DIO3000

DPDT USB 2.0 High-Speed and Mobile High-Definition Link (MHL) 5.8GHz Switch

Features

- **Wide V$_{CC}$ Input Voltage Range: 2.3V to 5.5V**
- **USB Channel:**
  Bandwidth (-3dB):5.8GHz
  R$_{ON}$ (Typ.): 4.6Ω
  C$_{ON}$ (Typ.): 1.2pF
- **Mobile High Definition Link (MHL) Channel:**
  Bandwidth (-3dB): 5.5GHz
  R$_{ON}$ (Typ.): 5.7Ω
  C$_{ON}$ (Typ.): 1.4pF
- **Ultra-Low Power Consumption: 20µA (Typ.)**
- **Additional Features:**
  Power-off Protection: Low Current Leakage in Powered-Down State (V$_{CC}$ =0V)
  Overvoltage Tolerance (OVT) on all I/O Pins up to 5.5V
  Overvoltage Protection of 9V Short to Data Pins
- **Packaged in QFN2*1.5-10**

Applications

- **Portable Instrumentation**
- **Digital Still Cameras**
- **Tablets**
- **Mobile phones**

Descriptions

The DIO3000 is a dual single-pole, double throw (SPDT) switch with a Mobile High-Definition Link (MHL) switch and an USB2.0 High-Speed (480Mbps) switch housed in the same package. Wide bandwidth of this product allows the sharing of the USB connector for both MHL video signals and USB data transmission.

The DIO3000 offers wide V$_{CC}$ input voltage range of 2.3V to 5.5V and features overvoltage tolerance (OVT) function, which allows the I/O pins to withstand overvoltage conditions (up to 5.5V). The power-off protection feature forces all I/O pins to be in high-impedance mode when power is not present or 0V without excessive leakage current. 1.8V compatible control logic of DIO3000 allows the direct interface with the General-Purpose I/O (GPIO) of the baseband processor.

The DIO3000 is housed in small QFN2*1.5-10, which makes it a perfect candidate to be used in handheld applications.

Block Diagram
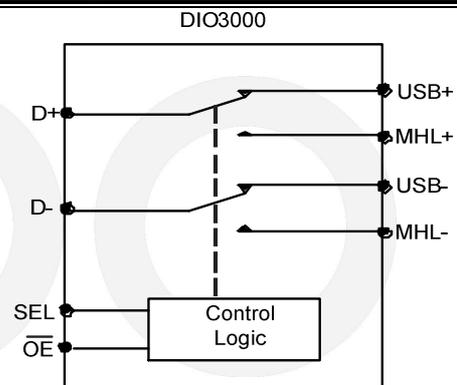
Ordering Information

Order Part Number	Top Marking		T$_A$		Package
DIO3000QN10	YW3C	Green	-40 to 85℃	QFN2*1.5-10	Tape & Reel,3000

