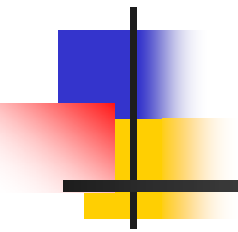


X2Y Attenuators, LLC

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**

- Intellectual Property (IP) Company
  - 200+ USA and International patents and patent pendings
  - 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:

SYFER

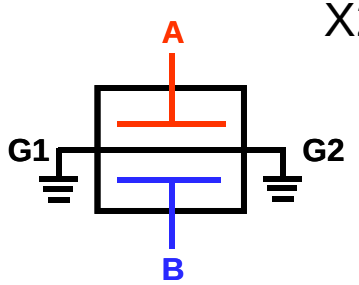
JOHANSON DIELECTRICS

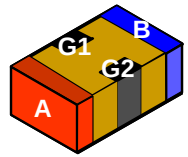
AMC Advanced Monolythic Ceramics

YAGEO Phicomp A YAGEO COMPANY

maida DEVELOPMENT COMPANY

X2Y®





X2Y facts:

- It's a passive circuit
- Effective for filtering *or* decoupling
- New internal electrode design = **I**ntegrated **P**assive **C**ircuit

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

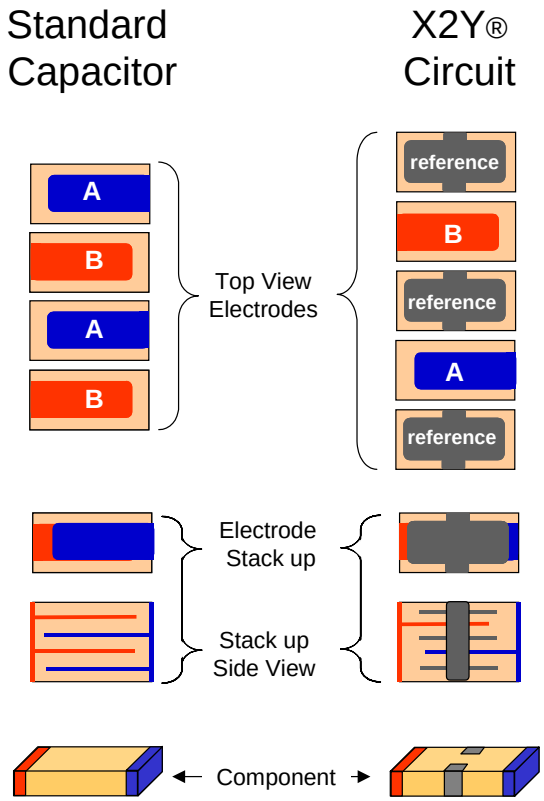
Internal/External Design Differences

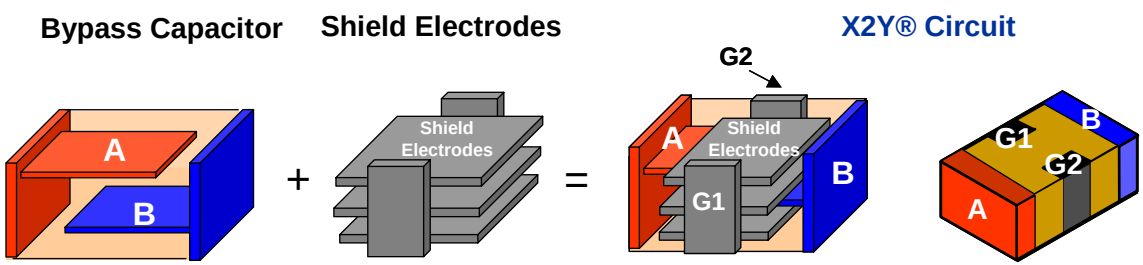
X2Y vs. Standard Caps :

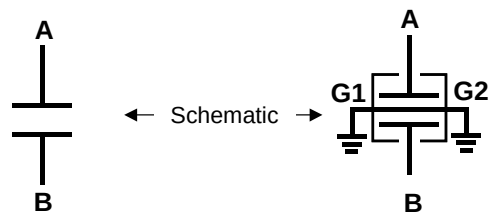
- Same standard component sizes
- Same standard capacitance values
- Same dielectric materials
- Same electrode materials
- Same termination materials

Here's what's new :

- New internal electrode arrangement
- Two new side terminations (G1 and G2)







Technology Formats

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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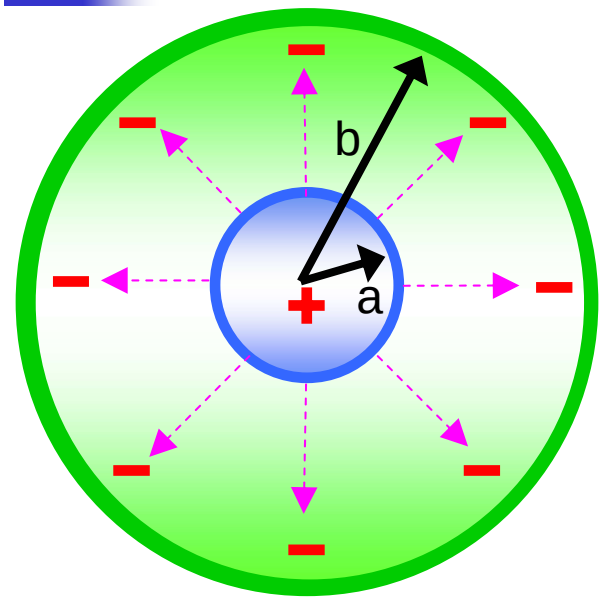
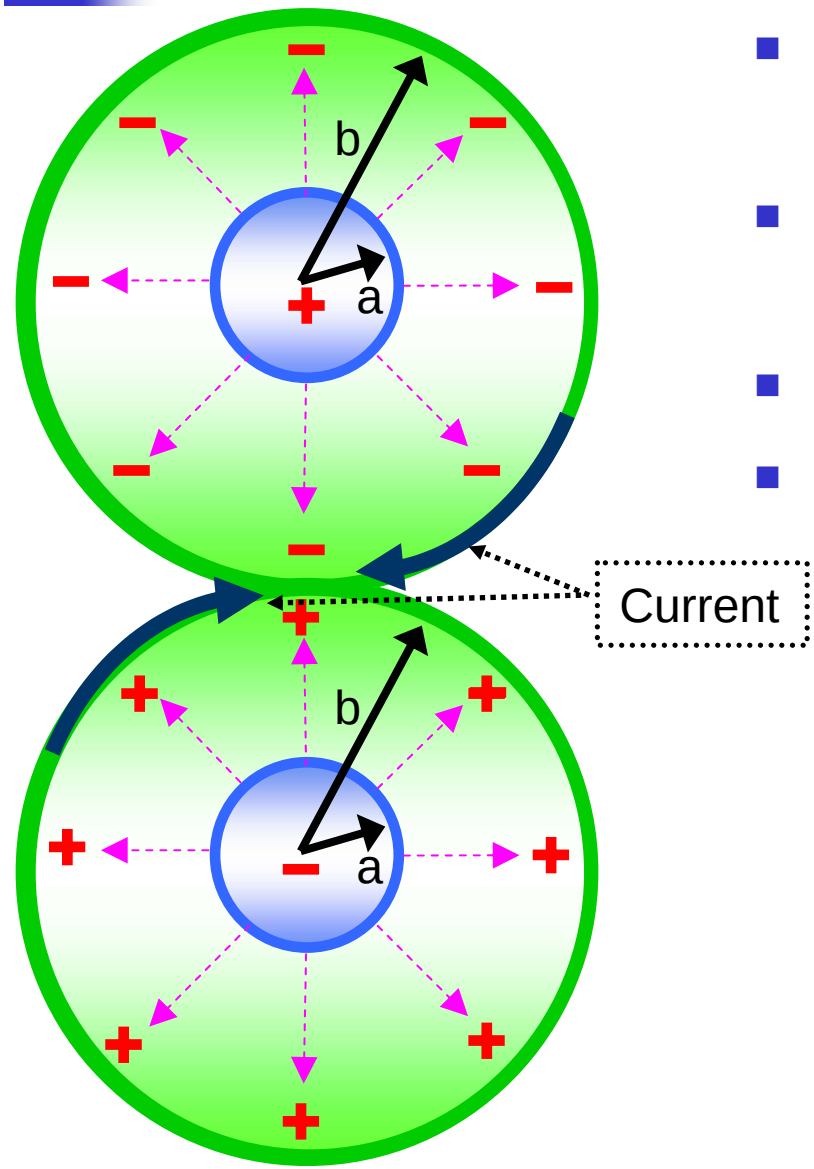
Ideal Capacitor (Spherical)



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

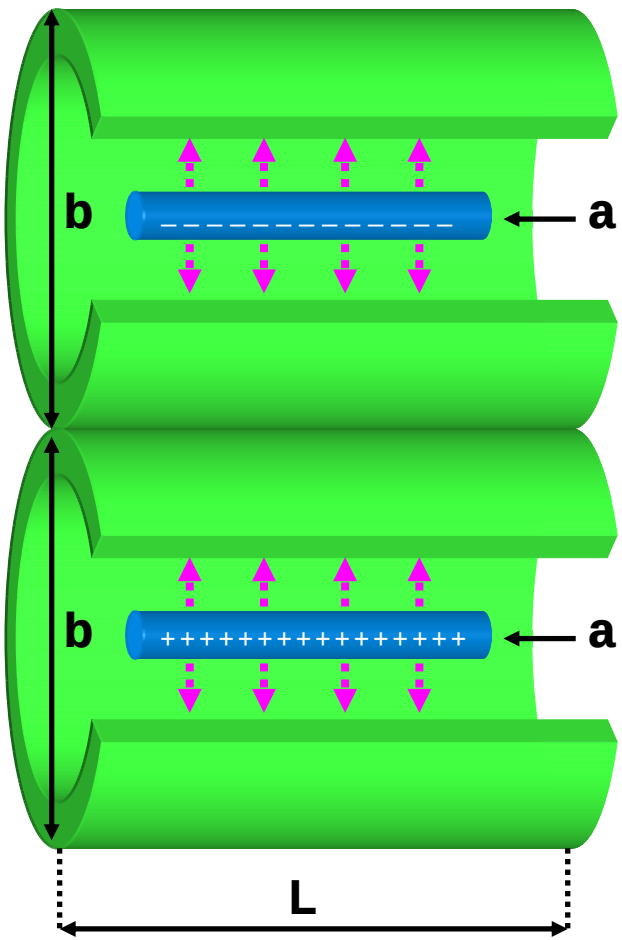
$$C = 2\pi\varepsilon_0 \frac{ab}{b-a}$$

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

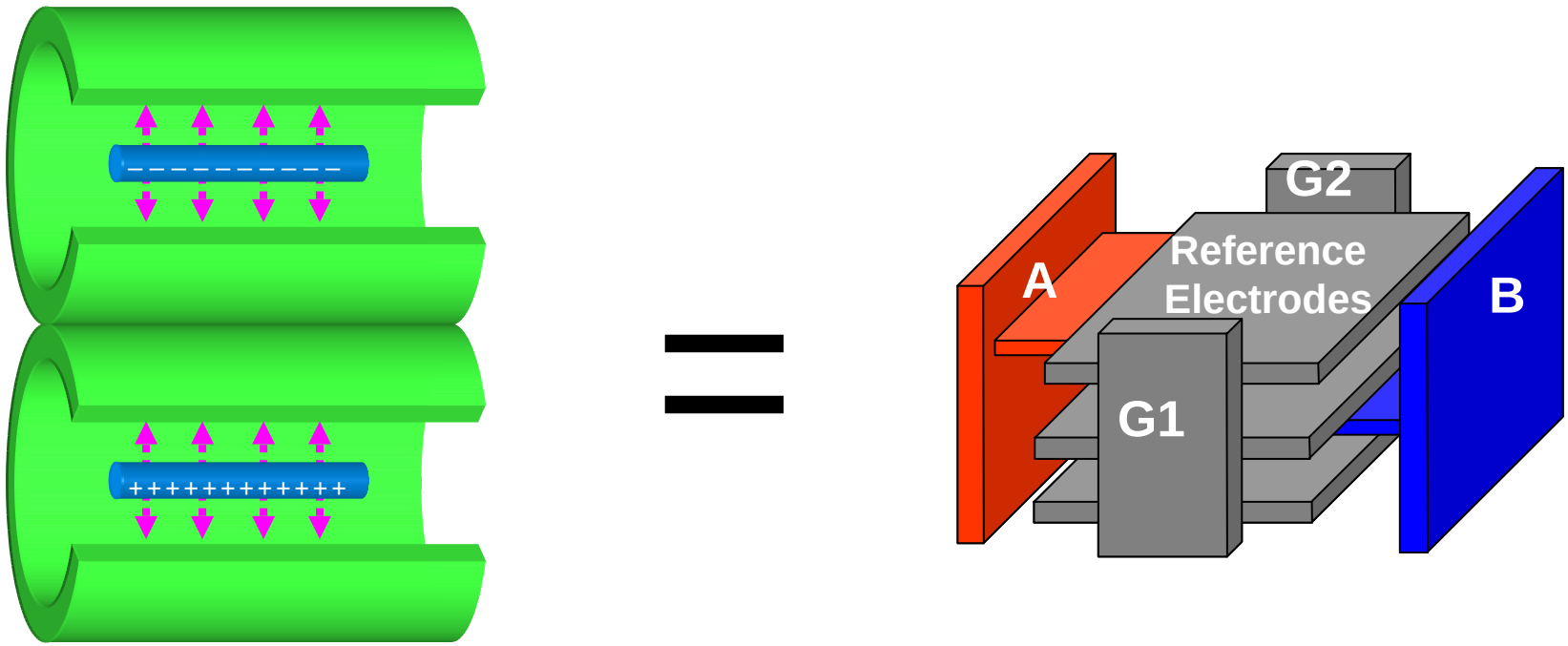
Ideal Differential Dual Cylindrical Capacitor

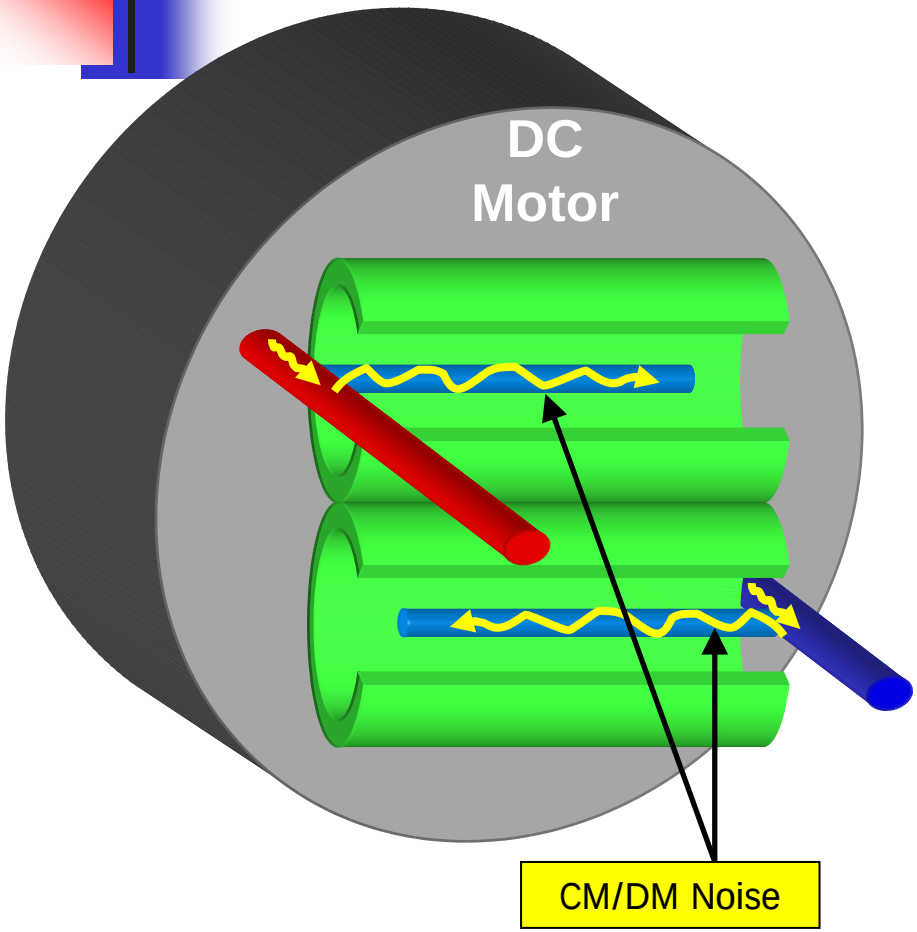


- Assume L >> b, edge fringing is negligible.
- Similar to Two Rectangular Coaxial Transmission Lines (RCTL) or Dual Coaxial cables.
- Outer cylinders share common reference.
- E- & H-image fields cancel on outer spheres.
- Outer sphere's potential is zero.
- 3-dimensional

X2Y® Structure

- 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.

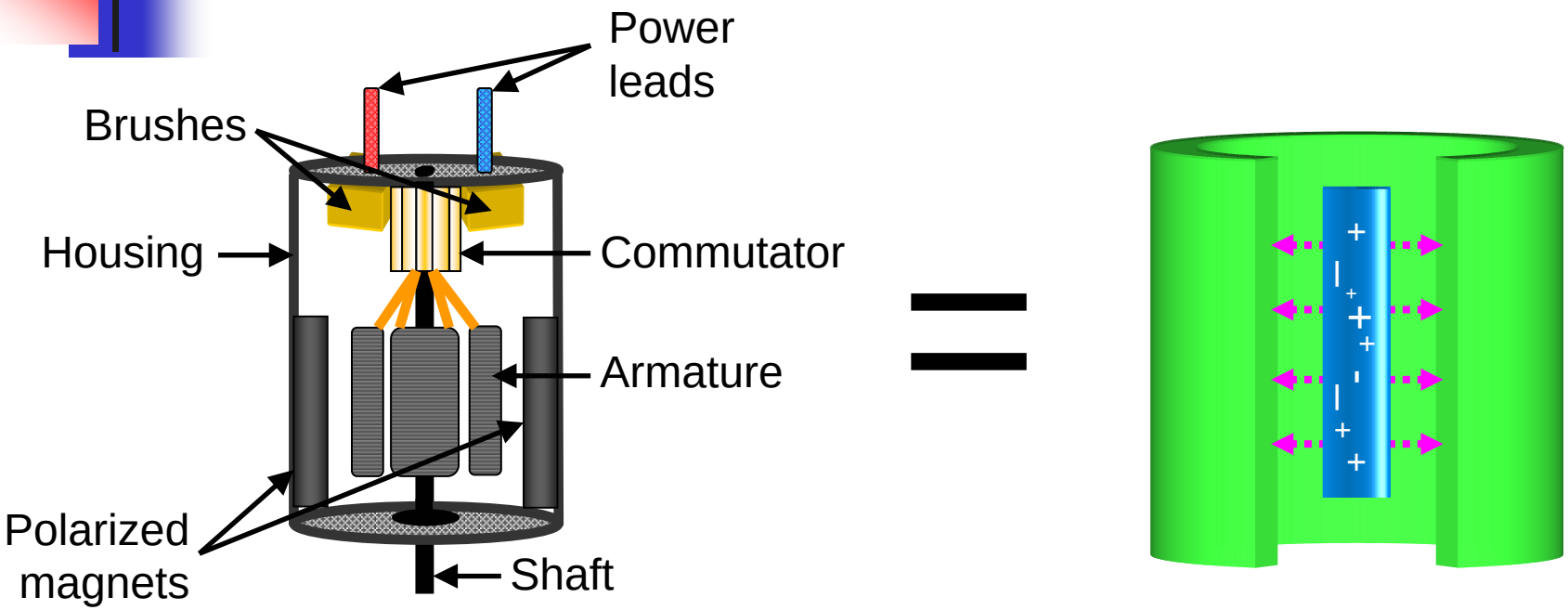




Note: Outer Cylinders are attached to housing (G1/G2 for X2Y®)

- The connection configuration along with the Structure forces both CM and DM noise in a opposite directions internally.
- Outer cylinder's potential is ideally zero (same as housing).
- Noise is cancelled in x, y, & z directions (3-dimensions).

