

# **TPS2071EVM-159**

## **Hybrid USB Hub Evaluation Module**

# *User's Guide*

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# Read This First

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### ***How to Use This Manual***

This document contains the following chapters:

- Chapter 1 – Introduction
- Chapter 2 – Test Summary
- Chapter 3 – Physical Layouts
- Chapter 4 – Bill of Materials
- Chapter 5 – Schematic

### ***Related Documentation From Texas Instruments***

*TPS2070, TPS2071 Hybrid USB Power Controller* data sheet, literature number SLVS287

*TPS202x/3x and TPS204x/5x USB Power Distribution Application Report*, literature number SLVA049.

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# Introduction

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This user's guide describes the TPS2071EVM-159 hybrid hub evaluation module (SLVP159). The EVM provides a convenient method for evaluating the performance of a hybrid (bus-powered/self-powered) hub using the TPS2071 hybrid USB hub controller. A complete designed and tested USB hub is presented. The hub is an EVM that can deliver up to 0.5 A of continuous output current at self-powered mode or up to 0.1 A of continuous output current at bus-powered mode.

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## 1.1 Background

The universal serial bus (USB) interface is a four-line multiplexed serial bus designed for low to high speed PC peripherals (e.g., keyboards, printers, scanners, ADSL modems). The maximum speed of the USB 1.1 interface is 12 Mb/s, while USB 2.0 can operate at up to 480 Mb/s. The four-line USB interface was conceived for dynamic attach-detach (hot-plug-unplug) of peripheral devices. Two lines are provided for differential data and two lines are provided for 5-V power distribution.

USB data is a 3.3-V level signal, but power is distributed at 5 V to allow for voltage drops in cases where power is distributed through long cables or more than one hub. Each function must provide its own regulated 3.3 V from the 5-V input or from its own internal power supply.

The USB specification defines the following five device classes (each differentiated by power sourcing and sinking requirements):

- Bus-powered hubs
- Self-powered hubs
- Low-power, bus-powered functions
- High-power, bus-powered functions
- Self-powered functions

Both self-powered and bus-powered hubs distribute data and power to downstream functions. A self-powered hub delivers five times the power of a bus-powered hub. In order to manage both low-power and high-power downstream functions, a hybrid hub is desired that can switch between bus-powered mode and self-powered mode. The Texas Instruments TPS2071 USB hybrid-hub power controller (see data sheet SLVS287), together with the Texas Instrument USB hub controller TUSB2046B, provides a simple hybrid-hub solution.

The TPS2071 controller was optimized for hybrid USB hubs and meets all USB specifications for parameters, such as quiescent current, voltage drop and current limitations.

## 1.2 Performance Specification Summary

This section summarizes the performance specifications of the hybrid-hub EVM in accordance with the USB specification requirements (see Table 1–1).

*Table 1–1. Performance Specification Summary*

PARAMETER	Test Conditions	Min	Typ	Max	Units
Bus-power input voltage range (BP)	0 mA to 100 mA/port	4.75		5.25	V
Self-power input voltage range (SP)	0 mA to 500 mA/port	4.85		5.15	V
Downstream output voltage range in bus-powered mode	0 mA to 100 mA/port	4.4		5.25	V
Downstream output voltage range in self-powered mode	0 mA to 500 mA/port	4.75		5.15	V
Output current range	Bus-powered	0		0.1	A
	Self-powered	0		0.5	A
Output current limit	Bus-powered		0.15		A
	Self-powered		0.9		A



# Test Summary

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This chapter presents the test setups used and the tests performed in designing the TPS2071EVM-159 hybrid hub evaluation module (refer to Figures 2–1 and 3–1).

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## 2.1 Test Setup

Testing the EVM requires a PC with Win98 or Win2000 OS and up to five USB cables. A 5-V/2-A ac adapter with a 2.1-mm (diameter) female connector (positive polarity on inner ring) is needed to operate the hub in self-powered mode. USB peripheral devices, such as USB mice and cameras, can be used as downstream USB loads to test the hub in both bus-powered mode and self-powered mode. To measure the voltage drop from the hub inputs to its outputs, four 50- $\Omega$  and four 10- $\Omega$  resistive loads are required.

