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Tektronix Type 547 Oscilloscope

Versatility... Breakthrough

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our latest model in the unique MDO series

The Tektronix 500 series was an industry breakthrough in the 1940s. Since then, breakthroughs like the Mixed Domain Oscilloscope have been a part of our legacy. The MDO is the world's ONLY scope of its kind: it can display frequency and time domain data together, which greatly simplifies debug on devices with integrated RF.

For quality products and traditional values, trust Tektronix.

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Do you have the oldest, working Tek scope? Go to uk.tek.com/oldestscope and register your instrument's details. You could win the brand new MDO4000B!

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THE NBT, AND OTHER MID-WINTER TALES

We have just emerged from the Christmas/ New Year break (or the Holiday Season, depending on where you are reading this): the shops were full of electronic gadgetry with eager purchasers snapping them up as seasonal gifts. Some retail outlets are still in their winter sales or discounting period, moving even more product off the shelves. Report after report tells us that even if you did not visit many retail outlets, you probably had consumer goods delivered to your door, as the figures for on-line shopping continue growing year-on-year and quarter-on-quarter.

In the last few days (first days of 2014) we have had reports across all types of media from the Consumer Electronics Show in Las Vegas; the event has become enormously diverse, from the type of component- and architecture-level topics that interest the engineering readership, to the toys-and-gadgets that fascinate... well, all of us, if we are honest. As EE Times' Junko Yoshida neatly observes, the event, "which started out strictly as a tradeshow for dealers of audio/video and home entertainment systems, has become the annual make-or-break showcase for startups, software designers, and propeller-heads to test innovative product concepts, breakthrough technologies, and clever application ideas among fellow engineers, marketers, consumer electronics OEMs, and investors...". Those reports have painted a picture of frenetic activity amongst the consumer electronics (CE) community.

So, prospects must look good for the CE sector – right? Perhaps not; US-based analyst IHS has issued a forecast for 2014 headed, "Consumer Electronics market to contract in 2014...". Worldwide CE manufacturing revenue will fall to $250.0 billion in 2014, down 2% from $255.7 billion in 2013... This will mark the fourth consecutive year of decline for the CE market.

You didn't know the CE market has been in decline these past few years? Immediate cautionary note; in this analyst's figures, [the traditional] CE sector comprises a range of devices, including televisions, set-top boxes, digital still cameras, video game consoles and Blu-ray players. It specifically does not include smartphones, tablets and other wireless devices which are in a separate category. As are "conventional" PCs. In fact, IHS says that in 2013, overall revenue from the smartphone and tablet markets grew to be larger than that of the entire traditional CE market for the first time. That perspective may bring the view back into something like the focus you were expecting.

So what is going on? To quote, again, from the analysts' statement, CES is "a showcase for exciting new products like ultra-high-definition (UHD) televisions and wearable technology devices. However, these products won't ship in high-enough volume in 2014 to rescue the traditional consumer electronics (CE) device from a decline in revenue this year".

This makes intuitive sense. There is little doubt now that ultra-high-definition will happen; already, every department store and electronics retail outlet has one on display as you walk in, and they are very impressive – but programme material is scarce and likely to remain so for some time. As with much else in the CE sector, the incumbent technology is pretty good, and likely to be long-lived. The price differential from 1080p HD set to early-production UHD model is around an order of magnitude; consumers will look at UHD and many will say that it's good, but it's not ten times better than what they already have.

So it always is with CE technology evolutions – these products are only beginning the familiar long march towards the point where the average buyer judges the performance gain is worth the extra cash demanded. IHS predicts just a 16% share of TV shipments for UHD by 2018, which might be optimistic or pessimistic. If the latter, then there will be big upswing in format-conversion designs as consumers demand that their UHD content be viewed on displays where they will not conceivably be able to see the difference.

Similarly with wearables, which fringes into the much-hyped area of the Internet of Things. Reports from CES identify countless products in entertainment, infotainment, navigation, augmented reality, medical monitoring and more, with everything becoming "smart" (and, naturally, "connected"); glasses, watches, shirts, and all manner of other garments.

What appears to be happening is that development is sitting on some sort of plateau. Designers have a palette of functional blocks that they can blend; assemble your very own combination of ultra-low-power computing/head-up display/GPS/ MEMS-accelerometer-based inertial navigation/3G/4G/Bluetooth/WiFi – the list, of course, goes on, and don't forget the software content – and you might just hit on the precise feature set that becomes the Next Big Thing (NBT?). For all that, there isn't much sense that the NBT is around just yet, but it is in the nature of such products that they appear as if from nowhere. Meanwhile, the industry's alchemists will continue throwing their chosen function sets into the pot and hoping to turn out CE gold.

And always, there is the presence of what we might call the Apple paradigm – the idea that you might already have access to all the basic technologies to be the father, or mother, of the NBT: you only need to wrap it up in just the right way. To the list of CE ingredients you can add an intangible; you need a generous helping of "cool". Sorry, but I don't know which distributor stocks that line.

pulse

9-axis movement/position sensor performance upgraded

ST has updated its 9-axis MEMS inertial motion-sensing module: improvements claimed include 20% power saving and 30% higher resolution in a package one-third smaller than its predecessor; ST is specifically targeting the needs of system designers in areas such as wearable devices.

In a 3.5mm x 3mm outline the LSM9DS1 module supports the "context awareness" - position and motion detection – needed for features such as gesture controls, indoor navigation, and augmented reality. Its small size and battery efficiency, with low-noise sensor technology, will allow designers to improve usability and comfort of wearable devices by reducing bulk and extending battery life between charges. Greater positional resolution enhances the stability and precision of applications such as smart-TV remotes, game controllers, and wearable sports or medical sensors.

The LSM9DS1 contains a 3-axis accelerometer, 3-axis gyroscope and 3-axis magnetometer, all fabricated using ST's MEMS process technology. These sensors detect linear acceleration, angular rate and magnetic field to provide complete position- and movement-sensing data. They are well integrated and synchronised to provide true 9-degree-of-freedom sensing rather than separate, uncoordinated data inputs. However, each sensor can be powered-down individually with automatic wake-up, allowing additional power management.

Compatibility with ST's LSM6 family of 6-axis IMUs (Inertial Measurement Units) simplifies upgrading or scaling of existing designs to add magnetic-field detection for functions such as e-compass and orientation sensing. Product developers can also upgrade current designs that combine a 6-axis LSM6 device with a discrete magnetometer to achieve a space-saving, simplified and reliable integrated solution based on the LSM9DS1.

Compared to earlier 9-axis sensor modules in the 4 x 4 mm LGA package, the LSM9DS1's footprint of 3.5 x 3 mm saves over 5 mm2 of PCB space. ST anticipates that this reduction in area, combined with the low package height of only 1 mm, will be valuable to designers seeking to add extra functionality in smartphones or create innovative new products in comfortable, wearable form factors, including glasses.

The device has 30% higher magnetometer resolution, achieved with low-noise process technology. ST's technology also delivers a significant reduction in accelerometer zero-g offset, to below 100 milli-g, and reduces typical gyroscope rate noise to 0.008 dps /√Hz at low full-scale. These improvements enable any mobile device such as a smartphone, tablet, controller or various wearables including smart glasses to support accurate motion tracking, efficient and reliable contextual awareness, and precise orientation and heading. The MEMS process technology also contributes to power savings in combination with smart power-management modes which, together, reduce typical operating current to 2 mA.

Engineering samples of the LSM9DS1 are available now, in the 3.5 x 3mm LGA leadless package, and unit pricing is $2.70 (1,000).

A further application of ST's MEMS technology is the L2G2IS, a tiny 2-axis gyroscope. Optical image stabilisation has become standard in digital photography; ST intends this device to extend that feature to a wider range of smartphones as well as digital still cameras. At 2.3 x 2.3 x 0.7 mm, the L2G2IS can be integrated into the next generation of stabilised camera modules, being 50% smaller than the previous generation by area and 60% smaller by volumevolume, while still providing the high performance demanded by the applications and consumers.

Key features of the new device include ±100 dps / ±200dps full-scale range, 3- and 4-wire SPI interface, and integrated low- and high-pass filters with selectable bandwidth. The L2G2IS operates with a supply voltage range of 1.7V to 3.6V. Pricing is $1.70 (1000).

STMicroelectronics
www.st.com

Power analyser offers 0.05% accuracy, 20-A current capability

Tektronix has added to its range of power analysers with the introduction of the PA1000 single-phase instrument. Previously, the company introduced the PA4000, which in turn marked a heightened interest from Tek in the power analysis field, following its acquisition of power-analysis intellectual property from Voltech, in early 2013.

Serving what Tek refers to as a "megatrend" focus on energy-efficiency, the PA1000 is organised for rapid measurement setup and for simple data transfer and reporting; it is certified to carry out testing to the IEC62301 standby-power standard. You can use it in any single-phase power measurement scenario; it will measure power, energy (Watt-hours), efficiency (or losses), power factor (PF), distortion (THD), and harmonics which it can present as a histogram on its graphical display. The same screen can also show a waveform display, which Tek says is a unique feature in this class of instrument.

The 1000 has two current ranges using internal shunts; as for the 4000 model, Tektronix highlights its use of the Spiral Shunt as a source of accuracy and stability. These shunts are formed of Manganin, an alloy that offers minimal change of resistance with temperature, and the "spiral" part refers to the way the shunt is wound to cancel self-inductance effects. The 1-A shunt is particularly useful, Tek says, for maintaining measurement resolution and accuracy on demanding low-current signals common to standby power testing. Maximum internal current range is 20Arms, and measured voltage is up to 600 Vrms; The

PA1000 claims the best overall performance in its class, with 0.05% basic accuracy and 1 MHz measurement bandwidth/ 1 Msample/sec sampling rate.

The colour graphics display accompanies one-button access to measurement results, power waveforms, harmonic bar graphs, and menus. Application-specific test modes for standby current, lamp ballast testing and energy integration help to simplify optimisation of instrument settings. PWRVIEW PC software further simplifies testing with one-click test automation for compliance-test applications.

There is a single model of the PA1000, with no additional options, and the associated software is a free download. Standard features include LAN, USB and GPIB interfaces, and harmonic analysis. The instrument carries a five-year warranty and costs €2470/£2080 (UK Pounds) from Tektronix distributors including Farnell and Mouser. More at www.tek.com/power-analyzer-series/pa1000

Based on recent field and metrology analysis, Tektronix has released improved accuracy specifications for the PA4000 power analyser and extended the standard warranty to five years from the previous three years. The new accuracy specifications apply to RMS voltage, RMS current and Power. For instance RMS voltage accuracy was rated at ± 0.04% and has now been improved to a rating of ± 0.01%.

Tektronix
For the full details visit the PA4000 product page;
www.tek.com/power-analyzer/pa4000

Keysight Technologies; the electronic measurement company formerly known as Agilent

In September 2013 Agilent announced its intention to divide into a Life-Sciences measurement company – that will retain the Agilent brand – and an electronic measurements company, un-named at that time. The name has now been revealed as Keysight Technologies; the formal spin-out of the new venture is scheduled for November 2014, when a stock split of existing Agilent shares will formally divide the two companies. Prior to that, from 1st August 2014, Keysight will operate for one quarter as a subsidiary of Agilent.

Through all this, according to UK Managing Director-designate of Keysight Chris Rennie, customers of the T&M business will see no change other than the transition of branding; all contracts will continue uninterrupted and (for example) the 3-year warranty that Agilent has recently introduced on its new prod-

ucts will continue.

The name, according to Agilent/Keysight, is intended to convey the, "Ability to Unlock Measurement Insights for Engineers.... to see what others cannot, offering the critical or key insights to understand and unlock the changing technology landscape". The new company will use the tagline, "unlocking measurement insights for 75 years," commemorating the 1939 birth of the original Hewlett-Packard Company, from which Keysight originated.

Keysight will concentrate solely on the electronic measurement industry, focusing on its test and measurement customers. The business, currently a part of Agilent, as a leading company in test and measurement, claims the No. 1 position in its industry segments of wireless data ecosystem; aerospace and de-

pulse

fence; and industrial, computers and semiconductors. The new company will include the entire portfolio of Agilent electronic measurement products and the largest sales and support team in the test and measurement industry.