Relationship of Housing to Image Sphere



- 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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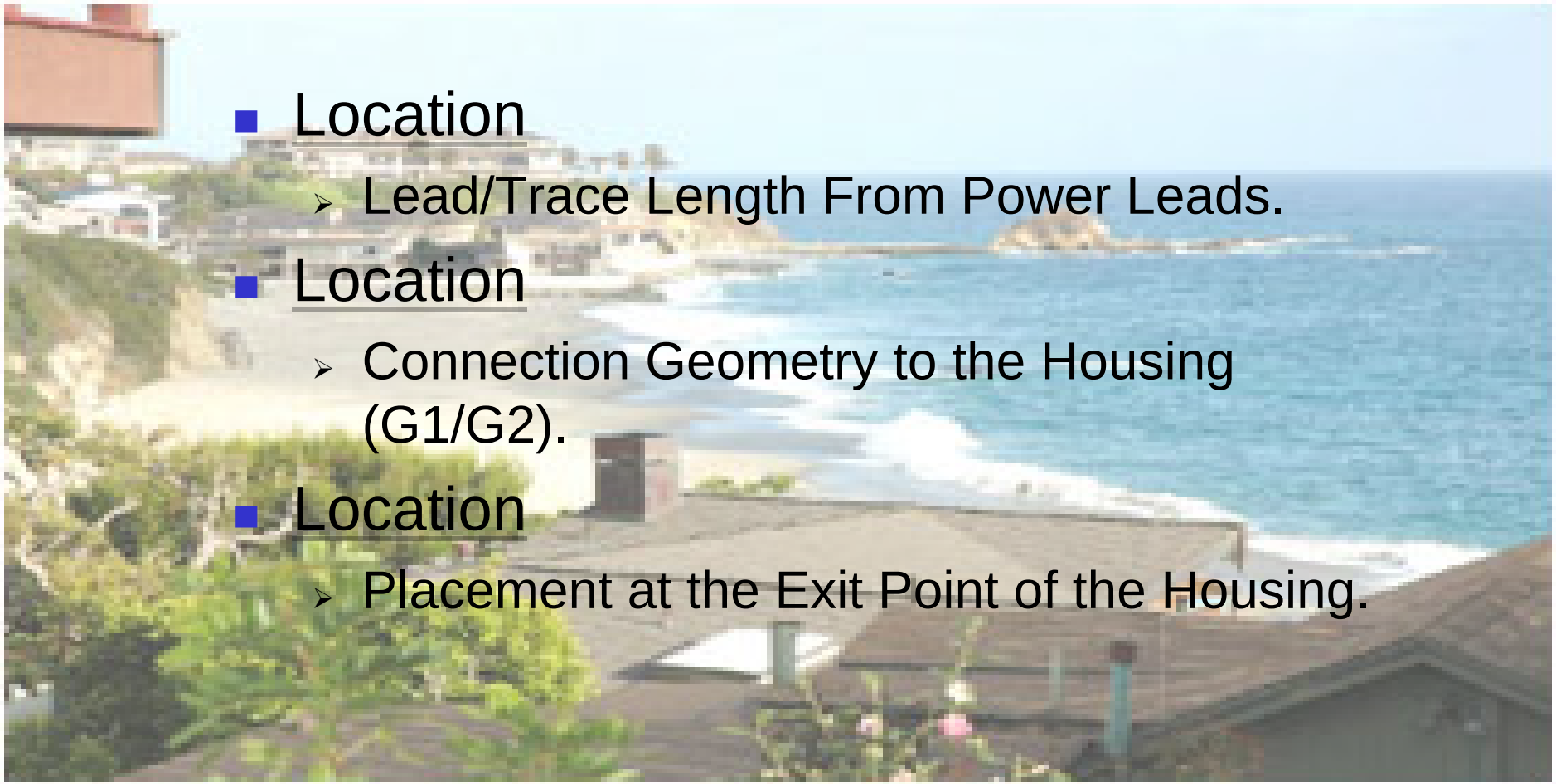
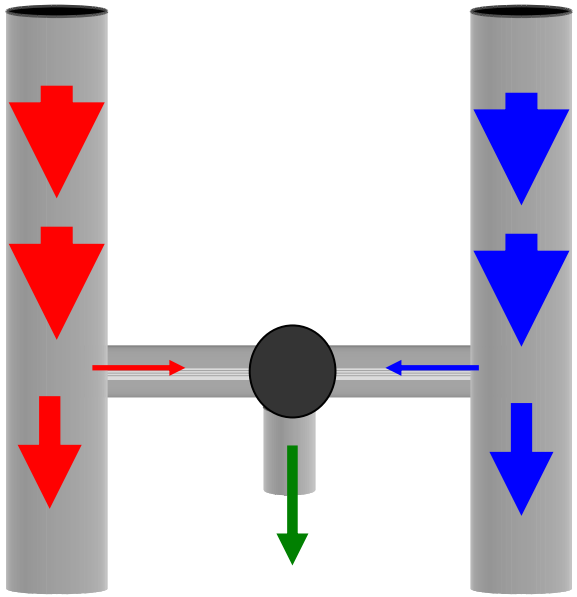
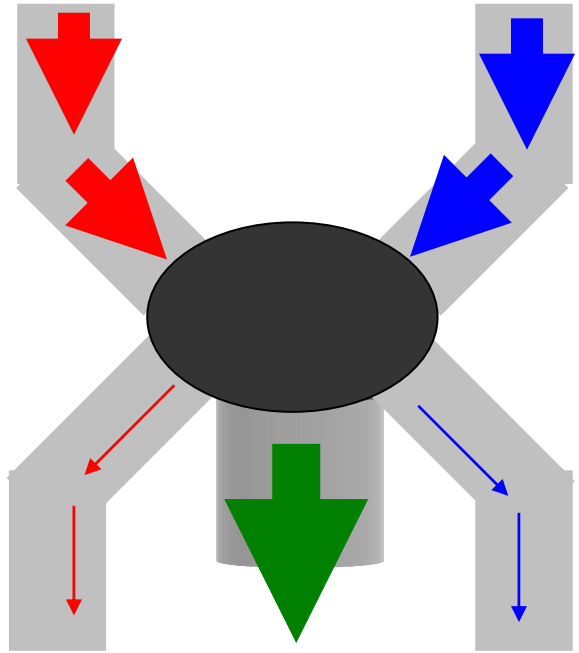
Considerations to Applying X2Y® Technology



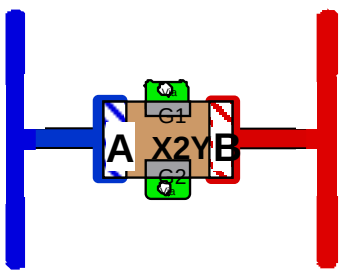
- Location
  - Lead/Trace Length From Power Leads.
- Location
  - Connection Geometry to the Housing (G1/G2).
- Location
  - Placement at the Exit Point of the Housing.

Lead/Trace Length From Power Leads

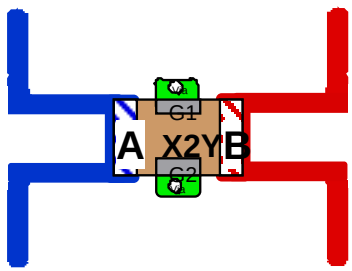




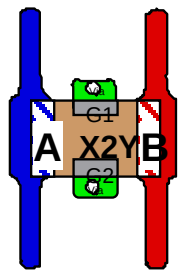
- Widen path for electron flow (reduce inductance).
- Don’t make sharp turns (reduce reflections).



Option

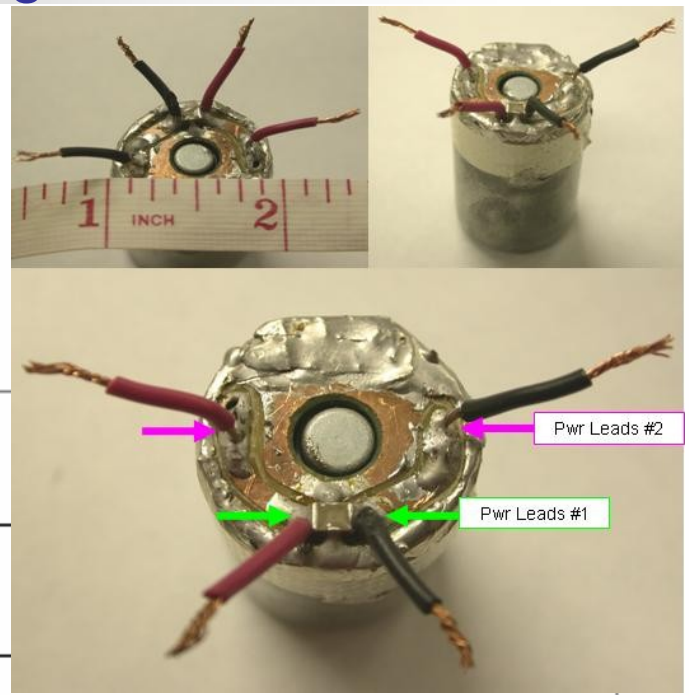


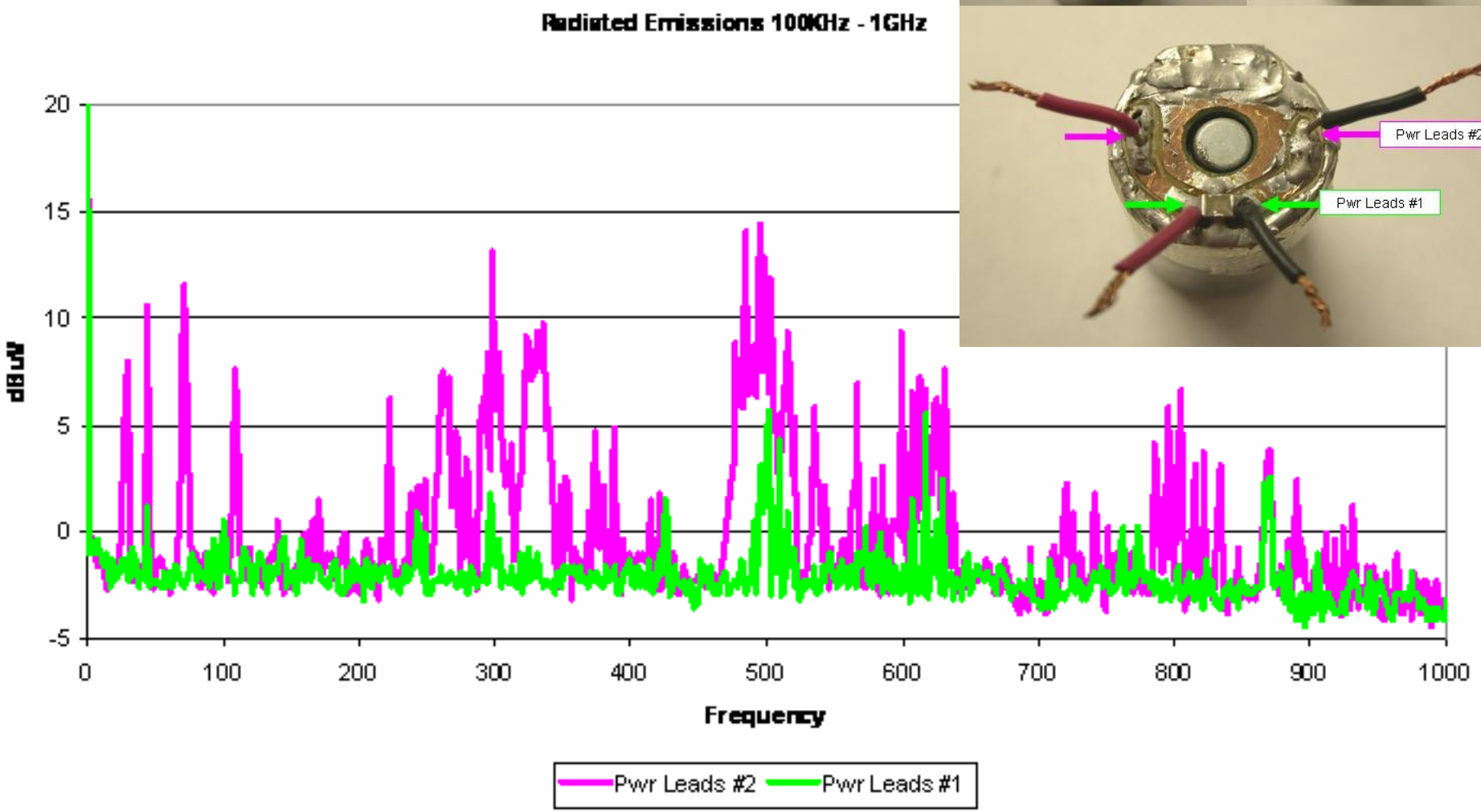
Improved



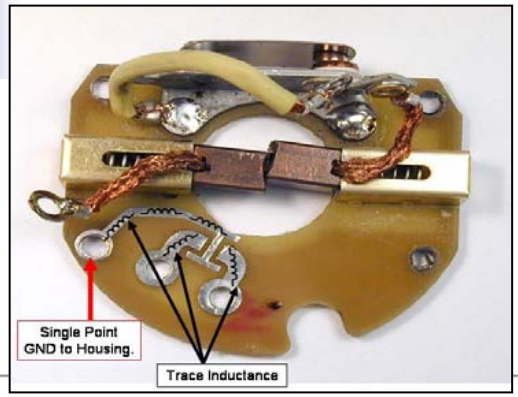
Best

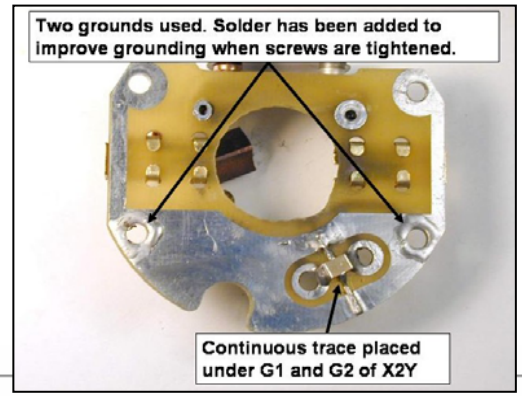
Lead Length From Power Leads

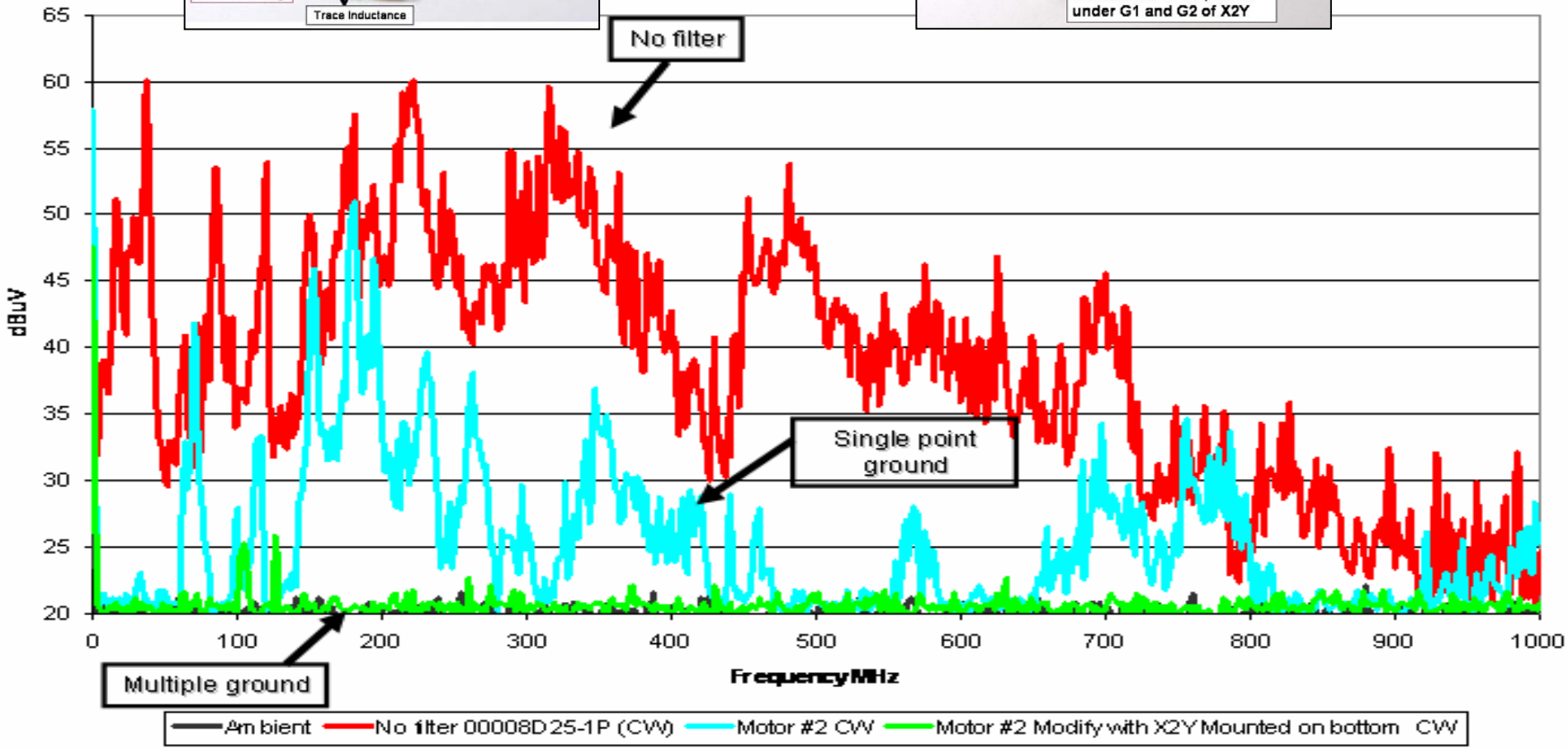




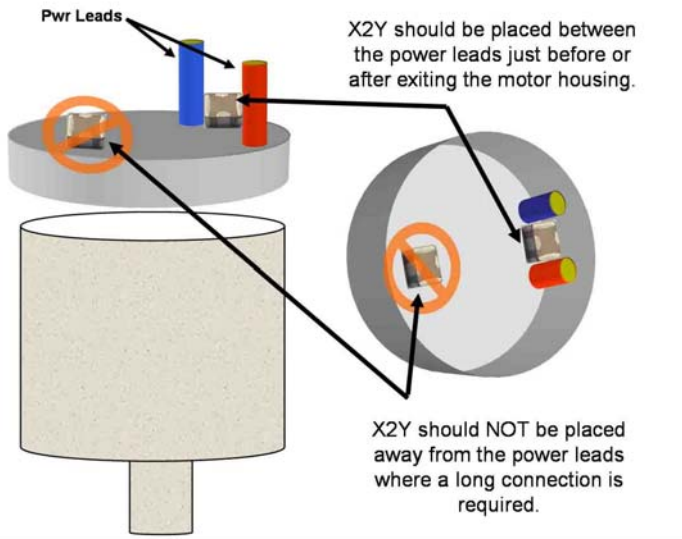
Connection Geometry to the Housing (G1/G2)

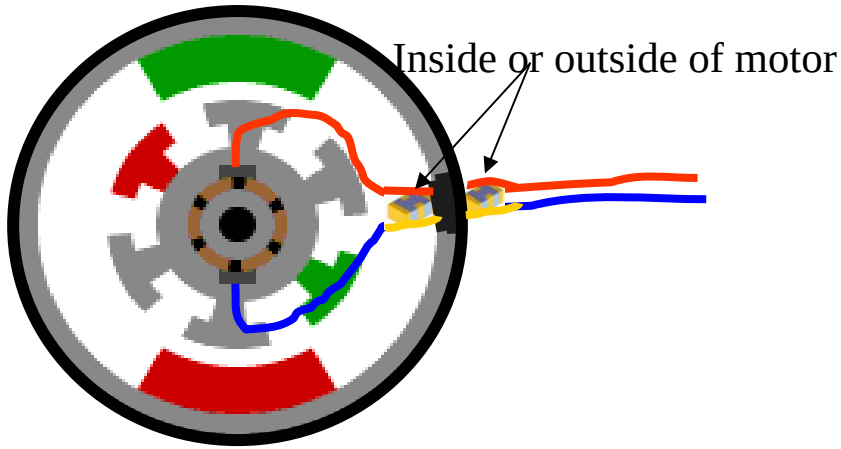






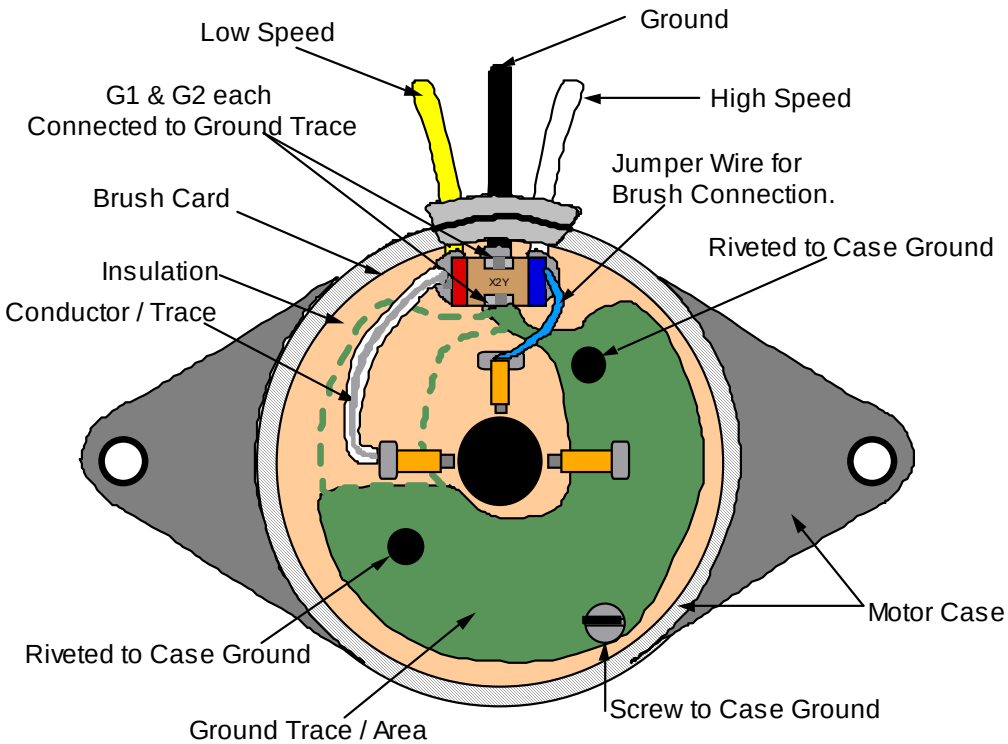
Placement at the Exit Point of the Housing





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

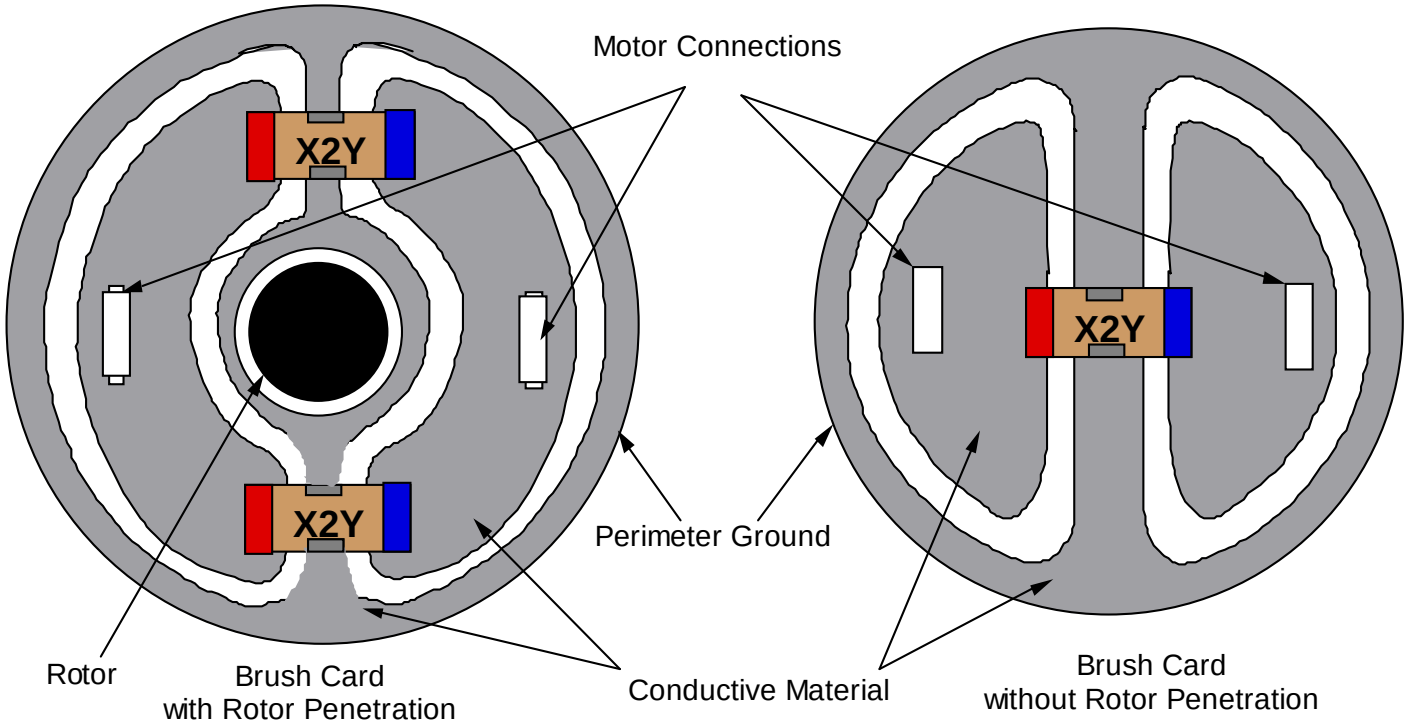
Two Speed Motor Attachment for X2Y



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

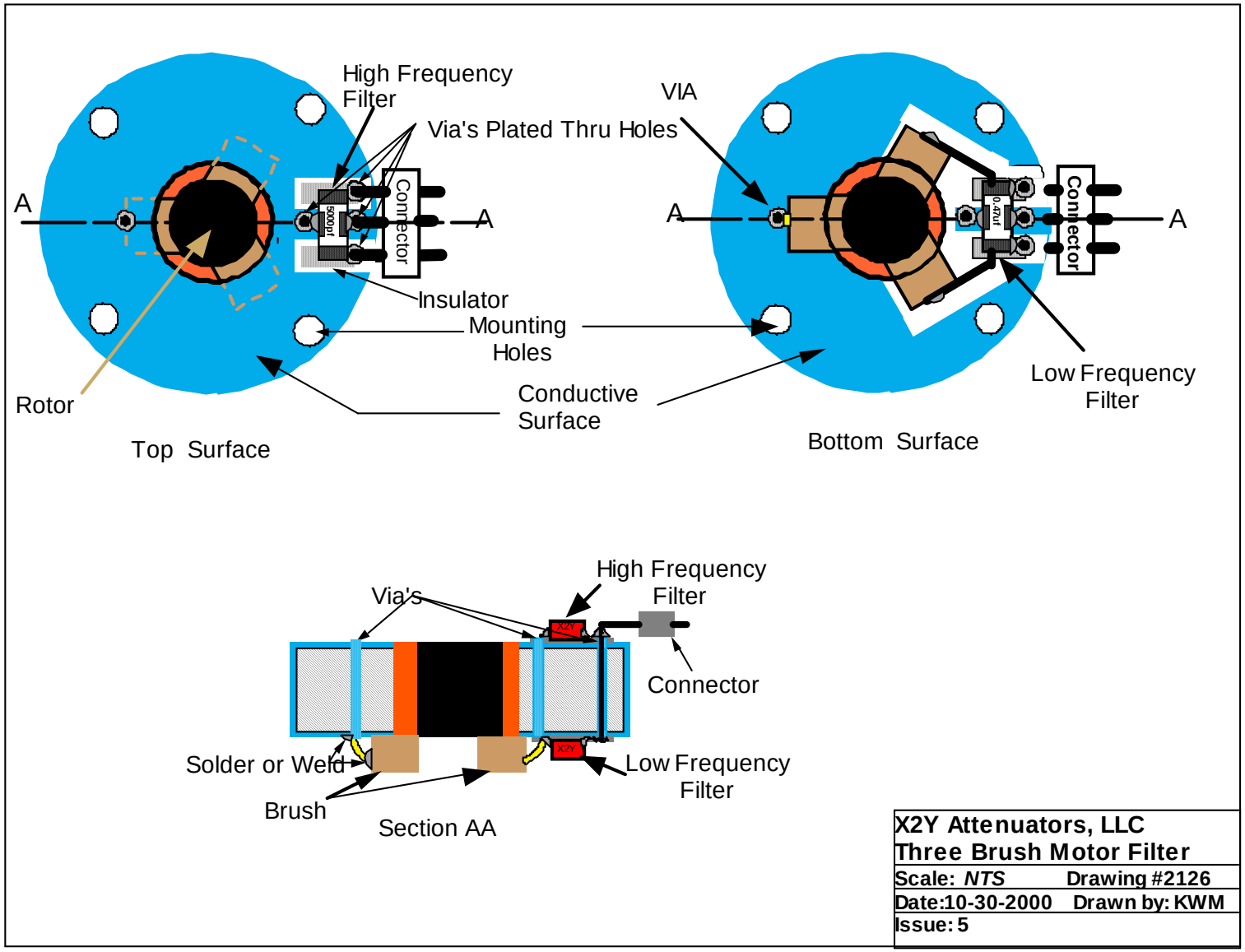


Notes:
(1) Can use 1 or 2 X2Y devices as required to meet specific filtering needs.
(2) Material recomendations are:
A) Plated or metalized Plastic
B) Insulated Metal
(3) Symmetry and Balance are very important.

