JOHANSON
DIELECTRICS

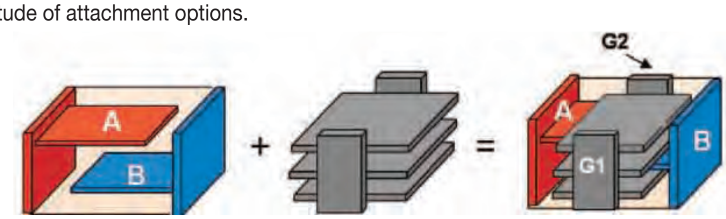
X2Y® Filter & Decoupling Capacitors

The X2Y® Design - A Capacitive Circuit

X2Y® components share many common features with standard multi-layer ceramic capacitors (MLCC) for easy adoption by end-users.

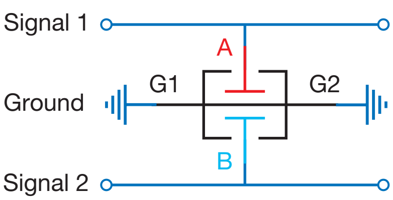
- *Same component sizes (0603, 0805, 1206, etc.)*
- *Same pick and place equipment*
- *Same dielectric, electrode and termination materials*
- *Same industry test standards for component reliability*

A standard multi-layer ceramic capacitor (MLCC) consists of opposing electrode layers A & B. The X2Y® design adds another set of electrode layers (G) which effectively surround each existing electrode of a two-terminal capacitor. The only external difference is two additional side terminations, creating a four-terminal capacitive circuit, which allows circuit designers a multitude of attachment options.



X2Y® Circuit 1: Filtering

When used in circuit 1 configuration the X2Y® filter capacitor is connected across two signal lines. Differential mode noise is filtered to ground by the two Y capacitors, A & B. Common mode noise is cancelled within the device.



Experts agree that balance is the key to a “quiet” circuit. X2Y® is a balanced circuit device with two equal halves, tightly matched in both phase and magnitude with respect to ground. Several advantages are gained by two balanced capacitors sharing a single ceramic component body.

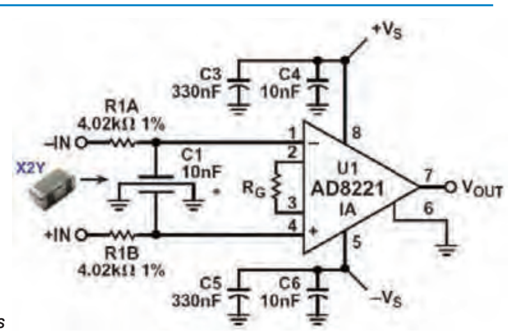
- *Exceptional common mode rejection*
- *Effects of aging & temperature are equal on both caps*
- *Effect of voltage variation eliminated*
- *Matched line-to-ground capacitance*

InAmp Input Filter Example

In this example, a single Johanson X2Y® component was used to filter noise at the input of a DC instrumentation amplifier. This reduced component count by 3-to-1 and costs by over 70% vs. conventional filter components that included 1% film Y-capacitors.

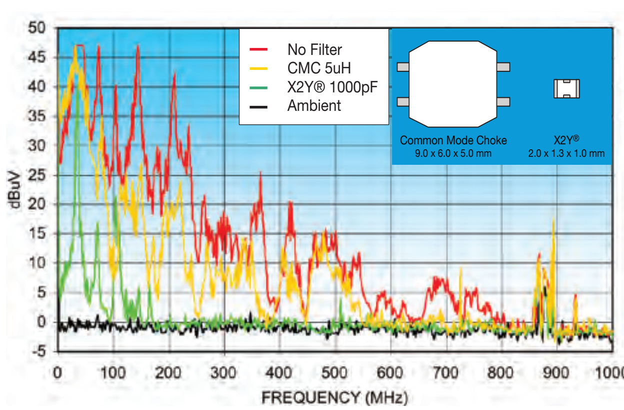
Parameter	X2Y® 10nF	Discrete 10nF, 2 @ 220 pF	Comments
DC offset shift	< 0.1 µV	< 0.1 µV	Referred to input
Common mode rejection	91 dB	92 dB	

