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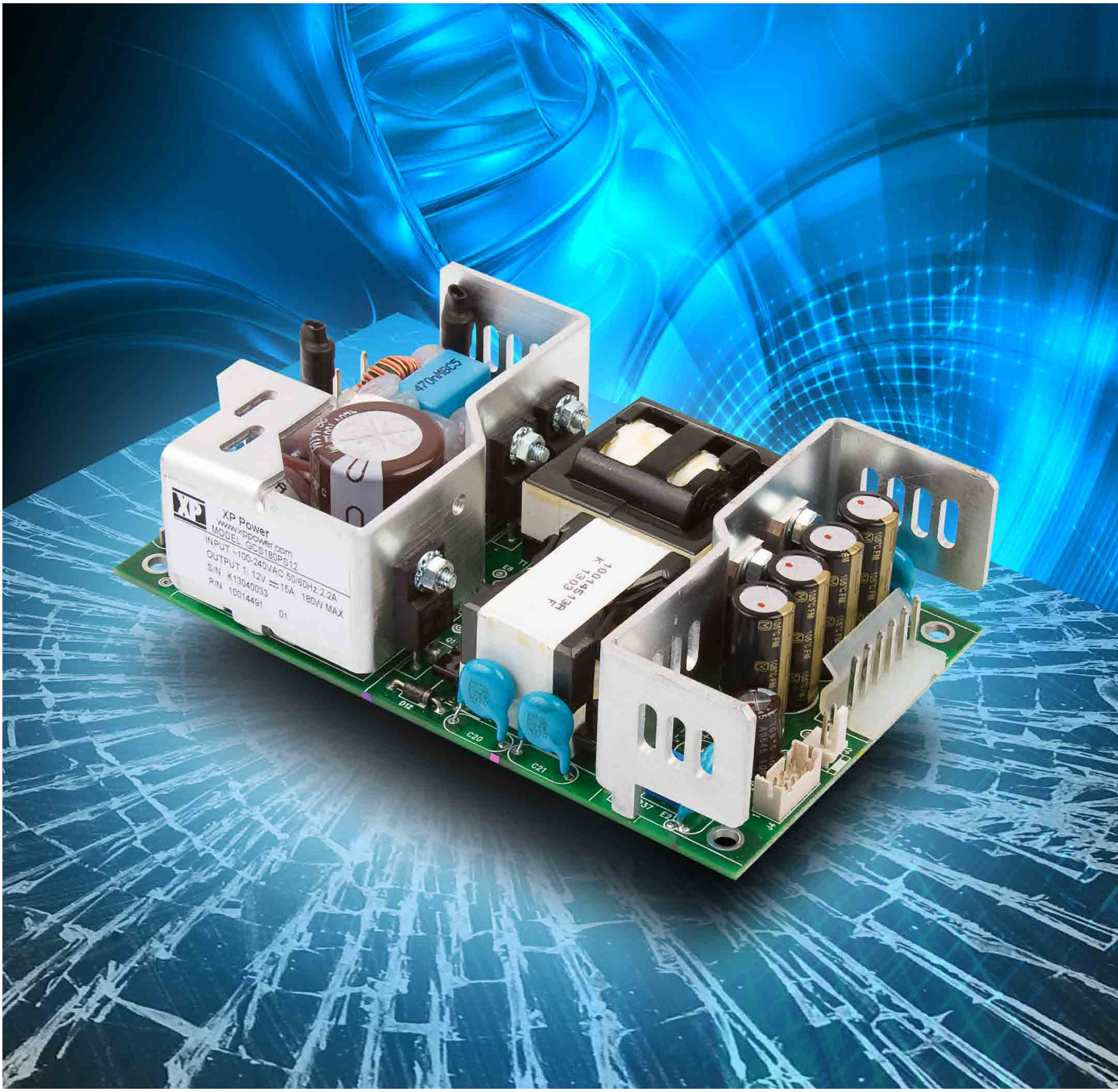

Special Report: Medical (pg 35)

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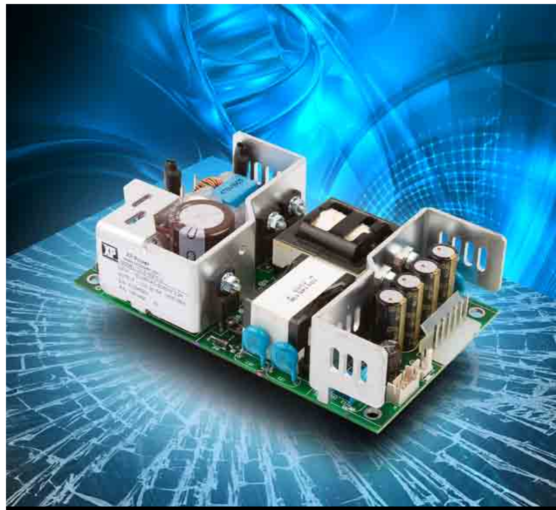

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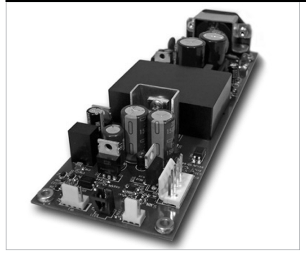

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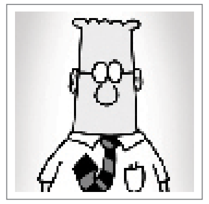

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Volume 10, Issue 8

Empowered outpatients are the future of medicine

Medical electronics have grown and matured over the past few decades, bringing intelligent diagnostic and treatment systems into every facet of medical care, transforming hospitals into meccas of high technology. From the electronic thermometer put into your mouth (or elsewhere) to the robotic scalpel performing surgery, medical technology extends its reach from the simplest procedure to the most complex operations.

The latest trend in medicine has been developing for several years now, but has accelerated development as portable and implantable technologies have increased in functionality while shrinking in size and cost. For example, portable blood diagnosis has been routine for diabetics for some time now, and the capability is extending to create devices that will function much like an artificial pancreas.

The biggest beneficiary of this trend is outpatient care, where technology not only enables patients to aid in the management of their own treatment with a telemetry connection to their care provider. This will be most impactful in the area of assisted living, as a huge number of retirees will require medical monitoring and/or treatment as well as mobility and/or prosthetic mobility support.

The geriatric marketplace will become a significant one. In 2009 a little less than half of all geriatric caregivers modified the place the recipient lives, but this number will increase as baby-boomer retirees who want to extend their living functionality well into their old age make their houses to be more "smart", integrating medical, security, and convenience functionality into advanced living systems. Considering that the current average hourly rate for home health aid was $19 in 2006, a cost-effectiveness benchmark can be determined for the value of a remote medical system based on how many care-hours it can eliminate from the patient's treatment schedule.

In the case of implantable systems, the market is just as promising. According to industry sources, the global market for Cardiac Rhythm Management (CRM) devices alone is forecast to reach $15.1 billion by 2017, the wearable technology market will exceed $6 billion by 2016, and implantable electrostimulation devices will drive a $16 billion market in the next few years. This number will only grow as

The biggest challenges we face in the medical field involve basic compliance issues, the medical regulations & standards we all must face. In addition to that, designers must also address inter-device protocols, user language & social acceptance issues, as well as market issues of technology acceptance, integration into existing infrastructures, and cross-platform issues between devices. Properly done, however, developing products for the medical marketplace can be a lucrative venture that also serves the public.

Best Regards,

Alix Paultre

Editorial Director, Power Systems Design
alixp@powersystemsdesign.com

Medical supply has ultra-low capacitance CF-rated output & independently controlled BF-rated output

BEAR Power Supplies has introduced a dual-output AC-DC converter for surgical instruments and other medical applications. The CF (Cardiac Floating)-rated output features an ultra-low capacitance of less than 15 pF. The CF-rated output can be switched off when not needed, while the BF (Body Floating)-rated output remains active to supply electronics used in the vicinity of a patient.

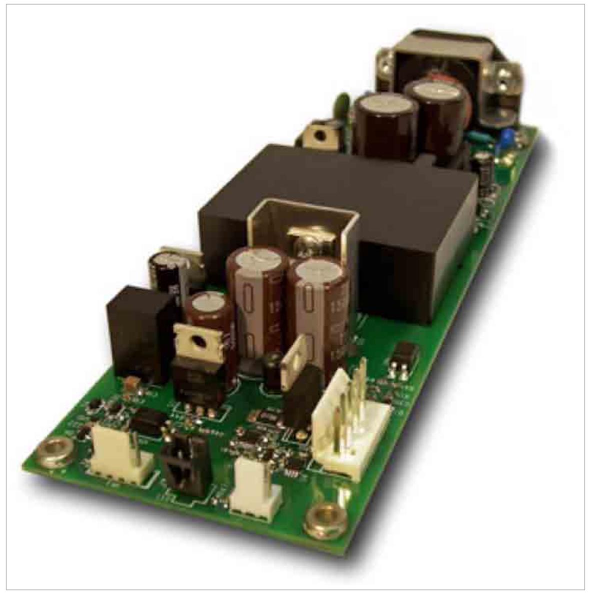
This 75-Watt medical power supply has universal input. Standard output is +24 V (CF) and +12 V (BF); other voltages are available on request. The power supply has very low EMI and is certified to EN 60601-1-2 (revision 2 and revision 3). It measures 8 x 2.5 x 1.25 inches.

Designed and manufactured in the USA, the supplies can be customized to meet OEM requirements for power, voltage, form factor, number of outputs and other specifications. Pricing starts at $80 in OEM volumes.

BEAR excels at innovative, high-reliability custom power supplies for medical instruments. The company designs and produce medical power supplies used in diagnostic instruments and patient care devices, from primary care physician offices to operating rooms.

Their innovative isolation techniques yield leakage current of less than 5µA, exceeding the requirements for Type CF-rated medical devices. The company excels at customization, even for low volumes: non-standard output voltages, unusual form factors to fit precise size and configuration constraints, and compact sizes for portable medical devices. BEAR has the manufacturing flexibility and capacity to support both low- and high-volume production.

BEAR is able to comply with medical device manufacturers' Quality Processes, supporting requirements such as Failure Mode Effects Analysis (FMEA) and lot traceability of components. The company has successfully passed quality audits by several of the world's largest medical device manufacturers. All BEAR power supplies are tested to medical equipment safety and EMC standards including UL, IEC, CAN/CSA and EN.



Figure

www.bearpwr.com

Myth busters: which is cheaper to implement, digital or analog power?

By: Mark Adams, CUI

Digital power is arguably one of the most important technology evolutions to emerge in recent years. It enables systems to be precisely optimized, taking into account many factors.

It has been widely adopted for telecom and networking systems, which draw lots of power. But, about 18 months ago, the technology was in danger of becoming niche, and seen as something that was too difficult to implement. The market responded, and products such as CUI's NSM2P allowed system designers to implement digital power without the digital bus.

The next block in its uptake from a myth. That myth is: "digital power is expensive". However, when the overall design costs are taken into consideration, adopting digital power cuts the design costs significantly. Let's look at some of the hidden design costs.

Module costs:
A digital point of load module may have a listed dollar value that compares with a similar analog module, and at first glance choosing analog and undertaking procedures such as manual loop compensation will appear to save you money. But as with many things in life, this isn't the entire story and several aspects must also be taken into consideration.

The key ones, in no particular order, are:

1. Digital power reduces board spins – Each board spin can cost in the order of $40,000 (and over), and adds several months to a project. Digital power allows changes to be made in the software, rather than via board-level component changes.
2. Digital power cuts time to market – Delays cost money and digital power not only leads to a reduction in board spins, it also eliminates the need to undertake manual loop compensation; on-the-fly modification to system parameters can be undertaken via a GUI, cutting months off a system's development.
3. Analog POLs require up to 10x the external capacitance, requiring additional external components that add to both the total solution cost and the overall board space.
4. Digital power enables design reuse – Implementing analog comes with a second, hidden limitation… the fixed circuit based on the previous board specifications (usually) cannot be implemented 'as is' for new designs.

While the core components may be reused, the analog solution itself must be modified, as the new design will have different timing needs, sequencing… and faults. All will require a new layout that incorporates these modifications. Conversely, the dynamic nature of digital designs can be easily 'cut and pasted' from one board to the next. Changes will still be needed, but these can be quickly implemented through the GUI.

The myth that 'digital is expensive' is just that, a myth. The system's complete design costs need to be taken into account before deciding on an analog or digital system.

www.cui.com

Medical Power Supply Market Projected to Grow

By: Jonathon Eykyn, IHS

The overall global power supply market declined in 2012 owing to a combination of low investment and weak end-equipment demand. As a result, few sectors in the market grew. The market for power supplies used in medical applications, however, remained resilient and grew by an estimated four per cent.

Growth in this market is forecast to continue in 2013 at 3.7% and is projected to remain strong annually for the next five years. This is predicted to generate an additional $100 million from 2012 to 2017.

The market for power supplies in medical applications often seems complicated for power supply manufacturers. It is driven directly by the medical equipment markets which themselves are affected by factors such as the demographic and social trends, reimbursement legislation and trends in healthcare provision. There is a broad range of products with widely differing power demands from low-powered consumer devices up to state-of-the-art MRI scanners. In addition, there are several additional standards that are demanded for power supplies being used in medical applications.

The market can be split into three main segments; consumer health, medical imaging and clinical care. The market has historically been dominated by the clinical care market (e.g. anaesthesia devices, patient monitors, neonatal incubators) and the medical imaging market (e.g. MRI, X-Ray, and ultrasound). These devices, especially those in the imaging markets often have complex power requirements and there are many more standards a power supply has to be certified to.

The market for power supplies in consumer medical applications is projected to be the fastest growing segment and represents a new opportunity in the market. In recent years, governments have come under pressure to find ways to improve the health of the population whilst reducing the burden on government finances. This is leading to a move towards healthcare being managed outside of the traditional hospital environment with a growing trend for patients to be monitored in their home using telehealth technologies once their treatment is complete. These telehealth monitors are one of the key emerging applications in the consumer medical market and are opening up a new opportunity for power supply manufacturers as they favour a low-power, AC-DC adapter solution.

For the next few years, Asia and America will drive the majority of growth in in this market. In particular, the BRIC countries of Brazil, Russia, India and China. Demand in the EMEA region continues to remain depressed due to the poor economic environment. However, recovery in the EMEA region is forecast to drive increased spending on medical equipment from 2015, raising demand for the accompanying power supplies.

With growth set to remain stable for the foreseeable future, the medical market provides a strong opportunity to manufacturers looking to diversify their product ranges as demand for power supplies in other sectors remains low.

www.ihs.com

Designing snubbers for nonisolated converters

By: Dr. Ray Ridley, President, Ridley Engineering

All power electronics circuits with devices which rapidly turn on and turn off will exhibit voltage ringing when currents are interrupted or initiated. For transformer-isolated designs, the leakage inductance of the transformer usually dominates the ringing inductance, and the first step in snubber design is to measure this inductance value. This process is described in detail in references [1] and [2].

For a buck converter, there is no transformer, and no clearly defined value of inductance with which to begin snubber circuit design. **Figure 1** shows the schematic of the input side of a buck converter with the FET, diode, and bypass capacitor forming the high-frequency current loop. The PCB layout of this part of the circuit is also shown in **Figure 1**. As discussed in [3], the PCB layout should keep any high frequency current loops as small as possible in order to minimize the stray inductance.

Even when this has been done, at higher power levels and with large discrete devices, it is inevitable that some stray inductance will remain in the circuit. Ringing will be a problem that has to be properly controlled in order to avoid excessive noise and stress.

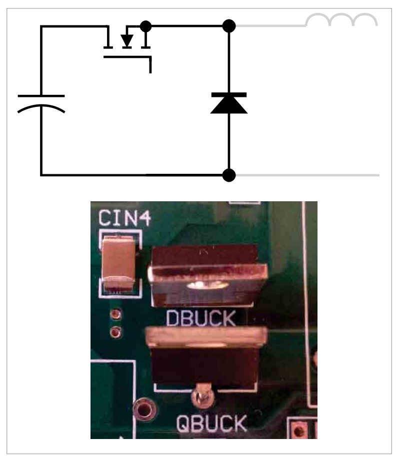


Figure 1: Buck Switching Cell and Circuit Placement

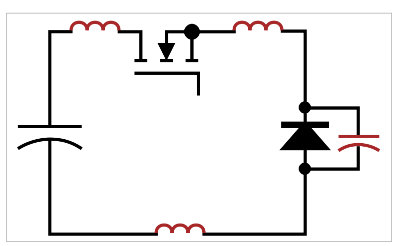
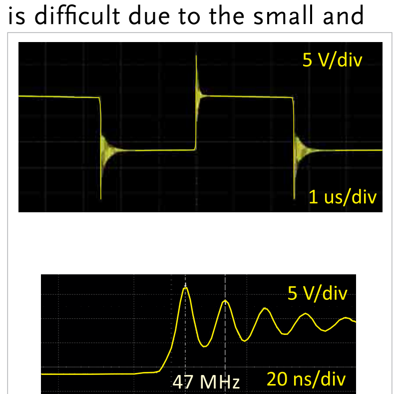


Figure 2: Stray Inductance Associated With Board Traces and Component Leads

Rings With Diode Output Capacitance When It Turns Off

Figure 2 shows the inductance elements on the schematic. (Of course, on your production schematic, these elements don't actually appear, but they will still cause trouble.) The inductance in the system is formed by the board traces, component leads, and internal component wiring of the die-attachments. The output capacitance of the diode will ring with the inductance of the circuit. Unfortunately, neither the L or the C that form the ringing are simple to define. The diode capacitance is a nonlinear value, which changes with applied voltage. We also have to account for package capacitance to heatsinks in some cases. Measuring the L and C directly is difficult due to the small and variable values.



$$f_{turn-on} = \frac{1}{2\pi\sqrt{L_s C_o}}$$

$$L_s = ?$$

$$C_o = ?$$

Figure 3: Ringing on FET Turn-On

Ringing Waveforms

While the loop shown in **Figure 1** on the PCB is small, it creates enough inductance to produce considerable ringing as shown in the oscilloscope waveforms of **Figure 3**. The top waveform of **Figure 3** shows both the turn-on and turn-off ringing. The ringing on the leading edge occurs when the switch turns on, and the diode turns off. The expanded waveform of **Figure 3** shows that this ringing frequency is approximately 47 MHz.