Patent Pending

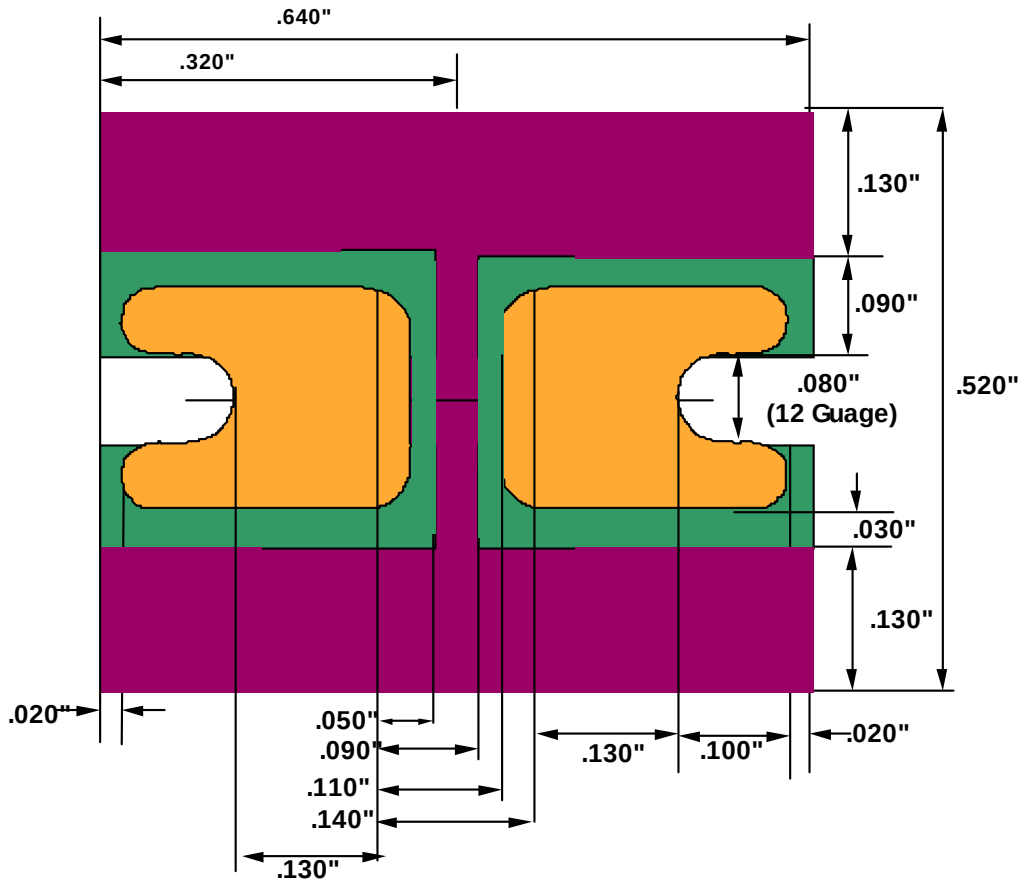
X2Y Attenuators, LLC.
Drawing # 2393
Brush Card Ideas
Issue 0, 10-22-2000

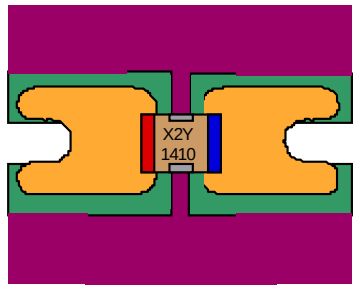
Mounting Options



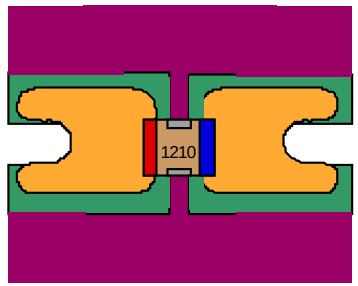
X2Y Attenuators, LLC	
Three Brush Motor Filter	
Scale: *NTS*	Drawing #2126
Date:10-30-2000	Drawn by: KWM
Issue: 5	

