



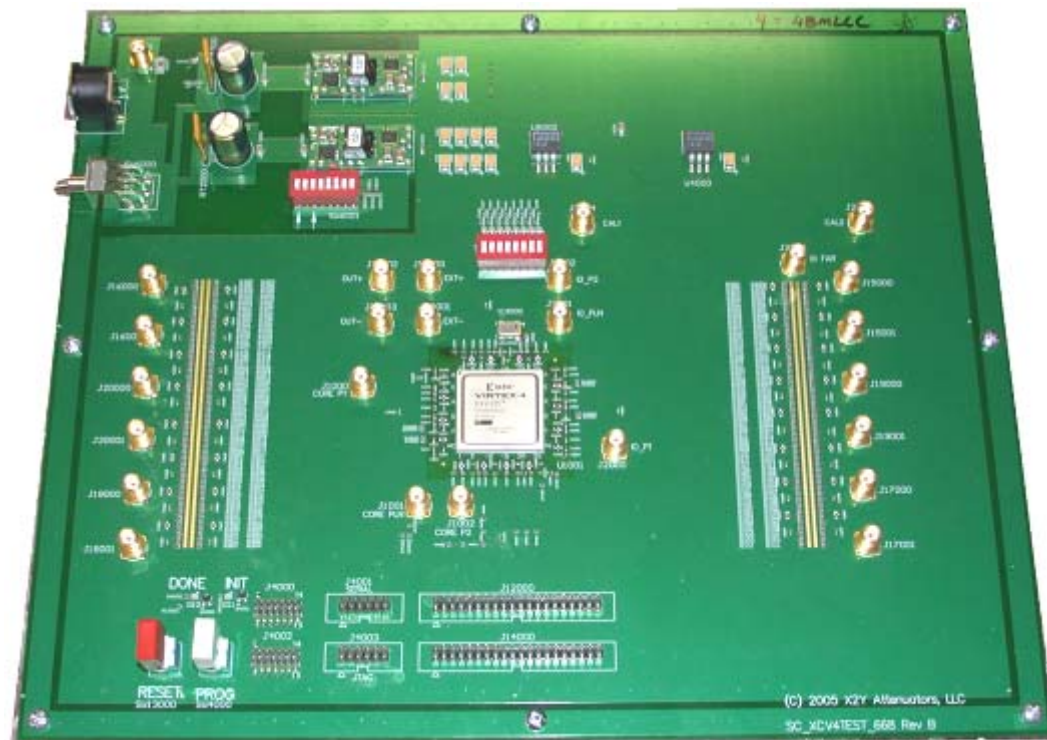
# X2Y Live FPGA Power Bypass

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

