Control Loop Analysis

Measuring Feedback Loop Response In Power Systems

Every power supply has a feedback loop that monitors the output voltage or current and keeps the device's on-time appropriate to the load. This means that the power device conducts longer if the output voltage is too low. Most switched mode power supplies use pulse width (PWM) or frequency modulation (FM) in their control loops. Analysis of the loop dynamics requires the ability to demodulate these signals. Power Measure Analysis (PMA2) software, available in LeCroy X-Stream™ oscilloscopes, includes easy-to- use modulation analysis capabilities.

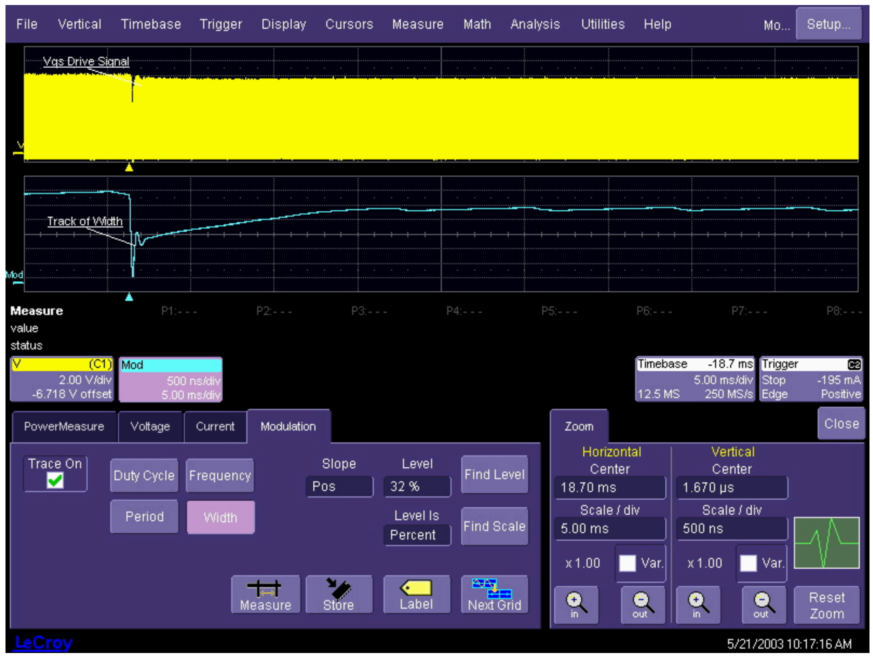

Figure 1- Measuring the step load response in a switched mode power supply using LeCroy's Power Measurement Analysis (PMA2) software

Modulation analysis functions produce a time domain display that represents the modulated parameter in a time vs. time graphical plot. They are convenient tools for intuitively viewing the time domain response of the entire control loop, including any time constants added by the pulse width modulator. Modulation analysis can be performed for duty cycle, period, frequency, or pulse width.

An example is shown in Figure 1, where the response to a step load change of a PWM-based control loop is shown. The upper trace is the gate-to-source drive signal to a MOSFET. This PWM signal is demodulated using a track function of width shown in the lower trace. The track function displays the width of the gate drive signal as a function of time, which is time synchronous with the source waveform. The user can use the zoom features and see the width of each individual cycle and the corresponding value of the track plot so each point in the track function can be related to the source waveform. It is easy to see that the control loop initially overshoots and then slowly recovers in about 15 ms. The time scale of this acquisition is 5 ms per division and the vertical scaling of the track of width is 500 ns per division. The pulse width before the load change is approximately 3.3 µs. After the change, it drops to 150 ns and then quickly recovers to 1.7 µs. From this point it slowly changes until it reaches the final value of 2.6 µs.

Note that the use of a relatively long acquisition memory length of 12.5 Mega Samples (MS) allows the measured waveforms to be digitized at 250 MS/s for a time resolution of 4 ns. This particular scope offers a maximum of 24 MS memory length. Since the switching frequency of this supply is only 68 kHz, the 250 MS/s sample rate is more than adequate to provide ample time resolution in the measurement.

Figure 2 A study showing the startup of the power supply

A related study is shown in Figure 2. In this example, PMA2 running on a WavePro 7300 DSO acquires a 20 ms record of every gate drive pulse from the time the power supply is turned on until it reaches steady state.

The modulation analysis display shows the pulse width of every cycle of the gate drive signal as it occurs. The soft start circuit's performance is readily observed. The minimum and maximum parameters read the range of pulse width variations as 843 ns to 5.7 µs.

PMA2 simplifies power analysis by automating the setup of even these relatively complex functions. Modulation analysis can be used to characterize power supply stability under load changes, line changes, soft-starts, dropouts, hot swap, and short circuits. We can see on a cycle-by-cycle basis, the behavior of the control loop.