Follow these steps for initial power up of the EVM:

- 1) Set the six jumpers (JP1-JP6) as follows:
  - JP1 shorting pin 1 and pin 2
  - JP2 shorting pin 2 and pin 3
  - JP3 shorting pin 1 and pin 2
  - JP4 shorting pin 1 and pin 2
  - JP5 shorting pin 2 and pin 3
  - JP6 shorting pin 2 and pin 3

JP4 connects 3.3 V to all the LEDs. Without this jumper, the LEDs will not turn on, reducing power consumption.

JP5 is used to set voltage at BP\_DIS. When the voltage at BP\_DIS is low, i.e. shorting pin 2 and pin 3 of JP5, the hub can automatically switch between bus-powered mode and self-powered mode. If JP5 is shorted between pin 1 and pin 2, BP\_DIS will be high and the EVM will only work in self-powered mode.

JP6 is used to set the voltage on EN\_REG that controls an integrated 5-V LDO controller. If JP6 is shorted between pin 1 and pin 2 by a jumper, the LDO controller of TPS2071 will be enabled and can regulate a high voltage (6 V to 9 V) to 5 V through an external N-Channel MOSFET.

- 2) Start Management Software of PC

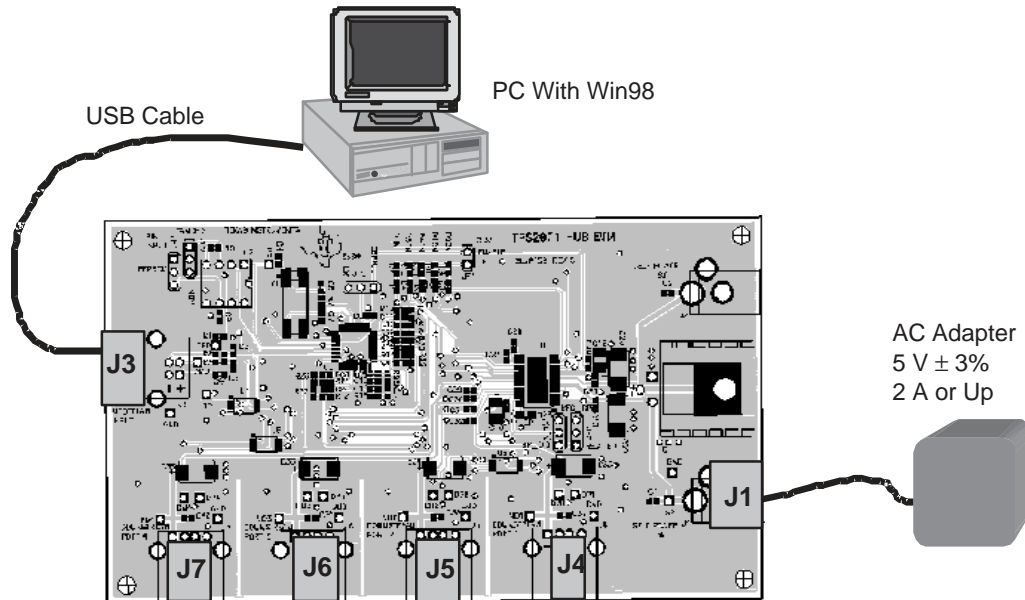
Before testing starts, open *Control Panel* in your PC. Double-click *System* to open *System Properties*, then click *Device Manager* from the *System Properties Window*. At bottom of the *Device Manager window*, you will see *Universal Serial Bus controllers*. Double-click on it; several USB devices should be already listed there.

- 3) Connect EVM to Upstream Host

Plug the upstream connection of the EVM (J3) into a USB connector on the PC (or through another self-powered hub that is connected to the PC). After the EVM is connected to the host, all LEDs on the EVM should illuminate if JP4 is shorted. Otherwise, the EVM is not functioning properly.

Figure 2–1 shows the EVM test setup.

Figure 2–1. EVM Test Setup



## 2.2 Test Summary

Detailed tests for the hybrid hub EVM are provided as follows.

