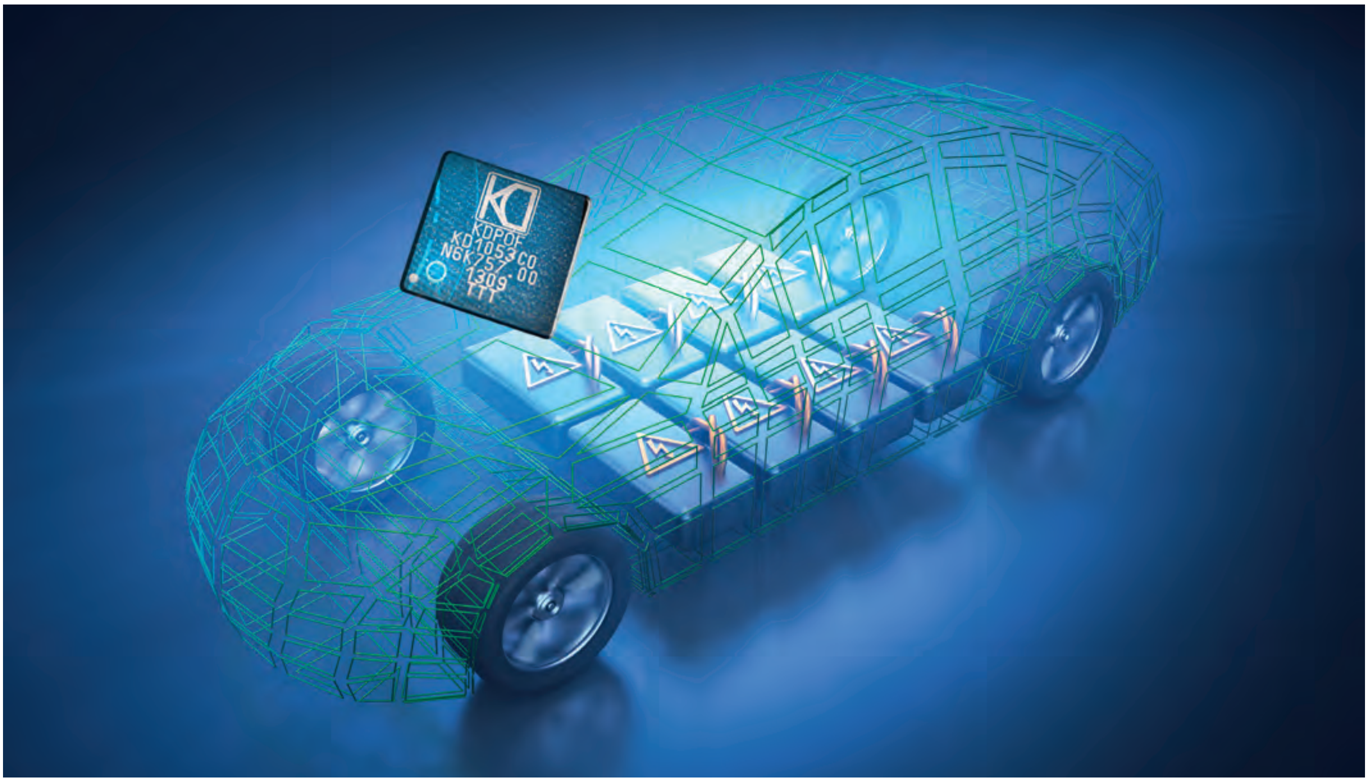
Optical Automotive Ethernet

for Electrical and Hybrid Powertrains



- Electromagnetic compatibility and robustness
- Galvanic Isolation secures new 48-volt electrical architectures and high-voltage electrical powertrains
- Reliable and smooth network integration
- Automotive Gigabit Ethernet Transceiver optimized for harsh automotive environments