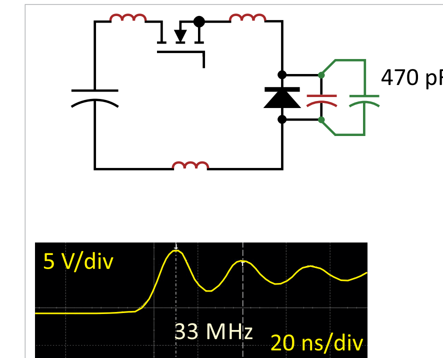
In order to damp the ringing frequency effectively without iteration, it is important to know one of the resonant values, either the L or the C. Without a transformer, L is a difficult measurement, so we will focus on finding the equivalent capacitance.

Determining Capacitance Value

You can look at datasheets to get an estimate of the capacitor value, and you will see the varying values with voltage. There are also variations in fabrication that lead to typical and maximum values, but no minimum value.

I always like to do an experimental verification of the diode capacitance. The procedure for this is as follows:

1. Measure the ringing frequency.
2. Add a known capacitance across the diode
3. Measure the new ringing frequency.
4. Repeat until the new frequency = 0.707 times

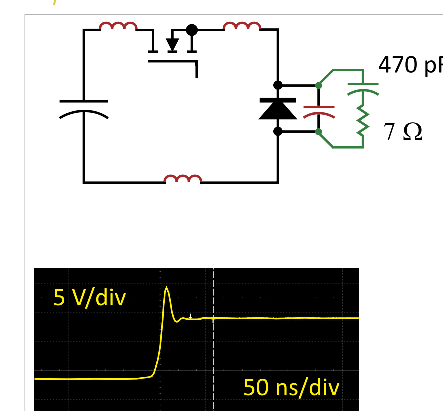


$$f_{new} = \frac{1}{\sqrt{2}} f_{old}$$

$$C_o = 470\ pF$$

$$L_s = 24\ nH$$

Figure 4: Adding a Parallel Discrete Capacitor Provides Estimation of Circuit Capacitance



$$P_d = \frac{1}{2} C_o V_{in}^2 f_{sw} = 0.047W$$

Figure 5: RC Snubber Eliminates Ringing, But Overshoot Is Still Present

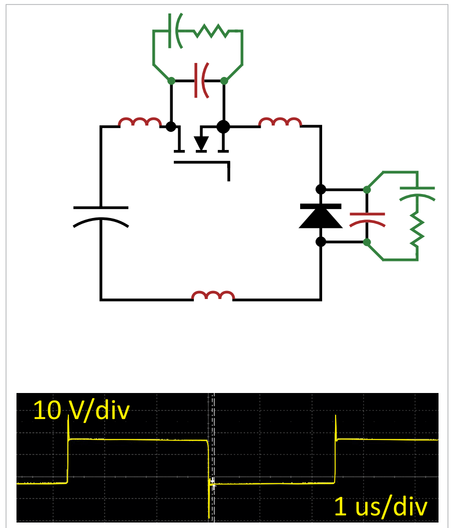


Figure 6: The Design Process Is Repeated For The FET Snubber

old frequency. The added capacitor is then equal to the intrinsic capacitance.

It is very important when you do this that the added capacitor does not have long leads attached. These will substantially change the inductance of the circuit, and that will also lower the ringing frequency.

Figure 4 shows the ringing frequency of the turn-off of the diode with a 470 pF ceramic capacitor added in parallel with the diode. The ringing frequency is reduced to about 33 MHz. This corresponds to the required reduction of the frequency, indicating that 470 pF is the equivalent average value of the diode capacitance.

With this value of capacitance, and a 47 MHz ringing, the stray inductance of the circuit is calculated to be about 24 nH.

Snubber Resistor Value

The snubber design is completed by selecting the resistor needed, and calculating its power dissipation. I always start the design of the snubber with the resistance equal to the impedance of the capacitor at the ringing frequency, in this case about 7 ohms (see **Figure 5**). The dissipation in the resistor is approximately equal to the energy stored in the capacitor multiplied by the switching frequency, or about 0.05 W in this case.

The entire design process is repeated for the second switching incident when the FET is turned off. A different resonant frequency will be observed since the FET capacitance will be different to the diode capacitance. **Figure 6** shows the resulting waveform with both the FET and diode snubbers in place in the circuit. Leading and trailing edge spikes can be observed, but the sustained ringing is suppressed quickly. For nonisolated converters, the dissipation energy in the snubbers will be quite small, but this does not mean that they should be omitted from the design.

Summary

Snubbers are crucial to include even in non-isolated converters. With very tight layout, the inductance can be minimized and this will reduce the peak overshoot on the ringing voltage. This article has described how to design snubbers from empirical measurements when the ringing inductor value is unknown. A series of short experiments allows the design of the snubber in a single attempt, and the dissipation in the snubber is kept to a minimum.

www.ridleyengineering.com

References

1. Flyback Circuit Snubber Design, Article [A39], http://www.ridleyengineering.com/design-center.html
2. Transformer Impedance Measurements, Article [46], http://www.ridleyengineering.com/design-center.html
3. Power Supply Development Diary Part XI, Article [44], http://www.ridleyengineering.com/design-center.html
4. Power Supply Laboratory Workshop, http://www.ridleyengineering.com/workshops.html
5. Join our LinkedIn group titled "Power Supply Design Center". Noncommercial site with over 2400 helpful members with lots of experience.

Designing to meet 3rd edition medical safety standards

One significant change in the 3rd edition standard is the additional MOOP protection

By: Tim Taylor, XP Power

First published in 1977, the internationally accepted IEC 60601-1 standard has been continuously developed to help alleviate safety issues relating to all types of medical equipment. The 3rd edition of this medical safety standard was first published by the IEC in 2005 (IEC60601-1:2005) and was adopted by the European Union in 2006 and published as EN60601-1:2006. The USA version was also published in 2006, but unlike 2nd edition, not by UL. It is published by the American Association for Medical Instrumentation (AAMI) and appears as ANSI/AAMI ES60601-1:2006. Canada published the standard in 2008 as CAN/CSA60601:2008.

As many OEMs look to design medical devices to meet 3rd edition, many key factors need to be considered. A critical safety part of any electrical design is the AC/DC power supply. The AC/DC supply provides the necessary safety protection for the entire system to which it is connected. Understanding the regulatory guidelines of 3rd edition is critical before starting the design,

One significant change in the 3rd edition standard is the additional MOOP protection. In 3rd edition we now find that you can use Means of Operator Protection (MOOP) instead of Means of Patient Protection (MOPP). This means that the end device will not be in the vicinity of the patient and that only operators will have access to it. The majority of new AC-DC power supplies sold for medical applications are now being approved to 3rd edition with MOOP certifications.

For example, here at XP Power we made the decision to certify all of our current medical power supplies to 3rd edition (with 2 x Means Of Patient Protection on the majority of the power supplies) and also to the supplies test against the older 2nd edition. The rationale here is that following 2 x MOPP in 3rd edition is equivalent to 2nd edition in terms of separation distance, insulation schemes and dielectric strength requirements. This means that the OEM will be able to claim the safety of the power supply is at least as good as the current standard (2nd edition) and will still maintain their end equipment 2nd edition approval, even with a 3rd edition (2 x MOPP) approved PSU. (see clause 3.4 and clause 54 in UL60601-1:2003)

While the 2nd edition simply addressed basic safety issues to ensure freedom from any electrical, mechanical, radiation, and thermal hazards, it did not require devices to remain functional. Being ail-safe was adequate, and compliance with test criteria relied upon a pass/fail result that did not take into account the essential performance of the device-under-test. Recognizing these limitations, the 3rd edition introduces specifications for "essential performance" that requires equipment to continue functioning as its designers intended throughout the test process.

Within the electrical safety arena, the standard continues to require

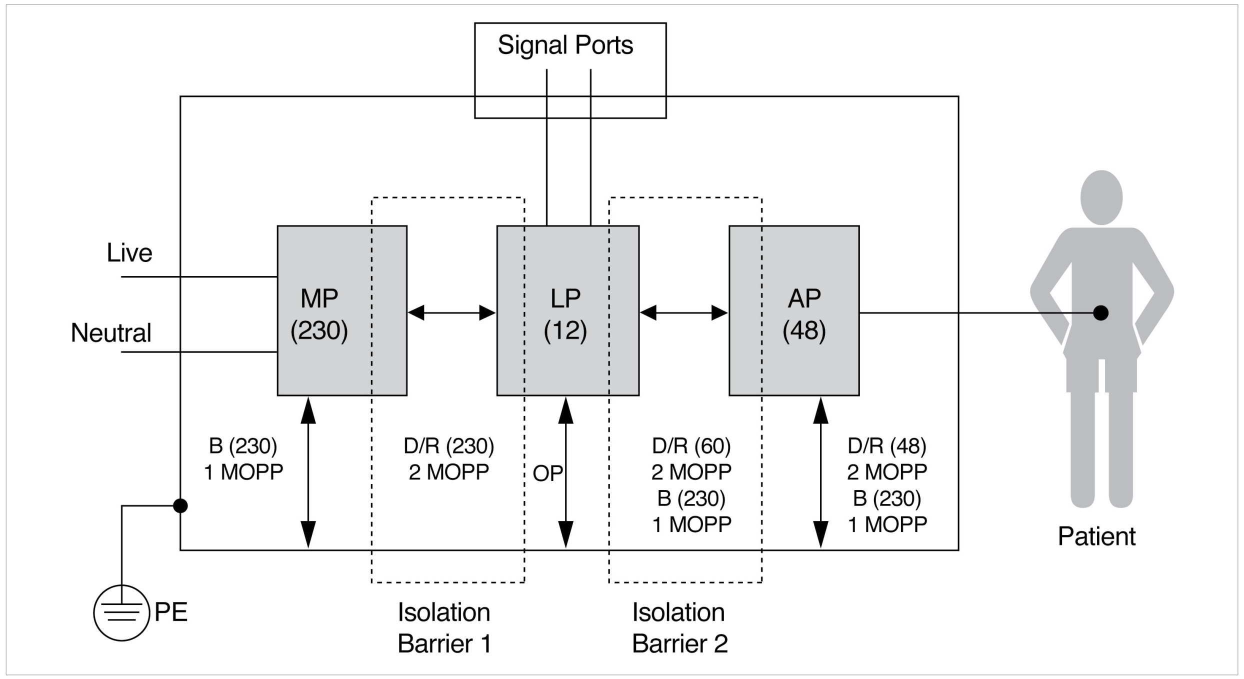


Figure 1: IEC60601-1 3rd edition demands that two means of protection (MOPs), or isolation barriers exist where patients may come into contact with equipment.

that medical power supply equipment implements two Means of Protection (MOP) such that if a failure occurs within one area, a second mechanism safeguards the operator and/or the patient against any electric shock hazard. **Figure 1** shows the insulation diagram that applies to the main circuit blocks in a typical medical device, and shows the two isolation barriers that provide the two Means of Protection that must be present within a device that may come into contact with a patient.

The standard allows for three defensive approaches that may be used in various combinations—safety insulation, protective earth, and protection impedance. It is critical to determine several key factors from the start of the equipment design process, including its insulation class and whether it will rely upon a protective earth connection. These considerations extend to the “applied part”, if present, that is deliberately attached to the patient. Such applied parts are separately classified by the level of electric shock protection that they provide.

Significantly for power supplies, the 3rd edition distinguishes between protecting the equipment's operator and the patient within its Means of Operator Protection (MOOP) and Means of Patient Protection (MOPP) categories. This distinction can result in quite different safety insulation and isolation requirements for circuits that operators and patients may come into contact with. Applications requiring operator protection only have to meet the clearance and creepage requirements that IEC/EN 60950 specifies for general-purpose information and technology equipment. By contrast, circuitry that is classified as patient protection must meet the far more exacting requirements that the 2nd edition of IEC 60601-1 introduced. As to who determines whether it is MOOP or MOPP is up to the manufacturer and they will need to record this in the risk management file.

Choosing a power supply with only MOOP you would have to ensure that other isolation schemes are in place between the output and the patient if the equipment is to come in contact

with the patient. It complicates the design and adds cost even though the cost of the MOOP power supply might be less than an MOPP power supply. No matter whether MOOP or MOPP is chosen the standard still requires that the leakage current requirements are met. For the power supply this means 300uA in the US and 500uA for the EU. As most power engineers know if one has to modify an ITE power supply to achieve these lower leakage current levels then the emissions will be impacted and additional filtering will most likely be required to be added to the equipment. From our standpoint at XP Power, we believe that the power supply for a medical device should provide the highest degree of protection and reduce the risk of a shock hazard. Therefore we made the decision to design our power supplies to have 2 x MOPP from input the output (mains to low voltage dc). This gives the customer flexibility and assurance that they have minimized the risk of a shock hazard.

Another significant change that the 3rd edition introduces is that equipment manufacturers must now follow a formal risk management procedure that follows the ISO 14971 model, which effectively means compliance with a process standard as well as the fundamental product standard.

XP Power believes that in any medical application quality is the most critical component. To ensure our power supplies are of the highest quality, we use the industy’s most stringent derating guidelines, complete a full design verification test (DVT), use of only the highest quality components, and compile full DFMEA reports for each medical power supply that we design. We also have a full offering of BF (Body Floating) and CF (Cardiac Floating) rated supplies

www.xppower.com

How a Dynamic Bus Voltage Architecture Cuts Energy Consumption in ICT systems

Advanced digital power control can dynamically change the power envelope to meet different load conditions

By: Patrick Le Fèvre, Ericsson Power Modules

Using Dynamic Bus Voltage (DBV) technology reduces board level energy usage at times of both high and low data-traffic demand in ICT systems. Energy savings from 3% to 10% are achievable. The European Commission DG INFSO (Directorate General – Information Society) estimates that communications network energy consumption will reach 35.8TWh in 2020, up from 21.4TWh in 2010, if 'green network technologies' are not adopted.

Every one percent energy saving will cut global ICT network energy consumption by 358GWh in 2020. The level of CO_2 emissions per GWh will depend on the energy source, and estimates vary, but coal-fired power stations may produce up to 1000 tons of CO_2 per GWh. The cost and environmental benefits of even modest improvements in ICT system energy efficiency are enormous.

Intermediate Bus Architecture (IBA)

The ICT industry adopted the Intermediate Bus Architecture (IBA) as a standard in 2003 and it now dominates in telecoms and other applications that need high availability.

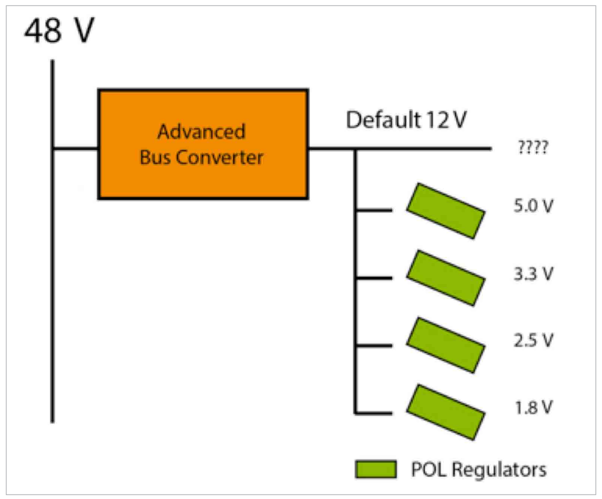


Figure 1: Intermediate Bus Architecture with 12V bus voltage and POL regulators

Intermediate Bus Converters (IBCs) convert a 48 VDC distribution-level power line to a typically static 12 VDC. The latter then feeds several non-isolated DC/DC Point-of-Load (POL) regulators, delivering 3V or below to power ICs, as shown in in **Figure 1**.

To maximize system-level power conversion efficiency there needs to be an optimal balance between the intermediate bus voltage and the load currents delivered from the POLs under differing conditions. Leaving the intermediate voltage at 12V is very inefficient low traffic conditions that result in low load. However, with advanced digital power control you can dynamically change the power envelope to meet different load conditions, adjusting the previously fixed 12 VDC intermediate bus voltage, reducing energy consumption, power dissipation, and cooling requirements.

