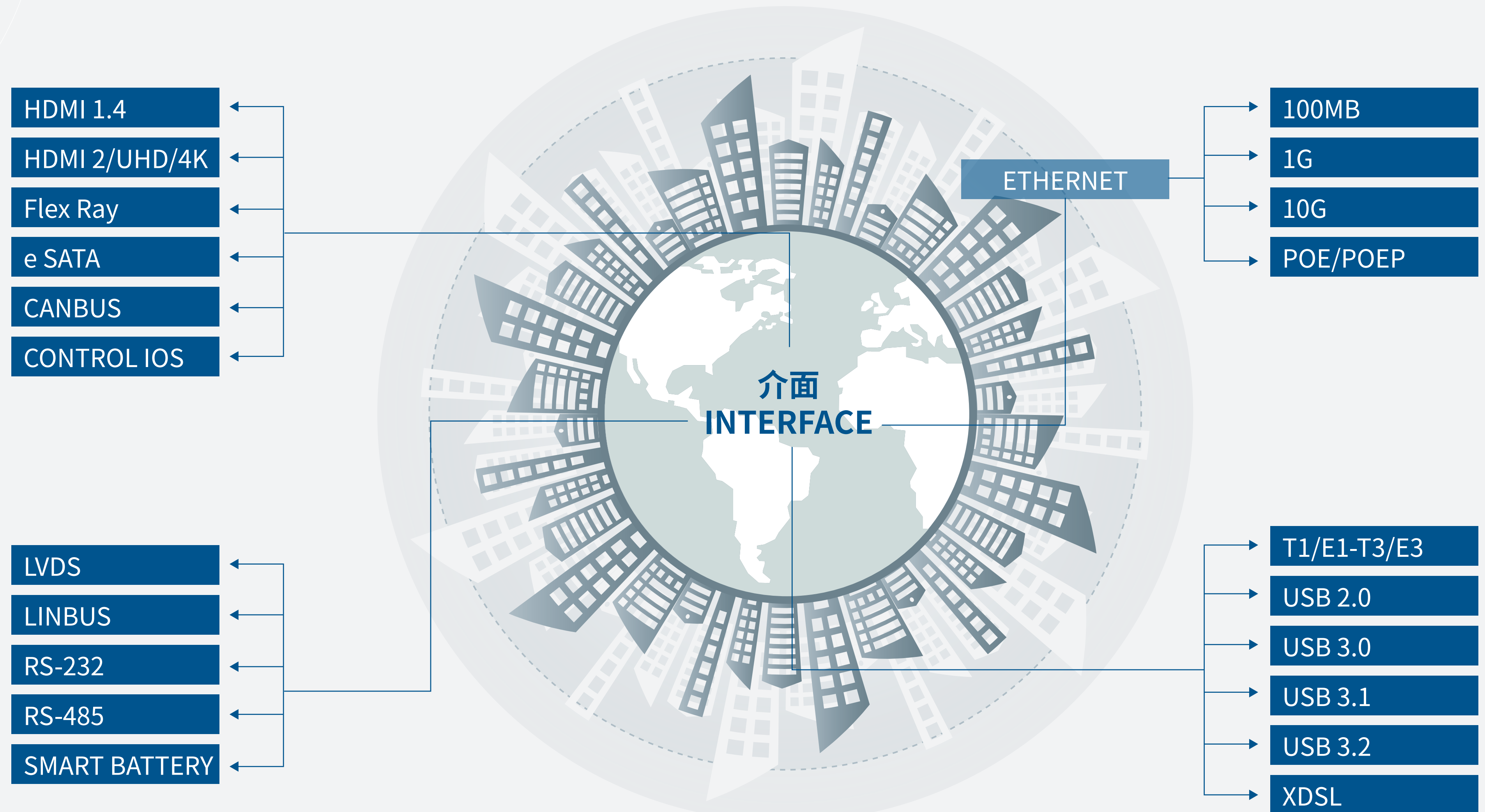




APPLICATION GUIDE **ESD PROTECTION**

COMMUNICATION APPLICATIONS



ESD Protection Solutions for High Speed Communication Ports

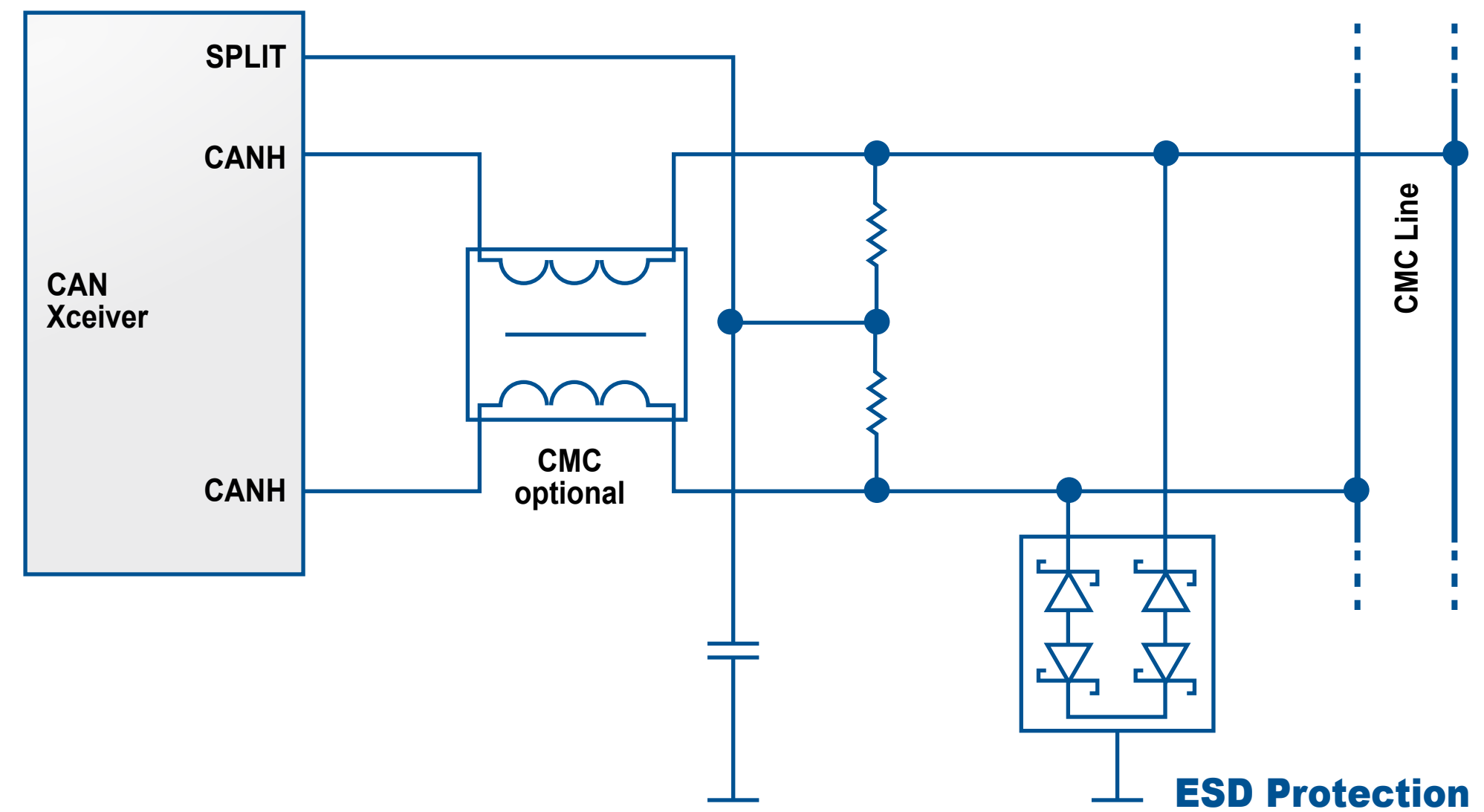
- Electrostatic discharge (ESD) occurs when a charge is exchanged between two objects of unequal charge potential. ESD most often occurs between people and metal objects. It is a result of an electron build-up behaving as capacitor when dielectric isolation is available. Manmade materials, such as shoe soles, achieve dielectric isolation while someone walks on carpet creating kinetic energy. The potential threat of an ESD transient poses a challenge to system designers to incorporate overvoltage protection. Often, the included protection must have capacitance while not degrading the transmission rate. Traditionally, the use of a high capacitor was used to provide protection. However, due to high speed requirements, the capacitance per line must be significantly reduced. It must be done while still providing overvoltage protection against potential threats. Threats can include ESD, electrical fast transients (EFT), or surges. This paper discusses standard requirements for ESD. It highlights overvoltage protection solutions for the most common high speed interfaces. These include USB, HDMI and Ethernet ports, as shown in Table 1.

Application	Data Rate	Capacitance
RS-232	0.20 Mbit/S	< 50 pF
T1	1.544 Mbit/S	< 30 pF
E2	2.048 Mbit/S	
I2C	3.4 Mbit/S	
Ethernet	10 Mbit/S	
USB1.1	12 Mbit/S	< 20 pF
E3	34.368 Mbit/S	
RS-485	35 Mbit/S	
T3	44.736 Mbit/S	
Fast Ethernet	100 Mbit/S	< 5 pF
T5	400.352 Mbit/S	< 3 pF
USB 2.0	480 Mbit/S	
E5	565.148 Mbit/S	
IEEE-1394b	786.432 Mbit/S	
Gigabit E	565.148 Mbit/S	
DVI	3960 Mbit/S	< 1 pF
USB 3.0	5000 Mbit/S	
DisplayPort	5400 Mbit/S	
SATA 3.0	6000 Mbit/S	
HDMI 1.3	10200 Mbit/S	
HDMI 2.0	10800 Mbit/S	

Automotive interfaces

- CAN

CAN system architecture with a single device to protect the CAN node

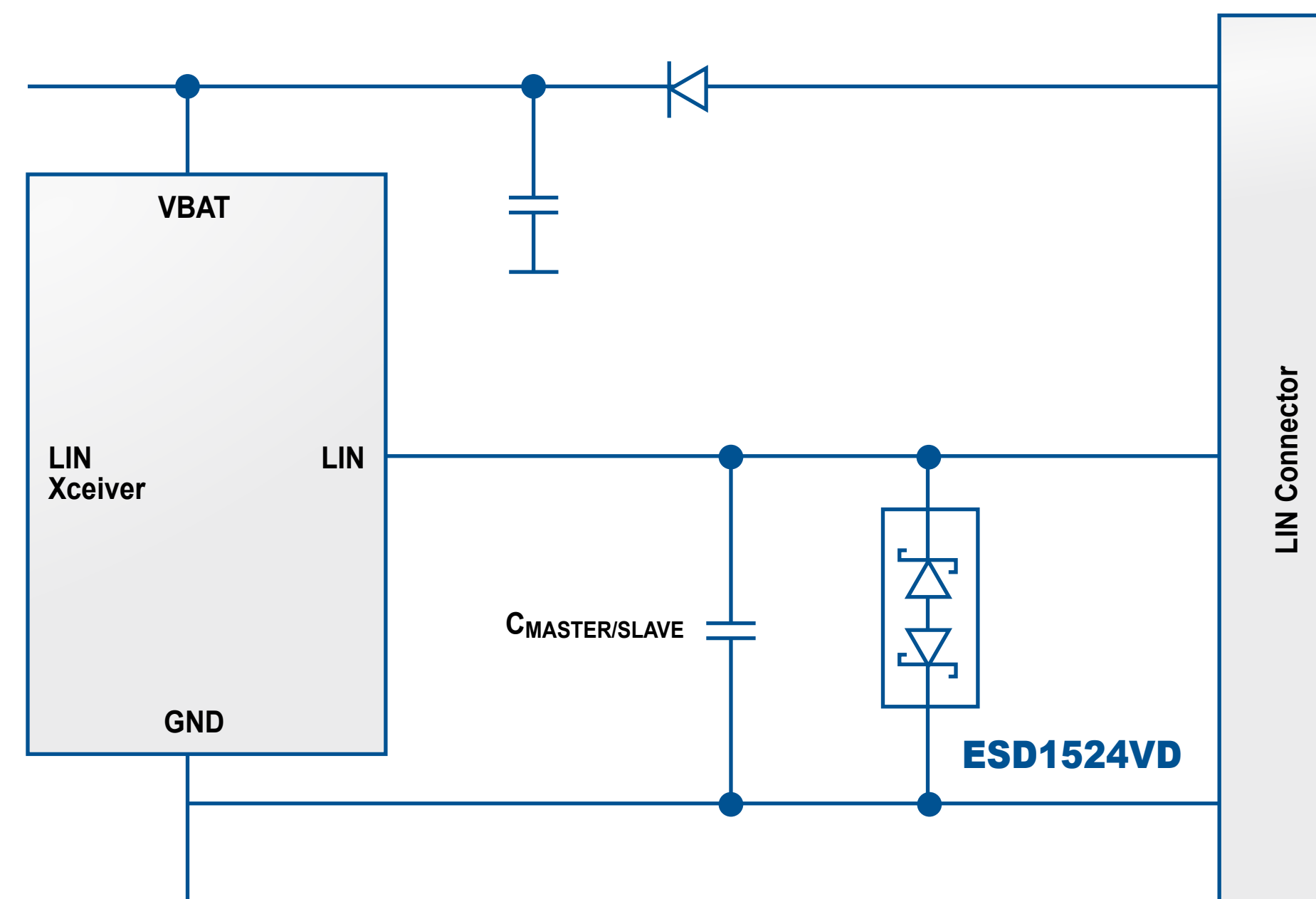


Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
FSSU24T23A	24V	350 Watts	45 pF	30KV	SOT-23
FDA2431T	24V	230 Watts	30 pF	30KV	SOT-23
SOT24C	24V	160 Watts	50 pF	30KV	SOT-23
FM712	7V / 12V	400 Watts	75 pF	30KV	SOT-23

Automotive interfaces

- LIN

LIN system architecture with a single device to protect the LIN node



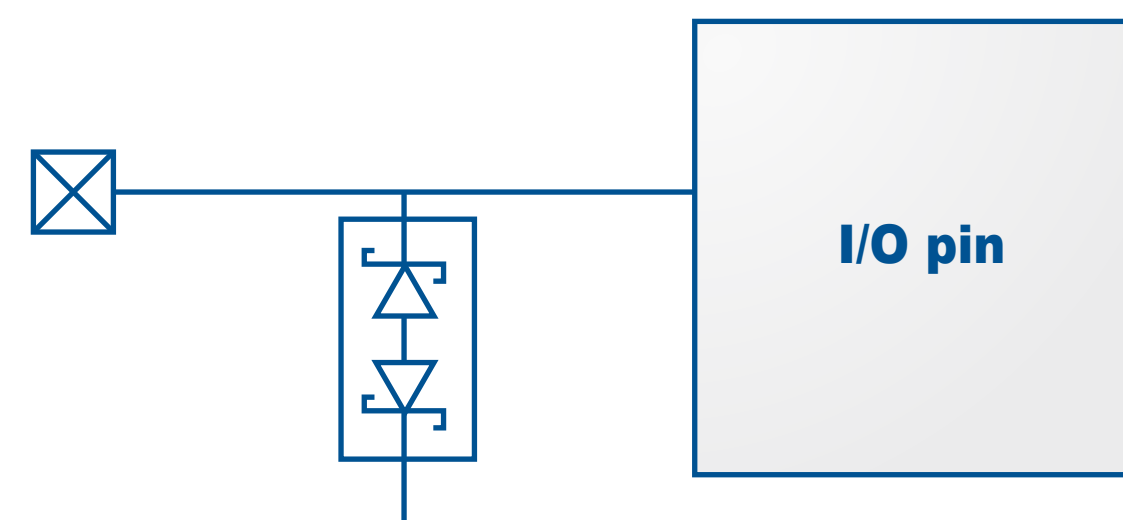
Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
ESD1524VD	15V/24V	160 Watts	20 pF	30KV	SOD-323