Mounting Options

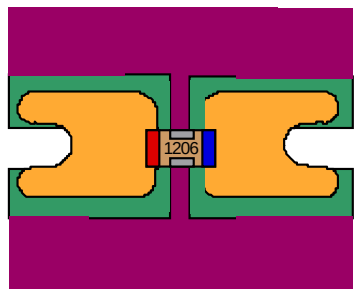




1410



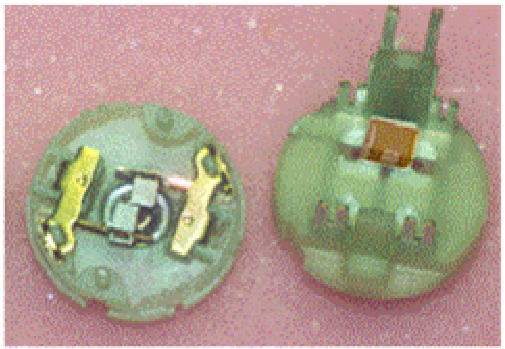
1210

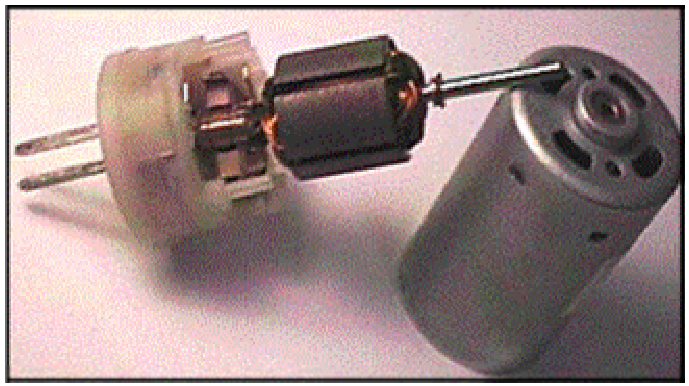


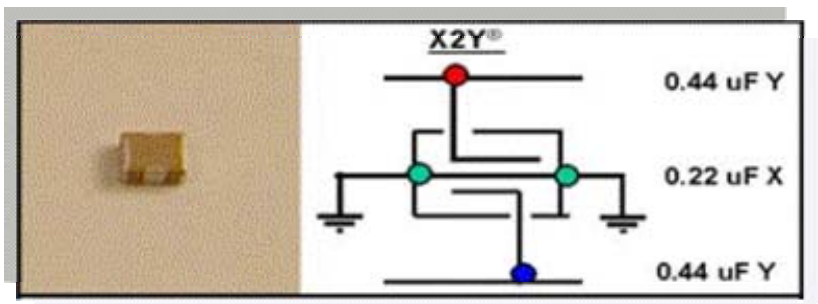
1206

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

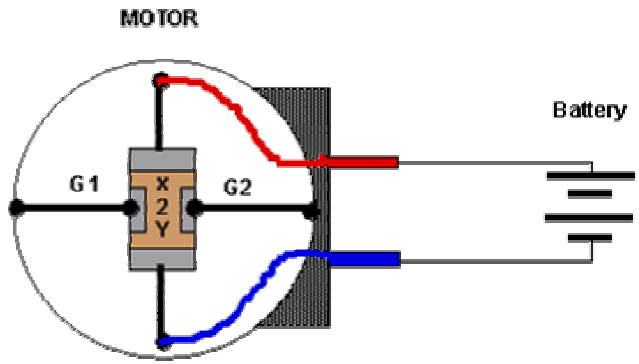
Mounting Options



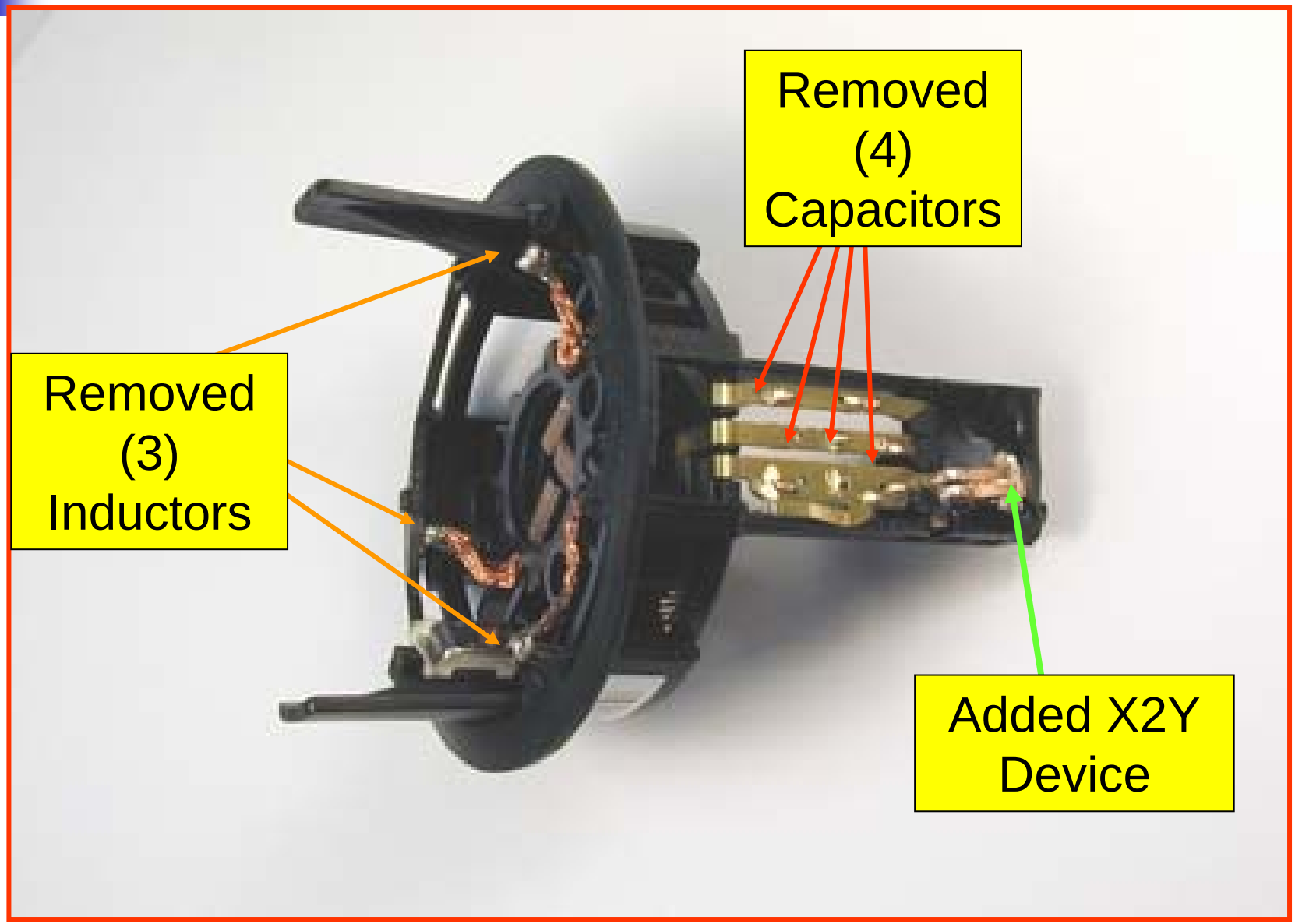




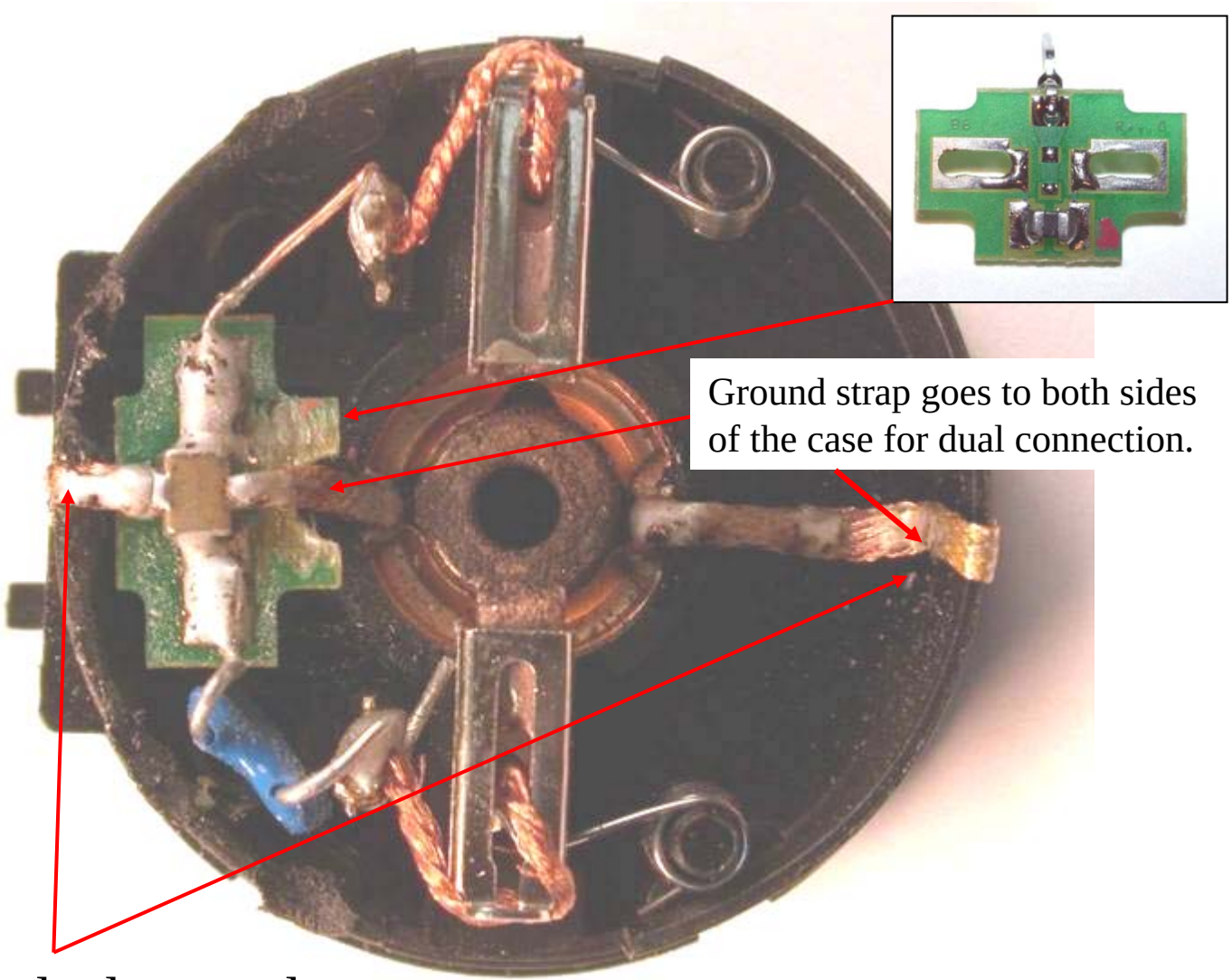
X2Y in a (2) Wire Motor Application



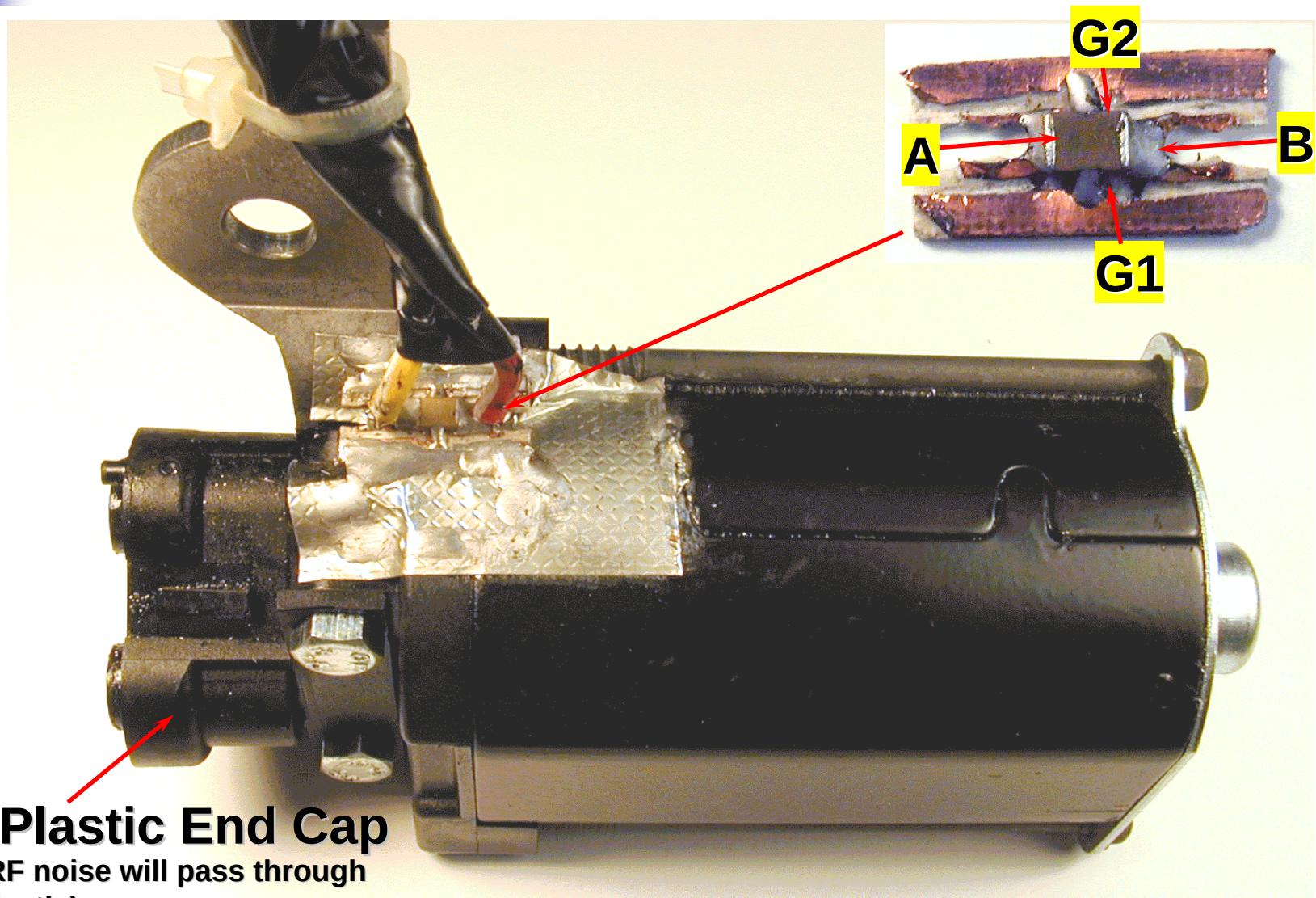
Mounting Options



Mounting Options



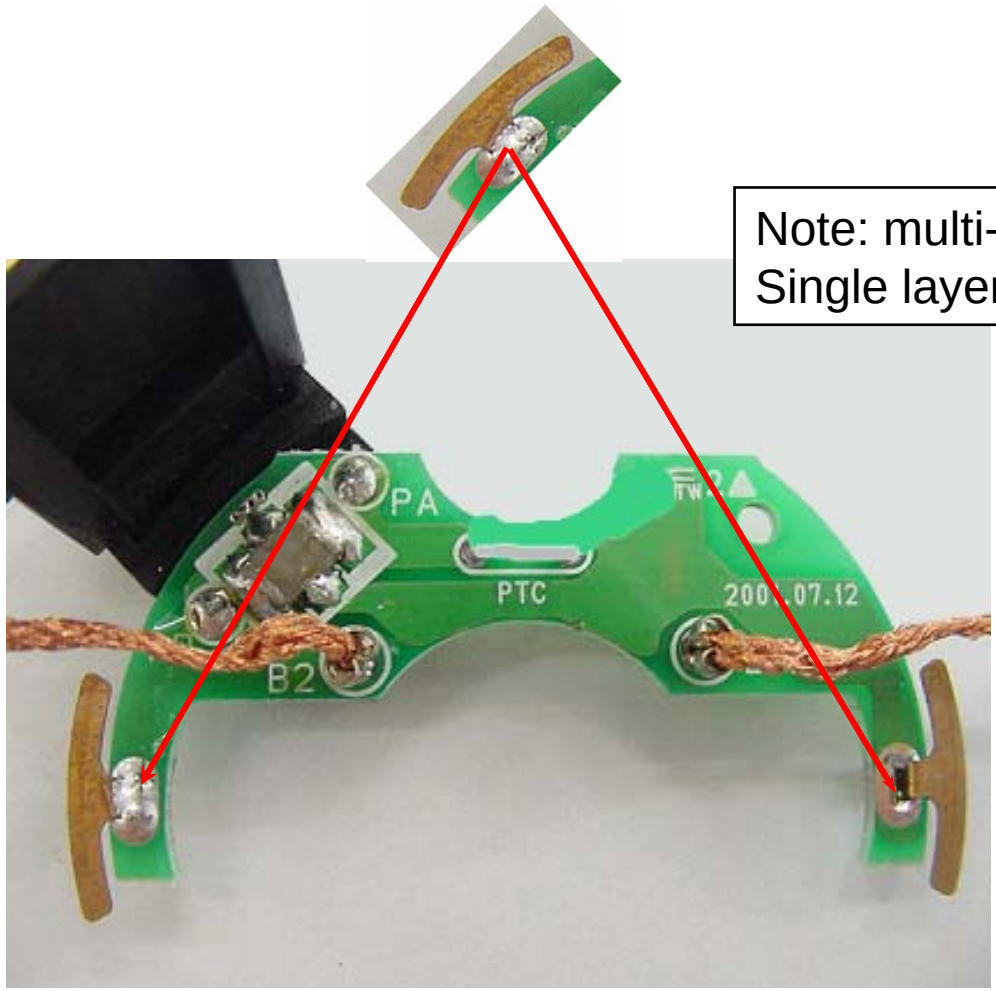
Mounting Options



Mounting Options

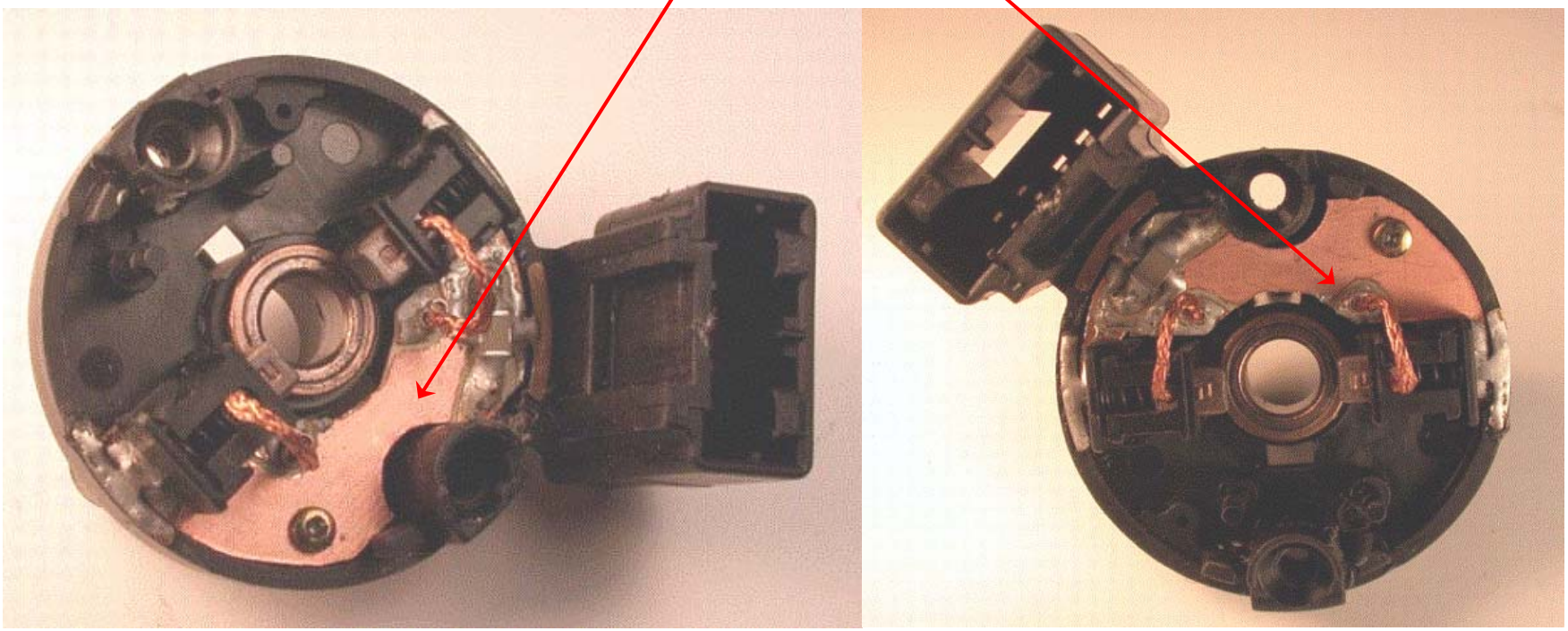
X2Y Between Leads

Add multiple ground tabs

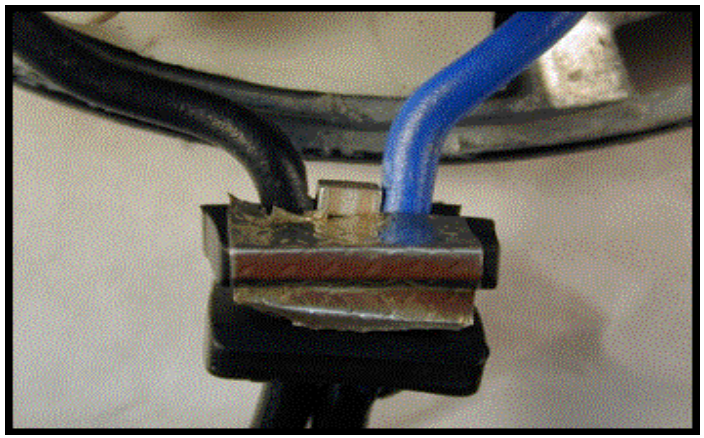


Note: multi-layer PC ground!
Single layer ground is better

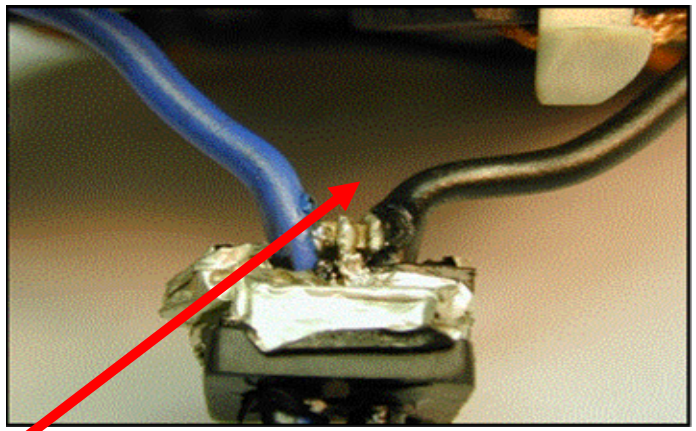
New board with X2Y mounted in motor



Engine Cooling Fan Motor

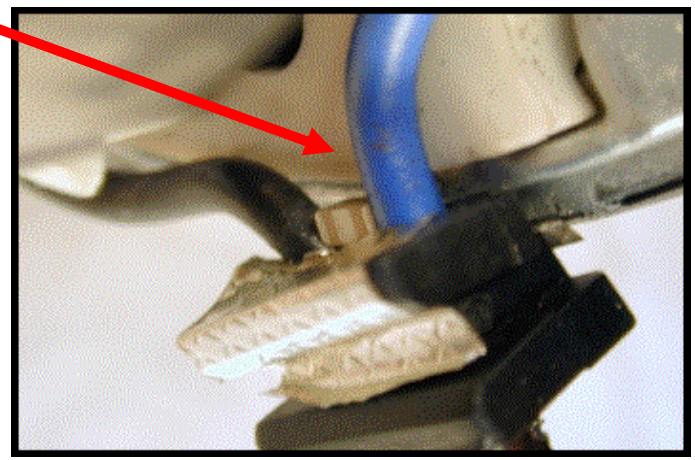


X2Y (2) Wire Grommet in a DC Motor



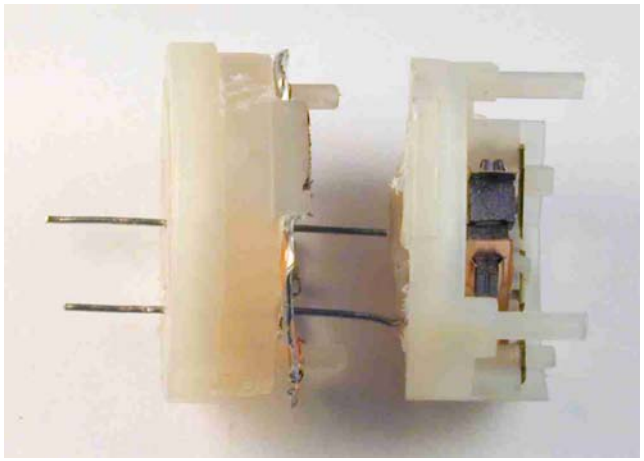
X2Y (2) Wire Grommet in a DC Motor

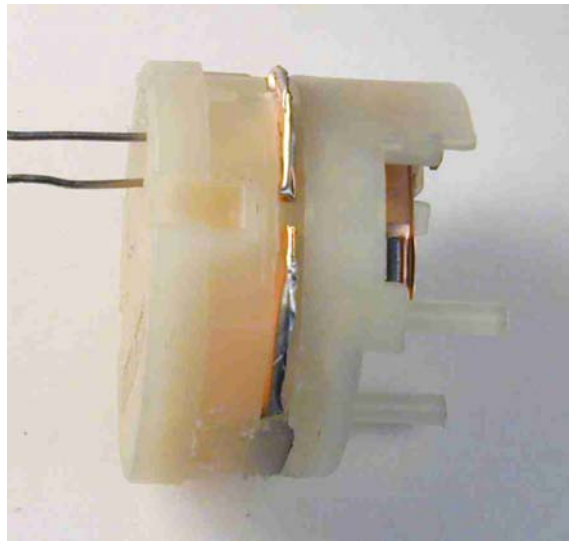
A grommet or a connector is a great place to put X2Y. X2Y is shown (not) soldered between A & B with G1& G2 connected to conductive screen or lining placed in grommet.

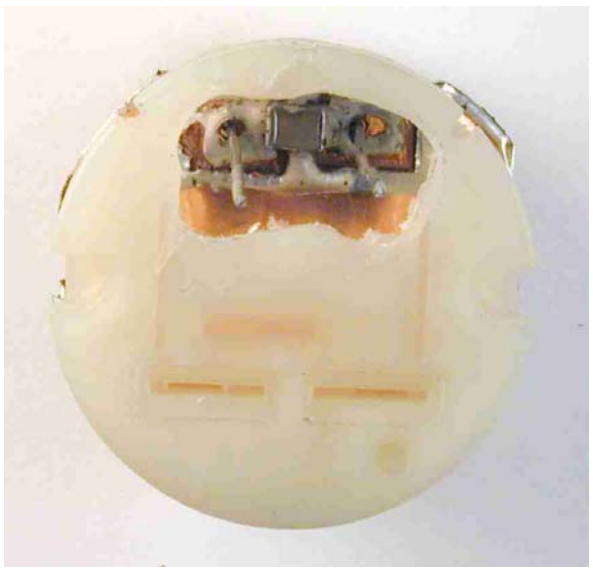


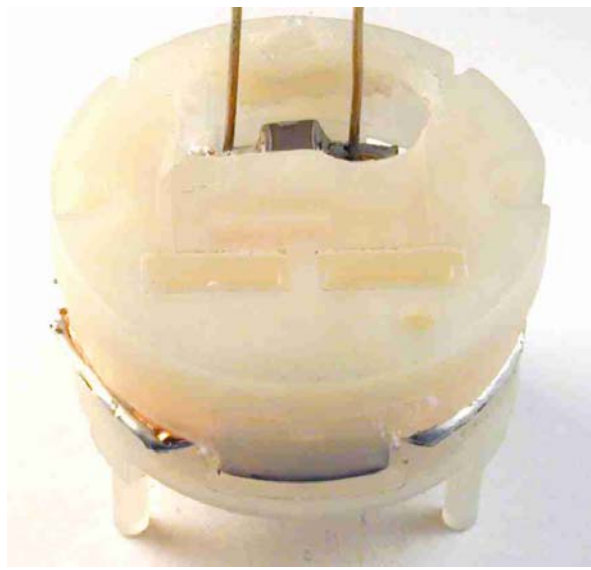
X2Y (2) Wire Grommet in a DC Motor

Mounting Options

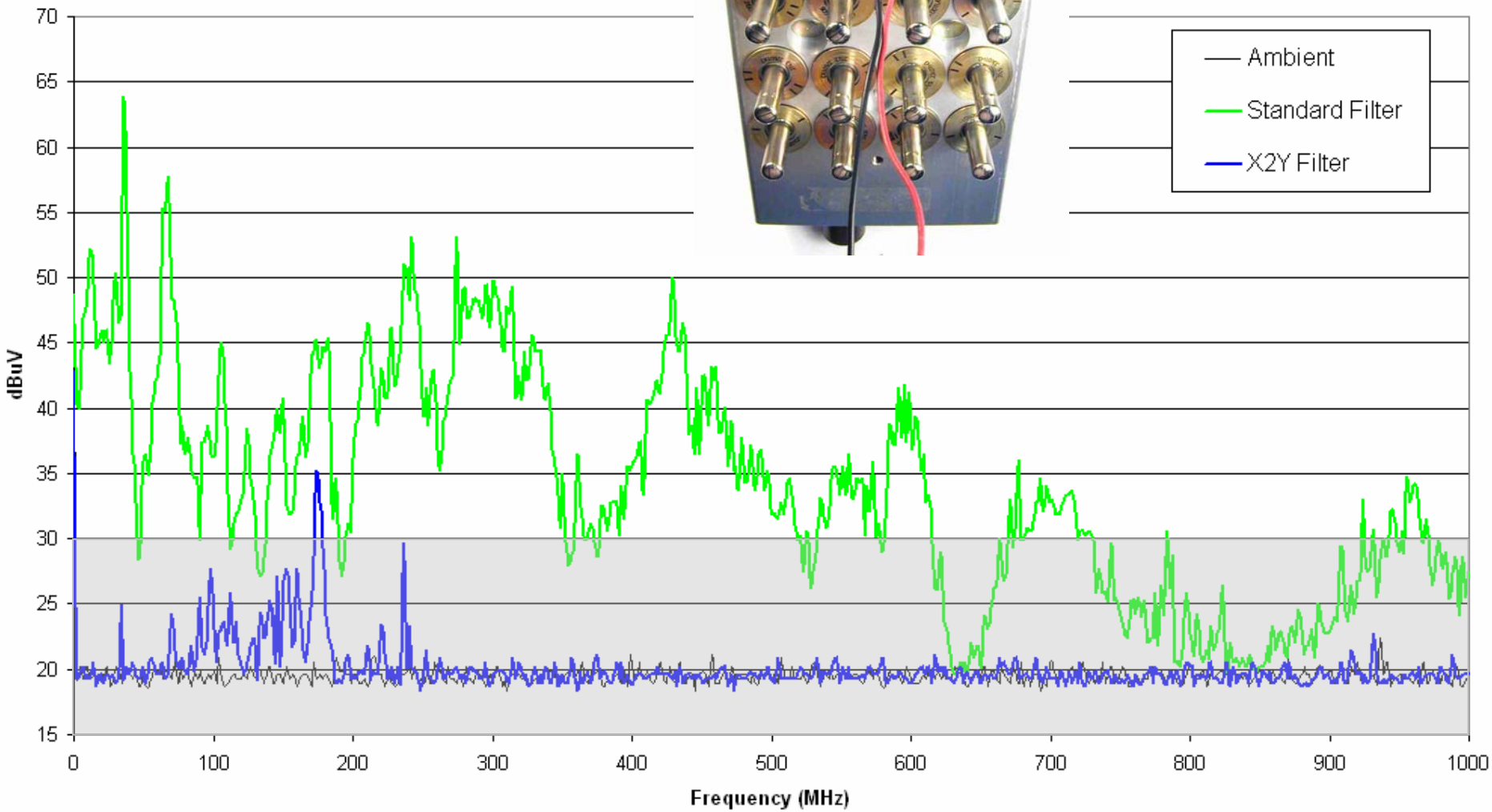








Radiated Emissions - ABS Motor



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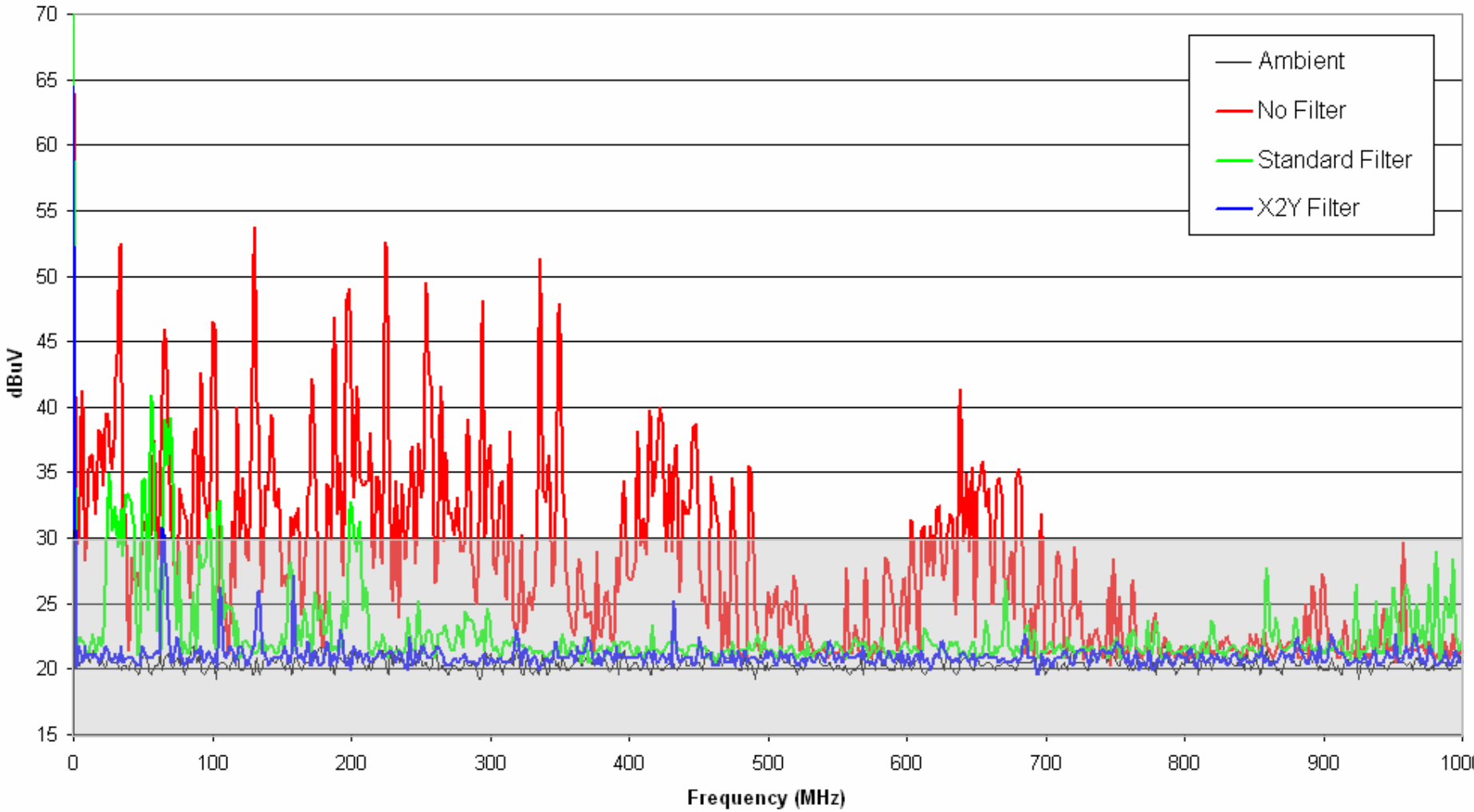
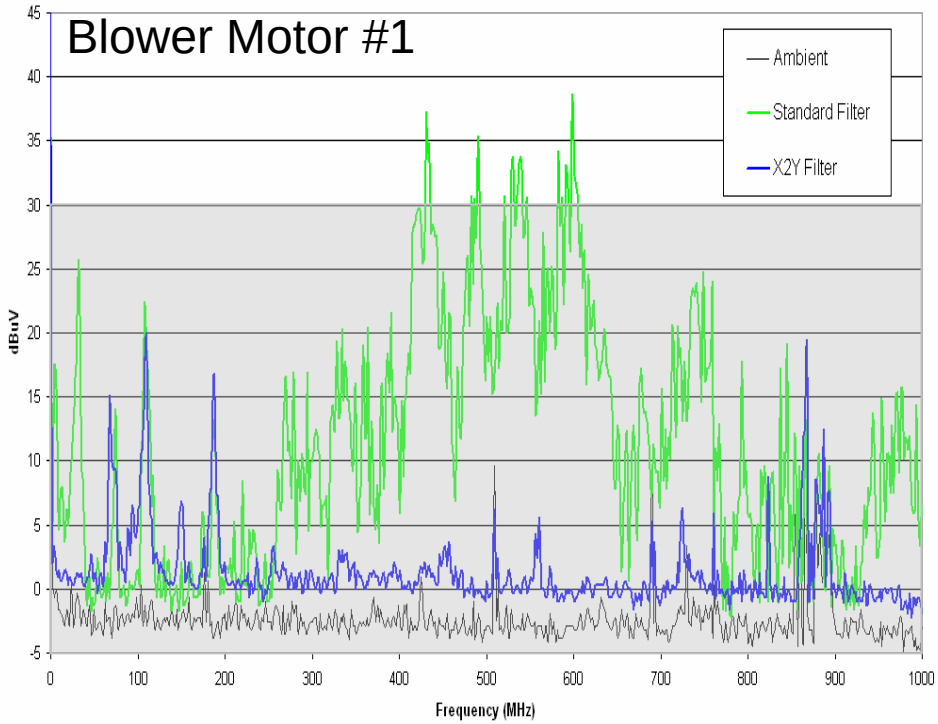
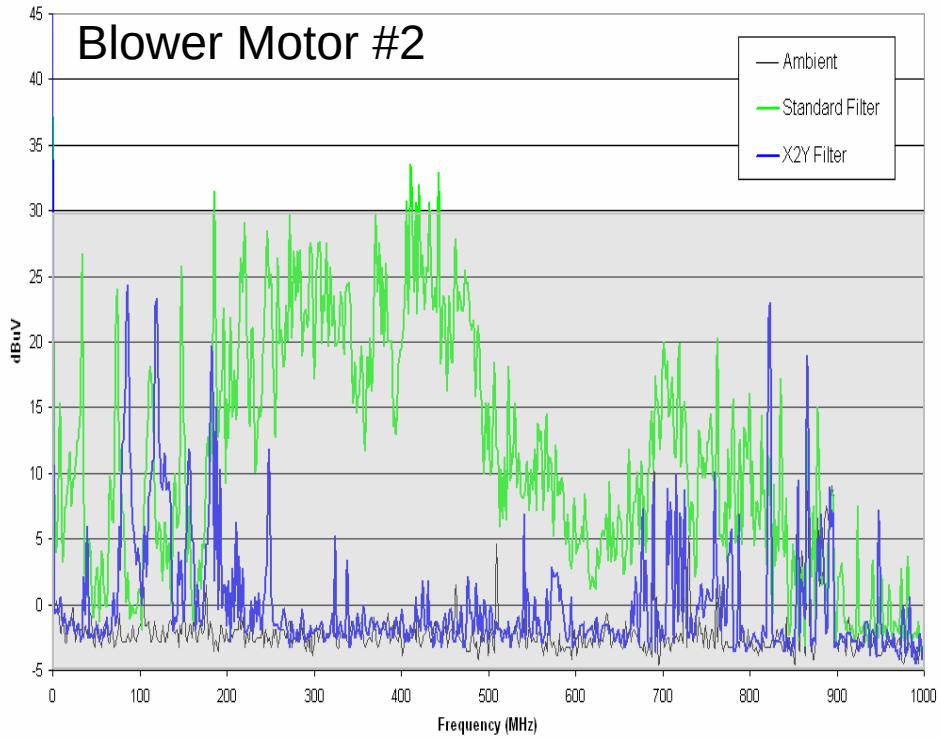
Radiated Emissions - Air Compressor Motor



Radiated Emissions - Blower Motors

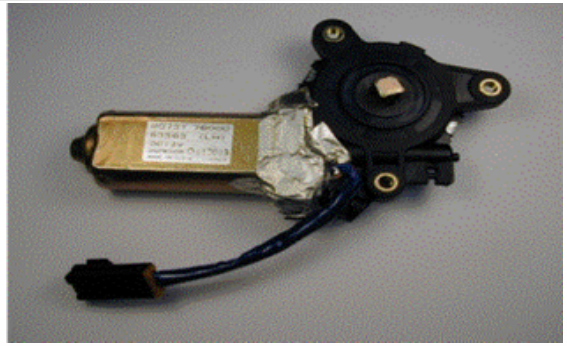
- 30dB pre-amp was used.

