DIA3000

Dual Single-Pole, Double-Throw USB 2.0 High-Speed Switch

Description

The DIA3000 is a dual single-pole, double-throw (SPDT) switch with an USB 2.0 high-speed (480 Mbps) switch. The device is designed to switch USB 2.0 signals in automotive hubs or controllers with limited USB I/O.

The DIA3000 offers a wide V_{CC} input voltage range of 2.3 V to 5.5 V and features an overvoltage tolerance (OVT) function, which allows the I/O pins to withstand a overvoltage of up to 5.5 V. The power-off protection feature forces all I/O pins to be in high-impedance mode when power is not present or 0 V without excessive leakage current. A 1.8 V compatible control logic of the DIA3000 allows the direct interface with the general-purpose I/O (GPIO) of the baseband processor.

The DIA3000 is housed in a small QFN2*1.5-10 package and is characterized by its free air temperature range from -40°C to 125°C, which makes it a perfect candidate for automotive applications.

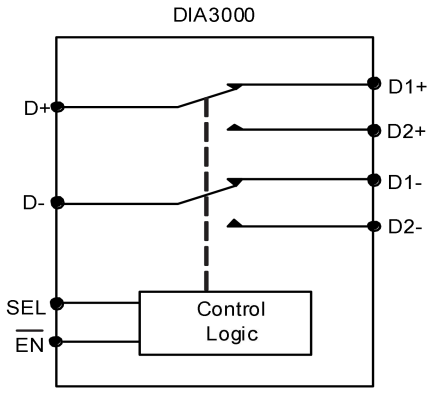
Features

- AEC-Q100 qualified
- Device temperature grade 1: -40°C to 125°C
- Device HBM ESD classification level H2
- Device CDM ESD classification level C5
- V_{CC} input voltage range: 2.3 V to 5.5 V
- Bandwidth (-3 dB): >1.5 GHz
- R_{ON} (typ.): 4.6 Ω
- C_{ON} (typ.): 1.2 pF
- Ultra-low power consumption: 20 μA (Typ.)
- Power-off protection: low current leakage in powered-down state (V_{CC} = 0 V)
- Overvoltage tolerance on all I/O pins: 5.5 V
- Overvoltage protection of 9 V short to data pins
- Package: QFN2*1.5-10

Applications

- Routing high-speed USB signals
- Automotive USB hubs
- Phone-controlled automotive infotainment

Schematic Diagram



Ordering Information

Part No.	Top Marking	RoHS	T_A	Package	
DIA3000QN10	YW3D	Green	-40 to 125°C	QFN2*1.5-10	Tape & Reel, 3000

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

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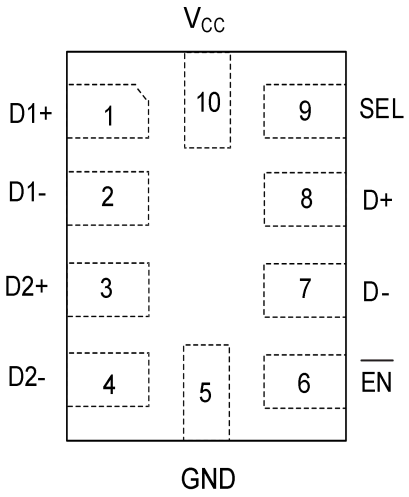
1. Pin Assignment and Functions



QFN2*1.5-10
Top view

Pin No.	Name	I/O	Description
1	D1+	I/O	Data link (Differential+)
2	D1-	I/O	Data link (Differential-)
3	D2+	I/O	Data link (Differential+)
4	D2-	I/O	Data link (Differential-)
5	GND	-	Ground
6	$\overline{EN}$	I	Output enable (Active Low)
7	D-	I/O	Switch output (Differential-)
8	D+	I/O	Switch output (Differential+)
9	SEL	I	Switch select (LOW=D+/D- To D1+/D1-, HIGH=D+/D- To D2+/D2-)
10	V_{CC}	-	Power supply pin