Automotive interfaces

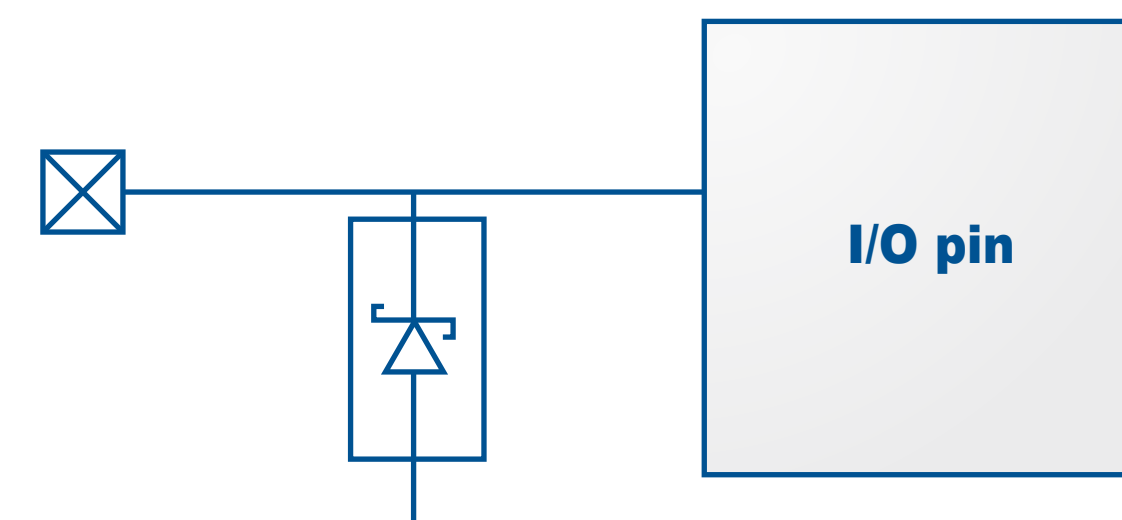
- FlexRay

Bi-directional and Uni-directional ESD protection for GRIO

GPIO Bi-directional protection



GPIO Uni-directional protection

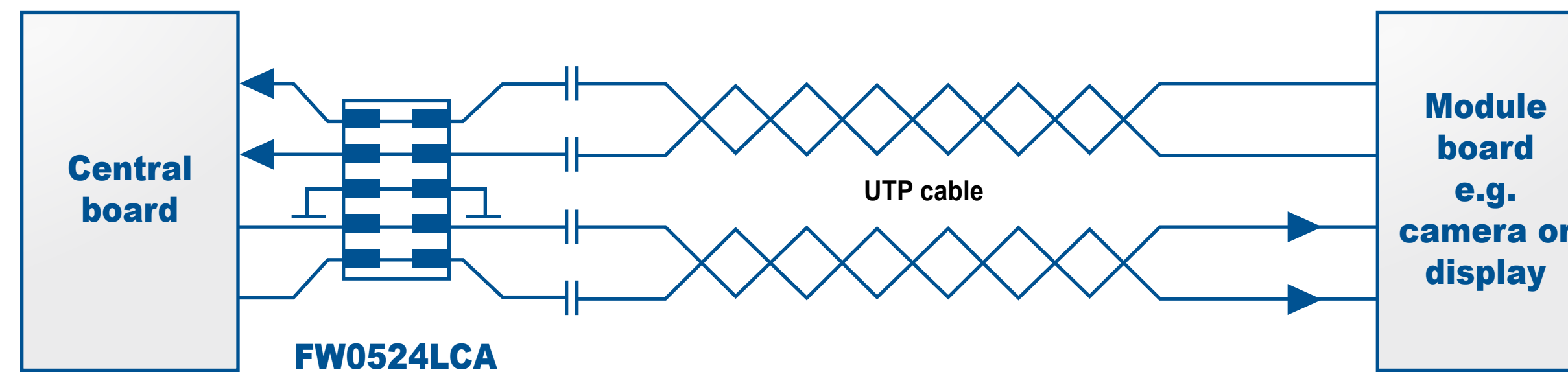


Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
BSD24C	24V	350 Watts	50 pF	30KV	SOD-323
FSD24C	24V	350 Watts	50 pF	30KV	SOD-323
GBLC24CI	24V	350 Watts	0.6 pF	30KV	SOD-323
GBLC24C	24V	350 Watts	0.6 pF	30KV	SOD-323

Automotive interfaces

- Car infotainment

In LVDS systems, the FW0524LCA provides ultra high-speed ESD protection that is fully AEC-Q101 compliant



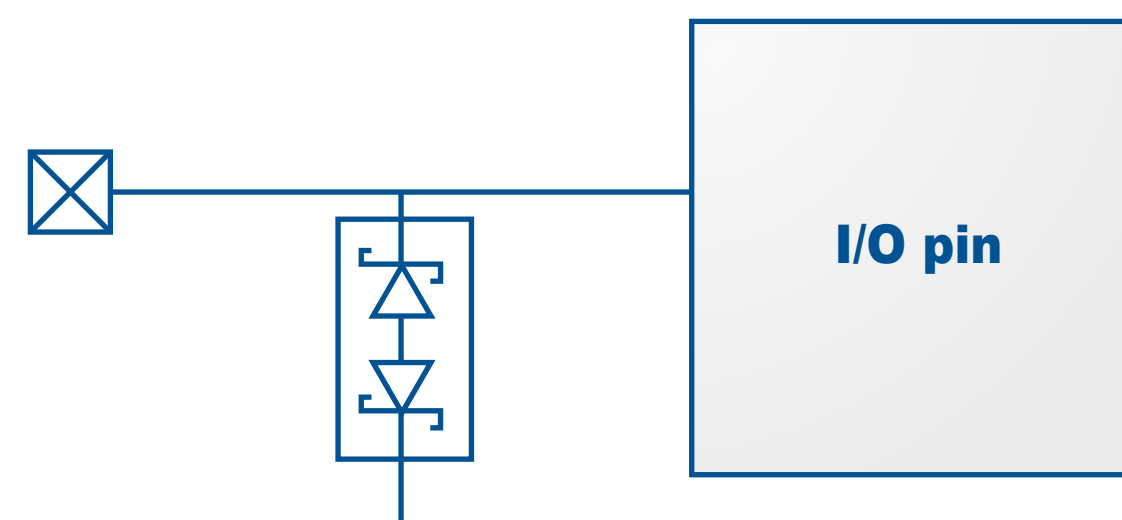
Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FW0524LCA	5V	150 Watts	0.4 pF	30KV	DFN2510-10L

General I/O protection

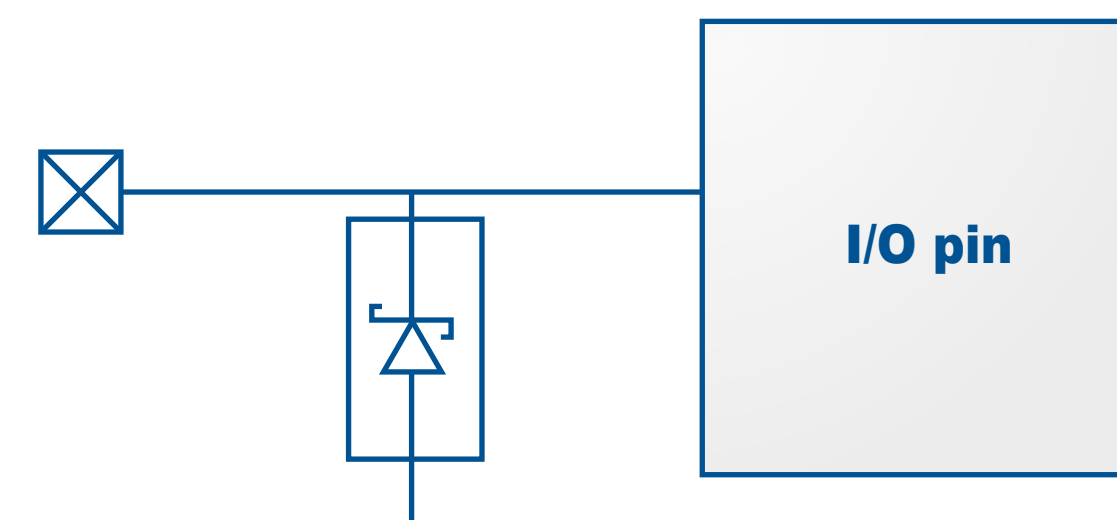
- Digital I/O

Bi-directional and uni-directional ESD protection for GPIO

GPIO Bi-directional protection



GPIO Uni-directional protection



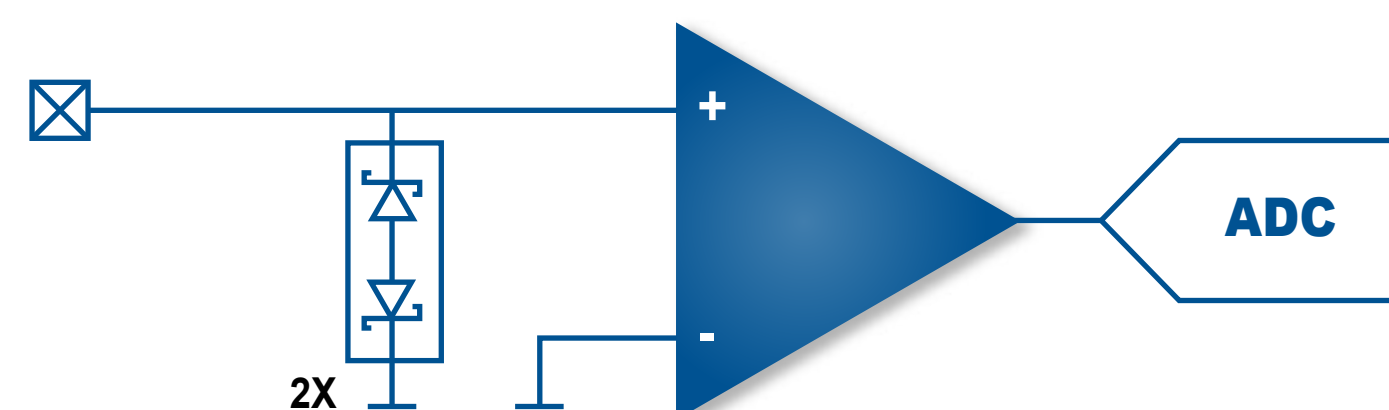
Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FLC052AD	5.0V	80 Watts	0.3 pF	25KV	DFN0603
FLC0529D	5.0V	40 Watts	0.3 pF	22KV	DFN1006
FLC052XD	5.0V	40 Watts	0.15 pF	22KV	DFN0603
FLC032XD	3.3V	45 Watts	0.20 pF	20KV	DFN0603
FHC2511D	2.5V	90 Watts	2.50 pF	30KV	DFN1006
FHC1815D	1.8V	200 Watts	1.50 pF	30KV	DFN1006

