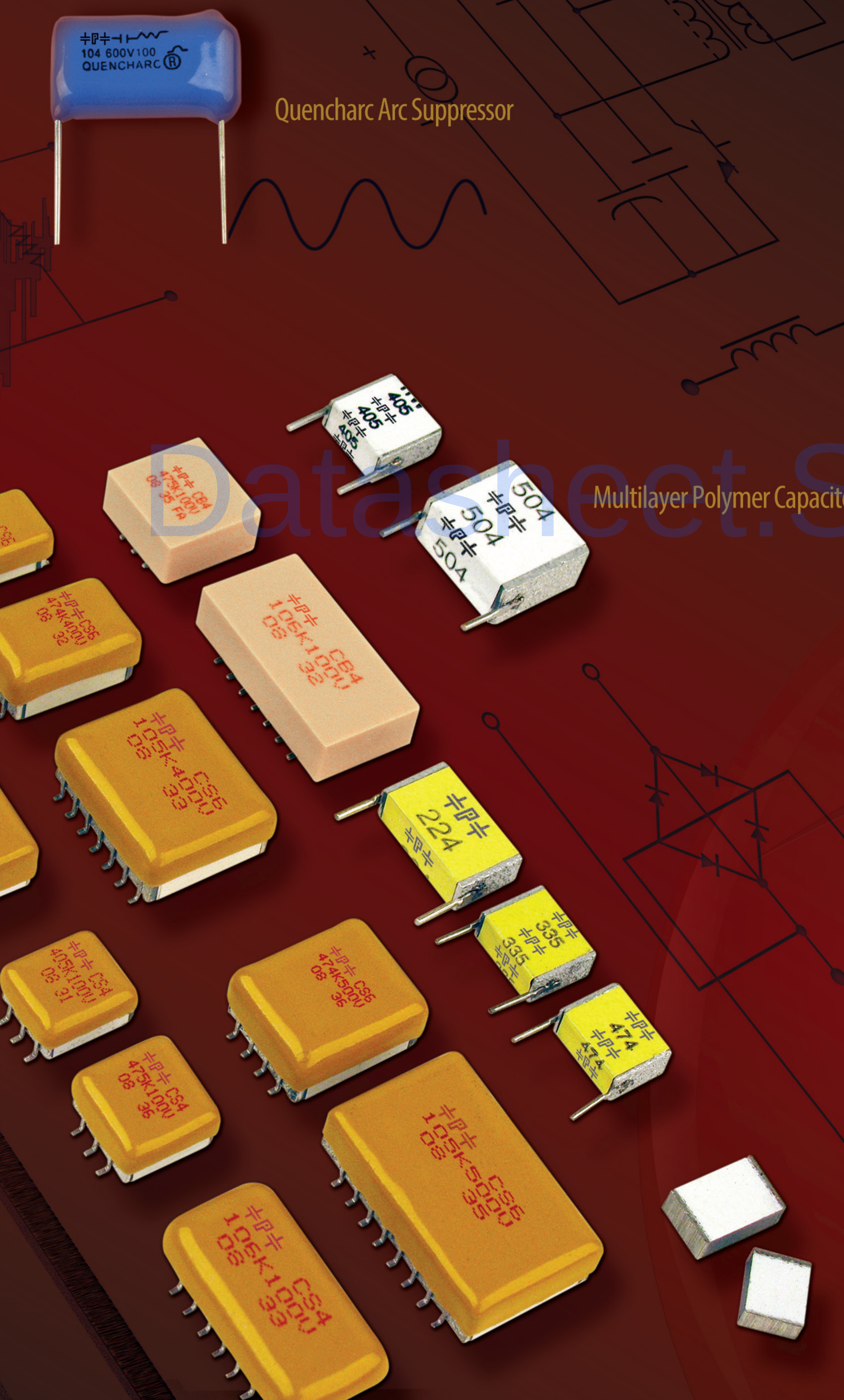
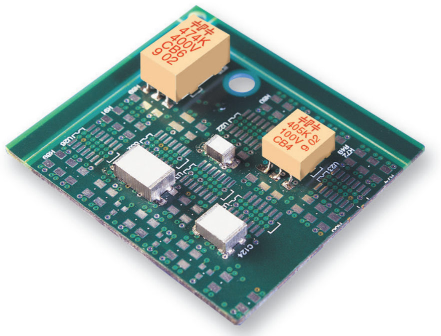
PAKTRON
CAPACITORS



a PANCON Corporation

PAKTRON CAPACITORS

MULTILAYER POLYMER CAPACITORS



- Ultra Low ESR
- High Ripple Current
- High Frequency
- Long Life

MLP Capacitor Advantages over Ceramics

Paktron specializes in Ultra Low ESR multilayer polymer film capacitors and leads in Film-Chip and SMT designs. Paktron has been manufacturing film capacitors for over 50 years. Paktron holds in excess of seventyfive patents for film capacitors and machine design.

Capacitors featured are:

Angstor® Miniature Radial

Capstick® Lead-Framed MLP

Surfilm® Surface Mount Chip

Quencharc® R-C Network/Snubber

The metallized electrode used in Paktron's proprietary Interleaf® Technology process assures reliable performance. Multilayer Polymer (MLP) surface mount, chip and lead framed capacitors are replacing MLC (ceramic) capacitors in higher voltage and reliability-sensitive equipment. This includes the popular -48 volt telecom bus, off-line HVAC and PFC front ends.

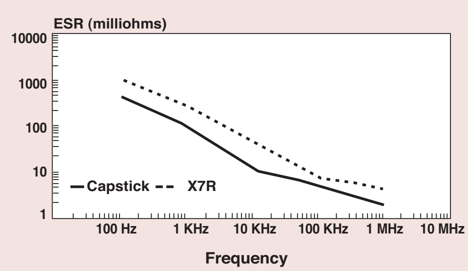
Today, the fastest-growing market segment that Paktron serves is Power Conversion for industries such as Telecommunications/Datacom, military infrastructure, automotive, medical and high-end industrial. The 100 volt rated MLP film capacitor is becoming the part of choice for input/output filtering in -48 volt telecom bus power applications (on-board or dc/dc modules). The MLP capacitor provides improved stability, both electrically and mechanically, compared to multilayer ceramics. The MLP features "non-shorting" operation and does not crack like large ceramic blocks.

Multilayer Polymer Film (MLP)	X7R Ceramic (MLC)
✔ Stable under voltage	Cap drops 40% at 100 volts bias
✔ Stable under AC voltage	DF increases with AC voltage
✔ Chip is plastic with good TCE	Body is ceramic which cracks
✔ Stable over temperature	DF increases at low temperature
✔ No aging mechanism	Cap drops per decade hour
✔ Resilient under thermal shock	Ceramic body cracks easily
✔ Self-clearing thin electrodes	Thick film electrodes fail short
✔ Stable under mechanical stress	Piezoelectric voltage sensitive
✔ Ultra Low ESR	Low ESR
✔ Dissipation Factor ≤ 1%	Dissipation Factor ≤ 2.5%

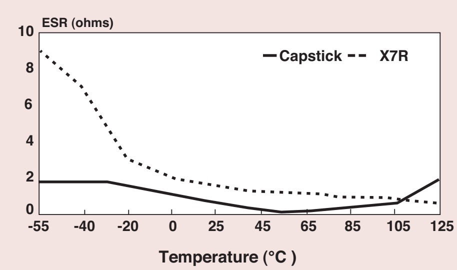
TYPICAL CHARACTERISTICS

The following graphs contrast important characteristics of MLP Capsticks to MLC ceramic units in typical, dynamic converter conditions. The electrical stability of the MLP capacitor is clear.

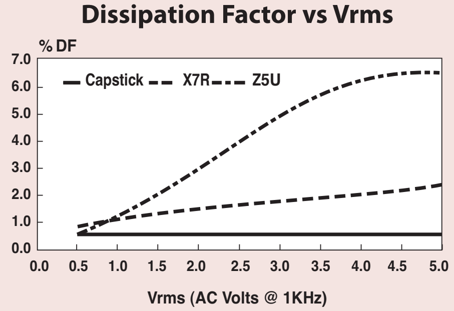
ESR vs. Frequency



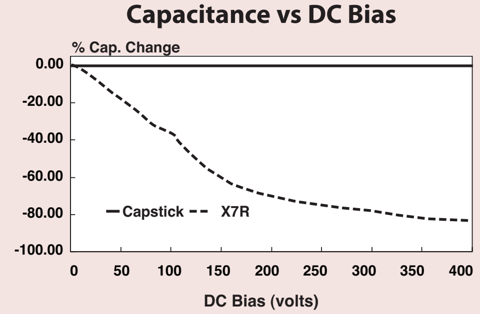
120 Hz ESR vs. Temperature



Dissipation Factor vs Vrms



Capacitance vs DC Bias



Metallized PET-SMD (Low Shrinkage Polyester) dielectric — MLP Capacitor Styles

Metallized PET (Polyester) dielectric with series resistor (snubber network)

Ordering/Part Number Information

Example:

405 K 100 CS4 G _ _

Suffix: A two-letter suffix may be added by the factory to denote special construction and/or RoHS (Pb-Free) status.

Lead Style or Packaging: G = Gull-wing lead, T = Tape/Reel

Product Type: Identifies the basic capacitor design and lead spacing. Includes resistor value for Type Q/QRL.

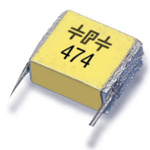
DC Voltage Rating: Expressed in hundreds of volts, except for Type Q/QRL, which is expressed in two digit voltage code.

Capacitance Tolerance: J = ±5%, K = ±10%, M = ±20%

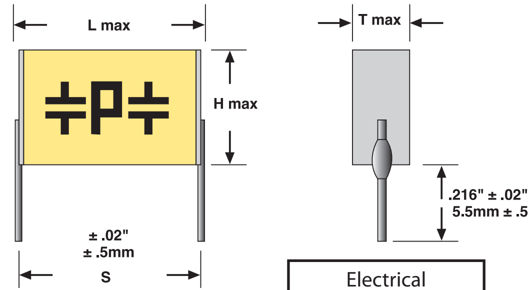
Capacitance: Expressed in picofarad code. The first two digits are the significant figures, the third digit is the number of zeros following. (i.e. 405 = 4000000 pF = 4.0 µF)

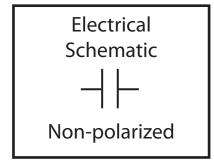
Capacitor Type

RA



- **Efficient size**
- **Rugged construction**
- **Does not fail short – Self healing**
- **Low ESR/ESL**
- **No entrapped moisture or air in self-encased design**
- **No dissimilar metals to chemically degrade or attract moisture**
- **High dv/dt**
- **Wave solderable**
- **Operating temperature range: –55°C to +125°C**
- **Made in U.S.A.**





100 VDC / 80 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
224	0.22	0.350 (8.9)	0.155 (3.9)	0.280 (7.1)	0.295 (7.5)	0.025 (.6)	75	RA3	224K100RA3 _ _
474	0.47	0.350 (8.9)	0.180 (4.6)	0.305 (7.7)	0.295 (7.5)	0.025 (.6)	65	RA3	474K100RA3 _ _
105	1.0	0.450 (11.4)	0.175 (4.4)	0.285 (7.2)	0.394 (10)	0.025 (.6)	35	RA4	105K100RA4 _ _
225	2.2	0.350 (8.9)	0.250 (6.3)	0.350 (8.9)	0.295 (7.5)	0.025 (.6)	25	RA3	225K100RA3 _ _
225	2.2	0.450 (11.4)	0.205 (5.2)	0.285 (7.2)	0.394 (10)	0.025 (.6)	25	RA4	225K100RA4 _ _
335	3.3	0.450 (11.4)	0.250 (6.3)	0.350 (8.9)	0.394 (10)	0.025 (.6)	25	RA4	335K100RA4 _ _
405	4.0	0.450 (11.4)	0.200 (5.1)	0.380 (9.7)	0.394 (10)	0.032 (.8)	20	RA4	405K100RA4 _ _
505	5.0	0.450 (11.4)	0.220 (5.6)	0.480 (12.2)	0.394 (10)	0.032 (.8)	20	RA4	505K100RA4 _ _
106	10.0	0.650 (16.5)	0.260 (6.6)	0.460 (11.7)	0.591 (15)	0.032 (.8)	13	RA6	106K100RA6 _ _

250 VDC / 160 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
104	0.1	0.450 (11.4)	0.160 (4.1)	0.255 (6.5)	0.394 (10)	0.025 (.6)	100	RA4	104K250RA4 _ _
224	0.22	0.450 (11.4)	0.190 (4.8)	0.305 (7.7)	0.394 (10)	0.025 (.6)	75	RA4	224K250RA4 _ _
334	0.33	0.450 (11.4)	0.250 (6.3)	0.330 (8.4)	0.394 (10)	0.025 (.6)	75	RA4	334K250RA4 _ _
474	0.47	0.450 (11.4)	0.210 (5.3)	0.305 (7.7)	0.394 (10)	0.025 (.6)	55	RA4	474K250RA4 _ _
474	0.47	0.650 (16.5)	0.230 (5.8)	0.340 (8.6)	0.591 (15)	0.032 (.8)	50	RA6	474K250RA6 _ _
105	1.0	0.650 (16.5)	0.240 (6.1)	0.340 (8.6)	0.591 (15)	0.032 (.8)	35	RA6	105K250RA6 _ _

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard, J (±5%) available

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead wires are plated with Sn / Pb and match conventional SnPb board assembly requirements.

