How to Apply an Isolated Power Module in Signal Isolation

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Signal transmissions are everywhere. In industrial applications, such as electric vehicle (EV) charging stations and automation systems with programmable logic controllers (PLCs), there is a high voltage (up to several kV) that can be dangerous to the human body. This type of hazardous voltage can also pass through the signal line, which can cause signal interference and could eventually destroy the terminal electronic devices.

Moving signals and power across an isolation barrier is a method that can help overcome these challenges. This article will provide an overview regarding signal isolation in reference to a serial peripheral interface (SPI), as well as RS-232, RS-485, and CAN interfaces. It will also explain how isolated power modules can be used for signal isolation by using the MIE1W0505BGLVH, an easy-to-use and ultra-small power module solution, as an example.

Introduction to Isolation

Simultaneously moving power and signals while ensuring that the transmission is isolated has presented a challenge for engineers, especially since isolation is critical for human safety, system protection, and signal integrity.

1. Safety: For applications such as industrial robots, EV charging stations, or medical equipment, there is a voltage level upward of kV, but humans are only able to survive about 36V. Isolation can protect users from dangerously high levels.
2. System protection: Isolation technology can protect important facilities and electronic devices from damage caused by surge voltages.
3. Signal integrity: Signal transmission might be affected by external electromagnetic interference (EMI) disturbances; isolation helps maintain signal integrity.

Semiconductor Isolation Technologies

A semiconductor IC can feature an integrated isolation barrier that provides isolation in electrical systems. Using an isolated IC is a simple way to form a high-voltage, high-power system without redundant isolation circuits. Common semiconductor isolation technologies include:

1. Optical isolation: An optocoupler is a passive component that converts an electrical signal into an optical signal, then converts the optical signal back into an electrical signal. This process allows an electrical signal to be transferred via optical carriers, such as a light-emitting diode (LED). Optocouplers are widely used in flyback power designs and other scenarios with signal transmission.
2. Capacitive isolation: A capacitor can stop the flow of DC currents while letting AC currents pass through. With this in mind, it is possible to modulate the signal when it flows across the capacitor, which achieves isolation during signal transmissions. Capacitive isolation differs from optical isolation in that only a small amount of bias current is required, which is advantageous compared to LEDs that require a larger bias current. In addition, capacitive isolation features a higher transmission speed, lower propagation delay, and strong EMI immunity.
3. Magnetic isolation: Power and signals are transmitted via magnetic field coupling through a magnetic coil. Typically, a transformer is used to achieve magnetic isolation, which is mostly used in switching power supplies and power module design.

How Isolated Power Modules Are Used in Signal Transmission

There are various signal transmission types, including SPI, RS-485, RS-232, and CAN. In high-power industrial applications, the hardware system is inevitably influenced by hazardous high voltages when signals are transmitted from one hardware system to another.

These high voltages can also break down the signal chain. To avoid this issue, it is essential to use a signal isolator and an isolated power module. This article will explain how an isolated power module can be used with signal transmissions (SPI, RS-485, RS-232, and CAN) (see Figure 1).

Figure 1: MPS Isolated Power Module

Serial Peripheral Interface (SPI)

An SPI is a high-speed and full-duplex communication mode that enables a signal to be transmitted via four signal channels (3 forward and 1 reverse) (see Figure 2). The signal can be transmitted either from the master to the slave, or reversely from the slave to the master. To achieve electrical isolation during signal transmission, designers can add an electrical isolation barrier between the master device microcontroller (MCU) and slave device (transceiver).

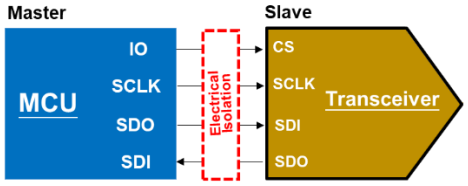

Figure 2: SPI Communication Interface with Electrical Isolation Barrier

The electrical isolation barrier can be implemented with an digital isolator, such as the MP27631, and an isolated power module, such as the MIE1W0505BGLVH (see Figure 3). The signal isolator can provide isolation while allowing the signal to pass through; however, this component is an active component that requires a bias voltage on its primary side and secondary side. The MIE1W0505BGLVH is part of a new generation of cost-effective, isolated power modules with excellent EMI immunity, as well as line and load regulation. This power module supports up to 2.5kV of isolation voltage in an ultra-small LGA (4mmx5mm) package.