pr@kdpof.com

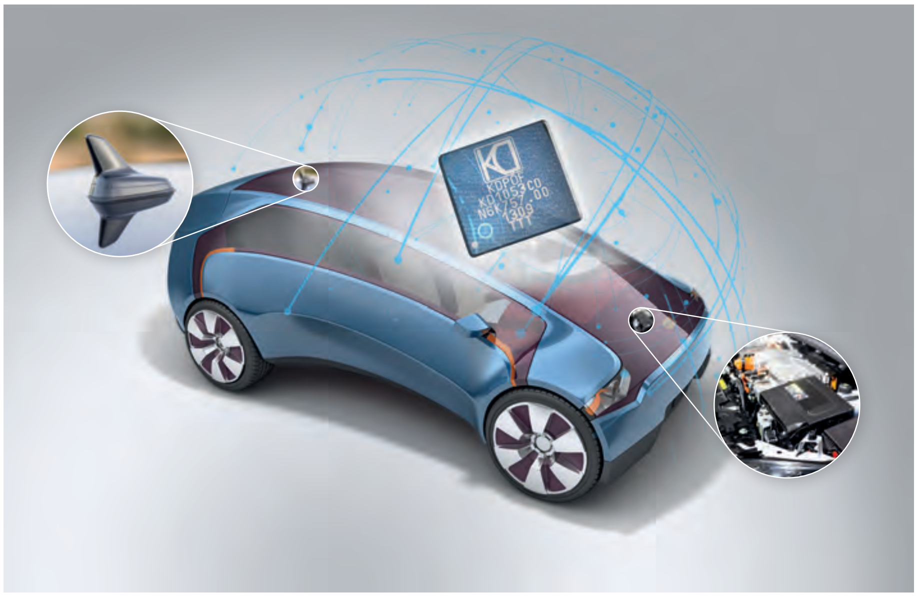
Optical Automotive Ethernet for Electrical and Hybrid Powertrains

Electromagnetic Compatibility and Robustness

Optical data networks, with their intrinsic Electromagnetic Compatibility (EMC), are the best technology choice for new powertrains that are either fully electrical or hybrid. Plastic Optical Fiber (POF) communications have excellent performance in Electromagnetic Interference (EMI) and in Electromagnetic Susceptibility (EMS). POF is inherently immune to and robust against electromagnetic fields. Moreover, its native galvanic isolation and mechanical robustness make optical Ethernet technology ideally suited for current and future in-vehicle network infrastructure.

Galvanic Isolation Secures New 48-volt Electrical Architectures

New 48-volt electrical architecture in cars pushes the envelope in terms of electromagnetic compatibility and safety requirements. New safety precautions are needed, since even a single malfunction between the 48-volt and the 12-volt electrical system, like a short circuit, may damage the entire 12-volt system due to overvoltage. Optical links are the optimal option for communications between the 48-volt domain and the 12-volt domain, as they guarantee inherent galvanic isolation. Optical Ethernet provides 100 Mbps and 1 Gbps Ethernet compatible solutions today, and multi gig in the future, with enough margin to withstand the harsh automotive environment.



Reliable and Smooth Network Integration

POF cables are the most reliable solution: they can withstand harsh environments, vibrations, misalignments, dirtiness, humidity, wide temperature range, etc. In addition, POF allows fast dynamic bending, tight static bending, and immersion in liquid. Furthermore, optical Ethernet generates no noise and can operate in noisy environments, such as in RF electronic boards.

As a plastic fiber with a large diameter, POF is more cost-effective to manufacture and install: installation is just easy plug and play; winding and clamping is similar to copper cables. Moreover, during the car assembly, the optical harness can be installed in the same process as the copper harness. POF has been present in vehicles for more than 10 years and is installed in millions of cars without any issues.