For a **RoHS-6** compliant part, add a **–FA** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

400 VDC / 250 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
224	0.22	0.650 (16.5)	0.230 (5.8)	0.340 (8.6)	0.591 (15)	0.032 (.8)	65	RA6	224K400RA6 _ _
474	0.47	0.650 (16.5)	0.290 (7.4)	0.440 (11.1)	0.591 (15)	0.032 (.8)	120	RA6	474K400RA6 _ _

500 VDC / 250 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
504	0.5	0.650 (16.5)	0.280 (7.1)	0.540 (13.7)	0.591 (15)	0.032 (.8)	120	RA6	504K500RA6 _ _

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard, J (±5%) available

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead wires are plated with Sn / Pb and match conventional SnPb board assembly requirements. For a **RoHS-6** compliant part, add a **–FA** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

Electrical

Capacitance Range:
0.1 µF to 10.0 µF @ 1KHz

Tolerance:
Available in ± 5%, 10% (standard), 20%

Voltage Range:
100, 250, 400, 500 VDC

Dissipation Factor:
≤ 1.0 % @ 25°C, 1KHz

Insulation Resistance:
≥ 1,000 Megohms x µF
Need not exceed 1,000 Megohms

Rated Voltage	≤ 100 VDC	> 100 VDC
Test Voltage	10 VDC	100 VDC

Dielectric Strength:
1.6 x RVDC, 2 seconds max.
(Bold P/Ns) 1.3 x RVDC, 2 seconds max.

Self Inductance:
2 to 6nh typical

Temperature Range:
-55°C to 125°C @ rated DC voltage
(Bold P/Ns) –55°C to 125°C,
derate voltage 1.25% / °C above 85°C

Performance

Accelerated DC Voltage Life Test:
1,000 Hours, 85°C, 1.25 × Rated VDC
Δ C/C ≤ 5%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 1,000 Megohm x µF
Need not exceed 1,000 Megohms

Moisture Test:
85°C / 85% RH / 21 days
Applied Voltage: zero bias
Δ C/C ≤ 7%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 30% of initial limit

Long Term Stability:
After 2 years storage, standard environment
Δ C/C ≤ 2%

Physical

Vibration:
Mil Std 202 Method 204D

Solder Resistance:
260°C, 5 Sec. Δ C/C ≤ 2%

Construction:
Non-inductively constructed with metallized polyester dielectric (polyethylene terephthalate). Parallel plate–multilayer polymer (MLP) design.

Electrode:
Aluminum metallization

Case:
Polyester tape wrap

Marking:
Parts are continuously marked ∓P∓ and pf code. Capacitance, tolerance and working voltage are printed on container.

Packaging:
Bulk Packaging Standard

Angstor® Capacitor Application Notes

Paktron developed the highly advanced Interleaf® Technology method of capacitor manufacturing to improve device electrical properties and stability in actual use conditions. As opposed to the conventional winding method, Interleaf® Technology uses a high laminating pressure, linear stacking technology. The resulting capacitor chip is a construction hybrid resembling a multilayer ceramic capacitor in cross section, while offering all the fail-safe advantages of a stacked plastic film capacitor. We refer to the resultant parts as MLP or multilayer polymer. The Angstor® Capacitor (or RA Style) is a self-encased, metallized film capacitor which features small size, high dv/dt capability and very low ESR at high frequency.

Intended for thru-hole and wired applications, the units feature all aluminum electrodes and terminals that are pulse welded to the lead wires. The units are back impregnated with a microcrystalline polymer sealant, and require no external coatings for moisture protection. The internal layers are heavily laminated to eliminate air from the core material which improves high frequency response compared to competitive units. Operating temperature limit is extended to125ºC.

The following are a few examples of applications wherein the Angstor's unique features have proven desirable:

HIGH FREQUENCY SWITCHING POWER INPUTS

As the modern power converter broke the 100 KHz switching frequency barrier, the ripple voltage and RFI control components changed drastically. On the input side of 48 volt converters, a low ESR and ESL capacitor is needed in the pi filter network to control EMI generated by the switching MOSFET. Metallized film capacitors should be used because of the voltage bias and due to the unit's ability to "clear" during a high voltage event, rather than short out like a common MLC capacitor. Electrolytic (aluminum and tantalum) capacitors are not useful because of their extremely high parasitic resistance and inductance. Under ripple voltage the Angstor is stable, while ceramic capacitors increase in loss factor, creating incremental I_2R losses.

LINE AND DATA LINE NOISE SUPPRESSION

A ≥ 250V Angstor will not lose value due to the bias voltage and can be used on higher voltage lines as a differential noise bypass for RFI control. High input dv/dt up to 100 volts per micro second can be handled. In modems, the Angstor is a space efficient alternative to other input current control devices. Since the capacitor body is "plastic" there exists no piezoelectric emf due to input di/dt.

EMI/RFI SUPPRESSION

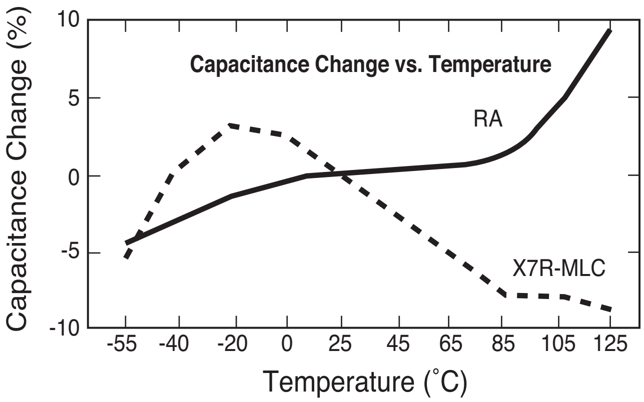
Noise suppression is required on a variety of motors and field effect devices close to the offending source to minimize RFI on the voltage bus. Noise or transients emanating from switched state motors or inductors require a low ESR capacitor as part of the filtering arrangement. The Angstor is an excellent choice for these 12, 36 and 48 volt bus-rails because of its small size compared to other film capacitors and better ESR and reliability than ceramic capacitors. As the automotive bus voltage rises from 12 to 36/42 volts, this technology will replace many ceramic and tantalum capacitors because of its enhanced voltage coefficient (stability).

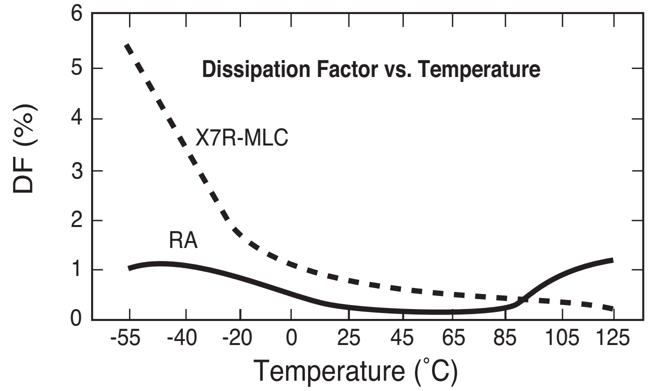
A significant new market is in on-board converters to charge batteries in EV and HEV applications.

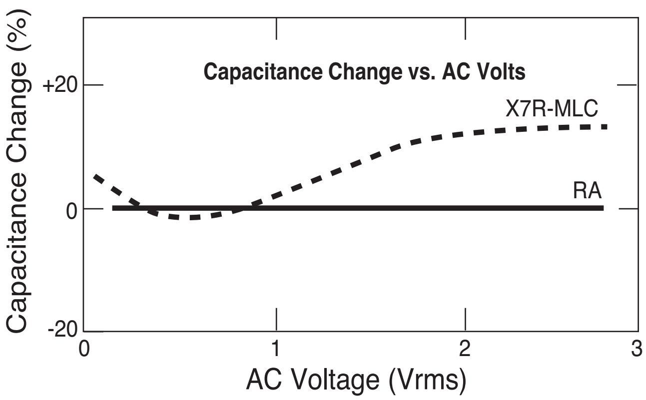
GRACEFUL AGING

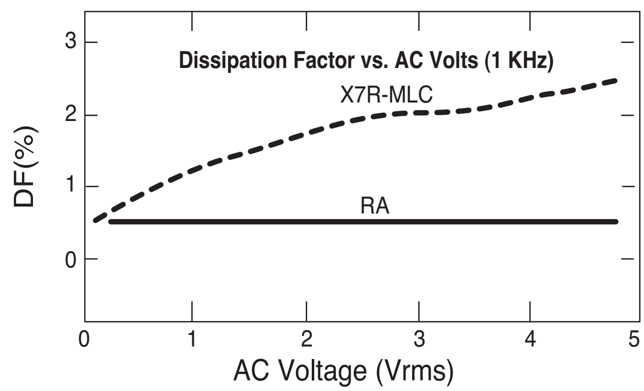
There exists no chemical interactions within the MLP Capacitor to effect long term life. The parts are suitable for 10 to 20 year life applications due to their stability and inherently low loss. The polymer dielectric becomes more crystalline over long periods of time, which can gradually lower the capacitance value. The thin-film metallized electrodes are capable of "self healing" under high voltage events. This feature avoids the shorting, cracking and rapid heat generation problem often found in ceramic capacitors.

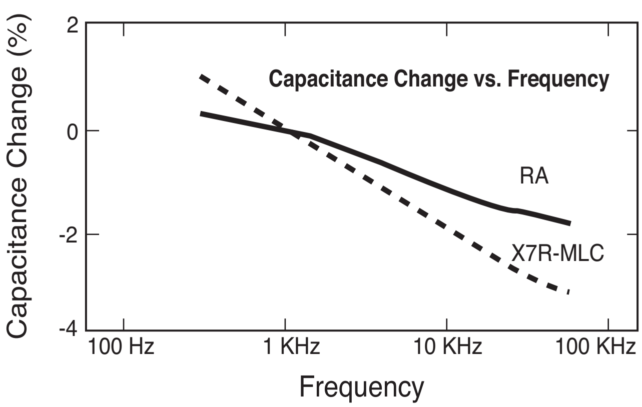
Typical Performance Curves
Comparison of Multilayer Polmer (RA) vs. Multilayer Ceramic (X7R)

