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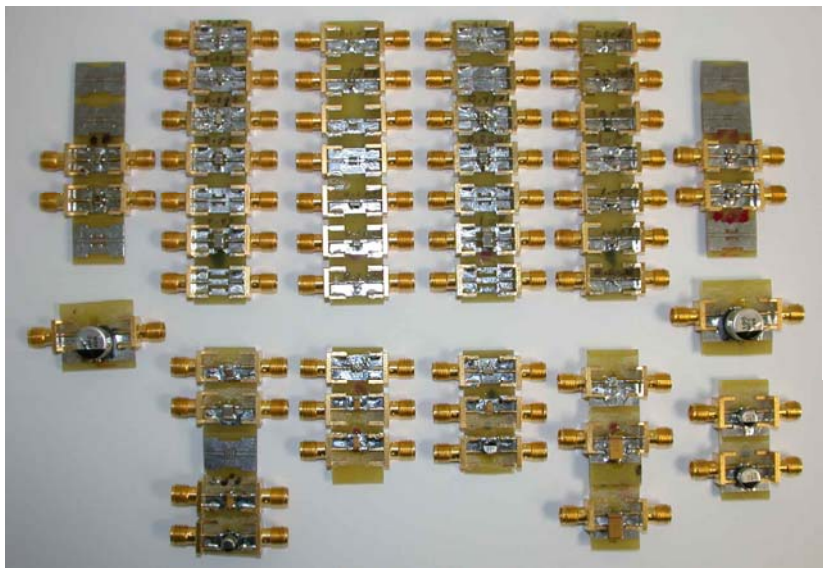
Presented by: Jim P. Muccioli

The Quantitative Measurement of the Effectiveness of Decoupling Capacitors in Controlling Switching Transients from Microprocessors

Panel Discussion on Bypass Capacitors – Are you missing the boat?

Coplanar PCB Test Fixture & DUTs

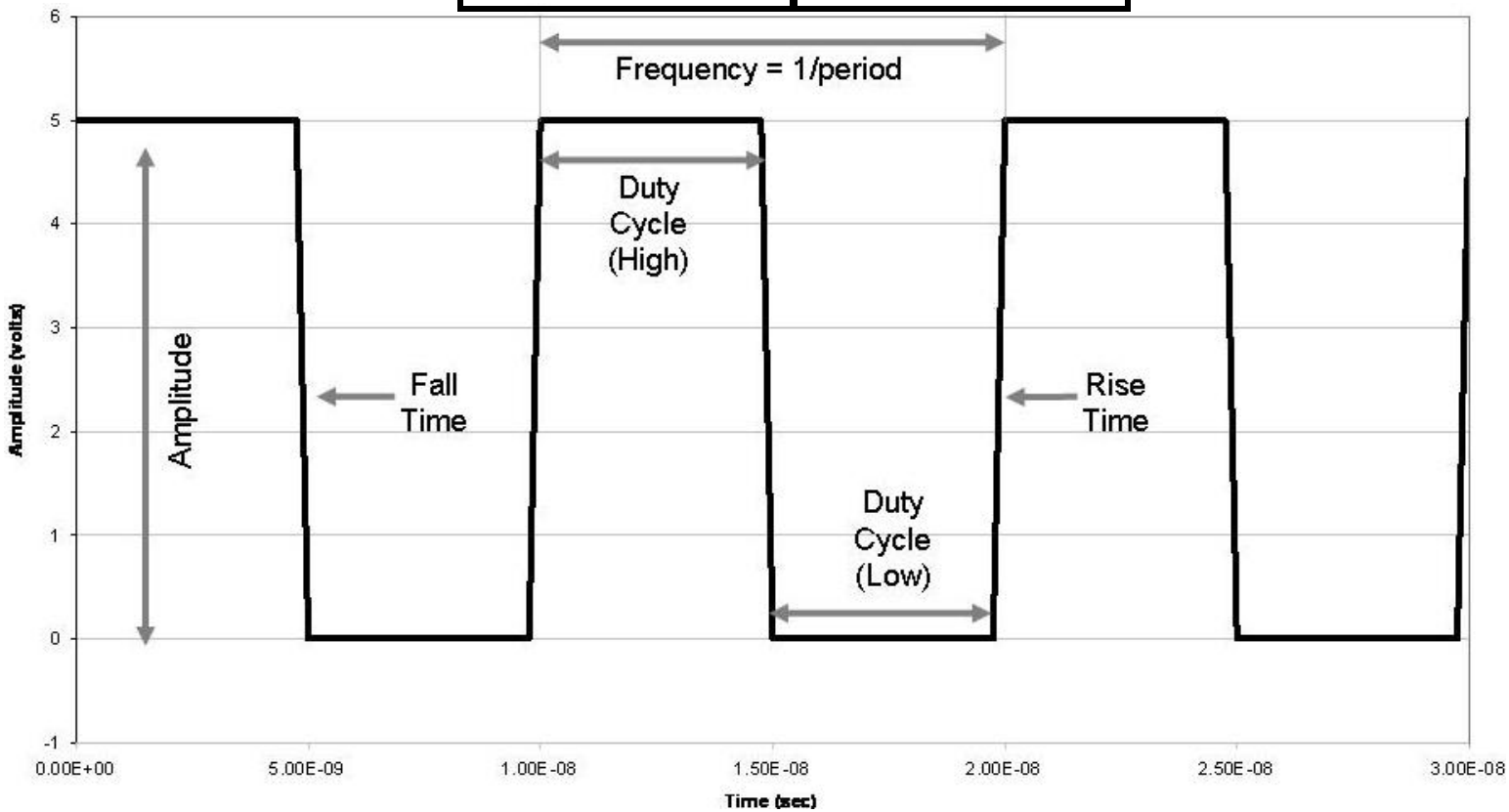
Coplanar S21 w/o DUT	
Frequency	**Insertion Loss (dB)**
300 kHz – 1 GHz	≤ 0.6dB
1 GHz – 5 GHz	≤ 4dB
5 GHz – 8.5 GHz	≤ 12.5dB



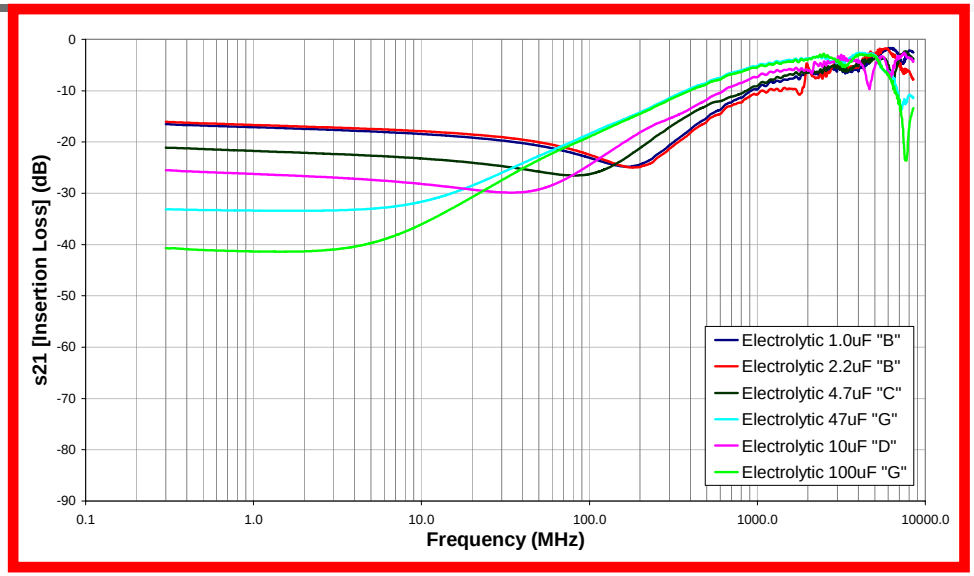
DUTs					
Type	Cap. Value (uF)		Volt. Rating (VDC)	Dielectric	Package
Aluminum electrolytic Capacitor	**1.0**		50	AL EL	B
Aluminum electrolytic Capacitor	**2.2**		50	AL EL	B
Aluminum electrolytic Capacitor	**4.7**		50	AL EL	C
Aluminum electrolytic Capacitor	**10**		50	AL EL	D
Aluminum electrolytic Capacitor	**47**		50	AL EL	G
Aluminum electrolytic Capacitor	**100**		50	AL EL	G
Tantalum Chip Capacitor	**1.0**		16	Tan	A
Tantalum Chip Capacitor	**2.2**		16	Tan	A
Tantalum Chip Capacitor	**4.7**		16	Tan	A
Tantalum Chip Capacitor	**10**		16	Tan	B
Tantalum Chip Capacitor	**47**		16	Tan	D
Tantalum Chip Capacitor	**100**		16	Tan	D
MLCC	**1.0**		10	Y5V	0603
MLCC	**2.2**		16	Y5V	0805
MLCC	**4.7**		10	Y5V	0805
MLCC	**10**		10	Y5V	1206
MLCC	**47**		6.3	X5R	1210
MLCC	**100**		6.3	X5R	1812
MLCC	**0.1**		16	X7R	0603
InterDigitated Capacitors (IDC) MLCC	**1.0**		10	Y5V	0612
InterDigitated Capacitors (IDC) MLCC	**2.2**		10	X5R	0612
Reverse Aspect Ratio, MLCC (Low-inductance)	**0.22**		10	Y5V	0306
Reverse Aspect Ratio, MLCC (Low-inductance)	**1.0**		10	X5R	0508
Reverse Aspect Ratio, MLCC (Low-inductance)	**1.0**		16	X5R	0612
	Rated	**Total**			
X2Y MLCC	0.47	**0.94**	16	X7R	1206
X2Y MLCC	0.56	**1.12**	25	X7R	1210
X2Y MLCC	0.47	**0.94**	63	X7R	1812
X2Y MLCC	0.82	**1.64**	10	X7R	1206
X2Y MLCC	0.82	**1.64**	16	X7R	1210
X2Y MLCC	1.0	**2.0**	25	X7R	1812
X2Y MLCC	5.0	**10**	10	Y5V	1210
X2Y MLCC	6.5	**13**	16	Y5V	1210