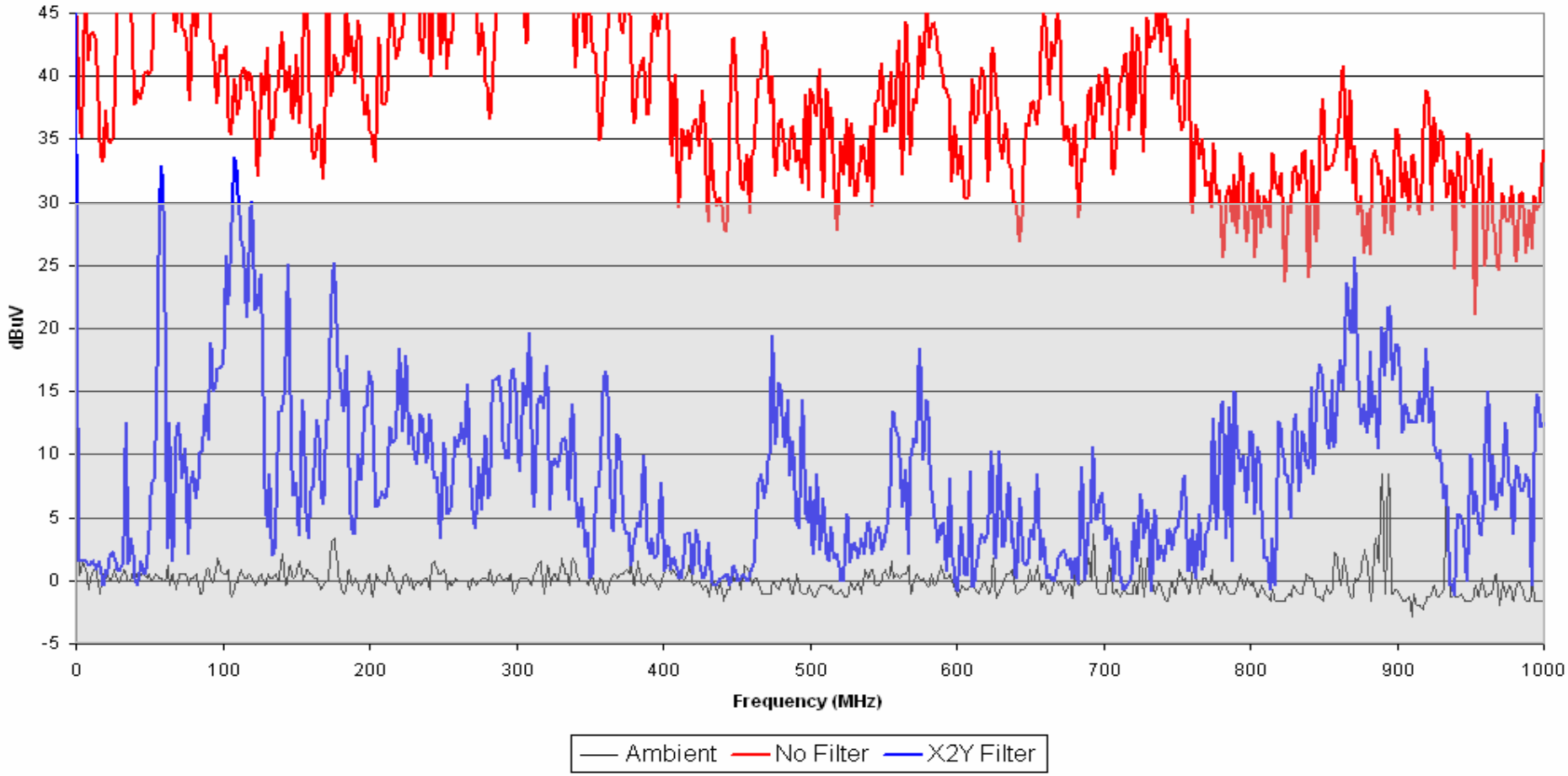




Radiated Emissions - Lift Gate Motor

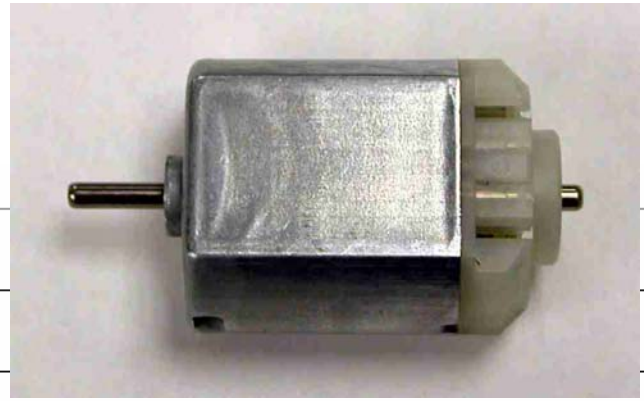
- 30dB pre-amp was used.

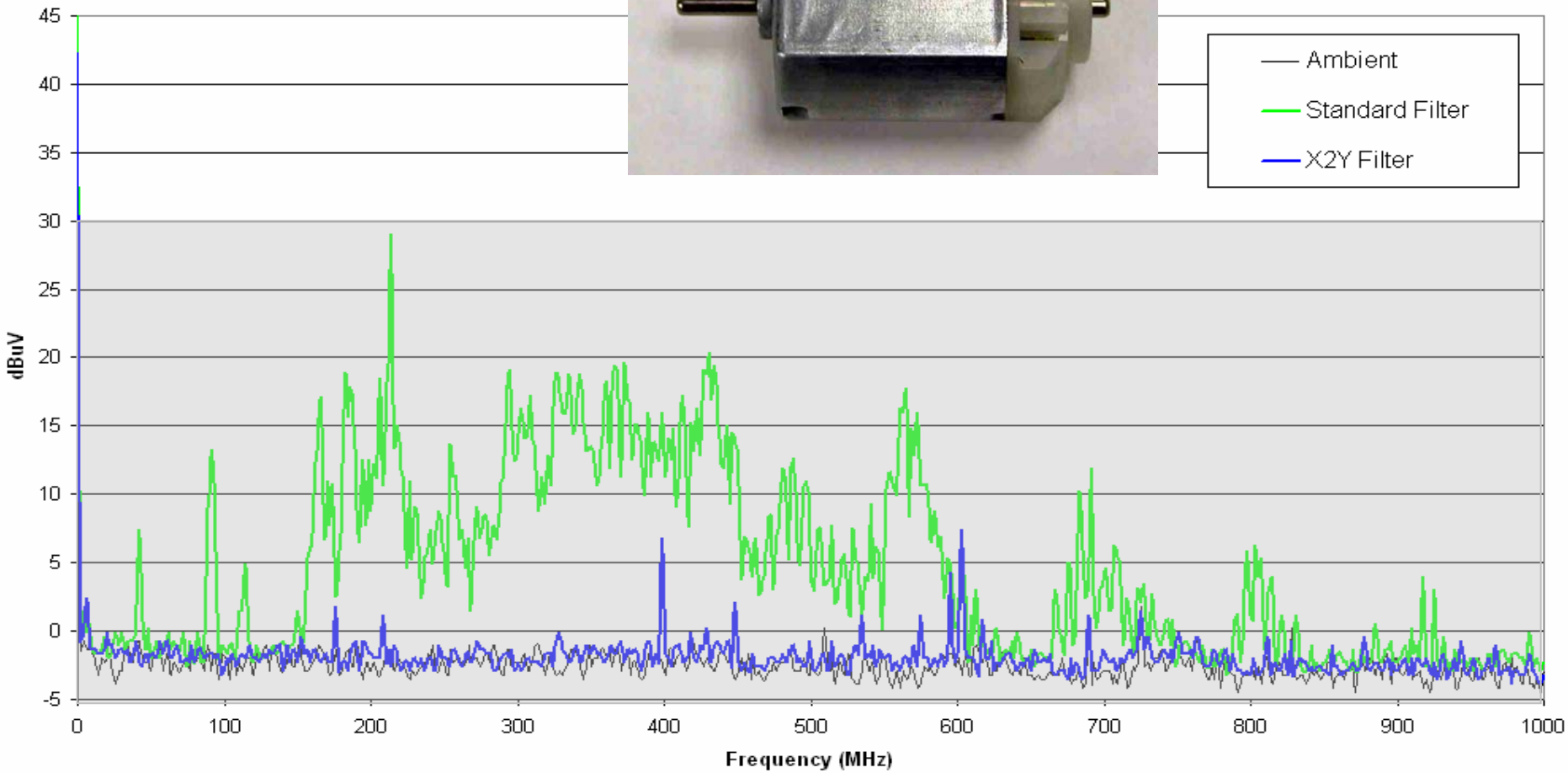




Radiated Emissions - Mirror Motor

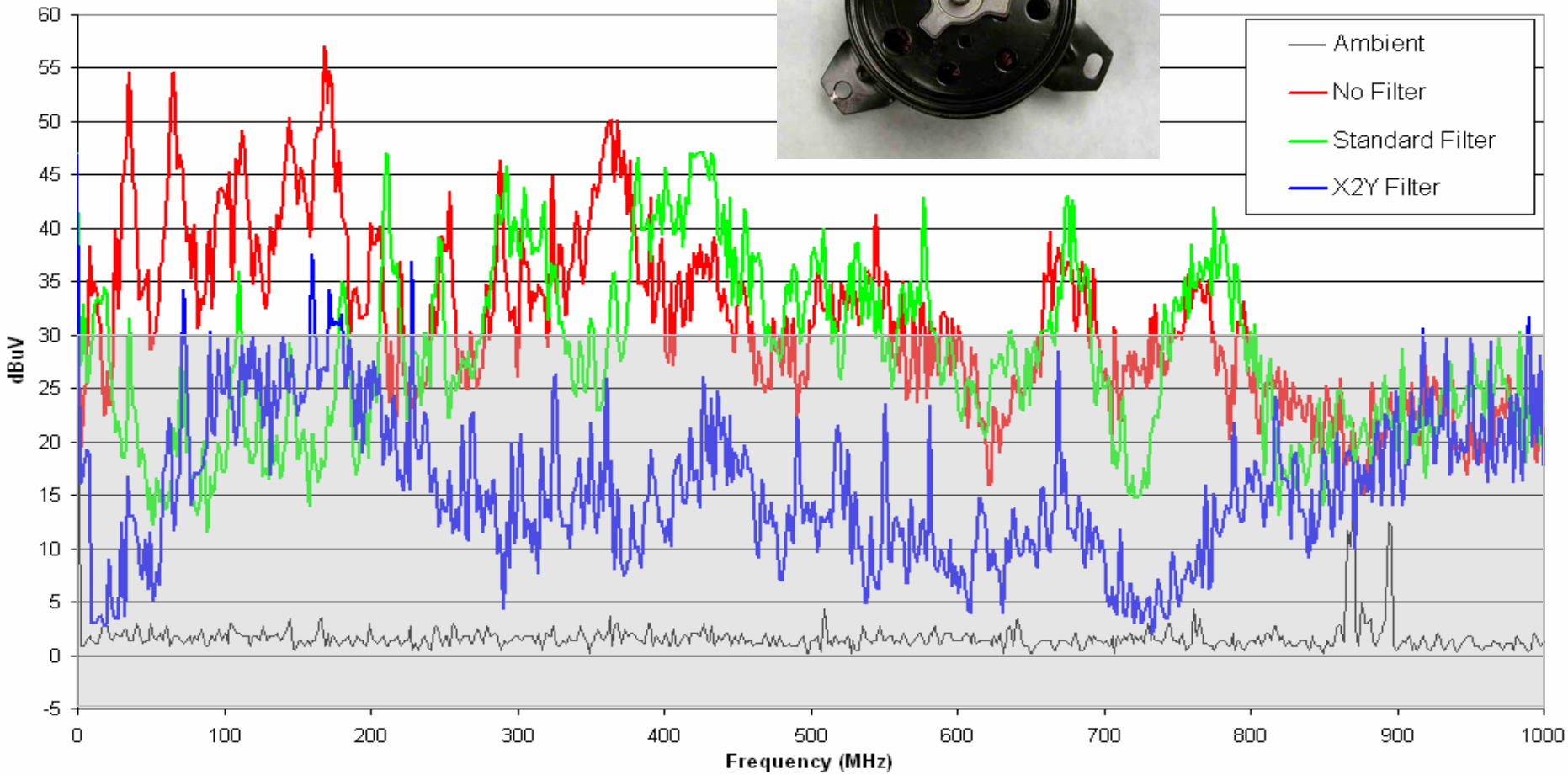
- 30dB pre-amp was used.





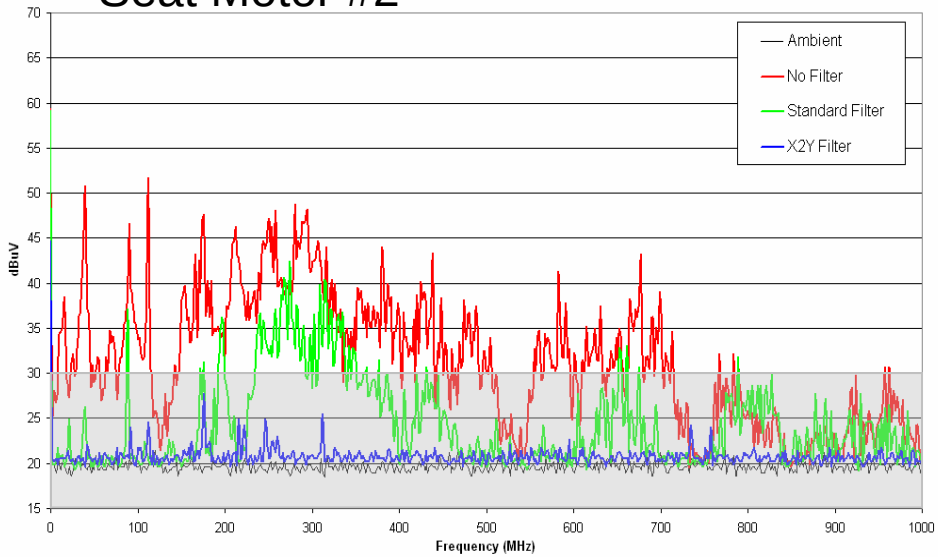
Radiated Emissions - Radiator Fan Motor

- 30dB pre-amp was used.