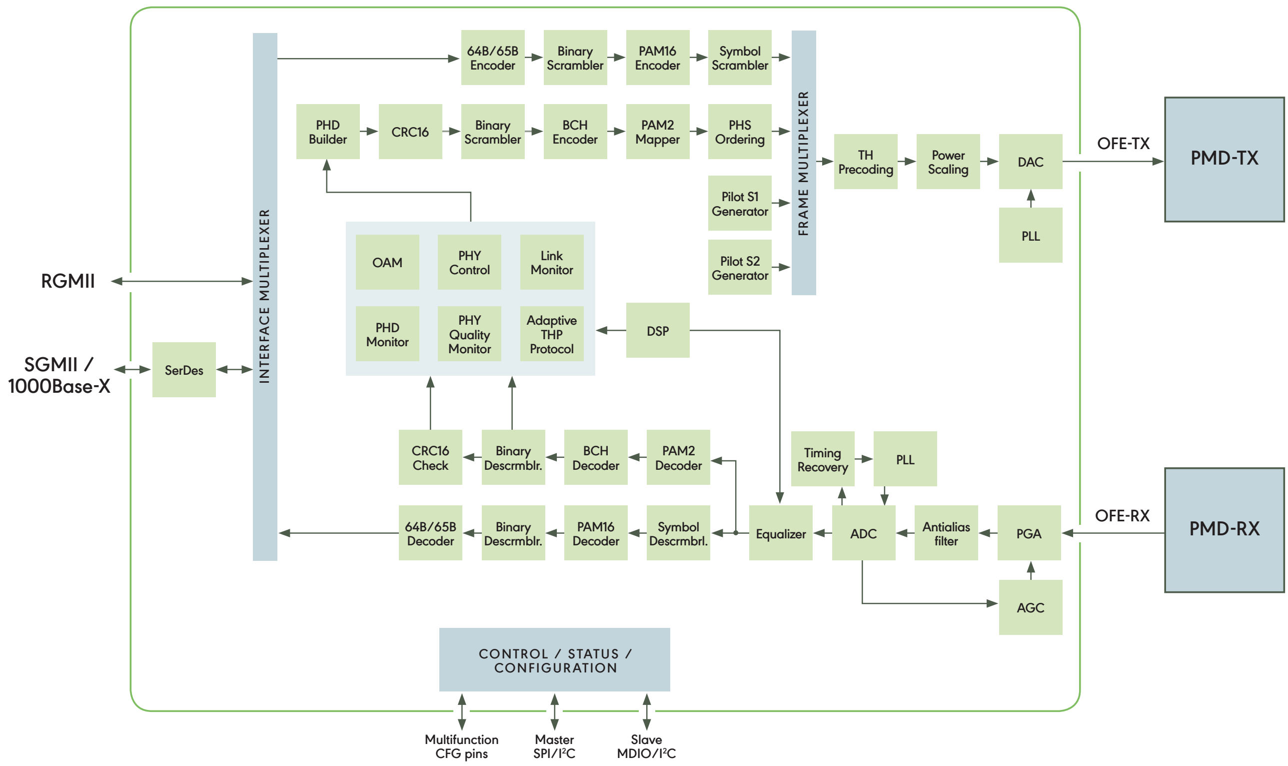
First Automotive Gigabit Ethernet Transceiver

The KD1053 IC is the first fully integrated automotive transceiver that implements the physical layer of gigabit Ethernet over POF.

It definitely meets the demands of carmakers:

- Data transmission at 1000/100 Mbps on standard SI-POF, MC-POF, or PCS, according to 1000BASE-RH (IEEE Std 802.3bvTM-2017)
- Flexible connectivity supporting multiple digital host interfaces
- SMI (MDC/MDIO) interface for configuration and monitoring supporting Clauses 22 and 45, which can also be configured as an I^2C bus
- SPI/I^2C master interface for reading external boot and configuration EEPROM memory
- Support for OAM, Wake-up & Sleep, interruption generation
- Support for jumbo packets up to 10 KB

- PTP support and SyncE clock generation support.
- Different loopback modes and PMD test-modes for diagnostics
- Link/activity monitoring and speed LED outputs
- Fully integrated digital adaptive non-linear equalizers
- BER < 10^{-12} for 1 Gbps and 100 Mbps operation modes
- 6.2 µs latency for 1 Gbps operation and 1.4 µs for 100 Mbps (local RGMII to remote RGMII); 5 ns RMS jitter for 1 Gbps operation and 9 ns for 100 Mbps
- 55 ms of link time for 1 Gbps operation
- Internal dependability functions: power supplies and temperature sensors, FOT input power monitoring
- Advanced power management with integrated linear voltage regulators
- Low power, 460 mW at 1 Gbps with serial interface
- Low-cost bill of materials (BOM)
- Designed to be compliant with the most stringent EMC specs of the OEM
- Automotive AEC-Q100 grade 2
- -40 to +105°C ambient temperature range
- 56-pin QFN (7 x 7 mm) ROHS package



Gigabit Communications

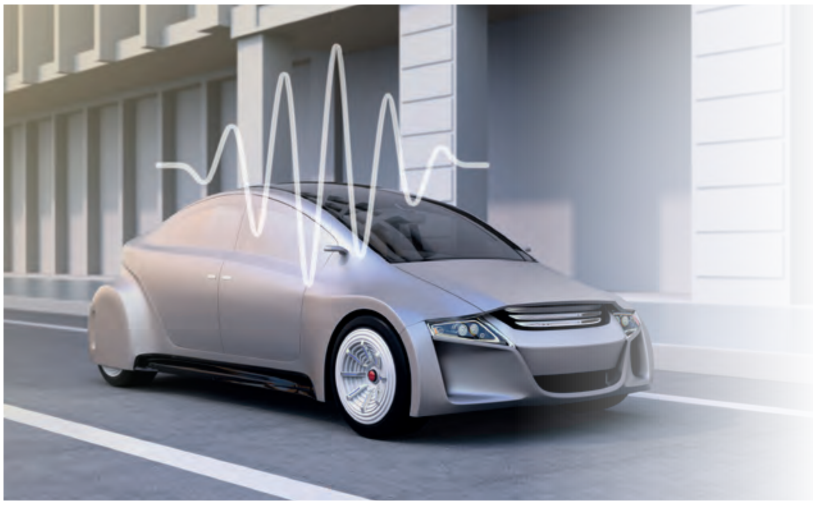
Making gigabit communications over POF a reality, fabless semiconductor supplier KDPOF provides 1 Gbps POF links for automotive, industrial, and home networks. KDPOF offers their technology as either ASSP or IP (Intellectual Property) to be integrated in SoCs (System-on-Chips).