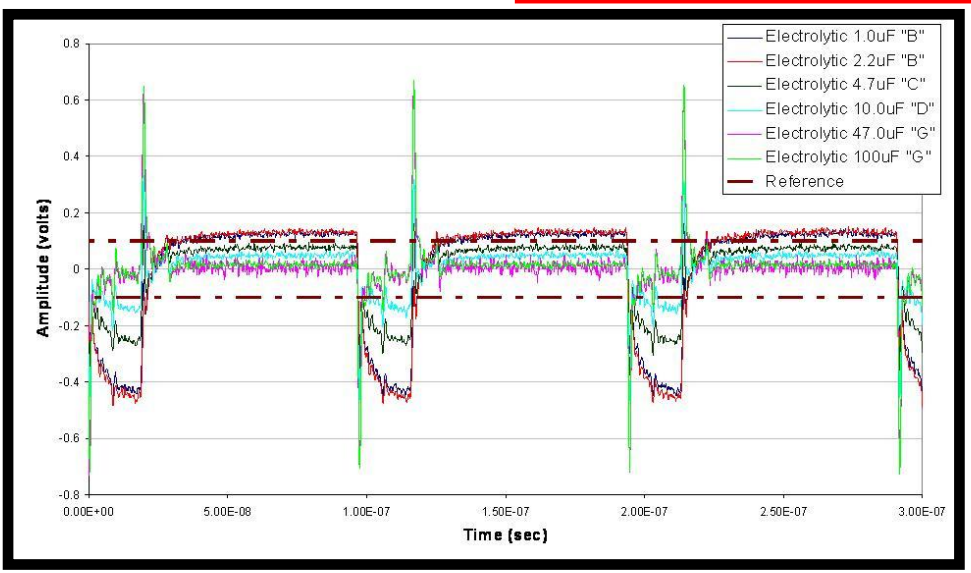
Time-Domain Experiment Set-up & Input Waveforms

Duty Cycle	Frequency
➢ 50/50 ➢ 80/20	➢ 100 kHz ➢ 1 MHz ➢ 10 MHz
Rise/Fall time	**Amplitude**
➢ 1 ns ➢ 5 ns	➢ 5 V ➢ 2.2 V

