19931e-007 165.004 4.23334e-008 -14.932 7 7000 9.32866e-007 -17.651 3.29285e-007 -197.59 8 8000 9.44459e-008 162.344 3.33377e-008 -17.591 9 9000 1.12278e-006 162.262 3.9632e-007 -17.674 ——

———————————————————————————

Inverting Amplifier - 20kHz-2Vout-2kLoad - Fourier Analysis

———————————————————————————

Fourier analysis for point 4:
DC component: 1.60816e-005
No. Harmonics: 9, THD: 0.000613166%, Gridsize: 256, Interpolation Degree: 1



Figures 13: *Transient analysis of the inverting amplifier with feedback*

Harmonic Frequency Magnitude Phase Norm. Mag Norm. Phase ——————————————————————————— 1 20000 2.83194 178.397 1 0 2 40000 1.53944e-005 157.507 5.436e-006 -20.89 3 60000 7.85796e-006 -156.31 2.77476e-006 -334.7 4 80000 2.29974e-007 -120.69 8.12071e-008 -299.08 5 100000 7.20876e-007 -5.7854 2.54552e-007 -184.18 6 120000 1.10824e-007 97.9798 3.91335e-008 -80.417 7 140000 9.94244e-007 -10.286 3.51082e-007 -188.68 8 160000 1.09324e-007 101.491 3.8604e-008 -76.906 9 180000 1.09782e-006 155.998 3.87655e-007 -22.399 ———————————————————————————

Table 2: Fourier analysis of the inverting amplifier with feedback

For each frequency, the table represents the first harmonic being the amplifier's output signal itself, and the harmonics of numbers from 2 up to 9 being distortion components of the output, their sum is closed-loop total harmonic distortion. These experimental values lie within 0.0005-0.0008%, which corresponds very well to the values calculated above and confirms a remarkable property of the inverting amplifier's circuitry – all distortion occurs at the very output (the emitter follower Q3 fed with the current source Q4). The input stage doesn't generate distortion at all, otherwise the distortion's presence couldn't be effectively reduced by the feedback and would be registered. **Figures 10-12** show graphical pictures of the conducted spectrum analysis at the most important frequencies 20Hz, 1kHz and 20kHz.

Virtual testing of the amplifier's circuit in Figure 2 is concluded by its transient analysis. The resulting 10V-100kHz square-wave output is depicted in **Figure 13**. It can be easily seen that slew-rate of this output is 20V/usec.

Concrete audio applications of the inverting amplifier are the subjects of separate articles, some of which may be published later or sent on request. Here, I make only the circuit's presentation, so everyone can try to use it at own discretion.

I have explored so far the circuit as a complete all-sufficient amplifying block whose main feature is class-A operation on its output and, hence, very low produced distortion, all this in combination with its ability of live sound reproduction. But the output linearity can be further considerably improved by using the inverting amplifier as a part of the operational amplifier in which the added input differential stage increases an open-loop gain and widens the amplifier's functionality; the subjective audio characteristics not being considered here is of prime importance. Such a discrete amplifier was designed for special ultra-low distortion applications in my VK-1 audio oscillator and VK-2 distortion meter and there it delivers a 2V output into a 300 Ohm load with less than 0.00003% (-130dB) distortion in the whole 20Hz-20kHz frequency range.

Vladimir Katkov
Ukraine

PIC microcontrollers (MCUs) are used in a wide range of everyday products from washing machines, garage door openers and television remotes to industrial, automotive and medical products. While some designs such as Switch Mode Power Supplies (SMPS) are traditionally implemented using a purely analogue control scheme, these designs can benefit from the configurability and intelligence that can only be realised by adding a microcontroller.

TIP 1: SOFT-START USING A PIC10F200

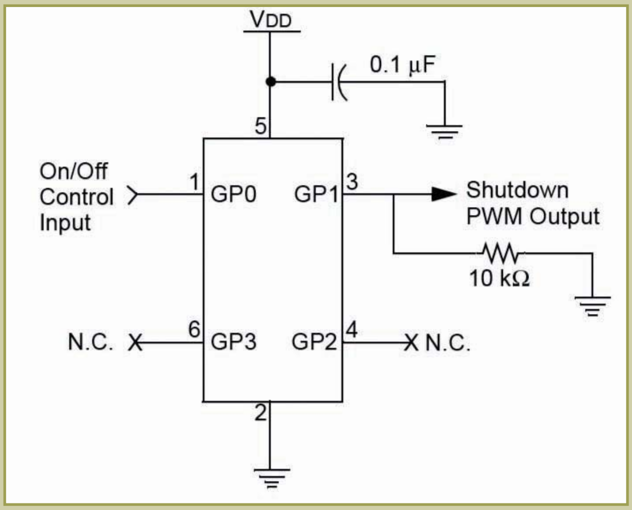


Figure 1: *SOFT-START CIRCUIT SCHEMATIC*

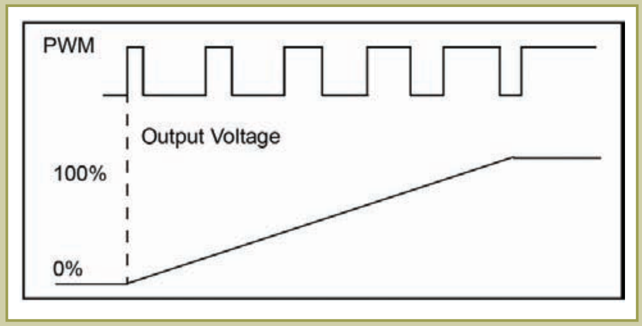


Figure 2: *TIMING DIAGRAM*

Almost all power supply controllers are equipped with shutdown inputs that can be used to disable the MOSFET driver outputs. Using Pulse-Width Modulation (PWM) the amount of time the power supply is allowed to operate can be slowly incremented to allow the output voltage to slowly rise from 0% to 100%.

This technique is called soft-start and is used to prevent the large inrush currents that are associated with the start-up of a switching power supply.

GP0 on the PIC MCU is used to enable or disable the soft-start. Once enabled, the on-time of the PWM signal driving the shutdown output will increase each cycle until the power supply is fully on.

