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October 2011

SPECIAL REPORT: HEALTH, MEDICAL & MOBILITY (PG33)

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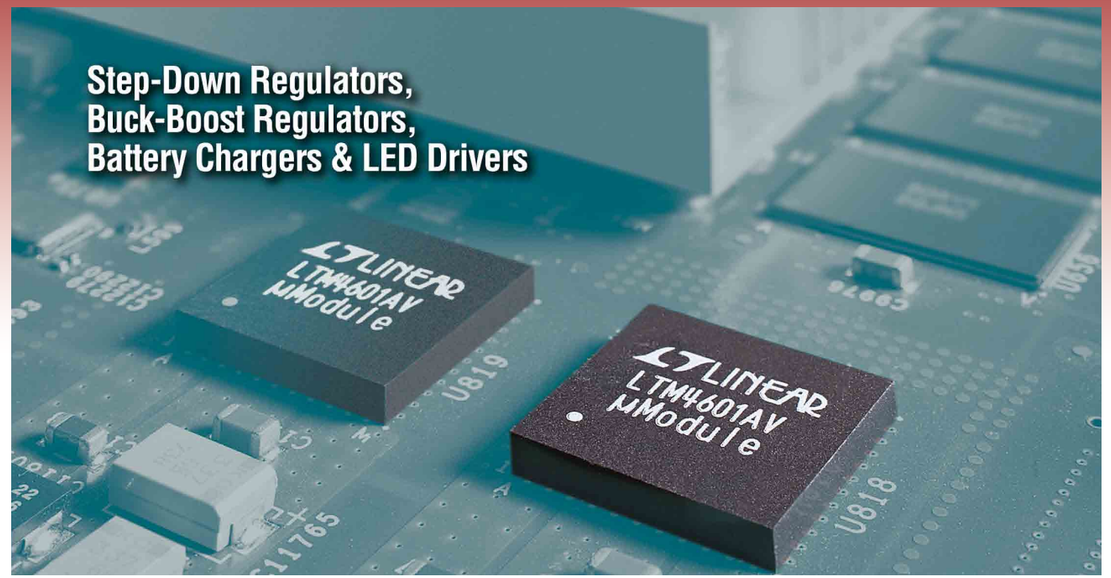

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Smart Components for Smart Grids (pg 14)

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AGS Media Group
146 Charles Street
Annapolis, MD 21401 USATel:
+410.295.0177
Fax: +510.217.3608
www.powersystemsdesign.com

Editor-in-Chief
Cliff Keys
cliff.keys@powersystemsdesign.com

Contributing Editors

Liu Hong, Editor-in-Chief, Power Systems Design China
powersdc@126.com

Ash Sharma, IMS Research
Ash.*sharma@imsresearch.com*

Dr. Ray Ridley, Ridley *Engineering*
RRidley@ridleyengineerng.com

David Morrison, How2Power
david@how2power.com

Publishing Director
Jim Graham
jim.graham@powersystemsdesign.com

Publisher
Julia Stocks
Julia.stocks@powersystemsdesign.com

Circulation Management
Kathryn Philips
Kathryn.phillips@powersystemsdesign.com

Research Director
Meghan Corneal
meghan.corneal@*powersystemsdesign.com*

Magazine Design
Louis C. Geiger
louis@agencyofrecord.com

Production Manager
Chris Corneal
chris.corneal@powersystemsdesign.com

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MEDICAL DRIVERS

Medical electronics is a booming industry. With us all living longer, the need for care - especially for the aged - is increasing. Hospitals need more 'smart' portable monitoring equipment that can be located quickly when needed over a hospital wireless network. Couple all this with the tight budgets of our hospitals and clinics and we have an almost 'perfect storm' for the development of new family home care products and systems. Treating people in their own homes is not only preferable from a patients' standpoint, it also reduces costs for healthcare authorities. The electronics industry has seized the opportunity to develop these products, especially those that can be used in a self-help capacity by the patient. Some of these systems can be very sophisticated with the addition of wireless connectivity and the use of tablet PCs.

The enablers for the ability to achieve this massive reduction in size of medical equipment include mass markets such as mobile phones which have played an important role on the electronics side. Displays, processors, and memory have all come down in price along with high performance data converters and amplifiers. There are also important breakthroughs on the biological and chemistry side.
In this issue, we have endeavoured to bring you the latest developments in this burgeoning industry.

Sparked by Apple Inc.'s adoption of accelerometer technology in its iPhone and iPad lines, the market for motion sensor devices in smartphones and tablets is set to nearly double during the next five years, according to a new IHS iSuppli MEMS & Sensors Special Report. Global revenue from motion sensor technology in smartphones and tablets will expand to $2.1 billion in 2015, up from $1.1 billion in 2011. The motion sensor category consists of a range of products, including microelectromechanical system (MEMS) accelerometers, MEMS gyroscopes, electronic compasses–also known as 3-axis magnetometers - and MEMS pressure sensors.

As you will see in our cover story from Dialog Semiconductor, home healthcare will certainly prove to be cost efficient for the health service providers and become a more acceptable form of after-care for patients who will be able to remain comfortable and independent in their own home environment.

I hope you enjoy the issue, please keep the feedback coming in and do check out Dilbert at the back of the magazine.

All the best

Cliff
Editorial Director & Editor-in-Chief, Power Systems Design
Cliff.Keys@powersystemsdesign.com

TI HELPS MEDICAL DEVELOPERS

Designed to help developers obtain safety certifications, Texas Instruments has announced its new Hercules safety microcontroller platform for medical, industrial and transportation applications. The platform consists of three ARM Cortex-based microcontroller families that deliver scalable performance, connectivity, memory and safety features for applications that require a high level of reliability.

Unlike many microcontrollers that rely heavily on software for safety capabilities, Hercules microcontrollers implement safeguards in hardware to maximize performance and reduce software overhead. Coupled with robust tools, software and safety documentation, this functionality gives developers the headroom to differentiate their end products and speed time to market.

Hercules safety microcontrollers are rooted in TI's 20+ years of safety-critical system expertise, industry collaboration and proven hardware for the automotive market. The new Hercules RM4x family provides the highest levels of performance for broad applications, including medical and industrial. The Hercules TMS570 family addresses transportation applications and the Hercules TMS470M family cost-efficiently meets the needs of applications that require less performance.

Tools and support for safety-critical development
To get started quickly, developers can use the low-cost Hercules USB Stick Development Kits or the full-featured Hercules Development Kits. Each kit comes with all the hardware and software required to get up and running quickly, including TI's Code Composer Studio™ integrated development environment, HALCoGen peripheral configuration tool and a Safety Demo that showcases BIST execution and error forcing modes.

Pricing and availability
Hercules microcontrollers range from $4.60 – $15.70 USD at 10K unit quantities and are immediately available for order. The RM4x Hercules USB Stick Development Kit (TMDXRM48USB) is priced at $79 USD and the RM4x Hercules Development Kit (TMDXRM48HDK) is priced at $199 USD.

www.ti.com/hercules-pr-lp

PREVENTING HOSPITAL INFECTIONS

Reported by Cliff Keys, Editorial Director & Editor-in-Chief, Power Systems Design

I talked with Jim Lindop, Chief Strategist, Low Power RF product line at NXP Semiconductors, about the company's new system approach to help eliminate bacterial infection transfer in hospitals.

Hand washing is the single most important procedure for preventing infections, according to the US Centers for Disease Control and Prevention (CDC). Nevertheless, contaminated healthcare workers' hands continue to play a major role in transmitting infections, contributing to prolonged hospital stays, long-term disability, increased bacterial resistance to antibiotics, high costs for hospitals and patients, and even death.

The HyGreen® Hand Hygiene and Recording System, designed by HyGreen, Inc., is an innovative solution that actively reminds busy healthcare workers to wash their hands, and records all hand-washing events and patient-staff interactions in the hospital environment. The HyGreen system uses low-power wireless chip technology from NXP Semiconductors N.V. to capture and transmit data on hand washing by healthcare workers, helping to improve hospital hygiene significantly.

HyGreen is using the NXP JN5139 wireless microcontroller and the JenNet wireless network protocol stack optimized for low-power, low-data rate, cost-sensitive applications, and plans to start using the JN5148 microcontroller later this year. Based on the IEEE 802.15.4 specification, JenNet enables a robust, self-healing network that helps HyGreen track all hand-washing events, as well as which patient bed each healthcare worker has visited, allowing hospitals to effectively monitor adherence to hand hygiene protocols.

The HyGreen Hand Hygiene and Recording System is now used in leading US hospitals. After cleaning his or her hands with soap or gel, a healthcare worker places them under a HyGreen sensor which sends a wireless "all clean" message to his or her HyGreen badge, which then blinks green. When the healthcare worker approaches a patient bed, the HyGreen monitor above the bed, checks if the badge is transmitting an "all clean" signal. If the badge is not green, the badge vibrates, reminding the healthcare worker to wash. Reports on hand-washing compliance are available to hospital management in real time.

A recent study reported that healthcare-associated infections were reduced by 89% during a seven-month period when the HyGreen Hand Hygiene Reminder System was used. The study also showed that the HyGreen components and tracking system performed with 100% accuracy, providing monitoring at the same intensity for all shifts in a busy paediatric oncology unit.

www.nxp.com/jennic/applications/healthcare

POWER OPPORTUNITIES IN BEDSIDE MONITORING

By Diane Wilkinson

As the healthcare industry globally remains to be characterized by spiraling costs and reduced budgets, the rapidly ageing world population and an increasing prevalence of chronic diseases continue to stretch resource. Consequently, focus has shifted to improving the efficiency of healthcare expenditure, while continuing to reduce healthcare costs. Governments within more developed regions worldwide are promoting long-term treatment in home-care or sub-acute environments, requiring bedside monitoring to fit this purpose.

This presents an interesting market for component manufacturers. Bedside monitoring, including devices for ventilation, patient monitoring and drug infusion, for both general hospital admissions and long-term care environments is attracting more attention. With annual production volumes exceeding 20 million units, this market presents a sizeable opportunity for component suppliers. IMS Research estimates that the global market for clinical care devices was worth $9.5 bn in 2010.

The ageing population has led to a larger proportion of patients requiring long-term care. In addition, despite the burden of disease reducing, there is a shift towards non-communicable illnesses, further compounding the need to manage healthcare provision. According to the World Health Organisation (WHO) cardiovascular disease was estimated to be the highest cause of death in 2004, killing an estimated 17.1 million people that year; this is expected to increase to 23.6 million in 2030. Furthermore, chronic respiratory diseases account for more than four million deaths a year which may have otherwise been preventable.

For example, with an increasing number of patients requiring longer term ventilation, there is a trend for patients to be transferred from the hospital into long-term care facilities. Coupled with the rising prevalence of respiratory diseases such as COPD and sleep apnea, demand for home care ventilation is expanding. Uptake of home care ventilation has been higher in the developed regions due to the infrastructure and support

required. As the hospital segment establishes in developing regions, more focus will be paid to the home care market globally. As such, the global market for home care ventilators is forecast to grow at a CAGR of 5.8% from 2009 to 2014.

Likewise, the increasing number of patients admitted to hospital for treatment for age-related diseases such as cardiovascular disease, is increasing demand for patient monitoring devices. In order to reduce financial burden on healthcare resource, patients are being transferred to low-acuity wards sooner. As a result, demand for low-acuity products such as low-end patient monitors, vital signs monitors and patient-worn telemetry monitors increased in 2010, with demand projected to remain strong in 2011.

By far the largest segment of the global bedside monitoring market is however, infusion pumps, accounting for nearly half of global revenues in 2010. Of note, demand for treatments in long-term environments, again driven by the ageing population, is fuelling growth in the market for enteral feeding pumps. In addition, moving treatments into out-patient settings, to further lower healthcare expenditure, is additionally driving the market for ambulatory pumps in both hospitals & clinics and importantly, home-based care. While unit shipments of enteral feeding pumps are forecast to grow with a CAGR of 7.4% from 2010 to 2015, ambulatory pumps are projected with double digit growth, a CAGR of 13.1%.

Bedside monitoring devices are playing an increasingly important role in improving the cost efficiencies of healthcare expenditure. With total global shipments forecast to almost double over the next 5 years, this market represents a significant opportunity for component suppliers.

Author: Diane Wilkinson
Research Manager – Medical Electronics (InMedica)
IMS Research
Wellingborough, UK

www.imsresearch.com

POWER SUPPLY DEVELOPMENT DIARY PART XVI

By Dr. Ray Ridley

In this article, the results of measurements of control-to-output characteristics are presented for the multiple-output forward converter. It is shown how to reduce a multiple-output power supply to its equivalent single-output buck converter. Measurements and predictions are compared.

Five-Output Forward and Single-Output Equivalent Circuit

Figure 1 shows the five-output forward converter with coupled inductors. The turns ratios of the magnetics are shown, and these will be used to reduce the converter to a system which can be modeled more easily.

The primary current is sensed as described earlier in this series of articles, and is scaled by 1.1 to provide the voltage signal for the feedback comparator.

There are very few articles which deal with the small-signal characteristics of multi-output converters. As will be seen later, there are complexities of multiple outputs which are difficult to model exactly.

The first step in arriving at the transfer functions for the circuit is to reflect all of the output components to the output which will be regulated. For this circuit, the 12 V output goes to the feedback controller, so all output capacitor values and load resistor values are reflected through the inductor and transformer turns ratios to arrive at the equivalent model shown in Figure 2.

