

How to Meet the Higher Isolation Creepage & Clearance Needs in Automotive Applications

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Introduction:

As technology moves forward towards miniaturization of integrated circuits, there are certain instances when the smallest package may not always be the answer. Especially when it comes to isolation in systems. Typically an isolator is used to separate systems with two different potentials. From the basic physics courses, one may remember the formula $E = (V/l)$, where E is the electric field that is created when the voltage difference of V exists across a length of wire l. So as we increase the isolation voltage across the isolator without increasing the length (or width of the package in the case of the isolators), it could cause arcing or breakdown.

Creepage and Clearance:

Creepage and clearance are two terms that are important when it comes to isolator package widths. Creepage as shown in Figure 1 is the shortest distance between the package leads along the surface of the package while clearance is shown in Figure 2 and is defined as the shortest distance between the leads along air.

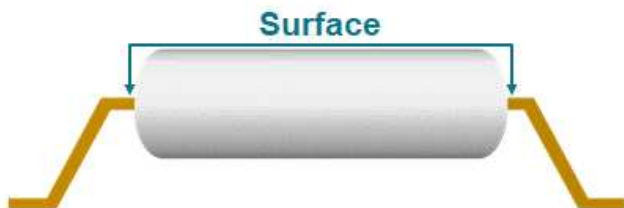


Figure 1. : Creepage across a isolator package



Figure 2. Clearance across a isolator package

Both these parameters are important because when the electric field is present across the isolator, the breakdown can happen either of the package or of the air that is below the package. Selecting the right width of the package become imperative to ensure reliable

operation of the isolator, especially with high voltage electric vehicles being designed at 400 V and beyond. Typically the isolation ratings are tied to the package dimensions so a quick look at the isolation ratings and the creepage/clearance data in the device datasheet should suffice.

For 400 V or below battery voltages, creepage/clearance of around 4 mm should be sufficient. While for 800 V batteries, 8 mm creepage/clearance is desired. These typical numbers are perfectly fine at sea level. But when you consider the higher altitudes, the atmospheric pressure drops causing the breakdown through air easier than at sea level. This requires the device leads to be moved further apart to prevent arcing, thereby increasing the clearance requirements. BMS systems, high voltage junction boxes and high voltage heaters beyond 800 V are some of the applications that are requiring higher creepage and clearance distances.

Solutions for higher creepage and clearance:

It is easy to find packages that meet up to 8 mm creepage/clearance. But what about beyond those numbers? One solution is to use two devices in series as shown in Figure 3. In the example ISO7741DBQ-Q1 (creepage/clearance of 3.7 mm) or ISO7741DW-Q1 (creepage/clearance of 8 mm) could be used with another ISO7741DW-Q1 (8 mm) device to get either 12 mm or 16 mm of total creepage or clearance. It may seem simple but by series connection, we have introduced an issue of the power supply for the second device as indicated by the symbol V_{cci}. This intermediate node needs to be supplied with an isolated power supply from either the 12 V side or the HV side.

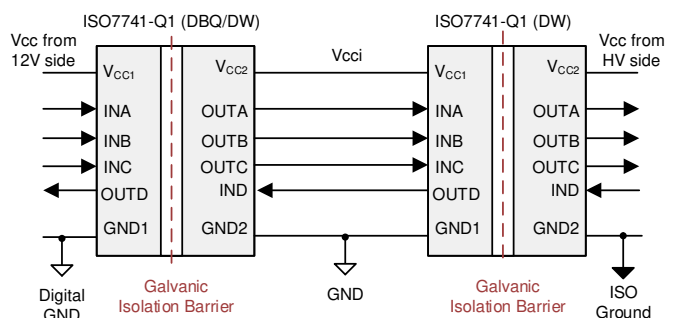


Figure 3. Two digital isolators in series for higher creepage/clearance

This can be resolved in multiple ways. Figure 4. shows a solution where the isolated power supply is created using a transformer driver (SN6501-Q1 or SN6505A-Q1), transformer, rectifier and regulator and output of the regulator (TPS76350-Q1) provides the power supply for the intermediate node Vcci. This is one discrete solution for the isolated power supply. Other discrete solutions can be created with fly-back or fly-buck converters.