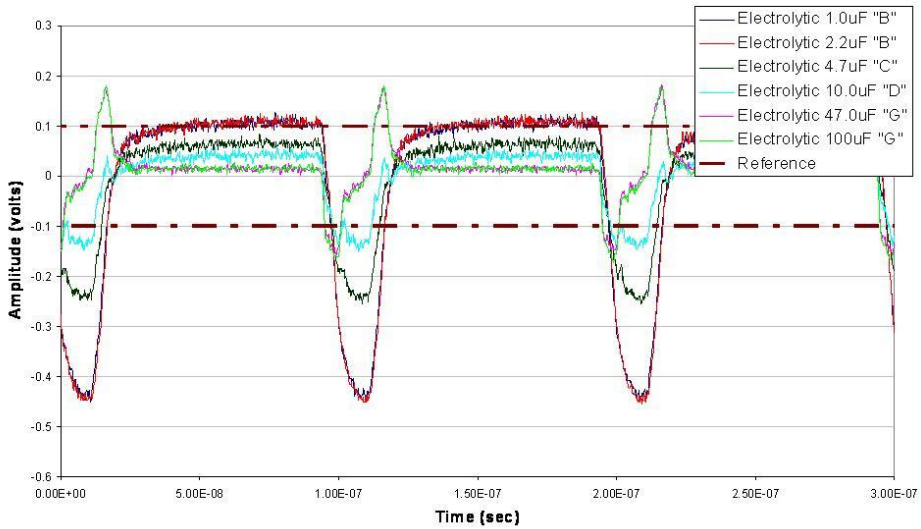


Electrolytic Capacitors



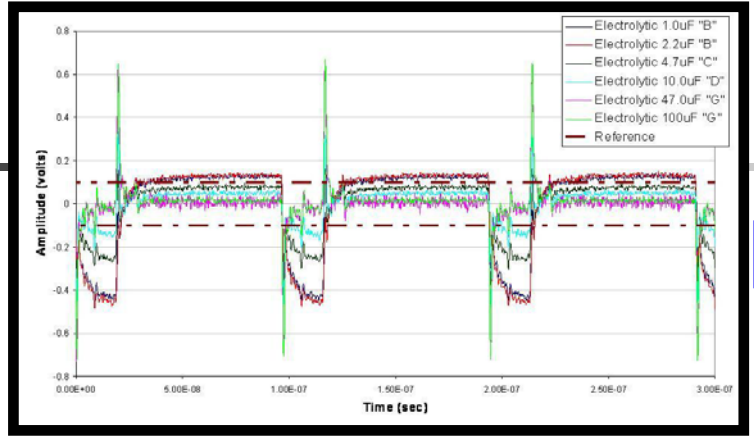


80/20 Duty Cycle



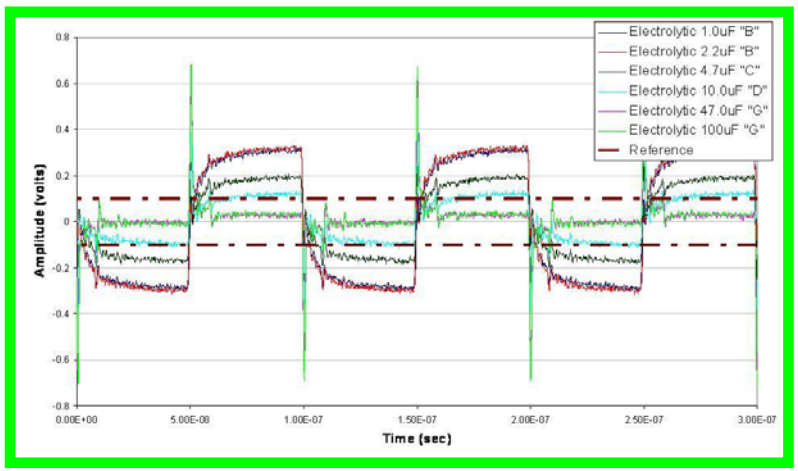
5ns rise/fall time

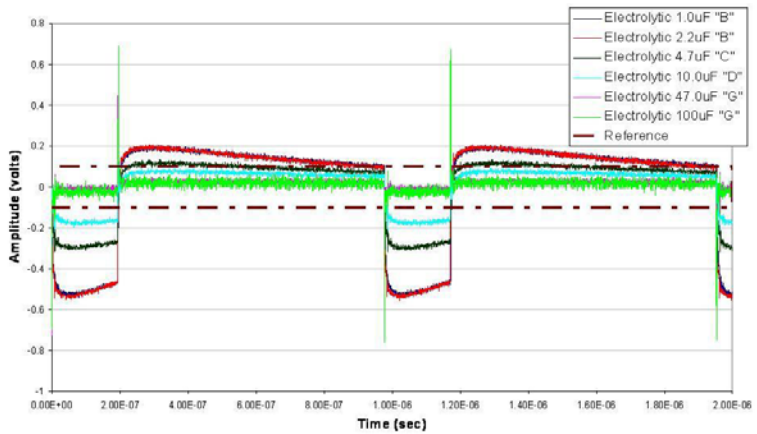
Electrolytic Capacitors



Reference - 80/20 Duty Cycle

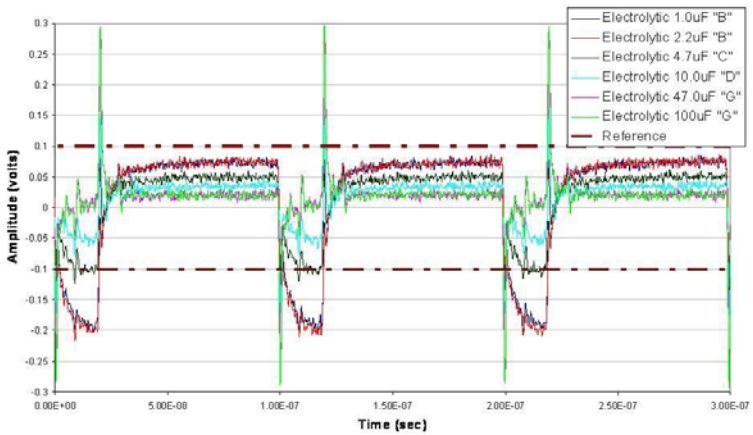
50/50 Duty Cycle

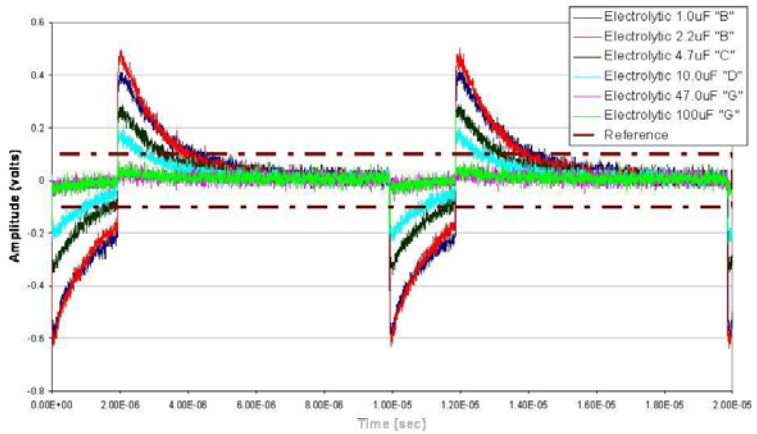




1 MHz

2.2 V Amplitude

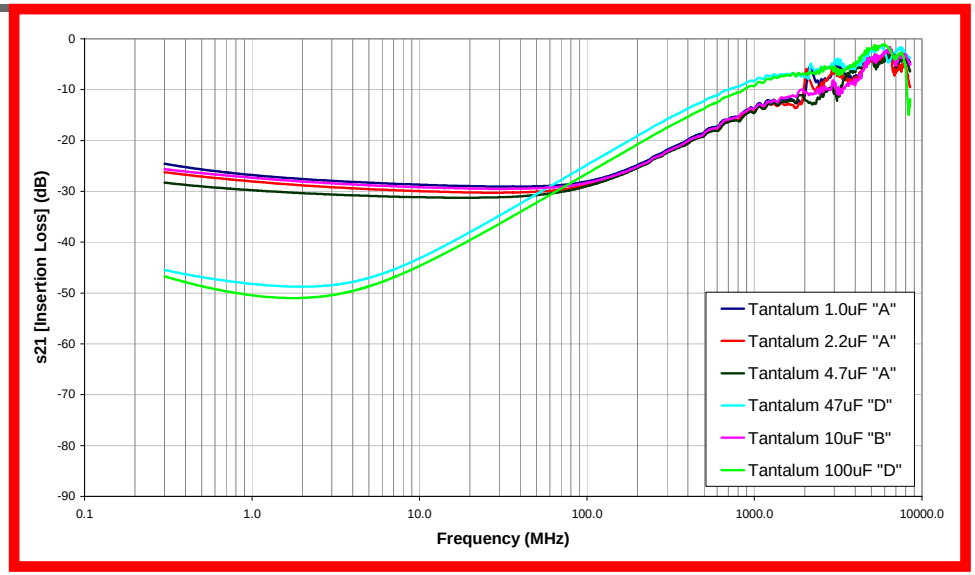


