Using the TPS22933AEVM-005 Triple-Input Power Multiplexer with Auto-Select and Integrated LDO

The TPS22933AEVM-005 evaluation module (EVM) allows the user to source up to 50mA from a fixed output Low Drop-Out Regulator (LDO) that is sourced by the highest of three inputs (2.5V to 12V). The EVM has fixed loads for each of the LDO outputs of 1mA and 25mA. The user can also supply an external load.

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1 Description

The TPS22933AEVM-001 evaluation module helps designers evaluate the operation and performance of the TPS22933A triple-input multiplexer with LDO. The board features the small 8-pin µQFN package for a small solution size. The TPS22933A LDO has one always on output (LOUT) and one switched output (VOUT). VOUT is enabled through the EN pin. When VOUT is disabled, the internal quick output discharge FET (QOD) is enabled to drain any residual voltage from the output.

Table 1. TPS22933A LDO Voltage Options[(1)]

EVM	Device	LOUT (V)
HVL005	TPS22933A	3.6 V

(1) Contact Factory for additional LDO output options.

1.1 Typical Applications

- Hand-held devices with multiple input sources (such as a battery, a USB port and a DC In jack).

1.2 Features

- Three integrated load switches automatically choose highest input
- Integrated 3.6V fixed LDO (contact factory for other LDO voltages)
- Switched and Always on LDO outputs
- Small µQFN package (1.5mm x 1.5mm)
- Input voltage range 2.5V to 12V
- Low ON-resistance (2.4Ω at 5V)
- 50mA max continuous current (split between LOUT and VOUT)
- Low threshold control input (EN)
- Switchover time 18µs typical
- Switchover voltage 150mV typical

2 Electrical Performance

Table 2. TPS22633AEVM-005 Electrical Performance

PARAMETER	TEST CONDITIONS [(1)]	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range		2.5		12	V
Maximum input current				50	mA
Electrical Characteristics					
Output voltage, LOUT	I_{LOUT} = 10 mA, VIN = 4.2 V		3.6		V
Output voltage, VOUT	I_{VOUT} = 10 mA, VIN = 4.2 V		3.6		V
ON resistance (Input to CAP)	VIN = 5.0 V, IOUT = 10 mA		2.4		Ω
ON resistance (LDO to VOUT)	IOUT = 10 mA		1.3		Ω
Pull-down resistance (VOUT to GND)	EN = 0 V		63.8		Ω
Systems Characteristics					
Switching Time			18		µs
Switching Voltage	VBAT = 4.2 V, VUSB rising from 4 V to 5 V		150		mV

(1) VIN = highest of BAT, USB, DC_IN

3 Operation

3.1 Equipment

- **Voltage Sources:**
  - Three supplies capable of supplying 12V at 100mA are recommended.
  - Supply capable of ramping voltages (function generators may be useful) can be used to measure changeover times and voltages.
  - EN can be tied high or low on the EVM. It can also be driven by an external source.
- **Multimeters:**
  - One to three meters can be used to measure voltages (commonly CAP, LOUT and VOUT).
  - One or two ammeters may be useful for measuring currents (commonly I_{LOUT} and I_{VOUT}).
- **Output Load:**
  - The EVM comes with jumpers to allow 1mA and 25mA loads on each output (LOUT and VOUT).
  - Custom loads can be used by removing the EVM jumpers and using TP8 for the always on LDO output (LOUT) and TP10 for the switched LDO output (VOUT). Any of the ground test point can be used (TP14, TP15, TP16, TP17).
- **Oscilloscope:**
  - 4 channel 100MHz to monitor input supplies, EN, CAP, LOUT and VOUT as needed.
- **Recommended Wire Gauge:**
  - 22 AWG