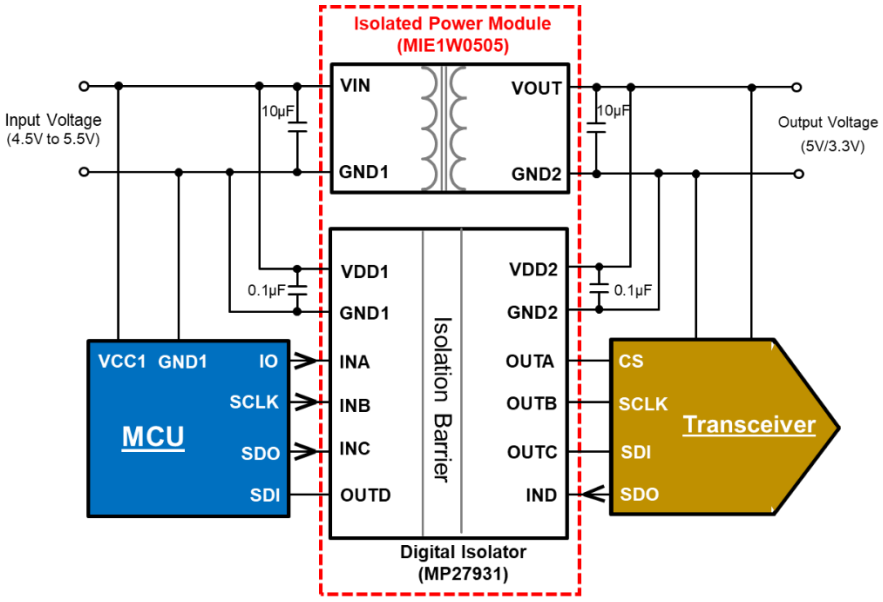

Figure 3: SPI Communication Isolation Barrier with Isolated Power Module and Signal Isolator

RS-485

In the RS-485 protocol, the signal is transmitted differentially in a twisted pair (where wire 1 = wire A, and wire 2 = wire B). Two logic levels are defined between wire A and wire B, and the positive logic level is +2V to +6V, while the negative logic level is -2V to -6V. These two logic level equivalents enable the system's state to be enabled or disabled. With differential transmission, RS-485 can significantly improve system EMI immunity. This transmission method requires 3 signal channels, and is widely used in industrial applications such as those with motion control and control system processing (see Figure 4).

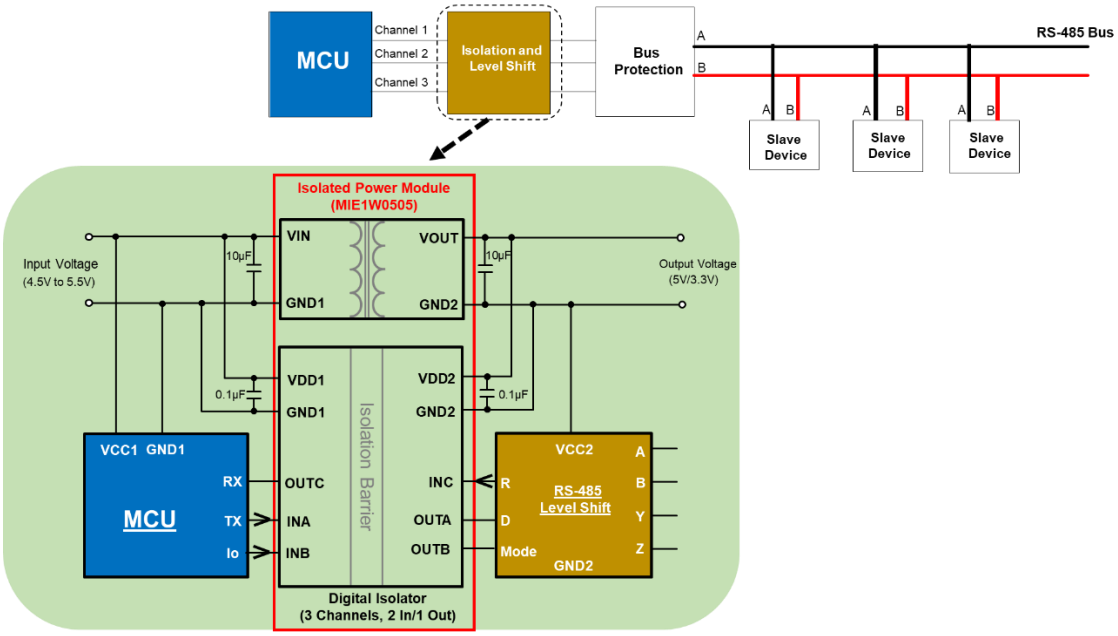

Figure 4: RS-485 Communication Isolation Barrier with Isolated Power Module and Signal Isolator

RS-232

The RS-232 protocol is a simple, point-to-point communication protocol (see Figure 5). Compared to RS-485, RS-232 has slower transmission speed and shorter distance. It was more widely used in older generations of PCBs.