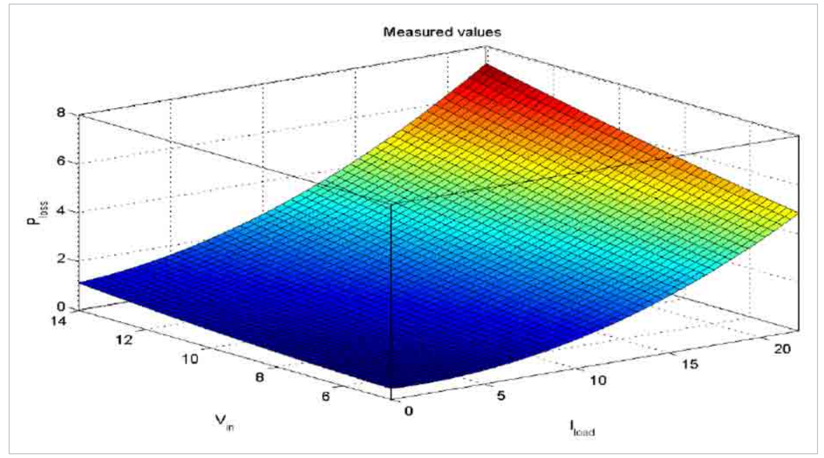


Figure 2: Graphing power losses resulting from setting a digitally controlled POL to 1.0Vdc output and ramping the load from zero to 20A, while stepping the input from 4.5 to 14Vdc

DBV in Practice

Early attempts at DBV using analogue components proved complex and costly to implement It is only recently that advanced digital converters have been introduced that offer on-the-fly programmability. The converter commands range from simple output-voltage adjustments to complex operations such as trimming the values of the digital filter that characterizes control-loop responses. The embedded functions within the digital controller IC simplify the implementation of dynamic bus control and simple PMBus commands perform complex measurement and control functions.

It is important to validate the potential energy savings by modeling a typical system before considering the implementation of DBV technology. Each IBC and POL in a system needs to be evaluated over at least the range of input voltages and output currents that they will experience in the end application. The power losses that result at each step are then recorded. Plotting these parameters against one another creates a three-dimensional graphical overview of each device's performance over the chosen measurement area, as shown in **Figure 2**.

The array of data points that build the graph come from the test results at each step. Evaluating the test results for each IBC and POL using the least-squares-fit approach builds a polynomial model of the corresponding device, which the Simulink environment can import and manipulate. Ericsson has built computer models of systems to explore the performance of alternative control strategies in maximizing the power savings delivered by dynamic bus voltage control, while ensuring that the system remains unconditionally stable.

The process begins by running an algorithm that derives a baseline power loss value. The first control cycle then starts, monitoring relative power loss until reaching a threshold value that triggers an optimization sequence.

Numerous iterations are derived from the complex algorithm but ultimately it drives the intermediate bus voltage to a value that minimizes power loss for the present conditions, then the sequence closes. The cycle repeats, each time minimizing power losses within constraints that include hysteresis to ensure stable triggering conditions for the optimization sequence. At the same time it ensures that the bus voltage does not fall below the level required to maintain regulation for the load current profile (see **Figure 3**).

$$P_{loss} = P_{Load\_HS} + P_{Load\_LS} + P_{L\_ESR} + P_{ripple\_LS} + P_{ripple\_HS} + P_{ESR} + P_{switch}$$

Figure 3: Simple theory of the power losses in a switch-mode power supply

A test system comprising an Advanced Intermediate Bus Converter supplying two 20A and four 40A digital POLs illustrates the efficiency improvement potential that results from dynamically adjusting the intermediate bus level compared

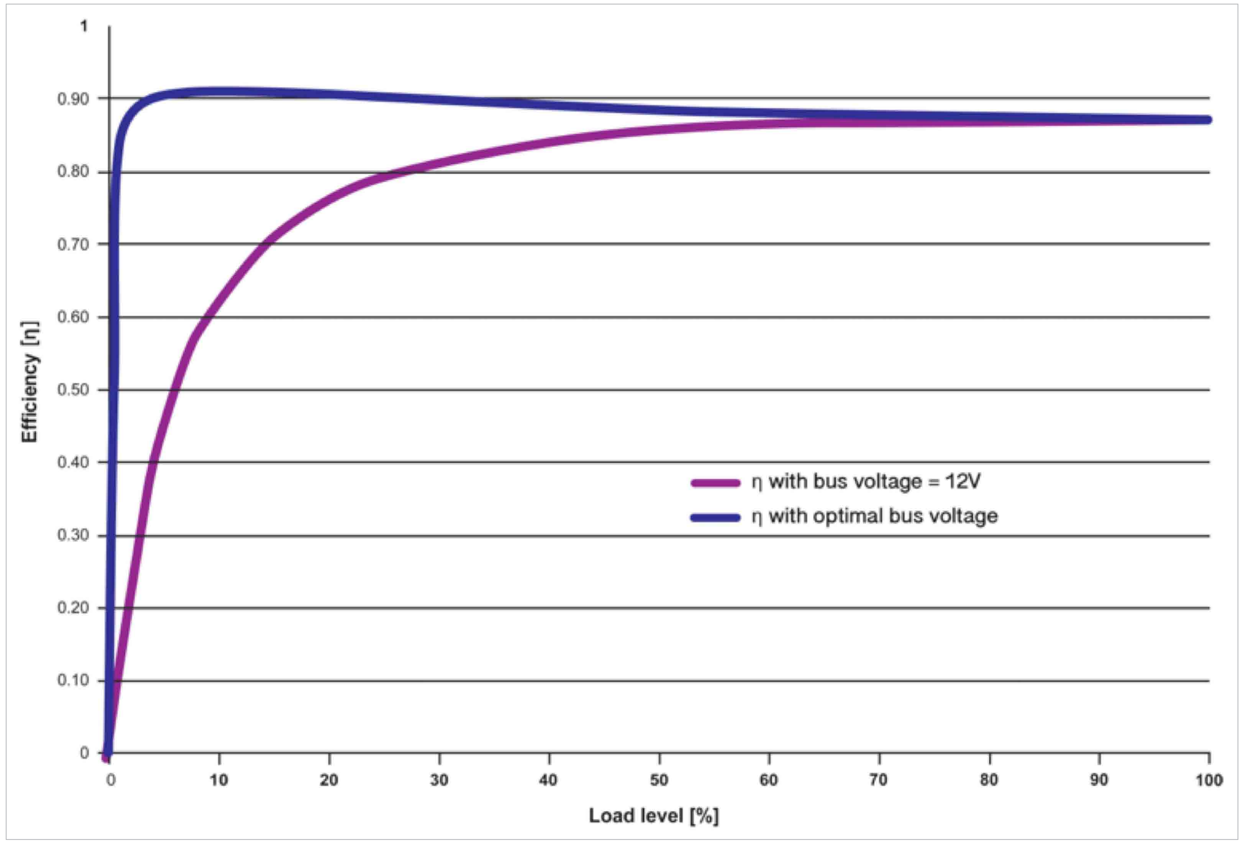


Figure 4: Improvement in board-level energy savings by adjusting bus voltage to suit the load

with a fixed 12 VDC level. Improvements are estimated at between 3 and 10%, depending on the average load per operation, as shown in **Figure 4**.

Simulation to Application

As data traffic levels have a profound effect on power consumption, DBV levels may be derived from traffic flow statistics. Here, controlling the bus voltage relies on lookup tables that reflect operational scenarios. The bus voltage falls as traffic levels fall and rises again with increases in traffic.

Systems architects can construct models to verify the accuracy of the profiles under consideration while they are compiling the lookup tables. They can then run a number of iterations that follow this sequence:

1. Simulate the power consumption that different load conditions create
2. Verify the simulation with hardware tests
3. Validate the simulation model or adjust it to optimize the profile

When the sequence is qualified, the profile is uploaded to the scenario library within a Board Power Manager, which controls the board's bus voltage, among other possible tasks. Tests then run under best- and worst-case conditions before final implementation.

Operational Sequence

Each application has unique scenarios, but these are the operational sequences that apply in this case study:

- Reference Scenario
- Compare data traffic with scenario
- Validate scenario
- Adjust bus voltage to situation
- Sense data traffic and compare with traffic in the network's neighboring cells
- Anticipate data traffic migrating from cell A to cell B

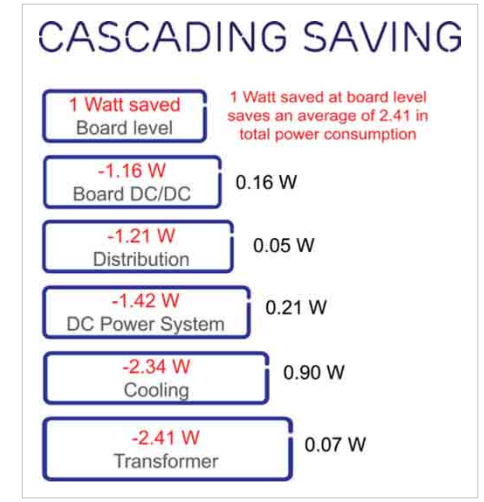


Figure 5: Power Cascading Effect

- Adjust bus voltage
- Sense and detect abnormal events
- (If Yes) Adjust bus voltage to priority High
- (If No) Adjust to local traffic scenario
- Repeat the sequence

This dynamically adjusts the intermediate bus voltage to the optimal level, while always delivering maximum power as a priority, in case of abnormal events or upon a specific user command.

In what is known as the 'power cascading effect', shown in **Figure 5**, every Watt saved at the board level delivers an average saving of 2W to 3W at the system level. The ratio depends upon several factors but the effect has been confirmed in practice.

In Summary

Dynamic optimization of the voltage delivered by a master DC/DC converter to a series of POL regulators has been made possible by advanced digital power techniques. These techniques directly enable reduced power consumption. However, the ability to optimize converter performance on-the-fly and adjust the intermediate bus voltage to match load conditions are just two of the many opportunities for energy savings made possible by digital power technology.

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Next-Generation Instrument Designs

Testing tools must support those working outside their "comfort zones"

By: Charles Cimino, Keithley Instruments

Since the recession of 2008–2009, many R&D organizations, including those within the green power and related industries, have had to become leaner and more efficient, just like their products. In addition to all the other cutbacks they've made, they are employing fewer dedicated test engineers with in-depth T&M training and experience, due to the compression of new product development schedules, the shift toward lean methods, and smaller design groups both in developed and emerging regions. Inevitably, that means there are fewer engineers on staff who are equipped to focus on ensuring test accuracy and efficiency and to support others on the team. For those who remain, that means new responsibilities related to characterization and test are being thrust upon them, tasks for which some are finding themselves somewhat unprepared to meet expectations.

These employees often find themselves forced to work far outside their comfort zones, that is, in areas others than those in which they were educated and/or acquired significant on-the-job training. For example, as power systems and supplies have grown more sophisticated, the people building and maintaining them increasingly need to use types of equipment that were previously used only by digital design engineers. Or, consider the designers of medical devices such as powered prostheses, which employ electric motors and drive controllers. Although these designers often hold degrees in biomedical engineering, they might need assistance on the finer points of characterizing these devices. Some of today's high precision instrumentation users may not have backgrounds in electrical engineering but instead trained in a different discipline, such as materials science, mechanical engineering, quality control, electrochemistry, physics, etc.

The non-traditional test instrument users

Here are some examples of these types of non-traditional test instrument users in fields related to power systems design:

- Materials scientists responsible for developing high-power advanced semiconductor materials and compound semiconductor materials for next-generation semiconductor devices
- Electrochemists involved in the design of new fuel cells; photovoltaic materials, cells and modules; lithium-ion batteries; and other power generation and conversion devices

In order to do their jobs, these non-traditional users need tools that can deliver accurate measurements quickly and easily without requiring them to navigate their way through the complexities common in traditional analog and digital instrument interfaces. To address the needs of this growing segment of the market, instrumentation manufacturers are beginning to employ some interface strategies from the consumer electronics world, such as smartphones and tablet computers.

Users Who Wear Many Hats

For engineers taking on multiple new test and measurement responsibilities, minimizing the time and effort required to get accurate, usable test and measurement results is critical. Time-pressured users simply don't have the leisure or the inclination to refer to the manual every time they need to change a setup or make a measurement. They want setting up, acquiring, and evaluating the results from all measurements to be virtually instantaneous; if they have questions, they want answers at their fingertips, not buried in a manual. To address the inherent challenges of this new category of users, instrumentation designers are beginning to offer touchscreen-based precision test instruments that are intuitive to understand and use. When problems arise, these interfaces offer on-line help and debug capabilities, minimizing the need for manuals or external guidance (see **Figure 1**).

Figure 1: Keithley's Model 2450 SourceMeter SMU has a high-resolution capacitive touchscreen

Keithley's Model 2450 SourceMeter® SMU is presented as the industry's first precision source measure unit instrument with a high-resolution capacitive touchscreen. The five-inch, full-color, 800x480 pixel screen allows for intuitive measuremen configuration, as well as numerical and graphical display of results. The touchscreen also provides context-sensitive help.

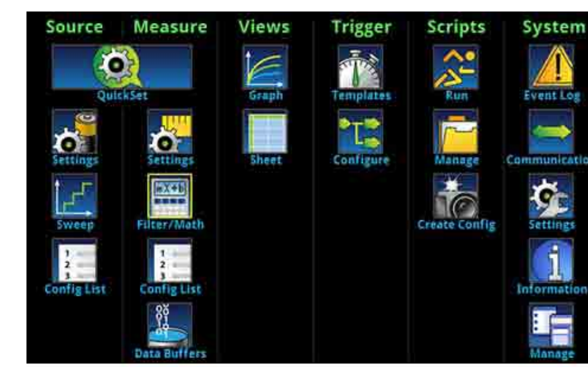

Figure 2: Touchscreen interfaces can help engineers use configuration and display functions quickly

Touch, Test, Invent

Touchscreen interfaces offer multiple advantages for test and measurement instrumentation. Anyone who owns a smartphone (as do more than half of all American adults) or a tablet computer (roughly one-third of all American adults) already knows how to control a touchscreen device. Touchscreens quite literally put interactive control at the user's fingertips. Rather than forcing engineers who are juggling new responsibilities to configure measurement functions using cumbersome, multilayer menu structures and confusing multi-function buttons, the newest benchtop test and measurement instruments with touchscreen GUIs offer the simplicity of flatter menu structures. Screen "clutter" is minimized by displaying only the options relevant to a specific function (see **Figure 2**).

By replacing complicated multifunction buttons and complex menu structures with on-screen icons, touchscreen interfaces can help engineers to find and access the measurement configuration and display functions they need quickly. By minimizing the need for extraneous buttons and options and showing only those controls needed to perform the function desired, touchscreens can greatly simplify the user experience for test instruments just as they have done for mobile consumer devices. In addition to presenting simple graphical icons for configuring measurement settings quickly, touchscreens offer the user the flexibility of displaying test results numerically and/or graphically.

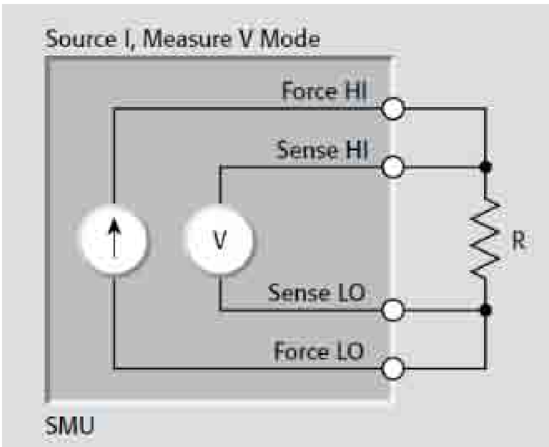

Figure 3: SMUs can measure resistance using the 4-wire method

Source Measure Units in Power Systems Design

As their name implies, source measure units (SMUs) combine current and voltage sourcing and measuring functions in a single instrument, as well as sweep capabilities. Although SMUs are widely recognized for their ability to force and measure I-V curves on linear and non-linear electronic devices like semiconductors, the highly configurable resistance measurements they offer can be critical in power systems design applications.

One of the most useful capabilities of Keithley's Model 2450 SourceMeter SMU Instrument for power systems design applications is the controlled source ohms mode. By default, this mode provides DMM-like operation, forcing a constant current through the unknown resistance and measuring the resulting voltage and computing the resistance value (see **Figure 3**). Built-in QuickSet modes allow configuring basic functions, including resistance measurements, with a single touch. SMUs can measure resistance using the 4-wire method, which eliminates offsets due to contact and lead resistances.

Figure 4: All the controls needed to configure a measurement function are accessible through the same screen

Figure 4 shows measurement results when the instrument is in 4-wire ohms mode, on the 2Ω range (auto-range with a 4-wire short installed), sourcing 100mA of current. Noise filtering, relative measurements, NPLC (number of power line cycles, which allows adjusting the tradeoff between speed and accuracy) and measurement resolution functions can be accessed via the on-screen controls. To minimize complexity, controls for functions that aren't relevant to a specific mode of operation don't appear on the bottom "swipable" control panel.

Sub-milliohm resistance measurements are often required in applications such as RDS(ON) measurements for power MOS semiconductors, precision current shunt measurements for current sensing circuits, switch and relay resistance measurements, etc. SMU instruments with very low source noise and extended low voltage measure range provide the low ohms performance power switching and monitoring applications demand. An offset compensation mode, which cycles the current source on and off and captures the difference in voltage across the unknown resistance with and without the current on, is useful for cancelling any thermoelectric EMFs that might create apparent resistance errors at low levels. A manual ohms mode provides direct control over the instrument's source and measure subsystems for applications that require setting the source current to a specific value.

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Advanced LED Drivers for Automotive Instrument Clusters

Increasing complexity in automotive instrument clusters raise the pressure on LED technology

By: Raimund Wagner, ROHM Semiconductor Europe

The usage of LEDs in automotive applications continues to grow due to their longer service life and lower power consumption. Simultaneously, the diversity and size of integrated state-of-the-art instrument cluster displays and in parallel the increasing complexity of automotive instrument clusters increase the demand in the LED technology. No longer, it is sufficient to only "drive" the LED with discrete components.