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Ratings	Unit
V_{CC}	Supply voltage	-0.3 ~ 6	V
$V_{I/O}$	Input-output DC voltage	-0.3 ~ 6	V
V_{D-}	D- DC voltage[1]	-0.3 ~ 9	V
V_I	Digital input voltage (SEL, $\overline{EN}$)	-0.3 ~ 6	V
I_K	Input-output port diode current ($V_{I/O}$ < 0)	-50	V
I_{IK}	Digital logic input clamp current (V_I < 0)	-50	mA
I_{CC}	Continuous current through V_{CC}	100	ºC
I_{GND}	Continuous current through GND	-100	ºC
T_{STG}	Storage temperature	-65 ~ 150	ºC

Note:
[1] This rating only applies to the D- pin with respect to GND. V_{CC} must be powered within the recommended operating conditions of 2.3 V to 5.5 V and the EN pin must be logic high for this rating to be applicable. Any condition where V_{CC} is unpowered or the EN pin is not high must refer to the rest of the Absolute Maximum Ratings Table.

3. Recommended Operating Condition

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply voltage	2.3 to 5.5	V
$V_{I/O\ (USB)}$	Analog voltage	0 to Vcc	V
V_I	Digital input voltage (SEL, $\overline{EN}$)	0 to V_{CC}	V
t_{RAMP} (V_{CC})	Power supply ramp time requirement (V_{CC})	100 to 1000	μs/V
T_A	Operating free-air temperature	-40 to 125	ºC

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Model	Condition	Value	Unit
Human-body model	ANSI/ESDA/JEDEC JS-001	±5500	V

5. Thermal Considerations

The thermal resistance determines the heat insulation property of a material. The higher the thermal resistance is, the lower the heat loss. Accumulation of heat energy degrades the performance of semiconductor components.

Symbol	Metric	Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	193	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	96	°C/W

6. Electrical Characteristics

6.1. General characteristics

The values are obtained under these conditions unless otherwise specified: T_A = -40°C to 125°C, typical values are at V_{CC} = 3.3 V.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R_{ON}	ON-state resistance	V_{CC} = 2.3 V, 3.6 V, 5 V, 5.5 V; $V_{I/O}$ = 0.4 V, I_{ON} = -8 mA		4.6	7.5	Ω
ΔR_{ON}	ON-state resistance match between + and - paths	V_{CC} = 2.3 V, 3.6 V, 5 V, 5.5 V; $V_{I/O}$ = 0.4 V, I_{ON} = -8 mA		0.1		Ω
I_{OZ}	OFF leakage current	V_{CC} = 5 V, switch off, $V_{D1/2±}$ = 0 V to 3.6 V, $V_{D±}$ = 0 V	-2		2	μA
I_{ON}	ON leakage current	V_{CC} = 5 V, switch on, $V_{1/2±}$ = 0 V to 3.6 V, $V_{D±}$ = NC	-2		2	μA
Digital control inputs (SEL, $\overline{EN}$)						
V_{IH}	Input logic high	V_{CC} = 2.3 V	1			V
		V_{CC} = 3.6 V	1.2			
		V_{CC} = 5 V	1.3			
		V_{CC} = 5.5 V	1.35			
V_{IL}	Input logic low	V_{CC} = 2.3 V			0.4	V
		V_{CC} = 3.6 V			0.6	
		V_{CC} = 5 V			0.7	
		V_{CC} = 5.5 V			0.75	
I_{IN}	Input leakage current	V_{CC} = 5 V, $V_{I/O}$ = 0 V to 3.6 V, V_{IN} = 0 to 5 V	-10		10	μA
Dynamic characteristic						
$C_{ON(USB)}$	USB path ON capacitance	V_{CC} = 3.3 V, $V_{I/O}$ = 0 or 3.3 V, f = 240 MHz, switch on		1.2	1.6	pF
C_I	Digital input capacitance	V_{CC} = 3.3 V, V_I = 0 or 2 V		2.2		pF
O_{ISO}	OFF isolation	V_{CC} = 2.3 V to 5 V, R_L = 50 Ω, f = 240 MHz, switch off		-36		dB
X_{TALK}	Crosstalk	V_{CC} = 2.3 V to 5 V, R_L = 50 Ω, f = 240 MHz, switch on		-40		dB
BW	Path -3 dB bandwidth	V_{CC} = 2.3 V to 5 V, R_L = 50 Ω, switch on		5.8		GHz
Supply						
V_{CC}	Power supply voltage		2.3		5.5	V
I_{CC}	Positive supply current	V_{CC} = 5 V, V_{IN} = V_{CC} or GND, $V_{I/O}$ = 0 V, switch on or off		20	40	μA
$I_{CC, HZ}$	Power supply current in high-Z mode	V_{CC} = 5 V, V_{IN} = V_{CC} or GND, $V_{I/O}$ = 0 V, switch on or off, $\overline{EN}$ = High		1	5	μA

