



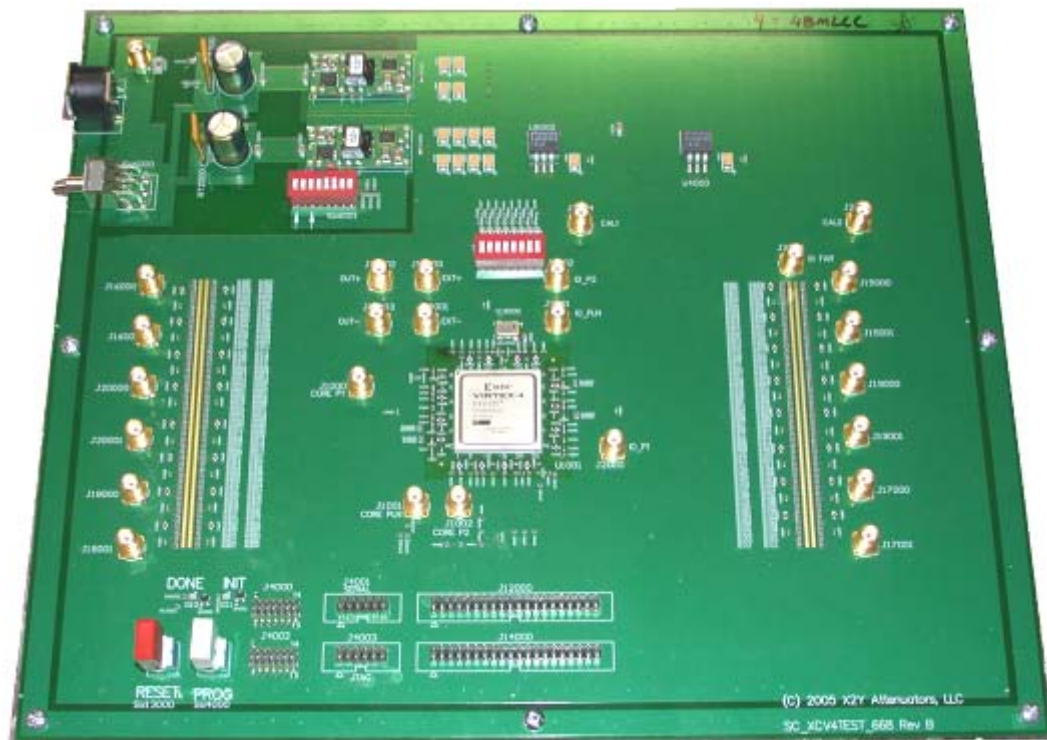
X2Y Live FPGA Power Bypass

Test comparisons, X2Y® 0603 capacitors
versus conventional 0402 capacitors in
high performance 12 layer board
construction

X2Y for FPGA Power Bypass

Our next demonstration board designed by Steve Weir will be shown in a soon to be released video production by Dr. Howard Johnson titled: "*Low Inductance Capacitor Packages*".

- X2Y bypass performance is compared to conventional two terminal capacitors:
 - Network analyzer measurements on test coupon boards
 - Bypass performance using an active FPGA circuit