3.2 Recommended Operating Setup

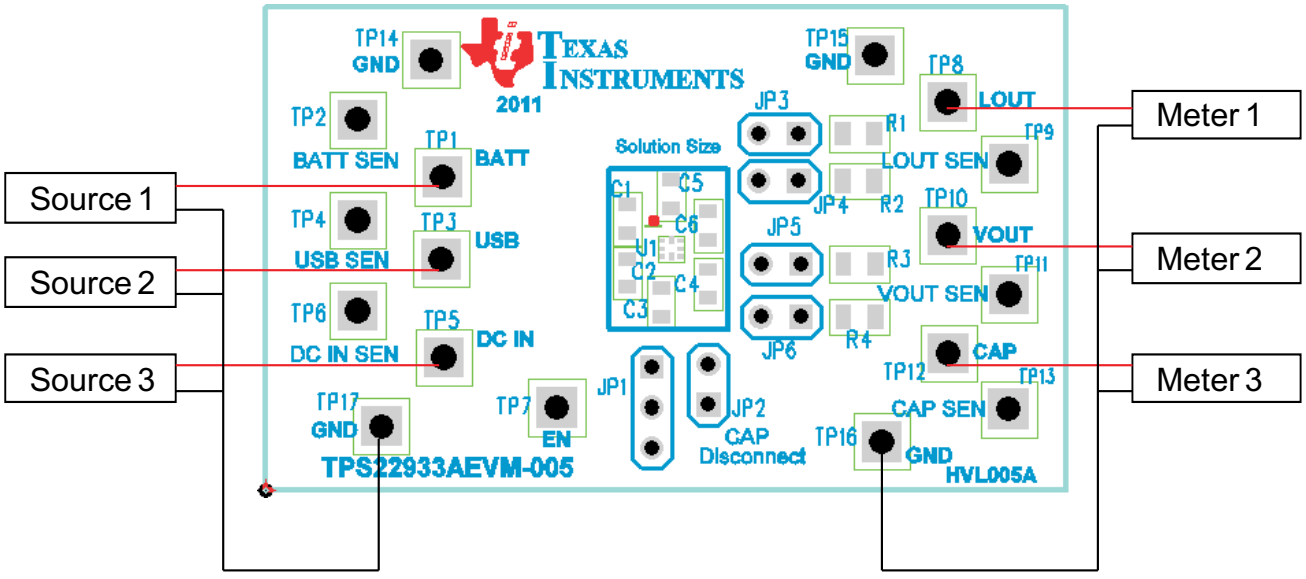


Figure 1. TPS22933AEVM-005 Recommended Operating Set Up

3.3 List of Test Points

Table 3. The Functions of Each Test Points

Test Points	Name	Description
TP1	BATT	Input for BAT pin
TP2	BATT SEN	BAT pin sense
TP3	USB	Input for USB pin
TP4	USB SEN	USB pin sense
TP5	DC_IN	Input for DC_IN pin
TP6	DC IN SEN	DC_IN pin sense
TP7	EN	Enable pin force or measure
TP8	LOUT	Connection for LOUT load
TP9	LOUT SEN	LOUT pin sense
TP10	VOUT	Connection for VOUT load
TP11	VOUT SEN	VOUT pin sense
TP12	CAP	CAP pin measurement point
TP13	CAP SEN	CAP pin sense
TP14	GND	Ground Connection
TP15	GND	Ground Connection
TP16	GND	Ground Connection
TP17	GND	Ground Connection

3.4 List of Jumper Connections

Jumper JP1 is a two position Jumper to allow EN to be tied Low (2:3), High (1:2) or driven externally by tying pin 2 to a function generator or microcontroller.

Table 4. Jumper Settings

Jumpers	Jumper Not Installed	Jumper Installed
JP1	External Signal for EN	(1:2) – High, (2:3) – Low
JP2	No Capacitor from CAP to GND	1 nF capacitor between CAP and GND
JP3	—	1 mA load added to LOUT
JP4	—	25 mA load added to LOUT
JP5	—	1 mA load added to VOUT
JP6	—	25 mA load added to VOUT

3.5 Operation Examples

The TPS22933A allows for much flexibility in a variety of applications and the EVM can be used to demonstrate its flexibility.

