TRF37x32 EVM

The TRF37x32 EVM board enables measurements of the TRF37x32 family of wideband dual down-convert mixers with integrated intermediate frequency (IF) amplifiers. The device employs integrated baluns for single-ended radio frequency (RF) and local oscillator (LO) inputs. The IF amplifier operates from 30 MHz to 500 MHz in an open collector topology to support a variety of IF frequencies and bandwidths. The TRF37x32 provides excellent mixer spurious performance and offers good isolation between channels for operation with diverse applications. The low-power mode allows operation at reduced power dissipation and the fast response power-down feature facilitates operation in TDD applications. Indicator components are located on the top side of the EVM to easily identify the component assembled on the board.

Table 1. Device Frequency Ranges

	Extended					
		Primary				
Device	MIN	MIN	TYP	MAX	MAX	Unit
TRF37A32	300	700	825	950	1400	MHz
TRF37B32	1200	1700	1950	2200	2700	MHz
TRF37C32	2000	2300	2600	2900	4000	MHz

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1 Quickstart Operating Procedures

These steps describe the evaluation module setup for basic operation on an EVM with default hardware configuration:

1. Connect the mini-USB connector. LED D2 draws power through the mini-USB connector and should light immediately. D1 indicates 5-V power and should also light immediately.
2. Connect an RF source to RFINA on J1. Frequency ranges are given in Table 1.
3. Connect an LO source to LO on J4 with a nominal frequency offset of 200 MHz and a nominal amplitude of 0 dBm
4. Connect the IFAP output on J9 to a spectrum analyzer

2 EVM Setup

The TRF37x32 EVM enables several supply options allowing easy setup and maximum evaluation flexibility.

2.1 EVM Power Supply

The TRF37x32 device operates with a 3.3-V supply. The EVM includes a TPS74201IRGW ultra-low noise LDO so that standard 5-V supply sources may be used to generate 3.3 V. In its default shipping configuration, the EVM is set to draw power from a USB port. The USB may be used to supply power without any need for USB communication. A standard 5-V power supply may instead be used as the supply source through plug J10 or TP8. The most testing flexibility is achieved by directly supplying 3.3 V from a lab supply. The 3.3-V supply connection also uses an SMA connector for mechanical robustness. Only one of the three supply options may be used.

Table 2. Power Supply Configuration Options

Source	JP4	JP5	J5	J7	J10
5-V USB	pins 1-2, REG	pins 1-2, 5VUSB	USB	do not care	do not care
5-V wall	pins 1-2, REG	pins 2-3, 5VEXT	do not care	do not care	5 V
3.3-V lab	pins 2-3, EXT	do not care	do not care	3.3 V	do not care

Table 3. Power Supply Controls and Indicators

Reference Designator	Label	Function
JP4	EXT, REG	Selects device 3.3-V VCC from external connector J7 or on-board regulated supply Pins 1-2 = Regulated supply Pins 2-3 = External connector J7
JP5	5VUSB, 5VEXT	Selects 5-V supply to be regulated down to 3.3 V Pins 1-2 = 5 V through USB Pins 2-3 = 5 V through J10 or TP8
J5	USB	Mini-USB input jack
J7	3P3V_EXT	External 3.3-V input connector
J10	5V	External 5-V input jack
TP8	TP8	External 5-V input clip connector
D1	5V	LED indicator for 5 V at input to LDO regulator, either through USB or external input
D2	USB_PWR	LED indicator for USB 5 V, prior to JP5

2.2 EVM Control

The EVM provides control over all device configurations including low-power mode and channel power-down control. The boards ship configured for manual control, although they can also be controlled through the USB port.

2.2.1 Low-Power Mode

Low-power mode reduces power consumption of the TRF37x32 device, trading linearity performance. A high voltage on LPM activates low-power mode. JP3 provides a manual control point for LPM. Low-power mode can also be controlled through a testpoint clip or through USB.

Table 4. Low-Power Mode Controls

Reference Designator	Label	Function
JP3	LPM, NORM or no label	Selects LPM Pins 1-2 = 0 V = Normal operation Pins 2-3 = 3.3 V = Low-power mode No jumper = Normal operation through internal pull-down
TP4	LPM	Clip point for LPM control

2.2.2 Power-Down Mode

Power-down mode allows individual channels to be disabled completely for minimal supply draw and interference. A high voltage on PD* activates power-down mode for the selected channel. Power-down mode can also be controlled through USB.