Rennie notes that the Life Sciences portion of Agilent has both grown to the point where it warrants operating as a stand-alone enterprise; and has seen a divergence of requirements – in terms of investment needs and business model – from those of the T&M sector. A "pure-play" T&M company will be more able to allocate investment where it is needed for its own purposes, Rennie adds; the New York Stock market already classifies

Agilent as a Life-Sciences company.
Keysight will be headquartered in Santa Rosa, California, and will have approximately 9,500 employees in 30 countries.

The new website is www.keysight.com – most content is still available under; Agilent Technologies www.agilent.com

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights for 75 Years

Fast wireless charging enabled by 5-Watt chipset

Toshiba Electronics has uprated its TB6865FG power transmitter and TC7763WBG receiver chipset enabling faster wireless charging of mobile devices. The wireless power chipset now supports 5W power transfer and is compatible with the Qi Standard Low Power Specification version 1.1. Features include a rigorous Foreign Object Detection (FOD) function and an integrated digital logic controller that reduces component count and minimises design complexity.

Built in Toshiba's mixed-signal process with optimised MOSFETs the chipset achieves high-efficiency wireless charging performance. The TB6865FG inte-
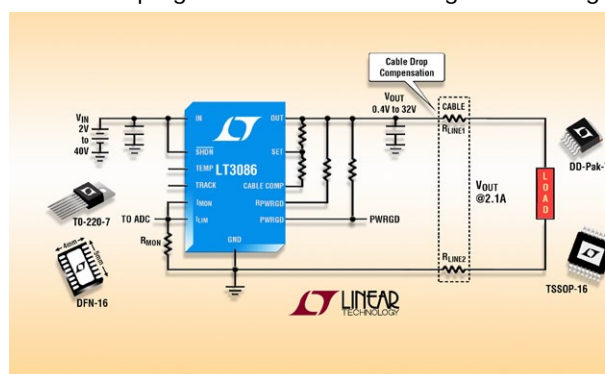
5W fast wireless charging

grates an MCU that can drive four external MOSFET H-bridges of four coils for a free positioning architecture supporting two mobile devices. The TC7763WBG receiver combines modulation and control circuitry with a rectifier power pickup, built-in low-dropout linear regulator (LDO) and circuit protection functions. The transmitter IC is housed in LQFP-100 14 x 14 mm package and the receiver IC is supplied in a WCSP-28 2.4 x 3.67 x 0.5 mm package. The recently announced TC7761WBG IC has been awarded Qi certification for an output power of 3.5 Watt.

Toshiba Electronics Europe
www.toshiba-components.com

LDO adds features for monitoring, protection & cable drop compensation

LT3086 is an addition to Linear Technology's LDO+ family, with features previously unavailable in linear regulators. The 40V, 2.1A low dropout linear regulator (LDO) includes current monitoring with externally settable current limit and temperature monitoring with external control of thermal limit temperature. The device includes a programmable power good status flag, cable drop compensation and features for paralleling. The current reference in the LT308x LDO family provides regulation, independent of output voltage.

The regulator has a 1.4V to 40V input voltage range. A single resistor programs output voltage from 0.4V to 32V and dropout voltage is 330 mV at 2.1A. Line and load regulation is to 0.1%, independent of output voltage. The trimmed, precision 50 μA current reference is ±1% accurate, providing ±2% output voltage tolerance over line, load and temperature. Output voltage regulation, bandwidth, transient response and noise (40 μVRMS) remain independent of output voltage due to the device's unity-gain voltage follower architecture.

Internal circuitry allows paralleling of multiple LT3086s for higher

load current and heat spreading without needing external ballast resistors. Programmable cable drop compensation cancels regulation errors caused by line drops to the load. Output current and temperature monitoring, in addition to a power-good flag with programmable threshold, provide system monitoring and diagnostic/debug capability. Internal fault circuitry includes thermal shutdown and current limit with foldback; thermal limit and current limit are externally programmable, and there is reverse battery and reverse current protection.

It comes in thermally enhanced surface mount packages, including a low profile (0.75 mm) 16-lead 4 x 5 mm DFN, a 16-lead thermally enhanced TSSOP and a 7-lead DD-Pak; all dissipate 2W in surface mount applications with no heat sink. The LT3086 is also available in a 7-lead TO-220 power package for vertical mounting to heat sinks for higher power dissipation capability. Pricing starts at $3.00 (1000).

Linear Technology
www.linear.com/product/LT3086

USB-TO-SPI Bridge chip joins 'smart interface' range

Silicon Labs has introduced a bridge controller that offers a turnkey solution for bridging a universal serial bus (USB) host and a serial peripheral interface (SPI) bus with driver support for Windows, OS X and Linux operating systems. The CP2130 USB-to-SPI bridge controller claims high data throughput, configurability and a high level of mixed-signal integration in a 4 x 4 mm package. It is suitable for new designs or upgrading legacy designs to include USB for a wide range of embedded applications including USB dongles, tablets, hand-held controllers and testers, blood glucose monitors, docking stations, point-of-sale products, data logging modules and card readers.

Silicon Labs says it developed the CP21xx bridge family to be a cost-effective solution to handle the proliferation of USB in the embedded world; you can add USB functionality to your applications without requiring USB software, firmware or hardware domain expertise typically required with more complex alternatives. The CP2130 bridge controller joins Silicon Labs' CP21xx Smart Interface portfolio, adding SPI to USB-to-UART, I²C/SMBus and I²S interface solutions.

The controller features on-chip functions and peripherals that eliminate the need for external components, including; a USB 2.0 full-speed controller and transceiver, an SPI controller that enables communication with a wide range of SPI slave devices

down to 1.8V, 348-byte programmable memory, crystal-less USB operation and an integrated 5V voltage regulator rated at 100 mA. Its configurable SPI controller can communicate with up to 11 SPI slave devices using any of its 11 GPIO pins as chip-selects or be configured for alternate functions that can be used to eliminate external circuitry and components. The CP2130 device is the fastest full-speed USB bridge controller available, Silabs says, providing up to 6.6 Mbps read through-put and 5.8 Mbps write throughput.

The CP2130 controller is priced at $1.23 (10,000). The CP2130EK USB-to-SPI evaluation kit, at $20, accompanies it.

Silicon Labs
www.silabs.com/USB-Bridge

Laptop chargers can be smaller with 100 MHz power-conversion switching

FINsix, a power conversion startup based in Boston and Silicon Valley, has developed laptop power adapters and LED drivers that claim to be 75% smaller than their conventional counterparts. FINsix's first product, which the company launched at the at the January 2014 Consumer Electronics Show in Las Vegas, replaces a conventional charger - the in-line module in the power lead - with a device a little bigger than an ordinary (US-style) plug. The 65-W power adapter - which delivers more power than many laptops use - can charge a further accessory of up to 10W at the same time as it is charging the main device. The product will be available by the middle of 2014.

The power adapter is the first commercial application of a novel circuit design developed by David Perreault, a professor of electrical engineering and computer science at MIT.

FINsix outlines a familiar story of increased efficiency in power conversion, citing higher switching frequency allowing the use of smaller inductors and capacitors, with reduced storage of energy on every cycle of the conversion. The key differentiator is that FINsix says it can use switching frequencies of up to 100 MHz.

Using improved semiconductor switches and circuit configurations in conventional topologies has reduced losses in the

switches, but (in established topologies) attempting to move beyond single-figure-MHz switching rates means that those factors become significant again, impacting efficiency.

FINsix says that its use of switching speeds as high as 100 MHz combined with "resonance and wave shaping with new power conversion architectures" enables a high conversion efficiency in a very small outline.
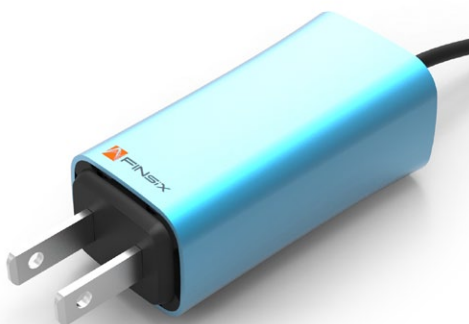
Details of the company's circuit techniques are not disclosed at present, beyond saying that it has "a way to recycle much of the energy that's normally lost inside a power adapter". It is not clear if the technology applies open-market or custom semiconductor power switches, but as the management team includes mixed-signal IC design specialists, it appears that FINsix is designing its own controller ASICs. FINsix's power adapter is an after-market charger that can work with a variety of laptops and other devices. The company is also working with a laptop manufacturer to produce a dedicated charger. The power adapter has the potential to be far cheaper than conventional ones, the company says, because it is smaller, it is simpler to manufacture, and it uses less material.

FINsix
finsix.com

BY JACOB BENINGO

10 TIPS FOR MAXIMISING BATTERY LIFE

Selecting a low-power microcontroller is an obvious first step, but you can follow a number of software and hardware tips to ensure that every milliampere-hour of battery charge is utilised.

Portable, battery-powered devices are sweeping through society like wildfire. Mobile computing and sensor devices are springing up everywhere, providing engineers with not only a plethora of data but also applications. Requirements often dictate constraints on size and weight that limit how much capacity the battery can carry. The number of features on devices in addition to the time between charges make it very challenging, to near-impossible, to meet the requirements.

Selecting a low-power microcontroller is an obvious first step, but there are a number of software and hardware tips that can be followed to ensure that every last milliampere-hour of charge is put to good use.

Tip #1: Create a battery budget
Early in the design cycle it is highly recommended that you put together a battery budget. Current requirements for each device on the board can be tallied to obtain a rough idea of how much battery current is going to be needed and whether the selected battery is up to the job. Device data sheets have become fairly good at providing minimum, typical, and maximum current data.
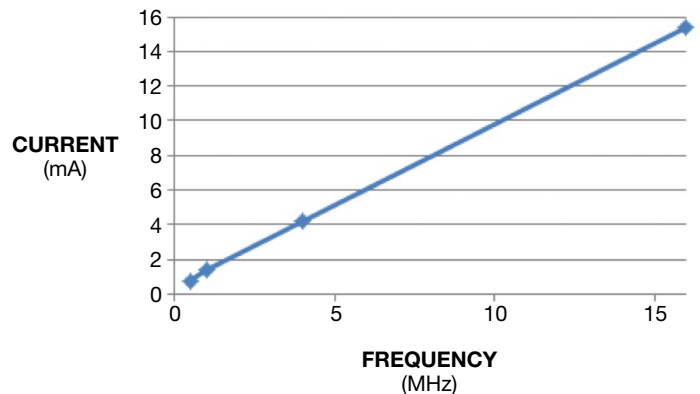
Taking a very conservative approach, a battery budget could be based solely on the maximum current values for the devices. An Excel worksheet is easy to duplicate, however, and creating a budget for both typical and maximum current data will produce a good ballpark range.

If more battery is needed than is available, please don't just move forward on the project. Make the necessary changes up front to spare weeks or months of heartache down the road. Figure 1 shows an example battery-budget template that can be downloaded from http://bit.ly/17XMtfe.

Tip #2: Set unused MCU I/O to lowest power state
It is easy to overlook what should be done with an input/output pin that is not being used. This oversight, however, can be the difference between having a marketable product and an expensive paperweight.

Each microcontroller has different recommendations on what to do with unused pins, and close examination of the data sheet will reveal what should be done. For example, an unnamed sili-

con-vendor data sheet recommends that any unused I/O be set as an output and driven low. The purpose of this approach is to minimise leakage and quiescent currents in an effort to minimise power usage. These currents are tiny, but each unused pin adds to this loss, and over the period of a day can be a substantial amount of battery life.

Tip #3: Turn off unused MCU peripherals
Just like in any home, if you aren't in a room, then the light should be turned off to conserve energy. It is the same thing with a microcontroller. If there is an unused peripheral such as an analogue-to-digital converter or a pulse-width modulator, turn it off to save power.

