A KYOCERA GROUP COMPANY

AVX
BestCap® Ultra-low ESR
High Power Pulse Supercapacitors

BestCap® Ultra-low ESR High Power Pulse Supercapacitors

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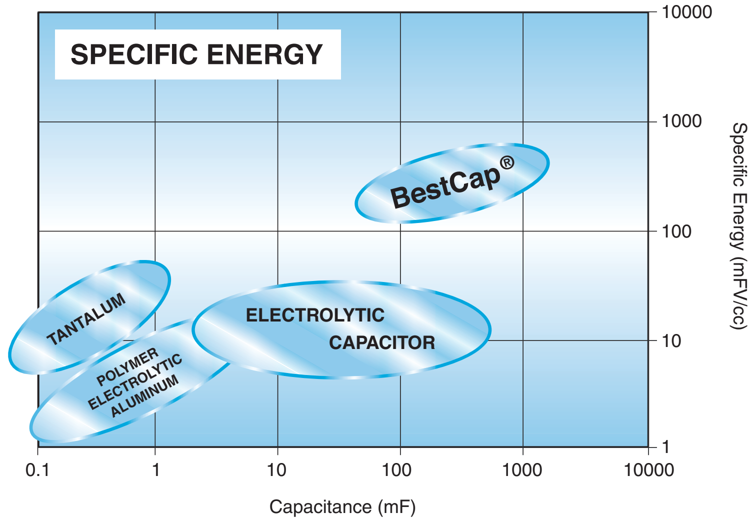
INTRODUCING
BESTCAP®: A NEW GENERATION OF PULSE SUPERCAPACITORS

Supercapacitors, (also referred to as Electrochemical Capacitors or Double Layer Capacitors) have rapidly become recognized, not only as an excellent compromise between "electronic" or "dielectric" capacitors such as ceramic, tantalum, film and aluminum electrolytic, and batteries (Figure 1), but also as a valuable technology for providing a unique combination of characteristics, particularly very high energy, power and capacitance densities.

There are however, two limitations associated with conventional supercapacitors, namely: high ESR in the tens of Ohms range, and high capacitance loss when required to supply very short duration current pulses. BestCap® successfully addresses both of these limitations.

The capacitance loss in the millisecond region is caused by the charge transfer (i.e. establishment of capacitance) being carried out primarily by relatively slow moving ions in double layer capacitors.

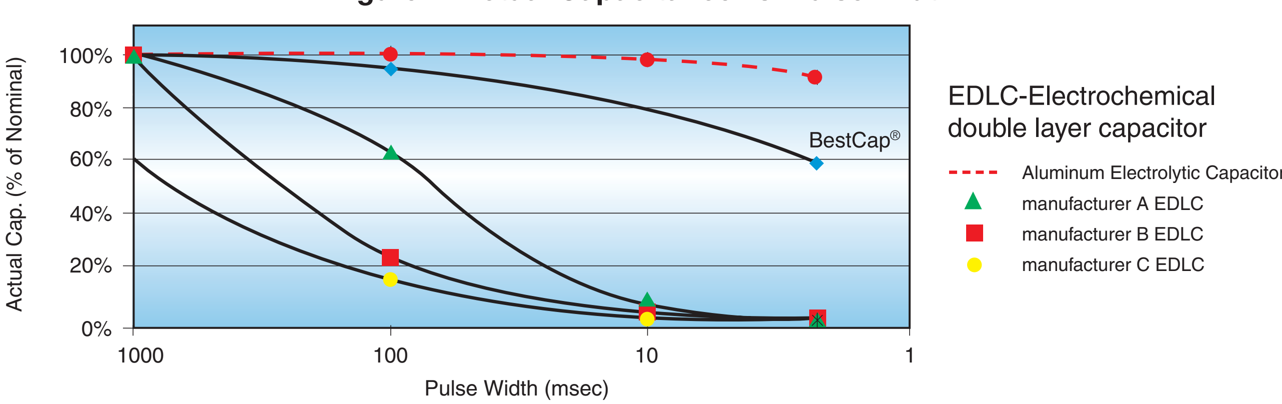
Figure 1. Specific Energy of Capacitor Types



In the above-mentioned "electronic" capacitors, the charge transfer is performed by fast electrons, thereby creating virtually instant rated capacitance value. In the BestCap®, a unique proton polymer membrane is used – charge transfer by protons is close to the transfer rate for electrons and orders of magnitude greater than organic molecules. Figure 2 below illustrates the severe capacitance loss experienced by several varieties of supercapacitors, under short pulse width conditions. It can also be seen from Figure 2, how well BestCap® retains its capacitance with reducing pulse widths.

For comparison purposes, the characteristic of an equivalent capacitance value aluminum electrolytic capacitor is shown in Figure 2. The electrolytic capacitor is many times the volume of the BestCap®.

Figure 2. Actual Capacitance vs. Pulse Width



BestCap® Ultra-low ESR High Power Pulse Supercapacitors

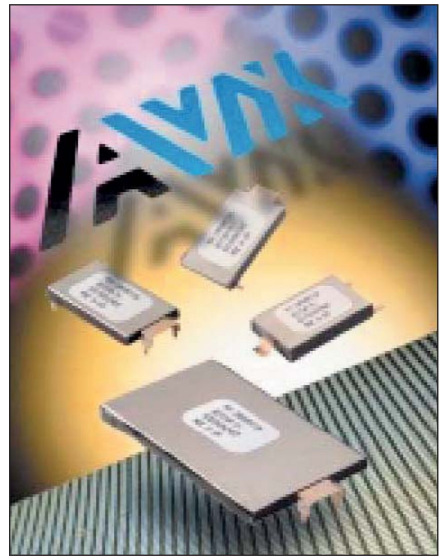
BESTCAP® – PRODUCT RANGE

AVX's BestCap® technology provides excellent high power pulse characteristics based upon the combination of very high capacitance and ultra-low ESR, together with extremely low leakage current.

Based on a unique patented aqueous chemistry and an innovative design, this series offers high capacitance, even with short pulse applications such as in GSM, GPRS, Edge and PCS based systems.

While BestCap® technology offers more efficient energy savings in battery circuits than conventional supercapacitors, its Low ESR results in a high current handling capability, making this an ideal solution for any portable or wireless device requiring high power availability.

The Low Profile versions are ideally suited to PCMCIA, PDA, DSC and similar applications.



BESTCAP® CASE CONFIGURATIONS

Standard Version

- 3 Solder-In Lead Styles, 3 Case Sizes
- Low Profile
- Low ESR
- Non-Polar
- Non-Organic

H-Lead PCB Stand-Off Version

- Placed OVER other SMDs post top-side assembly
- Insulated Body Available
- Non-Polar
- Non-Organic

BestCap® Ultra-low ESR High Power Pulse Supercapacitors

BESTCAP® – A SERIES – MAXIMUM CAPACITANCE, LOW ESR
B SERIES – LOW PROFILE, LOW ESR

The BestCap® is a low profile device from 2.1mm to 6.8mm, available in three case sizes. Capacitance range is from 15 to 560mF and includes 6 voltage ratings from 3.6v to 12v.

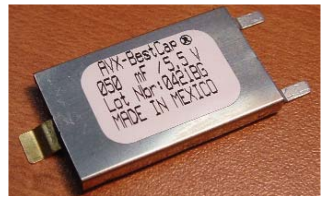
BESTCAP® – AVAILABLE LEAD CONFIGURATIONS

STANDARD:

A Style:
Through-Hole

L-Style:
Planar Mount
(available in BZ02 case only)

APPLICATION SPECIFIC:



S-Style:
Planar Mount
(available in BZ01 & BZ05 case only)

H-Style:
Extended Stand-Off
(Available in BZ01, BZ02 case size)

Case Size	BODY DIMENSIONS		
	L±0.5 (0.020) mm (inches)	W ±0.2 (0.008) mm (inches)	H nom mm (inches)
BZ01	28 (1.102)	17 (0.669)	2.1 (0.08) – 6.1 (0.24)
BZ02	48 (1.890)	30 (1.181)	2.1 (0.08) – 6.1 (0.24)
BZ05	20 (0.787)	15 (0.590)	2.1 (0.08) – 6.1 (0.24)

ELECTRICAL SPECIFICATIONS

Full dimensional specifications shown in section (2)

Capacitance range:	10mF – 560mF					
Capacitance tolerance:	–20% / +80%					
Voltage ratings (max):	3.6V	4.5V	5.5V	7V	9V	12V
Test voltages:	3.5V	4.2V	5.0V	7.0V	8.4V	10.0V
Surge test voltage:	4.5V	5.6V	6.9V	8.8V	11.3V	15.0V
Temperature range:	–20°C to 75°C (A Series)					
	–20°C to 70°C (B Series)					

HOW TO ORDER

(See Detailed Electrical Specifications for valid combinations)

BZ	01	5	A	503	Z	A	B	XX
BestCap®	**Case Size** 01 = 28mmx17mm 02 = 48mmx30mmb 05 = 20mmx15mmb	**Rated Voltage** 3 = 3.6V 4 = 4.5V 5 = 5.5V 7 = 7.0V 9 = 9.0V C = 12.0V	**Series** A = Maximum Capacitance B = Low Profile	**Capacitance Code (Farad Code)**	**Capacitance Tolerance** Z = (-20/+80)%	**Lead Format** A, H, L or S	**Packaging** B = Bulk	**Not Used For Standard Product (Consult Factory For Special Requirements)**