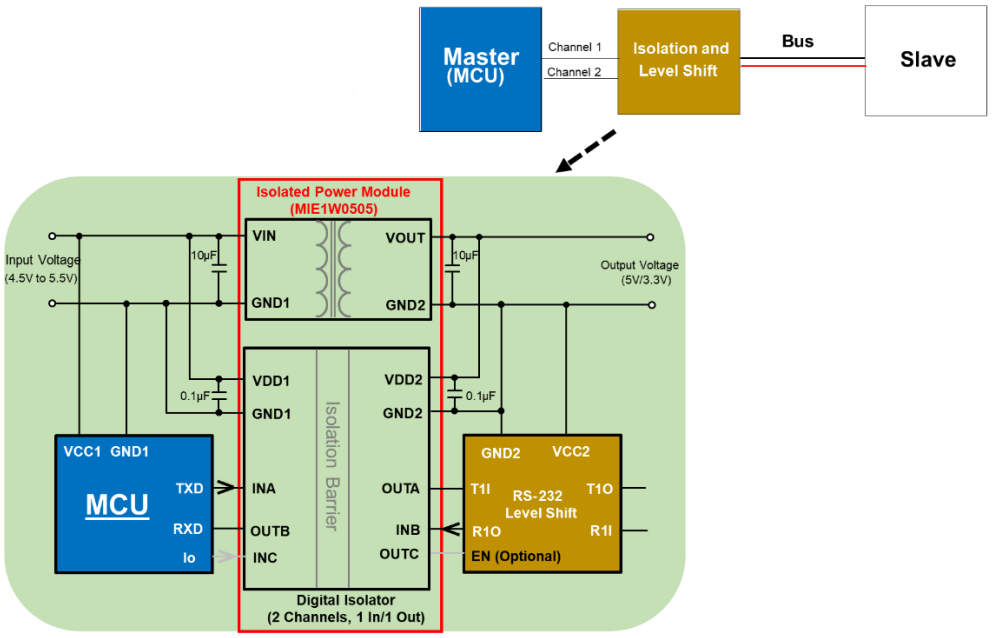

Figure 5: RS-232 Communication Isolation Barrier with Isolated Power Module and Signal Isolator

CAN

Developed by Bosch, the CAN protocol has high reliability and performance. Compared to RS-485, the real-time communication speed of a CAN bus is faster and more stable. At the same time, CAN has a simpler topology that only requires two signal channels (see Figure 6). The CAN communication protocol is widely used in high-reliability applications such as automotive, medical, and industrial devices.

