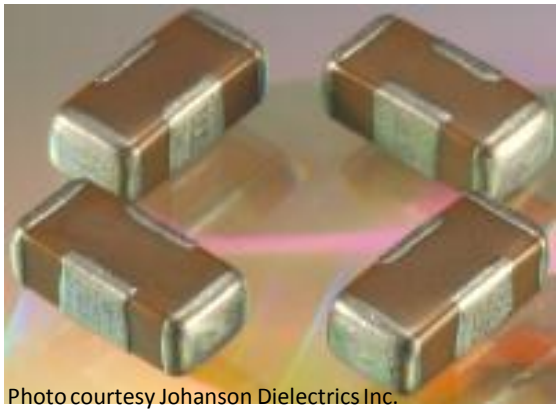


Photo courtesy Johanson Dielectrics Inc.

X2Y® FPGA SerDes Bypass

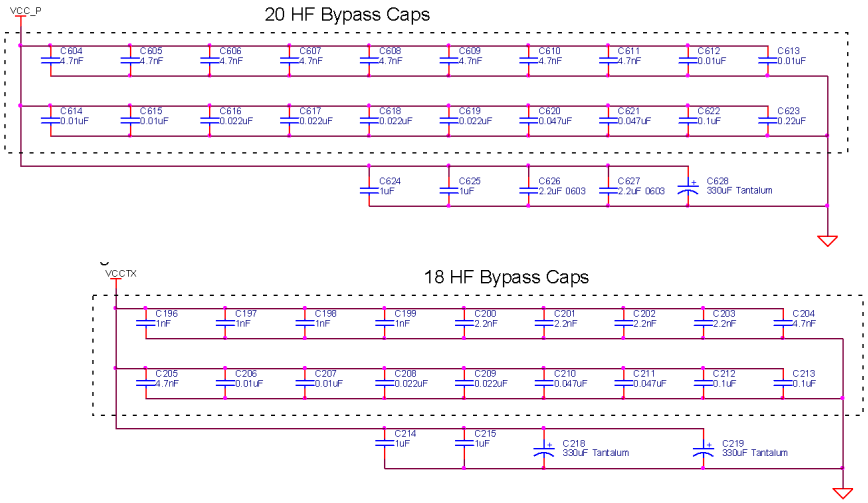
Simplified design and improved performance using X2Y® capacitors w/ Altera StratixII GX SerDes

Steve Weir, Consultant with Teraspeed® Consulting Group LLC and X2Y Attenuators, LLC, has more than 20 years of experience in the Electronics Industry, holds 17 U.S. patents and has architected a number of packet and TDM switching products. Steve has participated as a TecPanelist at several DesignCon Symposiums and authored numerous technical papers on the subject of bypass capacitor application for PDN design. Steve is a frequent contributor to the Si-List message reflector, dedicated to signal and power integrity.

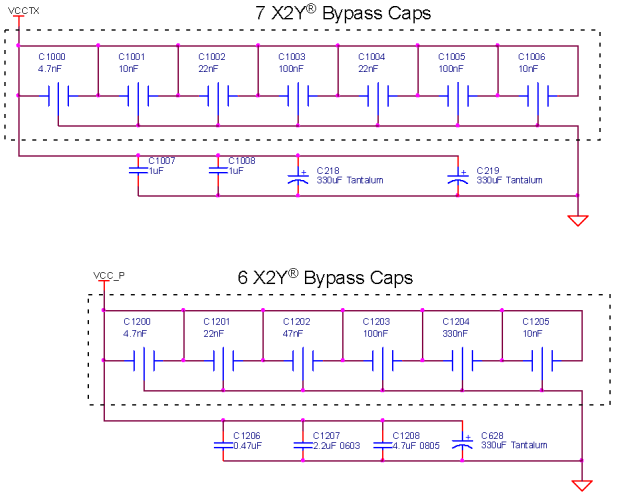
X2Y® vs. MLCC

- SERDES transmit power supplies: 13 X2Y® capacitors replace 38 0402 caps
  - X2Y bypass network engineered to match MLCC network impedance
- Plane inductance saturation for each supply is achieved w/ 2 X2Y® capacitors

