

SPE in Automotive & Industry

The number of SPE (Single Pair Ethernet) applications involving external connections for data transmission in automotive under a closed-loop control system is increasing. In this operating environment, there are specific requirements related to high voltage isolation. Also the number of application of SPE for IoT applications within e.g. industrial automation & equipment industries is growing.

Capacitors with 50V to 100V isolation requirements are no longer enough to protect the circuitry in these applications.

The installation of SPE in the industry environment requires deploying wires in the open space, sudden high voltage could damage the equipment if the capacitor insulation is not sufficient.

In automotive and in industrial SPE applications it is common to have 2 capacitors per channel to block the hazardous voltages (see figure 1. for schematic).

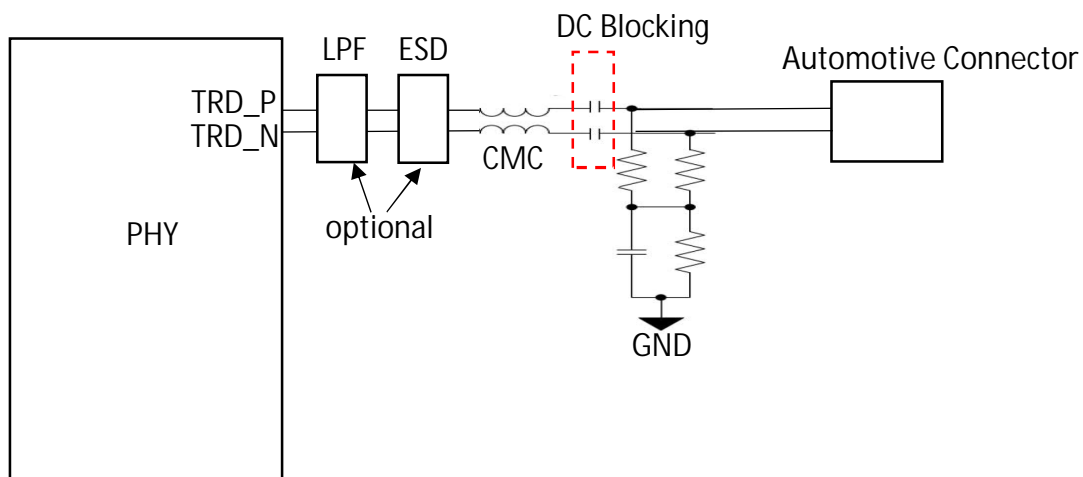


Figure 1. Typical Application

Transformers & Hi-POT Capabilities

The IEEE 802.3 standard for signaling systems stipulates the insulation requirement according to IEC 62368-1 which means withstanding a voltage of 1500Vac (2250Vdc) for 60 sec, to meet this requirement and the DC blocking capacitors must be capable of handling 2000V insulation voltage.

At present, the conventional capacitor of MLCC material X7R / capacitance value 0.1 μ F / size 2225 insulation voltage is only 1500V. Capacitors which can withstand 2000V are bound to be larger in size, higher in price and to occupy more PCB space.

(see figure 2. for images of capacitors with different power insulation capabilities)

