Battery and IC Products Enable Portable Consumer-Electronic Devices

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In the world of portable consumer-electronic devices, manufacturers are faced with a challenging prospect — creating physically smaller devices that have enhanced performance while maintaining or extending operating battery life. These requirements have rippled throughout the entire electronics industry, forcing battery and Integrated Circuit (IC) manufacturers to constantly push the boundaries of technology.

Innovative Use of Battery Chemistries

Battery manufacturers continue to innovate with the use of various battery chemistries, in order to provide more energy density in smaller, lighter-weight battery cells. IC manufacturers are addressing these market demands in a variety of ways, including lower operating voltage, higher efficiency and the use of power-saving modes.

The heart of portable consumer electronics is the battery, which supplies the electrical energy required to power the internal ICs. Since the battery performs such a critical role, it is worthwhile to briefly discuss the various battery chemistries currently found in portable consumer-electronic devices and some of the main characteristics of each.

The four main types of battery chemistries currently found in consumer electronics include Alkaline, Nickel Cadmium (NiCd), Nickel Metal Hydride (NiMH) and Lithium Ion (Li-Ion). Alkaline cells are based on the reaction between Zinc and Manganese dioxide. A typical alkaline cell produces a voltage of around 1.5V when fully charged. The cell will continue to decrease in voltage as the cell energy is consumed, with the cell producing around 0.9V at 90 percent utilization. Alkaline batteries have a relatively high capacity, but also high internal resistance, which makes them inefficient for high current-drain applications such as camera flash units, remote-control cars and power tools. Because of this limitation, NiCd battery cells are still used for high-current applications. NiCd cells have a nominal voltage of 1.2V, and will drop in voltage to as low as 0.9V at the end of the battery life.

NiMH cells have gained in popularity over NiCd, because they are more environmentally friendly. NiMH cells also have a nominal voltage around 1.25V and will drop below 1.0V at the end of the cell's life. NiMH cells are commonly found in digital cameras, flashlights, electric razors and various other consumer-electronic devices.

Li-Ion has become the dominant battery chemistry for most portable consumer-electronic devices. A single Li-Ion cell has an open-circuit voltage of approximately 3.6V when fully charged, and will decrease in voltage to approximately 2.7V when fully depleted. Some battery manufacturers estimate that by the year 2010, 90% of the rechargeable battery market will be Li-Ion/Li-Polymer based. This battery chemistry offers many benefits, including lighter weight, higher cell voltages and the ability to be shaped (for Li-Polymer). Additionally, the energy density of Li-Ion/Li-Polymer batteries continues to increase while cost decreases. One disadvantage of Li-Ion battery cells is their propensity to explode if overcharged. This safety concern has led some manufacturers to use NiMH chemistries in applications where size and weight are not absolutely critical.

ICs Offer Improved Power Efficiency, Overall Performance

In addition to advances within the battery industry, IC manufacturers continue to improve power efficiency and overall performance. These advances take many forms, including lower operating voltage and current, higher-efficiency power regulation and the use of shutdown modes.

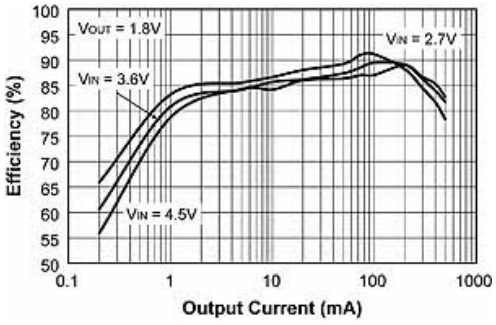
Battery Type	Nominal Voltage	End-of-Life Voltage
Alkaline	1.5V	0.9V
NiCd	1.2V	0.9V
NiMH	1.25V	1.0V
Li-Ion	3.6V	2.7V

Table 1 lists the operating and end-of-life voltages for single cells of the four types of battery chemistries discussed earlier. In order to fully utilize the battery cell, the electronic devices and their ICs must be able to operate over this entire range. Keep in mind that many applications contain multiple battery cells in series, in which case the voltage across each cell is added together. For example, a portable audio player that requires two "AA" alkaline batteries in series will have a nominal voltage of around 3.0V, which will decrease to approximately 1.8V when the batteries are depleted. Implementing ICs that can operate below 2V directly off of the battery cells can provide a simple, cost-effective solution that does not require voltage-regulation circuitry. For example, one available, CMOS operational amplifier (op amp) operates over a voltage range of 1.8V to 5.5V, enabling it to operate directly

off of two Alkaline or NiMH battery cells, and over the entire range of a single Li-Ion cell, without the need to regulate the power supply.

However, operating voltage is only half of the low-power equation. Low operating current is also critical in order to achieve low-power electronic devices that extend battery life. For digital circuitry, low voltage and low current go hand-in-hand. By running the digital circuitry at a lower voltage (say 3.3V, instead of 5.0V), the circuitry will consume less quiescent current. This is one of the reasons why microcontrollers, FPGAs and other digital ICs are continuing to support lower and lower operating voltages. For analog circuitry, this relationship between operating voltage and current is not as dramatic.

Going back to the op amp in this example, its operating current changes by only six percent over the entire operating voltage range of 1.8V to 5.5V this is a change of only 50 nanoAmperes!



Portable consumer-electronic device system designers are also concerned about system efficiency. Not only does higher efficiency lead to longer battery life, it also helps to eliminate thermal issues. DC-to-DC regulation is one area in which high efficiency is critical for portable applications. IC manufacturers continue to search for new architectures and techniques to wring the most efficiency out of these regulators. One example, is Microchip‘s MCP1603 switching regulator. This regulator can operate in a Pulse Frequency Modulation (PFM) mode or a Pulse Width Modulation (PWM) mode, in order to maximize overall system efficiency (see Figure 1). During heavy load conditions, the MCP1603 operates in PWM mode, while during light load conditions it operates in PFM mode. This automatic switching maximizes the efficiency across a wide range of load conditions.
Another way in which system designers are improving power consumption in portable consumer-electronic devices is through the use of low-power modes. Longer battery life can be achieved by powering down non-critical circuitry when not in use. IC manufacturers are designing devices with low-power modes in mind. For example, some op amps come with a shutdown pin, while some switching regulators have a shutdown pin that can disable the regulator when not in use.

Conclusion

The portable consumer-electronic device market will continue to grow. As

consumers demand more functionality, versatility, longer battery life and smaller form factors, battery and IC manufacturers must continue to find innovative ways to increase performance while reducing the operating voltage and current requirements.

Additionally, higher-efficiency battery regulation and the use of power-saving modes are likely to continue, to provide more value to the end users of portable electronic devices.

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