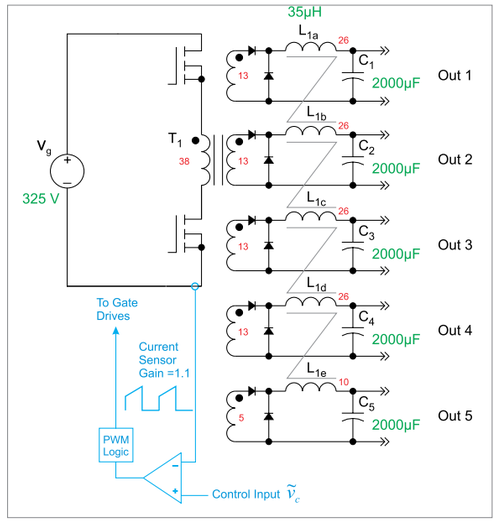


Figure 1: Forward Converter with Five Coupled-Inductor Outputs. Current Feedback is Taken from the Primary Side of the Circuit.

Notice that the inductor value of 35 µH on the higher voltage output is reduced by the square of the transformer turns ratio 5/13. The capacitor value of 8000 µF is increased by the square of the transformer ratio 13/5. This results in a rather large equivalent capacitance of about 59,000 µF for the 12 V equivalent circuit.

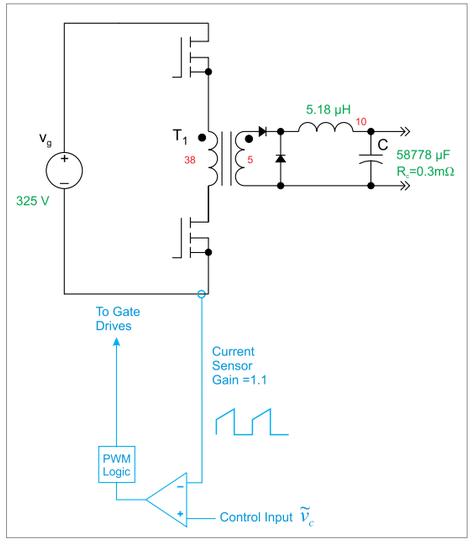


Figure 2: Five-Output Forward Converter Reduced to a Equivalent Single-Output Forward Converter

The second step in arriving at the model is to reduce the circuit further to an equivalent buck converter, shown in Figure 3. The input voltage is reduced by the transformer turns ratio, and primary resistances are reduced by the square of this ratio.

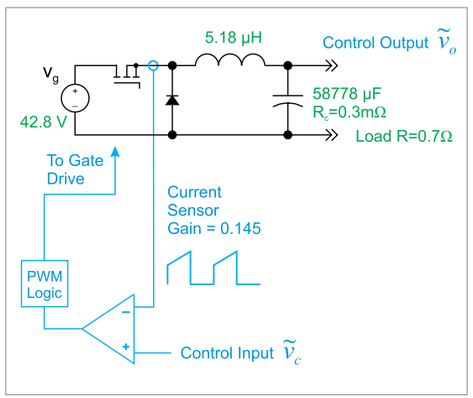


Figure 3: Equivalent Buck Converter for Small-Signal Modeling

Once the buck converter equivalent circuit is found, the transfer functions for current-mode control are well known, as derived in [2].

Control-to-Output Transfer Function

The current-mode transfer functions for the basic converters can be found in Reference [1], with full details of the derivation given in [2]. The equations are given below for readers that are interested in the theory.

For the current-mode buck converter, the control-to-output transfer function is given by:

$$\frac{\tilde{v}_o}{\tilde{v}_c} \approx \frac{R}{R_i}\frac{1+sCR_c}{1+sCR} f_h(s)$$

The first part of this expression is the transfer function obtained for a simple controlled current source feeding the output capacitor and load. The second part of the expression, shown in red, gives the correct modeling for the tendency of current-mode converters to oscillate at half the switching frequency. A pair of double poles is introduced in this expression given by:

$$f_h(s) = \frac{1}{1+\frac{s}{\omega_n Q_p}+\frac{s^2}{\omega_n^2}}$$

Where the radian frequency is determined by

$$\omega_n = \frac{\pi}{T_s}$$

And the damping is determined according to

$$Q_p = \frac{1}{\pi\left(m_c D' - 0.5\right)}$$

and

$$m_c = 1+\frac{S_e}{S_n}$$

For this particular forward converter, it was not necessary to add a compensating ramp, Se, to the system. Adequate ramp compensation is provided by the sensed magnetizing current of the transformer, as is usually the case with forward converters where the current is sensed on the primary.

If you want to plot these transfer for yourself, you can use the free software provided in [3]. More advanced modeling with additional parasitic components and large-signal simulation is provided in [4].

Control-to-Output Measurements

The control-to-output transfer function can be measured with the test setup shown in Figure 4. For new designers, it is important to point out that great

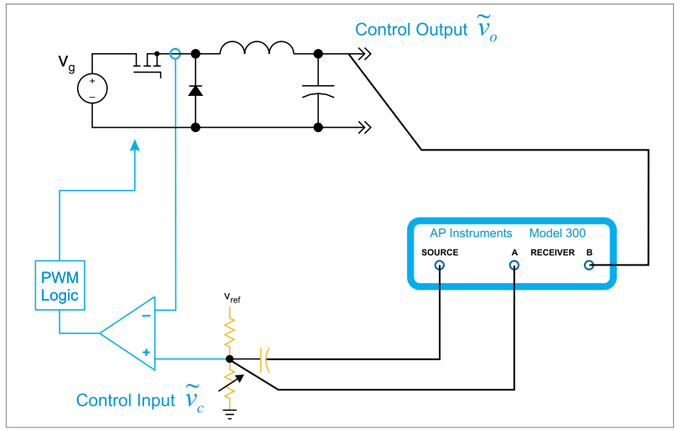


Figure 4: Measured Setup for Control-to-Output Transfer Function

care must be taken when working with high-voltage, and high-power circuits. It is always better to err on the side of caution when moving test probes and changing compensation components. Always turn the circuit off when moving connections. If possible, the control circuit should be grounded with a safety ground connection to keep high voltages away from test equipment as much as possible.

Figure 5 shows the result of the measured and predicted control-to-output transfer function for the multiple-output power supply. The measurements were made with a nominal input voltage of 240 VAC (325 VDC) and a load of 200 W.

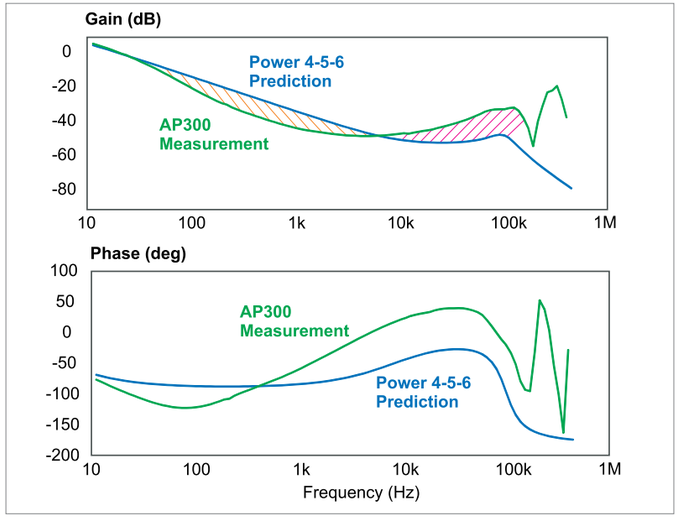


Figure 5: Measured and Predicted Control-to-Output Transfer Function

The lowest frequency parts of the measured and predicted responses are in very close agreement. However, there are significant discrepancies in the region from about 50 Hz to almost 10 kHz where the measurement is lower than predicted. Beyond this frequency, the measurements are higher than predicted.

There has been almost nothing published about this kind of result in the literature, despite the fact that this kind of result is typically seen in multiple output power supplies. The higher frequency deviations are a result of leakage inductances between the multiple outputs that cause the resulting effective capacitor on the single-output equivalent circuit to become lower than the fixed value given in Figure 3.

The lower frequency deviations are most likely a result of the ripple-steering effects which can be observed with multiple output coupled-inductor circuits. Very unusual effects can be seen with such circuit, including the generation of negative inductances in circuit models. Further discussion of this is beyond the scope of this article, and warrants attention from researchers who might be interested in an unexplored topic of power supplies.

It is very difficult, if not impossible, to generate accurate small-signal models that incorporate all of the effects and parasitic components necessary to exactly match measurements and predictions. This is one of the reasons why designing the control systems for power supplies still is very much an empirical process with a combination of both measurement and analysis to arrive at rugged designs.
Notice that both the predicted and measured responses predict quite low gains for the power stage due to the very large value of the equivalent output capacitor. This will present challenges in closing and measuring the loop of the circuit, as will be seen later in this series.

Summary
The multi-output forward converter was reduced to a single-output buck converter in order to perform the small-signal modeling of the power supply. The experimental results were compared with predictions, and significant discrepancies were found between the two. This is a common result for multiple-output converters. Much work still remains to be done in the field of modeling to properly explain these effects.

Author: Dr. Ray Ridley
President
Ridley Engineering

www.ridleyengineering.com

HOME HEALTHCARE TECHNOLOGY

Opening the door to cost-effective home recovery

By Jos van der Loop

A new generation of low power, self-configuring network devices capable of remote management via a web connected smartphone or tablet PC are set to deliver the next healthcare revolution.

The cost of providing healthcare to those recovering from illness or surgery has risen rapidly in recent years and there is now a significant pressure being placed on hospitals to release patients earlier, freeing up bed space and reducing costs. The desire to recover in familiar surroundings, and be close to family, has also led to this being a favourable option with the patient.

Yet it has remained limited to relatively few people and conditions, with figures from the US social medical insurance organisation, Medicare, stating that nearly 90% of those elderly and disabled patients in receipt of home care suffer just five conditions: circulatory disease (31%), heart disease (16%), injury and poisoning (15.9%), musculoskeletal and connective tissue disease (14.1%), and respiratory disease (11.6%). To enable a greater number of patients to receive home healthcare, clearly technology must be put in place to enable the monitoring of a greater number of conditions.

Technology requirements
If the number of conditions eligible for home treatment, and therefore the number of outpatients, is to increase the technology needs to be robust and several elements must be in place:

Web connectivity: Home care medical systems must be connected to the web, enabling easy remote monitoring by medical professionals from anywhere, via a 3G and WiFi connected tablet PC or smartphone. In addition, the web connectivity offers wide band voice connections up to 8KHz audio bandwidth.

Auto-configuration: There must be a great number of systems capable of monitoring a diverse range of symptoms, from sphygmomanometers for patients with blood pressure complications to blood sugar monitors for diabetic patients, these systems will likely come from a large number of manufacturers and must all connect with the same base station, therefore a single standard must be used, and this standard must allow for the auto-configuration of new devices as they're added to the network.

Low power and low interference design: To prevent any risk of clinical incidents, reliability is essential. Devices must be able to update constantly and warn of potential complications as they arise - with time for an ambulance or travelling nurse to arrive promptly to deal with these. This means signals cannot be affected by other wireless networks that use the same frequency. It also means that a low power wireless standard must be selected to avoid battery failure.

One of the key emerging standards for such applications is the new ultra low power variant of the robust and proven DECT protocol (DECT ULE).

What is DECT ULE?
At a basic level ULE adds fast switching to the devices enabling a standby or deep "sleep" mode, only waking when a pulse is given by the internal counter (for battery check) or from external events.

Like standard DECT, it operates in the 1880 to 1900 MHz frequency band (outside Europe the 1910-1930 MHz and 1900-1920 MHz bands are also used). This 20 MHz of radio spectrum is split into ten channels with a spacing of 1.728 MHz. In addition to this division by frequency (Frequency Division Multiple Access or FDMA), DECT also splits up the available space into time slots (Time Division Multiple Access or TDMA). In total, there are 24 time slots per frequency band (12 "down" and 12 "up"). And 100 frames per second can be sent over each of the ten frequency bands.

To transmit data, DECT equipment first scans the entire DECT band and selects a channel by choosing a specific time slot combination on a specific frequency. For instance, after scanning it may decide that downlink slot 2 and uplink slot 14 in frequency band 2 (1888.248 MHz) are available.

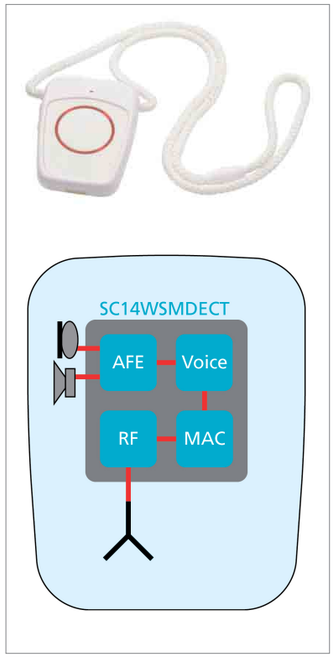
With twelve possible time slot combinations and ten frequency bands, there are a total of 120 radio channels available. The total capacity can be extended further by adding more basestations. As long as basestations are far enough apart so as not to disturb each other, each one can manage its own sector. In this way, hundreds of thousands of users in a single office environment can be supported. What's more, unlike many other low-power technologies, there is no need for frequency planning because the system dynamically selects the best channel to use.

Benefits of DECT ULE for medical applications
DECT ULE is an exceptionally wireless robust transmission protocol, which is essential in achieving healthcare product certification. Like the DECT standard, DECT ULE devices automatically configure with a base station unit to create simple star networks with over 100 connections, meaning new home healthcare system products can be easily added to a home's network.

Additionally, by operating in the 1.9GHz spectrum, the standard doesn't suffer interference from other wireless networks - reducing the chance of failure - and, unlike standards using 2.4GHz, DECT ULE base station chips can be integrated into a home's WiFi enabled broadband router, allowing DECT ULE wireless sensor network devices to easily connect with the web for remote monitoring of symptoms - indeed many broadband gateways already integrate DECT chips that, following a software upgrade, work with DECT ULE systems. Finally, healthcare professionals and family will be able to manage DECT ULE healthcare systems remotely via a smartphone, laptop or tablet PC.

