User's Guide

SLVUAO2–March 2016

TPS62770EVM-734 Evaluation Module

This user's guide describes the characteristics, operation, and use of TI's TPS62770 evaluation module (EVM). This EVM is designed to help evaluate and test the operation and functionality of the TPS62770. A step-down and a step-up converter are integrated in the TPS62770. The EVM converts a 2.5-V to 5.5-V input voltage to two regulated output voltages. The output voltage of the integrated buck converter is set between 1.0 V and 3.0 V. It has an ultra-low quiescent current of 360 nA. The integrated boost converter is adjustable from 4.5 V to 15 V output voltage. This user's guide includes setup instructions for the hardware, a printed-circuit board layout for the EVM, a schematic diagram, a bill of materials, and test results for the EVM.

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1 Introduction

The TPS62770 is a single-chip solution with an integrated 360-nA step-down converter and a step-up converter with output voltages up to 15 V in a tiny 1.65-mm × 1.65-mm, 16-ball DSBGA package. The EVM comes with two independent TPS62770 circuits. U1 has the ability to adjust the output voltage of the boost converter. In addition, the flexibility is given to use the boost converter as a constant-current LED driver. The brightness can be adjusted by an integrated PWM-to-analog converter. With the circuit of U2, the output voltage of the boost converter is 12 V fixed with no resistive divider, achieving a total solution size of 26.5 mm^2.

1.1 Background

The TPS62770EVM-734 uses the TPS62770 device. The EVM operates with full-rated performance with an input voltage between 2.5 V and 5.5 V.

1.2 Application Example

One application is to use the TPS62770 for wearable devices, where a small solution size is required. Here the device supplies a PMOLED display using the step-up converter while the Bluetooth™ low energy SoC is supplied by the ultra-low Iq step-down converter, enabling always-on functionality and a small total solution size. For further information go to the *PMOLED Wearable Reference Design PMP9792*.

2 Setup

This section describes how to properly use the TPS62770EVM-734.

2.1 Input and Output Connector Descriptions for U1

J1, Pin 1 and 2 – VIN,	Positive input connection from the input supply for the EVM.
J1, Pin 3 and 4 – S+/S–	Input voltage sense connections. Measure the input voltage at this point.
J1, Pin 5 and 6 – GND	Return connection from the input supply for the EVM.
J2, Pin 1 and 2 – VOUT	Output voltage connection. Buck
J2, Pin 3 and 4 – S+/S–	Output voltage sense connections. Measure the output voltage at this point. Buck
J2, Pin 5 and 6 – GND	Output return connection. Buck
J3, Pin 1 and 2 – VOUT	Output voltage connection. Boost
J3, Pin 3 and 4 – S+/S–	Output voltage sense connections. Measure the output voltage at this point. Boost
J3, Pin 5 and 6 – GND	Output return connection. Boost
J4 - Vin	Connects FB to Vin for internal feedback divider use
J5 - FBLED	Feedback for LED mode. Short in LED mode
J6 – VO2	Short for LED mode, open for normal operation
J7, Pin 1 - LOAD	Load switch output connection.
J7, Pin 2 - LOAD	Load switch output return connection.
J8, J9 – GND	Ground
JP1 – EN1	EN pin input jumper. Place the supplied jumper across ON and EN to turn on the step-down converter. Place the jumper across OFF and EN to turn off the IC.
JP2 – EN2	EN pin input jumper. Place the supplied jumper across ON and EN to turn on the step-up converter. Place the jumper across OFF and EN to turn off the IC. A PWM signal can be applied between ON and OFF, when used as a constant-current driver.
JP3 – BM1	This pin controls the operation mode of the boost converter. With BM = high, the device features a low feedback voltage of 200mV, which can be scaled down by the integrated PWM to analog converter. With BM = low, the device operates with a 0.8V feedback voltage and operates as a boost converter with voltage regulation.
JP4 - CTRL	CTRL pin input jumper. Place the supplied jumper across LOAD_ON and CTRL to activate (close) the internal load switch. Place the jumper across LOAD_OFF and CTRL to de-activate (open) the internal load switch.
JP5 through JP7 - VSELx	These three inputs set the output voltage. By connecting each pin high or low, the output voltage is programmed per Table 1. Do not leave any jumper open for proper operation. Buck converter

2.2 Input / Output Connector Descriptions for U2

J10, Pin 1 and 2 – VIN,	Positive input connection from the input supply for the EVM.
J10, Pin 3 and 4 – S+/S–	Input voltage sense connections. Measure the input voltage at this point.
J10, Pin 5 and 6 – GND	Return connection from the input supply for the EVM.
J11, Pin 1 and 2 – VOUT	Output voltage connection. Buck
J11, Pin 3 and 4 – S+/S–	Output voltage sense connections. Measure the output voltage at this point. Buck