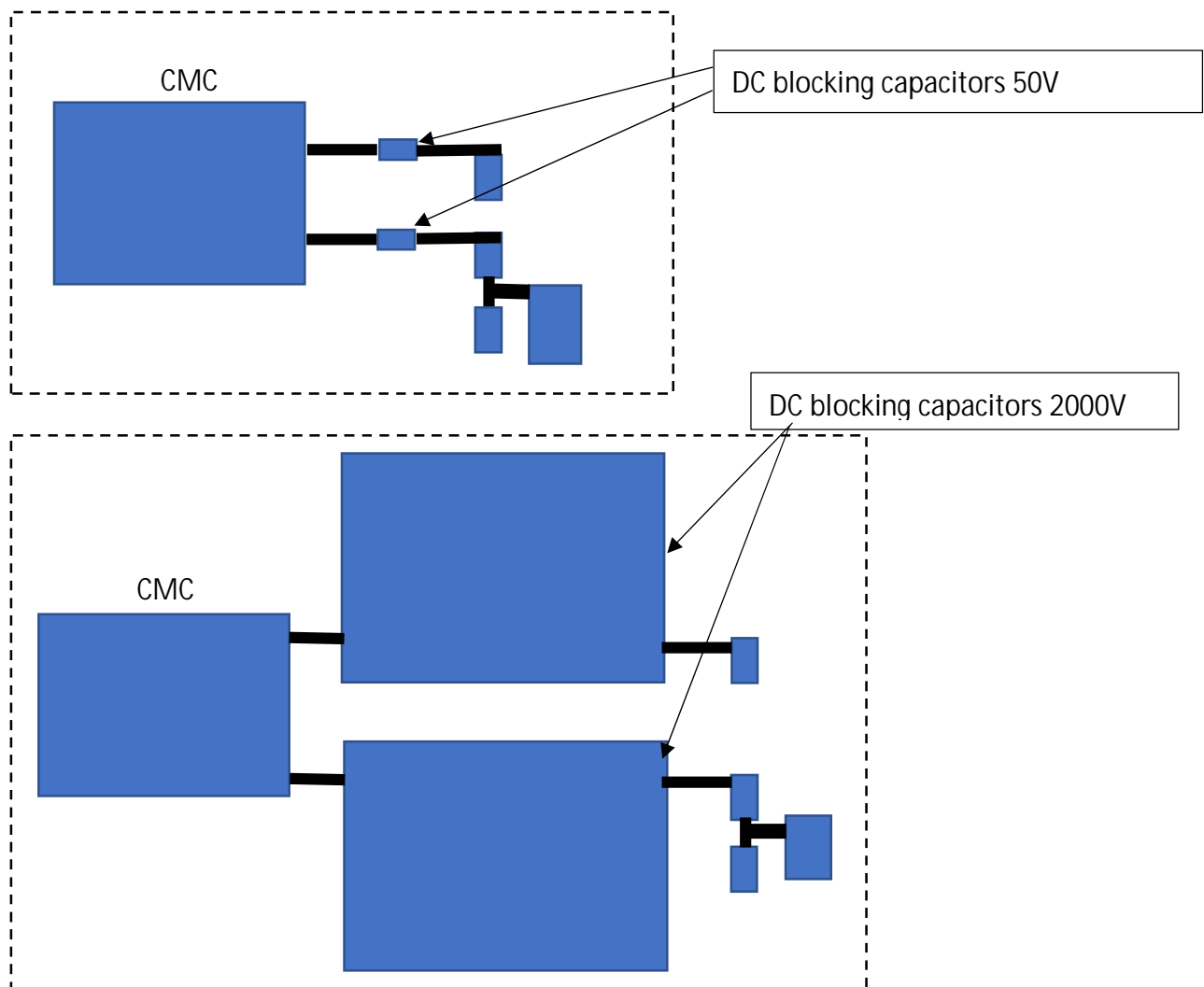


Figure 2.

To meet the requirements of IEEE802.3, and to fulfill 2000V DC blocking, also transformers can also be used. There are two types, chip type transformers and case type transformers with toroid cores. The circuit for external connection will now look as shown as figure 3.

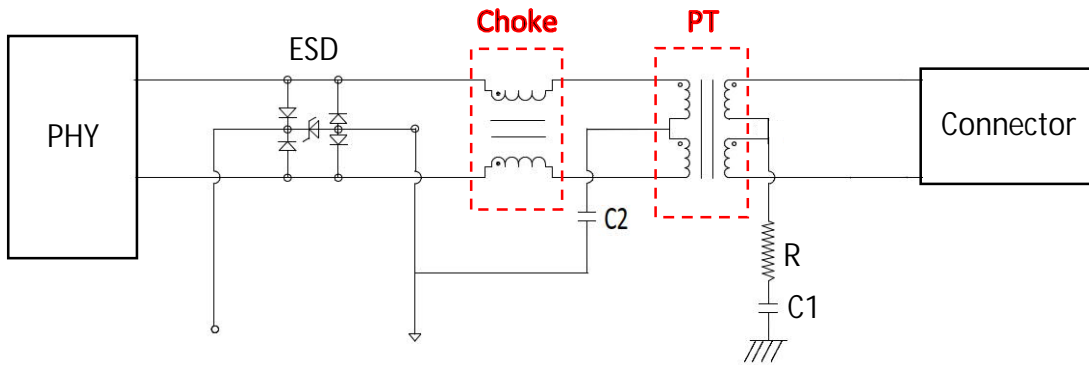


Figure 3.