What is really needed is a precise and constant light output for the different LEDs while dimming and varying brightness of the LEDs are in place as well, for example, to respond to different ambient light conditions. Demanding automotive environment also require several protection circuits and diagnostic functions in order to prevent a complete failure due to a single component in the fault state. Moreover, the fact that more and more performance has to be accommodated in a small space puts high demand onto the electronic circuits. And ultimately, a technological solution should also satisfy the different requirements of the automotive manufacturers, for example, in terms of color scheme, and provide the appropriate versatility and design options.

Following below, the article will describe ROHM's technological approach of a 12-channel LED driver solution which provides an ideal answer to these new requirements and which is ideally suitable for applications including a large number of LEDs such as automotive backlight applications.

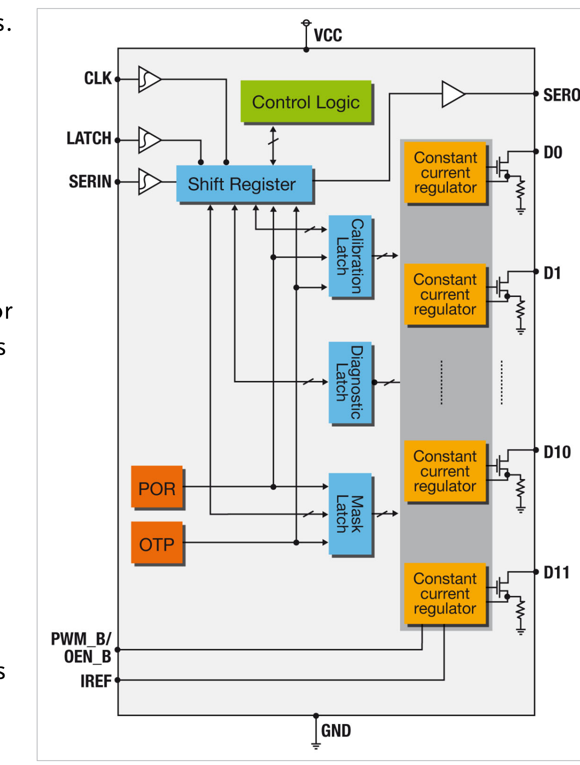

Figure 1: BD18377 block diagram

LED driver can be developed in a way that they provide a combination of serial and parallel LED control in order to address displays in instrument clusters, specific panels as well as panel elements in the center console such as air conditioning and radio. Components with this feature offer developers the flexibility to drive LEDs in various applications with a single driver and therefore save development and qualification time. Such highly integrated LED drivers have many advantages over simple current limiting circuits, as they reduce the need for external components and take up less space on the PCB.

ROHM has developed an LED driver which includes twelve constant current drivers in a single chip to control a large number of LEDs, a 6-bit per channel power calibration, and a global PWM brightness control as well as diagnostic functionality. Combined with the ultra flat RGB LEDs of the SRGB series the AEC-Q100 qualified device in a compact HTSSOP20 packaging offers a complete solution for automotive clusters (see **Figure 1**).

The first requirement for the LED power management is to provide constant current with high accuracy at the outputs to avoid fluctuating supply voltage and different LED VF values as well as different influences on the LED current and thus unwanted brightness variations.
ROHM addressed this via a three-channel serial input (Serial-in, clock, latch-in) that controls a total of twelve driver channels to drive multiple LEDs with an output current of 15 to 50 mA per channel. The regulation of the maximum current is done via an external resistor. If additional power is needed, multiple channels can be activated in parallel. Via the serial interface register settings can be read too in order to verify the settings at any time. This way, the driver can also address the built-in diagnostics functions. It also enables the detection of open or shorted connections (faulty LEDs) and to take appropriate countermeasures in order to prevent the failure of the entire system.

Similarly, a too high temperature on the chip can be detected as well. If the temperature rises above 125°C, a warning indicator is set within this solution while the chip remains fully functional. However, measures can be taken (for example the reduction of the brightness of the global PWM dimming) to prevent that the temperature is further rising. In such a case, multiple LED drivers can communicate with each other by means of a proprietary communication line to reduce the performance. In case that the temperature still rises, a power-on reset is conducted when it exceeds 150°C in order to protect the chip from irreparable destruction.

The BD18377 device also sets new standards when it comes to output current accuracy. At 30 mA, an accuracy is achieved of

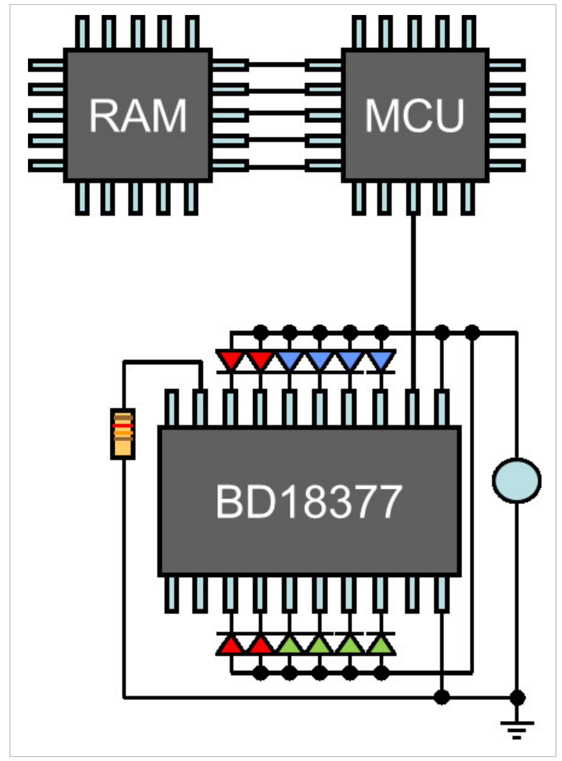

Figure 2: Example application with four red, blue and green LEDs

+/-2.5% from channel to channel (of one device) as well as of +/-1,7% between two different devices. The brightness of each LED can be individually adjusted via current control, calibrating from 1,6% up to 100% (6 Bit). Additionally, a global calibration of 0.1% to 100% is possible via PWM. Thus, LEDs with different brightness from different binnings can be deployed without having these adjusted to different resistor values. Only the register settings must be adjusted to the deployed LEDs. This way, subjective differences between LEDs featuring different colors can be regulated as well (see **Figure 2**).

Advanced dimming

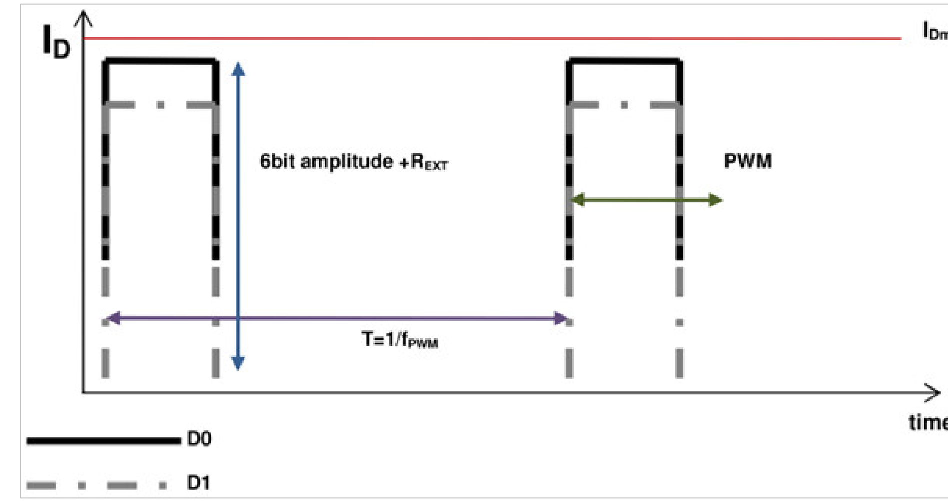

Figure 3: Calibration and dimming of the output current

The latest panel specifications define a brightness range that starts at very low light intensities, and can be widely scaled. Moreover, in order to implement different RGB color combinations, each LED must receive a dedicated dimming signal which can be set separately.

Figure 3 shows the calibration and dimming of the output current and the ratio of these two settings. The maximum current I_{Dmax} is adjusted via an external resistor Rext. The adjustment of the calibration bit changes the current value of the associated channel while the duty cycle in all active channels is simultaneously regulated through the PWM input. The PWM input is completely independent of the clock signal.

The use of a "PWM Control CR timer" block in addition to the switching regulator enables the adjustment of the modulation frequency and the duty ratio for a given product at a fixed resistor capacitor combination. The time required for the design is in this case reduced by the ability to use a single product platform. This way, less expensive (and overall less) devices can be used for the design.

In the given example, D0 and D1 are calibrated at a value below the maximum current, and D1 has set a lower current than D0. As indicated, the brightness of both channels can be simultaneously influenced by the PWM signal. Due to the fact that the defined current value and the duty cycle are independent of each other, it is ensured that the calibration of each of the channels does not affect the dimming curve and that no clang delay occurs. The propagation delay during the rise and fall has the same sizes and guarantees the linearity between input and output.

Diagnostics and reliability

High reliability in automotive applications is indicated by the need for protection circuits against over voltage, under voltage, polarity, overcurrent, short circuit and heat. Particularly overheating - especially in case of excessive system voltage - is a challenge in LED solutions due to the dependence of the current from the supply voltage. The voltage in cars ranges from a normal operating voltage of 9V to 16V (normal is 14V) to load the 12.6 battery. In addition, one has to consider extreme conditions such as inverse polarity protection up to 12V, jump start aid conditions with continuous double battery voltage (+24V) to failures such as load dump / over voltage which occurs when the battery is disconnected from the generator while the engine is running, as well as other power transitions. An undamped load drop may take several hundred milliseconds and easily exceed 80V but nowadays, many manufacturers have centralized limiting circuits for a load drop and therefore demand that components resist transient voltages of a range between 60 or 40V.

In order to meet the specifications of car manufacturers in terms of warranty requirements which may last more than 10 years, the BD18377 offers several features for system protection. Hence, shorted and open circuits are detected which could lead to high currents and voltages at the LED output. The extensive diagnostic functions can identify errors and can be read by the microcontroller. This allows corrective actions to be taken to prevent the destruction of individual components. Doing so, the reliability of the cluster can be increased significantly, and an expensive replacement of a complete system can be avoided in terms of cost minimization.

Summary

The presented LED driver - in combination with the SRGB RGB LED series - provides developers a complete solution for the energy-efficient and reliable lighting of vehicle clusters in a small, compact packaging and is also compatible with other device series. With its built-in protection functions it meets the demanding industry standards and stringent purchasing specifications of the automotive industry. The multi-channel configuration also allows the usage for various functions. The built-in communication features enable the individual adjustment of LED currents and voltages as well as protection functions which are different from one application to another. This facilitates the design of a consistent platform solution. ROHM will continue the development of multi-channel LED drivers featuring integrated communication capabilities to further drive these integration possibilities.

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Considering COTS connector solutions for solid-state lighting design:

Connector selection, a significant design challenge, is often and mistakenly taken for granted

By: Tom Anderson, Connector Product Manager, AVX

Now that the color, quality, and cost issues often associated with early solid-state lighting technologies have been addressed and overcome by so many leading manufacturers, consumers are adopting it at an ever-increasing rate. As a result, the market for SSL luminaires has expanded dramatically in recent years. Designing SSL luminaries poses several challenges for engineers and, throughout the industry, a great deal of effort has been put into solving challenges such as: selecting the right LED, integrating the best optical solution, choosing the best driver, and maximizing thermal management. However, connector selection, another significant design challenge, is often and mistakenly taken for granted.

Considerations for Connector Selection

Cost and size have been the driving factors behind connector selection in most SSL luminaire designs. However, although these factors are important and do affect the ultimate success of end products, there are several other factors that engineers should consider prior to specification. Operating at elevated temperatures in harsh environments requires careful connector selection if the design is intended to last. Consequently, engineers need to dig deeper into the design and construction of connector options, considering each connector's contact material, contact plating, plastic selection, and ease of use during assembly and disassembly.

A few of the questions design engineers should consider when specifying connectors for SSL luminaries include: Which connectors have the best materials for high-reliability performance and a long useful lifespan? Which connectors provide the desired mechanical stability and meet the current requirements of the device? Would a small, sleek connector or a large, robust one better suit the design? And, of course, does the connector solution meet the customer's cost targets? Such questions are critical when designing SSL luminaires, as each unique design can necessitate the prioritization of different parameters.

COTS Connector Solutions for SSL Applications

SSL luminaires demand high-performance, high-reliability connectors capable of supporting the efficiency and long lifespan of these devices. An abundance of commercial off-the-shelf (COTS) connectors that meet these two requirements are available across a broad range of price points. However, many (if not most) of these existing connector solutions are not ideal for use in SSL designs.

Although a host of COTS high-reliability connectors may be adequately durable and resistant to heat, the fact that they weren't developed with the specific needs of the SSL industry in mind typically results in their only meeting a portion of the specifications desired in today's continuously evolving lighting designs. As such, specifying COTS connectors that were developed years ago for either a different market, or even an earlier iteration of this one, often requires design engineers to make concessions regarding mechanical or electrical performance, size, and/or cost.

For example, if an SSL design requires a high-reliability wire-to-board (WTB) connector capable of handling high current (up to 10A), compatible with automatic placement, and able to withstand the harsh environment of an SSL luminaire, a surface-mount insulation displacement connector (IDC) like AVX's 9176 Series IDC would suffice. Providing a high-reliability, gas-tight, WTB termination that is resistant to automotive levels of temperature, shock, and vibration, the 9176 SMT IDC would meet the current, placement, environmental, and reliability requirements of the design but, having initially been developed for harsh automotive and industrial applications, would not be the most size- or cost-effective solution possible.

Consequently, as consumer adoption of solid-state lighting continues to expand and LED technology continues to advance, SSL design engineers are beginning to turn to the connector industry with increasing frequency in search of specialized solutions.

Specialized Connector Solutions for SSL Applications

In response, a number of components manufacturers have begun to develop connectors that are not only specifically designed to provide engineers with performance specs tailored to the unique environmental and reliability demands of SSL applications but that also, through critical materials selections or design configurations, attempt to satisfy the cost vs. performance outcome that is such a critical concern for SSL engineers. Achieving the ideal combination of these parameters isn't easy, though, especially for components manufacturers that remain focused on designing traditional connector solutions.

Utilizing input from myriad SSL engineers seeking COTS solutions for what initially appeared to be custom applications, a team of innovative design engineers at a leading global interconnect manufacturer closely examined the broader SSL market and was able to identify several common requirements among the disparate requests. In general, SSL designers require smaller, more cost-effective connectors that are just as capable of handling high current, as compatible with automatic placement, and as easy to assemble and disassemble as standard connectors – a discovery that has enabled the interconnect engineering team to develop more than 25 unique new COTS connectors designed specifically for SSL applications since the beginning of the LED revolution.

Challenge/Solution: Developing COTS Connectors for SSL Applications

Although the performance and cost requirements for SSL connectors are fairly standard across all applications, the various types of connections necessitated by certain designs require an equally varied assortment of connector architectures capable of fulfilling said requirements. For example, one of the primary interconnect challenges in linear LED strip lighting is coplanar board-to-board connection, which is typically achieved using hard soldering or connectors. Hard soldering the boards together tends to meet the cost model in low labor rate markets, but is a manual – and therefore time-consuming and inconsistent – process that doesn't allow for quick and easy PCB disconnection. As such, SSL designers typically prefer to use connectors, which enable quick and easy PCB assembly and disassembly. However, due to the size and budget constraints typical of most SSL applications, existing connectors are often too big for and/or fail to meet the cost targets of SSL designs. Similarly, SSL applications utilizing wire-to-board connections often require different connector architectures than board-to-board solutions and must not only meet the general cost and performance specifications for SSL applications, but must also be made available in several iterations compatible with a range of standard AWG wire sizes.

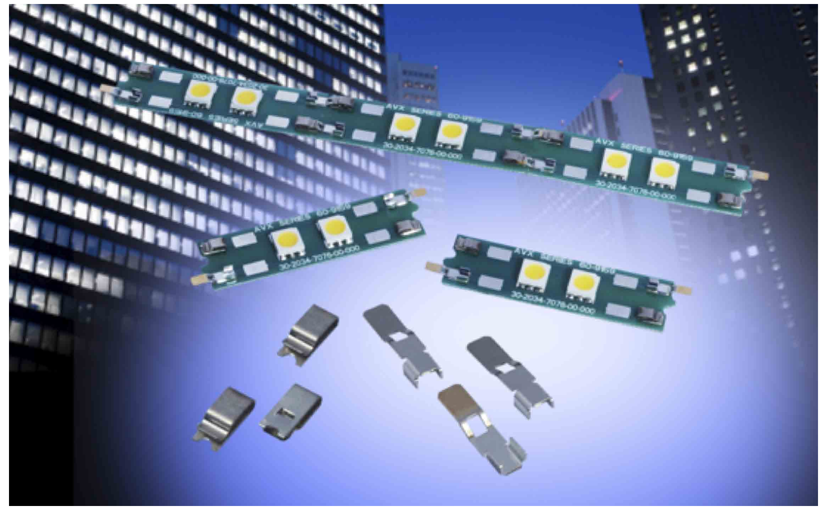

Figure 1: AVX's 70-9159 coplanar contact system

Faced with the challenge of designing unique new SSL connector solutions for these very applications, that same inventive design team broke the problem down to its most basic elements. Knowing that the critical functionality of a connector is concentrated in its contact, the team pushed itself to think well beyond the boundaries of existing solutions and status-quo connectors and challenged itself to create a single contact solution that functions just like a connector during the mating, un-mating, and wire termination processes. As a result, the team successfully developed several stripped down, insulator-less connector solutions capable of providing SSL designers with all of the critical functionality of a connector, but without the cost of the insulator and assembly, effectively satisfying the SSL industry's performance and cost targets.