X2Y for FPGA Power Bypass

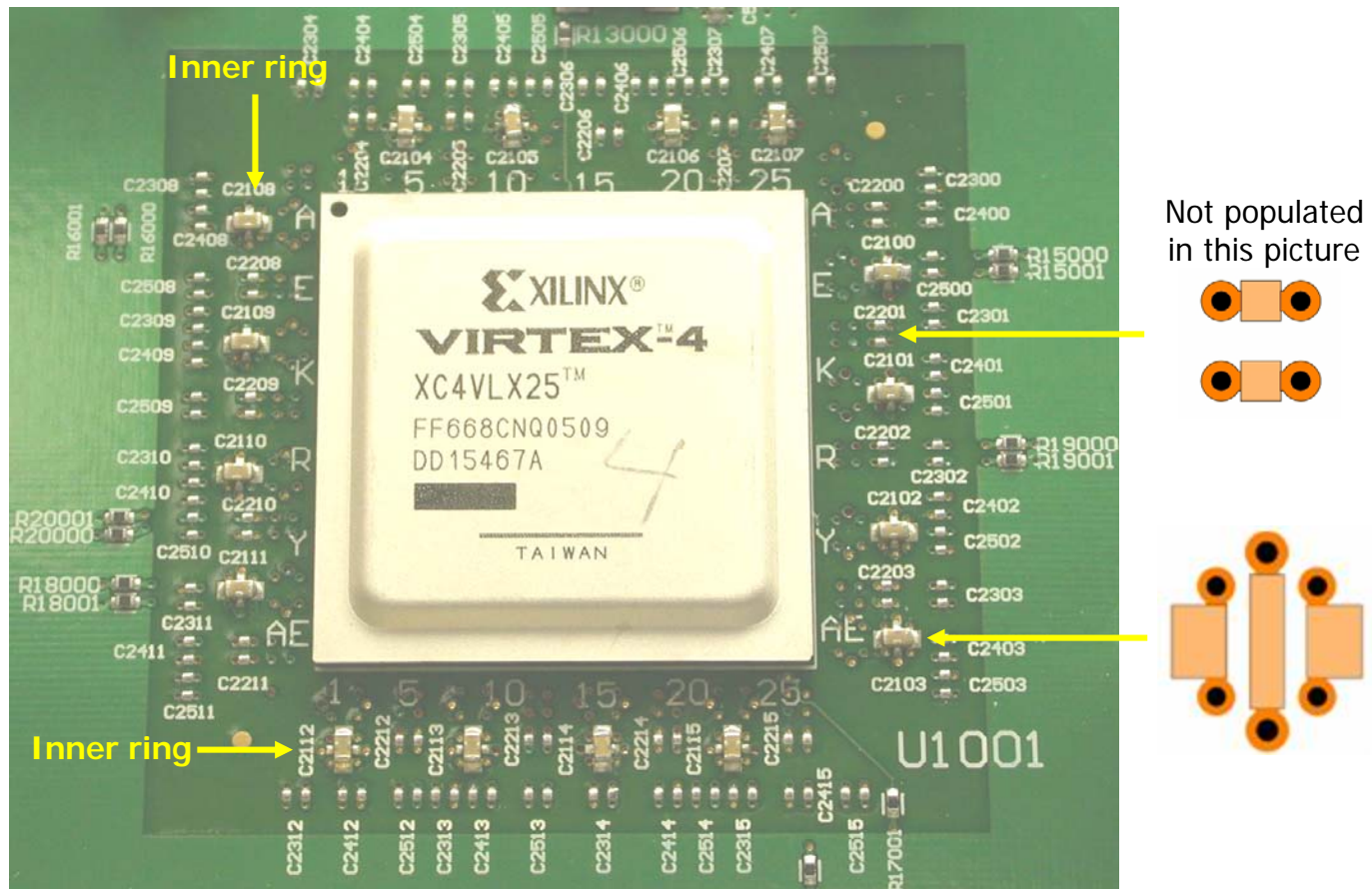
- I/O supply for target device does not have caps under device lid.
 - PCB must support I/O switching currents through entire B/W
 - Low impedance ⇔ Low inductance
- Stack-up optimizes I/O:
 - Power plane on layer 2
 - Vss plane on layer 3
 - Vss flood on surface outside BGA break-out
 - Lowest inductance between BGA substrate and I/O power plane
 - Lowest inductance between I/O power plane and bypass caps

X2Y for FPGA Power Bypass

- Additional Measures for high performance
 - Singulated planes
 - Raise power resonant frequency as high as possible
 - ❖ Frequency depends on mounted inductance
- Virtex 4 FPGAs
 - Rise/fall times of 0.4ns through mid-band region
 - Little energy above 1GHz
 - Makes well-behaved power system easier to realize
 - I/O prioritization in upper planes is **CRITICAL**
 - Large V4 parts w/internal caps still rely substantially on planes / external caps for support and do not escape this requirement
 - Parts like StratixII w/o internal caps **MUST** be affixed with I/O power closest to the part.

