Automotive Grade AC Line Rated Ceramic Disc Capacitors Class X1, 440 V_{AC}, Class Y2, 300 V_{AC}

FEATURES

- AEC-Q200 qualified
- Withstands 85 / 85 / 1000 h test
- Can pass 3000 temperature cycles (from -55 °C to +125 °C)
- Complying with IEC 60384-14 4th edition
- High reliability
- Vertical (inline) kinked or straight leads
- Singlelayer AC disc safety capacitors
- PPAP (AIAG version) is available
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

Pb

e3

RoHS COMPLIANT

HALOGEN FREE

GREEN (5-2008)

LINKS TO ADDITIONAL RESOURCES

3D Models

SPICE Models

QUICK REFERENCE DATA				
DESCRIPTION	VALUE			
Ceramic Class	1		2	
Ceramic Dielectric	U2J	U2J	Y5S, Y5U, Y5V	Y5S, Y5U, Y5V
Voltage (V_{AC})	300	440	300	440
Min. Capacitance (pF)	10		68	
Max. Capacitance (pF)	47		10 000	
Mounting	Radial			

OPERATING TEMPERATURE RANGE

-55 °C to +125 °C

TEMPERATURE CHARACTERISTICS

Class 1: N750 (U2J)
Class 2: Y5S, Y5U, Y5V

SECTIONAL SPECIFICATIONS

Climatic category (according to EN 60058-1)
Class 1 and class 2: 40/125/21

COATING

According to UL 94 V-0
Epoxy resin, isolating, flame retardant

APPROVALS

IEC 60384-14.4
UL 60384-14
DIN EN 60384-14
CSA E60384-1:03, CSA E60384-14:09

PACKAGING

Bulk, tape and reel, taped ammopack

APPLICATIONS

- X1, Y2 according to IEC 60384-14.4
- Application as Y capacitors for AC line filter and primary-secondary coupling on battery chargers for PHEV/EV
- Application as filter capacitors on DC/DC converters for PHEV/EV and HEV
- EMI / RFI suppression and filtering

DESIGN

The capacitor consists of a ceramic disc which is silver plated on both sides. Connection leads are made of tin plated copper-clad steel having a diameter of 0.6 mm.
The capacitors may be supplied with straight or kinked leads having a lead spacing of 5 mm, 7.5 mm, or 10.0 mm. Encapsulation is made of flame retardant epoxy resin in accordance with UL 94 V-0.

CAPACITANCE RANGE

10 pF to 10 000 pF

RATED VOLTAGE U_R

IEC 60384-14.4:
(X1): 440 V_{AC}, 50 Hz
(Y2): 300 V_{AC}, 50 Hz
1000 V_{DC}

TEST VOLTAGE

Component test (100 %):
2600 V_{AC}, 50 Hz, 2 s
Random sampling test (destructive test):
2600 V_{AC}, 50 Hz, 60 s
Voltage proof of coating (destructive test):
2600 V_{AC}, 50 Hz, 60 s

INSULATION RESISTANCE

≥ 10 000 MΩ

CAPACITANCE TOLERANCE

± 20 % (code M); ± 10 % (code K)

DISSIPATION FACTOR

Class 1: max. 0.3 % (1 MHz)
Class 2: max. 2.5 % (1 kHz)

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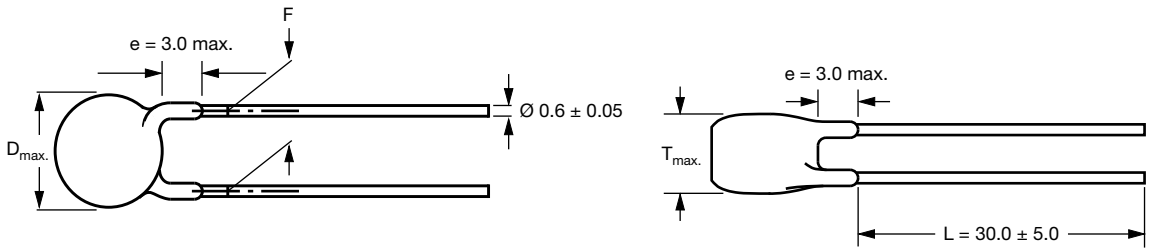
DIMENSIONS in millimeters