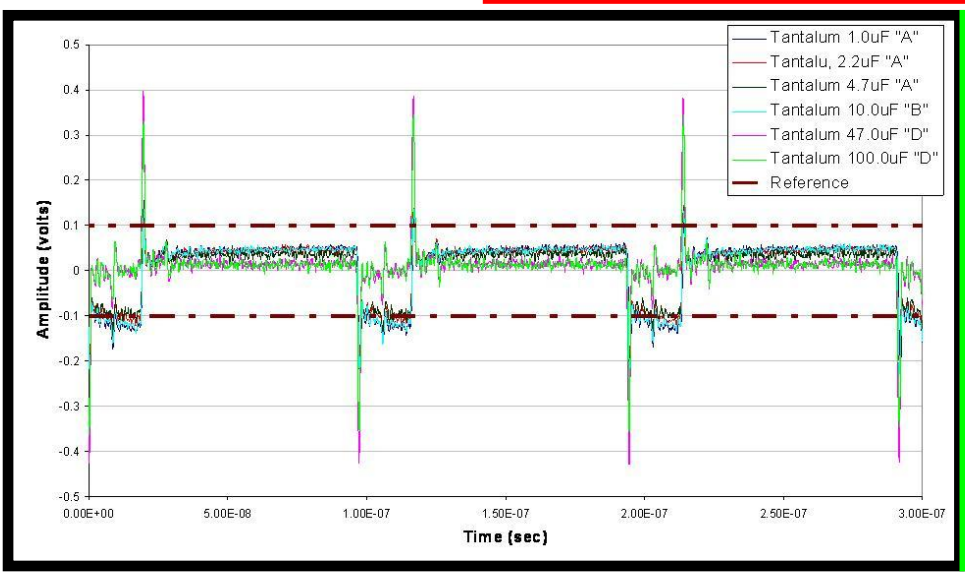


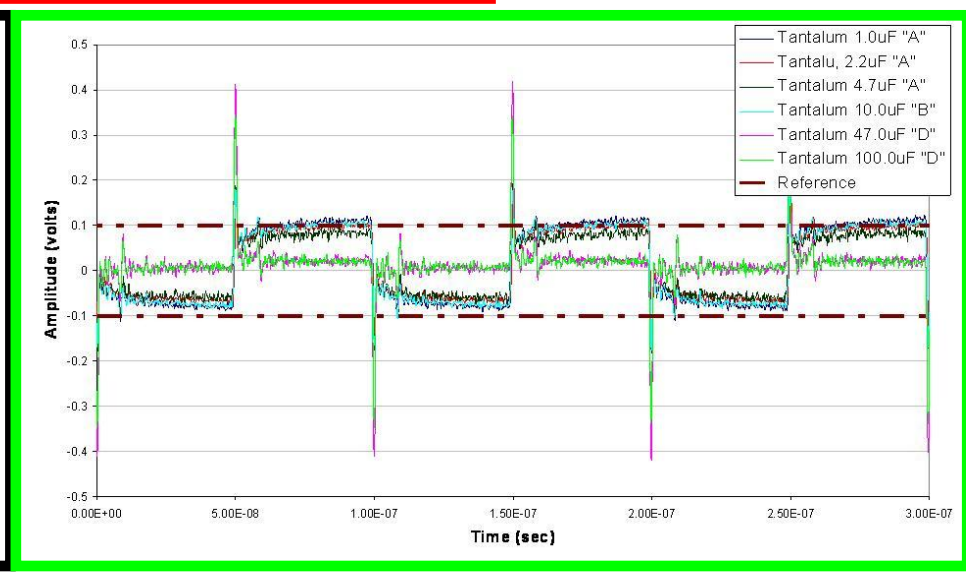
100 KHz *

*Note 5ns rise/fall time – equipment limitations

Tantalum Capacitors



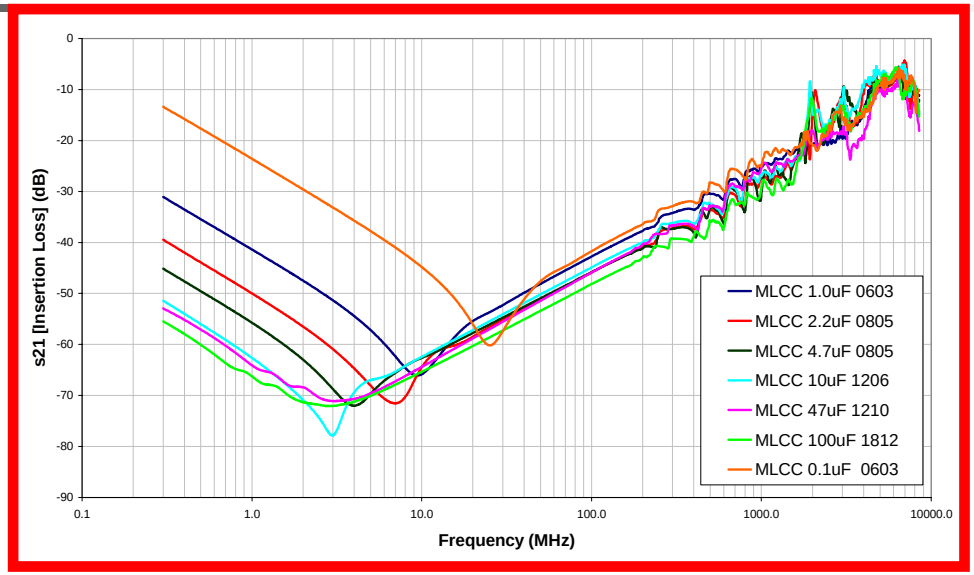


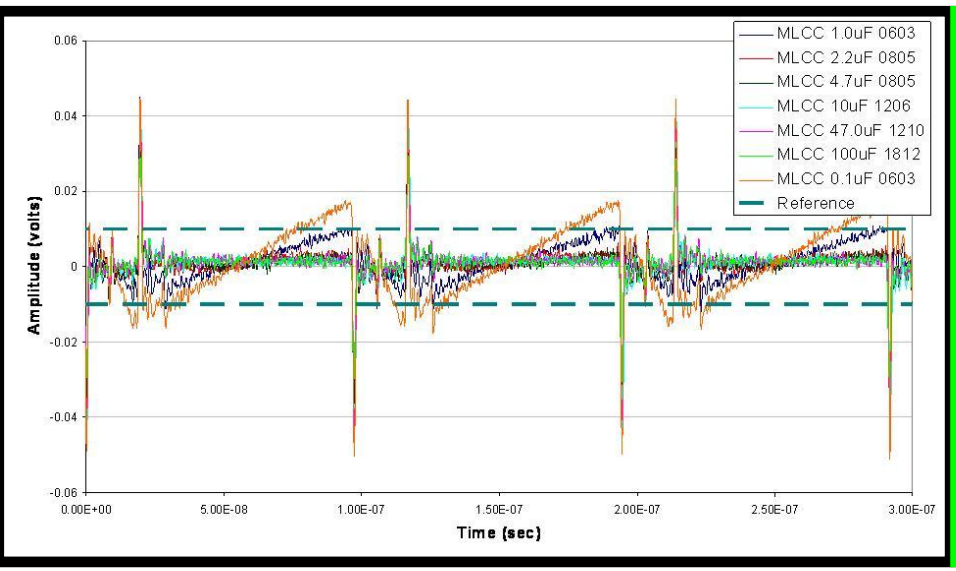


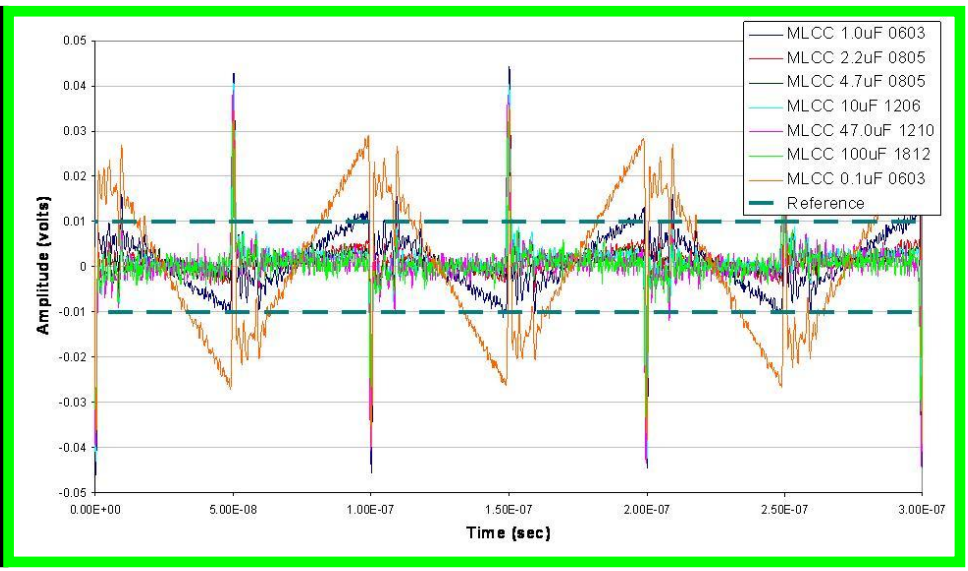
80/20 Duty Cycle

50/50 Duty Cycle

Standard MLCC



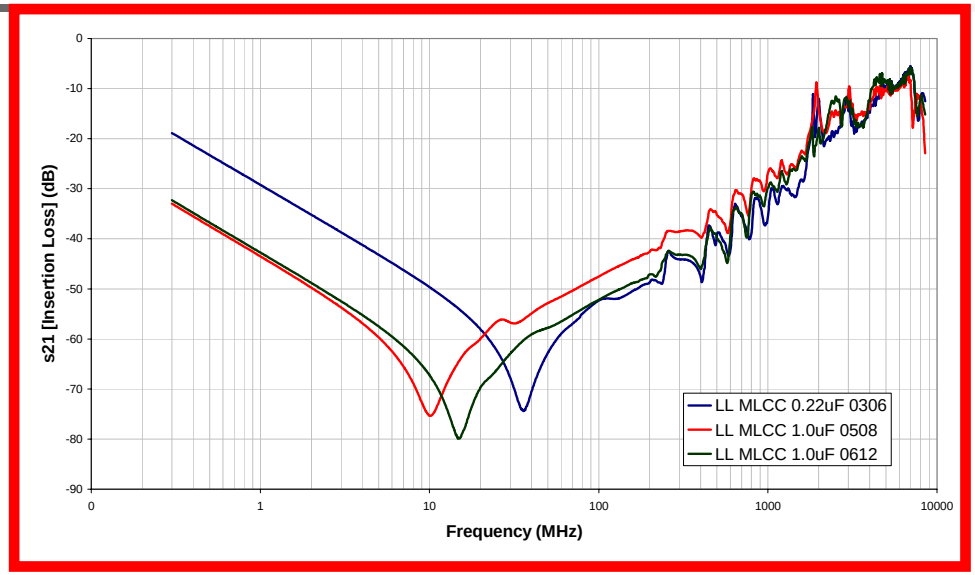


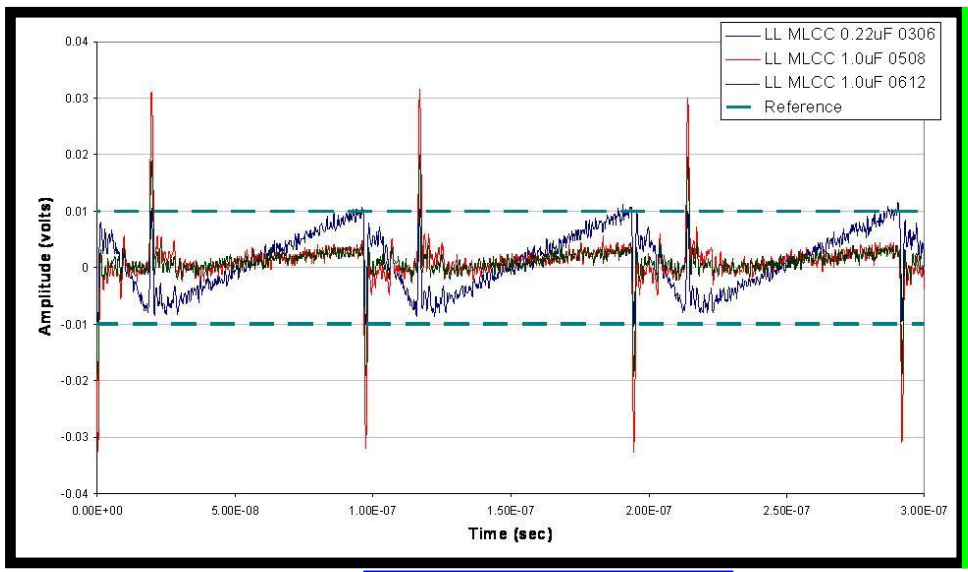


80/20 Duty Cycle