For the linear LED strip lighting application, the team developed an innovative, insulator-less coplanar contact system (see **Figure 1**) that allows LEDs to be placed in the center of the PCB, effectively minimizing LED pitch densities and maximizing light output, and contacts to be individually placed on the outer edges of the metal core or FR4 boards, effectively utilizing what is typically free space. Designed with a compression beam on the horizontal plane to absorb maximum X- and Y-axis assembly tolerances (1mm on each axis), compensate for placement errors, and optimize final lateral PCB alignment, the novel contact system also has a minimal 1.2mm Z-axis height, which enables it to be placed close to LEDs without impacting light output. Featuring gold-plated phosphor bronze socket contact and gold plug contact with tin tails, the 70-9159 contact system provides maximum contact and signal integrity both in the harsh environment and over the long lifetime of the LED fixture. It also meets the required 5A, 125°C, and automatic placement performance specifications and is capable of supporting both board-to-board and wire-to-board applications.

For the wire-to-board application, the team was challenged to develop a connector solution capable of supporting the high power (up to 20A) and ground requirements of up to a 12AWG solid or stranded wire while still satisfying all of the general SSL connector requirements with regards to size, cost, power, placement, and ease of assembly and disassembly. In response, the team created a unique surface-mount, closed-box contact system (see **Figure 2**) that provides simple, reliable poke home wire insertion and maximum wire retention with dual opposing high spring-force contact beams. In order to function like a connector, the box was designed with top and bottom contact tines that guide a stripped wire into the center of the contact zone and an integral end-stop to ensure proper insertion depth. There, the dual contacts mechanically hold and make constant electrical contact with the wires. In addition to facilitating wire guidance and high force retention, the novel, single-position, 9296 closed-box contact also features an enhanced solder pad for maximum mechanical stability on the PCB, enables easy twist-out wire removal, and is packaged on tape and reel for automated SMT placement. Effectively providing all of the benefits of a full-function connector in an insulator-free solution, mitigating both labor and materials costs,

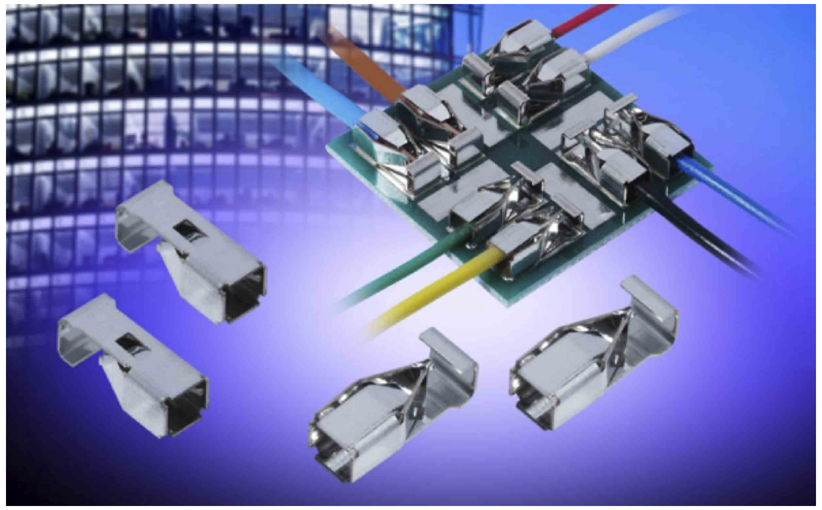

Figure 2: AVX's 9296 SMT single poke, dual-beam, closed-boxed contact system

as well as contributing to smaller and more cost-effective SSL designs, the 9296 SSL contact solution currently accepts 12-20AWG; a smaller 18-24AWG option is under development.

The team also developed a smaller and more cost effective single-contact iteration of its high-reliability, gas-tight, wire-to-board 9176 surface-mount insulation displacement connector (see **Figure 3**). Despite its stripped-down appearance, the 9176 contact makes no concessions with regards to mechanical or electrical performance; it is capable of handling high current (up to 10A), compatible with automatic placement, and able to withstand the harsh environment and match the extended lifetime of an SSL luminaire. Developed for SMT termination to the PCB, the singular SSL contact provides robust PCB attachment, supports 18-28AWG, and fulfills all of the standard SSL connector requirements.

Figure 3: AVX's 9176 IDC contact

Conclusion

Cost and size have long been and will continue to be driving factors behind connector selection in most SSL luminaire designs. However, there are several other factors that engineers should consider prior to specification, including: contact material, contact plating, plastic selection, and ease of use during assembly and disassembly, all of which are critical for high-reliability performance, mechanical stability, and a long useful lifespan. As consumer adoption of solid-state lighting continues to expand and the technology continues to advance, SSL design engineers will continue to turn to the connector industry in search of specialized solutions. In general, SSL designers require smaller, more cost-effective connectors that are just as capable of handling high current, as compatible with automatic placement, and as easy to assemble and disassemble as standard COTS connectors. However, these common denominators, while helpful for interconnect engineers, will never extinguish the need for the continuous development of innovative new contact solutions that both expand the industry's perception of connectors and provide SSL design engineers with ideal solutions for their cutting-edge designs.

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Solar thermodynamic power challenges traditional PV technology

Alternate solar technology could achieve up to 95% conversion efficiency

By: Scott Ludwig, Progea USA

In addition to photovoltaic systems to produce solar energy, another technology exists that can make better use of clean energy based on the principle known as thermodynamic solar power. Opened in October 2011, Gemasolar established the first commercial-scale solar power plant in Andalusia, in the region of Seville in Spain. This plant is capable of supplying electricity for 25,000 homes 24 hours a day by solar heating molten salt to over 500 °C.

Figure 1: The facility's 2, 650 mirrors reflect the sun's rays towards the top of the tower

The Gemasolar facility extends over a surface area equaling the size of 260 football fields, and is located along the motorway, which links Seville with Cordoba. The power plant's technical director, engineer Santiago Arias, stipulates that this photovoltaic power plant is the only one of its kind in the world that carries on working even when the sun has set. The photovoltaic panels used in the power plant are not those that convert sun light into electric energy but concentrate and use the sun's thermal energy.

The plant's structure consists of a forest of gigantic panels positioned around a big tower in the center. About 2, 650 mirrors reflect the sun's rays towards the top of the tower (see **Figure 1**). To maximize the concentration of solar energy, each one of the 110 square meter heliostats (mirrors) automatically follows the sun's movement from dawn to dusk in the same way sunflowers do. In the top of the tower, with thousands of rays focused on it, the molten salt used (which is a mixture of 60% potassium nitrate and 40% sodium nitrate) is heated to 565 °C. Inside a heat exchanger water is circulated in the manner of nuclear power plants, with the intense heat of the salt producing steam to spin the turbines connected to the electric generator.

Figure 2: Molten nitrate salts flow through the 140-meter-high tower where they are heated to 565°C.

The sun heats the tower until sunset, but this does not impede Gemasolar in keeping the turbines running for another 15 hours. The concentrated energy from the mirrors should in theory be able to heat the salt to even higher temperatures, but in order to withstand such extreme boiling temperatures a more robust and expensive structure would be needed. The actual structure alone amounts to 250 million euro in investments.

Torresol, the company that established and manages this company, is 60% owned by Sener Grupo de Ingenerìa S.A. a Spanish engineering company. The remaining 40% shares are in the hands of Masdar, from the emirates of Abu Dhabi, who invest heavily in renewable energy. Gemasolar is capable of producing 400 MWh a day while running continuously at 20 megawatts. This is four times more than the facility planned for construction in Curbans in the Provence region of France, which has been designed to alternate between day and night and is sensitive to cloudy weather.

The Solar Thermal Power plant structure

This center features rings of mirrors in an array measuring 10 x 10 meters that reflect solar radiation onto a receptor on top of the tower in the center. The receptor exchanges energy with the molten nitrate salt flowing through the tower. The salt is driven from a 'cold tank' to the receptor located at the top of a 140-meter-high tower where they are heated to 565°C. (see **Figure 2**) The heated molten salt then descends to the heat exchanger to produce steam. When sufficient solar radiation heat has been received to create energy for power driving the turbines, the surplus salt is then deposited in a storage hot tank by the system. This heat produced by the salt is therefore stored and used when the solar radiation level is low so that electricity can still be produced when there is no sun. When needed the salt then transfers the stored heat and continues to produce electric energy. The stored molt salt can continue providing electric energy up to seven hours without solar radiation.

Solar: Photovoltaic or Thermal Power?

The thermo-electricity is therefore a particular type of renewable energy that exploits sun radiation. There are some fundamental differences between solar thermoelectric power technology and Photovoltaic technology: whereas photovoltaic technology converts solar radiation directly into electric energy, without generating and using the movement of mechanical parts, the solar thermoelectric power technology uses the thermal energy of the sun to heat a liquid to produce high pressure steam.

Another difference in thermoelectric is that unlike photovoltaic technology that can also work in cloudy weather conditions with filtered solar radiation, the solar thermoelectric needs constant and direct sun radiation. Therefore there are two essential aspects to enable relatively efficient energy production using this technique: first of all and most apparent, solar thermoelectric plants need to be built in semi-arid areas to ensure that they are fully and constantly exposed to the sun.

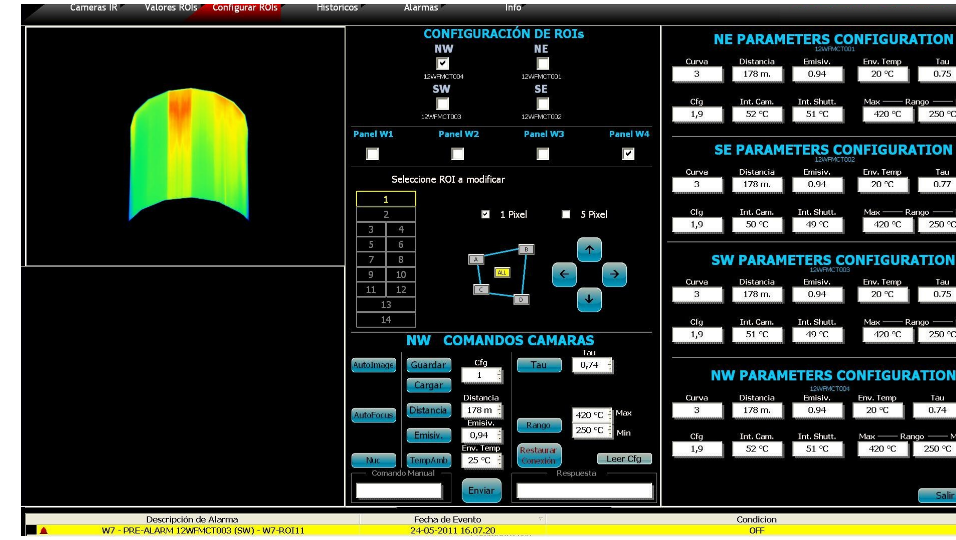

Figure 3: Movicon 11 includes alarm management for retrieving temperature data in realtime

Secondly, it is very important how the fluid is exposed so that it does not disperse heat easily: for this reason a specialized fluid has been developed to maintain its boiling hot temperature once heated to over 500 degrees for several days, without contact with the energy source.

This system can enable around 95% exploitation of the solar spectrum and represents a new frontier in the search for alternative energy. To guarantee that the system works correctly and to improve its efficiency, an innovative technology has been set up and deployed by Infraservice Srl, which uses thermographic detection by managing data in a supervision and control system based on the Movicon 11 Scada technology. Infraservice S.r.l is a young and dynamic company operating in the thermography applied to industrial automation sector.

To begin, Infraservice has engineered the use of a Scada system with a thermo camera obtaining optimum results and positive response from the market within which the company operates such as pharmaceutical, chemical, cement and die manufacturing with the assistance of the technical support which comes with the Progea products. The innovative approach used in applications has gained optimum results in industrial automation by offering solutions based on captivating and modern graphics with userfriendly interfaces that are greatly appreciated by clients for their simplicity-of-use.

The system designed for Gemasolar is composed of 4 thermocameras (640 x 480 pixels) mounted on poles in the four cardinal points. These thermocameras are connected with each other in fiber optic gigabit ethernet. The thermographic images are collected and processed at a frequency of around 30 Fps (frame per second) in real-time by the Movicon Scada Software residing in the control room and connected to the thermocameras using the Ethernet network.

Thermal data acquisition

By means of analyzing the thermographical images, retrieved from the thermographic cameras, the application created with Movicon, transfers the information concerning the temperatures of all the receptor surfaces highlighting eventual thermal anomalies that might cause serious damage to the structure. The retrieved information on temperatures is sent to a PLC, which relays it to the mirror control system. This system then regulates the inclination of each mirror to correctly radiate homogeneous temperature to the receptors placed on the central tower.

Movicon in the energy sector

Supervision, monitoring and control with Movicon 11 includes alarm management for retrieving temperature data in realtime while displaying trends on recorded temperatures with the ability to set a series of settings and commands to transmit to the four thermocameras. Each thermocamera has been configured using the 56 ROI thermographic software (Region of interest) with which the Maximum, Minimum and Average temperatures are measured in realtime for each camera. These values (672 temperature values altogether) are processed by a datalogger and displayed in the Trend Historical screen pages. In addition this data is sent to the PLC using the TCP-IP Modbus communication. This supervision application also manages alarms on the retrieved temperatures, displays Trends on recorded temperatures and provides the ability to set a series of settings and commands to transmit to the 4 thermocameras (see **Figure 3**).

Leading the industry by installing solar thermal power with 432 MW in early 2010 in Spain, the company has recently setup operation in the U.S.A by installing the equivalent to 422MW in solar thermal power at the beginning of this year.

Conclusion

It can be reaffirmed that the solar thermal power technology developed by Professor Rubbia, offers great advantages in the field of energy production from ecologically sustainable and renewable sources. The supervision and control technology implemented by Infraservice exploits the capacity to retrieve thermal data to ensure system efficiency and safety, simplifying the automation system and application of field components. Movicon has not only proved particularly effective for this application but also for other types of thermographic detection applications in various industries.

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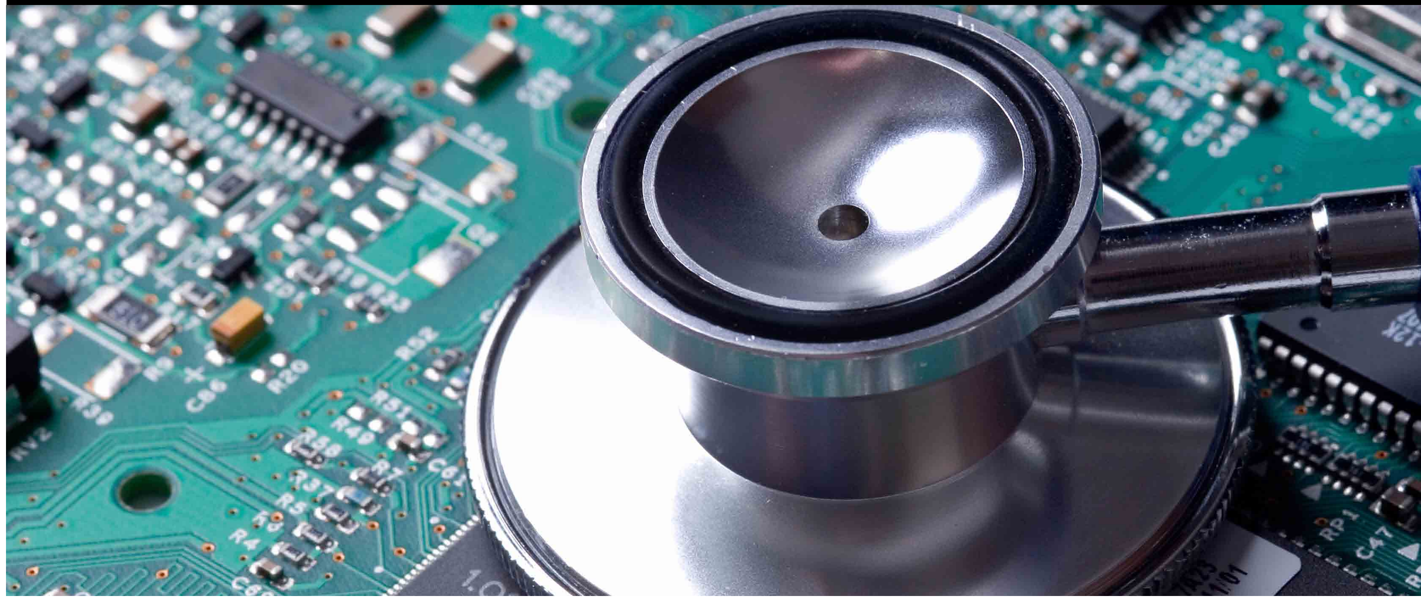

Inside:

Power Management in Health Care Applications

Medicine's high level of innovation is fueling the need for new health care electronics

By: Frederik Dostal, Analog Devices

Different health care applications require different power management solutions. From a power management view, health care is a very interesting market. Though design cycles within health care are quite long, a high level of innovation is fueling the need for new health care electronics. These do not only replace older apparatus but are used in new markets and applications which did not exist a few years ago. This article will look into four different health care application areas. They are home health care, instrumentation, patient monitoring and imaging. Power management solutions are discussed for each individually.