During the PIC MCU power-on reset, the PWM output (GP1) is initially in a high-impedance state. A pull-down resistor on the PWM output ensures the power supply will not unexpectedly begin operating.

It is important to note that this type of soft-start controller can only be used for switching regulators that respond very quickly to changes on their shutdown pins (such as those that do cycle-bycycle limiting). Some linear regulators have active low shutdown inputs, however, these regulators do not respond fast enough to changes on their shutdown pins in order to perform soft-start.

TIP 2: A START-UP SEQUENCER

Some new devices have multiple voltage requirements (e.g. core voltages, I/O voltages, etc). The sequence in which these voltages rise and fall may be important.

By expanding on the previous tip, a start-up sequencer can be created to control two output voltages. Two PWM outputs are generated to control the shutdown pins of two SMPS controllers. Again, this type of control only works on controllers that respond quickly to changes on the shutdown pin (such as those that do cycle-by-cycle limiting).

This design uses the PIC MCU comparator to implement an under-voltage lockout. The input on the GP0/CIN+ pin must be above the internal 0.6V reference for soft-start to begin, as shown in **Figure 4.**

Two conditions must be met in order for the soft-start sequence to begin:

1. The shutdown pin must be held at VDD (logic high).
2. The voltage on GP0 must be above 0.6V.

Once both start-up conditions are met, the sequences will delay and PWM #1 will ramp from 0% to 100%. A second delay allows the first voltage to stabilise before the sequencer ramps

PWM #2 from 0% to 100%. All delays and ramp times are under software control and can be customised for specific applications. If either soft-start condition becomes invalid, the circuit will shut down the SMPS controllers.

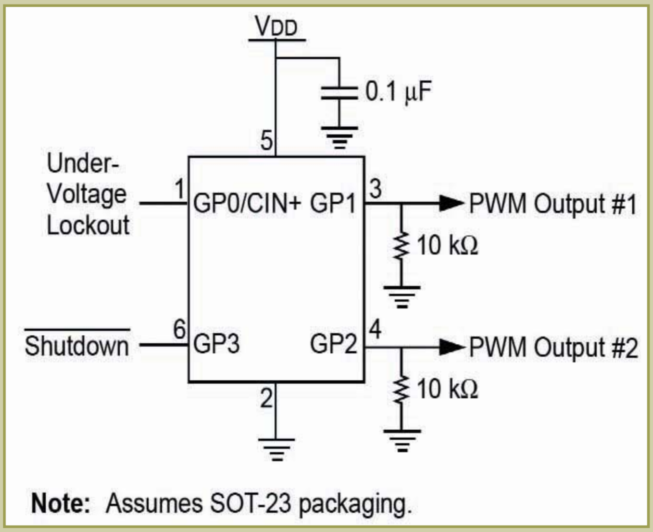


Figure 3: *MULTIPLE PWM OUTPUT SOFT-START CONTROLLER*

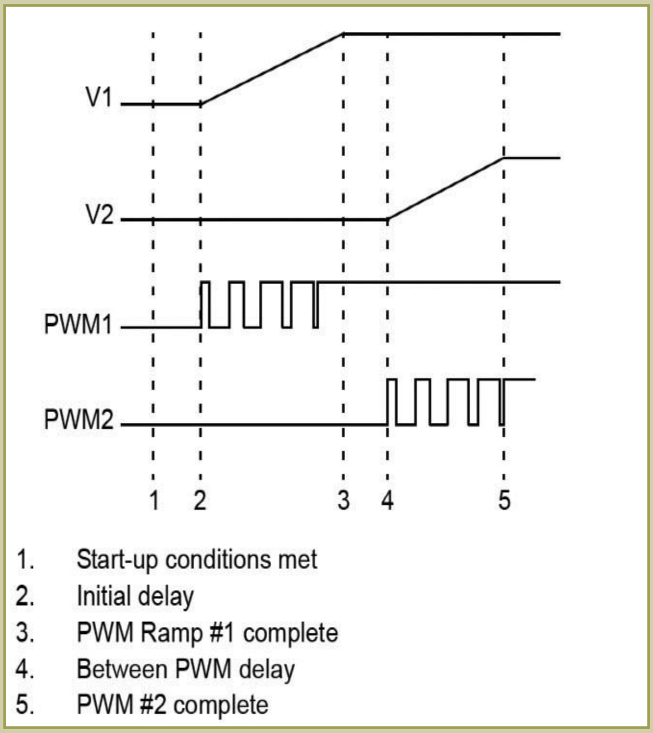


Figure 4: *TIMING DIAGRAM*

TIP 3: A TRACKING AND PROPORTIONAL SOFT-START OF TWO POWER SUPPLIES

Expanding on the previous tip, we can also use a PIC MCU to ensure that two voltages in a system rise together or rise proportionally to one another, as shown in **Figure 5**. This type of start-up is often used in applications with devices that require multiple voltages (such as I/O and core voltages).

Like the previous two, this tip is designed to control the shutdown pin of the SMPS controller and will only work with controllers that respond quickly to changes on the shutdown pin.

The comparator of the PIC MCU is used to determine which voltage is higher and increases the on-time of the other output accordingly. The logic for the shutdown pins is as shown in **Table 1.**

Case	Shutdown A	Shutdown B
$V_A > V_B$	Low	High
$V_B > V_A$	High	Low
$V_B >$ Internal Reference	High	High

Table 1: *SHUTDOWN PIN LOGIC*

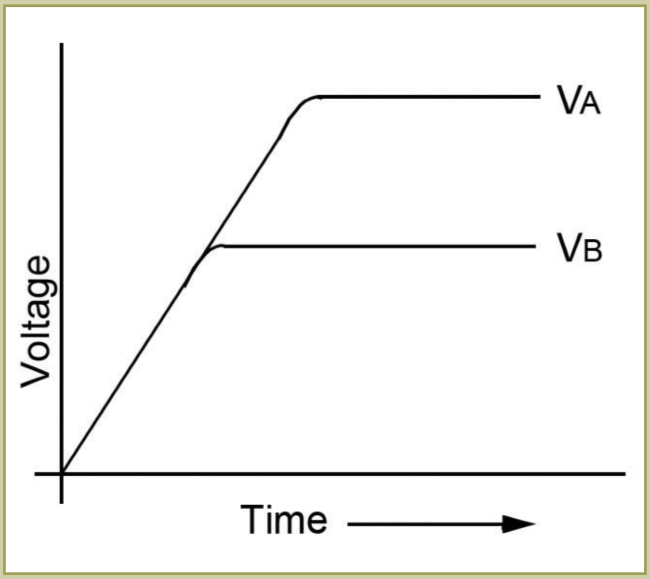


Figure 5: *TIMING DIAGRAM*

To determine if it has reached full voltage, VB is compared to the internal voltage reference. If VB is higher, both shutdown outputs are held high.