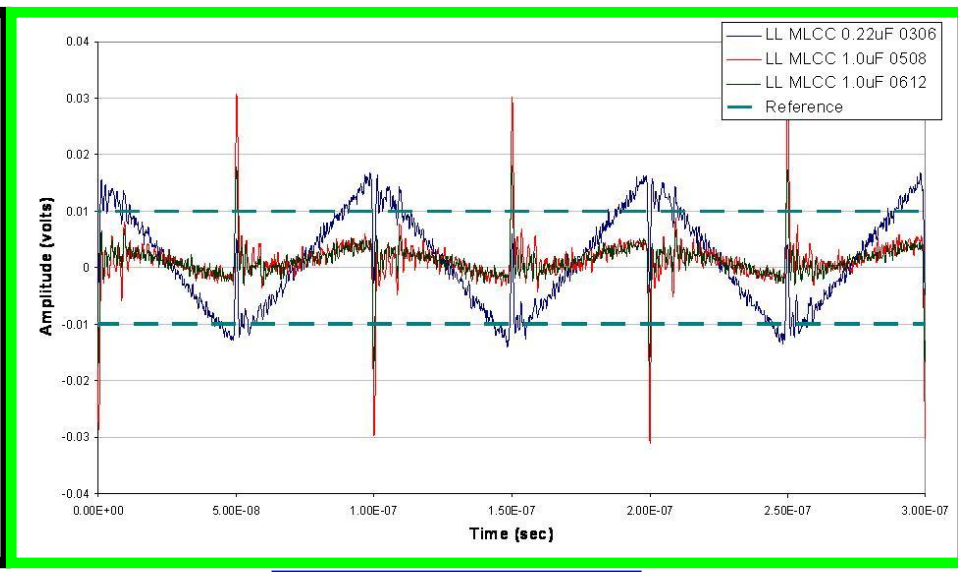
50/50 Duty Cycle

Reverse-Aspect-Ratio (Low-Inductance [LL]) MLCC



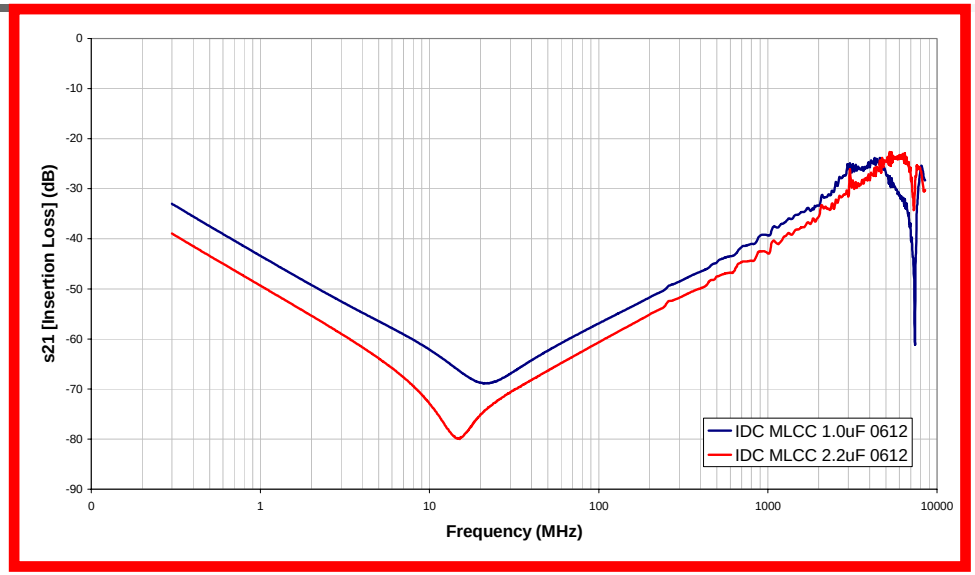


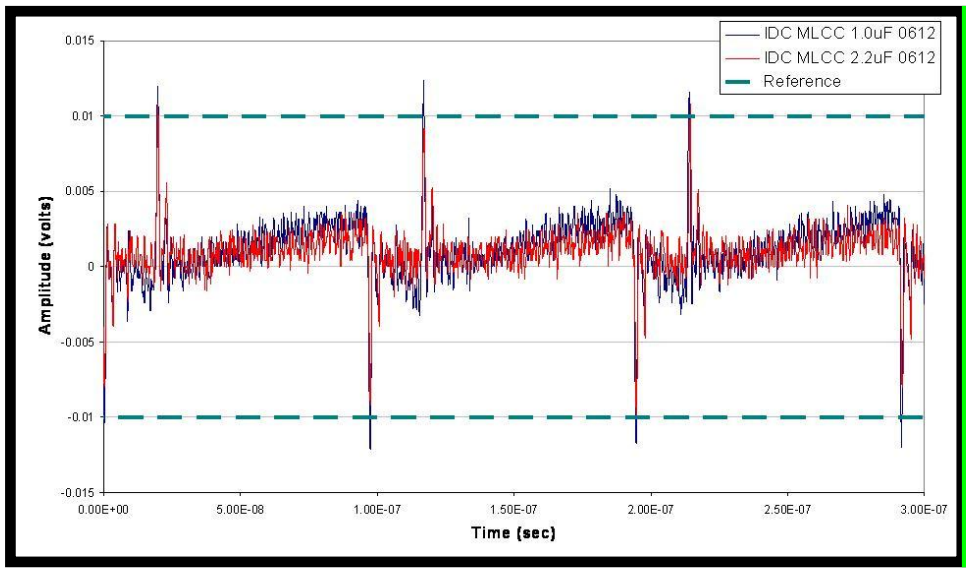
80/20 Duty Cycle



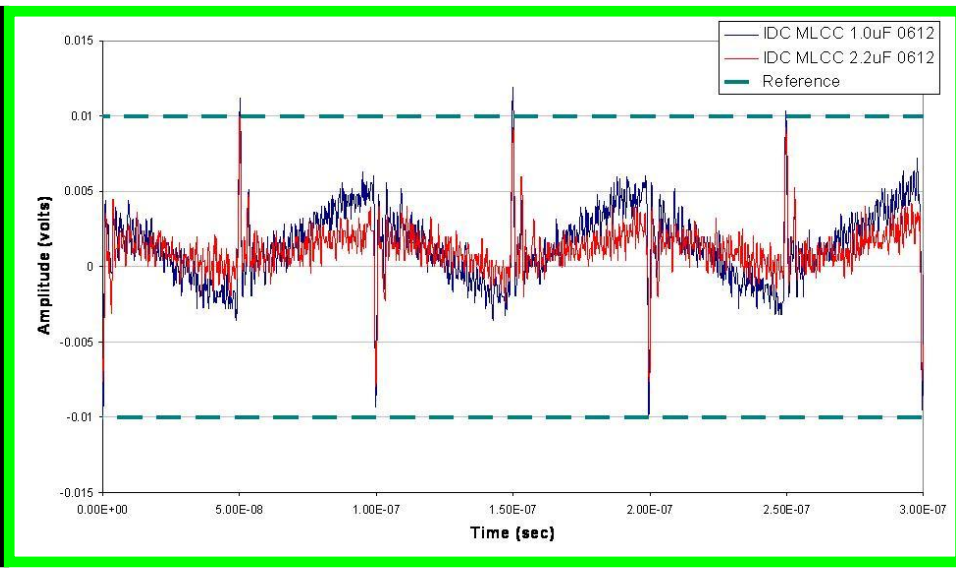
50/50 Duty Cycle

IDC™ MLCC



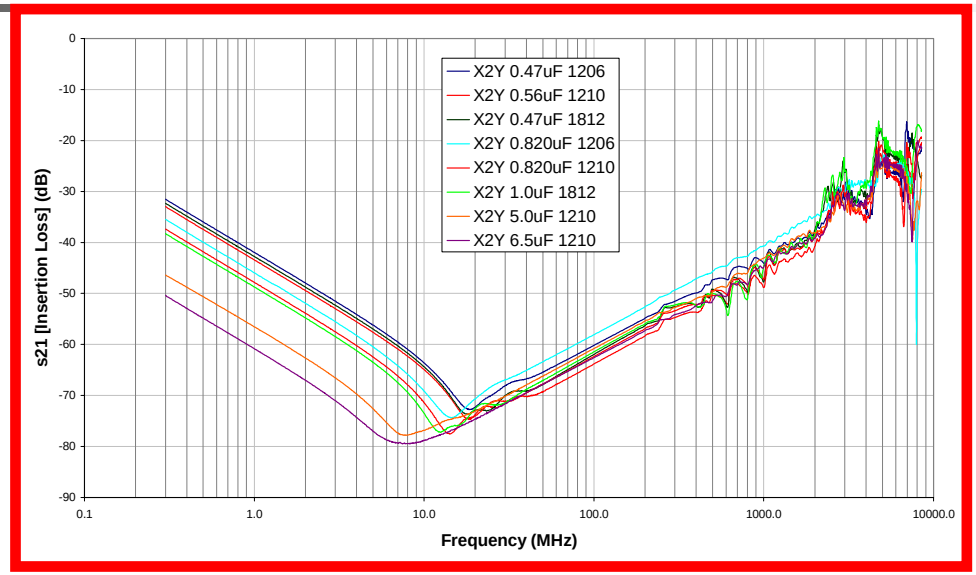


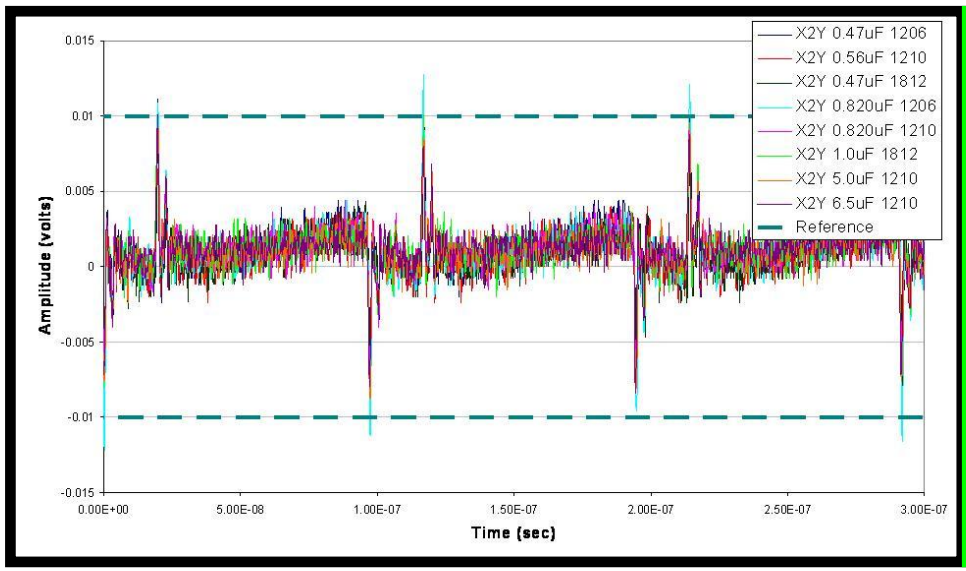
80/20 Duty Cycle

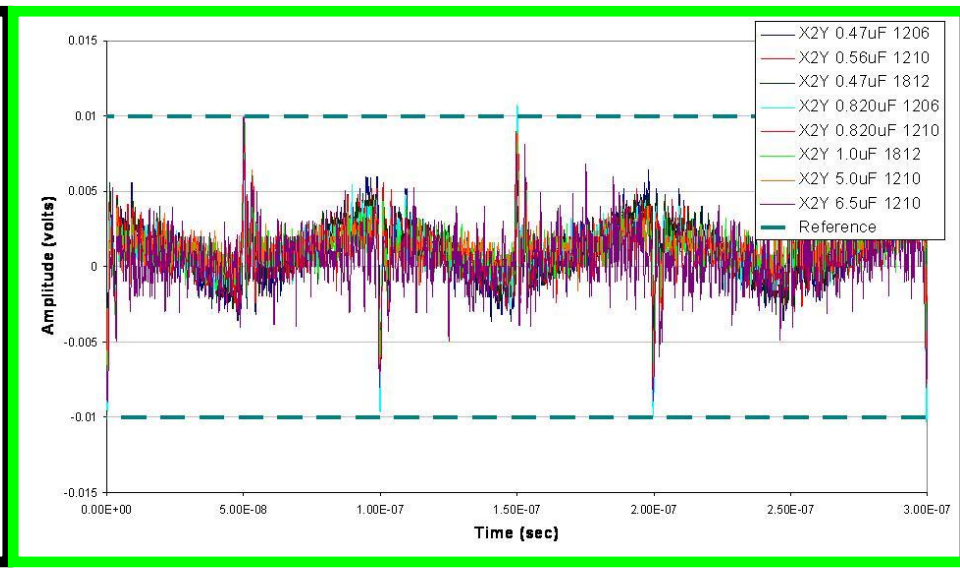


50/50 Duty Cycle

X2Y® MLCC