The diversity in DECT ULE applications also brings additional benefits that allow patients to stay at home and recover faster. Home healthcare devices are not solely those that monitor a patient's symptoms, a true home healthcare system enables greater control for the user. For example, patient communication systems are truly vital, and the DECT ULE standard enables the transmission of 232 bit data and high quality, wide band audio, ensuring nothing is missed during contact with medical professionals or service centre used to monitor vital signs. Furthermore, DECT ULE can be used to create a wide range of web connected home automation systems, one such example is a door lock actuator, allowing a nurse to more easily gain access

when a patient's mobility is limited. This can be done from either the nurse's tablet PC, or via a patient's dedicated control device.



Application example: Personal Health Button (PHB)

The company Viadact which is part of the Guard on Line family of companies, is a Belgian based provider of healthcare service solutions for care homes, hospitals and call centres and has recently launched one of the first home health communication devices that benefits from this new technology, the Personal Health Button. This wireless alarm pendant and base station integrates Dialog's DECT ULE offering, SmartPulse, and enables users to alert nurses or family members of incidents at the press of a button. Contact can be instantly made and an incident assessed more accurately, meaning the appropriate response is taken more quickly.

The device has a range of 50m inside and 300m outside, so it can be used anywhere in the home or garden and the PHB has been designed to be usable at all times - including when in the bath or shower. Furthermore, the base station unit is simple to install; once connected via Ethernet to a home's broadband router the device automatically establishes a secure connection with the correct server and uses 8kHz wideband VoIP to provide crystal clear audio quality.

Additionally, the system enables data transmission to communicate with other SmartPulse and DECT ULE devices throughout the home, allowing the patient, or nurse, to control almost anything, from light switches to door locks. Alerts for lost connections and low batteries have also been created and, as reliability is essential, GSM and PSTN fall back connectivity options are also implemented to enable continuous operation, even when the power grid goes down.

PHB in action

Once the PHB system is triggered, whether via a patient initiated request or via the system's 'listen-in' safety feature, medical care professions can determine the level and nature of the problem before sending out a locally based emergency response nurse if applicable. Once at the home the nurse can talk to the patient using the PHB's doorbell intercom link. Finally, using the PHB system the patient can give access for the nurse to enter the home, unlocking doors with DECT ULE actuators that control the locks – because the PHB system connects to the web, the nurse is also able to connect with and activate the door locks using an encrypted tablet PC or smartphone application should the patient be unconscious.

Door-lock control is an essential feature. According to our care institute end customers, elderly people can often fall in hurried moments, for instance at the point of opening doors with keys. To minimise this risk care institutes, such as the Belgian firm Wit-Gele Kruis, often keep the keys in a nearby safe – a solution that, it is reported, is seen as far from ideal by nurses performing home visits.

The PHB is the first commercialised healthcare product in Viadact's roadmap that uses SmartPulse. In developing the PHB, Viadact tested a wide range of wireless standards with the range and the network capabilities of the SmartPulse wireless system proving decisive for the choice of radio technology, according to Johan Fransen, CEO of Viadact

Long battery life

Of course, to avoid clinical incidents from occurring, failure is not an option. Battery life must be long as a door-lock, monitor or communication device that fails due to weak batteries could prove fatal for the patient. SmartPulse devices deliver up to 10 years of service from a single AAA battery pack: using just 5C per transaction and 3µA in sleep mode - based on six communications per hour to alert the base station that all is working well.

DECT ULE Implementation

The PHB is among the first devices to benefit from DECT ULE technology and the market is anticipated to grow rapidly.

Lisa Arrowsmith, a Senior Analyst in IMS Research's Connectivity Group has reported that DECT ULE enables a variety of in-home applications – citing home health monitoring along side security, and home automation. "DECT technology has already proven its performance in residential environments, and the emerging DECT ULE standard will benefit from the maturity of previous DECT solutions, in terms of both technical development and consumer awareness. With low sleep-mode power consumption and a range well-suited to residential environments, IMS Research projects rapid uptake of the DECT ULE standard for wireless sensor networks."

Dialog Semiconductor launched the industry's first commercially available family of DECT ULE IC based devices in September 2011. The suite of products consists of the SC14WSMDATA (data) and SC14WSMDECT (data and audio) wireless sensor nodes, and the SC14CVMDECT base station device that can be integrated into standalone hub products or internet gateways - allowing the remote management of SmartPulse enabled systems over an internet connection.

The 25x29mm, 123-pin packages meet certification standards for all global markets – FCC, EU and J-DECT and are available in high-volume quantities. Furthermore, SmartPulse devices are backwards compatible with standard DECT, enabling SmartPulse sensor nodes to communicate with existing legacy DECT enabled hubs and internet gateways from multiple manufacturers, with a simple software update.

Dialog development kits and reference designs

To help accelerate product creation cycle, Dialog offers complete development kits for all SmartPulse™ modules. The wireless sensor module kit includes a SC14CVMDECT-based base station, a SC14WSMDATA development board (featuring a module, various interfaces, battery and power connector)

SmartPulse reference design and dev kits enable rapid development of remotely managed home automation systems

and USB cables. Also included is demonstration software, application examples and the Athena IDE, enabling rapid application creation.

Dialog's DECT IP base station reference design kit offers easy prototyping of internet-enabled DECT ULE systems. The kit features a DECT IP base station that combines a SC14CVMDECT for base station-node communication with one of the company's energy-efficient VoIP processors for hassle-free internet connectivity. It comes complete with example sensor and actuator nodes based on the SC14WSMDATA wireless sensor module, plus the Rhea µClinux-based VoIP software development platform.

Athena IDE

The Athena Integrated Development Environment (IDE) is an easy-to-use, open-source toolset for creating new application software. It features an Eclipse-based IDE, a GNU C/C++

compiler and linker, and a code download and verification tool – all preconfigured and tested to work straight out of the box.

Conclusion
The cost of providing healthcare to those recovering from illness or surgery has risen significantly in recent times and this has led to many healthcare organisations around the globe seeking alternatives that allow patients to recover in comfort at home. The move frees up bed space and reduces cost. It is also extremely popular with patients, who prefer to recover in familiar surroundings and with greater access to family members.

New technologies are making it easier to remotely monitor a greater number of patients and classes of conditions, meaning home care is set to become more prevalent. But, healthcare providers and device manufacturers must get the technology decisions right if patients are to truly benefit from such systems.

Dialog's SmartPulse DECT ULE wireless sensor network devices enable the creation of robust systems for home healthcare applications. Using the 1.9GHz licensed band means that interference is minimised and the standard's efficiency enables long battery life, minimising the risk of failure and clinical incidence.
The standard enables devices to easily connect to and interact with other DECT ULE home automation and healthcare systems. Being a tested, robust and trusted standards-based communication protocol, it is simple to configure devices, from door locks and light switches to blood sugar monitors and sphygmomanometers. Furthermore, devices based on the technology connect easily with the web, enabling effective communication with medical professionals and allowing the remote management of such systems from a computer, or smartphone / tablet PC application.

Home healthcare will certainly prove to be cost efficient for the health service providers and become a more acceptable form of after-care for patients who will be able to remain comfortable and independent in their own home environment.

Author: Jos van der Loop
Product Marketing Manager
Low Energy & VoIP Division
Dialog Semiconductor

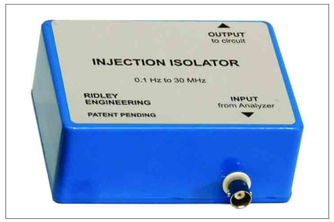
www.dialog-semiconductor.com

RIDLEY UNIVERSAL INJECTOR

Why you need only one injection isolator

By Dr. Ray Ridley

The RIDLEY UNIVERSAL INJECTOR offers extraordinary wideband operation with either large voltage drive, or high current drive.



A Brief History
I have been working with frequency response analyzers for over 30 years. My first introduction was when working on switching power supplies during my undergraduate degree at Boston University. My senior project was to design an offline switching power supply with a 20 kHz sine wave output regulated at 6,000 VAC. During that project, it quickly became apparent that the problems encountered during the design would have to be analyzed in both the frequency domain and the time domain. My first frequency response analyzer in school consisted of a vacuum tube amplifier, function generator, and oscilloscope. All measurements were done manually.

When I graduated in 1981, I went to work at Prime Computer in Massachusetts, designing 1 kW power supplies for computers. I attended Dr. David Middlebrook's course on structured analog design, and I was eager to try out his loop gain measurement techniques in the lab. This was a very new topic to power supply designers in those days, and most switchers were sent out into the field without any measurements. Of course, many of them were returned later for repair.

At Prime Computer, we used a narrow-band voltmeter from Hewlett Packard. This simple analog machine was capable of putting out a test signal, and measuring a single return signal at that frequency, with a switchable bandwidth. The output was purely analog and visual – a moving coil voltmeter that displayed the size of the measured signal. With a single input channel like this, Dr. Middlebrook taught his course attendees how to measure both gain and phase of a system.

How was this done? With a series of three measurements at each injection frequency. You measured the input signal, the output signal, and the differential injected signal. Then, by applying the cosine rule, you could calculate the phase angle between each of the signals. It was a wonderful teaching tool to learn how these measurements are made, and it gave incredibly clean results. The pure analog measurement technique, and the natural low-pass filtering of the moving coil voltmeter, eliminated almost all spurious measurements.
We were lucky at Prime to have computers everywhere to at least speed up the data entry and calculations with very early versions of spreadsheets, but it was very time consuming.

The Next Generation
Then, equipment appeared on the market that automated the process. After the narrow-band voltmeter approach, we purchased

another all-analog unit from Bafco – the Bafco 916XH. I remember it well, because I spent many hours in front of its mechanical logarithmic dials.

The Bafco was a great machine in that it had sufficient frequency range for those days, up to 100 kHz, and a massive drive signal of 20 V peak-to-peak. This drive was what sold us on the machine. We were working on high power switchers, and they needed a lot of signal to inject into output impedances, input rails, and the loop. The only problem with the was the lack of a computer interface.

I went to graduate school at Virginia Tech in 1984 and studied power supplies in the group led by Dr. Fred Lee. We had wonderful lab equipment there, including the flagship frequency response analyzer from HP, the HP4194A. This was a great machine, big and reliable, with a price tag equal to a very nice BMW. At the end of the model run, a fully-equipped instrument ran about $65,000.

I got to know this instrument intimately, working with it on a daily basis for my seven-year tenure at Virginia Tech. While it did a superb job, it had numerous drawbacks.

All of the problems described above were solved with the frequency response analyzers from AP Instruments. Their analyzers were designed very specifically for the power supply industry, and it included all of the features needed by power supply designers.

Why do I need an injection isolator?

Figure 2 shows how the loop of a power supply is measured with the AP300 frequency response analyzer. I learned this measurement technique first-hand from Dr. Middlebrook. It requires a transformer to inject differentially into the feedback loop of the power supply. Middlebrook suggested the use of a current probe, driven backwards, to inject into the loop. While a current probe can inject a signal over a wide frequency range, the injected signal is quite small

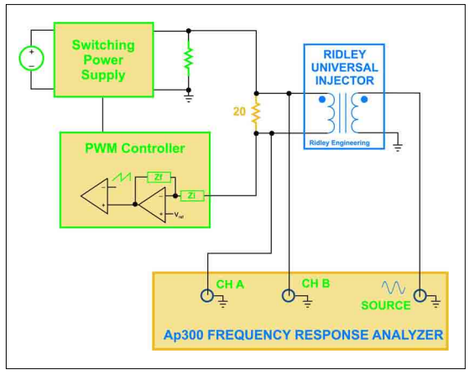


Figure 2: Standard loop injection technique uses a wide-band transformer for signal injection.

and inadequate for noisy switching power supplies. Many engineers designed their own transformers to work over the frequency range that they needed. With good transformer design, it was reasonable to expect several decades of operation of the injection transformer. Passive transformers are the technology of choice for this application since they provide a fully isolated signal with no added electronic noise.

How many injection isolators do I need?

The frequency response analyzer from AP Instruments covers the very wide range from 0.01 Hz to 30 MHz. It is necessary to go as low as 0.1 Hz, or less, in order to measure the loop gains of power factor correction circuits, which typically cross over at about 1 Hz. The 30 MHz upper frequency range is critical for characterizing power components, filters, and impedances. An injection isolator is necessary for many of these measurements.

Over the years, students have asked me how many injection isolators are necessary to cover this range. I was always puzzled by this question since I have always only had a single injection isolator for all of my applications. I saw after teaching for many years, that the industry's range of application was much wider than I expected. It was from this perspective that I created a new product to meet these needs.

At Ridley Engineering, we are now on our fourth generation injection isolator. The first model we created covered the range from about 100 Hz to 15 MHz. Our second product, released about 7 years ago, extended this range from 5 Hz to 15 MHz. The third iteration increased the range, and the present product lowered the output impedance of the device as we will see later.

The latest injection isolator, designed and manufactured by Ridley Engineering, is a truly amazing device. The RIDLEY UNIVERSAL INJECTOR covers the range from 0.1 Hz to 30 MHz. When used with the AP300 analyzer from AP Instruments, it is the only injection isolator you will need. In applications where a substantial current source is needed, it provides unmatched performance.

Voltage Injection Capability of the RIDLEY UNIVERSAL INJECTOR

When injecting into the loop of a power supply, we want to be able to provide a strong signal across the entire frequency range. It is not essential that the signal be perfectly flat, and in many cases, we deliberately adjust the size to avoid overdriving electronic components in the feedback loop. For an injector to be truly universal, it must be capable of a sizeable signal over a very wide range.

Figure 3 shows the absolute magnitude response of the RIDLEY UNIVERSAL INJECTOR over more than an eight-decade range. When working with the AP300, the output signal is maintained constant at a 1 V rms level (2.8 V peak-to-peak) over the truly amazing frequency range from 0.5 Hz (-3dB point) to 30 MHz. Even at 0.35 Hz, there is still 500 mV of signal (1.4 V peak-to-peak) and at 0.1 Hz, the signal is 150 mV rms (0.42 V peak-to-peak).