Peripherals can be quite a power hog. For fun, pick out a favourite microcontroller and scroll through the data sheet's power section to see how much current is being drawn by each peripheral. Some providers don't include this information, and it is up to the engineer to set up some hardware on the bench and then, using test software, turn peripherals on and off, one at a time, to get an understanding of the current draw. ADCs and USB peripherals tend to be near the top of the biggest current-users list.

Tip #4: Turn off unused MCU clocks
Now that all of the unused peripherals have been turned off, there is not much point in running a clock signal to them. Running clock signals to different peripherals within a microcontroller requires the use of energy. There are internal clock gates that need to be powered up in order to propagate the clock. These gates use voltage and a small amount of current. To help minimise the power profile of the MCU, turn off any unused clocks. It may be only a small amount, but once again, the laws of addition can be staggering!

Jacob Beningo continues his list of tips with numbers 5 to 10, in the complete article.

Battery Budget Worksheet (Typical)
Device - Example Device
BENINGO ENGINEERING

| Battery Capacity (mAh) | 1200 | | Calculated Values | |
| Desired Battery Life (hours) | 24 | | | |

Component	On (mA)	Idle (mA)	Standby (mA)	On Duty Cycle (% per hour)	Idle Duty Cycle (% per hour)	Standby Duty Cycle (% per hour)	mAh	Comments
Microcontroller	24	5.6	0.1	20	80	0	9.28	Wake-up every 10ms to handle maintenance tasks
EEPROM (Write)	7	0.001	0.001	5	0	95	0.35	Assume writing 100 data points per hour
Radio Receive	28	1	1	40	0	60	11.80	On once every minute for 100 ms.
Radio Transmit	33	1	1	40	0	60	13.80	Transmit data once per hour
Sensor	27	0	0	50	0	50	13.50	Always on. Current from datasheet ~100mW
Accelerometer	0.2	0.2	0.01	0	0	100	0.01	Always on
Add Next Device	0	0	0	0	0	100	0.00	Enter Comment

Results	
Average mA/h	48.74
Estimated Battery Life (hours)	24.62
Desired Life Remaining (hours)	0.62

Complete article, here

BY TREVOR BARCELO, LINEAR TECHNOLOGY

CHARGING BATTERIES WITHOUT WIRES IN A COMPACT & EFFICIENT MANNER

Batteries provide power to many different applications across a wide range of industries. In many of these applications, a charging connector is difficult or impossible to use. Wireless charging adds value, reliability and robustness in these and other applications.

Some products require sealed enclosures to protect sensitive electronics from harsh environments and to allow for convenient cleaning or sterilisation. Other products may simply be too small to include a connector, and in products where the battery-powered application includes movement or rotation, then charging with wires is even less feasible.
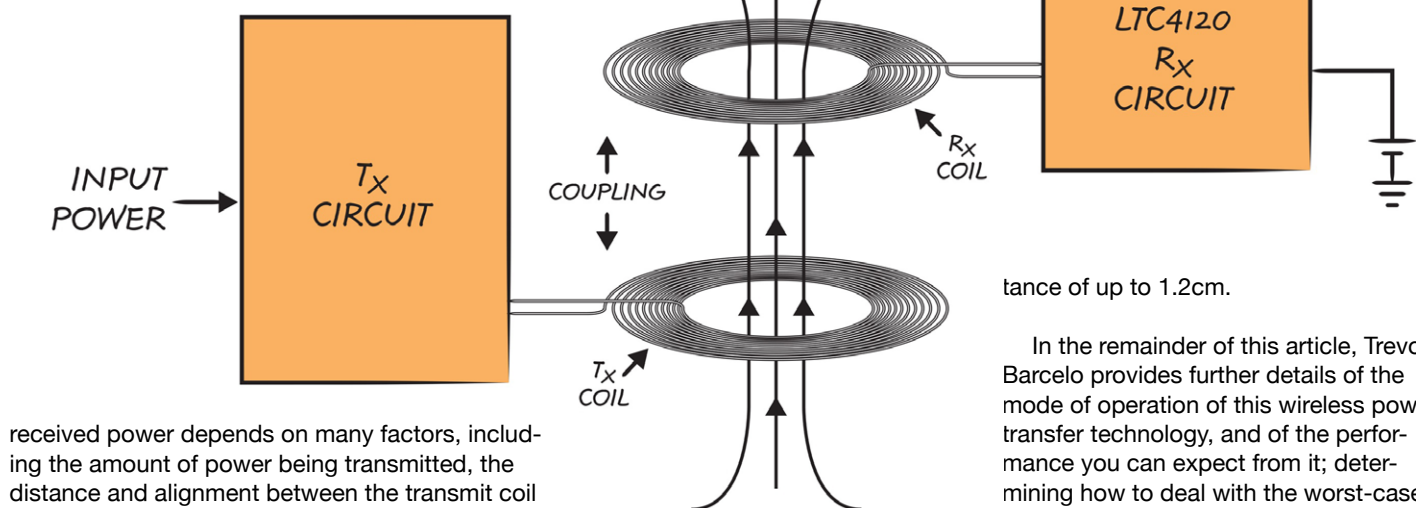
Wireless Power System Overview

As shown in Figure 1, a wireless power system is composed of two parts separated by a gap: transmit circuitry, including a transmit coil, and receive circuitry, including a receive coil. The transmit circuitry generates a high frequency alternating magnetic field around the transmit coil. This magnetic field is coupled to the receive coil and converted to electrical energy, which can be used to charge a battery or power other circuitry.

When designing a wireless power charging system, a key parameter is the amount of charging power that actually adds energy to the battery. This

received power depends on many factors, including the amount of power being transmitted, the distance and alignment between the transmit coil and the receive coil, also known as the coupling between the coils, and finally, the tolerance of the transmit and receive components.

The primary goal in any wireless power design is to guarantee delivery of the required power under worst-case power transfer conditions. However, it is equally important to avoid thermal and electrical overstress in the receiver during best-case conditions. This is especially important when output power requirements are low; for example, when the battery is fully charged or nearly fully charged. In such a scenario, available power from the wireless system is high, but demanded power is low. This excess power typically leads to high rectified voltages or a need to dissipate the excess power as heat.

There are several ways to deal with excess power capacity when the demanded receiver power is low. The rectified voltage can be clamped with a power Zener diode or transorb. However, this solution is typically physically large and generates considerable heat. Assuming no feedback from the receiver, the maximum transmitter power can be reduced, but this will either limit the available received power or it will reduce the transmit distance. It is also possible to communicate received power back to the transmitter and adjust real-time transmit power accordingly. This is the technique used by wireless power standards such as the Wireless Power Consortium Qi standard. However, it is also possible to solve this issue in a compact and efficient manner without resorting to complicated digital communication techniques.

To efficiently manage the power transfer from transmitter to receiver under all conditions, the LTC4120 wireless power receiver integrates technology patented by PowerbyProxi, a Linear Technology partner. PowerbyProxi's Dynamic Harmonization Control, or DHC, technique enables high efficiency contactless charging without thermal or electrical overstress concerns in the receiver. Using this technology, up to 2W can be transmitted over a distance of up to 1.2cm.

In the remainder of this article, Trevor Barcelo provides further details of the mode of operation of this wireless power transfer technology, and of the performance you can expect from it; determining how to deal with the worst-case condition of maximum load power with minimum coupling between the transmitter and receiver is often the easy part, he concludes: managing additional available power during low load or no load conditions with maximum coupling can be challenging.

Complete article, here ▶

SRUDEEP PATIL, MAXIM INTEGRATED

OP AMP DC ERROR CHARACTERISTICS AND THEIR EFFECT ON HIGH-PRECISION APPLICATIONS

This article discusses the DC limitations of operational amplifiers and their effects, including input bias currents, input offset voltage, CMRR, PSRR, and input impedance. The article will provide a reader with a better understanding of how these limitations can create accuracy issues in high-precision applications.

Operational amplifiers, or op amps, are two-port integrated circuits (ICs) that apply precise gain on the external input signal and provide an amplified output as: input × closed-loop gain. Precision op amps behave close to ideal when operated at low to moderate frequencies and moderate DC gains. However, even under these conditions, op-amp performance is influenced by other factors that can impact accuracy and limit performance. Most common among these limitations are input referred errors that predominate in high-DC gain applications.

In this article I will discuss the effects of input-referred errors on op amps. These errors include input bias current, input offset current, input offset voltage, CMRR, PSRR, and finite input impedance. In reality, all these errors will occur at the same time. I will also explain why a designer should be wary that the op-amp performance specifications described in the EC Table of a data sheet are only guaranteed for the conditions defined at the top of that table, unless otherwise noted as a specific characteristic. In reality, the effects of these DC errors change when the supply voltage, common-mode voltage range, and other conditions change.

Errors Caused by Input Bias and Input Offset Currents

We are all familiar with potential dangers around us, and we engineers tend to forget that there are also dangerous traps to avoid when designing. Let's see how this affects op amps (Figure 1A and 1B).

We start with two basic equations:

$$I_B = (I + I_{BN})/2 \quad \ldots\ldots \quad \text{(Eq. 1)}$$

$$I_{OS} = I_{BP} - I_{BN} \quad \ldots\ldots \quad \text{(Eq. 2)}$$

Where:

I_B is average input bias current flowing into input pins;

I_{BP} is input bias current flowing into the positive input;

I_{BN} is input bias current flowing into the negative input;

I_{OS} is the input offset current.

Input bias and input offset currents are two of the most critical characteristics in many precision amplifier applications; they affect the output with resistive and capacitive feedback. Many of the inverting, noninverting, summing, and differential amplifiers reduce to Figures 2A and 2B once their active inputs are set to zero. For this analysis, I will set all input signals as zero to assess the effect of input currents on the output accuracy, and will analyse resistive feedback (Figure 2A) and capacitive feedback (Figure 2B) circuits separately.

(Figures 2a and 2b appear in the full, online version of this article, click on the logo below.)

In the full version of this article, the author concludes his analysis of input effects, and continues to consider the other sources of DC errors and how they affect op-amp performance. Following the guidelines developed, designers can select both the correct op amp and the right passive components with the correct configurations for their applications.
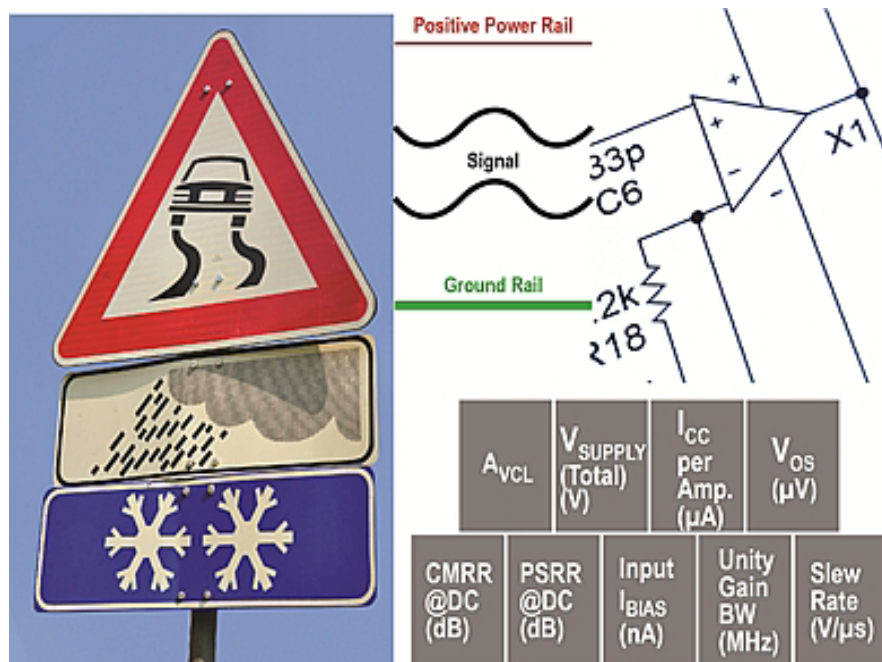

Figure 1A. A roadside danger sign, warning of an automotive skid hazard under certain conditions (rain and snow); Figure 1B on the right is an op-amp "alert sign," constructed from data sheet parameters and the specifications, warning that the signal must be contained between the power and ground rails.