Application Examples:

3.5.1 Application Examples:

3.5.1.1 3-Input Multiplexer with Always On and Switched LDO

This example shows the most common use of the TPS22933A. Any handheld device might have three input sources: Lithium battery, USB port and a DC jack. Once power is applied to any of the inputs, the TPS22933A powers up the LDO and the MSP430 microcontroller is powered through the LOUT pin. At this point, the MSP430 may decide to enable the VOUT to supply current to a subsystem – or, it may wait until the specific functionality is required and power it then.

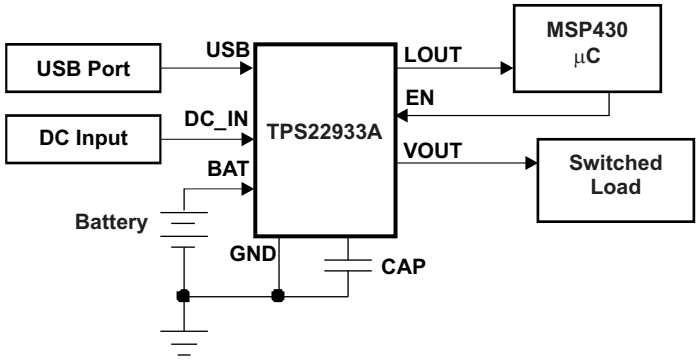


Figure 2. 3-Input MUX with LDO

3.5.1.2 3-Input Multiplexer with LDO Unused

This example shows the TPS22933A used solely as a 3-input multiplexer with the LDO left unused. The CAP pin is used as the output of the multiplexer. Since the CAP is simply the highest of the three inputs, the CAP pin will be as high as the input supply (minus the drop across the input switch). In this use in particular the user needs to keep in mind that the voltage picker has a 150mV (typical) switchover point. With a 2.4Ω R_{ON}, the maximum current would be limited by not only the power dissipation, but also by the switchover voltage. For 150mV and 2.4 Ω, a current of 62.5mA may result in a switch between supplies of equal voltage.

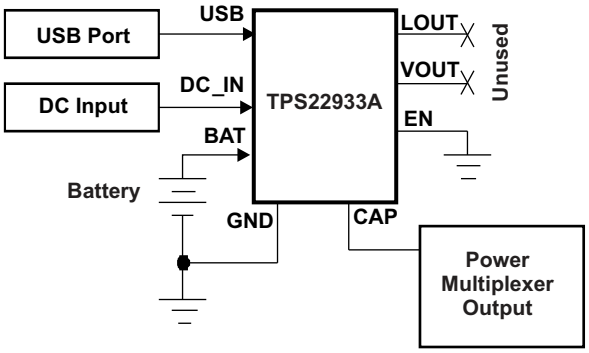


Figure 3. 3-Input Power MUX

4 Operating Procedure

The TPS22933A will select the highest input voltage from BAT, USB and DC_IN to source the LDO. The CAP pin can be used to monitor the selection process. As one input pin becomes higher (typically 150mV) than the input currently driving the LDO, that input is selected to source the LDO. The CAP pin will change from the original voltage to the new higher voltage. Figure 4 and Figure 5 show examples of the transfer in LDO sourcing.

