

Leveraging Supercapacitors to Mitigate Limitations and Enhance the Performance of Battery Energy Storage Systems- A Simulation and Experimental Validation.

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Supplementary file

S1: Process of charging and discharging energy storage element and recording the patterns during transient using Arduino Uno microcomputer

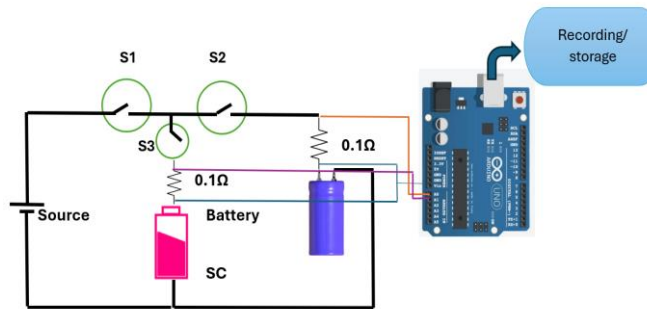


Fig 1: Charging process.

Figure 1 above represents a novel mechanism for recording the transient response of a storage element while it is being charged. In this case, a battery and a supercapacitor of known capacities are connected in parallel across a source for charging purposes. Since the present work focuses on the transient part of the response and wave shaping of the transient events, a proper recording mechanism plays a very important role. By either using the meters or conventional oscilloscopes, proper recording of transient events is not possible. The use of a storage or high-performance CRO would be costly. Hence the present study employs a simple mechanism using an Arduino-based circuit as shown. When S1 and S3 are ON, the battery will be charged and the voltage across the series resistance (0.1 ohm) is fed to Arduino through its analog input pins for recording the charging current. S1 and S2 connect the supercapacitor for its charging. Since the initial charging current of SC is 30 A (as per the catalog) the Arduino will not be able to record this value. Hence a standard series resistance (0.1 ohm) is used to obtain the corresponding voltage drop (Ex, 30A X

0.1=3V) which will be converted back to the current using a suitable scaling factor in the program. The continuous values of charging current and voltage were fed through the analog input pins of Arduino and recorded at any desired intervals (limited by the operating speed of the processor). These values were used as input variables to any plotting software (Like Origin Pro, MATLAB, etc. to get the transient response).

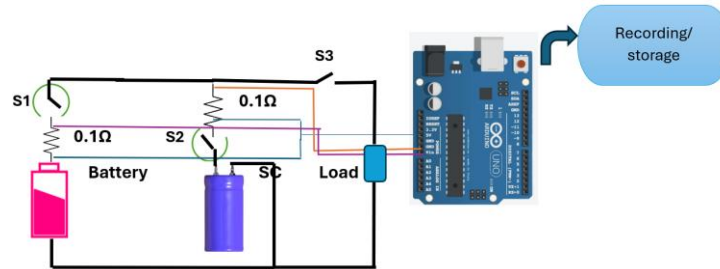


Fig 2: Discharging process

Fig 2 indicates the similar process during discharging. This is a simple low-cost mechanism to record any instantaneous or transient event, which can also serve as a recording/storing for further analysis of data.

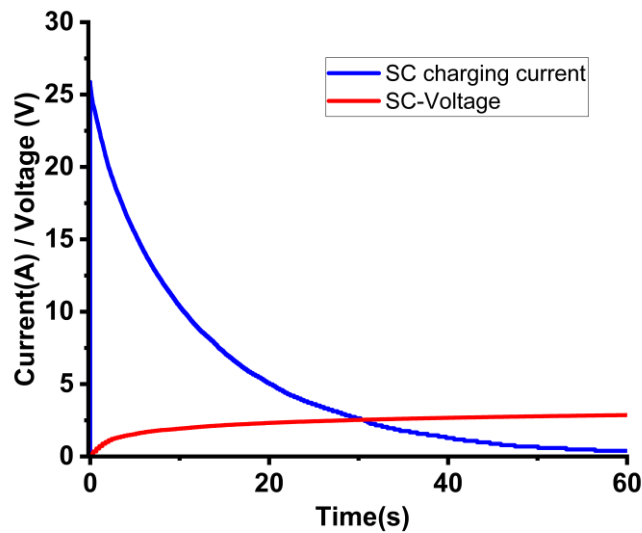


Figure 3: Charging pattern recorded for supercapacitor using Arduino-based circuit.

Figure 3 shows the plot of supercapacitor voltage and current using the mechanism as discussed in this literature. 'Origin Pro' plotting software is used for plotting after reading the values for the desired period from any given or known instant.