### 2.2.1 Operating in Bus-Powered Mode Without Downstream Devices

If the EVM is connected to the host with no self-powered voltage on J1, the hub will be working in bus-powered mode. *Universal Serial Bus controllers* on the PC will be updated. Double-click *Universal Serial Bus controllers* to see that a new *Generic purpose USB Hub* has been added. To find out the properties of the hub, double-click on the *Generic purpose USB Hub*. The hub information will be displayed in a *Generic purpose USB Hub Properties* window. Click on *Power* from this window, then click on *Power Properties*, all information about the power requirements and the downstream devices on the hub will be shown on *Power* window

Because the hub is in bus-powered mode, the top portion of the window, *Hub Information*, should display *The hub is bus powered. Total power available: 100mA per port*. The bottom part of the window, which is *Devices on this Hub*, should state that *4 port(s) available* in the *Device Description* column and *0 mA* in the *Power Required* column.

After all the above steps are performed, close the *Power* window and *Generic purpose USB Hub Properties* window, but leave the *System Properties* window open.

### 2.2.2 Operating in Self-Powered Mode Without Downstream Devices

Plug the 5V/2A AC adapter into Jack J1 on the EVM board; the hub will automatically switch to self-powered mode. *Universal Serial Bus controllers* on the PC will be updated, and you can check out the changes in *Power Properties* following the same steps described above.

Now the hub is in self-powered mode, thus the top portion of the *Power* window, *Hub Information*, should display *The hub is self powered. Total power available: 500mA per port*. The bottom part of the window, which displays *Devices on this Hub*, should state *4 port(s) available* in the *Device Description* column and *0 mA* in the *Power Required* column. After these steps, close the *Power* window and *Generic purpose USB Hub Properties* window, and leave the *System Properties* Window open.

### 2.2.3 Operating in Bus-Powered Mode With Downstream Devices

Plug a bus-powered USB device, such as a mouse, into any of the 4 ports of the hub EVM in either bus-powered mode or self-powered mode. Open the *Power* window and see what has changed in *Devices on this Hub*. When finished, close the *Power* window and *Generic purpose USB Hub Properties* window. This can be repeated with other ports or devices. If four bus-powered USB devices are available, they can be plugged into the EVM at the same time.

### 2.2.4 Operating in Self-Powered Mode With Downstream Devices

Plug a self-powered USB device (high power, >100 mA), such as a USB camera or a USB hub, into one port of the hub EVM. If the EVM is in bus-powered mode (low power), i.e., the ac adapter is not attached to J1, then an error message will pop up on the screen because the high power load causes overcurrent in the bus-powered hub. The TPS2071 will sense the overcurrent, limit its current and report it to USB controller. The controller then will shut down the channel and inform the host on the PC.

Unplug the self-powered USB device, close the error message, and then turn on the 5-V ac adapter at J1 so that the EVM is running in self-powered mode. Now, if the device is plugged into the EVM, *Universal Serial Bus controllers* on the PC will be updated, and you can check out the changes in *Power* window. When it is done, close the *Power* window and *Generic purpose USB Hub Properties* window. Repeat the testing at the other three ports. Any USB device can be connected to the hub in self-powered mode.

### 2.2.5 Voltage-Drop Measurement

The bus-power load test (no self power source on the EVM) is performed as follows:

- Connect 50- $\Omega$ , 1-W resistive loads to the V+ and V- terminals of each downstream port.
- Verify that the voltage drop from BP test point to VO1–VO4 is less than 100 mV (output voltage should be at least 4.4 V or higher).

The self-power load test (with self power source on the EVM) is performed as follows:

- Connect a 5-V adapter to self-power jack (J1).
- Connect 10- $\Omega$ , 5-W resistive loads from V+ to V- on each downstream port.
- Verify that the voltage drop from SP testing point to VO1–VO4 is less than 100 mV (output voltage should be at least 4.75 V or higher).

# Physical Layouts

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This chapter contains the board layout and assembly drawings for the TPS2071EVM-159 Hybrid Hub Evaluation Module.

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### 3.1 Board Layout

Figure 4–1 shows the top layer of the EVM. Figure 4–2 shows the bottom layer. Figure 4–3 shows the top assembly view.