General I/O protection

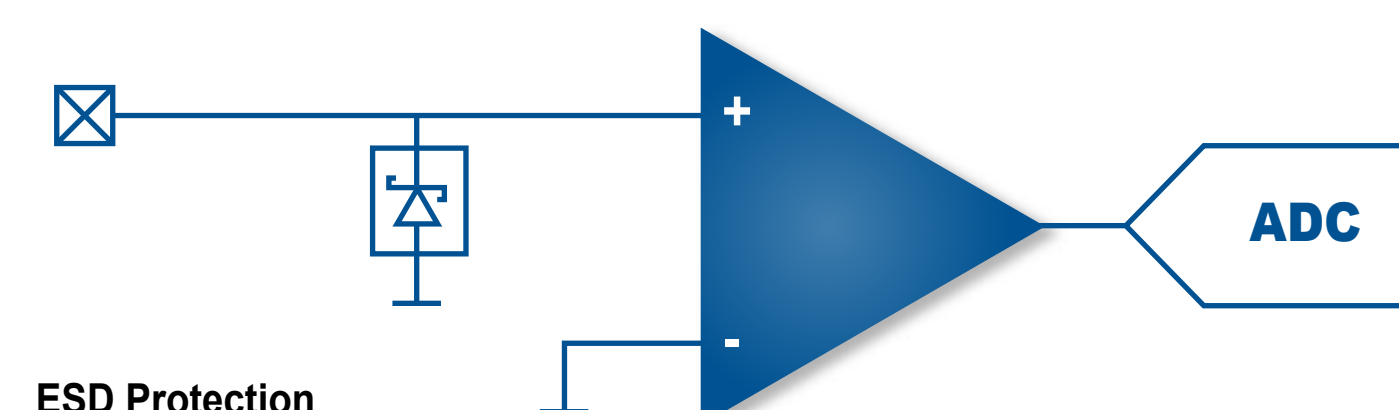
- Analog I/O

Analog I/O protection using the xxxx with single or multiple devices

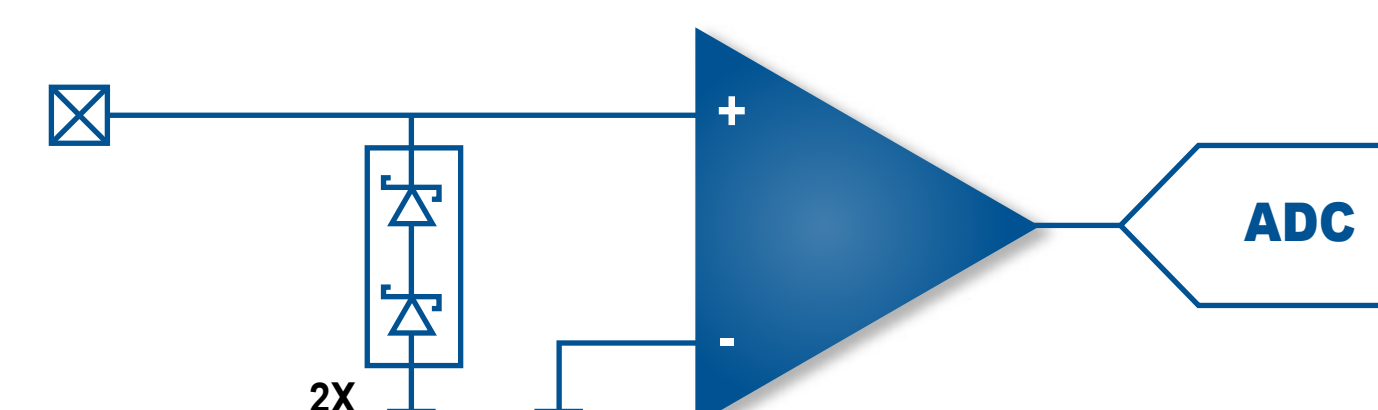
Bi-directional



Uni-directional



Uni-directional Double V_{RWM}



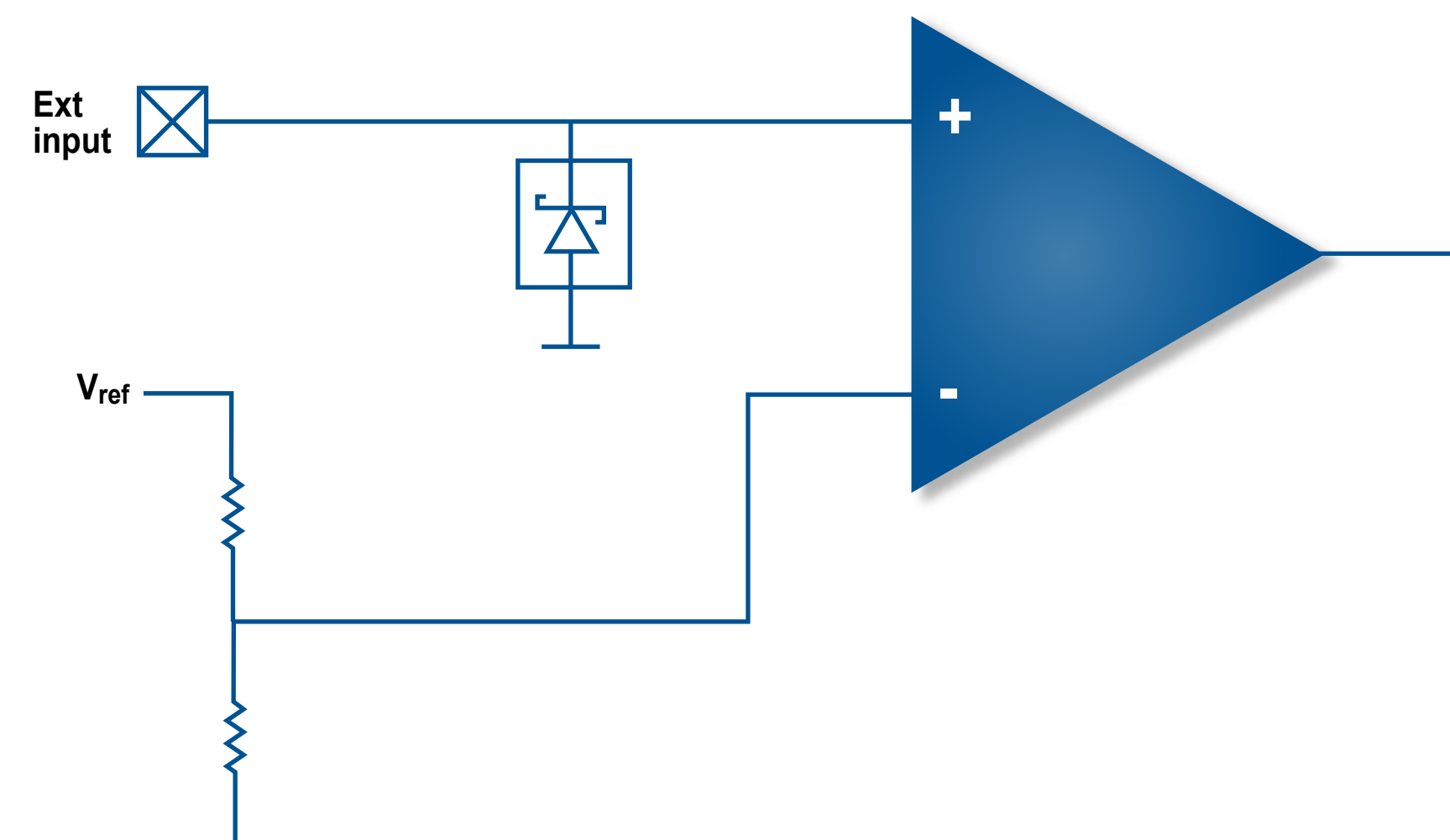
Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FSD12C	12V	350 Watts	100 pF	30KV	SOD-323
SOT12C	12V	180 Watts	40 pF	30KV	SOT-23
FSD24C	24 V	350 Watts	50 pF	30KV	SOD-323
FHC2421D	24 V	200 Watts	30 pF	30KV	DFN-1608

Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FDA2431T	24 V	200 Watts	30 pF	30KV	SOT-23
SD36A	36 V	350 Watts	30 pF	30KV	SOD-523
SOT36CB	36 V	120 Watts	30 pF	15KV	SOT-23

General I/O protection

- Low-Voltage Comparator

External ESD Protection for Internal microcontroller Comparator

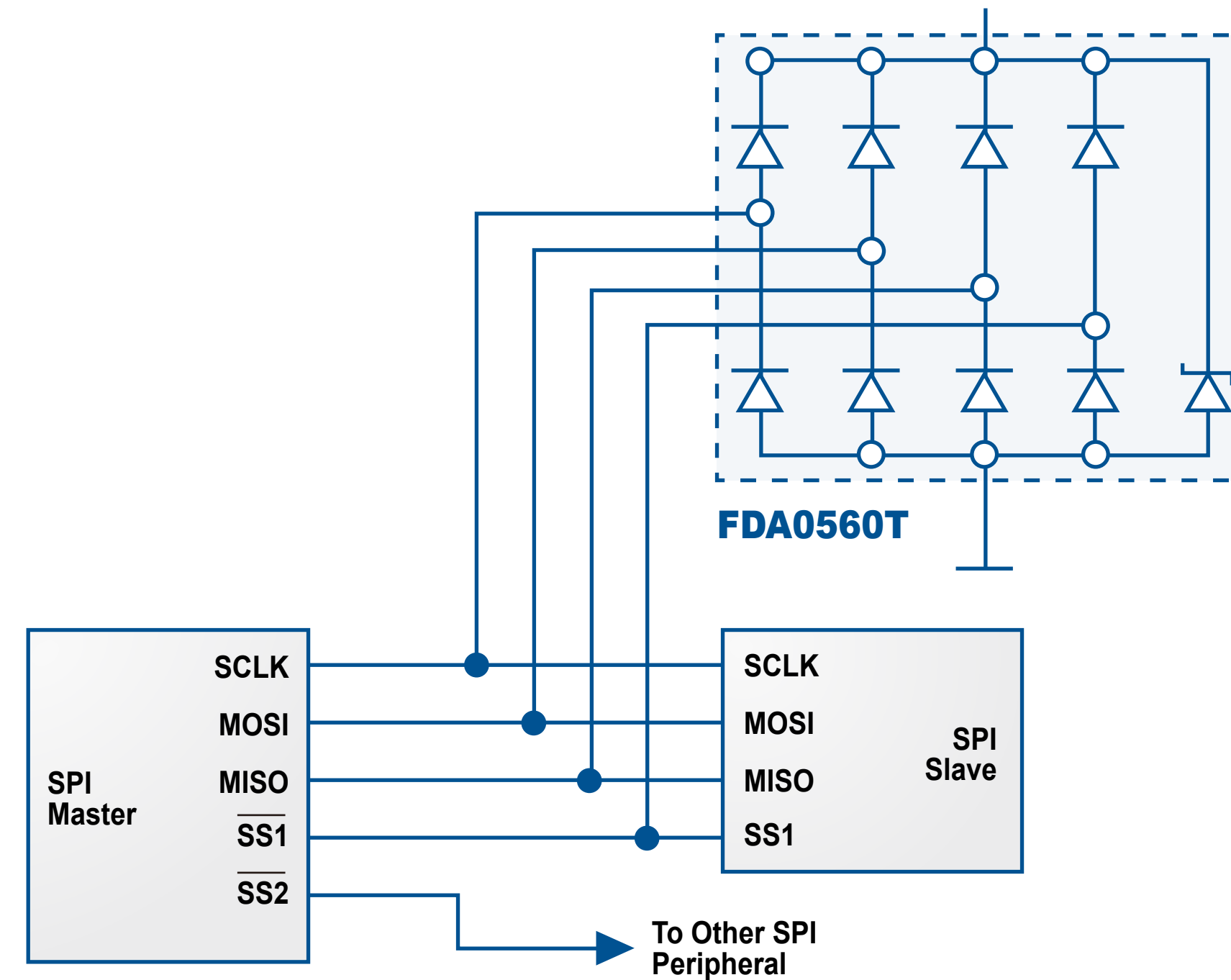


Part No.	V_{RWM}	$P_{PK, 8/20\mu S}$	$C_J, \text{Max.}$	ESD Level	Package
FSD0529D	5 V	45 Watts	6 pF	8 KV	SOD-523
FM05D5G	5 V	130 Watts	30 pF	30KV	SOD-523
FHC0521D	5 V	250 Watts	170 pF	30KV	DFN-1006
FHC3325DA	3.3 V	300 Watts	30 pF	30KV	DFN-1006
FLC0329D	3.3 V	200 Watts	30 pF	30KV	DFN-1006
FDA0535T	5 V	120 Watts	5 pF	30KV	SOT-23
SOT05C	5 V	260 Watts	125 pF	15KV	SOT-23

Serial Buses

- Legacy: SPI/SSI

SPI Protection showing a single device with a four-line, rail-to-rail diode

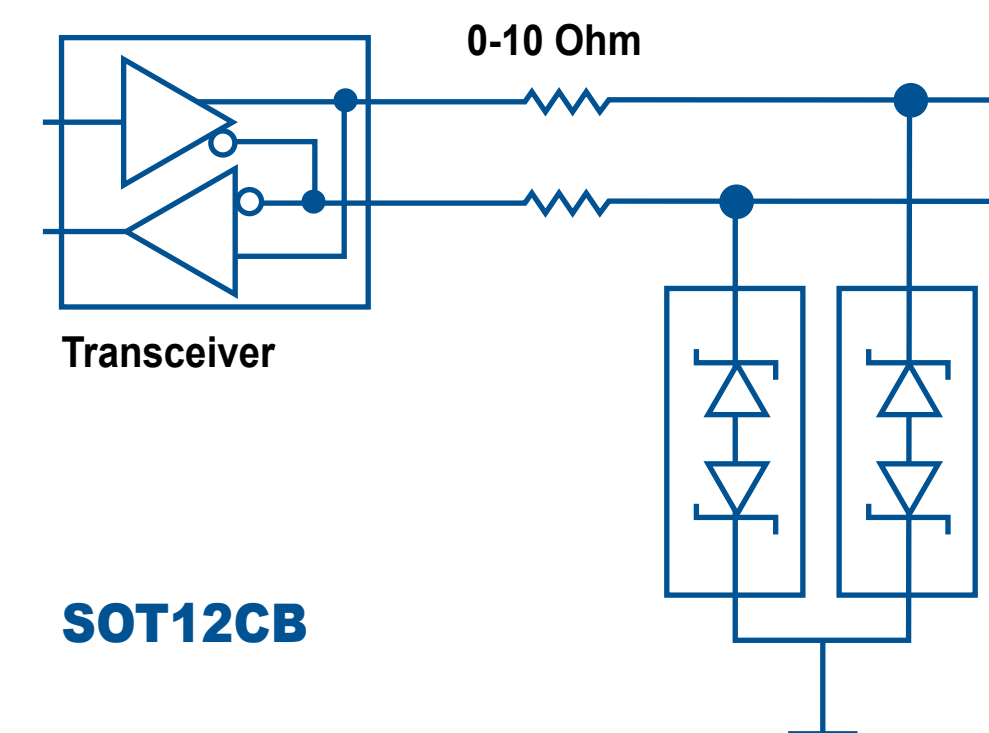
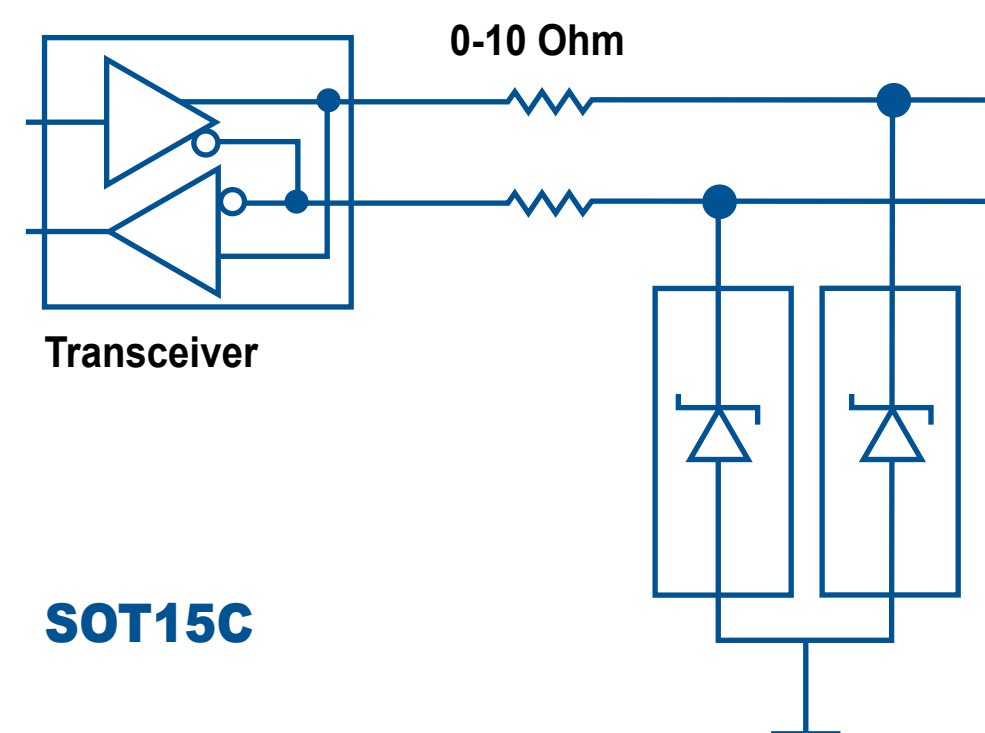


Part No.	V_{RWM}	P_{PK} , 8/20 μ S	C_J , Max.	ESD Level	Package
FDA0560T	5V	150 Watts	0.4 pF	8KV	SOT23-6