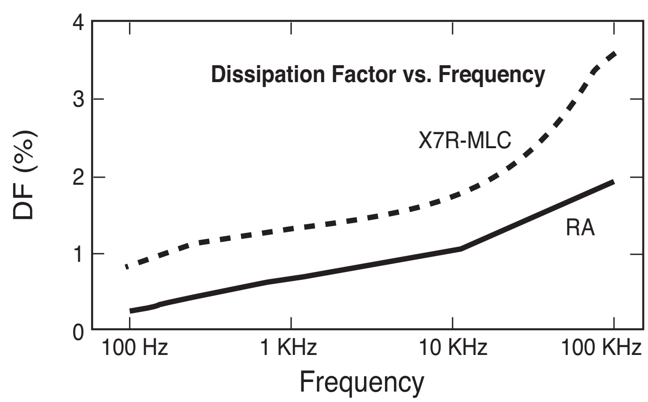


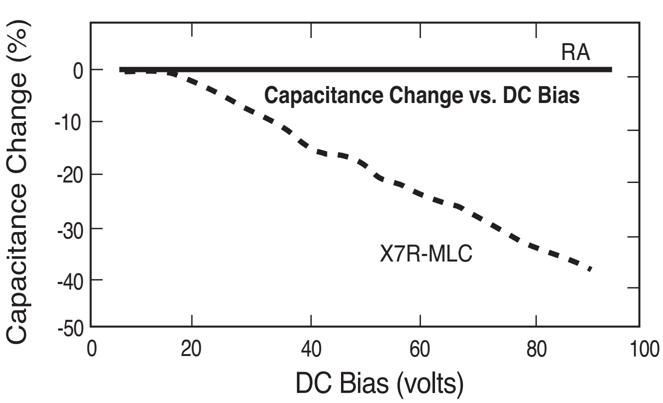


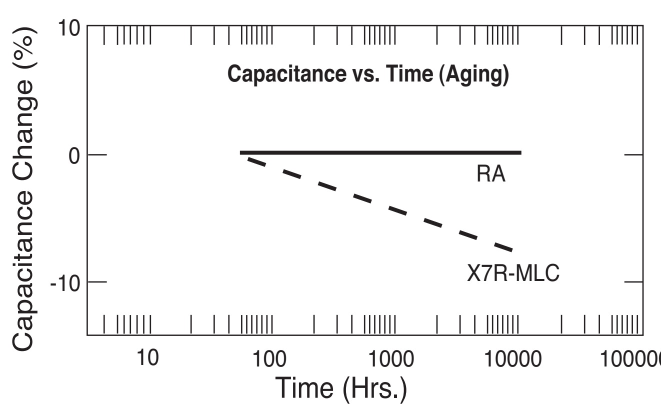






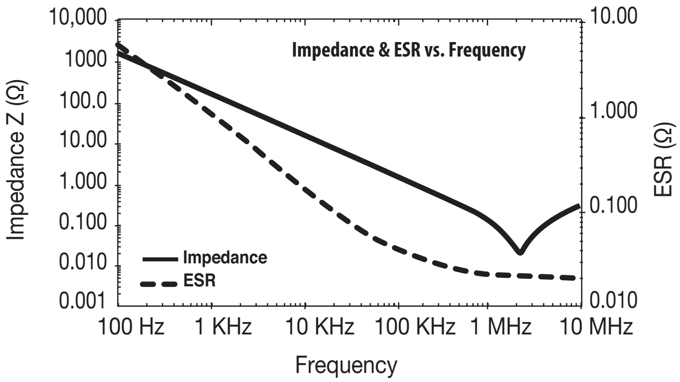




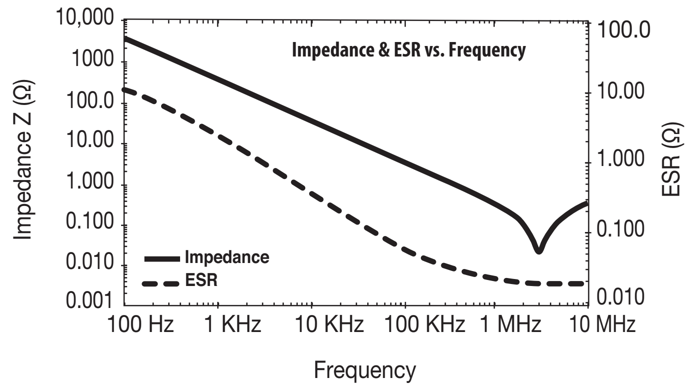


Typical Performance Curves
Selected High Value "Power" Capacitors

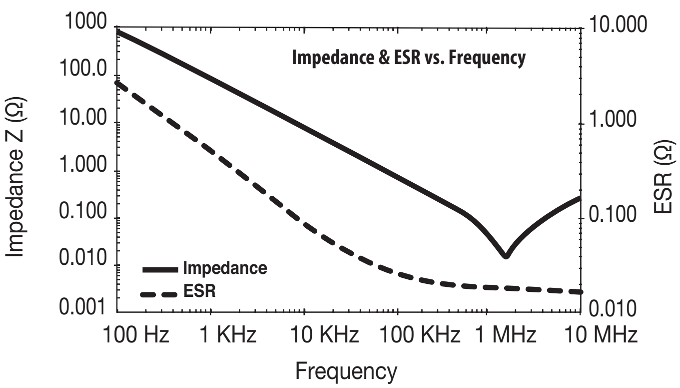
1.0 µF 100 VDC RA4



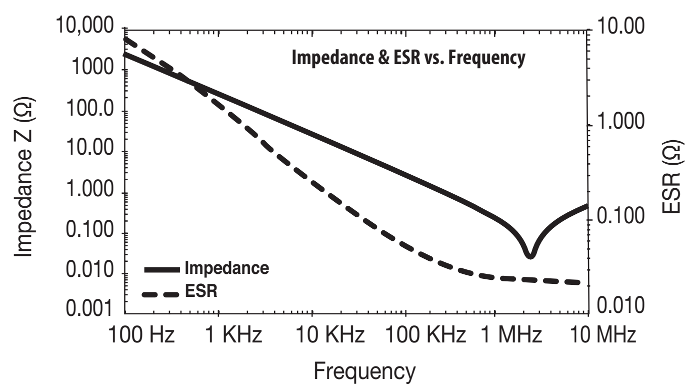
0.47 µF 250 VDC RA4



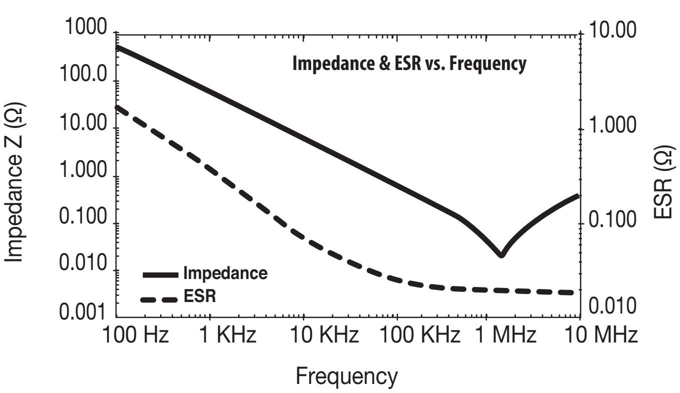
2.2 µF 100 VDC RA4



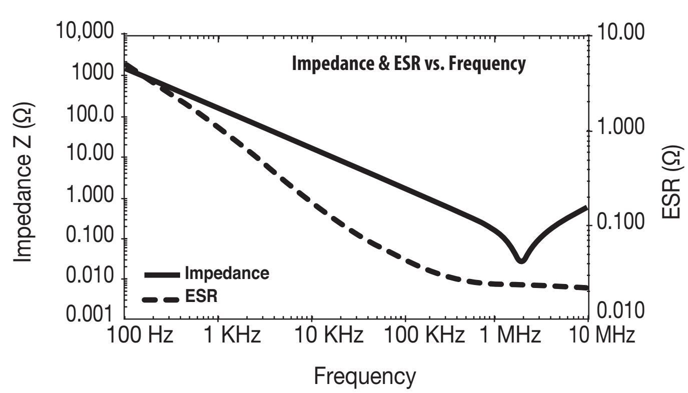
0.47 µF 400 VDC RA6



3.3 µF 100 VDC RA4

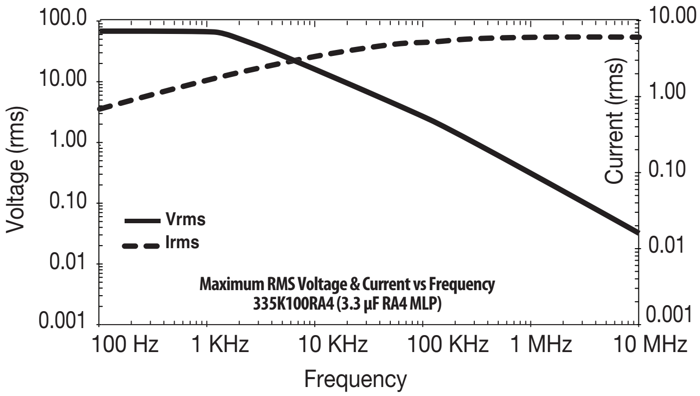


1.0 µF 250 VDC RA6

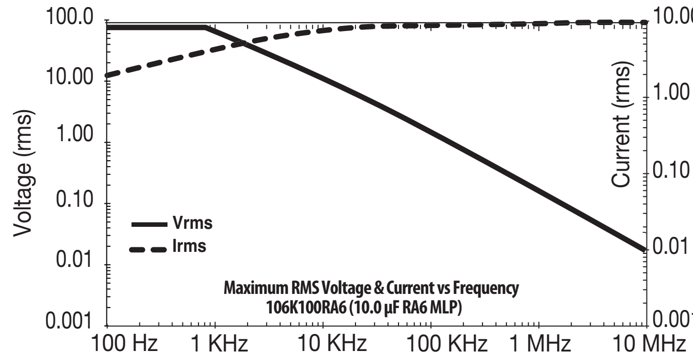


Typical Performance Curves
Selected High Value "Power" Capacitors

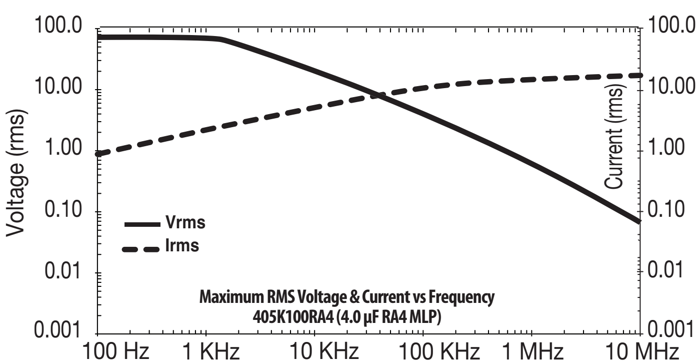
3.3 µF 100 VDC RA4



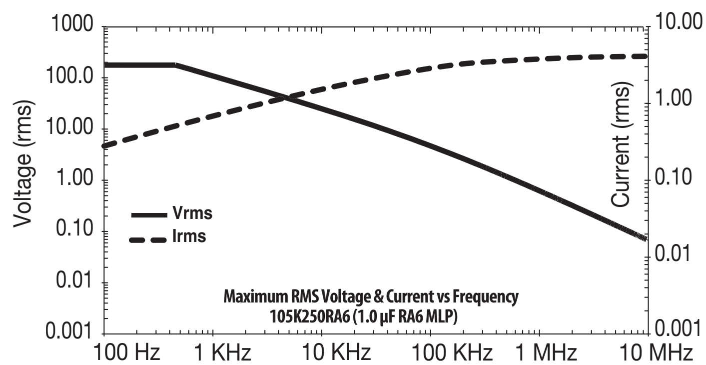
10.0 µF 100 VDC RA6



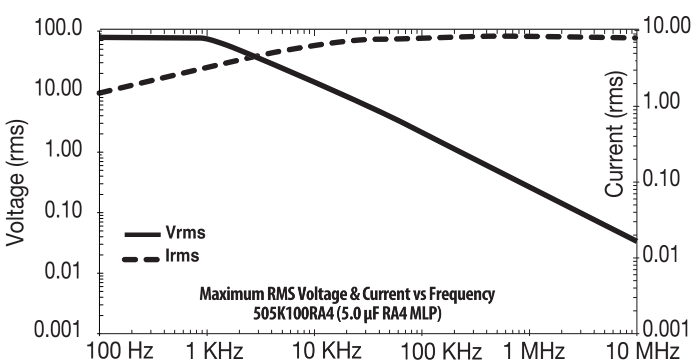
4.0 µF 100 VDC RA4



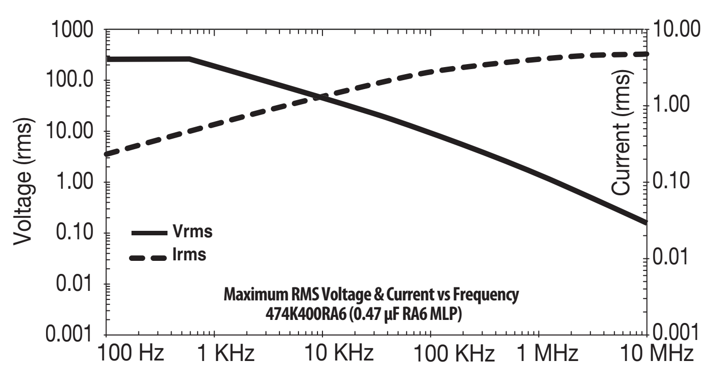
1.0 µF 250 VDC RA6



5.0 µF 100 VDC RA4



0.47 µF 400 VDC RA6



Capacitor Types

CS4 CS6

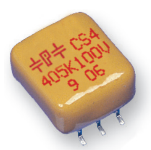
Ceramic Capacitor Replacements

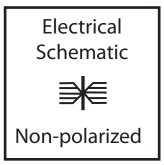
- **Surface mount capability**
- **Ideal for high frequency switching power supplies and DC to DC converters**
- **Low ESR/ESL**
- **High ripple current/ High capacitance**
- **Operating temperature range: –55°C to 125°C**
- **Volumetrically efficient**
- **Made in U.S.A.**

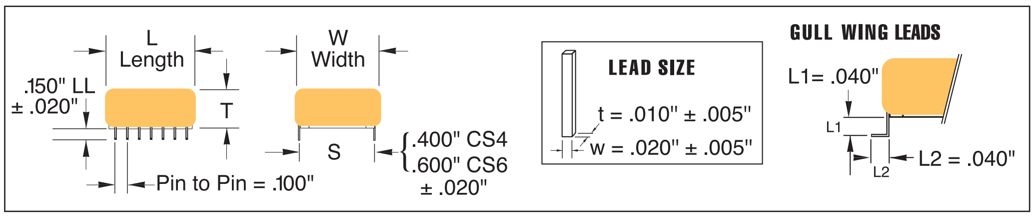
Voltage Ratings Note:

Like all film capacitors, Capstick capacitors have "true" voltage ratings and unlike other dielectric systems require no voltage deratings for maximizing reliability (MTBF) or use life. With FIT rates of well under 5 FIT when used at rated voltage, these units provide only a positive contribution to circuit MTBF calculations.

Circuit designers requiring 500 volt ratings in other dielectric systems for their 370 volt input applications are being penalized by that system's inherent deficiencies. In the film capacitor industry if a device is rated at a certain voltage, then the device is designed to be fully functional and reliable at that voltage for the life of the equipment. Many leading edge circuit designs take advantage of a film capacitor's inherent reliability at rated voltage to both reduce board size and improve performance.







50 VDC / 35 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
106	10.0	0.500 (12.7)	0.320 (8.1)	0.620 (15.7)	0.003	15.3	5	Thru-hole	CS4	106K050CS4 _ _
106	10.0	0.500 (12.7)	0.320 (8.1)	0.620 (15.7)	0.003	15.3	5	SMD	CS4G	106K050CS4G _ _
206	20.0	0.500 (12.7)	0.320 (8.1)	1.150 (29.2)	0.0025	17.8	9	Thru-hole	CS4	206K050CS4 _ _
206	20.0	0.500 (12.7)	0.320 (8.1)	1.150 (29.2)	0.0025	17.8	9	SMD	CS4G	206K050CS4G _ _

100 VDC / 80 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
205	2.0	0.500 (12.7)	0.250 (6.3)	0.450 (11.4)	0.009	8.3	3	Thru-hole	CS4	205K100CS4 _ _
205	2.0	0.500 (12.7)	0.250 (6.3)	0.450 (11.4)	0.009	8.3	3	SMD	CS4G	205K100CS4G _ _
405	4.0	0.500 (12.7)	0.250 (6.3)	0.450 (11.4)	0.007	11.5	3	Thru-hole	CS4	405K100CS4 _ _
405	4.0	0.500 (12.7)	0.250 (6.3)	0.450 (11.4)	0.007	11.5	3	SMD	CS4G	405K100CS4G _ _
475	4.7	0.500 (12.7)	0.250 (6.3)	0.525 (13.3)	0.006	12.2	3	Thru-hole	CS4	475K100CS4 _ _
475	4.7	0.500 (12.7)	0.250 (6.3)	0.525 (13.3)	0.006	12.2	3	SMD	CS4G	475K100CS4G _ _
685	6.8	0.500 (12.7)	0.250 (6.3)	0.700 (17.8)	0.005	13.7	5	Thru-hole	CS4	685K100CS4 _ _
685	6.8	0.500 (12.7)	0.250 (6.3)	0.700 (17.8)	0.005	13.7	5	SMD	CS4G	685K100CS4G _ _
106	10.0	0.500 (12.7)	0.250 (6.3)	0.995 (25.3)	0.003	15.3	7	Thru-hole	CS4	106K100CS4 _ _
106	10.0	0.500 (12.7)	0.250 (6.3)	0.995 (25.3)	0.003	15.3	7	SMD	CS4G	106K100CS4G _ _

250 VDC / 160 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
105	1.0	0.700 (17.8)	0.300 (7.5)	0.440 (11.2)	0.012	5.2	3	Thru-hole	CS6	105K250CS6 _ _
105	1.0	0.700 (17.8)	0.300 (7.5)	0.440 (11.2)	0.012	5.2	3	SMD	CS6G	105K250CS6G _ _