MLCC Design

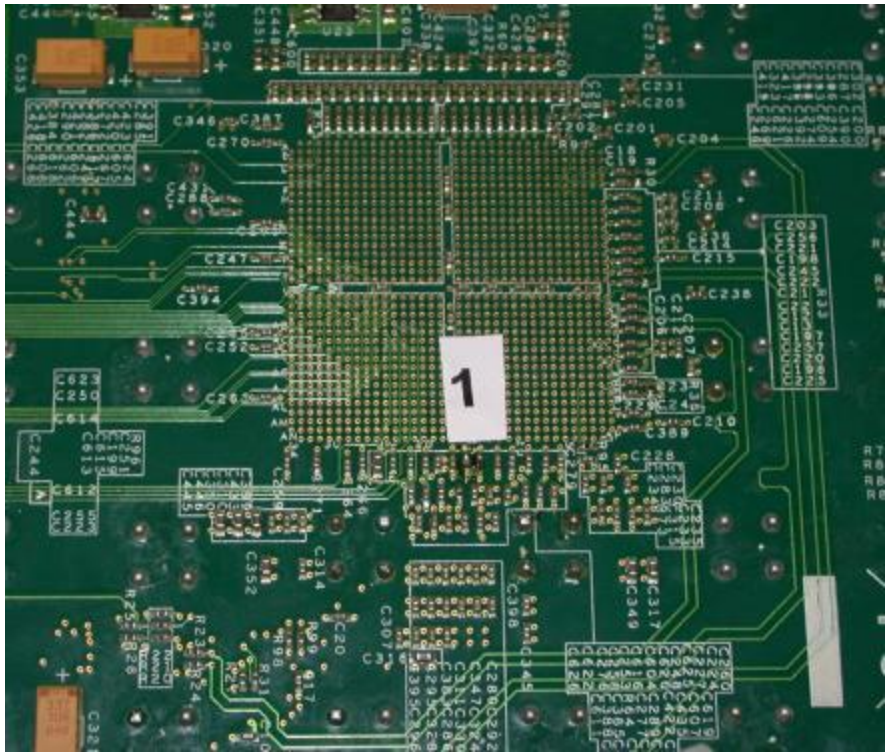


X2Y® Design

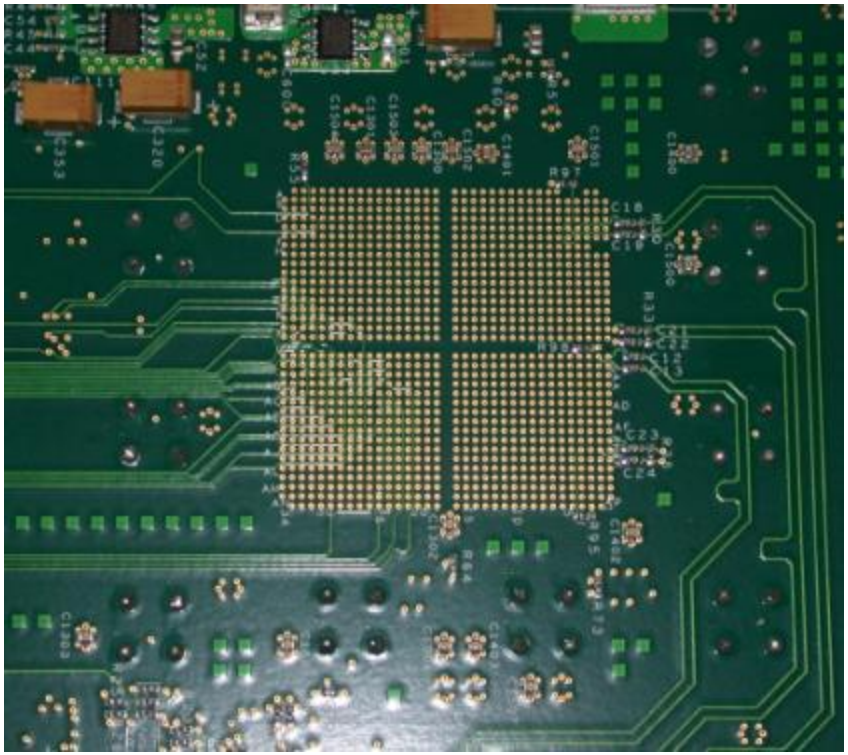


X2Y® vs. MLCC

MLCC Design

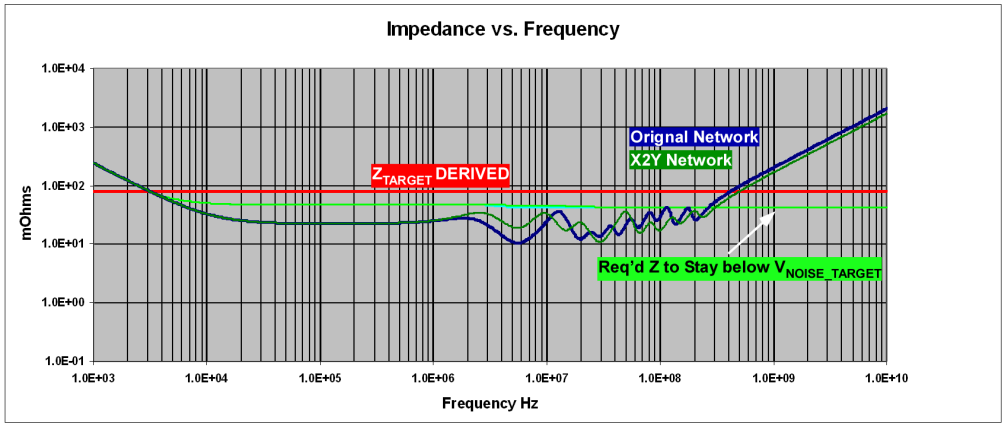


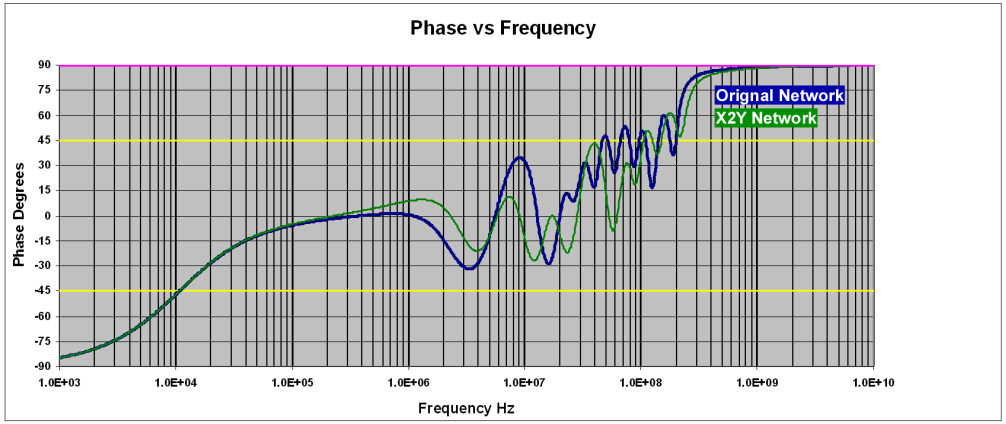
X2Y® Design



Transmit Analog: VCCH