Table 5. Power-Down Mode Controls

Reference Designator	Label	Function
JP1	PUp, PDn	Selects PDA Pins 1-2 = 0 V = Normal operation Pins 2-3 = 3.3 V = Power-down mode No jumper = Normal operation through internal pull-down
JP2	PUp, PDn	Selects PDB Pins 1-2 = 0 V = Normal operation Pins 2-3 = 3.3 V = Power-down mode No jumper = Normal operation through internal pull-down

2.2.3 USB Control

It is possible to use the mini-USB port to control both LPM and PD*. The USB port connects to an FTDI FT245RL device, which may be used to drive arbitrary digital signals on its output channels. The board is shipped with the USB ports not connected; 0-Ω shorts must be installed to use USB controls. To avoid contention between the control driver and header control, control jumpers must be removed. Also, when both R17 and R18 are installed, independent control of the A and B channels is not possible.

There is no TRF37x32 GUI. Using the static control pins on the TRF37x42 GUI is also an available option.

Table 6. USB Control Configuration

Control Channel	Control	Install Component	Remove Jumper
D6	PDA	R18	JP1
D6	PDB	R17	JP2
D7	LPM	R16	JP3

2.3 Signal Chain Setup

Channel A and B paths are identical. By default, the RFIN paths contain no matching components but do offer pads.

The IFOUT paths each route two traces of differential pairs to output SMA connectors. The transformer performs a 4:1 impedance transform to interface between the 200-Ω differential device outputs and single-ended 50-Ω lab equipment. The N side of the differential pair is tied to ground. The transformer pads are compatible with 0402 components so that the user may connect to additional signal chain components. Insertion loss of the transformer is near 0.5 dB at 200-MHz IF frequencies and this must be considered when taking high-performance measurements.

The TRF37x32 is a high-performance device and measured performance is extremely dependent on proper equipment setup. Linearity measurements require excellent signal generator linearity and return loss. High-performance pads may be required in order to isolate generators that are coupled through combiners. Spectrum analyzers must be configured to accurately measure low-level tones such as third-order intermodulation tones.

3 Physical Description

This section describes the schematic, layout and stackup, and bill of materials (BOM).

3.1 Schematic

Figure 1 through Figure 3 illustrate the EVM schematics.