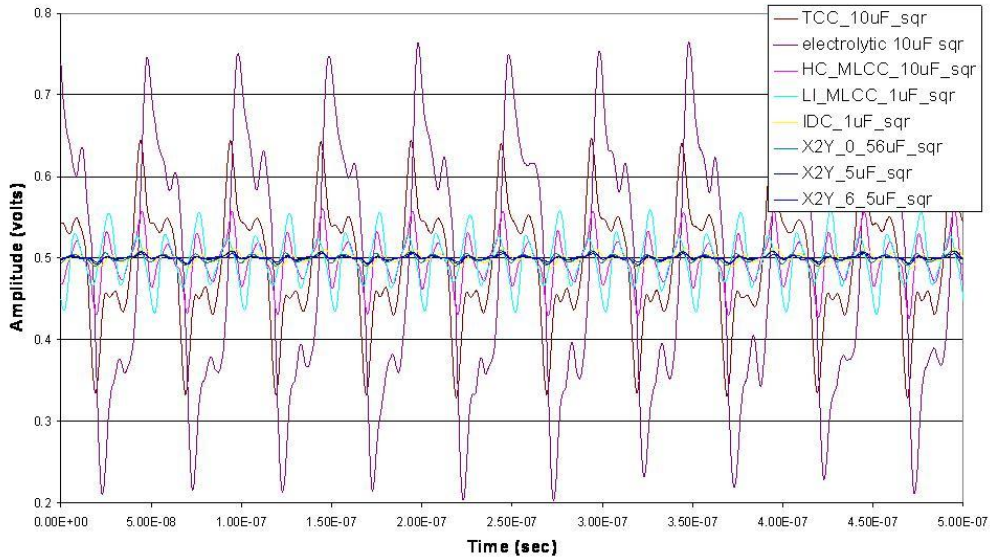


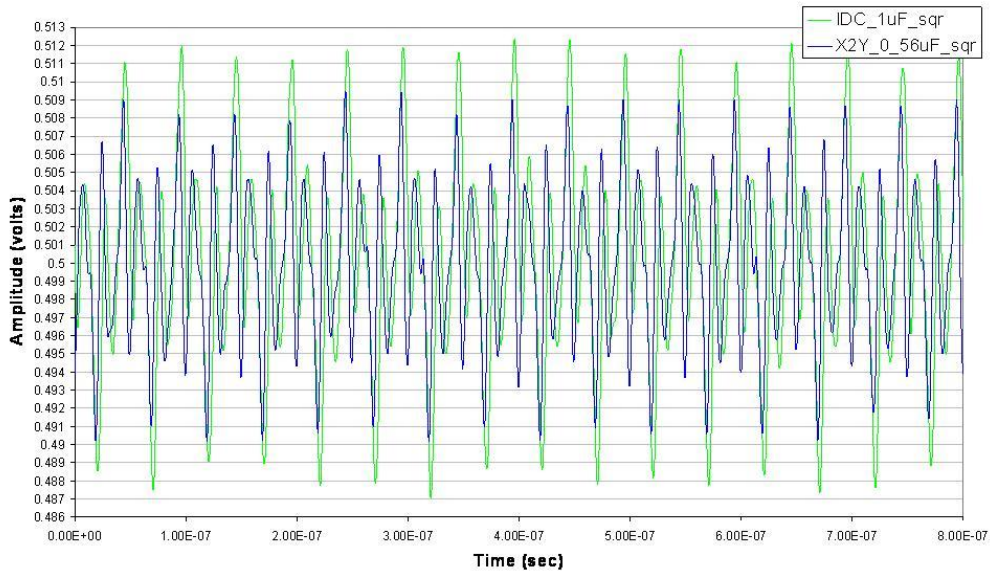
80/20 Duty Cycle

50/50 Duty Cycle

Additional High Frequency Test #1

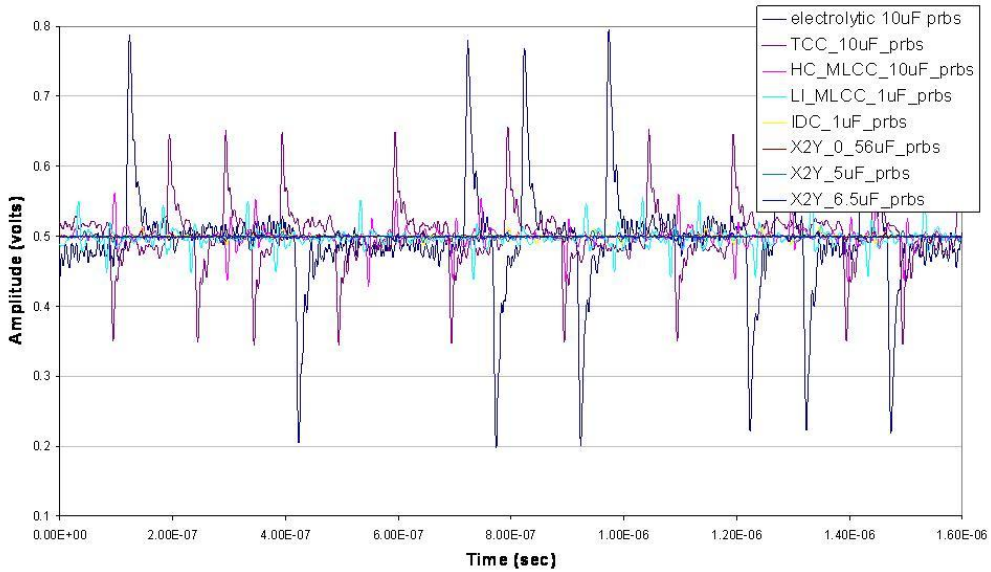
Component	Square Wave Δ Peak-to-Peak
Electrolytic 10uF	571 mV
Tantalum 10uF	319 mV
Std. MLCC 10uF	134 mV
LL MLCC 1.0uF	128 mV
IDC™ 1.0uF	**25.3 mV**
X2Y® 0.56uF (1.12uF total)	**19.6 mV**
X2Y® 5.0uF (10uF total)	16.7 mV
X2Y® 6.5uF (13uF total)	13.2 mV

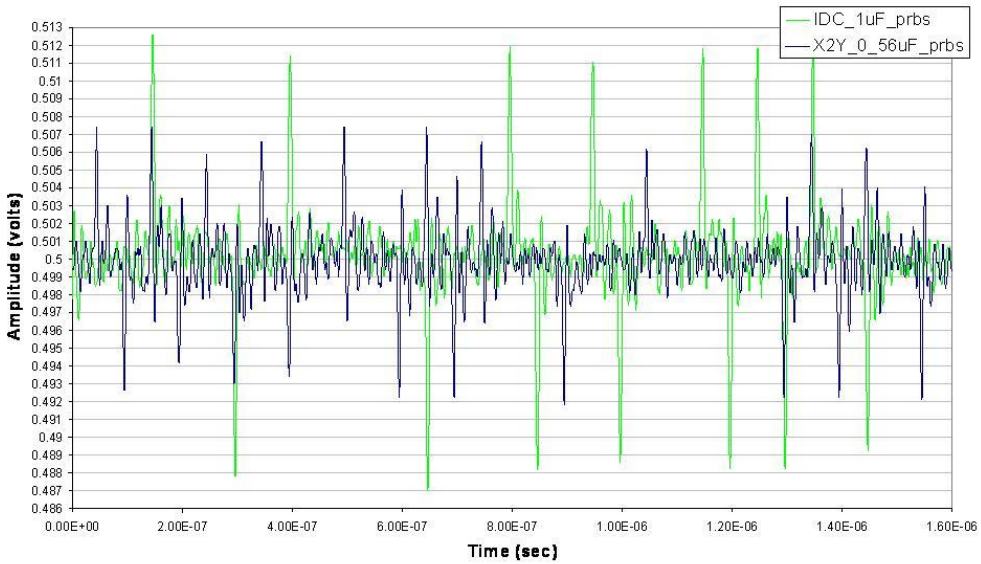




