X2Y® Technology in DC Motors
1. **X2Y® Technology Overview**
   - Company and manufactures
   - Technology General Overview
   - Internal/External Design Differences
   - Technology formats

2. **How X2Y® Technology Works**
   - Ideal capacitor (sphere)
   - Ideal differential dual spherical capacitor
   - Ideal differential dual cylindrical capacitor
   - X2Y® Structure

3. **How to Apply X2Y® Technology in DC Motors**
   - Relationship of housing to image sphere
   - Considerations to applying X2Y® Technology
   - Mounting Options

4. **X2Y® Technology vs. Std Filtering (Performance)**
   - Radiated Emissions
   - Conducted Emissions
   - Transients

5. **X2Y® Component Testing**

6. **Automotive Specs and Suppliers with X2Y®**

7. **Other Automotive Applications with X2Y®**

8. **Summary/Questions**
Company and Manufactures

- **Intellectual Property (IP) Company**
  - 200+ USA and International patents and patent pending
  - Patents based on the X2Y Circuit Layered Architecture
  - Also, patents to prevent “picket fencing” of the technology

- **Licensed Technology**
  - Non-exclusive license to manufacturers
  - Currently there are (5) manufacturing licensees:
Technology General overview

X2Y facts:
- It’s a passive circuit
- Effective for filtering or decoupling
- New internal electrode design = Integrated Passive Circuit

X2Y’s superior performance replaces multiple passives used in a circuit:
- Inductors (ferrites, chokes, coils)
- Standard capacitors, feedthru capacitors (leaded, surface mount)
- Low inductance caps (reverse aspect ratio, multi-terminal arrays)
- Bulk Capacitance
**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)

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**Diagram:**
- Bypass Capacitor
- Shield Electrodes
- X2Y® Circuit
- Standard Capacitor
- X2Y® Circuit
- Top View Electrodes
- Electrode Stack up
- Stack up Side View
- Component
- Schematic

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The X2Y Circuit Layered Architecture can be embedded in a variety of form factors and dielectric materials.

Current X2Y form factors:
- Multi-layer chip
- Planar (thru-hole, slab)
- Single layer

Current X2Y materials:
- Ceramic
- MOV
- Ferrite
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8. **Summary/Questions**
Ideal Capacitor (Spherical)

- 2 spheres with radii a & b.
- Uniform distribution of E- & H-fields in all directions
- 3-dimensional

\[ C = 2\pi\varepsilon_0 \frac{ab}{b - a} \]
Ideal Differential Dual Spherical Capacitor

- Outer spheres share common reference.
- E- & H-image fields cancel on outer spheres.
- Outer sphere’s potential is zero.
- 3-dimensional
Ideal Differential Dual Cylindrical Capacitor

- Assume $L >> b$, edge fringing is negligible.
- Similar to Two Rectangular Coaxial Transmission Lines (RCTL) or Dual Coaxial cables.
- Outer cylinders share common reference.
- E- & H-image fields cancel on outer spheres.
- Outer sphere’s potential is zero.
- 3-dimensional
- X2Y® Reference Electrodes encompass A & B to for a quasi Faraday Cage.
- A & B electrodes are inset to negate edge fringing (E- & H-field containment).
- X2Y® is a 3-dimensional passive cancellation component. Other IDCs only look 2-dimensionally.
The connection configuration along with the Structure forces both CM and DM noise in opposite directions internally.

- Outer cylinder’s potential is ideally zero (same as housing).
- Noise is cancelled in x, y, & z directions (3-dimensions).

Note: Outer Cylinders are attached to housing (G1/G2 for X2Y®)
The internal current loop inherent to DC motors couples noise to the housing in 3-D.

If a low impedance short that blocks DC is applied between the housing and +/- Power leads, noise cancels.
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8. Summary/Questions
Considerations to Applying X2Y® Technology

- **Location**
  - Lead/Trace Length From Power Leads.
- **Location**
  - Connection Geometry to the Housing (G1/G2).
- **Location**
  - Placement at the Exit Point of the Housing.
- Widen path for electron flow (reduce inductance).
- Don’t make sharp turns (reduce reflections).
Lead Length From Power Leads

Radiated Emissions 100KHz - 1GHz

![Graph showing radiated emissions between 100KHz and 1GHz with two power lead configurations: Pwr Leads #1 and Pwr Leads #2.](Image)

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Connection Geometry to the Housing (G1/G2)

- Single Point (GND to Housing)
- Trace Inductance

No filter

Single point ground

Multiple ground

Two grounds used. Solder has been added to improve grounding when screws are tightened.