Resistor Divider 1 should be designed so that the potentiometer output is slightly higher than the comparator voltage reference when VB is at full voltage. The ratio of resistors in Resistor Divider 2 can be varied to change the slope at which VA rises. Pull-down resistors ensure the power supplies will not operate unexpectedly when the PIC MCU is being reset.

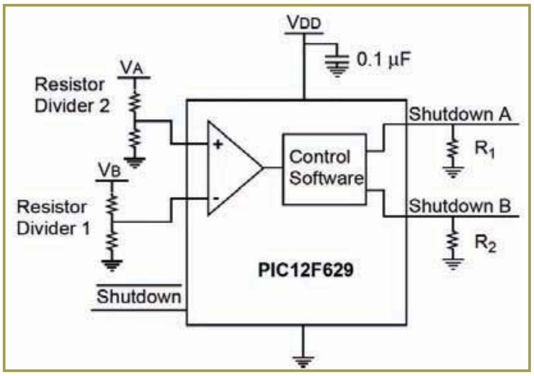


Figure 6: *EXAMPLE SCHEMATIC*

LOW COST THERMAL PROTECTION CIRCUIT – THERMAL PROTECTION WITH ADJUSTABLE TEMPERATURE LIMIT AND PROGRAMMABLE HYSTERESIS

BY CHARLIE ZHAO, LINEAR TECHNOLOGY

A simple and reliable thermal protection circuit is introduced in this article. The circuit uses a thermistor to sense temperature, and a comparator and voltage reference to set temperature trip point and hysteresis. The solution is low cost and very small in size.

Thermal protection is very important in many electronic systems. In case of an overload or short–circuit condition, for example, a lot of heat can be generated and the temperatures at certain PC board areas can quickly rise up. Extremely high temperature can cause controller chips and other components to fail their specifications and even burn up. Digital or analogue temperature sensor ICs can provide a variety of temperature monitoring features. But most of these temperature sensor ICs are relatively expensive and complicated to use.

Figure 7 shows a simple, reliable and low-cost thermal protection circuit. This circuit uses a thermistor for temperature sensing and an LTC1998 comparator and voltage reference for temperature trip point setup, hysteresis adjustment and analogue/digital output interface. A thermistor is a thermally sensitive resistor. The resistance of a thermistor will change with its body temperature. The LTC1998 is a micropower comparator and a precision adjustable reference in a 6-pin low profile (1mm) SOT-23 package. It is usually used for lithium-ion low battery detection applications and is borrowed for thermal protection purpose here.

An accurate internal reference and a proprietary comparison circuit, together with adjustable hysteresis and rail-to-rail push-pull output make it a good choice for the application. This thermal protection circuit provides very useful features such as adjustable trip temperature, programmable hysteresis and remote temperature sensing.

TEMPERATURE TRIP THRESHOLD SETUP

An NTC (negative temperature coefficient) thermistor RT is used here to sense the board temperature. **Figure 8** shows the resistance vs temperature curve of the Murata NCP18WF104J03RB NTC thermistor used in this design example. The resistance of the thermistor drops when the temperature rises.

The LTC1998 compares the voltage at pin 1 (BATT) to an accurate internal reference voltage. This internal reference voltage is set at 2.5V with pin 3 (VTH.A) grounded. When the voltage at pin 1 drops below the 2.5V internal threshold, the output pin (BATTLO) changes state from logic high to logic low.

At normal temperature condition, the resistance of the NTC thermistor is high and the voltage at LTC1998 pin 1 (BATT) is above 2.5V. So, the voltage at LTC1998 pin 6 (BATTLO) is logic high.

When the temperature at the sensed place rises, the voltage of LTC1998 pin 1 (Vbatt) decreases with the RT resistance. If Vbatt drops below 2.5V, the internal comparator of LTC1998 is tripped and the Vbattlo (pin 6) becomes logic low.

Pin 6 can be connected to the RUN/Soft Start (Enable/Shutdown) control terminal of the relative power supply. Therefore, if the temperature rises to a predetermined trip point, the power supply can be shutdown to prevent thermal runaway.

Temperature trip threshold can be set with the following equation:

$$V_{batt} = V_z \times RT(trip) / [R1 + RT(trip)] = 2.5V \qquad (1)$$

After the NTC thermistor and the temperature trip threshold are chosen, the RT (trip) resistance value at the temperature trip point can be determined from the resistance-temperature curve or formula provided by thermistor manufacturer's datasheet. For a known Vz (voltage across the Zener diode), R1 value can be calculated from the equation.

For example, assume the NCP18WF104J03RB NTC thermistor is selected and the desired temperature trip point is around 70ºC. From Figure 8 (or from test data/formula provided by the manufacturer), the RT (trip) resistance value is about 15.2kΩ. For 3.3V Vz, you

