X2Y

Technology In Balance
X2Y Live FPGA Power Bypass

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

![Diagram of FPGA chip with marked outer rings and populated vs. unpopulated capacitors](image-url)
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
Measurement Points

- 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

360 Outputs Switching SSTLII Class 2
Xilinx Virtex4 XC4VLX25-FF668

16 220nF 0402
304mV pp

32 220nF 0402
157mV pp

48 220nF 0402
129mV pp

58 220nF 0402
107mV pp

Mean 304.17 mV

Mean 157.01 mV

Mean 129.26 mV

Mean 107.06 mV
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

48 ea 220nF 0402 71mV p-p

16 ea 100nF (200nF) 0603 X2Y 64mV p-p
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
X2Y® capacitors reduce Vtt noise over 60% versus like number of conventional 0402 capacitors w/ 4 via attachments
FPGA Bypass Summary X2Y® vs 4 Via 0402s

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
The End

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.*