Complete article, here ▶

JOHN CALDWELL, ANALOGUE APPLICATIONS ENGINEER, TEXAS INSTRUMENTS

UNDERSTANDING THE DISTORTION MECHANISM OF HIGH-K MLCCS – PART 2

Capacitor voltage coefficient

In a previous article [Ref 1] I demonstrated the additional distortion produced when using High-K ceramic capacitors in a system's signal path. The underlying mechanism causing this distortion is the voltage coefficient of capacitance (VCC) of the capacitor. The term VCC is used to describe the change in the value of a capacitor with respect to the magnitude of the applied voltage. Power supply designers are well aware of this behaviour as it can directly affect the output ripple or stability of their system, but VCC is often ignored in small-signal circuitry. In order to understand why the capacitance varies with applied voltage and how the VCC varies with other capacitor parameters, it is necessary to first look at a capacitor's basic structure.
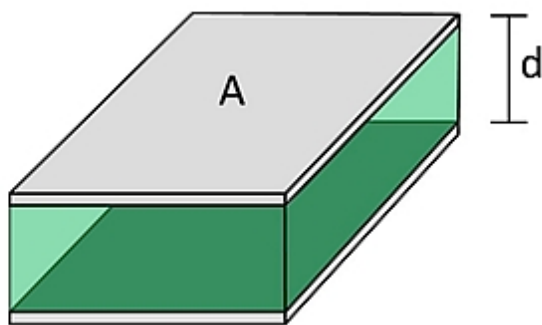

Figure 1. A basic parallel plate capacitor with electrode plates of area A and a separation distance d.

Figure 1 shows a simple capacitor consisting of two plate electrodes of area A, separated a distance d by a dielectric (green). The capacitance of this structure is given by equation 1:

$$C = \frac{\varepsilon_o \varepsilon_r A}{d}$$

where εo and εr are the permittivity of free space and relative permittivity of the dielectric, respectively. The magnitude of the electric field applied to the dielectric is a function of the applied voltage and the separation distance between the two plates.

$$\left|\vec{E}\right| = \frac{V}{d}$$

The voltage coefficient of many capacitors arises from the electrostatic force on the dielectric when a voltage is applied to the capacitor.

$$F = \frac{\varepsilon_o \varepsilon_r A V^2}{2d^2}$$

Because the dielectric material cannot be infinitely stiff, it is compressed by this force, reducing the separation distance d and increasing the capacitance [Ref 2]. Multilayer ceramic capacitors, on the other hand, exhibit an additional negative voltage coefficient that arises from other properties of the dielectric.

Ceramic capacitors owe their small size, high capacitance, and low cost to the use of barium titanate in the dielectric, which provides an extremely high relative permittivity [Ref 3]. Unfortunately, this material's relative permittivity varies depending upon the intensity of the applied electric field. Reference 4 presents an excellent example of this behavior in single barium titanate crystals, reproduced in Figure 2. As the applied electric field is increased, the relative permittivity of the barium titanate is reduced, showing a 55% reduction over the tested range. Therefore, increasing the voltage applied to a ceramic capacitor reduces the relative permittivity of the barium titanate in the dielectric material, causing a decrease in capacitance.
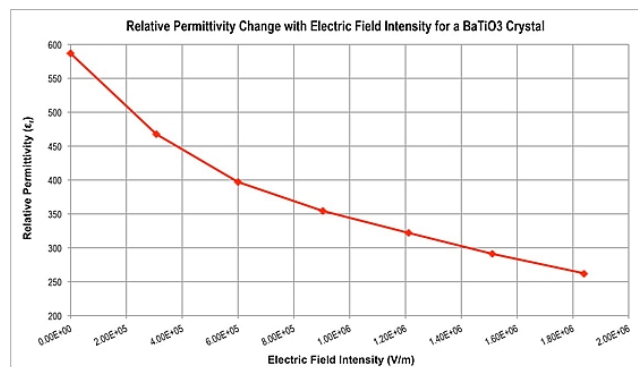

Figure 2. An example of the dependence of barium titanate's relative permittivity on the intensity of the applied electric field.

The electric field intensities in Figure 2 may seem unlikely to occur in small signal circuits. However, in the pursuit of higher volumetric efficiencies, capacitor manufacturers are able to produce ceramic capacitors with dielectric thicknesses below 5 microns, creating surprisingly high electric field intensities [Ref 5]. Using equation 2, we can see that applying 1V to a capacitor with a 5 µm dielectric thickness results in an electric field intensity of 200,000 V/m!

Understanding this property of barium titanate allows us to infer some rules for the voltage coefficient of ceramic capacitors. First, the voltage coefficient is worst (greatest change with applied voltage) in ceramic capacitors with the highest barium titanate content. Second, the voltage coefficient gets worse for smaller packages because the change in the relative permittivity is dependent upon the intensity of the applied electric field.

Complete article, here

JASON P LEE, EATON BUSSMANN

EXTENDING BATTERY LIFE IN TRANSPORTATION AND MOBILE APPLICATIONS WITH SUPERCAPACITORS

With battery life rising in prominence as one of the most critical areas of system performance and reliability, the introduction of supercapacitors is helping to extend life of batteries in two major application areas. First, they can dramatically reduce battery replacement costs in vehicles such as trucks, cars, ships and motor generators. Second, they can extend the run time as much as 400% in mobile devices such as smartphones and tablets.

Supercapacitors, or supercaps, with their unlimited recharging capability and high energy density, provide automotive, heavy transportation, marine and traction applications with guaranteed engine starting over broad temperature range even when a battery fails.

In mobile electronic systems, supercaps provide the ability to regulate peak current over several different application usage scenarios. With better regulation of the discharge, the batteries are able to hold their peak capacity of energy longer and extend the run time of devices.

Examining the market needs of both application areas demonstrates the benefits of adding super capacitors but in critically different ways.

Engine Starting

The most critical factor in the transportation sector is engine starting reliability. Every time a lead-acid battery is used to start an engine, it is one step closer to end-of-life. Using a bank of supercapacitors for ignition system relieves the battery from the harsh discharging of engine starts that typically diminish life span. A typical lead-acid battery can have its useful life extend by as much as 70% in certain applications through the use of supercaps. Additionally, starting an engine with a supercap enables greater reliability in colder temperatures.

In the case of the trucking industry, there are several factors where super capacitor usage could help improve daily operations. Typically, 18-wheel tractor trailer rigs and passenger buses carry three to four batteries. When one battery fails, and the vehicle requires a jump start, it can be relatively expensive at a cost of $600 per incident.

Additionally, battery replacement costs are about $200 each and because of this, market research shows that battery theft in both trucks and buses is a problem area. Furthermore, starting reliability for lead-acid cells drops precipitously in temperatures below -23°C. Supercaps, on the other hand can extend that range to -40°C, further improving engine start reliability where cold weather conditions prevail.

In the case of motor generators that are generally used at construction sites where grid power is unavailable, 60-to-80% of engine failure is due to bad batteries, according to market research conducted by Cooper Bussmann. Battery theft is also a significant issue, research shows.

Locomotives must operate reliably and operate in all conditions to meet very demanding train schedules. Cold weather is one of the most prevalent operation conditions and super capacitors can enable engine starting at -40°C, whereas lead-acid batteries aren't reliable below -23°C.

Engine starting for boats is critical because they operate in conditions where jump starts aren't readily available, and where environmental conditions such as storms or strong tides demand reliability. Additionally, other electrical systems on the boat for electronic equipment (fish finders and navigation) place a considerable load on lead-acid batteries when the engines aren't running.

In cars, emission regulations will drive makers to install stop-start systems. It is forecast that 40 to 70% of new vehicles by 2017 will have stop-start. Requiring a car's engine to automatically turn off after an idle period will require numerous more restarts that will strain lead-acid batteries and shorten their lifetime. Today, most vehicle manufacturers install a second battery to ensure reliability of stop-start systems.

Supercap Installation Methods

Super capacitors can provide benefits in all the situations above and they can be installed in one of three ways:

    Direct Parallel
    Supercap Starter
    Smart Start

The Direct Parallel approach installs a bank of super capacitors in between the battery and the engine's electrical system. It offers the simplest and least expensive way to have supercapacitors operate with existing batteries. A schematic diagram for this approach is presented in in the online, full version of this article; click the logo below.

With the Direct Parallel approach above, the supercap extends battery life and it shares the high current loads of the system. But it offers no protection from "house" load drain, so a vehicle with the lights turned on after the engine is turned off may still fail to restart.

Read the complete article for a continuing discussion of alternative configurations of supercap deployment, and the benefits for battery performance that can follow.

Complete article, here ▶

JAMES LEWIS, CEO REDUX LABS

TV SOUND: DELIVERING AUDIO QUALITY WHEN THE BEZEL HAS VANISHED

When it comes to a TV is it all about the look or the sound? If we're going to shrink the bezel, as current design trends dictate, we need to apply engineering to more than just structural integrity.

A TV's aesthetics are clearly vital; the success of Apple demonstrates that market dominance comes as much (if not more) from Sir Jonathan Ive's stunning designs as it has from any technological advantages of the company's products.

As such, the TV bezel has begun shrinking, with companies such as Samsung and LG bringing out large format TVs with very little bezel. LG's rather beautiful LM8600 LCD TV, for example, (Figure 1) has just a 1-mm bezel.

But the story doesn't end here as a small bezel means very little space for speakers. And this leads to a range of compromises: either tiny speakers, or speakers embedded into the rear of the TV, or an additional sound-bar, which sits in front of the TV – ruining the aesthetics that the purchaser has paid a premium for. None of these alternatives is good news for consumers.

Fig 1: LG's stunning LM8600 – CNET described its bezel as "impossibly thin".

The importance of audio

Audio is, aurguably, the most vital part of the viewing experience. Indeed, film production courses regularly state that audio quality is more important than image quality and, as the Production 101 film course states: "studies show that while people will tolerate the worst quality video images, they will not watch programs that have poor quality audio." You have only to watch YouTube to know this is true.

Despite this, the importance of audio quality isn't always recognised by the electronics industry. A good example of this comes from TV teardowns that examine the LCD / LED displays, the connectivity, the 3D system, the software… but not the speakers – see iSuppli's 2011 teardown of the LG 50PZ950 for a good example.

Small speakers

As anyone who has been seated in a public area near (almost invariably) a group of teenagers playing songs from their phones will know, small speakers deliver an appalling audio quality.

And, while television speakers will never shrink to the level of phone speakers, the audio quality is poor enough for even the national newspaper journalists on both sides of the Atlantic to complain. For example, here in the UK the Daily Telegraph's technology writer Matt Warman wrote:

"Televisions have never looked better – and they've never sounded worse…

"And as TVs are now marketed on their ultra-slim designs, with their miniature profiles as much a part of their supposed appeals as the quality of the picture, the problem has been exacerbated."

Indeed, there have even been marketing campaigns from independent bodies, see Clarity's It's Time To Upgrade videos, that demonstrate the problems that are being created.

Rear-firing speakers

An alternative that's been trialled by a few companies is to use larger speakers and mount them in the rear casing of the TV, directing the sound to the rear of the cabinet and assuming that reflections from walls will convey the audio to the viewer. While this does provide more powerful audio, and audio can be configured to take reflections into account, this would need to be tailored to the room… and doesn't solve the problem of poor audio quality.

Soundbars and audio systems

Clarity's marketing campaign video (shown above) highlights the problem but insists that the solution is to set up a separate audio system using soundbars or stereo equipment. I disagree: this will produce better audio quality, even exceptional quality if used with a correctly configured Dolby 7.1 surround sound system. But, this is not what's wanted by the average user.

In the continuation of this article, the author presents his alternative solution to the TV audio conundrum, in which the front glass of the LCD panel becomes a high-quality sound-radiator.