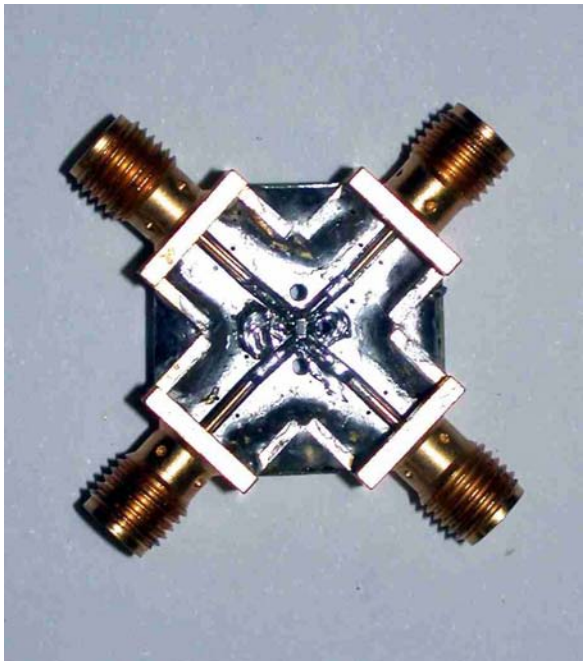
Additional High Frequency Test #2

Component	Random Δ Peak-to-Peak
Electrolytic 10uF	597 mV
Tantalum 10uF	311 mV
Std. MLCC 10uF	134 mV
LL MLCC 1.0uF	116 mV
IDC™ 1.0uF	**25.3 mV**
X2Y® 0.56uF (1.12uF total)	**15.5 mV**
X2Y® 5.0uF (10uF total)	17.2 mV
X2Y® 6.5uF (13uF total)	14.2 mV

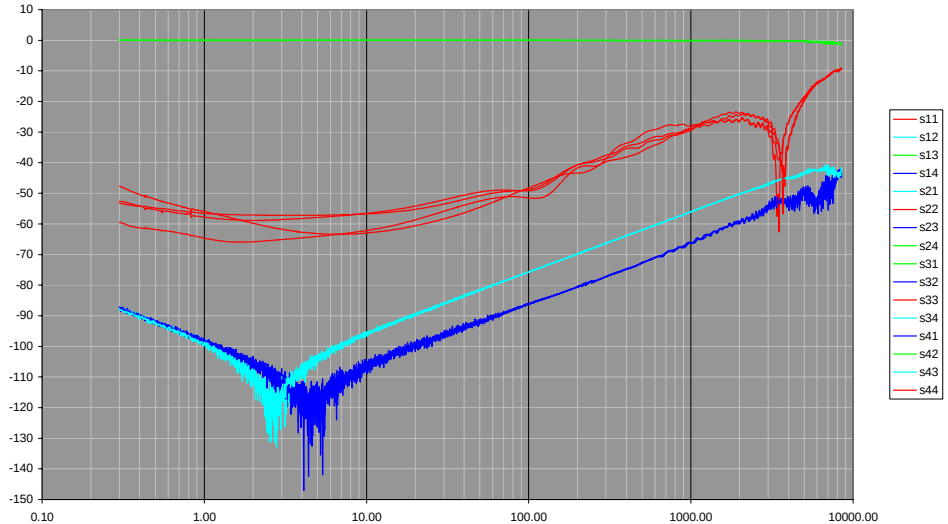




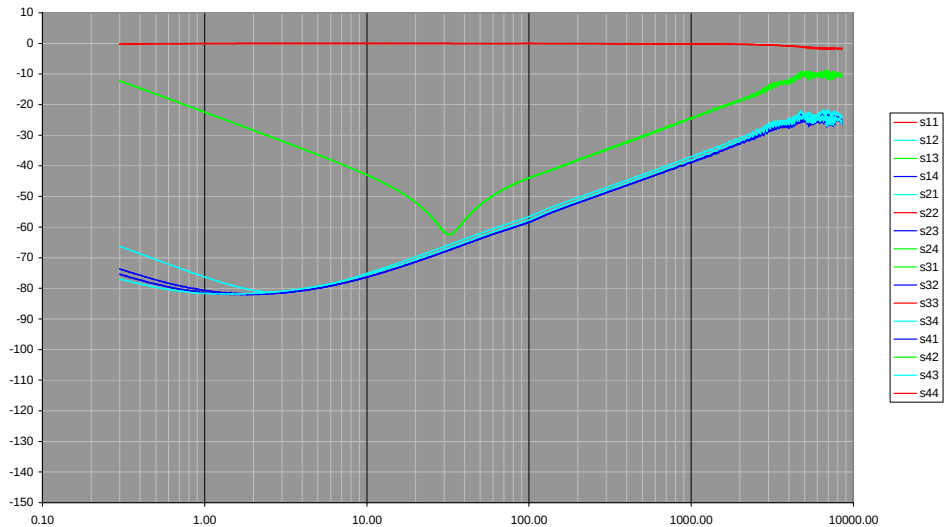
X2Y® Circuit 1 --- Multi-Plane Decoupling



