Honey, I Shrunk the Electronics!

Jonathan Bearfield

The drive towards mobility and miniaturization of medical electronics is a goal of many of today's device manufacturers. However, each of them is attempting to miniaturize at different levels. Regardless of to what degree they want to reduce the size of a device, they all face significant challenges. This article reviews the different levels of miniaturization and each level's respective challenges.

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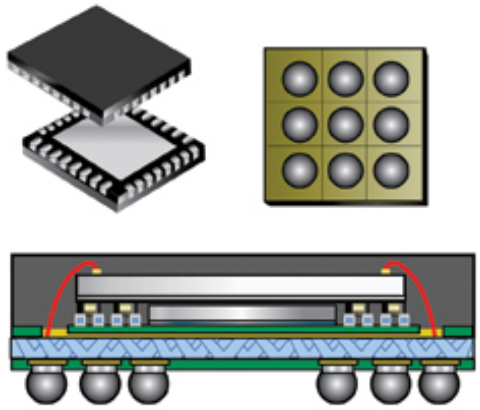
Although technological advances following Moore's Law drive a constant reduction in size and increase in performance of electronic systems, there are several real needs driving miniaturization into medical electronics–not the least of which is mobility. The migration of our "sick care" systems to healthcare and wellness monitoring has created the need for more and more devices to become portable, wearable, or even implantable. This trend focuses on getting patients out of the hospital sooner, while at the same time, into the hospital or doctor's office earlier when a problem is detected, by providing a means for continuously monitoring and/or managing a patient's wellness.

Portability, wearability, and implantability are perhaps the three basic levels of miniaturization for medical electronics. Following are a few of the biggest enablers of portability.

• Advancements in battery technologies and chemistries along with the introduction of better battery management techniques, like Impedance Tracking and power path

management
• Reduction in system power requirements driven by ultra-low power MCU and processor architectures, like OMAP and MSP430, lower power data converters, amplifiers, and interface ICs, as well as overall improvements in power supply efficiency
• Improvements in display technologies to include touch screen controls as a mainstream feature, reducing the controls needed on the equipment, while improving ease of use

Wearability is a level beyond portability in terms of miniaturization. Wearable patient monitors and other medical electronics have benefited from many of the same advances driving portable devices in the market. However, heat dissipation, and therefore overall efficiency, is a bigger challenge as there is a comfort level tied to body-worn electronics. Not only does power consumption and battery technology need to be pushed a little further, medical systems need to adapt wireless interfaces, like Zigbee and Bluetooth, into a support infrastructure as cabling is no longer an acceptable solution. Tapping into the infrastructure put in place by the cell phone service providers is also a key enabler. Additionally, integration is a key wearability driver. Whether it's a complete analog front end for an ECG/EKG on a single chip, or a processor that integrates the necessary peripherals to support the needs of the application, fewer and smaller ICs impact not only the size, but also the weight of the equipment being worn.



Implantability and affixability make up the third level of miniaturization. Affixables are a newer market including things like smart bandages, which use electronics to promote healing, or an adhesive strip with a complete ECG front end, including the wireless interface embedded into it. Most people are aware of implantable medical electronics such as pacemakers and neurostimulators, but technology advances are driving the development of implants to help restore sight, speech, hearing, and motor functions, as well as manage a vast array of other medical conditions. Much of this miniaturization is being enabled by advances in chip-scale packaging techniques and package-free options, as well as semiconductors etched on films and laminates, potentially being transparent enough to see through clearly or thin enough to be embedded in an arterial stint.

Additionally, if the advances in energy harvesting from solar, heat, and vibration are

included into the wearable and implantable mix, then completely self-powered, miniature (if not microscopic) devices for managing health and wellness are not just an R&D project; they easily become a reality.

Conclusion

Miniaturization is an ever-growing trend in medical electronics because it drives portability and accessibility. It is key to the success of worldwide medical initiatives, such as telemedicine and body area networks.

However, there are some potential design challenges and limitations within medical electronics brought on by miniaturization advances. Up-integration increases the functionality contained with a single IC, but can also reduce the feasibility of having redundant support for critical functions if that IC fails. Likewise, smaller bond pitches and tiny wafer chip-scale packages often increase the number of PC board layers needed to route the traces for the device, often requiring hidden vias on the board, thus creating through-hole connections that cannot be visually inspected.

As long as trade offs like these are understood and defined early on in the development process, they are fairly easy to compensate for. In the end, the real benefit from all of this miniaturization is the ability to save and improve lives simply because more of the right equipment is available whenever and wherever it is needed.

Online

For additional information on the technologies and products discussed in this article, see *MDT* online at www.mdtmag.com [2] and the following websites:

- www.ti.com [3]
- www.sonosite.com [4]

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