Power Management - Overview

Power management broadly refers to the generation and control of regulated voltages required to operate an electronic system. It plays a major role in virtually every piece of electronic equipment. An effective power management subsystem can affect the reliability, performance, and time to market of associated electronic equipment. Today's systems require power supply design to be integrated with the system design in order to maintain high efficiency.

Power management component depends a lot on the input and output conditions like whether the input source is AC or DC? Is input voltage higher or lower than required output voltage? What is the load current? Maybe the load is sensitive to noise, or requires a constant current (for LEDs), or maybe it has a dynamically changing current?

The Switch mode power supply uses semiconductor switching techniques to provide the required output voltage and offer a versatile way of converting power efficiently. Modern IC switching regulators are small, flexible, and allow Buck (step-down), Boost (step-up) or Buck-Boost (both) operation.

Buck converters are switch-mode step-down converters which can provide high efficiency and high flexibility at higher Vin / Vout ratios and higher load current. Boost converters are used when Vout needs to be higher than Vin. Boost converters will step-up the input voltage to a higher output voltage. The Buck-Boost switching regulator is a combination of the buck converter and the boost converter it is used in applications where input voltage can vary, either below or above the output voltage.

Integrated circuit components such as switching regulators, linear voltage regulators, switched capacitor voltage converters, DC-DC Converters, AC-to-DC Solutions, PMIC Power management IC, Battery Management, Power over Ethernet (PoE) and voltage references are typical elements of power management used in electronic equipments.

Few of the unique features and advantages of these are mentioned below:

- **DC-DC Converters:** The DC/DC converters could be any combination of buck converters, boost converters and/or LDOs in a single package. DC/DC switching regulators are specifically tailored to address critical design requirements of your application, such as wide input voltage, low input voltage, ease of use, high power density, and digital power.
- **AC-to-DC Solutions:** They are used in power electronic applications where the input power is 50 Hz or 60 Hz sine-wave AC voltage that requires power conversion to a DC output. AC-DC converters can have more than one output and may feature like overcurrent, overvoltage, or short circuit protection.
- **Wireless Charging:** Wireless battery charging or wireless inductive charging is a method for transferring electrical energy from a charger to a device without the need for a physical wire connection. Wireless charging is based on the principle of magnetic resonance, or Inductive Power Transfer (IPT).
- **Battery Management:** Battery management is required for extremely accurate charging current and output voltages to optimize battery life and performance. To address these features battery management uses battery Sensor ICs, battery cell controller ICs and battery charger ICs.

- **Power over Ethernet (PoE):** PoE is a mature and growing technology used to conveniently deliver power through Ethernet cables to a load rather than adding additional power cords. PoE systems provide high reliability, convenience, and low cost. IP phones, wireless access points, security cameras are few common applications.

Types of Power Management Overview

DC-to-DC Converters:

DC-DC converters are electronic devices used to convert DC electrical power efficiently from one voltage level to another. DC-DC converters are widely used to transform and distribute DC power in systems and instruments. DC power is usually available in the form of a system power supply or battery. The input to a dc-dc converter is an unregulated dc voltage Vg. The converter produces a regulated output voltage (5V or 3.3V) which is required by the electronic component ICs, having a magnitude (and possibly polarity) that differs from Vg.

The ideal dc-dc converter exhibits 100% efficiency in practice; efficiencies of 70% to 95% are typically obtained. This is achieved using switched-mode, or chopper circuits whose elements dissipate negligible power. Pulse-width modulation (PWM) allows control and regulation of the total output voltage.

DC-DC power converters are employed in a variety of applications, including power supplies for personal computers, office equipment, spacecraft power systems, laptop computers, and telecommunications equipment, as well as dc motor drives.

AC-to-DC Solutions:

AC-DC converters are electrical circuits that transform alternating current (AC) input into direct current (DC) output. They are used in power electronic applications where the power input a 50 Hz or 60 Hz sine-wave AC voltage that requires power conversion for a DC output. AC to DC converters use rectifiers to turn AC input into DC output, regulators to adjust the voltage level, and capacitors to smooth the pulsating DC. AC-DC converters can have more than one output and may feature like overcurrent, overvoltage, or short circuit protection. Some switching converters feature active or passive power factor correction to counteract the distortion and raise the power factor.