Use Cases for Optical Connectivity

As follows, a set of use cases show examples of how optical networking can be used to solve issues caused either by EMI/EMS or lack of galvanic isolation on copper-based networks in the powertrain of Hybrid Vehicles (HEV) and Electrical Vehicles (EV).

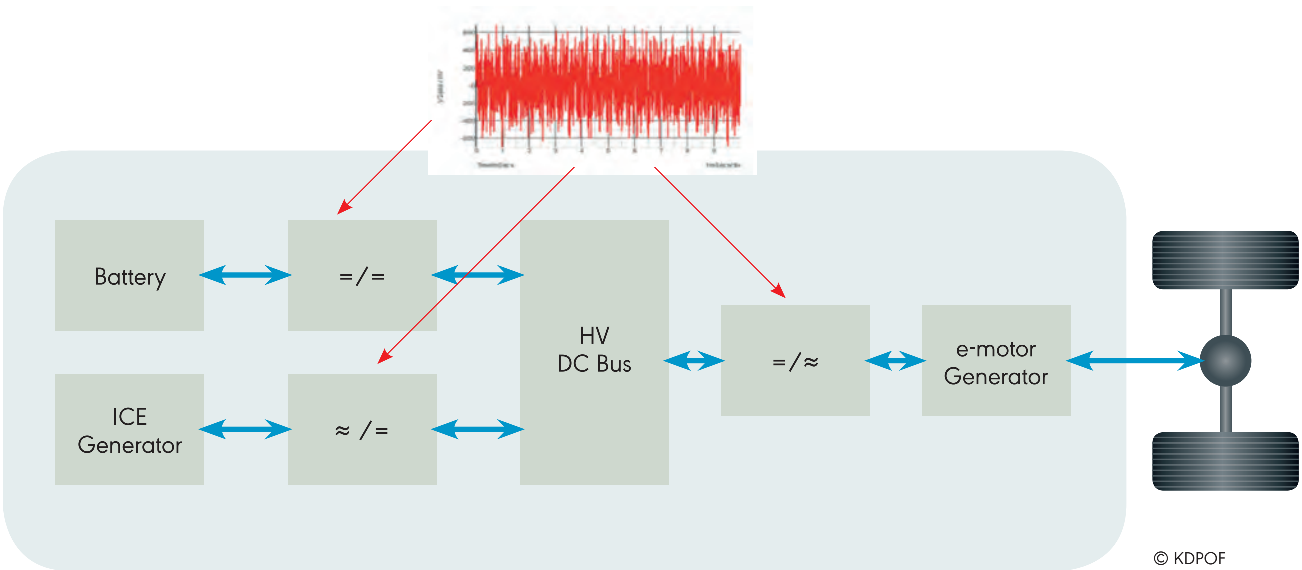
Use cases

Use Case: Noise Propagation in HEV/EV Powertrains



The powertrains of hybrid and electrical vehicles require multiple electronic units placed all around the car. These Electronic Control Units (ECU) regulate and control the electrical flow of the energy between the batteries, converters, and motors/generators. The energy flow and conversion generates electrical noise, which will affect other areas of the car like the infotainment or navigation systems today and the autonomous control systems tomorrow.

By optically connecting the ECUs, it is possible to isolate each noise within the ECU that originates it, avoiding its propagation to all the other ECUs dispersed all over the car. Trying to achieve a similar isolation with a copper-based network is very difficult and expensive, which translates into a longer engineering development cycle and a more expensive and complex ECU, which may in turn translate into lower reliability.