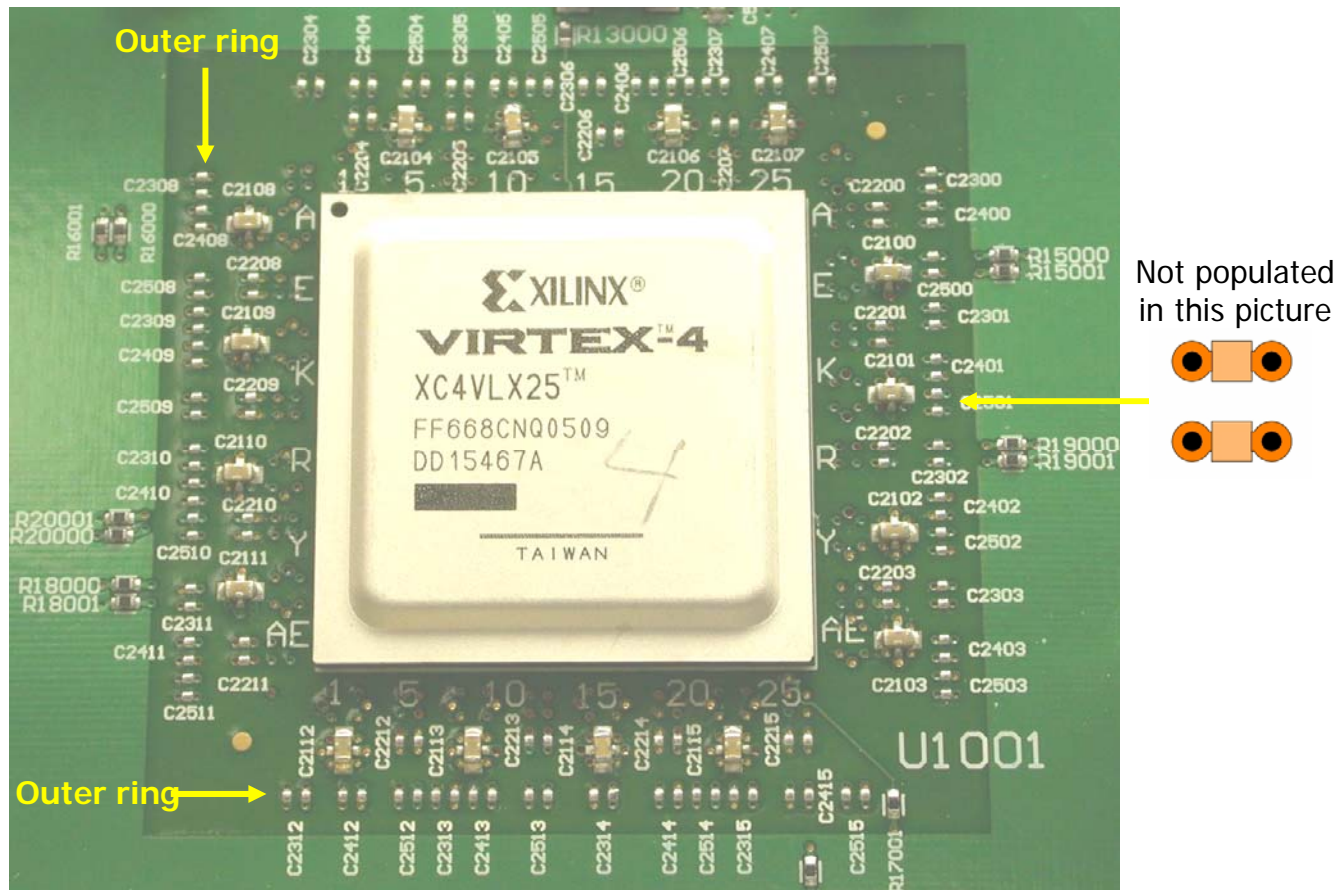
# X2Y for FPGA Power Bypass

- 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.