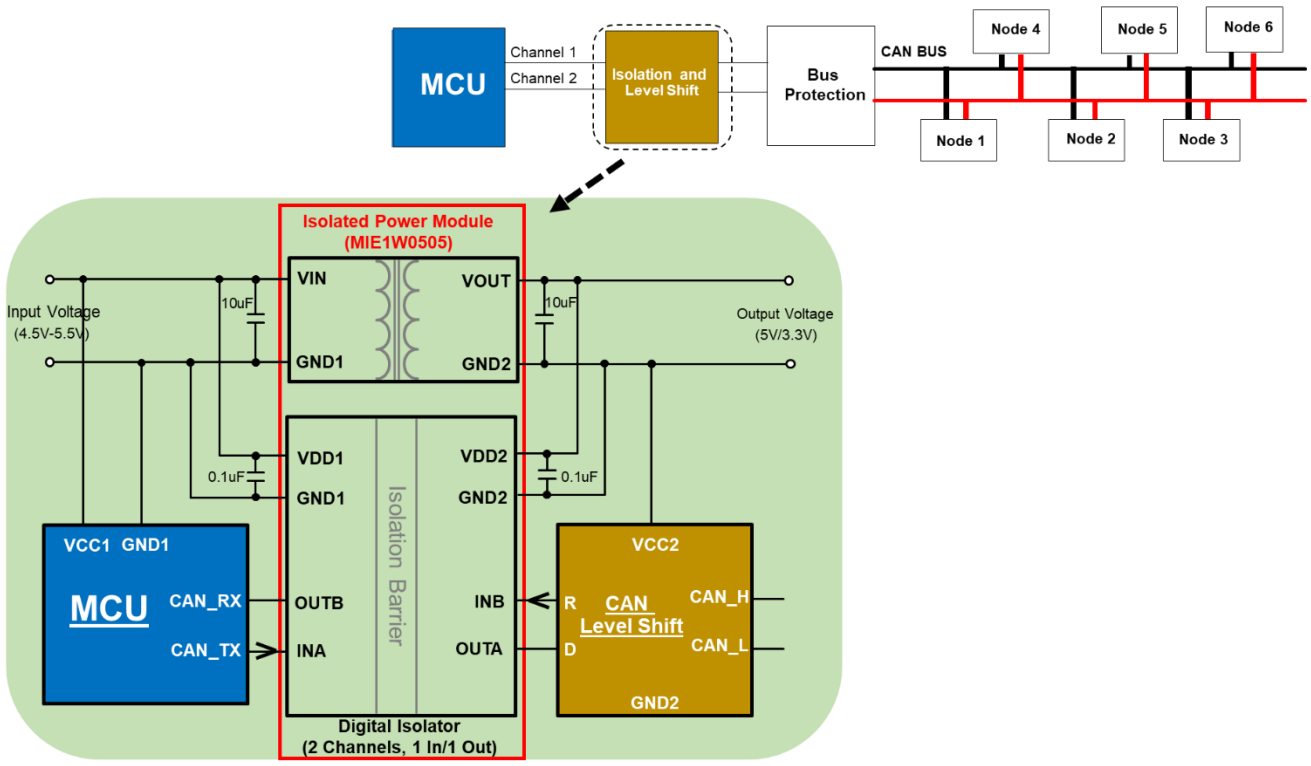

Figure 6: CAN Communication Isolation Barrier with Isolated Power Module and Signal Isolator

Isolated Power Modules in Real Applications

Below are several real applications that illustrate how isolated power modules can be used.

PLC Systems

PLCs are a digital control unit specifically designed for industrial automation systems. A PLC includes a CPU, memory, I/Os, motor drivers, and a power supply. The PLC is the brain of industrial automation systems, and can control machinery movements, detect gas pressure, detect temperature via sensors, interact with a human through a human-machine interface (HMI), and realize data communication with other electrical devices. Isolated power modules such as the MIE1W0505BGLVH can provide a robust power supply to the data communication chain through an RS-485 interface or I/O interface. Figure 7 shows a PLC functional block.