Figure 3–1. EVM Board Layout Top Layer

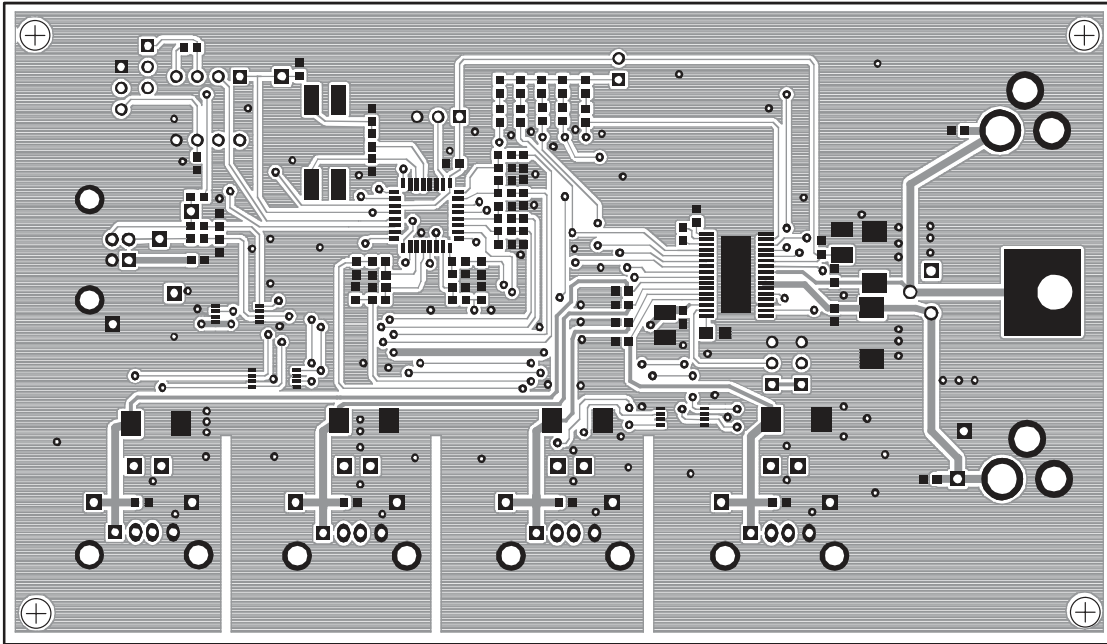


Figure 3–2. EVM Board Layout Bottom Layer

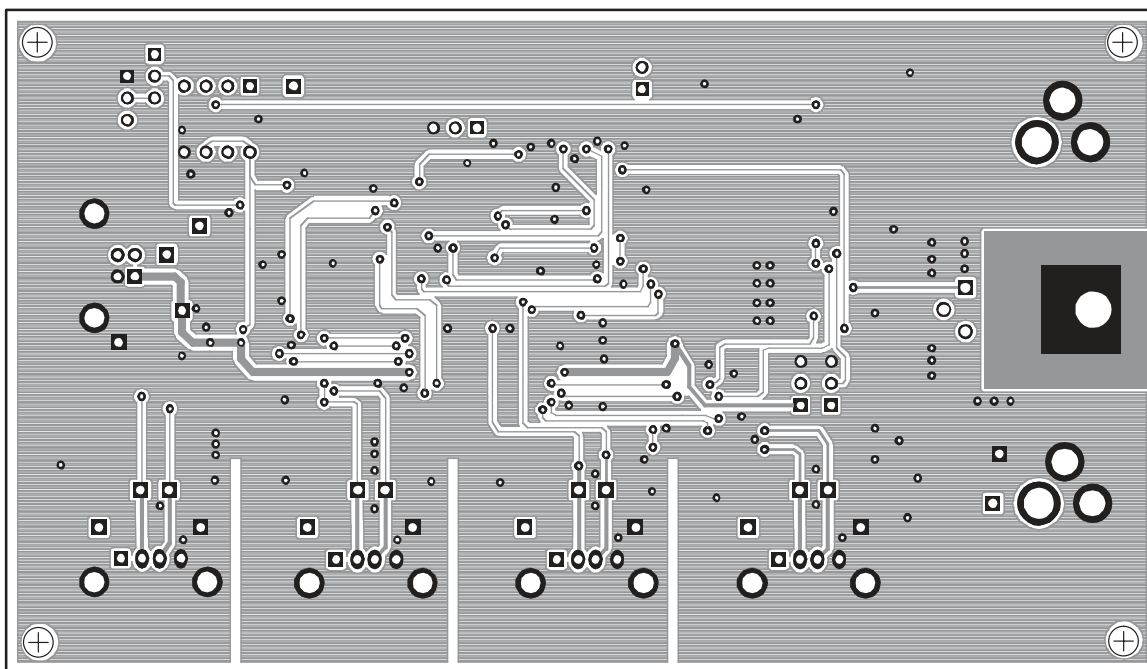
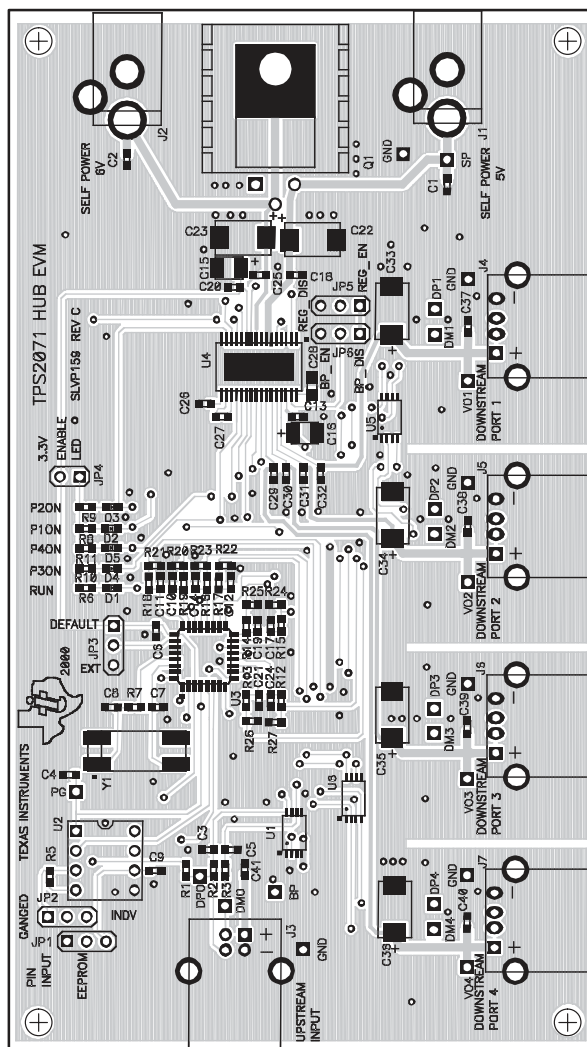


Figure 3–3. EVM Top Assembly View





# Bill of Materials

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This chapter contains the bill of materials needed for this EVM.

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## 4.1 Bill of Materials

Table 4–1 lists materials required for the TPS2071EVM-159.

Table 4–1. EVM Bill of Materials

Table 4–1 lists materials required for the SLVP159 EVM.

