Automotive ECU Designer Reduces Power Consumption by 10%

Introduction

The pace of innovation is accelerating in the automotive industry in the form of connected cars, autonomous driving (AD), advanced driving assistance systems (ADAS), and the next generation of electric vehicles. Innovations in these segments are driving the demand for automotive electronics. The number of electronic control units (ECUs) in vehicles continues to grow. Each ECU needs higher performance and more electronic capabilities to process information quickly since advanced programming is necessary to control the ECUs. New design challenges for these ECUs include managing increasing power consumption and heat generation.

One automotive ECU chipmaker successfully reduced power consumption to ensure product reliability. It succeeded by utilizing a device current waveform analyzer to enable precise measurement and analysis of power rail voltage and current during ECU design and development.
The Key Issues: ECU System Design and Development

ECU system design engineers face challenges in reducing power consumption and accompanying heat generation.

As the number of installed ECUs increases, power consumption reduction is necessary for each ECU. This process is especially true for the power consumption of ECUs for AD or ADAS designs — both design types manage an extensive amount of image data. Thermal design is also a critical factor to help reduce accompanying heat generation. Furthermore, standby power consumption requires evaluation and reduction since more ECUs are working even when the engine stops.

It is not enough to evaluate the average current to achieve lower power consumption and effective thermal design. It is necessary to accurately measure and analyze the dynamic current and its peak current flowing from the power source for each event to optimize the power consumption of the ECU.

Additional challenges are quantitative problem analysis and debugging to ensure product reliability for a complex system.

It is common to observe the voltage waveform with an oscilloscope during problem analysis. However, it becomes difficult to identify the problem with only voltage waveforms. Current measurement and analysis are alternative approaches to identify the problem. This process occurs during the debugging and failure analysis of the system-on-a-chip (SoC) and application-specific integrated circuit (ASIC) in the ECU.

ECUs must function in harsh environments within the wide interior space of a vehicle. Problems can occur outside a clean evaluation environment in different conditions and higher temperatures.

Measuring both voltage and current ensures product reliability for complicated systems where quantitative problem analysis and debugging are a requirement.
The Solution: Detailed Current Profiling

A digital multimeter (DMM) or an oscilloscope with a current probe or a shunt resistor are the most common ways to measure the current waveform. However, a DMM has limited bandwidth and sampling rate, and an oscilloscope has limited sensitivity and a larger noise floor. These instruments cannot capture sufficient information to describe the actual operation from their current waveform. Validation and debugging are time-consuming due limited information.

For an environmental test, such as a temperature test, a probe extension is necessary to place the ECUs in the chamber. The necessary information for analysis hides in the noise; the cable extension causes the larger noise floor. As a result, the quantitative evaluation and debugging processes are challenging.

The Keysight CX3300 Series device current waveform analyzer enabled the ECU chipmaker to measure and analyze the current waveform precisely with a single instrument. The solution has up to 200 MHz bandwidth, a maximum of 1 GSa/s sampling rate, and a wide current range from 150 pA to 100 A. It also has a wide 14-bit/16-bit dynamic range, and deep memory depth up to 256 Mpts/ch. In addition, it captures the detailed dynamic current of each event, including fast peak currents and other transients.

The CX3300 has convenient waveform analysis capabilities that enabled the chipmaker to quickly validate and debug the ECU. Concurrently, it captures the voltage waveform, digital signal, current waveform, including subtle changes. This process saved the chipmaker time and effort, making it easier to debug the chip designs. These subtle aberrations were previously not visible from just the voltage waveforms when the chipmaker was using an oscilloscope to validate its designs.

The chipmaker also used the Keysight CX1105A ultra-low noise differential sensor with a dedicated 1-m cable for temperature testing. The CX1105A measures differential voltage using a small onboard shunt resistor. With this cable, the chipmaker achieved precise current waveform evaluation even under temperature testing while keeping a low noise floor (see Figure 1).
The Results: Accelerated Validation

The automotive ECU chipmaker successfully evaluated accurate current consumption and large peak current occurrences at high temperatures using the CX3300A. After identifying and resolving the cause of the anomaly, the chipmaker reduced power consumption by 10%.

The chipmaker was evaluating the sleep current of ECUs using a DMM, and the active current using an oscilloscope with a differential probe. However, the engineers spent extensive time creating a current profile from the amount of data they had to analyze. The engineers encountered challenges while analyzing the larger peak current within the high temperature. The peak current was not visible under the larger noise floor making it difficult to analyze the problem quantitatively. The engineers could not easily identify the cause of the problem.

Capturing the transition current waveform from sleep to active with a single instrument — the CX3300A — was a straightforward process. With the instrument’s automatic power and current profiler, the chipmaker was able to immediately analyze how the current drains from the power supply for each event, and use this information to reduce the power consumption (see Figure 2). The result was more effective thermal design.
Also, the chipmaker was able to quantitatively evaluate the difference in the peak current due to the different temperature conditions using the clean current waveform captured by the CX3300. Its engineers could then analogize the inside state of the SoC from the current waveform. As a result, they easily found the cause of the larger peak current in the operating mode transitions and then quickly solved the problem to improve product reliability.