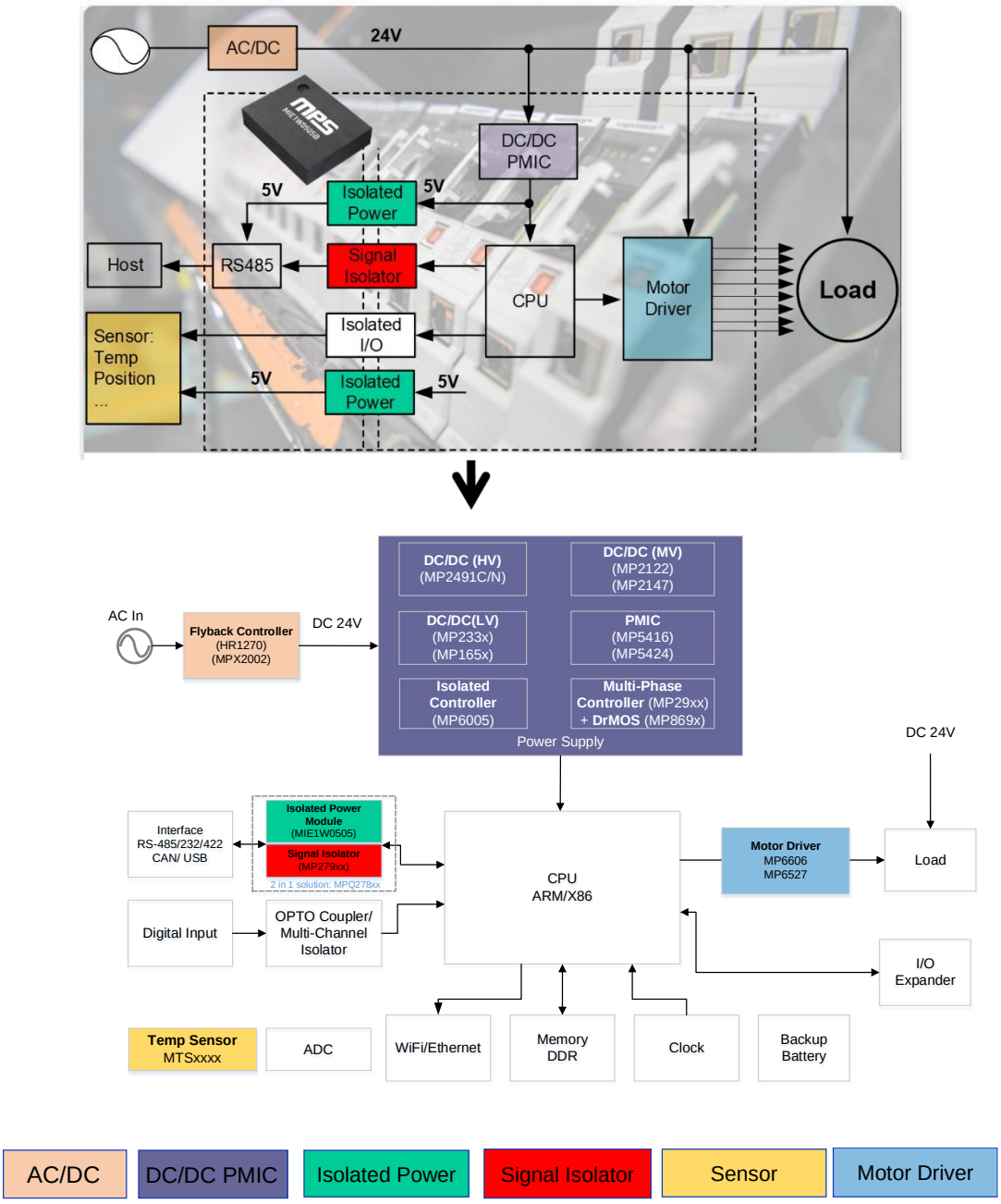

Figure 7: PLC Functional Block Diagram

EV Charging Stations

New energy is reshaping the world, and electrical vehicles (EVs) will continue to become more commonplace as we seek out sustainable energy sources. Charging stations take power from a power grid and use it as a power source to charge EV batteries. The power grid's output voltage (V_{OUT}) or the charging station's input voltage (V_{IN}) can reach up to $480V_{AC}$, which is dangerous. Isolated power modules such as the MIE1W0505BGLVH provide high-reliability isolation technology that can protect drivers and even car electronics from high voltages. Figure 8 shows an EV charging station functional block diagram.

