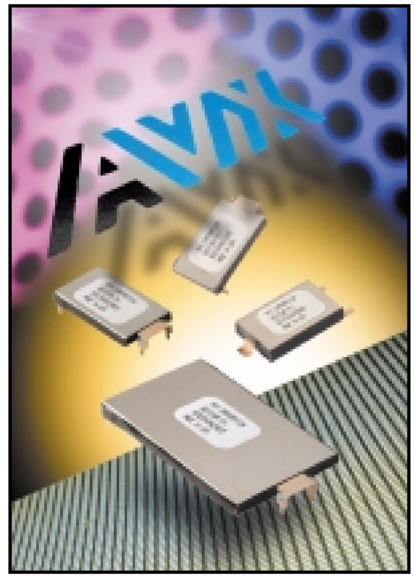
# BestCap™ Ultra-low ESR High Power Pulse Supercapacitors

## GENERAL DESCRIPTION



The BestCap™ series of electrochemical supercapacitors offer excellent high power pulse characteristics based upon the combination of very high capacitance and ultra low ESR in the milliOhm region.

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 PCS based systems, together with a variety of voltage ratings.

Depending upon package size, standard capacitance values of 30mF to 560mF are available in voltage ratings of 3.5V, 4.5V and 5.5V. ESR values for these standard devices range from 25 milliOhm to 230 milliOhm.

Used in conjunction with battery packs, BestCap™ improves the voltage performance for high current pulses, resulting in higher PA efficiency and longer battery talk-time as shown in Fig. 5. BestCap™ can also be used to boost instantaneous power availability in non-battery electronic applications where low level constant currents need to be supplemented by high current pulses.

## APPLICATIONS

RF Modems
Hybrid Battery Packs
Camera Flash Systems
Audio System "Base Line Stiffeners"
Mainframe Computer Decoupling
Hearing Aids
Prosthetics
Wireless Alarm Systems
Memory Back-up
UPS
Switch Mode Power Supplies
Systems/Products based on GSM/DSC1800/PCS/DECT/etc.

## PERFORMANCE CHARACTERISTICS & DIMENSIONS

| AVX CATALOG PART NUMBER | Size (mm) | Rated Voltage Volts | Capacitance milli farads +80%, -20% | ESR (ohms) ohms +/-20% @1khz | Leakage Current milli amps max |
|---|---|---|---|---|---|
| BZ015B303Z_B27 | 28 x 17 x 2.7 | 5.5 | 30 | 0.200 | 0.005 |
| BZ014B353Z_B24 | 28 x 17 x 2.4 | 4.5 | 35 | 0.180 | 0.005 |
| BZ013B403Z_B21 | 28 x 17 x 2.1 | 3.5 | 40 | 0.170 | 0.005 |
| BZ015A503Z_B35 | 28 x 17 x 3.5 | 5.5 | 50 | 0.230 | 0.005 |
| BZ014A603Z_B32 | 28 x 17 x 3.2 | 4.5 | 60 | 0.210 | 0.005 |
| BZ013A703Z_B29 | 28 x 17 x 2.9 | 3.5 | 70 | 0.200 | 0.005 |
| BZ015B603Z_B48 | 28 x 17 x 4.8 | 5.5 | 60 | 0.100 | 0.010 |
| BZ014B703Z_B43 | 28 x 17 x 4.3 | 4.5 | 70 | 0.090 | 0.010 |
| BZ013B803Z_B38 | 28 x 17 x 3.8 | 3.5 | 80 | 0.080 | 0.010 |
| BZ015A104Z_B61 | 28 x 17 x 6.1 | 5.5 | 100 | 0.120 | 0.010 |
| BZ014A124Z_B55 | 28 x 17 x 5.5 | 4.5 | 120 | 0.100 | 0.010 |
| BZ013A144Z_B47 | 28 x 17 x 4.7 | 3.5 | 140 | 0.090 | 0.010 |
| BZ025A204Z_B35 | 48 x 30 x 3.5 | 5.5 | 200 | 0.060 | 0.020 |
| BZ024A234Z_B32 | 48 x 30 x 3.2 | 4.5 | 230 | 0.050 | 0.020 |
| BZ023A284Z_B29 | 48 x 30 x 2.9 | 3.5 | 280 | 0.045 | 0.020 |
| BZ025A404Z_B60 | 48 x 30 x 6.0 | 5.5 | 400 | 0.035 | 0.040 |
| BZ024A474Z_B55 | 48 x 30 x 5.5 | 4.5 | 470 | 0.030 | 0.040 |
| BZ023A564Z_B47 | 48 x 30 x 4.7 | 3.5 | 560 | 0.025 | 0.040 |