Current Injection Capability of the RIDLEY UNIVERSAL INJECTOR

The RIDLEY UNIVERSAL INJECTOR is obviously adequate for voltage injection into control systems. However, sometimes we need to inject current into a system, as shown in Figure 4. The schematic of Figure 4 is a circuit that we have used in our power supply design courses over the last 11 years to measure the output impedance of a power supply.

The output signal from the analyzer passes through the RIDLEY UNIVERSAL INJECTOR , which is then connected with a dc blocking capacitor and 1 ohm sense resistor to the output of the power supply under test. For this test to be successful, we must be able to inject a substantial current into the power supply.

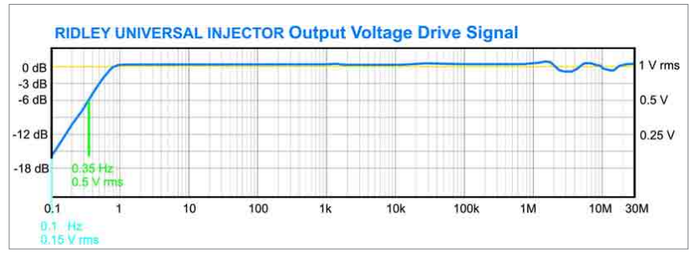


Figure 3: The RIDLEY UNIVERSAL ISOLATOR features an extraordinarily wide frequency range with large output voltage signal

Figure 5 shows the current drive capability of the RIDLEY UNIVERSAL INJECTOR . A very substantial 200 mA rms (560 mA peak-to-peak) is provided from 1.5 Hz to beyond 30 MHz. The passively-coupled signal works as both a current source and current sink. At 1.5 Hz, the drive becomes limited by transformer saturation. At 1 Hz, the current signal is reduce to 140 mA rms (395 mA peak-to-peak).

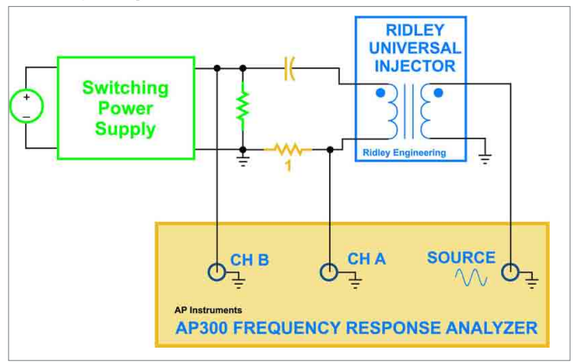


Figure 4: for measuring output impedance current must be injected into the output terminals of the power supply.

The impressive drive capability of the

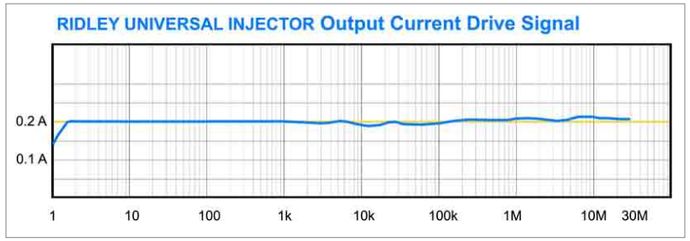


Figure 5: The RIDLEY UNIVERSAL ISOLATOR is designed with low output impedance to drive substantial current over a wide frequency range.

RIDLEY UNIVERSAL INJECTOR is a result of advanced transformer design, coupled with the output source capability of the AP300 analyzer. The analyzer has a low output impedance of 2 ohms, and is capable of sourcing 0.5 A rms. A power amplifier on the output of this analyzer makes this specification possible. The high drive level of the output 20 V peak-to-peak, allows a step-down turns ration to be used in the RIDLEY UNIVERSAL INJECTOR . This allows both high current and high voltage injection capabilities.

Summary

The RIDLEY UNIVERSAL INJECTOR is an unsurpassed component. When used with the AP300 frequency response analyzer, it can provide a full 1 V rms drive signal into a circuit from 0.5 Hz to 30 MHz, and still has a substantial signal available at 0.1 Hz.

The same universal isolator can provide 200 mA rms current from 1.5 Hz to above 30 MHz. This makes the RIDLEY UNIVERSAL INJECTOR very useful for injecting into the output of power supplies to measure output impedances. The combination of the impressive voltage and current output ensure that this is the only injection isolator that you need for all of your power supply frequency response measurement challenges.

Author: Dr. Ray Ridley
President,
Ridley Engineering

WHY SIMULATION SOFTWARE?

Getting to market faster

By Bruce Klimpke, Technical Director at Integrated Engineering Software

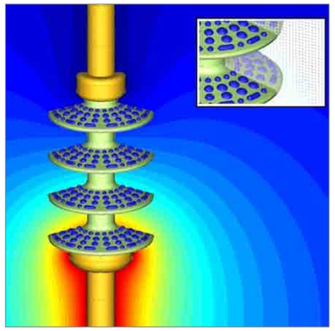
Using modelling software in this current economic market speeds up delivery time by increased accuracy at an early stage

The majority of engineering designers today across all power markets, from industrial to automotive, use some degree of modelling software to speed up the design process prior to prototyping and manufacture. With even the most oil and gas dependent countries placing greater impetus on green energy, the importance of efficient power management is permanently high on the agenda.

In the past designs were tested by building a physical prototype and trying to measure their performance. The drawback of this approach is twofold – firstly, it is costly to produce prototypes and secondly, little design insight is gained. The first problem is obvious but the second, whilst not so obvious, is ultimately more important as it is only by the simulation of a design that great leaps forward can be made. For example, when building a prototype test model the designer can often measure bulk quantities such as voltage or temperature.

However, simulation tools go far beyond these measureable quantities, allowing the engineer to 'see' the invisible, and no amount of prototyping can replicate this. The data accrued from the software can then be used to maximise performance alongside reducing materials and the costs associated with them.

This is, in general, the ultimate use of any design tool - to improve a design by minimising cost, maximising reliability and optimising parameters. To do this, design software should allow users to change parameters, such as dimensions and materials, to establish how they affect the ultimate performance. Software with built in parametric features allow the user to change models without learning a complicated scripting language. This means simulations that may require hundreds of solutions to find the optimal design can be achieved with a very small learning curve. For designers not using simulation tools daily this is especially important as no relearning is required every time a solution to a new problem is needed.



Analysis of insulator covered with water droplets

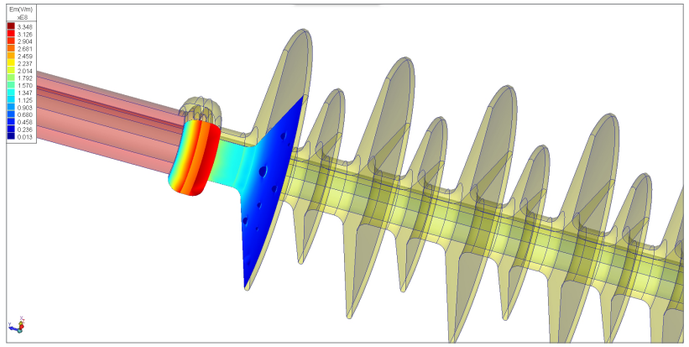
As an example, when designing products that require power, which is practically everything nowadays, it is important to initially be able to calculate the heat density volume. Having established that, it is then necessary to be able to minimise the amount of heat produced as the result of electrical current passing through a conductor, and next to manage that heat to minimise any cooling energy requirements.

Electrical energy is not conserved;

a proportion of it is converted into heat caused by eddy currents. This creation of heat through ohmic and or dielectric losses is highly important to the design and may ultimately determine its performance. Using simulation software for special modelling techniques such as Boundary Element Method (BEM) for electrical field calculation and Finite Element Method (FEM) for thermal analysis makes finding the solution for energy conservation much more simple and time efficient.

When using simulation software it is important to select the best field solver for your specific problem and using both FEM and BEM solvers gives an independent verification of the results. To simulate an electromagnetic problem, Maxwell's equations can be solved in either integral or differential form. Typically, the integral solution is associated with the Boundary Element Method (BEM) and the differential form with the Finite Element Method (FEM). As both methods are solving the same physical problem, the results from both should be the same. The two solution methods are completely different. So whilst one method might be the ideal solution for one type of problem it will be totally wrong for another.

Ideally both methods should be available for the designer to select which method will give the best result alongside the least amount



Electric Field Contours plotted on shed of High Voltage Bushing

of user input time with the fastest computation time. In general, the boundary element solution is the best approach if the problem is linear with a large open region to handle. The boundary element approach, however, can lose some of its lustre when solving highly non-linear material properties. Certain classes of transient analysis are not readily handled by the BEM method, so for many of these problems the FEM is a superb method.

The hybrid approach, where part of the problem is solved with FEM and the remainder solved with BEM would typically be the ideal solution. However, care must be taken when using hybrid methods as this can greatly increase the solution times for some problems. So, the question is not which is better, FEM or BEM, but which method is best suited for a specific application.

To undertake any simulation, the physics of the problem must be input into the software. Normally the most difficult part of this is entering the geometry. The geometry for certain programs can be created using the geometric modelling tools within the software or can be input from the major CAD vendors like Solid Works; Solid Edge, Inventor or Pro E. Normally geometry created with these tools is not precise enough for solving the problem but Integrated Engineering Software provides healing tools to prepare the geometry for either a FEM or BEM mesh.

One major question when simulating a design is whether to proceed in two dimension or three dimensions. As the real world is always 3D, ideally all problems would be solved in this way. However, most designers usually work in 2D due to the greater ease of inputting data and the radically faster solution times. To optimise a design thousands of solutions are often required and this is normally only practical for 2D models as the full equivalent 3D models can take hundreds of times longer to solve. As an added level, for coupled field problems, such as combined magnetic and thermal, the magnetic field may be solved in 2D but the thermal may require a full 3D solution.

As desktop computing has progressed including the time dimension has started to become practical, meaning that with the three spatial dimensions some practical solutions can be obtained for the full 4D world. As more processors and greater memory becomes available, 4D problem solution will move into mainstream computations and will be useful to the designer for even more realistic simulation of true world conditions.

Modelling permits an engineer to simulate innumerable options before beginning a build which in the past would have taken years, and now takes days. It is routinely used by companies wanting to create new energy efficient products, or to improve existing designs, as they can design and test product ideas prior to the manufacturing process, enabling them to modify the parameters to produce end products that minimise waste.

Simulation software therefore reduces costs and minimises risks associated with physical prototyping - be it for bushings for major grid electricity or the battery in a cell-phone. It also allows companies to reduce design time and costs, spend less money on expensive prototypes, improve product performance, decrease time to market and ultimately increase profitability.

Author: Bruce Klimpke
Technical Director
Integrated Engineering Software

www.integratedsoft.com

POWER CONDITIONING

A business case for significant cost savings

By Rob Morris

In a two-year study involving customer projects around the world, POWERVAR, a power management systems company, examined how power quality technology can significantly reduce the service burden rate, delivering cost savings and a measurable return on investment (ROI).

Most organisations today recognise that power quality is an issue when it comes to the detrimental effect of power disturbances, such as electrical noise and voltage impulses, on sensitive electronic systems. The problem, however, is in accurately calculating figures that demonstrate the financial downside of dealing with bad power. Simply put, how can you establish the Return on Investment (ROI) when selecting from different power protection systems?

For most organisations, power quality problems are 'out of sight, out of mind'. While the frequency of spikes, surges and other phenomena in power distribution is generally understood and accepted, many fail to make the connection between these irregularities and the impact to their bottom line.

Over the last two years, POWERVAR worked closely with its customers to identify a technique to help quantify and educate the industry about calculating real ROI. A major focus has been about understanding the so-called 'service burden rate' – this is the proportion of the price of a product allocated to cover ongoing maintenance and repairs during the warranty period.

Our extensive research found that the typical service burden rate ranged somewhere between 4 and 8 per cent of the price of the equipment or solution. But results gathered from more than a thousand pieces of equipment installed by our customers showed a reduction of between 43 and 88 per cent in warranty service costs. Even taking into account the cost of buying the power protection equipment, the ROI in these applications varied between 154 and a top level of 1,148 per cent.

POWERVAR SecurityPlus product

The benefits were not just financial either – there is a 'softer ROI' to consider, such as a reduction in service calls to the manufacturer, improved customer satisfaction and greater customer loyalty, as well as competitive advantage, important in commodity based businesses largely driven by price.

The challenges of power supply

Whether power comes from a public utility or produced onsite, the quality is always a challenge for today's electronic equipment. The power from utility companies, even in developed countries, still largely meets standards set in the very earliest days of electricity. This was fine for many years until the advent of hi-tech equipment incorporating sensitive components like integrated circuits.

POWERVAR UPM and power conditioning group of products

The power supply in the US and other developed nations experiences an average of 8.8 hours of outages a year. Less visible is the annual average of 79 hours in which the quality of power is poor. Spread over the course of a year, these incidents frequently cause costly damage or failures.

Such power irregularities are not immediately fatal to equipment, but can produce cumulative damage that will eventually cause sudden system failure or lock up without warning. As soon as one component is replaced the cycle begins again and it's a matter of time before the failure is repeated.

The key to delivering a higher ROI for OEMs is a direct and fast reduction in the service burden. We focus on increasing equipment reliability and uptime on the one hand, and reducing operational and service costs on the other. A notable proportion of service problems result in 'no trouble found' service calls, most likely caused by power quality problems. The ability to reduce these calls has a positive impact on warranty costs and customer satisfaction.

By reducing service costs by up to 88 or even 43 per cent, as reported in the study above, customers are saving millions in some cases. In addition, the average number of help desk calls dropped by 60 per cent. These are savings that every business, regardless of size or industry, wants to achieve. Harder to measure is the impact on reputation and market share, although these are real benefits too. An additional benefit is the increase in profits from service contracts – so manufacturers can look to extend their product warranties from say two to five years.

