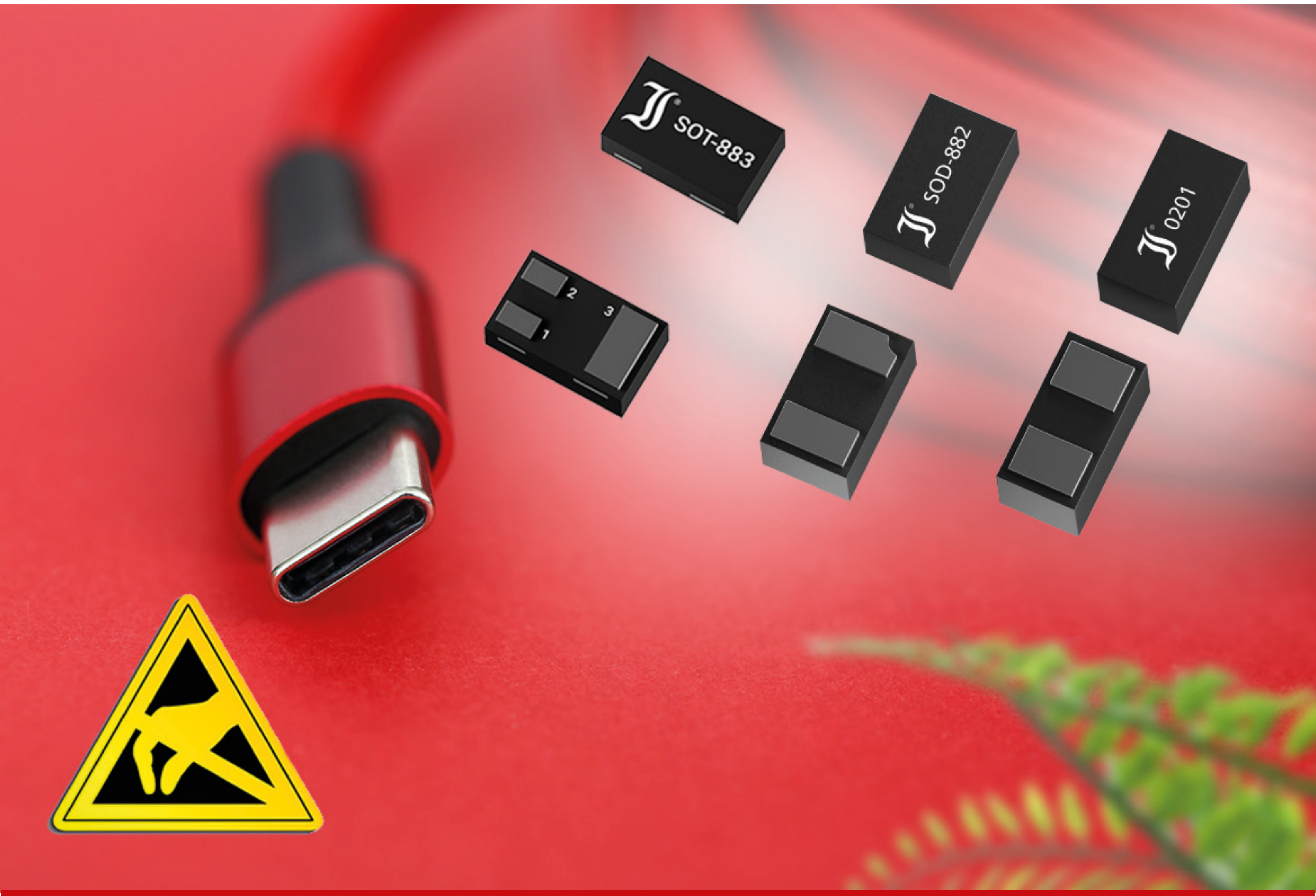
APPLICATION NOTE



ESD-Protection Diodes for High-speed Signal Interfaces

Introduction

This application note is about choosing suitable diodes for high-speed signal interfaces. One of the major industry trends towards smaller chip size and higher data rate decreases chip tolerance to any voltage transient surge events. Therefore, electrostatic discharge (ESD) protection diodes play a bigger role than before. In addition, designers are no longer relying on the internal capability of the semiconductor components, but on an external protection added to eliminate the risk against any voltage transient events.