Home Health Care

Within home health care we see vast design activity. The global pressures of aging societies, growing economic strength, and technical innovation have led to many new applications for home health care. The benefits for patients include increased flexibility, better services, and possibly fewer trips to the doctor. While home health care has

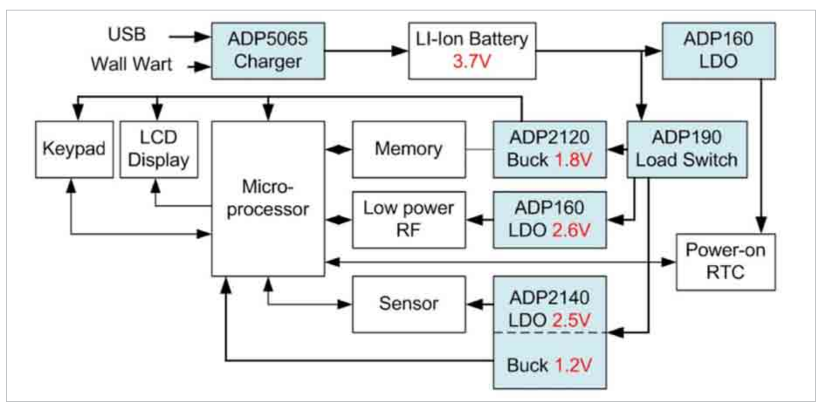

Figure 1: Typical power chain for portable battery powered home health care device

been around for quite some time, only recently do we see more and more advanced solutions available to consumers. Examples of such solutions are monitors for activity, blood pressure, and heart rate. In addition, portable blood analyzers and pulse oximetry systems are included in today's home health care.

From a power management perspective all these systems require a high level of integration due to the necessary portability. High power efficiency is needed for systems which are truly portable and thus battery operated. Here lower power consumption will increase the operation time of the device without recharging or replacing batteries. Lastly, one important specification is also the cost. While in some other health care applications the cost of a power management solution might not be a key specification, in home health care it is. Here cost constrains come close to what we see in the consumer electronics market.

Figure 1 shows a power chain for a rechargeable system utilizing a lithium-ion battery. The power architecture ensures that some parts of the circuit can be turned off using a load switch such as the ADP190, while other circuitry, such as the ADP160 powering the real time clock (RTC) is always turned on. The ADP190 has a ground current lower then 2µA when turned on and the ADP160 only consumes about 560nA of supply current with no load. This keeps the permanent discharge of the battery at a minimum. The ADP2140 is a highly integrated buck switching regulator combined with a linear regulator. This power management unit is saving space and cost.

To charge the lithium-ion battery, advanced battery charging solutions such as the ADP5065 are available. This device is a very efficient switching mode charger which is especially suitable to medical applications due to its many error detection and safety functions. It is fully compliant with the USB 2.0, USB 3.0, and USB battery charging specification 1.1 and enables charging via mini USB VBUS pin from a wall charger, car charger, or USB host port.

Some lower cost portable heath care systems, which are only used for short amounts of time, might be designed around a non-rechargeable alkaline battery. For weight and cost reasons there

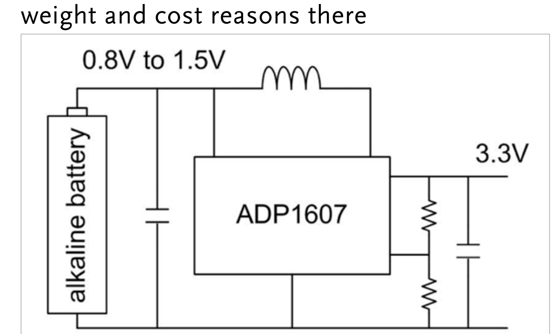

Figure 2: Powering a portable health care system with a single cell alkaline battery

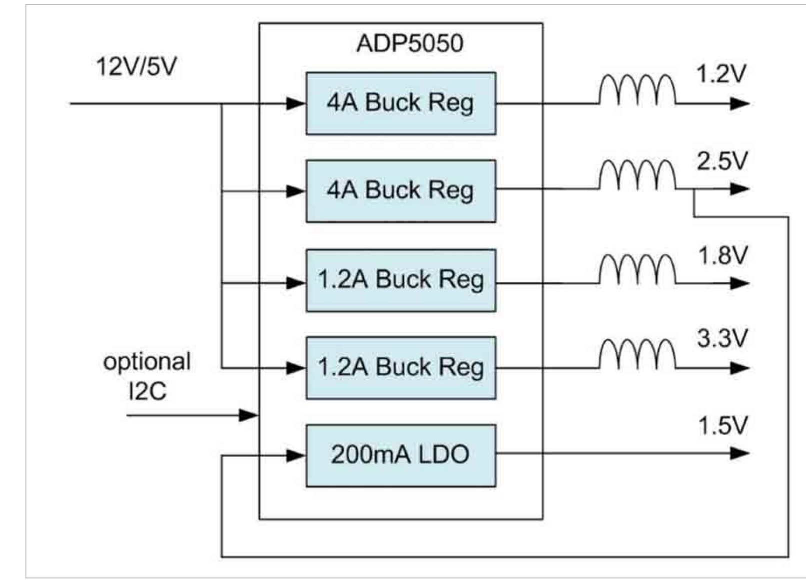

Figure 3: Micro Power Management Unit to provide multiple voltages and I2C connectivity

is a benefit when using only one battery cell than the common two cell setup. The difficulty of one alkaline cell systems is that the battery voltage is only in the range from 0.8V to 1.5V. To power the electronics, a boosting regulator capable of such low input voltages with high power efficiency is necessary. **Figure 2** shows the ADP1607 as a first power conversion step for such an application. It is generating 3.3V which is needed in most systems.

Instrumentation

Example applications in instrumentation are blood analysis, dialysis machines as well as clinical diagnostics. Instrumentation equipment is usually not portable. The power management requirements are not so much driven by the factors discussed in the 'home health care' section. In instrumentation we have usually more power available, thus power efficiency is not such a big concern. While a high level of integration is definitely a 'nice to have', it is often times not essential. What matters for instrumentation applications is very often low noise. Switching regulators as well as linear regulators need to be very low noise in order to allow for very high precision measurements.

Typically a silver box type AC / DC power supply is used to generate one or multiple intermediate voltages. These rails are then used to generate lower voltages.

Figure 3 shows a micro PMU (Power Management Unit). It is an ADP5050 which can operate of a 12V rail coming from the AC / DC power supply. This PMU includes four switching regulators as well as one linear regulator. While being compact, it also includes many desirable functions. Switching frequencies of the individual step down regulators are synchronized together and phase shifted for minimum noise on the input line and to enable small input capacitors. One unique feature is to be able to run two of the switching regulators at half the switching frequency of the other two regulators. This maintains a predictable low EMI profile while being able to use a higher switching frequency for a low power rail while using a lower switching frequency on a high power rail for highest efficiency.

Last but not least, there is an I²C interface available to dynamically change the output voltage, check chip temperature, set the phase shift of different channels, power good indication and enable of individual channels. These functions help intelligent instrumentation systems to monitor and control the power management.

Patient Monitoring

Systems in this category are clinical based. They are used to measure blood pressure but also in electrocardiography (ECG) and pulse oximetry systems. Here power management is usually line powered, thus power efficiency is not so important as long as dissipated heat can be managed. What really matters is reliability, galvanic isolation for safety

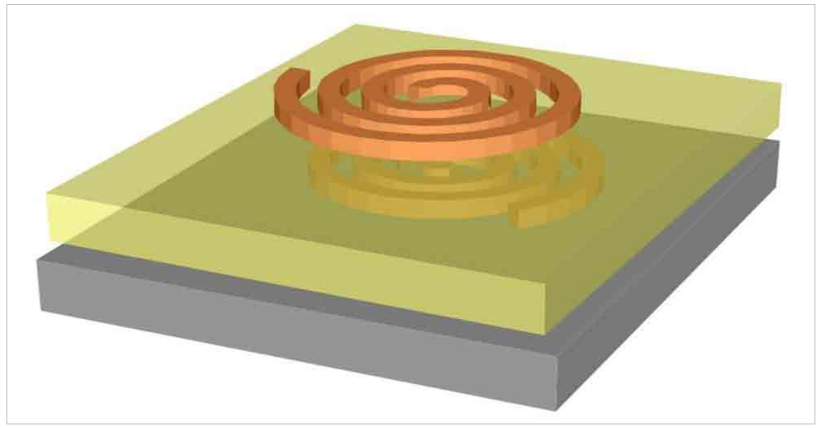

Figure 4: Concept of inductive digital coupling through an isolation barrier

purposes as well as low noise. For reliability, battery backup is sometimes provided. It is helpful when patients are transferred to different hospital stations and vital signs monitoring shall not be interrupted.

Isolation needs to comply to the most stringent medical safety standard IEC 60601-1. Digital isolation with Icouplers® is replacing optocouplers without compromising isolation integrity. The advantage is to avoid the aging effects of optocouplers for long term reliability as well as the availability of different semiconductor functions such as USB, I2C and power management switching regulators all in one package. These devices are capable of reinforced insulation and can withstand a 10kV surge as designated by IEC 60747-5-5. Icoupler products are using chip scale transformers which provide very robust common-mode transient immunity compared to optocouplers and capacitor based digital isolators. **Figure 4** shows the concept of inductive isolation. There are two inductors with an insulation barrier in between which consists of Polyimide, SiO2 or similar isolation materials.

Figure 5 shows a block diagram of a typical Icoupler device with Isopower functionality. Isopower

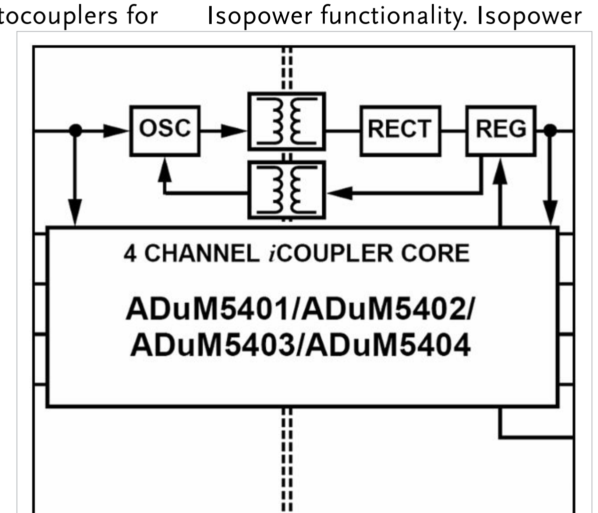

Figure 5: Picture of an Icoupler with Isopower for galvanic insulation

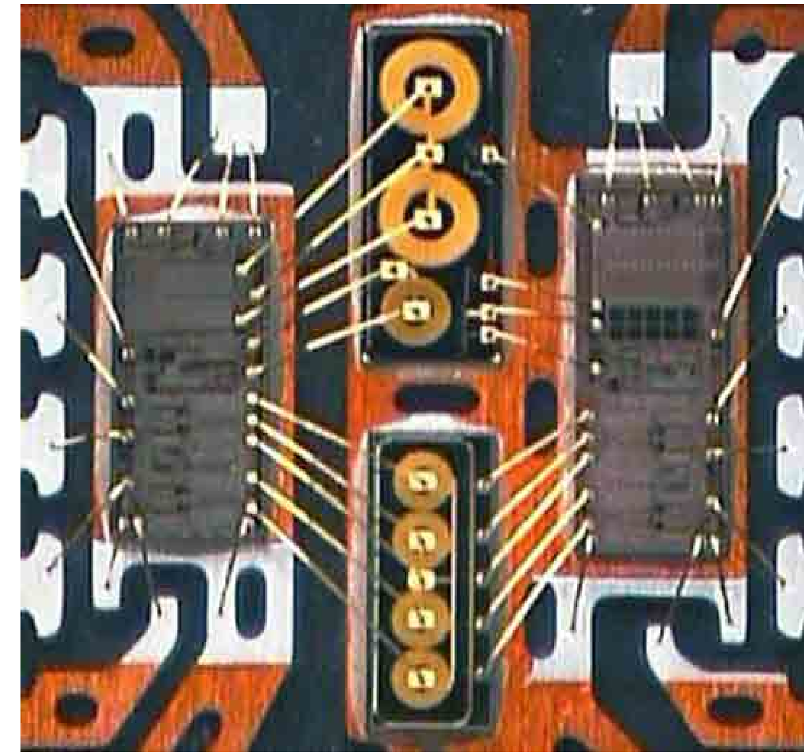

Figure 6: Setup of an Icoupler digital isolator with Isopower

is able to not only couple signals through an isolation barrier, but also power. The ADuM540x can deliver a total power of up to 500mW. Besides the coupling of power, the chip also integrates up to 4 channels of data coupling. **Figure 6** shows a photograph of the system inside the microchip package.

Imaging

These applications have come a long way. It truly is fascinating which advancements have been made in the field of imaging. This product group includes ultrasound, CT (computer tomography), digital X-ray, MRI (magnetic resonance imaging) and PET (positron emission tomography). Power management wise we see two trends. Larger systems such as MRI and PET are quite power hungry and require many distributed power supplies. These need to have a certain level of efficiency for heat dissipation purposes.

In imaging applications it is very likely that any type of system noise, including switching noise or even LDO output voltage noise, may be visible on the final image. It can mean ordinary error lines in the image but sometimes we also see picture quality degradation in contrast and color or grey scale levels.

Power supplies can introduce problems on the image sensing circuitry but also on the image display circuitry. Resulting picture quality issues in both parts of an imaging system are not acceptable. There are manufacturers of medical imaging equipment who used power management modules before but decided against them. While they would come with a guaranteed principle specification, the exact EMI behavior was not guaranteed. The slightest change in the manufacturing of the power modules could potentially yield issues in picture quality. In order to have a higher level of control, a discrete power design, fully developed and manufactured by the health care imaging design company can be the better way to go.

Conclusion

Power management requirements in health care applications are quite different depending on the application area. In all areas we see the requirement for specialized solutions. In home health care many solutions will be ASSP (application specific standard product) or even ASIC (application specific integrated circuit) based. The smaller quantity applications will use standard of the shelf power management units. In instrumentation, patient monitoring and imaging, power management solutions will be even more optimized to play well with the ultra-high accuracy signal path components.

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Microgrid Market Trends and Outlook

Microgrid power generation includes a mix of renewable and nonrenewable sources

By: Eric Davis, Energy Solutions Forum

In the wake of increasing blackouts and brownouts, and particularly after the recent power outages caused by Hurricane Sandy, the need for a more reliant grid is undeniable. One solution is to consider parallel or isolated systems that consist of energy generation, storage, distribution, and management. These systems—microgrids—operate either independently or parallel to the main grid, and help ensure reliable energy supply for consumers while also reducing the stress felt by the larger transmission and distribution system.

Power outages cost the U.S. approximately $104-$164 billion annually, half of which are specifically felt by the industrial sector and digital economy. Even brief outages can damage equipment or idle labor, which wastes critical resources, and losses can have further effects for downstream firms.

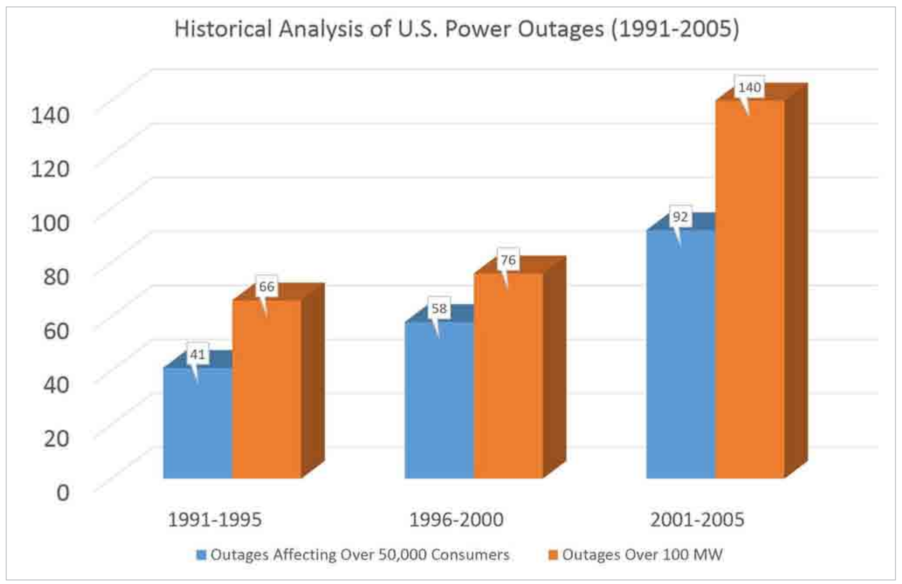

Figure 1

Losses from outages are increasing over time due to congestion and a lack of investment in transmission infrastructure. In the second half of the 1990s, there were 41% more outages than in the first half affecting 50,000 or more consumers. Further, U.S. power outages affecting 50,000 or more customers rose from 197 to 312 from the 2001-2005 period to the 2006 to May 2010 period (see **Figure 1**). There is a clear need for a stronger electrical grid. Microgrids offer substantial resiliency and cost-savings benefits. Governments, businesses, and educational institutions are exploring microgrid technology as a potential avenue to securing a more reliable energy future.