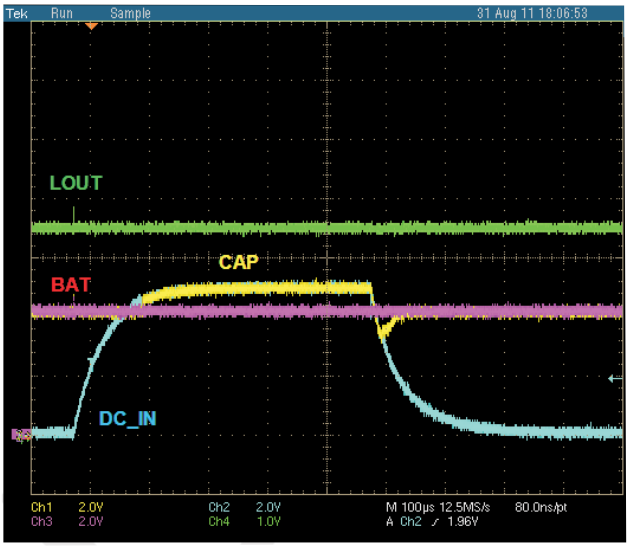


Figure 4. Voltage Changeover

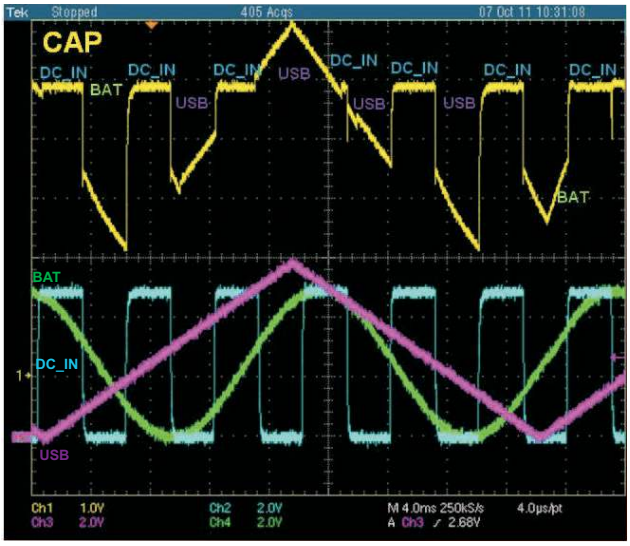


Figure 5. CAP Voltage During Switchover

Figure 4 shows the BAT pin (4.2V) controlling the LDO until the DC_IN supply overtakes the BAT voltage on its way to 5V. The CAP pin follows DC_IN up to 5V. As the DC_IN pin falls below BAT, the CAP pin goes back to the BAT voltage. Note that LOUT (at 3.6V) in unaffected by the changeover.

Figure 6. TPS22933A with Varying Inputs and CAP

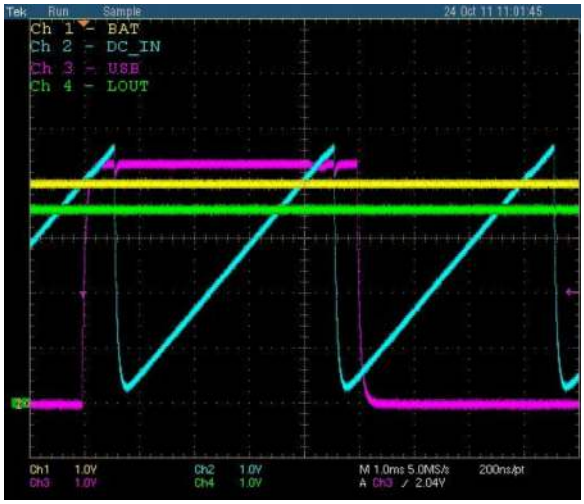
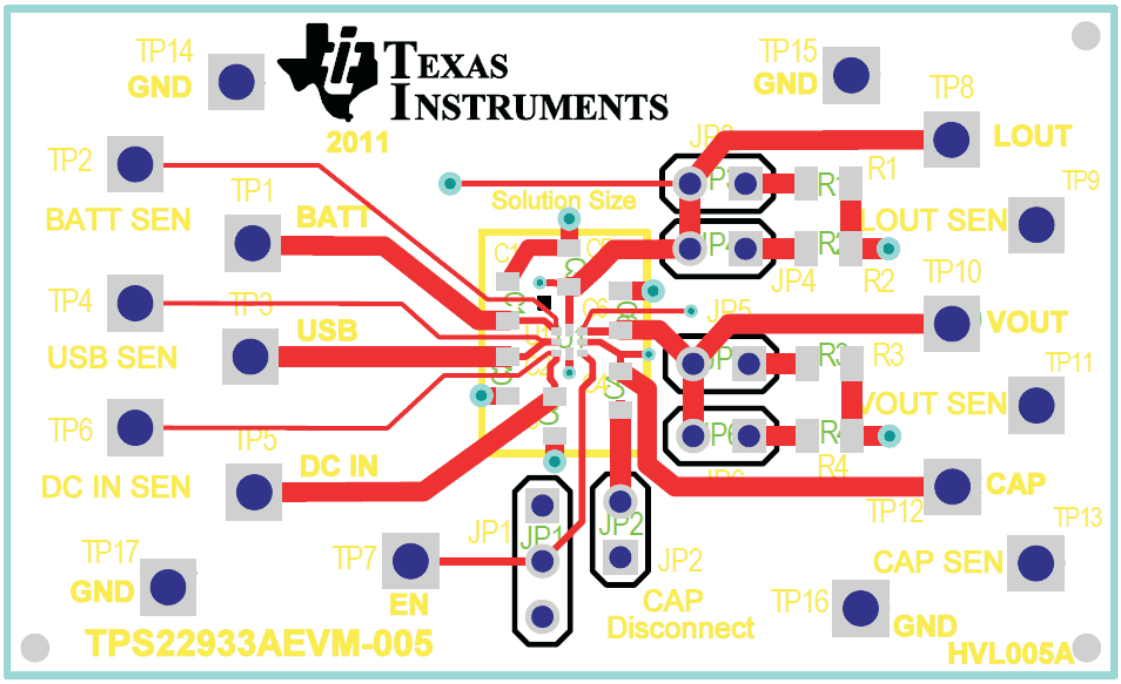