Complete article, here ▶
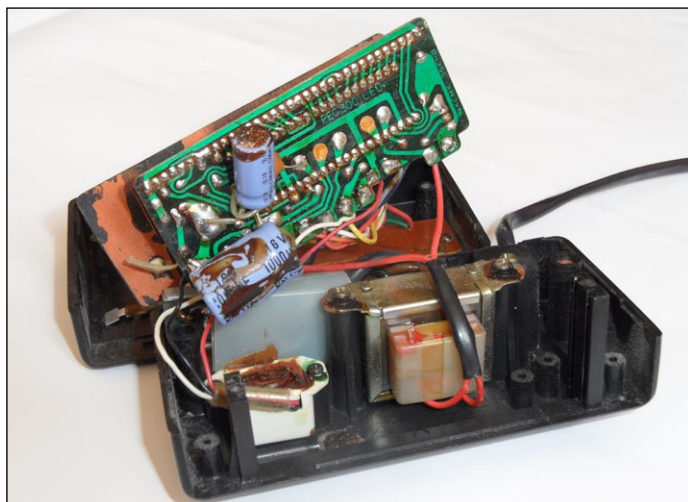
A minor repair reveals
a footnote to history

This little alarm clock very nearly qualifies as a family heirloom; it has performed uncomplainingly for around 35 years, and I would not have thought to dismantle it if it had not developed a slight fault. And in the course of attending to that fault I noticed something about it that had escaped me for all the time I have known it.

The clock is branded "Metamec" - prior to venturing into the digital domain, this company sold mains-powered analogue clocks using synchronous motors. The digital clock is as simple as you could expect it to be; 12 hour display with am/pm indication on red 7-segment LEDs, single alarm set-point, and deriving its timebase from counting 50-Hz mains cycles. An interruption to mains power, and therefore timing, is indicated by a flashing display. A particularly sophisticated feature – for the time it was manufactured – is the inclusion of a touch-panel to activate the "snooze" function.

Just lately, it would enter flashing-display mode without any mains outage having taken place and, given its long service, it seemed worthwhile fixing it. I wasn't in any doubt as to what I was going to find when I undid the retaining screws. I expected to see a pretty rudimentary linear power supply with electrolytic capacitor(s) totally dried out after all these years. My assumption was that the ripple on the DC rail had reached the point that the chip was reading the dips as a momentary power outage, and changing mode accordingly.

And that is exactly what I found, as you can see in picture 2; replacing the electrolytics restored normal operation, and that's the end of the repair story. It was such an open-and-shut case I didn't even bother to put a scope on it to see how bad the DC really was.

Having taken it apart, I was of course curious to find out what components had been used: it turns out to be completely stan-

dard. There is a single 40-pin dip, which is a National Semiconductor MM5387AA. Despite being long obsolete, the data sheet is still out there, archived on the web in multiple places. I had thought that by 1978 it might be NMOS, but the data sheet says it's PMOS, perhaps because the direct drivers for the LEDs were a bit easier to do in PMOS. The sheet doesn't say what process node it is built in, but purely by the date it's going to be around 5 microns – as it's PMOS, maybe still in something like 10 microns. For those who have only known the terminology of the last decade or two – yes, that's ten whole microns, 1/100th of a millimetre; if you could peer really closely at a bare die you could almost see the transistors. The data sheet also confirms that any excursion of VDD to within a small margin of the minimum value needed to retain timing data sets a latch into flashing-display mode.

The LED module – four digits in one moulding – has a part number, TLR2047, that similarly calls up a long-forgotten Toshiba data sheet, and as it has the plain upper-case "T" logo that the company used over many years, its identity is not in doubt. One reasonable conclusion to take away is that if you want longevity, using quality branded components is a good place to start.

Describing the power-supply arrangements as "rudimentary" is almost too generous; a single transformer winding (the white block with the remains of the electrolytics on it is the alarm buzzer) feeds a single diode with 220 µF hanging off it (electrically, and literally), to supply the LEDs; a second diode tapped off that line, followed by 1000 µF, feeds the IC.

The construction is entirely as you would expect and apart from the fact that there is nothing surface-mount, little has changed over three decades. The 40-pin DIP and the 4-digit, 7-segment display module is about all there is, apart from power supply and a handful of passives to handle switch inputs; there's a photocell to dim the display in low ambient light, and a single

transistor plus one resistor and a ceramic capacitor is enough to pull the "snooze" pin of the module low in response to a finger touch. The two main components sit on two single-side phenolic PCBs joined by a wire preform; assembly was clearly manual and the soldering probably is also. The tired electrolytics are tacked on to the boards and hang free, definitely a structure for the bedside table and not high-g tolerant. Build quality isn't great, but has clearly been good enough for the purpose.

So what was the unexpected and previously un-noticed discovery that prompted me to write this account? On a label on the underside of the case are the words, "Made for Metamec by Samsung, Korea". In 1978, few people in the west had ever heard of Samsung; probably not many people in the UK could even have placed a pin in the map and correctly located Korea. The only Asian manufacturing identities that most British purchasers would have recognised would have been "Made in Japan" or "Made in Hong Kong"; in China, it was only two years since the death of Mao Zedong: the Cultural Revolution was barely over and the idea that China would become the default low-cost manufacturer for the Western world would would have seemed absurd.

Samsung was long established as a leading *chaebol* (diversified industrial conglomerate) in Korea but in the late 1970s Samsung Electronics was a comparatively recent offshoot and even the company's entry into semiconductors and the DRAM market still lay some years in the future.

Here, therefore, we find the enterprise that would become one of the world's premier consumer-technology brands, developing a new business with what must have been small-volume contract assembly work. This was also largely before the days of freight containerisation: shipping costs were, relatively, far greater than we have today so it seems a reasonable guess that Samsung was prepared to operate on thin margins to penetrate this new sector.
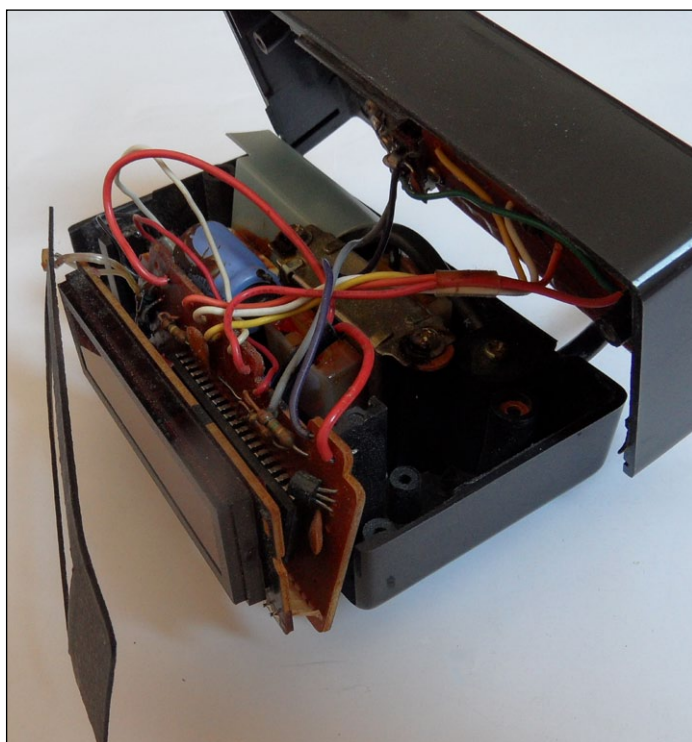
BY BONNIE BAKER

Phantom voltage dividers on your PCB

With a precision design, it is critical to have good circuit design and high-performance components. A precision system demands attention to detail, but the best system performance requires a good foundation at the PCB level. As you finish your circuit design concept, the next task is to evaluate phantom PCB resistances, inductors, and capacitors

The PCB doesn't show up on a schematic, however, it has very complex characteristics. In particular, the traces have resistance, inductance, and capacitance. Phantom voltage losses and dividers can be created with the PCB trace resistance.

The definition of precision depends on your signal range. Given a 16-bit system, a ±10V signal range gives a least significant bit (LSB) of 305 µV. A 5V signal only has a 76.2 µV LSB size. If a 24-bit resolution is needed, the LSB becomes 298 nV on the same 5V range. When adding gain to a system, the system LSB size can sink into the noise. For instance, consider a system with a sensor output of ±20 mV. If the system has a 16-bit converter with an analogue gain of 256 V/V or a 24-bit converter with a 20 mV reference, the required noise level must be less than 2 nV.

With requirements to keep errors down in the nanovolt range, there are many enemies to your desired precision. We'll start to investigate these different enemies in terms of the hidden PCB resistances, inductances, and capacitance. Today let's look at PCB resistances. Understanding how these phantoms come about and how to minimise them is key to helping you optimise your PCB layout signal chain.

All conductors (except superconductors) have finite DC resistance. Depending on the conductor type and its orientation (Figure 1), this resistance can be calculated by using the following equations.

- PCB trace: For 1 oz copper:
  $\rho = 1.724 * 10^{-6}$ Ω-cm
       for Y = 0.0038 cm
  R = sheet resistance for 1 square
       if Z equals X, R = 0.45 mΩ/square

  R = 0.45 Z/X mΩ
       Z/X = number of squares

- Wire
  R = 0.3219L / d^2
       L in metres
       d in mm

Even though these resistances are small versus actual circuit resistors, this parasitic resistance can cause undesirable effects. These effects can be divided into two categories: current times resistance (IR) losses, and voltage division losses.

When a trace is in series with a resistive component, an IR loss can occur. IR losses cause the voltage that should be present at any or all circuit nodes to be different due to current flow through a resistive conductor. This type of loss also can cause efficiency or power dissipation to be less than ideal.

Voltage division losses occur when the voltage output source is connected to a resistive trace, and this trace is connected to a low-input impedance (1Ω to 10 kΩ). At this point, the signal seen is not exactly what is expected. This is because the voltage output source is divided down by the ratio of the input impedance over the total impedance of the trace, plus the input impedance.

Even in a 12-bit design PCB layout is critical. As resolution increases, it should be obvious that layout errors will continue to affect your design.

In Figure 2, a one-inch run of 0.007-in.-wide (~0.2 mm) trace of 1/2 oz copper creates 0.13 Ω impedance. With 10 µA of current through this trace, voltage drop becomes 1.3 µV. This voltage drop is equivalent to four LSBs in a 24-bit system.

There are a lot of layout factors that impact a precision design and we have become aware of just one: trace DC resistance. Other PCB elements that can impact system accuracy are parasitic capacitances and inductances. Look for these topics in the coming months; Like the resistances dealt with here, they can affect the accuracy of your 16- to 24-bit design.
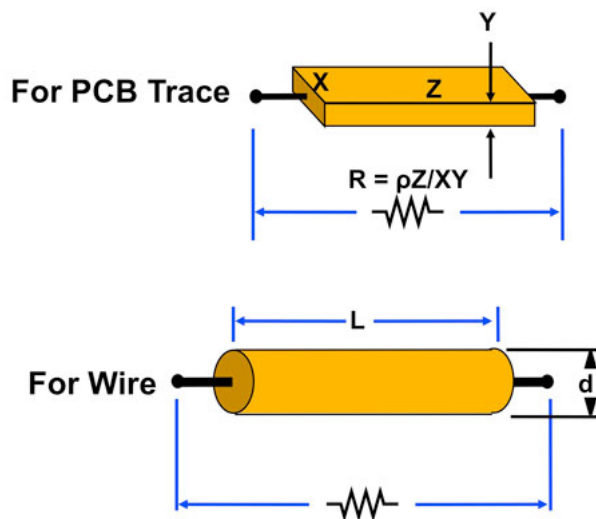

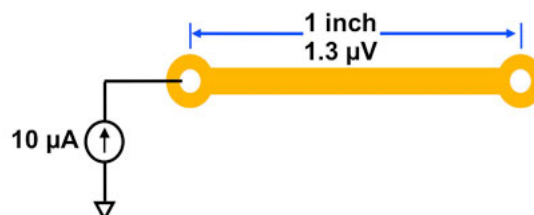
Figure 1. *All materials have a finite resistance.*

Figure 2 *A one-inch (7 mil) trace of 1/2 oz copper creates 0.13 Ω impedance.*

designideas

HV flyback converter improves efficiency

by Anil Maini, Varsha Agrawal, and Nakul Maini

This Design Idea significantly improves conversion efficiency of externally driven flyback converter-based capacitor charging units intended for flash-lamp-pumped, pulsed solid-state laser sources. In a flash-pumped pulsed solid state laser source, an energy storage capacitor is charged to a high voltage, dependant upon the amount of energy it is intended to deliver to the flash lamp when made to discharge.