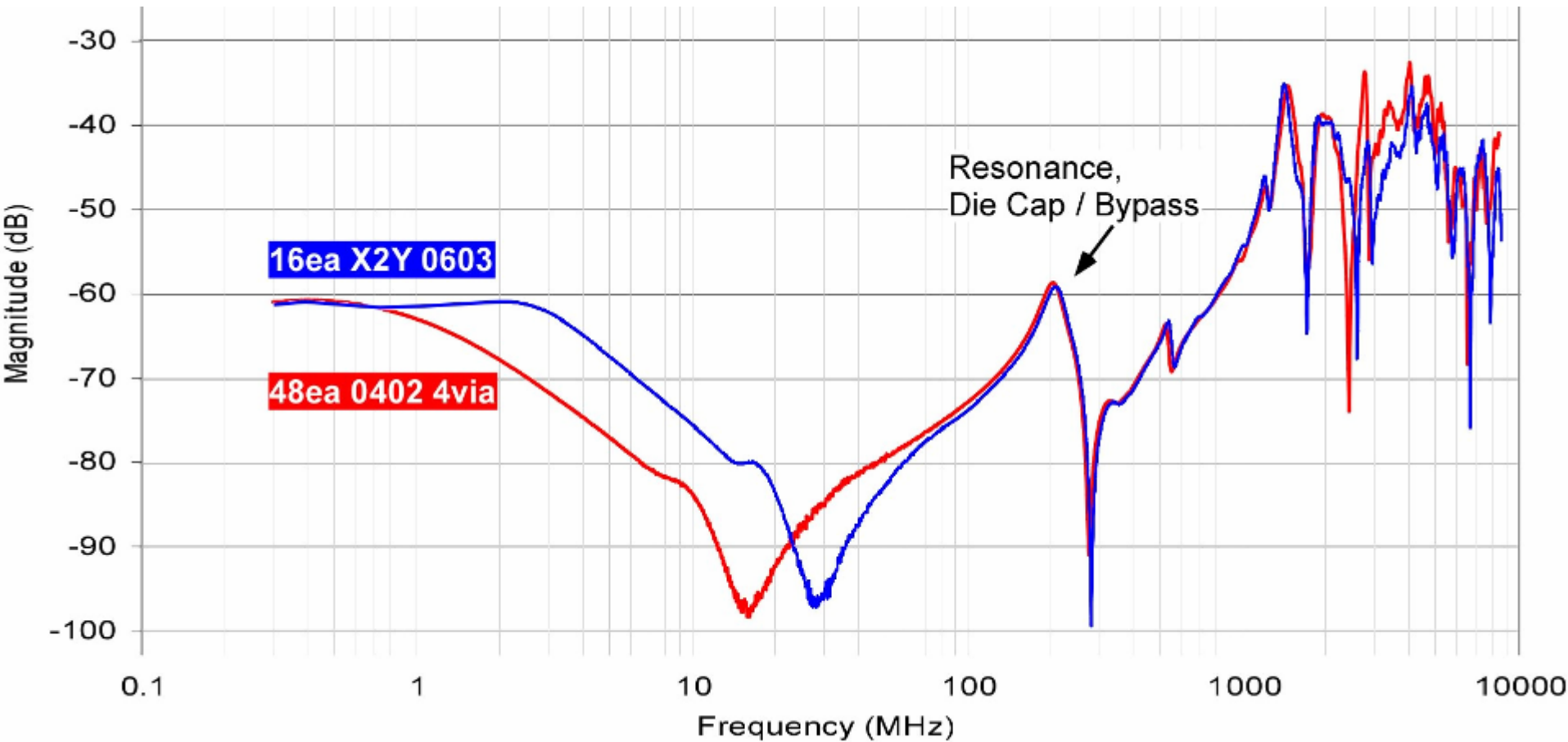
# X2Y for FPGA Power Bypass

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



# Frequency Response

## Transfer Impedance Active Test Card





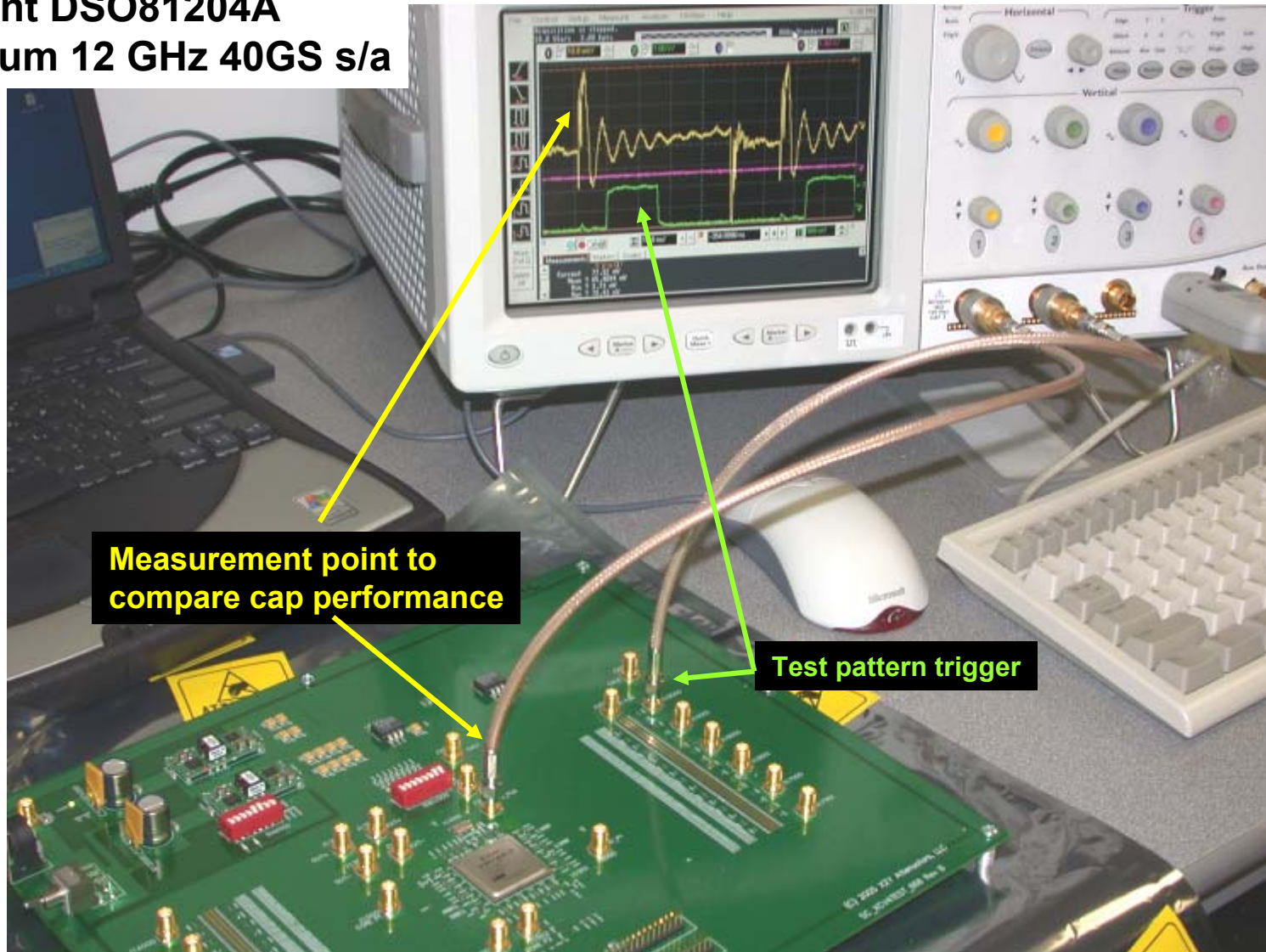