400 VDC / 250 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
334	0.33	0.700 (17.8)	0.320 (8.1)	0.435 (11.0)	0.012	6.0	3	Thru-hole	CS6	334K400CS6 _ _
334	0.33	0.700 (17.8)	0.320 (8.1)	0.435 (11.0)	0.012	6.0	3	SMD	CS6G	334K400CS6G _ _
474	0.47	0.700 (17.8)	0.320 (8.1)	0.460 (11.7)	0.011	6.2	3	Thru-hole	CS6	474K400CS6 _ _
474	0.47	0.700 (17.8)	0.320 (8.1)	0.460 (11.7)	0.011	6.2	3	SMD	CS6G	474K400CS6G _ _
105	1.0	0.700 (17.8)	0.320 (8.1)	0.880 (22.4)	0.008	9.5	7	Thru-hole	CS6	105K400CS6 _ _
105	1.0	0.700 (17.8)	0.320 (8.1)	0.880 (22.4)	0.008	9.5	7	SMD	CS6G	105K400CS6G _ _

500 VDC / 250 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
474	0.47	0.700 (17.8)	0.320 (8.1)	0.625 (15.9)	0.011	6.2	4	Thru-hole	CS6	474K500CS6 _ _
474	0.47	0.700 (17.8)	0.320 (8.1)	0.625 (15.9)	0.011	6.2	4	SMD	CS6G	474K500CS6G _ _
105	1.0	0.700 (17.8)	0.320 (8.1)	1.135 (28.8)	0.008	9.5	8	Thru-hole	CS6	105K500CS6 _ _
105	1.0	0.700 (17.8)	0.320 (8.1)	1.135 (28.8)	0.008	9.5	8	SMD	CS6G	105K500CS6G _ _

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead frame pin-outs are plated with Sn / Pb and match conventional SnPb board assembly requirements. For a **RoHS-6** compliant part, add a **–FA** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

Electrical

Capacitance Range:
0.33 µF to 20.0 µF @ 1KHz

Tolerance:
Available in K (±10%) standard

Voltage Range:
50, 100, 250, 400, 500 VDC

Dissipation Factor:
≤ 1.0 % @ 25°C, 1KHz

Insulation Resistance:
≥ 1,000 Megohms x µF
Need not exceed 1,000 Megohms.

Rated Voltage	*≤ 100 VDC*	*>100 VDC*
Test Voltage	*10 VDC*	*100 VDC*

Temperature Coefficient:
+6% from –55°C to 85°C

Dielectric Strength:
1.3 x rated voltage for 50/100/250/500 volt ratings.
1.6 x rated voltage for 400 volt rating

Self Inductance:
< 6nH (Typical) CS6
< 4nH (Typical) CS4

Temperature Range:
-55°C to 125°C , derate voltage 1.25% / °C above 85°C for 50/100/250 volt ratings.
-55°C to 125°C, with no voltage derating for 400/500 volt ratings.

Performance

Accelerated DC Voltage Life Test:
1,000 Hours, 85°C, 1.25 × Rated VDC
Δ C/C ≤ 5%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 1,000 Megohm × µF
Need not exceed 1,000 Megohms

Moisture/Humidity Test:
85°C / 85% RH / 21 days
Applied Voltage: zero bias
Δ C/C ≤ 7%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 30% of initial limit

Long Term Stability:
After 2 years storage, standard environment
Δ C/C ≤ 2%

Physical

Vibration:
Mil Std 202 Method 204D

Solder Resistance:
Thru-hole wave: 260°C, 5 Sec. Δ C/C ≤ 2%
SMD reflow: 220°C, 30 Sec. Δ C/C ≤ 2%

Construction:
Non-inductively constructed with metallized polyester dielectric (polyethylene terephthalate). Parallel plate–multilayer polymer (MLP) design.
Electrode: Aluminum metallization.

Case:
UL94V-0 rated epoxy coating

Lead Frame Material:
Tinned Cu Alloy Lead Frame

Lead Spacing:
.400" (10.0mm) nominal CS4
.600" (15.0mm) nominal CS6

Marking:
type, capacitance code, tolerance code, voltage and date code

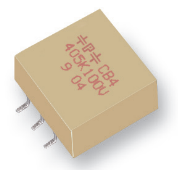
Packaging:
Anti-static tube. SMD units dry packed with desiccant in moisture barrier bag. JEDEC level on package.

Capacitor Type

CB4G

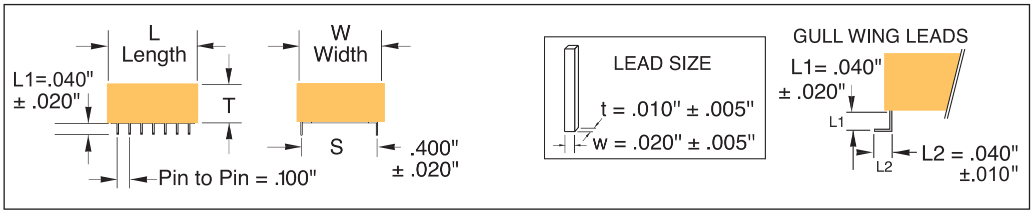
Second Generation High Frequency Switching Power Supply Capacitors

- Ideal for 48 volt bus input & output
- Low impedance (ESR/ESL) construction
- Self healing—Avoids shorts
- The reliable solution to ceramic and tantalum capacitor faults at elevated voltage
- Made for >100KHz switching power trains and reflected RFI
- Flat surface for pick and place
- Surface mount capability
- Operating temperature range: –55°C to 125°C
- High ripple current/High capacitance
- Volumetrically efficient
- Made in U.S.A.



Electrical Schematic

Non-polarized



100 VDC / 80 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
405	4.0	0.500 (12.7)	0.250 (6.3)	0.450 (11.4)	0.007	11.5	3	SMD	CB4G	405K100CB4G _ _
475	4.7	0.500 (12.7)	0.250 (6.3)	0.525 (13.3)	0.006	12.2	3	SMD	CB4G	475K100CB4G _ _
106	10.0	0.500 (12.7)	0.250 (6.3)	0.995 (25.3)	0.003	15.3	7	SMD	CB4G	106K100CB4G _ _

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead frame pin-outs are plated with Sn / Pb and match conventional SnPb board assembly requirements. For a **RoHS-6** compliant part, add a **–FA** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

Electrical

Capacitance Range:
2.0 µF to 10.0 µF @ 1KHz

Tolerance:
Available in K (±10%) standard

Voltage Range:
100 VDC

Dissipation Factor:
≤ 1.0 % @ 25°C, 1KHz

Insulation Resistance:
≥ 1,000 Megohms x µF
Need not exceed 1,000 Megohms.

Rated Voltage	*≤ 100 VDC*
Test Voltage	*10 VDC*

Temperature Coefficient:
+6% from –55°C to 85°C

Dielectric Strength:
1.3 x rated voltage

Self Inductance:
< 4nH (Typical) CB4

Temperature Range:
-55°C to 125°C , derate voltage 1.25% / °C above 85°C

Performance

Accelerated DC Voltage Life Test:
1,000 Hours, 85°C, 1.25 × Rated VDC
Δ C/C ≤ 5%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 1,000 Megohm × µF
Need not exceed 1,000 Megohms

Moisture/Humidity Test:
85°C / 85% RH / 21 days
Applied Voltage: zero bias
Δ C/C ≤ 7%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 30% of initial limit

Long Term Stability:
After 2 years storage, standard environment Δ C/C ≤ 2%

Physical

Construction:
Non-inductively constructed with metallized polyester dielectric (polyethylene terephthalate). Parallel plate–multilayer polymer (MLP) design. Electrode: Aluminum metallization.

Case:
UL94V-0 rated premolded shell

Lead Frame Material:
Tinned Cu Alloy

Vibration:
Mil Std 202 Method 204D

Solder Resistance:
Thru-hole wave: 260°C, 5 Sec. Δ C/C ≤ 2%
SMD reflow: 220°C, 30 Sec. Δ C/C ≤ 2%

Lead Spacing:
.400" (10.0mm) nominal CB4

Marking:
≑P≑ type, capacitance code, tolerance code, voltage and date code

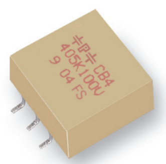
Packaging:
Tape/Reel. 13" reel. 250 pcs/reel. Units dry packed with desiccant in moisture barrier bag. IPC/JEDEC J-STD-20 Moisture sensitivity Level: MSL 4.

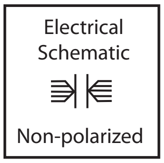
Capacitor Type

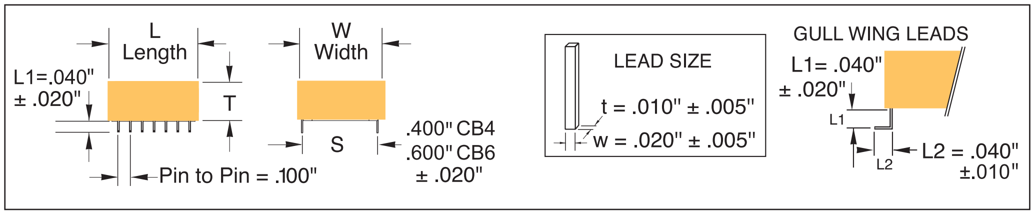
CB4G-FS CB6G-FS

3rd Generation, Thermally Shielded Capstick® Capacitor Type CB4G-FS / CB6G-FS for Pb-Free Soldering

- Ideal for 48 volt bus input & output
- Low impedance (ESR/ESL) construction
- Self healing—Avoids shorts
- The reliable solution to ceramic and tantalum capacitor faults at elevated voltage
- Made for >100KHz switching power trains and reflected RFI
- Flat surface for pick and place
- Surface mount capability
- Operating temperature range: –55°C to 125°C
- High ripple current/High capacitance
- Volumetrically efficient
- Made in U.S.A.







100 VDC / 80 VAC

PF Code	Value µF	W MAX	T MAX	L MAX	ESR @500 KHz (Ω)	RMS Current @500 KHz (A)	# Leads per side	Lead Configuration	Case	Part Number
405	4.0	0.500 (12.7)	0.350 (8.89)	0.525 (13.3)	0.007	11.5	3	SMD	CB4G	405K100CB4G-FS
475	4.7	0.500 (12.7)	0.350 (8.89)	0.525 (13.3)	0.006	12.2	3	SMD	CB4G	475K100CB4G-FS
106	10.0	0.500 (12.7)	0.350 (8.89)	0.995 (25.3)	0.003	15.3	7	SMD	CB4G	106K100CB4G-FS
500 VDC /250 VAC										
474	0.47	0.700 (17.78)	0.460 (11.68)	0.625 (15.88)	0.011	6.2	4	SMD	CB6G	474K500CB6G-FS

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead frame pin-outs are plated with Sn / Pb and match conventional SnPb board assembly requirements. For a **RoHS-6** compliant part, add a **–FS** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

Electrical

Capacitance Range:
0.47 µF to 10.0 µF @ 1KHz

Voltage Range:
100 VDC

Dissipation Factor:
≤ 1.0 % @ 25°C, 1KHz

Insulation Resistance:
≥ 1,000 Megohms x µF
100 VDC Rating: Test Voltage=10 VDC
500 VDC Rating: Test Voltage=100 VDC

Dielectric Strength:
100 VDC Rating: 130 VDC for 2 seconds max.
500 VDC Rating: 650 VDC for 2 seconds max.

Temperature Range:
100 VDC Rating: -55°C to 125°C , derate voltage 1.25% / °C above 85°C.
500 VDC Rating: -55°C to 125°C , no derating

Performance

Accelerated DC Voltage Life Test:
1,000 Hours, 85°C, 1.25 × Rated VDC
Δ C/C ≤ 5%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 1,000 Megohm × µF

Moisture/Humidity Test:
85°C / 85% RH / 21 days
Δ C/C ≤ 7%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 30% of initial limit

Long Term Stability:
After 2 years storage, standard environment Δ C/C ≤ 2%

Physical

Construction:
Non-inductively constructed with metallized polyester dielectric (polyethylene terephthalate). Parallel plate–multilayer polymer (MLP) design.
Electrode: Aluminum metallization.

Case: UL94V-0 rated premolded shell

Lead Frame Material:
Tinned Cu Alloy

Vibration:
Mil Std 202 Method 204D

Peak Reflow:
245°C max.

Solder Resistance:
245°C, 30 Sec. Δ C/C ≤ 2%

Marking:
type, capacitance code, tolerance code, voltage and date code

Packaging:
Tape/Reel. 13" reel. 250 pcs/reel. Units dry packed with desiccant in moisture barrier bag. IPC/JEDEC J-STD-20 Moisture sensitivity Level: MSL 4.

Low ESR, Multilayer Polymer (MLP) Capacitors

Miniaturized pass filters made possible by high frequency switching technology need small but low ESR and ESL capacitors to attenuate ripple and reflected RFI over wide frequency bands. With equivalent series resistance approaching zero, non-polar MLP Capacitors reliably sink high ripple currents in high density converters, run cool and are stable.

The trend toward distributed power management and modular power converters has driven the development of high efficiency, low profile power train components. The conventional capacitors historically used in ripple filtering applications are either too large or not suitable for popular methods of surface mounting. Electrolytic capacitors, while size efficient, do not provide the desired, stable electrical characteristics and reliability. Large value multilayer ceramic capacitors are notoriously fragile, expensive and unstable over voltage and temperature extremes. A novel but proven capacitor technology, built upon selected manufacturing techniques of multilayer ceramic and stacked, plastic film capacitors is now the preferred choice. Now film capacitor reliability can be found in chip and block shaped MLP capacitors that approach the board space sizes of X7R, MLC (Ceramic) types. These unique multilayer polymer capacitors (MLP's) offer excellent electrical stability under AC and DC current loads and are not subject to the cracking, shorting or TC mismatch inherent in Ceramic (MLC) capacitor products. They are suitable as input and output filter capacitors in megahertz frequency switching converters, high power ballasts and inverter drives at ambient temperatures from -55° C to 125° C.