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Pin Assignment

QFN2*1.5-10
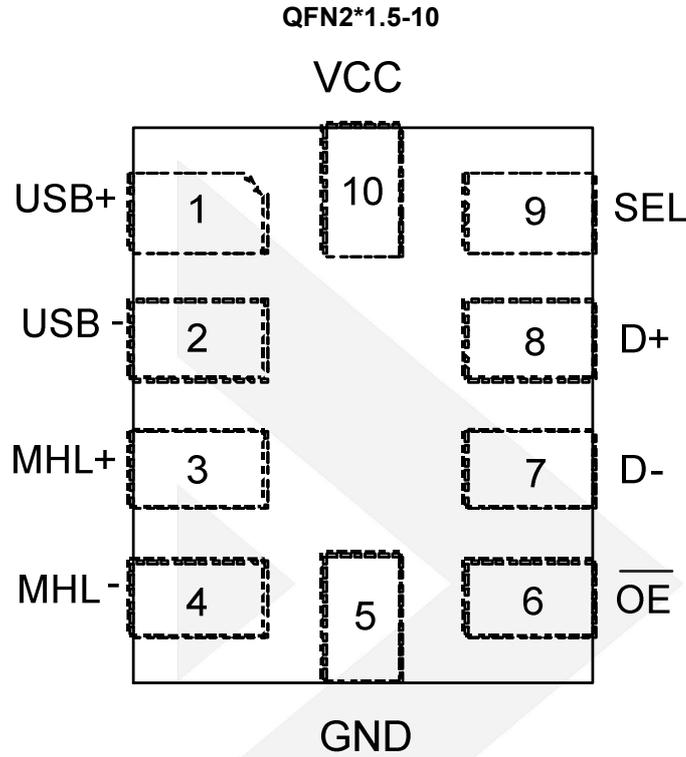
Figure 1. Top View

Pin Descriptions

Pin Name	Direction	Description
USB+	I/O	USB Data Link (Differential+)
USB-	I/O	USB Data Link (Differential-)
MHL+	I/O	MHL Data Link (Differential+)
MHL-	I/O	MHL Data Link (Differential-)
GND	-	Ground
$\overline{OE}$	I	Output Enable (Active Low)
D-	I/O	Switch Output (Differential-)
D+	I/O	Switch Output (Differential+)
SEL	I	Switch Select (LOW=D+/D- To USB+/USBHIGH=D+/D- To MHL+/MHL-)
VCC	-	Power Supply Pin

Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maxim rating conditions for extended periods may affect device reliability.

Symbol	Parameter	Min	Max	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, $\overline{OE}$)	-0.3	6	V
I_K	Input-Output Port Diode Current ($V_{I/O}<0$)	-50		mA
I_{IK}	Digital Logic Input Clamp Current ($V_i<0$)	-50		mA
I_{CC}	Continuous Current Through VCC		100	mA
I_{GND}	Continuous Current Through GND	-100		mA
T_{stg}	Storage Temperature	-65	150	°C
ESD	Human Body Model (HBM)	-5500	5500	V

(1) This rating only applies to the D- pin with respect to GND. VCC must be powered within the recommended operating conditions of 2.3V to 5.5V and the $\overline{OE}$ pin must be logic high for this rating to be applicable. Any condition where VCC is unpowered or the $\overline{OE}$ pin is not high must reference the rest of the Absolute Maximum Ratings Table.

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply Voltage	2.3to 5.5	V
$V_{I/O\,(USB)}$	Analog Voltage	0 to Vcc	V
$V_{I/O\,(MHL)}$			
V_I	Digital Input Voltage (SEL, $\overline{OE}$)	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 85	ºC
$R_{\theta JA}$	Junction-To-Ambient Thermal Resistance	193	°C/W
$R_{\theta JC(top)}$	Junction-To-Case (Top) Thermal Resistance	96	°C/W
$R_{\theta JB}$	Junction-To-Board Thermal Resistance	118	°C/W

θ$_{JT}$	Junction-To-Top Characterization Parameter	7.8	°C/W
θ$_{JB}$	Junction-To-Board Characterization Parameter	118	°C/W

Electrical Characteristics

T_A=-40°C to 85°C, Typical values are at V_{CC}=3.3V, T_A=25°C, (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
MHL SWITCH						
R_{ON}	ON-State Resistance	V_{CC}=2.7V, $V_{I/O}$=1.65V, I_{ON}=-8mA		5.7	9	Ω
		V_{CC}=2.3V, $V_{I/O}$=1.65V, I_{ON}=-8mA		5.7	9.5	
ΔR_{ON}	ON-State Resistance Match between + and - Paths	V_{CC}=2.3V, $V_{I/O}$=1.65V, I_{ON}=-8mA		0.1		Ω
I_{OZ}	OFF Leakage Current	V_{CC}=5V, Switch OFF, $V_{MHL\pm}$=1.65V to 3.45V, $V_{D\pm}$=0V	-2		2	μA
I_{ON}	ON Leakage Current	V_{CC}=5V, Switch ON, $V_{MHL\pm}$=1.65V to 3.45V, $V_{D\pm}$ = NC	-2		2	μA
Z_{ON_GND}	ON-State Impedance to GND	$V_{I/O}$=0V to 1.8V,TA=-40°C to 85°C	7			MΩ
USB SWITCH						
R_{ON}	ON-State Resistance	V_{CC}=2.3V, $V_{I/O}$=0.4V, I_{ON}=-8mA		4.6	7.5	Ω
ΔR_{ON}	ON-State Resistance Match between + and - Paths	V_{CC}=2.3V, $V_{I/O}$=0.4V, I_{ON}=-8mA		0.1		Ω
I_{OZ}	OFF Leakage Current	V_{CC}=5V, Switch OFF, $V_{USB\pm}$=0V to 3.6V, $V_{D\pm}$=0V	-2		2	μA
I_{ON}	ON Leakage Current	V_{CC}=5V, Switch ON, $V_{USB\pm}$=0V to 3.6V, $V_{D\pm}$=NC	-2		2	μA
Z_{ON_GND}	ON-State Impedance to GND	$V_{I/O}$=0V to 1.8V,TA=-40°C to 85°C	7			MΩ
DIGITAL CONTROL INPUTS (SEL, $\overline{OE}$)						
V_{IH}	Input Logic High	V_{CC}=2.3V to 5V	1.3			V
V_{IL}	Input Logic Low	V_{CC}=2.3V to 5V			0.6	V
I_{IN}	Input Leakage Current	V_{CC}=5V, $V_{I/O}$=0V to 3.6V, V_{IN}=0 to 5V	-10		10	μA