Capacitors with 5.0 mm, 7.5 mm, or 10.0 mm lead spacing

TECHNICAL DATA

CAPACITANCE C (pF)	CAPACITANCE TOLERANCE (%)	BODY DIAMETER $D_{max.}$ (mm)	BODY THICKNESS $T_{max.}$ (mm)	LEAD SPACING F (mm) ± 1 mm	PART NUMBER MISSING DIGITS SEE ORDERING CODE BELOW
U2J (N750)					
10	± 10	7.5	5.0	5.0, 7.5, or 10.0	AY2100K29U2JS6###
15					AY2150K29U2JS6###
22					AY2220K29U2JS6###
33					AY2330K29U2JS6###
47					AY2470K29U2JS6###
Y5S (2C3)					
68	± 10	7.5	5.0	5.0, 7.5, or 10.0	AY2680K29Y5SS6###
100					AY2101K29Y5SS6###
150					AY2151K29Y5SS6###
220					AY2221K29Y5SS6###
330					AY2331K29Y5SS6###
470					AY2471K29Y5SS6###
Y5U (2E3)					
680	± 20	7.5	5.0	5.0, 7.5, or 10.0	AY2681#29Y5US6###
1000					AY2102#29Y5US6###
1500		8.5			AY2152#31Y5US6###
2200		9.5			AY2222#35Y5US6###
3300		11.0			AY2332#41Y5US6###
3900		11.5			AY2392#43Y5US6###
4700		13.0			AY2472#49Y5US6###
Y5V (2F4)					
6800	± 20	13.0	6.0	7.5 or 10.0	AY2682M51Y5VS6#L#
10 000		15.5			AY2103M61Y5VS6#L#

Note

(1) ± 10 % available on request

ORDERING CODE

#	7th digit		Capacitance tolerance		± 10 % = K, ± 20 % = M					
###	15th to 17th digit		Lead configuration		Available configurations see below					
Example	**AY2**	**221**	**K**	**29**	**Y5S**	**S**	**6**	**U**	**V**	**7**
	Series	Capacitance value	Tolerance code	Size code	Temperature coefficient	Rated voltage	Lead wire diameter	Packaging / lead length	Lead style	Lead spacing
								3 = bulk T = tape and reel U = ammopack	L = straight V = inline kinked	5 = 5.0 7 = 7.5 0 = 10.0

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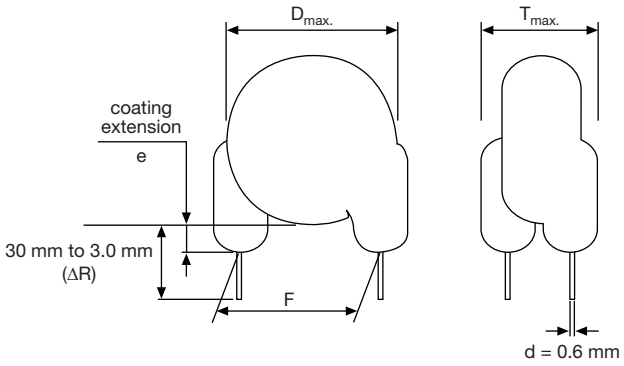
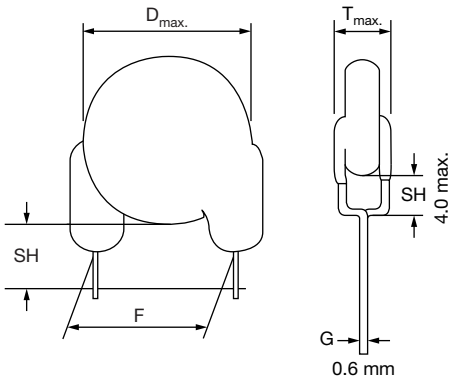
PACKAGING						
LEADSPACING (mm)	CAPACITANCE VALUE	BODY DIAMETER $D_{max.}$ (mm)	PACKAGING QUANTITIES			TAPING FIG.
			BULK	REEL	AMMO	
5.0	10 pF to 3900 pF	11.0	1000	1000	1000	Fig. 1
7.5	10 pF to 4700 pF	13.0	1000	1000	1000	Fig. 1
	6800 pF to 10 000 pF	15.5	500	500	500	Fig. 2
10.0	10 pF to 4700 pF	15.5	1000	500	750	Fig. 2
	6800 pF to 10 000 pF	15.5	500	500	500	Fig. 2

STRAIGHT LEADS



INLINE KINKED LEADS



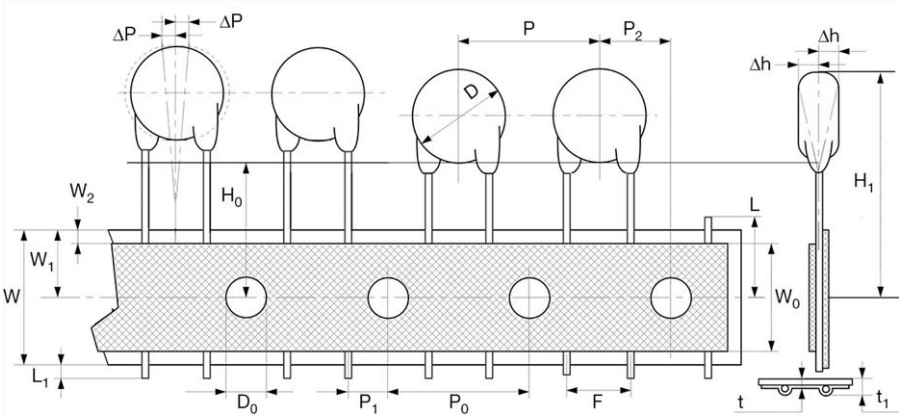


Fig. 1 - The hole pitch 12.7 mm for lead spacing 5.0 mm (0.2"), and hole pitch 15.0 mm for lead spacing 7.5 mm (0.3")