Clearly power quality is not the only factor impacting the service burden rate. There are all sorts of software, training, hardware and personnel issues that can also play a role, but addressing and eliminating the 'hidden' and often hard-to-trace problems caused by power fluctuations frees up time and resources to sort out these other important areas.

Sensitive sectors

There are a number of key market sectors where focusing on controlling the power variable and protecting the equipment's processes will significantly increase ROI, including:

- Medical and Healthcare systems – clinical and diagnostic equipment, patient monitoring, patient imaging and cardiac catherisation, etc
- Analytical Instrumentation – gas chromatography, liquid chromatography, mass spectroscopy and explosive detection
- Banking and Retail – point of sale, ATMs and kiosks
- Electronics Manufacturing – semiconductors, industrial automation, PCB manufacturing and automated test equipment
- Graphics and Printing – page layout and makeup and digital feed presses

The common element in all of the sectors listed above is that an improved ROI is not just about cost savings, but also about these 'softer' benefits as well – reducing service calls, keeping customers happy, protecting your brand and competitive advantage.

Case study: James Hall & Co (Spar Group wholesaler)

James Hall & Co saw an 80 per cent reduction in hard disk failures and data corruption in its EPOS and back office systems at its petrol retail forecourts compared with its retail outlets that had no power quality equipment in place. This

has led to an investment in power conditioning equipment across its entire retail base of 500 stores.

The company is also considering extending the lifecycle of its retail systems before replacement, from five to six years. It currently rents the equipment to its outlets for five years, but is confident that an investment of around £130,000 in POWERVAR equipment would make it possible to extend the trouble-free life of front and back office systems by 20 per cent and easily deliver additional rental income of more than £2m.

The financial case

Over the years, the power quality market and associated UPS business, which is highly competitive and largely driven by price, has been unable to demonstrate to customers how much power disturbances are costing their business and how power conditioning technology can deliver savings directly to the bottom line. But there is a financial case for investment in such equipment.

The market is now entering an era where investment is made on the grounds of measurable ROI and demonstrable cost savings from service and warranty costs. The industry must start to show customers the kind of savings achievable by working in partnership and by sharing information.

Author: Rob Morris
Country Manager
Powervar UK
www.powervar.com

MAKING THE MOST OF IRON

VAC's High-quality soft magnetic alloys

By Roman Klinger & Dr. Johannes Beichler

In recent years, innovative soft magnetic materials have moved to the forefront of electrical engineering and electronics and led to the development of many advanced components.

Today, VACUUMSCHMELZE (VAC) produces an array of high-quality soft magnetic alloys and advanced alloy products for a wide range of applications, including installation technology (e.g. electronic electricity meters) and renewable energies (solar, wind) to modern consumer products (computers, flat screen TVs). Although VAC's contributions are usually concealed within the finished product, they fulfil important functions such as device and personal protection, billing processes accurate to the last cent, low-loss energy transmission and the interference-free operation of electronic devices.

VAC is among the world's leading producers of amorphous and nanocrystalline magnetic alloys, manufacturing inductive components with cores of these materials. Its product portfolio ranges from power transformers and signal transformers, precision current transformers and current sensors to switched-mode power supply

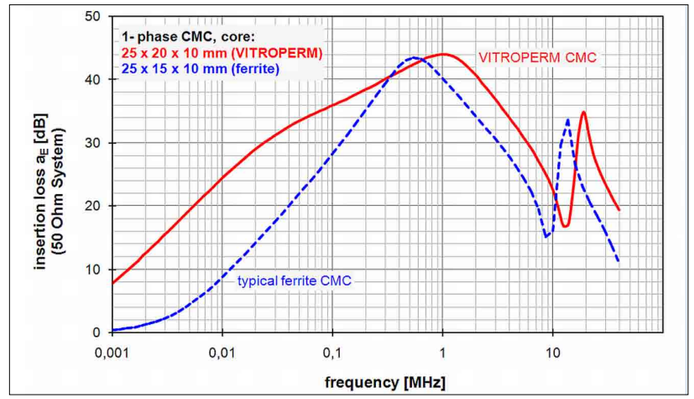


Figure 1: Broadband attenuation

chokes and EMC products.

Toroidal tape-wound cores made from the nanocrystalline alloy VITROPERM® have a proven track record in common-mode chokes (CMCs) for the interference suppression for electronic devices. The superior properties of VITROPERM CMCs enable high attenuation at low-frequency ranges and excellent high-frequency (HF) attenuation.

Compared to chokes made with ferrite cores, the broadband interference suppression, coupled with superior thermal properties, delivers significant advantages in filter design and enables the production of highly reliable EMI filters. In certain conditions, intelligent filter configuration enables single-stage filters to be used instead of two-stage filters, hence reducing the number of passive components, system costs and component dimensions.

VITROPERM has already established itself in a wide range of applications as a competitive universal solution for EMC problems through its use of low-cost alloy

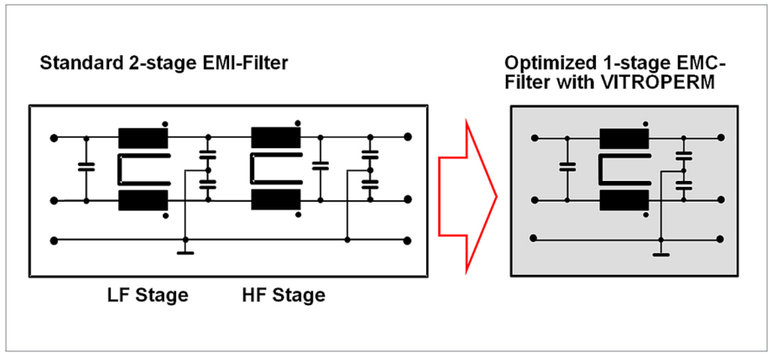


Figure 2: Nanocrystalline CMCs enable a reduction of filter stages

constituents (Fe-based) and modern large-scale production lines. Key applications for nanocrystalline CMCs are switched-mode power supplies, uninterruptable power supplies, welding equipment, photo-voltaic solar inverters, wind generators, electric and hybrid cars and frequency converters.

Nanocrystalline VITROPERM alloys are based on Fe, Si and B with Nb and Cu additions. Using rapid solidification technology, thin tapes or ribbons approximately 20 µm thick are produced from these alloys in a single process step.

Special winding machines are used to produce tape-wound cores from these ribbons, with external diameters ranging from 2 mm to 600 mm. The cores then undergo a heat treatment at 500 °C to 600°C while still in an amorphous state, to form the nanocrystalline microstructure. This process results in a two-phase structure in which fine crystalline grains (average grain size 10-40 nm) are embedded in an amorphous residual phase. This characteristic structure maximises the permeability µ and minimises the coercivity Hc. In addition, the low tape thickness and relatively high electrical resistivity of 1.1 – 1.2 µΩm ensures minimal eddy current losses and outstanding frequency response for the core. As a high-tech nanocrystalline soft magnetic alloy, VITROPERM combines these properties with a saturation flux density of 1.2 T and favourable thermal characteristics. It thus represents a universal solution to EMC problems which, in many aspects, is superior to conventional ferrites and amorphous materials.

VITROPERM vs. ferrite

The properties of VITROPERM differ widely from those of conventional ferrites. This must be considered in filter design if optimum solutions are to be achieved. In low-frequency ranges the permeability of VITROPERM 500F is significantly higher than that of ferrite. Nanocrystalline materials show a less marked reduction of permeability µ at higher frequencies. µ(f) of ferrites shows a flat characteristic over a range from several hundred kHz to approximately 1 MHz, dependent on the initial µ-value. In this flat range, attenuation properties are determined by the real part of the complex permeability µ' and the absolute value of the impedance |Z| is dominated by the inductance L. If the self-resonance of the choke is within this frequency range, the attenuation characteristic is narrowband and attenuation is primarily caused by reflection of the interference signal. The attenuation of ferrites is determined by its resistive parameters at frequencies above the flat range mentioned above because the real part of the impedance Re(Z) account for the major share of the attenuation and the imaginary part of the complex permeability µ'' becomes the dominant factor. If the self-resonance of the choke is in this range then the attenuation curve becomes increasingly broadband.

The flat sector of µ(f) of VITROPERM 500F only extends up to frequencies of several tens of kHz, depending on the individual permeability level. Consequently, at higher frequencies the attenuation (or |Z|) is already dominated by µ'', respectively Re(Z) and is always broadband in the whole EMC-relevant range above 150kHz. Inductance plays a minor role and only partially influences the attenuation. The determining factor is the total impedance. The approximation |Z|=ω is invalid for VITROPERM chokes, to which |Z|>>ω applies. Attenuation does not primarily result from a reflection of the interference signal, but from its absorption.

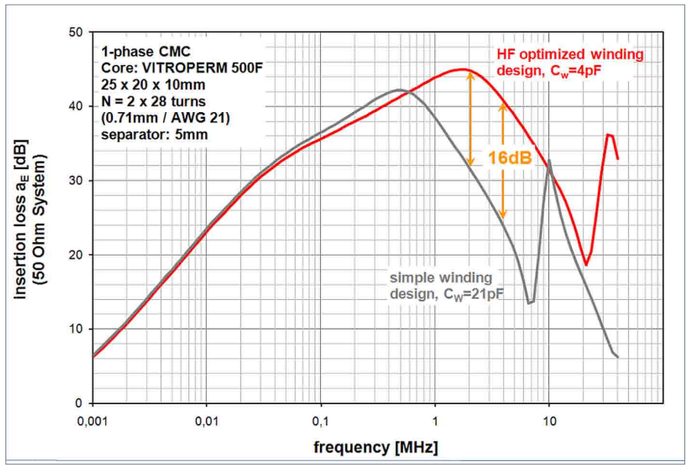


Figure 3: By optimizing choke design, attenuation is improved by up to 16 dB or over in the HF range.

High impedance is achieved more effectively by using a highly permeable core material, rather than by increasing the number of turns, since a low number of turns corresponds to a low winding capacitance and thus superior HF properties. VACUUMSCHMELZE has focused on the favourable material properties of nanocrystalline cores to build extensive practical and theoretical experience in the design of common-mode chokes and filters. Using identical material, VAC's optimized chokes with low winding capacitance achieve significantly better high-frequency properties.

Thermal properties

The saturation flux density of VITROPERM decreases by less than 5 – 10 % in the operating temperature range of up to 150°C, while MnZn ferrites declines by up to 40% at temperatures approaching 100°C. VITROPERM alloys have a high Curie temperature of over 600°C, temporarily allowing maximum operating temperatures as high as 180 - 200°C. The insertion loss (and impedance) of a CMC made of VITROPERM 500F is practically temperature-independent over a temperature range of -40°C to above 150°C. In contrast, ferrite chokes show a significant drop in insertion loss at increasing temperatures.

Saturation behaviour

High inductance levels in extremely compact cores or chokes increase the sensitivity to asymmetric magnetization conditions caused by common-mode, unbalanced or leakage currents. The saturation flux density of VITROPERM of 1.2 T has the advantage of being approximately three times higher than that of ferrites but a suitable µ level has to be selected very carefully to find the optimum saturation-resistant solution. High permeability VITROPERM cores are characterized by an extremely high impedance at low frequencies and they are clearly superior against ferrites at high frequencies. However, the price of this superior performance is a more sensitive saturation behaviour, which increases with increasing frequency but is still more critical than that of other low µ core materials.

The superior material properties of nanocrystalline core materials enable the production of common-mode chokes with high inductance and an extremely low number of turns. VITROPERM cores and chokes are thus equally suitable for high currents and high voltages. Further information on VAC cores and common-mode chokes can be found in the recently published application note 'Nanocrystalline VITROPERM - EMC Products'.

Authors: Roman Klinger
Product Marketing Manager - Industrial Applications
Business Cores and Components

Dr. Johannes Beichler
Developer Inductive Components
Business Cores and Components

www.vacuumschmelze.de

Special Report: Health, Medical & Mobility

PSD EUROPE
Power Systems Design: Empowering Global Innovation

Inside:

PATIENT PROTECTION

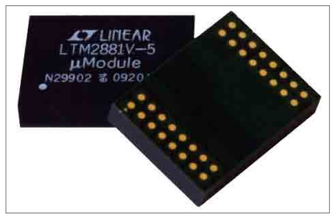
Isolation requirements for equipment

By Jeff Marvin

An important consideration when designing medical products is satisfying the IEC 60601-1 safety standard and the isolation ratings for products that come into contact with patients.

One of the most critical aspects of human safety and a challenging part of the product design is minimizing patient leakage currents, including AC currents. Since an isolation barrier always presents capacitance, it frequently must be minimized to limit AC leakage currents that result from signaling and switching supply voltages which induce capacitive currents. The most stringent leakage requirement is patient leakage from an applied part such as a floating cardio, type CF, applied part, for example an Electrocardiogram (ECG/EKG) probe pad. In normal operation the combined AC/DC leakage current must be less than 10µA.

Patients and operators must also be protected from leakage paths from an enclosure or accessible parts of the equipment. These currents that a patient or operator may be exposed to are known as "touch currents." Under normal conditions, the touch current from or between parts of the medical system within the patient environment shall not exceed 100µA. This touch current limit is 500uA during a single fault condition (SFC), which occurs when a single means of protection is defective or a single abnormal condition is present.



LTM2881 2.5kVRMS isolated RS485 µModule transceiver

Medical electrical equipment shall have two means of protection (MOP) to prevent applied parts and other accessible parts from exceeding leakage and touch currents. A MOP includes insulation, air clearances, creepage distances, impedances, and protective earth connections. There are two fundamental classes of medical electrical equipment. Class I refers to electrical equipment that includes basic insulation plus additional safety protection provided for accessible parts to be protectively earthed / grounded. Class II ME equipment includes protection against electric shock from not only basic insulation but includes additional safety protection by double or reinforced insulation. There is no requirement for protective earthing or reliance on installation conditions to meet the class II safety requirements.