Source: Analog Devices, “A Designer’s Guide to Instrumentation Amplifiers (2nd Edition)” by Charles Kitchin and Lew Counts



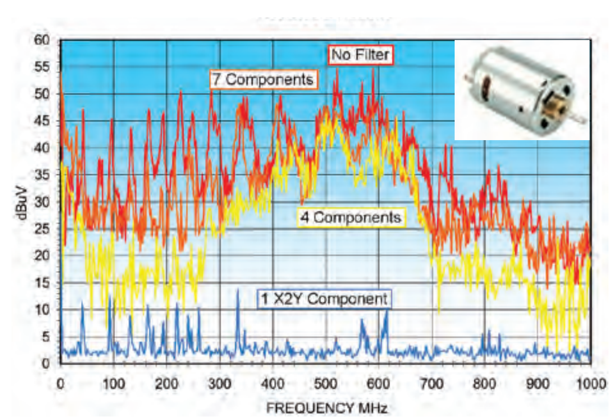
Common Mode Choke Replacement

In this example, a 5 µH common mode choke is replaced by an 0805, 1000pF X2Y® component acheiving superior EMI filtering by a component a fraction of the size and cost.



DC Motor EMI Reduction: A Superior Solution

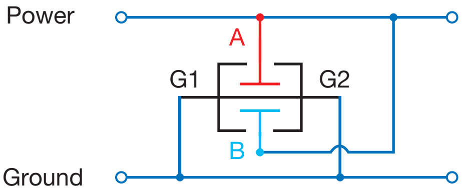
One X2Y® component has successfully replaced 7 discrete filter components while achieving superior EMI filtering.



X2Y® Filter & Decoupling Capacitors

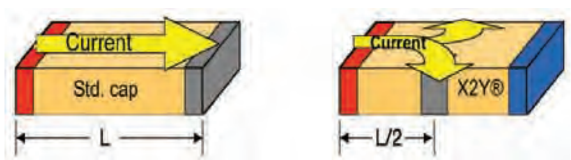
X2Y® Circuit 2: Decoupling

When used in circuit 2 configuration, A & B capacitors are placed in parallel effectively doubling the apparent capacitance while maintaining an ultra-low inductance. The low inductance advantages of the X2Y® Capacitor Circuit enables high-performance bypass networks at reduced system cost.

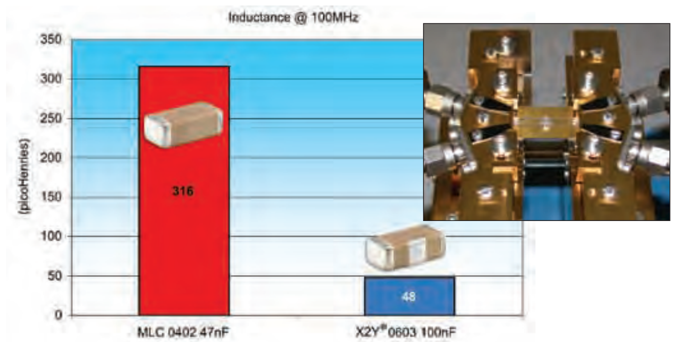


- *Low ESL (device only and mounted)*
- *Broadband performance*
- *Effective on PCB or package*
- *Lower via count, improves routing*
- *Reduces component count*
- *Lowers placement cost*

