Common Calculation Formulas For Supercapacitors

1. Capacity test method and calculation formula

a. Switch the transfer switch S to the constant current/constant voltage source and charge the capacitor under test with the recommended rated current of the capacitor.
b. After the voltage of the capacitor under test reaches the rated voltage UR, charge it at a constant voltage for 30 minutes.
c. After constant voltage charging for 30 minutes, switch the transfer switch S to the constant current discharge device to discharge with a constant current specified by the capacitor.

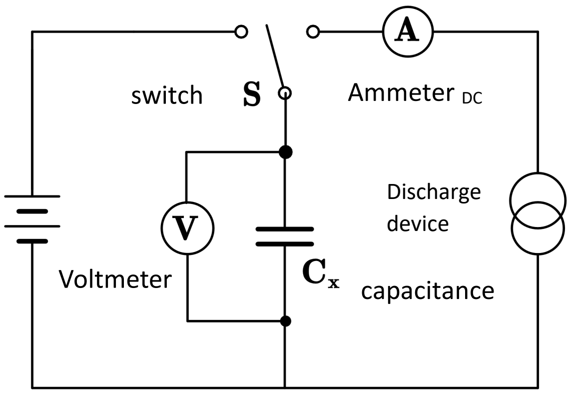

Figure 1 Capacity test circuit

d. Measure the time t1 and t2 from the discharge of the voltage across the capacitor to U1 (4.4 V) and U2 (2.2 V),
e. as shown in Figure 2, and calculate the capacity of the capacitor according to the following formula:

$$C = \frac{I \times (t_2 - t_1)}{U_1 - U_2}$$

C: capacity(F),
I: Discharge current(A)
t_1: Time from discharge start to U_1
t_2: Time from discharge start to U_2
U_1: Measure the starting voltage
U_2: Measurement termination voltage

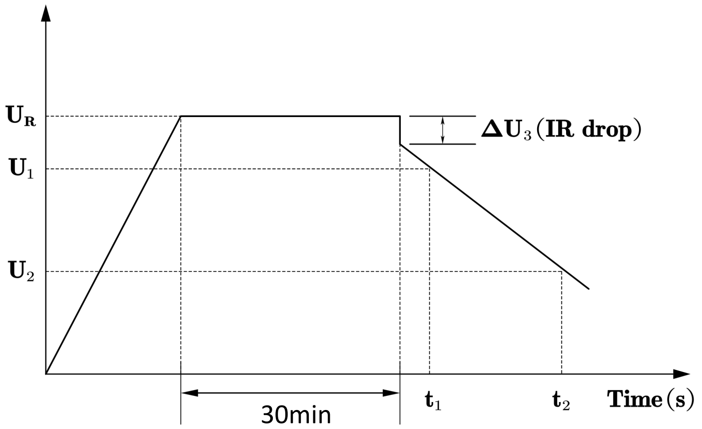

Figure 2. Charge and discharge curve graph

2. DC impedance calculation method

$$R_{DC} = \frac{U_3}{I}$$

R_{DC}: DC impedance(Ω),
U_3: constant current discharge 10 ms voltage drop(V),
I: constant current discharge current (A)

3. AC impedance test method

The AC impedance is measured by the LCR bridge, and the frequency of the measured voltage is 1 KHz. The RAC of the AC internal resistance of the super capacitor is calculated by the following formula

$$R_{AC} = \frac{U}{I}$$

R_{AC}: AC resistance(Ω)
U: Effective value of AC voltage(V r.m.s)
I: Effective value of AC current(A r.m.s)

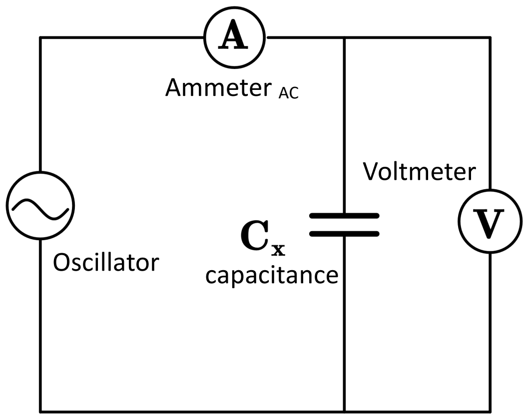

Figure 3. AC impedance test circuit diagram

4. Leakage current measurement

(1) The supercapacitor to be tested should be fully discharged before testing the leakage current, generally for more than 1 h;
(2) Apply rated voltage across the capacitor U_R;
(3) After the super capacitor voltage reaches the rated voltage UR, measure the voltage across the series protection resistor
Calculate leakage current:
Leakage current: the current after 72 hours constant voltage load in 25℃

$$LC = \frac{U_v}{R} \times 10^3 \text{mA}$$

LC: Leakage current (mA);
U_V: Voltage across the series resistance (V);
R: Series protection resistance, generally 1000 Ω and below.

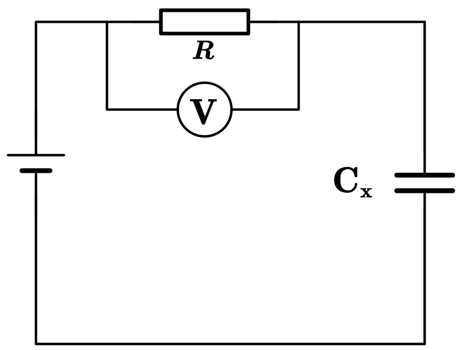

Figure 4. Leakage current test circuit diagram

5. Maximum operating current at 15℃ temperature rise

$$I_{MAX} = \sqrt{15 \times \mathrm{St}/\mathrm{ESR_{DC}}}$$

At a temperature rise of 15° C, the maximum operating current depends on many factors, including the rated current of the device, load conditions, heat dissipation design, and ambient temperature.

Generally speaking, the operating current of the equipment at a temperature rise of 15° C should not exceed its rated current. If the rated current is exceeded, the device may overheat or even be damaged. However, if the equipment is operated under light load or no-load conditions, or if the heat dissipation design is good and the ambient temperature is low, then the equipment may be able to carry a larger operating current at a temperature rise of 15° C.

In order to ensure the safe operation of the equipment at a temperature rise of 15° C, it is recommended to closely monitor the temperature and current of the equipment during actual use. If the device temperature is too high or the current is too large, corresponding measures should be taken to reduce the operating current or improve heat dissipation conditions. In addition, equipment should be inspected and maintained regularly to ensure it is in good working order.

It should be noted that the maximum operating current of different devices at a temperature rise of 15° C may be different. Therefore, in actual use, you should refer to the supercapacitor instructions or consult Zhifengwei (CDA) for accurate guidance.

6. Maximum peak current

Discharge to the maximum discharge current of 1/2UR in 1 second.

$$I_{MAX} = 0.5U_R/(R_{DC} + {}^{1}/_{C})$$

7. Maximum storage energy

$$\mathrm{E} = 0.5\mathrm{CU}_{R^2}$$

8. Power density

$$\mathrm{Pd} = \frac{(0.12 \times \mathrm{U_{R^2}}/\mathrm{ESR_{DC}})}{\mathrm{mass}}$$

9. Energy density

$$\mathrm{Ed} = \frac{(0.5 \times \mathrm{CU_{R^2}})}{3600 \times \mathrm{mass}}$$