Problem Statement

The challenge here entails using external transient voltage suppressors (TVS) with lower clamping voltage to protect the sensitive chipset in order to lower the clamping voltage; this will also result in a higher parasitic capacitance. These two electrical dimensions - clamping voltage and parasitic capacitance - are inversely proportional to each other. When using for high-speed signals or rather in high frequency applications, a fast rise time is important. The rise time is proportional to the capacitance, so that increasing the capacitance slows down the rise time. Furthermore, it is indispensable that the parasitic capacitance is so low that it doesn't spoil the signal pulse.
The correlation of these characteristics can be explained using the simplified step response in low-pass RC network.
The general equation for low-pass RC can be described as follows:

$$V(t) = V_0 \cdot \left(1 - e^{\frac{-t}{\tau}}\right)$$

It can be resolved according to:

$$t = -\tau \cdot \ln\left(1 - \frac{V(t)}{V_0}\right)$$

Now determine the rise time t_r from 10% to 90% of the output signal:

$$\frac{V(t_1)}{V_0} = 0.1\,;\ \frac{V(t_2)}{V_0} = 0.9$$

$$t_r = t_2 - t_1$$
$$t_r = -\tau \cdot (\ln(1-0.9) - \ln(1-0.1))$$
$$t_r = 2.197\,\tau$$

In low-pass RC network is known that:

$$\tau = R \cdot C = \frac{1}{2\pi \cdot f_H}$$

Therefore, the following applies:

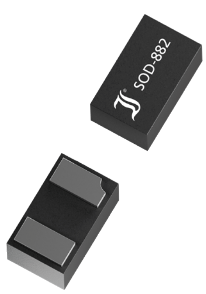
$$t_r = 2.197 \cdot R \cdot C \leftrightarrow C = \frac{t_r}{2.197 \cdot R}$$

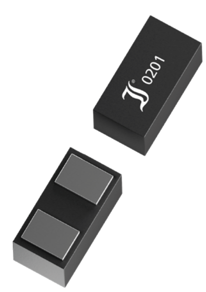
Since the frequency of high-speed signals is equal to the bandwidth, the capacitance can be determined as follows:

$$C = \frac{1}{2\pi \cdot R \cdot f_H} \cong \frac{1}{2\pi \cdot R \cdot BW}$$

Building on the above equation in order to apply an external ESD protection diode in high-speed signal, a lower parasitic capacitance is required. Luckily, the equation above can help to choose suitable ESD diodes.

	USB 2.0	USB 3.0	USB 3.1	HDMI 1.3/1.4	HDMI 2.0
Bandwidth	480 Mbps	5 Gbps	10 Gbps	3.4 Gbps	6 Gbps
Max. C_j	7.37 pF	0.44 pF	0.22 pF	0.94 pF	0.53 pF
Diotec's PN	**ESD0541Z** **ESD0521Z** **ESD-9BL0521P**	**DI5315-02F** **ESD9BL0522P**	**-**	**ESD0541Z** **ESD0521Z** **ESD-9BL0521P**	**DI5315-02F** **ESD-9BL0522P**
	LIN	CAN (low speed)	CAN (high speed)	CAN FD	
Bandwidth	20 kbps	125 kbps	1 Mbps	Up to 5 Mbps	
Max. C_j	220 pF	220 pF	220 pF	220 pF	
V_{BR}	>27 V	>24 V	>24 V	>24 V	
Diotec's PN	**ESD36CA** **PSOT36/C**	**ESD3B24WS** **ESD3ZW24**	**ESD9BL24P** **ESD5Z24**	**ESDB24C-AQ** **NUP2105L-AQ** **ESDBL24DP**	





Disclaimer
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