TPS66020 Evaluation Module

This document is the user guide for the TPS66020 Evaluation Module (TPS66020EVM). The TPS66020EVM allows for evaluation of the TPS66020 IC as part of a stand-alone testing kit and testing of USB Type-C and Power Delivery (PD) end products. Out of the box, the TPS66020EVM can be used to test the Source and Sink paths in addition to trying the different protection schemes, such as OVP (Overvoltage Protection).

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Trademarks

1 Introduction

Texas Instrument's (TI's) TPS66020 evaluation module helps designers evaluate the operation and performance of the TPS66020 device.

The TPS66020 is a full-featured power switch multiplexer that contains an integrated 5-V Source power path and a 4-V to 22-V Sink power path. The 5-V Source path limits the output current to a safe level by operating in a constant-current mode when the output load exceeds the selected current-limit threshold. Each power path supports overtemperature and reverse current protection. VBUS has overvoltage protection with its level being set by an optional external resistor divider. If no overvoltage protection is desired, it may be disabled by grounding the OVP terminal. The TPS6602x series supports a fault pin that indicates overcurrent and overtemperature events.

The TPS66020EVM has jumpers, header and test points that will permit to test the Source and Sink configuration in addition to the protection schemes.

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Figure 1 shows the TPS66020EVM board and Figure 2 shows a block level diagram.

Figure 1. TPS66020EVM Board

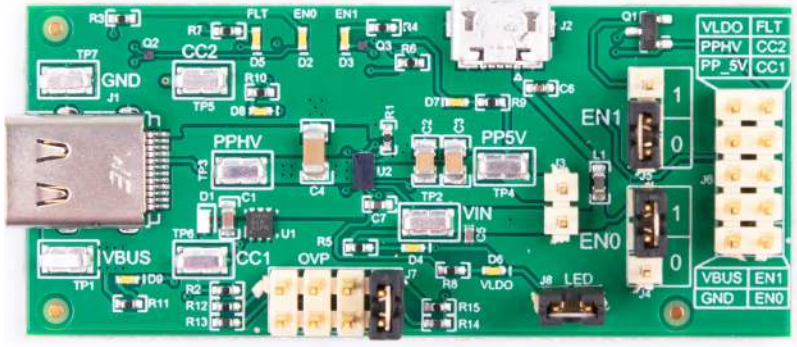
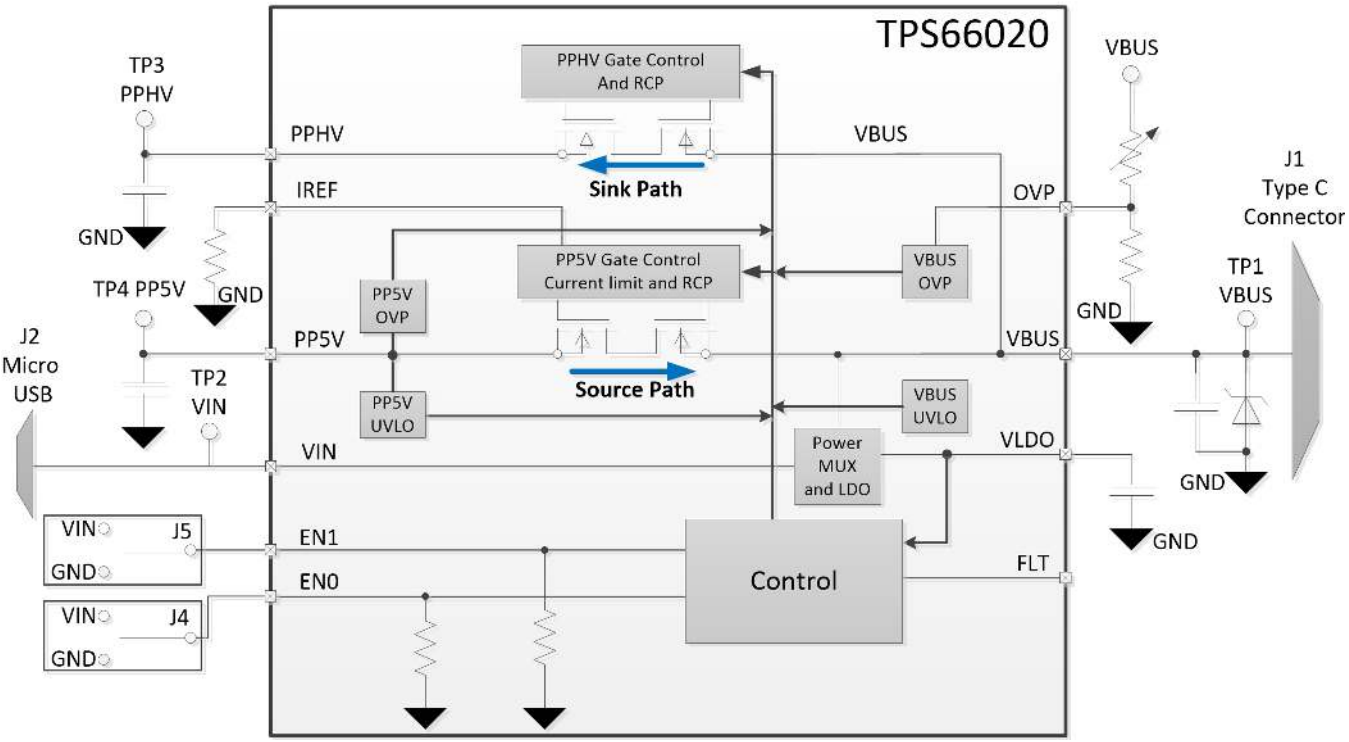


Figure 2. TPS660020EVM Block Diagram



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1.1 Items Required for Operation

The following is required to operate the EVM and reproduce the examples described in this users guide.