Continuous trace placed under G1 and G2 of X2Y
Placement at the Exit Point of the Housing

- **X2Y®** should be located just before or after the power leads exit the housing.
- This prevents noise from bypassing/coupling around the component.
Mounting Options

Two Speed Motor Attachment for X2Y

Low Speed
G1 & G2 each
Connected to Ground Trace

Ground

High Speed
Jumper Wire for
Brush Connection.

Brush Card

Insulation
Conductor / Trace

Riveted to Case Ground
Motor Case

Ground Trace / Area

Riveted to Case Ground

Screw to Case Ground

Note: (1) The "White" conductor / trace on brush card could be changed to jumper wire and then adding additional
ground area as indicated above with the dashed line.

2331, 2 Speed Motor with X2Y Circuit, Issue 1, 10-30-2000
Mounting Options

Notes:
(1) Can use 1 or 2 X2Y devices as required to meet specific filtering needs.
(2) Material recommendations are:
   A) Plated or metalized Plastic
   B) Insulated Metal
(3) Symmetry and Balance are very important.

Patent Pending

X2Y®

X2Y Attenuators, LLC.
Drawing # 2393
Brush Card Ideas
Issue 0, 10-22-2000
Mounting Options

X2Y Attenuators, LLC
PCB for Motor Applications
1410, 1210, and 1206 Size Devices
Drwg # 2426  Issue 0
Mar 2, 2001
Mounting Options

X2Y in a (2) Wire Motor Application

Diagram of motor connections and battery.
Mounting Options

- Removed (3) Inductors
- Removed (4) Capacitors
- Added X2Y Device
Mounting Options

Now a dual ground

Ground strap goes to both sides of the case for dual connection.
Mounting Options

Plastic End Cap
(RF noise will pass through plastic)
Mounting Options

X2Y Between Leads
Mounting Options

Add multiple ground tabs

Note: multi-layer PC ground! Single layer ground is better
New board with X2Y mounted in motor
A grommet or a connector is a great place to put X2Y. X2Y is shown (not) soldered between A & B with G1 & G2 connected to conductive screen or lining placed in grommet.
Mounting Options
Radiated Emissions - ABS Motor

Frequency (MHz)

dBmV

Ambient
Standard Filter
X2Y Filter

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Radiated Emissions - Blower Motors

- 30dB pre-amp was used.
30dB pre-amp was used.
30dB pre-amp was used.
30dB pre-amp was used.
Radiated Emissions - Seat Motors

Seat Motor #1

Seat Motor #2

Seat Motor #3

Note: 30dB pre-amp was used on Motor #1

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Radiated Emissions - Throttle Body Motor

![Graph showing radiated emissions comparison between Ambient, No Filter, and X2Y Filter conditions. The graph plots frequency (MHz) against dBmV, with a range from 0 to 1000 MHz and 15 dBmV to 70 dBmV. The Ambient line is the baseline, the No Filter line shows higher emissions, and the X2Y Filter line shows reduced emissions.](image-url)
Radiated Emissions - Washer Pump Motors

Washer Pump Motor #1

Washer Pump Motor #2
Radiated Emissions - Window Lift Motor

![Image of window lift motor]

- Ambient
- Standard Filter
- X2Y Filter

Frequency (MHz)

- dBoV

0 100 200 300 400 500 600 700 800 900 1000

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Radiated Emissions - Wiper Motor (3-brush, 2-speed)
Conducted Emissions – Radiator Fan Motor
Conducted Emissions – Fuel Pump Motor

No Filter

X2Y

cap & 2 ind’s
Transient Testing – 12v Brake Pedal Motor

Transients in a 12V DC Motor

- DC Power Supply
- Production Filter Motor
- with - X2Y 1812 (0.4 uF) 50v
- without - X2Y (re-verify)
Transient Testing – Seat Motor (UL Tested)

CCW-stalled-off to on

CCW-stalled-on to off

CW-stalled-off to on

CW-stalled-on to off
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8. Summary/Questions
Electrical Testing Conducted

- Capacitance distribution
- Capacitance balancing
- DC Voltage Breakdown testing
- Impulse/surge testing
- ESD testing
- Reliability testing
- Stress testing
Capacitance Distribution