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Dynamic Characteristics

Overoperating free-air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$C_{ON(MHL)}$	MHL Path ON Capacitance	V_{CC}=3.3V, $V_{I/O}$=0 or 3.3V, f=240MHz, Switch ON		1.4	1.8	pF
$C_{ON(USB)}$	USB Path ON Capacitance	V_{CC}=3.3V, $V_{I/O}$=0 or 3.3V, f=240MHz, Switch ON		1.2	1.6	pF
C_I	Digital Input Capacitance	V_{CC}=3.3V, V_I=0 or 2V		2.2		pF
O_{ISO}	OFF Isolation	V_{CC}=2.3V to 5V, R_L=50Ω, f=240MHz, Switch OFF		-36		dB
X_{TALK}	Crosstalk	V_{CC}=2.3V to 5V, R_L=50Ω, f=240MHz, Switch ON		-42		dB
$B_{W(MHL)}$	MHL Path -3dBBandwidth	V_{CC}=2.3V to 5V, R_L=50Ω, f=240MHz, Switch ON		5.5		GHz
$B_{W(USB)}$	USB Path -3dB Bandwidth	V_{CC}=2.3V to 5V, R_L=50Ω, f=240MHz, Switch ON		5.8		GHz
SUPPLY						
V_{CC}	Power Supply Voltage		2.3		5.5	V
I_{CC}	Positive Supply Current	V_{CC}=5V, V_{IN}=V_{CC} or GND, $V_{I/O}$=0V, Switch ON or OFF		20	40	µA
$I_{CC, HZ}$	Power Supply Current In High-Z Mode	V_{CC}=5V, V_{IN}=V_{CC} or GND, $V_{I/O}$=0V, Switch ON or OFF, $\overline{OE}$=H		1	5	µA

Timing Requirements

Symbol	Conditions			Min	Nom	Max	Unit
t_{switch}	Switching Time (SEL To Output)	See Figure 2			60		ns
$t_{ZH, ZL(MHL)}$	MHL Enable Time ($\overline{OE}$ To Output)	$V_{I/O}$=3.3V or 0V	R_L=50Ω,C_L=5pF, V_{CC}=2.3V to 5V		7		µs
$t_{HZ, LZ(MHL)}$	MHL Disable Time ($\overline{OE}$ To Output)				22		ns
$t_{ZH, ZL(USB)}$	USB Enable Time ($\overline{OE}$ To Output)	$V_{I/O}$=0.8V or 0V			7		µs
$t_{HZ, LZ(USB)}$	USB Disable Time ($\overline{OE}$ To Output)				17		ns
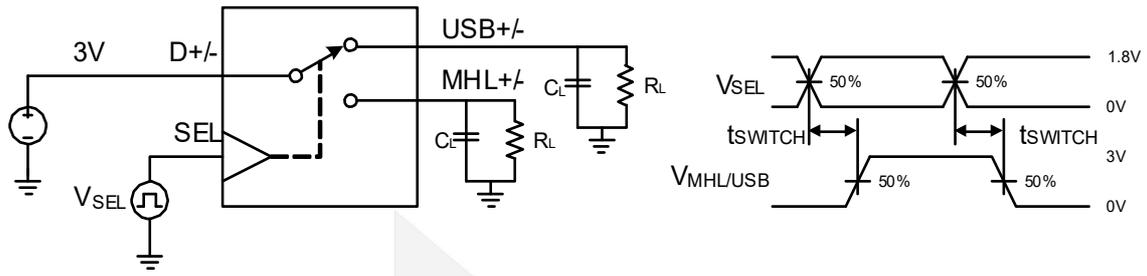
(1) All input pulses are supplied by generators having the following characteristics: PRR≤10MHz, Z_O=50Ω, t_r<5ns, t_f<5ns.