However, many AC/DC converters use more sophisticated, multi-stage conversion topologies. Rectifiers are implemented using semiconductor devices that conditionally conduct current in one direction only, like diodes. More sophisticated semiconductor rectifiers include thyristors. Silicon controlled rectifiers (SCR) and triode for alternating current (TRIAC) are analogous to a relay in that a small amount of voltage can control the flow of a larger voltage and current.

AC-DC converters are used in computers, televisions, cell phone chargers, and other electronic consumer devices. They are also used in medical, military, and telecommunications equipment; kitchen appliances; industrial machinery; and commercial products that use DC motors.

Battery Management:

Battery Management Systems are the brains behind battery packs. They manage the output, charging and discharging and provide notifications on the status of the battery pack. They also provide critical safeguards to protect the batteries from damage. To ensure that the batteries are charged correctly and their life and use is optimised, battery management or fuel gauge systems have grown in parallel.

A battery-management system (BMS) typically consists of several functional blocks, including cut-off field-effect transmitters (FETs), fuel-gauge monitor, cell-voltage monitor, cell-voltage balance, real-time clock, temperature monitors, and a state machine.

Battery management systems vary in the functionality they provide and accordingly in their flexibility. Some of the battery management functionality is Monitoring, Computation, Environment management and Communication.

By knowing the level of charge in the battery, it is possible to detect the length of time that the equipment can operate before it is re-charged. By using various algorithms the battery management system is able to determine figures including the Sate of Charge or Depth of Discharge as well as the State of Health of the battery. The state of health of a battery is important because as a rechargeable battery or cell is used, its capacity reduces, and this needs to be computed by the battery management system to enable it to know the full charge level and capacity.

Wireless Battery Charging:

Wireless battery charging or wireless inductive charging is a method for transferring electrical energy from a charger to a device without the need for a physical wire connection. Wireless charging is based on the principle of magnetic resonance, or Inductive Power Transfer (IPT). This is the process of transferring an electrical current between two objects through the use of coils to induce an electromagnetic field or to transfer the energy from one to another. The energy is transferred from the source to the receiver where it is typically used to charge the battery in the device.

The Mains voltage is converted into high frequency alternating current and this is sent to the transmitter coil by the transmitter circuit. The alternating current induces a time varying magnetic field in the transmitter coil. Current flowing within the transmitter coil induces a magnetic field which extends to the receiver coil. The magnetic field generates the current within the receiver coil of the device. Current flowing within the receiver coil is converted into direct current (DC) by the receiver circuit, which can then be used to charge the battery. The process of energy flow transmitted between the transmitter and receiver coil is also referred to as magnetic or resonant coupling and is achieved by both coils resonating at the same frequency.

It’s through this process that power is safely transferred over an air gap. As well as any non-metal object that might exist between the coils. Such as wood, plastic or granite. This makes wireless/inductive charging ideal for use with many portable devices such as mobile phones and other wireless applications.

Power over Ethernet (PoE):

Power over Ethernet (PoE) is a technology that lets network cables carry electrical power. It allows IP telephones, wireless LAN Access Points, Security network cameras and other IP-based terminals to receive power, in parallel to data, over the existing CAT-5 Ethernet infrastructure without the need to make any modifications in it. PoE integrates data and power on the same wires; it keeps the structured cabling safe and does not interfere with concurrent network operation.

A typical PoE system consists of Power sourcing equipment (PSE) and a powered device (PD). The PSE may either be an Endspan (L2 Ethernet switch supporting PoE) or a Midspan (PoE hub). The PD is a PoE-enabled terminal such as an IP phone, Wireless LAN access point, etc. PSE provides the power on the cable for the PD.

The IEEE 802.3af, also called Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI), is the first international standard to define the transmission of power over Ethernet infrastructure. This standard specifies the protocol for delivery of a nominal 48 Vdc over unshielded twisted-pair cables (such as CAT-5), eliminating the need for a local power source for the remote device. It consumes less than 13 watts of power.

The PoE facility was developed to reduce the cost of network planning, cabling and installation. PoE saves time and money by avoiding the need for separate installation of Data and Power infrastructures. PoE makes network planning flexible and independent of switch cabinets and power sources, and also saves additional outlay for power and telephone networks (VoIP).