Flyback converter topology suits capacitor charging power supply design well. Conventional flyback converter circuits employing voltage feedback for achieving the desired output voltage, and pulse width modulation for voltage regulation, cannot be used in the case of capacitive load for the following reason:

In a flyback converter, energy is stored during the on-time of the switching device, and transferred during the off-time. A large number of storage and transfer cycles are needed to charge the energy storage capacitor to the desired value. For a given amount of stored energy, the transfer of energy in every single transfer charges the capacitor by a certain voltage step, the size of which keeps reducing as the voltage across the capacitor builds up. As a result, the desired off-time changes from an initial maximum to a minimum value in the last storage and transfer cycle that takes the load to its final voltage. Any attempt to design the converter using a fixed switching frequency results in poorer efficiency. In the case of higher switching frequency, energy transfer would be incomplete in the earlier charging phase. This may lead to damage of circuit components connected on the primary side. There is also a chance of core saturation due to residual flux. In the case of lower switching frequency, the converter would be sitting idle for most of the time during the latter part of charging.

We have adopted a design approach based on a closed loop feedback system which ensures that energy transfer is complete in all individual cycles of the input waveform. In fact, the system is such that the status of the energy storage capacitor voltage is monitored at all times. Each cycle time period is reduced, keeping on-time fixed. That is, the off-time is reduced as per the requirement of the energy transfer process. So we have the ideal situation that ensures fastest possible charging time as well as optimum transformer design.

The circuit shown here is that of a flyback converter-based capacitor charging unit for a Q-switched Nd-YAG laser operating at 20 Hz. The design charges an energy storage capacitor (ESC) of 30 µF with the desired energy of 15 Joules in less than 50 msec so as to ensure operation at 20 Hz.

The circuit operates in an externally driven flyback configuration. Energy is stored during the on-time of the switching MOSFET and transferred to the energy storage capacitor during the time when it is switched to off-state. Each time the energy is transferred to the secondary circuit, the output capacitor charges by a certain voltage step. The magnitude of this step decreases with the buildup of voltage across the capacitor. The reduction of off-time of the switching device follows the same pattern as the buildup of voltage across the capacitor. The voltage across the energy storage capacitor is sensed and a control voltage VS is generated. This voltage is fed to a subtractor U2 that subtracts a negative reference voltage VREF 1 from the control voltage. The output of subtractor is VR = VS - VREF 1, which is fed to voltage-to-frequency converter (VFC) U1; hence the operating frequency is changed linearly with the voltage across the capacitor.

Initially, when the ESC is uncharged, the output voltage is zero and VS = VS(min) = 0V. At the output of U2, we have small positive voltage (VR(min) or -VREF1). This voltage determines the initial period at the VFC output. This output goes to monostable multivibrator U5 to achieve a fixed on-time. As the ESC voltage builds, the control voltage to the VFC converter increases, which reduces the off-time. A voltage sense loop compares VC – a fraction of the output voltage – with reference voltage VREF2 to generate the reset pulse for the monostable circuit and consequently achieve the desired output voltage.

The unit also has a feature of quenching the converter that prevents "afterglow" of the flash lamp. For quenching of the flash lamp, the charging of the ESC must be disabled for a few milliseconds at the instant of the flash lamp firing command. This is achieved by holding off U5 during this period. The holdoff is generated by triggering a second monostable, U7, by the firing command pulse. The EOC output indicates that the charging process has been completed.

Appendix: Transformer design

The transformer was designed to deliver an output power of 300W (15J of energy at 20 Hz rate), and a conversion efficiency of 80% was assumed.

Core Type: EE 4215 (Make: Cosmo Ferrite Limited)
Effective magnetic path length = 97 mm
Effective cross-sectional area = 181 mm^2
Maximum saturable flux density = 390 mT
Operating maximum flux density value taken for the design to avoid core saturation = 300mT
Initial Permeability = 3,000
Primary turns, NP = 11
Secondary turns, NS = 275
Primary Inductance, LP = 10 µH
Peak primary current, IP = 60A
Constant ON-time of the switching MOSFET = 25 µsec
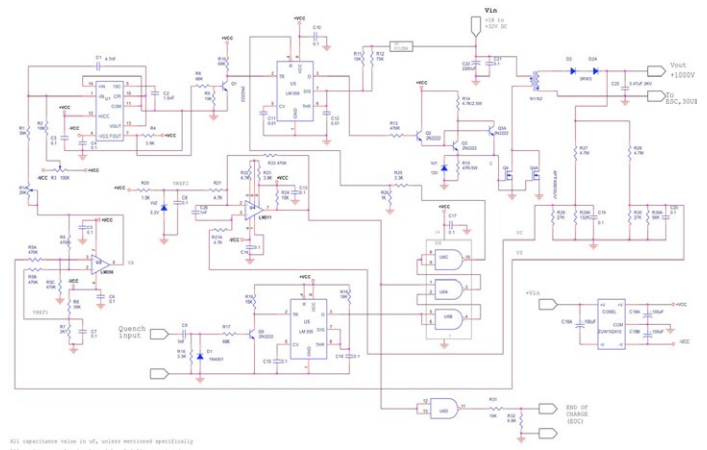
Figure 1. *Figure 1. Schematic of the converter/charger; VCC is +/-12V. Errata: U1 is a TI VFC32; The lower LM555 should be labelled U7; R14 should be 4.7Ω.* **Click to expand the diagram.**

Differential I/O low-power instrumentation amp

by Sandro Herrera

Currently, all commercially available three-op-amp instrumentation amplifiers (in-amps) offer a single-ended output, but many applications could benefit from an in-amp with a differential output. Offering many advantages over its single-ended counterparts, a fully differential in-amp features increased immunity to common-mode noise sources, achieves lower second-harmonic distortion and higher signal-to-noise ratio, and provides an easy way to interface with modern differential-input ADCs.

Figure 1 shows the circuit implementation of a low-power, fully differential instrumentation amplifier formed by the cascade of an OP2177 precision low-power, dual op-amp (IC1) and an AD8476 fully differential amplifier/ADC driver (IC2). Drawing less than 1.2 mA of supply current, the composite amplifier has 11 nV/√Hz input noise, 2 nA maximum input bias current, 75 mV maximum input-referred offset voltage, and 0.9 mV/K maximum input referred offset voltage drift.

The OP2177 and gain-setting resistors RF1, RF2, and RG form the in-amp's preamplifier and set the amplifier's voltage gain to:

$$Gain = \left(1 + \frac{R_{F1} + R_{F2}}{R_G}\right)$$

If RF1 = RF2, then

$$Gain = \left(1 + \frac{2R_F}{R_G}\right)$$

The AD8476 serves as the in-amp's subtractor; thus, it receives the amplified signal from the preamplifier, rejects its common-mode component, and passes its differential component. The AD8476 has a 90dB common-mode rejection ratio (CMRR), enabling the in-amp to have 90 dB CMRR even at unity gain. At higher gains, errors induced by a common-mode input signal are further reduced by the preamplifier's voltage gain when referred to the input.

Since the in-amp uses the three-op-amp topology, the match between discrete resistors RF1, RF2, and RG sets the amplifier's gain accuracy—a parameter that can be easily calibrated—but does not limit the amplifier's CMRR. The AD8476 also implements the in-amp's differential output drive, allowing it to directly drive up to 500 ksamples/sec differential input ADCs. Optional network RZ – CZ forms a single-pole low-pass filter that can be used as an antialiasing filter.

The instrumentation amplifier's output common-mode voltage is set by driving the AD8476's VOCM pin. If this pin is left unconnected, the amplifier's output common-mode voltage sits at mid-supply. When using the in-amp to drive an ADC, the AD8476's VOCM pin should be connected to the common-mode voltage required by the ADC.

Sandro Herrera is a senior IC designer with Analog Devices in the Linear Products Group. His current focus is on fully differential signal chains, data acquisition systems, and battery formation systems. Sandro received his M.Eng and B.Sc. in Electrical Engineering from MIT in 2005 and 2003 respectively.
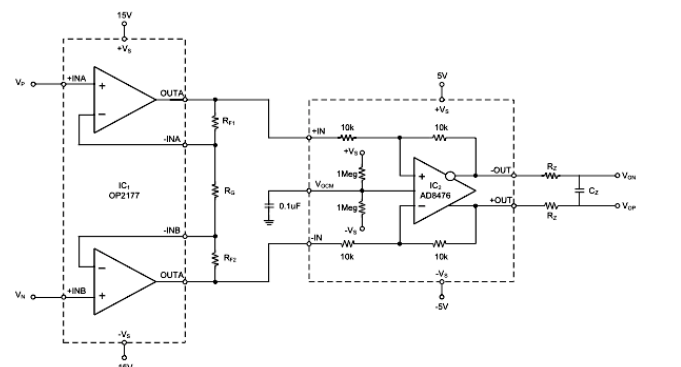

Figure 1. *Low power, fully differential instrumentation amplifier*

designideas

## Power Zener using the LM317

by Adolfo Mondragon

The LM317 voltage regulator is well known for its versatility and ability to perform many different and varied functions.

The standard and classic is the adjustable positive voltage regulator with a three terminal configuration. Another important and simple configuration of the LM317 is that of a two terminal current regulator.

But when the adjust terminal and output terminal are tied together, the LM317 is converted to a two-terminal component which behaves equivalently to a 1.5V, high-current Zener diode. This concept can provide a versatile and very useful circuit configuration that will allow it to source or sink a high current in either a positive or a negative voltage supply.
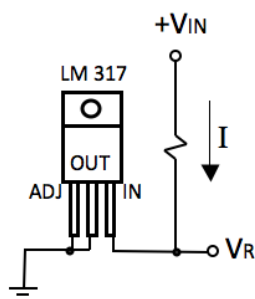
Tying the Adjust terminal to the Output terminal forces the internal regulator to compensate, pushing the internal NPN

VR vs. Current
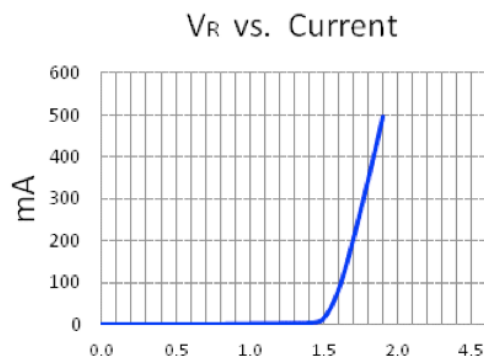
transistor into saturation. The NPN transistor in saturation has a VCE(sat) voltage drop of about 0.20V-0.25V which, when added to the 1.25V drop of the internal regulator, will yield a total voltage drop of 1.45V-1.50V.

Using the LM317 in this configuration causes it to behave similarly to a Zener diode with a dynamic internal resistance of approximately 1Ω or less. This dynamic internal resistance will provide a stiff reference, holding the voltage drop of the modified LM317 constant to within about 0.1V for every 100 mA change in current through the device.

Isolated AC linear power control

by Sajjad Haidar

Power control using the linear region of an active device, such as a MOSFET, is not an efficient option. However if the range of power control is restricted to the lower or upper end of the range, using the linear region is not a bad choice.

For instance, if we wish to control the power of a 45W soldering iron between 35W & 45W, an active device will dissipate between about 4W & 0.1W. With this in mind, the circuit shown in Figure 1 has been developed.

