Switching Noise Control, The original SMPS Buck board had no input filters and produced excessive noise at both inputs and outputs. Input noise is controlled by several EMI specs. MIL-STD-462D provides for a line impedance stabilization network, LISN, with values more in-tune with low voltage applications while CSPR16, the European standard is best suited to higher voltage applications. In any event, the object of the networks is to direct high frequency noise into a 50 ohm resistive load. You can always just measure the line current, multiply by 50 and compare with the standard specification without using an LISN. But the LISN acts as a filter that may improve results. Both standards have about the same requirement with the European standard being about 6dB more stringent in 400k to 5Meg frequency range.

Figure 1, Shows the noise level without input filters after modifying the board for 5 Amp operation, the red level is the CSPR16 limit.

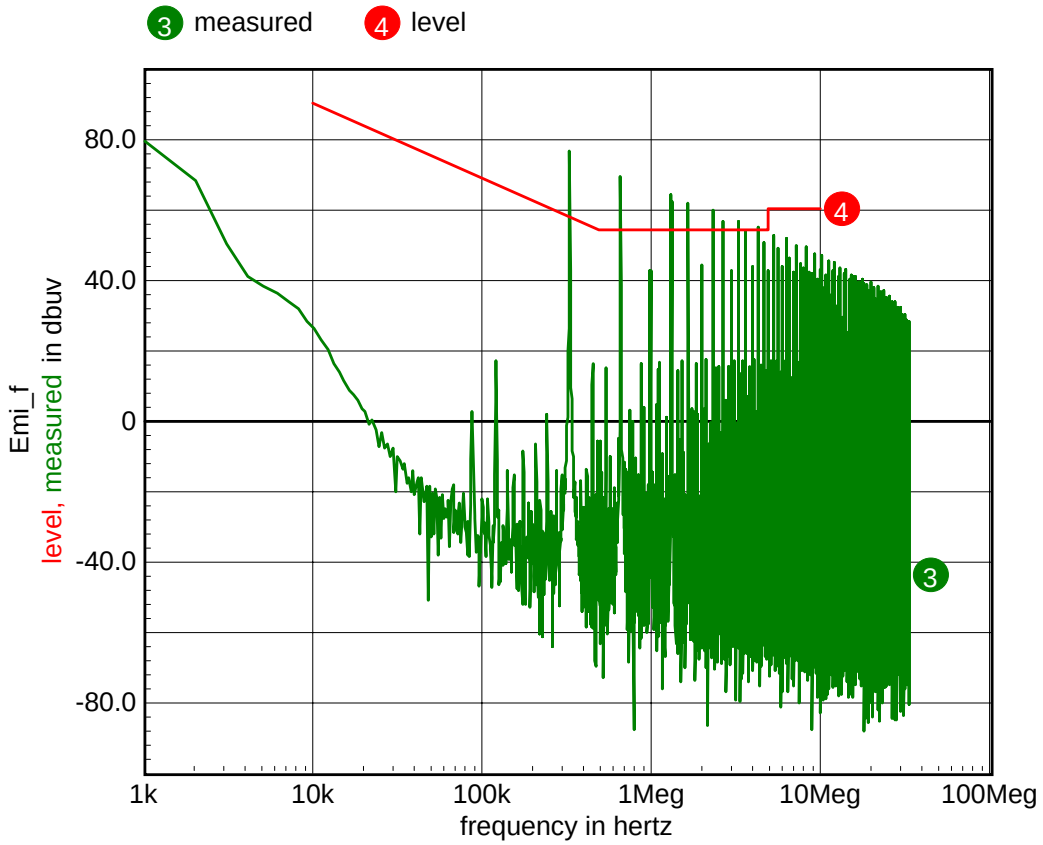

Figure 1, Simulated input noise compared to CSPR16 specification before adding input filter.

Replacing the NTC resistors with 2uHy inductors and upgrading capacitors to Al-Poly technology solve the input noise problem as shown in Figure 2.