- TPS66020EVM
- USB 2.0 Micro Cable and Power Supply or a 5V/1A Bench Power supply for power on the TPS66020 device.
- One Bench Power Supply up to 25 V, Maximum Current 5 Amps. To source or sink power.
- Cables for the power supply and the test points in the TPS66020EVM
- DMM (Digital Volt Meter)
- Oscilloscope
- TPS65988EVM
- PD Source such as a Type-C Power Supply.

2 TPS66020EVM Board Setup

This section describes the header and jumper connections on the EVM and getting started using the TPS66020EVM.

2.1 Functional Modes of Operation

The TPS66020 is a full-featured power switch multiplexer that contains an integrated 5-V Source power path and a 4-V to 22-V Sink power path. There are two digital control inputs signals, EN0 and EN1 to set four possible modes of operation. Table 1 lists the modes, and the corresponding jumper settings in the TPS66020EVM.

Table 1. TPS66020 Functional Table and EVM Jumper Settings

EN1	EN0	Device State	TPS66020EVM Jumper Settings
0	0	Source and Sink paths disabled.	J4-Short pins 1&2 J5-Short pins 1&2
0	1	Sink path enabled.	J4-Short pins 2&3 J5-Short pins 1&2
1	0	Source path enabled, 1.5 A	J4-Short pins 1&2 J5-Short pins 2&3
1	1	Source path enabled, 3.0 A	J4-Short pins 2&3 J5-Short pins 2&3

2.2 Other Jumpers Settings

Table 2 lists the rest of the jumpers functionality

Table 2. Jumpers Description

Jumper	Description
J3	Shorts VIN and PP5V. Quick way to provide power in source mode when Power is applied to VIN
J4 - J5	To enable Functional modes as shown in Table 1.
J6	Debug Header for all the relevant signals. For FLT pin operation, a pull-up resistor to Vin is required.
J7	VBUS Overvoltage Protection Level Configuration.
J8	To Enable Indication LEDs.

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2.3 Connector Functionality

Table 3 lists TPS66020EVM connector and functionality

Table 3. Connector Functionality

Designator	Description
J1	USB Type -C connector.
J2	Micro USB connector. Connect to a PC or USB type power supply to provide operating power to TPS66020. Goes to VIN.

2.4 Test Points

Table 4 lists the TPS66020EVM test points

Table 4. Test Points

Test Point	Label	Description
TP1	VBUS	V_{BUS} voltage on the USB Type-C connector. Sourcing and sinking is always in reference to V_{BUS} (Source to V_{BUS} or sink from V_{BUS})
TP2	VIN	To monitor or provide the device input supply.
TP3	PPHV	To monitor or provide HV System Supply from VBUS.
TP4	PP5V	To monitor or provide 5-V Supply to VBUS.
TP5	CC1	System side CC1. This could be VCONN or CC depending on polarity flip of the USB Type-C cable.
TP6	CC2	System side CC2. This could be VCONN or CC depending on polarity flip of the USB Type-C cable.
TP7	GND	Ground reference for entire board

3 Using the TPS66020EVM

This section discusses how to power the EVM, change the operation modes and evaluate some of the device features.

3.1 Powering the TPS66020EVM

The TPS66020 device is supplied power from the VIN pin. Supplying proper power to the part is enough to make the EVM functional. The easiest manner to provide this power is using J2, the micro USB connector from a laptop or a USB based powered supply as shown in Figure 3.

Alternatively a bench power supply can be applied on TP2.

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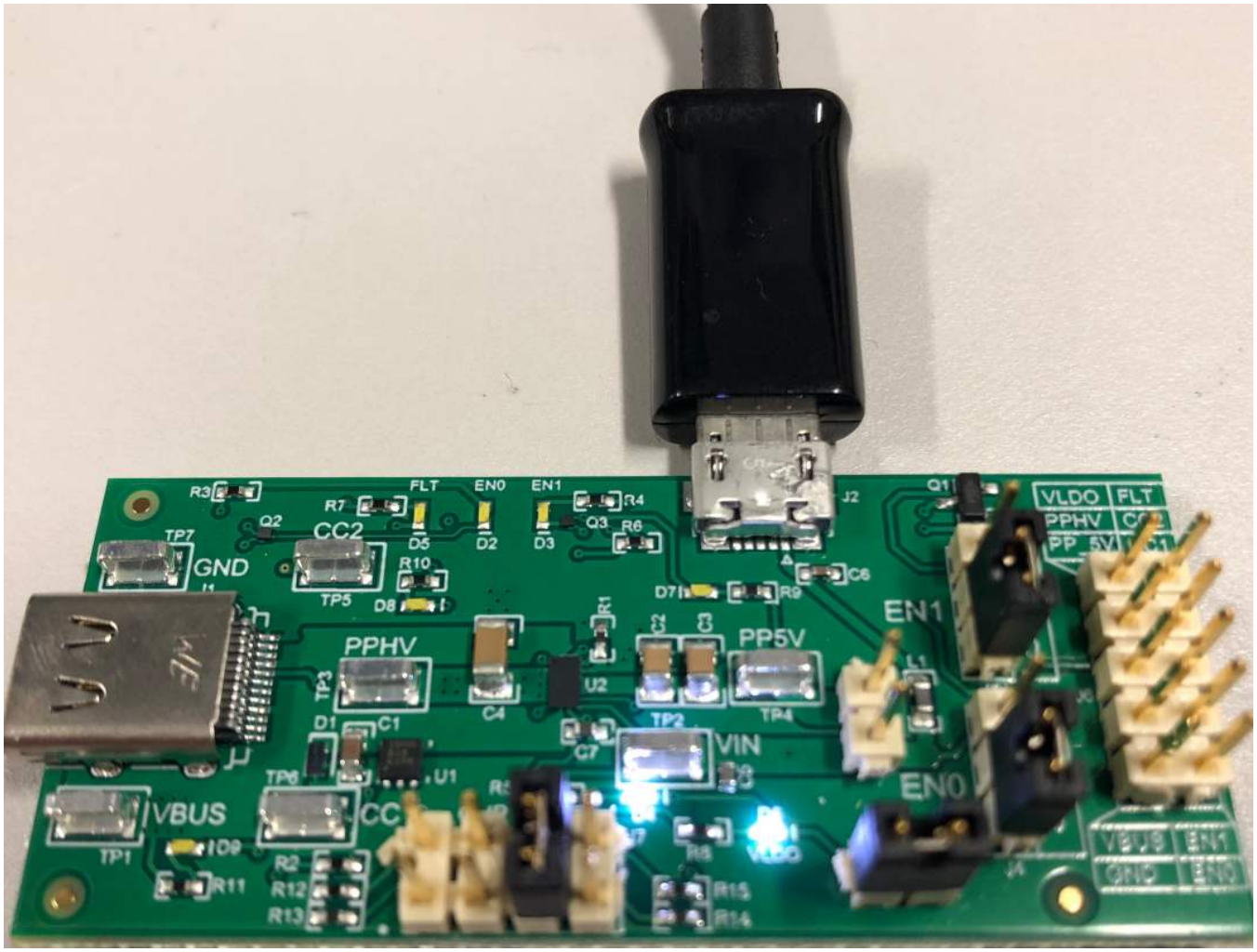
Figure 3. Supplying Power to the TPS66020EVM Using the Micro-USB Connector J2