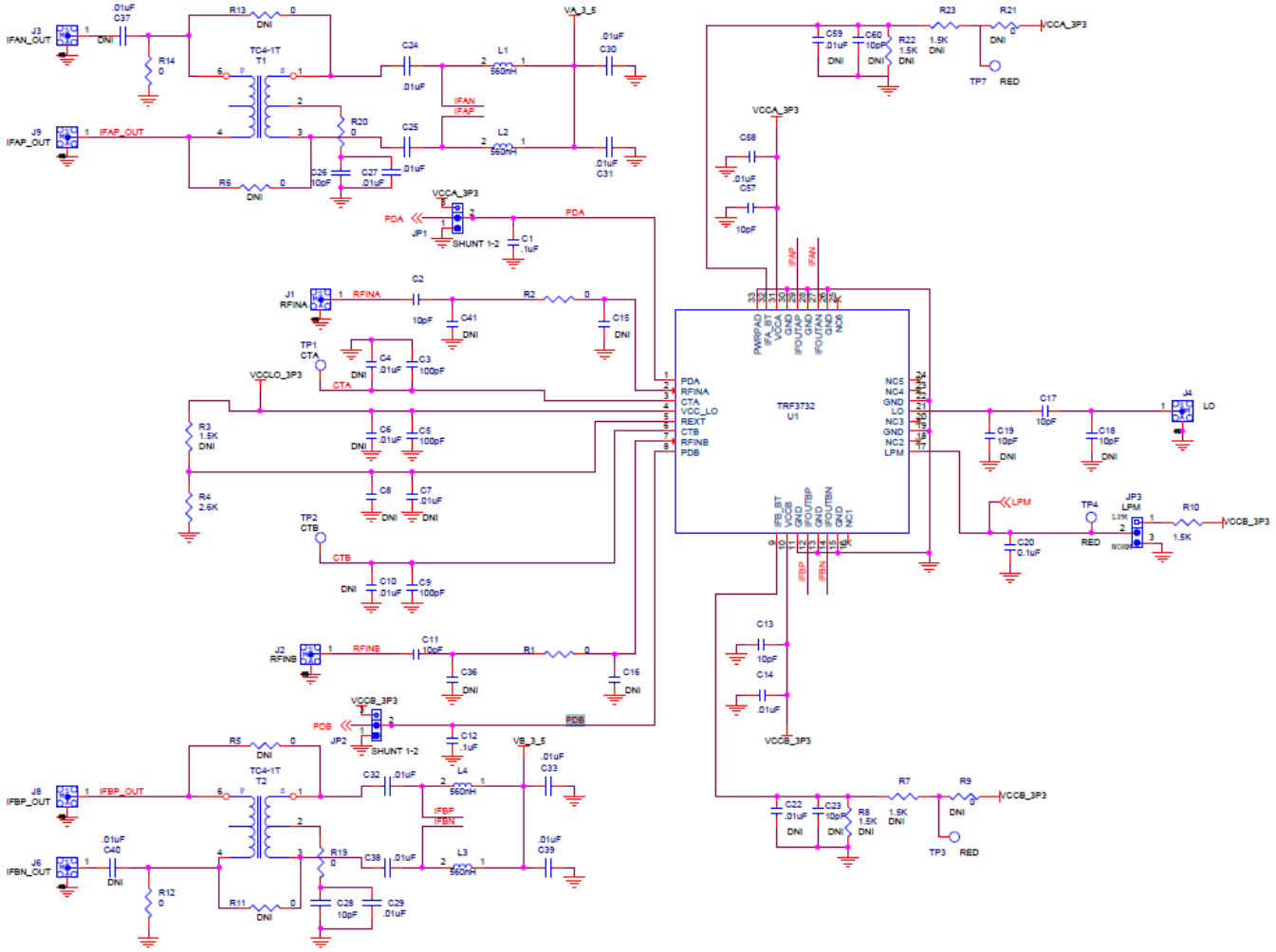

Figure 1. TRF37x32 EVM Schematic (1 of 3)

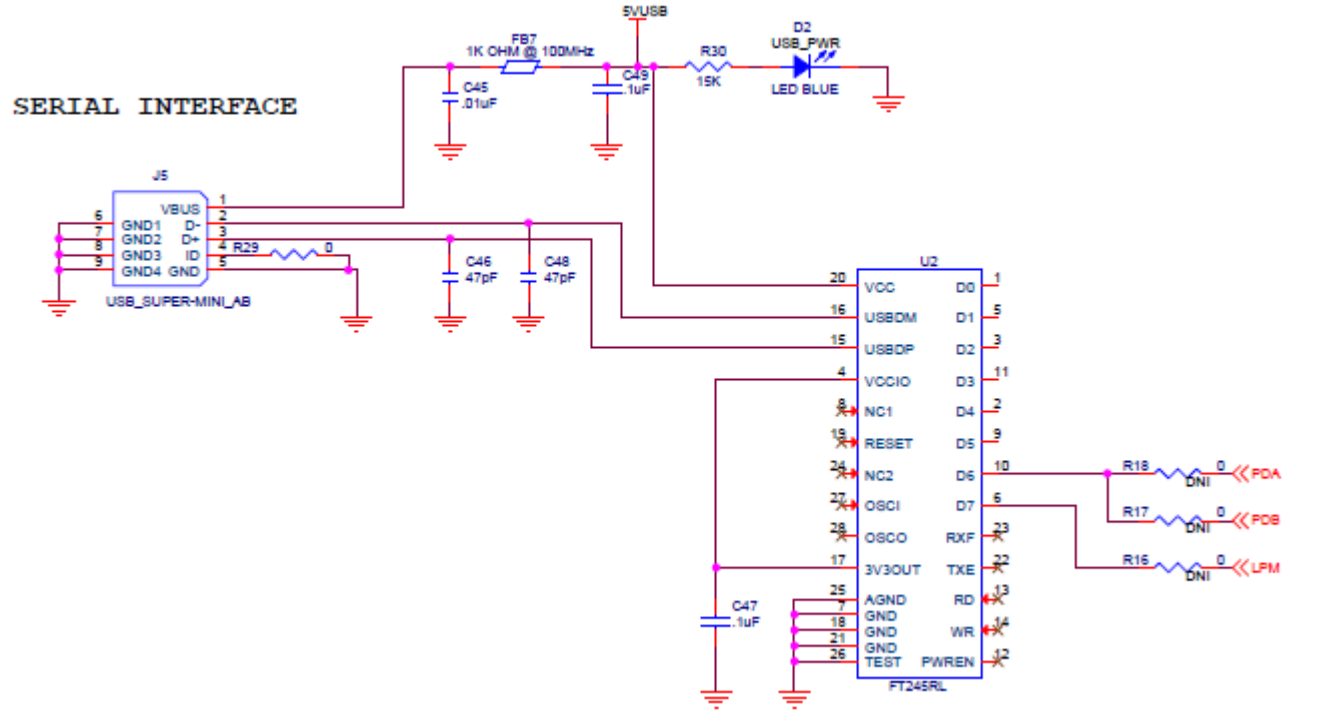

Figure 2. FTRF37x32 EVM Schematic (2of 3)