Syfer part 1410J0500404MXTE03

Capacitance Deviation from Mean Value - Line to Ground

![Graph showing capacitance deviation from mean value vs. standard deviations. The x-axis represents standard deviations ranging from -3 to 3, and the y-axis represents deviation from mean value in percent (%). The graph shows a trend line indicating the distribution of capacitance deviations.]
Capacitance Distribution

Syfer part 1410J0500404MXTE03

Capacitance Deviation from Mean Value - Line to Line
Capacitance Balancing

Syfer part 1410J0500404MXTE03

Capacitance Balance - Line vs Line to Ground
DC Breakdown Voltage

DC Breakdown Voltage - X2Y Chips - Line to Line

Max. DC Line to Line Rating

Dielectric Thickness (μm) Unfired

DC Breakdown Voltage (V)
Syfer Impulse Test Capability

- Waveform - 1.2/50u Second pulse, with either 2 or 12 Ohms source Impedance. All testing has been carried out at 2 Ohms (Worst case)
- Waveform – 10/700u Second pulse, with 15 Ohms source Impedance.
- Voltage range – 200 to 6,000Volts on both waveforms.
- Maximum Current output – 2,200 Amps
Impulse Testing

Impulse 1.2/50uS 2 Ohms Source Impedance

Dielectric Thickness μM Unfired

Volts

X2Y Line to Line
X2Y Line to Ground
Impulse 10/700μS 15 Ohms Source Impedance

Dielectric Thickness μM Unfired

- **X2Y Line to Line**
- **X2Y Line to Ground**
ESD Testing

- Up to 6KV on Contact Discharge Test.
- Up to 8KV on Air Discharge Test.

  No Failures on X2Y product have been seen at either 6KV Contact Discharge test or 8KV Air Discharge test on product rated at >=50Vdc.
Endurance Testing

- Upper Category Temperature  +125°C
- Voltage 1.5 x Rated Line to Ground voltage
  - 6,028 Components Tested
  - 8,753,000 Test hours
  - 3 Component failures:
    - 2 – manufacturing faults
    - 1 – unidentified
Data collected from 9,307,760 component test hrs, from which there were 6 failures
Summary

- Capacitance distribution and balancing
  - typically < ±3%

- DC voltage breakdown testing
  - identical to chip caps

- Impulse/surge testing - 1.5/50μS & 10/700μS
  - identical to chip caps

- ESD testing
  - contact – immune to 6 kV, air immune to 8 kV

- Reliability testing
  - approx. 10 million units hours of testing
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Automotive Specs and Suppliers with X2Y®

- **Current Automotive Specs w/ X2Y®:**
  - DCX – DS 100
  - GM – GMW3103

- **X2Y Attenuators, LLC Activity:**
  - Motor development projects with over 50 different manufacturers
  - Tracking over 70 active motor programs
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Other Automotive Applications with X2Y®

- Hall Effect Sensor
Other Automotive Applications with X2Y®

- **CANBUS**

**REMOVE** –
(2) caps & CMC

DIAGRAM:

- Can 2
- GND
- Vcc
- 8-PIN
- 82C250/1
- TXD
- RXD
- CANH
- CANL
- 120kΩ 1/4W
- 100pf
- CAN_H
- CAN_L

*Two per bus
*Optional

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Other Automotive Applications with X2Y®

- **PCB Decoupling (Circuit 2)**

<table>
<thead>
<tr>
<th>MLCC 0805 (0.1uF) (# in // = 1)</th>
<th>MLCC 0805 (0.1uF) (# in // = 2)</th>
<th>MLCC 0805 (0.1uF) (# in // = 3)</th>
<th>MLCC 0805 (0.1uF) (# in // = 4)</th>
<th>MLCC 0805 (0.1uF) (# in // = 5)</th>
<th>X2Y 1812 (0.22uF)</th>
</tr>
</thead>
</table>

**Frequency (MHz)**

**Impedance [Ω]**

- 0.01
- 0.1
- 1
- 10
- 100
- 1000
- 10000
For more information on EMI filtering of DC motors go to www.x2y.com and refer to Application Notes:

- 4001 - DC Motor Design with X2Y® Technology
- 4002 - DC Motor Design with X2Y® Example A
- 4003 - DC Motor Design with X2Y® Example B
- 4004 - DC Motor Design with X2Y® Example C


- www.jastech-emc.com