

**AVX**  
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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# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



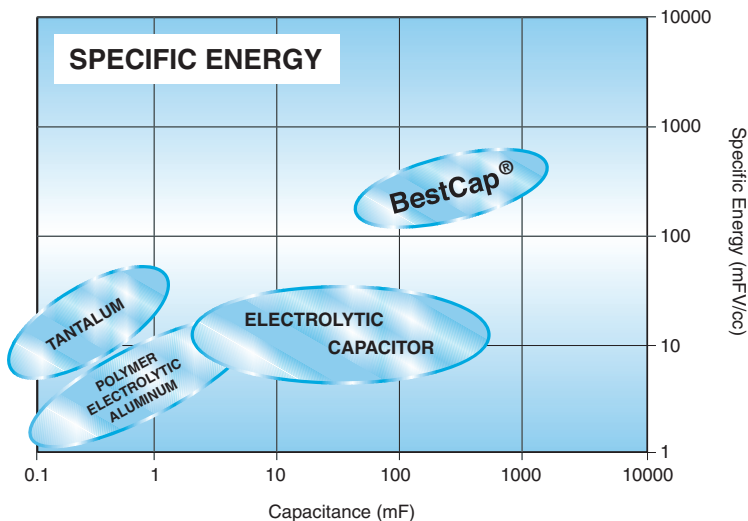
## INTRODUCING BESTCAP®: A NEW GENERATION OF PULSE SUPERCAPACITORS

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**

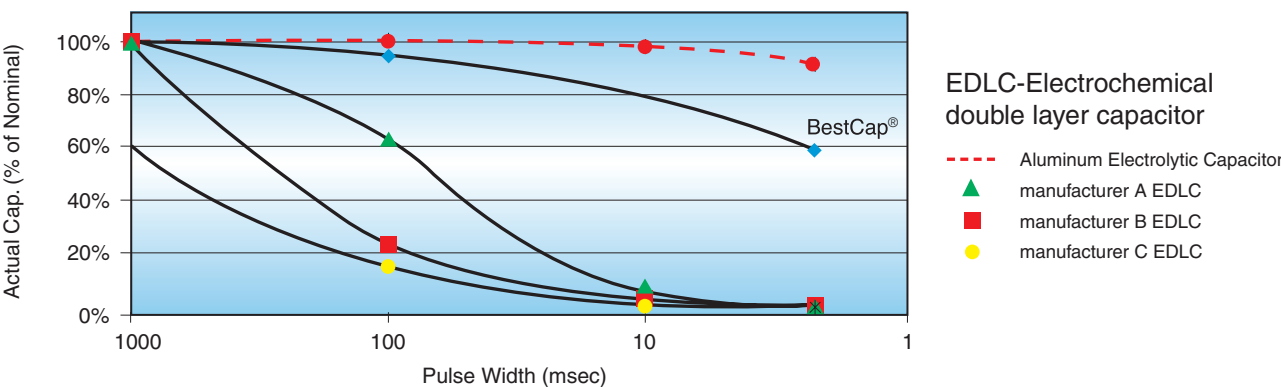


In the above-mentioned “electronic” capacitors, the charge transfer is performed by fast electrons, thereby creating virtually instant rated capacitance value. In the BestCap®, a unique proton polymer membrane is used – charge transfer by protons is close to the transfer rate for electrons and orders 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:

|                                                                                                                           |                                                                                                                                                             |                                                                                                                                                                         |                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><b>A Style:</b><br/>Through-Hole</p> |  <p><b>L-Style:</b><br/>Planar Mount<br/>(available in BZ02 case only)</p> |  <p><b>S-Style:</b><br/>Planar Mount<br/>(available in BZ01 &amp; BZ05 case only)</p> |  <p><b>H-Style:</b><br/>Extended Stand-Off<br/>(Available in BZ01, BZ02 case size)</p> |
|---------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### APPLICATION SPECIFIC:

| Case Size   | BODY DIMENSIONS              |                               |                         |
|-------------|------------------------------|-------------------------------|-------------------------|
|             | L±0.5 (0.020)<br>mm (inches) | W ±0.2 (0.008)<br>mm (inches) | H nom<br>mm (inches)    |
| <b>BZ01</b> | 28 (1.102)                   | 17 (0.669)                    | 2.1 (0.08) – 6.1 (0.24) |
| <b>BZ02</b> | 48 (1.890)                   | 30 (1.181)                    | 2.1 (0.08) – 6.1 (0.24) |
| <b>BZ05</b> | 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)

|           |                                                    |                                                                       |                                            |                               |                       |              |           |                                                                          |
|-----------|----------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------|-------------------------------|-----------------------|--------------|-----------|--------------------------------------------------------------------------|
| <b>BZ</b> | <b>01</b>                                          | <b>5</b>                                                              | <b>A</b>                                   | <b>503</b>                    | <b>Z</b>              | <b>A</b>     | <b>B</b>  | <b>XX</b>                                                                |
| BestCap®  | Case Size                                          | Rated Voltage                                                         | Series                                     | Capacitance Code (Farad Code) | Capacitance Tolerance | Lead Format  | Packaging | Not Used For Standard Product (Consult Factory For Special Requirements) |
|           | 01 = 28mmx17mm<br>02 = 48mmx30mm<br>05 = 20mmx15mm | 3 = 3.6V<br>4 = 4.5V<br>5 = 5.5V<br>7 = 7.0V<br>9 = 9.0V<br>C = 12.0V | A = Maximum Capacitance<br>B = Low Profile |                               | Z = (-20/+80)%        | A, H, L or S | B = Bulk  |                                                                          |

# 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

# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## 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

# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



| 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              |
| <b>3.6v</b>         |                       |                     |                      |         |                          |                    |                    |                    |
| <b>BZ023A284Z_B</b> | <b>3.6V</b>           | 280                 | 45                   | 54      | 20                       | 3.5                | 6.4                | 3.7                |
| <b>BZ023A564Z_B</b> |                       | 560                 | 25                   | 30      | 40                       | 5.3                | 8.2                | 5.5                |
| <b>5.5v</b>         |                       |                     |                      |         |                          |                    |                    |                    |
| <b>BZ025A204Z_B</b> | <b>5.5V</b>           | 200                 | 60                   | 72      | 20                       | 4.1                | 7.0                | 4.3                |
| <b>BZ025A404Z_B</b> |                       | 400                 | 35                   | 42      | 40                       | 6.7                | 9.6                | 6.9                |
| <b>9.0v</b>         |                       |                     |                      |         |                          |                    |                    |                    |
| <b>BZ029A124Z_B</b> | <b>9.0V</b>           | 120                 | 70                   | 84      | 20                       | 5.8                | 8.7                | 6.0                |
| <b>12.0v</b>        |                       |                     |                      |         |                          |                    |                    |                    |
| <b>BZ02CA903Z_B</b> | <b>12.0V</b>          | 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              |
| <b>5.5v</b>         |                       |                     |                      |         |                          |                    |
| <b>BZ055B153Z_B</b> | <b>5.5V</b>           | 15                  | 250                  | 300     | 5                        | 2.7                |
| <b>BZ055A333Z_B</b> |                       | 33                  | 250                  | 300     | 5                        | 3.5                |
| <b>BZ055B333Z_B</b> |                       | 33                  | 125                  | 150     | 10                       | 4.8                |
| <b>BZ055A683Z_B</b> |                       | 68                  | 125                  | 150     | 10                       | 6.1                |
| <b>4.5v</b>         |                       |                     |                      |         |                          |                    |
| <b>BZ054B223Z_B</b> | <b>4.5V</b>           | 22                  | 170                  | 204     | 5                        | 2.1                |
| <b>12.0v</b>        |                       |                     |                      |         |                          |                    |
| <b>BZ05CA103Z_B</b> | <b>12.0V</b>          | 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) |
|--------------|-------------------|---------------------|---------------------|---------|----------------------|-------------|
|              |                   |                     | Nominal             | Maximum |                      |             |
|              |                   | +80%, -20%          |                     |         | 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)