Serial Buses

- Legacy: RS-232 and RS-485

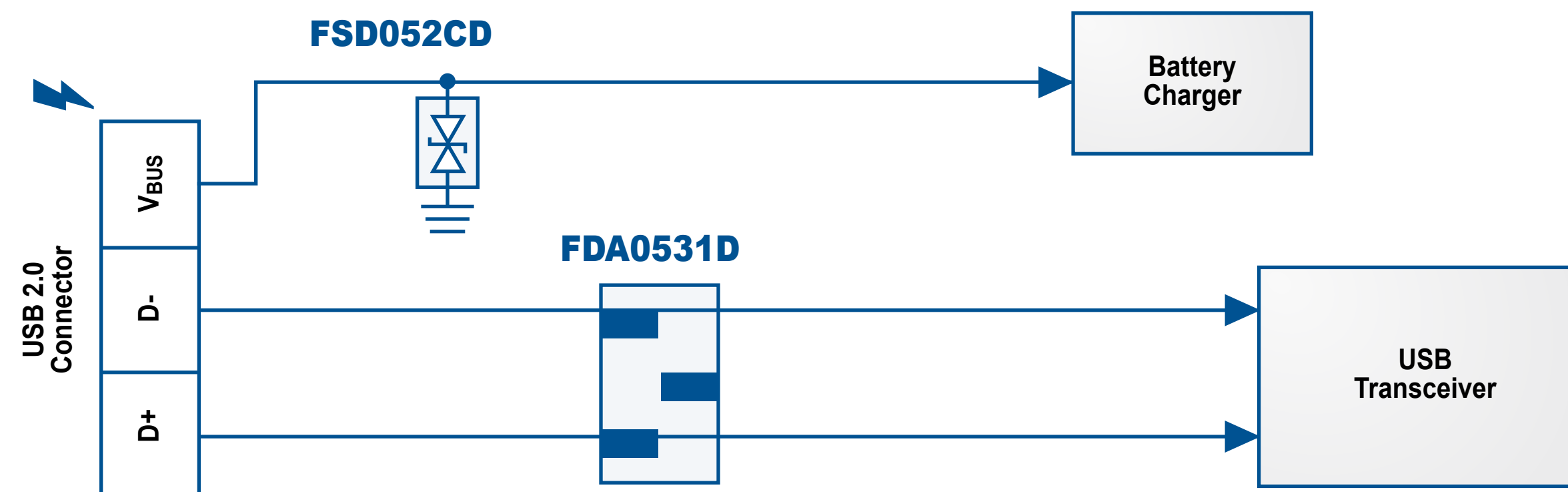
Standard serial port, RS-485, or RS-23 protection can be either unidirectional or bidirectional



Part No.	V_{RWM}	$P_{PK, 8/20\mu S}$	$C_J, \text{Max.}$	ESD Level	Package
SOT12CB	12 V	180 Watts	40 pF	30KV	SOT-23
SOT15C	15 V	160 Watts	30 pF	30KV	SOT-23

Serial Buses

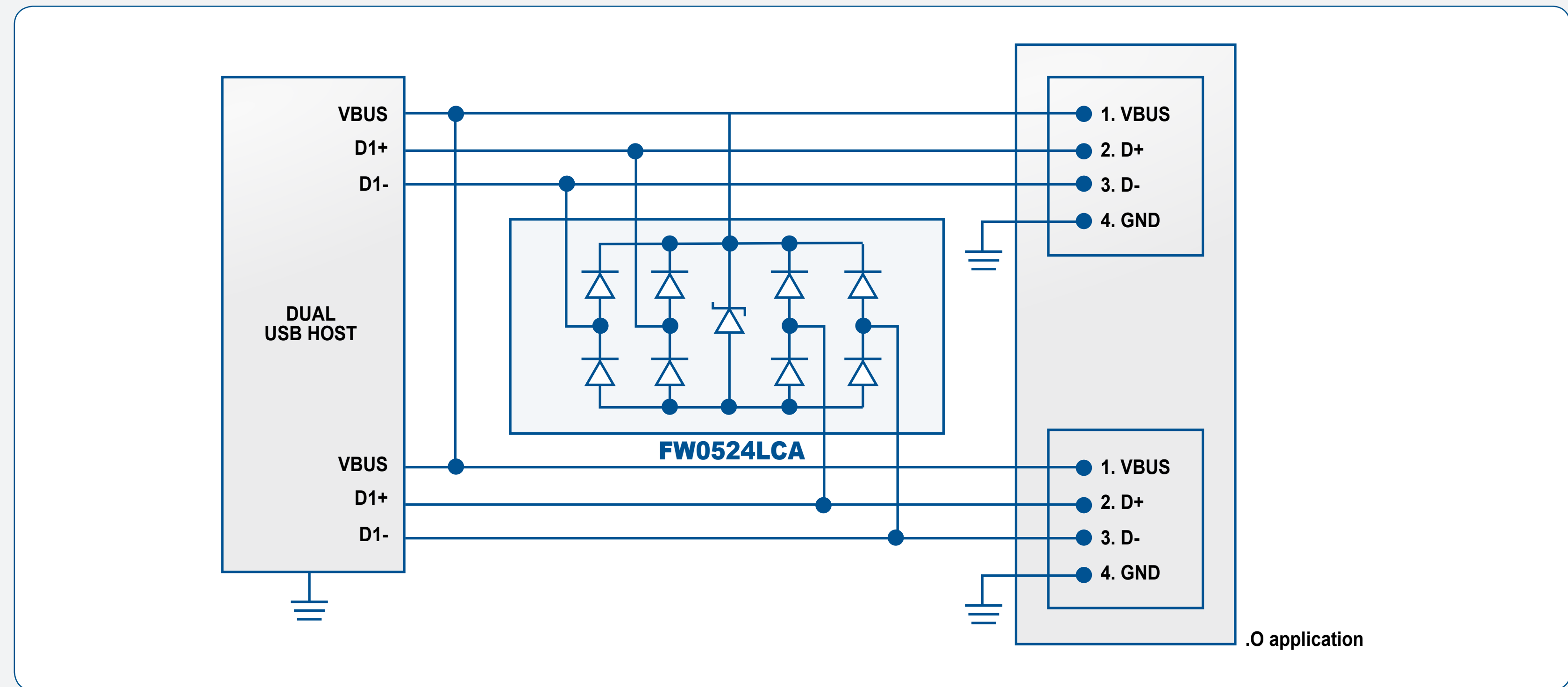
- USB2.0 Circuit Protection



Part No.	V_{RWM}	$P_{PK, 8/20\mu S}$	$C_J, \text{Max.}$	ESD Level	Package
FSD052CD	5 V	60 Watts	13 pF	8 KV	DFN1006
FLC052TDQ	5 V	80 Watts	0.3 pF	25 KV	DFN1006
FDA0531D	5 V	40 Watts	0.3 pF	22 KV	DFN1006-3L
FDA0331D	3.3 V	48 Watts	3.5 pF	8 KV	DFN1006-3L
FDA0533T	5 V	100 Watts	0.4 pF	8 KV	SOT23

Serial Buses

- Dual USB 2.0 Protection

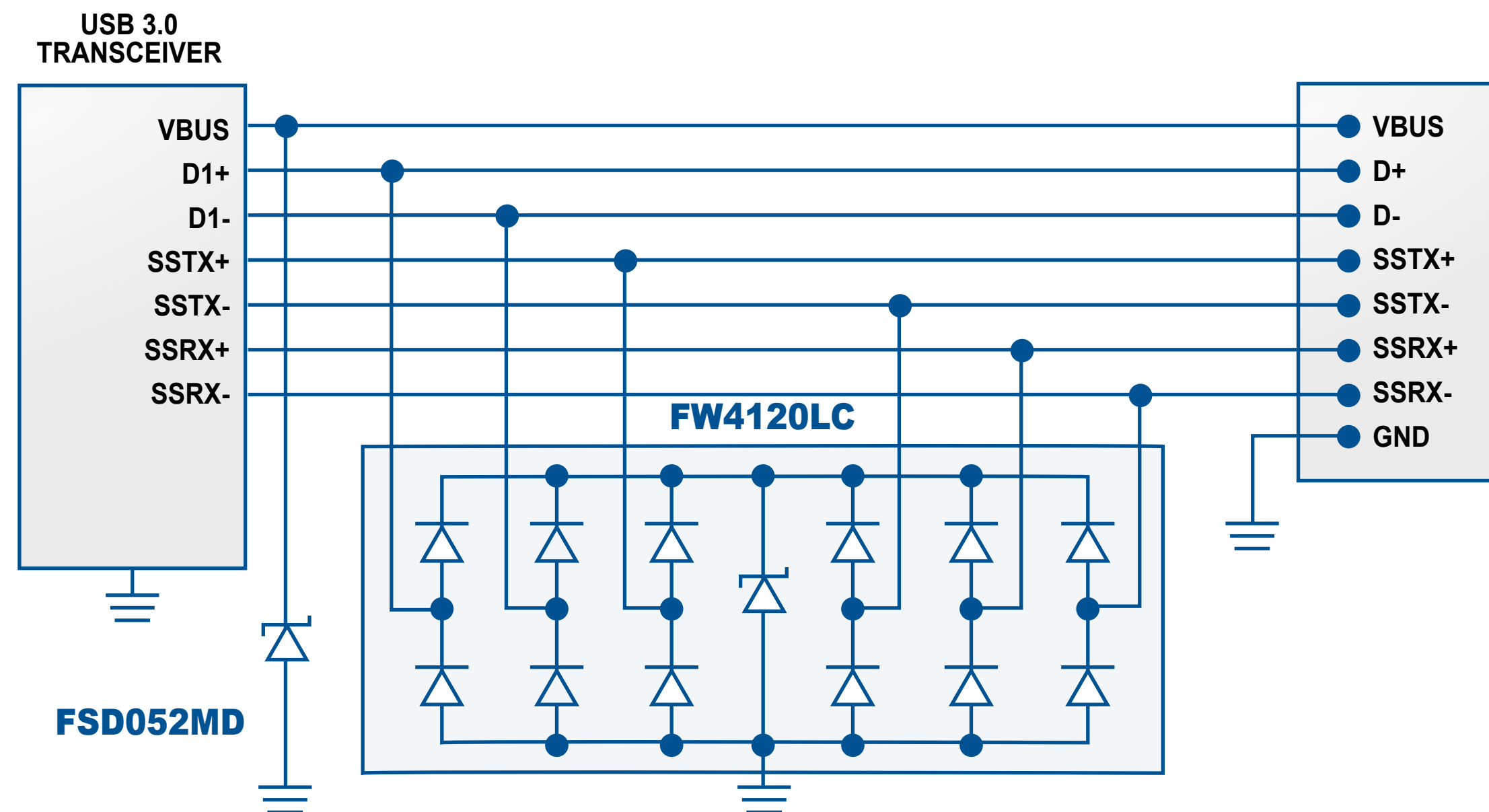


Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FW0524LCA	5V	150 Watts	0.4 pF	30 KV	DFN2510-10L

Serial Buses

- High data-rate: USB 3.0

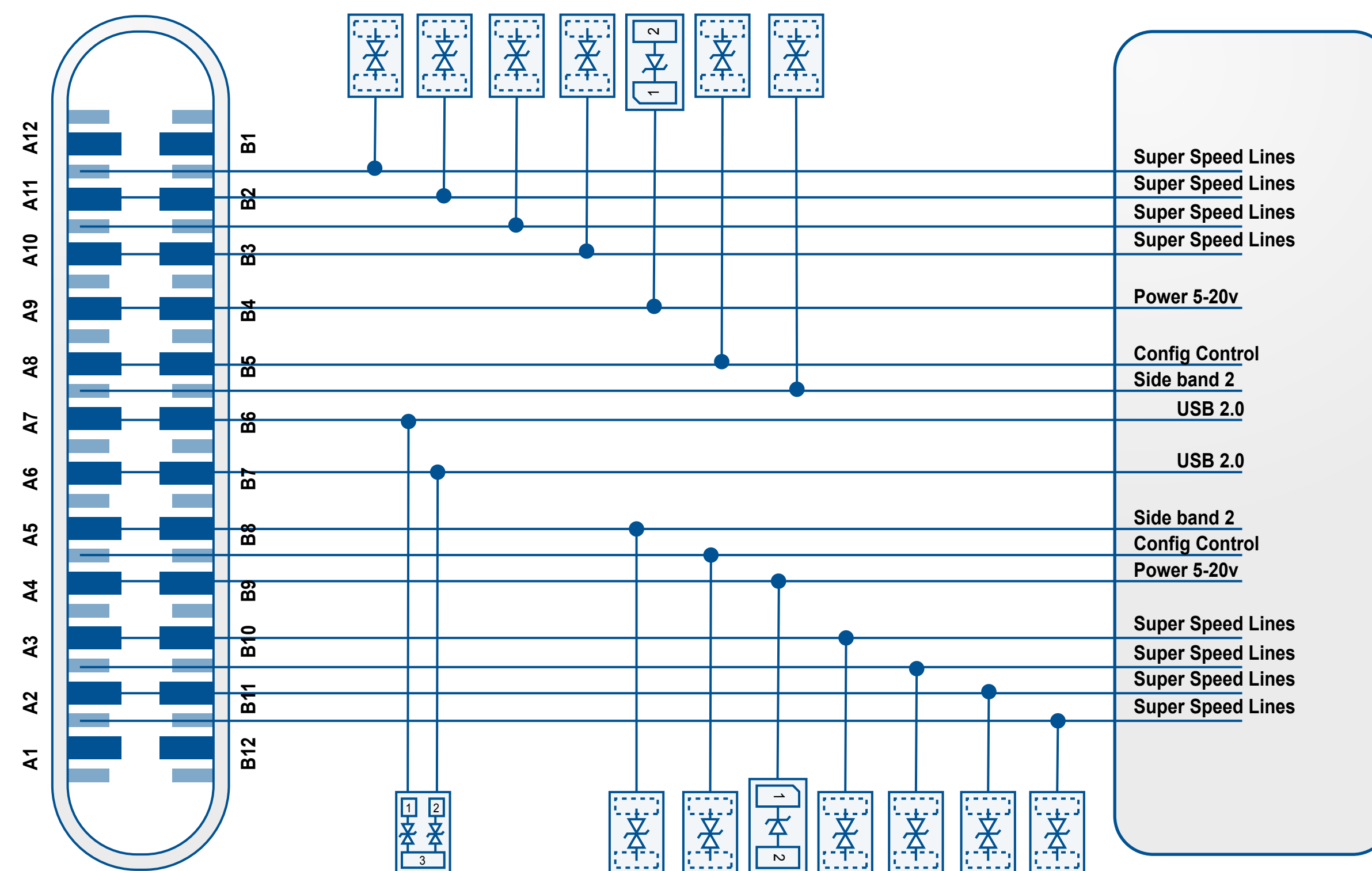
USB 3.0 ESD protection



Part No.	V_{RWM}	$P_{PK, 8/20\mu S}$	$C_J, \text{Max.}$	ESD Level	Package
FW4120LC	5V	150 Watts	0.4 pF	30KV	DFN4120-10L
FSD052MD	5V	45 Watts	13 pF	8KV	DFN1006