A simple current source is used to drive a VOM1271 photovoltaic (PV) coupler. The output voltage of the VOM1271 can be a maximum of 8.4V. Figure 2 shows the relationship between the input forward (I_F) current with the output short circuit current (I_{SC})—essentially linear. Photovoltaic output behaves like a constant current source until it nears the open circuit voltage (~8V). This output voltage can be utilised to drive a MOSFET with threshold voltage (V_{TH}) less than 8V.

A difficulty with MOSFETs in linear mode is that even in the same batch of devices, gate-source threshold voltages vary. Just after the threshold, drain current increases rapidly with little change in V_{GS} [Ref. 1]. MOSFET Q2 at the output of the PV coupler is biased in such a way that the output voltage to be
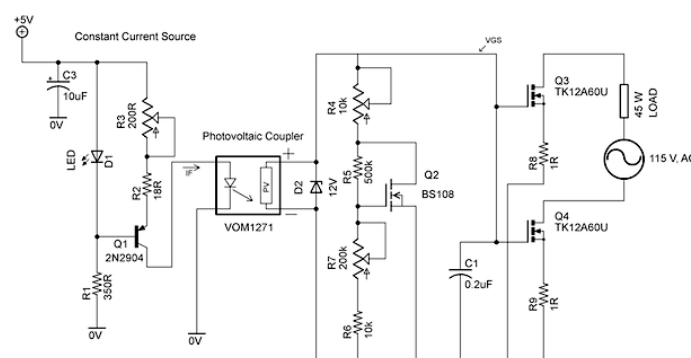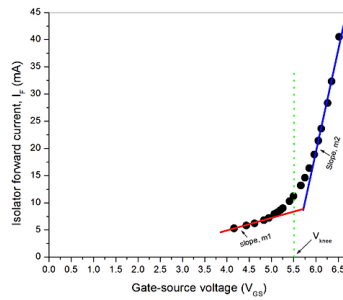

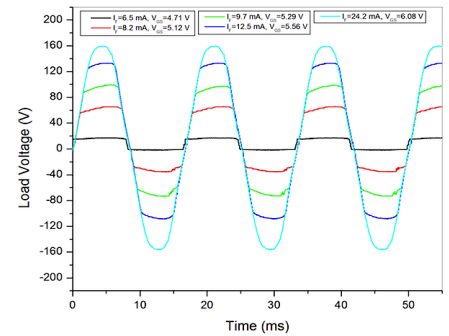applied to Q3 & Q4 gates (VGS) changes in accordance with the transconductance of Q3 and Q4.

Figure 3 shows the VOM1271 forward current (I_F) vs. V_{GS} relationship. With a little I_F, V_{GS} reaches the knee voltage (V_{knee}) with a slope m1. This slope is approximately proportional to (1/(R5+R6+R7)) as R5+R6+R7 >> R4. We can adjust R7 so that V_{knee} matches close to the threshold voltage of Q3 and Q4 (about 4V to 5V). After the knee, voltage V_{GS} changes more slowly with IF, with a steeper slope m2, similar to the V_{GS} vs. I_D curve of MOSFETs. Slope m2 is controlled by trimmer R4 (m2 ∝ 1/R4).
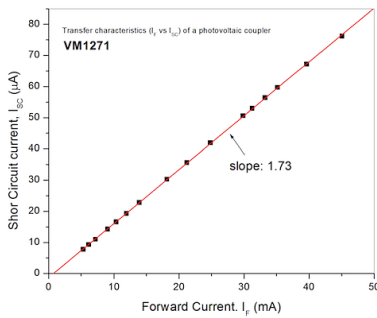
Q3 and Q4 are connected as shown in the schematic to conduct AC. A 45W soldering iron is used as the load to be controlled by the circuit. As the threshold voltages of Q3 and Q4 may vary, 1Ω resistors R8 and R9 are used to partly counteract this. As both Q3 and Q4 are getting the same gate voltage, higher load current causes higher voltage drop, which tends to reduce ID. The values of R8 and R9 should be chosen considering the AC load; the larger the load, the lower the values.

The voltage waveform across the load is shown in Figure 4 at various power levels. A little imbalance between the positive and negative halves is seen, especially at the lower power, because of the difference in VTH. The waveforms are much like a truncated sinusoidal wave. However, this distortion is less likely to generate RFI compared to conventional triac-controlled waveforms. Though a constant current source is used here for power control, it can be replaced by any other control sources. The optical isolation will keep the control sources safe from the AC. Though this circuit is used here for AC power control, it can be used for DC as well.

REFERENCES:

[1] Electronics - Circuits and Systems, Owen Bishop, Elsevier, 2011, pg. 63.

productroundup

Precision, mil-spec TCXO has low phase noise

THE M616X SERIES PRECISION TCXO (TEMPERATURE compensated crystal oscillator) from Link Microtek offers high stability, low vibration-induced phase noise and low power consumption, for use in avionics systems, portable satellite terminals and radio communications equipment. Manufactured by MtronPTI, this surface-mount oscillator uses specially processed crystals to achieve a consistent long-term stability of ±0.1 ppm over the temperature range 0 to 70C and ±0.2 ppm over the range -40 to 85C. The TCXO ha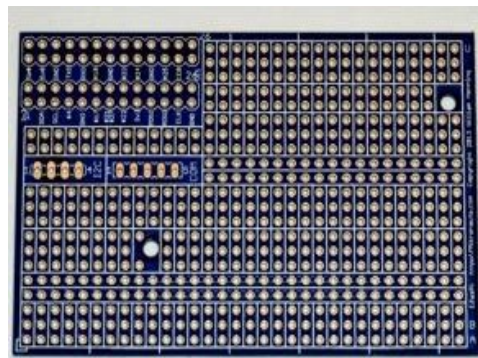s an operating frequency range of 8 to 52 MHz and delivers a low g-sensitivity of 0.6 ppb/g, with phase noise typically -156 dBc/Hz at 100 kHz offset. It uses 1.5 mA at 13 MHz.

Complete article, here

Prototyping boards target Raspberry Pi and BeagleBone

MIKRONAUTS' LINE OF PROTOTYPING BOARDS, DESIGNED to be easy-to-assemble, now includes versions that are specifically designed for the Raspberry Pi and BeagleBone hardware platforms, are silk-screened on both sides, highlighting power and signal buses. The EZasPi 85 × 56-mm prototyping board has mounting holes above the Raspberry Pi test mount holes, allowing it to be securely attached to the Raspberry Pi using common M3 18-mm standoffs. A second version, the EZasPi (B), takes advantage of the additional GPIO provided by Revision 2 of the Raspberry Pi platform. Intended for the BeagleBone Black development board, the EZasBone 86 × 54-mm prototyping board provides more than twice the prototyping area of competing bussed prototyping boards, its makers assert.
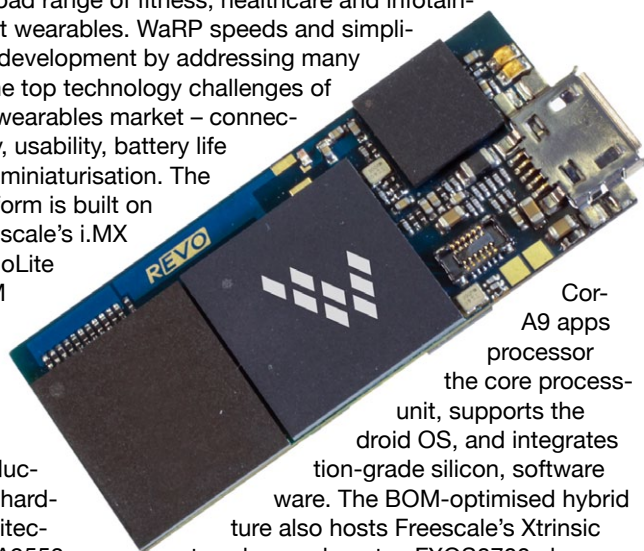
Complete article, here

Wearables Reference Platform hosts Freescale MCUs

SUPPORTS MULTIPLE APPLICATIONS, THIS FLEXIBLE platform built on a hybrid architecture enables simplified design for a broad range of fitness, healthcare and infotainment wearables. WaRP speeds and simplifies development by addressing many of the top technology challenges of the wearables market – connectivity, usability, battery life and miniaturisation. The platform is built on Freescale's i.MX 6SoloLite ARM Cortex-A9 apps processor as the core processing unit, supports the Android OS, and integrates production-grade silicon, software and hardware. The BOM-optimised hybrid architecture also hosts Freescale's Xtrinsic MMA9553 turn-key pedometer, FXOS8700 electronic compass and ARM Cortex-M0+ Kinetis KL16 microcontroller. WaRP is a result of collaboration between Freescale, Kynetics and Revolution Robotics.

Complete article, here

Mains-dimmable LED lamp driver cuts parts-count

AP1694 IS AN AC-DC CONTROLLER PROVIDING A universal high-performance driver solution for a variety of mains-dimmable LED lamp designs. Suitable for both 120V and 230V AC inputs, while supporting non-isolated buck, buck-boost and isolated flyback topologies, this part enables between 10% and 50% reductions in total BOM costs. As a primary side controller, this part removes the need for opto-coupler and secondary-side control circuitry, and being inherently stable, eliminates the need for loop compensation. The AP1694 delivers a 5% initial LED current accuracy, meeting the requirements of most mains-dimmable LED lighting applications and is compatible with a wide range of different dimmers, including both leading edge and trailing edge types. It achieves deep dimming down to 1%.

Complete article, here

productroundup

Simulation software updated for RFIC design

THE LATEST RELEASE OF AGILENT'S GOLDENGATE, ITS RFIC simulation, verification and analysis software, provides RFIC designers with EVM-, BER- and ACPR-type measurements and enables you to quickly analyse and diagnose problem areas in large-signal analysis. It offers a number of
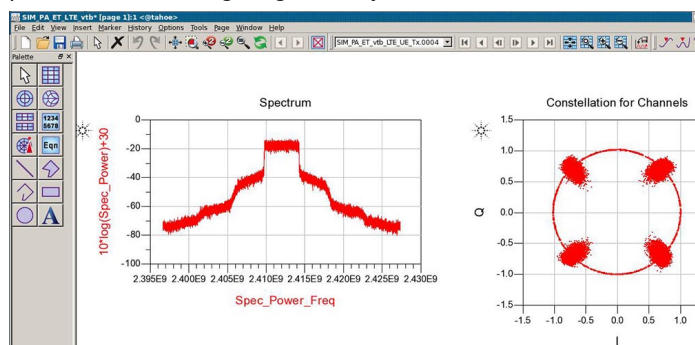

new capabilities to reduce simulation time and increase design efficiency. GoldenGate 2013 introduces new verification test benches that allow you to easily validate and optimise designs using standard-compliant waveforms and measurements such as EVM/ACLR in transmitters, or sensitivity/desensitisation in receivers. GoldenGate, known for RF circuit simulation, also provides technologies to explore, analyse and optimise RF circuits early in the design cycle. With this latest release, a new sensitivity analysis has been added that can be applied when analysing RF circuits, even when running large-signal analyses.

Complete article, here

Backlight panel LED driver ICs include voltage step-up

A SERIES OF HIGH PRECISION LED CONTROLLERS HAS PWM input for driving external bipolar transistors in LED backlight panels, also optimised for 2D and 3D operation in
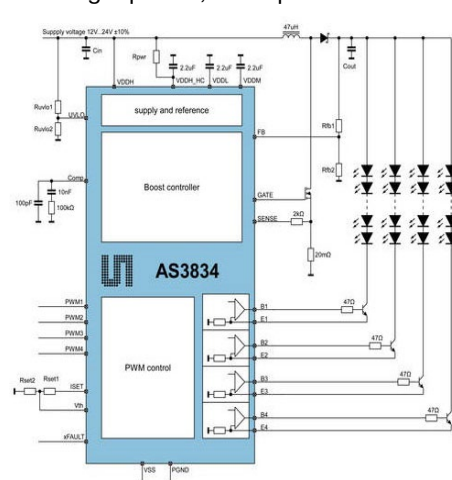
TV applications. AS3834/3834B are 4 channel devices with integrated step-up controller to provide the necessary output voltage for the LED string supply. The SMPS feedback control optimises the power efficiency by adjusting the LED string supply voltage. Output current is up to 270 mA per channel and built-in safety features include under-voltage and thermal shutdown as well as open and short LED detection. The AS3833 is a 6 channel LED controller with a similar specification, delivering output current up to 250mA per channel.

