



Medical Grade Capacitors (MD Series)

Design and Test Requirements for C0G, X7R, and X5R Monolithic Ceramic Chips

- **C0G:** -55°C to +125°C, 0 ± 30PPM/°C, 0201-1210 Sizes
- **X7R:** -55°C to +125°C, ±15%, 0201-1210 Sizes
- **X5R:** -55°C to +85°C, ±15%, 0201-1210 Sizes



Medical implantable devices require High Reliability Components to perform all the time, every time! To achieve this performance, Knowles screens every component. For medical implantable devices, screening is generally performed by following these two long-standing military specifications (MIL-SPECS) for reliability – MIL-PRF-55681 (Group A) and MIL-PRF-123 (Group A). Putting parts through our testing and screening processes means you can be confident that our components will produce the level of reliability and safety necessary for being on the circuit boards of your life-critical implantable medical devices.

Series	Chip Size	Dielectric	Capacitance	Tolerance	Voltage VDWC	Termination	High Reliability Testing**	Packing Option	-	Screening
MD	0201 0402 0603 0805 1206 1210	N = C0G/ NPO PME	Value in Picofarads	Cap Values <10pF B = ± 0.1pF C = ± 0.25pF D = ± 0.5pF	Two significant Figures, Followed by Number of Zeros:	N = Nickel Barrier 100% Tin (RoHS) Y = Nickel Barrier 90% Tin/Lead (4% min. Lead)	H	T = Tape & Reel W = Waffle Pack None = Bulk		B _x = B-Testing per MIL-PRF-55681 S _x = S-Testing per MIL-PRF-123
	Larger case sizes available upon request	B = X7R PME BB = X7R BME	Two Significant Figures, Followed by Number of Zeros: R = Decimal Point 1R0 = 1pF 102 = 1,000pF 103 = 10,000pF 104 = 100,000pF	Cap Values ≥10pF F = ± 1% G = ± 2% J = ± 5% K = ± 10%						
		BW = X5R BME		J = ± 5%* K = ± 10% M = ± 20% *Only for B Dielectric						
				K = ± 10% M = ± 20%						

P = Precious Metal Electrode (PME) B = Base Metal Electrode (BME)

**For more information on High Reliability Testing, please refer to page 14 of the Knowles MLCC Catalog

MEDICAL IMPLANTABLE CAPACITANCE RANGE

COG: -55°C to +125°C, 0 ± 30PPM/°C, 0201-1210 Sizes

HOW TO ORDER



MD	0603 Size	N Dielectric	102 Capacitance	J Tolerance	500 Voltage VDCW	N Termination	H Hi-Rel Testing	T Packing Option	BA Screening
Medical Grade	Size	N = COG/ NPO PME BN = COG/ NPO BME	Value in Picofarads Two Significant Figures, Followed by Number of Zeros: 102 = 1,000pF	B = ± 0.1pF* C = ± 0.25pF* D = ± 0.5pF* F = ± 1% G = ± 2% J = ± 5% K = ± 10%	Two significant Figures, Followed by Number of Zeros: 500 = 50V 250 = 25V 6R3 = 6.3V	N = Nickel Barrier 100% Tin (RoHS) Y = Nickel Barrier 90% Tin/Lead (4% min. Lead)	H	T = Tape & Reel W = Waffle Pack None = Bulk	B _x = B-Testing per MIL-PRF-55681 S _x = S-Testing per MIL-PRF-123

*<10 pF

EIA Case Size		0201				0402				0603				0805				1206				1210											
Cap	Code	6.3V	10V	16V	25V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V
0.5-9.9pF	0R5-9R9	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
10-82pF	100-820	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
100pF	101	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
120pF	121	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
150pF	151	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
180pF	181	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
220pF	221	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
270pF	271	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
330pF	331	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
390pF	391	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
470pF	471	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
560pF	561	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
680pF	681	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
820pF	821	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
1nF	102	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
1.2nF	122																																
1.5nF	152																																
1.8nF	182																																
2.2nF	222																																
2.7nF	272																																
3.3nF	332																																
3.9nF	392																																
4.7nF	472																																
5.6nF	562																																
6.8nF	682																																
8.2nF	822																																
10nF	103																																
12nF	123																																
15nF	153																																
18nF	183																																
22nF	223																																
33nF	333																																
47nF	473																																
82nF	823																																
100nF	104																																