|           |                                                    |                                                                       |                                            |                               |                       |              |           |                      |
|-----------|----------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------|-------------------------------|-----------------------|--------------|-----------|----------------------|
| <b>BZ</b> | <b>01</b>                                          | <b>5</b>                                                              | <b>A</b>                                   | <b>503</b>                    | <b>Z</b>              | <b>A</b>     | <b>B</b>  | <b>XX</b>            |
| BestCap®  | Case Size                                          | Rated Voltage                                                         | Series                                     | Capacitance Code (Farad Code) | Capacitance Tolerance | Lead Format  | Packaging | Special Requirements |
|           | 01 = 28mmx17mm<br>02 = 48mmx30mm<br>05 = 20mmx15mm | 3 = 3.6V<br>4 = 4.5V<br>5 = 5.5V<br>7 = 7.0V<br>9 = 9.0V<br>C = 12.0V | A = Maximum Capacitance<br>B = Low Profile |                               | Z = (-20/+80)%        | A, H, L or S | B = Bulk  |                      |

# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## SECTION 2: MECHANICAL SPECIFICATIONS

### 2.1 Case Dimensions & Recommended PCB Layout

#### 2.1.1: A-Style Configuration (Pin Through Hole)

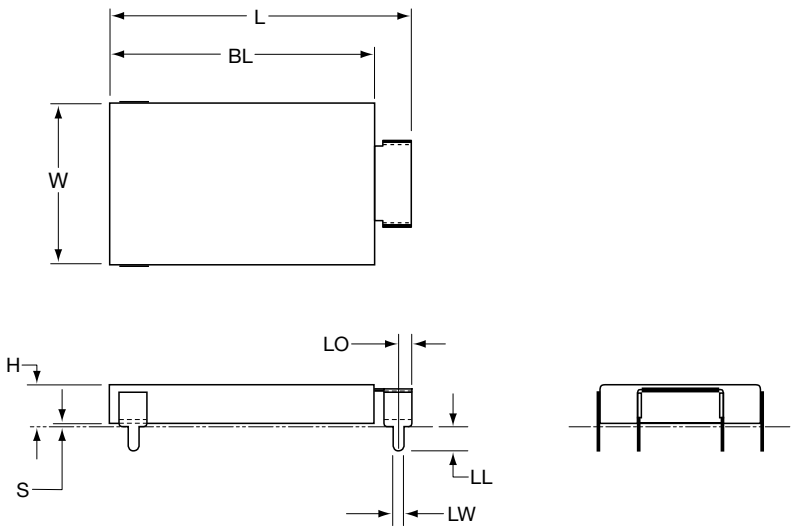


TABLE 2.1.1: A-STYLE DIMENSIONS

| Case Size | Case Dimensions: mm (inches) |                      |                |                   |                   |                    |                    |                    |
|-----------|------------------------------|----------------------|----------------|-------------------|-------------------|--------------------|--------------------|--------------------|
|           | BL<br>+1.0 (0.040)/-0        | W<br>+1.0 (0.040)/-0 | H<br>(Maximum) | L<br>±1.0 (0.040) | S<br>±0.1 (0.004) | LO<br>±0.2 (0.008) | LW<br>±0.2 (0.008) | LL<br>±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)

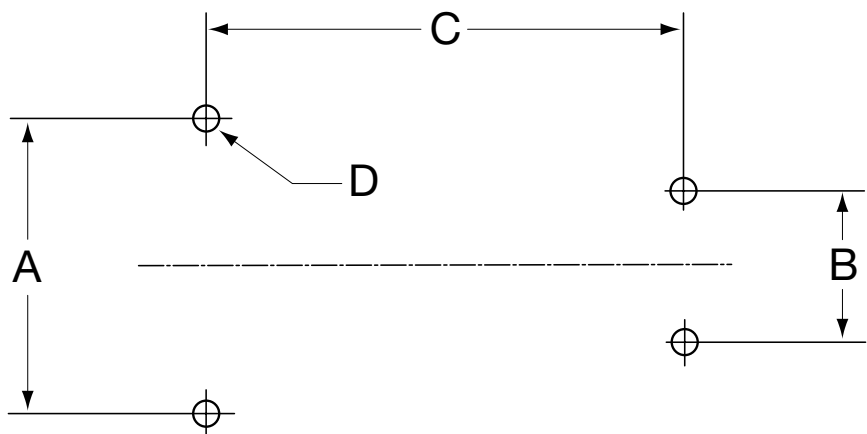


TABLE 2.1.2: A-LEAD LAYOUT DIMENSIONS

| Case Size | Recommended PCB Dimensions: mm (inches) |                    |                    |                   |
|-----------|-----------------------------------------|--------------------|--------------------|-------------------|
|           | A<br>±0.05 (0.002)                      | B<br>±0.05 (0.002) | C<br>±0.05 (0.002) | D<br>±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)      |



# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

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

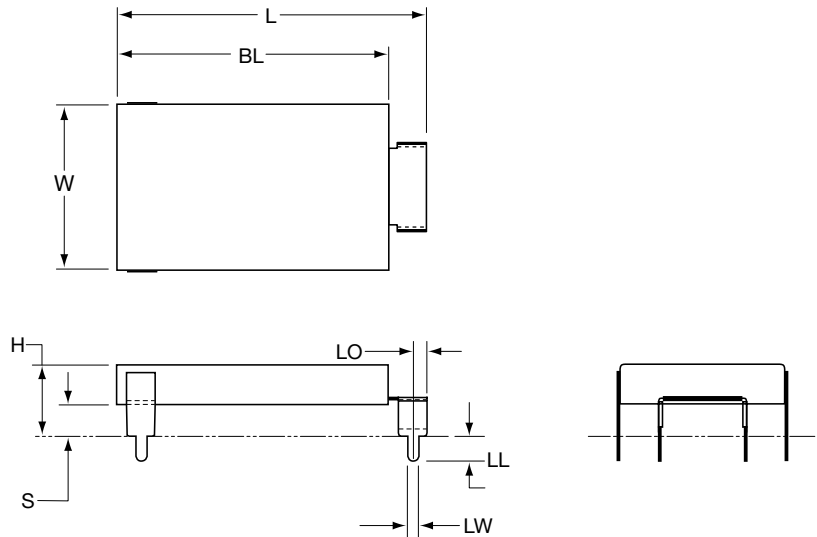


**TABLE 2.2.1: H-STYLE CASE DIMENSIONS**

| Case Size | Case Dimensions: mm (inches) |                        |                |                        |                                  |                         |                         |                         |
|-----------|------------------------------|------------------------|----------------|------------------------|----------------------------------|-------------------------|-------------------------|-------------------------|
|           | BL<br>$+1.0 (0.040)/-0$      | W<br>$+1.0 (0.040)/-0$ | H<br>(Maximum) | L<br>$\pm 1.0 (0.040)$ | S<br>$+0.5 (0.020)/-0.4 (0.016)$ | LO<br>$\pm 0.2 (0.008)$ | LW<br>$\pm 0.2 (0.008)$ | LL<br>$\pm 0.2 (0.008)$ |
| 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)

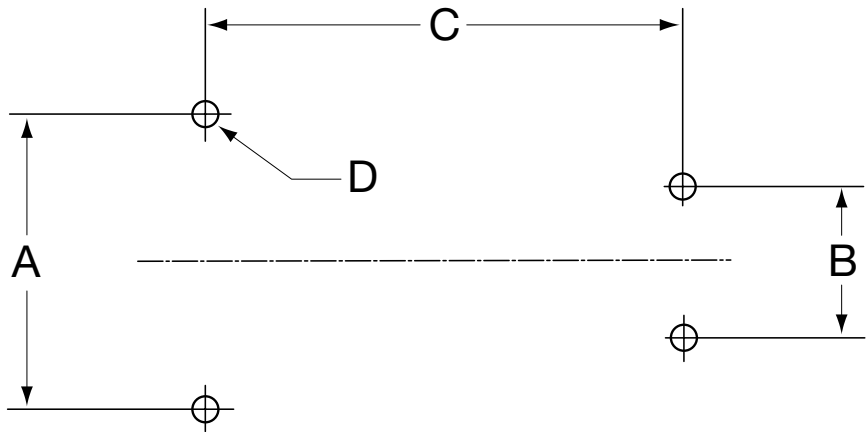


**TABLE 2.2.2: H-LEAD LAYOUT DIMENSIONS**

| Case Size | PCB Dimensions: mm (inches) |                         |                         |                           |
|-----------|-----------------------------|-------------------------|-------------------------|---------------------------|
|           | A<br>$\pm 0.05 (0.002)$     | B<br>$\pm 0.05 (0.002)$ | C<br>$\pm 0.05 (0.002)$ | D<br>$\pm 0.1 (0.004)$    |
| BZ01      | 17.25 (0.679)               | 8.90 (0.350)            | 28 (1.102)              | $\varnothing 1.4 (0.055)$ |
| BZ02      | 30.25 (1.191)               | 8.90 (0.350)            | 48 (1.890)              | $\varnothing 1.4 (0.055)$ |



# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

### 2.3.1: L-Lead Configuration (Planar Mount)

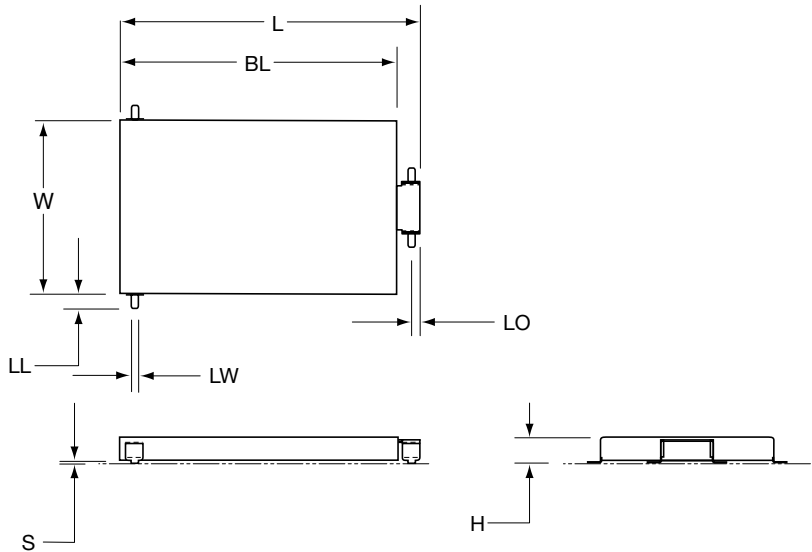


**TABLE 2.3.1: L-STYLE CASE DIMENSIONS**

| Case Size | Case Dimensions: mm (inches) |                      |                |                   |                   |                    |                    |                    |
|-----------|------------------------------|----------------------|----------------|-------------------|-------------------|--------------------|--------------------|--------------------|
|           | BL<br>+1.0 (0.040)/-0        | W<br>+1.0 (0.040)/-0 | H<br>(Maximum) | L<br>±1.0 (0.040) | S<br>±0.2 (0.008) | LO<br>±0.2 (0.008) | LW<br>±0.2 (0.008) | LL<br>±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)