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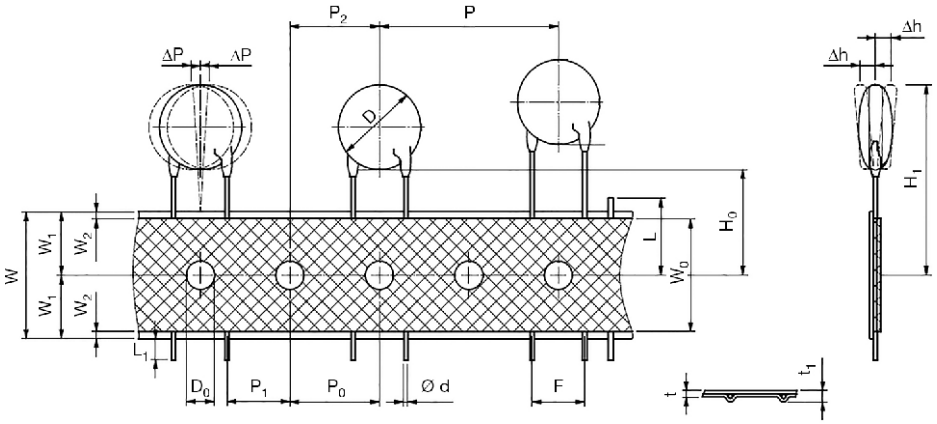

Fig. 2 - The hole pitch 12.7 mm for lead spacing 10.0 mm (0.4")

DIMENSION OF TAPE				
SYMBOL	PARAMETER	DIMENSIONS (mm)		
		FIG. 1 (5 mm)	FIG. 1 (7.5 mm)	FIG. 2 (10 mm)
D (1)	Body diameter	11.0 max.	14.0 max.	16.0 max.
d	Lead diameter	0.6 ± 0.05	0.6 ± 0.05	0.6 ± 0.05
P	Pitch of component	12.7 ± 1	15.0 ± 1	25.4 ± 1
P_0 (2)	Pitch of sprocket hole	12.7 ± 0.3	15.0 ± 0.3	12.7 ± 0.3
P_1 (3)	Distance, hole center to lead	3.85 ± 0.7	3.75 ± 0.7	7.7 ± 1.0
P_2 (3)	Distance, hole to center of component	6.35 ± 1.3	7.5 ± 1.5	12.7 ± 1.5
F	Lead spacing	5.0 (+ 0.6/- 0.4)	7.5 (+ 0.6/- 0.4)	10.0 (+ 0.6/- 0.4)
Δh	Average deviation across tape	± 1.0 max.	± 1.0 max.	± 1.0 max.
ΔP	Average deviation in direction of reeling	± 1.0 max.	± 1.0 max.	± 1.0 max.
W	Carrier tape width	18.0 + 1/- 0.5	18.0 + 1/- 0.5	18.0 + 1/- 0.5
W_0	Hold-down tape width	5.0 min.	5.0 min.	5.0 min.
W_1	Position of sprocket hole	9.0 + 0.75/- 0.5	9.0 + 0.75/- 0.5	9.0 + 0.75/- 0.5
W_2	Distance of hold-down tape	3.0 max.	3.0 max.	3.0 max.
H_1	Maximum component height	32	40	40
H_0	Height to seating plane (for kinked leads)	16.0 ± 0.5	16.0 ± 0.5	16.0 ± 0.5
H_0	Height to seating plane (for straight leads)	20.0 ± 0.5	20.0 ± 0.5	20.0 ± 0.5
L	Length of cut leads	11.0 max.	11.0 max.	11.0 max.
L_1	Length of lead protrusion	1.0 max.	1.0 max.	1.0 max.
D_0	Diameter of sprocket hole	4.0 ± 0.2	4.0 ± 0.2	4.0 ± 0.2
t	Total tape thickness	0.9 max.	0.9 max.	0.9 max.
t_1	Maximum thickness of tape and wires	1.5 max.	1.5 max.	1.5 max.

