Safe Operating Area

TECHNICAL BRIEF

Improving Reliability By monitoring Device Stress Limits

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Summary

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Every switching device has a maximum voltage, current and power specified by the device manufacturer, displayed on its technical application note. Reliability of the power supply is dependent on not exceeding these limits. Safe Operating Area (SOA) plots help confirm operating margins.

In Figure 1 the upper trace shows a MOSFET's drain-source voltage, and the center trace shows the MOSFET's drain current waveform in a switch mode power supply. Amplitude of current vs. amplitude of voltage is displayed as an XY trace known as a Safe Operating Area Plot. Horizontal Axis in the X-Y plot is voltage, the vertical axis is current. The upper-right corner of the XY trace represents maximum power.

Figure 1: A Safe Operating Area Plot for a single power supply switching cycle

The SOA plot is a feature of Teledyne LeCroy's Power Analysis software. Because of the long memories available in these oscilloscopes it is possible to find SOA violations that occur for only a few cycles after an

event, such as a short circuit or startup. Such low duty cycle events can be problematic. If they go undetected they can degrade the device over time reducing system reliability. Figure 2 shows an SOA plot taken over 20 ms. Note that the long acquisition memory maintains the same 2.5 GS/s sample rate used in Figure 1.

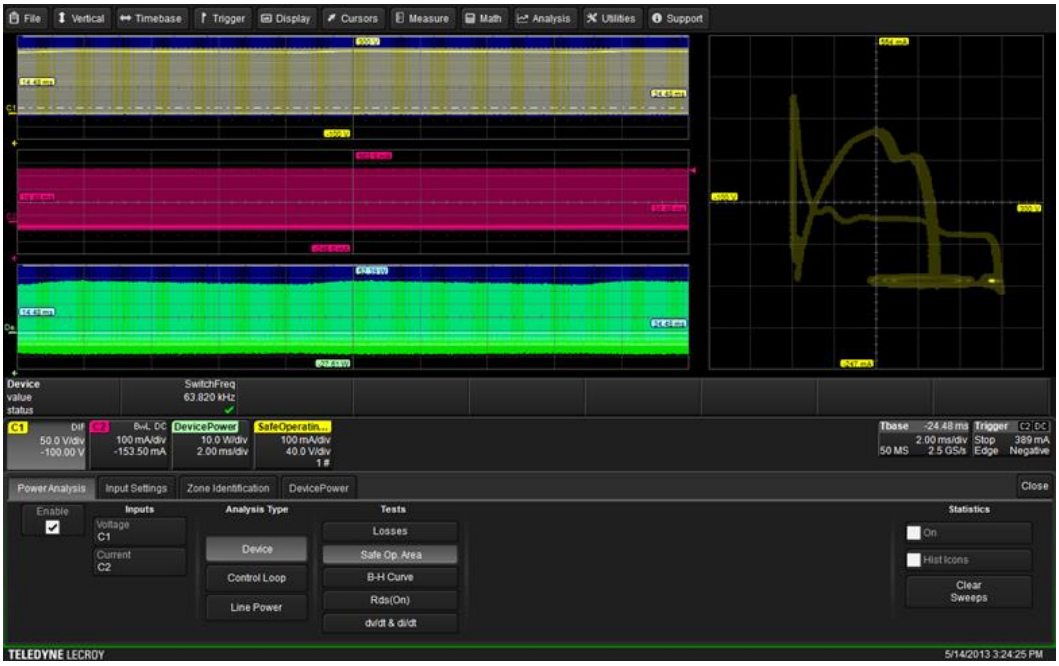

Figure 2: An SOA plot for a whole cycle of the AC line (mains). Note the use of long acquisition memory to maintain the 2.5 GS/s sample rate

The primary interest in the SOA plot is to determine if the device exceeds its maximum voltage, current, or power ratings. In Figure 3 the steady state operation of a switched mode supply yields the SOA plot shown. In addition, parameters read the maximum current, voltage, and power for the whole waveform.

Figure 3: Using the maximum parameter to measure the maximum voltage, current, and power

The SOA plot for the power supply startup, Figure 4, shows a much different characteristic. The shape of the SOA plot shows larger excursions from the origin. This indicates a greater stress on the device. Note that the peak voltage has increased from 252 to 290 Volts. Peak current is 1.79 A compared to 0.436 A during steady state. The maximum power dissipated by the MOS-FET increases from 42 to 92 W.

Figure 4: The SOA plot for power supply startup shows a more severe operational range of voltage, current and power

Safe Operating Area plots reveals a great deal about the operating conditions of power devices under different operating modes. Combined with parameter measurements for interpretation of maximum voltage, current and power levels they are unequalled in device characterization tools.