1. Chip type transformer

The circuit for external connection of chip type transformer requires a common mode choke which is separately mounted on PCB (see figure 4.) so PT transformer & common mode choke are separately mounted on PCB.

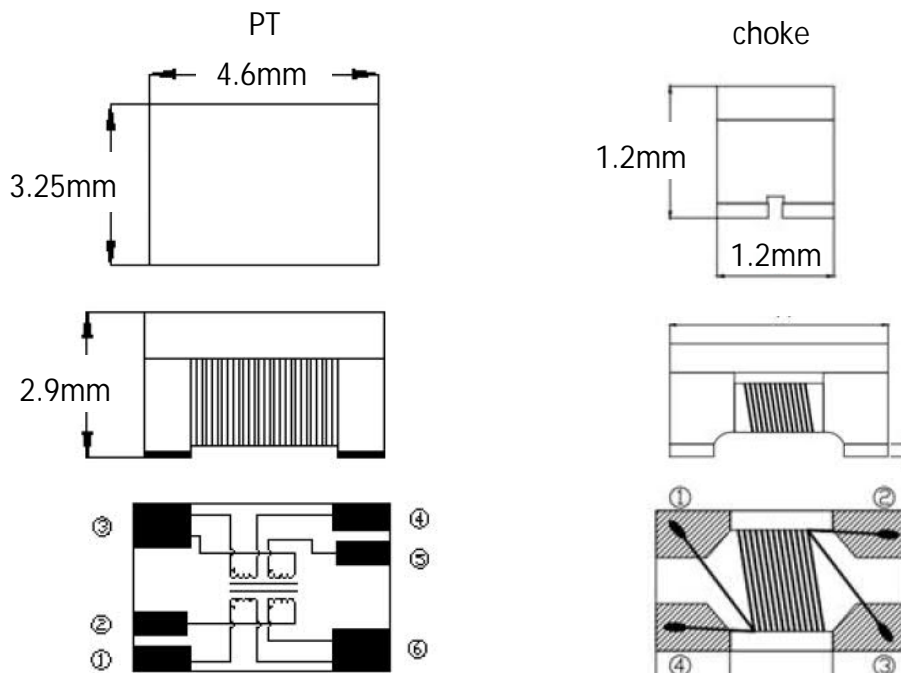


Figure 4.

2. Case type transformer

A case type transformer includes a wire-wound PT and a common mode choke.