6.2. Timing requirements

Symbol	Parameter	Conditions		Min	Nom	Max	Unit
t_{switch}	Switching time (SEL to output)	See Figure 1	R_L = 50 Ω,		60		ns
$t_{ZH, ZL}$	Enable time ($\overline{EN}$ to output)	$V_{I/O}$ = 0.8 V or 0 V	C_L = 5 pF,		7		µs
$t_{HZ, LZ}$	Disable time ($\overline{EN}$ to output)		V_{CC} = 2.3 V to 5 V		17		ns

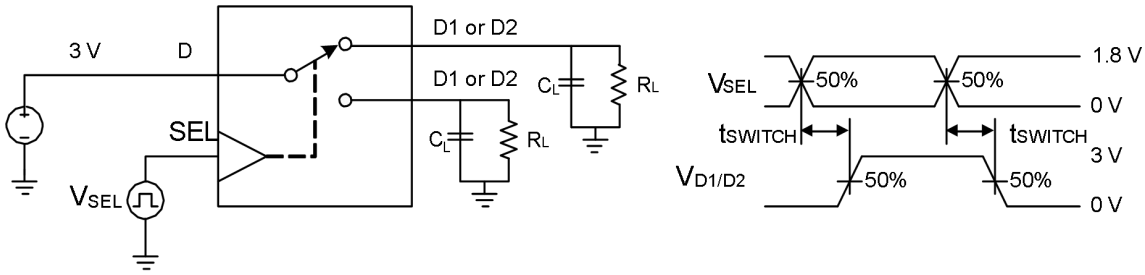


Figure 1. Timing diagrams

Note:

1. Input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r < 5 ns, t_f < 5 ns.
2. C_L includes probe and jig capacitance.

