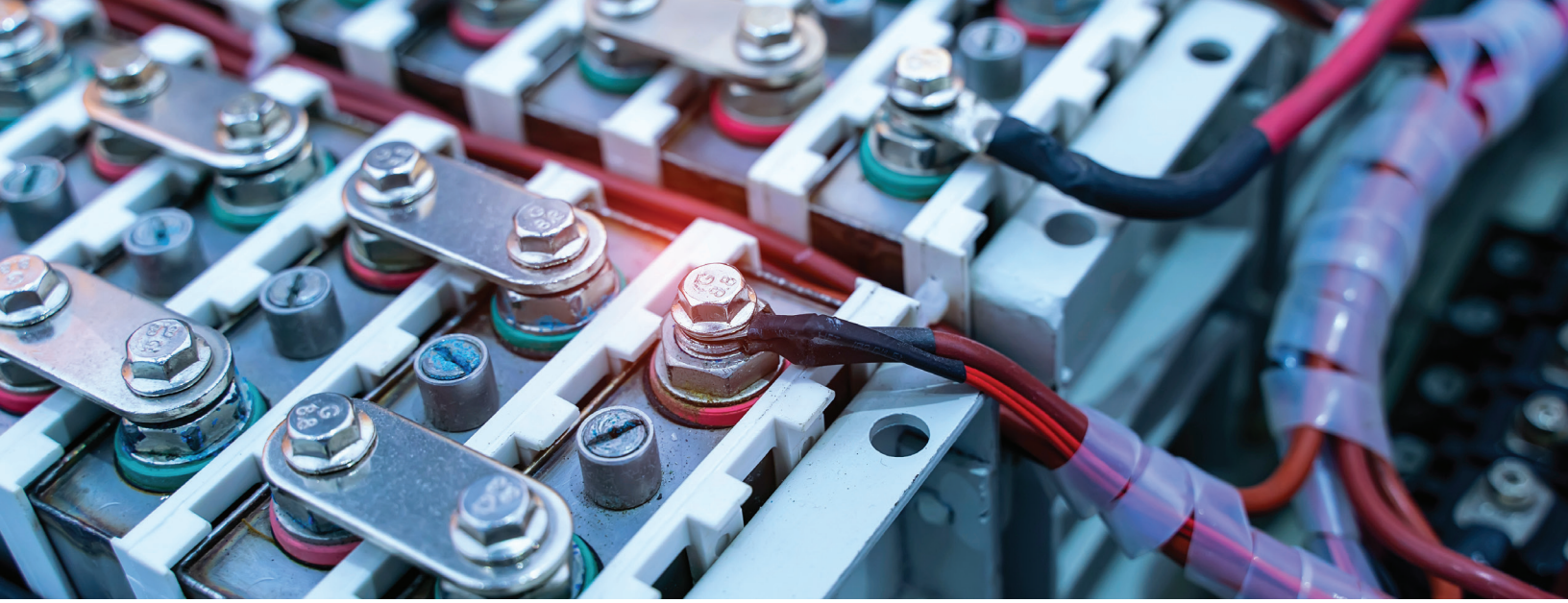

MOSFET RELAYS' CRITICAL ROLE WITHIN

BATTERY MANAGEMENT SYSTEMS

Using High Voltage & High Current MOSFET Relays to Improve System Efficiency & Safety

In recent years, the rapid advancement of power storage system technologies has led to widespread battery usage in various applications, including commercial electric and hybrid vehicles (EV/HEV), automatic guided electric vehicles (AGV), renewable energy systems (solar, wind, etc.), as well as ordinary power supply systems. Integral to these systems is the Battery Management System (BMS), which manages battery packs comprised of multiple cells. The BMS is tasked with ensuring optimal performance and longevity, as well as maintaining the highest standards of safety and efficiency. Two functions employed by the BMS to achieve these goals are *cell balancing* and *insulation monitoring*. CotoMOS ® Solid State MOSFET relays (SSMRs) play a vital role within each of these functions and offer advantages over other switching component types.

BMS Cell Balancing

Cell balancing addresses the differences in total capacity, internal resistance, discharge rate and aging process found in the various individual cells that make up a battery pack. These differences may cause some cells to charge and discharge faster than others, resulting in them becoming overcharged during the charging process or deeply discharged during use. Unfortunately, this can cause long term damage and compromise the performance and useful life of the battery stack. To counteract this, cells can undergo Passive or Active balancing. *Passive cell balancing* employed during charging, involves connecting cells that charge more quickly to a resistive element to dissipate some of the energy, allowing slower cells to continue charging and "catch up." *Active cell balancing* involves transferring charge between individual cells (usually with DC/DC converters) not only during the battery charge but also during operation. While passive cell balancing is simpler to implement, its discharge current is limited to hundreds of milliamps to avoid overheating inside the system – which also means a longer discharge time. *Active balancing*, on the other hand, involves more components but it can work with higher currents (several amps), which enables faster charge transfer; it also minimizes losses, which has the added benefit of extending the total battery run time. Figure 1 shows a simplified diagram for Active and Passive balancing.