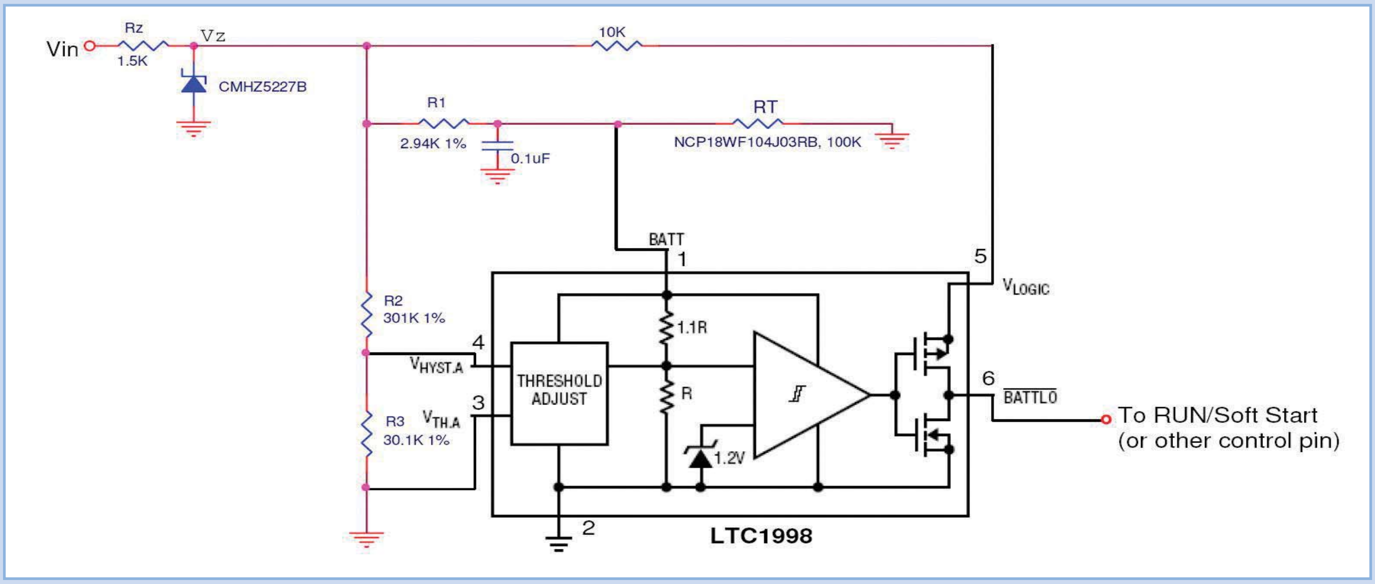


Figure 7: *Thermal protection circuit with adjustable temperature limit, programmable hysteresis and remote temperature sensing*

should select a 4.87kΩ (standard 1% accuracy) resistor as R1 based on **Equation 1.**

HYSTERESIS SETUP

Programmable hysteresis is added to prevent oscillation at trip point on pin 6 (BATTLO) as a basic requirement. The hysteresis voltage is the voltage at LTC1998 pin 4 and is adjustable from 10mV to 750mV. After the temperature trip and the power supply shutdown, the board temperature drops. The NTC thermistor resistance increases and so does the voltage of LTC1998 pin 1 (Vbatt). After the Vbatt rises to a predetermined level above 2.5V, which is the internal 2.5V reference plus the hysteresis voltage, the LTC1998 internal comparator is tripped again. This time, the pin 6 (battlo, RUN/SS) turns to logic high from logic low and the power supply will resume normal operation.

The hysteresis voltage can be set by a resistor divider connected to the pin 4 ($V_{H.A}$), see Figure 7:

$$V_{HYST} = V_{H.A} /2 = Vz \times R3/(R2+R3)/2 \quad (2)$$

To select the temperature of restarting the power supply, the hysteresis voltage can be determined according to the resistance-temperature curves or formula on the thermistor datasheet. Then, R2 and R3 values can be chosen from **Equation 2**. The higher the hysteresis voltage, the lower the restarting temperature for a given temperature trip threshold.

The hysteresis voltage can also be supplied by a voltage source or a circuitry to change the hysteresis at any time. An example of a thermal protection circuit with multiple restarting temperatures is shown in **Figure 9**. When S1 switch is closed, the hysteresis voltage is 150mV. When S1 switch is open, the hysteresis voltage increases to 276mV and the restarting temperature is lower. The S1 switch can be controlled by a microprocessor in the system, for example, based on the temperature and other conditions of the system at the real time.

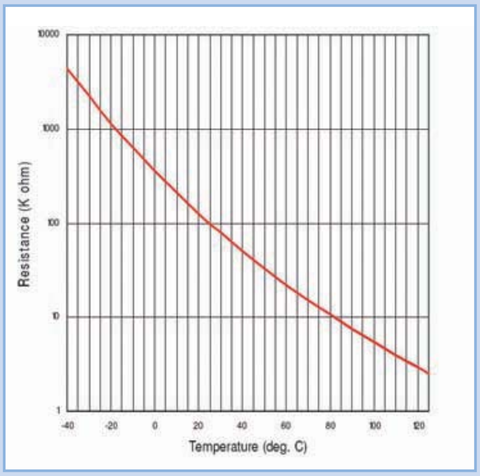


Figure 8: *NTC thermistor resistance vs temperature (Murata NCP18WF104J03RB example)*

REMOTE TEMPERATURE SENSING

Unlike an on-chip temperature sensing scheme, this thermal protection circuit uses NTC thermistor to sense the temperature. So it is possible to sense remote temperatures. A tiny thermistor can be located away from the LTC1998 circuit and be used to monitor the temperature at any point of interest on the board.

VERSATILE OUTPUT STAGE AND MULTIPLE-PLACE TEMPERATURE PROTECTION

The LTC1998's output (BATTLO) is a push-pull CMOS driver with a separate supply pin (V_{LOGIC}) that can be used to provide an output voltage rail matching the voltage requirement of the RUN/Soft Start (Enable/Shutdown) control terminal of the relative power supply. This output stage can also interface with a microprocessor. The V_{LOGIC} pin may be tied to a voltage between 1V and Vbatt (pin 1 voltage) directly. The V_{LOGIC} pin may also be tied to a voltage higher than Vbatt via a series resistor and the output stage will have the open-drain configuration.

Some systems may require temperature sensing and protection at multiple places across the board or boards. For this kind of applications, multiple thermal protection circuits can be used. Each thermal protection circuit can have individual temperature threshold and hysteresis setup. The output pins (pin 6 of LTC1998) can be tied together to form a wire-OR with the open-drain configuration. When the temperature at one of these critical spots is too high and exceeds the protection threshold, the system can be shut down or enter protection mode. For example, a fan may be turned on to cool the board. The fan may be turned off after the temperature drops to a predetermined level based on the hysteresis setup.

