APPLICATION NOTE

Matching 1500 V Battery Energy Storage Requirements with Bourns® Magnetic Components

Bourns® Model SM91527L Transformer

Introduction

The trend to expand renewable energy usage has led to the development of flexible energy systems to allow renewable sources such as solar and wind to be reliably and safely connected to the energy grid. To support widespread adoption of these systems calls for significant magnetic component technology advancements that deliver solutions for power protection, switching and conversion.

Energy storage systems are emerging as one of the potential solutions to increase system flexibility due to their unique capability to quickly absorb, hold and then reinject electricity. Over the last few years, DC voltages in energy storage systems have continued to advance higher using lithium-ion battery technology. Today, 250 VDC, 600 VDC, 1000 VDC and now even 1500 VDC are employed.

One of the key drivers of these higher-voltage systems is the availability of advanced solar inverters and power converters. Considering that most utility-scale battery energy storage systems are now being deployed alongside utility scale solar installations, it makes sense that the battery systems match the input DC voltages of the inverters and converters. Most utility-scale solar inverters and converters now use 1500 VDC input from solar panels.

The Wood Mackenzie Power & Renewables Report forecasts strong growth in the renewable energy industry, with annual revenue projections growing from $1.2B in 2020 to $4.3B in 2025. At this level of market expansion, manufacturers are continually looking for ways to increase system efficiency.

This application note covers the higher voltages, features and capabilities required for magnetic components to connect various sources of energy to an electricity grid that uses battery storage in order to maximize efficiencies. It also provides the insulation requirements designers should be aware of in specifying transformers rated to 1500 V.

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Components that Support Higher DC Voltages

There are several ways energy sources can be connected to the grid such as with breakers, disconnect switches, insulation monitors, fuses and ground fault devices. Figure 1 illustrates how renewable energy systems are connected to the grid, while Figure 2 shows in more detail the placement of connected sources for battery energy storage. These systems have evolved to support higher DC voltages, which has caused additional design challenges in finding components rated at higher voltages that also provide embedded protection features.

