X2Y
Technology In Balance
CONTENTS

- X2Y Overview
  - Internal Design
  - Balance
  - Low Inductance
    - Component-only
    - Mounted Component
- X2Y® In DRAM Applications
- Summary
Standard two terminal MLCCs contain opposing electrode sets, labeled A and B while the X2Y design adds shield or ground electrodes surrounding each A and B electrode set. These shield electrodes connect at the center termination bands of the device, labeled G1 and G2.  

(Click here for an audio version)
X2Y® Overview

Technology in Balance

Unique Three Node, Four Terminal Component

**CIRCUIT 1**
RFI FILTER
SMALL, LOW-COST, VERY EFFECTIVE

**CIRCUIT 2**
BYPASS CAPACITOR
TYPICALLY REPLACES 4 MLCC CAPS
Balance by Design

- Matched Y capacitors
- Y caps share same mounts
- PCB traces are uniform
- Temperature and voltage effects are equal on both Y caps at all times

There are many advantages to having both Y capacitors present in one device. In addition to the balanced internal electrode structure, the external effects of voltage, time, and aging are equal on both capacitors at all times. Also, the PCB layout for the device is inherently balanced compared to two discrete capacitors. These factors lead to exceptional common mode rejection for EMI filtering applications.
The magnitude and phase of the X2Y’s A & B capacitors track almost identically from 1.0kHz up to 6GHz. This balanced performance translates to high common mode rejection in EMI filtering applications.
X2Y® Overview

- X2Y® caps are 1/10th the inductance of a like sized conventional MLCC
- Device-only SPICE models available for Circuit 2 configuration, bypass.
  - Four branch model to represent the field penetration effects at increasing frequency. At sufficiently high frequencies, the plate metalization confines the magnetic field to the plates closest to the PCB, decreasing the effective inductance.
  - R240, R241, L240, L241 (mounting) is effectively zero’d out.
X2Y® Test Fixtures

- Mounted Capacitor Inductance
- Teraspeed/SigCon test cards

<table>
<thead>
<tr>
<th></th>
<th>X2Y</th>
<th>0402</th>
<th>Ratio</th>
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<tbody>
<tr>
<td>Surface</td>
<td>114pH</td>
<td>465pH</td>
<td>4.1:1</td>
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<tr>
<td>5 mils</td>
<td>137pH</td>
<td>575pH</td>
<td>4.1:1</td>
</tr>
<tr>
<td>14 mils</td>
<td>180pH</td>
<td>773pH</td>
<td>4.3:1</td>
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<tr>
<td>60 mils</td>
<td>396pH</td>
<td>1784pH</td>
<td>4.5:1</td>
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RF CAVITY MODEL

Top Layer Land Pattern w/Short
PCB Top RF Plane
No Capacitor Connections
Power Cavity Top Plane
Power Cavity Bottom Plane

H1

H2

H3

Uppermost PCB Plane
Power Cavity

[Diagram of RF cavity model with labeled layers and connections]
X2Y® Mounted inductance better than 4:1 conventional caps.
- Total 25% fewer vias used w/ X2Y®.

X2Y® Circuit 1 has unique advantages for $V_{TT}$ bypass:
- Balanced construction insures tight match of $V_{TT_{AC}}$ to $V_{DD_{AC}}/2$ at the PCB.
- Through inductance in $V_{DD}$ to $V_{SS}$ loop of only one capacitor.

X2Y® $V_{TT}$ bypass also provides useful $V_{DD}$ bypass.
AC voltage ratio at $V_{TT}$ depends on the ratio of complex impedance magnitude between combined upper and lower bypass networks.

- Conventional capacitors unit to unit and mounting variations disturb balance
- X2Y® Circuit 1, balance is inherent
Inherent impedance balance of X2Y® A/B sides versus frequency insures better $V_{DD}/2$ tracking on $V_{TT}$ than with conventional capacitors.

**X2Y® CIRCUIT 1**

**COMBINED VTT / VDD BYPASS**

Tightly Balanced Parasitics
< 0.1dB DIFFERENCE TO 1GHz+
Insure 50% Voltage Division Across Frequency

$V_{TT_{AC}} = \frac{V_{DD_{PCB_{AC}}}}{2}$

Balance by Design

- The magnitude and phase of the X2Y® A & B capacitors track identically from 1 MHz up to 500 MHz. This balanced performance translates to high common mode rejection in EMI filtering applications.
Inductance Presented to $V_{TT}$ Loads

- Conventional presents combined mounted ESL of two capacitors in parallel.
- X2Y® presents effectively better than mounted ESL of four capacitors in parallel.
X2Y® Inductance Presented to V_{TT} Loads

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**X2Y® CIRCUIT 1**

**COMBINED VTT / VDD BYPASS**

X2Y® INDUCTANCE APPEARS AS G1/G2 TO A IN PARALLEL W/ G1/G2 TO B IN SERIES W/ V_{DD} BYPASS NETWORK

ON A CAPACITOR BY CAPACITOR BASIS < 1/2 THE INDUCTANCE OF TWO CONVENTIONAL CAPACITORS IN PARALLEL.

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Inductance presented to VDD / VSS loop is the series combination of the elements.

- **Conventional Caps:**
  - 2X caps, + island between caps.

- **X2Y Circuit 1**
  - 1X capacitor body
X2Y® Combined $V_{TT} / V_{DD}$ Loop Inductance

- **X2Y Circuit 1**
  - Only one capacitor in series path from $V_{DD}$ to $V_{SS}$
  - $V_{DD} / V_{SS}$ loop currents cancel in $G1 / G2$ inductance.
    - $G1/G2$ and VTT effectively transparent.
  - No additional inductance due to interconnect island between capacitors.
Summary X2Y® In DRAM Bypass

- Straight inductance = impedance proposition:
  - X2Y® translates to 4:1 component, and 25% via reduction.
- X2Y® Circuit 1 improves $V_{TT}$ AC tracking of $V_{DD}/2$.
  - Balance is inherent part by part.
- X2Y® improves $V_{TT}$ bypass inductance typically more than 4:1 by component versus conventional.
- X2Y® used for $V_{TT}$ bypass provides useful bypass to $V_{DD}$ that conventional capacitors typically do not.