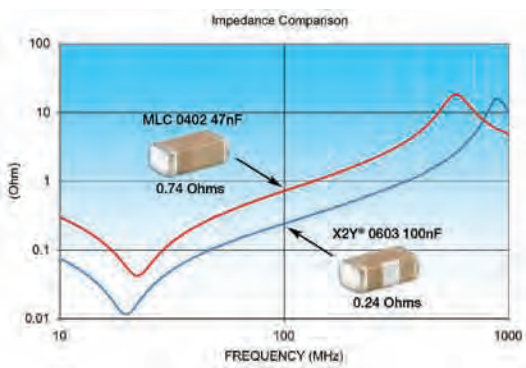
Component Performance



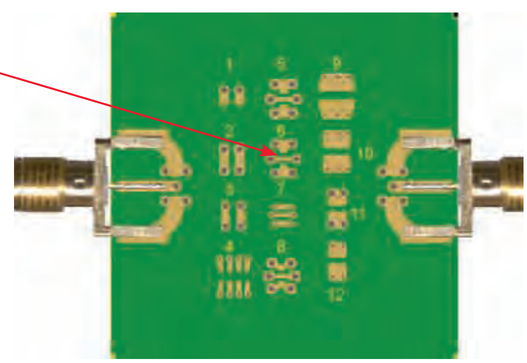
The X2Y® has short, multiple and opposing current paths resulting in lower device inductance.



Mounted Performance



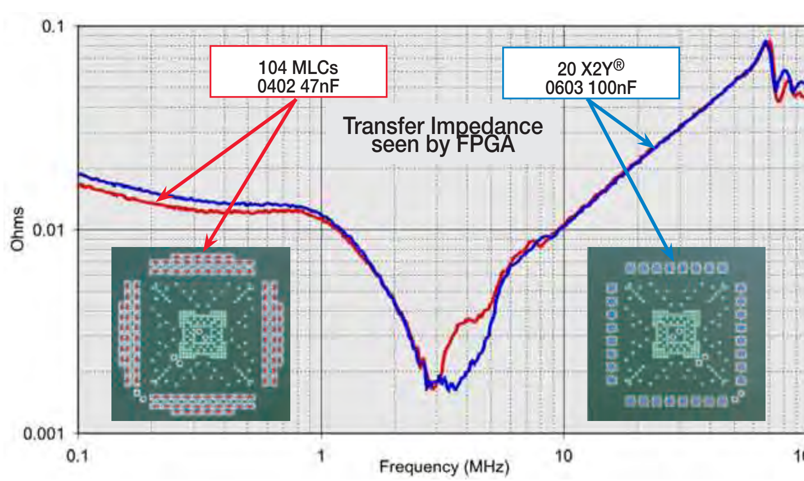
Mutual coupling from opposing polarity vias lowers inductance when mounted on a PCB.



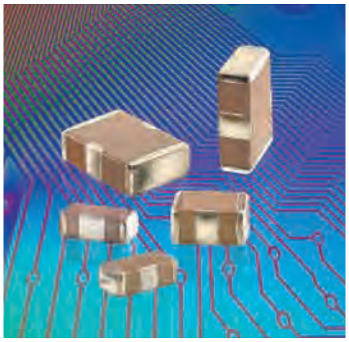
SYSTEM PERFORMANCE

1:5 MLCC Replacement Example

X2Y's® proven technology enables end-users to use one X2Y capacitor to replace five conventional MLCCs in a typical high performance IC bypass design. Vias are nearly cut in half, board space is reduced and savings are in dollars per PCB.



X2Y® Filter & Decoupling Capacitors



X2Y® filter capacitors employ a unique, patented low inductance design featuring two balanced capacitors that are immune to temperature, voltage and aging performance differences.
These components offer superior decoupling and EMI filtering performance, virtually eliminate parasitics, and can replace multiple capacitors and inductors saving board space and reducing assembly costs.

