Remove the “Frankenstein Effect” from Medical Devices by Utilizing Analog ASICs

— *Bob Frostholm* —

Mary Shelley’s 1818 novel *Frankenstein* tells the story of a monster created with parts collected from random cadavers. The creature stands eight feet tall due to an inability to integrate all the necessary components into a standard humanoid form factor. Additionally, this haphazard collection of organs lacks sufficient neural network connections, accounting for its awkward gate and general stiffness of its arms and shoulders as it walks with forearms extended. This is perhaps the first documented evidence of the problems that can occur when designing a system using “point-products,” parts selected for their unique special functions without regard for their perfect interoperability.

Clearly, Mary Shelley was a visionary, since nowhere is the concept of developing a system with point-products more hazardous than in medical devices. It is here that the performance of every aspect of the system is critical to the long-term behavior of the end product. Interoperability between semiconductor components takes on a whole new meaning in the context of critical care and life support. But the issue isn’t confined to medical applications. Like Mary Shelley’s monster, multiple devices from multiple suppliers (e.g. ICs produced on different processes in different fabs) will perform differently under identical environmental conditions in any type of application.

Her monster’s unsteady locomotion and imperfect speech were the result of the inability of disparate subsystems to communicate anything other than rudimentary information…just enough to function. Any system using multiple ICs faces the same challenges. Ask any designer. Getting two chips to talk to one another, regardless of their specification matches, can often be challenging. Add more devices and the problem expands by the power n, where n is the number of ICs that must intercommunicate. This is just one of many reasons to seek solutions that offer higher integration in the small signal path (the monster’s nerve endings), where interfacing discrete elements such as A/Ds, DACs, low-noise amplifiers, MUXes, and more can create issues.

The reality of the situation is that sometimes this just isn't possible. Even after investigating the use of ASICs, their requirements for speed, power, voltage, frequency, noise immunity, and more will dictate the use of multiple ICs, each with their own unique power needs. Yet somewhere in the biosphere of the medical device, there is but one source of power (often a battery) and all other power requirements must somehow be derived from it. This is one area where the ASIC plays well in medical devices. There is much commonality in the power management center of a medical device.

The human body is not unlike an analog system.

We have inputs,
our five senses.

We have outputs,
our controlled motions.

We have a processor,
our mind.

We have a power supply,
our heart.

We have a signal path,
our central nervous system.

Mary Shelley's knowledge of anatomy aided her in vividly describing her grotesque monster, allowing readers to draw comparisons to their more perfect selves. As we all strive to make our designs perfect, we need to learn from her.

Like Mary Shelley, each part we select for our design involves a compromise of one sort or another. To compromise is to add errors, and errors accumulate. So, how do we avoid turning our design into a Frankenstein monster?

The first logical step is to reduce the parts count. Mary Shelley's monster was an amalgamation of cadaver parts, some human and some animal. Imagine the theoretical complications of interfacing such disparate elements. Designing an analog system can sometimes feel just as daunting. In reality, our job as system designers is far easier but no less important.

Let's focus on power management. Power management is more than researching the dozens of companies that offer thousands of chips to provide suitable output voltages and currents for your complex application. Anyone can do that. It's merely a selection exercise, eliminating those solutions that are unfit and winnowing down the remainder to a manageable collection of devices available from suppliers with whom you prefer to do business. Who cares if some of the chips contain functions you don't need? The bottom line is that if it does all that you want it to do, you use it.

Power management is also more than developing solutions that run cool and conserve power. Today's complex systems employ a wide variety of semiconductor technologies and may need a vast array of supply voltages for proper performance. It's easy to see the need for power management devices for 1.0V, 1.2V, 1.5V, 1.8V, 2.2V, 2.5V, 2.8V, 3.0V, 3.3V, and more, all in the same box. Power management involves ensuring that no aspect of these various components causes interoperability issues. For example, boost converters require a small oscillator and different chips offer their maximum efficiencies at different frequencies. To supply the many voltages required by a medical device, multiple converters may be needed, all operating at different frequencies for maximum efficiency. The potential for their frequencies to generate RFI either directly or through their respective harmonics and modulated sub frequencies is high.

By embodying all of the power management functions into a single chip, the device can be designed to provide multiple boost converters, driven from a single oscillator whose maximum efficiency frequency is chosen so it will not interfere with any other component in the medical device, and thus eliminate the problems of point-products.

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