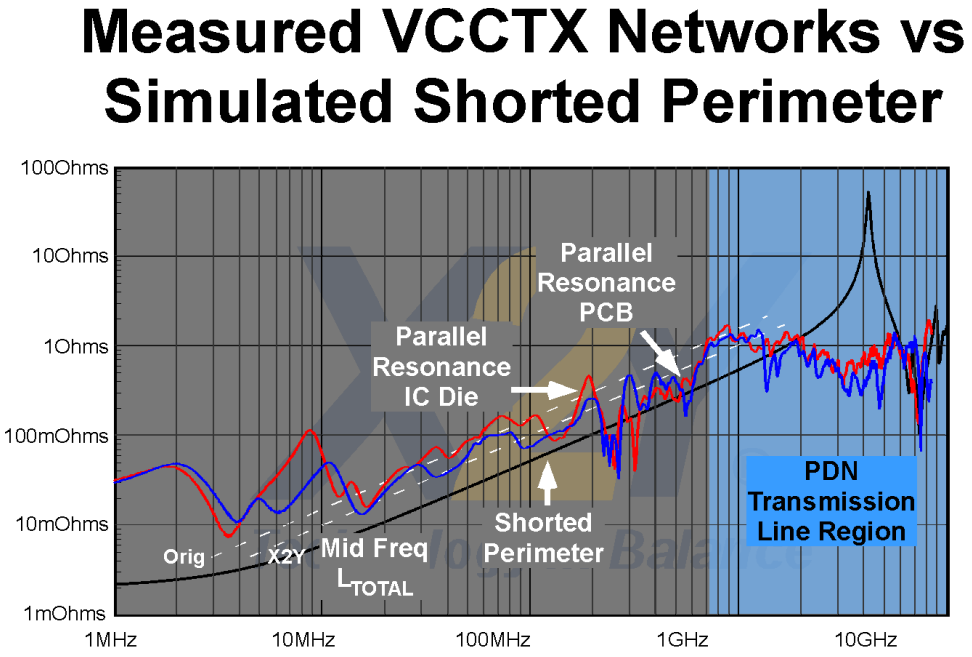
- X2Y® Design
  - 2 x 330uF tantalum caps + 2 MLCCs + 7 X2Y®
  - 1D < 80mOhms equivalent resistive to 250MHz
    - ✓ Ignores spatial effects and IC parasitics
    - ✓ Spatial effects dominate above 10MHz