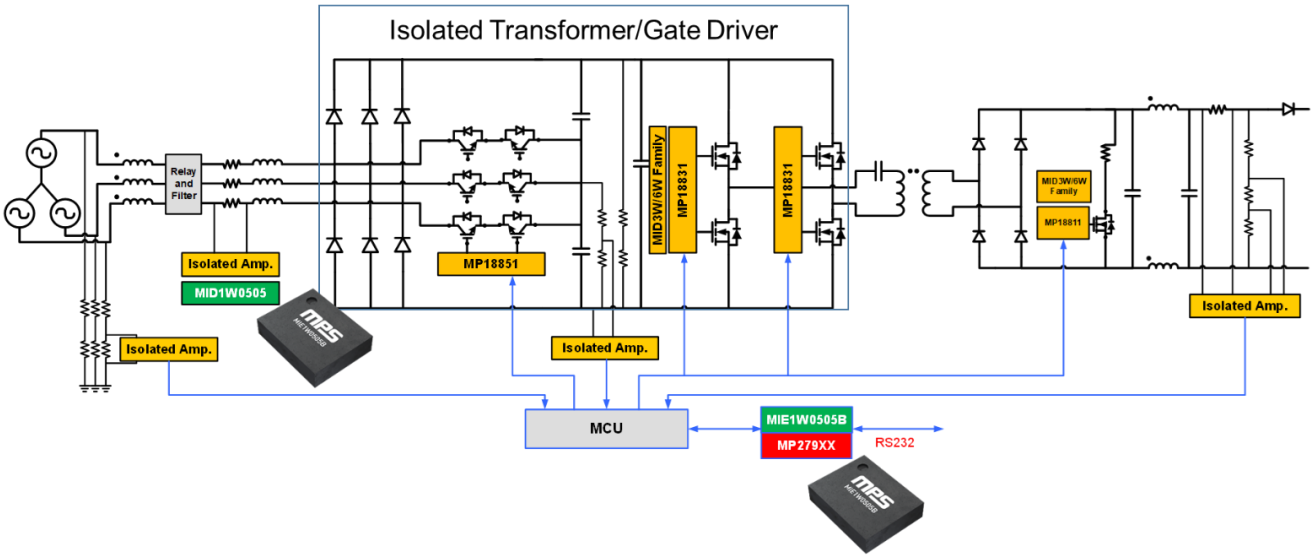

Figure 8: EV Charging Station Functional Block Diagram

E-Bikes

Highly populated cities with fast economic growth suffer from traffic congestion that can increase commute times, carbon emissions, and lead to injuries when there are accidents. E-bikes are an emerging and easier way of transportation, especially for short distances. Modules like the MIE1W0505BGLVH can protect cyclists from being harmed by the bike's 48V battery pack, all while maintaining signal integrity for the signal communication interface. Figure 9 shows an e-bike functional block diagram.

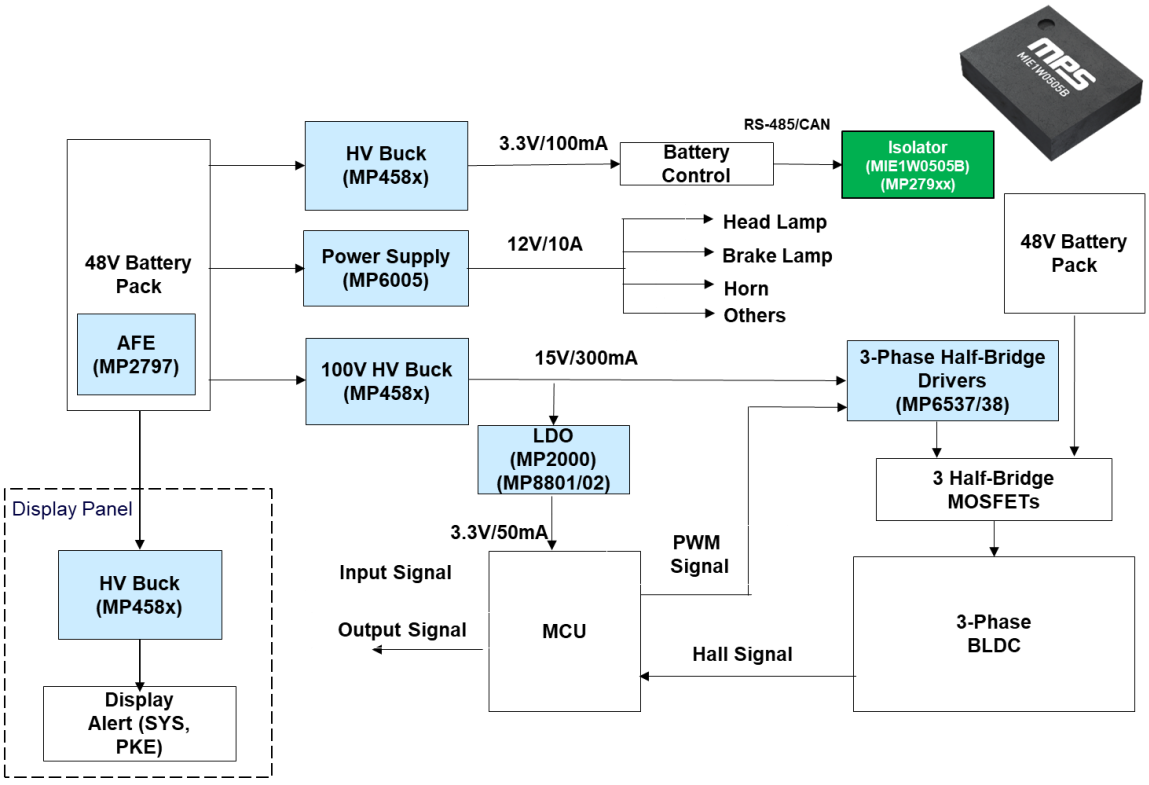

Figure 9: E-Bike Functional Block Diagram

Conclusion

This article explained the basic concept of isolation and how an isolated power module, such as the MIE1W0505BGLVH, can be implemented in signal isolation. The MIE1W0505BGLVH is an easy-to-use, ultra-small power module solution with excellent performance.

As Internet of Things (IoT) applications develop and utilize more energy, industrial environments will become more complex. In particular, designers will face changes as additional signal integration is required between industrial equipment and equipment being used by humans. This is why it is vital to have isolated power modules in addition to other products like digital isolators, isolated gate drivers, and transformer drivers to meet any application needs.