Comparison of MLCC and X2Y® Technology for Use in Decoupling Circuits
Goal: To investigate the performance of the X2Y® Technology as a decoupling device.

1. What is X2Y® Technology?
   - Structure
   - Circuit 1 & Circuit 2 Configurations

2. Evaluation #1 – Flux Containment
   - Performance vs. Spacing Requirements

3. Evaluation #2 – X2Y® vs. Low-Inductance Capacitors
   - Inductive behavior beyond SRF

4. Evaluation #3 – X2Y® Package Size and Inductance Correlation
   - Inductive behavior and physical geometry

5. Evaluation #4 – X2Y® Circuit 1 vs. Circuit 2
   - Utilizing the full potential of the X2Y® Technology

6. Conclusion
Internal/external design differences

**X2Y vs. Standard Caps:**
- Same standard component sizes
- Same standard capacitance values
- Same dielectric materials
- Same electrode materials
- Same termination materials

**Here’s what’s new:**
- New internal electrode arrangement
- Two new side terminations (G1 and G2)
A balanced circuit

Symmetrical structure:
- Matched capacitance (1-2.5%) line-to-gnd
- Effects of temperature variation eliminated
- Effect of voltage variation eliminated
- Effect of aging is equal on both caps

Balanced Magnitude

Matched Phase
How is the X2Y capacitor specified in data sheets?

Cap and Voltage rating:

- Capacitance is specified by either single Y capacitor (measured line-to-ground)
- Static measurement of the X capacitor = ½ of the specified Y capacitor

- Voltage rating is specified by either single Y capacitor (measured line-to-ground)
- Voltage rating for the X capacitor = 2x the specified Y capacitor voltage rating
Summary of the main circuit uses for the X2Y component.

**Circuit 1 Mode:**
- Used for a (3) conductor circuit (signal, return, ground or reference)
- Differential applications

(3) Conductor System
- Signal
- Return
- Reference

**Circuit 1 Schematic**

**Circuit 2 Mode:**
- Used for a (2) conductor circuit (signal, return)
- Single ended applications

(2) Conductor System
- Signal
- Return

**Circuit 2 Schematic**
Available Modeling Information.

**Circuit 1 Mode:**

**Circuit 2 Mode:**

*Circuit 1 Schematic*

- Signal (Pwr 1) connected to A
- GND connected to B
- Return (Pwr 2)

*Circuit 2 Schematic*

- Signal (Pwr) connected to A
- Return (GND)

*Model by Phycomp/Yageo, www.yageo.com*
EVALUATION #1 – FLUX CONTAINMENT

- Overall dimension of 28mm x 28mm
- FR-4 substrate
- Double layered, 1.0688mm thick
- Relative permittivity of 4.6
- Signal trace is 1.345mm
- Ground trace widths are 12.9475mm
- SMA connectors are soldered at each end of the signal trace
EVALUATION #1 – FLUX CONTAINMENT

- Std MLCC 2MM Separation
- Std MLCC 10MM Separation

Approx. 6dB Improvement
EVALUATION #1 (continued)

Approx. 15dB Improvement

Nominal Difference
Summary Evaluation #1

1. Std. MLCC spaced 10mm vs. 2mm apart have a 6dB improvement in inductance beyond SRF.

2. X2Y® components spaced 10mm vs. 2mm apart show nominal differences beyond SRF.

3. Both spacing distances of the X2Y® components had a 15dB improvement over the best case (10mm) Std. MLCC.

4. X2Y® components contain magnetic flux internal to the component which reduces spacing requirements Std. MLCC have due to mutual inductance between them.
EVALUATION #2 – X2Y® vs. Low-Inductance Caps (Microstrip)

Inductance beyond SRF

1. X2Y® exhibits a 16dB improvement beyond SRF over a Std. MLCC.
2. X2Y® exhibits a 3dB improvement beyond SRF over a Low-Inductance reverse geometry MLCC.
Evaluation #2 – (using vias)

- 4 layer boards
- Overall size of 1.2” by 1.2”
- 0.062” thick
- FR-4 substrate
- Planes are solid copper (1 ounce)
- Planes located 0.012” and 0.05”
- Nominal Er is 4.6 at 1MHz.
Evaluation #2 – (using vias)
Inductance and Geometry

1. X2Y® 1812 has a 1 – 2dB improvement over the X2Y® 0603.

2. The larger package size allows for more parallel electrodes, thus more internal cancellation of mutual inductance and larger cap values.

3. Counters the notion of “smaller is better”.

![Graph showing insertion loss vs. frequency for different X2Y® packages]
X2Y® Circuit Configuration Comparisons

1. Circuit 1 & Circuit 2 configurations have the same low-inductive behavior beyond SRF.

2. Circuit 1 improves the low end frequencies before SRF by providing a more efficient means of energy transfer.
Questions