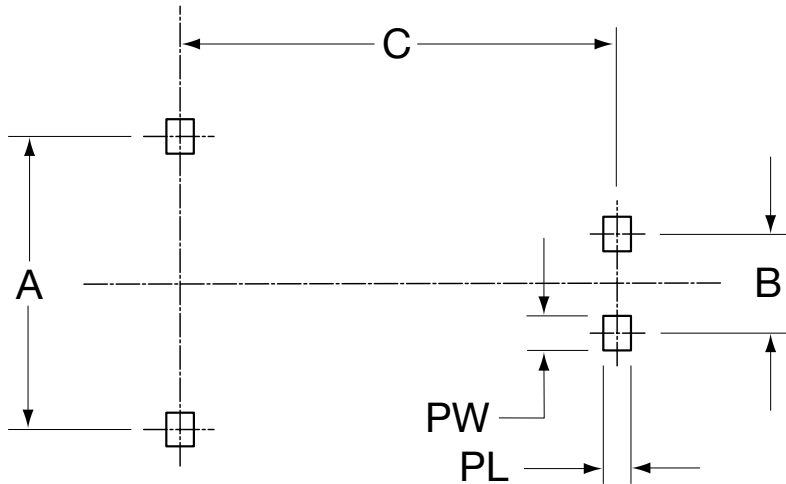


**TABLE 2.3.2: L-STYLE LEAD LAYOUT**

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



# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

### 2.4.1: S-Lead Configuration (Planar Mount)

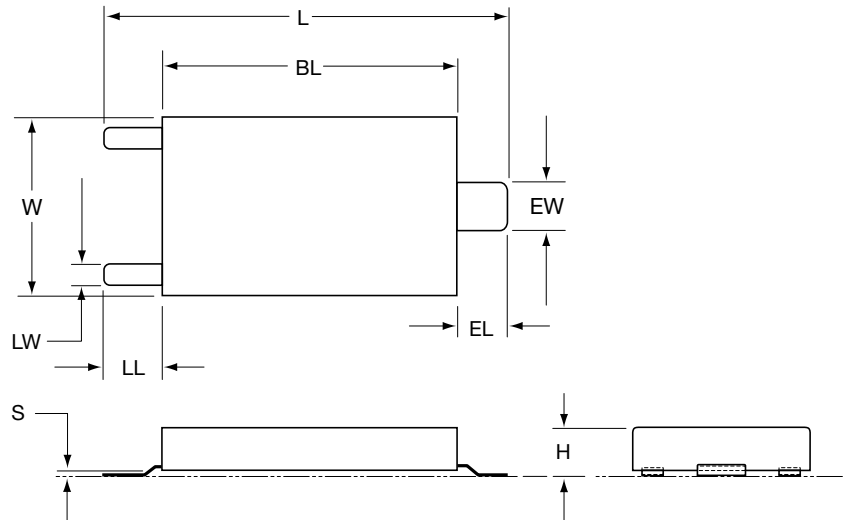
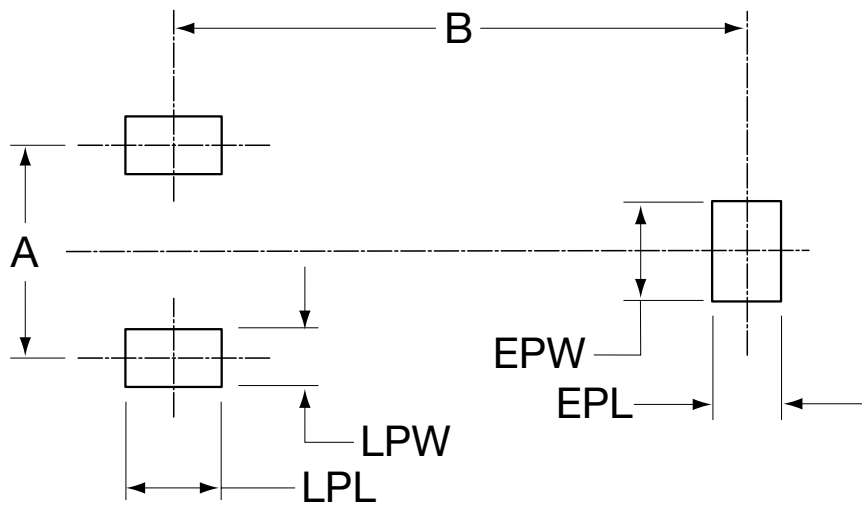


TABLE 2.4.1: S-STYLE CASE DIMENSIONS

| Case Size | Case Dimensions: mm (inches) |                      |                |                   |                    |                    |                    |                    |
|-----------|------------------------------|----------------------|----------------|-------------------|--------------------|--------------------|--------------------|--------------------|
|           | BL<br>+1.0 (0.040)/-0        | W<br>+1.0 (0.040)/-0 | H<br>(Maximum) | L<br>±1.0 (0.040) | EL<br>±0.5 (0.020) | EW<br>±0.2 (0.008) | LL<br>±0.5 (0.020) | LW<br>±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<br>±0.1 (0.004)           | B<br>±0.1 (0.004) | EPL<br>±0.1 (0.004) | EPW<br>±0.1 (0.004) | LPL<br>±0.1 (0.004) | LPW<br>±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)         |



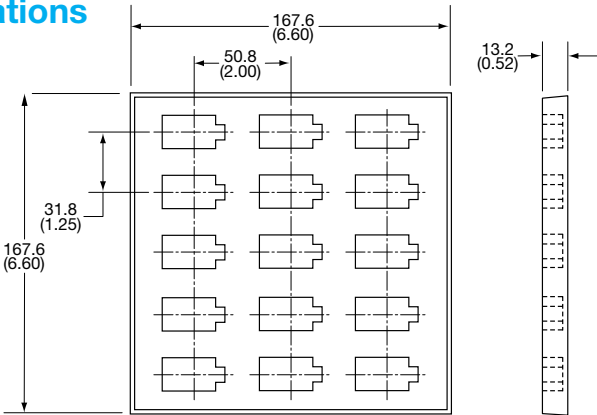
# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



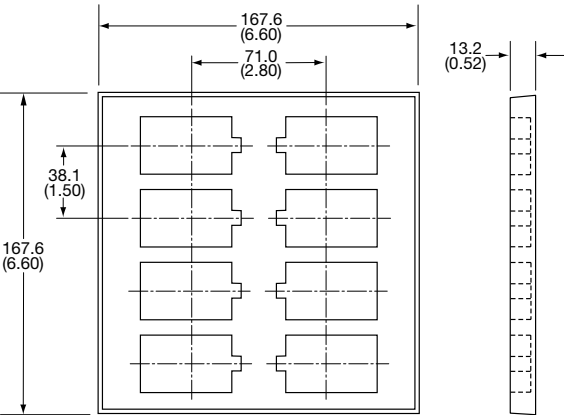
## SECTION 2: MECHANICAL SPECIFICATIONS (cont'd)

### 2.5: Packaging Specifications

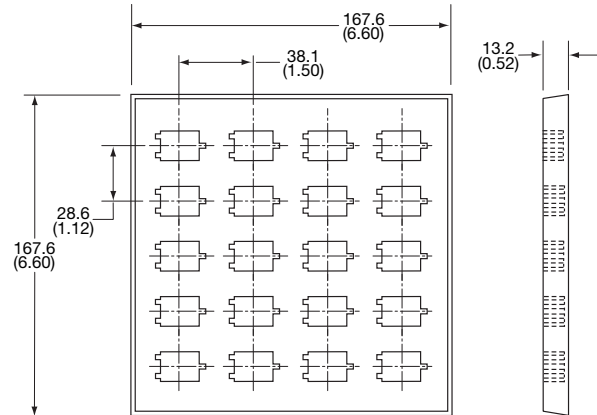
#### BZ01 Case:



