PCB power supply noise measurement procedure
What has changed?

• Measuring power supply noise in high current, high frequency, low voltage designs is no longer simply a case of hooking up an oscilloscope to the power supply and looking for the max and min voltage excursions. The voltages seen at the device pins WILL be very different to that seen at the power supply source, and even different supply pins on the device will see different voltages.
Why has it changed?

• In high current designs the inductance of vias, traces and device connections cause significantly more voltage drop which is spread across many frequencies.

• Impedance is frequency dependent so cannot bandwidth limit oscilloscope to remove “measurement noise” since this noise is exactly what we need to see !!!

• Very short term violations are now significant.
Vias

- Vias contribute significant inductance.
- If PCB stack-up includes many layers then capacitor to plane inductance might be much higher than plane to BGA if planes are near top.
- We need to measure what the BGA sees.
Equivalent circuit

- Measuring across points A yields completely wrong values due to many series inductors and resistances.
- Measuring across points B yields completely wrong values due to many series inductors and resistances.
- Measuring across points C yields only low frequency noise components due to filter formed by capacitor and via inductors.
Pessimistic(ish) measurement

- Removing the decoupling capacitor allows more direct measurement of the plane noise
- No (very little) current flows through decoupling cap vias hence no voltage drop or filtering
- Measured noise will be higher than actual noise across the planes with the capacitor populated and will be higher than the noise across the capacitor when populated, hence is a pessimistic plane noise measurement i.e. actual noise will be less than this measurement (pessimistic measurement)
- BGA noise will be higher than this measurement due to BGA via inductance. Can’t measure this without adding PCB test points though
• In reality there **should** be multiple capacitors on the power rail. Moving rather then removing the measurement point capacitor will help maintain decoupling but will still not be as effective as original connection

• **If there is a significant difference in measurements for point C and point D then there is insufficient additional decoupling capacitance**
Where to measure

- Try to measure at furthest point from the power supply
Oscilloscope

• High speed scope required (250MHz + BW preferred)
• Correct oscilloscope configuration and usage is critical in analyzing high speed, high current, low voltage power supply effectiveness
• Differential probes must be used
• ‘Background’ noise measurements should be taken
• High frequency components up to Fcutoff need to be considered. Fcutoff ~ 120MHz. BW limiting is OK above ~250MHz but do not limit much lower
Oscilloscope connections

- Differential probes should be used for all noise measurements
- Probe tip connections to PCB should be short and soldered in place
Oscilloscope configuration

- Set the scope to infinite persistence
- Set the scope to trigger on a low falling voltage
- Put the scope on NORMAL trigger mode (not AUTO and not SINGLE)
- Add a measure function for the minimum, maximum and average voltage. If available also enable statistics
Baseline measurements

- Clean measurements require the amount of baseline noise to be understood
- With the test system **powered down** short the capacitor test points together and measure the peak to peak, minimum and maximum voltage levels
- Make measurements at ~40ns, 1us and 1ms/div
- If more than ~25mV then check the setup and connections
- If random spikes then check the setup and connections
Supply noise measurements

• Set scope to its maximum acquisition speed.
  – On Tektronix scopes this is called “FastAcq”
• Power up the system and allow the application to start running
• Determine the nominal voltage level (zoom out vertically)
• Set the channel offset to match the nominal voltage
• Zoom in as much as possible vertically to cover ~2/3 of the vertical range
• Slowly adjust the trigger threshold as low as possible so that only occasional trigger events occur (every few seconds)
• Clear the display persistence image (keep persistence on)
• Leave running for as long as possible, at least few minutes
Results

• Long term noise = (max:max – min:min)
  – If statistics are enabled then use the maximum max and the minimum min values and not the mean values
  – Check these values with cursors on the persistence image
  – Measurement we need is therefore the highest level attained and the lowest level attained
Example measurements...

• Maximum max and minimum min measurements
Example measurements...

• Lots of issues
Example measurements...

- 360KHz switcher noise should be fairly simple to control with correct switcher component selection.