BestCap® Ultra-low ESR High Power Pulse Supercapacitors

SECTION 1: ELECTRICAL RATINGS

CAPACITANCE / VOLTAGE / CASE SIZE MATRIX

A-SERIES – MAXIMUM CAPACITANCE

Capacitance		Rated Voltage DC at 25°C									
mF	Code	3.6V		5.5V		7.0V		9.0V		12.0V	
		Case Size	Lead Styles	Case Size	Lead Styles	Case Size	Lead Styles	Case Size	Lead Styles	Case Size	Lead Styles
10	103									BZ05	S
22	223									BZ01	A, H, S
33	333			BZ05	S	BZ01	A, H, S	BZ01	A, H, S		
50	503			BZ01	A, H, S						
68	683			BZ05	S						
70	703	BZ01	A, H, S								
90	903									BZ02	A, H, L
100	104			BZ01	A, H, S						
120	124							BZ02	A, H, L		
140	144	BZ01	A, H, S								
150	154										
200	204			BZ02	A, H, L						
280	284	BZ02	A, H, L								
400	404			BZ02	A, H, L						
560	564	BZ02	A, H, L								

■ Available

■ In Development

B-SERIES – LOW PROFILE

Capacitance		Rated Voltage DC at 25°C									
mF	Code	3.6V		4.5V		5.5V		9.0V		12.0V	
		Case Size	Lead Styles	Case Size	Lead Styles	Case Size	Lead Styles	Case Size	Lead Styles	Case Size	Lead Styles
15	153					BZ05	S			BZ01	A, H, S
22	223			BZ05	S			BZ01	A, H, S		
30	303					BZ01	S				
33	333			BZ01	S	BZ05	S				
50	503	BZ01	S								
60	603					BZ01	A, H, S				

■ Available

■ In Development

SECTION 1: ELECTRICAL RATINGS

ELECTRICAL RATINGS - SEE SECTION 2 FOR DIMENSIONAL REFERENCES

BZ 01 CASE SIZE									
Part Number	Rated Voltage (Volts)	DC Capacitance (mF)	ESR (mOhms at 1 kHz)		Leakage Current (µA max)	Height A-Lead (mm)	Height H-Lead (mm)	Height S-Lead (mm)	Height S-Lead (AJ)* (mm)
		Nominal +80%, –20%	Typical	Maximum	Maximum	H max	H max	H max	H max
3.6v									
BZ013B503Z_B	**3.6V**	50	100	120	5	N/A	N/A	3.2	2.1
BZ013A703Z_B		70	140	168	5	3.5	6.4	4.0	2.9
BZ013A144Z_B		140	70	84	5	5.3	8.2	5.8	N/A
4.5v									
BZ014B333Z_B	**4.5V**	33	150	180	5	N/A	N/A	3.5	2.4
5.5v									
BZ015B303Z_B	**5.5V**	30	160	192	5	N/A	N/A	3.8	2.7
BZ015A503Z_B		50	160	192	5	4.1	7.0	4.6	3.5
BZ015B603Z_B		60	80	96	10	5.4	8.3	5.9	N/A
BZ015A104Z_B		100	80	96	10	6.7	9.6	7.2	N/A
7.0v									
BZ017A223Z_B	**7.0V**	22	225	270	5	5.1	8.0	5.6	4.5
9.0v									
BZ019B223Z_B	**9.0V**	22	250	300	5	4.7	7.6	5.2	4.1
BZ019A333Z_B		33	250	300	5	5.5	8.4	6.0	4.9
12.0v									
BZ01CB153Z_B	**12.0V**	15	350	420	5	5.9	8.8	6.4	5.3
BZ01CA223Z_B		22	350	420	5	7.1	10.0	7.6	6.5

*Select S-Lead BZ01 BestCap® are available with insulation on the bottom of the part and zero clearance from the PCB. See section 2.5 for dimensions. To order, please add special requirement AJ to the end of the part number. Example: BZ013B503ZSBAJ

BZ 02 CASE SIZE

Part Number	Rated Voltage (Volts)	DC Capacitance (mF)	ESR (mOhms at 1 kHz)		Leakage Current (µA max)	Height A-Lead (mm)	Height H-Lead (mm)	Height L-Lead (mm)
		Nominal +80%, –20%	Typical	Maximum	Maximum	H max	H max	H max
3.6v								
BZ023A284Z_B	**3.6V**	280	45	54	20	3.5	6.4	3.7
BZ023A564Z_B		560	25	30	40	5.3	8.2	5.5
5.5v								
BZ025A204Z_B	**5.5V**	200	60	72	20	4.1	7.0	4.3
BZ025A404Z_B		400	35	42	40	6.7	9.6	6.9
9.0v								
BZ029A124Z_B	**9.0V**	120	70	84	20	5.8	8.7	6.0
12.0v								
BZ02CA903Z_B	**12.0V**	90	90	108	20	7.4	10.3	7.6

BZ 05 CASE SIZE

Part Number	Rated Voltage (Volts)	DC Capacitance (mF)	ESR (mOhms at 1 kHz)		Leakage Current (µA max)	Height S-Lead (mm)
		Nominal +80%, –20%	Typical	Maximum	Maximum	H max
5.5v						
BZ055B153Z_B	**5.5V**	15	250	300	5	2.7
BZ055A333Z_B		33	250	300	5	3.5
BZ055B333Z_B		33	125	150	10	4.8
BZ055A683Z_B		68	125	150	10	6.1
4.5v						
BZ054B223Z_B	**4.5V**	22	170	204	5	2.1
12.0v						
BZ05CA103Z_B	**12.0V**	10	500	600	5	6.5

BestCap® Ultra-low ESR High Power Pulse Supercapacitors

EXTENDED PCB STAND-OFF BESTCAP®

Based on a unique patented aqueous chemistry and an innovative design, the system offers high capacitance, even with short pulse duration regimes such as in GSM and GPRS based systems.

Used in conjunction with battery packs, BestCap® improves the voltage performance and high current pulses, resulting in higher PA efficiency and longer battery talk-time.

BestCap® can also be used to boost instantaneous power availability in non-battery electronic applications.

A SERIES, STANDARD H LEAD

Capacitance		Rated Voltage DC at 25°C				
mF	Code	3.6V	5.5V	7.0V	9.0V	12.0V
		Case Size	Case Size	Case Size	Case Size	Case Size
22	223					BZ01
33	333			BZ01	BZ01	
50	503		BZ01			
70	703	BZ01				
90	903					BZ02
100	104		BZ01			
120	124				BZ02	
140	144	BZ01				
200	204		BZ02			
280	284	BZ02				
400	404		BZ02			
560	564	BZ02				

ELECTRICAL RATINGS
–See page 4 for dimensional references

Part Number	Rated Voltage (V)	DC Capacitance (mF)	ESR (Ohms at 1 kHz)		Leakage Current (µA)	Height (mm)
		+80%, –20%	Nominal	Maximum	Maximum	H max
BZ013A703ZHB	**3.6V**	70	0.140	0.168	5	6.4
BZ013A144ZHB		140	0.070	0.084	10	8.2
BZ023A284ZHB		280	0.045	0.054	20	6.4
BZ023A564ZHB		560	0.025	0.030	40	8.2
BZ015A503ZHB	**5.5V**	50	0.160	0.192	5	7.0
BZ015B603ZHB		60	0.080	0.096	10	8.3
BZ015A104ZHB		100	0.080	0.096	10	9.6
BZ025A204ZHB		200	0.060	0.072	20	8.3
BZ025A404ZHB		400	0.035	0.042	40	9.6
BZ017A333ZHB	**7.0V**	33	0.225	0.270	5	8.0
BZ019B223ZHB	**9.0V**	22	0.250	0.300	5	7.2
BZ019A333ZHB		33	0.250	0.300	5	8.4
BZ01CB153ZHB	**12.0V**	15	0.350	0.420	5	8.8
BZ01CA223ZHB		22	0.350	0.420	5	10.0
BZ02CA903ZHB		90	0.090	0.108	20	10.3

B SERIES, LOW PROFILE CASE H LEAD

mF	Code	5.5V	9.0V	12.0V
		Case Size	Case Size	Case Size
15	153			BZ01
22	223		BZ01	
60	603	BZ01		

HOW TO ORDER

(See Detailed Electrical Specifications for valid combinations)

BZ	01	5	A	503	Z	A	B	XX
BestCap®	**Case Size** 01 = 28mmx17mm 02 = 48mmx30mmb 05 = 20mmx15mmb	**Rated Voltage** 3 = 3.6V 4 = 4.5V 5 = 5.5V 7 = 7.0V 9 = 9.0V C = 12.0V	**Series** A = Maximum Capacitance B = Low Profile	**Capacitance Code (Farad Code)**	**Capacitance Tolerance** Z = (-20/+80)%	**Lead Format** A, H, L or S	**Packaging** B = Bulk	**Special Requirements**