Noise propagation in HEV/EV powertrains

Use cases

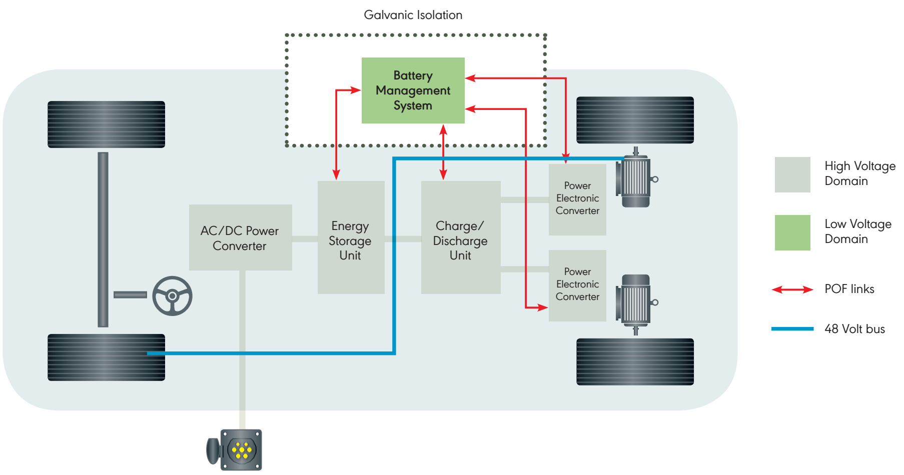
Use Case: Galvanic Isolation in Battery Management Systems

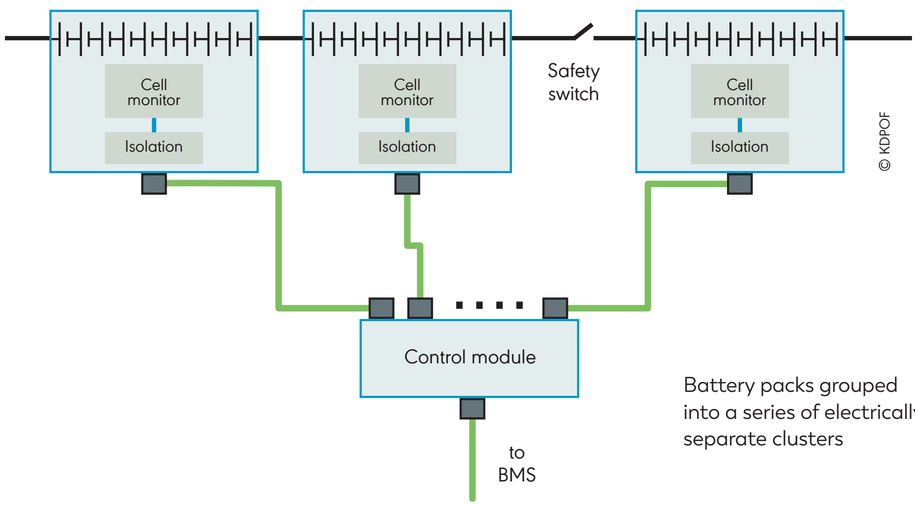
Propulsion batteries in EVs or HEVs are grouped into clusters that need to be controlled. Responsible for this control is the so-called Battery Management System (BMS). The BMS communicates with each battery cluster in order to gather information relevant for control, such as state of charge or cell temperature. The BMS in turn sends control commands to the local ECUs inside each cluster.

Although the amount of data moving back and forth between the clusters and the control module is not very high (typically below 100 Mbps), the communication between the BMS control module and the individual clusters is crucial and needs to be very reliable. These BMS links are critical to avoid battery damage, and must be suitable in emergency situations like crashes or fires.

Optical links between the BMS control module and the battery clusters are the best means to ensure the high reliability needed. Copper-based communications create parasitic loops, which, in the case of emergency events, may translate into dangerous conditions for the driver and occupants.

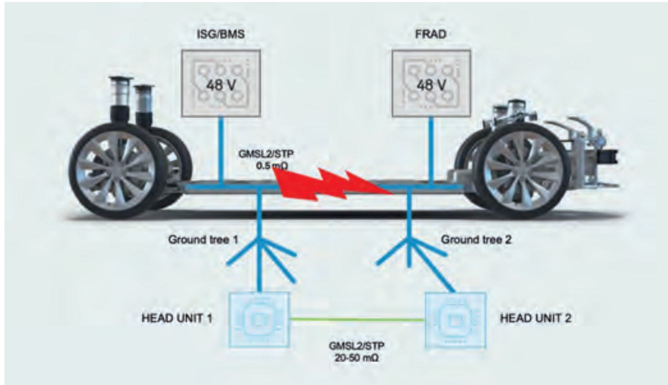
A dielectric medium such as plastic optical fiber reduces to zero the contribution of the data cables to the conducted emissions and conducted immunity. Radiated emissions and radiated immunity can be optimized to pass with ample margin all the OEM specs with high-quality reference designs from the optical PHY vendor.