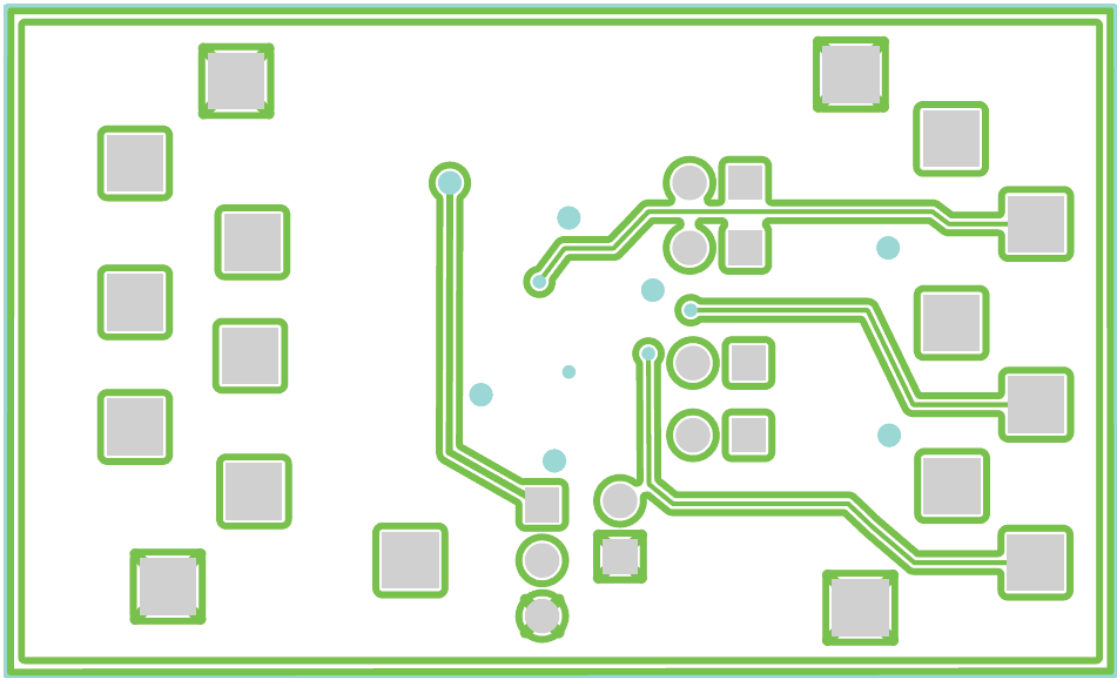
Figure 7. TPS22933A with Varying Inputs and Stable LOUT