INPUT VOLTAGE OF THE CIRCUIT

It is recommended to set the Vz voltage from about 2.7V to 5.5V. For example, if a 3.3V voltage source is available in the system, then Vz can be directly connected to the 3.3V source, so that Rz and Zener diode would not be needed, like the example in Figure 9.

If a suitable bias supply is not available in the system, Rz and Zener diode will be required to connect the protection circuit to the input of the power supply. Choose the Rz and Zener diode according to the input voltage range.

TEST RESULT

In the Figure 7 example, a 0603 size 100K NTC thermistor from Murata (NCP18WF104J03RB) is used. Rz and Zener section works well from input voltage about 3V to 40V.

With Vin of 24V, Vz is about 3.3V and the hysteresis voltage is 150mV. The pin 1 trip voltage is 2.5V, which is set by the LTC1998 internal reference. The temperature trip threshold is around 90°C and there is 10°C hysteresis (approximately -0.3kΩ/°C for the thermistor in that temperature range). In other words, the power supply under control will be shutdown above 90°C and will resume operation when the temperature drops below 80°C.

THERMAL ASPECTS

Today's electronic designs are getting more complex, with faster, power-hungry systems and many more features. However, in most cases the components and boards are shrinking in size. Temperature management and thermal protection become increasingly important. Local or remote thermal protection is possible with the circuit shown in this article. The circuit is very small in size and inexpensive, with very few external components required.

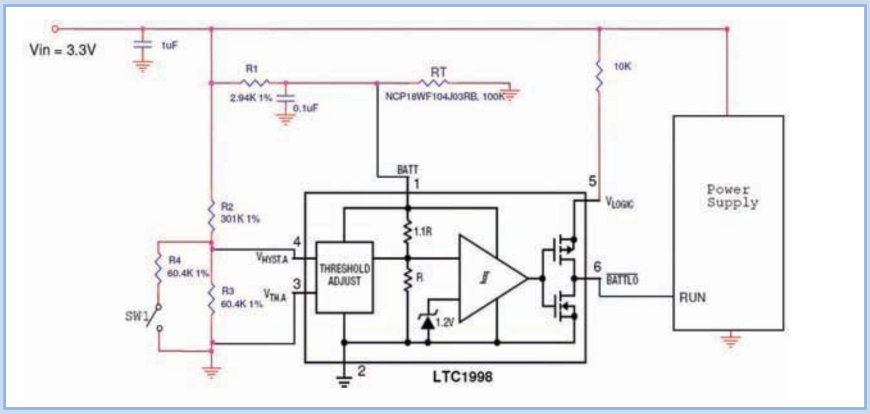


Figure 9: Thermal protection circuit able to restart the power supply at different temperatures after thermal shutdown

Win a Microchip PICDEM 2 Plus Demo Board

Electronics World is offering its readers the chance to win a Microchip PICDEM 2 Demonstration Board. This board now has an ICD port, LCD read-out, sounder and a temperature sensor. The enhanced PICDEM 2 Plus Demonstration Board provides designers with a tool for immediate programming and debugging Flash-based microcontrollers. The board is supplied with software loaded on a PIC18F452 microcontroller to demonstrate the device's features and peripherals. The program also sets up the microcontroller as a real-time clock and measures the local temperature, both of which are displayed on an LCD display. A PWM signal is sent directly to the Piezo sounder. There is an active RS-232 port and on-board Serial EEPROM and there is ample room in the generous prototyping area for project development work. A second Flash-based microcontroller with its own demonstration program, the PIC16F877, is also included.

Source code is provided allowing users to understand and dissect the programming algorithm. Additionally, users with an MPLAB® In-Circuit Debugger 2 can take advantage of the Flash-based microcontroller's in-circuit debugger capability by cutting, pasting, rewriting or adding to the program.

The PICDEM 2 Plus Demonstration Board is available separately or as part of the MPLAB ICD 2 Evaluation Kit, which also includes a power supply, serial cable and USB cable.
If you would like to be in with a chance of winning Microchip's PICDEM 2 Plus Demo Board, log onto **www.microchip-comp.com/ew-picdem2** and enter your details into the online entry form.

WIRELESS COMMUNICATION – THE FUTURE

WILLIAM WEBB

WILEY

Professor Webb is a brave man in trying to extrapolate from today's fragmented and inefficient wireless world towards a future in 20 years when he envisages a more joined-up approach to voice, data and video communications. He has assembled a panel of very capable experts to write a chapter each in this wide-ranging book, and although there is almost none of the duplication that one might expect from nine contributors, there is a remarkable convergence of informed opinion as to the direction that wireless communication will take.

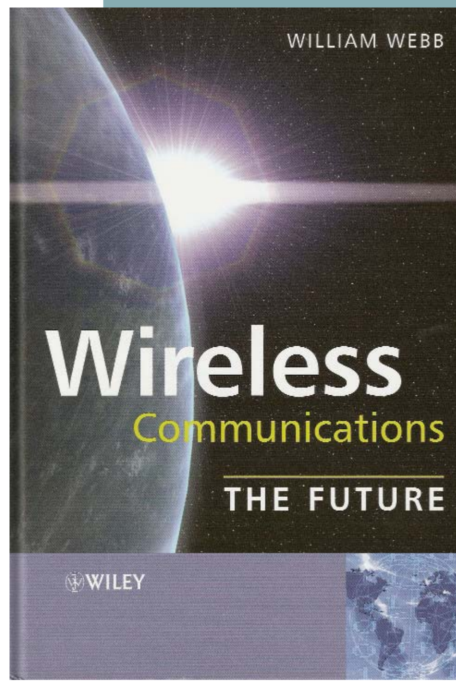
LIKE FOOD AND CLOTHING, CONNECTIVITY AND TELECOM SERVICES WILL BE ESSENTIALS OF LIFE THAT WE NEED, BUT TAKE FOR GRANTED, AND WE WILL BE UNWILLING TO PAY FOR THEM

Let's look at the conclusions first, since that's what the book is all about. First, it is unlikely that a distinctive 4G will ever take off. All significant developments in this field tend to take 15-20 years from inception to maturity, and a viable 4G isn't even at the design stage. Instead, 3G will become more fully accepted over the next 10 years, with GSM remaining viable long beyond that in rural areas and for machine-to-machine communication.