## HOW TO ORDER

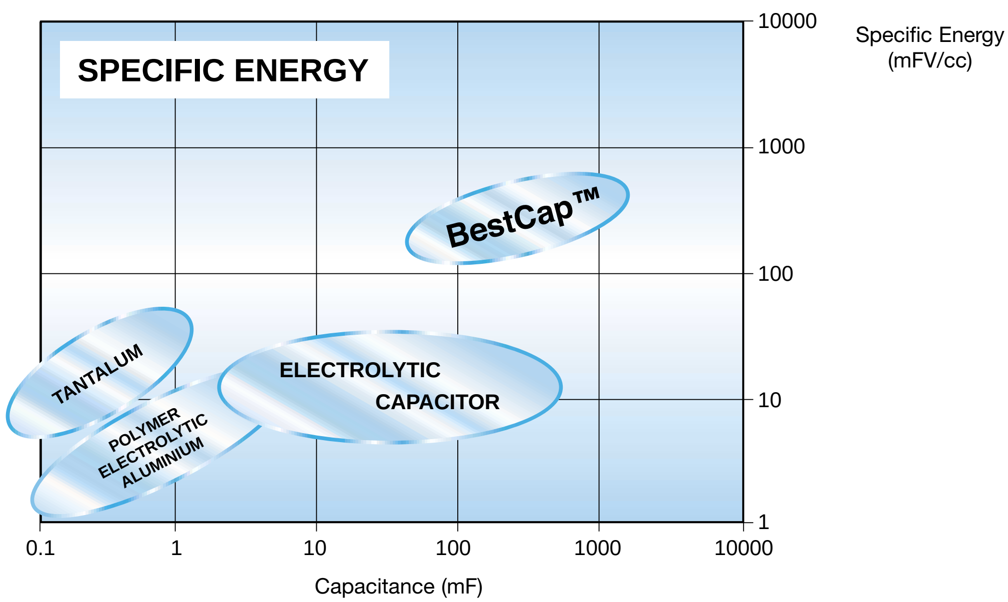
| BZ | 01 | 5 | A |
|---|---|---|---|
| BESTCAP™ | CASE SIZE<br>Where:<br>01 = 28mm x 17mm<br>02 = 48mm x 30mm | VOLTAGE<br>Where<br>5 = 5.5 volts<br>4 = 4.5 volts<br>3 = 3.5 volts | A = Standard<br>B = Thin |

| 503 | Z | A | B | 35 |
|---|---|---|---|---|
| CAPACITANCE VALUE (μF)<br>First two numbers express the significant digits; the third number refers to the number of zeros.<br>Example: 503 → 50,000μF = 50mF. | CAPACITANCE TOLERANCE<br>Where:<br>Z = +80%, -20% | TERMINATION STYLE<br>Where:<br>A = Leaded<br>S = SMT<br>L = L lead | PACKAGE CODE<br>Where:<br>B = Bulk | MAXIMUM PART HEIGHT<br>Where:<br>29 = 2.9mm 42 = 4.2mm<br>32 = 3.2mm 53 = 5.3mm<br>35 = 3.5mm 60 = 6.0mm |

## 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" capacitors such as ceramic, tantalum, film and aluminium electrolytic, and batteries (Fig. 1), but also as a valuable technology for providing a unique combination of characteristics, particularly very high energy, power and capacitance densities.

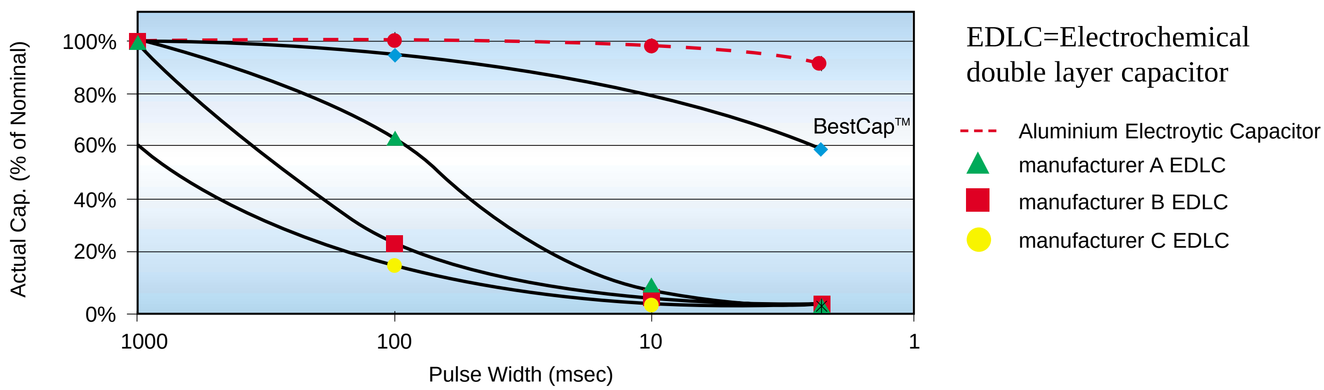
**Fig. 1 Specific Energy of Capacitor Types**