(2) C_L includes probe and jig capacitance.

Figure 2. Timing Diagram

## Typical Performance Characteristics
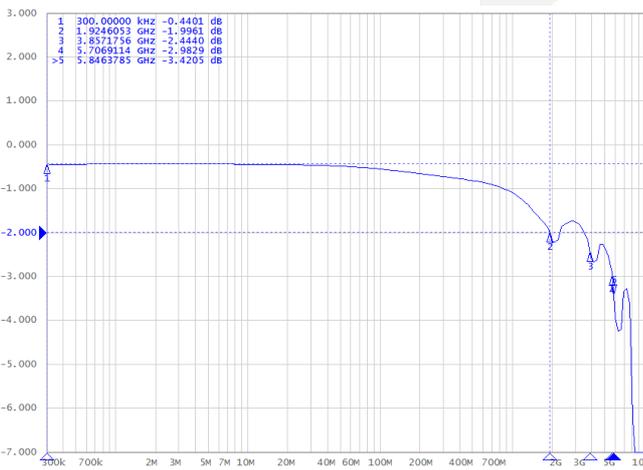
**Figure3. Differential S21 vs Frequency USB Switch**
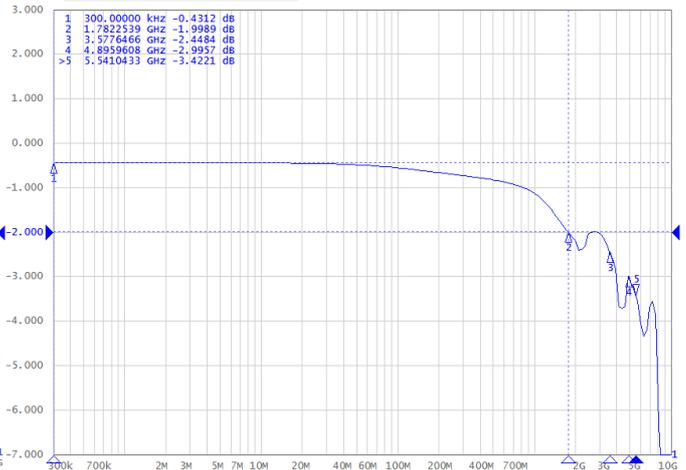