7. Typical Characteristic

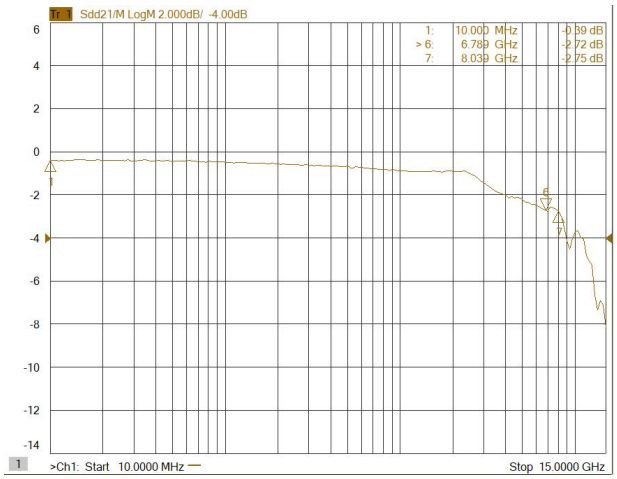


Figure 2. Differential Sdd21 vs. Frequency USB switch

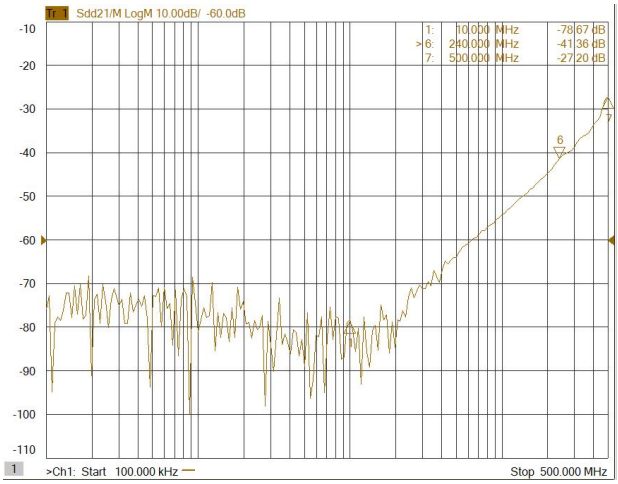


Figure 3. Differential crosstalk vs. Frequency for USB path

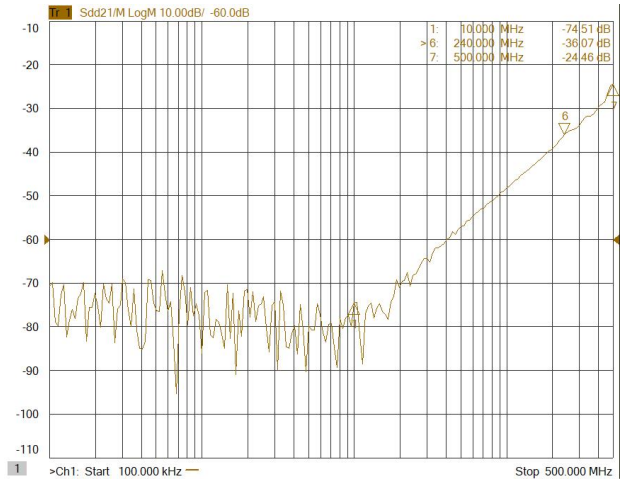


Figure 4. Differential off isolation vs. Frequency for USB path

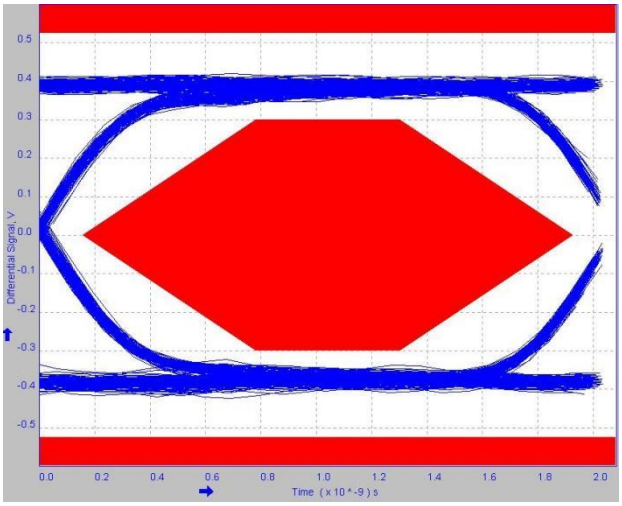
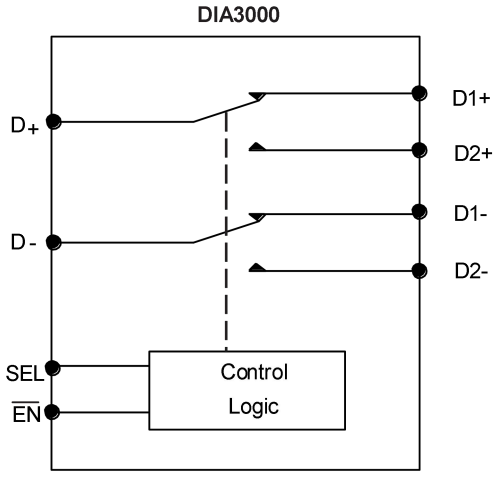


Figure 5. 480 Mbps USB 2.0 eye pattern for USB switch

8. Block Diagram



9. Function Description

9.1. Low power mode

The DIA3000 has a low power mode that reduces the power consumption to 1 μA when the device is not in use. Setting the enable pin $\overline{EN}$ with a logic high signal will put IC in low power mode.

9.2. Overvoltage protection when 9 V short to D-pin

The DIA3000 can protect the system when the D-pin is exposed to a voltage less than 9 V. A voltage higher than 9 V might damage the device.

In Figure 6, the system has an application processor (AP) which cannot survive 9 V on the USB data lines. The following procedure protects the system and the DIA3000.

1. The AP detects a dedicated charging port (DCP) connected to the USB port.
2. To disable the switches, the AP pulls the EN pin high. The DIA3000 is now in low-power mode and can protect the AP.
3. The AP negotiates with the charger for a faster charging mode to allow VBUS up to 9 V.