It is likely that 3G with GPS, WiFi and DVB-H will gradually be integrated on-chip, to provide a 4-way solution which will be made, at the software level, to appear seamless to the user. Secondly, the demand for higher bandwidth is going to be satisfied by the use of smaller and smaller cells, even of "femto-cells" on every street corner, so that the limited spectrum can be shared across a large number of low-power nodes. It is only at ranges like this that technologies such as UWB can make a useful contribution to the solution, but backhaul becomes a new problem area.

Thirdly, although user demand will continue to escalate, competition from wired services is keen: there is already significant integration with VoIP, data and video/TV, all easily available at the PC. Thus our willingness to pay will not increase in proportion to wireless functionality, so the pressure will be on seeing devices that can be sold at supermarket prices. The author's view is that "like food and clothing, connectivity and telecom services will be essentials of life that we need, but take for granted, and we will be unwilling to pay for them".

After the first five introductory chapters, there are particular contributions by the different specialists. William Webb himself kicks off with a major assault on the technological possibilities for the next twenty years. He looks at ways of getting as near as



possible to Shannon's ideal data-rate and also at the potential for increasing component density; he predicts the final demise of Moore's Law as transistors reach atomic dimensions, which he reckons will be about 2016.

In a discussion of spectrum utilisation, he concludes that "Cooper's Law tells us that despite being close to the Shannon limit for a single channel, there is no end in sight for practical increases in wireless transmission . . . if we are prepared to invest in an appropriately dense infrastructure". This is the basis of the later prediction that most of the progress will be made in urban areas, leaving the rural communities serviced at a much lower level.

Paul Cannon and Clive Harding then cover the development of military wireless and Peter Cochrane sees the future up to around 2060 as connecting everyone to everyone, on the move or not. Gary Grube and Hamid Ahmadi speak of the democratisation of wireless, foreseeing the universality of information access with ad-hoc connectivity, self-configuring systems, multi-hopping and dynamic routing. Dennis Robertson, in an interesting chapter on interference, demonstrates from actual records of spectrum occupancy the surprising fact that there need be no shortage of space: many channels are very under-used, and if we can move away from the concept of spectrum ownership and more towards spectrum utilisation, there should be enough space for any foreseeable future needs.

Simon Saunders takes up the challenge of crystal-ball gazing and outlines three successive phases, speculating that the rapid proliferation of wireless-based systems today will change gear around 2012, ushering in a period when all these diverse solutions will begin to settle down into similarity. By 2017, he reasons that solutions to most of the problems will have been found and we shall be taking it all so much for granted, that the wireless-enabled society will have become mundane. Stephen Temple follows this with a profound look at the social, political and economic forces that get in the way of straightforward technological development.

There is much, much more, and it is all good stuff in a very readable book. Professor Webb's credentials are impeccable and he has consulted wisely. His previous book, "The Future of Wireless Communications", was published in 2000 and its predictions have been substantially vindicated, despite the traumatic times during the five years it covered, years in which 500,000 jobs were lost in the telecoms industry.

The author has the integrity – and the courage – to tabulate on page 242 the failures and successes of this earlier book and, in doing this, I think he is establishes that he is in the business of developing a useful methodology, rather than just trying to be clever.

You might think this work would become redundant fairly soon, as reality begins to move in other directions than those it predicts, but the careful choice of these multi-disciplinary contributions makes it interestingly possible to use the regular technology updates provided by Electronics World to track our current position on this broad road-map of development.

There's a good index and a most useful list of acronyms that saves a lot of frustration as one reads. I think this will be a useful reference for some years to come and I for one will be re-reading it as each new development in the wireless field comes along.

Hedley Richardson

High Performance Scanning in Miniature

New from Metrologic, the IS4910 is a powerful and versatile image scanner built to capture 1D, 2D, OCR and images of barcodes and documents. Its compact size and crisp high-resolution image capture capability make the IS4910 the ideal choice for kiosk applications such as payment terminals, price check kiosks and lottery terminals, as well as read application specific OCR requirements including passport reading.

With a set of features specifically engineered for the kiosk market, the IS4910 comes with a 1.2-megapixel CMOS sensor, allowing a large field of view for easy scanning and a handy power saving mode which lowers power consumption when the scanner is not in use. Offering aggressive scanning performance, the IS4910 features Metrologic's patented FirstFlash technology, capable of capturing images regardless of lighting conditions and so offers increased battery life.

Designed to provide unmatched barcode scanning, the IS4910 is also capable of capturing images for archiving and analysis purposes. The image size is scalable to fit specific application requirements.

With its low power consumption and reduced size, the Metrologic IS9410 is easy to integrate into both new and existing kiosk applications.

www.ded.co.uk

Cost-Effective IP Solutions for Audio Distribution and Security

Barix AG will display its complete range of IP audio devices at Integrated Systems Europe (ISE), the leading show for professional A/V and electronic systems integrators in Europe, taking place at the RAI Exhibition Centre in Amsterdam from January 29-31, 2008. Barix (Booth #R78), will offer insight on how A/V professionals and integrators can simply and cost-effectively use Barix IP devices for entertainment, security, PA and other audio applications.

Barix recently introduced the Annuncicom 1000, a professional grade device that combines intercom, paging and IP-based audio conversion for PA system playback into a half-width 19-inch, rack mountable box. For entertainment applications, the Annuncicom 1000 is ideal for multi-room audio distribution and for integration into complex, professional intercom and paging environments. Security system operators at universities, business campuses, shopping districts, industrial facilities, airports or transportation centers can route voice and contact closures to PA systems for playback of live or recorded voice announcements and ensure that the messages are instantly broadcast across the entire facility loud and clear.

www.barix.com

High-Resolution Fully Automated Solder Joint Inspection

Phoenix|x-ray has launched the breakthrough software platform called x|act for fast, CAD-based, fully automated inspection of solder joints (µAXI) at highest magnifications. It comes with a specifically designed, intuitive inspection program, which requires only a simple, one-time configuration and can be used with all phoenix|x-ray systems of the same type, which saves time and costs. By means of a scanning device, the component's CAD-data is read into the X-ray system and laid over the image (live CAD-Overlay). This allows the user to have the complete sample data available at all times, even when rotating and tilting the sample and during ovhm.