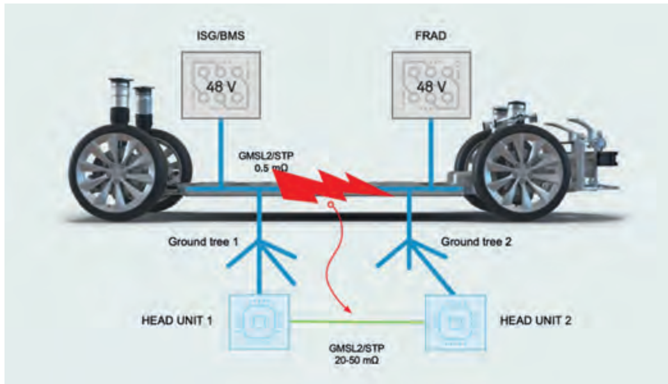


Battery packs grouped into a series of electrically separate clusters

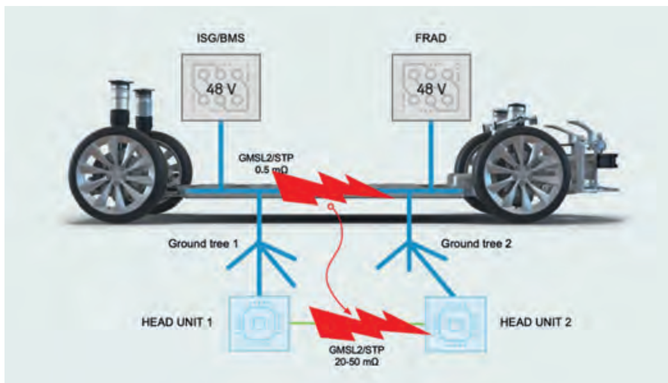
Use cases



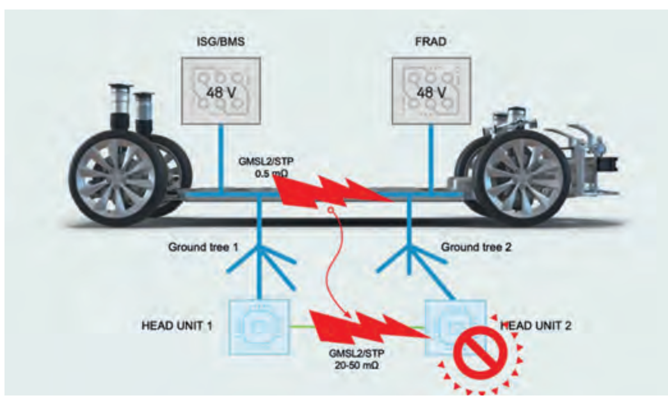
1. 800-900 A current circulates along chassis at jump-start.



2. Surge current develops a 400 V chassis potential, which couples into STP data link.



3. Induced pulse develops an 8 A current over STP shield.



4. Head Unit is damaged.

Use Case:
48 Volts Jump-start
Parasitic High Energy Pulse

48-volt-based energy networks or mixed 12-48 volts topologies are and will keep being the mainstream of HEV and Plug-in Hybrid Electrical Vehicle (PHEV) powertrains. The electrical ground, which is connected to the vehicle chassis and is common to high and low voltage ECUs, creates problems on start-up events that are continuously taking place in such powertrains.

For example, the infotainment system shares the electrical ground with the energy generation and control systems. The high return currents flowing through the chassis on start-up couple into the infotainment low-voltage system through the cable shielding, which is connected to the same electrical ground of the vehicle. Copper-cable shielding provides a parallel return path (alternative to the chassis) for the currents of the diverse ECUs. Due to this, currents higher than 8 amperes can be measured in the cable shielding during a typical jump start.

If the communications link between the ECUs in the low-voltage systems like infotainment or ADAS is optical, then the native galvanic isolation will isolate them from the high voltage/high energy systems and their associated events, thus preserving their reliability.

The graphics show the chassis of a car that uses 48 volts as the voltage level to power the different electronic units, which are included in different areas. In this case, two electronic units (ISG/BMS and FRAD) are shown in two different places of the car; however, they are electrically connected through the chassis, which has certain parasitic resistance (0.5 milli ohms).