Advantages

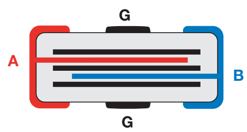
- One device for EMI suppression or decoupling
- Replace up to 7 components with one X2Y
- Differential and common mode attenuation
- Matched capacitance line to ground, both lines
- Low inductance due to cancellation effect

Applications

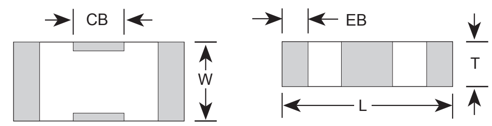
- FPGA / ASIC / µ-P Decoupling
- DDR Memory Decoupling
- Amplifier FIlter & Decoupling
- High Speed Data Filtering
- Cellular Handsets

Equivalent Circuits

Cross-sectional View



Dimensional View



SIZE EIA (JDI)		Circuit 1 (Y Cap.)	1.0pF	5.6pF	10pF	22pF	27pF	33pF	47pF	100pF	220pF	470pF	1000pF	1500pF	2200pF	4700pF	.010mF	.022mF	.047mF	0.10mF	0.12mF	0.22mF	0.33mF	0.40mF	0.47mF
		Circuit 2 (2*Y Cap.)	2.0pF	11.2pF	20pF	44pF	54pF	66pF	94pF	200pF	440pF	940pF	2000pF	3000pF	4400pF	9400pF	.020mF	.044mF	.094mF	0.20mF	0.24mF	0.44mF	0.68mF	0.80mF	0.94mF
		Order Code	1R0	5R6	100	220	270	330	470	101	221	471	102	152	222	472	103	223	473	104	124	224	334	404	474
0402 X07	X7R	50											●	●	●	●									
		6.3														●	●								
0603 X14	NPO	50	●	●	●	●	●	●	●	●	●														
	X7R	100							●	●	●	●	●	●											
		50							●	●	●	●	●	●	●	●	●								
		25							●	●	●	●	●	●	●	●	●								
		10							●	●	●	●	●	●	●	●	●	●	●	●					
		6.3																●	●	●					
0805 X15	NPO	100			●	●	●	●	●	●	●														
		50							●	●	●	●													
	X7R	100											●	●	●	●	●								
		50											●	●	●	●	●	●	●						
1206 X18	NPO	50											●												
	X7R	100																●	●						
		50																●	●	●					
1210 X41	X7R	100																	●	●	●	●			
		50																	●	●	●	●	●		
1410 X44	X7R	100																		●	●	●	●	●	
		50																		●	●	●	●	●	
1812 X43	X7R	100																				●	●	●	
		50																				●	●	●	●

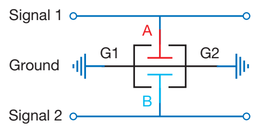
= RoHS NPO
= RoHS X7R

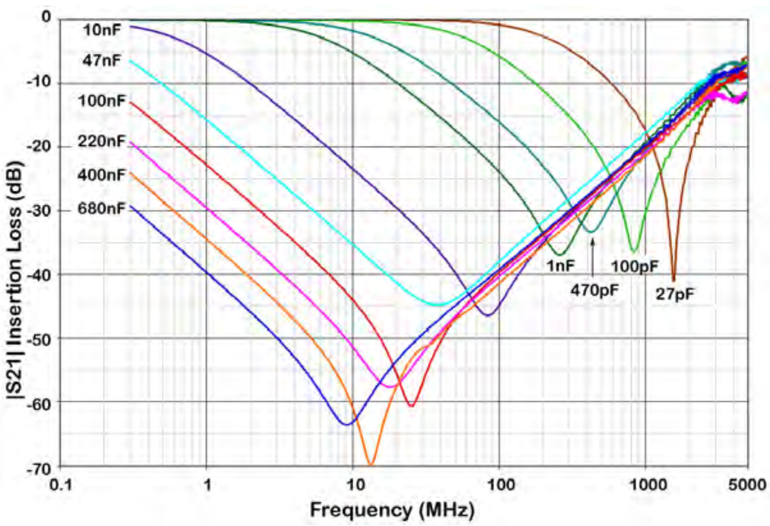
Circuit 1 (Balanced Filtering) = A (or B) to G   Circuit 2 (Decoupling) = A + B to G   [A to B capacitance = 1/2 C1]

Rated voltage is for A or B to ground.   A to B rating is 2 X Vrated   Contact the factory for other voltage ratings and capacitance values.