Original VCCTX and X2Y® Networks

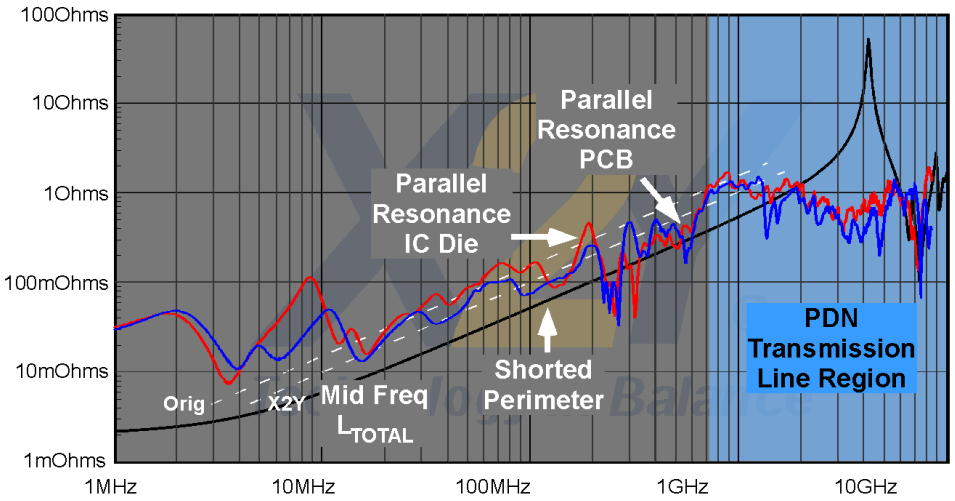
- Original network, FDTIM
  - L_{BYPASS} decreases with increasing freq.
  - Near 20MHz about L_{TOTAL} about 220pH
  - Die / bypass PRF near 200MHz
  - Bypass / PCB PRF near
- X2Y® network selective zeroes
  - Lower L_{BYPASS} @ 20MHz up
  - Zero for Die / bypass PRF
  - Zero for PCB / bypass PRF



VCCTX PCB / Bypass Resonance

- Original network
  - @ relatively low PRF
- X2Y® Network
  - Lower distributed L of 6/7 X2Y® caps raises to 580MHz
  - Suppressed w/ single 100pF rated X2Y®
    - ✓ Good suppression w/ conventional caps difficult due to high Q
  - Measured results, PRF completely suppressed

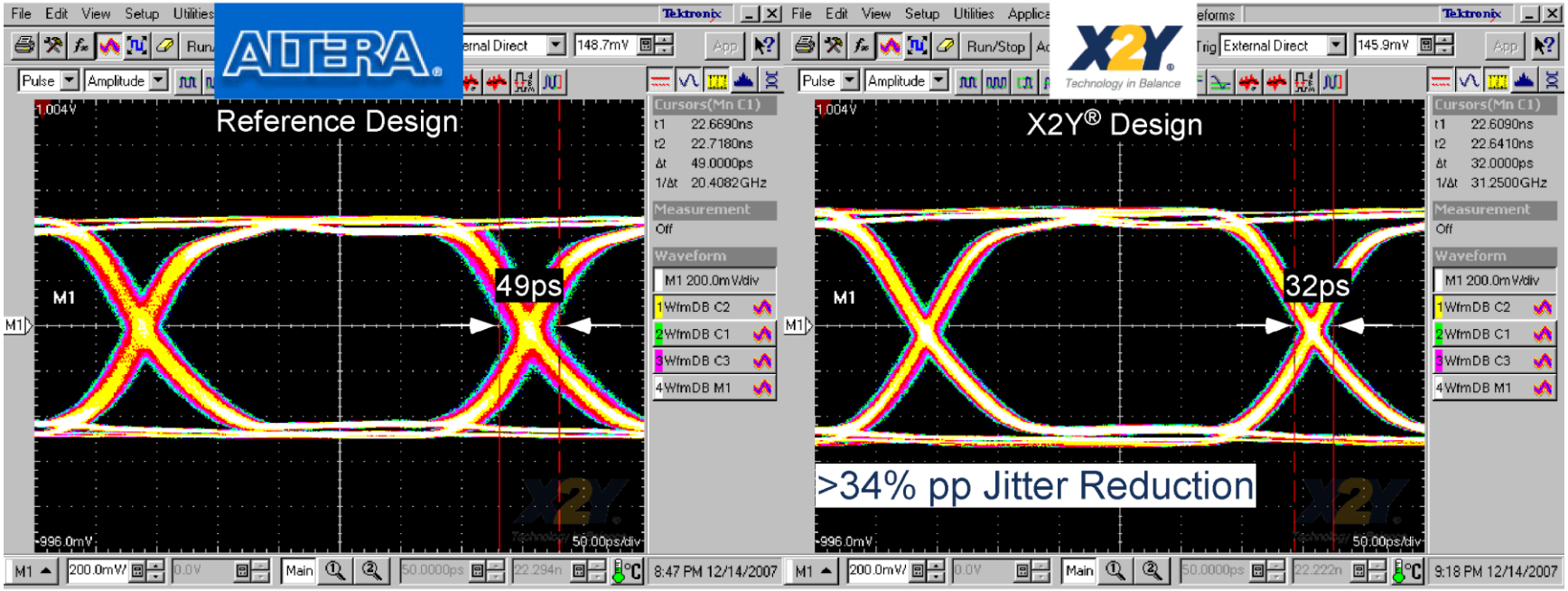
Measured VCCTX Networks vs Simulated Shorted Perimeter