Serial Buses

- High data-rate: USB 3.1



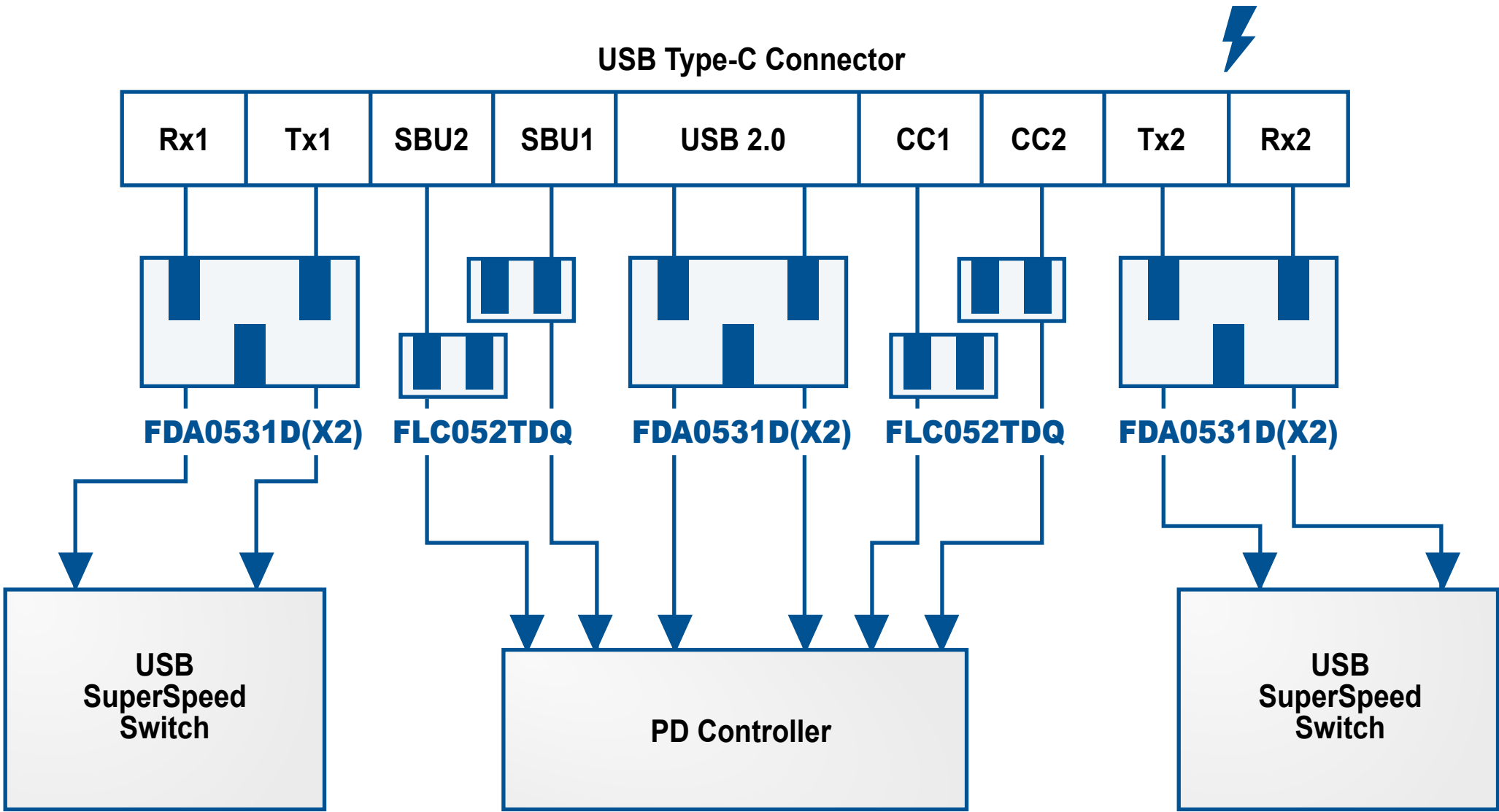
Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
FLC0529D	5 V	40 Watts	0.15 pF	22 KV	DFN1006
FDA0531D	5 V	100 Watts	0.40 pF	17 KV	DFN1006-3L

Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
FSD052MD	5 V	40 Watts	0.3 pF	30 KV	DFN1006
FW56 Series	3.3 V– 20 V	>300 Watts	35 pF-600 pF	30 KV	DFN1610

Serial Buses

- High data-rate: USB Type C

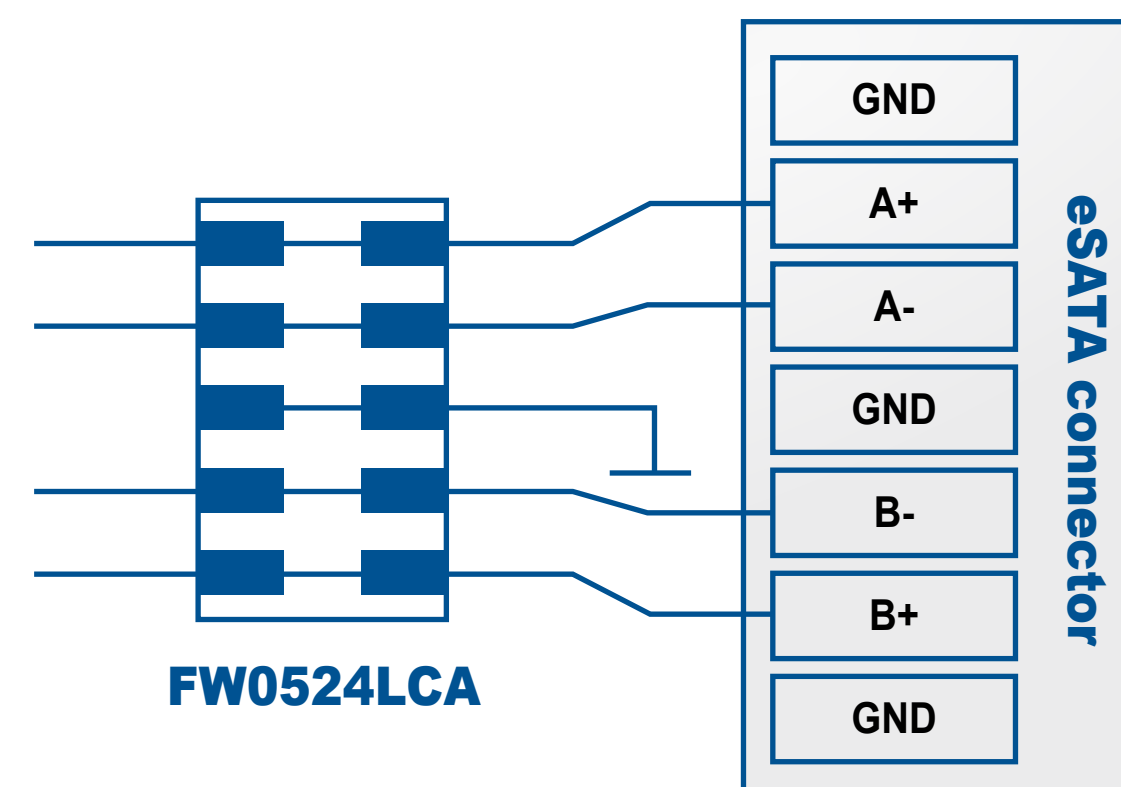
Description:
 USB Type-CTM has a 24-pin connector that can support USB 3.1 Gen2, DisplayPort, HDMI, and a variety of other alternate modes. There are 16 pins that require ESD protection. Since the SuperSpeed USB lines for USB 3.1 Gen2 (Tx1+, Tx1 -, Rx1+, Rx1 -, Tx2+, Tx2 -, Rx2+ and Rx2 -) can reach speeds up to 10 Gbps, capacitance must be minimized. The USB 2.0 lines (D+ top, D+ bottom, D - top and D - bottom) also require low capacitance. The CC1, CC2 and SBU1, SBU2 Type-C pins can reach up to 5.5 V and while low capacitance is not required.



Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
FDA0531D	5.5 V	40 Watts	0.15 pF	22 KV	DFN1006-3L
FLC052TDQ	5.5 V	80 Watts	0.30 pF	25 KV	DFN1006

Serial Buses

- High data-rate: eSATA

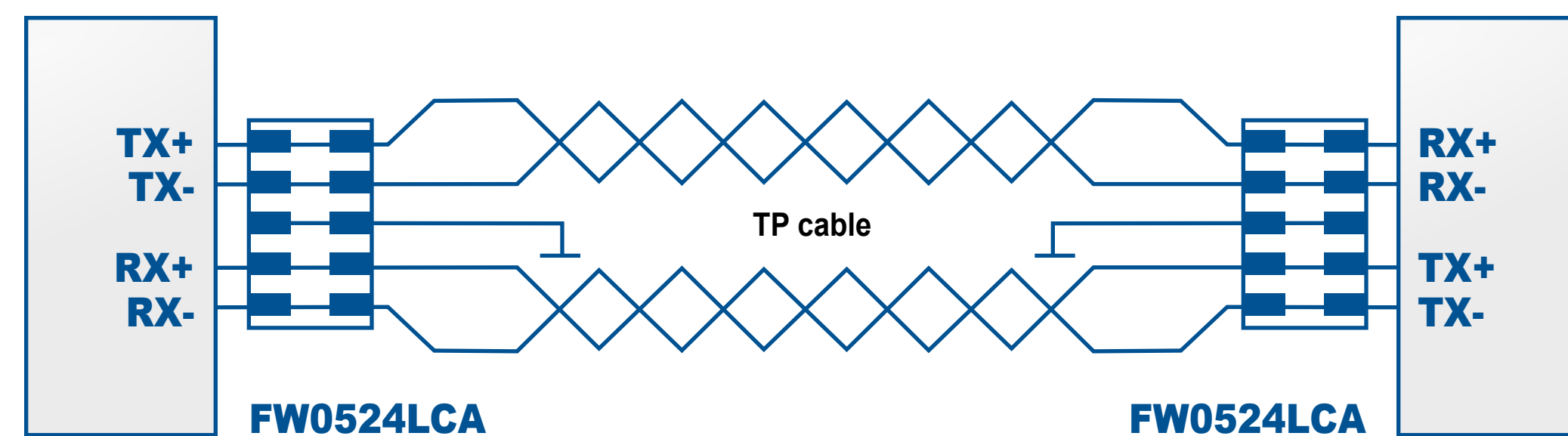


Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FW0524LCA	5 V	150 Watts	0.4 pF	30 KV	DFN2510-10L

Serial Buses

- High-speed differential mode signaling

General high-speed differential mode signaling line ESD protection

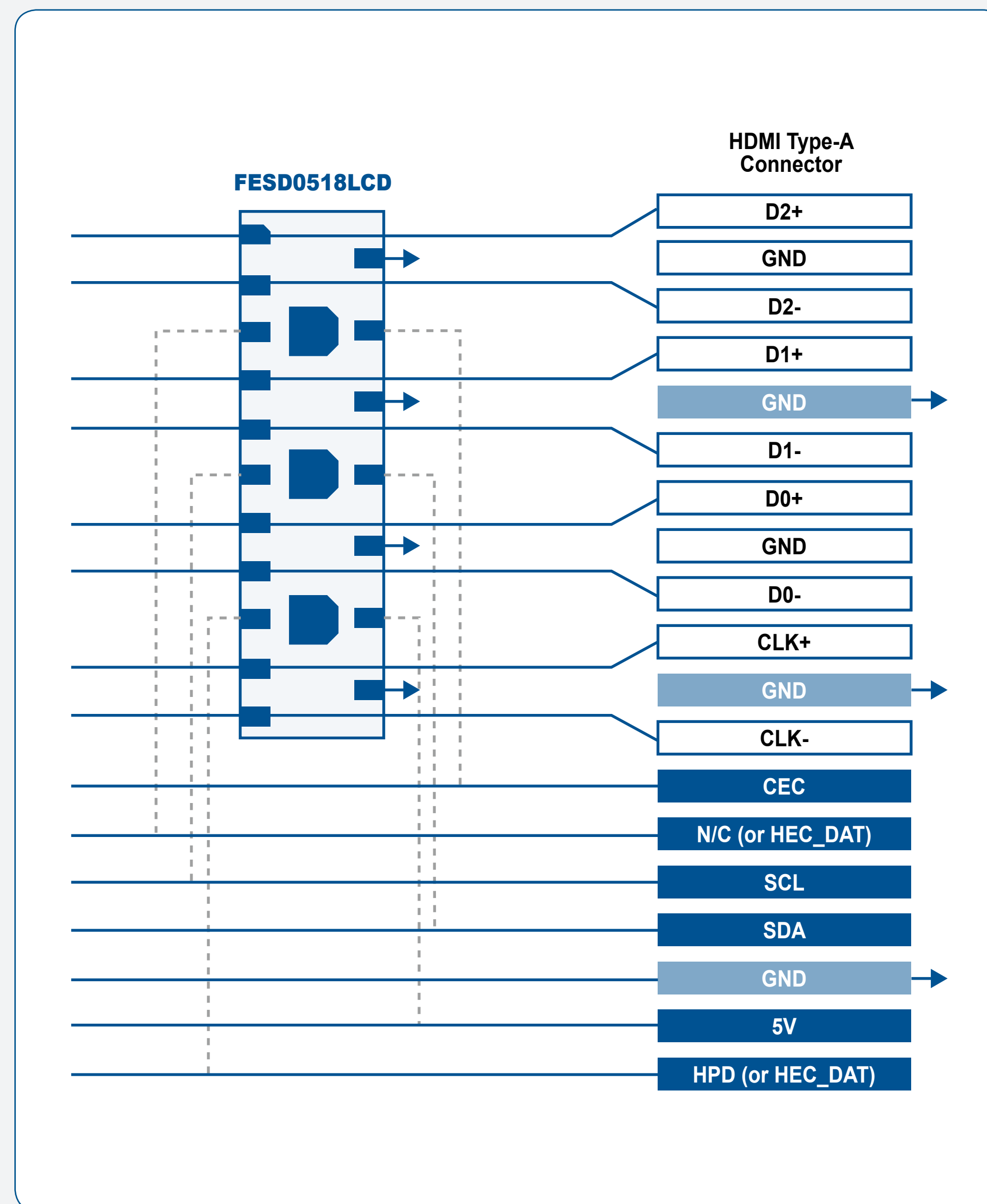


Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FW0524LCA	5 V	150 Watts	0.4 pF	30 KV	DFN2510-10L

Display Interfaces

- HDMI-Type A

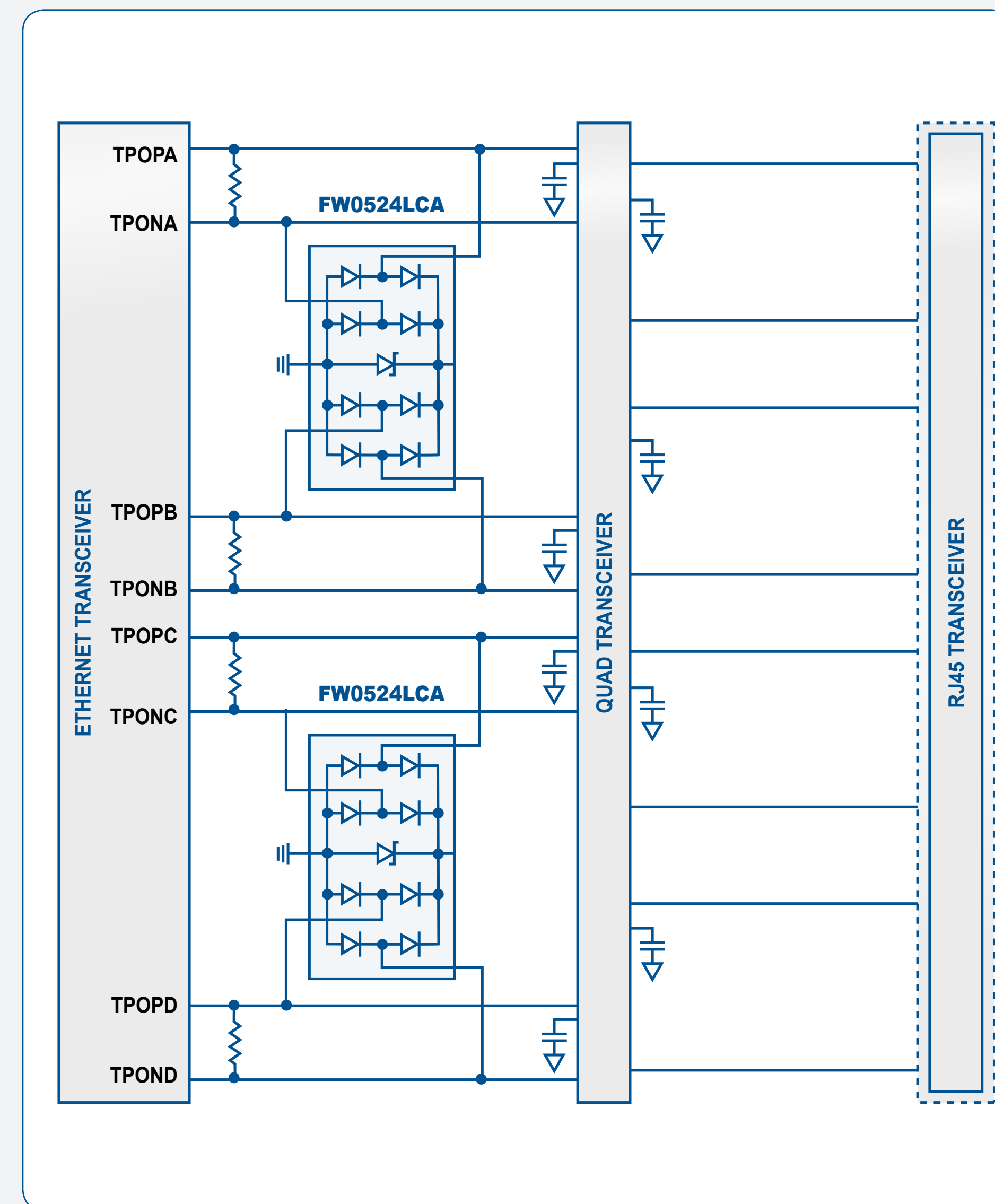
Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FESD0518LCD	5 V	150 Watts	0.4 pF	30 KV	DFN5515-18L