3.2 Setting the EVM for Sourcing Mode.

As described in Section 2.1, there are two different types of sourcing modes, 1.5 A and 3 A. The description under this section is applicable to both modes. Figure 4 shows the current flow for Sourcing Mode.

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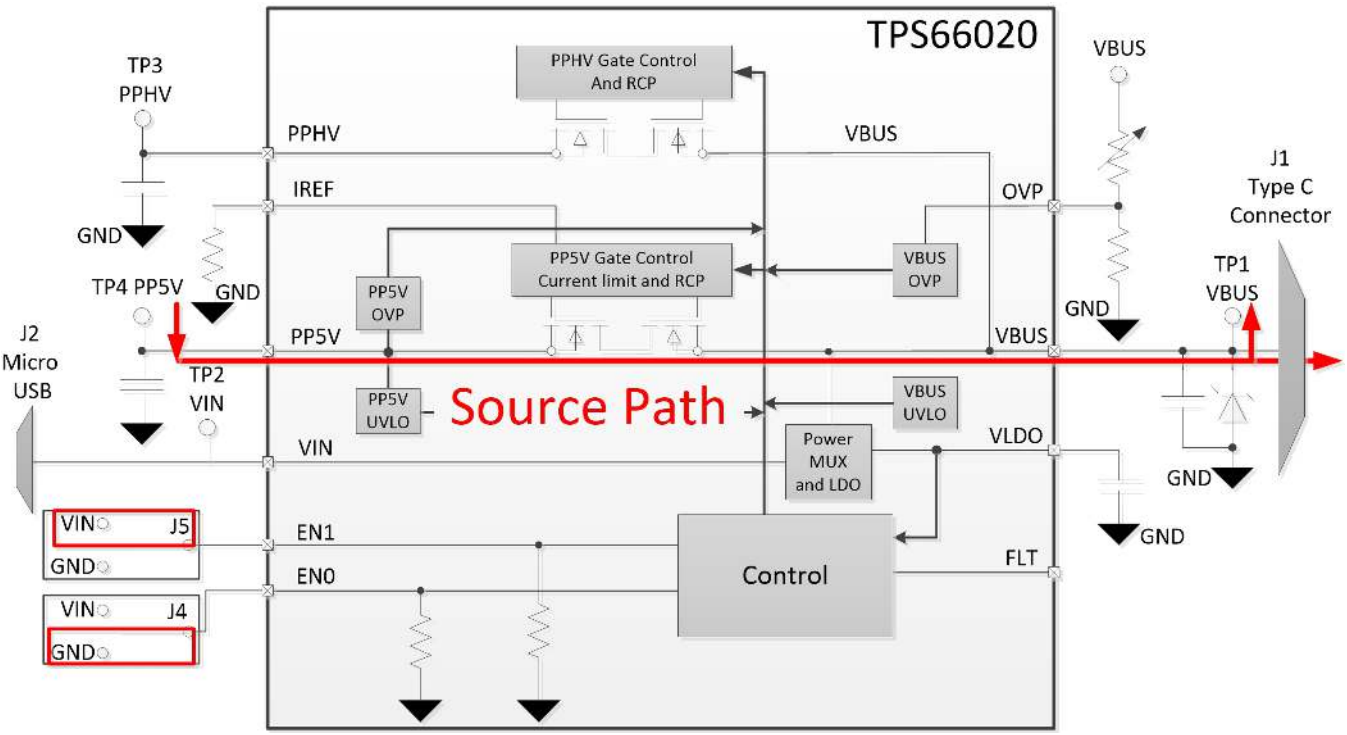
Figure 4. Source Path Configuration



- Place the jumper on J4 to connect VIN to PP5V, therefore 5 V will be applied to PP5V. This can be checked with a DMM on TP4.
- Short pins 1 and 2 on J4 and short pins 2 and 3 on J5 with the jumpers provided. This sets the functional mode to Source Path enabled as shown in Figure 4.
- Measure VBUS voltage on TP1 with a DMM or an Osilloscope to confirm this voltage. This voltage should be close to the PP5V voltage level assuming light loading on VBUS.
- In order to open the source switch, disabling the Sourcing Mode, short pins 1 and 2 on J5. VBUS voltage should be close to 0 V.

