
RD2000 Testbed

The RD2000 testbed is an engineering tool to investigate degradation signatures of a typical 12 VDC switch-mode power supply (SMPS). The testbed design is based on the National Semiconductor (NS) LM5116 Wide Range Synchronous Buck Controller reference design, which produces a 12 V/5 A output operating at a 250 kHz PWM frequency. The NS reference design is assembled on a Ridgetop Group printed circuit board (PCB) customized with output filter capacitor fault injection capability.

This particular 12 VDC SMPS is designed to provide nominal operation with approximately 200 microfarads (μF) of filter capacitance installed across the output terminals. Three electromagnetic relays at the bottom edge of the PCB are employed to programmatically inject various levels of synthetic output filter capacitor degradation. When energized, each normally closed relay opens to remove one of three 47 μF capacitors connected in parallel across the output. Another 47 μF capacitor is permanently connected on the back side of the PCB.

Via programmatic digital control, three levels of synthetic output filter capacitance degradation are possible: -47 μF (low degradation), -94 μF (moderate degradation), and -121 μF (severe degradation). Effectively, decreasing the output filter capacitance increases the gain of the SMPS servo loop. As the controller attempts to regulate the output voltage upon an abrupt increase in current demand, the servo loop produces the characteristic under-damped ringing response (i.e., RingDown™).

The RD2000 testbed includes a commercial USB data acquisition module to manage load impulse injection and SMPS response acquisition. The data acquisition module and load board are installed underneath the top panel of the testbed. The captured waveform is transferred, in real time, to the host computer for processing. Utilizing advanced digital signal processing (DSP) techniques, the “ringing” characteristics, or eigenvalues, indicative of the system’s control loop health are extracted from the raw waveform and used to measure the degradation.

The prominent and measurable effect of various levels of output filter capacitor degradation on SMPS operation is observed with the companion “virtual” control panel that accompanies the RD2000 testbed. The control panel graphical user interface (GUI) provides a toggle switch to inject output filter capacitor degradation and analyze the effect on SMPS State-Of-Health (SOH). As the degradation level is increased from low to moderate to severe, via the slider control above toggle switch, the user can view the corresponding decrease in SOH. The RD2000 User Guide provides more information on installing and using the testbed software.