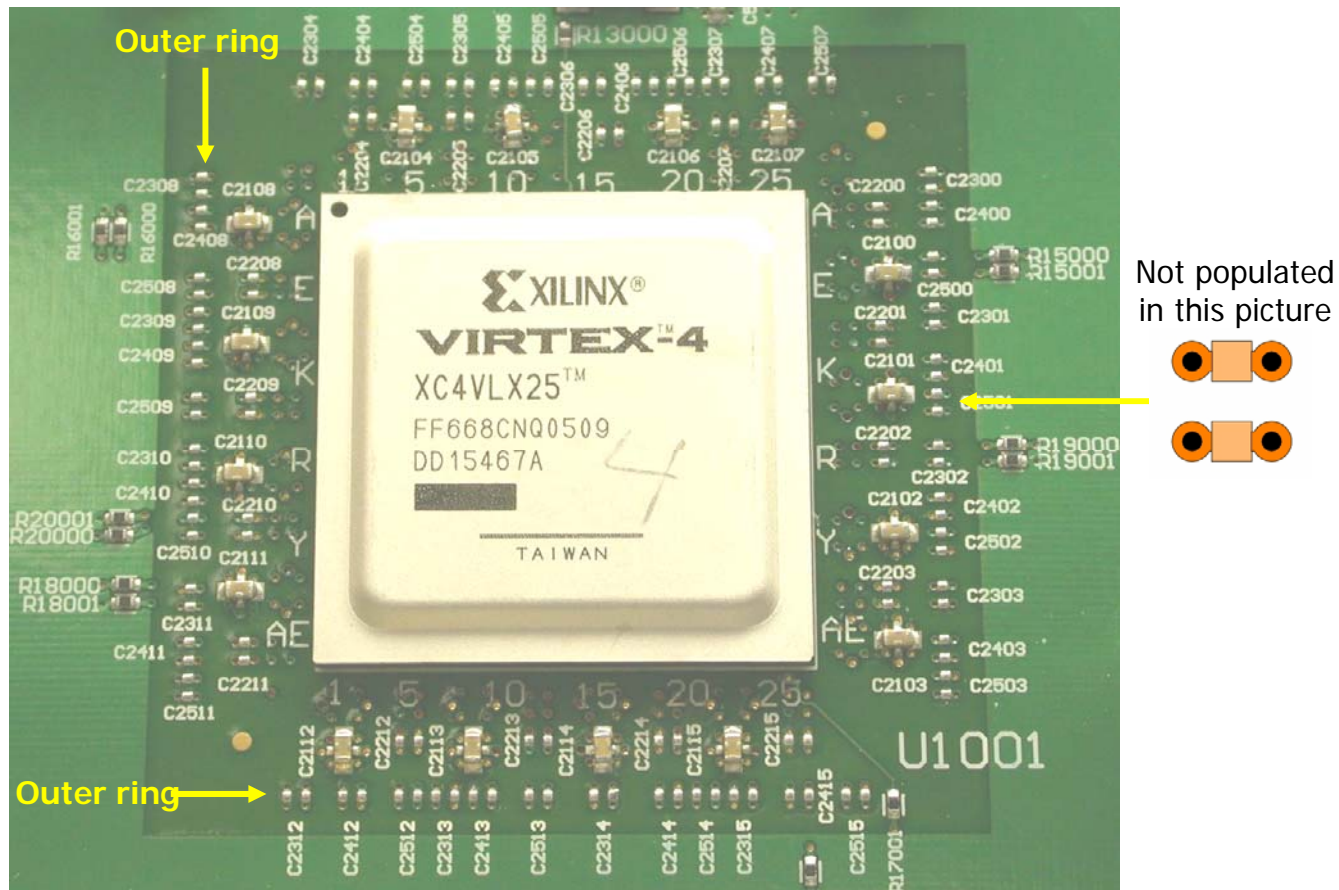
X2Y for FPGA Power Bypass

- Inner ring capacitor population consists of either 16 ea X2Y population OR 16 ea 0402 population
 - 0402 4via mounts, near zero SM dam allowance