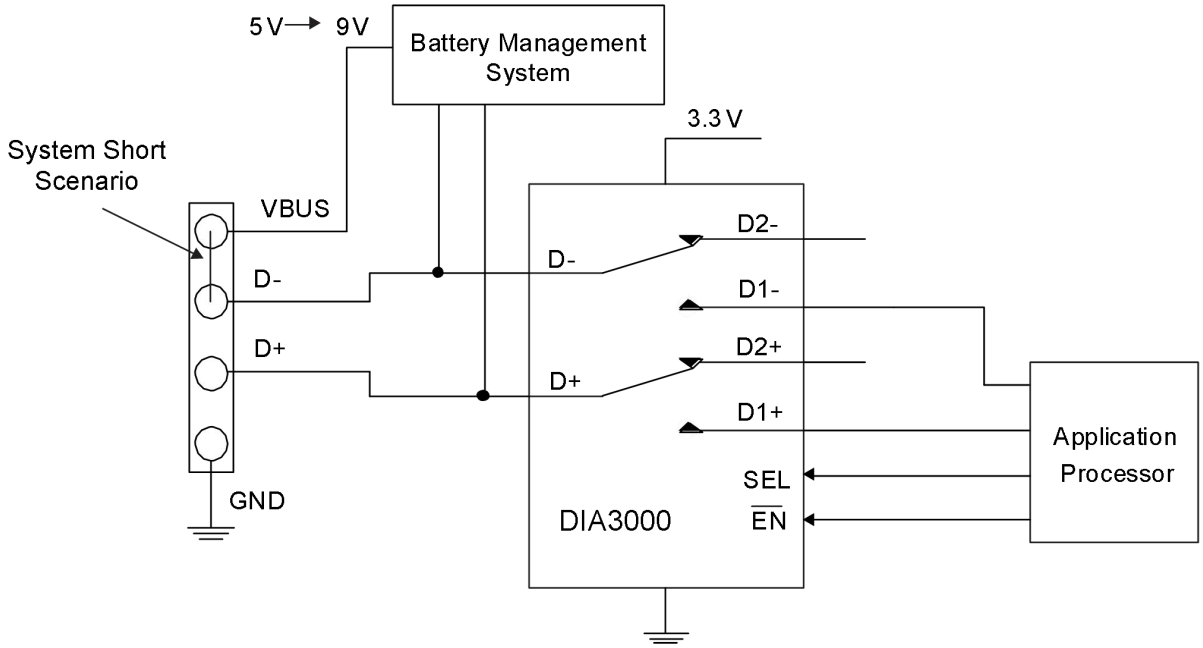


Figure 6. Potential VBUS to D-short example

9.3 High impedance mode

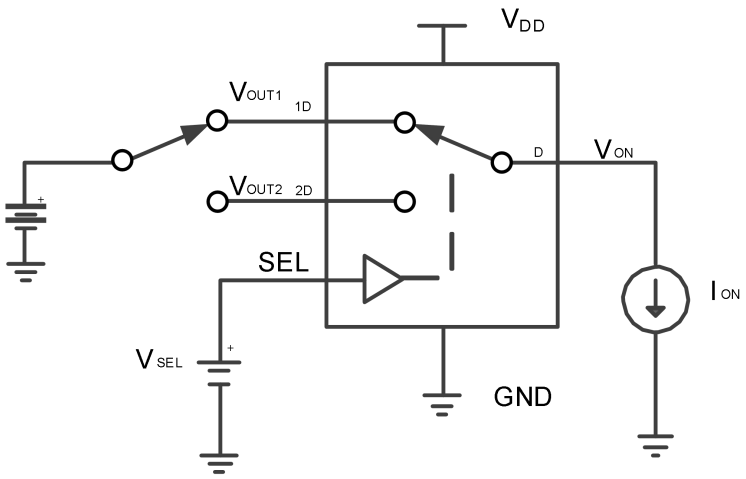
When the device is not in use, the DIA3000 switches to a high impedance mode. As shown in Table 1, high impedance mode is achieved by providing logic high to the bus-switch enable pin $\overline{OE}$.