5 EVM Layout

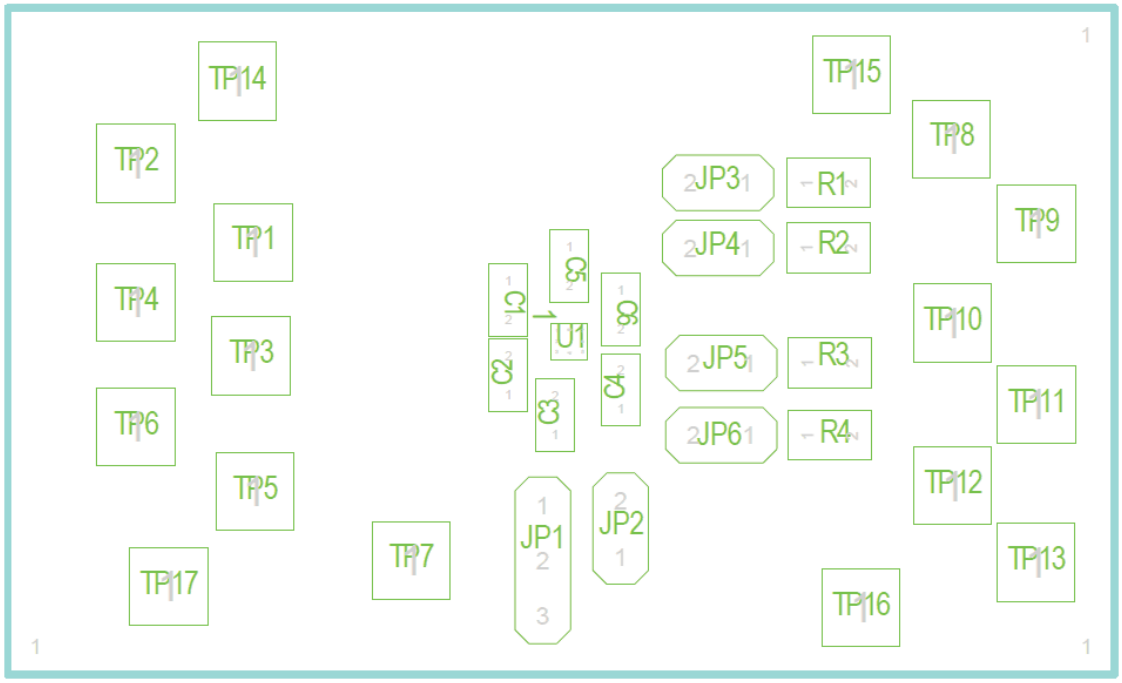
5.1 Top Side



5.2 Bottom Side

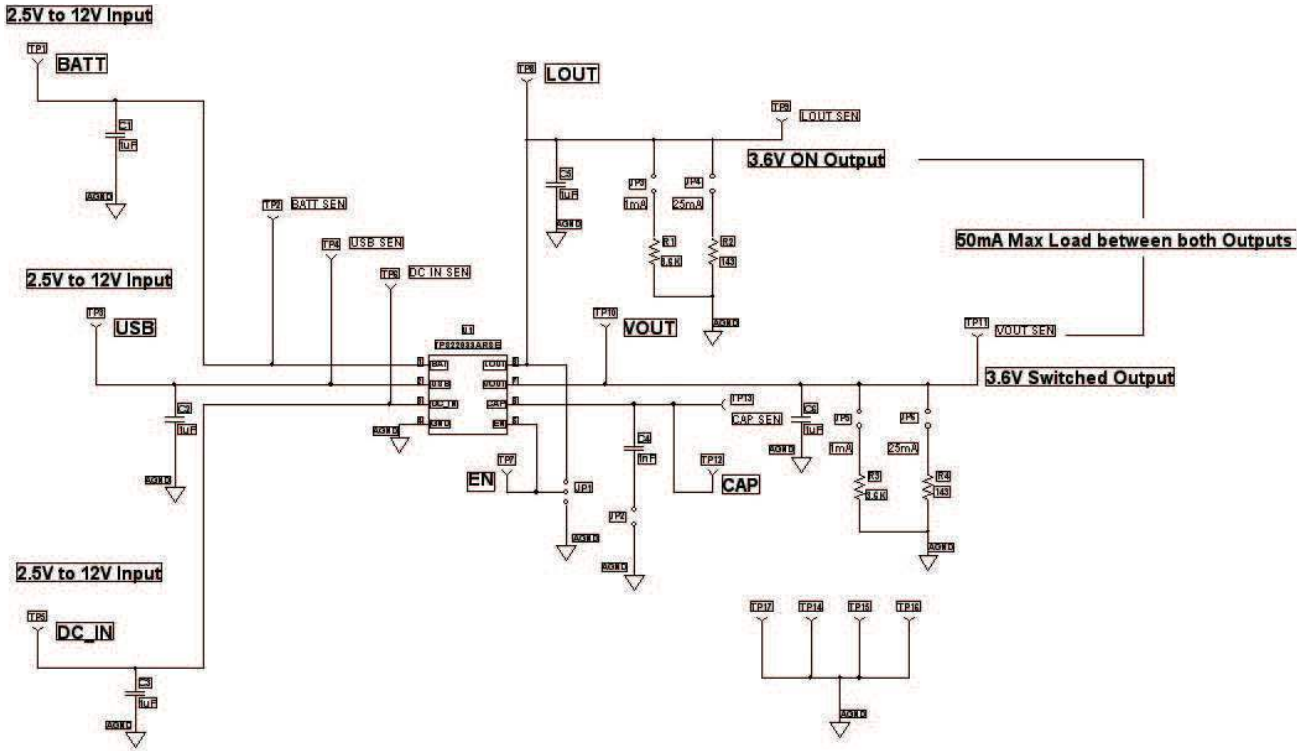


5.3 Top Assembly



6 Schematic and Bill of Materials

6.1 Schematic



6.2 Bill of Materials

Count	Reference Designator	Value	Description	SIZE	Part Number	MFR
1	--		PCB, 1.2" x 2.0" x 0.062"		HVL005	Any
1	C4	1000pF	Capacitor, Ceramic, 25-V, NPO,5%	603	Std	Std
5	C1–C3, C5–C6	1uF	Capacitor, Ceramic, 25-V, X5R,10%	603	Std	Std
2	R1,R3	3.6K	Resistor, Chip 1/8W 5%	805	Std	Std
2	R2,R4	143	Resistor, Chip 1/8W 1%	805	Std	Std
5	JP2-JP6	PEC02SAAN	Header,2pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
1	JP1	PEC03SAAN	Header,3pin, 100mil spacing	0.100 inch x 3	PEC03SAAN	Sullins
1	U1	TPS22933ARSE	IC, Single Chip, Triple Load Switch w/ integrated LDO	RSE	TPS22933ARSE	TI
6	TP1, TP3, TP5, TP9, TP11, TP13	5012	Test Point PC Multipurpose WHT	0.063" (1.60mm) Hole Diameter	5012	Keystone
6	TP2, TP4, TP6, TP8, TP10, TP12	5014	Test Point PC Multipurpose YLW	0.063" (1.60mm) Hole Diameter	5014	Keystone
4	TP14–TP17	5011	Test Point PC Multipurpose BLK	0.063" (1.60mm) Hole Diameter	5011	Keystone
1	TP7	5010	Test Point PC Multipurpose RED	0.063" (1.60mm) Hole Diameter	5010	Keystone
3	NA	NA	Shunt, 100-mil, Black	0.100	929950-00	3M

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It is important to operate this EVM within the input voltage range of 0 V to 14 V and the output voltage range of 3 V to 5 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

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During normal operation, some circuit components may have case temperatures greater than 50° C. The EVM is designed to operate properly with certain components above 50° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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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.

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.

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2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
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3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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