Figure4. Differential S21 vs Frequency MHL Switch
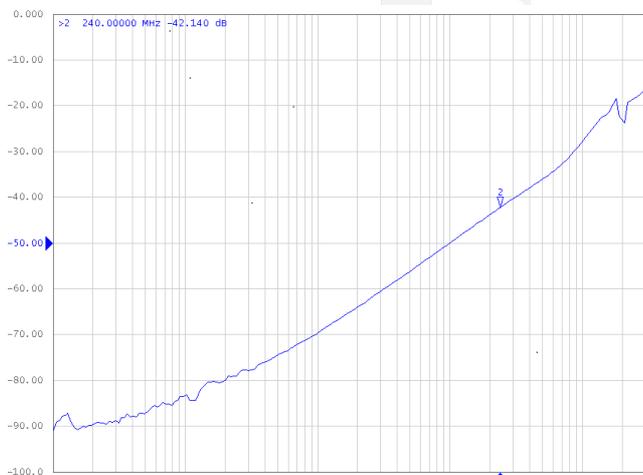
**Figure 5. CrossTalk Vs Frequency for USB Path**
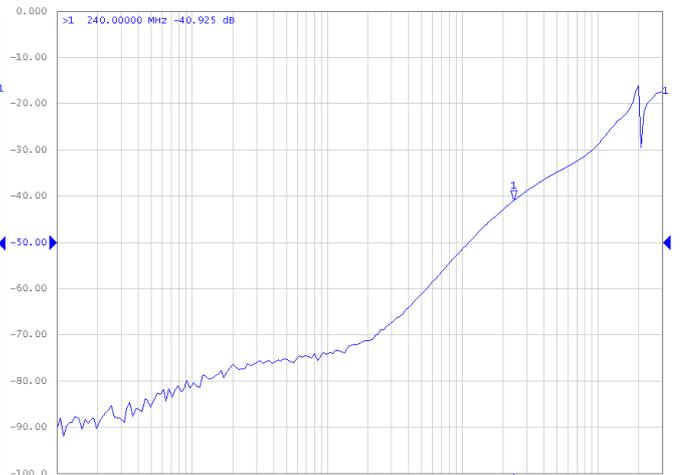
Figure 6. CrossTalk Vs Frequency for MHL Path

DIO3000

Typical Performance Characteristics (Continued)
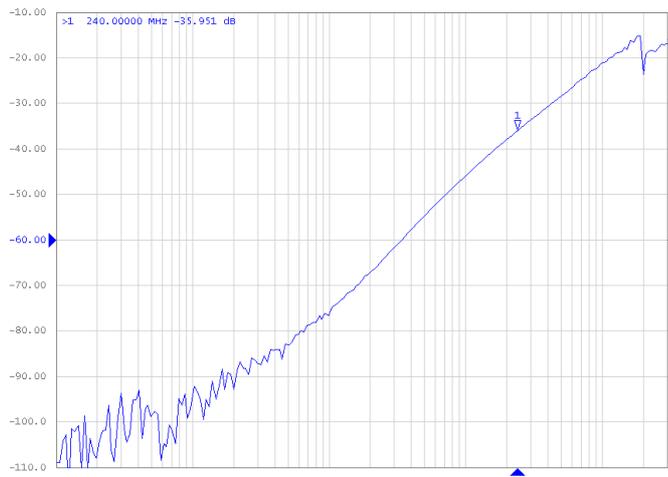
Figure 7. Off Isolation Vs Frequency for USB Path
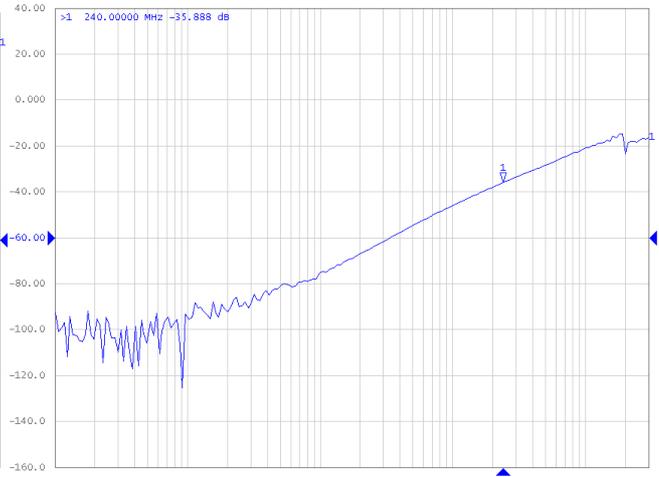
**Figure 8. Off Isolation Vs Frequency for MHL Path**
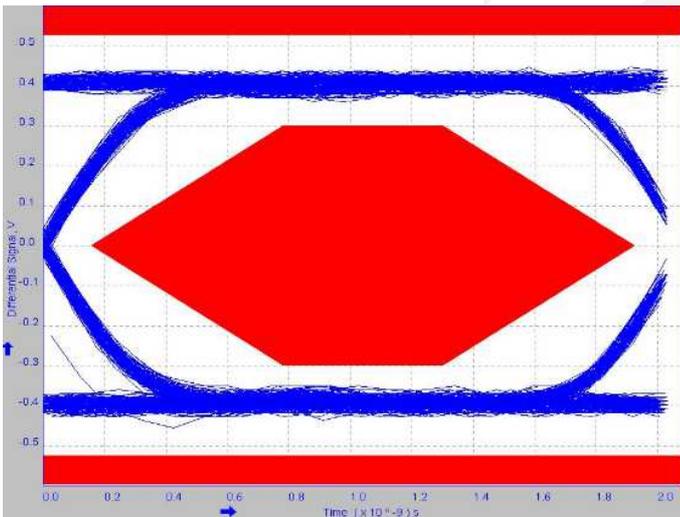
Figure 9. 480-Mbps USB2.0 Eye Pattern for USB Switch With DIO3000

