48V SCM Series
Series-Connected SuperCapacitor Modules

This new series of electrochemical, double-layer, series-connected SuperCapacitor modules offers excellent pulse power handling characteristics based on the combination of very high capacitance and very low ESR. Used by themselves or in conjunction with primary or secondary batteries, they provide extended back up time, longer battery life, and provide instantaneous power pulses as needed. Offers great solutions to Hold Up, Energy Harvesting, and Pulse Power Applications.

FEATURES
• Low ESR provides high efficiency and high power density
• Withstands high vibrations and high current applications
• Life time capable of millions of cycles
• Active cell balancing

APPLICATIONS
• Heavy industrial equipment
• Grid storage
• UPS/Industrial systems
• Regenerative energy capture
• Pitch control

HOW TO ORDER

<table>
<thead>
<tr>
<th>SCM</th>
<th>Z</th>
<th>1E</th>
<th>P</th>
<th>167</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>SuperCap Module</td>
<td>Width (190mm)</td>
<td>Length (413mm)</td>
<td>Voltage Code (P = 48V)</td>
</tr>
</tbody>
</table>

QUALITY INSPECTION
Parts are tested for life cycle, high temperature load life, temperature characteristics, vibration resistance, and humidity characteristics. See page 2 for more information.

TERMINATION
Power terminals are M8 (+) and M10 (-). Recommended torque is 20 Nm (M8) and 30 Nm (M10). See page 6 for more information on polarity.

OPERATING TEMPERATURE
-40°C to +65°C @ 48V Balanced

For RoHS compliant products, please select correct termination style.
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Series-Connected SuperCapacitor Modules

RATINGS & PART NUMBER REFERENCE

<table>
<thead>
<tr>
<th>AVX Part Number</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
<th>Capacitance (F)</th>
<th>Capacitance Tolerance</th>
<th>Rated Voltage (V)</th>
<th>Rated Temperature (°C)</th>
<th>DCL Max @ 72 Hrs (uA)</th>
<th>ESR Max @ 1000 Hz (mΩ)</th>
<th>ESR Max @ DC (mΩ)</th>
<th>Peak Current (A)</th>
<th>Power Density (W/kg)</th>
<th>Max Energy (Wh)</th>
<th>Energy Density (Wh/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCMZ1EP1679RBB0</td>
<td>413</td>
<td>190</td>
<td>160</td>
<td>165</td>
<td>+30% / -10%</td>
<td>48</td>
<td>65</td>
<td>5.22</td>
<td>2165.8</td>
<td>52.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

QUALIFICATION TEST SUMMARY

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Parameter</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Cycle</td>
<td>Capacitors are cycled between rated voltage and half-rated voltage under constant current at +25°C for 500,000 cycles</td>
<td>Capacitance Change</td>
<td>≤30% of initial spec value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ESR</td>
<td>≤2 times initial spec value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appearance</td>
<td>No remarkable defects</td>
</tr>
<tr>
<td>High Temperature Load Life</td>
<td>Temperature: +65°C</td>
<td>Capacitance Change</td>
<td>≤30% of initial spec value</td>
</tr>
<tr>
<td></td>
<td>Voltage: Rated Voltage</td>
<td>ESR</td>
<td>≤2 times initial spec value</td>
</tr>
<tr>
<td></td>
<td>Test Duration: 2,000 hours</td>
<td>Appearance</td>
<td>No remarkable defects</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>Storage Duration: 2 years</td>
<td>Capacitance Change</td>
<td>≤30% of initial spec value</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td>ESR</td>
<td>≤2 times initial spec value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appearance</td>
<td>No remarkable defects</td>
</tr>
<tr>
<td>Vibration Resistance</td>
<td>Amplitude: 1.5mm</td>
<td>Capacitance Change</td>
<td>≤30% of initial spec value</td>
</tr>
<tr>
<td></td>
<td>Frequency: 10 ~ 55Hz</td>
<td>ESR</td>
<td>≤2 times initial spec value</td>
</tr>
<tr>
<td></td>
<td>Direction: X, Y, Z for 2 hours each</td>
<td>Appearance</td>
<td>No remarkable defects</td>
</tr>
<tr>
<td>Humidity</td>
<td>Voltage: Rated Voltage</td>
<td>Capacitance Change</td>
<td>≤30% of initial spec value</td>
</tr>
<tr>
<td></td>
<td>RH: 90%</td>
<td>ESR</td>
<td>≤2 times initial spec value</td>
</tr>
<tr>
<td></td>
<td>Temperature: +60°C</td>
<td>Appearance</td>
<td>No remarkable defects</td>
</tr>
<tr>
<td></td>
<td>Test Duration: 1,500 hours</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
QUALITY AND RELIABILITY

Capacitance vs. Temperature

Leakage Current vs. Temperature

Equivalent Series Resistance vs. Temperature
MECHANICAL SPECIFICATIONS

Pin Out Designation

Pin 2, the overvoltage signal, is an open collector transistor that pulls the pin low if any cell experiences an overvoltage condition. Pin 4, the temperature signal, has a 10K NTC device connected between it and the ground pin. The module temperature can be determined by reading the resistance of the NTC. See table below for resistance values at select intermediate temperatures.