Complete article, here

Flash MCU with onboard LED/LCD outputs

HOLTEK SEMICONDUCTOR HAS INTRODUCED A FLASH MCU with LCD/LED Driver which includes fully integrated LCD and LED driver circuits that can directly drive display panels and eliminate the need for large number of external components. The HT69F240 includes 4 kwords of flash program memory, 256 bytes of data RAM, 64 bytes of data EEPROM and an 8-level stack. Peripheral functions include multifunctional timer modules, external interrupts, I2C and UART interfaces, and internal and external high accuracy oscillators. Holtek supports the HT69F240 with hardware and software development tools. The hardware development tool is the e-Link which works together with an OCDS structured evaluation MCU, providing users with an actual device with which full emulation and debug can be implemented. The software development tool is the HT-IDE3000, which includes features such as real time emulation, full memory and register access, hardware breakpoints complete with logical setups, and trace analysis.

Complete article, here

400-4000MHz dual-port USB vector network analyser

THE VNA-0440 VECTOR NETWORK ANALYSER FROM MEGIQ is a bi-directional two-port unit allowing detailed impedance measurements of antennas, circuits and components. With its 400 to 4000MHz measuring range, the instrument covers the most popular communication bands for GSM-LTE, GPS, ISM, Wifi, and Dect. A version with an extra generator output allows the characterisation of 3-port devices, such as splitters and hybrids. It features an internal, programmable bias generator
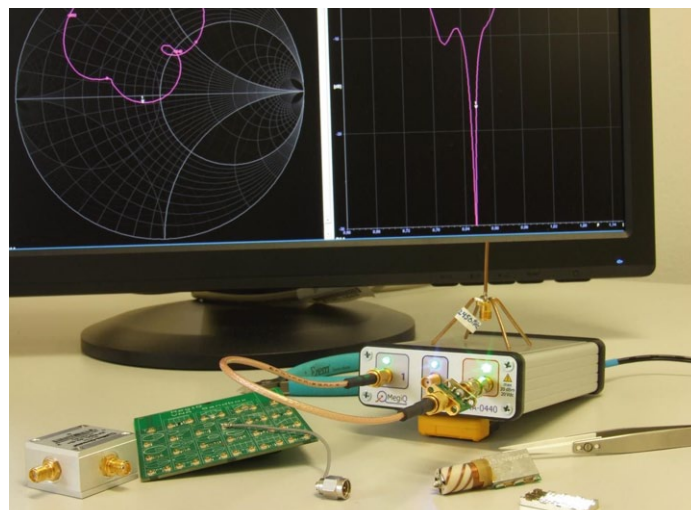
with bias-Ts allowing full automatic parametric measurements of amplifier and varactor or PIN circuits. A UFL kit allows you to measure circuits on micro-PCBs, for example baluns, antennas, and amplifiers. Other kits are available, such as WFL, SMA, balanced, including calibration tools. The 'RF Sandbox' provides new users with a series of experiments. PC software provides intuitive control, extensive graphing, data export and reporting. The 'Click-and-Match' function calculates and simulates matching circuits.

Complete article, here

productroundup

Configurable, programmable digital Hall effect devices

MELEXIS TECHNOLOGIES HAS INTRODUCED TWO PARTS to its programmable digital Hall effect sensor line; MLX92231 and MLX92211 feature EEPROM memory, allowing magnetic switching thresholds to be configured (including hysteresis). Both are factory pre-programmed to precise Hall effect switch or latch specifications, bringing tailored results that match your specific application requirements. MLX92211 targets applications requiring Hall effect latch magnetic characteristics. MLX92231 supports applications for Hall effect switch magnetic behaviour. A 32 bit unique ID code in each sensor gives lifetime traceability. The devices both feature a low voltage capability, differentiating them from other Hall effect sensors, by allowing them to interface with microcontrollers and other digital ICs placed on supply lines at under 3V.

Complete article, here

Low-cost Bluetooth Smart starter kit

A $99 SDK ENABLES DEVELOPERS TO BRING BLUETOOTH Smart devices to market quickly and cost-effectively; based on the CSR µEnergy platform, the Starter Development Kit provides a complete environment for developers who are looking to create their first Bluetooth Smart products and get them to market rapidly with a low initial investment. The CSR Starter Development Kit also accelerates hardware development due to the inclusion of FCC and ETSI RF certified reference module designs which are supported with 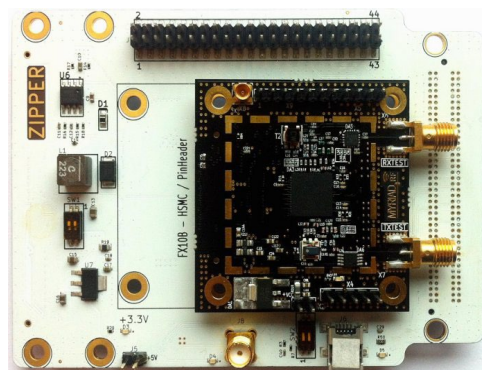full design files. The kit comes supplied with a hardware development board, a CSR1010 module, mini USB cable, setup and quick start guides straight out of the box. The kit includes a full suite of profiles and example applications to run on-chip. These are coupled with example source code for iOS and Android to give developers a starting point for their application development. Developer support is provided by the newly launched CSR developer forum and wiki.

Complete article, here

Open-source software-defined radio gets FPGA links

THE OPEN SOURCE RF HARDWARE INITIATIVE, MYRIAD RF, has launched an open-source interface board to connect field programmable RF (FPRF) transceiver systems directly to FPGA boards, creating a wireless development platform for complex wireless systems. The mezzanine board, called Zipper, is a multi-carrier board with HSMC, FMC, general purpose pin header and USB connections. It allows the FPRF boards to interface with both Altera and Xilinx development platforms – and enables direct connection with a PC for control and calibration. The resulting system enables wireless systems of almost any size and complexity to be created on any wireless standard or frequency. Zipper was designed in collaboration between Lime Microsystems and Azio Electronics. The Zipper board's design files can be downloaded in KiCad format free of charge and under liberal open source licensing terms. Prebuilt versions of the interface board will soon be available via Azio, DigiKey, Eastel, Richardson and Vitec, at $199.

Complete article, here

Bluetooth Smart design for Rezence Wireless Charging

A WIRELESS CHARGING APPLICATION ENABLES CHARGE pads with support for simultaneous charging of up to eight devices; Nordic Semiconductor has introduced the S120 8-link central protocol stack and the nRF51 Wireless Charging Software Development Kit (SDK) for wireless charging applications based on the Rezence standard, developed and maintained by the Alliance for Wireless Power (A4WP). Rezence is a wireless power transfer technology and specification based on the principles of magnetic resonance. S120 is an 8-link central role Bluetooth low energy SoftDevice for the nRF51822 System-on-Chip (SoC). The nRF51 Wireless Charging SDK includes services/profiles for a Rezence Power Transmitting Unit (PTU) and Power Receiving Unit (PRU) as well as state machine examples. S120 together with the nRF51 Wireless Charging SDK provides a solution for the Out-of-Band (OOB) signalling part of a Rezence charge pad.

Complete article, here

Vertical dual-Hall sensor for rotation direction and speed

TLE4966V IS A VERTICAL DUAL-HALL SENSOR FOR detecting rotation direction and speed. The TLE4966V is the first dual-Hall device with its integrated Hall plates oriented

vertically and not horizontally on the chip surface, thus making it sensitive to magnetic fields with in-plane direction. This 90-degree orientation change provides flexibility to fit designs into space-constrained areas. The design flexibility and the 4mA to 7mA current consumption of the TLE4966V suit it to energy-sensitive electronic automotive systems such as trunk lifts, power window lifts, sun roofs and seat adjustment. In non-automotive applications, the sensor is also a solution for escalators, motorised window blinds and shades.

Complete article, here ▶

DC-DC converter provides 3 kVDC isolation for industrial automation

SUITABLE FOR USE IN INDUSTRIAL, AUTOMATION AND instrumentation applications, Murata's MEF1 series of 1-W regulated DC-DC converters are tightly regulated single output units, rated to better than 1% of nominal output voltage. In a fully encapsulated single-in-line through-hole format occupying less than 1.17 cm^2 footprint, MEF1 converters are available with either 1 kVDC or 3 kVDC input-to-output isolation, the latter model having an enhanced immunity to voltage transients. Output voltage options are 3.3 or 5.0 VDC, with input voltages covering the popular nominal inputs from 3.3 to 24 VDC. Compared to previously available models, the MEF1 offers a 13% improvement in energy efficiency. Both the 3.3 VDC input and 3.3 VDC output options can operate over the full industrial temperature range of -40 to +85C without derating.

Complete article, here ▶

Automotive Hall-effect switch offers self-diagnostics for SIL

A1160 FROM ALLEGRO MICROSYSTEMS EUROPE IS A unipolar Hall-effect switch with built-in diagnostic capabilities that provide a solution to the monitoring of device performance, and the self-diagnosis of incorrect device operation. It is claimed to be the only Hall sensor IC capable of verifying proper electrical performance and magnetic sensing: a critical
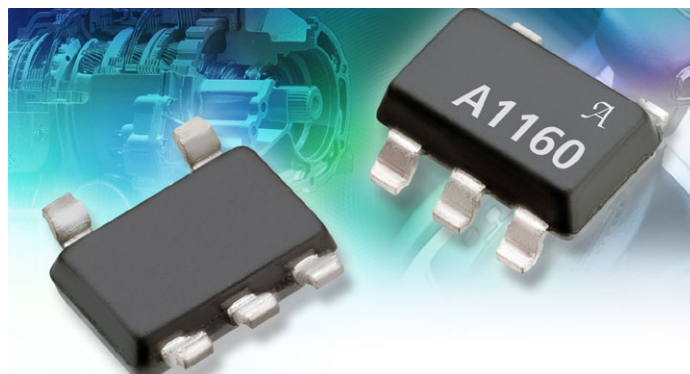
feature for safety applications that must adhere to Automotive Safety Integrity Level standards or for those applications requiring two sensors for redundancy. In diagnostics mode the device will output a PWM (pulse-width modulated) signal of 50% duty cycle when the device is properly sensing the internally generated magnetic field. The diagnostics mode exercises the entire electrical signal path of the integrated circuit, and ensures proper sensing of the magnetic signal to provide accurate device functionality. The A1160LLH-T is targeted at both the automotive and industrial markets.
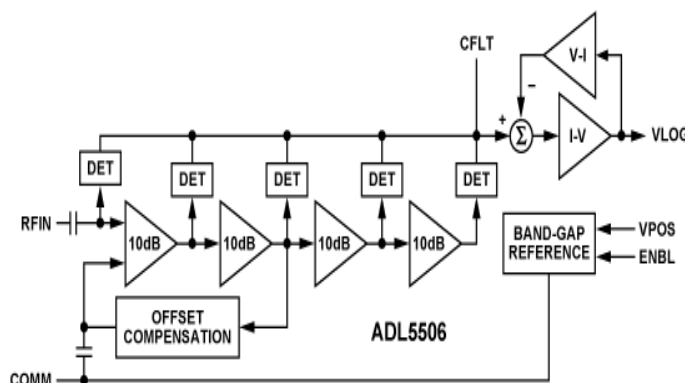
Complete article, here ▶

Wide-dynamic-range, high-accuracy RF power detectors

ANALOG DEVICES HAS ADDED TWO RF POWER detectors with wide dynamic range and high levels of accuracy and temperature stability. ADL5903 is a solution for a variety of high frequency systems, to 6 GHz, requiring accurate measure-

ment of signal power independent of waveform characteristics. The ADL5506 RF detector is a complete subsystem for the measurement of RF signals to 4.5 GHz in a wide range of wireless terminal devices. Both detectors come in small packages with low-power operation.

Complete article, here ▶