COOPER Bussmann

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Aerogel Supercapacitor Calculator

Performing supercapacitor calculations and predicting solutions for applications can be tedious, therefore PowerStor® has developed an Aerogel Supercapacitor Calculator in Microsoft Excel®. This program is available online at http://www.cooperbussmann.com. An example of this program is shown on the following page.

To determine the aerogel supercapacitor requirements for an application, four key parameters are required:

- Working voltage, V_W, in Volts
- Minimum voltage, V_{min} in Volts
- Average discharge current, I, in Amps
    - If necessary convert power, P, in Watts to current, where $I = P / V_{avg}$
- Discharge time, t, in seconds

Simply enter these four parameters into the calculator in step 1 and the program will calculate:

- Energy requirement, W, in Joules
- Minimum capacitance requirement, C, in Farads
- Maximum resistance, R, in Ohms

In step 2, select the operating parameters specific to the application including whether the discharge is more similar to a DC pulse or AC pulse at a 1kHz frequency. Next select the operating temperature and use the "deviation from nominal capacitance" factor to build in a safety margin, if necessary. The program will then use these correction factors for both capacitance and resistance throughout the remainder of the calculations.

The pull-down menu in step 3 has a list of PowerStor supercapacitor products. Select the appropriate supercapacitor that meets both the capacitance and resistance requirements from step 1. In this step there is an option to configure supercapacitors in parallel and/or to force the number of supercapacitors in series to a specific number. For example, the calculator would recommend six 2.5V supercapacitors for an automobile voltage of 14.4V (14.4V / 2.5V per supercapacitor = 5.76 supercapacitors, which round up to 6). In practice, increasing the number of supercapacitors to eight in automobile applications lowers the voltage to 1.8V per supercapacitor, providing an increased reliability margin for high temperature exposure, with a direct result of longer life. The number of supercapacitors in series (actual) can be overwritten from the calculated value.

Confirmation of the predicted aerogel supercapacitor solution is done in step 4. First the total capacitance and resistance values calculated are compared to the required values. Next the energy and hold-up time requirements are confirmed. If the energy and hold-up time are insufficient, chose a larger supercapacitor or increase the number of supercapacitors in parallel. Finally, the voltage drop is confirmed. The calculated components of resistive and capacitive discharge are summed and compared to the maximum value allowed. If the maximum voltage drop value is exceeded, simply chose a supercapacitor solution with lower ESR or increase the number of supercapacitors in parallel.

Our goal for this calculator was to assist you in finding a solution for your design challenges. Note: this program is only intended to predict aerogel supercapacitor solutions. All calculated solutions should be tested in the final application. Contact Cooper Bussmann directly for further assistance and application support.

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Aerogel Supercapacitor Calculator

PowerStor Aerogel Supercapacitor Calculations for: **Enter Company or Project Name**

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Four Simple Steps for Determining Supercapacitor Requirements

1. Enter values for Working Voltage, Minimum Voltage, Current and Time

Legend
Input Values in Yellow
Required Values in Gray
Calculated Values in Light Blue
Comments in Greer

		Enter Known Value	
Working Voltage (Vw)	Vw =	2.5	Volts
Minimum Voltage [Vmin]	Vmin =	1	Volts
Current [I]	I =	1	Amps
Time [t]	t =	1	seconds
Energy needed during hold-up period (Minimum)	W = (Vw+Vmin)/2*I*t =	1.75	Joules
Desired Capacitance (Minimum)	C = 2 Vw*I*t / (Vw^2 - Vmin^2) =	0.6667	Farads
Desired Impedance (Maximum)	R = (Vw - Vmin) / I =	1.500	Ohms

2. Select Operating Parameters and Correction Factors from pull-down menu

Use pull-down menu for Correction Factors to Capacitance and ESR	Discharge Pulse Frequency	Temperature		Deviation from Specified Capacitance (-20% to +80%)
	DC	-20°C		Nominal Capacitance
Capacitance Correction Factors :	1	0.8		1
ESR Correction Factors :	1.5	2.25		

3. Choose Supercapacitor from pull-down menu to meet Desired Capacitance and Desired Impedance

Note 1: Total Capacitance equals 1/2x for two in series, 1/3x for three in series, etc.
Note 2: Total Capacitance equals 2x for two in parallel, 3x for three in parallel, etc.
Note 3: Total Resistance equals 2x for two in series, 3x for three in series, etc.
Note 4: Total Resistance equals 1/2x for two in parallel, 1/3x for three in parallel, etc.

Use pull-down menu to choose a specific model Supercapacitor	Part Number	Capacitance	ESR (AC @ 1 kHz)
	B0820-2R5225	2.2 F	0.225 Ohms

			Standard Values		Corrected Values	
Single Device Capacitance		C =	2.2	Farads	1.76	Farads
Single Device Resistance		R =	0.225	Ohms	0.759375	Ohms
Single Device Max Voltage		Vmax =	2.5	Volts	2.500	Volts
# supercapacitor(s) in parallel	Increase p to increase Capacitance or reduce Resistance		1			
# supercapacitor(s) in series (min. calculated)	Vw / Vcap (A = 2.5V; B = 2.5V; P = 5.0V) =		1.00			
# supercapacitor(s) in series (actual) (See Note 5		s (rounded up) =	1			

Note 5: Formula for # supercapacitor(s) in series (actual) can be manually overwritten if lower or higher Vw per supercapacitor desired. View Corrected Value for actual Single Device Max Voltage.

4. Confirm Time requirement is met for hold-up applications and/or Voltage Drop is acceptable for pulse applications.

Final Supercapacitor Configuration		Calculated Values		Required Values		Comments
Total Capacitance	C =	1.76	Farads	0.6667	Farads	Capacitance Value Met
Total Resistance	R =	0.759375	Ohms	1.500	Ohms	Resistance Value Met

Check Energy and Time Requirements		Calculated Values		Required Values		Comments
Energy available in supercapacitor(s)	W = 1/2 C * (Vw^2 - Vmin^2) =	4.62	Joules	1.75	Joules	Energy Value Met
Max. Hold-up Time with chosen supercapacitor(s)	t = C (Vw - IR -Vmin) / I =	1.30	seconds	1	seconds	Time Requirement Met

If Energy is insufficient, choose a Single Device with higher Capacitance or increase # supercapacitors in parallel.

Check to ensure that Energy available in supercapacitors is greater than Energy needed during hold-up period, or Maximum Hold-up Time is sufficient.

Check Voltage Drop		Calculated Values		Required Values		Comments
Total Voltage Drop of supercapacitor(s) = Vdrop (resistive) + Vdrop (capacitive) =		1.328	Volts	1.500	Volts	Voltage Drop Acceptable
Voltage drop (resistive)	Vdrop (resistive) = IR =	0.759	Volts			
Voltage drop (capacitive)	Vdrop (capacitive) = I (t / C)	0.568	Volts			

If Total Voltage Drop is greater than Maximum Allowed, determine whether resistance or capacitance is the main factor.
Choose supercapacitors with either more capacitance or less resistance, or increase # capacitors in parallel.
If Total Voltage Drop is less than Maximum Voltage Drop Allowed, STOP.

This program is intended to provide product design solutions that will help the user with design applications.
Once a product design solution has been determined, it should be tested by the user in all possible applications.

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