Display Interfaces

- PHY side in Gbe

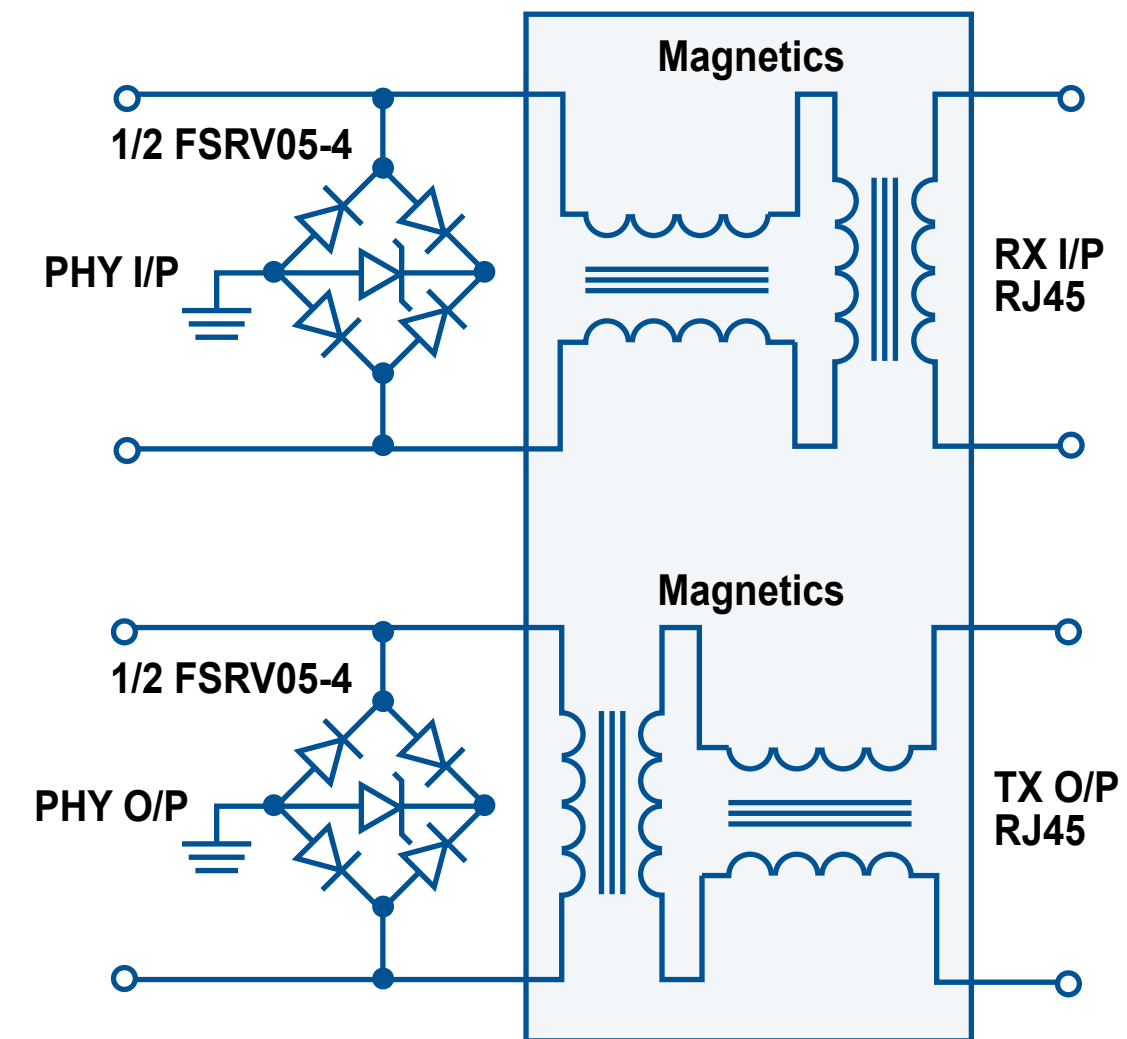
Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FW0524LCA	5 V	150 Watts	0.4 pF	30 KV	DFN2510-10L



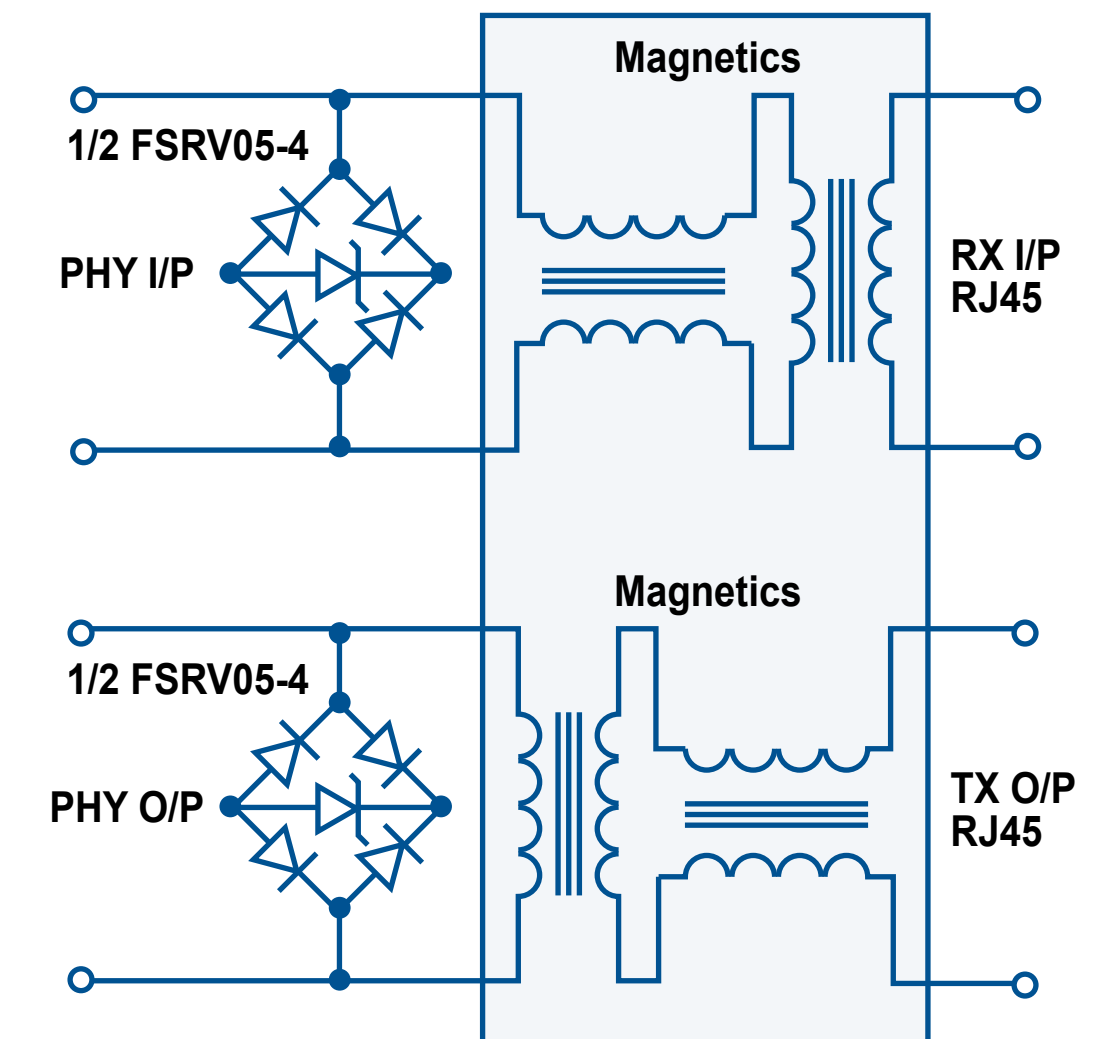
Display Interfaces

- Gbe Mode

Gbe common mode



Gbe Differential mode



Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FSRV05-4	5 V	350 Watts	1.2 pF	30 KV	SOT23-6

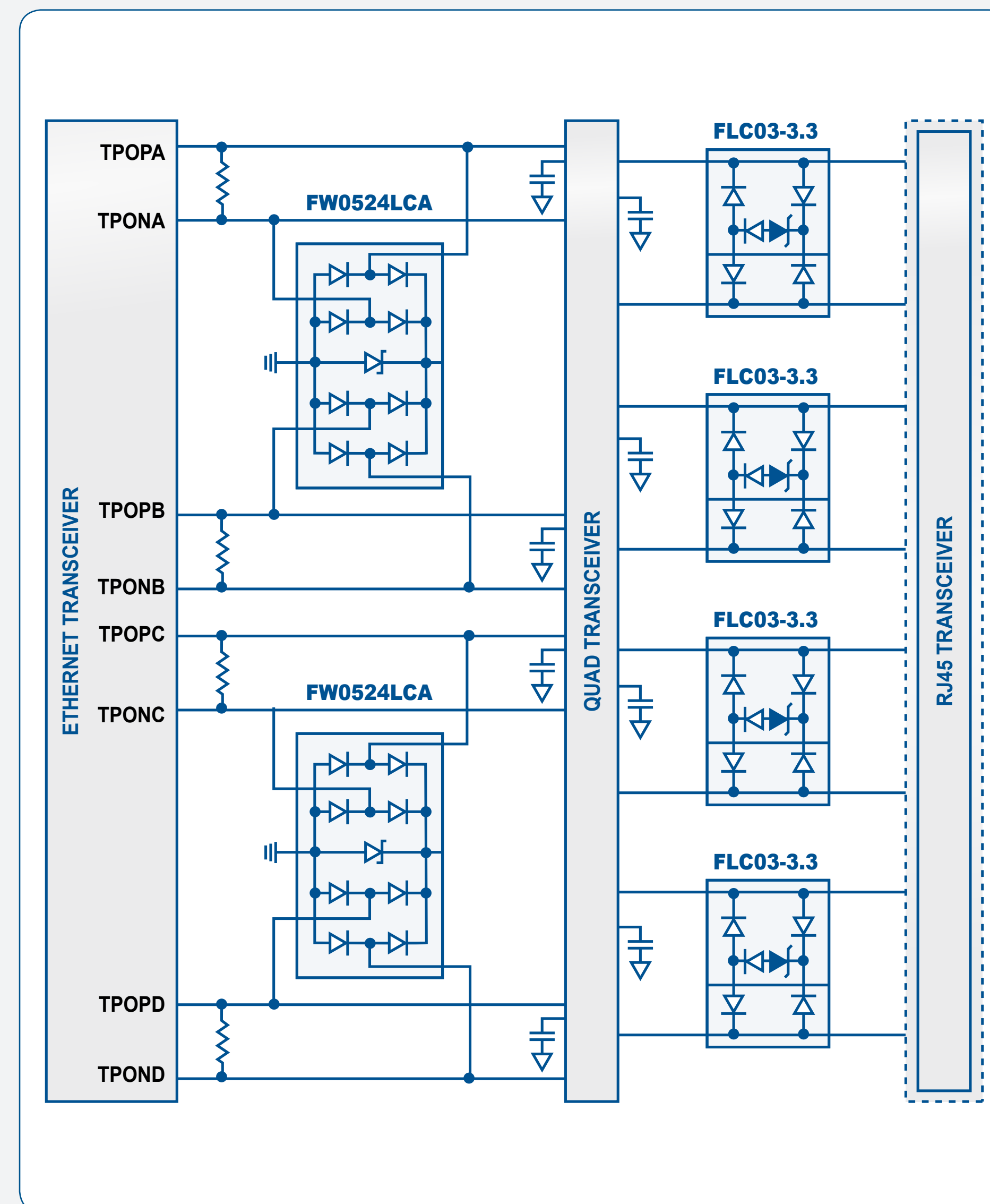
Display Interfaces

- Gbe Mode

Display Interfaces

- Gbe Mode

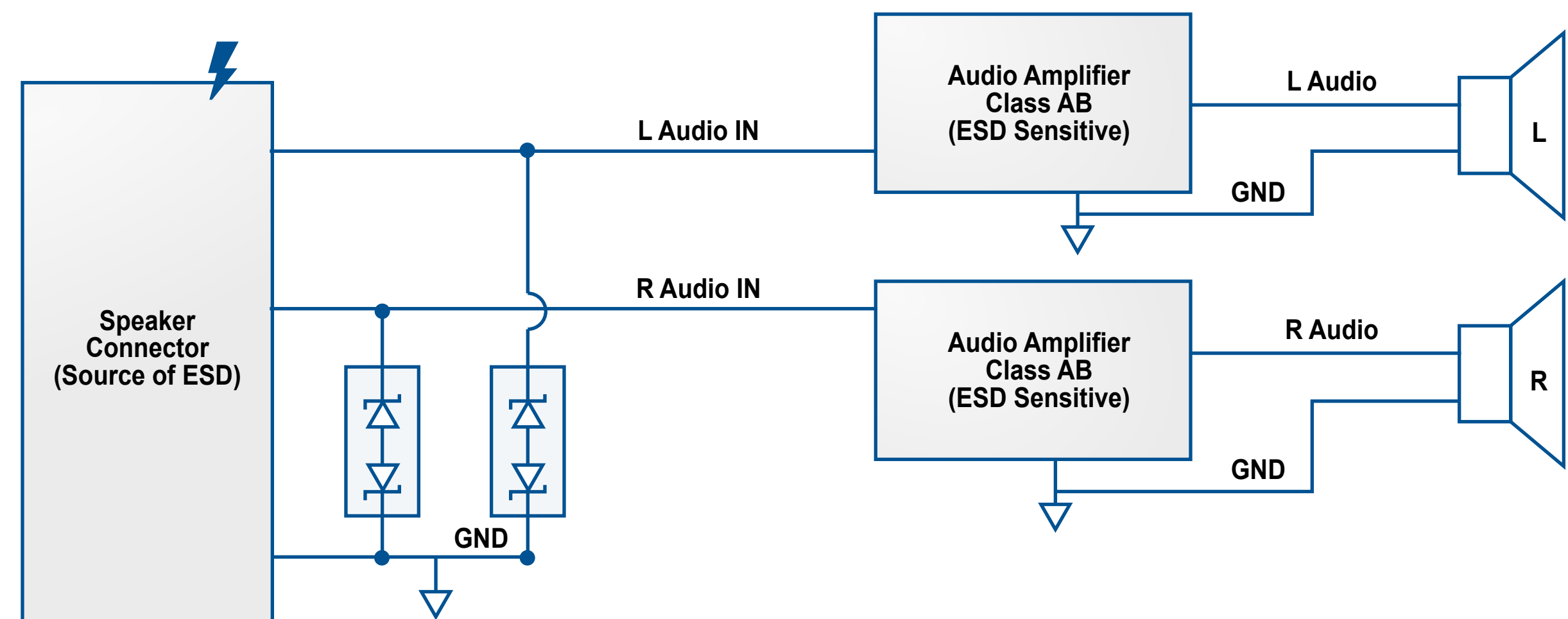
Part No.	V_{RWM}	$P_{PK, 8/20\mu S}$	$C_J, \text{Max.}$	ESD Level	Package
FSRV05-4	5V	350 Watts	1.2 pF	30 KV	SOT23-6
FLC03-3.3	2.8 V	2500 Watts	12 pF	30 KV	SOP-8



