

# Safe Operating Area

## Improving Reliability By monitoring Device Stress Limits

Every switching device has a maximum voltage, maximum current and maximum power specified by the device manufacturer, displayed on its technical application note. Reliability of the power supply is dependent on not exceeding these limits.

In figure 1 the upper trace shows a MOSFET's drain-source voltage, and the lower trace shows the MOSFET's drain current waveform. Amplitude of current vs. amplitude of voltage is displayed as an XY trace known as a Safe Operating Area Plot (SOA). The lower left corner of the XY plot shows zero current and zero voltage. The upper-right corner of the XY trace shows maximum power.

The SOA plot is a feature of LeCroy's PMA 2 Power Measure Analysis software. Because of the long memories available in LeCroy scopes 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 1 GS/s sample rate used in figure 1.

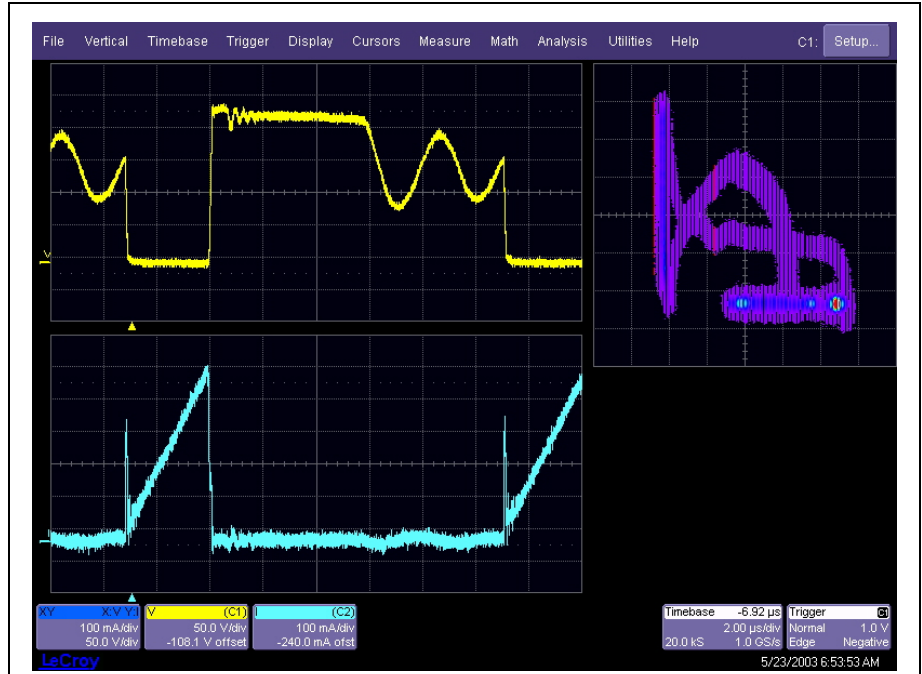


Figure 1 - A Safe Operating Area Plot for a single power supply switching cycle

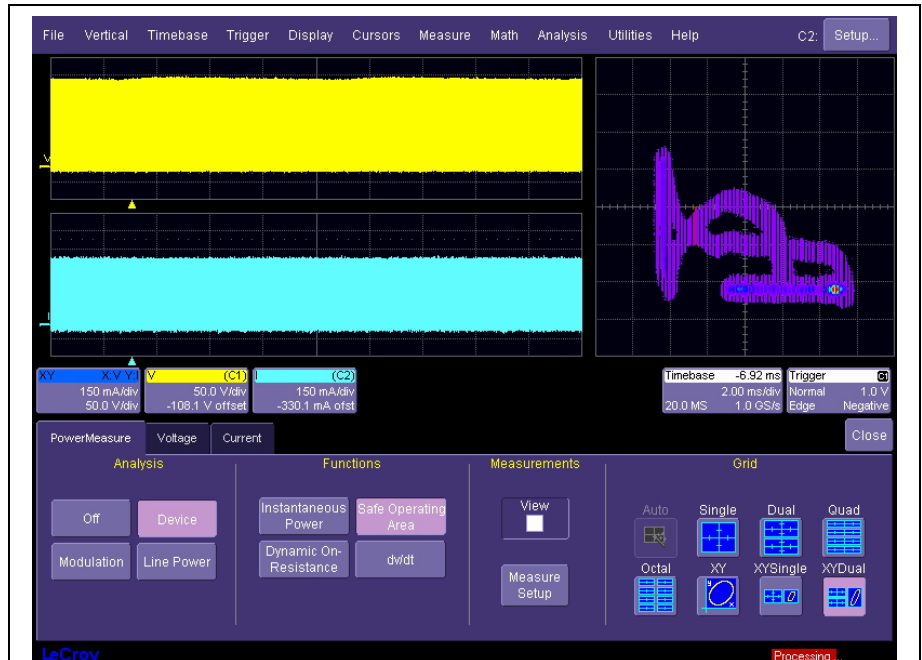
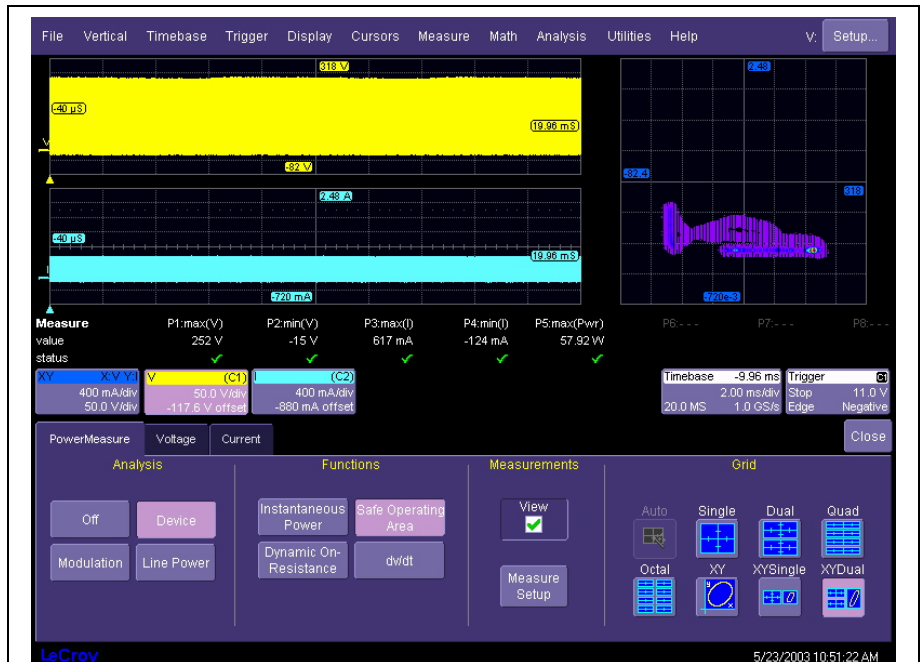


Figure 2 An SOA plot for a whole cycle of the AC line (mains)

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.

The SOA plot for the power supply startup, plotted with the same voltage and current scaling as used in the steady state condition, 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 292 Volts. Peak current is 1.3 A compared to 0.617 A during steady state. The maximum power dissipated by the MOSFET increases from 57.92 to 105.24 W.

X-Stream™ scopes have a host of features that can be combined with the PMA2 software to aid analysis and troubleshooting. Automatic testing of the peak values can be enabled to automatically monitor out of specification conditions. Auto-scrolling of zoom traces allows the user to play the long waveform through on a cycle by cycle basis to see the effects on the SOA plot



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



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