SECTION 2: MECHANICAL SPECIFICATIONS

2.1 Case Dimensions & Recommended PCB Layout
2.1.1: A-Style Configuration (Pin Through Hole)

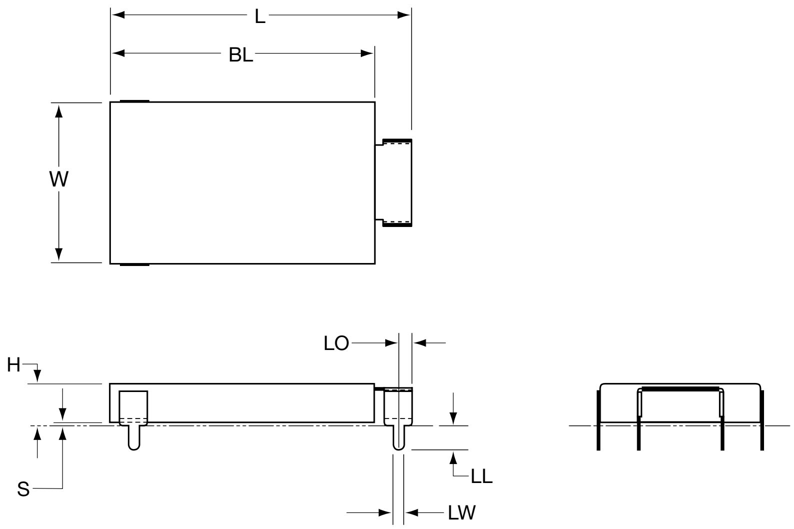


TABLE 2.1.1: A-STYLE DIMENSIONS

Case Size	Case Dimensions: mm (inches)							
	BL **+1.0 (0.040)/-0**	**W** **+1.0 (0.040)/-0**	**H** **(Maximum)**	**L** **±1.0 (0.040)**	**S** **±0.1 (0.004)**	**LO** **±0.2 (0.008)**	**LW** **±0.2 (0.008)**	**LL** **±0.2 (0.008)**
BZ01	28 (1.102)	17 (0.669)	See Section 1	32	0.45 (0.018)	1.5 (0.059)	1.27 (0.050)	2.5 (0.098)
BZ02	48 (1.890)	30 (1.181)	See Section 1	52	0.45 (0.018)	1.5 (0.059)	1.27 (0.050)	2.5 (0.098)

2.1.2: A-Lead Configuration (Through Hole)

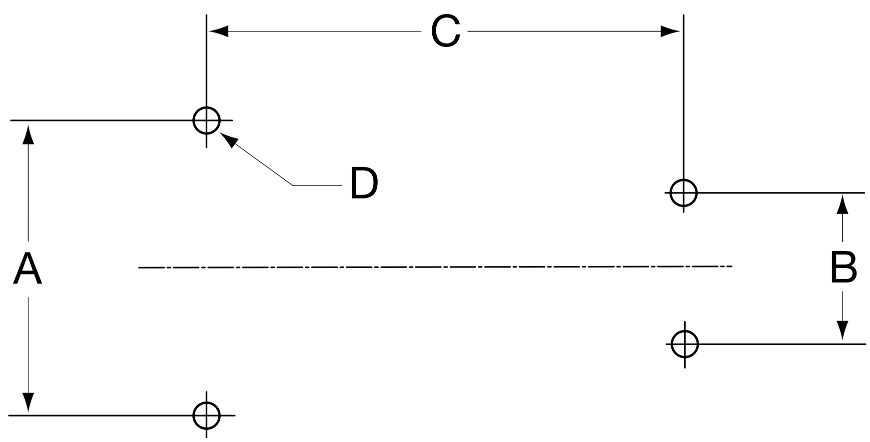


TABLE 2.1.2: A-LEAD LAYOUT DIMENSIONS

Case Size	Recommended PCB Dimensions: mm (inches)			
	A **±0.05 (0.002)**	**B** **±0.05 (0.002)**	**C** **±0.05 (0.002)**	**D** **±0.1 (0.004)**
BZ01	17.25 (0.679)	8.90 (0.350)	28 (1.102)	Ø1.4 (0.055)
BZ02	30.25 (1.191)	8.90 (0.350)	48 (1.890)	Ø1.4 (0.055)

SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

2.2.1: H-Style Case Dimensions (Through Hole Extended Height)

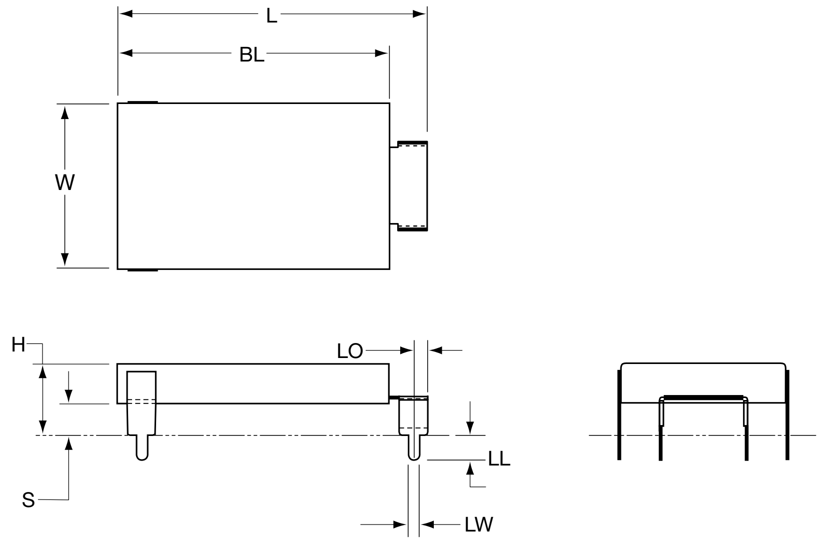


TABLE 2.2.1: H-STYLE CASE DIMENSIONS

Case Size	Case Dimensions: mm (inches)							
	BL +1.0 (0.040)/-0	W +1.0 (0.040)/-0	H (Maximum)	L ±1.0 (0.040)	S +0.5 (0.020)/ -0.4 (0.016)	LO ±0.2 (0.008)	LW ±0.2 (0.008)	LL ±0.2 (0.008)
BZ01	28 (1.102)	17 (0.669)	See Section 1	32	3.0	1.5 (0.059)	1.27 (0.050)	2.5 (0.098)
BZ02	48 (1.890)	30 (1.181)	See Section 1	52	3.0	1.5 (0.059)	1.27 (0.050)	2.5 (0.098)

2.2.2: H-Lead Configuration (Through Hole Extended Height)

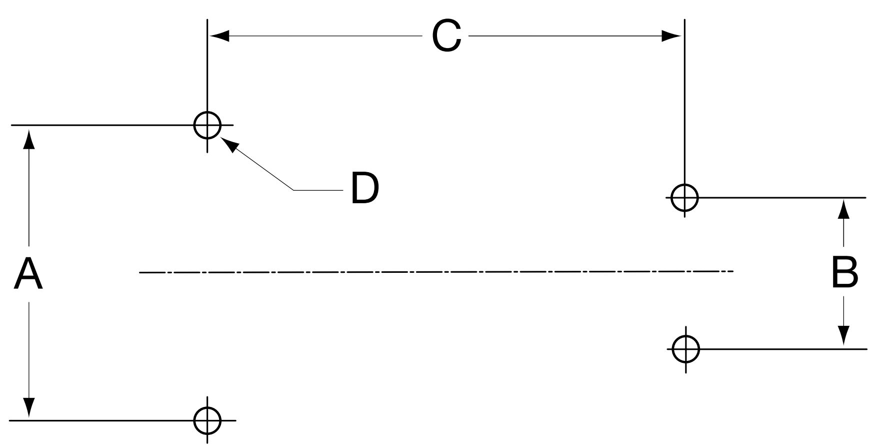


TABLE 2.2.2: H-LEAD LAYOUT DIMENSIONS

Case Size	PCB Dimensions: mm (inches)			
	A ±0.05 (0.002)	B ±0.05 (0.002)	C ±0.05 (0.002)	D ±0.1 (0.004)
BZ01	17.25 (0.679)	8.90 (0.350)	28 (1.102)	Ø1.4 (0.055)
BZ02	30.25 (1.191)	8.90 (0.350)	48 (1.890)	Ø1.4 (0.055)

SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

2.3.1: L-Lead Configuration (Planar Mount)