Double insulation comprises both basic insulation and supplementary insulation. Double insulation provides two means of protection and reinforced insulation is a single insulation system that provides two means of protection. To satisfy two means of patient protection (MOPP) the component must be subject to AC test voltages.

With a 5kVRMS rated component using solid insulation this translates into 707VPK or 500VRMS working voltage. There is a common perception that medical isolation devices must satisfy a minimum distance through insulation of 0.4 mm thickness. The other acceptable criterion is that the insulation must comprise at least two layers of material, each of which will pass the appropriate dielectric strength test. For reinforced insulation the appropriate dielectric strength test must be sufficient for two means of protection (MOP).

IEC 60601 specifies patient leakage currents when equipment is connected to the patient with limits as low as 10µADC for normal operation and 50µADC for a single fault condition. The safest patient applied parts are F-type isolated (floating) applied parts in which the patient connections are isolated from other parts of the ME equipment. The isolation must prevent any current higher than the allowable patient leakage current to flow even if an unintended voltage originating from an external source is connected to the patient, and thereby applied between the patient connection and earth. F-type applied parts are further classified as either type BF for body applied floating or CF for cardio type floating. See Table 1. The table includes individual applied part currents as well as total patient leakage current which is a measure of the leakage current when all applied parts required for the operation of the medical device are in contact with the patient.

Touch current, also listed in Table 1, is a leakage current flowing from the enclosure or from equipment parts, excluding patient connections, accessible to any operator or patient in normal use, through an external path other than the protective earth conductor, to earth or to another part of the enclosure. The meaning of this term is the same as that of "enclosure leakage current" and is now aligned between IEC 60601 and IEC 60950 and properly reflects the fact that the leakage applies also to parts that are normally protectively earthed.

Current	Applied Part	Normal (DC / AC)	SFC (DC / AC)
Patient Applied Part Leakage	Type BF	10 µA / 100 µA	50 µA / 500 µA
	Type CF	10 µA	100 µA
Total Patient Leakage	Type BF	50 µA / 500 µA	100 µA / 1 mA
	Type CF	50 µA	100 µA
Touch		100 µA	500 µA

Table 1: Allowable Patient Leakage and Touch Currents

Per the IEC60601-1 standard, components on the isolation barrier that satisfy two means of patient protection need to meet 4kVRMS isolation for a period of 1 minute. This standard also defines means of patient protection (MOPP), which describes the isolation protection required to reduce the risk of electric shock to the patient. There are also requirements for means of operator protection (MOOP). ME equipment requires two means of protection to reduce the electrical risk to the patient and the operator when a fault or failure bypasses one means of protection. The isolation protection requirements include the creepage/clearance distances, insulation and protective earth connections, pollution degree and total leakage current specifications. Two MOPP requires double the creepage distance and air clearance. Many ME products are powered from standard 120VAC as well as 240VAC and this standard working voltage is usually rounded up to 250VAC. The required creepage distance for one MOPP is 4mm and two MOPP is 8mm. This 250VRMS is equivalent to 354VDC (or peak) and requires a test voltage for two MOPP equal to 4kVRMS.

As shown, 4kVRMS is a common isolation requirement for a patient-applied part to directly satisfy two MOPP. There is an additional, optional requirement that can apply to many medical instruments to stand off voltage up to 5kVPK, which reiterates the need for 4kVRMS. This is when the medical equipment and applied parts need to be defibrillation-proof. A defibrillation-proof applied part is where the part is protected against the effects of a discharge of a cardiac defibrillator to the patient. A defibrillator is basically a charged capacitor in series with an inductor to limit the current. This makes a decaying sine wave when fired and the peak voltage of the first ring can be significantly higher than the charge on the capacitor itself. It has been determined and agreed to in IEC 60601 that 5kVPK

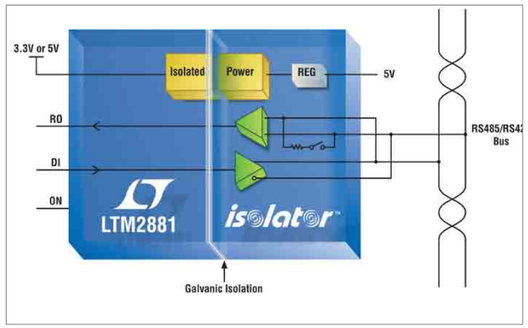


Figure 1: Complete Isolated RS485/RS422 µModule Transceiver + 1W Power

is the maximum value of this voltage overshoot, so that is what is required to keep the patient safe from electric shock if an isolation barrier were to breakdown when they are defibrillated.

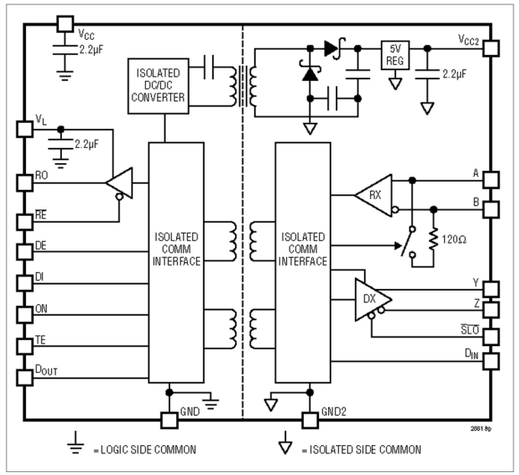
This type of design environment is extremely challenging. Meeting the requirements of IEC 60601 is required when developing products for medical markets. Linear Technology offers an expanding line of isolation devices that help meet the requirements for medical isolation.

Linear Technology are introducing a line of 5kVRMS isolation devices offering integrated power to deliver up to 1Watt plus isolated data interface with no external components required. This family is based on the LTM2881 2.5kVRMS isolated RS485 µModule transceiver that provides uninterrupted communication through high voltage transient events at speeds of up to 20Mbps. The product includes an isolated 1W DC/DC converter with up to 62% efficiency, offering surplus power at a 5V regulated output. Everything from decoupling caps, diodes and even a switchable termination resistor are integrated into the module. The isolation barrier is constructed with two layers of dielectric material capable of up to 5kVRMS, which will meet the creepage and clearance requirements of the specification. The LTM2881 offers ±15kV of ESD protection on the transceiver pins and across the isolation barrier.

A superior failsafe receiver guarantees the receiver output to be in a logic-high state when the inputs are shorted, left open, or terminated, but not driven. The receiver thresholds are balanced to maintain data duty cycle with long network connections. The LTM2881 also protects itself by disabling the driver and receiver outputs in the case of excessive power dissipation.

Meanwhile, a 1.62V to 5.5V logic supply pin makes it convenient to interface to digital components, while still maintaining TIA/EIA-compliant RS485 signals with either a 3.3V or 5V supply. The LTM2881 also offers a low current shutdown mode, drawing less than 5µA when not required to communicate.

These new devices offer a robust solution that provides continuous communication, even through transient events greater than 30kV/µs. The LTM2881 offers a low EMI solution, with nominal barrier capacitance of 6pF, and can meet the requirements of EN 55022/CISPR 22 Class B radiated emissions provided good layout practices are followed. RS232 and digital logic isolator versions are also available.



Block Diagram

Author: Jeff Marvin
Design Center Manager,
Mixed Signal Products
Linear Technology Corp
www.linear.com

SPECIAL REPORT : HEALTH, MEDICAL & MOBILITY

DESIGNING FOR MEDICAL

Choosing the right power partner

By Shane Callanan

The vital selection process required for choosing the most suitable supplier for a medical power supply and to achieve requirements for EN60601 specifications

Power supplies are a critical part of any system and great care must be taken in choosing the right product. For medical power supplies that must comply with EN60601, an additional requirement that must also be considered and is the Risk Analysis and Risk Management issues. EN60601-1-1:2005, more commonly referred to as EN60601, 3rd edition, requires not only the additional risk management aspect but also the competency of the individuals to carry out this risk analysis. In light of this requirement alone it is imperative that you choose not only the right power supply but also the right company to ensure that you will be supported throughout the lifetime of the product.

Identify a potential power supply vendor

Once you have a general concept of your system you will begin to have an understanding of the electrical and mechanical requirements. From here your specifications can then be categorized into three sections Basic, Critical, or Special requirements.

Basic Specifications will cover some key items such as input voltage range, output voltage and current requirements, and the form factor. Critical Specifications will cover your isolation requirements, safety approvals, EMI performance, and on-board protection and so on. And finally Special requirements will involve any particular requirements for your given application. Once these are established and your budget is defined you can now engage with a vendor.

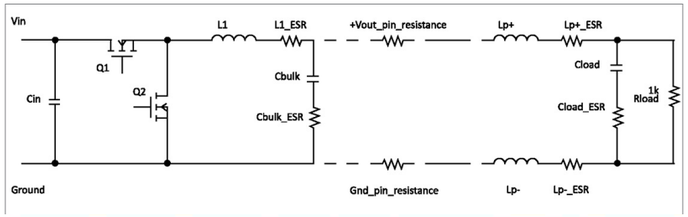
Establish the power supply and the company are the right choice

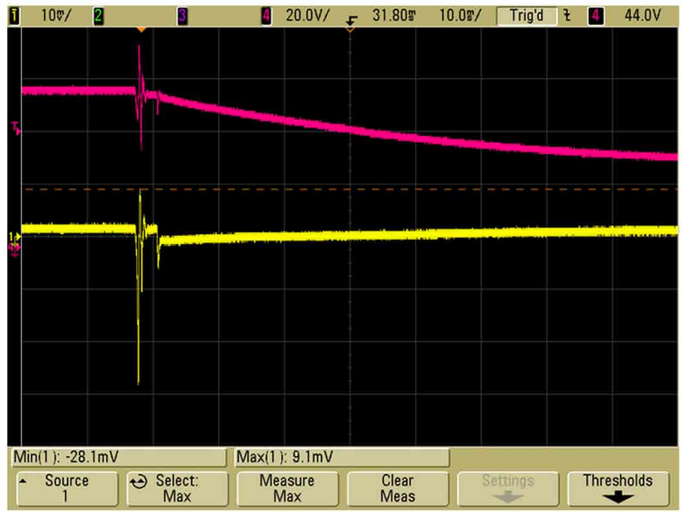
In choosing a vendor you should not limit your search to identifying a company that can just supply you with a once off solution. You should instead be looking to identify a company who can support you on all aspects of the project for the lifetime of the project. After all, you will not be looking for the company to just sell you a solution. You will need support in many forms. Customer support, engineering support, and field support issues are just but a few that will be required over the lifetime of the project. There will also be support documentation required for various agencies as your finished product goes through with approvals agencies. So in many ways you should not just looking for a vendor, but focus your efforts on finding the right partner.

Choosing the right partner

Despite the level of detail that you put into before integrating a power supply into your system, there will inevitably be some characteristic of the design that will need to be looked at in more detail. When this arises it is paramount that all relevant parties get involved as soon as possible. This may range from some obscure (any maybe irrelevant) event right up to the unit not been able to accommodate the applications requirements at some particular operating condition. This is where choosing the right partner will really pay dividends.

In one such case a customer of Excelsys was using the Xgen series with very high capacitive loading. Because of this large capacitive loading, we saw excessive energy being forced back into our unit on shut down. On-board the Xgen we have negative current limit, and this was being engaged. Consequently we observed high voltage peaks on shut down, which was being interpreted by our unit as an Over Voltage event. A further protective circuit on-board was thus engaging and our design was latching itself in an off state. If the user tried to power cycle within a 2-minute period, the latch circuit remained charged, and the unit would not turn on. This was being reported as an intermittent failure at the customer's location. After early discussions with our customer, we were able to offer a number of solutions, both internal and external to the Xgen series. After reviewing all solutions an agreement was reached to offer the customer a modification of our standard product on which we moved the trigger level of the over voltage protection. The key point to resolving this issue in a timely fashion was based on the relationships between our two companies. Engineering staff from both sides had a clear understanding of the issue, it was communicated clearly, and once a resolution was identified and agreed by all it was implemented in the product. Channel1 (Red) above shows the resultant output voltage spike occurring when the negative current limit is reached, and the output





stage goes high impedance. Energy from the load is no longer being dissipated by the power supply and the voltage rises.

Ensure the right questions are asked of your partner

A full divulgence of your design to the power supply company is not required, and the reality is, that your company will want to protect its intellectual property. This may curtail the amount of information that can be divulged to outside parties. However, the more information that can be supplied to the technical team the better equipped they will be to assist you. This is again where the relationship should be viewed as partnership. Non Disclosure Agreements should be sufficient to protect the concerns of all parties.

What would be required is an understanding of the type of load. Is it primarily a capacitive, resistive or an inductive load? Are you driving a motor, or will there be large transients on the output? Of course a customized power supply will be designed to accommodate all of the specified requirements, but in some situations the standard off the shelf design may not meet every requirement of a particular application. This may require an external circuit or component to enable reliable use in your system. When reviewing the datasheet you should dig a little bit deeper, understand of the values presented are typical, minimum or maximum values. You should also look at how thing like PFC, efficiency, ripple and noise will perform for your particular line and load requirements. Often the banner headlines do not portray the full picture.

Another key feature to be addressed is compliance and certification to EN60601-1-1:2005

EN60601 3rd Edition risk analysis compliance

As a medical device manufacturer, "risk management" is a term you will be familiar with. The 3rd Edition of IEC 60601-1 now requires you to demonstrate that you have a documented risk management system in place, to verify that your device is safe. Manufacturers are not necessarily required to have a risk management audit and UL does offer the option of a desktop assessment to receive a UL mark to 3rd edition. Field experience can also be used, as long it is not the sole basis of establishing compliance.

