Power considerations in advanced embedded systems

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The migration of smart subsystems into products at every level of operation represents a true fusion of the electronic and mechanical, representing the next, and possibly the culmination of, the industrial revolution. However, the integration of sense, motion, and logic into all portions of a system also brings with it new (or old in new clothing) challenges in power management.

The integration of senses, logic, motion, and expression into the objects around us promises to leverage our industry upward and give us increased opportunity to add value to our products. Although the increase user functionality helps everyone from the designer and manufacturer to the user and society itself, it also challenges the designer to ensure the power infrastructure of the systems involved can perform as demanded.

Internal pressures
The forces driving technical development sometimes pull in the same direction (whether that direction is the right one is another discussion entirely). In the arena of embedded systems, the forces driving the market are multifold. The need for small size and light weight in personal devices may dovetail neatly with the advances in circuit complexity and integration, but they also challenge the designer to create an elegant system architecture that serves and supports the subsystems involved. Additional demands for materials savings and size and weight reductions from industry complete the picture, as electronic subsystems are smaller, more efficient, and integrate more functionality into a single package than ever before.

In the area of power management, these forces often create contradictory system demands, as when the desire for miniaturization runs up against device-embiggening demands such as for large batteries to enable longer operational times or heat-diffusing/shielding technology to ensure a comfortable product handling temperature. Such pressures create procrustean-fit issues for the design engineer. In most cases, however, the solutions generated to address these issues bring out newer and better products from every sector of the marketplace. Better batteries, power management software and devices, and improved design topologies address many of the issues, but still many remain.

System concerns
There are many system space and architecture issues in every modern product. Antennas, connectors, displays, and other I/O and interface systems not only require real estate in and on the device, they also have system infrastructure needs that may conflict with the primary design requirements. Most of these subsystems also bring power issues to the table - displays need backlights, connectors need shielding and grounding, and some antennas need power (and sometimes logic) to

operate properly.

Other system considerations include potential peripherals. In the case of consumer devices, for example, one cannot predict what the customer is going to plug into a port, or even if they will properly use the ports given. Many of you have probably personally experienced plugging in a USB product that overwhelms the parent device's ability to power it. To add insult to injury, we've all seen "hacks" of consumer devices that may make the device "cooler" in style or functionality (not to be confused with "cooling" hacks) but render the product unsafe. In industrial, medical, and mil/aero systems similar situations can potentially occur (especially with field-deployed military systems, as soldiers are wont to improvise) but that issue can be mitigated by case and/or connector design.

The unknown nature of peripherals places a burden on the designer to be a clairvoyant as well as an engineer. In the area of power, this problem is exacerbated by the fact that every common mixed signal/power interface was driven by the signal needs, with a nod towards power needs. In some cases, like powered Ethernet, the connector standard wasn't designed to handle power in the first place, and in others, like USB 3, the upgraded power requirements have created headaches for legacy connectors and standards built around them.

The many flavors of power in USB offer a potential for many degrees of confusion to the user, as there are multiple power levels allowed in USB-compatible devices. In addition, since the USB Battery Charging Specification of 2007 the category of "charging" port was created, allowing supply currents above 0.5 A without digital negotiation. A product can identify whether it is accessing a charging downstream ports (CDP), which also supports transfers, and a dedicated charging port (DCP) without data from the way the D+ and D- pins are connected.

Today many view the USB port as a portable device power standard, to the point that one can buy a multi-port USB power jack as easily as a standard AC socket.

This problem also exists with other signal-cable-oriented systems. Powered Ethernet is an expansion of the standard cable specification far beyond what the designers originally intended for the spec, and even today to use power in Ethernet systems one must usually use a power injector device of some kind. A real solution would be to create a general power-oriented databus standard, one that uses SMBus or other generally-recognized inter-device standard for system management but with the power handing capability to power sensors, actuators, transducers, and heating or lighting subsystems without overwhelming the cables and interconnects.

External issues

Every product ever made was forced to operate in environments it was not designed for, but proper design can ensure as wide an environmental tolerance as possible. Every consumer product should be tolerant of internal temperature and moisture conditions within vehicles, for example. Most devices created for personal use not only get used in the car, they often wind up migrating into the car as internal or aftermarket electronics or as a left-behind device in the glove box. Thermal issues directly impact device performance negatively by derating the operation of the power systems involved and raising the temperature of the logic systems. In the worst cases, underestimating the impact of the ambient environment could result in catastrophic failure of the battery system involved.

Other ambient vehicle issues include transport by sea or air. The issues of the sea are well-known challenges, mostly involving moisture resistance and galvanic protection. Shock and vibration are often overlooked issues, which impact power systems in the area of power connector and board-trace integrity. Heat is another overlooked issue, as the micro-environment on a ship can vary significantly depending on the location and nature of the heat loads (sunlight, engine heat)

involved.

In air travel there is another little-known (more likely, little-remembered) issue in thermal management. Depending on the type of aircraft and where the device is, the air pressure can vary significantly. Just as there is a major difference to the oxygen level in your lungs whether you are in an aircraft pressurized to 8,000 or 12,000 feet, there is also a major difference in the amount of physical air there is to blow across your heatsink. A convection-based system that works within satisfactory tolerances at sea level may not sufficiently cool a device at altitude (especially if it is near a heat load like engines, other electronics, or sunlight). Cooling systems, especially in critical operation or datalogging products, should always take into account potential environments that could be reasonably expected to encounter.

There are many other issues when it comes to powering advanced embedded systems, but with a good power bus infrastructure and attention to ambient operating environments, one can better address those other problems and create a better product. If you need help with your power issues, feel free to contact me here at GlobTek (paultrea@globtek.com [1]) and I will be happy to assist you.

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