Market Drivers and Technology

There are critical factors that drive demand for microgrids, including cyber security, growing energy demand, and the general need for a more secure electricity supply. Reliance on modern technology continues to increase, which makes power systems vulnerable to cyber

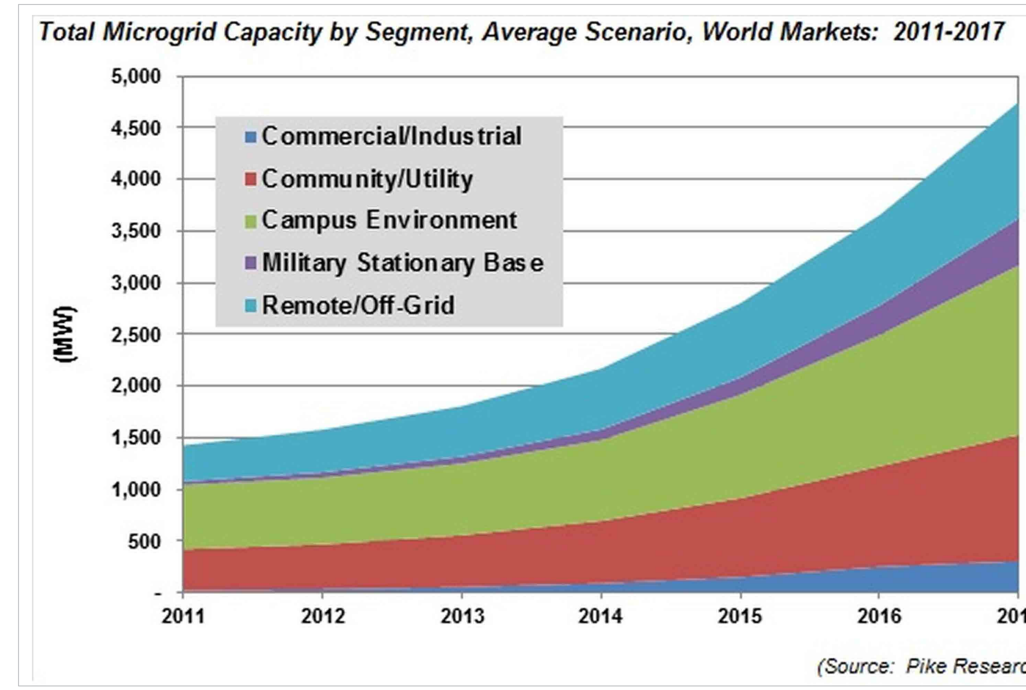

Figure 2

attacks with particularly drastic implications for large-scale interconnected power grids the systems upon which they rely. Reducing outages and increasing quality of energy supply can significantly benefit sectors that are reliant upon constant power supply, such as data centers, infrastructure critical to national security, and critical service providers such as hospitals.

Microgrid power generation includes a mix of renewable and nonrenewable sources. This includes, but is not limited to fossil-fuel-fired generators or turbines, and renewable sources such as solar PV and wind turbines. Integration of cogeneration - combined heat and power (CHP) - and trigeneration systems - combined cooling, heat, and power (CCHP) - can further microgrid system efficiency and cost-effectiveness.

As grid-scale energy storage technology continues to improve, so does its capacity to smooth and complement renewable power generation, and provide cheaper peak-demand power. Also, in the case of an unpredicted utility grid outage, stored energy can provide momentary power bridging as microgrid system generators come on line.

Recent Applications and Success Stories:

Utilities

Electric utilities have approached microgrids in a variety of ways. While some remain skeptical, many have moved forward with projects despite significant obstacles. U.S. utilities that have pursued microgrid activities include San Diego Gas & Electric (SDG&E), American Electric Power (AEP), Sacramento Municipal Utility District, DTE Energy, and Consolidated Edison. However, because the most prominent obstacle for utilities in this case is justifying costs passed on to ratepayers, the business case still needs to be thoroughly explored and quantified.

Campuses

Institutional campuses are also beginning to implement microgrids to help reduce energy use. According to Pike Research, total installed generation capacity strictly for campus microgrids will increase by 164 percent from 2011 to 2017. The market for campus microgrids could reach $777 million by 2017. **Figure 2** shows the potential increase in campus microgrid planned capacity from 2011 through 2017.

Santa Clara University

Santa Clara University became

one of the first universities in the Bay Area to launch a smart microgrid, a project that is estimated to reduce energy consumption by 50 percent and to save approximately 20 percent in energy costs.

Consisting of a 1-megawatt solar PV system, a wind turbine, a 60-collector solar thermal system, and a smart microgrid system that regulates the campus sources, the Santa Clara University system will manage and optimize energy on the campus from production to storage to consumption. Not only is the university able to better manage its energy sustainability and reliability, but the system gives them the best return on investment for its 106-acre campus. The university has been able to grow its campus size by 30% while still reducing energy costs and use.

The Military
Military bases are seeking to maintain operations despite disruptions in the larger grid as the U.S. Department of Defense (DoD) works to mitigate energy security threats. More than 40 DoD military bases currently either have operating or planned microgrids, or have pursued demonstrations or studies, according to the Secretary of Defense. Pike Research projections indicate that U.S. military microgrids for stationary bases could potentially reach 54.8 megawatts by 2018.
In May 2013, the U.S. Army launched its first grid-connected microgrid demonstration at Fort Bliss, Texas, integrating renewable resources and energy storage. The $2.4 million project, funded through the DoD's Environmental Security Technology Certification Program, will integrate 120 KW of solar, 300 KW of energy storage, grid interconnection, on-site backup generators, and a control system.

The project aims to reduce greenhouse gas emissions and energy costs while also offering energy security benefits by allowing the base to operate off the grid, reducing risk of power outages and cyber security attacks. Costs will be lower and energy storage will enable peak-demand to be met. The demonstration phase is set to continue through July.

Key Takeaways
The market for microgrids in the U.S. is moving towards full-scale commercialization. There are not only reliability and security benefits, but revenue generation, cost-savings, and emissions reduction opportunities as well. There remains tremendous potential particularly for industrial and educational campuses as well as the commercial and industrial sectors. As governments continue to aim to meet clean energy deployment goals while reducing energy costs, microgrids offer an attractive option.

www.energysolutionsforum.com

References:
Asmus, Peter, 2012. “Evolving Microgrids: What About Utilities?” Navigant Research Blog.

Kremers, Enrique. "A Complex Systems Modelling Approach for Decentralized Simulation of Electrical Microgrids." A Complex Systems Modelling Approach for Decentralized Simulation of Electrical Microgrids. AnyLogic, Mar. 2010. Web. 09 Aug. 2013.

Navigant Research, 2013. Market Data: Microgrids. Forecasts for Commercial/Industrial, Commercial/Utility, Campus/Institutional, Military, and Remote Microgrids: 2013-2020.

"U.S. Energy Information Administration - EIA - Independent Statistics and Analysis."Electricity Storage Technologies Can Be Used for Energy Management and Power Quality. U.S. Energy Information Agency, 14 Dec. 2011. Web. 09 Aug. 2013.

Connected health empowers patients and providers

Technology innovation is successfully making the transition to commercial reality

By: David Pettigrew, Sagentia

Ageing populations and the growing prevalence of chronic diseases are placing healthcare infrastructure under greater pressure than ever before. The UK's Department of Health estimates these issues could require £5 billion in additional expenditure by 2018, yet NHS budgets are currently allocated on a flat-cash basis. At a time of significant budgetary constraint, healthcare providers must find new ways to reduce costs and increase the efficiency and quality of care. Treating patients quickly and effectively frees-up hospital beds and critical resources. Ensuring underlying health issues are properly addressed and encouraging lifestyle improvements drives reductions in both the number of people visiting healthcare providers and repeat visits.

Technology is proving a key enabler in realizing these aims, particularly in the form of connected health. Broadly defined as the use of technology to provide healthcare at a distance and improve speed of response, connected health is seeing new levels of capability being realized in areas such as user interfaces, storage, smartphones, low power connectivity, and data processing and analytics. These are being combined with medical sector advances around novel sensing and imaging technologies, as well as microfluidics, haptic feedback, and robotics, to deliver practical solutions to some of the most pressing healthcare issues.

Making the connection
Connected health is an evolution from existing delivery models such as telehealth and telemedicine services, which are focused on the transmission of raw data between two locations – for example, the electronic transmission of drug prescriptions to a patient, or medical images between clinicians. Connected health takes this further by abstracting these data using sophisticated context-aware algorithms to provide actionable information to the patient, payer or clinician. It is this ability to provide real-time data management and decision support that distinguishes connected health.

The solution can be as simple as a bed-side monitor linked to a nursing station that alerts nurses to a critical event, or a series of networked devices collecting clinical data that is stored together with patient records and other administrative and financial data within a central clinical information system (CIS).

More advanced connected health solutions combine the latest advances in smart sensing technology, fixed and wireless networking, and cloud computing. They also employ sophisticated algorithms and centralized storage (either locally or via remote servers) to enable the mining and analysis of ‘big data’ to uncover trends and insights, and generate decision-making outputs.

Crucially, connected health solutions can be applied at any point in the care pathway, from a patient's first contact with a healthcare professional, service, or organization, through to the completion of their treatment and subsequent aftercare. Moreover, they can be delivered in the home, between the home and surgery, within a surgery or even between surgeries, in areas including vital signs, sleep, and medication compliance monitoring.

A technology applied

Monitoring and prevention are two promising areas for connected health. Commercial examples include solutions for monitoring diabetes (blood sugar levels, insulin administration) and for preventing co-morbidities through the monitoring of blood pressure, cholesterol, and weight. There are also PT/INR self-testing solutions (Prothrombin Time/International Normalized Ratio) allowing patients taking medication such as coumadin or warfarin to measure their blood's anti-coagulation level (i.e. how long it takes their blood to 'clot'), as well as cloud-based platforms that log patient data and refine algorithms to enable more accurate diagnosis in areas such as cardiology and image analysis.

Arrhythmia detection is another major area of focus, as it is important for patients to be able to monitor and record their heart rate outside of the surgery. An electrocardiogram (ECG) rhythm monitoring technology has been implemented by AliveCor for example, in the form of a hand-held device consisting of two finger-pads embedded in an iPhone cover. The ECG data acquired via this device can be transferred to a secure online server for review by a clinician.

Although AliveCor's system is approved for clinician use only at present, the next step could be to put this device in the hands of patients for recording their own ECG traces for remote review in-between their appointments. This would significantly increase the likelihood of detecting relatively rare arrhythmia events. Another connected health innovation under development is the Endotronix system, which uses an implanted sensor to communicate pressures from inside the patient's heart to a smartphone app via a transmitter. The system is able to accurately capture internal heart pressure data at any time and communicate it securely from a remote location to the patient's care team. It will be possible for both patients and clinicians to view the data in various formats, and on multiple devices.

Delivering successful outcomes

Some connected health solutions are already providing doctors with new levels of visibility of their patient's progress, and empowering patients to take more responsibility for their own health and care. 'Health Buddy', for example, is a personal and interactive communications device developed by Health Hero Network (now part of Bosch Healthcare). It enables a doctor or nurse coordinator to send a set of queries to the patient each day via the Internet. The patient answers them by pressing one of four buttons. The device automatically transmits this data to a processing center, where it is analyzed and published to a secure website for review by the coordinator.

Piloted as part of a computerized interactive asthma self-management and education program in the U.S., the device was found to increase self-management skills while reducing the number of urgent calls to the hospital. There are now more than 20 clinical trials of the Health Buddy system in post-acute and chronic care coordination, with consistent demonstration of positive outcomes across a variety of disease states and settings. One Health Buddy program that is supporting chronically ill patients has achieved spending reductions of approximately 7-13 per cent ($312–$542) per intervention patient per quarter.

The U.S. has been an early adopter of connected health solutions and digital health technology in general. Electronic health records (EHRs) are subsidized under 'ObamaCare',

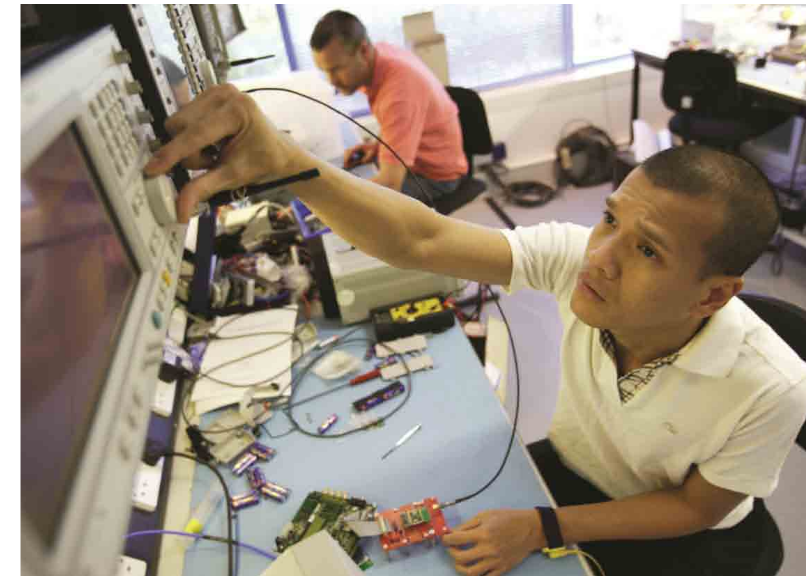

Figure 1: There is an increased concern about how rapid changes in hardware and operating systems will affect the intended function of attached medical devices

while VC funding for digital health is on track for another record year, with start-up incubator Rock Health reporting a 35 per cent increase during the first quarter of 2013 compared with Q1 2012. Last year, total annual VC funding in the digital health industry stood at $1.4 billion and $968 million in 2011.

In Europe, take up has been slower, but industry commentators believe all the elements are now in place for connected health to make the transition from small-scale pilots to mass market implementation. According to the European Connected Health Alliance, the path for connected medical devices will be smoother in Europe than in the US, because it is easier and faster to get over the regulatory hurdles and the process is better understood.

Fit for purpose

The regulatory landscape in the U.S. remains highly uncertain, with the FDA due to publish its final guidelines on mobile medical apps shortly. FDA draft guidelines released at the end of 2012 stipulate that certain types of medical mobile apps will be regulated, placing a large burden on R&D in terms of managing risk. There are also considerable challenges around protecting the privacy and security of personal health information, and concerns over the impact on development schedules and costs should products require FDA approval.

Nevertheless, the 510(k) number issued by the U.S. Food and Drug Administration (FDA) is considered the 'gold standard' for solution developers globally due to the rigour of the regulatory process, and the fact it clears medical devices for sale in a market where providers, payers, and physician groups are forecast to spend over $69 billion on healthcare-related IT and telecommunications services between 2012 and 2017, according to analysts at Insight Research Corporation.

Functionality of connected health devices varies and is based on their technical sophistication, but their success will depend on end user acceptance. This explains the rising prominence of smartphone apps, which at first glance, would appear to provide an easy route for manufacturers to deliver a 'consumer friendly' user interface for their connected systems. However, manufacturers and regulators are increasingly concerned about how rapid changes in smartphone hardware and operating systems will affect the intended function of their medical devices (see **Figure 1**).

Depending on the level of risk of the intended connected health system, it can still be cheaper and less risky in the long run to develop a platform-independent system that they can control entirely. Alternatively, a model explored by many companies involves the use of custom 'smart sensors', which perform the 'high risk' data processing functions using sophisticated embedded algorithms. These devices can in turn transmit the result to the smartphone,

which displays the data to the user. In this way, the usability of a smartphone interface is brought to bear without adding in the extra risk of using 'unregulated' hardware and software to generate the data.

Connecting the future with the present

Additional challenges remain, particularly in respect of the networking technologies employed in connected health applications and their respective power requirements and data rates. Using Wifi or broadband for example, has the advantage that the medical device can be connected to a backbone of wireless hotspots using an existing hospital network, and the investment will be relatively low from a technology perspective.

The drawback of this approach is that it is power hungry and cannot be used if the device is battery powered and has very limited dimensions. In this case, Bluetooth Low Energy (Bluetooth Smart®) is often the preferred solution as it has low-power consumption but also means a low data rate. This constrains the amount of information that can be transmitted back and forth, in real time, and thus limits the application. This is an area in which leading manufacturers continue to innovate by embedding processes within the portable device so that less data is being exchanged.

Given that connected health bridges the consumer and healthcare space, development of robust and interoperable platforms is essential. Recent FDA regulations and harmonized global standards are driving manufacturers to increasingly focus on usability engineering, in order to develop devices and services that minimize the risk of patient harm through user error. Considerable progress in terms of interoperability has been made by the Continua Health Alliance, which is developing a system of interoperable personal connected health solutions.

As these challenges are addressed, connected health will enable efficiencies and improve patient outcomes. It will also free-up healthcare professionals to focus triage on patients where it is needed most. And as people become more open to owning their own healthcare, advances in connected health mean they will have a growing range of tools at their disposal. Ultimately however, the transition to connected health will be borne out of necessity, as conventional healthcare and its associated costs become less feasible in respect of fiscal and demographic pressures.

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Powering up universal mobile telemedicine

Technology can help service the underserved

Universal health care is one of the most important governmental, societal and economic issues in recent time. Attention has been mainly focused on providing health insurance to the uninsured. However, universal health care also means reaching hard to reach and underserved populations with medical services. So, how can service be provided to the underserved? Technology is the obvious solution, and that points to smartphones, tablets, and bio-medical sensors.