For 3rd edition certification, the manufacturer's risk management process will be assessed. The risk management file is key and will need to capture the outputs of your risk management process. The guidelines for these call for all foreseeable misuse, and should take into consideration some modes of operation that would be outside of the specified operating limits. You will need to outline the work carried out detail how you reached these conclusions. It should be carried out and be in keeping with ISO14971, which provides a framework to develop a risk management. The requirements of this standard apply to all stages of the product's life cycle, from concept through to volume production.

The competency of those involved in carrying out this analysis is key to ensuring the smooth transition to 3rd edition compliance and your relationship with your vendor.

Summary

When choosing a power supply vendor, look for a long-term solution. You will need to satisfy yourself that your partners can support you over the lifetime of your design and in the long term.

Author: Shane Callanan
Applications Engineering Manager
Excelsys Technologies

www.excelsys.com

INFORMATION FUSION IN MEDICAL SYSTEMS

Providing higher quality data to augment information

By Richard F. Zarr

As medical instrumentation acquires increased processing power, the amount of information that is gathered from a patient is growing exponentially.

Whenever large amounts of data are presented to operators (in this case medical professionals), it is possible to overwhelm them with the information sometimes preventing them from identifying root causes or other underlying conditions. In this article we will examine the concept of data fusion and the additional requirements of medical equipment to allow real-time analysis from the many sources.

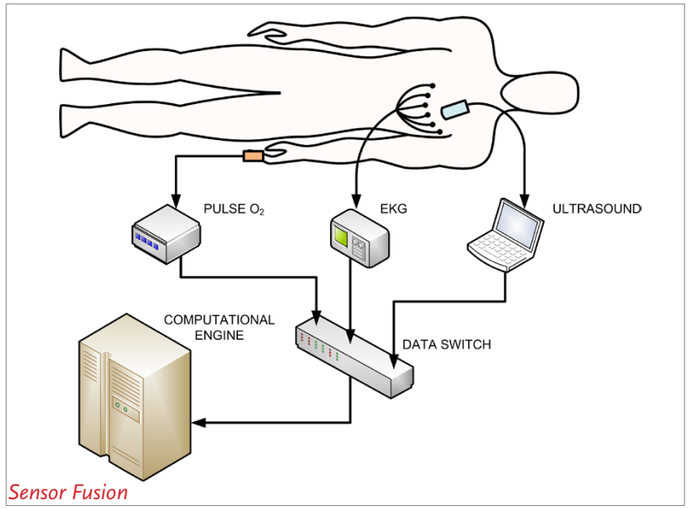
Sensing and imaging technologies have revolutionised the medical industry allowing much faster diagnosis and treatment of disease. What is most interesting to note is that many different types of sensors and imaging systems are employed today depending on what a physician or team is looking for. In effect, they already need to have some idea of the problem. However, imaging and sensing technologies have different problems and by incorporating data fusion, the quality of the data can be greatly improved. Some experimental imaging systems are already combining Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) scanners which show both function and anatomy. From a hardware point of view, this usually means collecting large amounts of data and by computational methods fuse this data in post processing... thus a new problem of rapid, high speed data acquisition appears as well as Time of Acquisition (ToA) accuracy.

The Benefits and Drawbacks of Data Fusion

The concept of sensor fusion is to overcome individual sensor technology shortcomings by combining the best features of each. For example, it is very common today to find hybrid PET/CT scanners. These machines provide two modalities of imaging – Positron Emission Tomography and x-ray Computed Tomography – in a single gantry. This helps eliminate the error with doing the scan separately and attempting to combine the images. The benefit of both is that the resulting image provides both function and anatomy.

Imaging is a clear area that can benefit from data fusion, however it can increase the patient cost since hybrid machines must incorporate both sensor technologies as well as additional computational power. However, the advantage of this configuration is that both sensors are co-located. The question then becomes - what happens when sensors are distributed between different systems? Time coordination is extremely important when gathering data since the algorithms used must know the exact time the data was sampled in order to properly combine sources.

For instance, there may be benefit from combining an Electrocardiogram (EKG) with ultrasound imaging allowing the electrical information to augment the video of the moving heart. This allows for what is often termed "augmented reality" which is a fusion of multiple data sources to the actual event being observed – usually in real time. In the case of the EKG / ultrasound hybrid, separate devices must provide data to the computational engine doing the data fusion. If Pulse Oximetry or CO-oximetry is added, then multiple devices must all coordinate their data with accurate time stamps to ensure the delivery of the information for proper fusion (see figure 1). If the data is not accurately time-stamped, then fusion of the data becomes error prone and more difficult making real-time augmentation complicated.



Sensor Fusion

Many times sensors have advantages and disadvantages. Different sensor types provide good quality information on different aspects of the physical property being sensed. That is, some provide good long term drift but poor dynamic response. Others provide good dynamic response, but poor drift or accuracy. If both sensor types are employed, then the outputs can be combined (or fused) to provide the best of both worlds. Both worlds in the example above would be good dynamic response and long term drift or accuracy.

Usually this combining function is accomplished through a method called Kalman Filtering. This method is very useful in noisy environments, but can be used in sensor fusion as well. Kalman filtering uses calculations to predict estimates of what the output should be. The uncertainty of the prediction is estimated and a weighted average of this value and the actual measurement (or input) is calculated. The most influence is given to the average with the least uncertainty. This method provides a much closer value to the actual value since the weighted average has a lower uncertainty to either the estimated or measured value.

For a medical example, certain medical sensors do an excellent job at specific tasks, but do not always provide enough information. In the case discussed earlier, pulse oximetry provides the percentage blood oxygen saturation information, however in the case of certain blood poisoning (e.g. CO_2 or Cyanide) these devices do not provide enough information, so supplemental equipment is used to measure the exchange rate of oxygen with CO_2. By using sensor fusion between these two devices, a more complete picture of the patient's blood oxygen levels is provided.

Standard Time Coordination Protocols

Medical data fusion is only one area that suffers from the problem of sample time accuracy. Many other distributed data

acquisition and communications applications such as cellular radio require extremely controlled timing information. Much research has gone into providing highly accurate clocks locally, however in a distributed environment, it becomes much more difficult.

There are standard time protocols provided within certain frameworks like Ethernet such as Network Time Protocol (NTP), but this lacks the precision required to build high performance distributed systems with any accuracy. Knowing the limitations of NTP and other time protocols, the IEEE proposed the IEEE1588 standard in 2002. This proposal later was adopted into a standard (IEEE1588-2008) which is now called Precision Time Protocol (PTP). This standard can easily provide sub-microsecond synchronisation between Ethernet nodes that support it.

PTP works by exchanging time information in a deterministic way from a master clock which is chosen via the Best Master Clock (BMC) algorithm. Once the master clock in known within the domain, nodes calculate the offset from the master by a series of exchanges with the master clock (see figure 2).

There is a great deal of hidden complexity in this protocol to assure accurate time keeping. The closer the logic of this protocol is to the physical layer, the more tightly controllable is the time. If the protocol is performed in software above the MAC layer, then the accuracy may only be within 100's of microseconds. This be may OK for some alternate reality fusion applications, but for higher resolution, it needs to closer to the hardware.

The best solution is to place the 1588 protocol engine directly into the PHY which removes much of the non-deterministic jitter caused by random processing events in the layers above the physical and MAC layers. Some semiconductor vendors have built this logic directly into an Ethernet physical layer device such as the National Semiconductor DP83640 which when connected to other DP83640 devices in the system can provide sub 10 nanosecond accuracy in synchronisation.

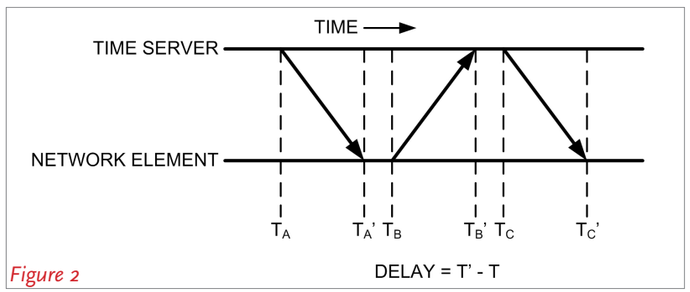


Figure 2

Conclusion

Sensor fusion can overcome the short-comings of individual sensors providing higher quality data along with the ability to augment information being provided to physicians. When considering systems that provide augmented reality in distributed architectures, time synchronisation is extremely important. Without it, greater amounts of processing power are required to "re-align" the data to the point where real-time imaging or displays become difficult. In the future, scanners that show a patient's condition will use many different inputs to provide physicians the ability to "see" combined information in a way that will make diagnosis faster and more accurate.

Richard F. Zarr
MTS Technologist
National Semiconductor
Corporation by Texas Instruments

www.national.com

SPECIAL REPORT : HEALTH, MEDICAL & MOBILITY

IEC60601 MEDICAL STANDARDS

Understanding the changes from 2nd to 3rd edition

By Peter Blyth

The internationally accepted IEC 60601-1 standard has been continuously developed to help alleviate safety issues relating to all manner of medical equipment.

Engineers need to be aware that when using these standards, there are a number of key dates specified for the implementation of the 3rd edition, and that these vary by region.

In Europe, from 1st June 2012 the 2nd edition (EN60601-1/A2:1995) will be withdrawn, and all products will need to be certified to the 3rd edition, EN60601-1:2006. This includes both new products introduced to the market and products already on sale. The situation is rather different in the United States. The cessation date for 2nd edition (UL60601-1:2003 1st edition) is 30June 2013 but, unlike the EU, the FDA only requires that new products brought to market after this date will need to be 3rd edition certified (ANSI/AAMI ES60601-1:2005). In Canada the cessation date for 2nd edition (CAN/CSA C22.2 No. 601.1) is 1 June 2012, but again the 3rd edition (CSAω C22.2 NO. 60601ω:08) is only needed for products new to the market after this date.

Another complicating factor is the particular standards that are part of the 60601 family. These are commonly referred to as "part 2's" and will have the standard number 60601-2-xx, such as IEC60601-2-46, particular requirements for the safety of operating tables. Where these are applicable the equipment needs to be certified to these standards and therefore the date for 3rd edition adaption will be dictated by the date that the 2nd edition part 2 is withdrawn. This could be before the main date or after it. Some countries are, to date, not adopting 3rd edition. This means that equipment will need to be certified to IEC60601-1/A2:1995 2nd edition for those regions, because after 1st June 2012 EN60601-1 2nd edition will be withdrawn and UL60601-1 will be withdrawn in June 2013.

At XP Power all power supplies are certified to 3rd edition (with 2 x Means Of Patient Protection on the majority of power supply) but to also test against 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. The OEM can claim the safety of the power supply is at least as good as the current standard (2nd edition) and will still maintain the 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)
One of the most significant changes in the 3rd edition 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.

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—fail-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 that 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 models the insulation diagram that applies to the main circuit blocks in a notional 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.

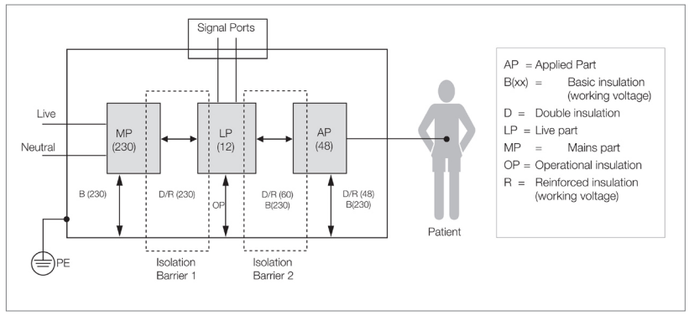


Figure 1: IEC60601-1 3rd edition demands that two means of protection (MOPs), or isolation barriers exist where patients may come into contact with equipment.

The standard allows for three defensive approaches that may be used in various combinations—safety insulation, protective earth, and protection impedance. It's therefore essential to determine several key factors from the outset 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 as to 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. Specifically, anything that falls within the remit of operator protection only has to meet the clearance and creepage requirements that IEC/EN 60950 specifies for general-purpose information and technology equipment. By contrast, circuitry that falls within the realm of patient protection must meet the far more exacting requirements of the 2nd edition of IEC 60601-1. 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, other isolation schemes need to be in place between the output and the patient if the equipment is to come in contact with the patient. It complicates the design and increases 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 for the USA and 500uA for the EU.

At XP Power, the power supply for a medical device must provide the highest degree of protection and reduce the risk of a shock hazard and have make our power supplies with 2 x MOPP from input to output (mains to low voltage dc). This gives customer flexibility and minimizes the risk of a shock hazard.

A major component to the 3rd edition is for a Risk Management Process to be included as part of the submittal to the certified body who will undertake the product certification. While risk management is not a new concept to device manufacturers it is new for the power supply manufacturers. Under 2nd edition the certified body would test against a pass/fail criterion which was very black and white. It is true that this same pass/fail criterion exists under 3rd edition but it is also required that risk management is included.
The IEC recently published a guidance note for power supply manufacturers stating that 3rd edition could be gained without risk management, but that the device manufacturer would have to cover this during their submittal, but this merely pushes the cost back to the device manufacturer and ultimately the device manufacturer will require the PSU manufacturer to provide risk analysis, Failure Mode Effects Analysis (FMEA) etc. If the power supply manufacturer doesn't have this prepared then there could be a delay in getting this valuable information.

XP Power submits a risk management process with all submittals and make this available to customers where necessary. Customers can now assume the power supply is a "black box" and just consider the implications of output failing etc.

The internal analysis is done by XP Power. In order to achieve this, we embraced ISO14971 such that risk management is now part of our design process. For the production aspects of certification we have our factory approved to ISO13485; this being the quality management system for medical devices.

Author: Peter Blyth
Industry Director
Medical, XP Power
www.xppower.com

ULTRASOUND POSES ULTIMATE TEST OF LOW-NOISE DESIGN SKILLS

By David G. Morrison, Editor, How2Power.com

As in many other industries, companies in the medical equipment field that once designed and built power supplies for their applications, now turn to power supply and contract manufacturers to develop and produce the ac-dc power supplies required in many medical applications. However, in these applications, the task of power design does not end with specification of the ac-dc supply, as there are significant power conversion challenges within medical devices at the board-level.