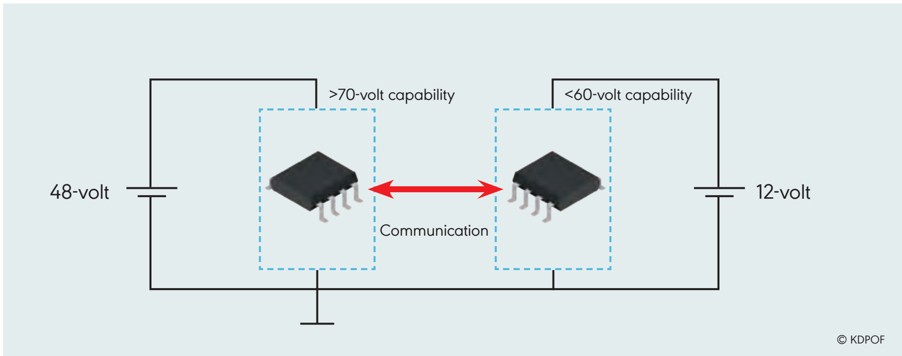
The graphics also show two head units that correspond to the infotainment system in the car. They are also connected to the chassis through different ground trees, and between them by a shielded twisted pair (copper).

Use cases

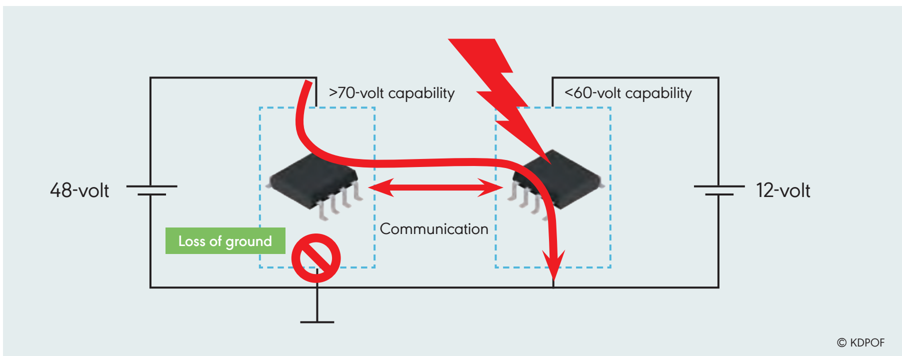
Use Case: Fault Protection in 48-/12-volt Systems

Mixed 48-/12-volt energy systems will be the mainstream in next generation HEV and PHEV cars. 48 volts are reserved for „hungry“ electrical modules like starters, alternators or battery modules, while 12 volts are dedicated for the more „delicate“ electronic modules like Infotainment or ADAS processing units. Both domains share the same ground system, the car chassis.

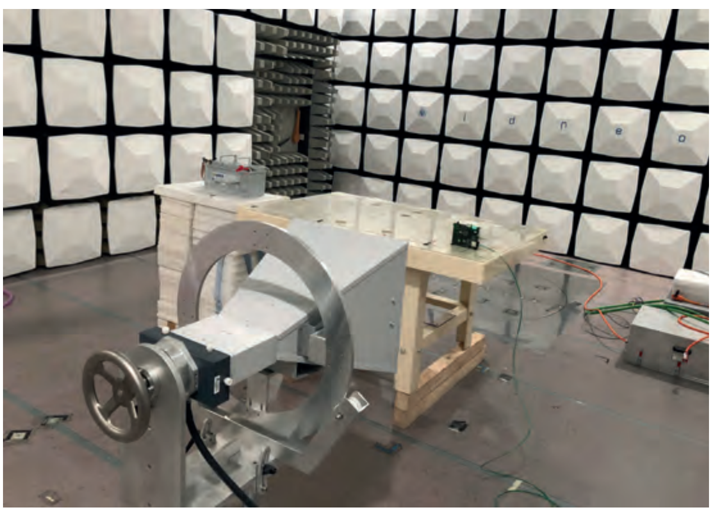
The ECU in the 48-volt domain is designed with electronic components sized for such voltages. These components are typically rated to withstand more than 70 volts. The 12-volt ECUs are designed with electronic components that support up to typically 60 volts. In case of an event like a loss of ground in a 48-volt ECU, and if there are non-galvanic isolated links between the 48-volt and the 12-volt domains, there will be an electrical path between both domains. This will expose the 12-volt ECUs and its components to voltages higher than the ones they were rated to support, causing failures or a reduction of its service life.