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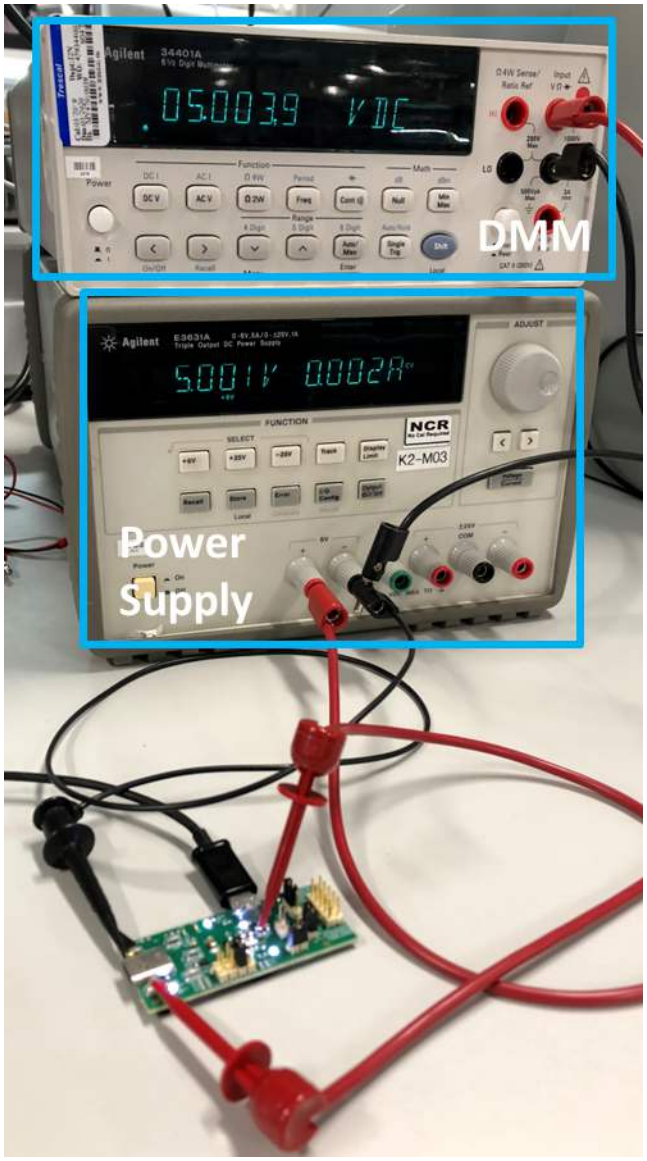

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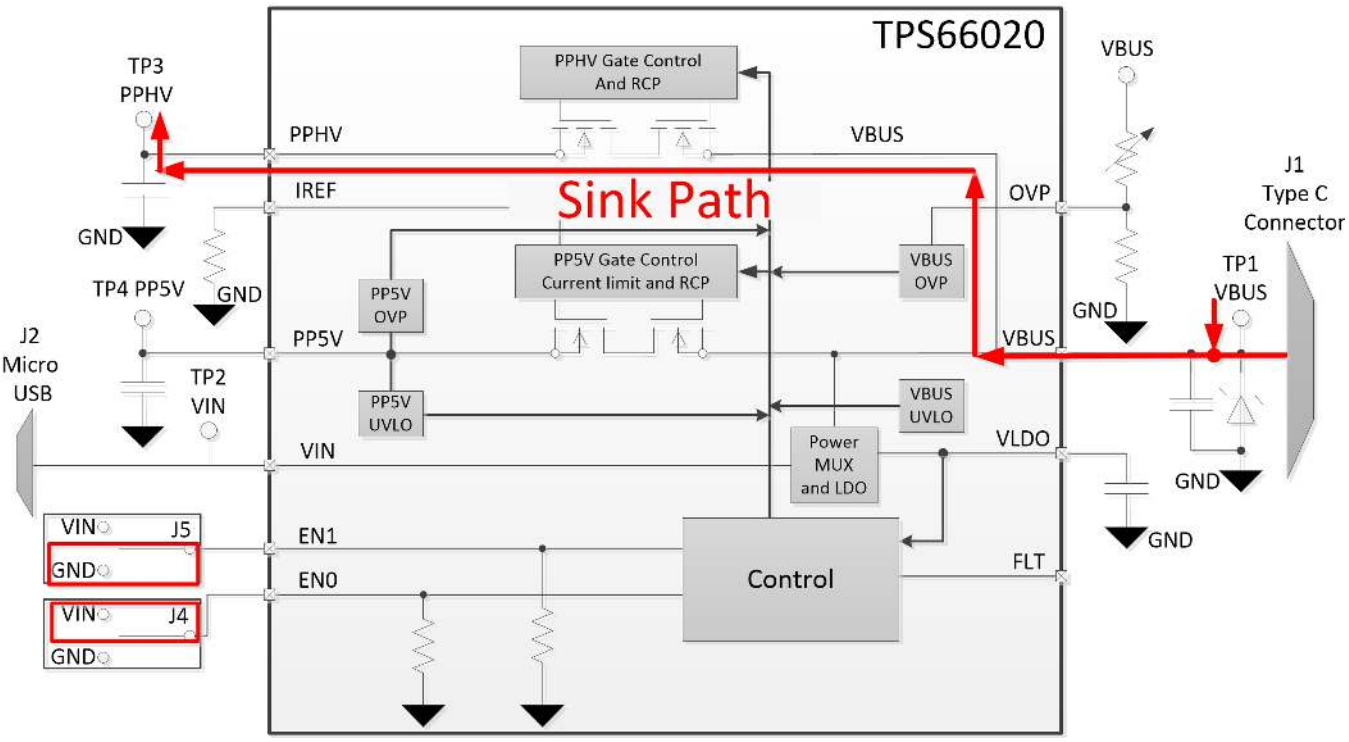
3.3 Setting the EVM for Sinking Mode

Figure 5 shows the current flow for Sinking Mode.