Notes

(1) See “Technical Data” table

(2) Cumulative pitch error: ± 1 mm/20 pitches

(3) Obliquity maximum 3°

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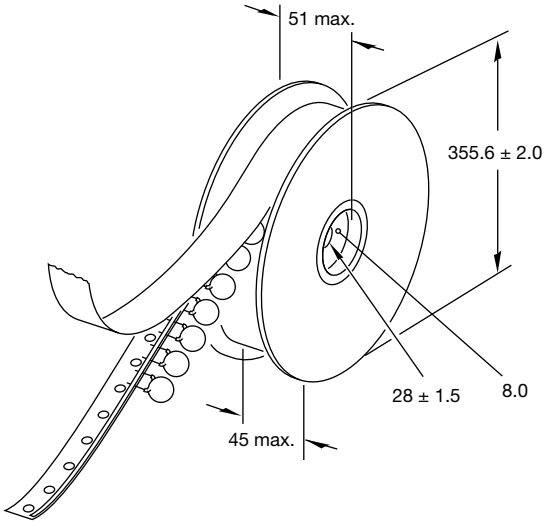
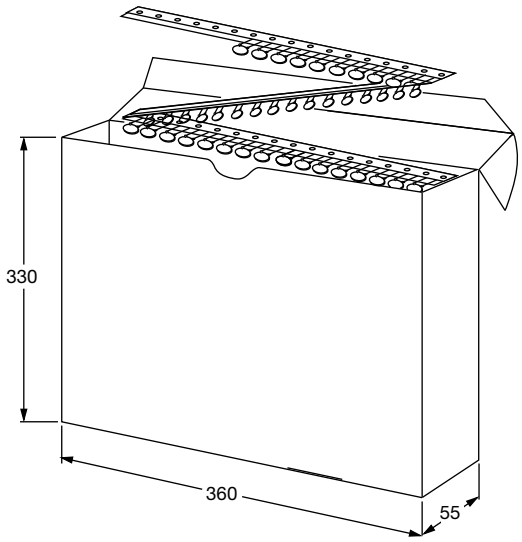
REEL AND TAPE DATA in millimeters



Reel with capacitors on tape



Ammopack with capacitors on tape

APPROVALS

IEC 60384-14.4 - Safety tests
This approval together with CB test certificate substitutes all national approvals.

CB Certificate

Y2-capacitor: CB test certificate:	US-26163-UL	10 pF to 10 nF	300 V_{AC}
X1-capacitor: CB test certificate:	US-26163-UL	10 pF to 10 nF	440 V_{AC}

VDE

Y2-capacitor: VDE marks approval:	40009669	10 pF to 10 nF	300 V_{AC}
X1-capacitor: VDE marks approval:	40009669	10 pF to 10 nF	440 V_{AC}

DIN EN 60384-14 VDE 0565-1-1:2006-04 - Safety tests

Underwriters Laboratories Inc./Canadian Standards Association

Y2-capacitor: UL-test certificate:	E183844	10 pF to 10 nF	300 V_{AC}
X1-capacitor: UL-test certificate:	E183844	10 pF to 10 nF	440 V_{AC}

UL 60384-14, CSA E60384-1:03 2nd edition, CSA E60384-14:09 2nd edition

Across-the-line, antenna-coupling and line-by-pass component

CQC

Y2-capacitor: CQC test certificate:	CQC05001012316	10 pF to 10 nF	300 V_{AC}
X1-capacitor: CQC test certificate:	CQC05001012316	10 pF to 10 nF	440 V_{AC}

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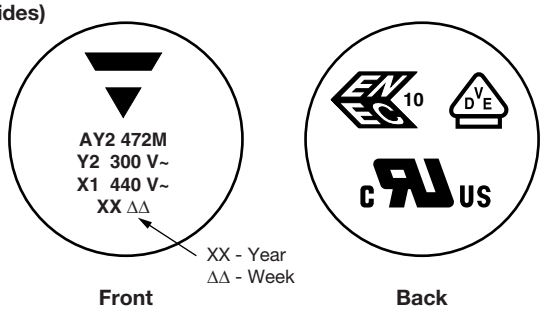
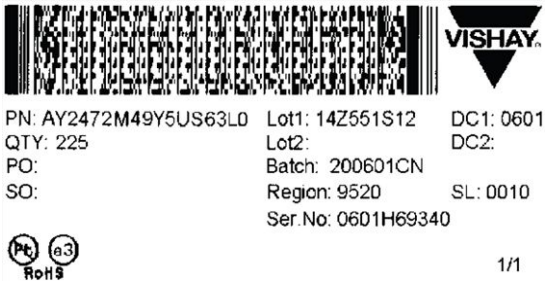
MARKING

Sample
(2 sides)