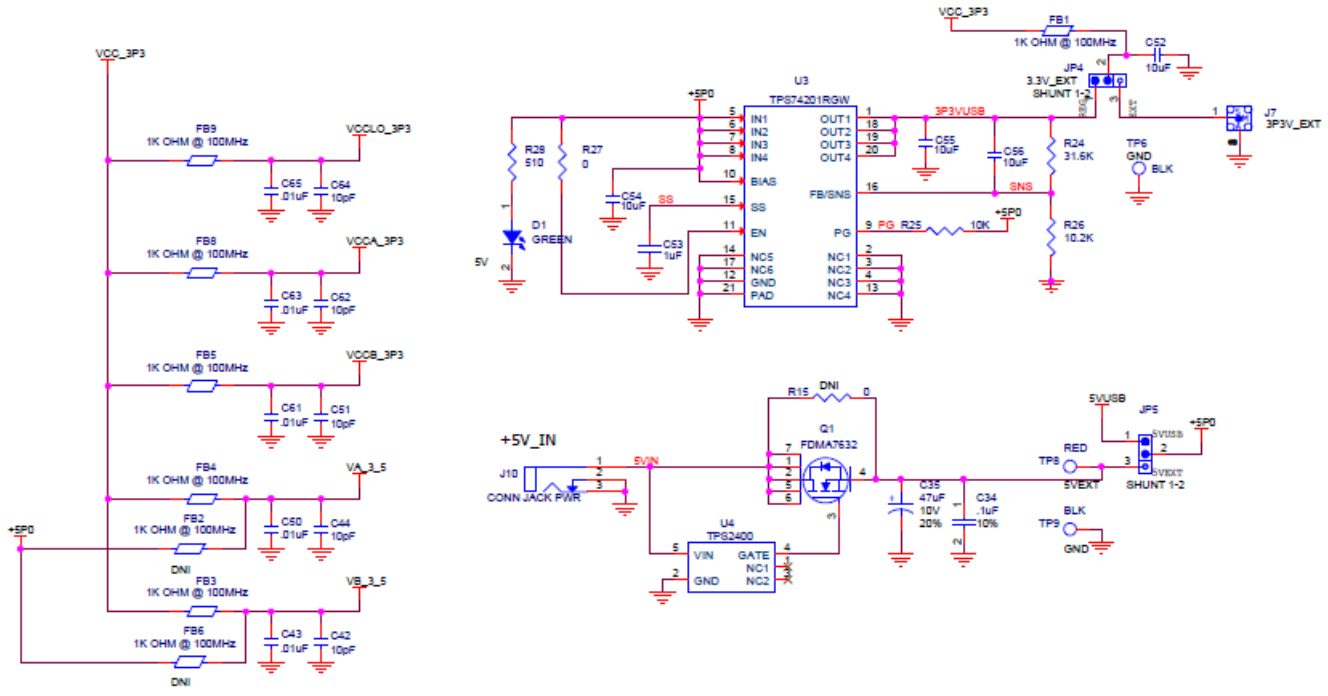

Figure 3. TRF37x32 EVM Schematic (3 of 3)

3.2 Layout

Figure 4 through Figure 9 illustrate the printed-circuit board layout views.

