Optocouplers in On-Board Chargers and Battery Monitoring Systems

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INTRODUCTION

The number of electric vehicles on the roads is steadily growing, increasing the need for safe and reliable battery systems and high efficiency battery chargers. Modern electric vehicles use battery systems with voltages up to 1000 V and charge times down to a few hours. This application note uses two examples to illustrate how optocouplers play a major role in on-board chargers battery monitoring systems, and explores the benefits they provide to designers and drivers.

SAFETY ISOLATION

Safety is a key element in electric vehicles. Designers need to ensure that drivers and passengers will not come in contact with high voltage or high current parts or wires. Well known from common switchmode power supplies, optocouplers are safety elements that deliver proven long term, reliable optical isolation. Vishay offers a wide selection of optocouplers in a variety of packages to address a broad range of applications. In accordance with national requirements, Vishay optocouplers are certified by the most demanding safety houses. Key parameters of each certificate are isolation voltage, creepage, and clearance distance, and on some certificates also the distance through isolation (DTI). In battery chargers, the devices protect humans from the high battery system voltage and the high voltage grid.

NOISE ISOLATION

In addition to safety isolation, optocouplers are the first choice for protecting sensitive low power devices such as microcontrollers and user interfaces from high voltage devices like the AC/DC converter stage. They provide low driving currents of 1 mA for microcontroller usage at various output configurations to drive individual loads. Due to very high noise immunity ratios up to 50 000 V/µs, transient spikes and high voltage switching effects will not negatively impact the sensitive low voltage microcontroller controller part of the circuit.

GALVANIC ISOLATION

To deliver the high system voltage to the electric vehicle motor control unit, low voltage battery cells are stacked in row. Because of natural aging and lot to lot variations, the charge and discharge behavior of each cell needs to be controlled and monitored. Due to optical isolation, optocouplers provide galvanic isolation, which makes them perfectly suited to perform floating ground and high side measurements on individual battery cells within a battery stack. Vishay optocouplers support those requirements and provide higher reliability than conventional electromechanical relays, which are an outdated technology.

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ONBOARD CHARGER

Battery chargers provide the interface between the grid line and the electric vehicle and can be separated into two different variants: off-board charging stations and on-board chargers. Charging stations are directly connected to the grid, providing fast charging times, and can be found in public areas as well as in the home. Protecting humans from hazardous high line voltages and high current is one key element of such devices. On-board chargers are mounted in the car and require a simple wall plug. Downside is the limited available power. However, they provide the most flexibility because the electric vehicle can be charged almost anywhere without the need for a fixed and expensive charging station.

Taking the second variant as an example, an on-board charger is placed in the electric vehicle and connects the AC grid voltage to the high voltage DC battery. The AC grid voltage - typically 110 V_{AC} or 230 V_{AC} - is transformed with an AC/DC inverter stage to the high voltage battery system voltage across an isolation barrier. The control unit manages the charging process. The battery stack provides status information about the charging level, health status, temperature, and more back to the control unit across the isolation barrier by using optocouplers. For on-board chargers, Vishay offers suitable automotive-qualified optocouplers like the VOMA617A with a low input drive current (I_F) of 5 mA and a working voltage of > 700 V.

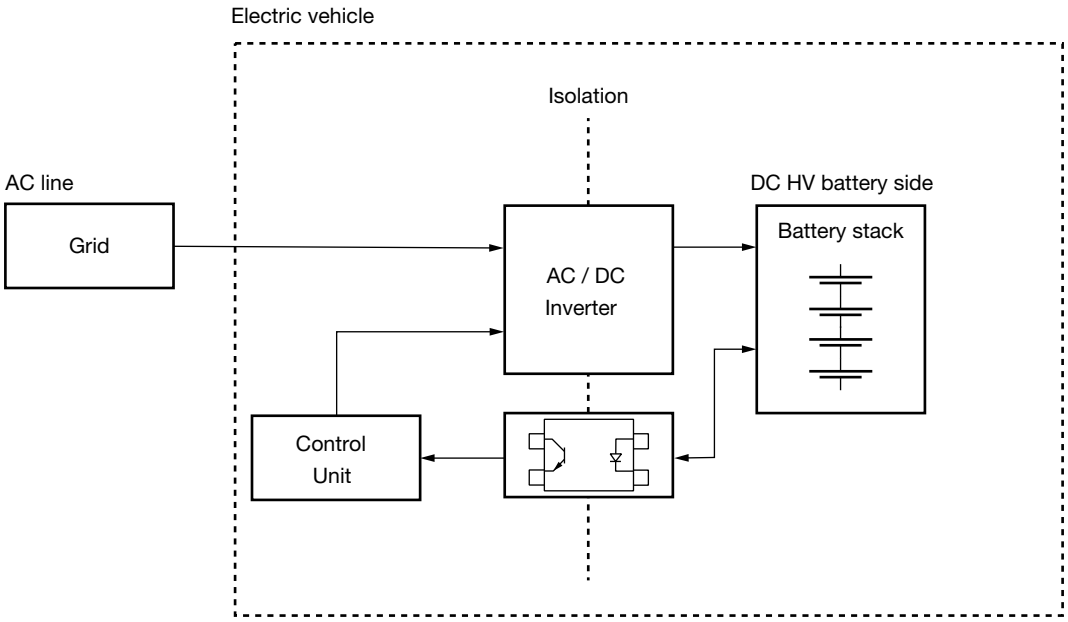

Fig. 1

APPLICATION NOTE

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BATTERY MONITORING SYSTEMS

Monitoring the voltage of each cell within a battery pack and the system voltage, including the chassis isolation, is essential to determining its overall health and to ensuring safe operation. There are a variety of architectures and concepts available, depending on the number of cells and their configuration within the battery pack. A common problem is that data or status signals need to be transferred to a control unit along a floating ground or across an isolation barrier, which in this case is the battery pack package. In the example below, the individual battery cells are controlled with a load balancing system. Information about the charging level, health status, and more is transferred via an optocoupler to the control unit. Using optocouplers is an elegant way to avoid floating ground and noise issues.

