Blog entry

Low Current MOSFET Balances High Value Supercapacitors Greater Than 1000 Farads

We have frequent input from our customers who are developing supercapacitor modules consisting of two or more cells stacked in series and who want to know how to utilize MOSFETs to balance leakage current. Several engineers had a misconception and dismissed low current MOSFETs because the charge and discharge current of the supercapacitor exceeded that of the MOSFET.

A MOSFET can have low current and low voltage and still effective balance a wide range of supercapacitors with values beyond 1000F because the supercapacitor current does not flow through the MOSFET. The MOSFET only control the leakage current of individual supercapacitor cells and therefore a device designed for a few milliamps of power is quite sufficient for even high-value, high-current supercapacitors.

The company has months of data measurements that demonstrate supercapacitor stacks with individual supercapacitor value as large as 3,000F each can be balanced readily with ALD9100/ALD8100 SAB MOSFETs. The balance currents are self-regulating, and operate automatically as long as the individual supercapacitor leakage current is less than 3 mA each. However, for any leakage currents over 3 mA, MOSFETs can be double or parallel connected to balance any amount of leakage current desired. Therefore, any large supercapacitor stack can be balanced regardless of their individual supercapacitor values. The actual circuitry involved is also much simpler and it operates at much lower power levels than other balancing methods.

The high current levels of 1,000A involved cycling through supercapacitor charging and discharging cycles do not affect the balancing leakage currents of ALD9100/ALD8100 series SAB MOSFET devices, as they are purely voltage driven due to their input high impedances.

In a balancing circuit design, the individual voltage across any one of the SAB MOSFET in parallel to a supercapacitor cannot exceed about 7V, when the SAB MOSFET itself would dissipate up to about 80 mA. The rest of the 1,000A current goes to the supercapacitor and does not go through the MOSFET. For example, with 4 supercapacitors in series, the total maximum theoretical voltage across them in a stack cannot exceed 28V. As long as the charging source voltage is less than 28V, then the MOSFETs can balance the supercapacitors safely. The 7V provides a rather large voltage margin to the 2.7V typical supercapacitor voltage limit.

The actual charging and discharging currents through the supercapacitors, meanwhile, can be as high as 1,000A. As long as each individual supercapacitor voltage is kept to less than 2.7V, there is no damage to either the supercapacitor or the MOSFET. Recent data also suggest that SAB MOSFETs inserted into a balancing circuit reduces the total supercapacitor stack leakage. The added MOSFETs do not contribute to power dissipation while balancing the supercapacitors. But they actually help reduce total leakage-induced power dissipation of the supercapacitor stack. To understand why, a member of your engineering team needs to engage with the engineering staff of the MOSFET vendor, as this relationship between discharge current and leakage current is neither as intuitive nor as simple as it first appears.

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