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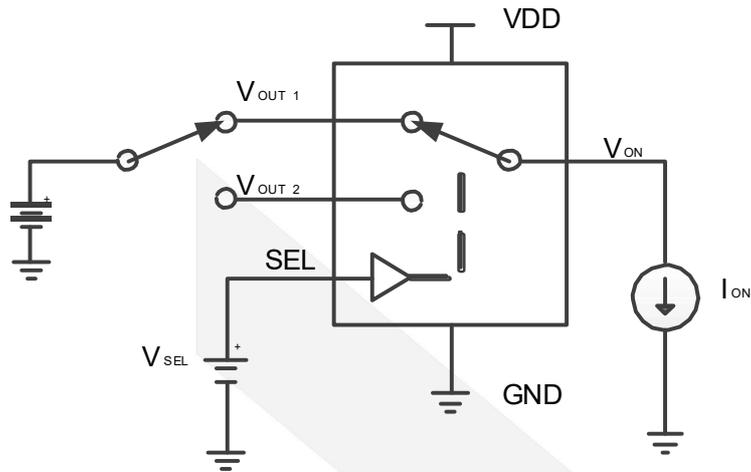
Channel ON, $R_{ON}=(V_{ON}-V_{I/O1})/I_{ON}$ or $(V_{ON}-V_{I/O2})/I_{ON}$, V_{SEL}=H or L

Figure 10. ON-State Resistance (R_{ON})
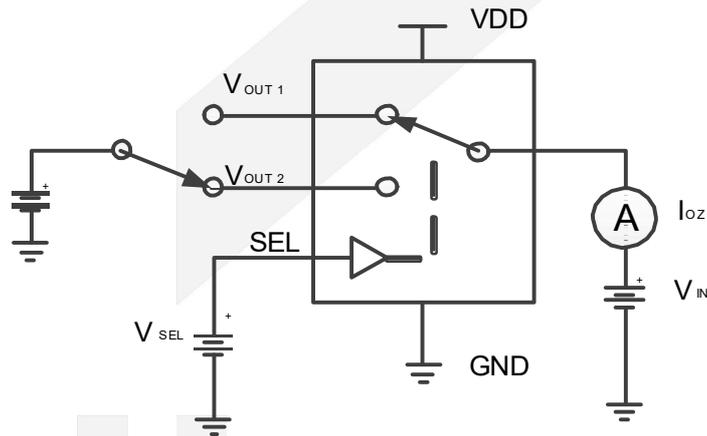
Channel OFF, V_{SEL}=H or L

Figure 11. OFF Leakage Current (I_{OZ})
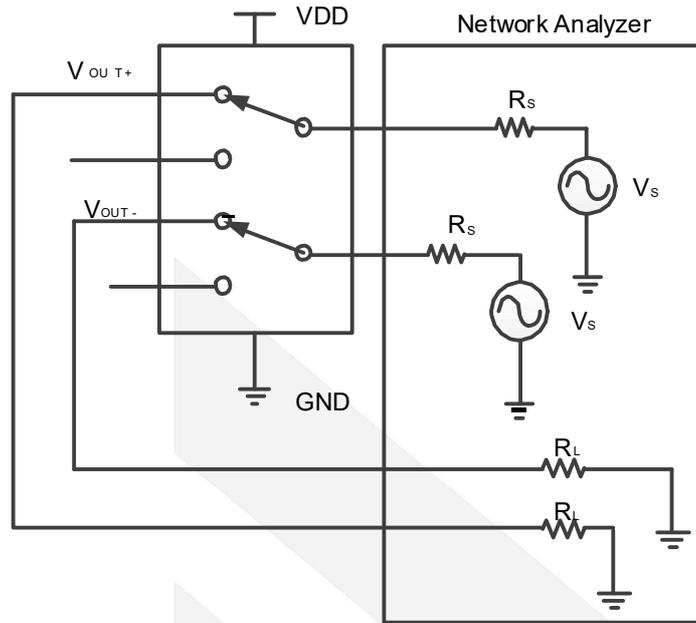
Channel ON, V_{SEL}=H or L, R_S=R_L=50Ω