Figure 5. Sink Path Configuration



- Remove the short from J4 to disconnect VIN from PP_5V
- Connect an external supply to VBUS on TP1 and set the voltage to 5 V.
- J4-Short pins 2 and 3, J5-Short pins 1 and 2
- Short pins 2 and 3 on J4 and short pins 1 and 2 on J5 with the jumpers provided. This sets the functional mode to Sink Path enabled as shown in Figure 5.
- Measure PPHV voltage at TP3 with a DMM or an Osilloscope to check the 5 V applied to VBUS is present in PPHV.
- Change the power supply output connected to VBUS on TP1 to 9 V, 15 V, 20 V and measure at TP3 each time. PP_HV should track the changing voltage applied to VBUS.

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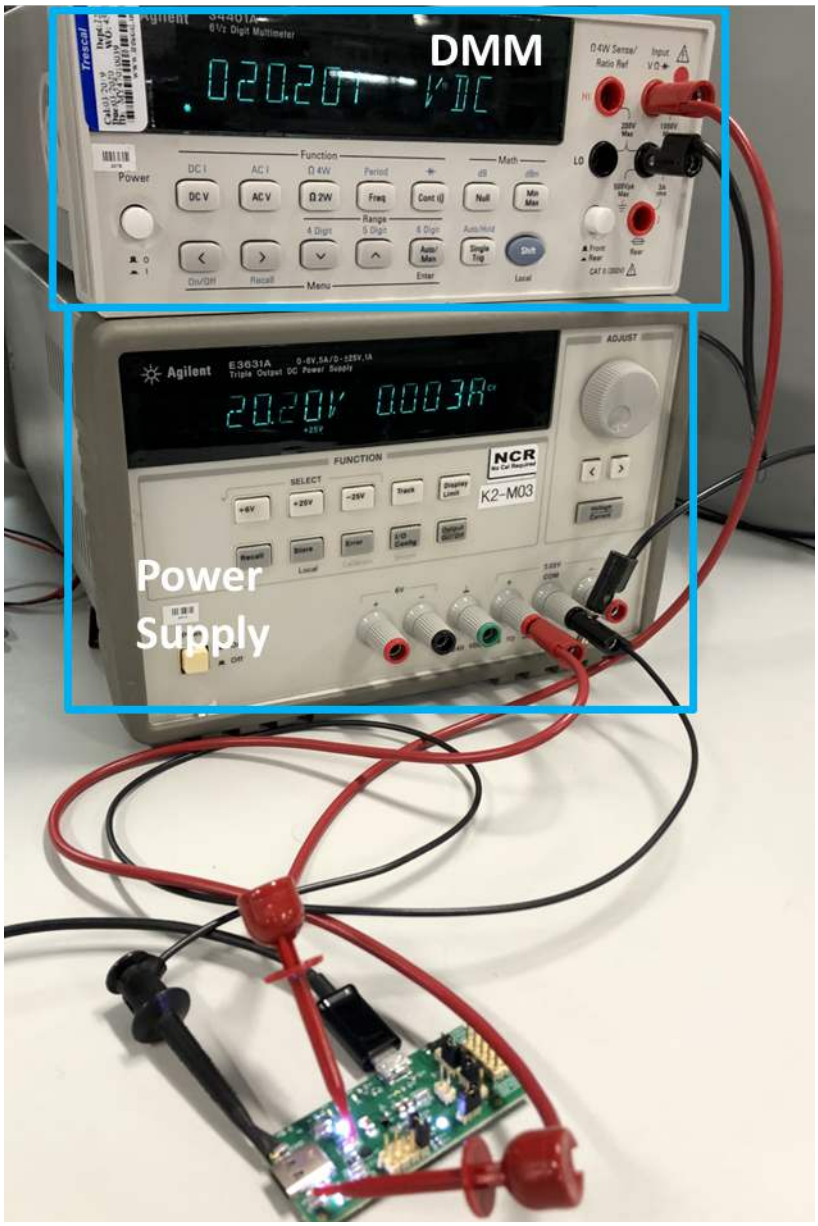

3.4 VBUS Overvoltage Protection (OVP)

Figure 6 shows the jumper settings in J7 to configure different levels for VBUS OVP. VBUS OVP is only applicable to the PPHV path.

When the voltage detected on OVP exceeds a set level, the PPHV power path will automatically be disabled (if enabled), and will remain disabled until the OVP event is removed. FLT is asserted when an overvoltage event occurs.

If Pins 7 and 8 in J7 are shorted, the OVP (Overvoltage Protection) scheme should be set to approximately 22.6 V. Increasing the voltage applied to VBUS beyond this value will make the protection scheme to open the internal switch and PP_HV should be disconnected from VBUS.

You can easily monitor this with an oscilloscope and adjusting the output of the power supply applied to VBUS. Try the other jumper positions on J7 to change the OVP level to 6.1 V, 10.2 V and 16.4 V.