J11, Pin 5 and 6 – GND	Output return connection. Buck
J12, Pin 1 and 2 – VOUT	Output voltage connection. Boost
J12, Pin 3 and 4 – S+/S–	Output voltage sense connections. Measure the output voltage at this point. Boost
J12, Pin 5 and 6 – GND	Output return connection. Boost
J13, Pin 1 - LOAD	Load switch output connection.
J13, Pin 2 - LOAD	Load switch output return connection.
J14, J15 – GND	Ground
JP8 – EN1	EN pin input jumper. Place the supplied jumper across ON and EN to turn on the step-down converter. Place the jumper across OFF and EN to turn off the IC.
JP9 – EN2	EN pin input jumper. Place the supplied jumper across ON and EN to turn on the step-up converter. Place the jumper across OFF and EN to turn off the IC. A PWM signal can be applied between ON and OFF, when used as a constant-current driver.
JP10 – BM1	This pin controls the operation mode of the boost converter. With BM = high, the device features a low feedback voltage of 200 mV, which can be scaled down by the integrated PWM to analog converter. With BM = low, the device operates with a 0.8-V feedback voltage and operates as a boost converter with voltage regulation.
JP11 - CTRL	CTRL pin input jumper. Place the supplied jumper across LOAD_ON and CTRL to activate (close) the internal load switch. Place the jumper across LOAD_OFF and CTRL to deactivate (open) the internal load switch.
JP5 through JP7 - VSELx	These three inputs set the output voltage. By connecting each pin high or low, the output voltage is programmed per Table 1. Do not leave any jumper open for proper operation. Buck converter

2.3 Output Voltage Settings

Table 1 provides the output voltage settings for the TPS62770EVM-734. A 0 refers to logic low, while 1 refers to logic high.

Table 1. Output Voltage Settings

VOUT	VSEL 3	VSEL 2	VSEL 1
1.0	0	0	0
1.05	0	0	1
1.1	0	1	0
1.2	0	1	1
1.8	1	0	0
1.9	1	0	1
2.0	1	1	0
3.0	1	1	1

2.4 Operation

To operate U1 of the EVM, set jumpers JP1 through JP7 to the desired positions per Section 2.1. Connect the input supply to J1 and connect the load to J2 and J3.

To operate U2 of the EVM, set jumpers JP8 through JP14 to the desired positions per Section 2.2. Connect the input supply to J10 and connect the load to J11 and J12.

3 Common Efficiency Measurement Errors with Ultra-Low Iq Devices

Efficiency is a common measurement for a power supply. With an ultra-low quiescent current device, such as the TPS62770, measurement errors can have a large impact on the measured efficiency, especially at very low load currents (< 100 µA).

3.1 Efficiency Measurement Setup

To accurately measure the efficiency of the TPS62770EVM-734, use the setup described in SLVA236, Figure 6. To measure the quiescent current of the step-down converter, disable the step-up converter of the TPS62770 by placing the jumper across OFF and EN of JP2 or JP9. The 'Additional Input Capacitor' referred to in that application report is not needed as C5 is already included on the TPS62770EVM-734. Any additional input capacitance is not recommended as it incurs increased leakage on the input which lowers the measured efficiency. When measuring the efficiency through the setup as described in SLVA236, special care must be taken to remove the current consumed by the measurement instruments from the efficiency calculations. Such measurement instruments typically include the input voltage and output voltage multimeters as well as the remote sense lines of the input power supply (if it has this capability). The current into these points affects the measured efficiency at very light loads. Two possible methods to overcome this are: measuring the current into these points (measure the current into the multimeters or remote sense lines) and then subtracting this current from the efficiency calculation or simply removing these instruments from the test setup. At very light load currents, it is typically best to remove the remote sense lines of the input power supply and then measure the current into the input and output voltage multimeters to get the most accurate efficiency measurement.

3.2 Pullup and Pulldown Resistors

In addition to the input capacitor and remote sense lines noted in Section 3.1, any pullup or pulldown resistors can draw significant current and affect the measured efficiency. For example, if the VSEL2 pin were pulled up to the input voltage with a 1-MΩ resistor and the pin were tied low through JP4, this would draw an extra 3.6 µA from the input source at a 3.6-V input voltage. This would greatly affect the efficiency at very light loads. For this reason, no pullup or pulldown resistors have been used on the TPS62770EVM-734. The final application circuit should ensure that all digital inputs to the TPS62770 are terminated either high or low and not left floating, per the device data sheet (SLVSCX0).