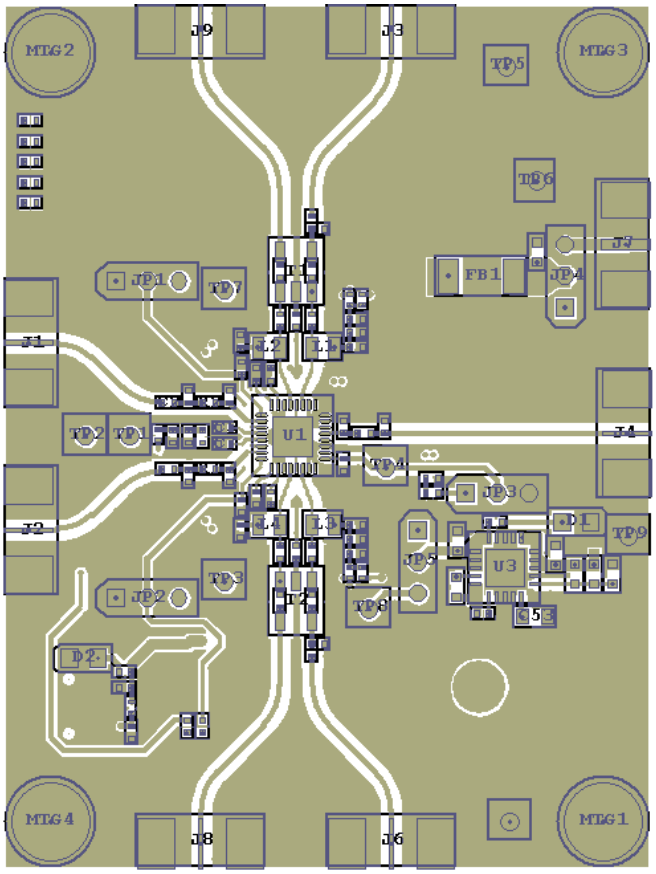

Figure 4. Top Layer

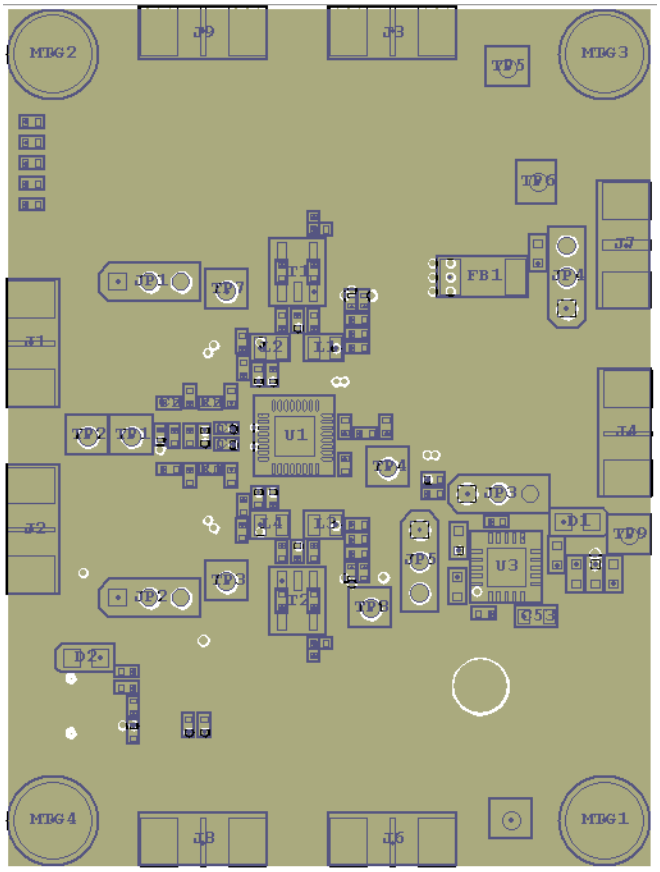

Figure 5. Layer 2, Ground

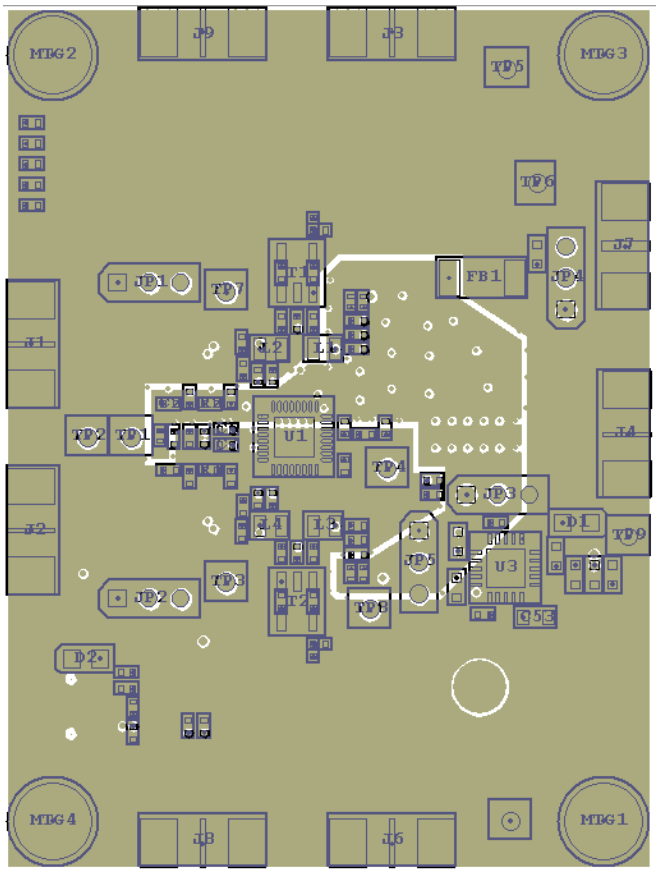