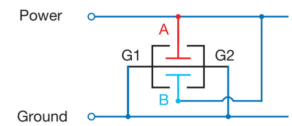
X2Y® FILTER & DECOUPLING CAPACITORS

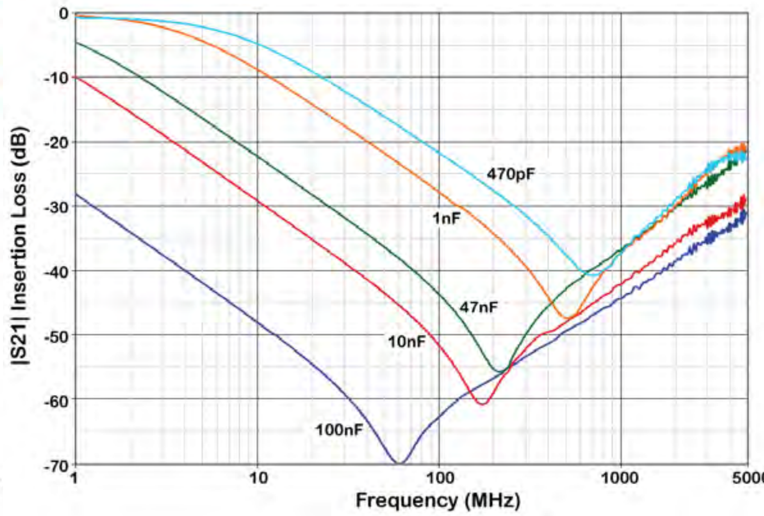
Filtering
Circuit 1 S21
Signal-to-Ground





Decoupling
Circuit 2 S21
Power-to-Ground





Additional test data and related information available at www.johansondielectrics.com/x2y/

MECHANICAL CHARACTERISTICS

	0402 (X07)		0603 (X14)		0805 (X15)		1206 (X18)		1210 (X41)		1410 (X44)		1812 (X43)	
	IN	mm	IN	mm	IN	mm	IN	mm	IN	mm	IN	mm	IN	mm
L	0.045 ± 0.003	1.143 ± 0.076	0.064 ± 0.005	1.626 ± 0.127	0.080 ± 0.008	2.032 ± 0.203	0.124 ± 0.010	3.150 ± 0.254	0.125 ± 0.010	3.175 ± 0.254	0.140 ± 0.010	3.556 ± 0.254	0.174 ± 0.010	4.420 ± 0.254
W	0.024 ± 0.003	0.610 ± 0.076	0.035 ± 0.005	0.889 ± 0.127	0.050 ± 0.008	1.270 ± 0.203	0.063 ± 0.010	1.600 ± 0.254	0.098 ± 0.010	2.489 ± 0.254	0.098 ± 0.010	2.490 ± 0.254	0.125 ± 0.010	3.175 ± 0.254
T	0.020 max	0.508 max	0.026 max	0.660 max	0.040 max	1.016 max	0.050 max	1.270 max	0.070 max	1.778 max	0.070 max	1.778 max	0.090 max	2.286 max
EB	0.008 ± 0.003	0.203 ± 0.076	0.009 ± 0.004	0.229 ± 0.102	0.009 ± 0.004	0.229 ± 0.102	0.009 ± 0.004	0.229 ± 0.102	0.009 ± 0.005	0.229 ± 0.127	0.009 ± 0.005	0.229 ± 0.127	0.009 ± 0.005	0.229 ± 0.127
CB	0.010 ± 0.003	0.305 ± 0.076	0.018 ± 0.004	0.457 ± 0.102	0.022 ± 0.005	0.559 ± 0.127	0.040 ± 0.005	1.016 ± 0.127	0.045 ± 0.005	1.143 ± 0.127	0.045 ± 0.005	1.143 ± 0.127	0.045 ± 0.005	1.143 ± 0.127