Figure 12. Bandwidth (BW)

# Detailed Description

Functional Block Diagram
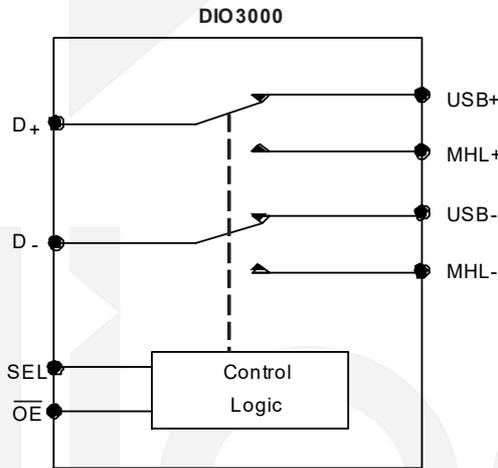
Table 1. Function Table

SEL	$\overline{OE}$	SWITCH STATUS
X	High	Both USB and MHL switches in High-Z
Low	Low	D+/D- to USB+/USB-
High	Low	D+/D- to MHL+/MHL-

Feature Description

Low Power Mode

The DIO3000 has a low power mode that reduces the power consumption to 1µA while the device is not in use. Set enable pin $\overline{OE}$ with a logic High signal to put IC in low power mode.

Overvoltage Protection when 9V Short to D- Pin

The DIO3000 can be used to protect the system when the D- pin is exposed to voltages less than 9V. Voltages higher than 9V may damage the device.

In Figure 13, the system has an application processor (AP) which cannot survive 9V on the USB data lines. The following procedure protects the system and the DIO3000.

1. The AP detects a dedicated charging port (DCP) is connected to the USB port.
2. To disable the switches, the AP pulls the $\overline{OE}$ pin high. The DIO3000 is now in low-power mode and can protect the AP.
3. The AP negotiates to Charger for a faster charging mode with VBUS up to 9V.
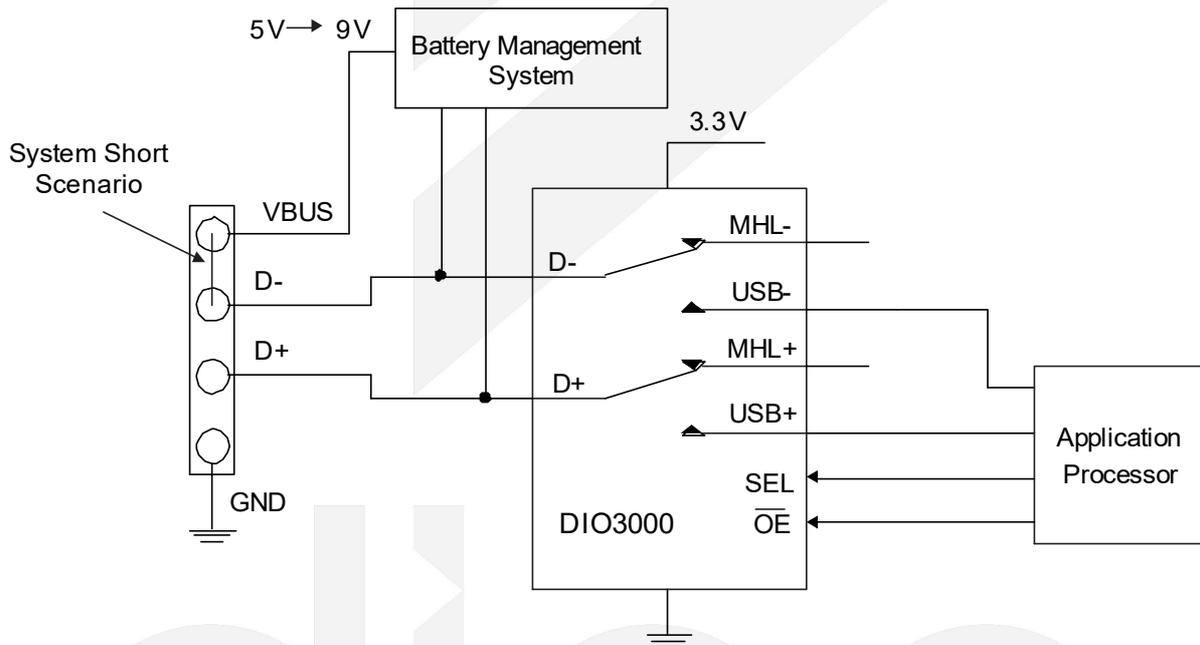