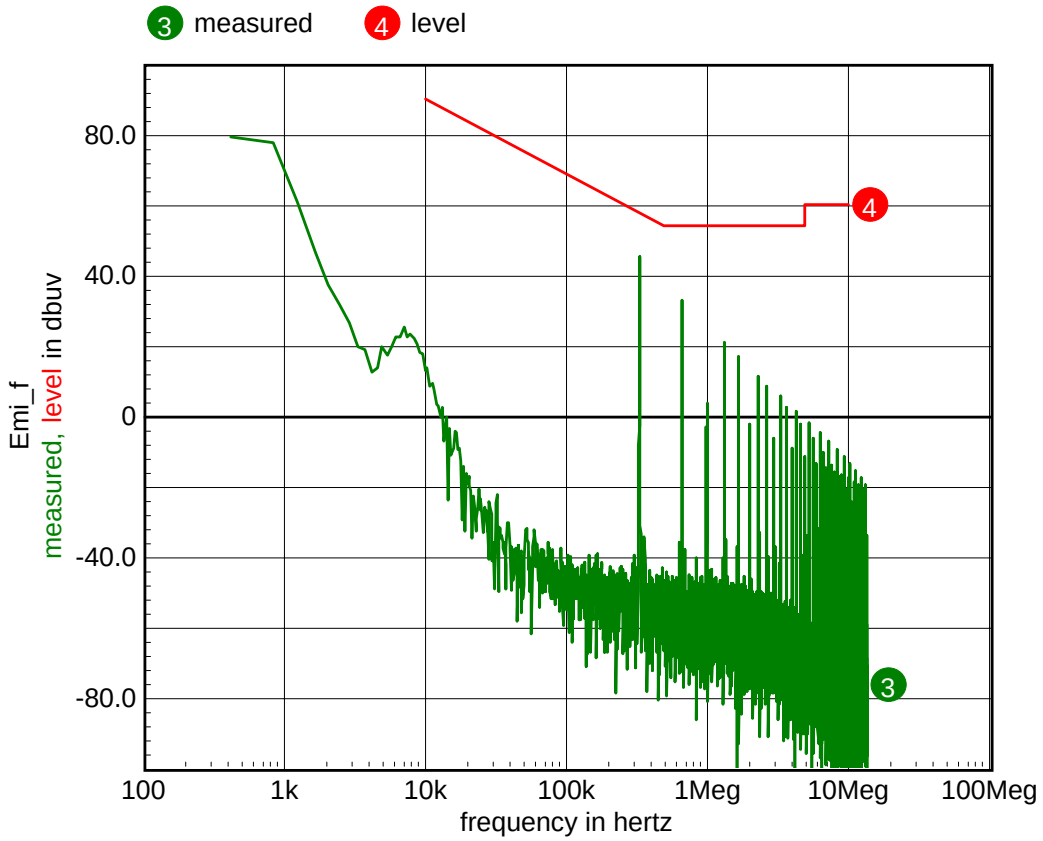

Figure 2, Added filters solve the noise problem.

This circuit is not subject to this noise specification if it is used as an internal power supply. However, the noise could still upset other circuits.

Of equal or greater concern is the noise that seems to appear just about everywhere, caused by fast di/dt switching of the MOSFETS. This rapid change in magnetic filed induces eddy currents in the ground plane. These eddy currents sum together, creating a large net current at the edge of the ground plane, just where the input and output connections are made. Typically the noise peaks in the 50 to 100megHz range. The tighter the circuit (lower inductance traces) the higher the frequency and higher pk voltages are seen. Visualize the output ground, located a small distance from the filter capacitor ground. The impedance in this path is very small and contains a ground plane voltage the can be very large. Placing a high quality ceramic capacitor across the output does nothing! Without controlling the di/dt source, voltages approaching 1 volt pk-pk can be seen. That's enough to upset nearby IC's by conducting excess substrate current. Two circuit changes are needed to control this noise. First, the top switch needs a schottky rectifier to prevent storage time spikes when current flows backwards. Secondly, a small filter needs to be placed in series with the switches to prevent turn-on shoot-thru. The MOSFETS don't have to be both on for this to occur, the schottky diode conduction is sufficient. Figure 3 shows the final result in which high frequency noise has been reduced below the noise cause by capacitor ESR and ESL.

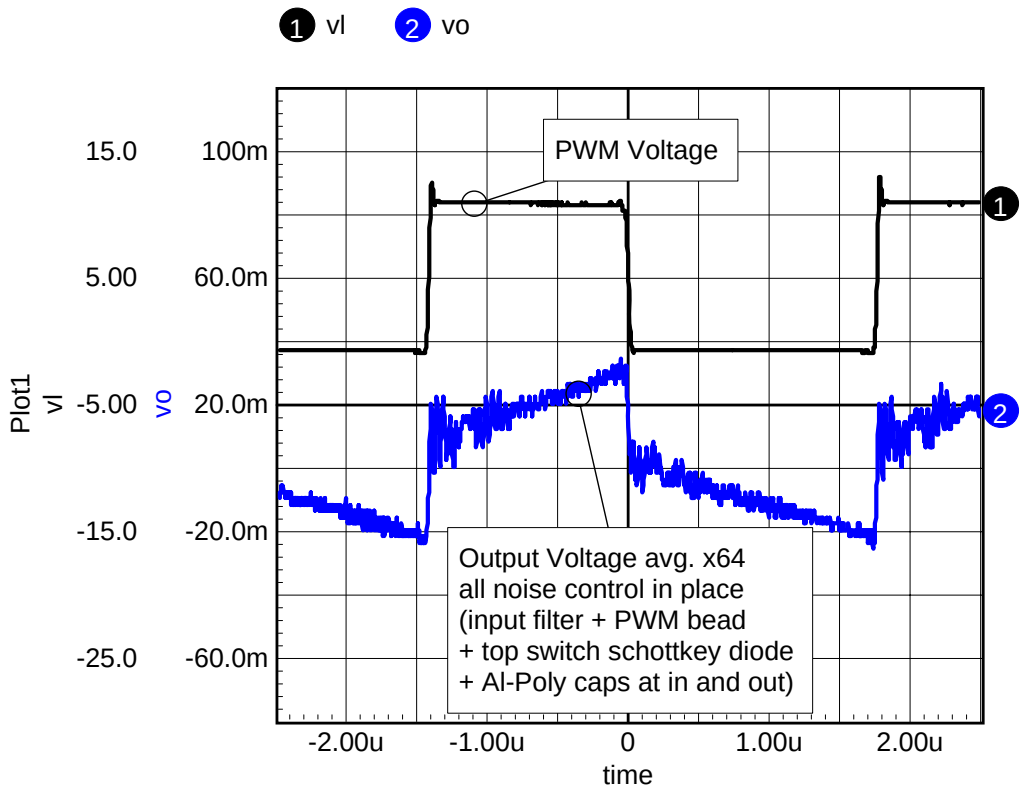

Figure 3, Output noise measured after all noise control circuits have been added.

The signals were averaged to eliminate asynchronous noise. This noise comes from the DSP switching and is larger than SMPS high frequency noise that is measured here.