QTY.	REF DES	PART NUMBER	DESCRIPTION	MFR	SIZE
16	C1,C6,C9,C13, C18,C20,C26, C29,C30,C31, C32,C37,C38, C39,C40, C41	GRM39X7R104K016D	Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R	Murata	603
2	C2,C25	GRM39X7R104K016D	Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R (not used)	Murata	603
10	C3,C5,C10, C11,C12,C14, C17,C19,C21, C24	GRM39COG220J50	Capacitor, ceramic, 22 pF, 50 V	Murata	603
2	C4,C27	GRM39X7R103K025AD	Capacitor, ceramic, 0.01 $\mu$ F, 25 V, X7R	Murata	603
2	C7,C8	GRM39COG330J50	Capacitor, ceramic, 33 pF, 50 V	Murata	603
2	C15,C16	T491B475K010AS	Capacitor, B size, tantalum, 4.7 $\mu$ F, 10 V, 10%	KEMET	B Size
5	C22,C33,C34, C35,C36	T491D686M006AS	Capacitor, D case, tantalum, 68 $\mu$ F, 6.3 V, 20%	KEMET	D Size
1	C23	T491D686M006AS	Capacitor, D case, tantalum, 68 $\mu$ F, 6.3 V, 20% (not used)	KEMET	D Size
1	C28	GRM40X7R474K25	Capacitor, ceramic, 0.47 $\mu$ F, 25 V, X7R	Murata	805
1	D1	160-1181-1-ND	Diode, LED, red, 1.8-V, 20-mA, 20-mcd	Liteon	603
4	D2,D3,D4,D5	160-1183-1-ND	Diode, LED, green, 2.1-V, 20-mA, 6-mcd	Liteon	603
1	J1	RAPC 722	Connector, 2,1 mm, dc jack w/switch, TH	Switchcraft	
1	J2	RAPC 722	Connector, 2,1 mm, dc jack w/switch, TH (not used)	Switchcraft	
1	J3	67068-1000	Connector, USB upstream (Type B)	Molex	
4	J4,J5,J6,J7	87531-001	Connector, USB downstream (Type A)	Molex	
5	JP1,JP2,JP3, JP5, JP6	PTC36SAAN	Header, 3-pin, 100 mil spacing, (36-pin strip)	Sullins	
1	JP4	PTC36SAAN	Header, 2-pin, 100 mil spacing, (36-pin strip)	Sullins	
1	Q1	IRLZ24N	Mosfet, N-ch, 55 V, 60 m $\Omega$ , 45W (not used)	IR	TO-220V
2	R1,R7	STD	Resistor, chip, 1.5 k $\Omega$ , 1/16W, 5%		603
6	R5,R6,R8,R8, R10,R11	STD	Resistor, chip, 1.0 k $\Omega$ , 1/16W, 5%		603
10	R2,R3, R12–R19	STD	Resistor, chip, 22 $\Omega$ , 1/16W, 5%		603
8	R20-R27	STD	Resistor, chip, 15 k $\Omega$ , 1/16W, 5%		603
17	TP1–TP13, TP18, TP20–TP22	240-345	Test point, red, 1 mm	Farnell	
6	TP14–TP17, TP19,TP23	240-333	Test point, black, 1 mm	Farnell	

QTY.	REF DES	PART NUMBER	DESCRIPTION	MFR	SIZE
3	U1,U5,U6	SN75240PW	IC, Dual USB Port Transient Suppressor (not used)	TI	TSSOP8
1	U2	NM93C46	IC, 1024-Bit Serial EEPROM (not used)	Fairchild	DIP8
1	U3	TUSB2046VF	IC, 4-Port USB Hub w/Opt. Serial EEPROM Interface	TI	VF- PQFP32
1	U4	TPS2071DAP	IC, Pwr-Distribution Controller, 2-In/4-Out	TI	DAP32
1	Y1	MA-505-6.00M-C2	6.00 MHz with 18pF load	Epson Elect.	MA-505
1	HS1	6073B	Heatsink (not used)	Thermalloy	
6	Shunts	SPC02SYAN	Shorting Jumper Flash	Sullins Electronics	