For ultimate ease-of-use, the software platform features a CAD view, which is constantly displayed in small part of the screen, to facilitate navigation of the sample. Another innovative feature is the height map, which displays differences in height in circuit boards caused by warping, shrinkage and strain and equalises them automatically. The software platform was designed to offer the greatest possible ease of operation and can be controlled by either joystick or mouse control.

www.phoenix-xray.com

DC-Input Bulk Front-End Power Modules

Emerson Network Power has launched four DC-input bulk front-end power modules for systems that use distributed power architectures. The modules are the latest additions to the company's popular DS series of power supplies, which until now only offered AC-input options.

The new DS450DC, 550DC, 650DC and 850DC modules all feature a very wide 40-72Vdc input voltage range, which is ideal for telecom and central office applications, operating from 48V battery plants. All four modules produce a main +12Vdc output, together with an auxiliary 'always-on' +3.3Vdc output for applications that require standby operation.

The DS450DC, 550DC, 650DC and 850DC modules have power output ratings of 450, 550, 650 and 850W respectively. The highest power module in the series, the DS850DC, can deliver up to 70A at +12Vdc from its main output and up to 6A from its 3.3Vdc auxiliary output. All four modules offer active single-wire current sharing which operates from 10 to 100% of full load, enabling multiple modules to be easily paralleled for very high current applications.

The modules incorporate low-loss internal ORing FETs on their main 12V output, for fault-tolerant and N+1 redundancy applications.

www.emerson.com

Digital Oscilloscope Range Expands with 350MHz Instrument

The DL1735E is a new 350MHz bandwidth addition to the Yokogawa DL1700E Series of digital oscilloscopes.

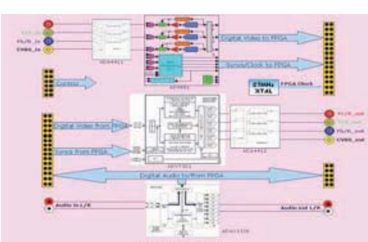
Targeted at general-purpose test and measurement applications in the automotive, home electronics and telecommunications industries, the compact, lightweight 4-channel instrument combines its 350MHz bandwidth with up to 1GS/s sampling rate and up to 2MW per channel memory length (1MW per channel for four channels).

The DL1735E incorporates USB interfaces which support USB storage devices, optional I2C and SPI bus triggers and analysis, and web server, FTP and network printing functions via an optional Ethernet interface.

The instrument is supplied with passive probes as standard.

www.yokogawa.com/tm

Audio/Video Interface with Analogue Connectivity



SingMai Electronics has introduced DP1, an audio/video interface card that provides analogue connectivity to Altera and third party FPGA development boards utilising the Santa Cruz connectors, for example http://www.altera.com/products/devkits/altera/kit-nios-2c35.html.

The board provides a high quality analogue/digital interface capability for the development of audio and video processing algorithms for applications in consumer electronics, security, broadcast and general purpose image processing.

DP1 provides three 10-bit video ADCs using Analog Devices's AD9981 IC that allow conversion of SD and HD analogue video in a variety of formats to digital video for processing by the development board FPGA. In addition, clocks and sync signals can be extracted from the input video.

Output video processing is provided the ADI ADV7321, which provides simultaneous RGB/YPbPr outputs, again for SD and HD video, as well as composite video outputs.

Audio interfacing is provided via another ADI codec. Stereo analogue audio is converted to I2S using a 24-bit ADC whilst a high quality stereo DAC provides output analogue capability.

The board provides all the necessary input and output buffering, power and interfacing for these ICs, and also incorporates a free-running 27MHz crystal output.

www.singmai.com

First nanoETXexpress Computer-On-Module

Kontron introduced the first nanoETXexpress computer-on-module to pack low power VIA Eden ULV processing performance and high-end graphics capabilities, as well as PCI Express and Serial ATA interfaces on a credit card footprint of merely 55mm x 84mm.

The Kontron nanoETXexpress-VX8 is the first member of a new scalable family of nanoETXexpress computer-on-modules. Future members will also include nanoETXexpress COMs based on processors and chipsets from other manufacturers. This new form-factor standard is the logical addition to the existing PCI and/or ISA-based computer-on-modules standards, X-board and DIMM-PC.

Designed according to the pin definitions of the COM Express specification, the new Kontron nanoETXexpress computer-on-modules are ideal for the emerging generation of mobile embedded applications that require low power performance and the latest interfaces on the smallest form-factor.

Processing performance for the first Kontron nanoETXexpress computer-on-module is provided by the new low power VIA Eden ULV processor up to 1.5GHz along with the highly integrated VIA VX800 chipset up to 400MHz FSB and up to 1GB DDR2 RAM.

www.kontron.com

Dual Channel Memory Portfolio for COM Express Computer-On-Modules

Kontron launched its COM Express compliant Kontron ETXexpress-CD computer-on-modules with Dual Channel Memory support.

The Kontron ETXexpress-CD follows the ETXexpress-MC to become Kontron's second COM Express compliant computer-on-module (COM) with support for up to 4GByte Dual Channel Memory via two 533MHz or 667MHz DDR2 SO-DIMM sockets. Therefore, these modules are ideal for the latest generation of performance-hungry applications that require high levels of data processing. Extreme data processing capacities are needed especially by applications running (a)synchronous multiprocessing and/or virtualisation technologies.

For applications requiring the latest, high-end dual core performance up to 2GHz, the Kontron ETXexpress-CD computer-on-module with support for up to 4GBytes of Dual Channel Memory is the perfect choice. Kontron's ETXexpress-CD module is equipped with the Intel Core Duo processor T2500, the Mobile Intel 945GM Express chipset and the ICH7M Southbridge. For ultimate performance, the new COM Express compliant Kontron ETXexpress-MC with the latest Intel Core 2 Duo processors up to 2.2GHz and Intel 965GM Express chipset with 800MHz FSB as well as Dual Channel Memory, is the most powerful member of Kontron's proven ETXexpress range of computer-on-modules.

www.kontron.com

KISS-1U 19-Inch/1U Server Family

Kontron launches its new industrial Silent Server 19-inch/1U server family, the KISS-1U. The new slimline server is one of the most compact, quietest and fastest high-availability servers for long-lifecycle applications under harsh conditions.