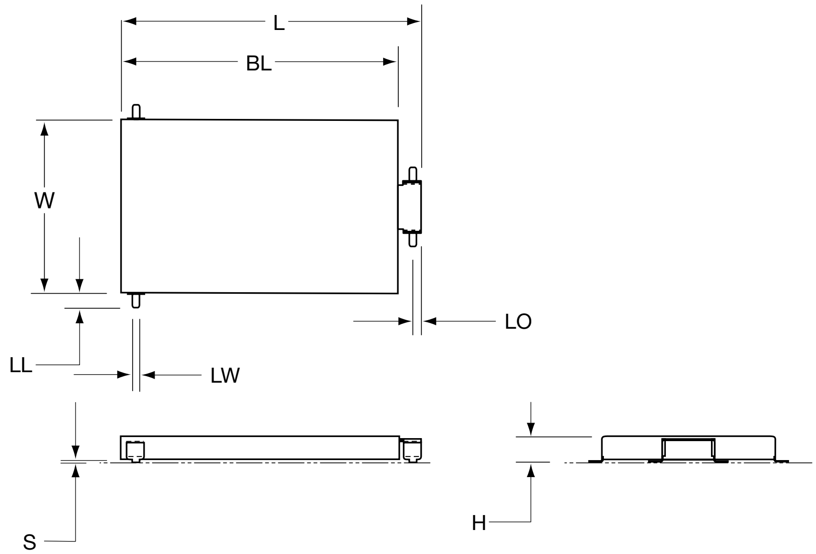


TABLE 2.3.1: L-STYLE CASE DIMENSIONS

	Case Dimensions: mm (inches)							
Case Size	BL +1.0 (0.040)/-0	W +1.0 (0.040)/-0	H (Maximum)	L ±1.0 (0.040)	S ±0.2 (0.008)	LO ±0.2 (0.008)	LW ±0.2 (0.008)	LL ±0.5 (0.020)
BZ02	48 (1.890)	30 (1.181)	See Section 1	52	0.55 (0.022)	1.5 (0.059)	1.27 (0.050)	2.4 (0.098)

2.3.2: L-Lead Configuration (Planar Mount)

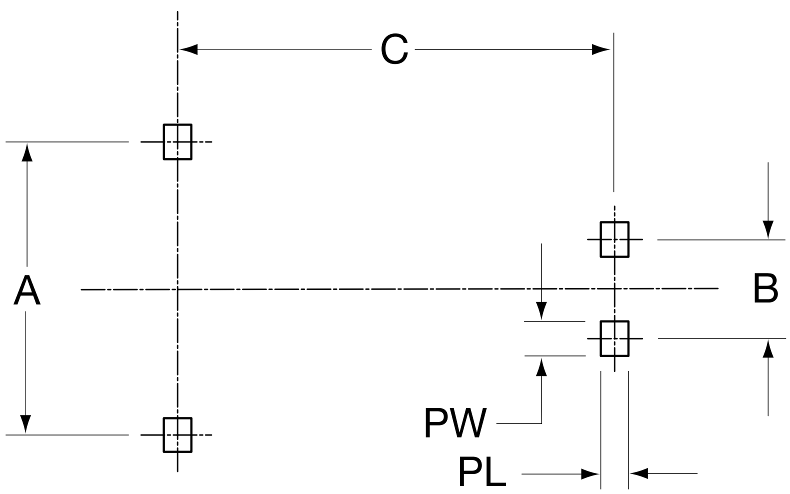


TABLE 2.3.2: L-STYLE LEAD LAYOUT

	PCB Dimensions: mm (inches)				
Case Size	A ±0.1 (0.004)	B ±0.1 (0.004)	C ±0.1 (0.004)	PL ±0.2 (0.008)	PW ±0.2 (0.008)
BZ02	32.2 (1.268)	10.8 (0.425)	48 (1.890)	3.2 (0.126)	3.7 (0.146)

SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

2.4.1: S-Lead Configuration (Planar Mount)

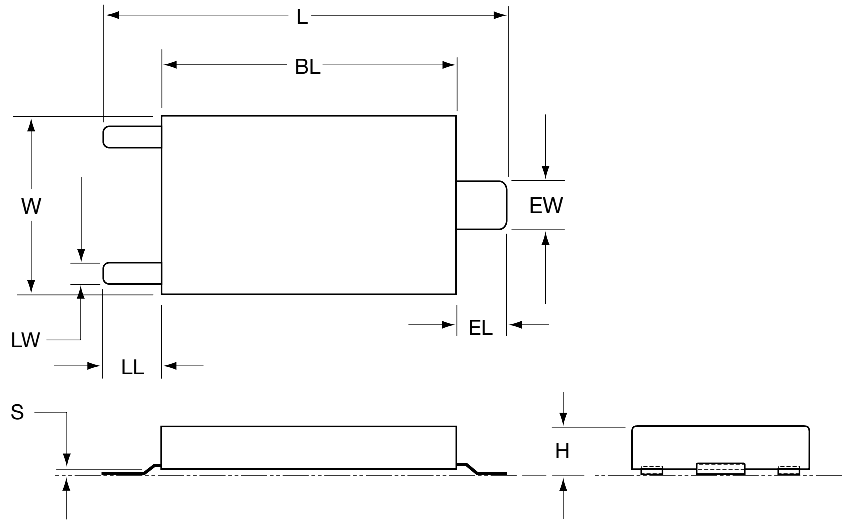
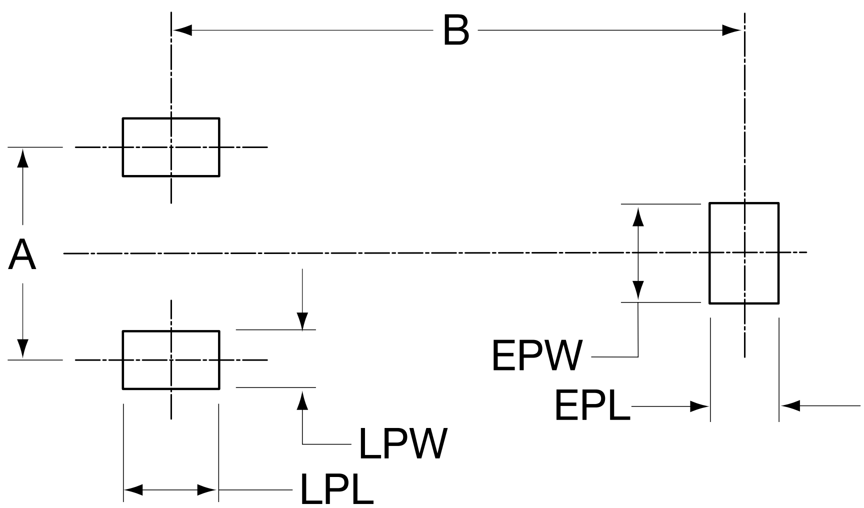


TABLE 2.4.1: S-STYLE CASE DIMENSIONS

Case Size	Case Dimensions: mm (inches)							
	BL +1.0 (0.040)/-0	W +1.0 (0.040)/-0	H (Maximum)	L ±1.0 (0.040)	EL ±0.5 (0.020)	EW ±0.2 (0.008)	LL ±0.5 (0.020)	LW ±0.2 (0.008)
BZ01	28 (1.102)	17 (0.669)	See Section 1	38.7 (1.524)	5.0 (0.197)	4.5 (0.177)	5.7 (0.224)	2.0 (0.079)
BZ05	20 (0.787)	15 (0.591)	See Section 1	26 (1.024)	3.5 (0.138)	2.5 (0.098)	2.5 (0.098)	2.5 (0.098)

2.4.2: S-Lead Layout (Planar Mount)



Planar Mount
"S"
Available in
BZ01 & BZ05
Case Size Only

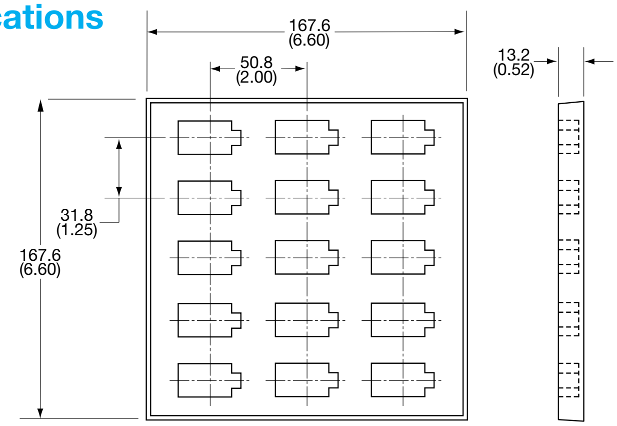
TABLE 2.4.2: S-STYLE PAD LAYOUT DIMENSIONS

Case Size	PCB Dimensions: mm (inches)					
	A ±0.1 (0.004)	B ±0.1 (0.004)	EPL ±0.1 (0.004)	EPW ±0.1 (0.004)	LPL ±0.1 (0.004)	LPW ±0.1 (0.004)
BZ02	13.0 (0.512)	35.1 (1.382)	4.5 (0.177)	6.0 (0.236)	5.8 (0.228)	3.5 (0.138)
BZ05	10.0 (0.394)	25.0 (0.984)	3.0 (0.118)	4.5 (0.177)	2.9 (0.114)	4.5 (0.117)

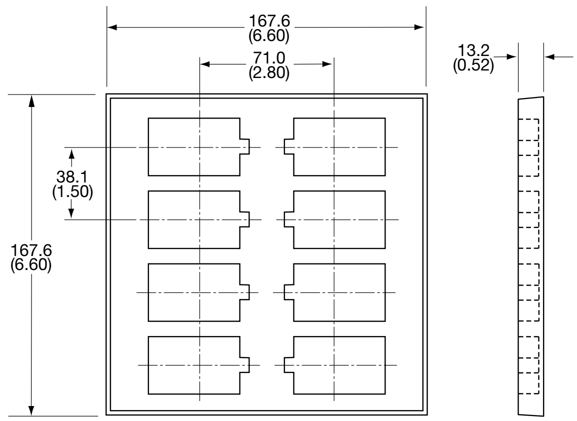
SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

2.5: Packaging Specifications

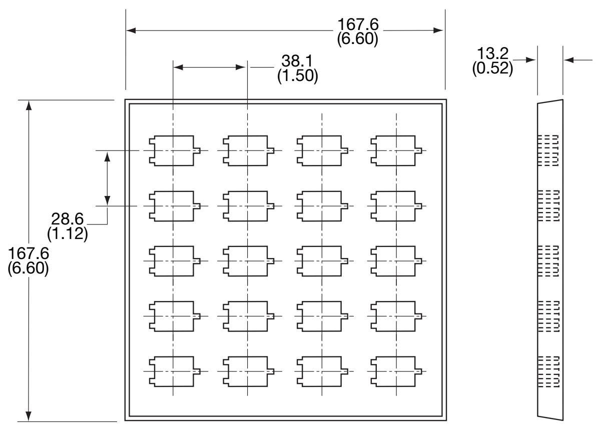
BZ01 Case:



BZ02 Case:



BZ05 Case:



This specification applies when our electrochemical supercapacitors are packed using a 165mm by 165mm container. The parts are held in place by a 166mm by 166mm lid.