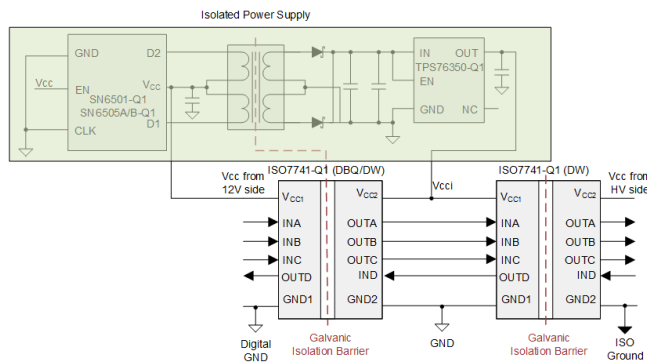


Figure 4. Discrete power supply for isolation solution with wider creepage/clearance

On the other hand, an integrated isolated power supply solution can be used as shown in Figure 5. The isolated data and power IC ISOW7841A-Q1 provides an isolated output voltage Viso than can be used to power up the secondary isolator. This makes the solution more compact as compared to the discrete approach.

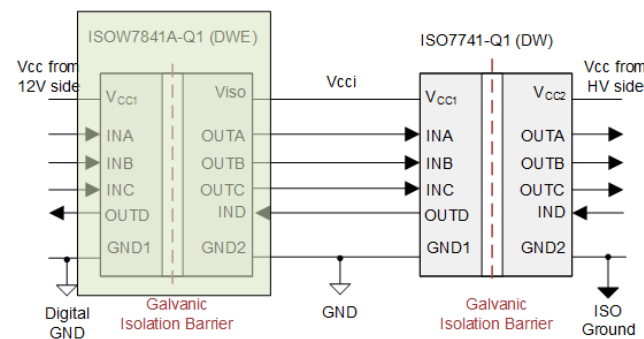


Figure 5. Integrated power supply for isolation solution with wider creepage/clearance

While both the solutions shown in Figure 4 and Figure 5 meet the requirements of higher creepage and clearance, the need for isolated power supply adds to the cost of the solution. Figure 6 shows an alternate solution using a single device Grade 1 ISO7741DWW-Q1, which has 14.5 mm distance between the leads. This ultra-wide body package eliminates the need for the intermediate power supply with the two power supplies of the device connected to the 12 V and HV sides directly. This makes the design simpler with fewer components and smaller board size, thereby reducing the overall system cost.

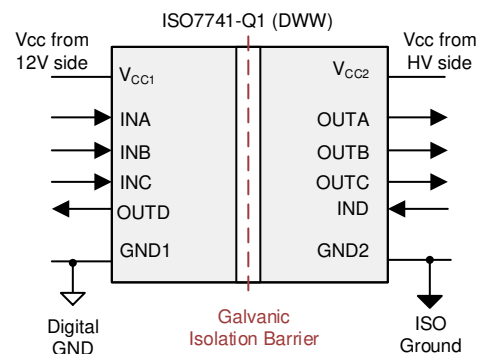


Figure 6. Ultra wide body digital isolator

Conclusion:

Choosing the isolator with the right creepage and clearance is as important or even more important than the parametric performance for an isolator. Proper distance between the leads prevents arcing and package or air breakdown. With the industry trends of increasing battery voltages, the onus of the system protection rests on the shoulder of the isolator and it needs to be the right dimension for withstanding the high voltages. In cases with higher than 8 mm creepage/clearance requirements, the ultra wide body digital isolators provide a economical and space saving solution.

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