Why Common Mode Filters support ESD protection – and how much benefit to expect in practice.

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Common Mode Filters are popular devices to avoid EMI issues with differential data lines. They are a pair of coupled coils, whose magnetic fields cancel each other out for differential signals. As a consequence, the line impedance is much lower for differential signals compared to common-mode noise or single-ended transients. For an ideal Common Mode Filter, a differential digital signal will pass while any common mode noise or single-ended transient will be suppressed.

Since the fundamental can be converted to higher harmonics due to nonlinearities in the system, suppressing Common Mode at the fundamental will also reduce noise excited at other frequencies. Nexperia offers a family of Common Mode Filters with integrated ESD protection to allow the matching of differential pass-bands to common mode rejections for USB and HDMI/DisplayPort data lines.

In practice, Common Mode Filters have a low differential signal attenuation and a high common mode rejection at signal frequencies, since the most common EMI issue is that wireless signals are disturbed by wired signal transmissions. A strong Common Mode Rejection at the fundamental of the wired signal is beneficial, since the fundamental carries most of the energy.
Combining Common Mode Filters with ESD protection offers an additional benefit, which is less known – since the inductance of their coils is also effective for single-ended transients such as Electro-Static Discharge (ESD), they are also highly effective ESD protection devices, if connected with diodes facing the connector side, as shown in the data sheet. To achieve this, lines 1 and 2 can be exchanged to allow transmitter or receiver operation, as shown in Figure 3:

As Notermans et al. have shown [1], it is obvious that the ESD protection inductance to GND Lc should be minimized and the board inductance Lb maximized to achieve the best possible system-level protection of the system below:

Comparing measured (solid) and simulated (dashed) residual currents of this setup when exposed to the first peak of an ESD pulse, we get two conclusions, when comparing the same protection technology with different Lc and Lb values (Figure 5):

› Increasing the board inductance Lb by using a Common Mode Filter with integrated ESD protection is offering a further significant reduction of this residual current (green)

› Reducing the ESD protection inductance by moving from a wire-bonded package (red) to a monolithic DSN package (blue) without bond wires like Nexperia’s SOD962 offers already a significant reduction of this residual current.

To establish the amount of reduction we can expect in practice, we have run a test series using Transmission Line Pulse (TLP) measurements to compare the peak voltage over TLP current with and without Common Mode Coils of Nexperia Protection + CMF devices PCMF1USB3S, PCMF1USB3B and PCMF1USB3BA. TLP is our preferred method of characterization, since, opposed to ESD gun measurements, it allows reproducible measurements [1][2]. TLP measurements were performed with 0.6 ns rise time to match the first peak of an IEC61000-4-2 standard ESD pulse. The outcome can be seen in Figure 6:
The coils of the PCMF1USB3B integrated Common Mode Filter are offering a peak voltage reduction of about 30% at 30 A TLP compared to the coil-less reference.

Repeating the same test series with two filters with lower (PCMF1USB3S) and higher (PCMF1USB3BA) frequency optimization showed that these filters offer a significant reduction of the peak voltage as well:

![Graph showing peak voltage reduction](image)

**Figure 7** Peak ESD pulse reduction in a Transmission Line Pulse (TLP) setup for further integrated Common Mode Filters with ESD protection.

**Conclusion**

As predicted [1], integrated Common Mode Filters with ESD protection offer a significant reduction of the peak voltage of ESD pulses.