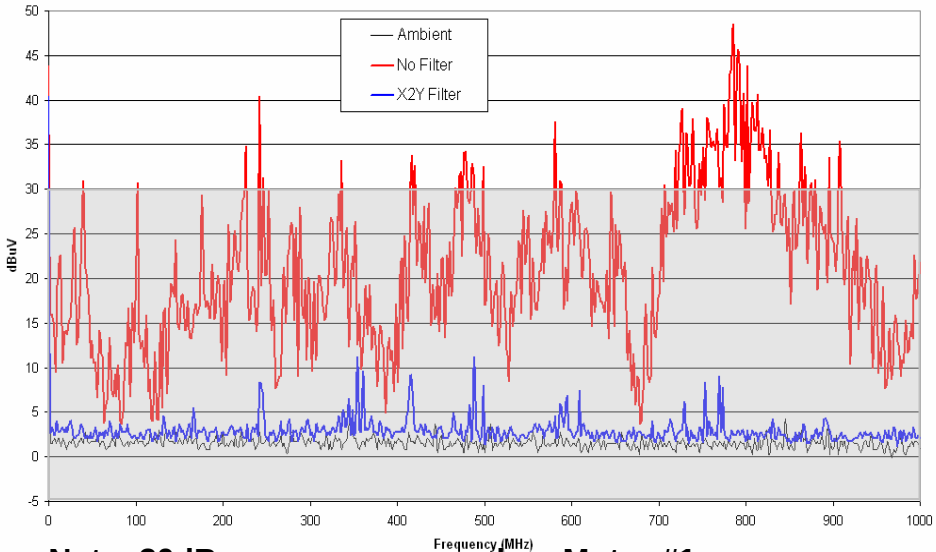


Radiated Emissions - Seat Motors

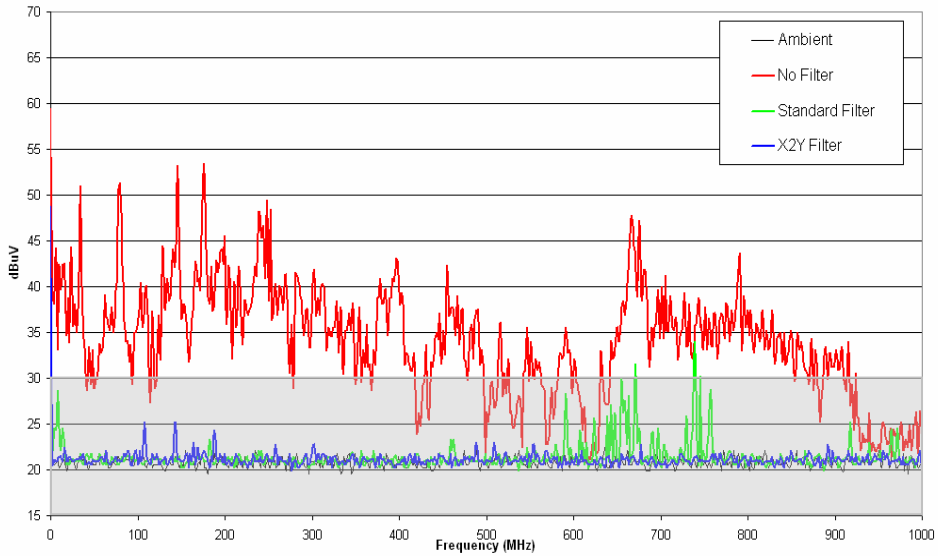
Seat Motor #2



Seat Motor #1

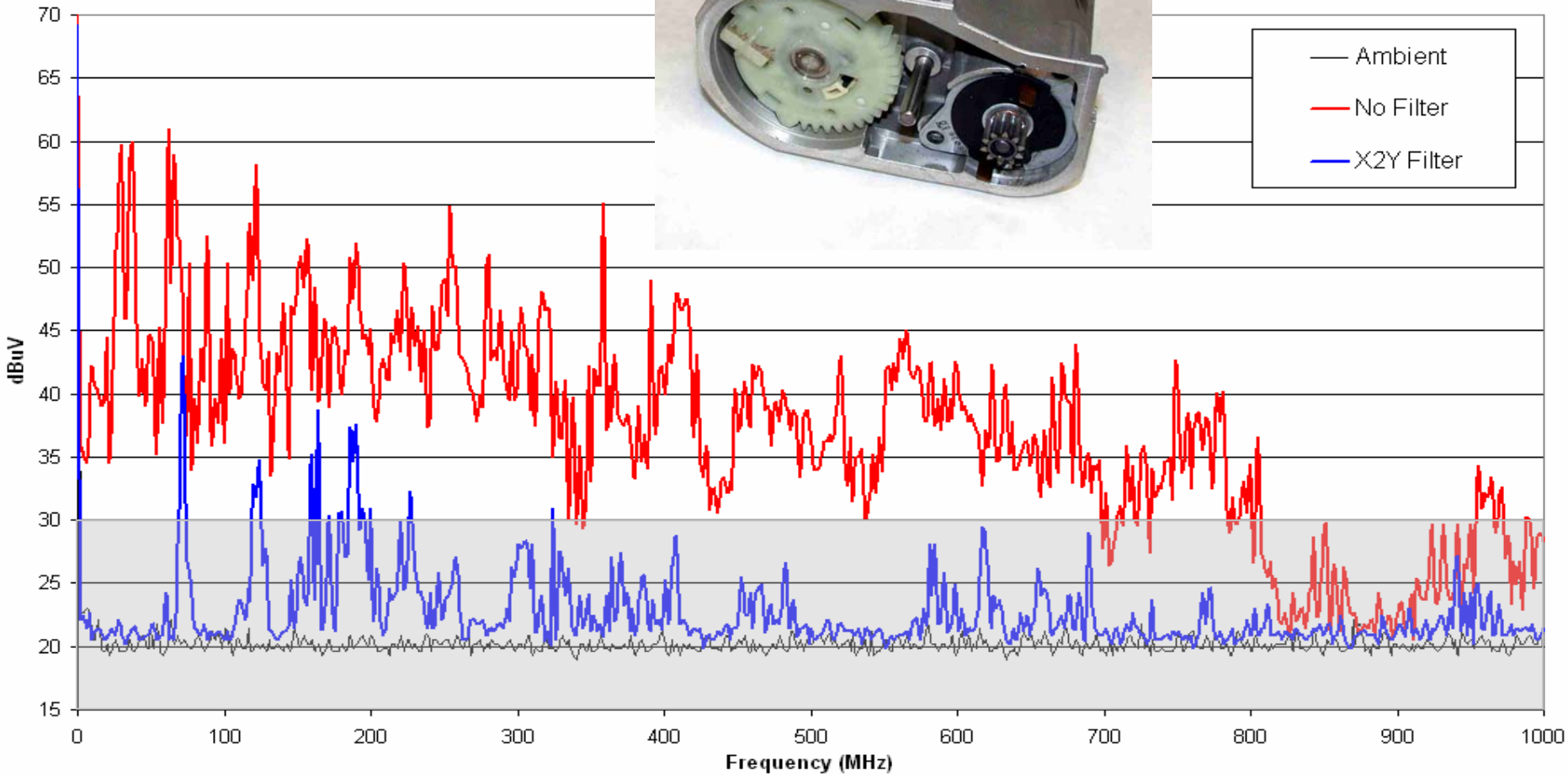


Seat Motor #3

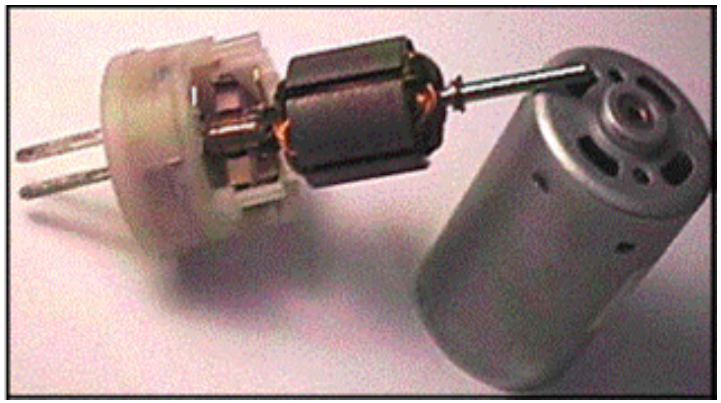


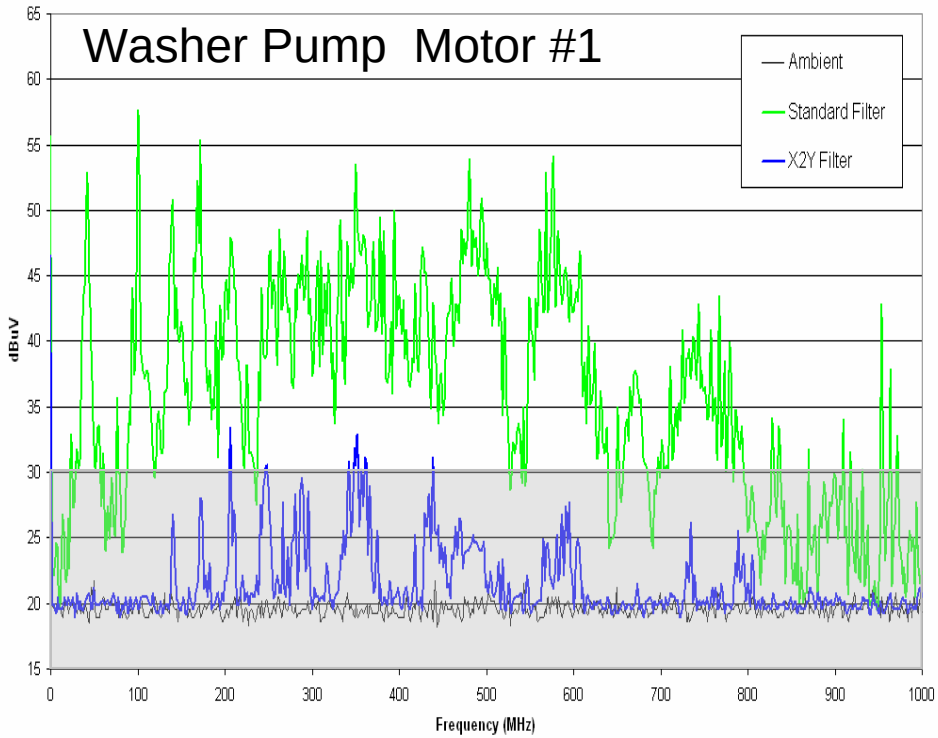
Note: 30dB pre-amp was used on Motor #1

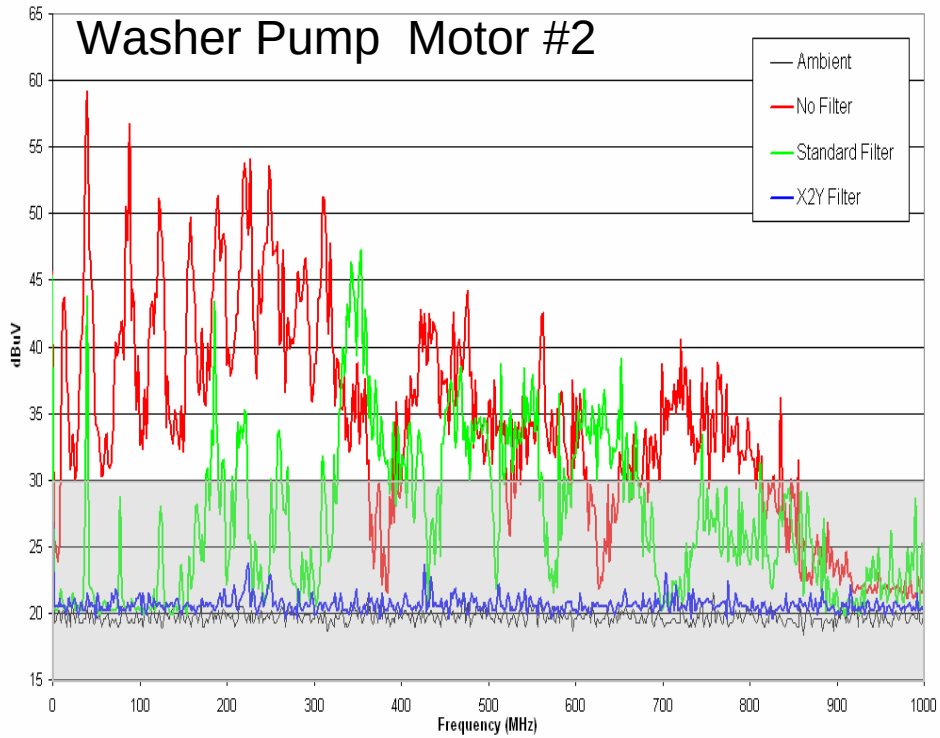
Radiated Emissions - Throttle Body Motor



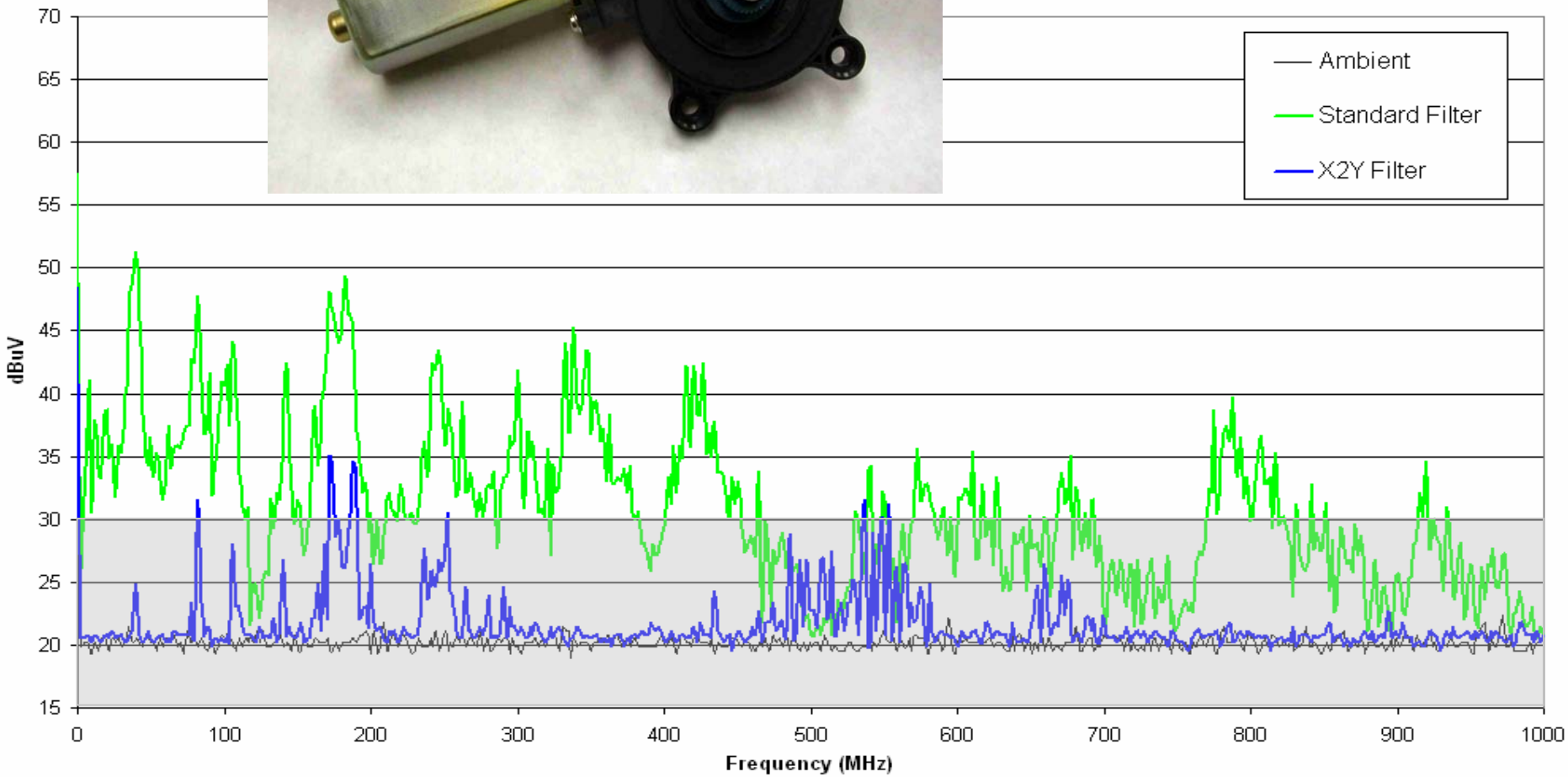
Radiated Emissions - Washer Pump Motors



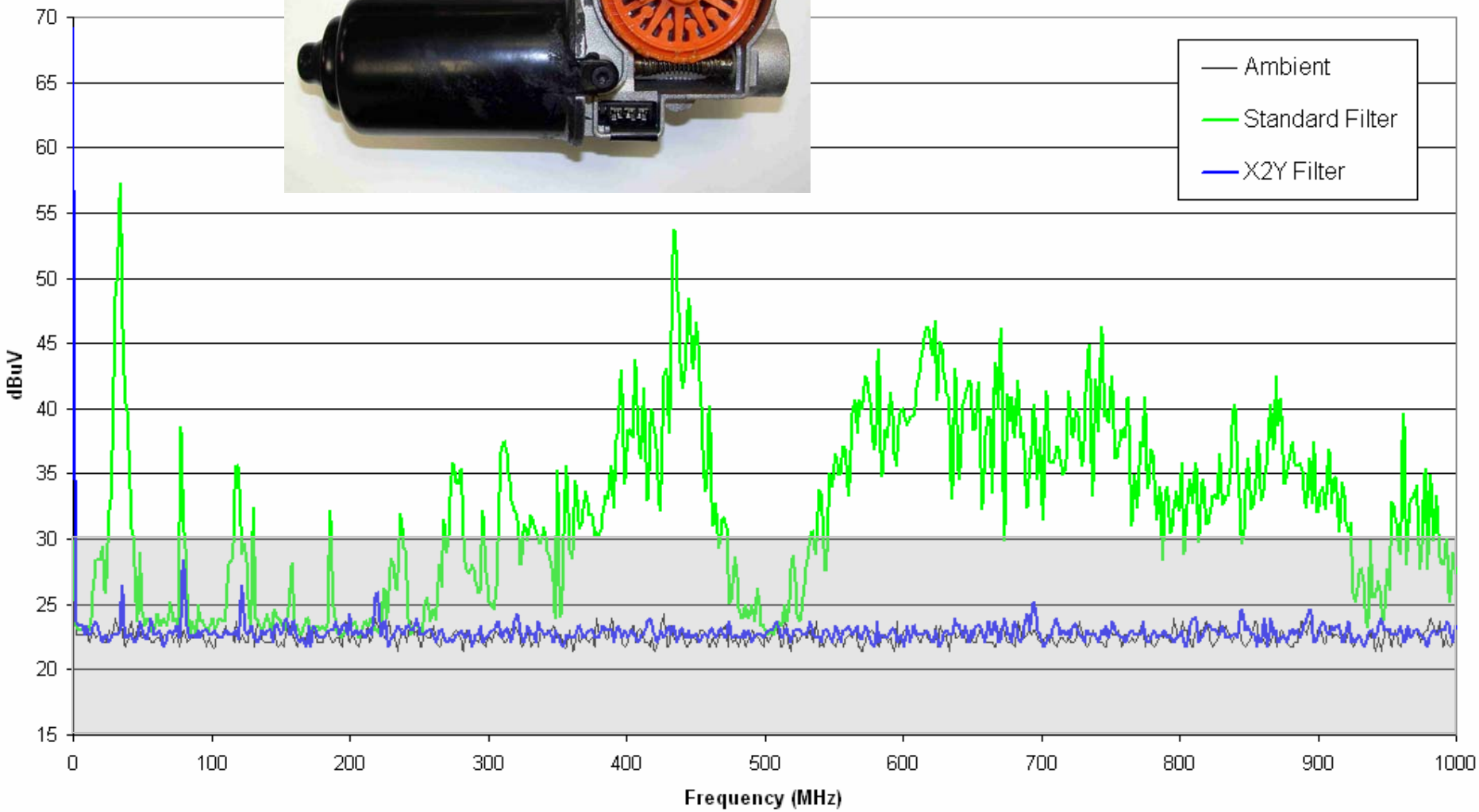




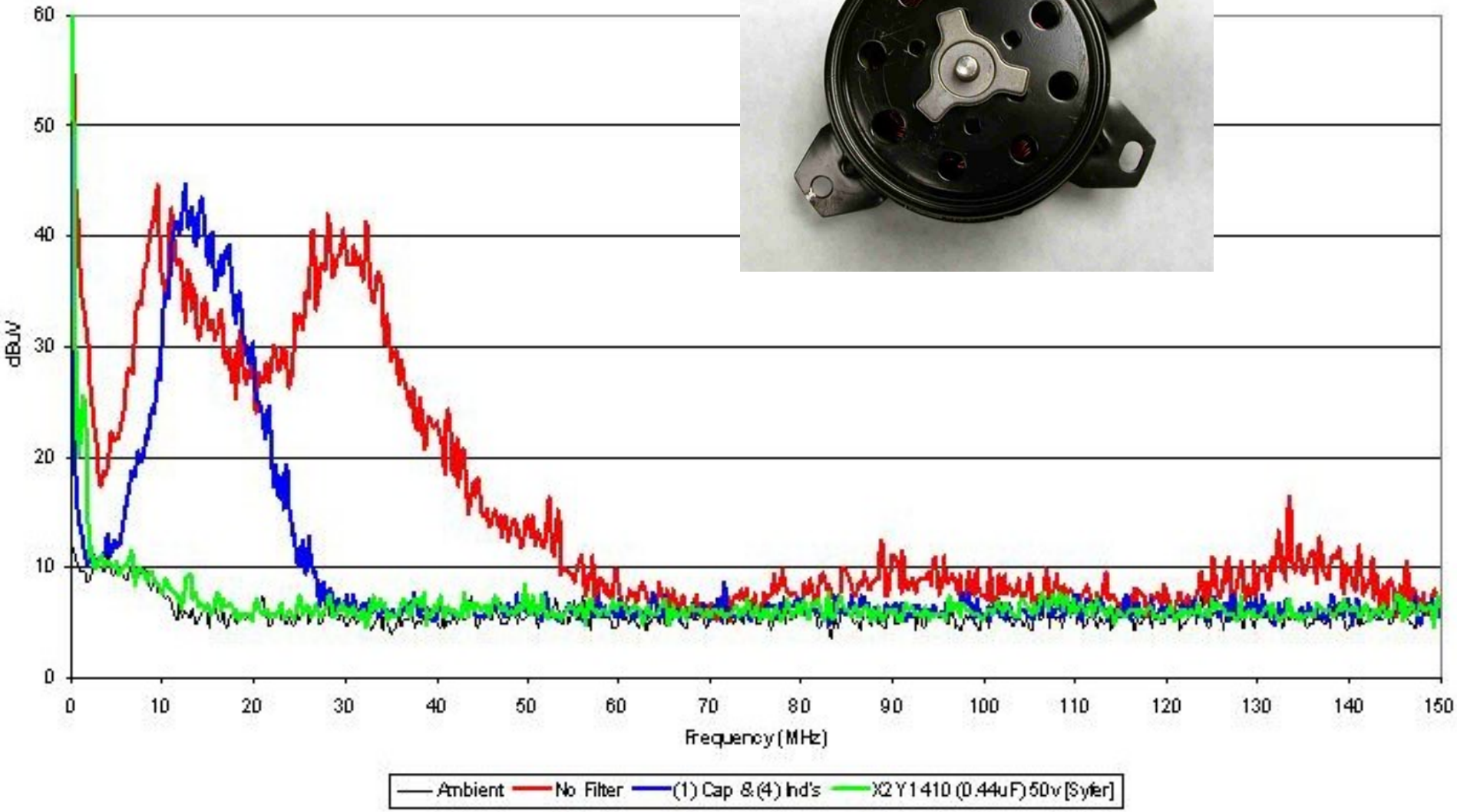
Radiated Emissions - Window Lift Motor



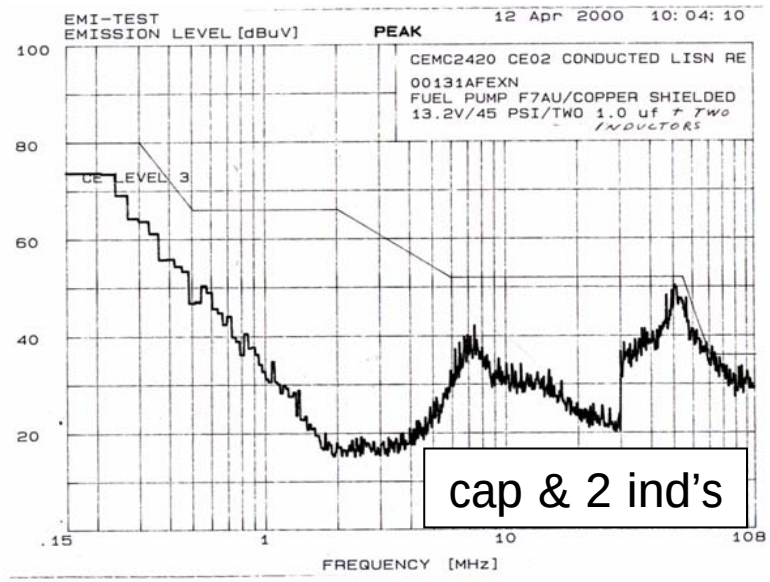
Radiated Emissions - Wiper Motor (3-brush, 2-speed)

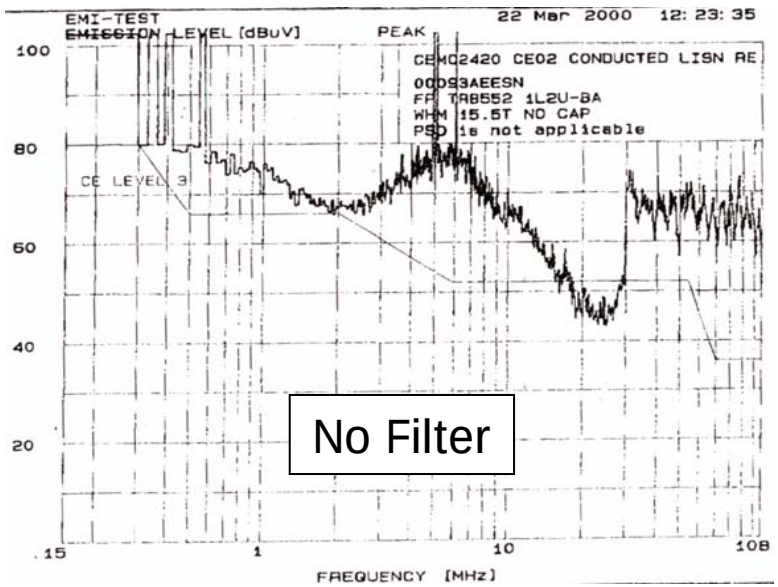


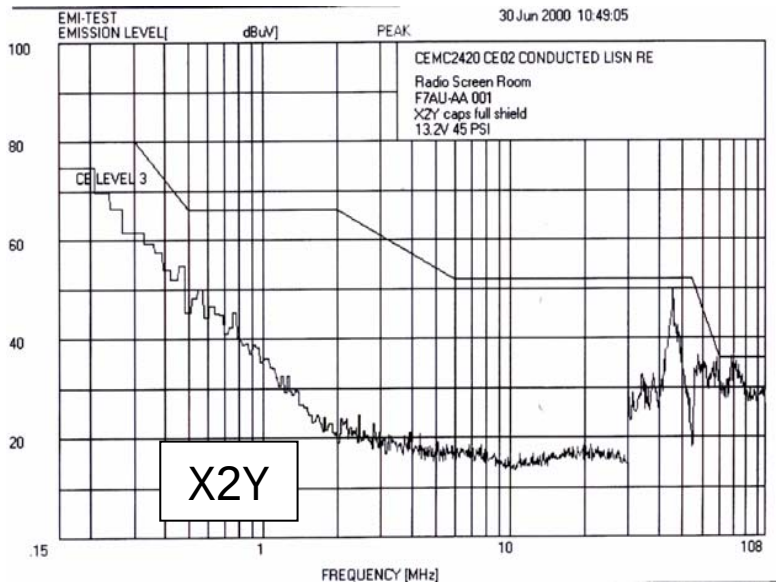
Conducted Emissions – Radiator Fan Motor