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>R_T (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>332094</td>
</tr>
<tr>
<td>-25</td>
<td>129287</td>
</tr>
<tr>
<td>0</td>
<td>32554</td>
</tr>
<tr>
<td>25</td>
<td>10000</td>
</tr>
<tr>
<td>45</td>
<td>4372</td>
</tr>
<tr>
<td>65</td>
<td>2084</td>
</tr>
<tr>
<td>85</td>
<td>1070</td>
</tr>
<tr>
<td>100</td>
<td>677.3</td>
</tr>
<tr>
<td>125</td>
<td>338.7</td>
</tr>
<tr>
<td>150</td>
<td>182.8</td>
</tr>
</tbody>
</table>

Note: Pin 2, the overvoltage signal, is an open collector transistor that pulls the pin low if any cell experiences an overvoltage condition. Pin 4, the temperature signal, has a 10K NTC device connected between it and the ground pin. The module temperature can be determined by reading the resistance of the NTC. See table below for resistance values at select intermediate temperatures.
TEST METHODS

IEC Capacitance Test Method

- Capacitance is measured using a Keithley 2400 or 2602 Meter
- Procedure
  - Charge Capacitor to Rated Voltage at room temperature
  - Disconnect parts from voltage to remove charging effects
  - Discharge cells with a constant current I determined by \( 4 \times C \times VR \)
  - Noting \( V_1 \), \( t_1 \), \( V_2 \), \( t_2 \) and performing the calculation for C

\[
C = \frac{I \times (t_2 - t_1)}{(V_1 - V_2)}
\]

DCL Measurement @ 25°C

- DCL is measured using a Multimeter with high internal impedance across a resistor
  - Charge Capacitor to Rated Voltage at room temperature for 72 Hours
  - Disconnect parts from Voltage by opening switch 1 (Stabilize for 10 Min)
  - Measure Voltage across a known Valued Resistor (1K Ohm)
  - Calculate \( DCL = \frac{V}{R} \)

DC ESR Measurement

- Six steps capacity and ESRDC Test Method is used as illustrated in the figure right.
- Tests are carried out by charging and discharging the capacitor for two cycles at rated voltage and half rated voltage
- \( C = \frac{(CDC1+CDC2)}{2} \)
- \( ESRDC = \frac{(ESRDC1 + ESRDC2)}{2} \)
Where: \( CDC1 = \frac{I_2 \times (I1-I4)}{(V3-V4)} \)
\( CDC2 = \frac{I_2 \times (I11-I10)}{(V9-V10)} \)
\( ESRDC1 = \frac{(V5-V4)}{I2} \)
\( ESRDC2 = \frac{(V11-V10)}{I2} \)
\( I1 = I2 = 75mA/F \)

Initial ESR Measurement @ 25°C

- Using an Agilent 4263B LCR Meter and a Kelvin connection
- Measure at frequency of 1000 Hz
- Measurement Voltage of 10mV

Maximum Operating Current

- This is the maximum current when capacitor temperature rise of the capacitor during its operation is less than 15°C

Maximum Peak Current

- This is the maximum current in less than 1 sec

Watt Density

- \( \text{Watt Density} = \frac{(0.12 \times V^2)}{\text{RDC}} / \text{mass} \)

Energy Density

- \( \text{Energy density} = \frac{(\frac{1}{2} CV^2)}{(3600 \times \text{mass})} \)
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POLARITY / REVERSE VOLTAGE
For product consistency and optimum performance, it is recommended that the capacitor be connected with polarity indicated. Reversing polarity will result in reduced module performance and permanent damage to the circuit.

LIFE TIME AND TEMPERATURE PERFORMANCE
The life of a SuperCapacitor is impacted by a combination of operating voltage and the operating temperature according to the following equation:

\[ t = \frac{V}{n \cdot V} \cdot \exp \left( \frac{-Q}{k \cdot T} \right) \]  

where \( V \) is the voltage of operation, \( Q \) is the activation energy in electron volts (eV), \( k \) is the Boltzmann's constant in eV and \( T \) is the operating temperature in °K (where K is in degrees Kelvin). Typical values for the voltage exponent, \( n \), is between 2.5 - 3.5, and \( Q \) is between 1.0 - 1.2 eV in the normal operating temperature range of 40° to 65°C.

The industry standard for SuperCapacitor end of life is when the equivalent series resistance, ESR, increases to 200% of the original value and the capacitance drops by 30%. Typically a supercapacitance shows an initial change in the ESR value and then levels off. If the capacitors are exposed to excessive temperatures the ESR will show a continuous degradation. In the extreme case, if the temperatures or voltages are substantially higher, than the rated voltage, this will lead to cell leakage or gas leakage and the product will show a faster change in the ESR which may increase to many times the original value.

Expected Lifetime at Various Voltages
SCM Series 48V Rated for Balanced Modules
SAFETY RECOMMENDATIONS

Warnings
- To Avoid Short Circuit, after usage or test, Super Capacitor voltage needs to discharge to ≤ 0.1V
- Do not Apply Overvoltage, Reverse Charge, Burn or Heat Higher than 150°C, explosion-proof valve may break open
- Do not Press, Damage or disassemble the Super Capacitor, housing could heat to high temperature causing Burns
- If you observe Overheating or Burning Smell from the capacitor, disconnect Power immediately, and do not touch

Emergency Applications
- If Housing is Leaking:
  - Skin Contact: Use soap and water thoroughly to wash the area of the skin
  - Eye Contact: Flush with flowing water or saline, and immediately seek medical treatment
  - Ingestion: Immediately wash with water and seek medical treatment

Transportation
Not subjected to US DOT or IATA regulations
UN3499, <10Wh, Non-Hazardous Goods
International shipping description –
"Electronic Products – Capacitor"

Regulatory
- UL810a
- RoHS Compliant
- Reach Compliant / Halogen Free

Storage
- Capacitors may be stored within the operating temperature range of the capacitor
- Lower storage temperature is preferred as it extends the shelf life of the capacitor
- Do Not Store the Super Capacitors in the following Environments
  - High Temperature / High Humidity environments >40°C / 70% RH
  - Direct Sunlight
  - In direct contact with water, salt oil or other chemicals
  - In direct contact with corrosive materials, acids, alkalis, or toxic gases
  - Dusty environment
  - In environment with shock and vibration conditions

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