Audio Circuit protection

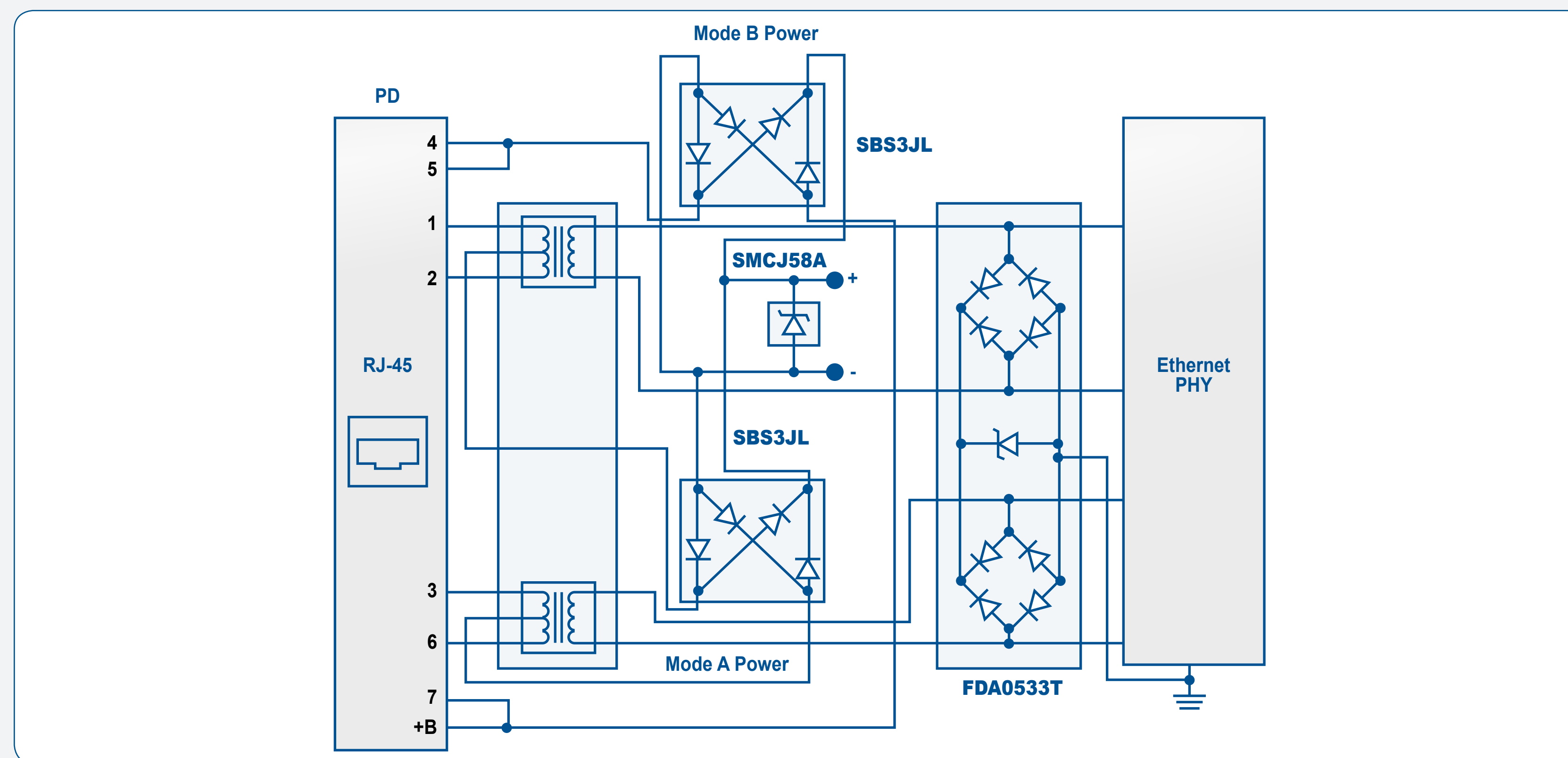
Description:

Audio jacks and connectors can present an entry point for ESD to enter the system. Audio signals do not typically exceed $\pm 5\text{ V}$ before amplification but can reach higher voltages after the amplifier. Since the maximum frequency does not exceed 30 kHz , the capacitance of the ESD diode is not a concern. Because analog audio can have both positive and negative voltage swings, ESD solutions should be bidirectional to prevent premature breakdown which would interfere with the signal.



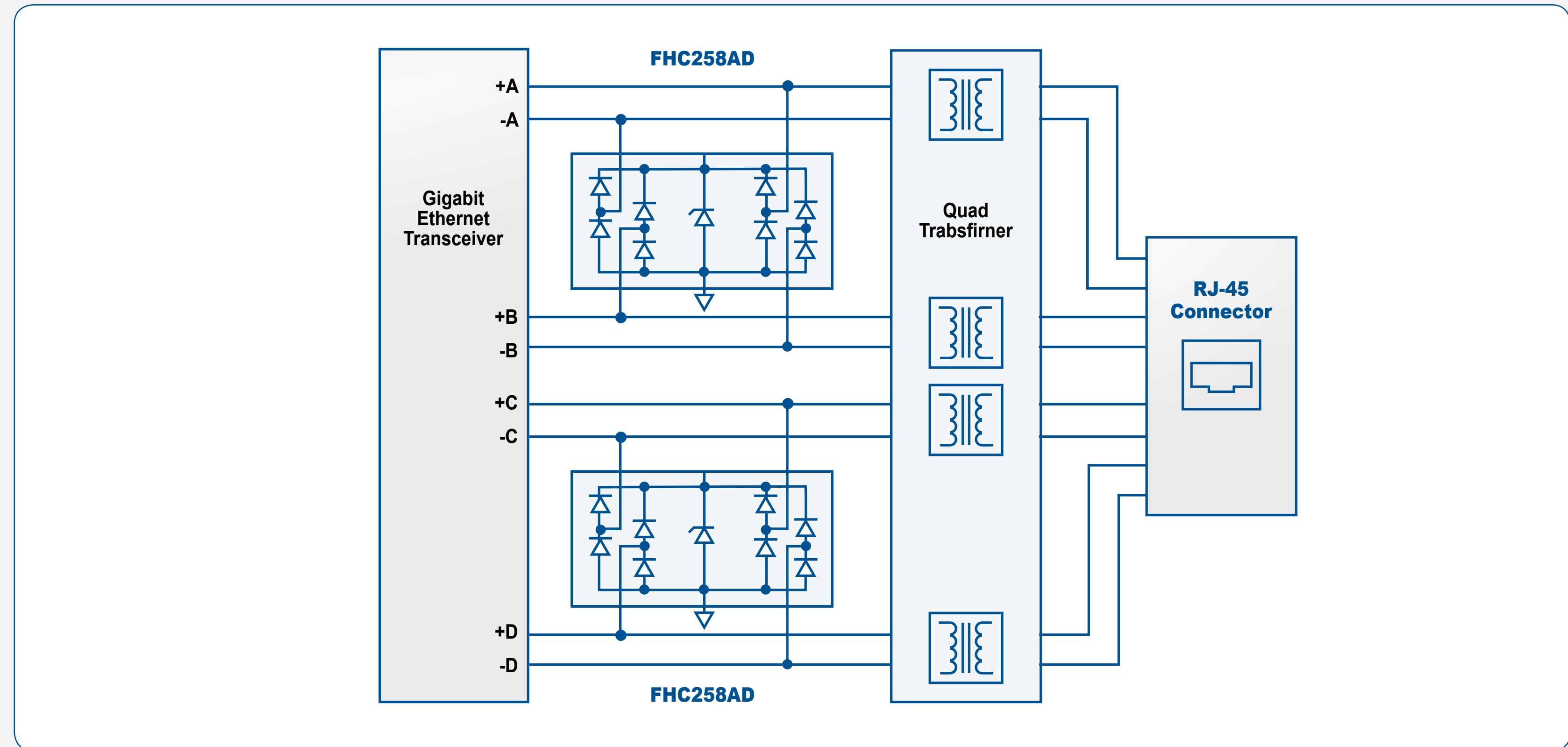
Part No.	V_{RWM}	$P_{PK}, 8/20\mu S$	$C_J, \text{Max.}$	ESD Level	Package
FLC052TDQ	5 V	80 Watts	0.3 pF	25 KV	DFN1006

Power Over Ethernet POE PD Unit Protection



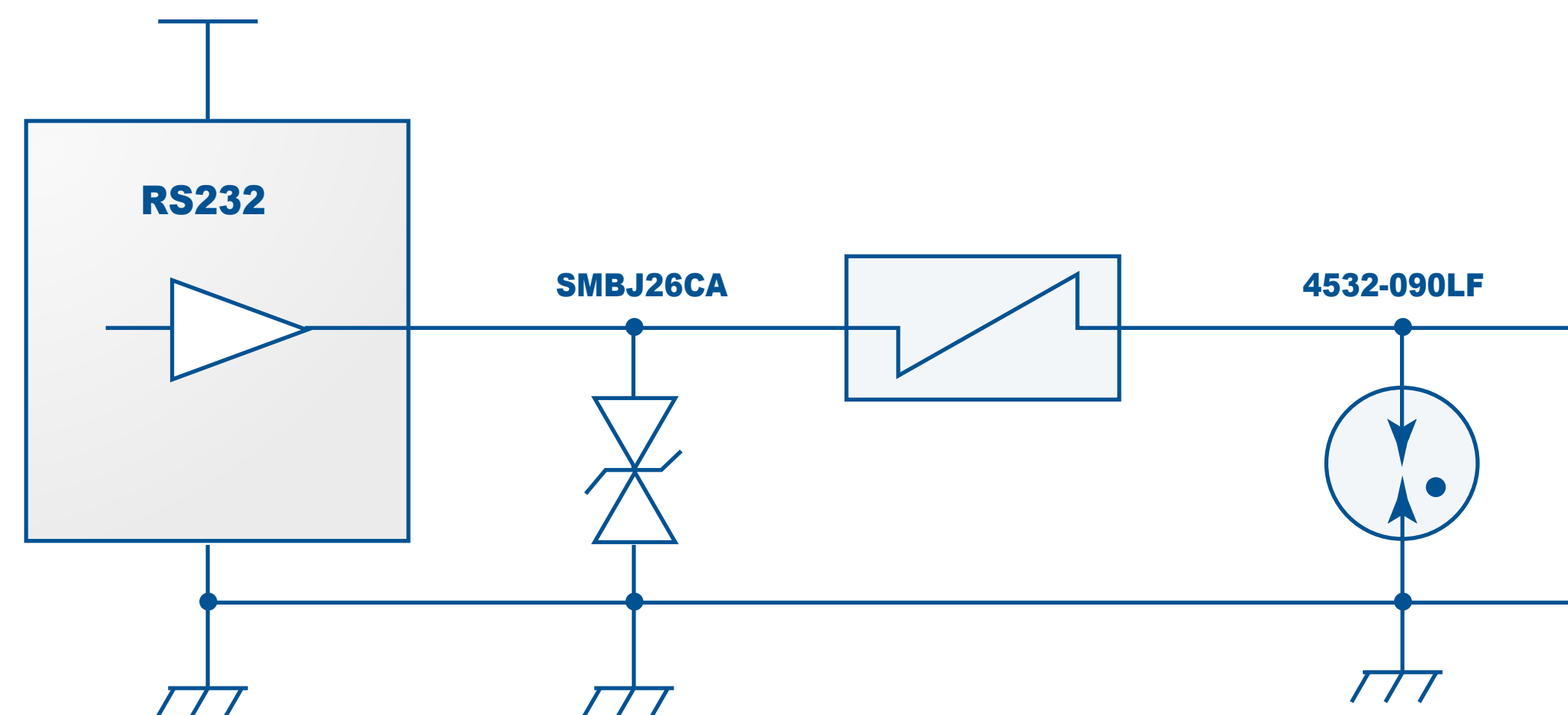
Part No.	V_{RWM}	P_{PK} , 8/20 μ S	C_J , Max.	ESD Level	Package
FDA0533T	5 V	100 Watts	0.4 pF	8 KV	SOT23-6

Gb Ethernet Surge and ESD Protection



Part No.	V_{RWM}	P_{PK} , 8/20 μ s	C_J , Max.	ESD Level	Package
FHC258AD	2.5V	1000 Watts	1.5 pF	30 KV	DFN3020-10L