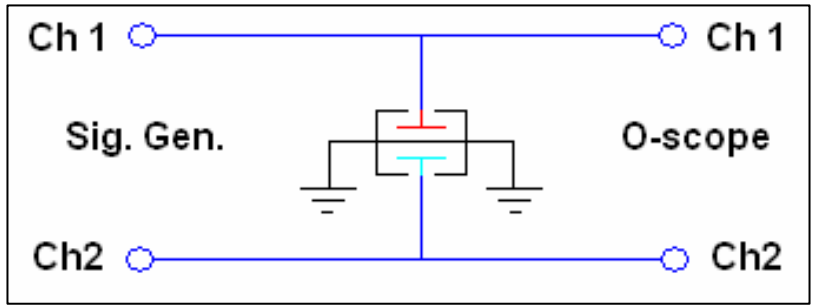
PCB Fixture

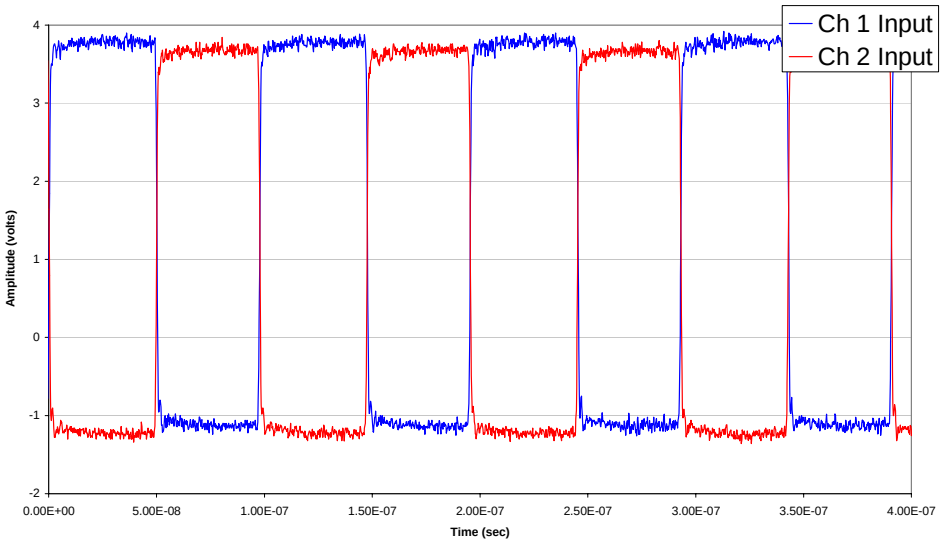


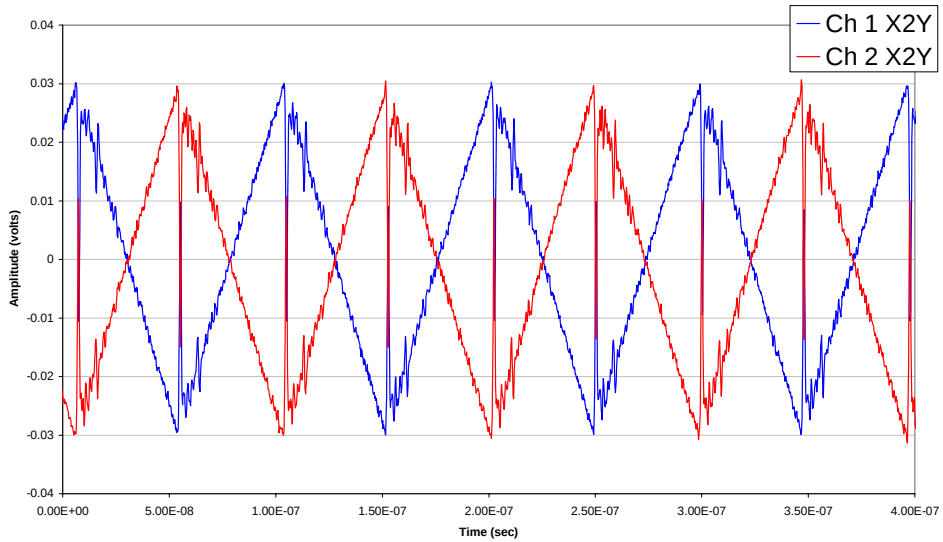
X2Y 0603 100nF



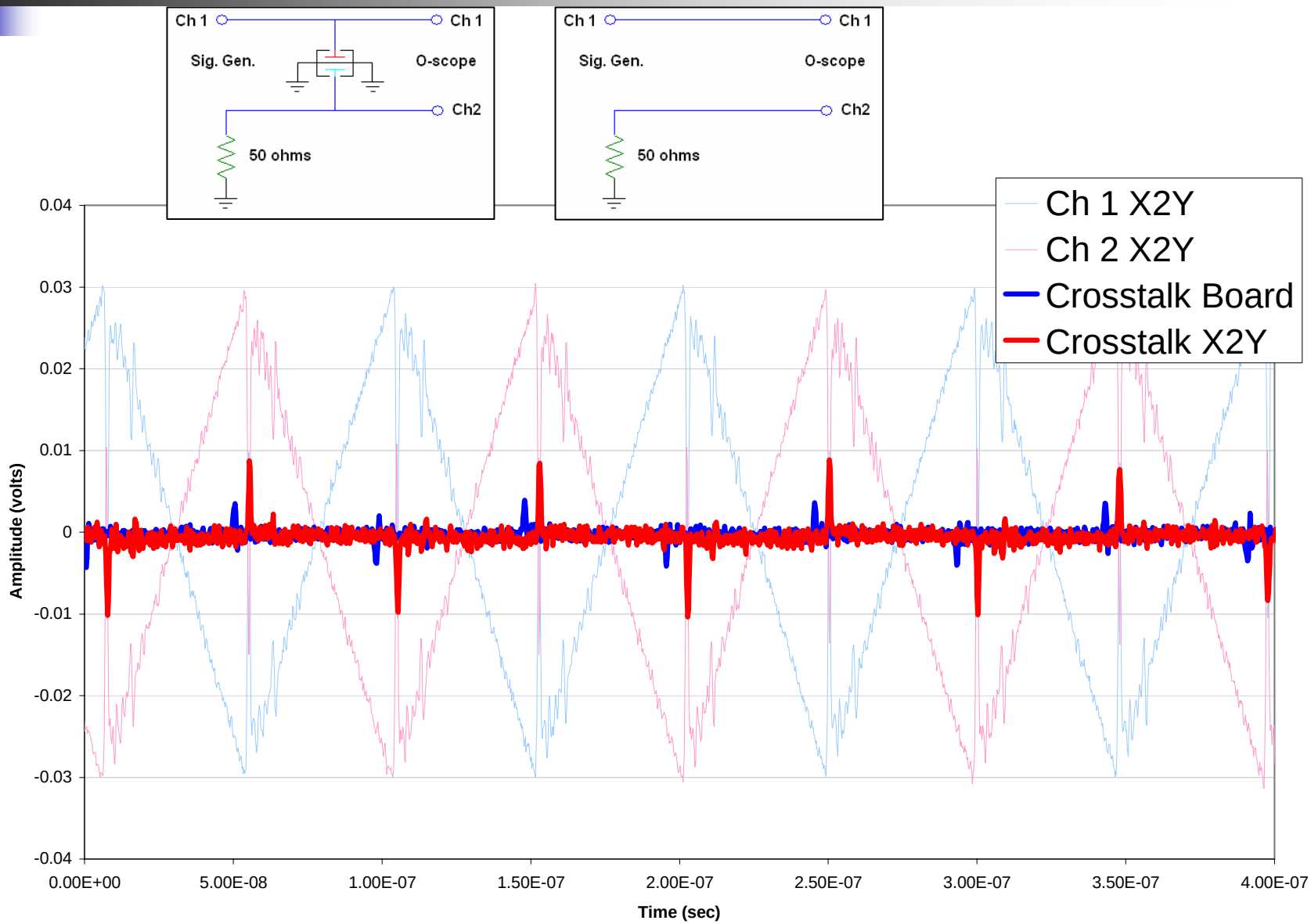
X2Y® Circuit 1 --- Multi-Plane Decoupling







X2Y® Circuit 1 - Multi-Plane Decoupling (crosstalk)



Questions?

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x2y@x2y.com

- IPCs are the foremost capacitor technology that can supply the instantaneous current needs and HF transient filtering for ICs.
- NEMI Roadmap shows IPC also offer cost savings advantages to OEMs.
- X2Y® is the premier IPC for performance and cost.