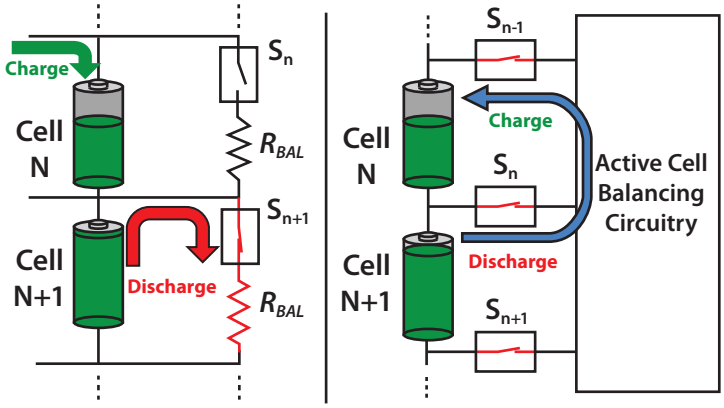

Figure 1: Passive (left) and Active (right) Battery Balancing

BMS Insulation Monitoring

Another BMS function employed to maintain efficiency and safety in high voltage (HV) systems is regular monitoring of the insulation health between HV conductors and ground. Damaged insulation can lead to leakage currents that reduce the efficiency of the system and can even create safety hazards for the system

itself and/or people. To monitor the insulation level, a BMS switches known resistances between each HV conductor and ground; the resulting leakage current is measured, and provides an indication about whether the insulation is appropriate or not. Figure 2 shows what an HV insulation monitoring configuration looks like.

Advantages of Using SSMRs in Battery Management Systems

Solid state MOSFET relays (SSMRs) provide the precision and reliability required by both BMS functions (Cell Balancing and Insulation Monitoring) while providing various advantages over other switching component types. For instance, SSMRs can handle the high voltages required for insulation monitoring, as well as the high currents required during cell balancing – all while providing a compact solution; this makes them a preferred option over electromechanical relays. Additionally, an SSMR 's output can handle both positive and negative currents, which means a single relay can be used for cell balancing in place of two simple MOSFETs which only conduct current in one direction. Furthermore, SSMRs provide a fast response and offer a high degree of electrical isolation between their input and output pins, which separates the control/processing circuitry from the High Voltage components, ensuring system safety. Finally, SSMRs are extremely reliable and are not susceptible to arcing – due to their not having any moving contacts.

With the growing need for battery management systems to ensure the safety, longevity and efficacy of power storage systems, SSMRs provide the reliable solutions essential for optimum performance. Coto Technology offers a full selection of High Voltage and High Current SSMRs ideally suited for the BMS market; in addition, Coto's application engineers are available to assist you with inquiries related to your application design.

Visit **www.cototechnology.com** to view our CotoMOS products, download our selector guide or contact our application engineers.