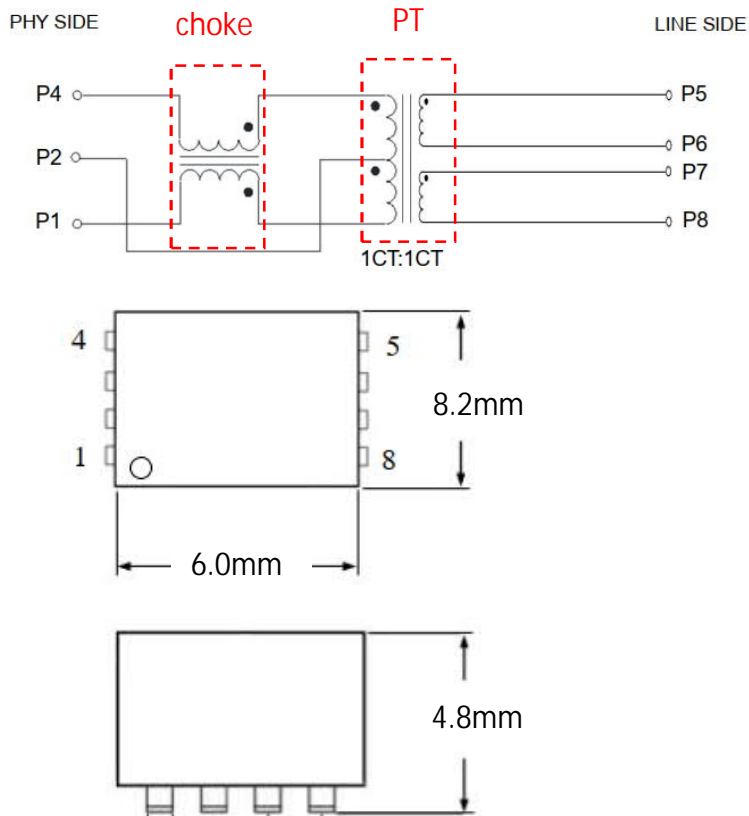


Figure 5. PT & common mode choke

Both the chip type transformers and case type transformers can be applied to the following SPE spec to meet insulation requirement of IEEE 802.3:

Standard	Data Rate	Bandwidth	Length
IEEE 802.3cg	10BASE-T1	0.1 to 20 MHz	1000m
IEEE 802.3bw	100BASE-T1	0.3 to 66 MHz	40m
IEEE 802.3bp	1000BASE-T1	1 to 600 MHz	40m

Due to the limited size of chip type transformer can only reach 1500V Max in Hi-POT. On the other hand, a case type transformer gives the advantage from 1500V to 3000V.

Industrial SPE requires higher voltage isolation to comply with IEEE802.3, case type transformers are more suitable for higher voltages compared to chip type transformers, in

in addition, the center-tap which is connected to GND (see figure 3) in transformer type offers an excellent low impedance path for common mode signals and the noise resistance can be improved by connecting the transformer center tap to ground.

Powering SPE applications with power over data line (PoDL)

There are two ways to apply power in SPE, namely isolated and Power over Data Line (PoDL). TEXAS INSTRUMENTS has developed a 10BASE-TIL physical layer (PHY) using full-duplex communications over a single balanced-pair of conductors with an effective data rate of 10Mbps simultaneously in each direction which also enables sending power over data lines (PoDL) along the same single-pair cable through a low-pass filter. (see figure 6), (<https://www.ti.com/lit/snla360>)