PACKAGING QUANTITIES:

Size	No. of Rows	No. of Columns	Pieces/Tray
BZ01	5	3	15
BZ02	4	2	8
BZ05	5	4	20

BestCap® Ultra-low ESR High Power Pulse Supercapacitors

SECTION 2: MECHANICAL SPECIFICATIONS

2.6 CLEANING

The BestCap® supercapacitor is cleaned prior to shipment. Should cleaning be required prior to insertion into the application, it is recommended to use a small amount of propanol taking care not to remove the label. The cell should not be immersed due to possible deterioration of the epoxy encapsulation. Care must also be taken not to bend the leads.

2.7 HANDLING

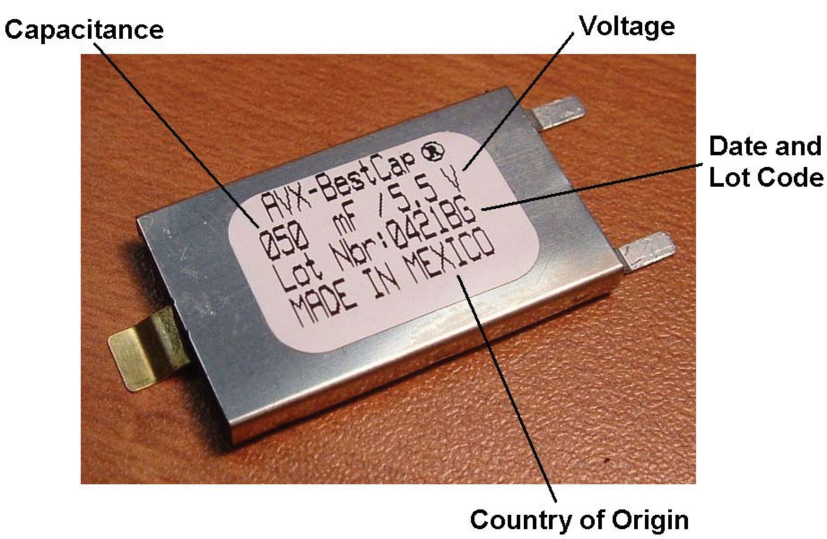
Care should be taken not to allow grease or oil into the part as it may lead to soldering problems. Handling should be minimized to reduce possible bending of the electrodes leads.

2.8 STORAGE CONDITIONS

AVX BestCap® supercapacitor are unaffected by the following storage conditions.

Temperature:	15°C ~ 35°C
Humidity:	45% RH ~ 75% RH

2.9 PART MARKING



2.10 TERMINATION FINISH

Gold over nickel, tin over nickel.

2.11 PRODUCT SAFETY MATERIALS HANDLING

Precautions

- Do not disassemble the capacitor.
- Do not incinerate the capacitor and do not use incineration for disposal.
- The capacitor contains polymeric electrolyte and carbon electrodes. However, since the polymer is composed of acid based chemical ingredients, if punctured or dismantled and the skin is contacted with the capacitor internal components, it is recommended to wash the skin with excess of running water.
- If any internal material contacts the eyes, rinse thoroughly with running water.
- Be aware not to apply over-voltage. Combination of charging at voltage greater than the nominal, plus high temperature, plus prolonged time-may result in capacitor bulging or rupturing.

2.12 BESTCAP® MATERIALS AND WEIGHT

BestCap® Sub-Assembly Analyzed	Typical percentage of total device mass	EU RoHS directive								EU additional items	
		Pentabrominated diphenyl ether	Octabrominated diphenyl ether	Polybrominated biphenyl (PBB)	Polybrominated dipheyl ether (PBDE)	Hexavalent Chromium	Cadmium	Mercury	Lead	Dibutyl phthalate (DBP)	Diocthyl phthalate (DOP)
Case	50.2%	0	0	0	0	0	0	0	0	0	0
Current Collector	16.0%	0	0	0	0	0	0	0	0	0	0
Separator	2.7%	0	0	0	0	0	0	0	0	0	0
Electrode	9.1%	0	0	0	0	0	0	0	0	0	0
Electrode Gasket	4.2%	0	0	0	0	0	0	0	0	0	0
Sealant	17.8%	0	0	0	0	0	0	0	0	0	0

BestCap® is RoHS compliant and Pb Free (all stated materials < 0.01% content by weight).

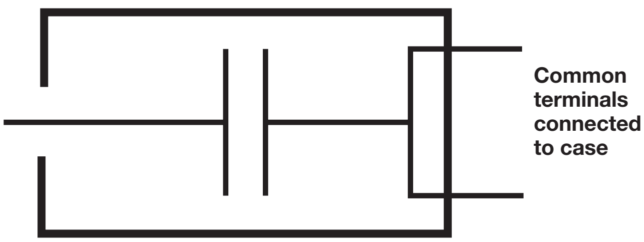
Termination materials are:
May be assembled with Pb-Free materials

BESTCAP® – TYPICAL WEIGHT DATA

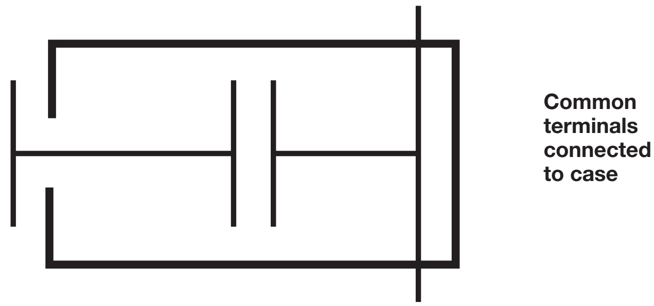
Voltage	Part Number	Typical Weight (g)
3.6 V	BZ013B503Z_B	2.9
	BZ013A703Z_B	4.2
	BZ013A144Z_B	5.3
	BZ023A284Z_B	12.2
	BZ023A564Z_B	15.9
4.5 V	BZ014B353Z_B	3.2
5.5 V	BZ055B153Z_B	1.7
	BZ015B303Z_B	3.4
	BZ055A333Z_B	2.3
	BZ055B333Z_B	2.1
	BZ015A503Z_B	4.6
	BZ015B603Z_B	5.5
	BZ055A683Z_B	3.4
	BZ015A104Z_B	6.1
	BZ025A204Z_B	13.3
	BZ025A404Z_B	18.4
7.0 V	BZ017A333Z_B	4.3
9.0 V	BZ019B223Z_B	4.4
	BZ019A333Z_B	5.0
	BZ029A124Z_B	15.6
12.0V	BZ05CA103Z_B	3.5
	BZ01CB153Z_B	5.0
	BZ01CA223Z_B	6.2
	BZ02CA903Z_B	19.3

SECTION 3: ELECTRICAL CHARACTERISTICS – SCHEMATIC

3.1 Terminal Connections:
3.1.1: S-Lead



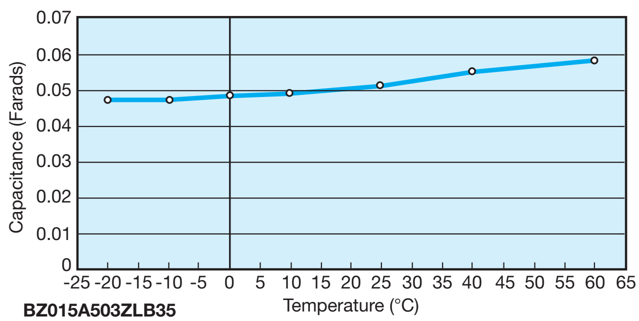
3.1.2: A-, H- & L-Lead



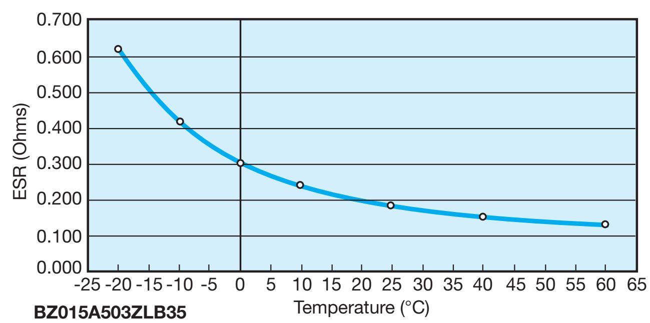
Devices are non polar but it is usual to maintain case at ground potential