ULTRA LOW IMPEDANCE CONSTRUCTION

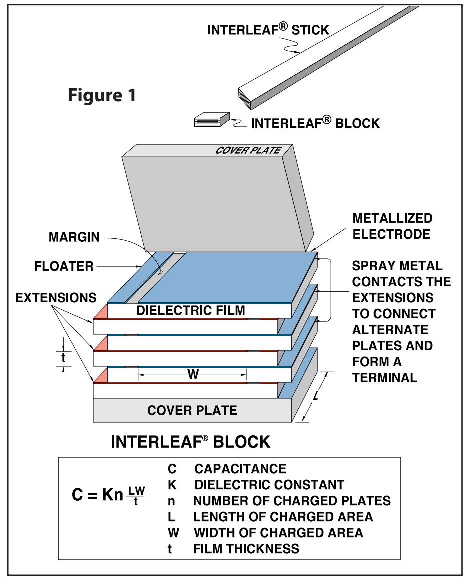
Figure 1 illustrates the multiple stacking technique used to make the MLP structures and the cross section which highlights similarities to stacked film and MLC construction. An all aluminum electrode and termination construction results in a low resistance and high current connection. The terminations are gathered to multiple pin lead frames for lowest ESR and ESL current handling. Low loss and frequency stable, ultra thin polyethylene-terephthalate polymer film is used as the dielectric.

DRIVEN BY HIGH FREQUENCY POWER CONVERSION APPLICATIONS

The trend in power conversion is the increase in switching frequency to minimize the size of the magnetic and filter components and boost the wattage per unit volume. Driven by portable computers and the distributed power approaches of both telecom and computer systems, switching frequencies have risen from 20 kilohertz to between 400 KHz and 1 megahertz in high density power converters. The filter capacitors have become an important issue as low impedance and equivalent series resistance are needed for reliable high frequency current handling. The MLP Capstick Capacitor can increase the series current of the converter which translates into higher wattage density at maximum efficiency.

NOTES ON USABILITY AND RELIABILITY

Because of the use of the well known PET dielectric in ultra thin sheet, the reliability of these capacitors is far better than the industry experience with electrolytic or ceramic capacitors. There exists no capacitance drop or aging with time. The dissipation factor is stable over time. The insulation resistance tends to get better under the influence of heat and voltage. We have shown that in-circuit problems are evident immediately and usually the result of mishandling or overheating during mounting



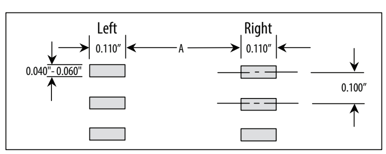
assembly. There exist no metal leaching or dielectric diffusion mechanisms to affect the reliability over time. A complete reliability data package on this and other quality MLP capacitor styles may be obtained by contacting Paktron.

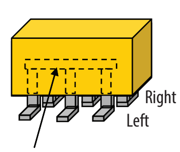
MOUNTING OPTIONS

The Capstick can be conditioned for surface mounting (including IR Reflow). Leads can be trimmed to a dimension for butt or through-hole mounting, or configured as gull wing leads. See Appendix for Capstick soldering guidelines.

CS/CB Surface Mount Pad Layout

Typical Recommendations





Note: All left side capacitor leads are joined in common internal to the capacitor and all right side capacitor leads are also joined in common internal to the capacitor

Part Number	Number of Leads per Side	A
474K500CS6G, 474K500CB4G-FS	4	0.565"
105K500CS6G	8	0.565"
334K400CS6G	3	0.565"
474K400CS6G	3	0.565"
105K400CS6G	7	0.565"
205K100CS4G,	3	0.365"
405K100CS4G, 405K100CB4G, 405K100CB4G-FS	3	0.365"
475K100CS4G, 475K100CB4G, 475K100CB4G-FS	3	0.365"
685K100CS4G	5	0.365"
106K100CS4G, 106K100CB4G, 106K100CB4G-FS	7	0.365"
106K050CS4G	5	0.365"
206K050CS4G	9	0.365"

CS/CB Performance Characteristics over a range of -55°C to +85°C

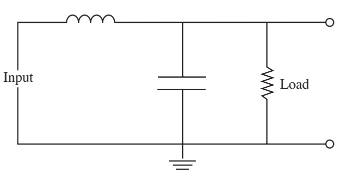
MAXIMUM RMS CURRENT (AMPS) VS. FREQUENCY

Value µF	Rated VDC	1 KHz	10 KHz	100 KHz	500 KHz	1MHz
0.47	500	0.8	1.9	3.9	6.2	7.1
1.0	500	1.1	2.4	5.9	9.5	10.6
0.33	400	0.7	1.3	3.5	6.0	6.9
0.47	400	0.8	1.9	3.9	6.2	7.0
1.0	400	1.1	2.4	5.9	9.5	10.5
1.0	250	0.7	1.6	3.3	5.2	5.9
2.0	100	0.4	2.6	6.0	8.3	8.9
4.0	100	1.9	4.2	10.2	11.5	12.0
4.7	100	2.0	4.5	10.8	12.2	12.6
6.8	100	2.9	6.6	12.5	13.7	14.0
10.0	100	4.3	9.9	14.1	15.3	15.6
10.0	50	4.2	9.7	14.0	15.3	15.6
20.0	50	9.3	13.3	16.7	17.8	18.0

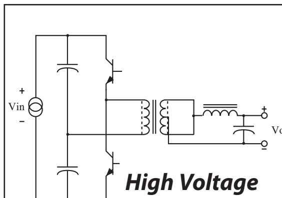
MAXIMUM RMS VOLTAGE VS. FREQUENCY

Value µF	Rated VDC	1 KHz	10 KHz	100 KHz	500 KHz	1MHz
0.47	500	250	64	13.1	4.2	2.4
1.0	500	176	38	9.4	3.0	1.6
0.33	400	250	64	17.2	6.9	4.0
0.47	400	250	64	13.1	4.2	2.4
1.0	400	176	38	9.4	3.0	1.6
1.0	250	94	24	5.0	1.6	0.9
2.0	100	35	21	4.7	1.3	0.7
4.0	100	35	18	4.2	1.0	0.4
4.7	100	35	18	3.7	0.8	0.3
6.8	100	35	18	2.9	0.6	0.3
10.0	100	35	18	2.2	0.5	0.3
10.0	50	35	18	2.2	0.5	0.2
20.0	50	35	18	1.3	0.3	0.1

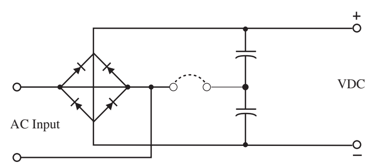
TYPICAL APPLICATIONS



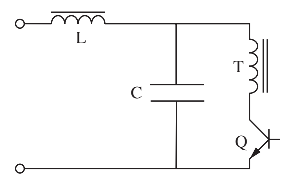
Output Filter



High Voltage Input Filter



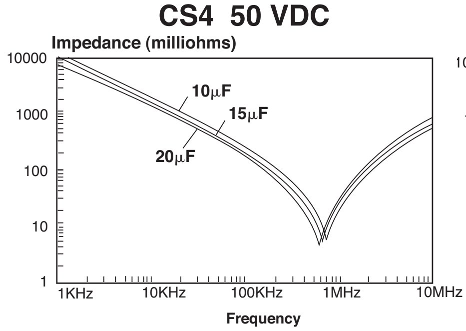
AC & Quasi AC Input Filter



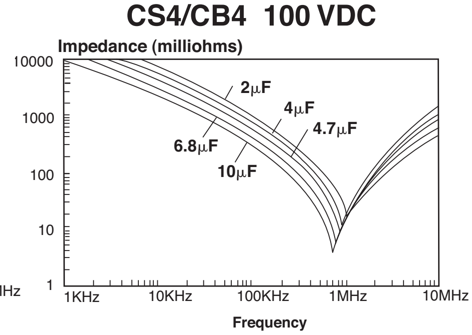
Low Pass Filter

TYPICAL IMPEDANCE VS. FREQUENCY

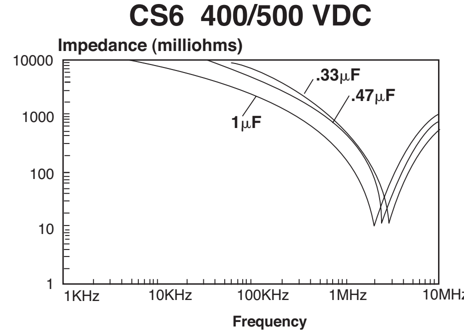
CS4 50 VDC



CS4/CB4 100 VDC

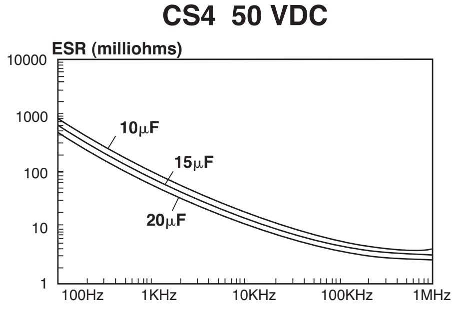


CS6 400/500 VDC

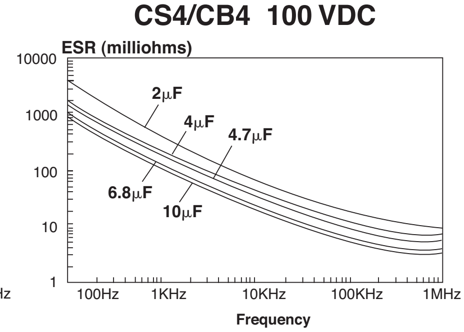


TYPICAL ESR VS. FREQUENCY

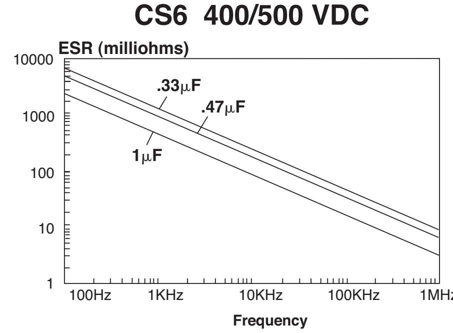
CS4 50 VDC



CS4/CB4 100 VDC

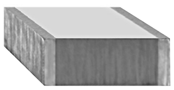


CS6 400/500 VDC



Capacitor Type

ST

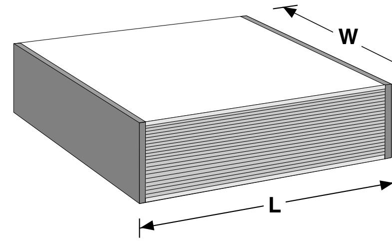


Electrical Schematic

Non-polarized

- **Pb free machined terminations**
- **Multilayer metallized polymer surface mount chips**
- **EIA Chip sizes**
- **Reflow solderable**
- **Made in U.S.A.**

ST2824/ST3827 CHIP STYLE



100 VDC / 80 VAC

PF Code	Value µF	L	T MAX	W MAX	Case	Part Number
105	1.0	0.280 - 0.305 (7.1 – 7.7)	0.175 (4.4)	0.256 (6.5)	ST2824	105K100ST2824T
225	2.2	0.380 - 0.405 (9.6 – 10.3)	0.200 (5.1)	0.286 (7.3)	ST3827	225K100ST3827T

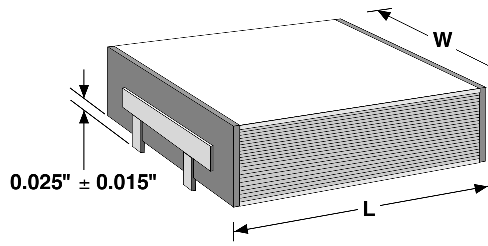
Dimensions in inches, metric (mm) in parenthesis.

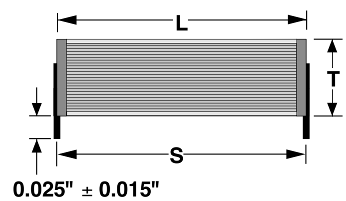
RoHS-6 Compliant

RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits

ST3/ST4 Lead Frame Style

Lead Frame Pins		
Thickness	*0.010"*	*±0.005"*
Width	*0.020"*	*±0.005"*
Pitch	*0.100"*	*±0.015"*
Height	*0.025"*	*±0.015"*
# of Pins	*2*	





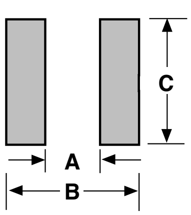
100 VDC / 80 VAC

PF Code	Value µF	L	T MAX	W MAX	Case	Part Number
105	1.0	0.280 - 0.310 (7.1 – 7.9)	0.175 (4.4)	0.256 (6.5)	ST3	105K100ST3T
225	2.2	0.380 - 0.410 (9.6 – 10.4)	0.200 (5.1)	0.286 (7.3)	ST4	225K100ST4T

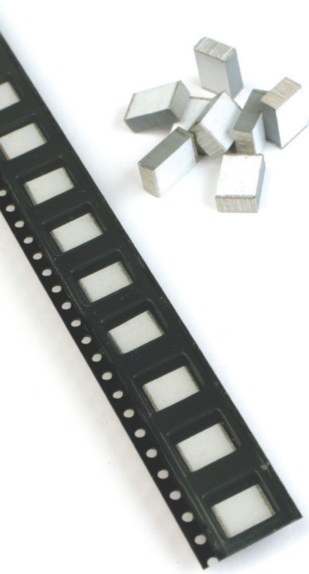
Dimensions in inches, metric (mm) in parenthesis.