#### 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

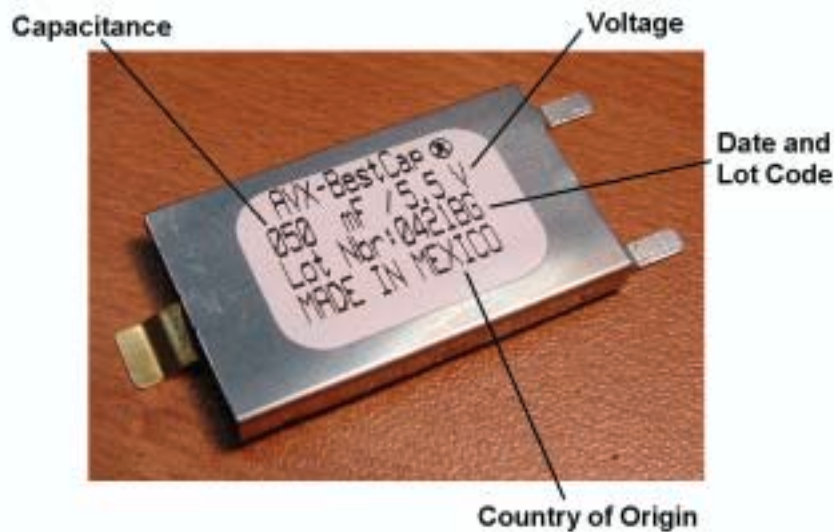
Care should be taken not to allow grease or oil into the part as it may lead to soldering problems. Handling should be minimized to reduce possible bending of the electrodes leads.

### 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.

# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## 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 diphenyl ether (PBDE) | Hexavalent Chromium | Cadmium | Mercury | Lead | Dibutyl phthalate (DBP) | Diethyl phthalate (DEHP) |
| 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               |



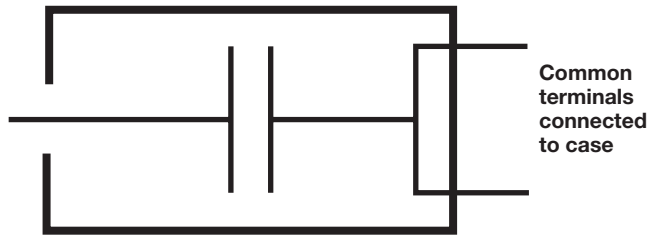
# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



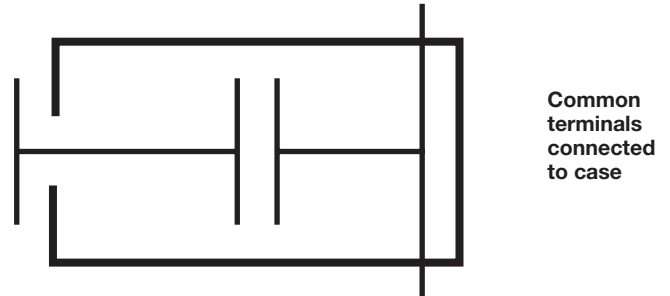
## SECTION 3: ELECTRICAL CHARACTERISTICS – SCHEMATIC

### 3.1 Terminal Connections:

#### 3.1.1: S-Lead



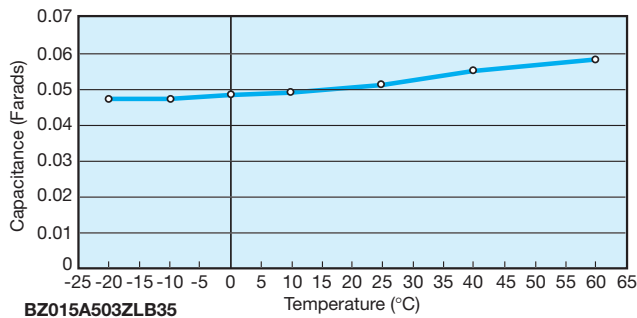
#### 3.1.2: A-, H- & L-Lead



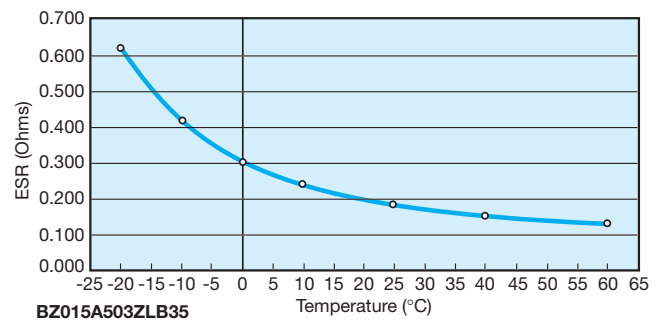
Devices are non polar but it is usual to maintain case at ground potential

