Current and Future Trends in Medical Electronics

By Steven Dean, Medical Marketing Director, Texas Instruments
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Key trends driving the medical electronics market are aging populations, rising healthcare costs around the globe and the need for access to medical diagnosis and treatment in remote and emerging regions and in our own homes. The different world economies will continue to drive trends in these areas and others for years to come. Consequently, some of the key concerns medical electronics manufacturers face today lie in the areas of portability and miniaturization, connectivity, safety, data security and quality, and reliability.

Power Management

An important trend over the next decade will be the proliferation of portable medical electronics equipment. Making power management decisions early in the design cycle will help define system-level tradeoffs that may be necessary to meet portability and run-time targets. Smaller portable medical products may use disposable batteries, whereas larger systems might leverage various rechargeable battery chemistries and battery pack sizes. Features such as dynamic power path management (DPPM) permit the system to draw power independently of the battery charging path. This allows a device with completely discharged batteries to be used as soon as it is plugged in, rather than waiting for the batteries to recharge. This could be life-saving in emergency situations.

Since battery voltages do not drop off in a linear fashion, voltage tracking alone will not give a true reading of battery life. Especially since the middle third of the voltage scale comprises 60 to 70 percent of the discharge cycle time. Coulomb counting will not compensate for battery aging, so over time it “assumes” the state of the battery. Impedance tracking, however, allows the medical device to calculate the remaining run-time to within one percent error over the entire life of the battery. This is often accomplished by integrating a voltage translation to extract individual cell voltages and charge/discharge current. Additional protection in portable power solutions includes cell overvoltage, undervoltage, over current and short circuit protection.

System reliability is critical in medical electronics, so battery authentication is a key requirement. In some battery management products a single-wire, bi-directional communication system can be used to link a 96-bit device ID; device-unique 16-bit seed; and a 16-bit device specific cyclic redundancy check (CRC) to provide security. This is an effective means of validating that the battery in use meets the original equipment manufacturer’s (OEMs) requirements. Using an incorrect battery pack can impact system run time as well as damage the system, or even cause harm. An appropriate power management approach enables portability and makes it affordable by delivering both increased battery life and safety.

Miniaturization & Integration

Ultrasound is a medical imaging market segment seeing high levels of innovation in portable equipment. Manufacturers of today’s advanced portable or handheld ultrasound systems require highly integrated, scalable solutions. This allows medical professionals to move beyond the lab or office to reach clients in remote settings or emergency situations around the world.

Integration continues to enable this trend of portability, as well as cost savings. A good example of this is illustrated in the ultrasound imaging space. While efficiently maximizing memory usage and power consumption, embedded processors play a key role in balancing computational power, flexibility, battery life and system size in medical imaging devices. For example, today’s high-performance DSPs have enough horsepower to efficiently tackle the back-end digital processing on an ultrasound system. At the same time the DSP’s programmability provides the ability to implement the newest software algorithms available without changing system hardware. OEM development teams benefit from increased system performance and reduced time-to-market provided by the high level of system integration found on DSP system-on-chips (SOCs). By

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providing the right mix of DSP processing, general purpose control, dedicated peripherals, and optimized image and video compression, these SOCs provide a cost-efficient, low-power, single-package solution. This allows developers to reduce board space and design time, letting them focus more of their efforts on developing differentiated products.

In addition to continued integration of embedded processing technology enabling ultrasound portability, integrating the analog signal chain is key. On the analog receive side of the signal chain, a single integrated analog front end (AFE) can displace the discrete multiple-channel LNA, VCA, PGA, low-pass filter and high-speed analog-to-digital (ADC) functions, providing LVDS data outputs. By reducing the system’s device count, an integrated AFE can decrease power consumption by up to 20 percent, offer a 40 percent lower noise figure, and save 40 percent on board space. Thus, saving significant system cost as a result. Integrated AFES achieve levels of image performance suitable for ultrasound systems of all sizes, from handheld to high-end.

Figure 1 – Portable ultrasound system block diagram.

Expect to see hardware and software tool kits built specifically to leverage these technologies. This is an exciting time for medical imaging technology because with integration such as this, coupled with system level tool kits; it is poised to evolve at a faster rate than ever before.

**Connectivity and Remote Patient Monitoring**

For connectivity in 2009 and beyond, we can expect several discrete pieces of the ecosystem puzzle to come together, providing exciting innovations in telehealth and telemedicine. Data integrity, system flexibility and mobility are important factors for most patient monitoring systems. Interfaces such as Ethernet or wireless allow hospitals to network all of the equipment in the facility, as well as connect to a patient’s home. Today’s interfaces allow care givers to remotely connect to a patient via a wireless body sensor network worn by the patient. This leverages a hospital’s internal network or links to the patient’s home security system or cell phone. The system ties into the Ethernet or call center enabling constant monitoring in the privacy of their home. It seems that Continua Health Alliance, a non-profit, open industry coalition comprised of healthcare and technology companies joining together in collaboration to improve the quality of personal healthcare, may adopt Bluetooth® technology. Continua recently won the 2009 ATA President’s Innovation Award for its work in telemedicine, and its first wireless protocol includes a medical device profile. Other Wireless interfaces such as Zigbee® also can be seen winning traction in consumer medical devices and portable patient monitoring equipment.