Figure 6. Layer 3, Power

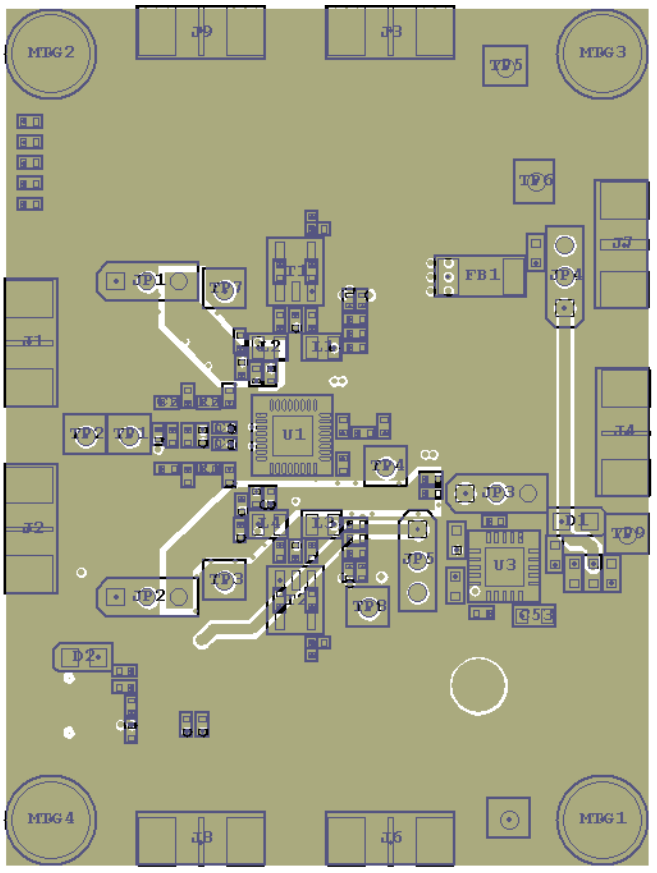

Figure 7. Layer 4, Power

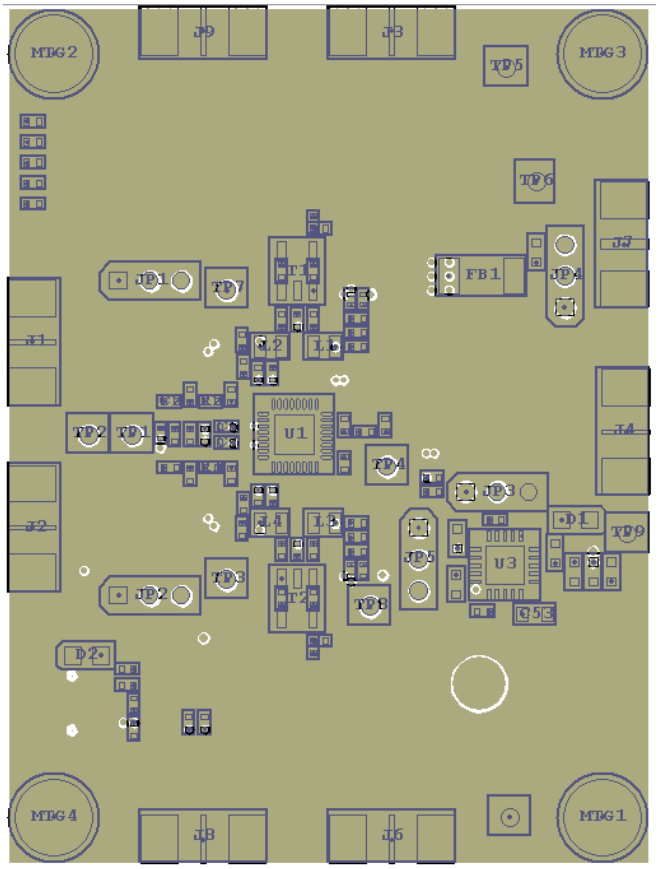

Figure 8. Layer 5, Ground

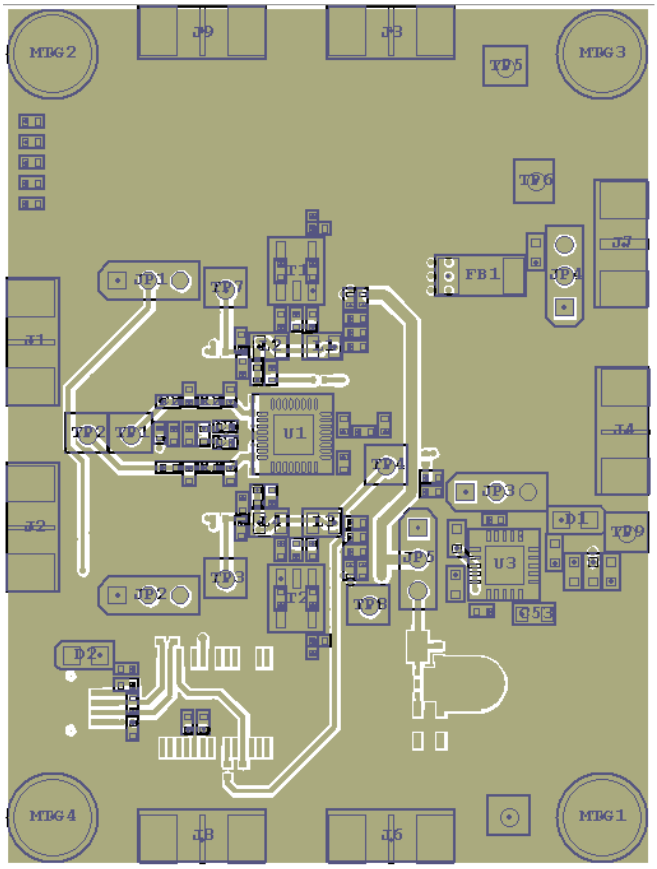