3.125Gbps Performance PRBS7

- X2Y® Redues jitter to 32ps p-p jitter
  - vs 49ps in reference design

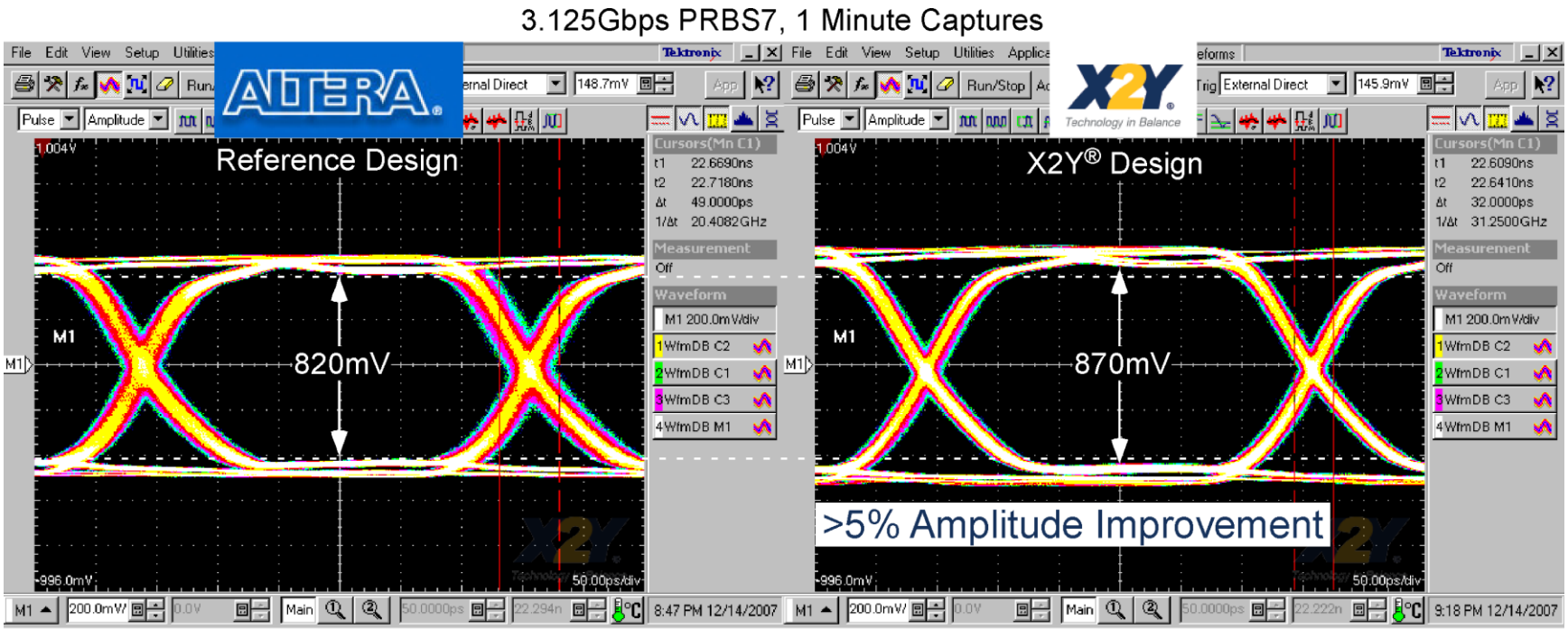
3.125Gbps PRBS7, 1 Minute Captures



Trigger Source: 156.25MHz Reference Clock

3.125Gbps Performance PRBS7

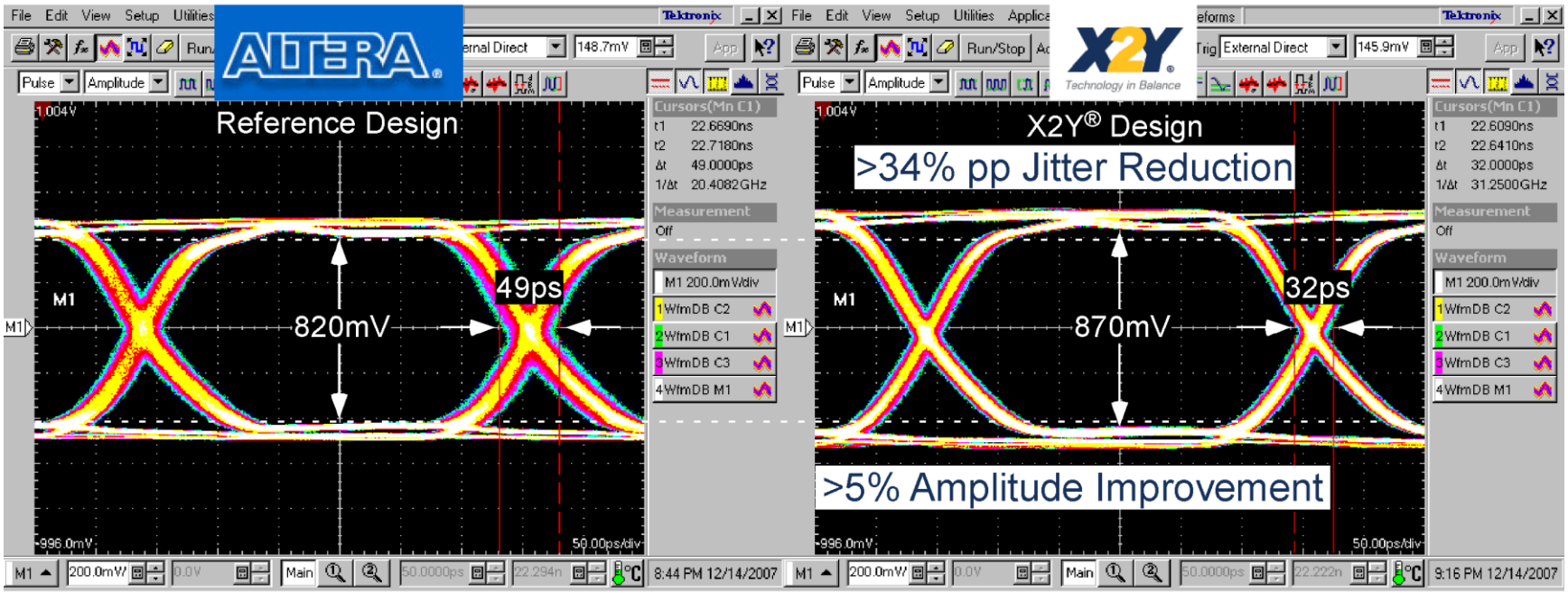
- X2Y® improves better eye amplitude >5%
  - 870mV pp @ sample point vs 820mV pp reference



3.125Gbps Performance PRBS23

- Shows same improvements in jitter and eye amplitude:
  - X2Y® 32ps p-p jitter vs 49ps in reference design
  - X2Y® 870mV pp vs 820mV pp in reference design