P = Precious Metal Electrode (PME) B = Base Metal Electrode (BME)

For additional capacitance not shown on this chart, please email our sales team:

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MEDICAL IMPLANTABLE CAPACITANCE RANGE

X7R: -55°C to +125°C, ±15%, 0201-1210 Sizes



HOW TO ORDER

MD	0603 Size	B Dielectric	102 Capacitance	J Tolerance	500 Voltage VDCW	N Termination	H Hi-Rel Testing	T Packing Option	BA Screening
Medical Grade	Size	B = X7R PME BB = X7R BME	Value in PicoFarads Two Significant Figures, Followed by Number of Zeros: 102 = 1,000pF	J = ± 5% K = ± 10% M = ± 20%	Two significant Figures, Followed by Number of Zeros: 101 = 100V 250 = 25V 6R3 = 6.3V	N = Nickel Barrier 100% Tin (RoHS) Y = Nickel Barrier 90% Tin/Lead (4% min. Lead)	H	T = Tape & Reel W = Waffle Pack None = Bulk	B _x = B-Testing per MIL-PRF-55681 S _x = S-Testing per MIL-PRF-123

EIA Case Size		0201				0402				0603				0805				1206				1210							
Cap	Code	6.3V	10V	16V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V
150pF	151	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
220pF	221	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
330pF	331	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
470pF	471	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
680pF	681	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
1nF	102	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
1.5nF	152	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
2.2nF	222	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
3.3nF	332	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
4.7nF	472	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
6.8nF	682	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
10nF	103	B	B	B	A	A	A	A				P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
12nF	123											P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
15nF	153				B	B	B					P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
22nF	223	B	B		B	B	B					P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
33nF	333				B	B	B					P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
47nF	473				B	B	B					P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
68nF	683											P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
100nF	104				B	B	B	B				A	A	A	A				P	P	P	P				P	P	P	P
120nF	124																		P	P	P					P	P	P	P
150nF	154																		P	P	P					P	P	P	P
220nF	224				B	B						B	B	B	B				P	P	P	B				P	P	P	P
330nF	334																												
470nF	474				B							B	B	B	B				B	B	B	B				B	B	B	B
680nF	684																												
1µF	105											B	B	B	B				B	B	B	B				B	B	B	B
1.5µF	155																												
2.2µF	225											B	B						B	B	B					B	B	B	B
3.3µF	335																												
4.7µF	475																		B	B						B	B	B	
6.8µF	685																												
10µF	106																		B	B						B	B	B	
15µF	156																												
22µF	226																												
33µF	336																												

P = Precious Metal Electrode (PME) B = Base Metal Electrode (BME) A = Available as PME and BME

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MEDICAL IMPLANTABLE CAPACITANCE RANGE

X5R: -55°C to +85°C, ±15%, 0201-1210 Sizes



HOW TO ORDER

MD	0603 Size	BW Dielectric	102 Capacitance	K Tolerance	500 Voltage VDCW	N Termination	H Hi-Rel Testing	T Packing Option	BA Screening
Medical Grade	Size	BW = X5R BME	Value in Picofarads Two Significant Figures, Followed by Number of Zeros: 102 = 1,000pF	K = ± 10% M = ± 20%	Two significant Figures, Followed by Number of Zeros: 500 = 50V 250 = 25V 6R3 = 6.3V	N = Nickel Barrier 100% Tin (RoHS) Y = Nickel Barrier 90% Tin/Lead (4% min. Lead)	H	T = Tape & Reel W = Waffle Pack None = Bulk	B _x = B-Testing per MIL-PRF-55681 S _x = S-Testing per MIL-PRF-123