Figure 13. Potential VBUS to D-Short Example

Typical Application

Figure 14 is a typical application of the DIO3000 USB/MHL switch. The DIO3000 has internal 6MΩ pulldown resistors on $\overline{OE}$ and SEL. The pulldown on $\overline{OE}$ pin enables the switch when power is applied. The pulldown on SEL pin ensure the USB channel is selected by default. The DIO3157E is a separate SPDT switch that is used to switch between MHL's CBUS and the USB ID line that is needed for USB OTG (USB On-The-Go) application.
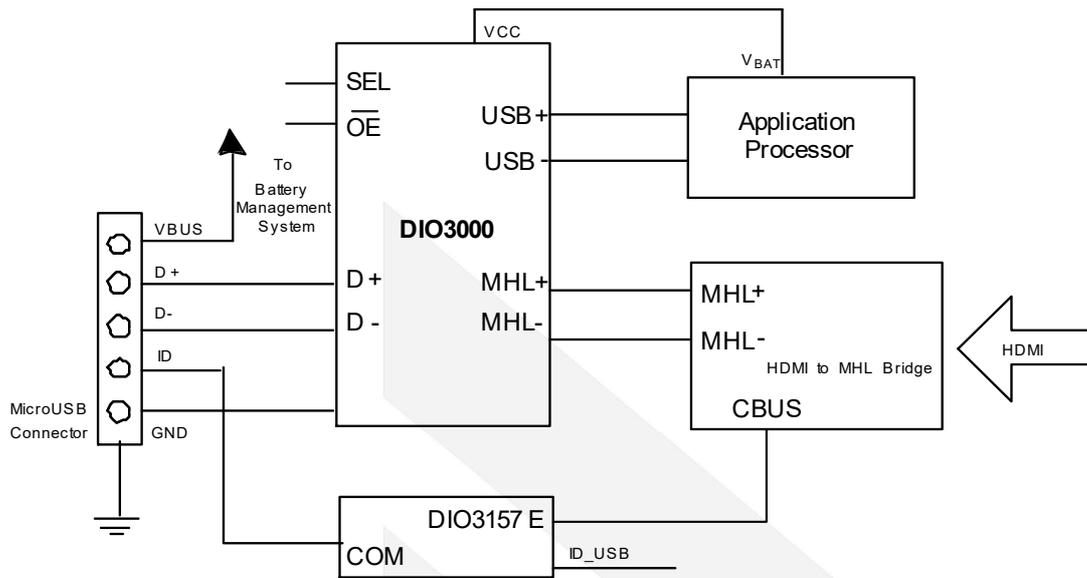
Figure 14. Typical DIO3000 Application

CONTACT US

Dioo is a professional design and sales corporation for high-quality and performance analog semiconductors. The company focuses on industry markets, such as, cell phone, handheld products, laptop, and medical equipment and so on. Dioo's product families include analog signal processing and amplifying, LED drivers and charger IC. Go to http://www.dioo.com for a complete list of Dioo product families.

For additional product information, or full datasheet, please contact with our Sales Department or Representatives.