## SECTION 3.2: TYPICAL CHARACTERISTICS

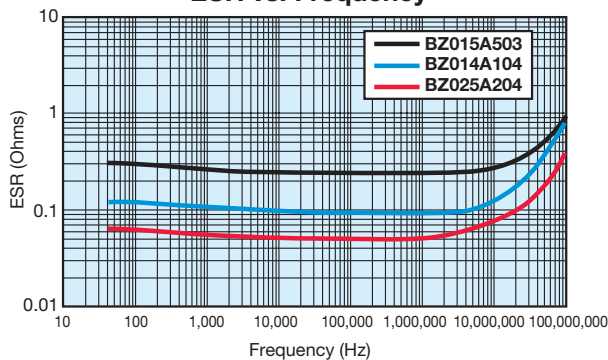
Capacitance vs. Temperature



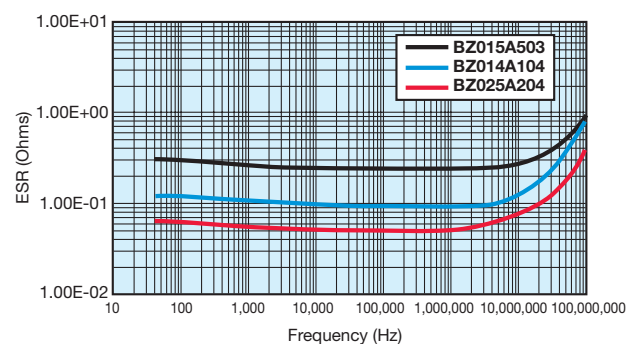
ESR vs. Temperature



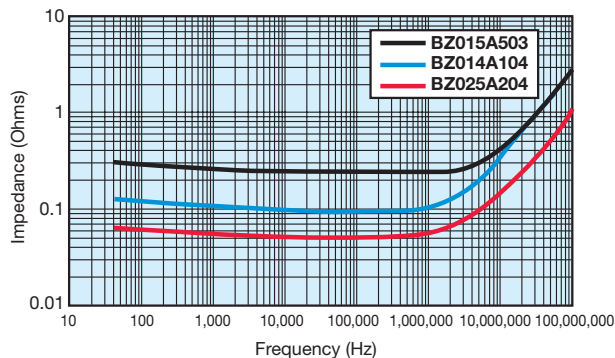
ESR vs. Frequency



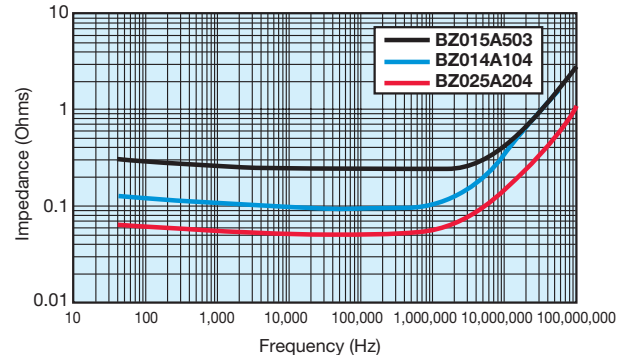
ESR Comparison



Impedance vs. Frequency



Impedance Comparison



# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## SECTION 3.3: 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. $C = I \cdot dt/dv$                                                  |                                                                                                                | 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<br>Cap<br>ESR                  | < 2.0x rated max.<br>> 0.7x rated<br>< 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<br>Cap<br>ESR                  | < 1.5x rated max.<br>> 0.7x rated<br>< 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<br>Cap<br>ESR                  | < 2.0x rated max.<br>> 0.7x rated<br>< 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                                                                 | DCL                                | < 1.5x rated max.                                 |
|                                 | 2                                                                                                                                                         | Short the cell for 10 minutes                                                                                  | Cap                                | > 0.7x rated                                      |
| Temperature Cycling             | 3                                                                                                                                                         | Repeat 1 and 2 for 1000 cycles                                                                                 | ESR                                | < 1.5x rated                                      |
|                                 | Step                                                                                                                                                      |                                                                                                                |                                    |                                                   |
|                                 | 1                                                                                                                                                         | Ramp oven down to -20°C and then hold for 30 min.                                                              | DCL                                | < 1.5x rated max.                                 |
| Temperature Characteristics     | 2                                                                                                                                                         | Ramp oven up to 75°C (A series BestCap®), 70°C (B series BestCap®) and then hold for 30 min.                   | Cap                                | > 0.7x rated                                      |
|                                 | 3                                                                                                                                                         | Repeat 1 and 2 for 100 cycles                                                                                  | ESR                                | < 1.5x rated                                      |
|                                 | Step                                                                                                                                                      | Temp                                                                                                           | Time                               |                                                   |
|                                 | 1                                                                                                                                                         | -20°C                                                                                                          | 4 hours                            | DCL                                               |
|                                 |                                                                                                                                                           | Measure Cap, ESR, DCL                                                                                          |                                    | 70°C                                              |
|                                 | 2                                                                                                                                                         | -10°C                                                                                                          | 4 hours                            | Cap                                               |
|                                 |                                                                                                                                                           | Measure Cap, ESR, DCL                                                                                          |                                    |                                                   |
|                                 | 3                                                                                                                                                         | 0°C                                                                                                            | 4 hours                            | ESR                                               |
|                                 |                                                                                                                                                           | Measure Cap, ESR, DCL                                                                                          |                                    |                                                   |
|                                 | 5                                                                                                                                                         | 25°C                                                                                                           | 4 hours                            | -20°C                                             |
|                                 |                                                                                                                                                           | Measure Cap, ESR, DCL                                                                                          |                                    | -10°C                                             |
|                                 | 6                                                                                                                                                         | 40°C                                                                                                           | 4 hours                            | 60°C                                              |
|                                 |                                                                                                                                                           | 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                                                                                          |                                    |                                                   |
| Thermal Shock                   | Step                                                                                                                                                      |                                                                                                                |                                    |                                                   |
|                                 | 1                                                                                                                                                         | Place cells into an oven at -20°C for 30 min.                                                                  | DCL                                | < 2.0x rated max.                                 |
|                                 | 2                                                                                                                                                         | In less than 15 seconds, move cells into a 75°C (A series BestCap®), 70°C (B series BestCap®) oven for 30 min. | Cap                                | > 0.7x rated                                      |
| Vibration                       | 3                                                                                                                                                         | Repeat 1 and 2 for 100 cycles                                                                                  | ESR                                | < 2.0x rated max.                                 |
|                                 | Step                                                                                                                                                      |                                                                                                                |                                    |                                                   |
|                                 | 1                                                                                                                                                         | Apply a harmonic motion that is deflected 0.03 inches                                                          | DCL                                | < 2.0x rated max.                                 |
|                                 | 2                                                                                                                                                         | Vary frequency from 10 cycles per second to 55 cycles at a ramp rate                                           | Cap                                | > 0.7x rated                                      |
|                                 | 3                                                                                                                                                         | Vibrate the cells in the X-Y direction for three hours                                                         | ESR                                | < 2.0x rated max.                                 |
|                                 | 4                                                                                                                                                         | Vibrate the cells in the Z direction for three hours                                                           |                                    |                                                   |
|                                 | 5                                                                                                                                                         | Measure Cap, ESR and DCL                                                                                       |                                    |                                                   |

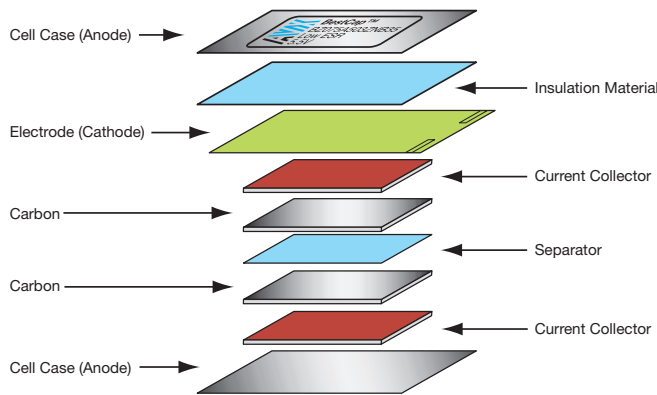
# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## 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 may be 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:

|                                                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• A capacitor basically consists of two conductive plates (electrodes), separated by a layer of dielectric material.</li> </ul>                        |
| <ul style="list-style-type: none"> <li>• These dielectric materials may be ceramic, plastic film, paper, aluminum oxide, etc.</li> </ul>                                                      |
| <ul style="list-style-type: none"> <li>• EDLCs do not use a discrete dielectric interphase separating the electrodes.</li> </ul>                                                              |
| <ul style="list-style-type: none"> <li>• EDLCs utilize the charge separation, which is formed across the electrode – electrolyte interface.</li> </ul>                                        |
| <ul style="list-style-type: none"> <li>• The EDLC constitutes of two types of charge carriers: IONIC species on the ELECTROLYTE side and ELECTRONIC species on the ELECTRODE side.</li> </ul> |

### 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.

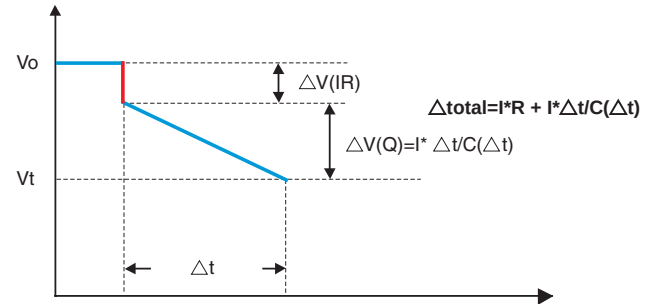


Figure 4. Voltage-time relation of capacitor unit

The instant voltage drop  $\Delta V_{ESR}$  is caused by and is directly proportional to the capacitor's ESR. The continuing voltage drop with time  $\Delta V_C$ , 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.