Examples of these challenges can be found in the development of ultrasound imaging equipment where designers face exceptionally tough requirements for noise control in a product that one industry expert describes as "the world's most sensitive receiver."

To power the various analog and digital circuits, designers of ultrasound imaging equipment must be able to generate various supply voltages with extremely low levels of noise, particularly at audio frequencies, which pose a great risk for interference with the signals being transmitted and received in the ultrasound equipment. This requirement for low noise influences many aspects of equipment design, particularly issues such as portability (i.e. battery life and product size), product cost, and time to market. Engineers interested in applying their power design expertise in the development of ultrasound equipment should take note of the special design challenges in this field and how these challenges influence the way ultrasound products are developed.

In-band Versus Audio Band Noise

In medical ultrasound systems, a phased array of transducers transmits pulses at frequencies of approximately 1 to 15 MHz into a patient's body. These pulses travel through the body as sound waves, and as they do, a portion of their energy is reflected back and detected by the transducer array. Those reflected signals or echos are processed by the ultrasound system to create a high-definition image of the area being studied.[1] The electronics required to transmit and receive these pulses includes a mix of analog and digital, as well as high-voltage and low-voltage circuitry.[1 and 2]

For ultrasound system designers, the greatest challenge in powering these systems is noise control, says John Scampini, an executive director at Maxim Integrated Products. Scampini is Maxim's main authority on ultrasound systems for which it develops a variety of ICs. Prior to joining Maxim, Scampini worked for many years in Hewlett-Packard's ultrasound division.

Scampini explains that there are two types of power supply noise that must be managed in ultrasound systems—in-band noise that falls into the 1- to 15-MHz range of the ultrasound receiver, and lower-frequency noise that falls into the audio spectrum. Either type of noise can enter the receive path through the power supply and interfere with system operation. But according to Scampini, the lower-frequency interference poses a greater threat to system operation.

"Typically the in-band noise is much easier to deal with," says Sampini, who explains that's "because you have the ability to do bypass filtering in those frequency ranges." Unless, the in-band noise on the power supply is very strong, he says, it can normally be eliminated through serial inductive coupling and capacitive bypassing to ground.

On the other hand, power supply noise that falls into the audio spectrum poses a greater problem because this low-frequency noise will modulate signals in the receiver, creating sidebands and other undesired frequency components. Filter capacitors are not effective in reducing this low-frequency noise on the supply rails, but linear regulators can be. "So typically in these systems, the general rule of thumb is to use linear regulators everywhere," says Scampini. "And ultrasound system designers use linear regulators on both the analog as well as even a lot of the digital circuitry. That keeps the low-frequency noise down and keeps it from becoming a problem."

Ultra-Sensitivity To Noise

But not just any linear regulators will do says Scampini. They have to be very low-noise devices because with most commercial linear regulators, the 1/f noise produced by the output stages produces too much noise in the audio spectrum. Moreover, even when the noise produced by a linear regulator is too low to measure with available RF test equipment, that noise may still be picked up by the ultrasound receiver.

To illustrate the magnitude of difficulty, Scampini cites an example scenario in which the ultrasound system is transmitting a carrier at 5 MHz and the receiver is looking for a reflected signal that's 1 kHz away from this carrier and 160 dB down. An RF spectrum analyzer (at least one which is available to ultrasound designers) may not be able to resolve this received signal, explains Scampini. Yet the ultrasound system will pick it up and show this signal on its display. So noise, even that generated by a standard linear regulator can cause noticeable interference to the received signal.

Competing Requirements

Nevertheless, using low-noise linear regulators represents the safe way to generate the clean supplies required in ultrasound systems since this approach is least likely to produce noise-related problems that will have to be debugged later when the system is prototyped. Unfortunately, using linear regulators conflicts with market requirements for portability and lower cost.

"You're starting to see more and more portable ultrasound systems," says Scampini. These portable systems resemble laptop computers in contrast with the larger, cart-based ultrasound systems. "The portable systems will have an option of operating on a battery for a minimum of maybe an hour of continuous operation, so there's a big drive to reduce their power draw."

But battery-powered operation is not the only reason to reduce power consumption in portable systems. Making systems smaller means packing more circuitry into a smaller volume. This demands that heat dissipation be reduced for the sake of thermal management.

These requirements for lower power consumption and heat dissipation have forced ultrasound system designers to replace some linear regulators with more-efficient switching regulators. These regulators must be synchronous, says Scampini, so that "you don't wind up with RF components that are not synchronous to some clock." Initially, these regulators were implemented using discrete designs, but more recently monolithic (IC) versions have become available from semiconductor vendors.

Even so, the use of any switching regulators in ultrasound systems poses risks that they will interfere with system operation. As a result, they are used "only when they're absolutely necessary," says Scampini.

Power design in ultrasound systems is also complicated by the pressure on engineers to take cost out of the design. Even though ultrasound equipment is expensive—perhaps in the range of $30,000 to $100,000 per system—there is "tremendous cost pressure" on the equipment makers, says Scampini, because of the large number of competitors in this field. In addition to the big players such as GE, Philips, Siemens, and Toshiba, there are currently dozens of ultrasound companies in China and perhaps another 20 vendors worldwide, according to Scampini.

One of the impacts of trying to lower cost is that designers may try to apply less sophisticated shielding in the ultrasound products, which further increases the risk that designs will suffer from power supply noise-related problems.

For more on the power design-related challenges faced by developers of ultrasound systems, see "Managing Design Risks" in the online version of this article.

About the Author

David G. Morrison is the editor of How2Power.com, a site designed to speed your search for power supply design information. Morrison is also the editor of How2Power Today, a free monthly newsletter presenting design techniques for power conversion, new power components, and career opportunities in power electronics. Subscribe to the newsletter by visiting www.how2power.com/newsletters.

Additional materials for online version of this article:

Managing Design Risks

In terms of predicting noise-related problems, simulation is not always effective, says Scampini. Systems must be physically prototyped, tested, and debugged—often using the ultrasound system itself since it is usually more sensitive than the RF test equipment on-hand. Speaking of his own experience in the industry, Scampini notes that much of this debugging involves a trial-and-error approach adding capacitors or a better linear regulator or changing a ground to see if one of these steps influences a signal.

Occasionally a designer gets lucky and the system prototype works the first time, says Scampini. But that may be the exception. "Typically, they'll build a system and it will have [noise-related] problems. They'll re-lay out the board, put some shielding in, and try to get rid of these things. Then, they'll get the board back and it might still have problems. They'll do it again. So the time to market becomes an issue. And I've seen some of these projects delayed years as a result of these kinds of problems that designers struggle to fix."

Ultrasound system designers try to prevent these problems by adopting low-risk design strategies like using low-noise linear regulators everywhere. Such conservative approaches to design don't guarantee there won't be any noise-related problems in the prototype stage but, says Scampini, they "minimize your risks so the number of problems you're going to encounter when you build the system are reduced to an acceptable level."

So for ultrasound system designers, power design becomes a balancing act of minimizing design risks which threaten product development schedules, while still meeting product design goals such as portability and low cost.

As might be expected, development cycles for ultrasound systems are relatively long to begin with, when compared with development cycles for consumer products and other applications.

"If you're going to design a full [ultrasound system] platform, most of the companies will say they have to do it in a year and a half," says Scampini. "The reality is, that by the time they seriously start looking at product development to the time they actually ship it, it's probably closer to three years."

That long cycle includes the time required to obtain FDA (or equivalent) approvals, which require a process of verification and validation. According to Scampini, this means that ultrasound system developers specify the imaging performance of their system and then verify that performance through clinical trials where the new ultrasound system is tested alongside known-good ultrasound equipment in a hospital setting.

Although the focus of this article has been on the power design challenges at the board level, there's another component to power design in ultrasound applications. That is the development of the ac-dc power supply that feeds power to the ultrasound system's motherboard. This switching power supply is generally external to the actual ultrasound equipment, housed in a shielded enclosure, and connected to the ultrasound equipment via a cable.

As in other industries, ultrasound equipment makers once designed and built their own ac-dc power supplies but now rely on power supply and contract manufacturers to produce them. So ultrasound system designers now specify these supplies to meet the power and noise requirements of their application.

According to Scampini, the requirements for these supplies are not extraordinary. However, some of the demands specific to ultrasound are things like a variable ±100-V supply for the ultrasound transmitter, and remote sense to correct for voltage drops on the cable. Low-noise outputs on the ac-dc power supply are desirable. However, system designers will mainly be relying on linear regulators to produce clean supplies for the various circuit functions within the system.

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Author: David G. Morrison
Editor

How2Power.com
www.how2power.com

GREEN: BOOM OR BUST?

By Cliff Keys, Editorial Director & Editor-in-Chief, Power Systems Design

The medical electronics industry is not only providing a cost-effective and patient-friendly range of products for the home as well as hospitals, the use of low power ICs made cost-effective by consumer industry volumes, has meant a greener side to this fast growing sector.

US PV module supplier, Solyndra, announced that it has shut its manufacturing facility and file for bankruptcy, the third to do so in a month. The seemingly overnight decision, and the failure of the business, should really come as no surprise and is a warning to all other PV module start-ups according to IMS Research.

Solyndra began commercially shipping its innovative PV module solution, featuring cylindrical modules mounted in frames, in 2008. The product offered a unique solution and some compelling advantages, but ultimately PV is an investment and the price has to be right. Despite Solyndra operating its 110MW facility close to full capacity in recent months, IMS estimated that its manufacturing costs still far exceeded the price at which it had to sell its modules in order to make an investment case for its customers.

After slumping in July and August, Germany's orders for new photovoltaic (PV) solar systems are set to soar in October and November, generating a surge in demand that may be difficult for major suppliers to accommodate, according to the IHS iSuppli Photovoltaic Service. The boom in orders in Germany, the world's largest PV installation market, is being driven by the looming drop in the country's feed-in-tariff (FIT) in January of next year. The FIT acts as a major incentive for PV installations. Investors and homeowners are rushing to place orders for solar systems before this incentive decreases.

The new report from IMS Research found that, although the market is still incredibly young, several factors are likely to either enhance adoption of the technology or hinder it. A number of microinverter and power optimizer suppliers are known to be in active partnership discussions with module suppliers, to provide module-integrated solutions. It is predicted that 45% of microinverters and 40% of power optimizers will be shipped in combination with a module in 2015. "By partnering with module suppliers, microinverter and power optimizer suppliers gain access to a huge customer base and an established sales channel, present a better price proposition to customers, and also offer product differentiation to module suppliers." said Haddon.

Going green in solar manufacturing can come with a hefty price tag it seems.

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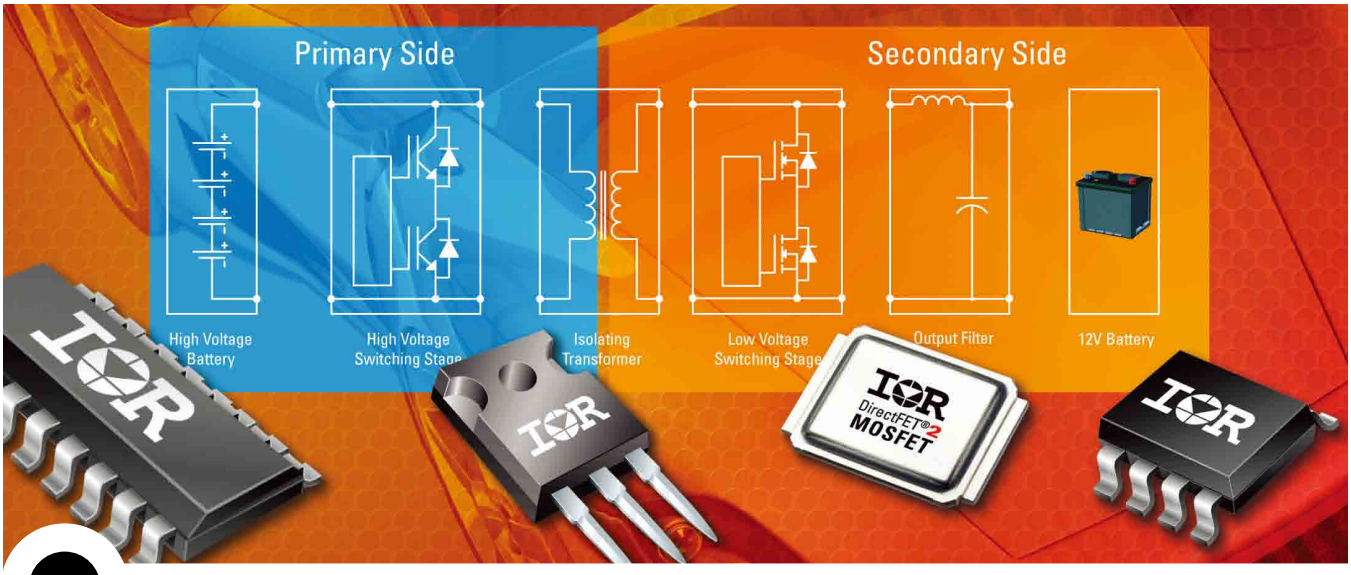

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AUIRF7739L2	40 V	1 mΩ	270 A	220 nC	DirectFET L
AUIRF7736M2	40 V	3.1 mΩ	141 A	83 nC	DirectFET M

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AUIRS21811S	High Speed High and Low Side	+1.9 / -2.3 A	8.2 V	SOIC8

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AUIRGP50B60PD1	45 A	2.00 V	TO-247

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AUIRS4427S	Dual Channel Low Side	+2.3 / -3.3A	SOIC8
AUIRS4428S	Dual Channel Low Side	+2.3 / -3.3A	SOIC8

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