With its extremely low installation height of 44mm, the Kontron KISS-1U server is particularly attractive for densely packed, rugged server applications that require long-term availability. Flexibility in choice of processors, drives and expansions enables customisation for applications in industrial automation, process control, high-speed image processing, medical technology, defense engineering, transportation and building control technology.

Performance for the first available Kontron KISS-U1 is supplied by the mobile Intel Core Duo and Intel Core 2 Duo processors up to the T7400 processor (2 x 2.16GHz) and a thermal design power of only 31W. The Intel 945GM chipset offers up to 4GB of DDR2-SDRAM and 800MHz FSB. Whilst shock and vibration protection for the internal 3.5 HDD and the flexibility of two full-size, 32-bit PCI slots make the low-maintenance KISS-1U server ideal for robust applications.

www.kontron.com

ETX-PM3 Defines a New Generation of Intel Pentium M and Celeron M based COMs

Kontron introduced the ETX-PM3, the new generation of Intel Pentium M and Celeron M processor-based computer-on-modules. The Kontron ETX-PM3 joins the Kontron ETX-LX, ETX-CN8 and ETX-CD to become the fourth member of Kontron's ETX 3.0 generation of computer-on-modules. The Kontron ETX family now offers true scalability with a full range of performance from Geode processing capabilities up to Intel Core 2 Duo processors.

The Kontron ETX-PM3 combines fast SerialATA hard drive access and extended sleep state modes with the Intel Pentium M and Celeron M processors to round off the highly scalable 3.0 generation of ETX computer-on-modules. Performance for the new Kontron computer-on-module is provided by the low power Intel Celeron M processors from 600MHz to 1.0GHz and Pentium M processors from 1.4GHz to 1.8GHz.

Mobile applications in particular will benefit from the Kontron ETX-PM3 module's new power saving feature: The 'suspend to RAM' functions ensure that power is supplied only to the RAM when all other system components are idle. This not only increases battery life, but also provides more convenient operation, enabling field personnel to awaken sleeping applications at the click of a button.

www.kontron.com

Micro Client M@C 70: Extremely Small Panel PC

Kontron announced the latest and smallest member of its slimline Micro Client family of panel PCs. With a touch-screen display of only 7 inches, the space-saving and versatile Kontron M@C 70 offers scalable Intel Celeron performance and a host of interfaces in an easy-to-mount and flexible design.

The new Micro Client M@C 70 is an extremely compact and slim-line (installation depth < 50mm) panel PC that is less expensive than a full-fledged IPC but still offers sophisticated graphics, intuitive GUIs and touch-screen operation on a 800x480 TFT display. Designed with flexibility in mind, this panel PC provides scalable performance up to the Celeron M 600MHz processor for use as either a thin-client, web client, user terminal or controller. The Kontron M@C 70 is a flexible solution with 2 x 10/100 Ethernet, 2 x USB 2.0, 1 x RS232 with optional RS422/RS485, as well as optional CAN bus. Power supplies ranging from 11.4V to 28.8V ensures safe and direct connection to industrial power systems, making the M@C 70 ideal for a wide range of applications in machine and system manufacturing, vehicle engineering, building management systems, medical technology and transportation to name just a few.

www.kontron.com

Kontron OM6040: Open Modular MicroTCA Platform

Kontron has introduced the Kontron OM6040, a compact and modular MicroTCA platform that is ideally configured for the design of small, compact and highly integrated multiprocessor systems based on either PCI Express (PCIe) and Gigabit Ethernet (GbE) packet switching backplane technologies.

Small, packet-switched backplane systems are the first choice for telecommunication applications in markets such as 3GSM, triple play, military, police, government and avionics. As well as telecommunications, image and video processing applications in the medical, industrial quality management and simulation sectors profit form the extremely fast serial communication protocols.

For entry-level systems and lab validation, the Kontron OM6040 open modular MicroTCA platform provides the most cost-effective and pre-validated solution that is perfectly equipped with either the Kontron AM4010 AdvancedMC processor module or with the optional Kontron AM4100. The Kontron AM4010 AdvancedMC processor module is available in an array of LV and ULV Intel Core Duo and Intel Core 2 Duo processor options that represent substantial processing power and maximum MIPS per Watt for both AdvancedTCA and MicroTCA redundant system designs.

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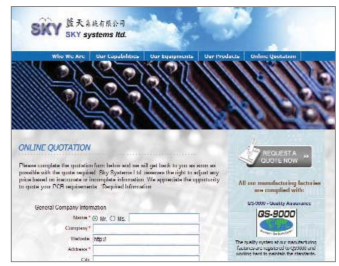

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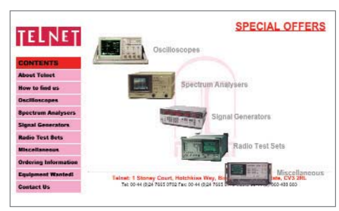

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TTI named Kemet 'Charged' Distributor of 2007

TTI has been awarded the Kemet 'Charged' European Distributor of the year award for financial year 2007. This completes a 'Triple Crown' of Distributor awards in North America, Europe and Asia. This recognition has never before been achieved by a Kemet distributor.

Kemet places a great deal of value on its distributor business, and its annual awards are based on a number of key factors - sales growth, market share, new product development, ease of doing business, and field and corporate relationships

Andrew Kerr, European Director of Passive Supplier Marketing at TTI said: "Kemet offers one the world's most complete line of surface-mount and through-hole capacitor technologies across tantalum, ceramic, aluminum, film and paper dielectrics. We are delighted to have been named as Kemet's European Distributor of the Year for a second consecutive year, and believe it reflects the value that our two companies place on building excellent partner relationships."

Graeme Dorkings, Director Distribution Sales of EMEA added: "TTI continues to operate a business model which delivers strong performance on all key criteria and this award truly demonstrates that their model works."


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