There are however, two negative characteristics associated with conventional supercapacitors, viz: high ESR in the Ohms or tens of Ohms area, and severe capacitance loss when called upon to supply very short duration current pulses. BestCap™ successfully addresses both of these drawbacks.

This 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. In the above-mentioned "electronic" capacitors, the charge transfer is performed by fast electrons, thereby creating virtually instant rated capacitance value. Fig. 2 illustrates the severe capacitance loss experienced by several varieties of supercapacitors (N, M & P), under short pulse width conditions. It can also be seen from Fig. 2, how well BestCap™ retains its capacitance with reducing pulse widths.

**Fig. 2 Actual capacitance vs. pulse width**



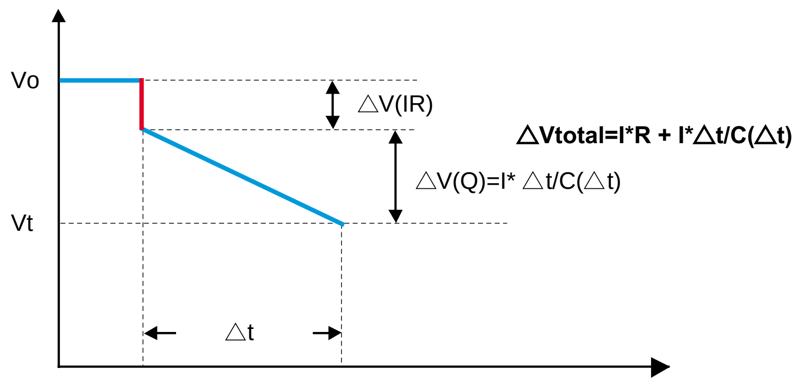

For comparison purposes, the characteristic of an equivalent capacitance value aluminium electrolytic capacitor is shown in Fig. 3. The electrolytic capacitor is many times the volume of the BestCap™.

**Fig. 3 Sized comparison, BestCap™ vs aluminium electrolytic capacitor**

## VOLTAGE DROP

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

**Fig 4 Voltage-time relation of capacitor unit**



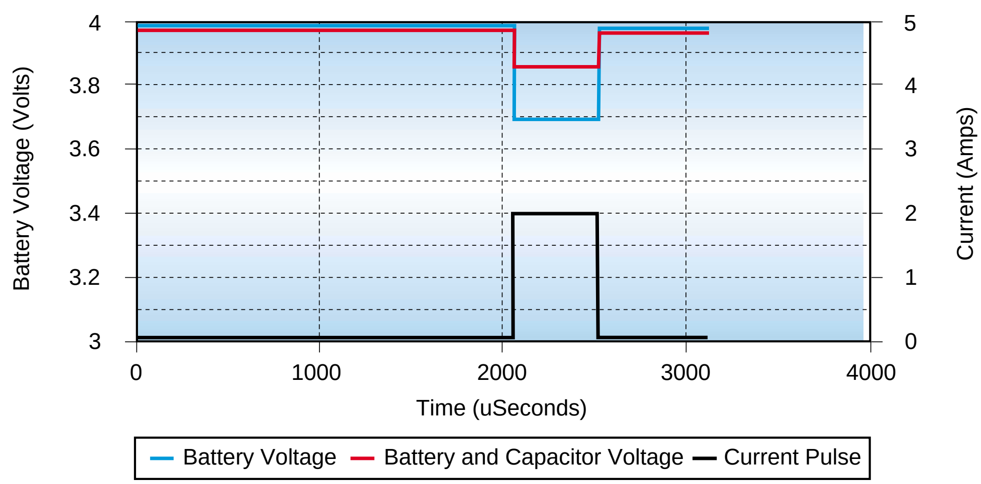

The instant voltage drop △V (IR) is caused by and is directly proportional to the capacitor's ESR. The continuing voltage drop with time △V (Q), is a function of the available charge, i.e. capacitance.