4 Board Layout

This section provides the TPS62770EVM-734 board layout and illustrations. The gerbers are available on the EVM product page: TPS62770EVM-734.

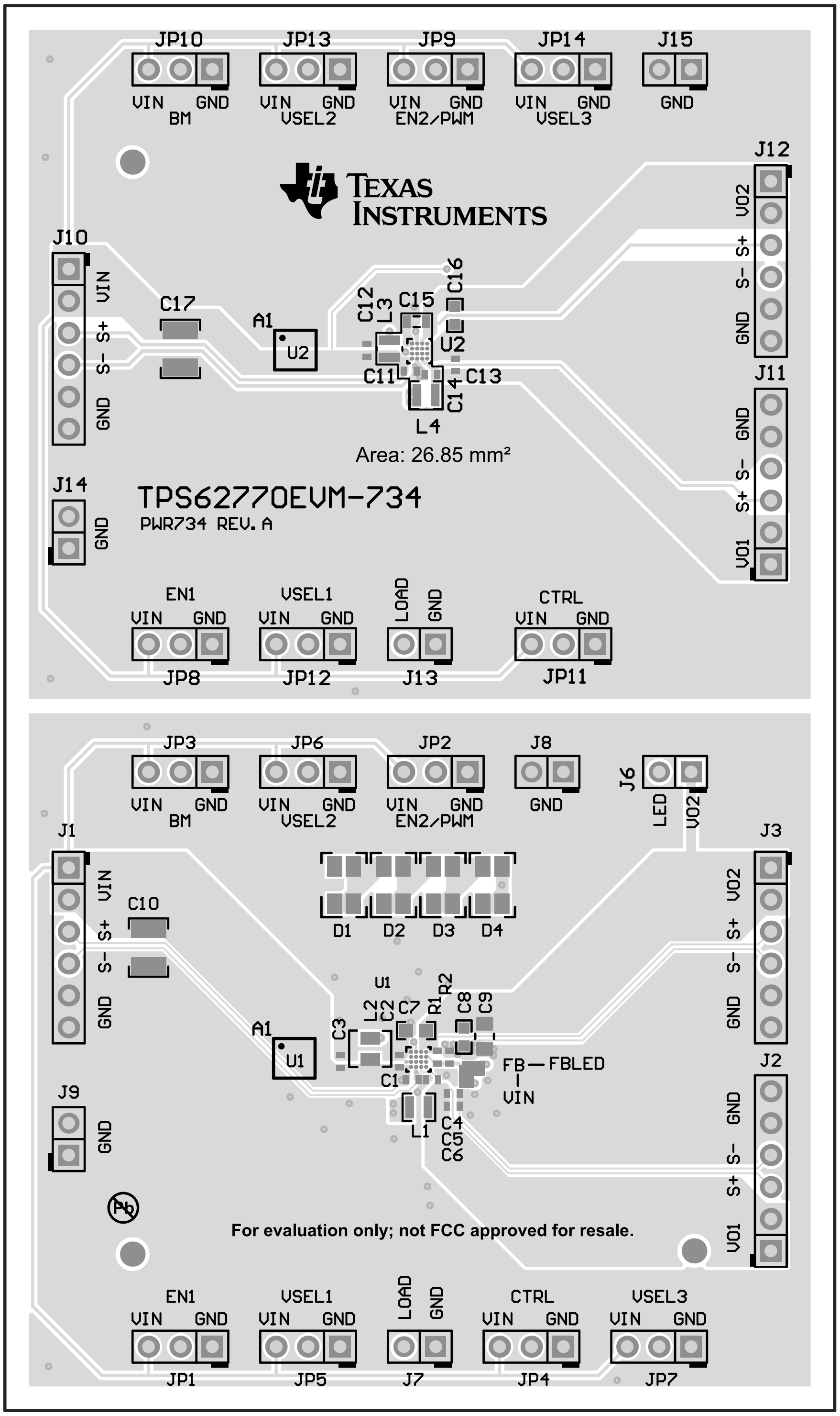

Figure 1. Assembly Layer

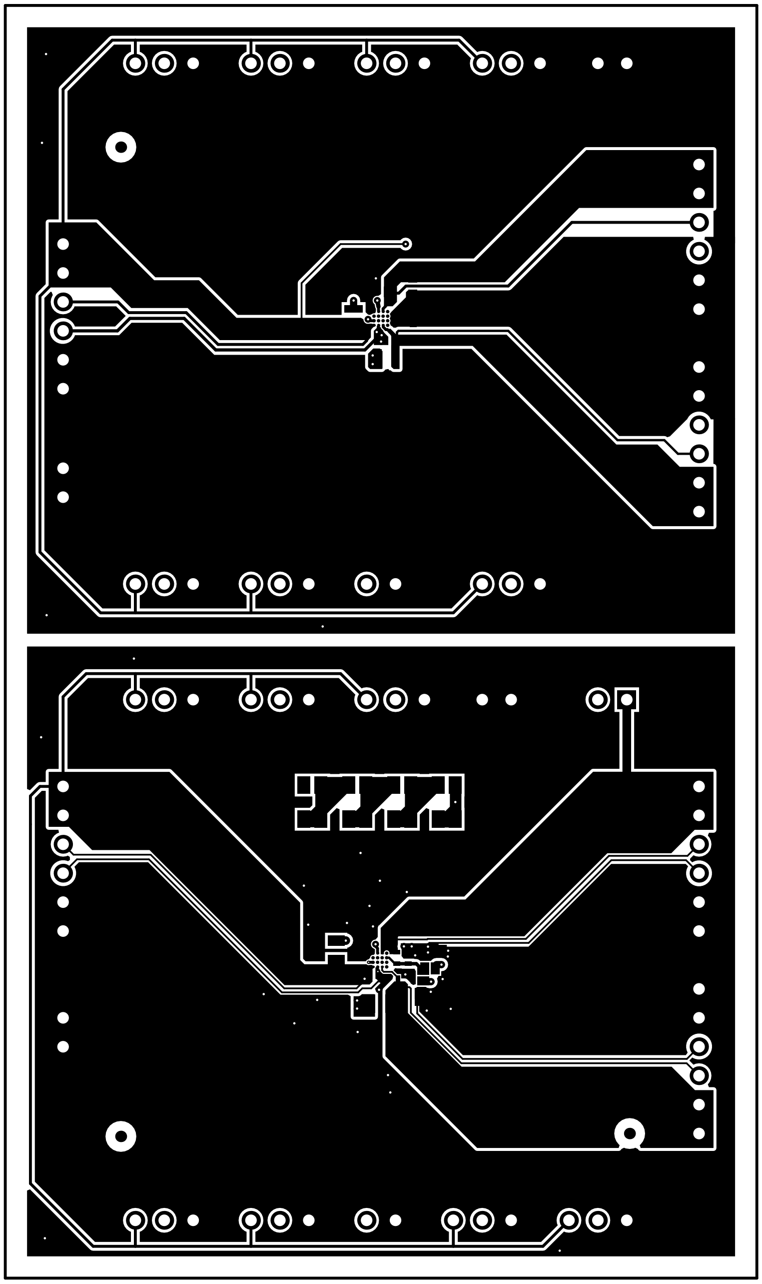

Figure 2. Top Layer

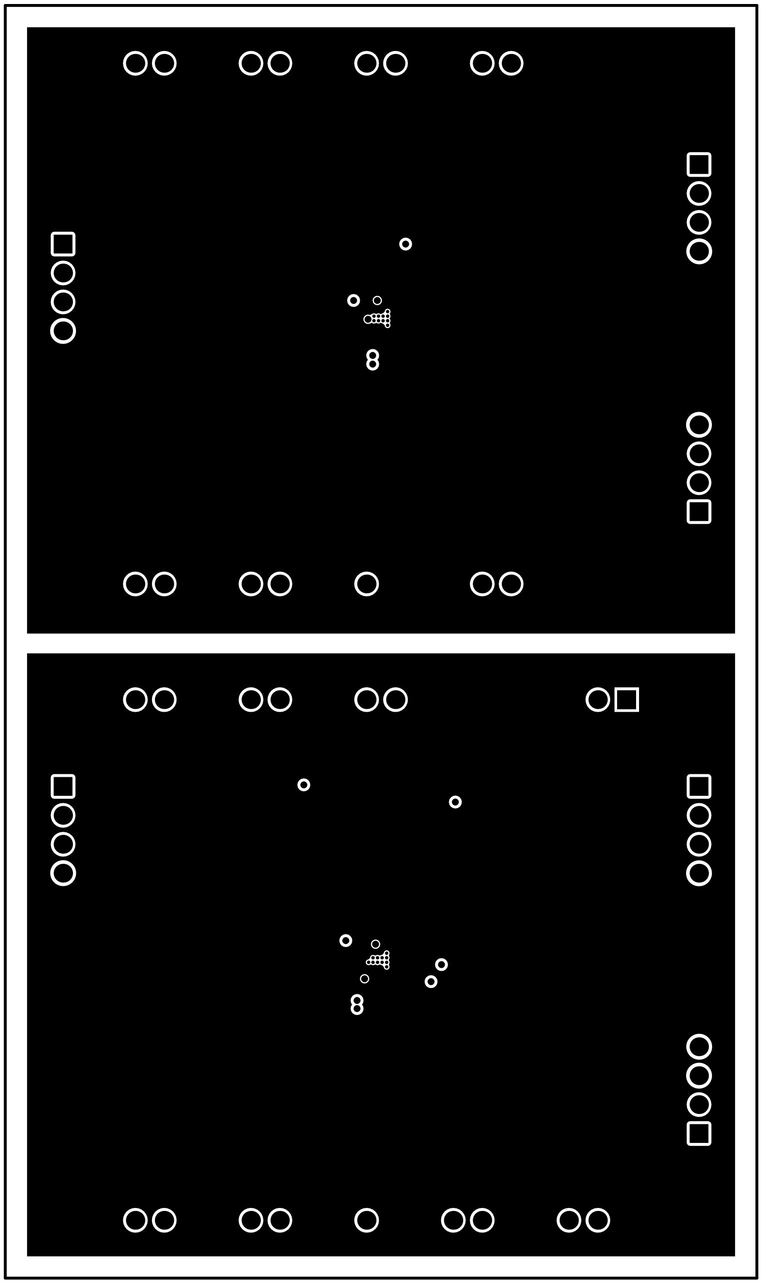