RoHS-5 Compliant

RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB, and PBDE) in levels exceeding the industry defined limits. Component lead frame pin-outs are plated with Sn /Pb and match conventional SnPb board assembly requirements



Recommended Pad Sizes (inches)			
Case Code	A	B	C
ST2824/ST3	0.210	0.365	0.275
ST3827/ST4	0.310	0.465	0.305



Surfilm® Capacitors Type ST Performance Characteristics

Electrical

Capacitance Range
1.0 & 2.2µF @1KHz

Voltage Range
100 VDC

Tolerance
±10% (K)

Dissipation Factor
≤1.0% @ 1KHz

Insulation Resistance
≥ 1K MegOhms x µF, measured after 1 minute of electrification at 10 VDC

Dielectric Strength
1.3 x Rated Voltage

Temperature Coef.
+6.0% from -55°C to 85°C (typical)

Dielectric Absorption
0.30% (typical)

Self Inductance
6.0nH (typical) ST2824/ST3
9.0nH (typical) ST3827/ST4

Physical

Construction
Non–inductively constructed with metallized polyester dielectric (polyethylene terephthalate). Parallel plate–multilayer polymer (MLP) design. Electrode: Aluminum metallization

ST2824/ST3827
Chip Style
Tin-based solderable surface

ST3/ST4
Lead Frame Style
Tin Cu Alloy Lead Frame,
"I" lead configuration for SMD butt joint mounting

Enclosure
Self-encased

Marking
Parts are not marked.
Capacitance code, tolerance and rated voltage are printed on container.

Temperature Range
-55°C to 125°C, derate voltage 1.25% / °C above 85°C

Packaging
Tape/Reel
Dry packed with dessicant in moisture barrier bag. JEDEC level on package.

Quantity per reel

ST2824	1200
ST3827	850
ST3	800
ST4	700

Solder Attachment

	Yes	No
Conductive Reflow	√	
Convection Reflow	√	
IR Reflow	√	
Soldering Iron (220°C)	√	
Wave Solder		√

See Soldering Guidelines Spec. for details.

Performance

Accelerated DC Voltage Life Test:

Test Conditions

Temperature	85°C ±5°C
Applied Voltage	1.25 x Rated Voltage
Test Duration	1000 hours

Performace Requirements

Capacitance	delta of ≤ 5.0%
Dissipation Factor	≤ 1.00%
Insulation Resistance	> 50% of specification

Humidity:

Test conditions

Temperature	85°C ± 5°C
Applied Voltage	Zero voltage
Humidity	85%
Test Duration	21 days

Performance Requirements

Capacitance	delta of ≤ 7.0%
Dissipation Factor	≤1.00%
Insulation Resistance	≥ 50% of specification

Solderability (Convection Reflow):

Test Conditions

Solder Temperature	220°C +0°C, -10°C
Test Duration	30 seconds ±1

Performance Requirements

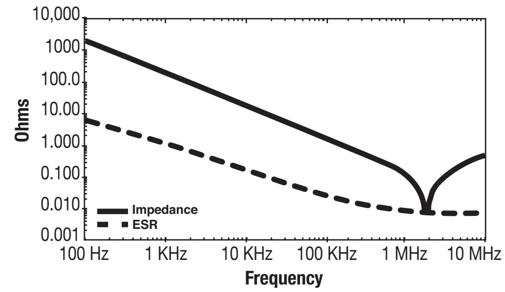
Capacitance	delta of ≤ 5.0%

Terminal Adhesion:
0.5 Kg through hole in substrate, centered. Solder fillets ≥ 1/3 T, 5 seconds with no damage.

Long Term Stability:
≤ 2.0% over two years at a temperature of between 0°C and 35°C and a RH of between 35% and 65%.

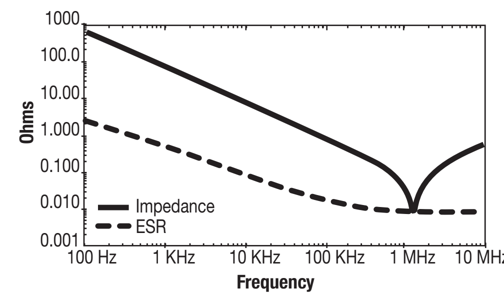
Impedance & ESR vs Frequency

ST2824/ST3 100VDC 1.0 µF (Typical)



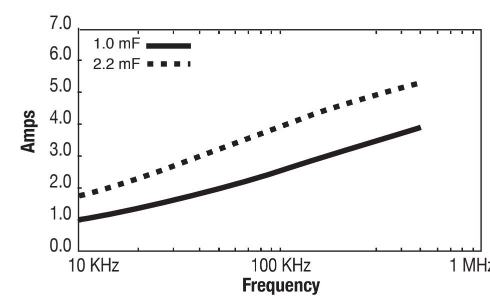
Impedance & ESR vs Frequency

ST3827/ST4 100VDC 2.2 µF (Typical)

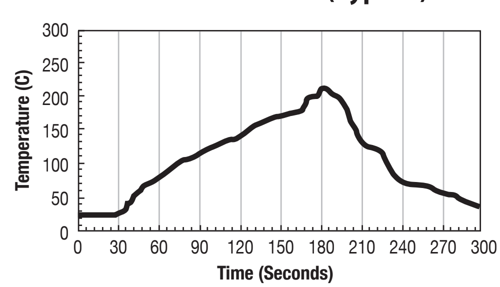


Maximum RMS Current

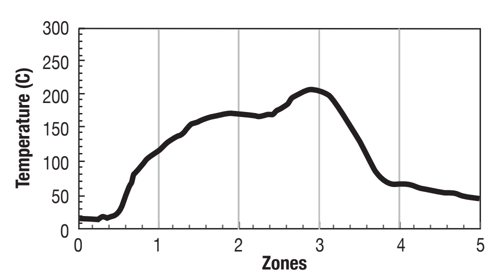
ST2824/ST3 1.0 µF & ST3827/ST4 2.2 µF (Typical)



Convection Reflow Profile (Typical)



IR Reflow Profile (Typical)



PAKTRON CAPACITORS

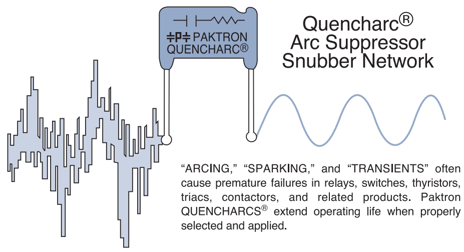
Arc Suppressor
Snubber Network

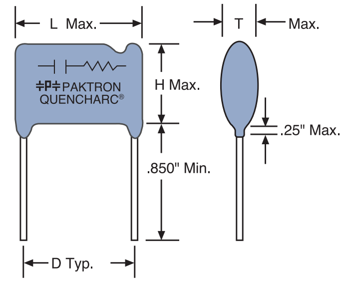
Q/QRL

UL/CSA version

Energy Efficient Noise Suppression

- Relay contact protection
- dv/dt suppression on thyristor and triacs
- No lag time in suppression
- Type QRL – UL/CSA version
- Noise reduction on controllers/drivers
- EMI/RFI reduction
- Available voltages: 125 VAC - 660 VAC
- RoHS-6 Compliant

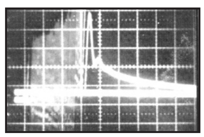




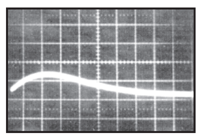
Electrical Schematic

Non-polarized

VOLTAGE WAVEFORM

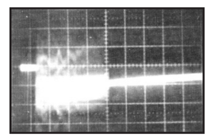


UNSUPPRESSED
100V/div .1ms/div

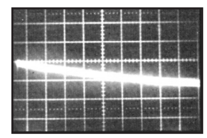


SUPPRESSED
100V/div .5ms/div

CURRENT WAVEFORM



UNSUPPRESSED
100V/div .1ms/div



SUPPRESSED
100V/div .1ms/div

PF Code	Value µF	Voltage VDC/VAC	Type	Ohms ±10%	Watt	L MAX	T MAX	H MAX	D Typical	Part Number
104	0.1	600 / 250	QC	22	0.5	1.08 (27.4)	0.39(9.9)	0.66 (16.7)	0.82 (20.8)	104M06QC22
104	0.1	600 / 250	QC	47	0.5	1.08 (27.4)	0.39(9.9)	0.66 (16.7)	0.82 (20.8)	104M06QC47
104	0.1	600 / 250	QC	100	0.5	1.08 (27.4)	0.39(9.9)	0.66 (16.7)	0.82 (20.8)	104M06QC100
104	0.1	600 / 250	QC	150	0.5	1.08 (27.4)	0.39(9.9)	0.66 (16.7)	0.82 (20.8)	104M06QC150
104	0.1	600 / 250	QC	220	0.5	1.08 (27.4)	0.39(9.9)	0.66 (16.7)	0.82 (20.8)	104M06QC220
104	0.1	600 / 250	QC	330	0.5	1.08 (27.4)	0.39(9.9)	0.66 (16.7)	0.82 (20.8)	104M06QC330
104	0.1	1200 / 480	QH	39	2.0	1.60(40.6)	0.64(16.3)	1.04(26.4)	1.29(32.7)	104M48QH39
104	0.1	1600 / 660	QV	39	2.0	2.18(55.3)	0.54(13.7)	1.00(25.4)	1.80(45.7)	104M66QV39
254	0.25	600 / 250	QD	22	0.5	1.45(36.8)	0.42(10.6)	0.75(19.0)	1.20(30.5)	254M06QD22
254	0.25	600 / 250	QD	47	0.5	1.45(36.8)	0.42(10.6)	0.75(19.0)	1.20(30.5)	254M06QD47
254	0.25	600 / 250	QD	100	0.5	1.45(36.8)	0.42(10.6)	0.75(19.0)	1.20(30.5)	254M06QD100
254	0.25	600 / 250	QD	150	0.5	1.45(36.8)	0.42(10.6)	0.75(19.0)	1.20(30.5)	254M06QD150
504	0.5	600 / 250	QE	22	0.5	1.45(36.8)	0.59(15.0)	0.92(23.4)	1.20(30.5)	504M06QE22
504	0.5	600 / 250	QE	47	0.5	1.45(36.8)	0.59(15.0)	0.92(23.4)	1.20(30.5)	504M06QE47
504	0.5	600 / 250	QE	100	0.5	1.45(36.8)	0.59(15.0)	0.92(23.4)	1.20(30.5)	504M06QE100
504	0.5	600 / 250	QE	150	0.5	1.45(36.8)	0.59(15.0)	0.92(23.4)	1.20(30.5)	504M06QE150
504	0.5	200 / 125	QA	22	0.5	1.08(27.4)	0.37(9.4)	0.64(16.3)	0.82(20.8)	504M02QA22
504	0.5	200 / 125	QA	47	0.5	1.08(27.4)	0.37(9.4)	0.64(16.3)	0.82(20.8)	504M02QA47
504	0.5	200 / 125	QA	100	0.5	1.08(27.4)	0.37(9.4)	0.64(16.3)	0.82(20.8)	504M02QA100
504	0.5	200 / 125	QA	220	0.5	1.08(27.4)	0.37(9.4)	0.64(16.3)	0.82(20.8)	504M02QA220
105	1.0	200 / 125	QB	22	0.5	1.45(36.8)	0.39(9.9)	0.66(16.7)	1.20(30.5)	105M02QB22
105	1.0	200 / 125	QB	47	0.5	1.45(36.8)	0.39(9.9)	0.66(16.7)	1.20(30.5)	105M02QB47

Dimensions in inches, metric (mm) in parenthesis.

UL/CSA Recognized Across-the-Line Application

Note: Complies with UL1414 / CSA-C22.2 No.1

104	0.1	125 VAC	QRL	150	0.5	1.08(27.4)	0.44(11.18)	0.66(16.7)	0.82(20.8)	104MACQRL150
104	0.1	125 VAC	QRL	680	0.5	1.08(27.4)	0.44(11.18)	0.66(16.7)	0.82(20.8)	104MACQRL680

Type QRL: UL Recognized for 125 VAC across-the-line. UL File No. E33628
CSA Certified for 125 VAC across-the-line. CSA File No. LR32208

HOW QUENCHARC® WORKS

The most popular and commonly used method of arc suppression is to connect a resistor-capacitor network as shown in Figures A and B. The preferred method of connection is across the contacts it wants to protect. However, the network can be hooked across the load, as is shown by the dashed line, when all inductance of the load circuit is considered lumped together.

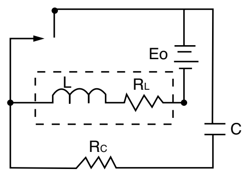


Figure A

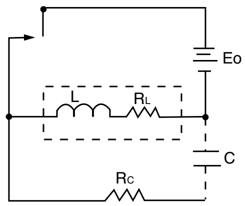


Figure B

When the contacts open, the voltage across the uncharged capacitor is zero and the transient voltage starts charging the capacitor. In the meantime, the gap of the contact is steadily widened, and by the time the capacitor is charged to its full potential, the contact gap is widened well beyond the minimum breakdown potential of air, thus preventing the arcing. When the contact closes, the inrush current from the capacitor may damage the contact, and here resistance is needed to limit the maximum current to E_o/R_c during the contact closure.
The induced voltage on opening the contact is:

$$V = IR_C = \frac{R_C}{R_L} E_o \qquad (1)$$

and, as can be seen, the larger the value of a series resistor, the higher the induced voltage. On the other hand, the lower series resistance makes the current on contact closure higher. The time dependence of the voltage is given by:

$$V(t) = L\frac{di}{dt} + (R_L + R_C)i + E_o + \frac{1}{C}\int_0^t i\,dt \qquad (2)$$

and the rate of voltage change, which is important in transient suppression of triac switching, is:

$$\frac{dv}{dt} = L\frac{d^2i}{dt^2} + (R_L + R_C)\frac{di}{dt} + \frac{i}{C} \qquad (3)$$

Equation 3 tells us that by knowing the circuit conditions with given values of L and coil resistance that limit the current prior to contact opening, the rate of voltage rise is inversely proportional to capacitance. In other words, the larger the capacitance, the greater is the transient suppression. However, when the contact closes, the additional energy stored in the capacitor has to be discharged through the contact. Hence, a compromise has to be made in the selection of both resistance and capacitance.
In an effort to provide a simple answer to designers' requests for proper values of resistance and capacitance, some relay manufacturers came out with empirical formulas and nomographs. For instance, C.C. Bates[1] gives the equations:

$$C = \frac{I^2}{10} \qquad R = \frac{E_o}{10I\left(1+\frac{50}{E_o}\right)} \qquad (4)$$

where
C = capacitance in µF
I = load current in amperes prior to contact opening
R = resistance in ohms in series with capacitor
E_o = source voltage

The choice of resistance and capacitance value however, is quite flexible. In fact, the choice is so simple that one does not need a nomograph at all. Besides, a nomograph published by a certain relay manufacturer may be for the particular relays the firm manufactures, not necessarily universal.