Figure 9. Bottom Layer

3.3 Stackup

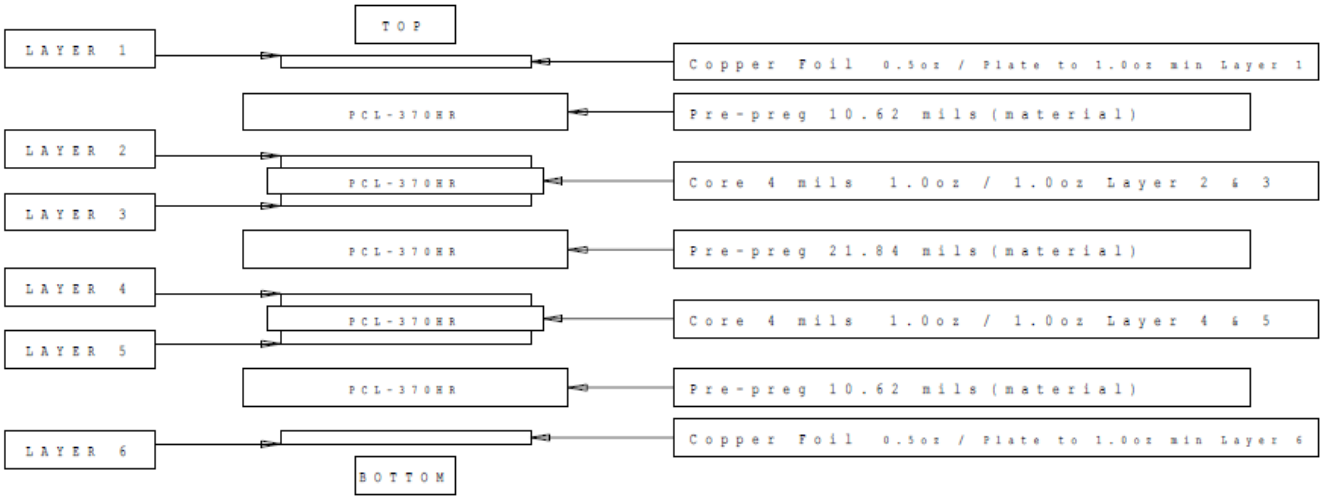

Figure 10. Stackup

3.4 Bill of Materials

Table 7 lists the BOM for this EVM.