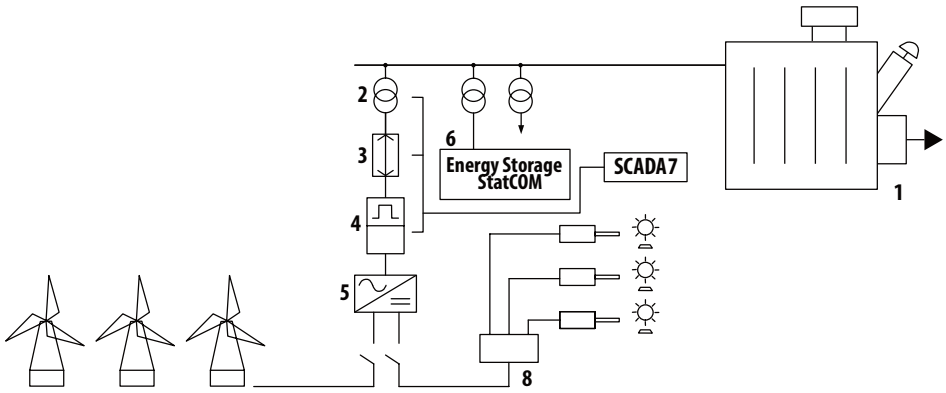

Figure 1. | Representation of Energy Network with Renewable Sources

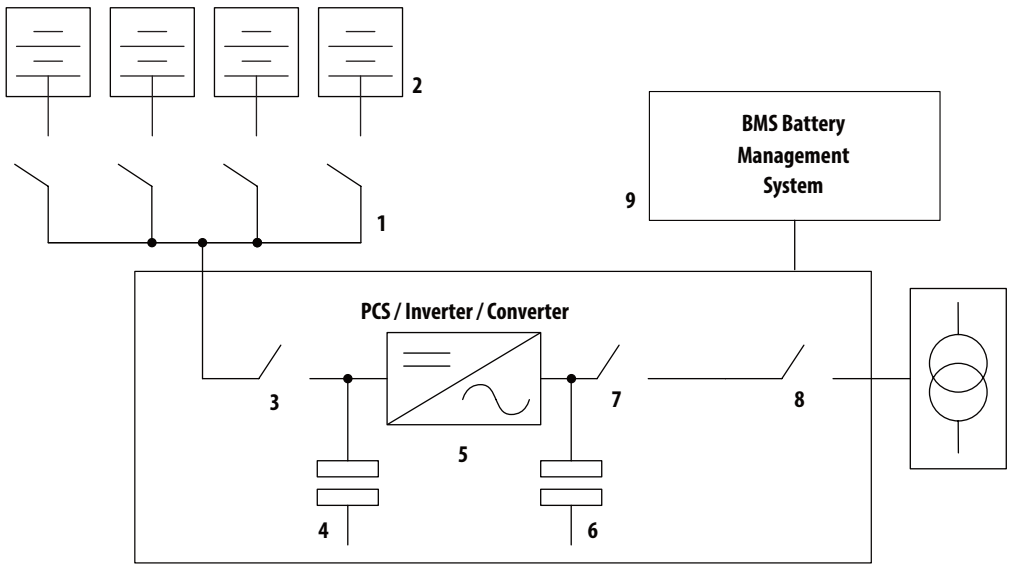

Figure 2. | Detailed View of Energy Storage System (Figure 1)

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Components that Support Higher DC Voltages (Continued)

To address these concerns, Bourns has developed insulated magnetics products rated at 1500 VDC. The recently released Model SM91527L single channel signal transformer with integrated common mode choke is designed to meet the demanding isolation and EMI filter requirements on isoSPI™ communication buses in a Battery Energy Storage System (BESS). Bourns® Model SM91527L has a creepage of 15 mm between primary and secondary, allowing for use in environments requiring reinforced isolation with working voltages of 1500 V. Furthermore, Bourns' new signal transformer has UL approval, which gives designers a higher guarantee of safety.

As Figure 3 shows, this 1500 V signal transformer isolates and protects the battery management system (BMS) board isoSPI™ interface. It is important to note that the BMS interface is operating in a nonhazardous environment separate from the battery pack voltage, and at the same time, provides the necessary matching and common mode noise removal. This is so that the communications between the monitoring ICs and the central management board are also secure and uninterrupted. In addition, the features of the Model SM91527L transformer allow it to still meet isoSPI™ driver recommendations in terms of insertion loss (Max. 1.2 dB at 4 MHz) and EMI (-50 dB 1-100 MHz CMRR).

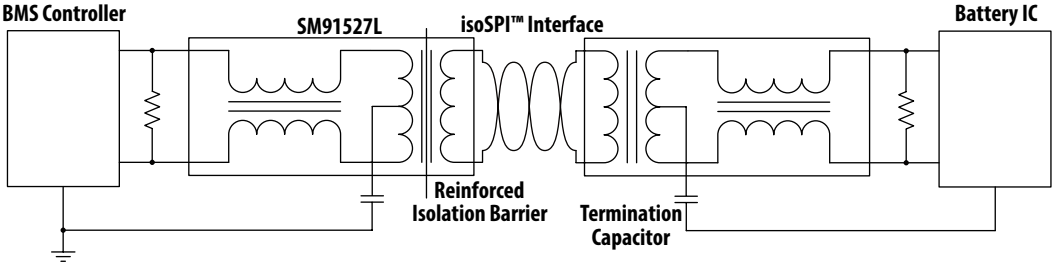

Figure 3. | Block Diagram Showing the Connection of the IsoSPI™ Bus

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Insulation Requirements for Transformers Rated to 1500 V

Transformers with reinforced insulation up to 1500 V must pass tests as defined by IEC 60664 to prove the insulation will survive sudden surges, which could happen on the electricity grid or on the battery pack itself. One of the factors designers need to consider is the type of application as consumer equipment has a particular overvoltage category requirement while industrial equipment may need to be rated to a different category. These categories determine the level of surge testing that is required during qualification. Surge tests are used to primarily check that there is adequate clearance, so that if an event such as a lightning strike were to occur, the gap between the windings on the transformer would not break down and ionize causing a crossover. To be rated at 1500 V for an overvoltage category 2 up to a 5000-meter altitude, the reinforced transformer must be able to withstand an impulse test of 12 kV peak. The Bourns® Model SM91527L can meet the above requirements.

Another series of tests are mandatory for checking the quality of the insulation material itself. Reinforced insulation is checked by applying a DC or AC voltage between the primary and secondary side and measuring the amount of leakage current between the two sides. This is also known as a dielectric test as the permittivity of the insulation material will accumulate charge, which translates into a leakage current. Another name for this test is Hi-POT.

In addition to the Hi-POT test, there is another procedure that is required in systems with working voltages higher than 750 VDC. This procedure puts the transformer through an ageing process using high temperature and humidity. To test ageing, the test consists of ramping up the DC voltage from zero to a value dependent on the working voltage while at the same time measuring the amount of charge in coulombs gathered in the insulation. This test is also known as partial discharge. Bourns performs partial discharge testing as a normal procedure in its manufacturing process to check signal and power transformers rated for systems with working voltages of up to 1500 V.