PERFORMANCE

NO.	ITEMS		SPECIFICATION	TEST METHOD	
1	Visual and mechanical examination		No visible damage. The marking shall be legible. Dimensions are within specification.	Capacitors shall be visually inspected for visible evidence of defect. Dimensions shall be measured with calipers or micrometers.	
2	Capacitance		Within the specified tolerance.	The capacitance shall be measured at 25 °C ± 3 °C, 75 % RH maximum with 1.0 V_{RMS} ± 0.2 V_{RMS}, 1 kHz for Y5U, Y5S, and 1 MHz for U2J.	
3	Dissipation factor (D.F.)		U2J: 0.3 % max. Y5U, Y5S: 2.5 % max.	The dissipation factor shall be measured at 25 °C ± 3 °C, 75 % RH maximum with 1.0 V_{RMS} ± 0.2 V_{RMS}, 1 kHz for Y5U, Y5S, and 1 MHz for U2J.	
4	Insulation resistance (I.R.)		10 GΩ min.	Insulation resistance shall be measured within 60 s ± 5 s of charging at 500 V_{DC}.	
5	Dielectric strength (between lead wires)		No damage.	2600 V_{AC} are applied for 60 s. 50 mA max. (destructive test)	
6	Temperature characteristic	External appearance	No visible damage. The marking shall be legible.	The capacitance shall be measured at each step specified in table below. The capacitance change from the value of step 3 shall not exceed the limit specified.	
		Capacitance change	n/a		
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	Step	Temperature
		Insulation resistance	10 GΩ min. at 500 V_{DC} 60 s at 25 °C and -40 °C 500 MΩ min. at 500 V_{DC} 60 s at 125 °C	1	25 °C ± 3 °C
				2	-40 °C ± 3 °C
				3	25 °C ± 3 °C
		Dielectric strength (between lead wires)	5 s 250 % rated voltage	4	125 °C ± 3 °C
				5	25 °C ± 3 °C

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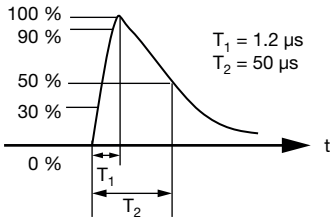
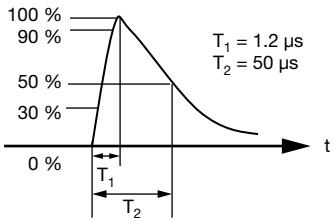
PERFORMANCE				
NO.	**ITEMS**		**SPECIFICATION**	**TEST METHOD**
7	High temperature operation life	External appearance	No visible damage. The marking shall be legible.	Test voltage: 1.5 kV_{AC}, 60 s Impulse voltage: each individual capacitor shall be subjected to a 5 kV impulse for three times. Before the capacitors are applied to life test.  The specimen capacitors shall be submitted to an endurance test of 1000 h + 48 h / - 0 h in a chamber at 125 °C ± 3 °C with a voltage of 550 V_{AC}. Pre-treatment: capacitor shall be backed at 125 °C ± 3 °C for 1 h before initial measurements. Post-treatment: capacitors shall be placed at room condition for 24 h ± 2 h before measurements.
		Capacitance change	± 15 % max.	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	3 GΩ min. at 500 V_{DC}, 60 s	
		Dielectric strength (between lead wires)	No failure at 1.5 kV_{AC}, 60 s	
8	Life Test	External appearance	No visible damage. The marking shall be legible.	Test voltage: 1.5 kV_{AC}, 60 s Impulse voltage: each individual capacitor shall be subjected to a 5 kV impulse for three times. Before the capacitors are applied to life test.  The specimen capacitors shall be submitted to an endurance test of 1000 h + 48 h / - 0 h in a chamber at 125 °C ± 3 °C with a voltage of 550 V_{AC}, except that once every hour the voltage shall be increase to 1000 V_{AC} for 0.1 s. Pre-treatment: capacitor shall be backed at 125 °C ± 3 °C for 1 h before initial measurements. Post-treatment: capacitors shall be placed at room condition for 24 h ± 2 h before measurements.
		Capacitance change	± 15 % max.	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	3 GΩ min. at 500 V_{DC}, 60 s	
		Dielectric strength (between lead wires)	No failure at 1.5 kV_{AC}, 60 s	