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, (milliOhm), ESR minimizes the instantaneous voltage drop, while the very high retained capacitance drastically reduces the severity of the charge related drop.

## EFFICIENCY/TALKTIME BENEFITS OF BESTCAP™

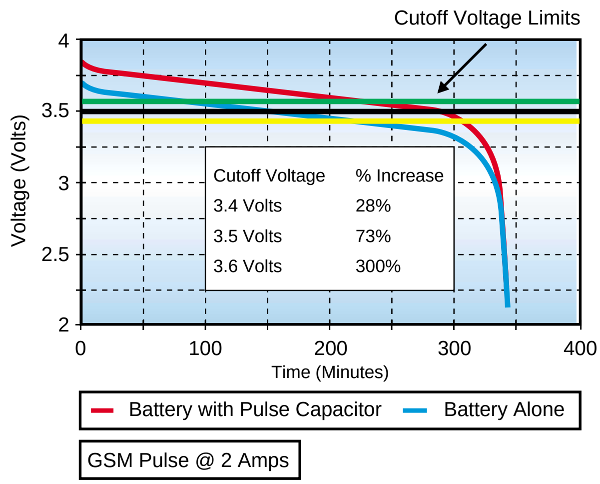
Because BestCap™, when used in parallel with a battery, provides a current pulse with a substantially higher voltage than that available just from the battery as shown in Fig. 5, the efficiency of the RF power amplifier is improved.

**Fig. 5 GSM Pulse**

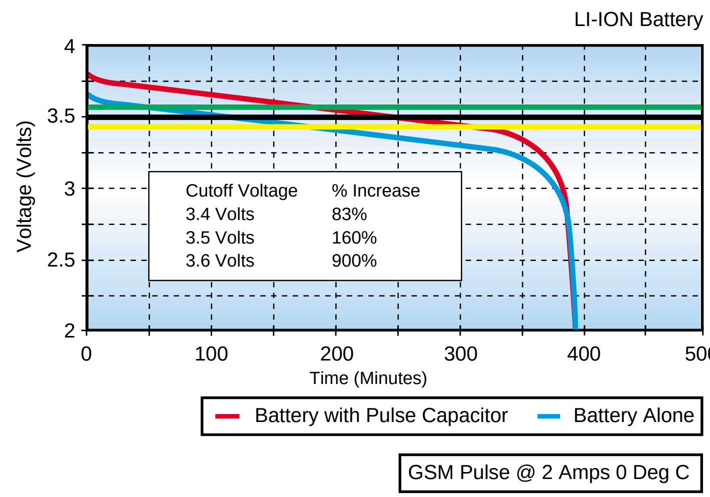


Additionally, the higher-than battery voltage supplied by the BestCap™ keeps the voltage pulse above the "cut off voltage" limit for a significantly longer time than is the case for the battery alone. This increase in "talktime" is demonstrated in figures 6a) (Li-Ion at +25°C); 6b) (Li-Ion at 0°C); 6c) (Ni-MH at +25°C) & 6d) (Ni-MH at 0°C).