Table 7. Bill of Materials

Qty	Reference	Part	Part Number	Mfr
2	C1, C12	0.1 µF	GRM155R71C104KA88	Murata
10	C2 ,C11, C13, C17, C42, C44, C51, C57, C62, C64	10 pF	GRM1555C1H100JZ01D	Murata
3	C3, C5, C9	100 pF	GRM1555C1H101JA01D	Murata
DNI	C4, C7, C8, C10, C22, C59	0.01 µF	GRM155R71H103KA88D	Murata
DNI	C6	0.01 µF	GRM155R71E103KA01D	Murata
7	C14, C43, C50, C58, C61, C63, C65	0.01 µF	GRM155R71H103KA88D	Murata
DNI	C15, C16, C36, C41	2.2 pF	GRM1555C1H2R2CA01D	Murata
DNI	C18, C19, C23, C60	10 pF	GRM1555C1H100JZ01D	Murata
1	C20	0.1 µF	GRM155R61A104KA01D	Murata
10	C24, C25, C27, C29, C30, C31, C32, C33, C38, C39	0.01 µF	GRM155R71E103KA01D	Murata
2	C26, C28	10 pF	04025U100FAT2A	AVX
1	C34	0.1 µF	GRM155R61A104KA01D	Murata
1	C35	47 µF	TPSB476K010R0500	AVX
DNI	C37, C40	0.01 µF	GRM155R71E103KA01D	Murata
1	C45	0.01 µF	GRM155R71E103KA01D	Murata
2	C46, C48	47 pF	04025A470JAT2A	AVX Corp
2	C47, C49	0.1 µF	GRM155R61A104KA01D	Murata
4	C52, C54, C55, C56	10 µF	GRM188R60J106ME47D	Murata
1	C53	1 µF	C2012X5R1E105K	TDK Corp
1	D1	GREEN	LTST-C170KGKT	LITE ON
1	D2	LED BLUE	LTST-C170TBKT	LITE ON
1	FB1	1 kΩ	FBMH4525HM102NT	TAIYO YUDEN
DNI	FB2, FB6	1 kΩ	BLM15AG102SN1	Murata
6	FB3, FB4, FB5, FB7, FB8, FB9	1 kΩ	BLM15AG102SN1	Murata
2	JP1, JP2	HEADER	HTSW-103-07-G-S	SAMTEC
1	JP3	HEADER	HMTSW-103-07-G-S-.240	SAMTEC
1	JP4	HEADER	HMTSW-103-07-G-S-.240	SAMTEC
1	JP5	HEADER	HMTSW-103-07-G-S-.240	SAMTEC
8	J1, J2, J3, J4, J6, J7, J8, J9	SMA	142-0701-851	Johnson
1	J5	USB_MINI	MNE20-5G5P10	ACON
1	J10	JACK PWR	RAPC722	Switchcraft
4	L1, L2, L3, L4	560nH	0805CS-561XGL	Coilcraft
1	Q1	FDMA7632	FDMA7632	Fairchild
7	R1, R2, R12, R14, R19, R20, R27	0	ERJ-2GE0R00X	Panasonic
DNI	R3, R7, R8, R22, R23	1.5K	ERJ-2RKF1501X	Panasonic
1	R4	2.6K	ERJ-2RKF2601X	Panasonic
DNI	R5, R6, R9, R11, R13, R15, R21	0	ERJ-2GE0R00X	Panasonic
1	R_indicator	0	ERJ-2GE0R00X	Panasonic
1	R10	1.5K	ERJ-2RKF1501X	Panasonic
DNI	R16, R17, R18	0	ERJ-2GE0R00X	Panasonic
1	R24	31.6K	ERJ-3EKF3162V	Panasonic
1	R25	10K	ERJ-3EKF1002V	Panasonic
1	R26	10.2K	ERJ-3EKF1022V	Panasonic

Table 7. Bill of Materials (continued)

Qty	Reference	Part	Part Number	Mfr
1	R28	510	ERJ-2RKF5100X	Panasonic
1	R29	0	ERJ-3GEY0R00V	Panasonic
1	R30	15K	ERJ-2GEJ153X	Panasonic
5	TP1, TP2, TP3, TP4, TP7	RED	5010	Keystone
2	TP5, TP10	BLK	5011	Keystone
1	TP6	BLK	5011	Keystone
1	TP8	RED	5010	Keystone
1	TP9	BLK	5011	Keystone
2	T1, T2	TC4-1T	TC4-1T	Minicircuits
1	U1	TRF3732	TRF37X32	TI
1	U2	FT245RL	FT245RL	FTDI
1	U3	TPS74201	TPS74201RGW	TI
1	U4	TPS2400	TPS2400DBV	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.

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*

Concerning EVMs Including Radio Transmitters:

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

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 are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

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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.

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:*

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