SECTION 3.2: TYPICAL CHARACTERISTICS

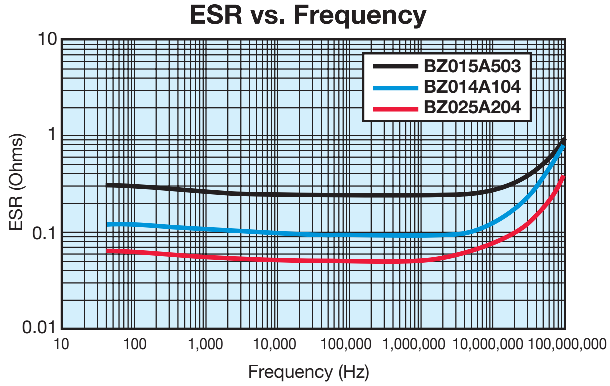
Capacitance vs. Temperature



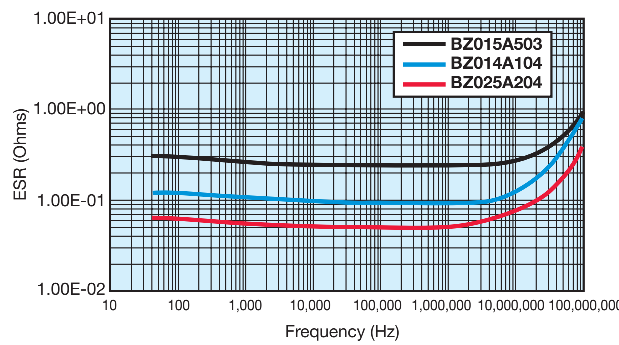
ESR vs. Temperature



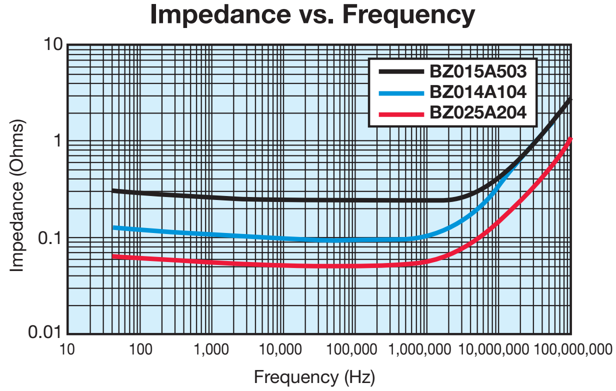
ESR vs. Frequency



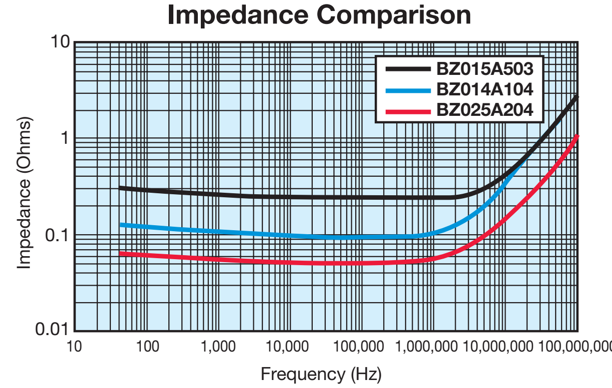
ESR Comparison



Impedance vs. Frequency



Impedance Comparison



SECTION 3.3: MOUNTING PROCEDURE ON A PCB FOR BESTCAP®

BestCap® products can be mounted on PCBs by either selectively heating only the capacitor terminals by using a pulsed reflow soldering station or by using hand soldering. IR Reflow or wave soldering may not be used. The main body of the device should be less than 60ºC at all times.

PULSED REFLOW SOLDERING

Application data for the 'Unitek' pulsed-reflow soldering station.

Equipment:

Controller	Uniflow 'Pulsed Thermode Control'
Head	Thin-line Reflow Solder Head
Solder paste type	No Clean Flux
Solder composition	63% Sn, 37% Pb
Percent solids	88%
Solder thickness	6 mils
Solder-weld tip size	0.075"
Solder-weld tip force	6 lbs.

Temperature profile:

	Temperature	Time
Pre-heat	130ºC	0 sec.
Rise	440ºC (±10)	2 sec.
Reflow	440ºC (±10)	2 sec.
Cool	165ºC	

HAND SOLDERING STATION

Equipment:	Temperature controlled, 50W general purpose iron
Solder type:	63Sn/37Pb, rosin core wire
Temperature:	400ºC (+20ºC - 100ºC)
Time:	2 to 5 seconds maximum, smaller time (2 sec.) at 420ºC and 5 sec. at 300ºC, overall it being a time-temperature relationship. Shorter time, higher temperature is preferred.
Solder Type:	Lead Free, 95Sn/5Ag
Temperature:	430ºC (+20ºC - 100ºC)
Time:	2 to 5 seconds maximum, smaller time (2 sec.) at 450ºC and 5 sec. at 330ºC, overall it being a time-temperature relationship. Shorter time, higher temperature is preferred.

In both cases, the main body of the BestCap® part should be less than 60ºC at all times.

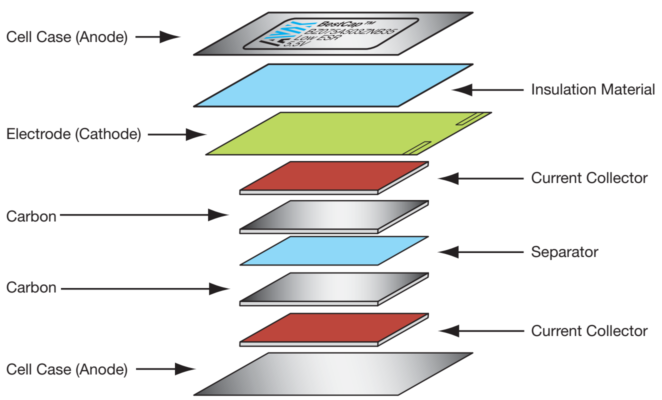
SECTION 3.4: QUALIFICATION TEST SUMMARY

Test	Test Method	Parameter	Limits
Initial Capacitance Measurement	Discharge cells with a constant current after a full charge noting voltage and time. C = I * dt/dv	Capacitance (Cap)	+80% / –20% of rated Cap
Initial DCL Measurement	Apply rated voltage. Note current after exactly 3 hours.	Leakage Current (DCL)	Within Limit
Initial ESR Measurement	Measurement frequency @ 1kHz; Measurement voltage @ 10 mV	Equivalent Series Resistance (ESR)	+20% / –50% of typical value
Load Life	Apply rated voltage at 75°C (A series BestCap®), 70°C (B series BestCap®) for 1000 hours. Allow to cool to room temperature and measure Cap, DCL and ESR.	DCL Cap ESR	< 2.0x rated max. > 0.7x rated < 3.0x rated
Shelf Life	Maintain at 75°C (A series BestCap®), 70°C (B series BestCap®) for 1000 hours. Allow to cool to room temperature and measure Cap, DCL and ESR.	DCL Cap ESR	< 1.5x rated max. > 0.7x rated < 2.0x rated
Humidity Life	Maintain at 40°C / 95% RH for 1000 hours. Allow to cool to room temperature and measure Cap, DCL and ESR.	DCL Cap ESR	< 2.0x rated max. > 0.7x rated < 1.5x rated
Leg pull strength	Apply an increasing force in shear mode until leg pulls away.	Yield Force (A and L leads only)	Not less than 25 pounds shear
Surge Voltage	Step 1 Apply 125% of the rated voltage for 10 seconds 2 Short the cell for 10 minutes 3 Repeat 1 and 2 for 1000 cycles	DCL Cap ESR	< 1.5x rated max. > 0.7x rated < 1.5x rated
Temperature Cycling	Step 1 Ramp oven down to –20°C and then hold for 30 min. 2 Ramp oven up to 75°C (A series BestCap®), 70°C (B series BestCap®) and then hold for 30 min. 3 Repeat 1 and 2 for 100 cycles	DCL Cap ESR	< 1.5x rated max. > 0.7x rated < 1.5x rated
Temperature Characteristics	Step / Temp / Time 1 –20°C 4 hours Measure Cap, ESR, DCL 2 –10°C 4 hours Measure Cap, ESR, DCL 3 0°C 4 hours Measure Cap, ESR, DCL 5 25°C 4 hours Measure Cap, ESR, DCL 6 40°C 4 hours Measure Cap, ESR, DCL 7 60°C 4 hours Measure Cap, ESR, DCL 8 70°C (B series ONLY) 4 hours Measure Cap, ESR, DCL 9 75°C (A series ONLY) 4 hours Measure Cap, ESR, DCL	DCL 70°C Cap ESR –20°C –10°C 60°C	 < 10x rated Not less than –30% Within +400% Within +300% Within +30%
Thermal Shock	Step 1 Place cells into an oven at –20°C for 30 min. 2 In less than 15 seconds, move cells into a 75°C (A series BestCap®), 70°C (B series BestCap®) oven for 30 min. 3 Repeat 1 and 2 for 100 cycles	DCL Cap ESR	< 2.0x rated max. > 0.7x rated < 2.0x rated max.
Vibration	Step 1 Apply a harmonic motion that is deflected 0.03 inches 2 Vary frequency from 10 cycles per second to 55 cycles at a ramp rate 3 Vibrate the cells in the X-Y direction for three hours 4 Vibrate the cells in the Z direction for three hours 5 Measure Cap, ESR and DCL	DCL Cap ESR	< 2.0x rated max. > 0.7x rated < 2.0x rated max.