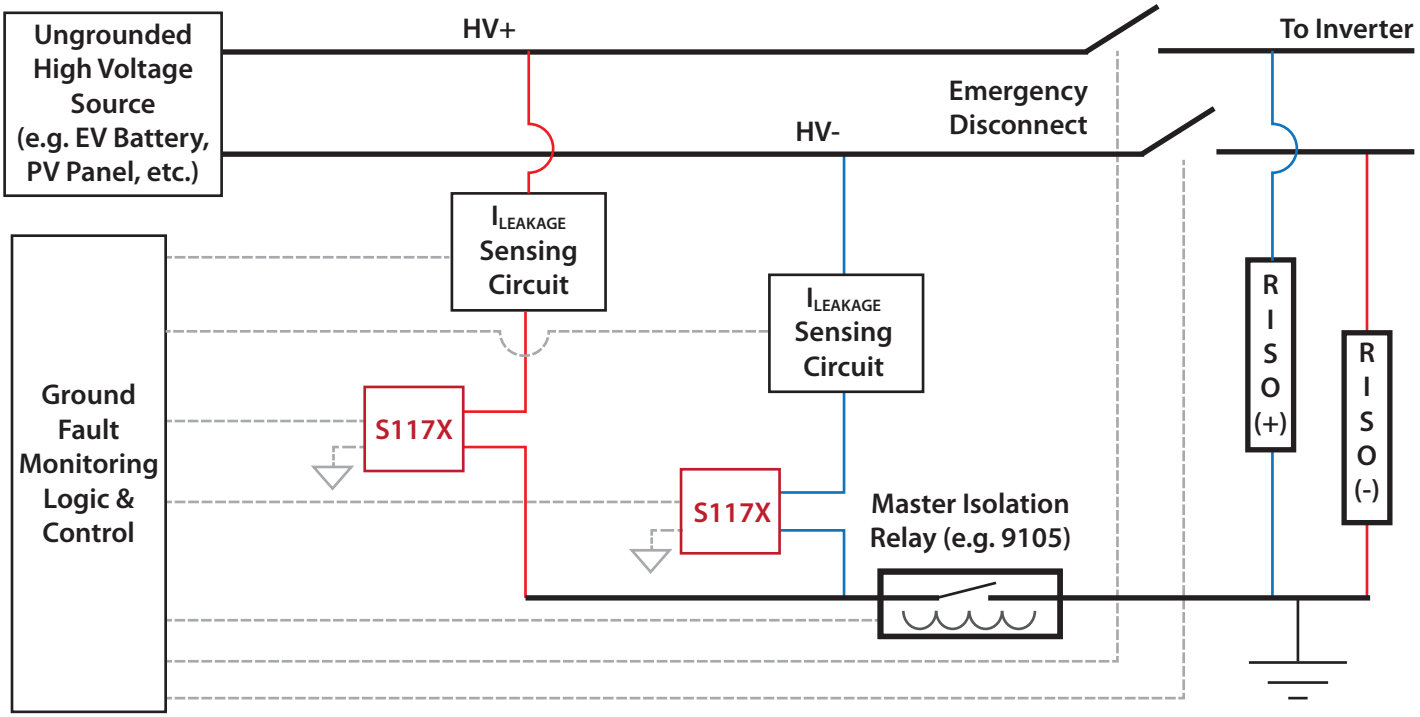

Figure 2: In this *Insulation Monitoring Configuration*, RISO(+) and RISO(-) represent the insulation resistance between each of the High Voltage Conductors and system ground. Here, two CotoMOS® S117X SSMRs are used to switch leakage current sensing circuits which allow the BMS system to calculate the values of RISO(+) and RISO(-) and ensure they remain at appropriate levels. A *Master Isolation Relay*, such as Coto's 9105, is used to provide true isolation from ground when the insulation resistance is not being measured.

CotoMOS® High Voltage SSMRs

For High Voltage BMS applications , Coto Technology offers the CotoMOS® **140 Series** and our newly released **Silicon Carbide (SiC) S117 Series** High Voltage MOSFET relay. The CS140 series can switch up to 1,500V, while the S117 series can switch up to 1,700V .

The S117X, being a Silicon Carbide device, provides many of the benefits of this trailblazing technology that is revolutionizing power electronics, such as higher voltage capability, lower leakage currents, faster switching speeds and better thermal conductivity. The S117X can handle a load current of 120mA, has an ultra-low leakage of 1µA and boasts a Turn On time of 0.15ms allowing for a fast response. Both the 140 Series and the S117 Series are available in either a DIP-6 or SMD-6 package that is 9.1mm x 6.4mm.

CotoMOS® High Current SSMRs

For high current applications, Coto Technology offers the **C224S, C236S, C241S** High Current MOSFET relays. These relays can switch voltages between 20-60V and currents between 2.5-5.0A, allowing them to work in both passive and active cell balancing. In addition, these MOSFET relays have extremely low On Resistance (0.02-0.06 Ω) which minimizes unwanted voltage drops in Cell Balancing and/or Cell Voltage measurement applications. These are available in an SOP-4 package.

A summary of the main specs for each of these product offerings follows along with links to the product datasheets.

CotoMOS® 140 Series

- Load Voltage: **1,500V** max
- Load Current : **75mA** max
- I/O Breakdown Voltage **3,750/5000** Vrms
- Leakage current **10uA** max
- Package Type: **DIP-6/SMD-6** (9.1mm x 6.4mm)

CotoMOS® S117 Series

- Silicon Carbide technology
- Load Voltage: **1,700V** max
- Load Current : **120mA** max
- I/O Breakdown Voltage of **3,750/5000** Vrms
- Leakage current **1µA** max
- Turn ON Time **0.15ms** (typ)
- Package Type: **DIP-6/SMD-6** (9.1mm x 6.4mm)

CotoMOS® 241 CotoMOS® 236 CotoMOS® 224 Series

- Load Voltage: **20V** (241) / **40V** (224) / **60V** (236)
- Load Current: **5A** (241) / **3.5A** (224) / **2.5A** (236)
- I/O Breakdown Voltage of **1,500** Vrms
- Leakage current **0.1µA** max (224), **1µA** (236, 241)
- Package Type: **SOP 4** (7.1mm x 4.6mm)

To learn more about Coto Technology's CotoMOS MOSFET relay offerings, or for any other questions, please visit our website, at ***www.cototechnology.com***