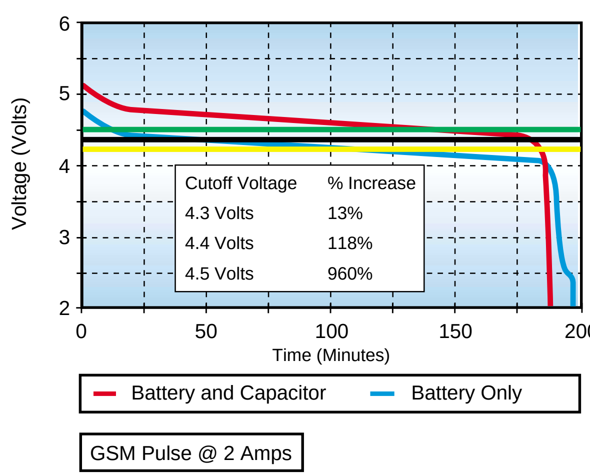
## Fig. 6a Li-ION Battery



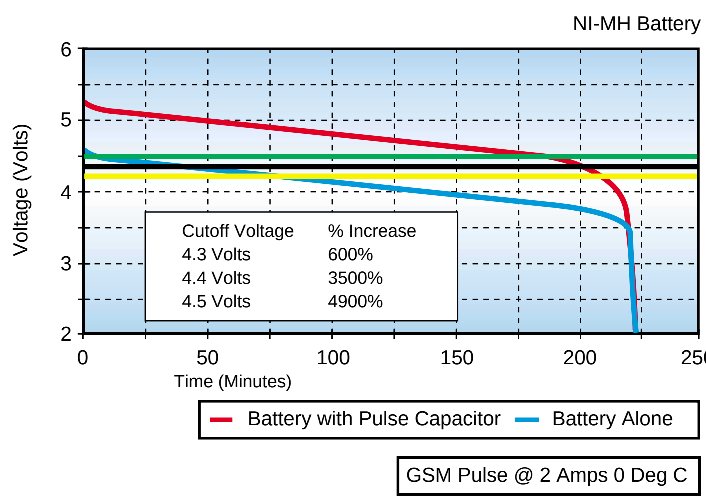

## Fig. 6b Battery Life at 0°C




## Fig. 6c NI-MH Battery




## Fig. 6d Battery Life at 0°C

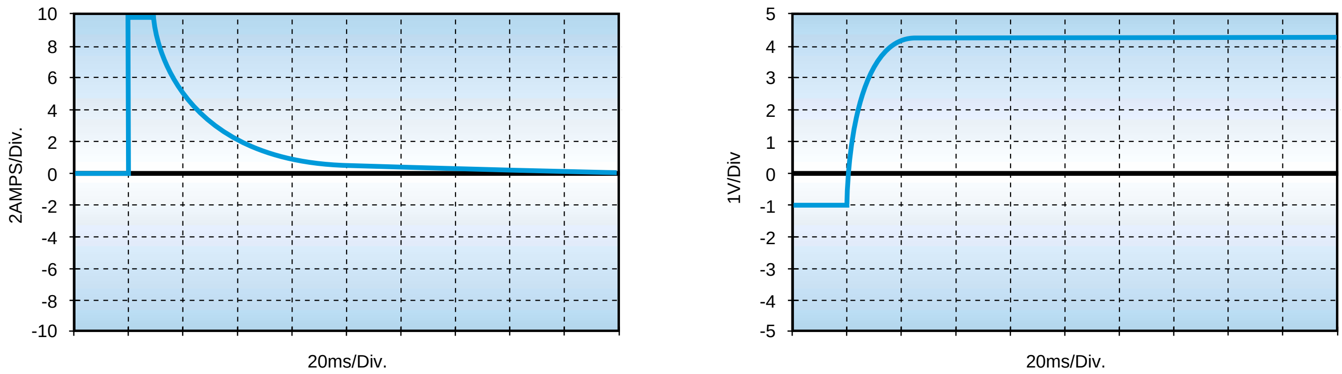


# BESTCAP™ INRUSH CURRENT/SHORT CIRCUIT DISCHARGE CAPABILITIES

Testing of capacitors, including supercapacitors, is normally carried out using milliAmpere signals. However, for many applications it is important to know the true capability of the device in terms of inrush and discharge currents. In Figs. 7 & 8, shown below, show BestCap™ charging to 10 Amps max., (28 x 17mm version) and discharging with a peak current of 25 Amps (48 x 30mm version) into a load impedance of approximately 70 milliOhms.

### Fig. 7 Inrush Characteristics

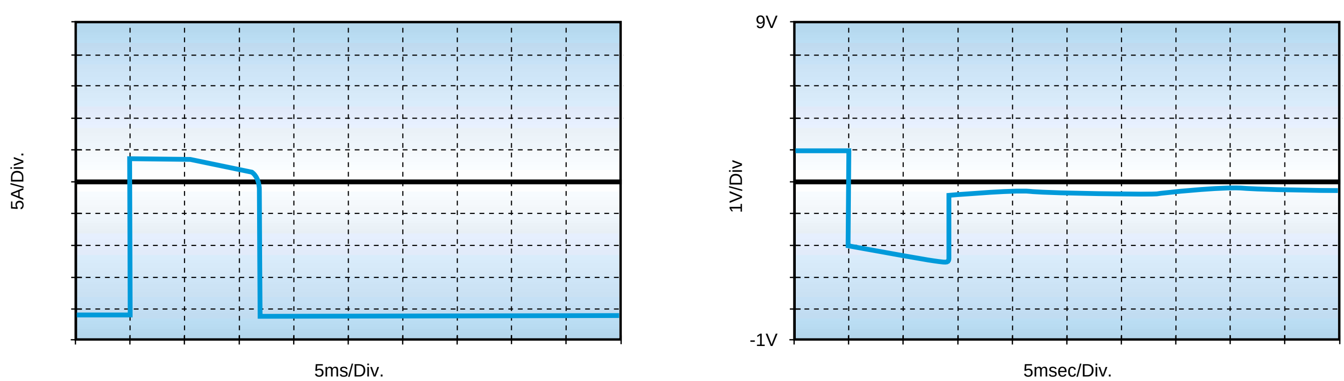
**Current** **Voltage**




Charging to 5.5V with maximum current of 10Amps.