SECTION 4: APPLICATION NOTES

4.1: ELECTRONIC VS. ORGANIC EDLC TECHNOLOGY – BESTCAP® CONSTRUCTION

To understand the benefits offered by the BestCap®, it is necessary to examine how an electrochemical capacitor works. The most significant difference between an electronic capacitor and an electrochemical capacitor is that the charge transfer is carried out by the electrons in the former and by electrons and ions in the latter. The anions and cations involved in double layer supercapacitors are contained in the electrolyte which maybe liquid, (normally an aqueous or organic solution) or solid. The solid electrolyte is almost universally a conductive polymer.



Electrons are relatively fast moving and therefore transfer charge "instantly". However, ions have to move relatively slowly from anode to cathode, and hence a finite time is needed to establish the full nominal capacitance of the device. This nominal capacitance is normally measured at 1 second.

The differences between EDLC (Electrochemical Double Layer Capacitors) and electronic capacitors are summarized in the table below:

• A capacitor basically consists of two conductive plates (electrodes), separated by a layer of dielectric material.
• These dielectric materials may be ceramic, plastic film, paper, aluminum oxide, etc.
• EDLCs do not use a discrete dielectric interphase separating the electrodes.
• EDLCs utilize the charge separation, which is formed across the electrode – electrolyte interface.
• The EDLC constitutes of two types of charge carriers: IONIC species on the ELECTROLYTE side and ELECTRONIC species on the ELECTRODE side.

4.2: VOLTAGE DROP

Two factors are critical in determining the voltage drop when a capacitor delivers a short current pulse; these are ESR and "available" capacitance as shown in Figure 4.

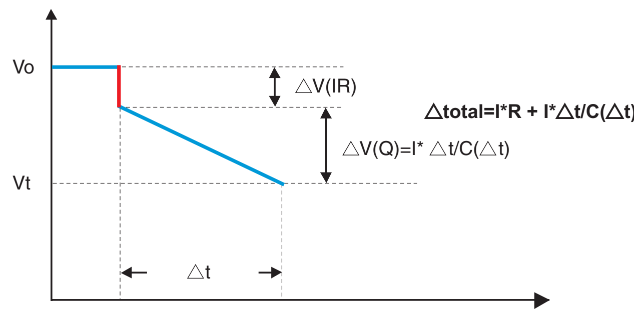


Figure 4. Voltage-time relation of capacitor unit

The instant voltage drop ΔV_{ESR} is caused by and is directly proportional to the capacitor's ESR. The continuing voltage drop with time ΔV_C, is a function of the available charge, i.e. capacitance. From Figures 3 and 4, it is apparent that, for very short current pulses, e.g. in the millisecond region, the combination of voltage drops in a conventional supercapacitor caused by a) the high ESR and b) the lack of available capacitance, causes a total voltage drop, unacceptable for most applications. Now compare the BestCap® performance under such pulse conditions. The ultra-low ESR, (in milliOhms), minimizes the instantaneous voltage drop, while the very high retained capacitance drastically reduces the severity of the charge related drop. This is explained further in a later section.

EFFICIENCY/TALKTIME BENEFITS OF BESTCAP®

Because BestCap®, when used in parallel with a battery, provides a current pulse with a substantially higher voltage than that available just from the battery as shown in Figure 5, the efficiency of the RF power amplifier is improved.

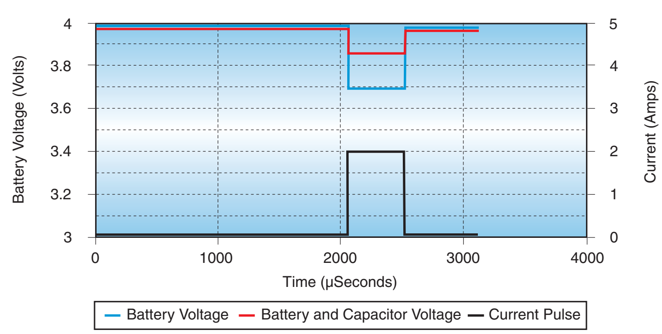


Figure 5. GSM Pulse

Additionally, the higher-than battery voltage supplied by the BestCap® keeps the voltage pulse above the "cut off voltage" limit for a significantly longer time than is the case for the battery alone. This increase in "talk time" is demonstrated in Figures 6(a) (Li-Ion at +25°C), and 6(b) (Li-Ion at 0°C).

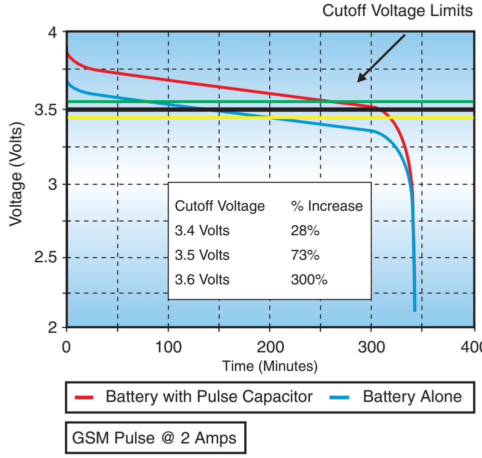


Figure 6a. Li-ION Battery at +25°C

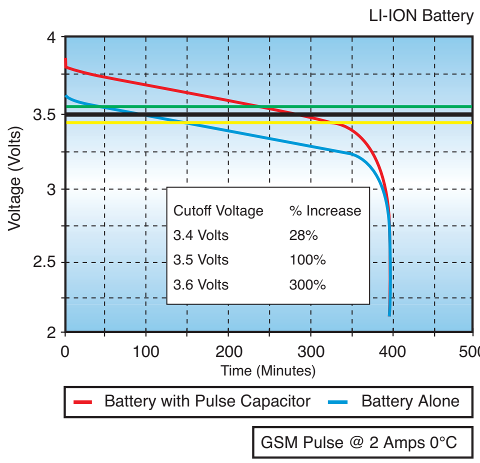


Figure 6b. Li-ION Battery at +0°C

PULSE CAPACITOR APPLICATIONS

As mentioned earlier, the voltage drop in a circuit is critical as the circuit will not operate below a certain cut-off voltage. There are two sources of voltage drop (ΔV) which occur, the first ΔV_{ESR} is because of the equivalent series resistance (ESR) and the second, called the capacitive drop, is ΔV_C. From Ohm's law,

voltage = current x resistance or V = IR

Let us say that the instantaneous starting voltage is Vo, or voltage for the circuit from where the voltage drops. If the capacitor has an ESR of 100 milliOhms and the current is 1 amp,

ΔV_{ESR} = 1 amp x (0.100) ohms = 0.1 volts or 100 milli-volts.

On demand, during the discharge mode, the voltage V = Vo - ΔV_{ESR} = (Vo - 0.1) volts

The second voltage drop is because of the capacitance. This is shown in the equation as a linear function because of simplicity. Simply put,

Q (charge) = C (capacitance) x V (voltage)

The derivative, dQ/dt = I (current, in amps) = C x dV/dt

Hence, ΔV_C (dV, the voltage drop because of capacitance) = I x dt/C. This formula states that the larger the capacitance value the lower the voltage drop. Compared to a Ta capacitor this ΔV_C is reduced by a factor of about 10 to 100. So, BestCap® has an advantage where higher capacitance is needed. If the current pulse itself is 1 amp, the current pulse width is 1 second, and the capacitance is 10 millifarads, the ΔV_C = 1A x 1Sec/0.01F, or a 100 volts; such an application is out of the range of BestCap®. However, if the pulse width becomes narrower, say 10 milli-seconds, and the capacitance is 100 millifarads, the ΔV_C = 1 x (10/1000)/(100/1000) = 0.1 volt or 100 milli-volts. This shows the advantage of the large capacitance and hence the term "pulse" capacitor. The specific power – specific energy graphs are used in the battery industry to compare competitive products. As the dt becomes smaller i.e.100 milliseconds, 10 milliseconds and then 1 millisecond, our estimates show that the specific power for the BestCap® is the highest as compared to our competitors because of our choice of internal materials chemistry.

Conclusion: we now clearly show that BestCap® has an advantage over competitors for short current pulse whose widths are smaller than a few hundred milliseconds.

4.3 ENHANCING THE POWER CAPABILITY OF PRIMARY BATTERIES

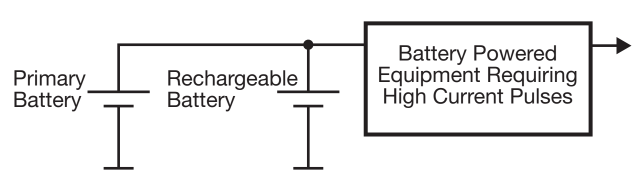
When electronic equipment is powered by a primary (non rechargeable) battery, one of the limitations is the power capability of the battery.