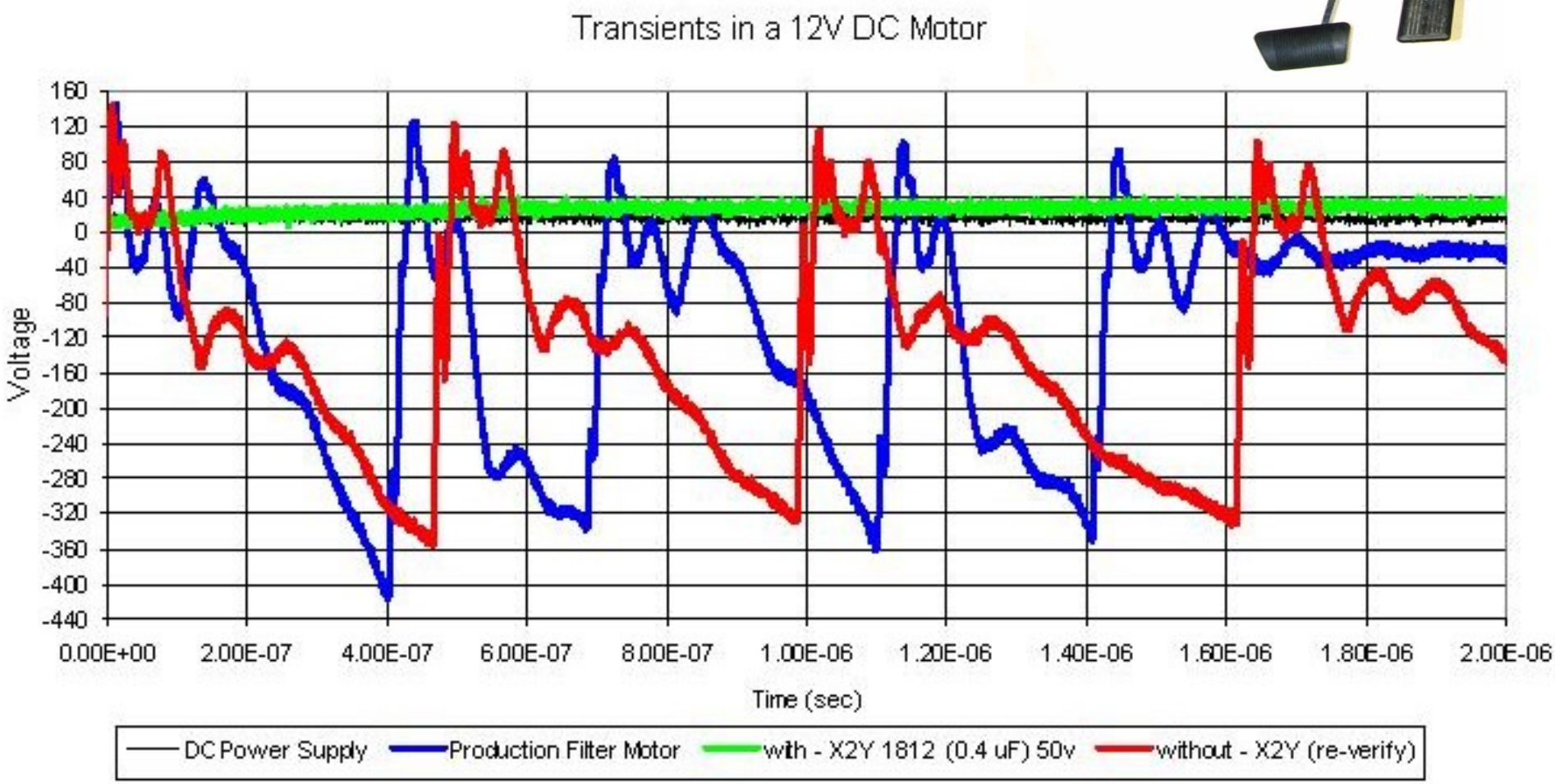
Conducted Emissions – Fuel Pump Motor



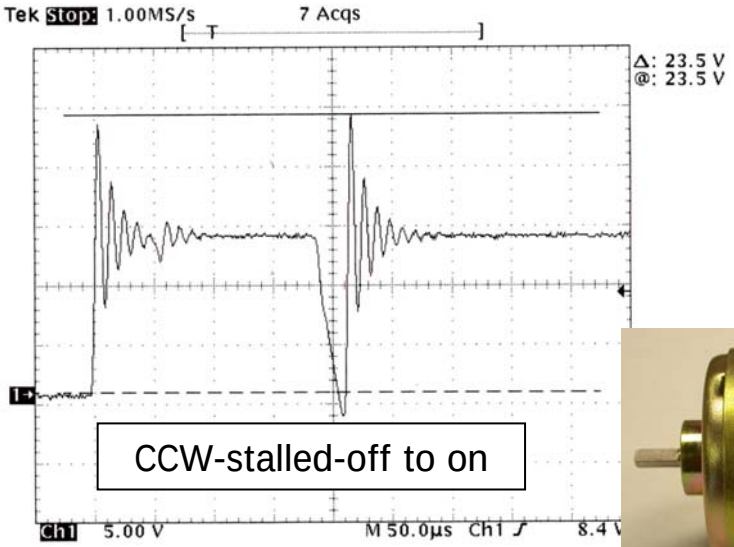




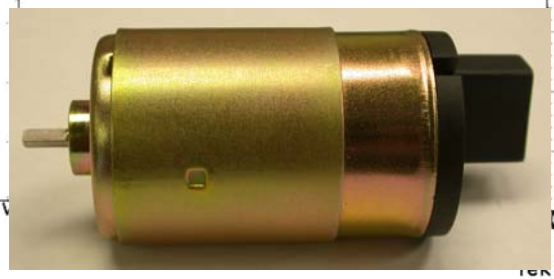
Transient Testing – 12v Brake Pedal Motor

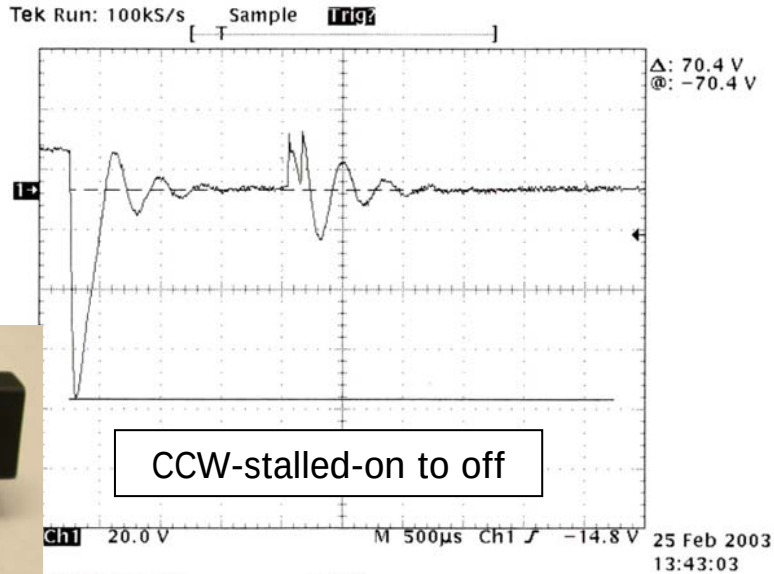


Transient Testing – Seat Motor (UL Tested)

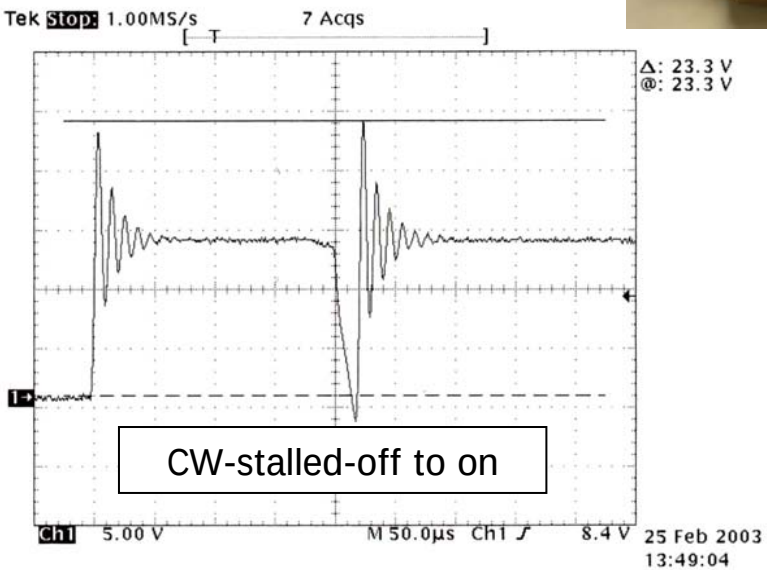


CCW-stalled-off to on

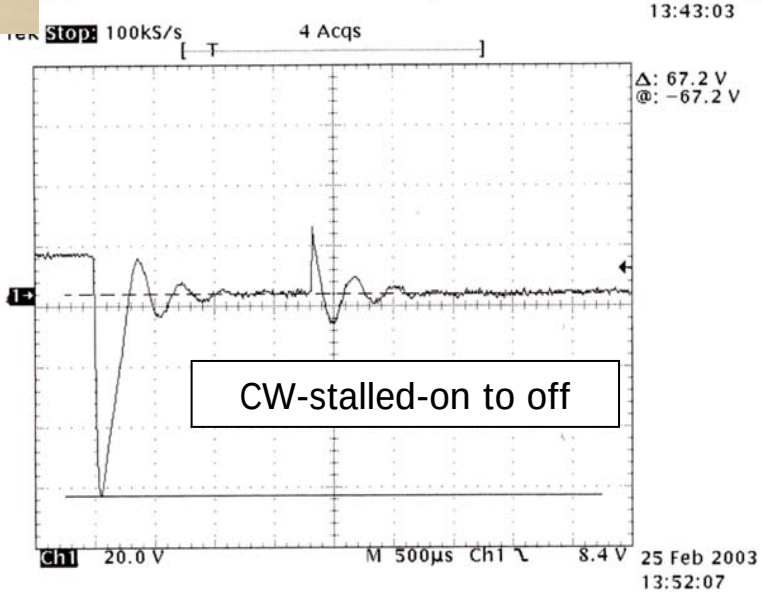




CCW-stalled-on to off



CW-stalled-off to on



CW-stalled-on to off

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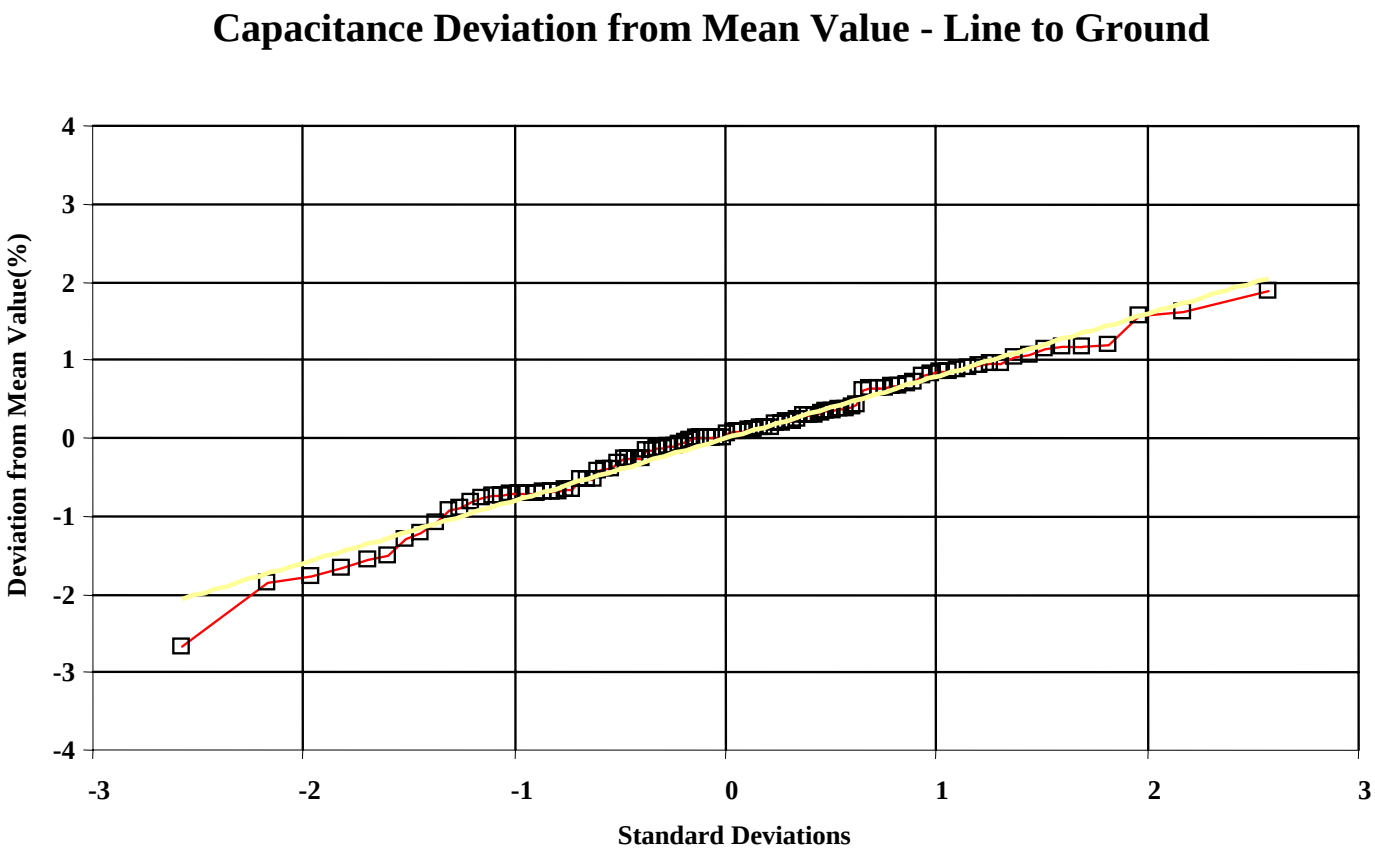
Electrical Testing Conducted

