This new series of plastic, epoxy-filled SuperCapacitor modules feature high reliability when used in elevated temperatures and/or high humidity conditions. In addition to moisture resistance features, these SuperCapacitor modules offer excellent pulse power handling characteristics based on the combination of very high capacitance and very low ESR. Degradation of electrical characteristics under normal conditions are lengthened in large part to the special plastic, epoxy-filled packaging technology of these SuperCapacitor modules. 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. These modules offer great solutions to hold up, energy harvesting, pulse power applications, and battery replacement.

**FEATURES**
- High Pulse Power Capability
- Low ESR
- Low Leakage Current
- Plastic, Moisture Resistant
- High Reliability

**APPLICATIONS**
- Smart/Remote Metering
- Telemetry
- Hybrid Battery Packs
- Scanners
- Environmental Controls
- Network Power Hold-Up
- Pulse Power Handling
- Solid State Drives
- UPS/Industrial
- Energy Harvesting

**HOW TO ORDER**

```
<table>
<thead>
<tr>
<th>SCM</th>
<th>R</th>
<th>14</th>
<th>C</th>
<th>474</th>
<th>P</th>
<th>S</th>
<th>B</th>
<th>A</th>
<th>0</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>SuperCap Module</td>
<td>Diameter</td>
<td>R = 9.5mm</td>
<td>Case Length</td>
<td>Two digits</td>
<td>Represent case</td>
<td>Length in mm</td>
<td>Voltage Code</td>
<td>C = 5.0V</td>
<td>D = 5.4V</td>
</tr>
</tbody>
</table>
```

*Inquire about availability

**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**
These SuperCapacitors are compatible with hand soldering, as well as reflow and wave soldering processes, so long as appropriate precautions are followed. See page 4 for more information.
# High Reliability SCM Series
## Series-Connected SuperCapacitor Modules

### RATINGS & PART NUMBER REFERENCE

<table>
<thead>
<tr>
<th>AVX Part Number</th>
<th>Diameter (mm)</th>
<th>Length (mm)</th>
<th>Rated Capacitance (F)</th>
<th>Capacitance Tolerance</th>
<th>Rated Voltage (V)</th>
<th>Rated Temperature (°C)</th>
<th>DCL Max @ 72 Hrs (µA)</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>SCMR14C474PSBA0H</td>
<td>9.5</td>
<td>16</td>
<td>0.47</td>
<td>+100%/-0%</td>
<td>5.0/4.2*</td>
<td>65/85*</td>
<td>2</td>
<td>300</td>
<td>1720</td>
<td>0.85</td>
<td>447</td>
<td>0.0016</td>
<td>0.42</td>
</tr>
<tr>
<td>SCMR14D474PSBB0H</td>
<td>9.5</td>
<td>16</td>
<td>0.47</td>
<td>+100%/-0%</td>
<td>5.4/4.6*</td>
<td>65/85*</td>
<td>6</td>
<td>300</td>
<td>1720</td>
<td>0.70</td>
<td>522</td>
<td>0.0019</td>
<td>0.49</td>
</tr>
<tr>
<td>SCMR19C105PSBA0H</td>
<td>9.5</td>
<td>20</td>
<td>1.0</td>
<td>+100%/-0%</td>
<td>6.0/4.2*</td>
<td>65/85*</td>
<td>6</td>
<td>250</td>
<td>720</td>
<td>1.45</td>
<td>906</td>
<td>0.0035</td>
<td>0.75</td>
</tr>
<tr>
<td>SCMR18D105PSBB0H</td>
<td>9.5</td>
<td>20</td>
<td>1.0</td>
<td>+100%/-0%</td>
<td>5.4/4.6*</td>
<td>65/85*</td>
<td>10</td>
<td>250</td>
<td>720</td>
<td>1.57</td>
<td>1057</td>
<td>0.0041</td>
<td>0.88</td>
</tr>
<tr>
<td>SCMR22C155PSBA0H</td>
<td>9.5</td>
<td>24</td>
<td>1.5</td>
<td>+100%/-0%</td>
<td>5.0/4.2*</td>
<td>65/85*</td>
<td>10</td>
<td>200</td>
<td>560</td>
<td>2.04</td>
<td>974</td>
<td>0.0052</td>
<td>0.95</td>
</tr>
<tr>
<td>SCMR22D155PSBB0H</td>
<td>9.5</td>
<td>24</td>
<td>1.5</td>
<td>+100%/-0%</td>
<td>5.4/4.6*</td>
<td>65/85*</td>
<td>15</td>
<td>200</td>
<td>560</td>
<td>2.20</td>
<td>1136</td>
<td>0.0061</td>
<td>1.10</td>
</tr>
</tbody>
</table>

*with appropriate voltage derating operating temperature can be extended to 85°C

### OPERATING TEMPERATURE
-40°C to +65°C @ 5.4V Balanced, 5.0V Unbalanced
-40°C to +85°C @ 4.6V Balanced, 4.2V Unbalanced

### 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 ESR Appearance</td>
<td>≤30% of initial spec value ≤2 times initial spec value No remarkable defects</td>
</tr>
<tr>
<td>High Temperature Load Life</td>
<td>Temperature: 70°C Voltage: Rated Voltage Test Duration: 2,000 hours</td>
<td>Capacitance Change ESR Appearance</td>
<td>≤30% of initial spec value ≤2 times initial spec value No remarkable defects</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>Storage Duration: 2 years No Load Temperature: +35°C</td>
<td>Capacitance Change ESR Appearance</td>
<td>≤30% of initial spec value ≤2 times initial spec value No remarkable defects</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration Resistance</td>
<td>Amplitude: 1.5mm Frequency: 10 ~ 55Hz Direction: X, Y, Z for 2 hours each</td>
<td>Capacitance Change ESR Appearance</td>
<td>≤30% of initial spec value ≤2 times initial spec value No remarkable defects</td>
</tr>
<tr>
<td>Humidity</td>
<td>Voltage: Rated Voltage RH: 90~95% Temperature: 60°C Test Duration: 3,000 hours</td>
<td>Capacitance Change ESR Appearance</td>
<td>≤30% of initial spec value ≤2 times initial spec value No remarkable defects</td>
</tr>
</tbody>
</table>
QUALITY AND RELIABILITY