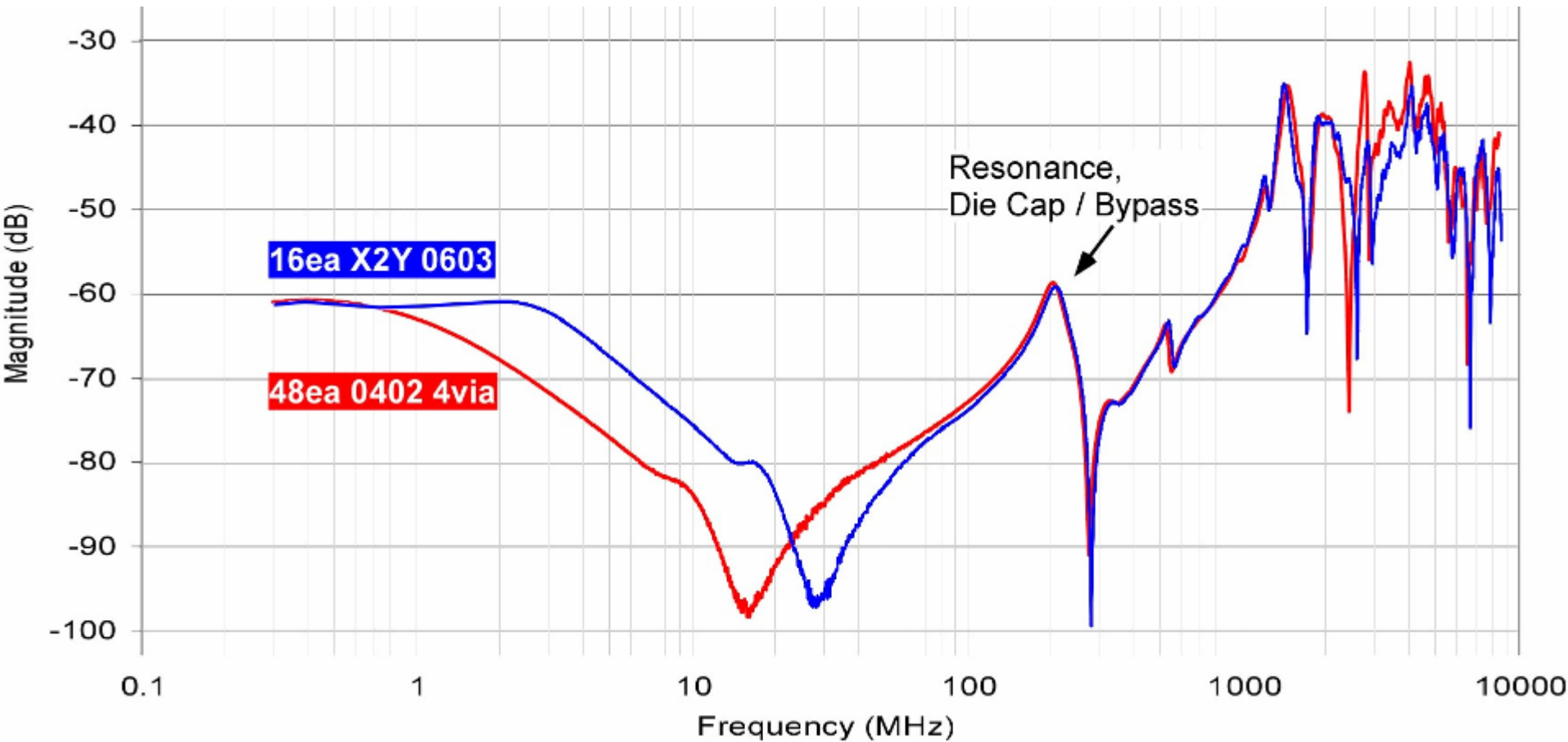
X2Y for FPGA Power Bypass

- Outer ring capacitor population can accommodate up to 48 ea 0402s



Frequency Response

Transfer Impedance Active Test Card



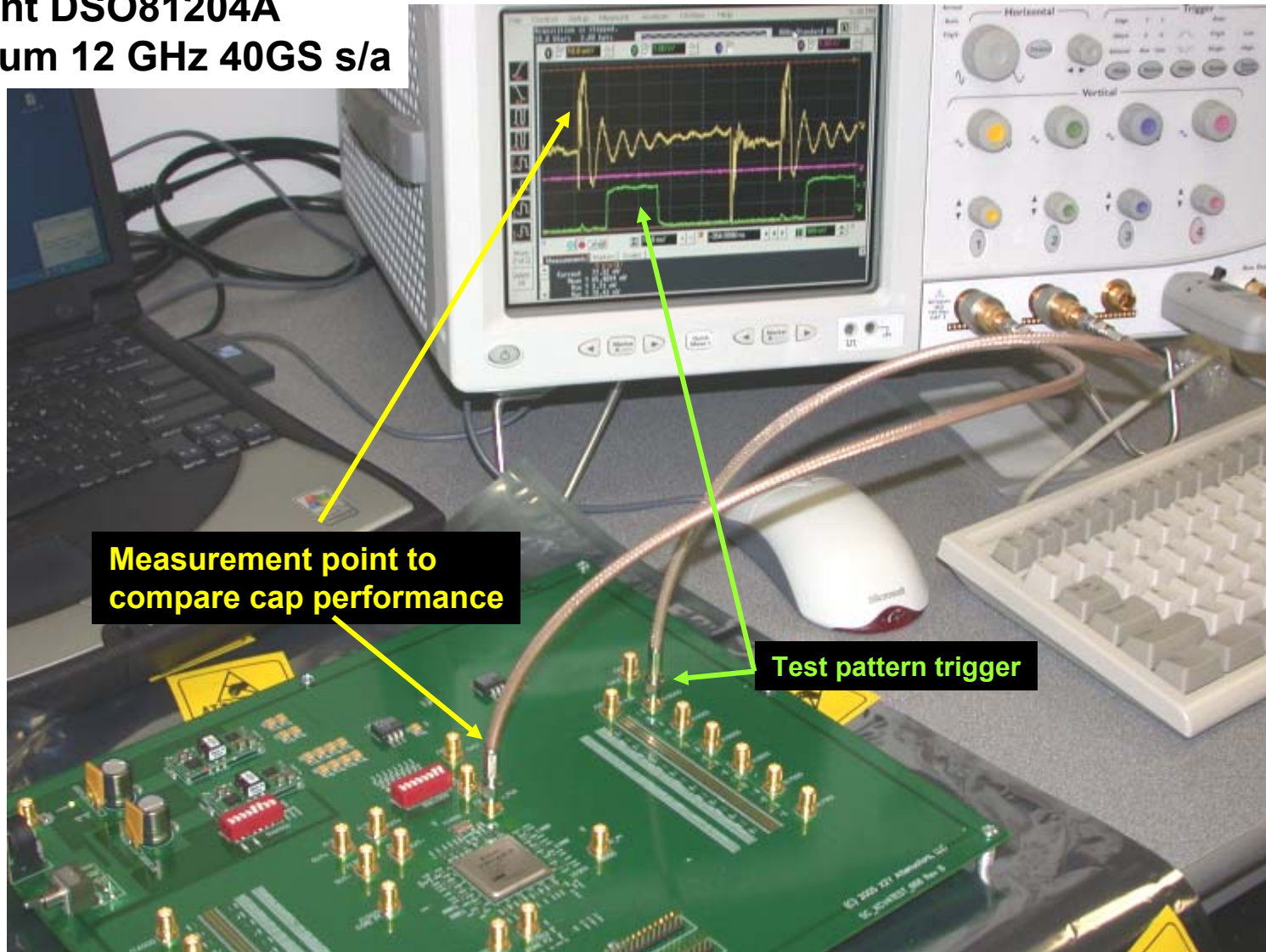
Transient Response Tests

- Virtex 4 LX25 FF668
- 1 – 6 Banks Switching
- 60 Outputs / Bank
- Outputs set to SSTLII Class 2 (DDR RAM I/O standard)
- Two test patterns:
 - 16ns high / 48ns low
 - PRBS5, 125MHz

- VCCIO Outside Capacitor Ring
 - Indicates noise transferred to rest of PWB, and EMI
 - Most proportional to capacitor performance
 - Performance not compressed by plane spreading Inductance
 - Plane cavity height and perforation limits impedance to device attachment

Measurement Setup

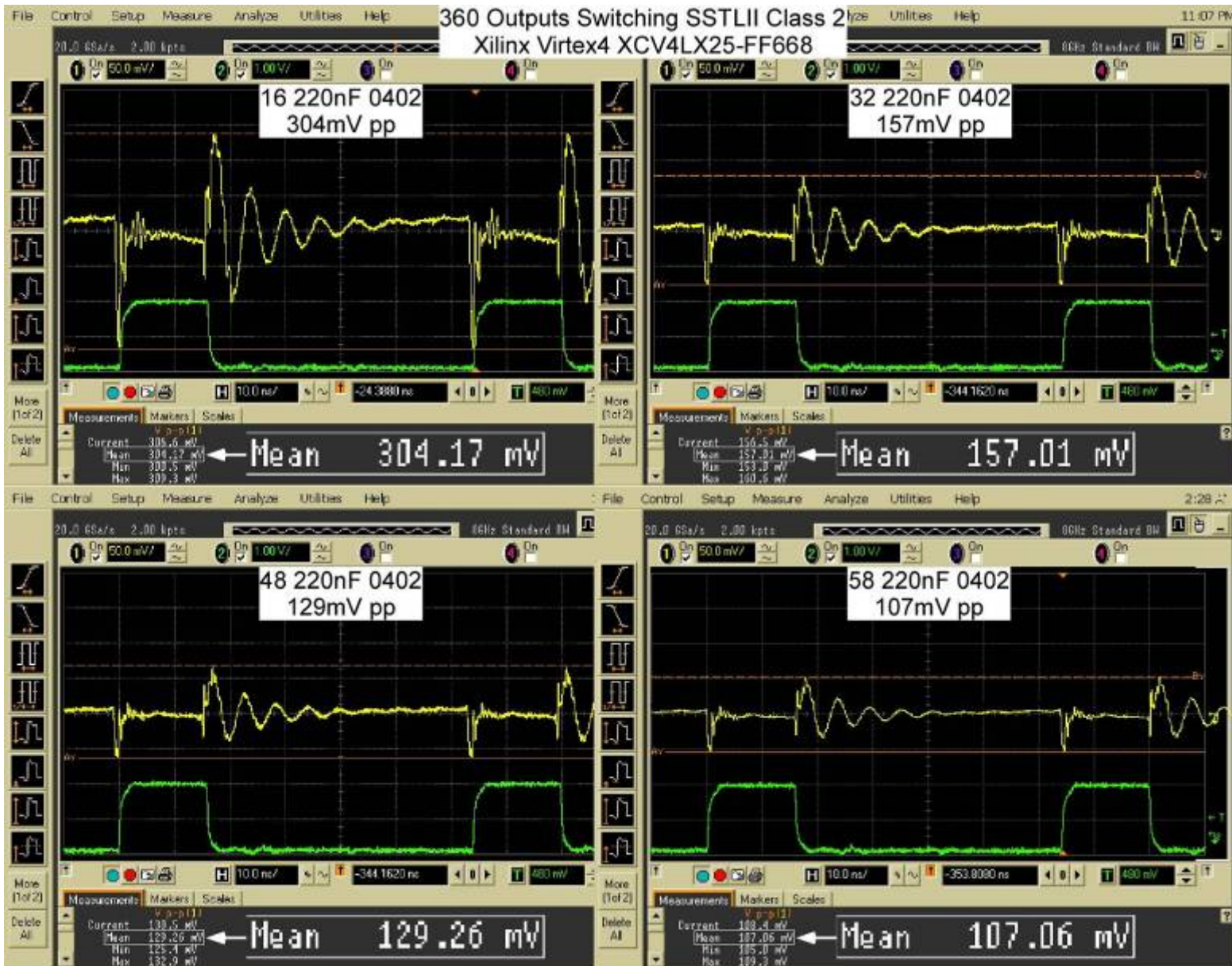
Agilent DSO81204A
Infinium 12 GHz 40GS s/a