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

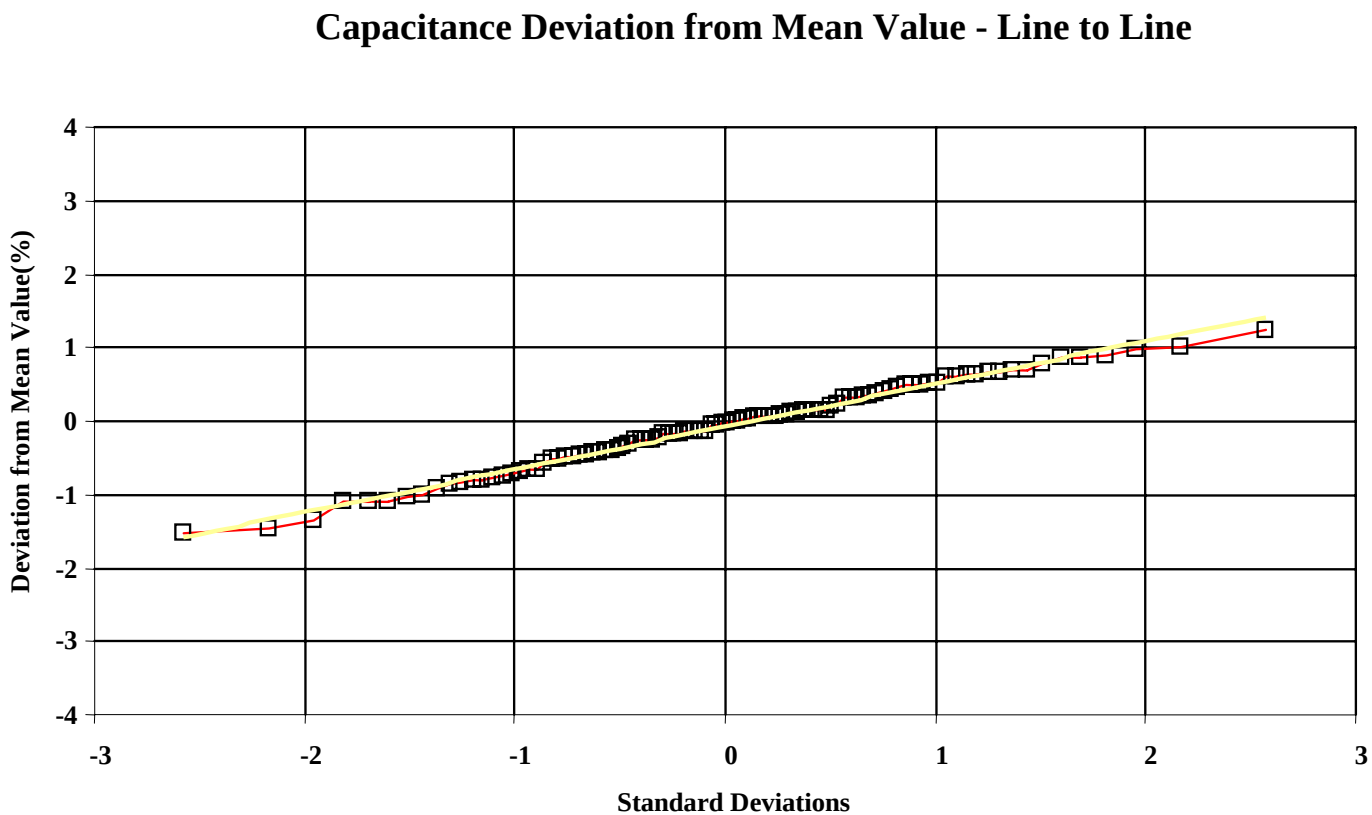
Capacitance Distribution

Syfer part 1410J0500404MXTE03



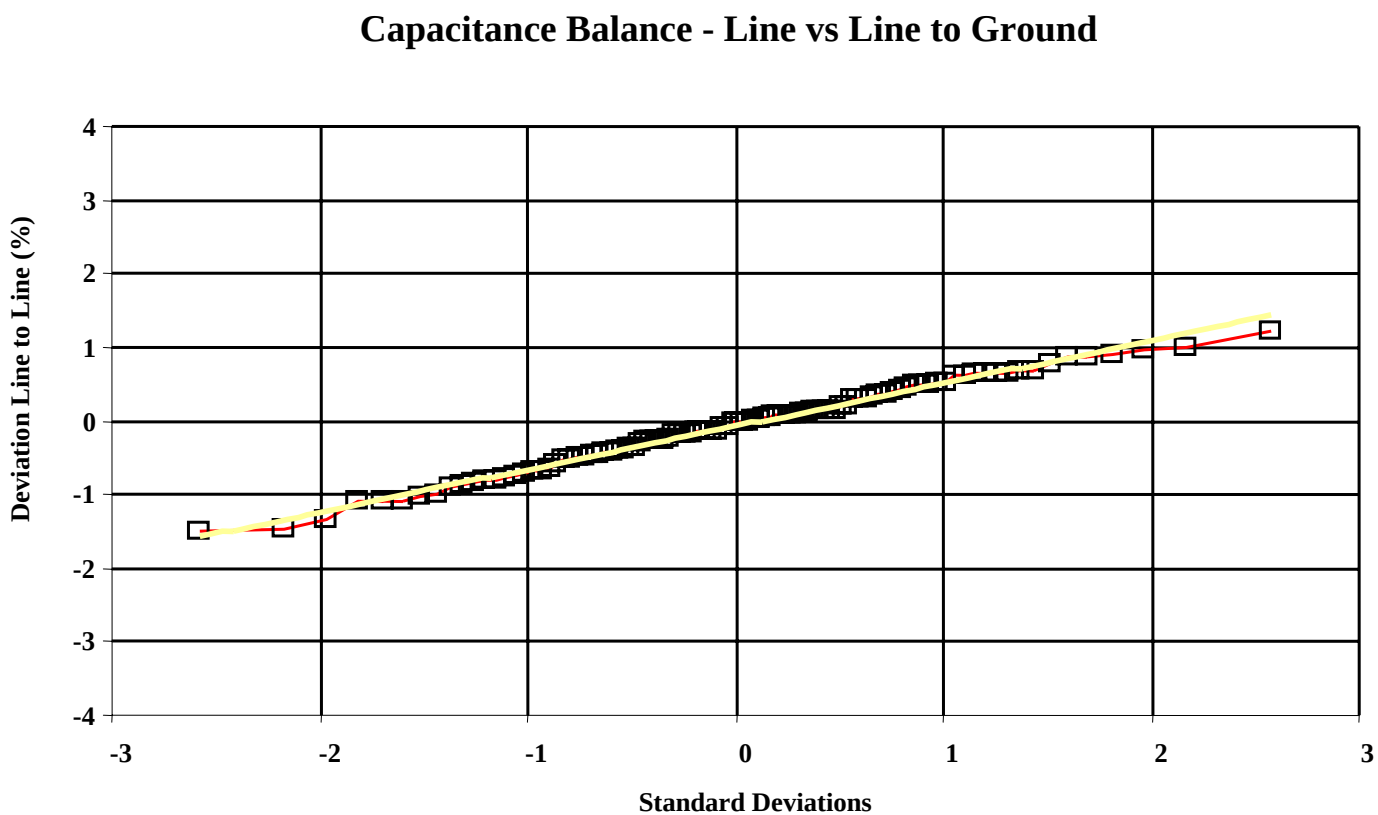
Capacitance Distribution

Syfer part 1410J0500404MXTE03

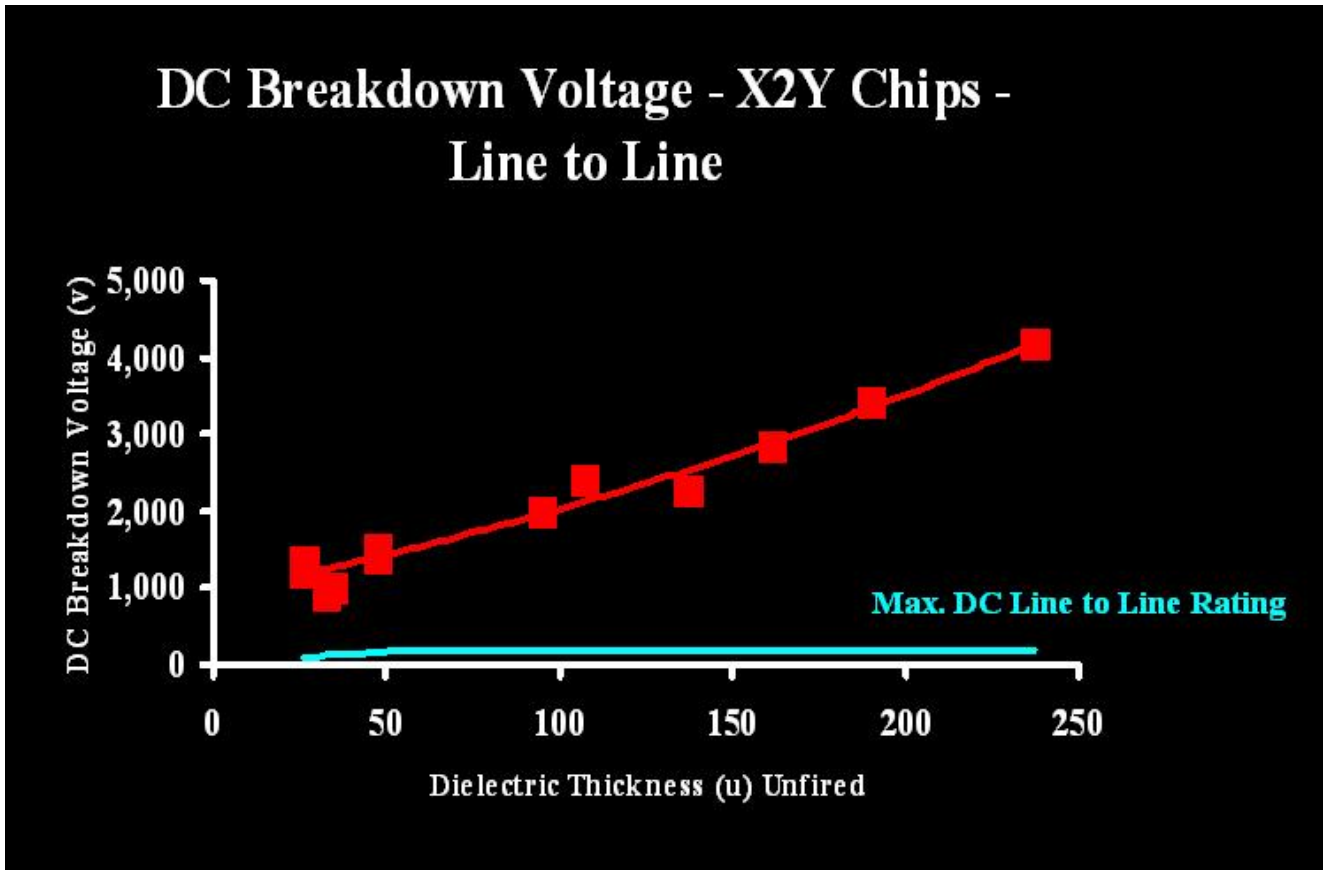


Capacitance Balancing

Syfer part 1410J0500404MXTE03



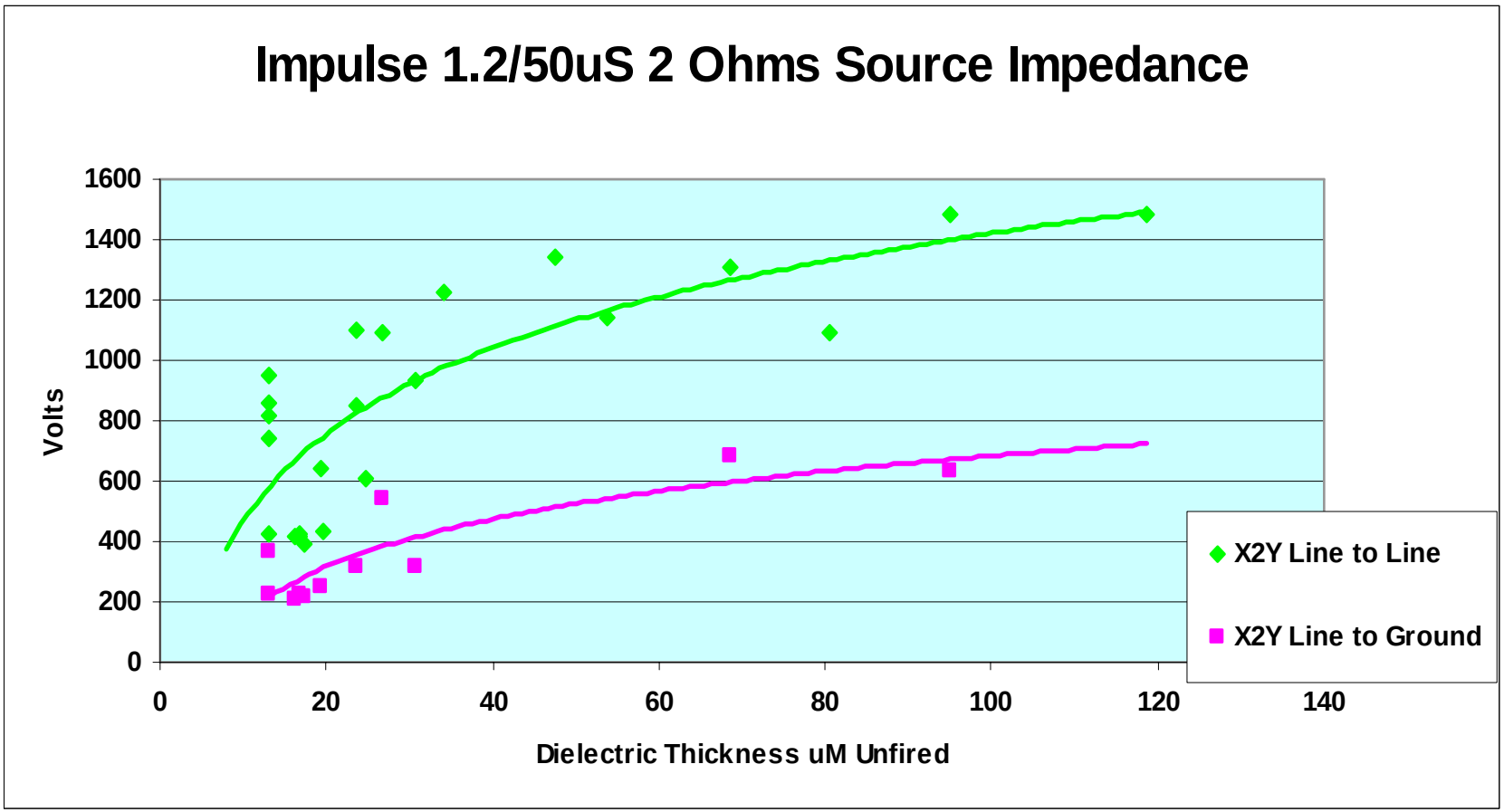
DC Breakdown Voltage



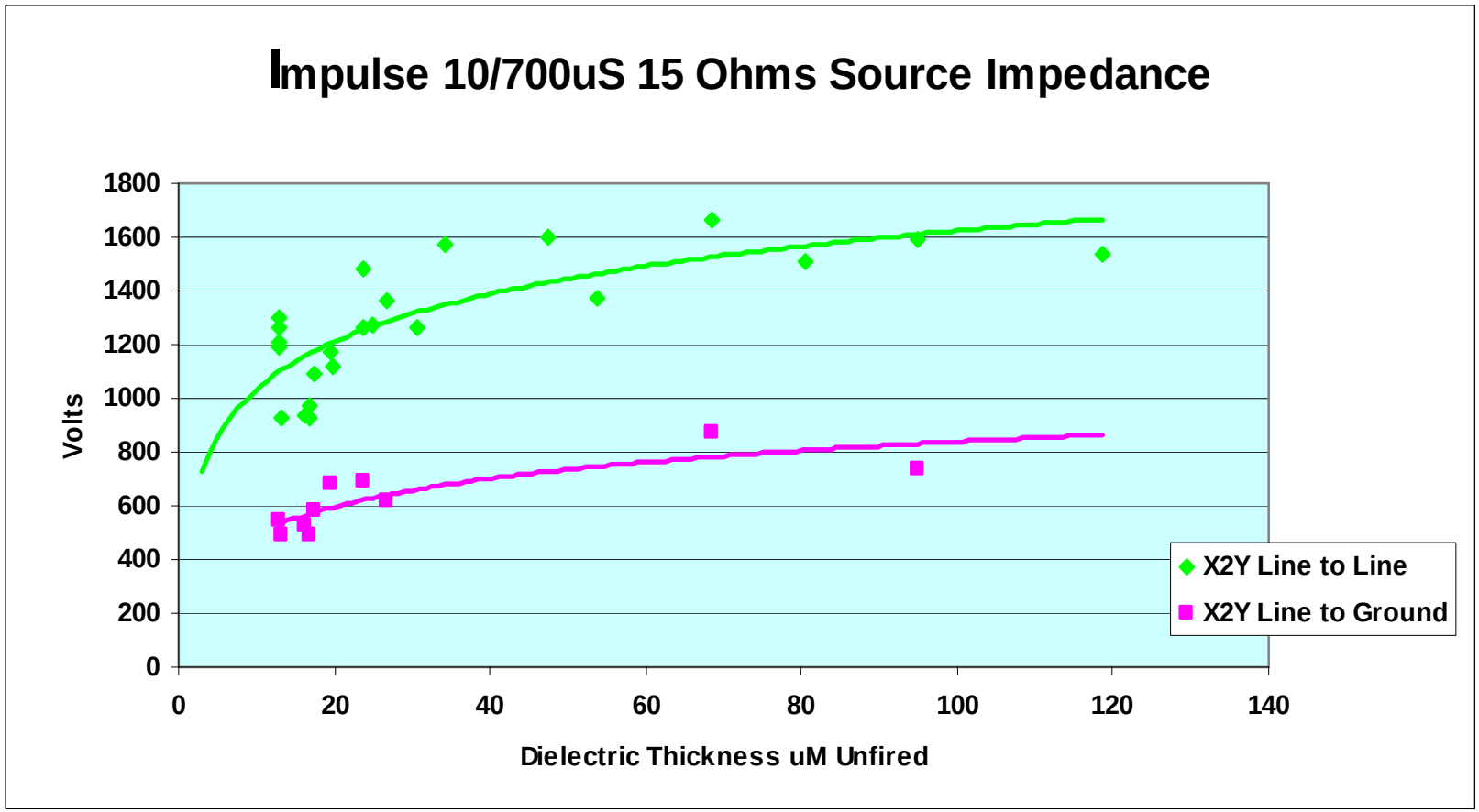
Syfer Impulse Test Capability

- 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 Testing



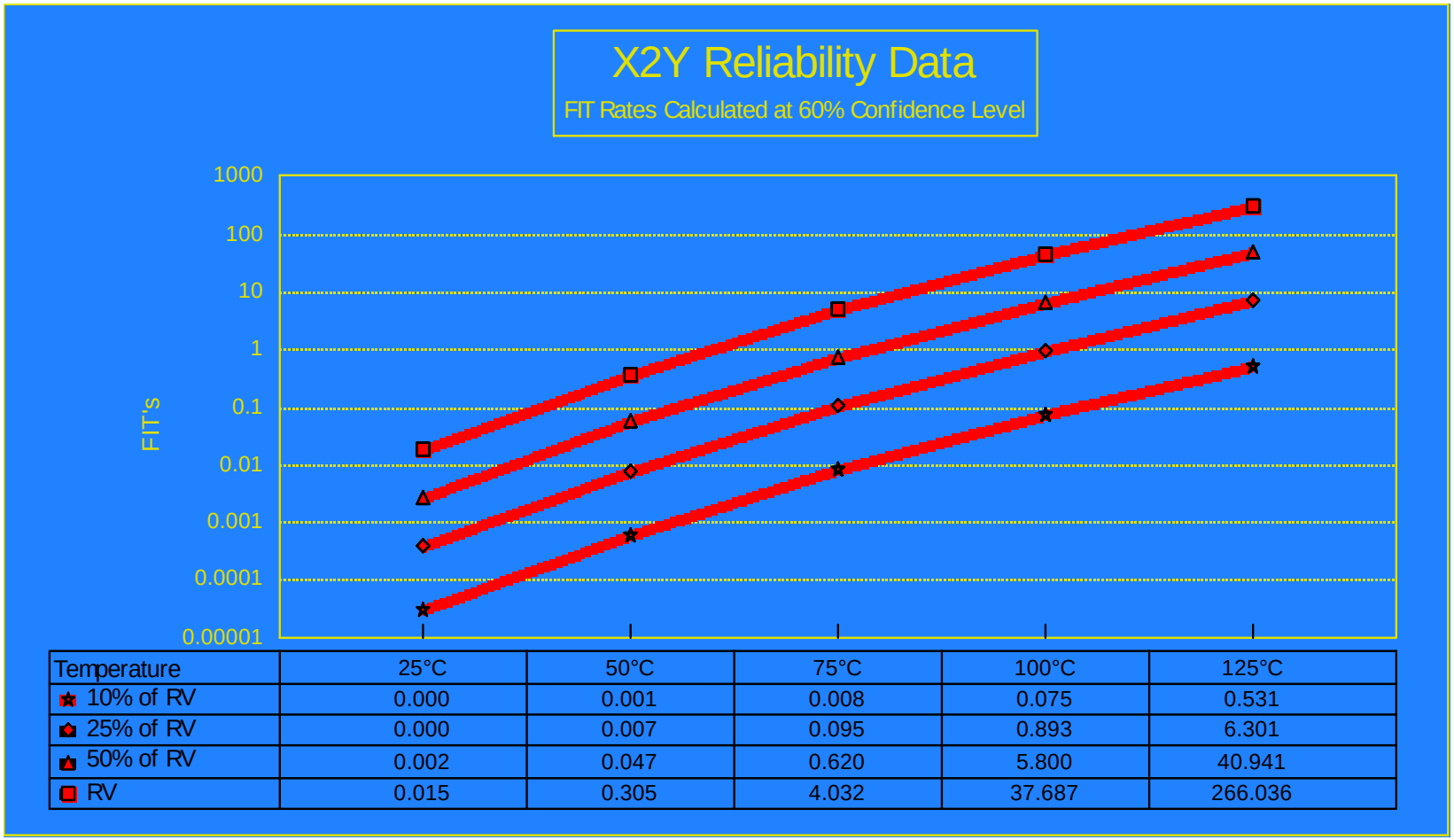
ESD Testing

- 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

F.I.T. Rates



Temperature	25°C	50°C	75°C	100°C	125°C
10% of RV	0.000	0.001	0.008	0.075	0.531
25% of RV	0.000	0.007	0.095	0.893	6.301
50% of RV	0.002	0.047	0.620	5.800	40.941
RV	0.015	0.305	4.032	37.687	266.036

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 - 1.5/50uS & 10/700us
  - 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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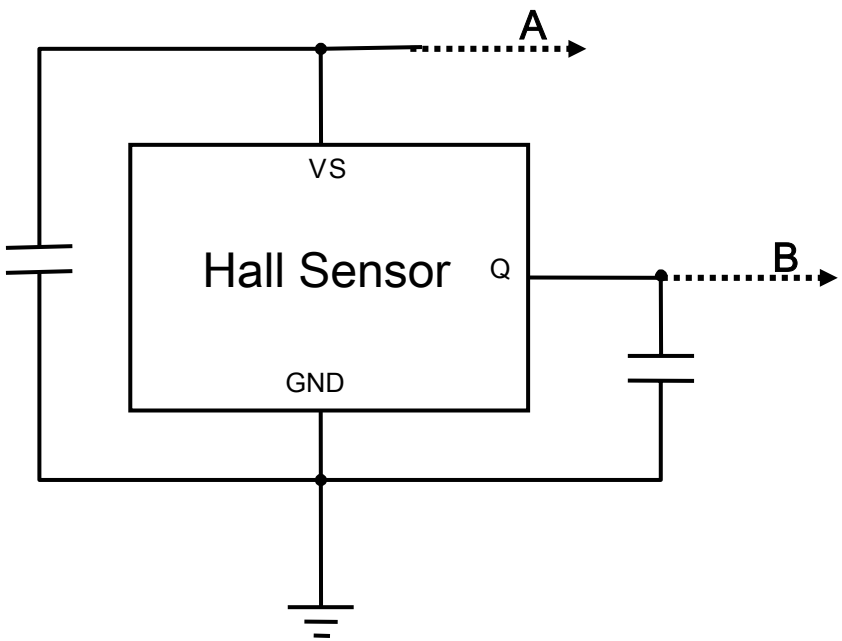
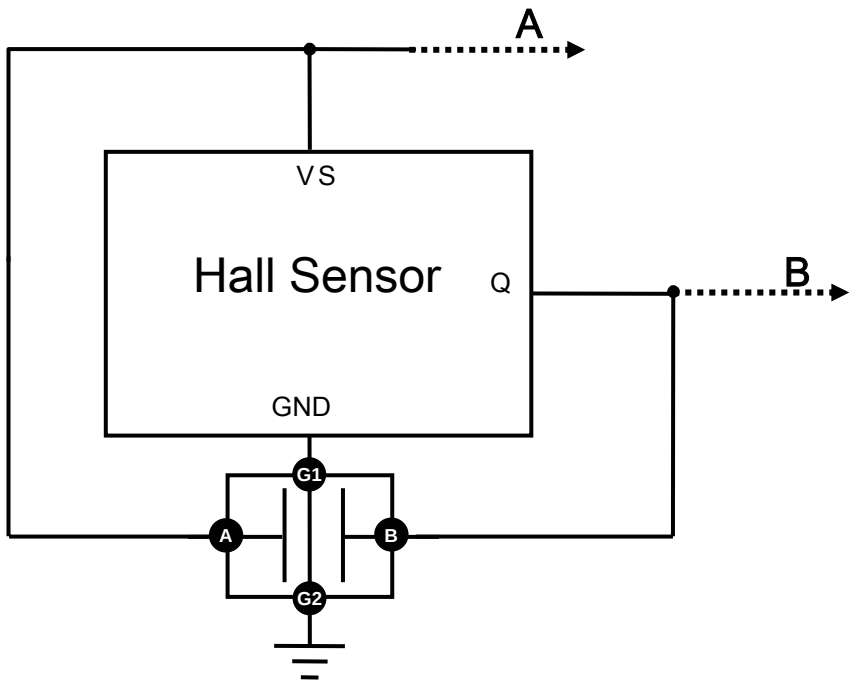
Other Automotive Applications with X2Y®

- Hall Effect Sensor

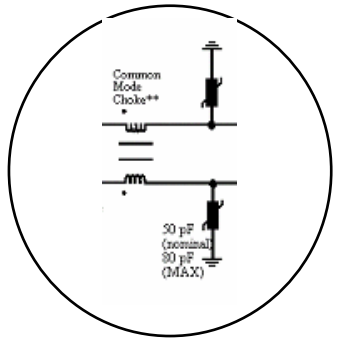


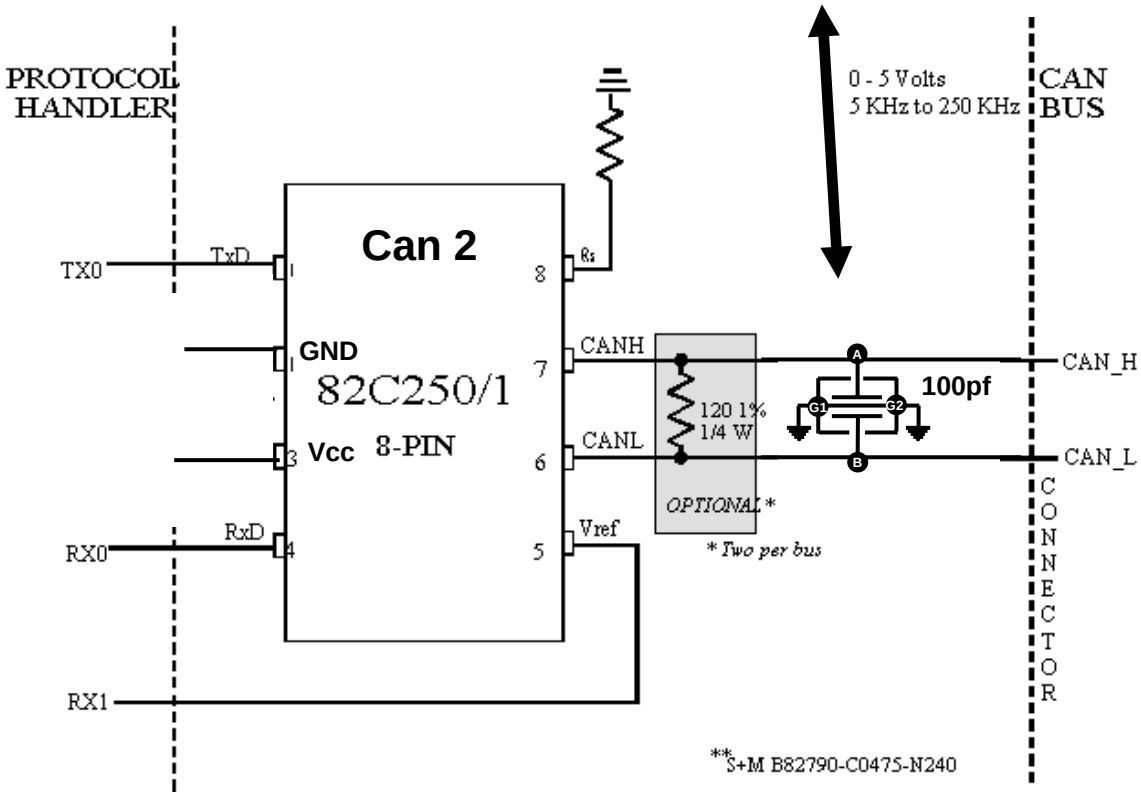


Other Automotive Applications with X2Y®

- CANBUS

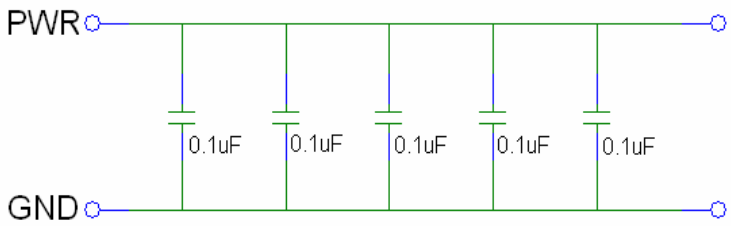
REMOVE –
(2) caps & CMC

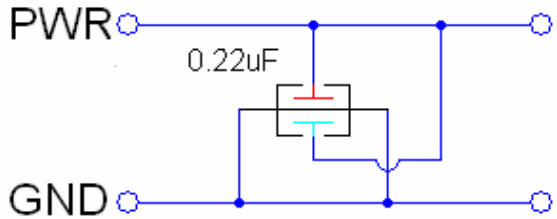


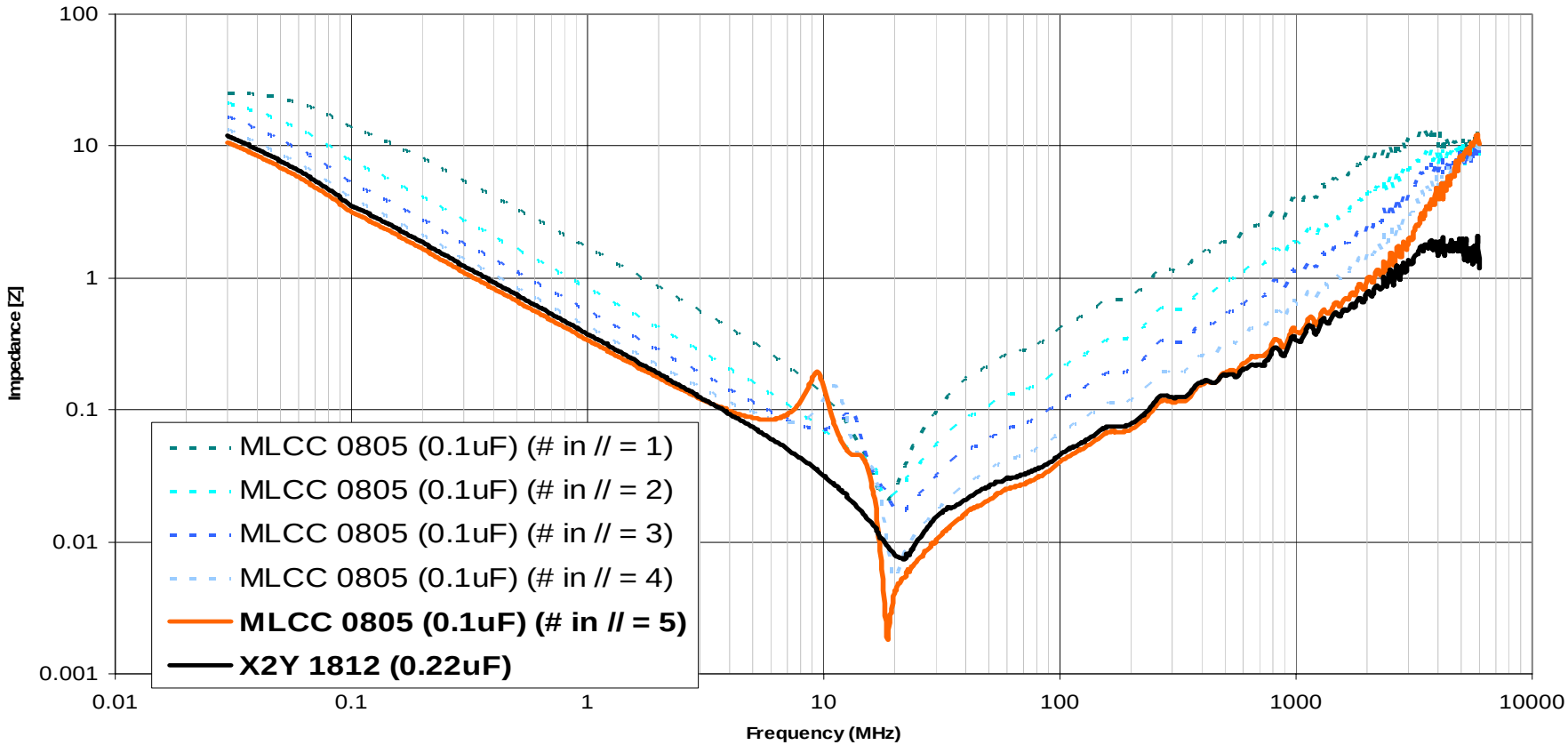


Other Automotive Applications with X2Y®

- PCB Decoupling (Circuit 2)







Questions?

Please Contact:

X2Y Attenuators, LLC
37554 Hills Tech Dr.
Farmington Hills, MI 48331
248-489-0007
x2y@x2y.com

- **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
- **"*Suppression Techniques Using X2Y as a Broadband Filter",* Symposium Record – Workshops and Tutorials, 2003 IEEE Symposium on Electromagnetic Compatibility.**
- **"*Using Image Planes on DC Motors to Filter High Frequency Noise*." 2004 IEEE EMC Symposium, Santa Clara, CA. Aug 9-13, 2004.**
- **www.jastech-emc.com**