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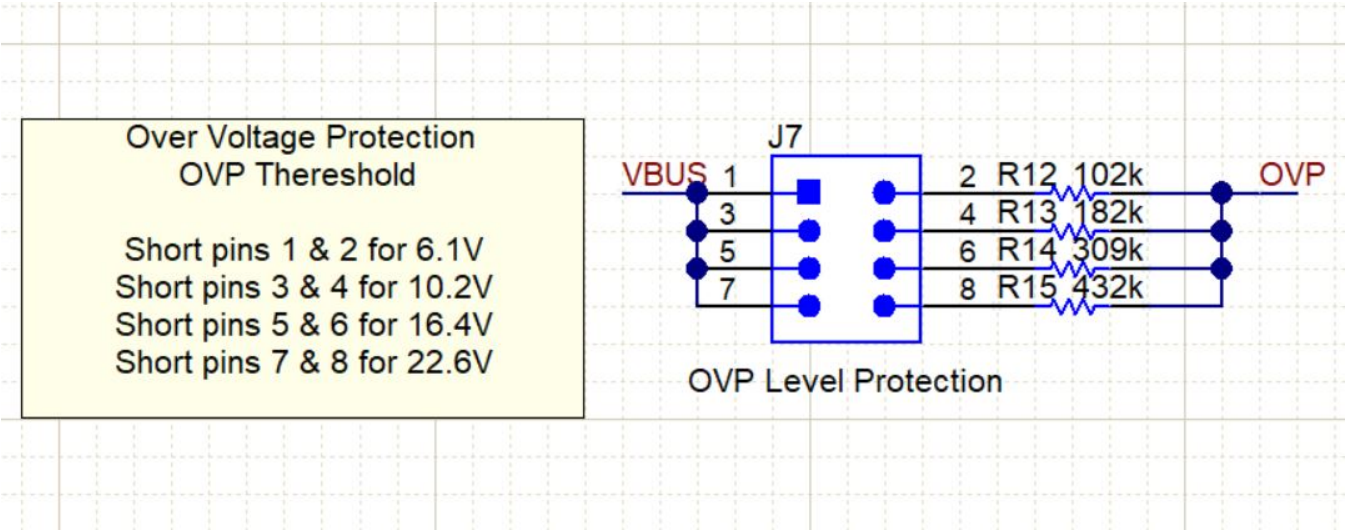
Figure 6. Overvoltage Protection Level Jumper



4 Application Example: Interfacing the TPS66020 EVM with a PD Controller EVM.

This example uses the TI TPS65988 EVM to interface the TPS66020 EVM.

Before trying the example, remove the jumpers from J4 and J5 on the TPS66020EVM.

TPS65988EVM is configured to control the Sink Path with GPIOs connected to EN0 and EN1 in the TPS66020EVM.

TPS65988 PD controller negotiates a PD contract with a PD Source (such as a Type-C Power Supply) connected into the USB Type C receptacle as shown in Figure 7.

The GPIOs from TPS65988 trigger the signals to control the Sink Path in TPS66020, white wire goes to EN0, blue wire goes to EN1. VBUS TP from the TPS65988EVM Port B is connected to VBUS TP1 on TPS66020, red cable. GNDs are also connected, black cable.

After a PD contract is negotiated the TPS66020 Sink Path is enabled closing the sink switch. The PD transactions and timing are shown in Figure 8.