# Schematics

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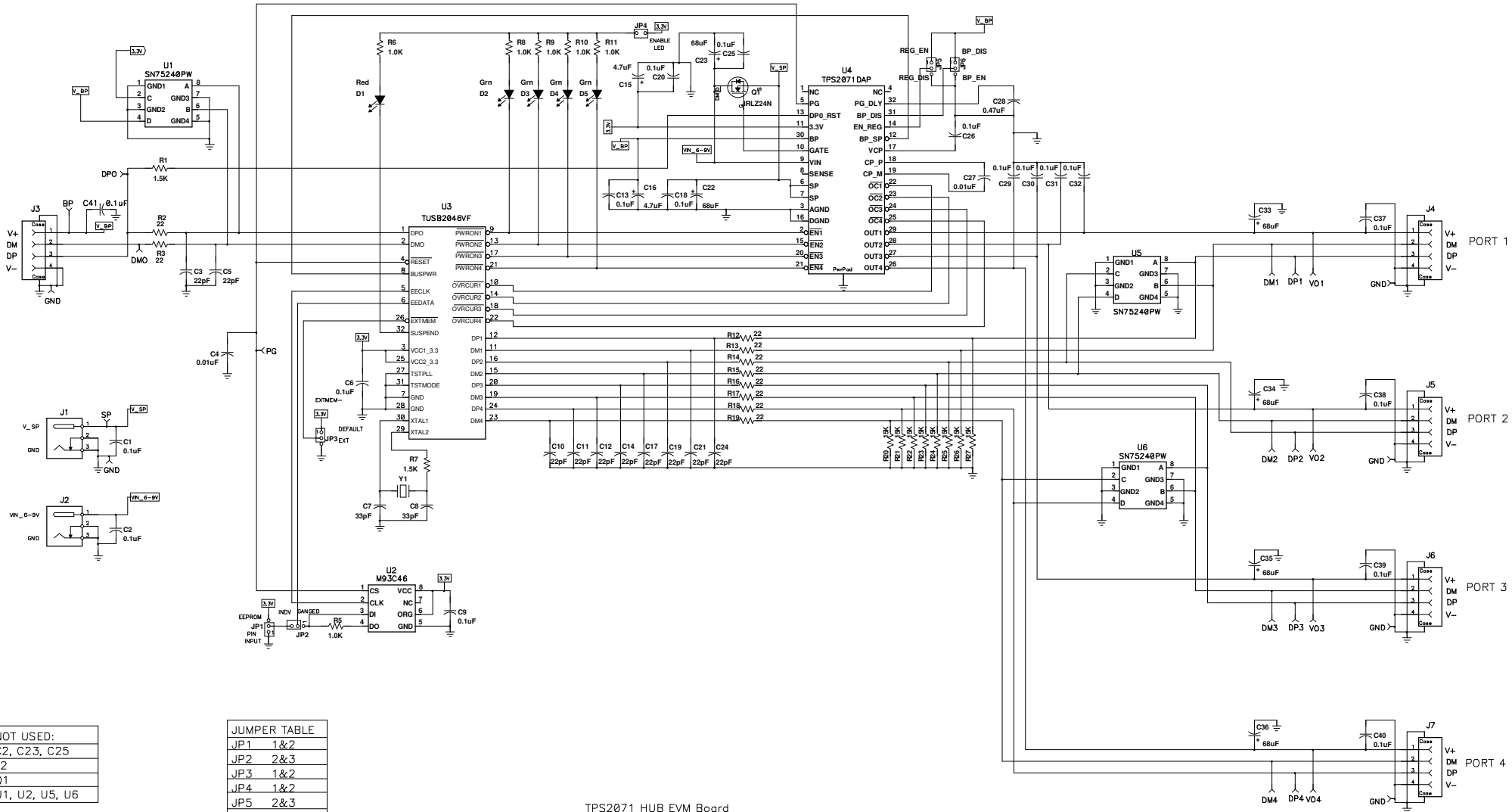
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Figure 5–1 on the next page shows the TPS2071EVM-159 schematic diagram.

The following notes apply to the following schematic:

- Notes:**
- 1) C2, C23, C25, J2 and Q1 are not on the EVM. They are normally used with TPS2071 to form an external LDO that regulates a 6-V to 9-V voltage source down to 5-V for self power (SP) when a 5-V regulated self power source is not available. To use the external LDO, place all the above components on the board (plus heatsink with Q1) and short pin 1 and pin 2 of JP5.
  - 2) U2 is also omitted on the EVM, U2 is normally used to describe Vendor ID (VID) and custom PID.
  - 3) U1, U5, and U6 are not placed on the EVM. These devices are USB transient voltage suppressors normally used to improve the performance and reliability of USB hubs. Commercial USB hubs require them.



NOT USED:

C2, C23, C25
J2
Q1
U1, U2, U5, U6

JUMPER TABLE

JP1	1&2
JP2	2&3
JP3	1&2
JP4	1&2
JP5	2&3
JP6	2&3

TPS2071 HUB EVM Board