Table 1. Function for high impedance mode

SEL	$\overline{EN}$	Switch Status
X	High	BothD1 and D2 switches in high-Z
Low	Low	D+/D- to D1+/D1-
High	Low	D+/D- to D2+/D2-

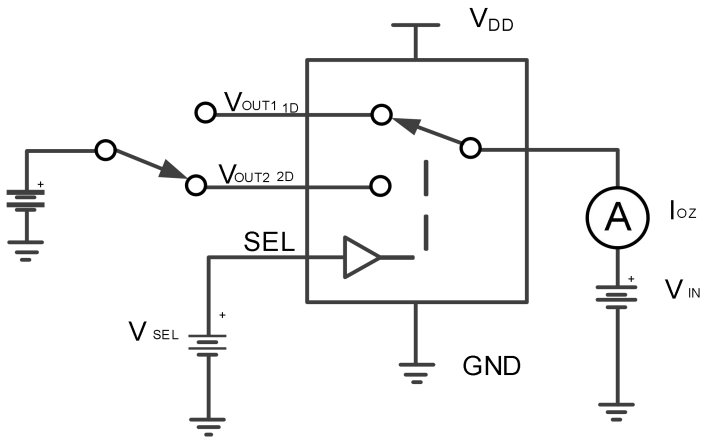
10. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.



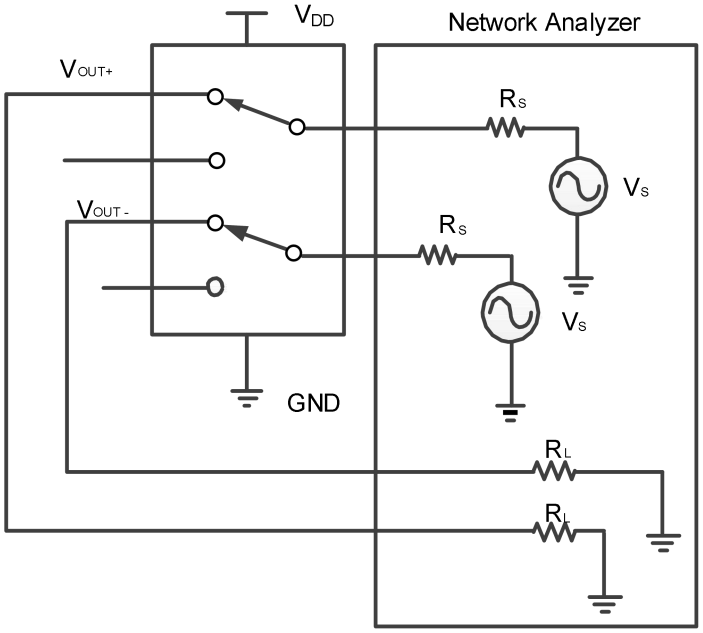
Channel on, R_{ON} = (V_{ON}-$V_{I/O1}$)/I_{ON} or (V_{ON}-$V_{I/O2}$)/I_{ON}, V_{SEL} = H or L

Figure 7. On-state resistance



Channel off, V_{SEL} = H or L

Figure 8. Off leakage current



Channel on, V_{SEL} = H or L, R_S = R_L= 50 Ω

Figure 9. Bandwidth (BW)

10.1 Application examples

Figure 8 is a typical application of the DIA3000 USB switch. The DIA3000 has internal 6 MΩ pull-down resistors on $\overline{EN}$ and SEL. The pull-down resistor on $\overline{EN}$ pin enables the switch when power is applied. The pull-down resistor on SEL pin ensure the USB channel is selected by default.

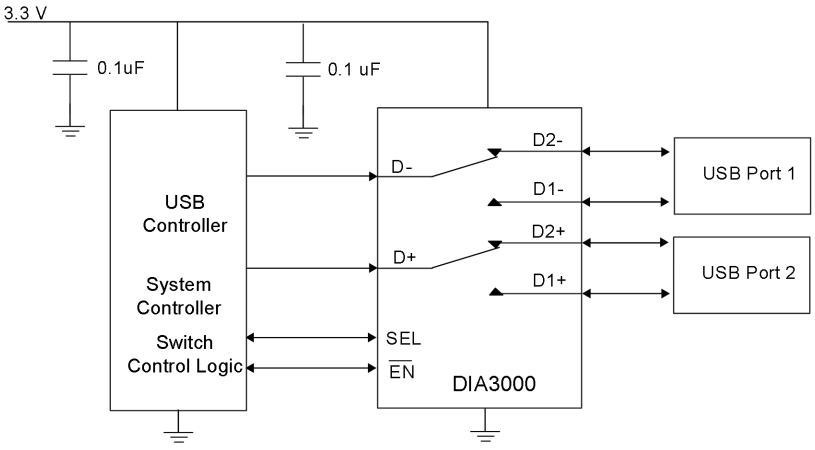


Figure 10. Potential VBUS to D-short example

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