EIA Case Size		0201				0402				0603				0805				1206				1210											
Cap	Code	6.3V	10V	16V	25V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V
150pF	151	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
220pF	221	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
330pF	331	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
470pF	471	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
680pF	681	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
1nF	102	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
1.5nF	152	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
2.2nF	222	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
3.3nF	332	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
4.7nF	472	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
6.8nF	682	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
10nF	103	B	B	B	B	A	A	A	A																								
12nF	123																																
15nF	153					B	B	B																									
22nF	223	B	B	B		B	B	B																									
33nF	333	B	B			B	B	B																									
47nF	473	B	B			B	B	B																									
68nF	683	B	B																														
100nF	104	B	B			B	B	B	B																								
120nF	124																																
150nF	154																																
220nF	224	B	B			B	B	B	B																								
330nF	334																																
470nF	474	B				B	B	B																									
680nF	684																																
1µF	105	B				B	B	B																									
1.5µF	155																																
2.2µF	225					B	B	B																									
3.3µF	335																																
4.7µF	475					B	B	B																									
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P = Precious Metal Electrode (PME) B = Base Metal Electrode (BME) A = Available as PME and BME

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Screening Options

Screening options are tailored for selectable-combination testing. This reduces or eliminates costs associated with the development and maintenance of device-specific documentation packages while maintaining performance integrity.

SCREENING	REQUIREMENTS AND CONDITIONS	SUFFIX CODE OPTIONS*							
		Engineering Model	MIL-PRF-55681			MIL-PRF-123			
		-EM	-BA	-BB	-BC	-SA	-SB	-SC	-SD
Ultrasonic inspection (CSAM)	MIL-PRF-123, MIL-STD-202-220, and EIA-469	NR	NR	NR	NR	NR	X	X	X
Thermal shock	MIL-PRF-123, MIL-STD-202-107, 20 cycles	NR	NR	NR	NR	X	X	X	X
Voltage conditioning	MIL-PRF-123, 168-264 hours, 3(0.1)% PDA, max rated temp.	NR	NR	NR	NR	X	X	X	X
Voltage conditioning	MIL-PRF-55681, 100 hours 8% PDA, max rated temp	NR	X	X	X	NR	NR	NR	NR
Hot Insulation Resistance	MIL-PRF-123, 125C (X5R 85C), 100%.	NR	NR	NR	NR	X	X	X	X
Hot Insulation Resistance	MIL-PRF-55681, 125C (X5R 85C), (sample quantity based on lot size**)	NR	X	X	X	NR	NR	NR	NR
Insulation Resistance 25C	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-302, 100%	X	X	X	X	X	X	X	X
Dielectric Withstanding Voltage	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-301, 100%	X	X	X	X	X	X	X	X
Capacitance	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-305, 100%	X	X	X	X	X	X	X	X
Dissipation Factor	MIL-PRF-123, MIL-PRF-55681, 100%	X	X	X	X	X	X	X	X
Solderability	MIL-STD-202-208, 85%, sample 13(0)	X	X	X	X	X	X	X	X
Visual Inspection	MIL-PRF-123, MIL-PRF-55681, 100%	X	X	X	X	X	X	X	X
Destructive physical analysis	MIL-PRF-123, EIA-469, 5(0)	NR	NR	NR	NR	X	X	X	X
Life test	MIL-PRF-123, MIL-STD-202-108, 1000 hours, (sample quantity based on lot size**)	NR	NR	NR	NR	NR	NR	X	X
Life test	MIL-PRF-55681, MIL-STD-202-108, 2000 hours, sample 25(1)	NR	NR	X	X	NR	NR	NR	NR
Humidity, steady state, low voltage	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-103, 12(0)	NR	NR	X	X	NR	NR	X	X
Voltage Temperature Limits	MIL-PRF-123, MIL-PRF-55681, 12(0)	NR	NR	X	X	NR	NR	X	X
Moisture Resistance	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-106, 12(1)	NR	NR	NR	X	NR	NR	NR	X
Resistance to Soldering Heat	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-210, 12(0)	NR	NR	NR	X	NR	NR	NR	X
Board Flex	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-218, 12(0)	NR	NR	NR	X	NR	NR	NR	X
Shear	MIL-PRF-123, MIL-PRF-55681, MIL-STD-202-219, 12(0)	NR	NR	NR	X	NR	NR	NR	X