# Transient Response Tests

- 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

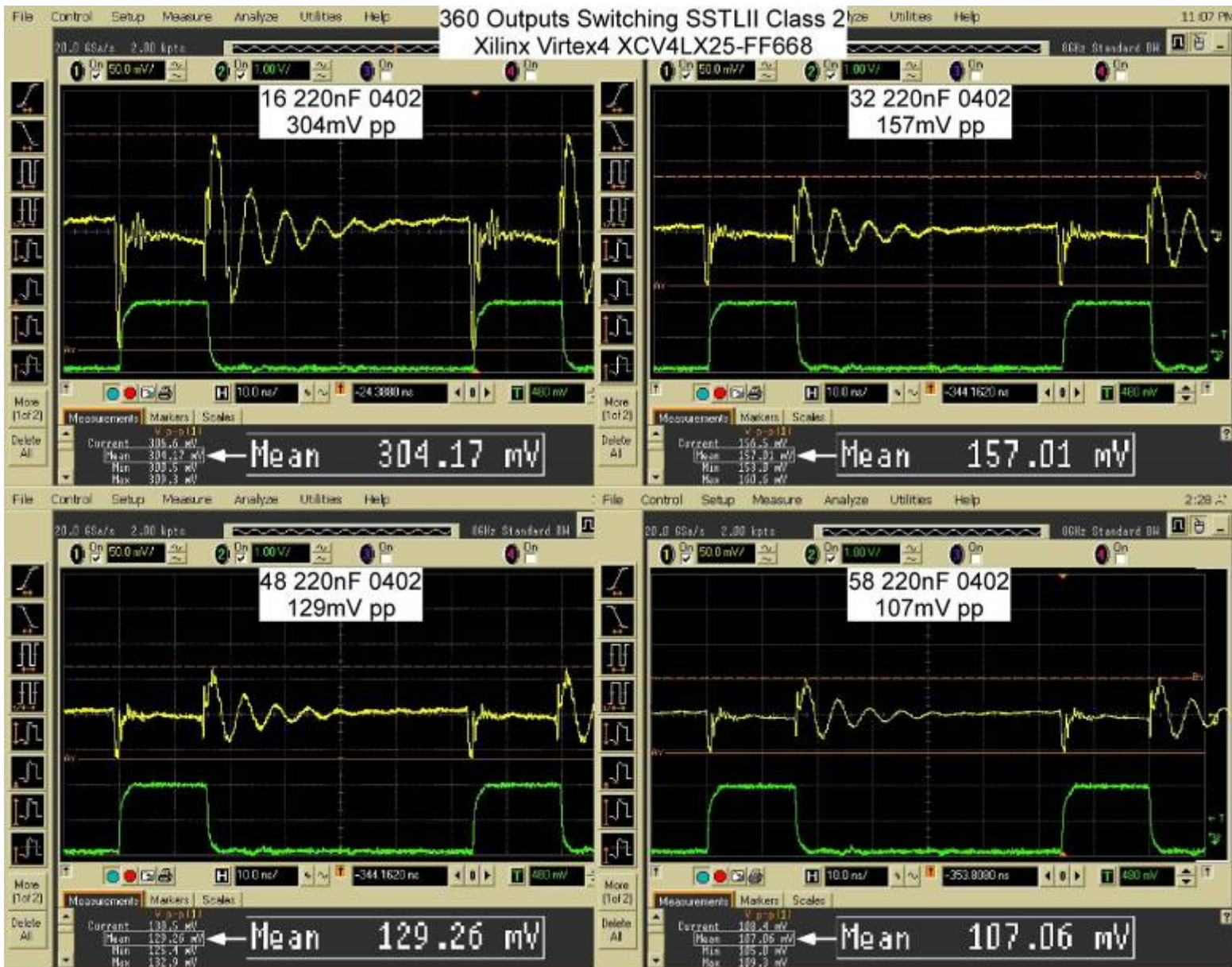
- VCCIO Outside Capacitor Ring
  - Indicates noise transferred to rest of PWB, and EMI
  - Most proportional to capacitor performance
    - Performance not compressed by plane spreading Inductance
  - Plane cavity height and perforation limits impedance to device attachment