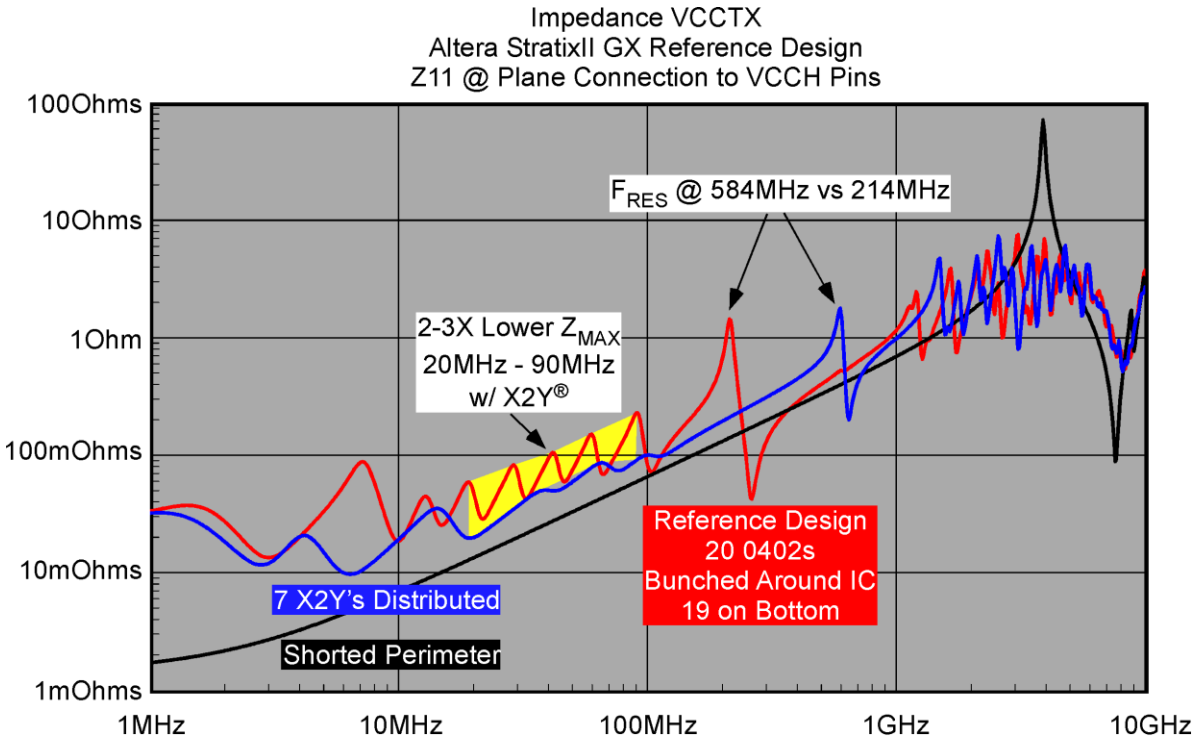
3.125Gbps PRBS23, 1 Minute Captures



Trigger Source: 156.25MHz Reference Clock

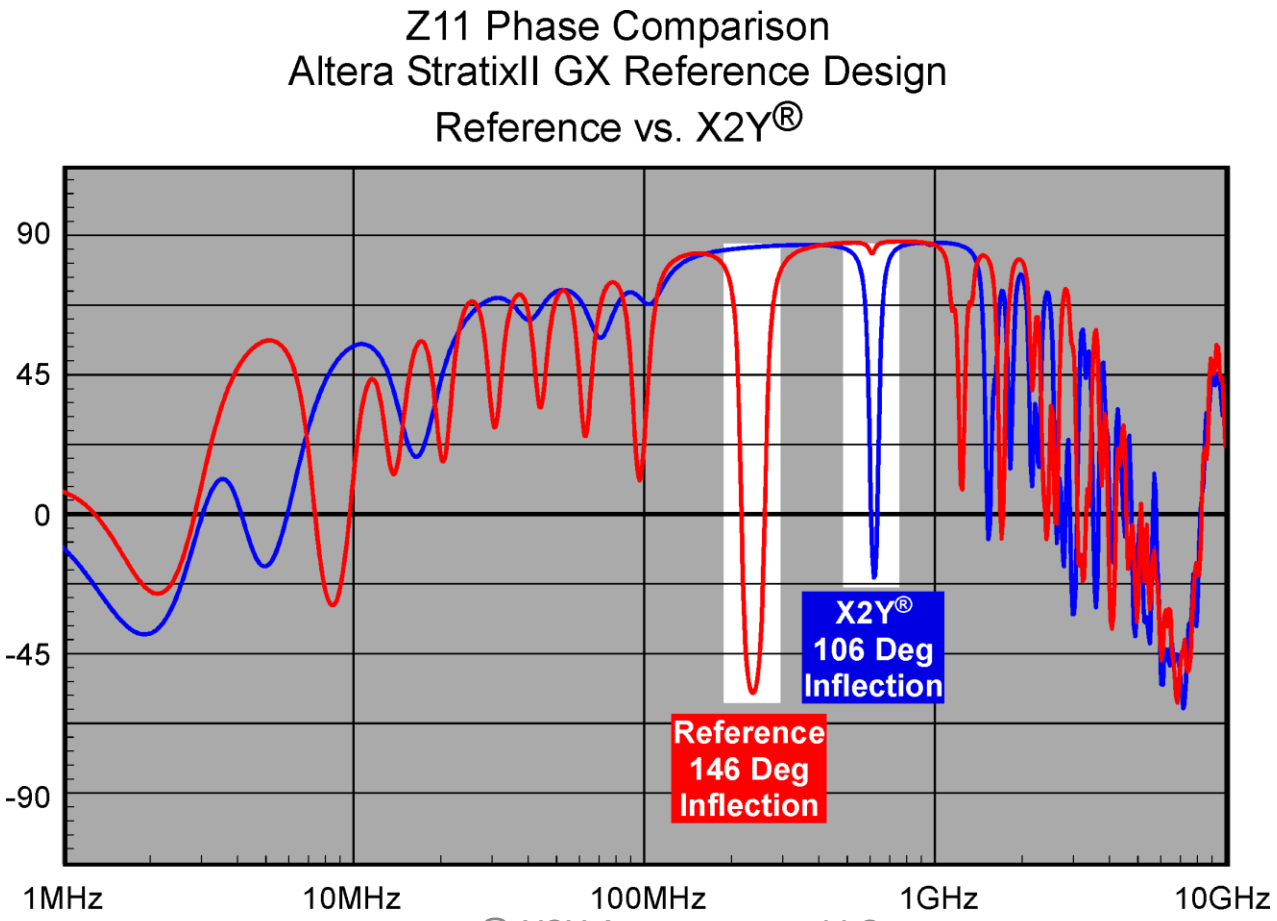
Impedance Comparisons w/o IC

- X2Y provides the following benefits:
  - 2-3X lower impedance 20MHz-100MHz w/ 7 X2Y® capacitors instead of 20 ordinary capacitors
  - >2.5:1 Higher F_{RES}
  - 2.5:1 reduction in Q