-EM = Engineering Model

-BA = MIL-PRF-55681 Group A
 -BB = BA + Life, Humidity, Steady State, Low Voltage, and Voltage-Temperature Limits
 -BC = MIL-PRF-55681 Group A and C

-SA = MIL-PRF-123 Group A

-SB = CSAM + MIL-PRF-123

Group A

-SC = SB + Life, Humidity, Steady State, Low Voltage, and Voltage-Temperature Limits

-SD = CSAM + MIL-PRF-123

Group A, B, and C

* Screening options are defined by suffix code. There are two military based options for screening:

- **MIL-PRF-55681:** -Bx where the second character lists the various environmental testing options.
- **MIL-PRF-123:** -Sx where the second character lists the various environmental testing options.

X = Required

NR = Not Required

**Please contact Knowles for more information

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Electrical Requirements

Voltage – Temperature Limits (Temperature Characteristics)

- COG/NPO (Code N, BN) – Shall be $0 \pm 30 \text{ PPM}/^\circ\text{C}$ over the rated voltage over -55 to +125C.
- X7R (Code B, BB) – Shall be $\pm 15\%$ at 0 V over -55 to +125C.
- X5R (Code BW) – Shall be $\pm 15\%$ at 0 V over -55 to +85C.

Dielectric Withstanding Voltage (DWV) - Parts shall be capable of withstanding a dielectric voltage potential of 2.5 times the rated voltage, when tested in accordance with MIL-STD-202 Test Method 301 and as specified in MIL-PRF-55681/MIL-PRF-123.

Capacitance and Dissipation Factor (DF) - Capacitors shall be tested in accordance with MIL-STD-202-305. The following details and exceptions shall apply:

- COG/NPO – 1 MHz, 1.0 V ± 0.2 V rms for all capacitors ≤ 100 pF., and 1 kHz, 1.0 V ± 0.2 V rms for all capacitors >100 pF.
- X7R/X5R - 1 kHz, 1.0 V ± 0.2 V rms for all capacitors ≤ 10 uF., and 120 Hz, 0.5 V ± 0.2 V rms for all capacitors >10 uF.

Insulation Resistance (IR) - Capacitors shall be tested in accordance with MIL-STD-202-302. The following details shall apply:

Test potential: Rated voltage.

COG/ NPO and X7R:

Insulation Resistance @ 25°C

- PME >100 Giga-Ohm or $1000\Omega\text{F}$ (whichever is less)
- BME >10 Giga-Ohm or $100\Omega\text{F}$ (whichever is less)

Insulation Resistance @ 125°C

- PME >10 Giga-Ohm or $100\Omega\text{F}$ (whichever is less)
- BME >1 Giga-Ohm or $10\Omega\text{F}$ (whichever is less)

X5R:

Insulation Resistance @ 25°C

- BME >10 Giga-Ohm or $100\Omega\text{F}$ (whichever is less)

Insulation Resistance @ 85°C

- BME >1 Giga-Ohm or $10\Omega\text{F}$ (whichever is less)

Included with each lot of High Reliability parts is: a screening lot traveler and screening data, electrical test attributes and variables data as required by MIL-PRF, and a Certificate of Conformance.

REFERENCE DOCUMENTS

MIL-PRF-55681

Capacitor, Chip, Multiple Layer, Fixed Ceramic Dielectric, Established Reliability and Non-Established Reliability, General Specification

MIL-PRF-123

Capacitors, Fixed, Ceramic Dielectric (Temperature Stable and General Purpose), High Reliability, General Specification

MIL-STD-202

Test Methods for Electronic and Electrical Component Parts

MIL-STD-883

Test Methods for Microcircuits

EIA-469

Standard Test Method for Destructive Physical Analysis of High Reliability Ceramic Monolithic Capacitors

EIA-198-1

Ceramic Dielectric Capacitors Classes I, II, III, and IV Part I: Characteristics and Requirements

EIA-481

8 mm Through 200 mm Embossed Carrier Taping of Surface Mount Component for Automatic Handling