It has become a requirement to use transformers with reinforced insulation (color red) at the point of entry into networks, especially if the battery management board could be exposed to enable testing and diagnostics by a technician. However, if the racks that hold battery modules are shielded by plastic walls and use transformers for communications in a daisy chain configuration, they will not require reinforced insulation. For this application, signal transformers (color orange) with functional insulation for 1500 V can be used such as the Bourns® Model SM91501ALO transformer, which is also UL listed. This device has two channels instead of one and is suited for placement in the middle of a daisy chain. Hi-POT and impulse tests are still required but the procedure is less severe (4.3 kV DC Hi-POT and 8 kV Impulse).

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Insulation Requirements for Transformers Rated to 1500 V (Continued)

Figure 4 illustrates where the reinforced single-channel transformer and the functional two-channel transformer would be located in a 1500 V BESS. The BESS is divided into strings of 50 V battery modules where each is monitored and each has a two-channel functional insulation transformer in the isoSPI™ bus. This configuration enables the string to be protected with the reinforced single-channel magnetics component such as the Bourns® Model SM91501ALO transformer.

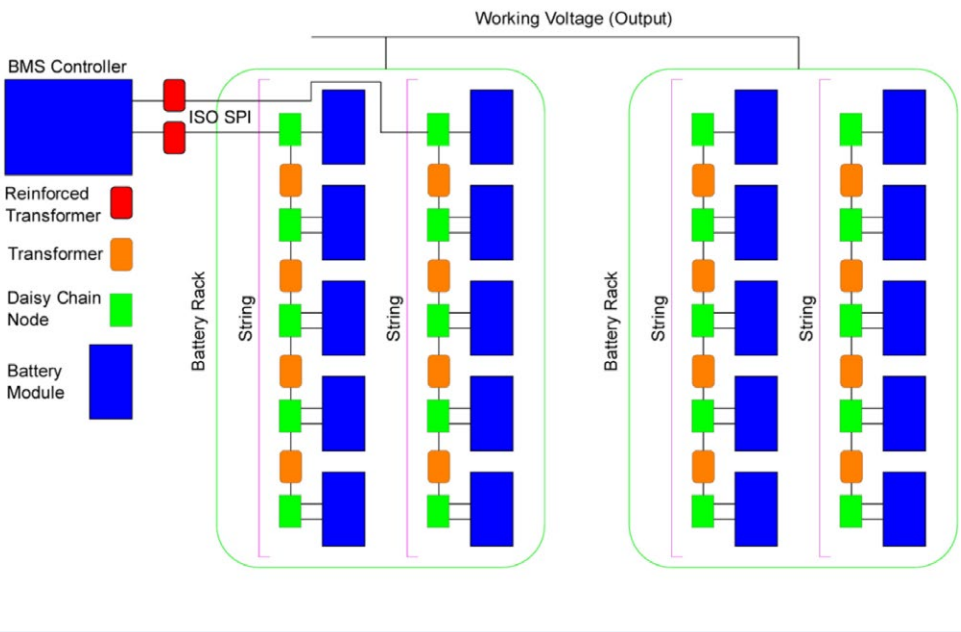

Figure 4. | Block Diagram of Elements in a High Voltage Battery System

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Increased 1500 V Battery Storage Efficiency with Bourns® Components

In this application note, a viable reinforced insulation solution for isoSPI™ buses in renewable energy systems working at 1500 V was highlighted. Using the example of Bourns® Model SM91527L was shown to help meet higher battery energy storage efficiency needs. This UL listed single-channel signal transformer with common mode choke is designed for entry points into strings of battery modules. The signal performance of the Model SM91527L has been tested to meet recommendations by IC manufacturers for operation with their drivers. The Bourns® transformer featured in this application note matches the strict specifications in terms of surge voltage and other tests for insulation.

In addition, the Bourns® Model SM91501ALO has UL recognition and is a two-channel transformer rated to 1500 VDC (functional insulation), which is suitable for battery module enclosures inaccessible to human contact. Because both Bourns® transformers have UL recognition, they give designers a higher level of safety, quality and reliability.

As the industry for renewable energy systems expands, 1500 V battery packs and inverters will need a growing supply of components also rated to 1500 V. Bourns is committed to continued innovation in the development of magnetics components for 1500 V to address these needs.

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