Figure 7. Connecting the TPS66020EVM to the PD Controller TPS65988 EVM

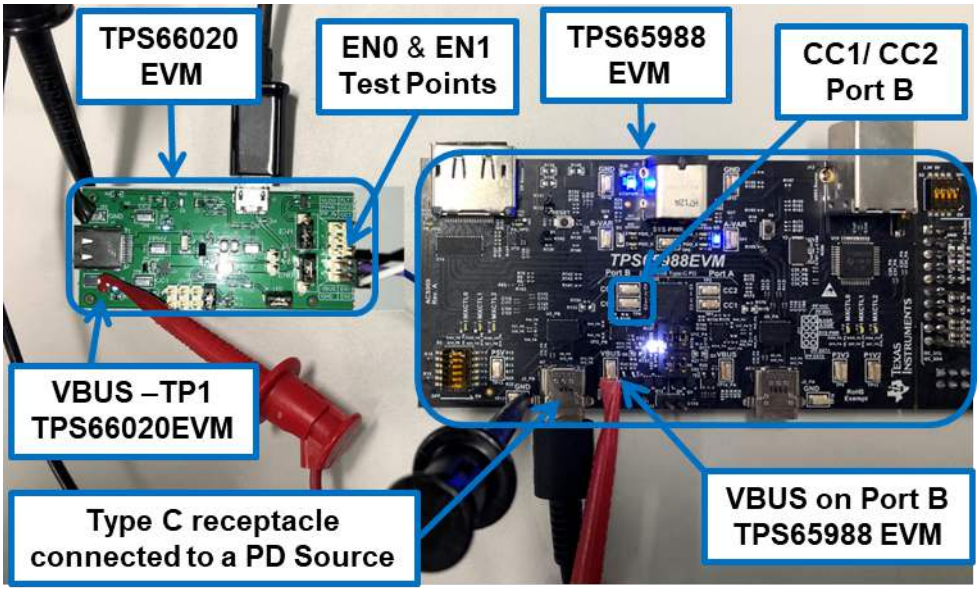


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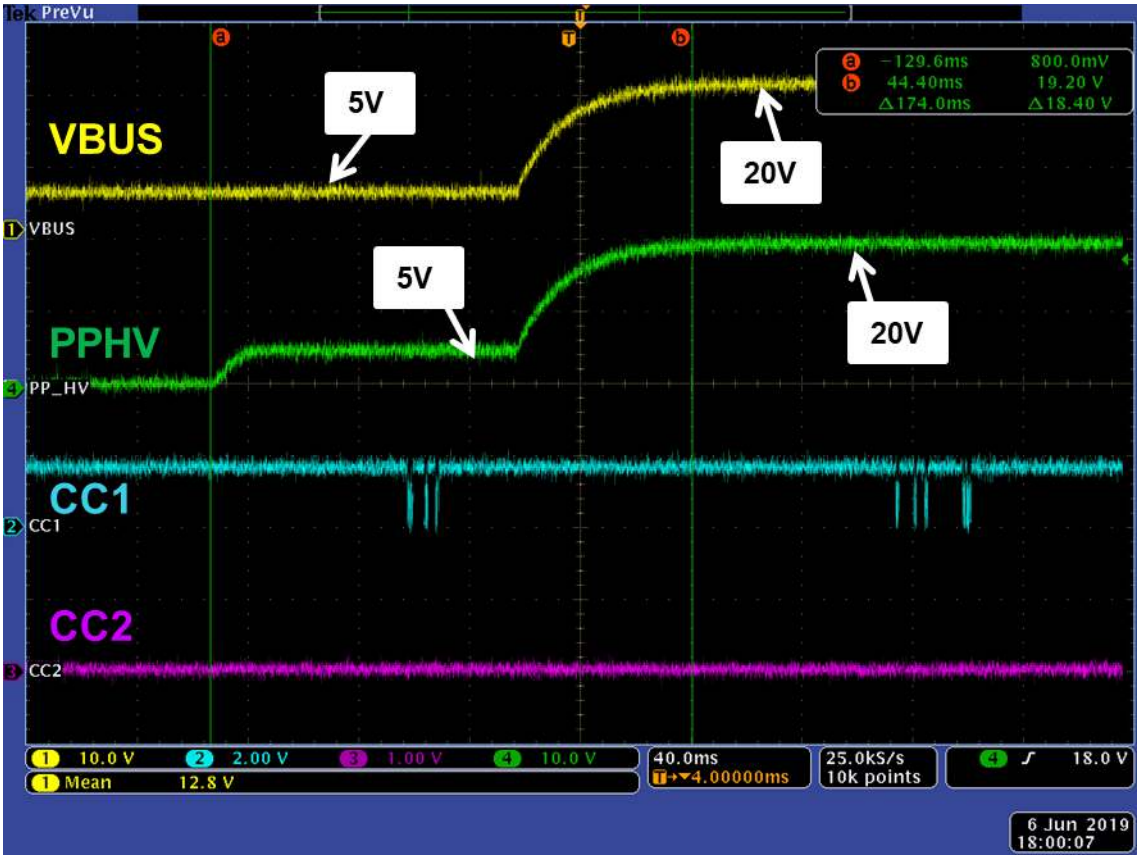
Figure 8. PD Transactions and VBUS Timing Waveform



VBUS: TPS66020EVM VBUS. Rises from 0 to 5 V when the PD Power Source is connected to TPS65988EVM Port B Type-C plug.

PPHV: GPIO signals on the TPS65988 EVM to EN0 and EN1 set the Functional Mode Sink Path enabled on TPS66020.

CC1: Showing PD transactions and power contract with the PD power source.

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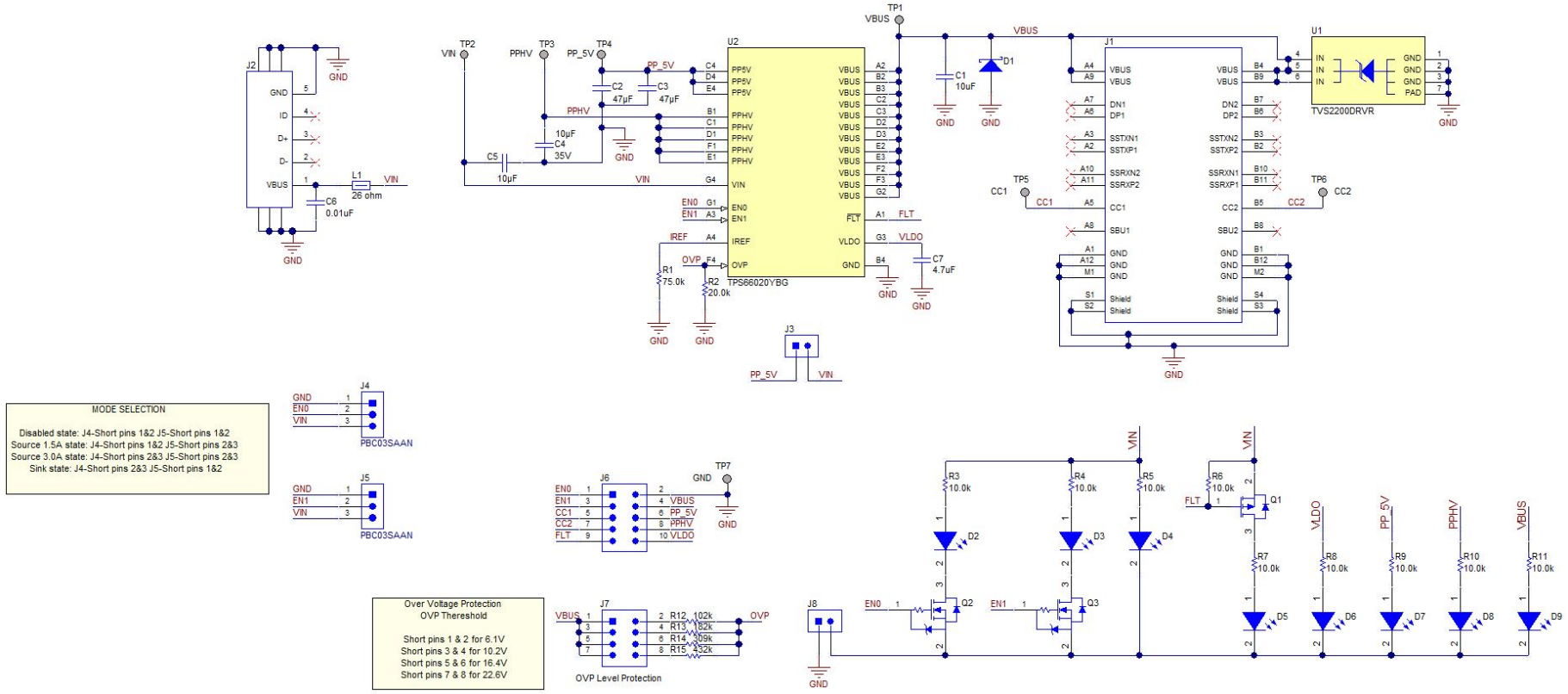
5 Schematic and Bill of Materials

