TEXAS INSTRUMENTS

Power Supply Design Seminar - Topic Abstracts

Topic 1: Power-Conversion Techniques for Complying with Automotive Emissions Requirements

Comité International Spécial des Perturbations Radioélectriques (CISPR) 25 is the typical starting point for evaluating conducted and radiated emissions in automotive systems. This topic addresses the unique challenges of designing power converters to pass automotive EMC requirements based on CISPR 25, including background information on the CISPR 25 standard and test setups. We explain common noise sources in power converters and various techniques to reduce conducted and radiated emissions, including input filter design, frequency selection, mode selection, snubber design, shielding and layout. Measured results from a 13.5-V input to a 3.3-V, 5-A output converter case study demonstrate the relative effectiveness of electromagnetic interference (EMI) mitigation techniques and the path to passing CISPR 25 Class 5 conducted emissions.

Topic 2: Power Factor Correction (PFC) Circuit Basics

From laptop adapters to power tools, any end equipment powered from the AC grid represents a complex load where the input current is not always in phase with the instantaneous line voltage. As such, the end equipment consumes both real power as well as reactive power from the grid. The ratio between real, usable power (measured in watts) and the total real- plus-reactive power is known as the power factor. A power factor correction (PFC) circuit intentionally shapes the input current to be in phase with the instantaneous line voltage and minimizes the total apparent power consumed.

While this is advantageous to utility companies, a PFC circuit also provides benefits in end applications. This topic presents these benefits, how the PFC circuit can impact the AC-to-DC power-conversion architecture, common PFC circuit types,

the benefits/disadvantages of different approaches, and a PFC solution selection process based on end-equipment priorities.

Topic 3: Voltage Regulator Design and Optimization for High-Current, Fast-Slew-Rate Load Transients

Designing to the tight voltage tolerances of today's modern central processing units and field-programmable gate arrays (FPGAs) is becoming more difficult as their current draw increases and becomes more dynamic. Getting the correct output capacitance mix to ensure first-time power-delivery success is no small feat, with >100-A steps and a slew rates in excess of 100 A/µs. Standard point-of-load design techniques no longer hold true; we need new methods to choose the output capacitance.

This topic breaks down regulator transient response, the effects of load slew rate on COUT selection and two methods of calculating COUT in processor power applications. The first method is a charge-based approach in the time domain, while the second method calculates a target impedance across a range of frequencies. When used in conjunction with one another, these approaches meet the transient specifications of a high-current FPGA core voltage rail. This topic also includes an overview of regulator output impedance, load lines and the effect of control topology on transient response.

Topic 4: Common Mistakes in Flyback Power Supplies and How to Fix Them

When you run into a problem in your power-supply design, the odds are that someone else has already solved the same problem on another design. Wouldn't it be great if you could learn from their mistakes? This topic focuses on some of the most common mistakes in the design and troubleshooting of low-power AC/DC power supplies, specifically focusing on the flyback topology.

Presenting the material in an engaging and interactive format promotes brainstorming and the logical thought processes needed to be successful at debugging power supplies. This topic presents the symptoms of each problem, followed by possible causes, solutions and tips on how to avoid similar issues.

Topic 5: Designing a High-Power Bidirectional AC/DC Power Supply Using SiC FETs

High-power bidirectional AC/DC power supplies are found in applications including uninterruptible power supplies, energy storage systems and onboard chargers with vehicle-to-grid capability. Compared to the traditional approach – using one unidirectional rectifier and one unidirectional inverter to achieve a bidirectional energy flow – a bidirectional rectifier can provide advantages such as smaller dimensions, higher power density and higher efficiency.

This topic will review bidirectional AC/DC power supplies, bridgeless power factor correction (PFC), and isolated DC/DC topologies and design challenges. Resolving these challenges entails a deep dive into the total bidirectional AC/DC rectifier solution, including a totem-pole PFC solution and an isolated CLLLC resonant DC/DC converter solution using silicon carbide (SiC) field-effect transistors (FETs). Together, these two designs form a high-density, high-efficiency 6.6-kW bidirectional AC/ DC power supply. We will discuss the implementation details of hardware and software in order to easily apply the concepts and results presented.

Topic 6: Practical EMI Considerations for Low-Power AC/DC Supplies

Electromagnetic interference (EMI) is an essential part of every power-supply design, but too often gets relegated to the end of the design flow, at which point its resolution can be time-consuming, costly and inefficient. This topic will help dispel fears about EMI, and show how to find and fix the issues.

Most EMI issues are caused by component parasitics that are not even represented in design schematics, such as transformer input/output capacitance, stray capacitance and inductances on the board assembly. EMI filter components have a parasitic capacitance and inductance that limit their useful frequency range, and can even make EMI worse.

To highlight the debugging techniques, we will show practical examples throughout, using a high-density 65-W USB Power Delivery active clamp flyback adapter. These examples will illustrate how a few basic changes result in an almost 50-dB improvement at the fundamental switching frequency without a major sacrifice in efficiency, size or cost.