Capacitance vs. Temperature

Leakage Current vs. Temperature

Equivalent Series Resistance vs. Temperature

High Reliability SCM Series
Series-Connected SuperCapacitor Modules
MECHANICAL SPECIFICATIONS

Plastic Type - Straight Leads

When soldering SuperCapacitors to a PCB, the temperature & time that the body of the SuperCapacitor sees during soldering can have a negative effect on performance. We advise following these guidelines:

- Do not immerse the SuperCapacitors in solder. Only the leads should come in contact with the solder.
- Ensure that the body of the SuperCapacitor is not in contact with the PCB or other components during soldering. Temperature cycling during soldering may cause the case to shrink or crack, potentially damaging the PCB or other components.

HAND SOLDERING

Keep some distance between the SuperCapacitor body and the tip of the soldering iron; contact between SuperCapacitor body and soldering iron will cause extensive damage to the SuperCapacitor. It is recommended that the soldering iron temperature should be less than 350°C, and contact time should be limited to no more than 4 seconds. Too much exposure to terminal heat during soldering can cause heat to transfer to the body of the SuperCapacitor, potentially damaging the SuperCapacitor.

<table>
<thead>
<tr>
<th>Cap (F)</th>
<th>D (mm)</th>
<th>W (mm)</th>
<th>L (mm)</th>
<th>P (mm)</th>
<th>d (mm)</th>
<th>B (mm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.47</td>
<td>9.5</td>
<td>18.5</td>
<td>16.0</td>
<td>11.5</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>1</td>
<td>9.5</td>
<td>18.5</td>
<td>20.0</td>
<td>11.5</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>1.5</td>
<td>9.5</td>
<td>18.5</td>
<td>24.0</td>
<td>11.5</td>
<td>0.6</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*for version with bent leads

SOLDERING RECOMMENDATIONS

Plastic Type - Bent Leads

WAVE SOLDERING

Only use wave soldering on Radial type SuperCapacitors. The PCB should be preheated for no longer than 60 seconds, with temperature at, or below, 100°C. Soldering tin should be 0.8mm or thicker.

<table>
<thead>
<tr>
<th>Solder Temperature (°C)</th>
<th>Suggested Solder Time (s)</th>
<th>Maximum Solder Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>240</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>250</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>260</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

REFLOW SOLDERING

Infrared or conveyor over reflow techniques can be used on these SuperCapacitors. Do not use a traditional reflow oven without clear rated reflow temperature for SuperCapacitors.
## 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 \( C \)

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

\( I \) – Discharge Current [mA], \( 4 \times C \times VR \) – Rated Voltage
\( V_1 \) – Initial Test Voltage, 80% of \( VR \)
\( V_2 \) – Final Test Voltage, 40% of \( VR \)
\( t_1 \) – Initial Test time
\( t_2 \) – Final Test time

### 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 = V/R

### 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

\[ ESR_{DC} = \frac{(ESR_{DC1} + ESR_{DC2})}{2} \text{ Where: } C_{DC1} = \frac{I_2 \times (t_5 - t_4)}{(V_3 - V_4)} \]

\[ C_{DC2} = \frac{I_2 \times (t_11 - t_10)}{(V_9 - V_{10})} \]

\[ ESR_{DC} = \frac{(V_8 - V_9)}{I_2} \text{ Where: } I_2 = 75mA/F \]

### 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
- Watt Density = \( \frac{0.12 \times V^2}{R_{DC}} \) / mass

### Energy Density
- Energy density = \( \frac{1}{2} CV^2 \) / (3600*mass)
High Reliability SCM Series
Series-Connected SuperCapacitor Modules

POLARITY / REVERSE VOLTAGE
For product consistency and optimum performance, it is recommended that the capacitor be connected with polarity indicated. Reversing polarity could result in permanent damage to the circuit including much higher leakage current for a short duration of time and the life time of the supercapacitors will be reduced.

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:

\[ t \propto V^n \exp \left( \frac{-Q}{kT} \right) \]  

(1) 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 20% of the original value and the capacitance drops by 30%. Typically a SuperCapacitor 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, 5.4V/5.0V Rated

Expected Lifetime at Various Voltages
SCM Series, 4.6V/4.2V Rated

POLARITY / REVERSE VOLTAGE
For product consistency and optimum performance, it is recommended that the capacitor be connected with polarity indicated. Reversing polarity could result in permanent damage to the circuit including much higher leakage current for a short duration of time and the life time of the supercapacitors will be reduced.

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The life of a SuperCapacitor is impacted by a combination of operating voltage and the operating temperature according to the following equation:

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(1) 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 20% of the original value and the capacitance drops by 30%. Typically a SuperCapacitor 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, 5.4V/5.0V Rated

Expected Lifetime at Various Voltages
SCM Series, 4.6V/4.2V Rated
SAFETY RECOMMENDATIONS

Warnings
• To avoid short circuit, after usage or test, SuperCapacitor voltage needs to discharge to ≤ 0.1V
• Do not apply over-voltage, reverse charge, burn or heat higher than 150°C, explosion-proof valve may break open
• Do not press, damage or disassemble the SuperCapacitor, 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
• UL 810A
• 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 SuperCapacitors in the following environments
  • High temperature / high humidity environments
  • 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