HOW TO ORDER X2Y® EMI FILTER CAPACITORS

500	X18	W	473	M	V	4	E

VOLTAGE
6R3 = 6.3 V
250 = 25 V
500 = 50 V
101 = 100 V

CASE SIZE
X07 = 0402
X14 = 0603
X15 = 0805
X18 = 1206
X41 = 1210
X43 = 1812
X44 = 1410

DIELECTRIC
N = NPO
W = X7R

CAPACITANCE
1st two digits are significant; third digit denotes number of zeros.
474 = 0.47 µF
105 = 1.00 µF

TOLERANCE
M = ± 20%

TERMINATION
V = Ni barrier w/ 100% Sn Plating

MARKING
4 = Unmarked

TAPE MODIFIER

Code	Tape	Reel
E	Embossed	7”
U	Embossed	13”
T	Paper	7”
R	Paper	13”

Tape specs. per EIA RS481

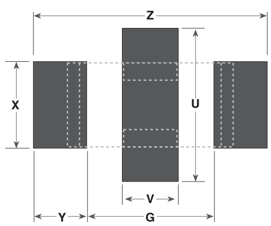
P/N written: 500X18W473MV4E

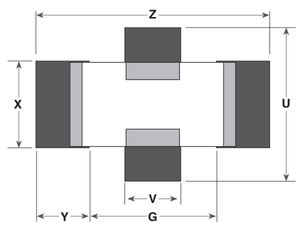
X2Y® FILTER & DECOUPLING CAPACITORS

SOLDER PAD RECOMMENDATIONS

	0402 (X07)		0603 (X14)		0805 (X15)		1206 (X18)		1210 (X41)		1410 (X44)		1812 (X43)	
	IN	mm	IN	mm	IN	mm	IN	mm	IN	mm	IN	mm	IN	mm
X	0.020	0.51	0.035	0.89	0.050	1.27	0.065	1.65	0.100	2.54	0.100	2.54	0.125	3.18
Y	0.020	0.51	0.025	0.64	0.035	0.89	0.040	1.02	0.040	1.02	0.040	1.02	0.040	1.02
G	0.024	0.61	0.040	1.02	0.050	1.27	0.080	2.03	0.080	2.03	0.100	2.54	0.130	3.30
V	0.015	0.38	0.020	0.51	0.022	0.56	0.040	1.02	0.045	1.14	0.045	1.14	0.045	1.14
U	0.039	0.99	0.060	1.52	0.080	2.03	0.120	3.05	0.160	4.06	0.160	4.06	0.190	4.83
Z	0.064	1.63	0.090	2.29	0.120	3.05	0.160	4.06	0.160	4.06	0.180	4.57	0.210	5.33

Use of solder mask beneath component is not recommended.





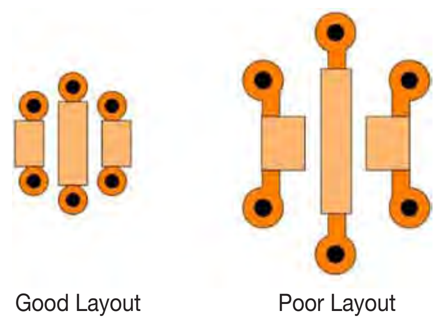


Figure 1

OPTIMIZING X2Y PERFORMANCE WITH PROPER ATTACHMENT TECHNIQUES

X2Y® capacitors excel in low inductance performance for a myriad of applications including EMI/RFI filtering, power supply bypass / decoupling. How the capacitor is attached to the application PCB is every bit as important as the capacitor itself. Proper attention to pad layout and via placement insures superior device performance. Poor PCB layouts squander performance, requiring more capacitors, and more vias to do the same job. Figure 1 compares the X2Y® recommended layout against a poor layout. Because of its long extents from device terminals to vias, and the wide via separation, the poor layout shown performs badly. It exhibits approximately 200% L1 inductance, and 150% L2 inductance compared to recommended X2Y layouts.

For further details on via placement and it’s effect on mounted inductance, please refer to X2Y Attenuators, LLC. application note “Get the Most from X2Y Capacitors with Proper Attachment Techniques” at www.x2y.com/bypass.htm

JOHANSON DIELECTRICS

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