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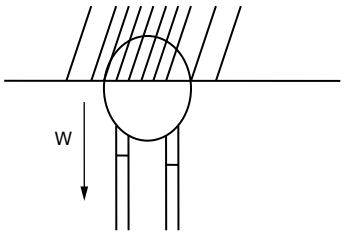
PERFORMANCE					
NO.	ITEMS			SPECIFICATION	TEST METHOD
9	Humidity test (under steady state)	External appearance		No visible damage.	Ambient temperature: 40 °C ± 2 °C Relative humidity: 90 % to 95 % RH Duration: 500 h + 48 h / - 0 h Without loading Pre-treatment: capacitor shall be stored at 40 °C ± 2 °C for 24 h ± 5 h before initial measurements. Post-treatment: capacitor shall be stored for 2 h at room conditions before final measurements.
		Capacitance change		U2J: ± 10 % Y5U, Y5S: ± 20 %	
		Dissipation factor		U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance		3 GΩ min. at 500 V_{DC}, 60 s	
		Dielectric strength (between lead wires)		No failure at 1.5 kV_{AC}, 60 s	
10	Humidity test (under load state)	External appearance		No visible damage. The marking shall be legible.	Ambient temperature: 40 °C ± 2 °C Relative humidity: 90 % to 95 % RH Duration: 500 h + 48 h / - 0 h Loading voltage: 440 V_{AC} Pre-treatment: capacitor shall be stored at 40 °C ± 5 °C for 24 h ± 2 h before initial measurements. Post-treatment: capacitor shall be stored for 2 h at room conditions before final measurements.
		Capacitance change		U2J: ± 10 % Y5U, Y5S: ± 15 %	
		Dissipation factor		U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance		3 GΩ min. at 500 V_{DC}, 60 s	
		Dielectric strength (between lead wires)		No failure at 1.5 kV_{AC}, 60 s	
11	Biased humidity	External appearance		No visible damage. The marking shall be legible.	Loading voltage: 440 V_{AC} Ambient temperature: 85 °C ± 3 °C Relative humidity: 85 % RH Duration: 1000 h + 48 h / - 0 h Pre-treatment: capacitor shall be stored at 40 °C ± 5 °C for 24 h ± 2 h, then place at room condition for 24 h ± 2 h before initial measurements. Post-treatment: capacitor shall be stored for 24 h at room conditions before final measurements.
		Capacitance change		U2J: ± 10 % Y5U, Y5S: ± 15 %	
		Dissipation factor		U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance		3 GΩ min. at 500 V_{DC}, 60 s	
		Dielectric strength (between lead wires)		No failure at 1.5 kV_{AC}, 60 s	
12	Termination strength	Pull test	External appearance	Lead wire should not be cut off, capacitor should not be broken.	As a figure, fix the body of capacitor, apply a tensile weight gradually to each lead wire in the radial direction of capacitor up to 20 N, and keep it for 10 s ± 1 s. 
			Capacitance change	Within specification	
			Dissipation factor	Within specification	
			Insulation resistance	Within specification	
		Bending test	External appearance	Lead wire should not be cut off, capacitor should not be broken.	Bending each lead wire to 90° from the lead egress with 2.5 N force, then back to original position and bent again from the same direction. Totally 3 bends, 3 s each time. 1 bend: bending to 90° the return to normal position is one bend. Start from 1.6 mm to 3.2 mm from the part body.

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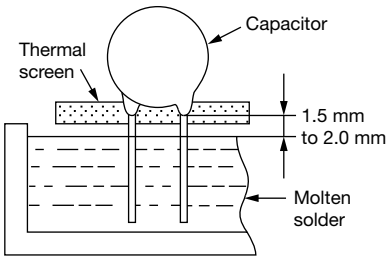
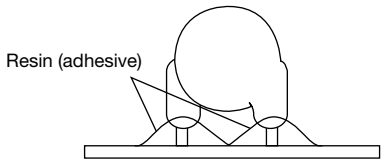
PERFORMANCE				
NO.	**ITEMS**		**SPECIFICATION**	**TEST METHOD**
13	Resistance to solder heat	Visual	No visible damage. The marking shall be legible.	The lead wire shall be immersed into the melted solder of 260 °C ± 5 °C up to about 1.5 mm to 2 mm from the main body for 10 s ± 2 s. Inspect under 10 x magnification  Pre-treatment: Capacitor shall be stored at 125 °C ± 5 °C for 1 h, then placed at room condition for 24 h ± 2 h before initial measurements. Post-treatment: Capacitor shall be stored for 24 h ± 2 h at room condition.
		Capacitance change	Within ± 10 %	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	1 GΩ min. at 500 V_{DC}, 60 s	
		Dielectric strength (between lead wires)	No failure at 1.5 kV_{AC}, 60 s	
14	Solderability	External appearance	95 % of terminations evenly covered with solder under 10 x magnification.	Method A at category 3, steam aging for 8 h ± 15 min. Solder and temperature: a) Lead (Pb)-free solder (Sn-3Ag-0.5Cu) 245 °C ± 5 °C b) H63 eutectic solder 235 °C ± 5 °C dip lead wire into an ethanol solution of 25 % ± 0.5 % rosin and then into molten solder for 5 s + 0 s / - 0.5 s. Depth of immersion within 1.25 mm, immerse and withdraw at 25 mm/s ± 6 mm/s
15	Vibration test	Visual	No visible damage. The marking shall be legible.	 Solder the capacitor and gum up the body to the test jig by resin (adhesive). The capacitor should be firmly soldered to the supporting lead wire. Vibration change from 10 Hz to 2000 Hz, then back to 10 Hz. Total amplitude: 1.5 mm with 5 *g* max., 12 cycles, 20 min for each mutually perpendicular directions, 3 directions.
		Capacitance change	Within ± 10 %	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	10 GΩ min. at 500 V_{DC}, 60 s	