# Measurement Setup

Agilent DSO81204A  
Infinium 12 GHz 40GS s/a

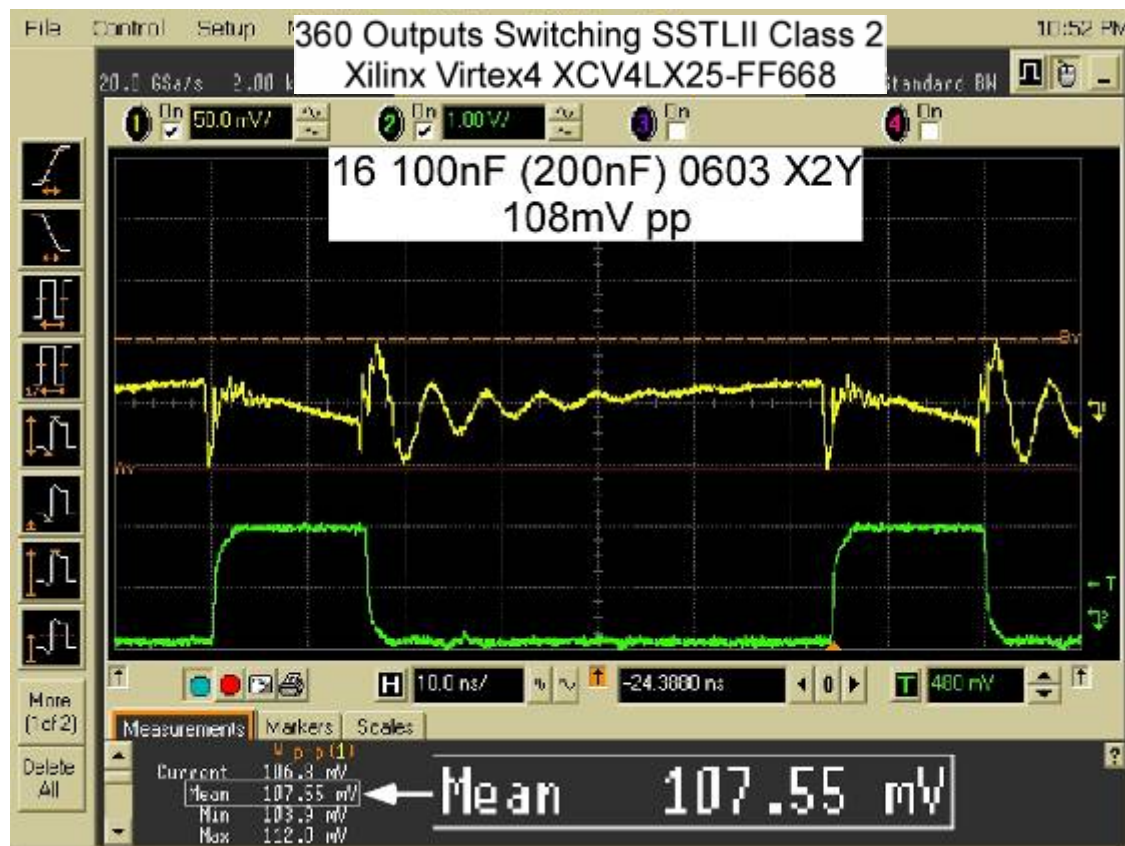


# Transient Response, Conventional 0402s



# 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

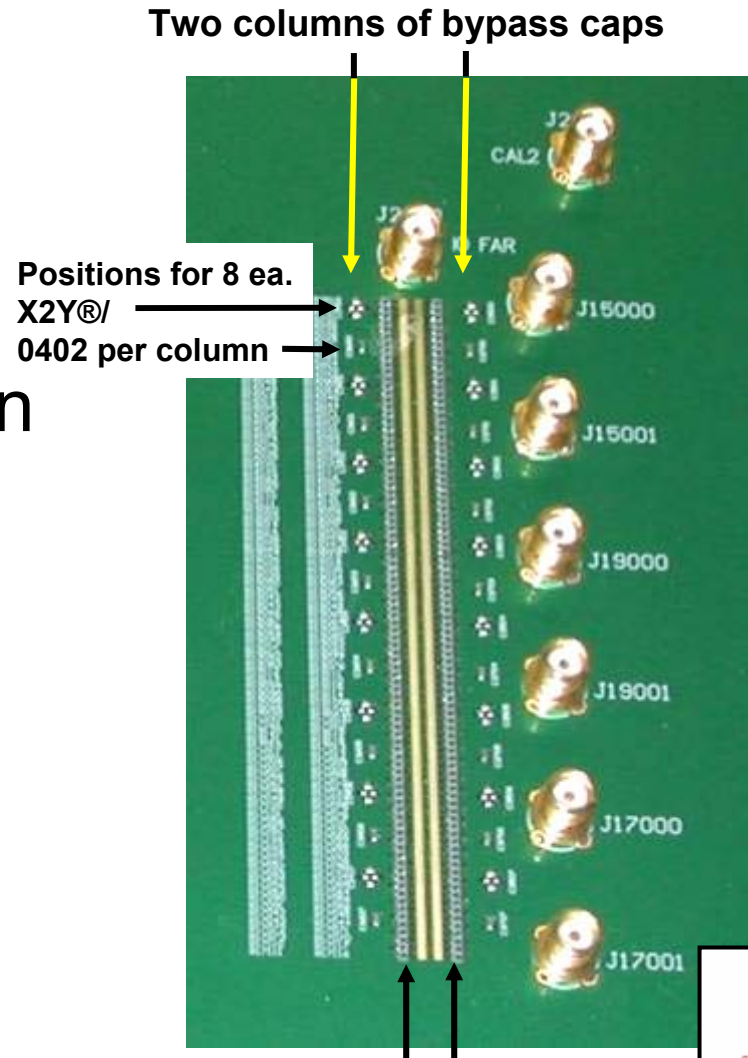


# Transient Response, Planes PRBS5

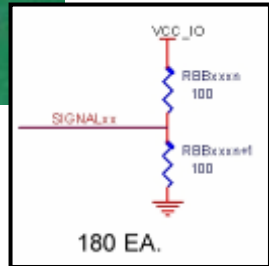


# Vtt Bypass

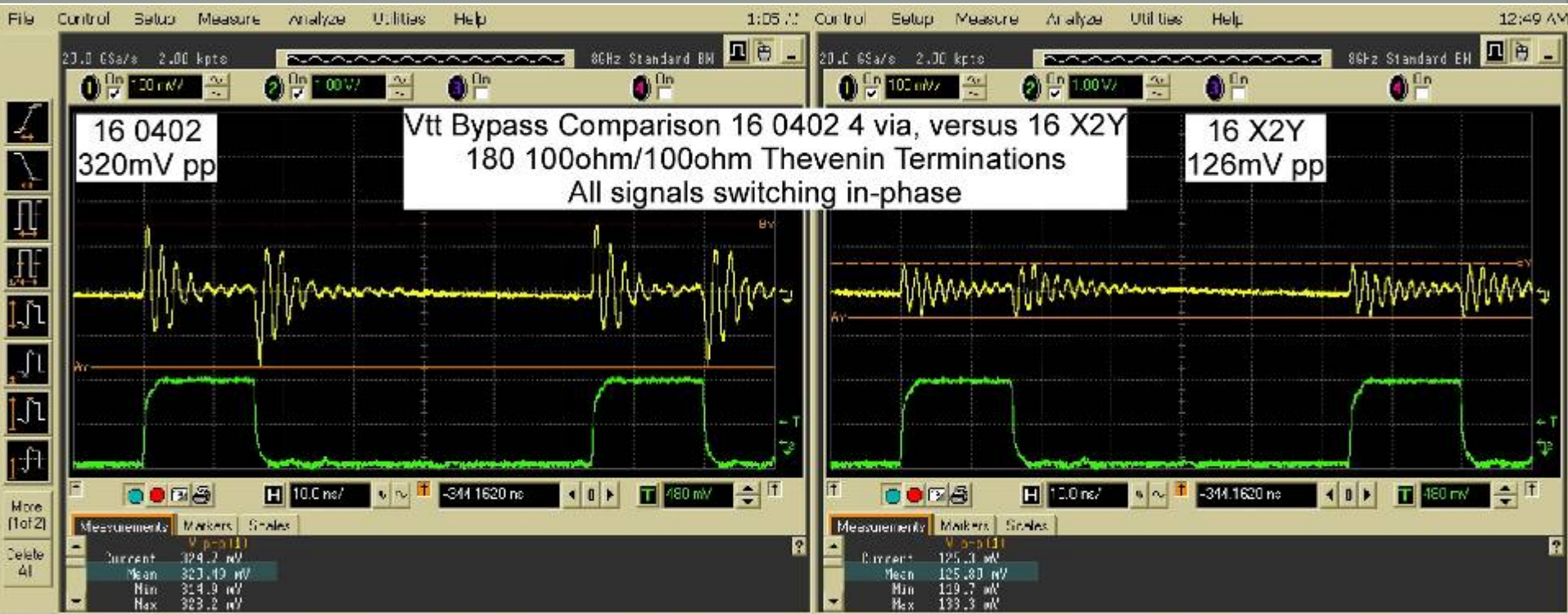
- Comparison of:
  - 16 ea. X2Y 0603 versus
  - 16 ea. 0402 4 via mount caps
- 180 signal bank Thevenin terminations
  - 100 ohm resistor signal to VCC\_IO
  - 100 ohm resistor signal to Vss
- Planes
  - 2 sets Vss/VCC\_IO/Vss
  - Dielectric 4mils
  - Equivalent to 1mil plane pair



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.](#)*