[1]Bates, C.C., "Contact Protection of Electro-magnetic Relays." *Electro-mechanical Design*, August, 1966.

CHOOSING A QUENCHARC®

In choosing a Quencharc®, first of all, check the maximum switching current rating of the contacts to be protected. This value differs for different types of contact materials and different types of relays. The maximum current during the contact closure with an RC network is E_o/R_c, where E_o is the source voltage and R_c is the resistance value of the network. The quantity Eo/Rc must be lower than the maximum switching current for obvious reasons. Next, the selection of capacitance is best done with an oscilloscope.
Connect the oscilloscope probe to the relay wiper and ground the other plate of the contact. Without an RC network across the contacts, check the amplitude of the transient voltage on contact break and the amplitude of the current on contact make. If the voltage is less than 300V and the current less than the maximum switching current rating of the relay, and if you don't see any arcing, you may not need the contact protection at all. If you spot arcing, connect a 0.1 µF + 100Ω, 250 VAC, QC100 (our most widely used Quencharc®), across the contacts, and observe the levels of suppression, voltage on break and current on make. The suppressed voltage should be below 250V, which provides 70 volts of safety margin from the breakdown potential of air. If the voltage is still above 250V, try a 0.25 µF + 220Ω or a 0.5 µF + 330Ω range. If you need a higher capacitance than 1.0 µF, you may be better off with a Zener or a varistor in terms of cost and space. For most relays and triacs 0.1 µF + 100Ω provides a satisfactory suppression.
When protecting contacts in AC circuits, the same general guidelines as for DC circuits can be used, but the wattage of the resistor must be considered if current flow is sustained for a long enough period of time to heat the component. Compute the impedance of the RC unit to obtain a current value, then use I^2R and time considerations to determine whether the standard network resistor is adequate.

OPERATING

TEMPERATURE RANGE –55°C to +85°C at full rated voltage.

DISSIPATION FACTOR
The nominal dissipation factor is determined from the following equation:
$DF = 2\pi fCR + 0.006$
where:
f = test frequency in hertz
C= nominal capacitance value in farads
R = nominal value of series resistor in Ω.

DIELECTRIC WITHSTANDING VOLTAGE
Unit shall withstand a DC potential of 1.6 times the DC voltage rating. Testing conducted at 25°C.

DC LIFE TEST
Unit shall withstand a test potential of 125% of the rated voltage for a period of 500 hours at a temperature of 85°C. A failure shall consist of:
- Capacitance change greater than 5%.
- Dissipation factor greater than original limits.

LONG TERM STABILITY
The capacitance shall not change more than 2% when stored at ambient temperature and humidity for a period of 2 years or less.

PHYSICAL

TOLERANCE
Capacitor ± 20%, Resistor ± 10%.

CONSTRUCTION*
Metallized polyester capacitor in series with a carbon composition resistor.

CASE
Coated with a UL94V-0 flame retardant epoxy.

WIRE LEADS
#20 AWG (0.032") capacitor end. Resistor end 0.025" to 0.032".

MARKING
Quencharc®, capacitance, resistance, voltage.

** 39Ω resistors are power wirewound*

General

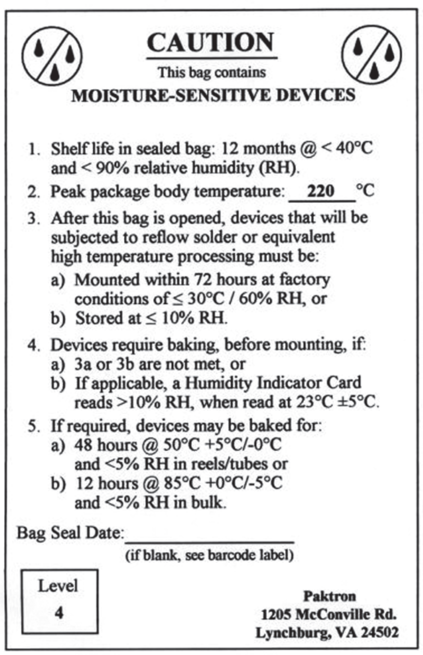
The Capstick and Surfilm capacitors Type CB, CS and ST use PET as the film dielectric and have been thermally stabilized to withstand reflow soldering temperatures for a maximum of 220°C for 30 seconds, with 1.5 minutes of allowable time at temperatures above 183°C., while products with the "-FS" suffix can be reflow soldered at a maximum of 245°C for 30 seconds, with 1.5 minutes of allowable time at temperatures above 217°C.

Dielectric Film		
Type	Name	Code
CB	polyethylene terephthalate	PET
CS	polyethylene terephthalate	PET
ST	polyethylene terephthalate	PET

To prevent excessive changes to both the electrical and mechanical characteristics, Paktron recommends that the following soldering guidelines be observed when processing Capstick and Surfilm capacitors.

Pre-Conditioning

In case of high humidity storage and short cycle reflow soldering profiles, it is recommended that the capacitors be pre-conditioned in an 85°C oven for a minimum of 12 hours prior to reflow soldering to minimize any effects caused by the rapid vaporization of the moisture.



CAUTION

This bag contains

MOISTURE-SENSITIVE DEVICES

1. Shelf life in sealed bag: 12 months @ < 40°C and < 90% relative humidity (RH).
2. Peak package body temperature: 220 °C
3. After this bag is opened, devices that will be subjected to reflow solder or equivalent high temperature processing must be:
   a) Mounted within 72 hours at factory conditions of ≤ 30°C / 60% RH, or
   b) Stored at ≤ 10% RH.
4. Devices require baking, before mounting, if:
   a) 3a or 3b are not met, or
   b) If applicable, a Humidity Indicator Card reads >10% RH, when read at 23°C ±5°C.
5. If required, devices may be baked for:
   a) 48 hours @ 50°C +5°C/-0°C and <5% RH in reels/tubes or
   b) 12 hours @ 85°C +0°C/-5°C and <5% RH in bulk.

Bag Seal Date: ____________

(if blank, see barcode label)

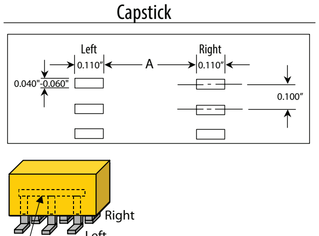
Level 4

Paktron
1205 McConville Rd.
Lynchburg, VA 24502

MLP Mounting Pad Layout

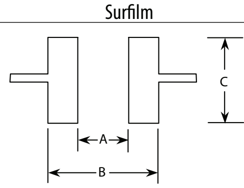
Typical Recommended

Capstick



Note: All left side capacitor leads are joined in common internal to the capacitor and all right side capacitor leads are also joined in common internal to the capacitor.

Surfilm



Recommended Pad Sizes (inches)			
Case Code	A	B	C
ST2824/ST3	0.210	0.365	0.275
ST3827/ST4	0.310	0.465	0.305

Solder Paste Thickness

Depending upon pad geometry, the recommended solder paste thickness is .006" (6 mils) to .010" (10 mils). For optimum performance, 8 mils to 10 mils should be used. In the case where small pitch components do not allow extra paste thickness, use of a "step screen" should be considered.

Board Attachment

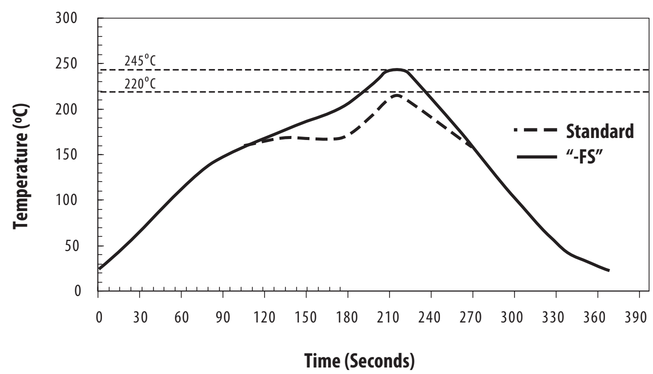
Due to their low mass, it is recommended that for optimum soldering results, Surfilm capacitors be spot glued to the substrate.

Maximum Solder Reflow Temperatures

Do not exceed the following temperatures:

Manufacturing Solder Method	Maximum Temperature			
	CB	CS	ST	"-FS"
Conductive Reflow	220°C	220°C	220°C	245°C
Convection Reflow	220°C	220°C	220°C	245°C
IR Reflow	220°C	220°C	220°C	245°C
Vapor Phase Reflow	NA	NA	220°C	NA
Soldering Iron	220°C	220°C	220°C	245°C
Wave Solder	NA	NA	NA	NA
Wave Solder (thru-hole)	260°C	260°C	NA	245°C

Typical Convection Reflow Solder Profiles



Profile Criteria	CB, CS, ST	"-FS"
Average Ramp-Up Rate	3°C/second max	3°C/second max
Preheat:		
Temperature Min	100°C	150°C
Temerature Max	150°C	200°C
Time	60 - 120 seconds	60 - 180 seconds
Time Above:		
Temperature	183°C	217°C
Time	90 seconds	90 seconds
Peak Temperature	220°C	245°C
Time within 5°C of Peak	30 seconds	30 seconds
Ramp-Down Rate	6°C/seconds max	6°C/second max
Time from 25°C to Peak	360 seconds max	480 seconds max

Board Cleaning

When cleaning the boards, avoid the use of alcohol based solvents. These may cause a temporary drop in the insulation resistance of the capacitor. The manufacturer's safety data sheet should also be studied carefully before using any solvent.

Hand Soldering Surfilm Capacitors

The following hand soldering method has proven to be satisfactory for soldering small quantities of Surfilm capacitors to printed circuit pads.

Materials and Equipment:

a. Use a soldering iron that will control the iron tip temperature to 220°C maximum. The Weller EC 2002C Soldering station and the EC1201P Iron will provide the temperature control needed

b. To reduce the heat exposure time, use a low temperature solder alloy with a low residue solder flux.

c. For ease of handling, prevention of contamination and personal injury, a pair of small tweezers should be employed to position the units for hand soldering.

Procedure:

1. Flow a thin bead of solder to one printed circuit pattern.

2. Center the capacitor to be soldered on the printed circuit electrode and place a small quantity of solder on the iron tip. Place the iron point at the junction of the capacitor electrode and printed circuit electrode and reflow the solder while applying a force to the top surface of the capacitor so that it will seat flush against the printed circuit pattern.

3. Clean the iron tip and apply the tip and solder to the opposite printed circuit and capacitor electrode junction until the solder wets the full length of the PC electrode and capacitor electrode. Do not apply a force to the top of the capacitor when soldering the second electrode.

4. Examine the first side soldered and repeat step 3 on the first side if required. The first solder application of step 2 is to mechanically position the capacitor on the board and hold it in place so that both hands are free to apply both the solder and iron tip to the second electrode. A full solder wetting may not be accomplished in step 2.

Important Points In MLP Soldering

1. Reflow Temperature: The maximum reflow solder temperature for capacitors made with PET based film dielectric is specified at 220°C. Type CB, CS and ST are made with low shrinkage PET dielectric film that has been thermally stabilized to withstand reflow soldering temperatures for a maximum of 220°C for 30 seconds, with 1.5 minutes of allowable time at temperatures above 183°C. The exception to this is product with the "-FS" suffix which is capable of withstanding reflow soldering temperatures for a maximum of 245°C for 30 seconds, with 1.5 minutes of allowable time at temperatures above 217°C. Typical reflow temperature profiles are shown on the proceeding page. Exceeding the recommended maximum temperature is one of the leading causes of soldering problems. On Type ST Product, excessive reflow temperatures can cause product swelling and shrinkage/curling of the white cover-plates, which can lift the terminations out of the solder paste and create a "drawbridge" condition that prevents complete soldering.

2. Solder Paste Thickness: While reliable solder joints have been formed using paste thicknesses as low as 4 mils, for optimum performance, 8 mils to 10 mils should be used.

3. Mounting Pad Sizes: The recommended pad size geometry is shown on the proceeding page.

4. Board Attachment: Due to the low mass of the Type ST product, it is recommended that the chips be spot glued to the substrate for optimum soldering results.

5. Storage Conditions and Floor Life: The Capstick and Surfilm component reel packaging from the factory is "dry pack." Dry packing involves sealing the reel of product with a desiccant inside a moisture-barrier bag. This type of packaging provides moisture protection for 12 months @ <40°C / <90% RH. The Floor Life or "out-of-bag" exposure time is categorized according to the "JEDEC Moisture-Sensitivity Level" specification. The Capstick and Surfilm products meet "Level 4" which allows for "out-of-bag" exposure time @ 30°C / 60% RH of 3 days (72 hours).

6. In the case of open exposure to high humidity storage, it is recommended that the capacitors be pre-conditioned prior to reflow soldering to minimize any effects caused by the rapid vaporization of the moisture. The capacitors can be pre-conditioned either while still in the reels and tubes @ 50°C for 48 hours or in bulk/loose @ 85°C for 12 hours at <5% RH.