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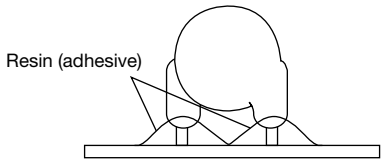
PERFORMANCE				
NO.	**ITEMS**		**SPECIFICATION**	**TEST METHOD**
16	Mechanical shock	External appearance	No visible damage. The marking shall be legible.	 Solder the capacitor and gum up the body to the test jig by resin (adhesive). 3 shocks in 2 directions should be applied, totally 3 mutually perpendicular axes, 18 shocks. Shock from: half-sine Duration: 6 ms Acceleration: 100 *g*
		Capacitance change	Within the specified tolerance.	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	10 GΩ min. at 500 V_{DC}, 60 s.	
17	Resistance to solvents	External appearance	No visible damage. The marking shall be legible.	Leave parts in solvent for 3 to 8 min at 25 °C ± 5 °C, 1 min air-drying Rub parts against wet bristle 10 times (3 x for marking, 10 x for part damage) Solvent 1: 1 part (by volume) of isopropyl alcohol, 3 parts (by volume) of mineral spirits Solvent 2: Terpene defluxer Solvent 3: 42 parts (by volume) of water, 1 part (by volume) of propylene glycol, 1 part (by volume) of monoethanolomine
18	Temperature cycle	Capacitance change	Within ± 10 % for U2J Within ± 20 % for Y5U and Y5S	The capacitor should be run 3000 temperature cycles. Step as below: Step 1 -55 °C + 0 °C / - 3 °C, dwell time ≤ 30 min Step 2 Transition time ≤ 1 min Step 3 +125 °C + 3 °C / - 0 °C, dwell time ≤ 30 min Step 4 Transition time ≤ 1 min Pre-treatment: capacitor shall be stored at 125 °C ± 3 °C for 1 h, then placed at room condition for 24 h ± 2 h before initial measurement. Post-treatment: capacitor shall be stored for 24 h ± 2 h at room condition. **Note** • 6800 pF and 10 000 pF only 1000 cycles
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	3 GΩ min at 500 V_{DC}, 60 s	
		Dielectric strength	No failure at 1.5 kV_{AC}, 60 s	
		External appearance	No visible damage. The marking shall be legible.	
19	High temperature exposure (storage)	External appearance	No visible damage. The marking shall be legible.	Storage capacitor at 125 °C ± 3 °C for 1000 h + 48 h / - 0 h without loading. Pre-treatment: capacitor shall be stored at 125 °C ± 3 °C for 1 h, then placed at room condition for 24 h ± 2 h before initial measurement. Post-treatment: capacitor shall be stored for 24 h ± 2 h at room condition.
		Capacitance change	Within ± 10 % for U2J Within ± 20 % for Y5U and Y5S	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	1 GΩ min. at 500 V_{DC}, 60 s	

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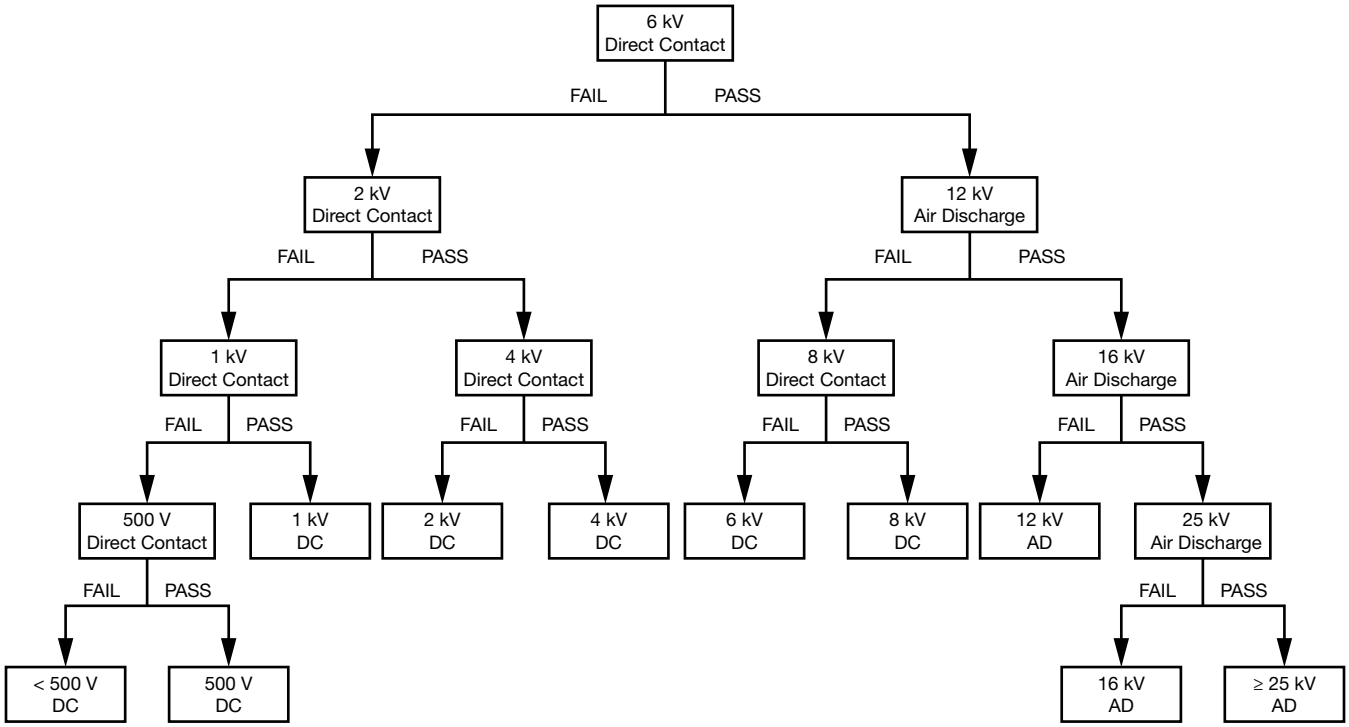
PERFORMANCE				
NO.	ITEMS		SPECIFICATION	TEST METHOD
20	ESD	External appearance	No visible damage. The marking shall be legible.	See chart “ESD Test Method” below
		Capacitance change	Within ± 10 %	
		Dissipation factor	U2J: 0.5 % max. at 1 V, 1 MHz Y5U, Y5S: 5 % max. at 1 V, 1 kHz	
		Insulation resistance	1 GΩ min. at 500 V_{DC}, 60 s.	