Power consumption, data rate and range are the three key considerations when selecting a wireless interface (see Figure 2). The Zigbee protocol, for example, provides worldwide coverage,
a moderate data rate and duty cycle, and supports a mesh network allowing multiple sensors in
the same system with a wide range. Bluetooth and Bluetooth Low Energy® protocols provide for
limited range but higher data rate. Bluetooth Low Energy is more power efficient on the sensor
side, allowing smaller form factor batteries than classic Bluetooth.

Ultimately, the solution choice must fit the system power budget range, and data transfer
requirements.

Moving patient care from the hospital environment to the home utilizing these technologies
depends on the adoption rate of remote patient monitoring – not availability of technology.
Remote patient monitoring (RPM) will be the enabling technology allowing these movements.
RPM, such as the body area networking (BAN) example in Figure 3, will be slow in developing in
the United States due to lack of a favorable reimbursement climate for caregivers and patients.
The adoption rate is highly dependent on financial reimbursement, which needs to enable
caregiver payment for remote monitoring, diagnosis and therapy delivery. Interoperability trials of
these ecosystems are also important and must show efficacy, and then be followed by a
favorable reimbursement model to drive adoption.

Data Security
Medical data security is yet another key requirement and concern. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) defines federal standards, and can be supported with various technical safeguards. Within these standards are specific privacy and security rules. These rules prohibit data from being transmitted over open networks and being downloaded on public computers. They also require data encryption and access control. These safeguards are appropriate worldwide, so you can expect to see more feature-rich hardware and software tools supporting medical data security now and in the next decade.

For example, several wireless IEEE 802.15.4-compliant RF transceivers designed for low-power, low-voltage portable applications provide hardware MAC security operations for data encryption and authentication. Some offer various encryption / decryption modes such as counter mode (CTR) and CMC-MAC authentication and encryption. Of course, keys must be determined and set in order to utilize these security operations, which is usually left to the highest layer of the communications protocol. The CC2530, for example, is compliant with multiple network protocols such as IEEE 802.15.4, Zigbee, Zigbee RF4CE, smart energy and Internet protocol (IP). It also offers a government standard advanced encryption standard (AES) 128-bit encryption / decryption core. The core supports AES operations required by the IEEE 802.15.4 MAC security, the Zigbee network layer and application layer, providing additional security.

Given the defined federal standards with respect to transmitted patient data and the need to protect this data, expect to see more feature-rich hardware and software tools supporting medical data security now and in the next decade.

**Quality and Reliability**

Medical device company concerns are changing due to tighter governmental quality requirements, regulations at worldwide agencies and current legal climates. When designing semiconductor products for medical OEMs today, quality and reliability considerations are paramount and known table stakes. Including enhanced product (EP) flows to catalog processes bring extended product lifetimes, well-defined and improved change control processes. To meet the demands of the medical market dedicated and controlled manufacturing lines effectively eliminate facility-to-facility variations, extended qualification practices, improved product traceability and enhanced or customer production testing rigors. Enhanced product flows also can save manufacturers cost and time-to-market by offering an alternative to upscreening, which is commonplace in high-reliability markets. Another way to address these concerns is to adopt portions of ISO13485, a quality management system for medical devices as they apply to the semiconductor industry.

**Conclusion**

The future of medical electronics will be paved with technologies that allow portability, connectivity and data security. Leveraging these technologies, systems will be moving quickly from the hospital environment to the home, enabling care-givers from doctors to family members to monitor patients’ biological trends and events. Instant and continuous access to a patient’s medical history and their current medical condition is not just in our future, it is here today. Secure infrastructures and feature sets in the monitoring systems are one key to enablement. Texas Instruments’ broad portfolio of analog and processing solutions, dedication to reliability and continued investments in the medical market puts it in a leadership position to help manufacturers of medical devices optimize their designs now and in the future.

**References**

To download a copy of TI’s medical guide and related documents, visit: [www.ti.com/medicalguide-ca](http://www.ti.com/medicalguide-ca).

**About the author**
Steven Dean, medical marketing director at Texas Instruments, has over 20 years of experience in the semiconductor and medical industries. Currently, Steven is responsible for leveraging TI’s diverse portfolio of products for medical applications, as well as establishing relationships with eco-system partners in the medical device sector. Steven obtained his degree in Electrical Engineering from Purdue University, with postgraduate work in Business.