To protect the user from overvoltage or overcurrent, it is essential to measure the battery stack DC HV system voltage. In case of an overload, short circuit, or other undesired failure mode, it is necessary to interrupt the voltage supply. The control unit continuously monitors and feeds back the status of the electric vehicle to the driver by using optocouplers. Another possible failure mode is the lack of isolation from the battery cells to the electric vehicle chassis. In such a case, the driver might come into contact with dangerous high voltages. The isolation test unit monitors this failure mode and provides the status to the control unit across an optocoupler.

The control unit plays a major role in controlling all of the battery pack's components. Vishay optocouplers like the VOMA618A makes the design very easy. A low forward current (IF) of 1 mA allows for operation with a standard microcontroller without the need for an additional driver stage.

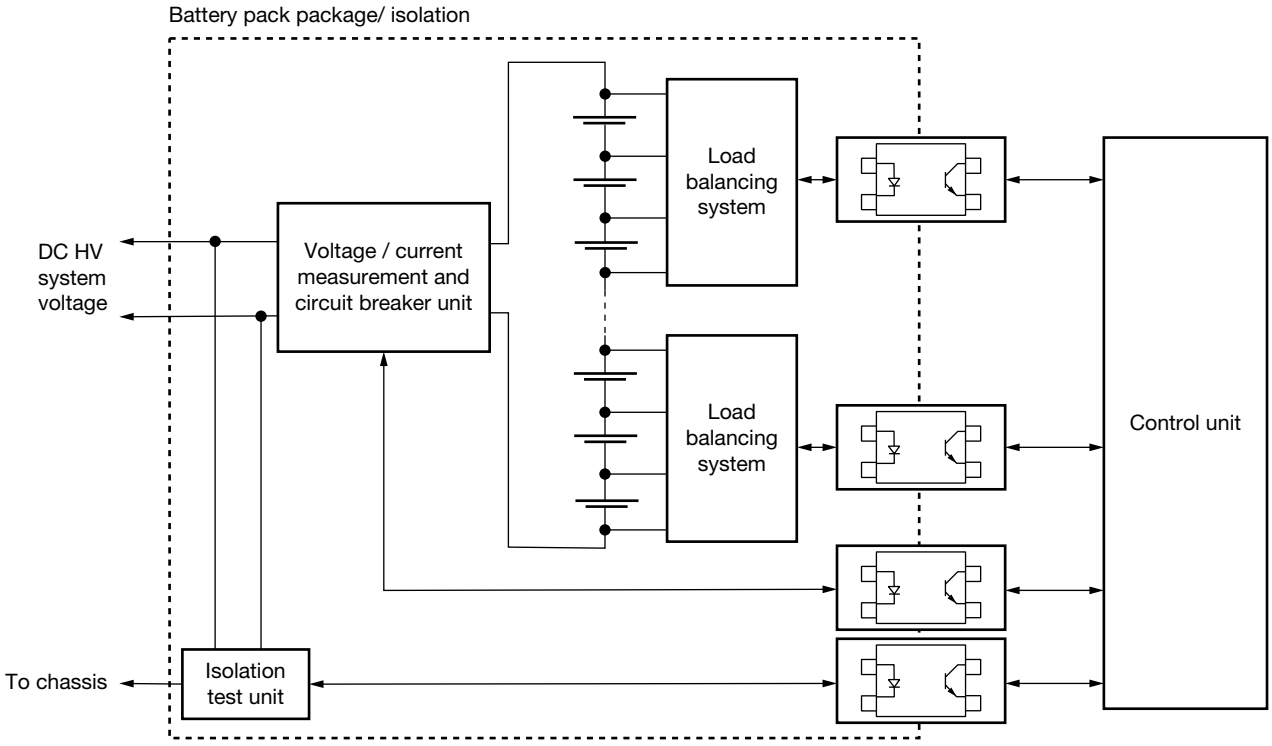

Fig. 2

APPLICATION NOTE

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CONCLUSION

Vishay optocouplers provide safety and noise and galvanic isolation in electric vehicles. To transmit signals, they use infrared light across an isolation barrier - typically > 400 µm - through a high isolation mold compound. Compared to other isolation techniques, where the internal isolation distance is only a few µm, their usage of RF signals to transmit information must be seen as critical in such noisy environments.

Using low forward current optocouplers makes it very easy to control with a microcontroller. Various output types besides phototransistor or photodarlington output - like high speed or MOSFET / photovoltaic stack output and TRIAC and IGBT driver output - make it easy for the designer to select the best fit.