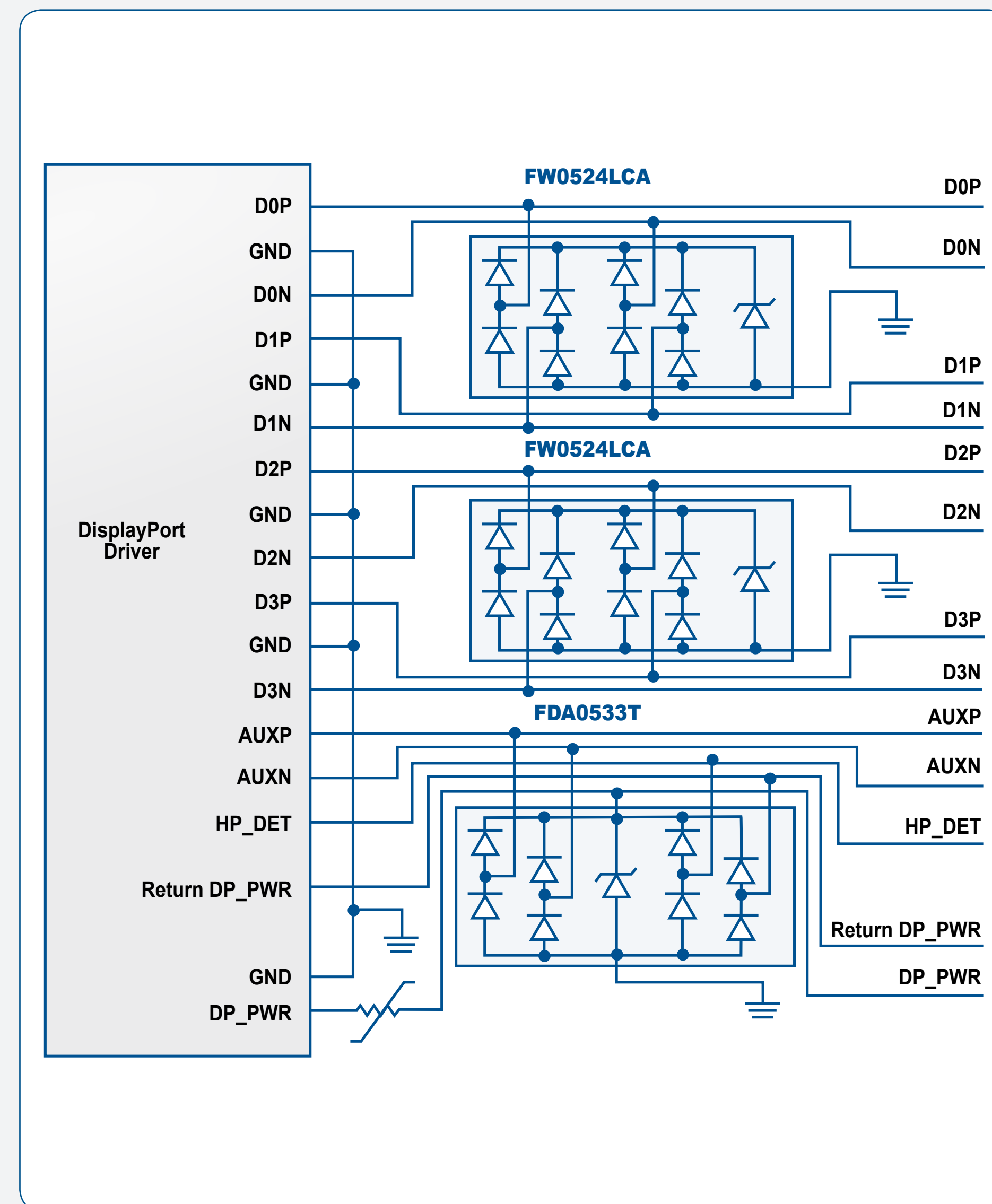
RS-232 Serial Port Surge Protection



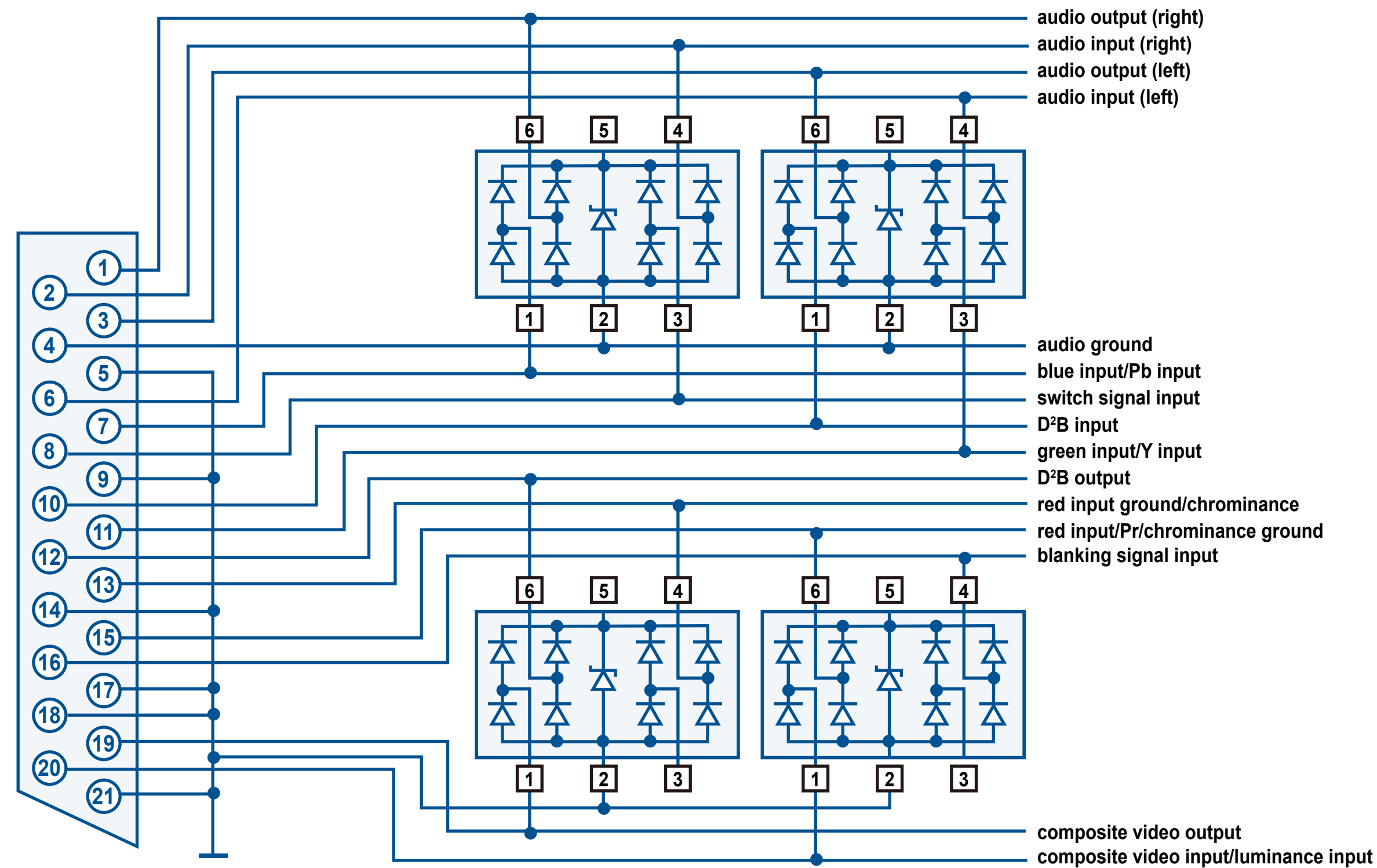
Part No.	V _{RWM}	P _{PK} , 8/20uS	C _J , Max.	ESD Level	Package
SMDJ26CA	26 V	600 Watts, 10/1000us	1200 pF	30 KV	SMBJ
4532-090LF	90 V	2000A, 8/20us	12 pF	30 KV	4532

Display Port 1.2 ESD and Overcurrent Protection

Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FW0524LCA	5 V	150 Watts	0.4 pF	30 KV	DFN2510-10L
FDA0533T	5 V	100 Watts	0.4 pF	30 KV	SOT23-6

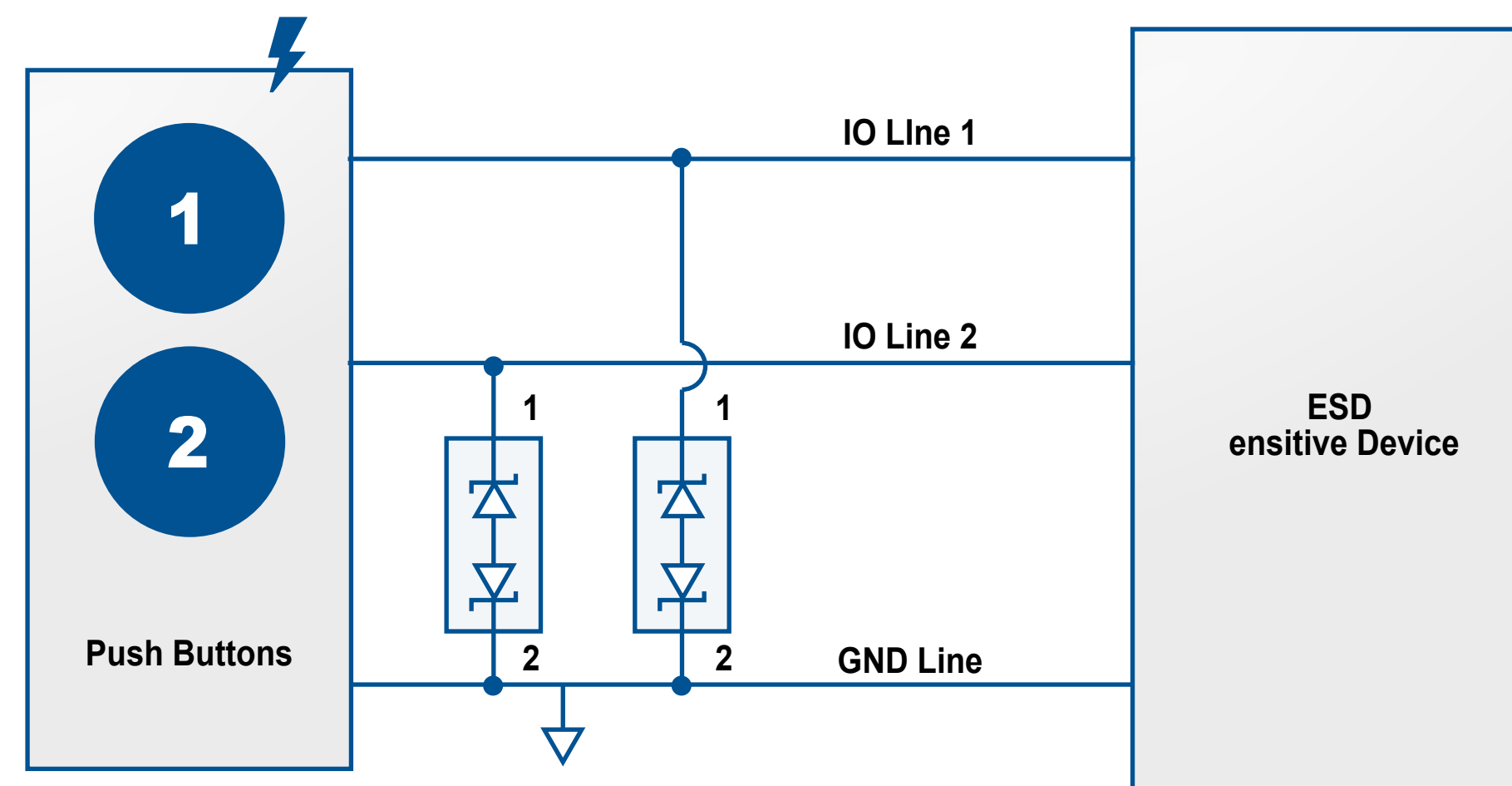


ESD Protection for SCART



Part No.	V_{RWM}	$P_{PK}, 8/20\mu S$	$C_J, \text{Max.}$	ESD Level	Package
FDA0533T	5 V	100 Watts	0.4 pF	30 KV	SOT23-6

Keypad and Pushbutton Circuit Protection

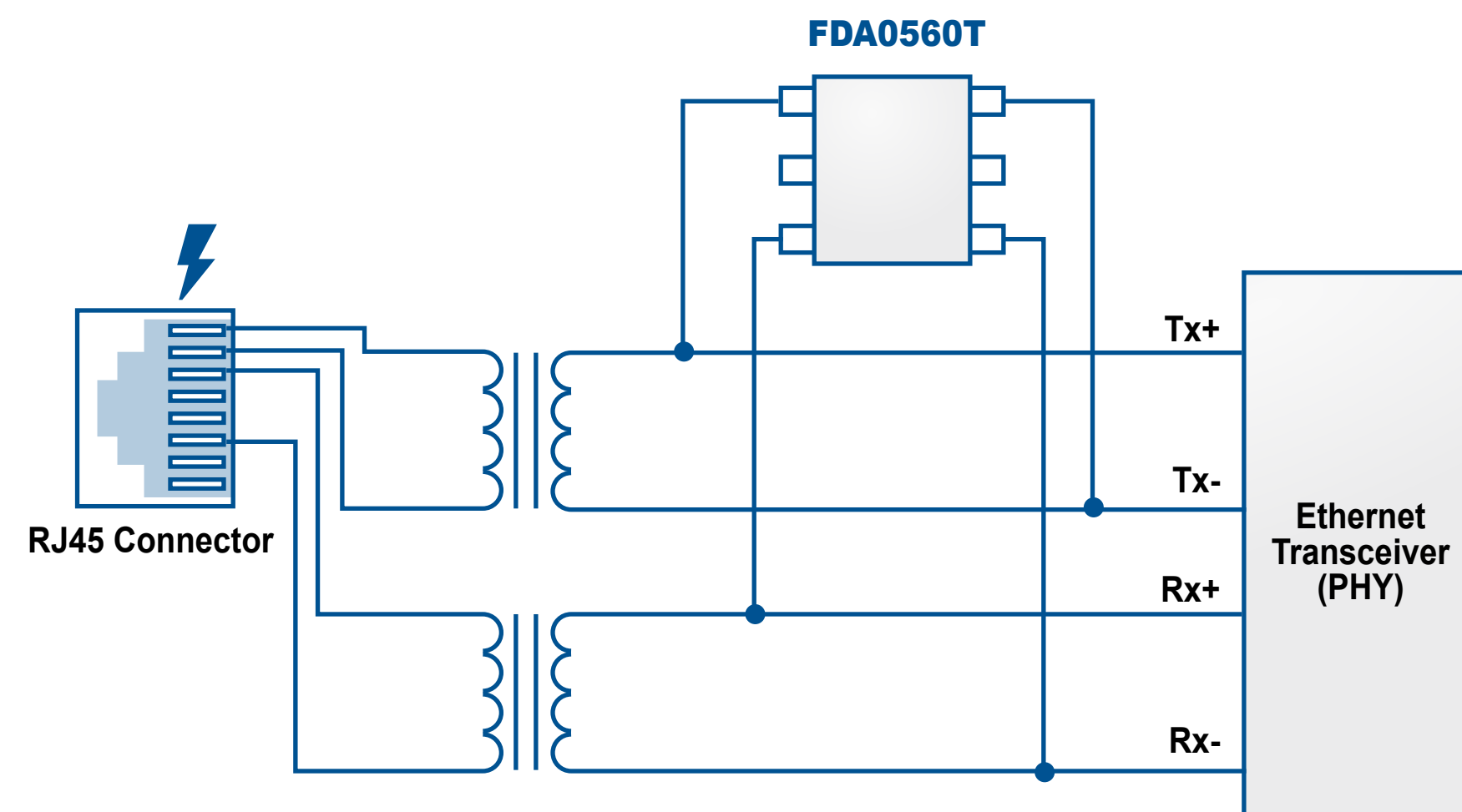


Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FLC052TDQ	5 V	80 Watts	0.3 pF	25 KV	DFN1006

Ethernet

- Ethernet ESD protection

10/100 ESD protection, with ground-referred protection on the MAC side and common mode protection on the connector side



Part No.	V_{RWM}	P_{PK} , 8/20uS	C_J , Max.	ESD Level	Package
FDA0560T	5 V	150 Watts	0.4 pF	30 KV	SOT23-6



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