ESD TEST METHOD



Notes

- DC means “direct contact discharge”
- AC means “air discharge”
- Classify the components according to the highest ESD voltage level survived during ESD testing

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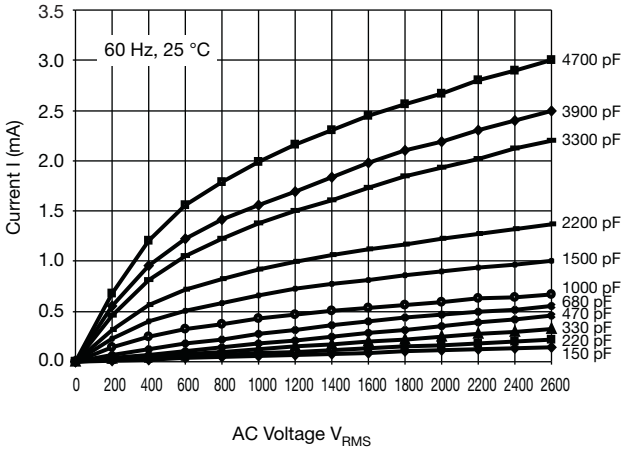
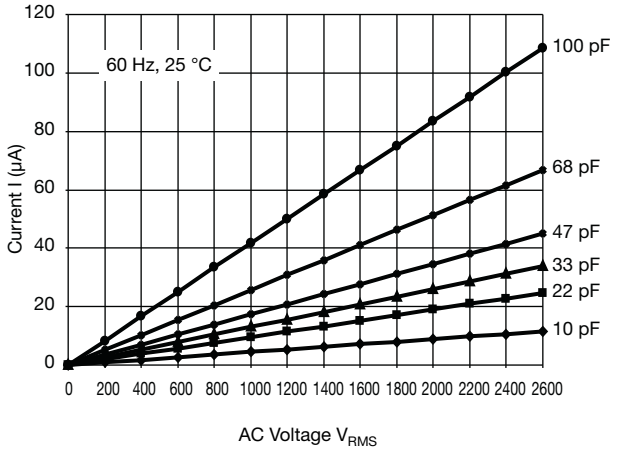
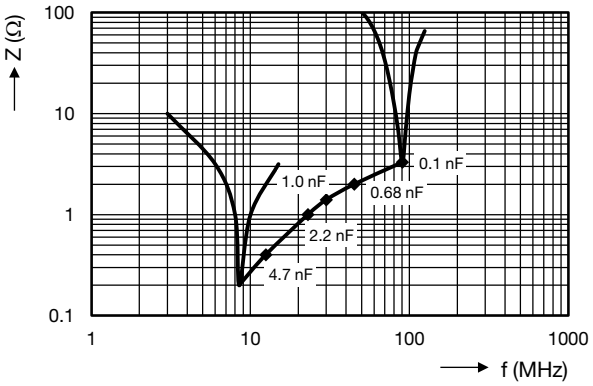
LEAKAGE CURRENT VS. VOLTAGE (Typical)





IMPEDANCE VS. FREQUENCY (Typical)



Lead configuration: length = 30 mm, lead spacing: standard, lead diameter: standard, inline crimp

Note

- The capacitors meet the essential requirements of “EIA 198”. Unless stated otherwise all electrical values apply at an ambient temperature of 25 °C ± 3 °C, at normal atmospheric conditions

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