In order to increase the available current from the battery, while maintaining a constant voltage drop across the battery terminals, the designer must connect additional cells in parallel leading to increased size and cost of both the battery and the finished product.

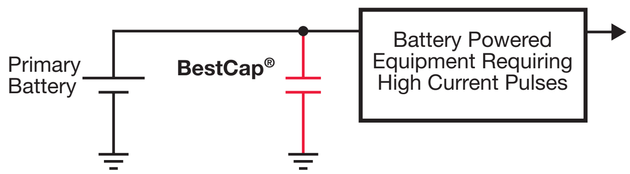
When high power is only required for short periods more sophisticated approaches can be considered. The traditional approach involves using a high power rechargeable battery, charged by a low power primary cell.

A far superior solution, however, is the use of a BestCap® Supercapacitor, which is a device specifically designed to deliver high power.

Traditional design:



Design using BestCap®:



BestCap® Supercapacitor benefits to the designer are:

- Substantially lower voltage drop for pulse durations of up to 100msec.
- Substantially lower voltage drop at cold temperatures (–20°C).
- Discharge current limited only by the ESR of the capacitor

The following analysis compares a primary battery connected in parallel to a Lithium Tionil Chloride, to the same primary battery connected to a BestCap® Supercapacitor. Various current pulses (amplitude and duration) are applied in each case.

BestCap® 5.5V 100mF

Pulse	Voltage Drop (mV) BestCap® Supercapacitors	Voltage Drop (mV) rechargeable battery
250mA / 1msec	25	150
500mA / 1msec	50	220
750mA / 1msec	75	150
200mA / 100msec at –20°C	232	470

BestCap® 3.5V 560mF

Pulse	Voltage Drop (mV) BestCap® Supercapacitors	Voltage Drop (mV) rechargeable battery
250mA / 100msec	50	190
500mA / 100msec	100	350
750mA / 100msec	152	190
1500mA / 1msec	43	220
1500mA / 100msec	305	350
750mA / 100msec at –20°C	172	470

Additional Characteristics	BestCap®	Rechargeable Battery
Maximum discharge current (single pulse)	Not limited	5A Maximum
Number of Cycles	Not limited	40K to 400K (to retain 80% capacity)

4.4 BESTCAP FOR GSM/GPRS PCMCIA MODEMS

There is an increasing usage of PCMCIA modem cards for wireless LAN and WAN (Wide Area Network) applications.

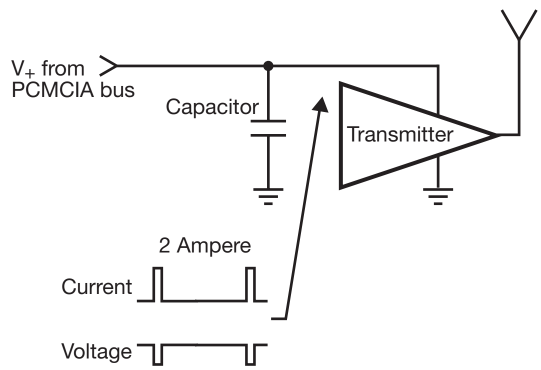
The PCMCIA card is used as an accessory to Laptops and PDA's, and enables wide area mobile Internet access, including all associated applications like Email and file transfer.

With the wide spread use of GSM networks, a PCMCIA GSM modem is a commonly used solution. To achieve higher speed data rates, GSM networks are now being upgraded to support the GPRS standard.

The design challenge:

GSM/GPRS transmission requires a current of approximately 2A for the pulse duration. The PCMCIA bus cannot supply this amount of pulsed current. Therefore, there is a need for a relatively large capacitance to bridge the gap.

The capacitor supplies the pulse current to the transmitter, and is charged by a low current during the interval between pulses.



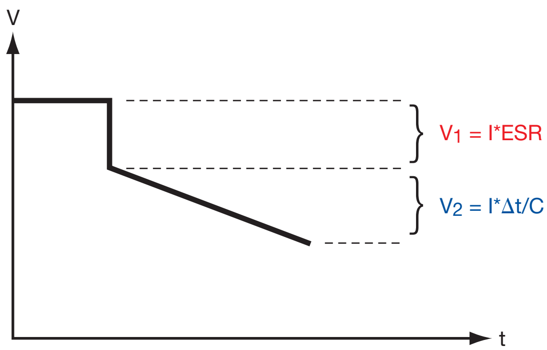
THE SOLUTION:

	SOLUTION A	SOLUTION B	
	Chip Tantalum	BestCap®(1) BZ014C353ZSB	BestCap®(1) BZ055B353ZSB
Rated Capacitance (milli Farad)	1	35	35
Capacitance @ 0.5msec Pulse (milli Farad)	1	17	17
Working Voltage (V)	6.3	4.5	5.5
ESR (milli ohm)	30	120	110
Size (mm)	7.2 x 6.3 x 3.8	28 x 17 x 2	20 x 15 x 4.2
Voltage Drop* (V) GSM Pulse	0.9	0.23	0.21
Voltage Drop** (V) GPRS Pulse (25% duty cycle)	1.75	0.28	0.26

(1) Calculation:

* $V=V_1+V_2$ =1.5A*ESR + (1.5A*0.577msec)/C

** $V=V_1+V_2$ =1.5A*ESR + (1.5A*1.154msec)/C

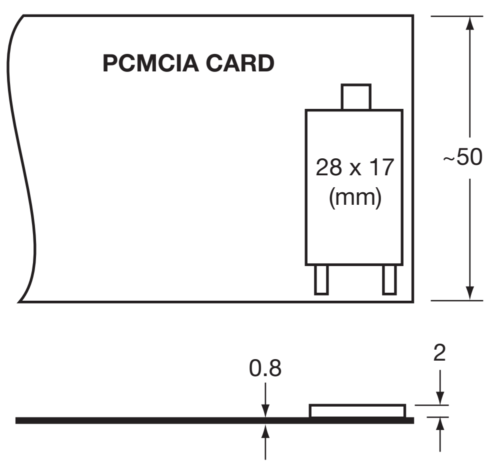


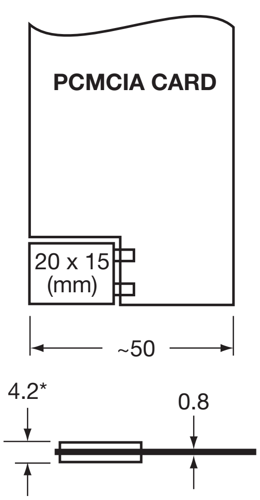
It is assumed that during the pulse, 0.5A is delivered by the battery, and 1.5A by the capacitor.

Conclusion: High capacitance is needed to minimize voltage drop. A high value capacitance, even with a higher ESR, results in a lower voltage drop. Low voltage drop minimizes the conductive and emitted electro magnetic interference, and increases transmitter output power and efficiency.

MOUNTING SOLUTIONS:

1. Parts with 2mm height that can be mounted on the board.

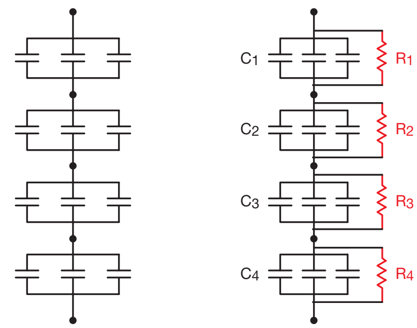




*4.2 for 5.5V part
2.3 for 2.5V part

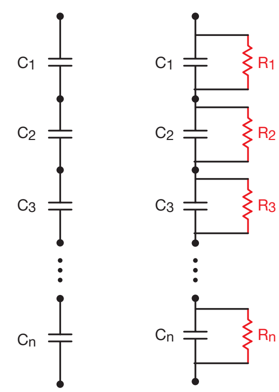
2. Smaller parts, consuming less PCB real estate and with flexible termination tabs, enable mounting the capacitor by cutting the PCB and placing the capacitor as shown in the drawing, utilizing the PCMCIA housing height.

4.5 PREFERRED SERIES PARALLEL COMBINATIONS



C - BestCap®
R - Balancing resistor suggested values: (50kΩ to 200kΩ)

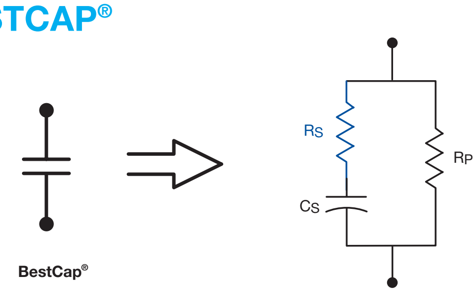
OPTIONS FOR SERIES COMBINATIONS



Preferred Configuration

C - BestCap®
R - Balancing resistor suggested values: (50kΩ to 200kΩ)

EQUIVALENT CIRCUIT DIAGRAM: BESTCAP®



Rs = ESR
= equivalent series resistance, mΩ
Cs = capacitance, mF
Rp = parallel resistance, inverse of leakage current i, in DC mode

AMERICAS

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