As of now, there are over 40,000 medical apps in the market – and this is just the start. In 2011 there were 124 million medical app downloads and it almost doubled to 247 million in 2012. Health and fitness sensors are expected to have a compound annual growth of over 37% (see **Figure 1**).

Apps and bio-sensors on mobile platforms are now able to monitor sleeping, eating, pregnancy, prescription management, moods, blood pressure, glucose levels, pollen levels, peak flow, auscultation, heart rhythm,

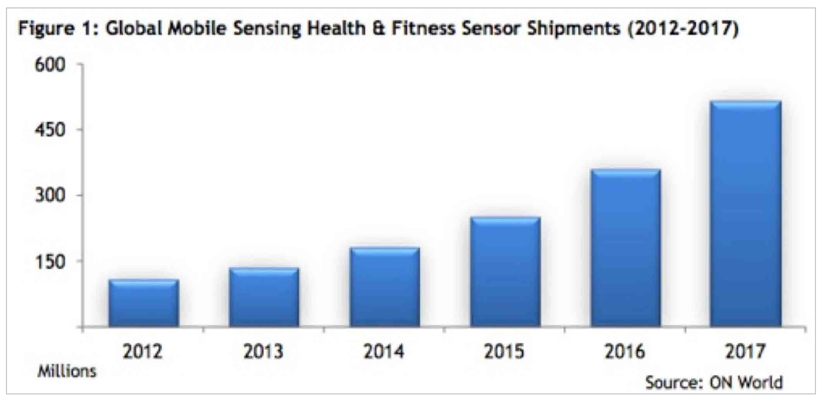

Figure 1: Global Mobile Sensing Health & Fitness Sensor Shipments.

ultrasound diagnostics, skin stress chemicals, and many other things. With more advanced instruments connected to the phones any number of diagnostic procedures can be provided.

New mobile medical sensing and processing functions come at a cost, however. And that cost

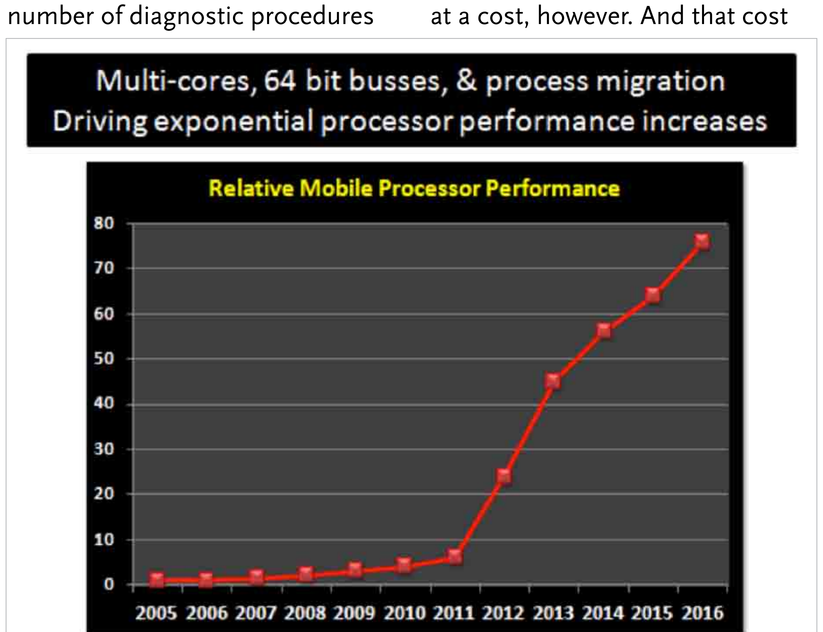

Figure 2: Relative mobile processor performance.

is power drain. At the heart of handsets are advanced application processors, which are gaining in speed and processing capabilities every year. However, with each new generation of processors more pressure is put on battery life. This is especially problematic for battery powered remote medical systems running on mobile platforms (see **Figure 2**).

The ability to take readings over long periods of time is often mission critical for medical telemetry. When important care is tied to battery life, battery life becomes an important care. So, can typical mobile batteries keep up with processor improvements? In many cases, probably not (**Figure 3**).

Even though the performance of batteries is improving, it is not improving as fast as the processors that they power. Battery performance, which is measured by energy density, only increases at a linear rate, which is much slower than processor improvements, which are exponential. This gives rise to a power gap that is anathema to medical applications that need long battery life.

Charging a cell phone once a day is a routine for most users, but that will not be adequate for many medical apps. Common mobile medical diagnostics such as holter monitors (i.e. mobile EKG), for example, must operate a full day, several days, or even weeks between charges. Therefore, mobile medical designs must investigate all opportunities for reducing power drain and augmenting current mobile platform powering arrangements.

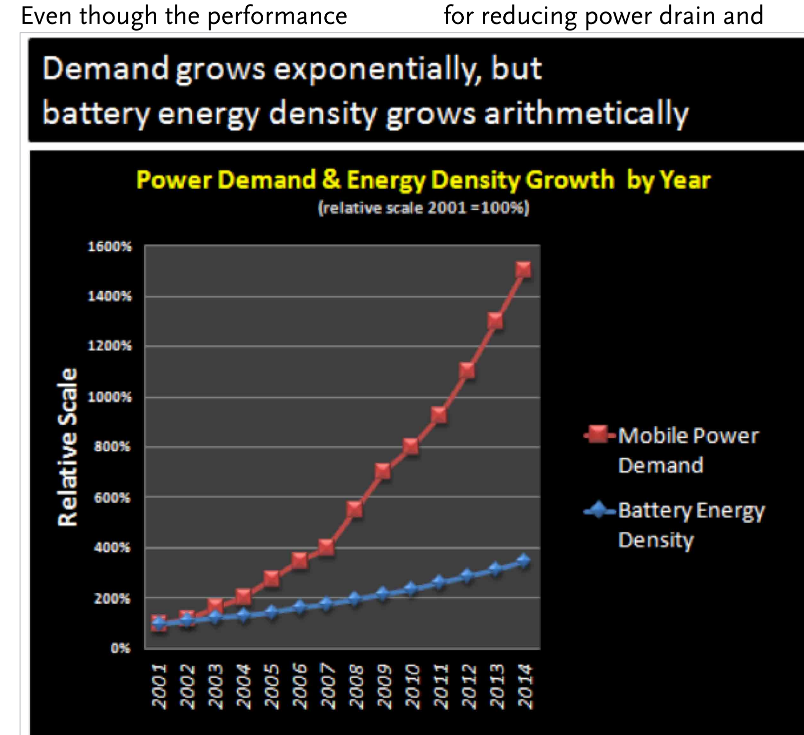

Figure 3: Power demand & energy density growth by year.

The rechargeable single cell Li-ion battery is a common starting platform for most mobile designs due to the abundant ICs available to navigate the 2.5 V – 4.2 V voltage range. But, they may not be practical for many medical units. Batteries have increased in size to cope with the increased power drain from larger and brighter display technologies now common in handsets, phablets and tablets. 3000 mAh batteries are becoming common now. Even still, a daily recharge routine is nearly mandatory because as batteries get bigger more features are added to take advantage of that (or is it the other way around?). Anyway, medical handhelds and sensors have a much different use profile than consumer phones and tablets, and that can quickly eliminate the possibility of using an integrated rechargeable battery that needs daily charging. So, if longer life is needed how can that be provided?

This is where the concept of the primary battery comes into play. A "primary battery" is defined as a battery that generates potential by using an irreversible chemical reaction. This, by definition, does not allow the battery to be charged. Primary batteries are old-school batteries that you buy in the store, use until depleted and then toss them out. The advantage of primary

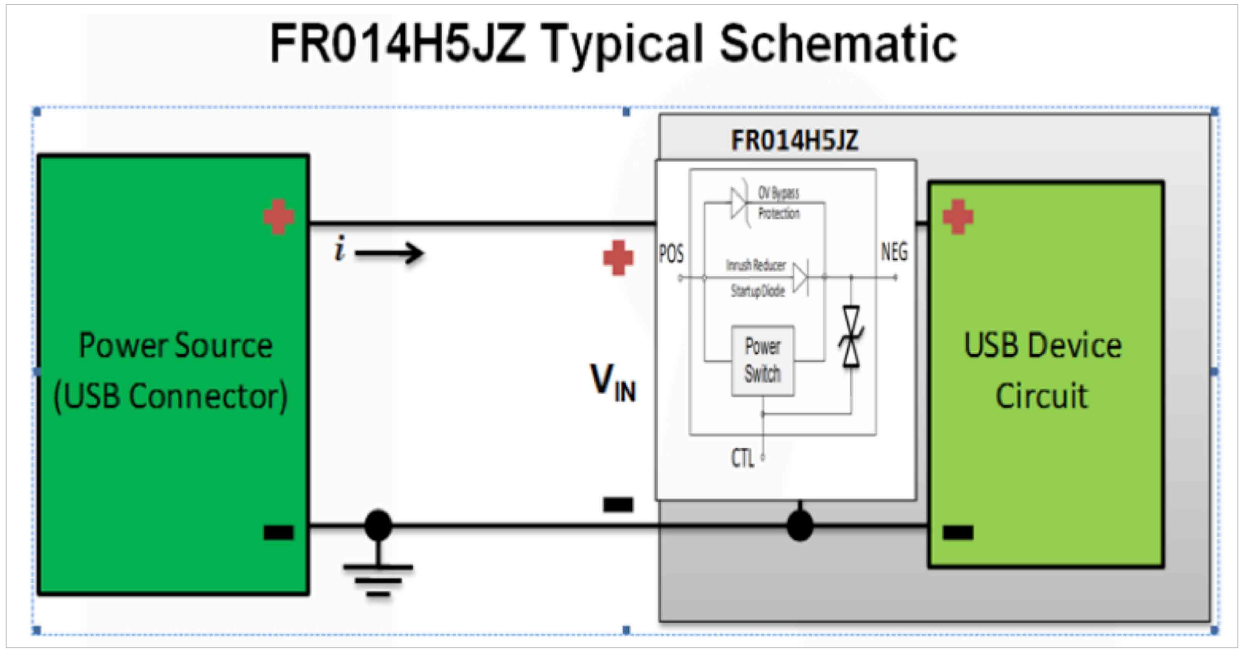

Figure 4: The configuration of the reverse polarity protection device

batteries is that they typically retain more charge over a longer period than rechargeables. There are many form-factors for primary batteries, but the common voltages for handheld or wearable applications are 1.5 V cylinders (e.g. AA, AAA, etc.) or 3 V coin cells. These batteries are known for their long shelf life when under no-load and their relatively low replacement costs. The typical 1.5 V alkaline battery is designed with 0.9 V Vmin, but is commonly stacked in series to double or triple the output voltage range. A coin cell such as the CR2032 lithium-based form factor is known for a stable 3 V output voltage over a large percentage of its life expectancy (depending on the load transient profile). Due to this useful 3 V potential, they are often nested in parallel to handle larger load transients, and interface directly to a microprocessor without DC/DC regulation being needed.

Since a human is required to insert primary batteries into the unit when a cell is depleted, incorrect battery insertion is possible. The negative potential of a reversed battery is harmful to most ICs and microprocessors. So, reverse polarity protection must be provided. The most simplified form of protection is a Schottky blocking diode, but the voltage drop and corresponding efficiency losses are not acceptable in long battery life applications. A P-channel FET can be used, but may not be characterized for true negative voltage blocking. Two FETs are typically needed in series to orient the body-diodes in an opposing structure when reverse blocking is desired. The appropriate gate drive of these MOSFETs needs to also be considered for the various battery configurations, as well as the timing when they are applied.

To address reverse polarity protection, Fairchild has introduced an IC family that blocks like a Schottky diode, but signals passes through with the efficiency of a MOSFET. The FR014H5JZ is a high-side protection device in this family with -30 V blocking capability and +32 V forward passing capability. When the battery is inserted correctly, the FR014H5JZ is nearly transparent to the power budget at less than 20 mOhm. This simple but effective device can replace multiple devices while still improving battery life. **Figure 4** shows the configuration of this reverse polarity protection device.

Progressing downstream in the power path for all battery power designs, intelligent load switches can be used to disconnect high leakage loads or exposed connectors when not needed. These are common in high reliability medical applications. The various flavors of the Intellimax™ series incorporate digital ON/OFF control, in-rush current protection; reverse current blocking, temperature protection, and over-current protection. The reverse current blocking feature is useful in the event that the load could be at higher potential than the source, even if only briefly. Wafer level chip-scale packaging with solder bumps on the bottom and geometries down to 0.8mm x 0.8mm aid in board space optimization. A simple P-channel FET can be used, but if any additional protection is needed, particularly when the switch is far enough upstream such that a failure would result in multiple downstream power outages, the additional components required around the P-FET justify the migration to an intelligent load switch.

Mobile power sources, especially for medical applications may become more hybridized using rechargeable batteries with an onboard primary battery and possibly low-power energy harvesting. In such situations, reverse polarity protection devices and intelligent load switches will become even more valuable. The key to longer battery life is to align the source potential with the load requirements while limiting any required DC/DC regulation.

It is becoming very clear that smartphones and tablets will provide benefits that reach far beyond their current usage patterns including tele-medical applications. Bio-medical sensors, medical apps, and the cloud are intersecting with mobile platforms and societal ethics and public policy to drive an expansive market for mobile medical hardware devices. It is the job of hardware engineers and IC providers to ensure that those platforms are powered up and stay powered up.

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User tracking in the Internet of things – a privacy concern?

By: Alix Paultre, Editorial Director, PSD

Among the many concerns we have as individuals in the information society, one of the most pressing to us is our privacy. Once upon a time, protecting your privacy only required a small amount of operational security; shred important documents, don't give strangers your information, and don't lose your wallet. Today, there are aspects to our identity that we can't even control ourselves anymore.

The "how" in the "who" online

We all know (or should) that your activity can be tracked online using tracking chits called "cookies". Most people know that if they want some privacy, they should disable the cookie functionality in their browser, to prevent websites from collecting user data and other personal information. This is an aspect of our online identities that we can control to some degree.

However, many organizations are starting to use powerful information warfare techniques to the world of online activity, removing a lot of the control people had on their identities. One of the most powerful tools one can use involves pattern and traffic analysis. One can discover a great deal about you just by tracking who you talk to and where you go, without having to even listen to what you say when you talk, or what you do when you get there. Pattern analysis is now becoming a major weapon in the online arsenal.

Internet of things

But what happens when the Internet moves into the real world, and we live in an environment full of connected intelligent devices? This will enable the creation of even more comprehensive pattern analysis, to the point where your actions and activities can be tracked whether you want them to or not. Just like the old Morse-code senders of old, your behavioral "fist" in the Internet of things will betray you to the skilled observer.

Just as companies are currently beginning to track people cookie-free online just through their behavior and the "fingerprint" of user settings in their browser, they will track people through the real world by their interactions with the devices and systems around them. It will probably get to a point where your actions to mask your activity will actually highlight you to the system as a depression in the data patterns.

The good side

This is not necessarily a bad thing, if individual information is protected while the system is allowed to use the macro market and usage data to optimize infrastructure operational efficiencies by leveraging the information to better control power, lighting, traffic, and signal management (among the many facets of societal infrastructure that could be improved through Big Data) to significantly reduce waste and increase operating efficiencies.

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Ultra-Low $R_{DS(ON)}$ Automotive COOLiRFET®

Package	$R_{DS(on)}$ Max@ 10Vgs (mΩ)	Q_G Typ (nc)	I_D Max (A)	RthjC Max	Part Number
D²PAK-7P	0.75	305	240	0.40°C/W	AUIRFS8409-7P
	1.0	210	240	0.51°C/W	AUIRFS8408-7P
	1.3	150	240	0.65°C/W	AUIRFS8407-7P
D²PAK	1.2	300	195	0.40°C/W	AUIRFS8409
	1.6	216	195	0.51°C/W	AUIRFS8408
	1.8	150	195	0.65°C/W	AUIRFS8407
	2.3	107	120	0.92°C/W	AUIRFS8405
	3.3	62	120	1.52°C/W	AUIRFS8403
TO-262	1.2	300	195	0.40°C/W	AUIRFSL8409
	1.6	216	195	0.51°C/W	AUIRFSL8408
	1.8	150	195	0.65°C/W	AUIRFSL8407
	2.3	107	120	0.92°C/W	AUIRFSL8405
	3.3	62	120	1.52°C/W	AUIRFSL8403
TO-220	1.3	300	195	0.40 °C/W	AUIRFB8409
	2.0	150	195	0.65 °C/W	AUIRFB8407
	2.5	107	120	0.92 °C/W	AUIRFB8405
DPAK	1.98	103	100	0.92 °C/W	AUIRFR8405
	3.1	66	100	1.52 °C/W	AUIRFR8403
	4.25	42	100	1.90 °C/W	AUIRFR8401
IPAK	1.98	103	100	0.92 °C/W	AUIRFU8405
	3.1	66	100	1.52 °C/W	AUIRFU8403
	4.25	42	100	1.90 °C/W	AUIRFU8401

The new International Rectifier AEC-Q101 qualified COOLiRFET® technology sets a new benchmark with its ultra-low $R_{DS(on)}$. The advanced silicon trench technology has been developed specifically for the needs of automotive heavy load applications offering system level benefits as a result of superior $R_{DS(on)}$, robust avalanche performance and a wide range of packaging options.

The COOLiRFET® Advantage:

- Benchmark $R_{DS(on)}$
- AEC Q101 qualified
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- Battery switch
- Pumps
- Actuators
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