5.1 Schematic

Figure 9 illustrate the TPS66020 schematics.

Figure 9. TPS66020EVM Schematics



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5.2 Bill of Materials

Table 5 lists the TPS66020EVM BOM.

Table 5. Bill of Materials[1]

Designator	QTY	Value	Description	Package Reference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
PCB1	1		Printed Circuit Board		PSIL073	Any		
C1	1	10 uF	CAP, CERM, 10 uF, 35 V, +/- 20%, X5R, 0603	0603	GRM188R6YA106MA73	MuRata		
C2, C3	2	47 uF	CAP, CERM, 47 µF, 10 V,+/- 20%, X5R, 0805	0805	GRM21BR61A476ME15L	MuRata		
C4	1	10 uF	CAP, CERM, 10 µF, 35 V,+/- 10%, X5R, 1206	1206	GRM319R6YA106KA12D	MuRata		
C5	1	10 uF	CAP, CERM, 10 µF, 10 V,+/- 20%, X5R, 0402	0402	CC0402MRX5R6BB106	Yageo		
C6	1	0.01 uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, X7R, 0402	0402	C0402C103J5RACTU	Kemet		
C7	1	4.7 uF	CAP, CERM, 4.7 uF, 10 V, +/- 10%, X5R, 0402	0402	C1005X5R1A475K050BC	TDK		
D1	1	30 V	Diode, Schottky, 30 V, 2 A, 2-XFDFN	2-XFDFN	NSR20F30NXT5G	ON Semiconductor		
D2, D3, D4, D5,D6, D7, D8, D9	8	White	LED, White, SMD	0402, White	LW QH8G-Q2S2-3K5L-1	OSRAM	QH8G-Q2OO-3K5L-1	OSRAM Opto Semiconductors Inc.
J1	1		Connector, Receptacle, USB Type C, R/A	Connector, Receptacle, USB Type C, R/A, THT/SMT	632723300011	Wurth Elektronik		
J2	1		Receptacle, Micro-USB Type B, 0.65 mm, 5x1, R/A, Bottom Mount SMT	Receptacle, 0.65mm, 5x1, R/A, SMT	47346-1001	Molex		
J3, J8	2		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec		
J4, J5	2		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions		
J6	1		Header, 100mil, 5x2, Gold, TH	5x2 Header	TSW-105-07-G-D	Samtec		
J7	1		Header, 100mil, 4x2, Gold, TH	4x2 Header	TSW-104-07-G-D	Samtec		
L1	1	26 ohm	Ferrite Bead, 26 ohm at 100 MHz, 6 A, 0603	0603	BLM18SG260TN1D	MuRata		
Q1	1	–50 V	MOSFET, P-CH, -50 V, -0.13 A, SOT-23	SOT-23	BSS84-7-F	Diodes Inc.		None
Q2, Q3	2	20 V	MOSFET, N-CH, 20 V, 0.5 A, YJM0003A (PICOSTAR-3)	YJM0003A	CSD15380F3	Texas Instruments		None
R1	1	75.0 k	RES, 75.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040275K0FKED	Vishay-Dale		

[1] Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

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Table 5. Bill of Materials[(1)] (continued)

Designator	QTY	Value	Description	Package Reference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R2	1	20.0 k	RES, 20.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040220K0FKED	Vishay-Dale		
R3, R4, R5, R6, R7, R8, R9, R10, R11	9	10.0 k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0FKED	Vishay-Dale		
R12	1	102 k	RES, 102 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402102KFKED	Vishay-Dale		
R13	1	182 k	RES, 182 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402182KFKED	Vishay-Dale		
R14	1	309 k	RES, 309 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402309KFKED	Vishay-Dale		
R15	1	432 k	RES, 432 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402432KFKED	Vishay-Dale		
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100mil, Gold plated, Black		382811-6	AMP		
TP1, TP2, TP3, TP4, TP5, TP6, TP7	7		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
U1	1		22-V Precision Surge Protection Clamp, DRV0006A (WSON-6)	DRV0006A	TVS2200DRVR	Texas Instruments		Texas Instruments
U2	1		Integrated Source and Sink Power Multiplexer with VBUS LDO Regulator, YBG0028-TEMP (DSBGA-28)	YBG0028-TEMP	TPS66020YBG	Texas Instruments		Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount	N/A	N/A	N/A		

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   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

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Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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