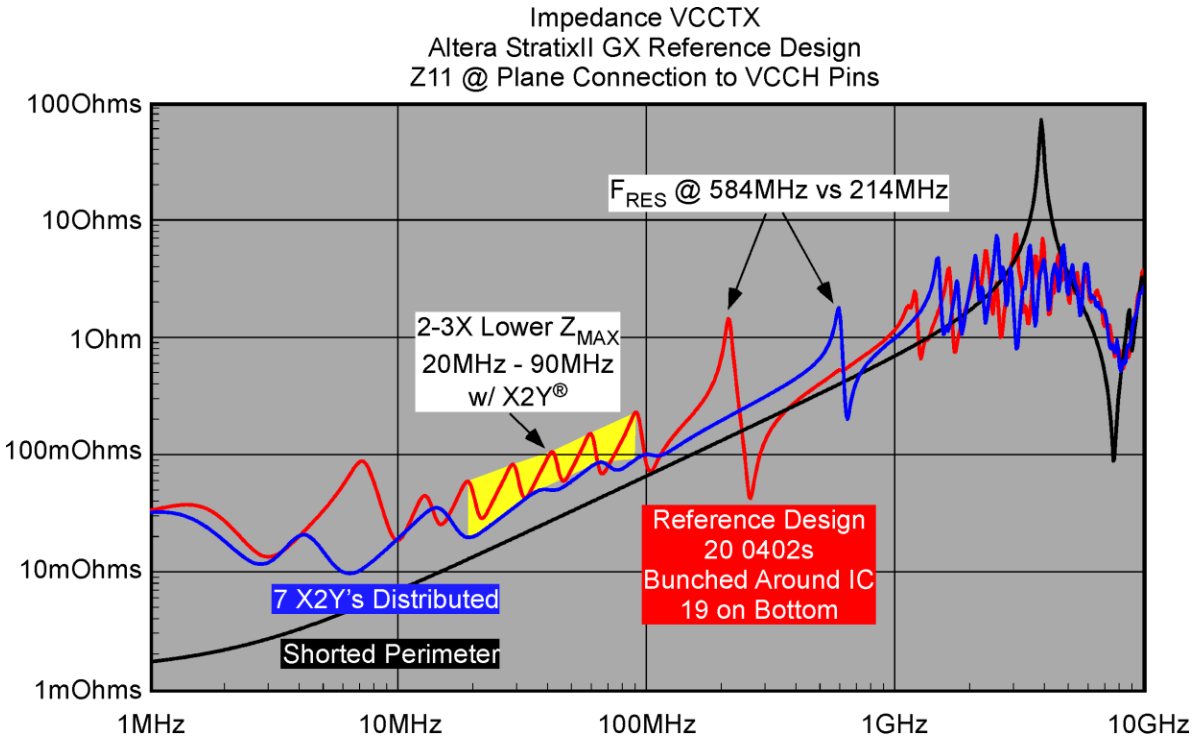
Impedance Comparisons w/o IC

- Phase inflection @ resonance much smaller, and narrower w/ X2Y® solution.



Impedance Comparisons w/o IC

- Radically lower mounted L / cap w/ X2Y® top-side solution flattens impedance modulation.
  - Remains much closer to limit of shorted planes
- Higher F_{RES} w/lower Q stabilizes power system much faster after each transient.



Summary

- Using 13-X2Y capacitors to replace 38 ordinary MLCCs in the SERDES transmit power supplies resulted in:
  - Significant improvements in jitter and eye amplitude
    - ✓Component reduction
    - ✓Less board space used
    - ✓Placement cost reduction
    - ✓More room for trace routes
    - ✓Improved reliability through fewer components

MLCC Manufacturers

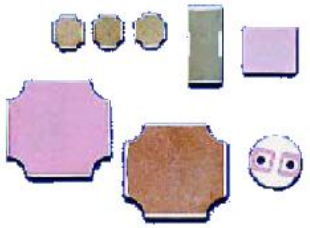
SAMSUNG

JOHANSON DIELECTRICS

YAGEO

SYFER

Through-hole and Planar Manufacturers



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