Measurement point to compare cap performance

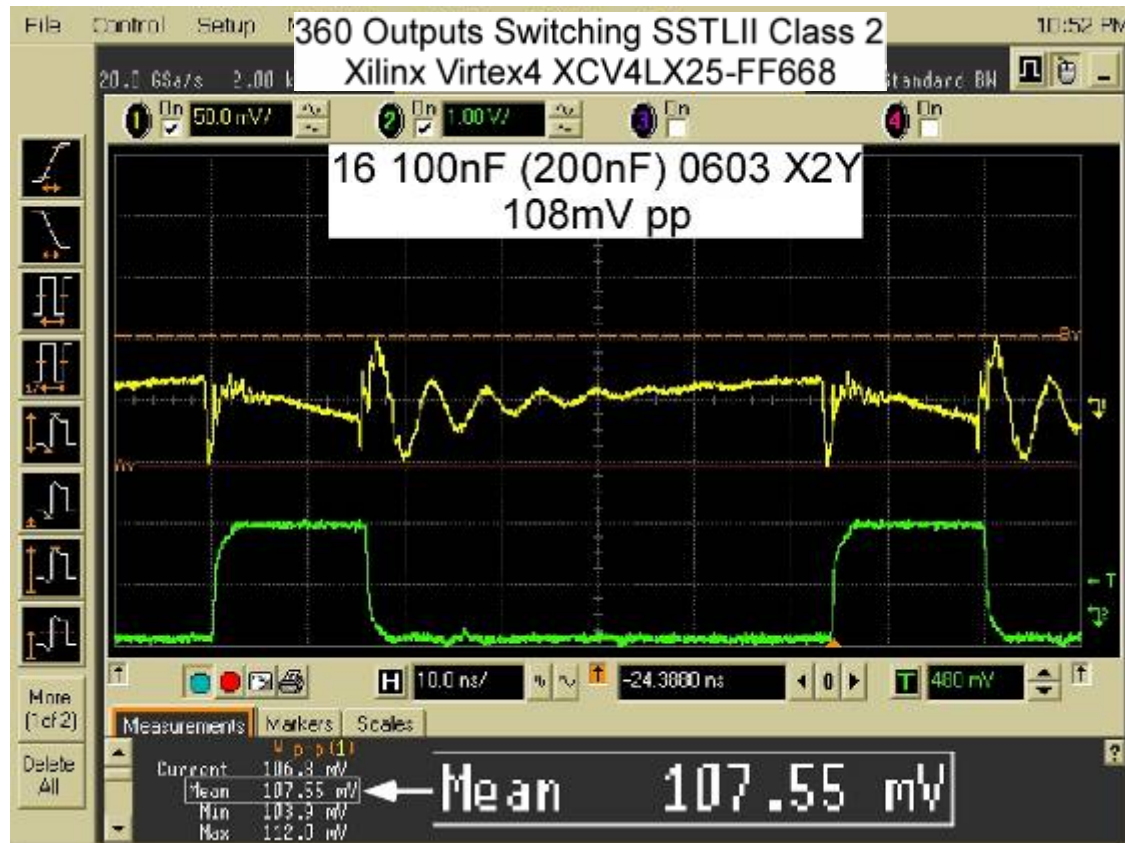
Test pattern trigger

Transient Response, Conventional 0402s



Transient Response, 0603 X2Ys

- **16** 0603 X2Ys match pp noise of **58** 0402s
 - **96** Vias total X2Y, **232** Vias total 0402
- **3.6:1** Capacitor ratio, **2.4:1** via ratio