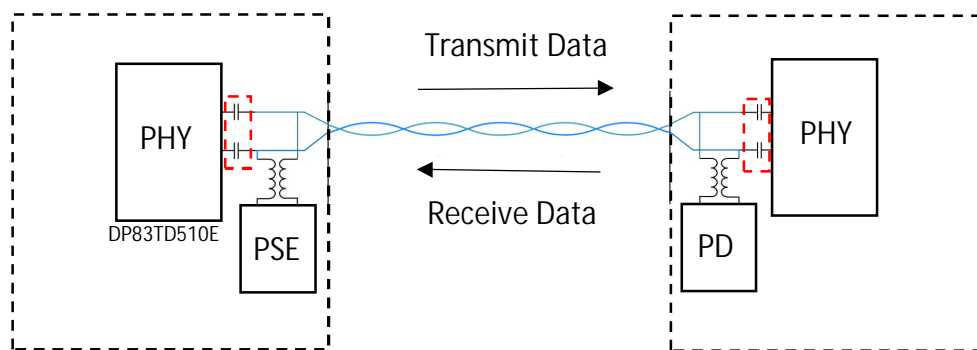


Figure 6 capacitor PoDL

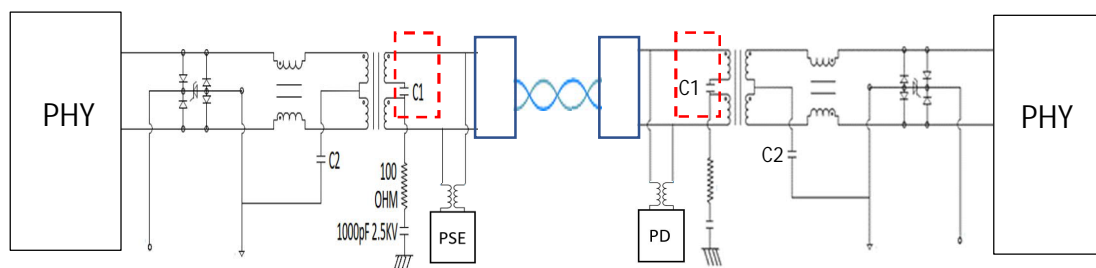


Figure 7 transformers PoDL



Figure 7 is showing schematic of a transformer with PoDL. In this circuit, capacitor C1 isolates DC voltage to protect the coils. So the power will not pass through the coil. This way, it waives the concern of current withstanding capability of POE Ethernet transformer.

It still leaves the questions of the current withstand capability of the other components as connectors and cable used for the PoDL cabling.

Case type transformers with or without PoDL are showing higher capabilities in handling Hi-POT, and protect equipment from being damaged by sudden high voltage. The advantage is also extended to integrated SPE connectors. PCB space wise, we can conclude as:

Case type < chip type + chip type choke

*A case type includes PT transformer & choke already.

Magcom Products

Magcom introduces SPE discrete magnetic and integrated SPE connectors with the advantages of less PCB space consumption, higher hi-POT performance, moreover the operating temperature from -40°C to 105°C.

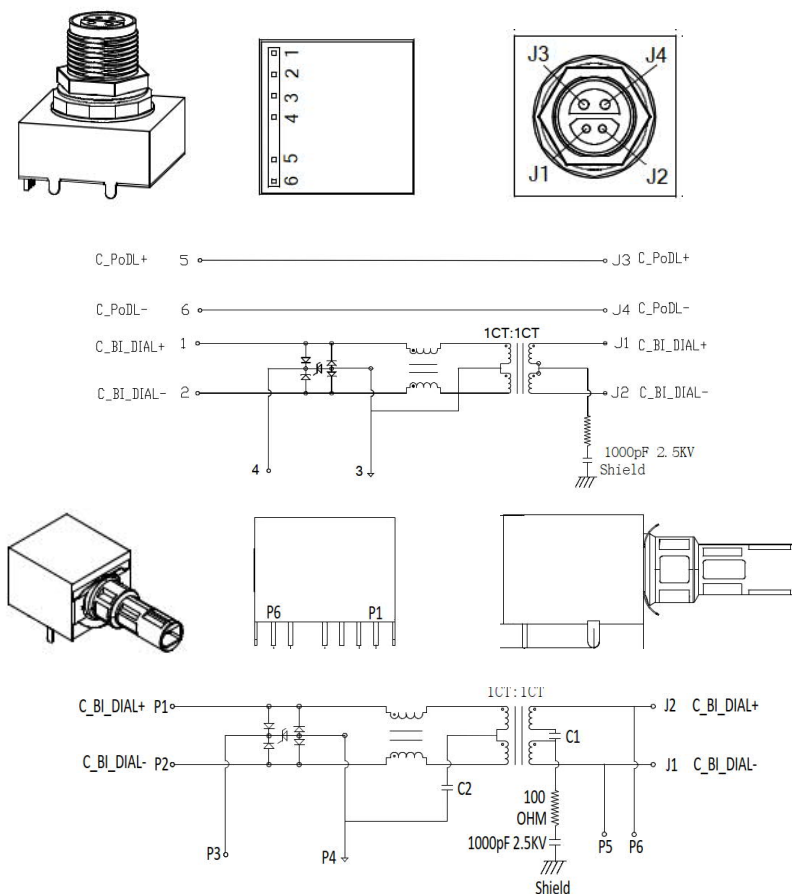


Figure 9. M8 Connector + SPE



About the author:

Paul Su, the Senior R&D engineer of MAGCOM with more than 25 years in magnetic design. He is especially capable of finding the best solution in transmit in high frequencies and has knowledge of core materials.