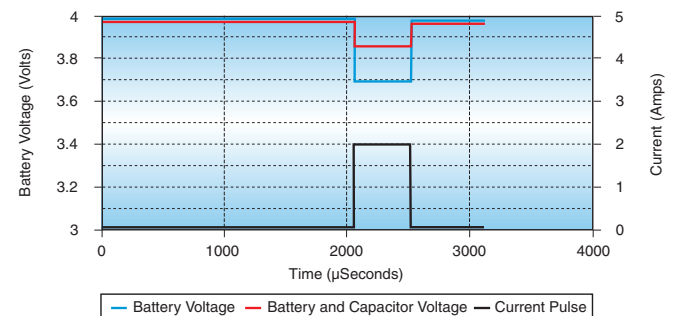


Figure 5. GSM Pulse

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

# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



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).

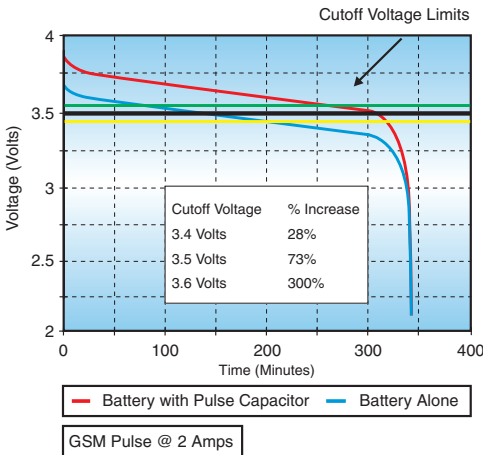


Figure 6a. Li-ION Battery at +25°C

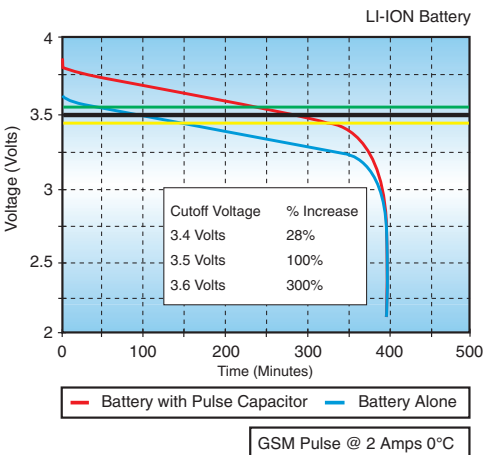


Figure 6b. Li-ION Battery at 0°C

## 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 ( $\Delta V$ ) which occur, the first  $\Delta V_{ESR}$  is because of the equivalent series resistance (ESR) and the second, called the capacitive drop, is  $\Delta V_C$ . From Ohm's law,

$$\text{voltage} = \text{current} \times \text{resistance or } V = IR$$

Let us say that the instantaneous starting voltage is  $V_0$ , 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,

$$\Delta V_{ESR} = 1 \text{ amp} \times (0.100) \text{ ohms} = 0.1 \text{ volts or } 100 \text{ milli-volts.}$$

On demand, during the discharge mode, the voltage  $V = V_0 - \Delta V_{ESR} = (V_0 - 0.1) \text{ volts}$

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

$$Q (\text{charge}) = C (\text{capacitance}) \times V (\text{voltage})$$

$$\text{The derivative, } dQ/dt = I (\text{current, in amps}) = C \times dV/dt$$

Hence,  $\Delta V_C$  (dV, the voltage drop because of capacitance) =  $I \times dt/C$ . This formula states that the larger the capacitance value the lower the voltage drop. Compared to a Ta capacitor this  $\Delta V_C$  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  $\Delta V_C = 1A \times 1\text{Sec}/0.01F$ , 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  $\Delta V_C = 1 \times (10/1000)/(100/1000) = 0.1 \text{ volt or } 100 \text{ milli-volts}$ . 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

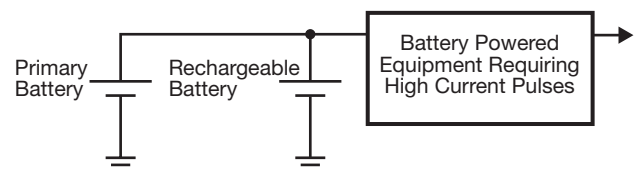
When electronic equipment is powered by a primary (non rechargeable) battery, one of the limitations is the power capability of the battery.

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.

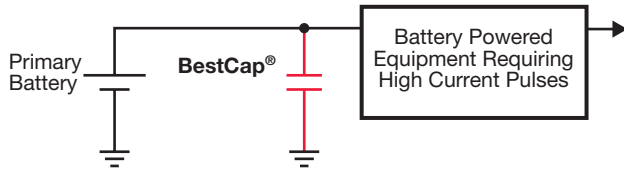
### Traditional design:



# BestCap® Ultra-low ESR High Power Pulse Supercapacitors



## 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)<br>BestCap® Supercapacitors | Voltage Drop (mV)<br>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)<br>BestCap® Supercapacitors | Voltage Drop (mV)<br>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.

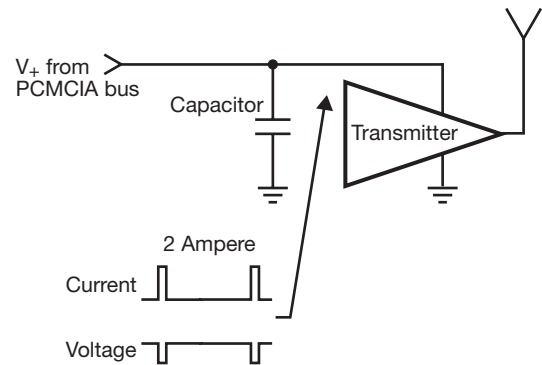
The PCMCIA card is used as an accessory to Laptops and PDA's, and enables wide area mobile Internet access, including all associated applications like Email and file transfer.