Figure 3. Signal 1 Layer

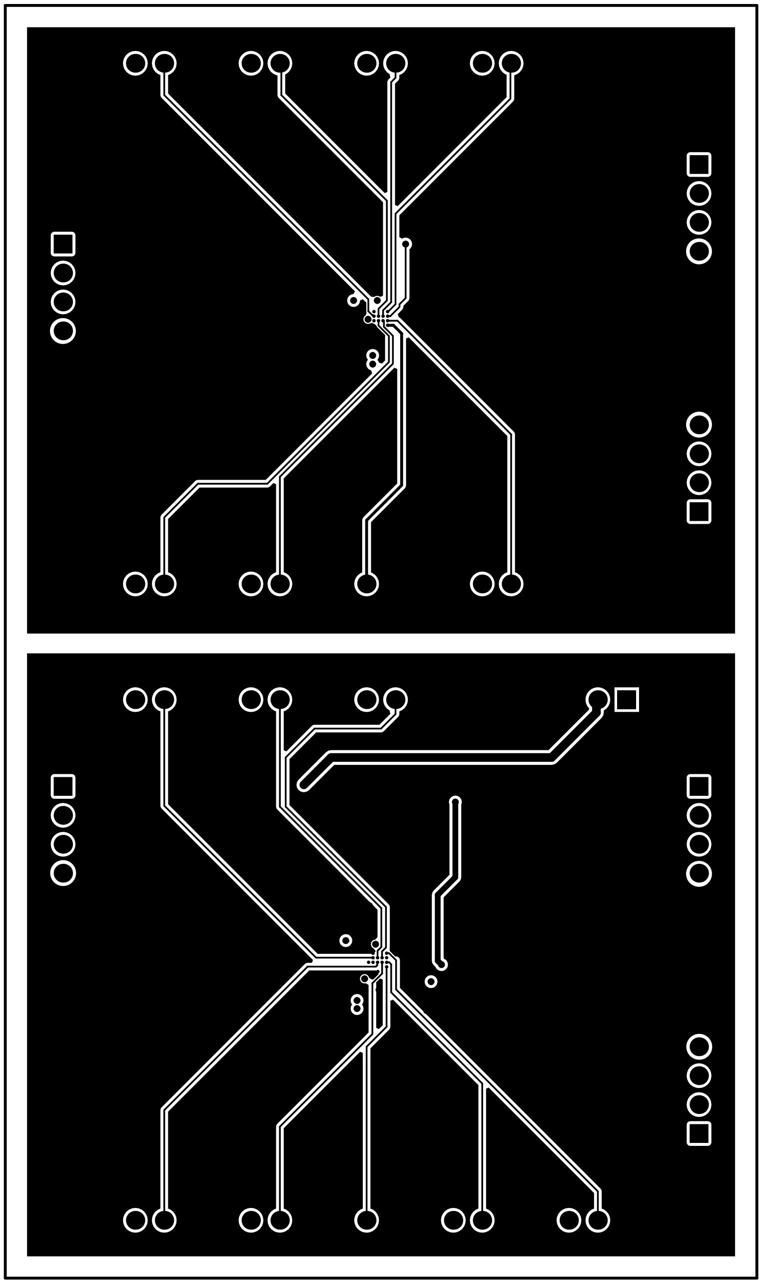

Figure 4. Signal 2 Layer

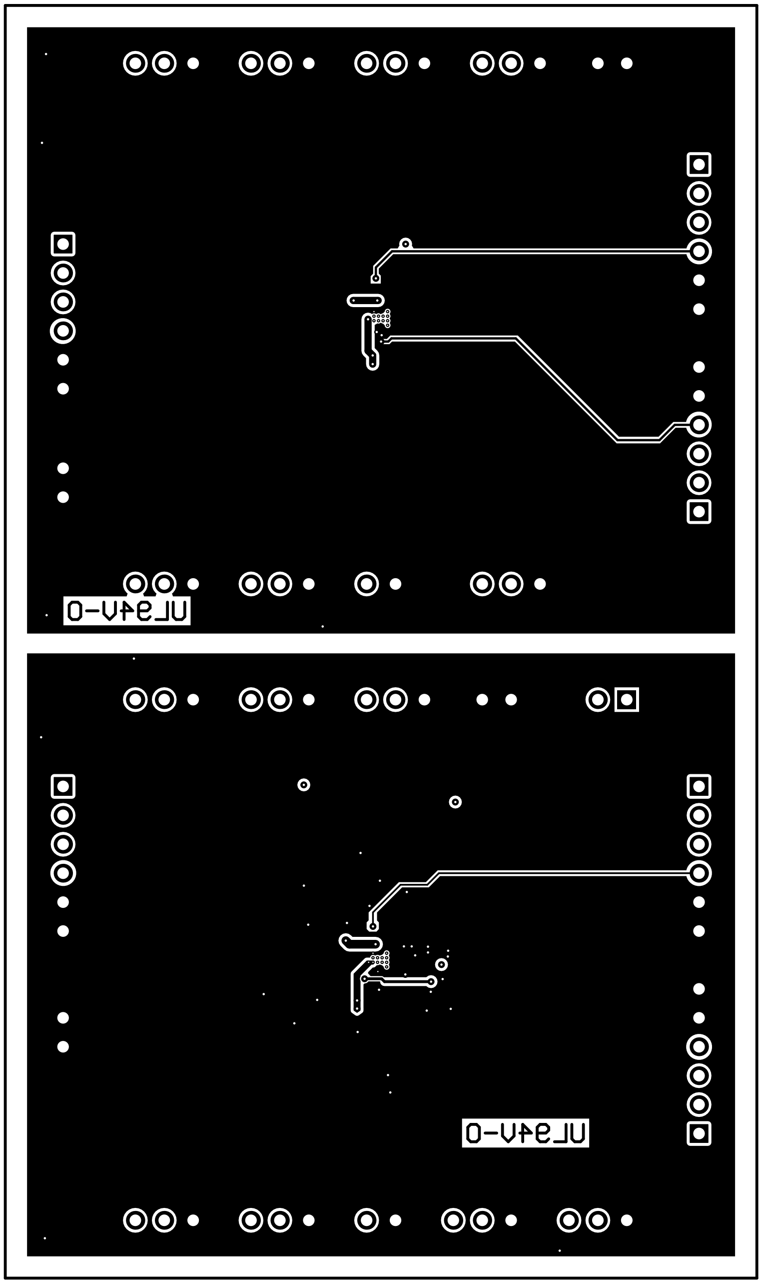

Figure 5. Bottom Layer

5 Schematic and Bill of Materials

This section provides the TPS62770EVM-734 schematic and bill of materials.

5.1 Schematic U1

Figure 6 illustrates the TPS62770EVM-734 U1 schematic.