### Fig. 8 Short-Circuit Discharge Characteristics

**Current** **Voltage**




Discharge into load of 70 milliOhms; peak current = 25Amps.

These figures graphically illustrate the exceptional peak current handling capabilities of BestCap™.

# BESTCAP™ IN BATTERY BACK-UP APPLICATIONS

BestCap™ is normally utilized as a power-boosting device to assist the main battery during pulse power demand periods. However, the capacitor may also be used as a back-up unit when, for example, the battery is being replaced.

Back-up time of the BestCap™ may be calculated using the following formula:

$$C = I * t / \triangle V$$

$$\triangle V = Vo - Vt - I * R_{ESR}$$

At low current (as is the case in the back-up application):

$$\triangle V = Vo - Vt$$

$$\mathbf{t = C\triangle V/I = C*(Vo - Vt)/I}$$

Where

C is the Capacitance in F

Vo is the initial voltage

Vt is the end voltage

I is the back-up current drain in Amperes

$R_{ESR}$ is the ESR in Ohms

t = back-up time in seconds

Example: System Clock Time Maintenance

Using a BZ015A503ZAB35 BestCap™ 5.5V, 50mF, 28 x 17 footprint, 3.5 mm (max) height

If Vo = 5.0V   Vt = 2.5V   $I_{(Back-up)}$ = 40µA ($40*10^{-6}$ Amp.)

The discharge current of the Cap shall be the sum of the back-up current drain plus leakage current.

Leakage Current is a function of the Capacitor voltage. In the specific case,

the Leakage Current is 5µA at 5.0V and it comes down to <1µA at 2.5V.

In the "worst" case the Leakage Current = 5µA. Practically, the Leakage Current is 3µA[(5+1)/2].

The total discharge current during the back-up period is

40µA (back-up) + 5µA (Leakage Current) = 45µA, in the worst case, or

40µA (back-up) + 3µA (Leakage Current) = 43µA, practically.

Thus the back-up time would be:

**t** = $50*10^{-3} * (5-2.5)/45*10^{-6}$ = **46 minutes**

## Engineering Guidance Notes

1. Operational and storage temperature

   -20°C to +70°C. Storage at room temperature is recommended.

2. Voltage

   Rated voltage of the capacitor is per the data sheet and the label on the product. A surge voltage of V rated +2% may be applied to the capacitor for <5 sec without damage or performance degradation.

3. Temperature/Voltage Recommendations

| Temperature | -20°C to +35°C | +35°C to +70°C |
|---|---|---|
| Rated Voltage | Recommended Maximum Applied Voltage | |
| 3.5V | 3.5V | 3.2V |
| 4.5V | 4.5V | 4.2V |
| 5.5V | 5.5V | 5.0V |

4. Polarity

   BestCap™ capacitors are non-polar, so can handle both positive and negative voltages. The polarity marking on the label relates to internal test procedures only and may be ignored in normal use.

5. Mounting

   BestCap™ may **not** be reflow or wave soldered. Hand soldering of the device is acceptable. When hand soldering, use a soldering iron of <30W rating and ensure that the tip temperature does not exceed +350°C. Duration of the soldering operation should be <3 sec. Mounting chips which may be automatically placed, (i.e. via Pick n' Place machine) and reflow soldered, and into which the BestCap™ may subsequently be inserted, are available for some versions of BestCap™. Please check with your AVX Sales Office for further information.

6. Other Precautions

   - Do not disassemble the capacitor
   - Do not dispose of the capacitor by incineration.
   - Should the internal material come in contact with the skin or eyes, wash/rinse thoroughly with running water.

## Other BestCap™ Characteristics

The material systems used in the Bestcap structure features the following characteristics:

- Completely non-toxic.
- Capable of very thin formats.
- Shock resistance to >30000G's.
- Various voltage ratings.
- Non-Polar.
- Low leakage current <0.2µA/mF.
- Capacitance values 30-560mF.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