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:

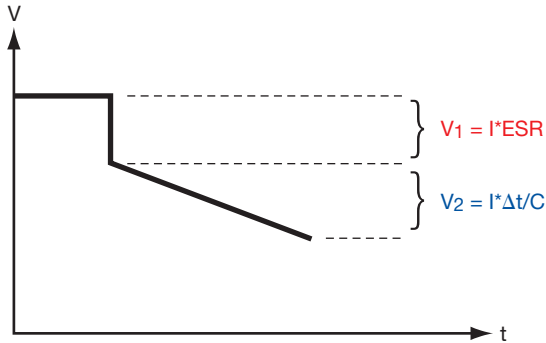
|                                                | SOLUTION A      | SOLUTION B                  |                             |
|------------------------------------------------|-----------------|-----------------------------|-----------------------------|
|                                                | Chip Tantalum   | BestCap®(1)<br>BZ014C353ZSB | BestCap®(1)<br>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:

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

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

# BestCap® Ultra-low ESR High Power Pulse Supercapacitors

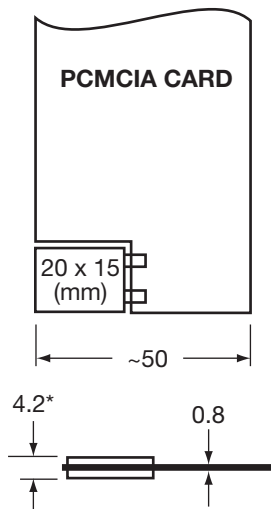
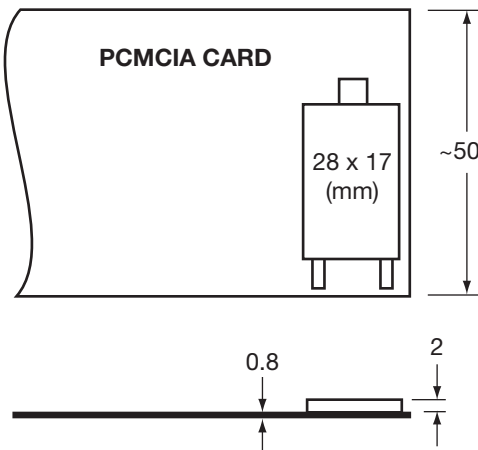


It is assumed that during the pulse, 0.5A is delivered by the battery, and 1.5A by the capacitor.

**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:

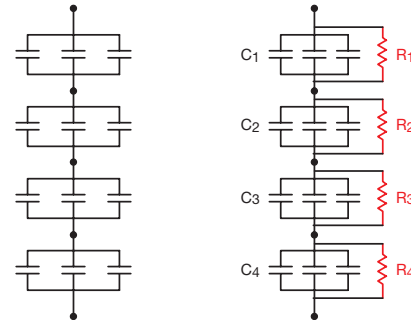
1. Parts with 2mm height that can be mounted on the board.



\*4.2 for 5.5V part  
2.3 for 2.5V part

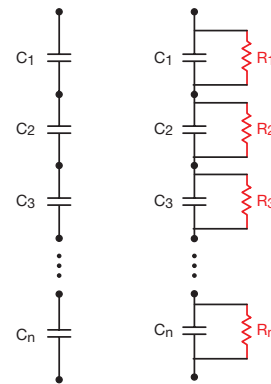
2. Smaller parts, consuming less PCB real estate and with flexible termination tabs, enable mounting the capacitor by cutting the PCB and placing the capacitor as shown in the drawing, utilizing the PCMCIA housing height.

## 4.5 PREFERRED SERIES PARALLEL COMBINATIONS



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

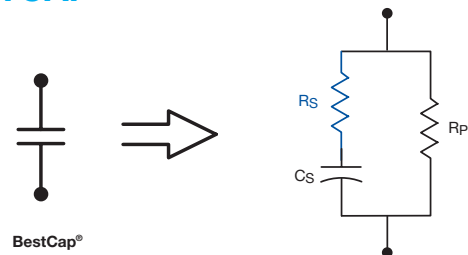
## OPTIONS FOR SERIES COMBINATIONS



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



## USA

**AVX Myrtle Beach, SC**  
Corporate Offices  
Tel: 843-448-9411  
FAX: 843-448-1943

**AVX North Central, IN**  
Tel: 317-848-7153  
FAX: 317-844-9314

**AVX Southwest, AZ**  
Tel: 602-678-0384  
FAX: 602-678-0385

**AVX Southeast, GA**  
Tel: 404-608-8151  
FAX: 770-972-0766

**AVX Northwest, WA**  
Tel: 360-699-8746  
FAX: 360-699-8751

**AVX Mid/Pacific, CA**  
Tel: 510-661-4100  
FAX: 510-661-4101

**AVX South Central, TX**  
Tel: 972-669-1223  
FAX: 972-669-2090

**AVX Canada**  
Tel: 905-238-3151  
FAX: 905-238-0319

## EUROPE

**AVX Limited, England**  
European Headquarters  
Tel: ++44 (0) 1252-770000  
FAX: ++44 (0) 1252-770001

**AVX/ELCO, England**  
Tel: ++44 (0) 1638-675000  
FAX: ++44 (0) 1638-675002

**AVX S.A., France**  
Tel: ++33 (1) 69-18-46-00  
FAX: ++33 (1) 69-28-73-87

**AVX GmbH, Germany**  
Tel: ++49 (0) 8131-9004-0  
FAX: ++49 (0) 8131-9004-44

**AVX srl, Italy**  
Tel: ++390 (0)2 614-571  
FAX: ++390 (0)2 614-2576

**AVX Czech Republic**  
Tel: ++420 465-358-111  
FAX: ++420 465-323-010

## ASIA-PACIFIC

**AVX/Kyocera, Singapore**  
Asia-Pacific Headquarters  
Tel: (65) 6286-7555  
FAX: (65) 6488-9880

**AVX/Kyocera, Hong Kong**  
Tel: (852) 2-363-3303  
FAX: (852) 2-765-8185

**AVX/Kyocera, Korea**  
Tel: (82) 2-785-6504  
FAX: (82) 2-784-5411

**AVX/Kyocera, Taiwan**  
Tel: (886) 2-2698-8778  
FAX: (886) 2-2698-8777

**AVX/Kyocera, Malaysia**  
Tel: (60) 4-228-1190  
FAX: (60) 4-228-1196

**Elco, Japan**  
Tel: 045-943-2906/7  
FAX: 045-943-2910

**Kyocera, Japan - AVX**  
Tel: (81) 75-604-3426  
FAX: (81) 75-604-3425

**Kyocera, Japan - KDP**  
Tel: (81) 75-604-3424  
FAX: (81) 75-604-3425

**AVX/Kyocera, Shanghai, China**  
Tel: 86-21 6886 1000  
FAX: 86-21 6886 1010

**AVX/Kyocera, Tianjin, China**  
Tel: 86-22 2576 0098  
FAX: 86-22 2576 0096

**Contact:**