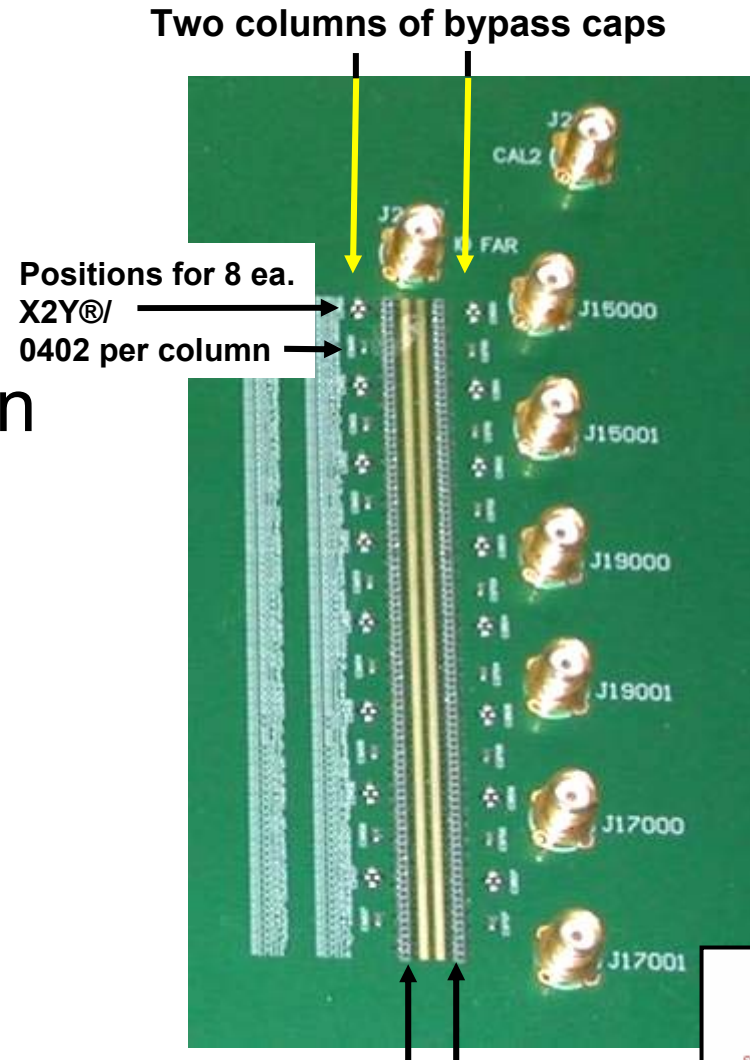


Transient Response, Planes PRBS5

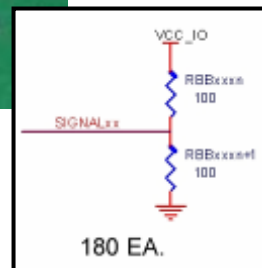


Vtt Bypass

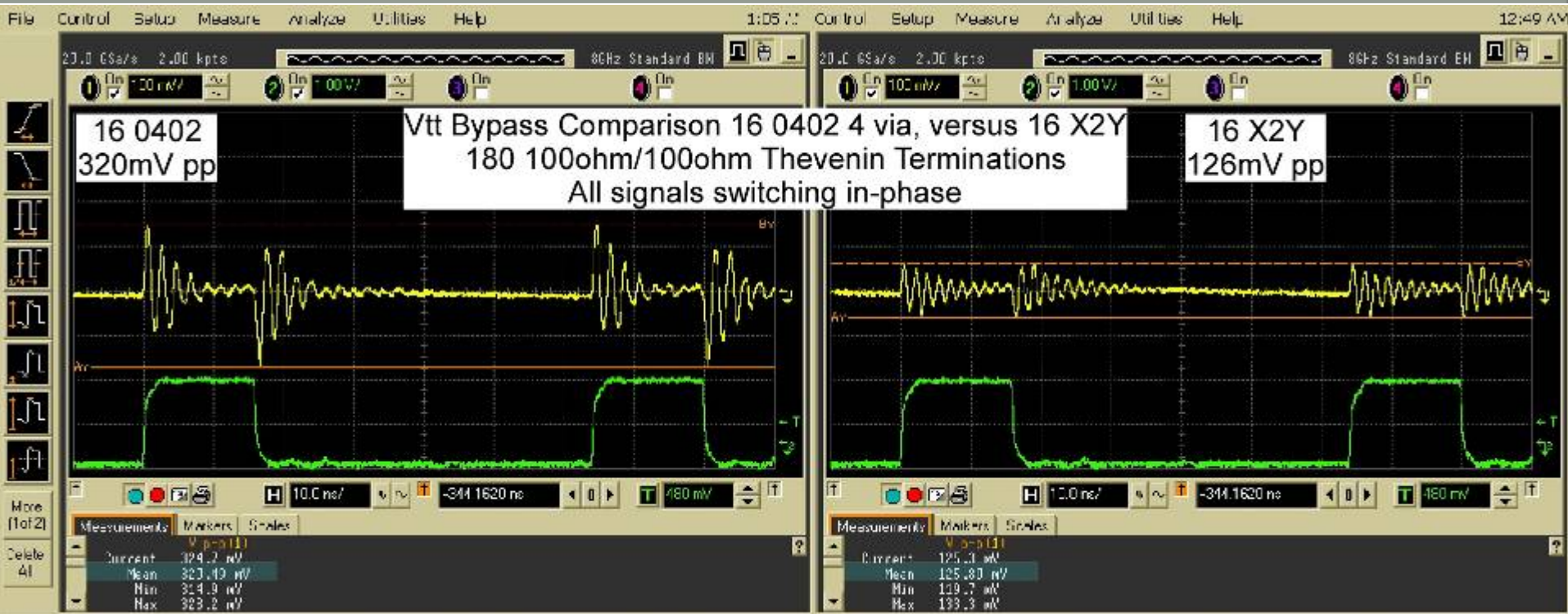
- Comparison of:
 - 16 ea. X2Y 0603 versus
 - 16 ea. 0402 4 via mount caps
- 180 signal bank Thevenin terminations
 - 100 ohm resistor signal to VCC_IO
 - 100 ohm resistor signal to Vss
- Planes
 - 2 sets Vss/VCC_IO/Vss
 - Dielectric 4mils
 - Equivalent to 1mil plane pair



45 PU/PD
Resistors pairs / column
4 columns total
Front and Back PWB



Vtt Bypass



- X2Y® capacitors reduce Vtt noise over 60% versus like number of conventional 0402 capacitors w/ 4 via attachments

16 X2Y w/ 96 vias total deliver:

- Just 36% the noise of 16 0402 caps even when 0402s use 4 aggressively mounted vias
 - Improved IC Power Delivery
 - Improved Vtt Power Delivery
- Less noise than 48 0402 caps using 192 vias
- **Matched noise of 58 0402 caps using 232 vias**
 - **3.6:1 Capacitor Ratio**
 - **2.4:1 Via Ratio**

X2Y® vs 0402 Replacement Ratios

X2Y Capacitors

- Replace ***aggressively mounted*** 4 via 0402 capacitors on nearby planes at 3.6:1.
 - Vias at 2.4:1, a nearly 60% reduction!