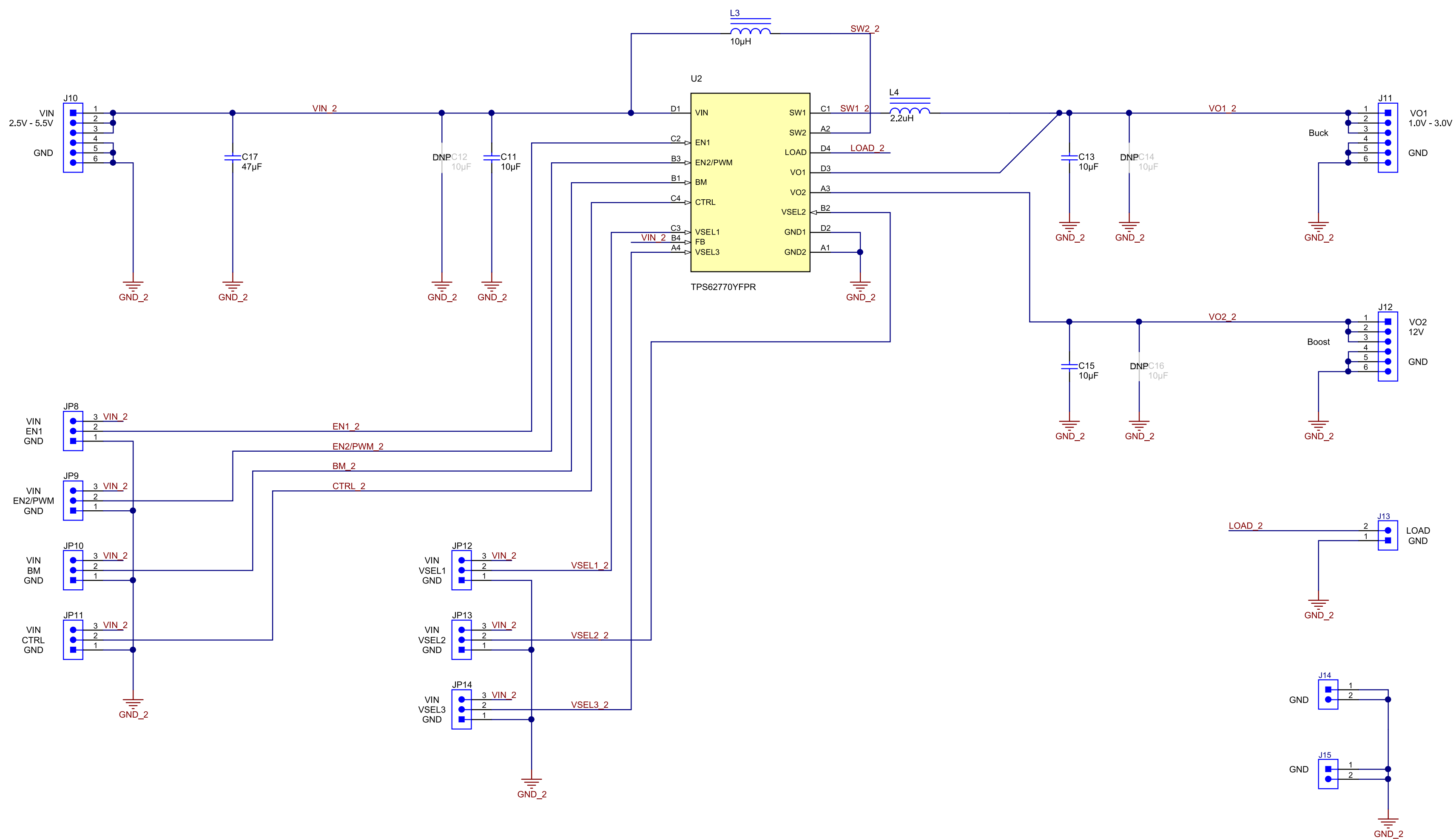

Figure 6. TPS62770EVM-734 Schematic U1

Figure 7 illustrates the TPS62770EVM-734 U2 schematic.