Failure mode – loss of ground. No failure



Failure mode – loss of ground at 48-volt side

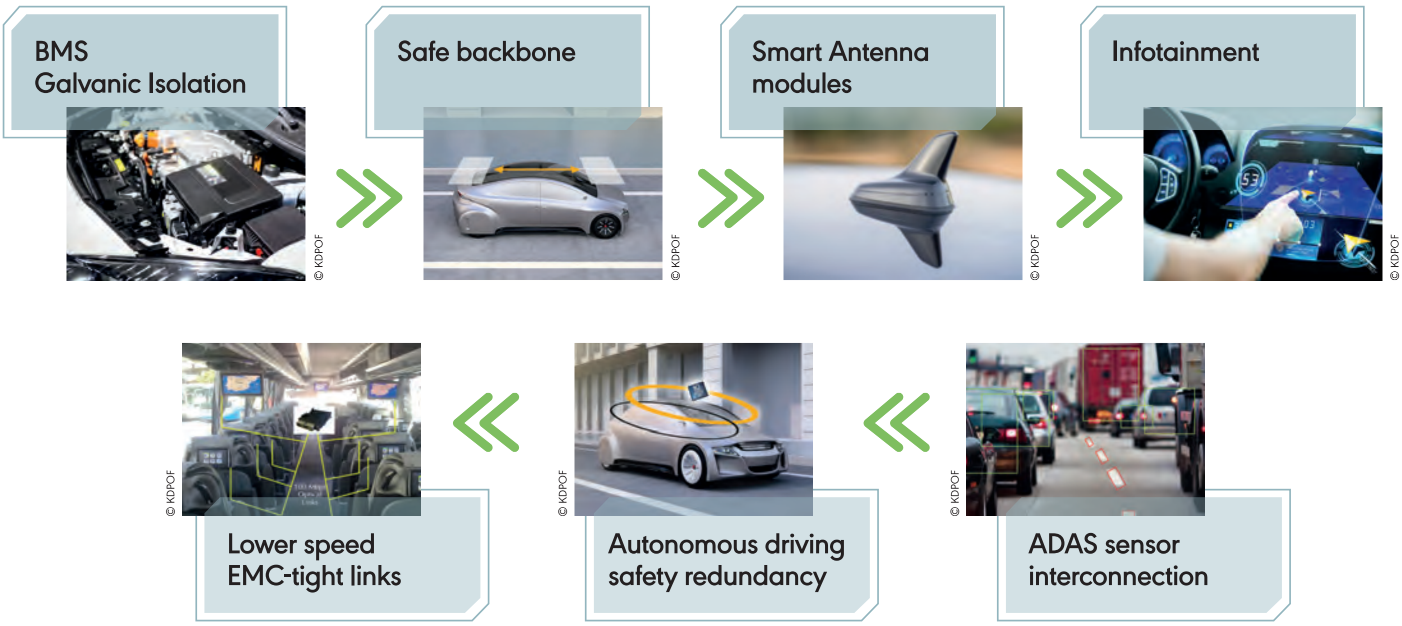


Use Case: EMC Compliance

EMC qualification is one of the critical steps of a platform validation by TIER-1 and OEMs. Copper links for communication rates above 100 Mbps need sophisticated and expensive solutions to comply with the stringent OEM’s EMC specs: high-quality shielding, controlled pair twisting, complex in-line connectors, etc. Optical ports can pass both EMI and EMS much more easily. This directly impacts the cost of the harness and the connectors, not to mention the engineering resources assigned to the development and debugging stages.

Gigabit Connectivity over Plastic Optical Fiber

Use Cases:
Gigabit Optical Links



Fabless semiconductor supplier KDPOF provides innovative gigabit and long-reach communications over Plastic Optical Fiber (POF). Making gigabit communications over POF a reality, KDPOF technology supplies 1 Gbps POF links for automotive, industrial, and home networks. Founded in 2010 in Madrid, Spain, KDPOF offers their technology as either ASSP or IP (Intellectual Property) to be integrated in SoCs (System-on-Chips). The adaptive and efficient system works with a wide range of optoelectronics and low-cost large core optical fibers, thus delivering carmakers low risks, costs, and short time-to-market.

KDPOF – Óscar Ciordia
pr@kdpof.com - +34 918043387 - www.kdpof.com
Knowledge Development for POF, S.L.
Ronda de Poniente, 14 2° C-D
28760 Tres Cantos, Madrid, Spain