Company Overview

In existence since 1953, Paktron is one of the oldest capacitor manufacturers in the US. Paktron is the technological leader in the manufacture of multilayer polymer film capacitors and sells across diverse markets including automotive, commercial, Hi-Rel, military, space, and telecommunications. As a quality conscience company, Paktron follows the proven philosophy of building quality into its products. Inherent quality provides for both long-term reliability as well as outstanding product performance. Paktron's longevity is testament to its commitment to Quality.

Quality System Overview

Because of Paktron's multi-industry sales markets, rather than attempting to maintain registrations to each of the vast assortment of standardized qualty sytems specific to each of these markets, since 1953 Paktron has utilized an ever evolving, capacitor industry specific, documented quality system of its own which equals or exceeds the requirements of market oriented, standardized systems without the limitations imposed by market standardization. Paktron's Quality Assurance System is a full-featured system giving Paktron the ability to produce the finest products possible. The system includes, but is not limited to:

1. Operator Training
2. Receiving Inspection
3. Calibration
4. Out-going Inspection
5. Failure Analysis
6. Statistical Process Control
7. New Product/Process Authorization
8. Vender Qualification
9. Material Review
10. In-Process Inspections
11. Surveillance Testing
12. Qualification Testing
13. Reliability Testing

Documentation System

The Paktron documentation system strictly follows the guidelines as outlined in ISO-900x. The documentation system is separated into three different sections:

1) Procedure manuals:
   - a) Quality Manual
   - b) Document Control Procedures Manual
   - c) Accounting Procedures Manual
   - d) Engineering Procedures Manual Specifications
   - e) Marketing and Sales Procedures Manual
   - f) Purchasing Procedures Manual
   - g) Production Control Procedures Manual
   - h) Quality Control Procedures Manual
   - i) Shipping and Receiving Procedures Manual
   - j) Supplier Quality Assurance Procedures Manual
   - k) Test and Reliability Procedures Manuals

2) General Procedures:

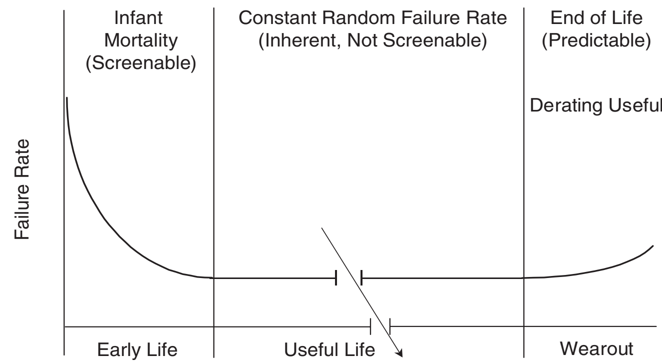
3) Specification systems:
   - a) Assembly Specifications
   - b) Design Specifications
   - c) Equipment
   - d) Material Specifications
   - e) Process Specifications
   - f) Quality Specifications

Statistical Process Control

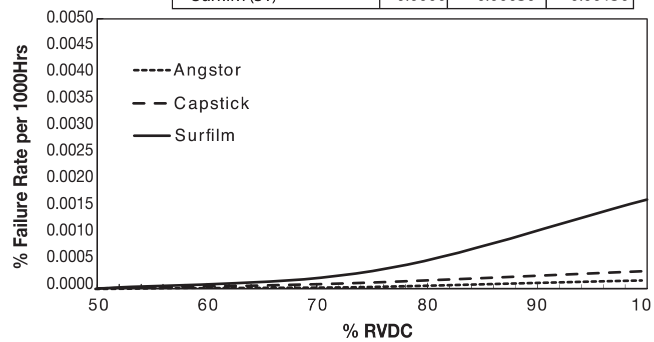
Like many other manufacturers, in order to meet the changing quality needs of its various customers, Paktron has long ago implemented a program of Statistical Process Control (SPC). This program placed the responsibility for quality directly on the production operators who must build quality into the product rather than trying to test defects out in the final test operations. This results in the production of more consistent quality and performance products. Day-to-day process control is being done with process control charts (X bar and R, percent defective, histograms and range charts) with the Paktron QA department moving into an overview function of doing trending analysis, process averaging, specification compliance control, etc. Using these systems of certification, quality levels in the low PPMs becomes not just a goal, but a reality.

Reliability

Paktron's Quality Assurance does not end once the product has been shipped to the customer. The long-term reliability of the product is as important as its initial implementation. Theoretically, a well-designed, well-engineered, thoroughly tested and properly applied component should "never" fail in operation (within the life of the equipment). However, practical experience shows that even the best design, manufacturing, and engineering efforts do not completely eliminate the occurrence of "field" failures. Usually, field failure categories encountered in components are the "infantile", "random", and in the case of mis-application, "wearout". Paktron eliminates the "infantile" category through extensive testing and strict controls (QA/SPC). The "wearout" category is eliminated by "guard-banding" the performance characteristics of the products and by maintaining close contacts between the Paktron and customer Engineering groups. "Random" failures occur after the infant mortality stage. They occur because of "undetectable" weaknesses in the products. Although the time of occurrence of random failures cannot be predicted, the probability of occurrence or non-



	@ %RVDC and 40°C		
	50%	75%	100%
Angstor (RA)	0.0000	0.00003	0.00014
Capstick (CS, CB)	0.0000	0.00010	0.00030
Surfilm (ST)	0.0000	0.00030	0.00150



occurrence of such failures can be calculated by means of the theory of probability. Paktron's reputation for "Quality" in the Industry is based not only on its ability to eliminate "infantile" failures through strict QA controls, but also on being able to minimize "random" failures through its SPC controls which detects/eliminates heretofore "undetectable" weaknesses and significantly increases the reliability of the product. Paktron's film capacitors are so inherently reliable that use life is measured in decades rather than hours of operation. While Paktron's own rigorous accelerated testing shows theoretical PPM failure levels in the single digits, customer feedback consistently reports zero PPM failure levels.

Voltage Ratings

Like all polymer film capacitors, Paktron's product offerings have "true" voltage ratings and unlike other dielectric systems require no voltage de-ratings for maximizing reliability (MTBF) or use life. With FIT rates of well under 5 FIT when used at rated voltage, these capacitors provide a positive contribution to circuit MTBF calculations.

Circuit designers requiring 500 volt ratings in other dielectric systems for their 370 volt input applications are being penalized by that dielectric system's inherent deficiencies. In the polymer film capacitor industry, if a capacitor is rated at a certain voltage, then the capacitor is designed to be fully functional and reliable at that voltage for the life of the equipment. Many leading edge circuit designs take advantage of a polymer film capacitor's inherent reliability at rated voltage to both reduce board size and significantly improve performance.

Material Content

Paktron's product offerings neither contain nor are manufactured with any risk level hazardous material. The material content for polymer film capacitors is basically: polymer, aluminum, copper, tin, iron, microcrystalline polyolefin, trace amounts of other materials such as antimony and lead and various non-toxic, non-hazardous thermoplastics used for encasements. The polymers typically used are polyethylene terephthalate (PET), polyethylene napthalate (PEN) and/or polyphenylene sulfide (PPS). The products' terminations are coated (tinned) with either 60Sn-40Pb or 100% Sn to a thickness of 100-500 micro inches in order to facilitate soldering without the possibility of whisker growth with the 100% Sn meeting current industry guidelines for lead-free (Pb-free) with a lead (Pb) material content of under 0.1 wt% (1000ppm).

RoHS-5
Standard Product
Angstor, Capstick and Surfilm (RA, RB, RS, CB, CS, ST3 and ST4):

I hereby certify that Paktron is in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the use of certain hazardous substances in electrical and electronic equipment for all articles, products, materials and parts thereof being supplied to Paktron's target Sales markets on a RoHS-5 compliance level and that the information submitted is true and accurate. RoHS-5 means that the content of five RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) are under the industry-defined limits stated below. RoHS-5 compliant products have Pb in the termination (secondary interconnect: i.e. terminal leads and lead frames) and match conventional SnPb board assembly requirements for those markets exercising Pb solder exemptions. Exempt categories under RoHS currently include the Servers, Storage, Network and Telecom equipment, Medical, Aerospace, Military and Automotive markets. While the terminations contain Pb, the total unit Pb content of Paktron's products is under the industry-defined limits stated below.

RoHS-6
Standard Product
Quencharc and Surfilm (QA, QB, QC, QD, QE, QH, QRL, QV, ST2824 and ST3827):

I hereby certify that Paktron is in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the use of certain hazardous substances in electrical and electronic equipment for all articles, products, materials and parts thereof being supplied by Paktron on a full RoHS-6 compliance level and that the information submitted is true and accurate. These Paktron products do not contain any of the six RoHS banned chemicals, compounds or elements listed, in levels exceeding the industry-defined limits stated below.

Chemical, Compound, or Element Content:

Maximum limit of 0.1% by weight (0.1w percent or 1000ppm):

- Polybrominated Diphenyl Ethers (PBDE); C12H(10–n)BrnO
  - Pentabromodiphenyl ether (PentaBDE) –
    CAS number 32534-81-9; C12H5Br5O;
  - Octabromodiphenyl ether (OctaBDE) -
    CAS number 32536-52-0; C12H2Br8O
  - Decabromodiphenyl ether (DecaBDE) –
    CAS number 1163-19-5; C12Br10O
- Polybrominated Biphenyls (PBB)
  - Decabromobiphenyl (DeBBB) –
    CAS number 13654-09-6; C12H(10–x-y)Brx+y
- Mercury – CAS number 7439-97-6; Hg
- Hexavalent Chromium – CAS number 18540-29-9; CrVI
- Lead – CAS number 7439-92-1; Pb

Maximum limit of 0.01% by weight (0.01w percent or 100ppm):

- Cadmium – CAS number 7440-43-9; Cd

Special Lead-Free Product
Angstor, Capstick and Surfilm (RA, RB, RS, CB, CS, ST3 and ST4):

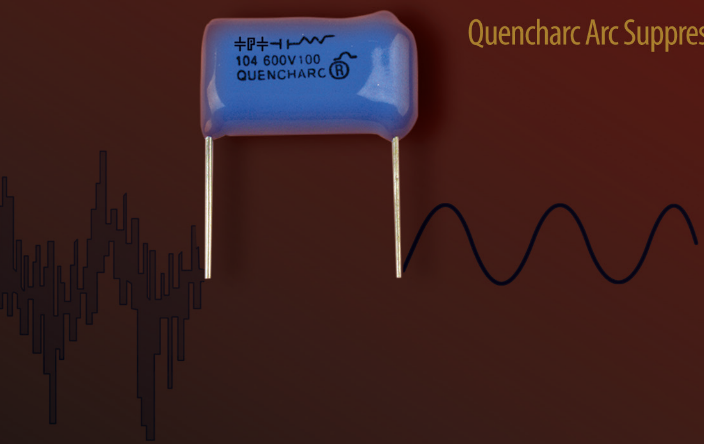
Subject to minimum order quantities and limited availability, I hereby certify that Paktron is in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the use of certain hazardous substances in electrical and electronic equipment for all articles, products, materials and parts thereof being supplied by Paktron on a full RoHS-6 compliance level, on a specialized part number basis (consisting of an added suffix of –F?; with the ? assigned at time of order/quote), and that the information submitted is true and accurate. Paktron's special lead-free products do not contain any of the six RoHS banned chemicals, compounds or elements listed, in levels exceeding the industry-defined limits stated below and also do not contain Pb in the terminations.

The maximum reflow temperature for surface mount product remains at 220°C while the maximum wave solder temperature for thru-hole product is 260°C. The maximum reflow temperature for surface mount product with the "-FS" suffix is 245°C.

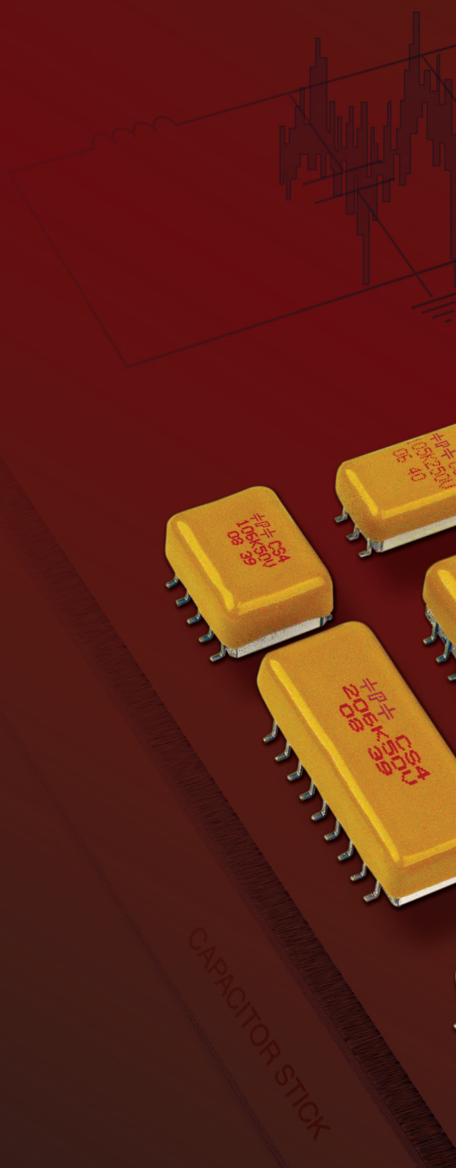
PANCON CORPORATION

The Pancon Corporation, headquartered in Stoughton MA is comprised of three businesses;
Pancon Connectors, Ark-Les Connectors and Paktron Capacitors.

Pancon and Ark-Les Connectors manufacture custom and standard connectors that are used in power and signal applications, while Paktron Capacitors multilayer polymer capacitors primarily serve power conversion applications, Industries served include telecommunications/datacom, appliances, military, automotive, medical and industrial.



Quencharc Arc Suppressor



PAKTRON CAPACITORS

1205 McConville Road
Lynchburg, Virgina 24502 USA
phone | 434.239.6941
fax | 434.239.4730
www.paktron.com