- Replaces ***aggressively mounted*** 2 via 0402 capacitors on nearby planes at approx. 4.5:1.
 - Vias at 1.5:1, a 33% reduction
- Replaces ***typically mounted*** 2 via 0402 capacitors on ***many*** plane configs. at ratios ***greater*** than **5:1**

Summary X2Y® Bypass Characteristics

- X2Y capacitors vs 0402 10:1 in microstrip. But for bypass apps ratio is lower.
- In bypass apps
 - X2Y outperform conventional 3:1 or better in low performance 4 layer boards.
 - In more sophisticated boards, replacement ratios of 4.5:1 or better versus 2 via 0402s, and better than 3.5:1 versus 4 via 0402s is readily attainable
- The higher the performance supply, the greater the advantage of X2Y:
 - Massive reduction in parts count
 - Massive reduction in via count and blocked routes

Summary X2Y® Bypass Characteristics

- X2Y yield higher performance through ***near optimum use*** of vias
- X2Y capacitors uniquely scale to larger packages and larger CV without raising attached inductance
- X2Y and proper stack-up make bypass capacitor “carpet bombing” obsolete



- Visit X2Y at DesignCon booth #128
- Get your copy of our new DVD release, ***Low Inductance Capacitor Packages***
 - *Produced by Dr. Howard Johnson of [Signal Consulting Inc.](#)*