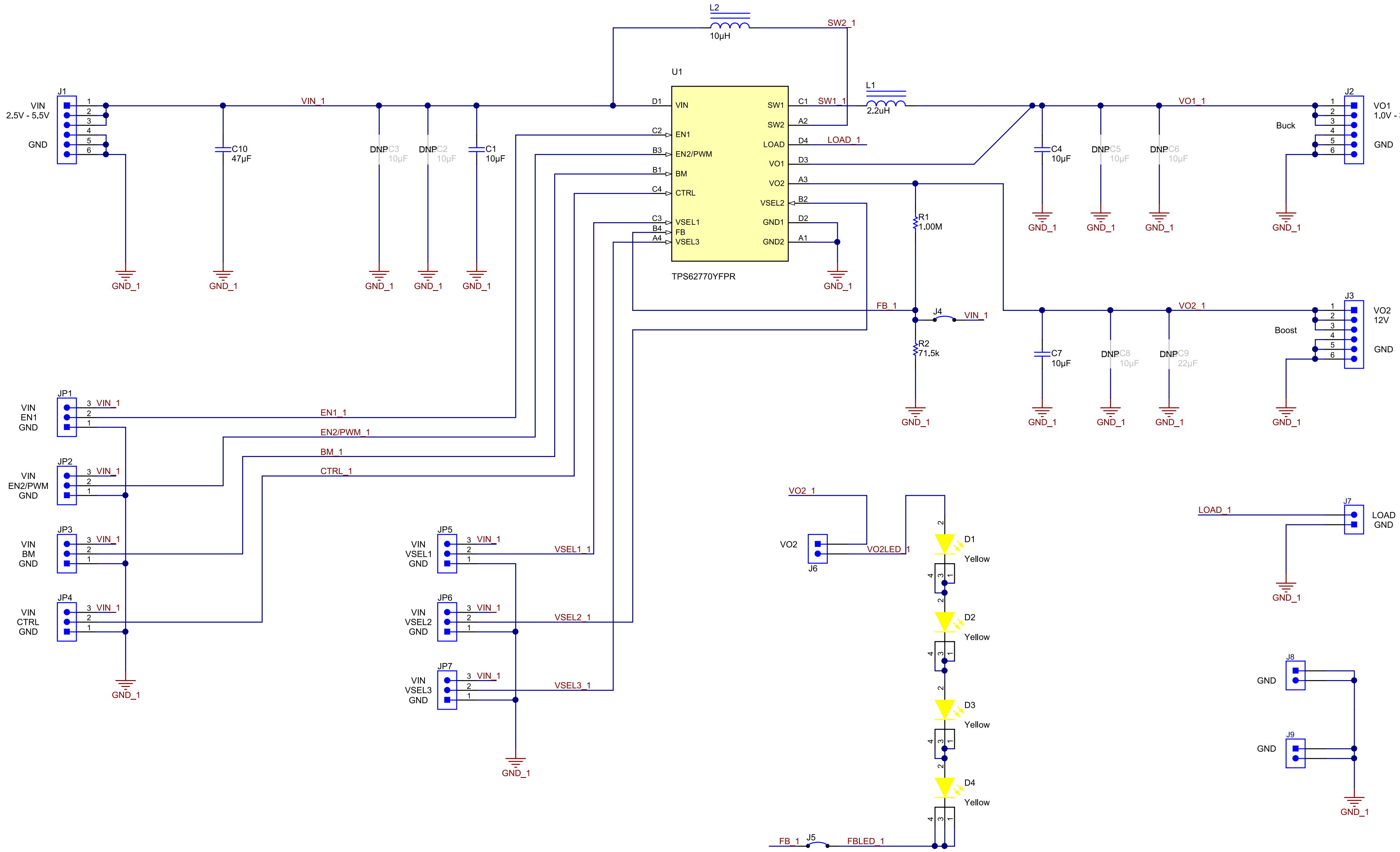

Figure 7. TPS62770EVM-734 Schematic U2

5.2 Bill of Materials

Table 2 lists the TPS62770EVM-734 bill of materials.

Table 2. TPS62770EVM-734 Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
4	C1, C4, C11, C13	10uF	Capacitor, Ceramic, X5R, 6.3V, 20%	0402	GRM155R60J106ME15D	Murata
4	C7, C15	10uF	Capacitor, Ceramic, X5R, 25V, 20%	0603	GRM188R61E106MA73	Murata
2	C10, C17	47uF	Capacitor, Ceramic, X5R, 16V, 20%	1210	GRM32ER61C476ME15L	Murata
6	C2, C3, C5, C6, C12, C14	not populated		0402		
2	C8, C16	not populated		0603		
1	C9	not populated		0805		
4	D1, D2, D3, D4	Yellow	LED, Yellow, SMD	2.8x3.2mm	LTW-E670DS	Lite-On
2	L1, L4	2.2uH	Inductor, SMD, 1.2A, 204-mΩ	1.6x2.0mm	1285AS-H-2R2M	Toko
1	L2	10uH	Inductor, SMD, shielded, 10 µH, 0.71 A, 152-mΩ	3.0x1.5x3.0mm	VLF302515MT-100M	TDK
1	L3	10uH	Inductor, SMD, shielded, 10 µH, 0.47 A, 1026-mΩ	2.0x1.2x1.6mm	VLS201612ET-100M	TDK
1	R1	1.00MΩ	Resistor, SMD, 1.00MΩ, 1%	0402	CRCW04021M00FKED	Vishay-Dale
1	R2	71.5kΩ	Resistor, SMD, 71.5kΩ, 1%	0402	CRCW040271K5FKED	Vishay-Dale
2	U1, U2	TPS62770	Multi Rail DC/DC Converter For Wearable Applications	1.65mmx1.65mm 16-Ball DSBGA	TPS62770YFP	TI

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

      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.

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- *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*

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This device complies with Industry Canada license-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.

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

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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.

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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.

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4.3 *Safety-Related Warnings and Restrictions:*

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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.

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