This document outlines the basic steps and functions that are required to ensure the proper operation and quick setup of the TRF37x73 and TRF37x75 EVM. This document also includes a schematic diagram, a bill of materials (BOM), printed-circuit board (PCB) layouts, board loss plots, and test block diagrams. Throughout this document, the abbreviations EVM, TRF37x73/75 EVM, and the term evaluation module are synonymous with the TRF37x73 and TRF37x75 EVM, unless otherwise noted.

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The TRF37x73/75 EVM consists of the following components:

- TRF37x73/75 EVM board

2 EVM Overview

This section includes the schematic diagram, a bill of materials (BOM), and general usage information.

2.1 Schematic and BOM

The TRF37x73/75 EVM for RF gain blocks comes in a 2 × 2 WSON package. The device type is visually identified in component U1 by the 0402 selection resistors TRF37A73, TRF37B73, TRF37C73, TRF37A75, TRF37B75, and TRF37C75.

The TRF37x73 are a family of 3.3-V, RF gain blocks that have 3 gain variants (A73 = 12 dB, B73 = 15 dB, and C73 = 18 dB). The TRF37x75 are a family of 5-V, RF gain blocks that have 3 gain variants (A75 = 12 dB, B75 = 15 dB, and C75 = 18 dB).

The TRF37x73/75 EVM schematic is shown in Figure 1.

Figure 1. TRF37x73/75 EVM Schematic
# 2.2 TRF37x73/75 EVM Bill of Material

## Table 1. TRF37x73/75 EVM BOM

<table>
<thead>
<tr>
<th>Component</th>
<th>Description (Footprint)</th>
<th>Value</th>
<th>Manufacturer</th>
<th>Part Number</th>
</tr>
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<tbody>
<tr>
<td>C1, C2, C6</td>
<td>AC coupling capacitor (0402)</td>
<td>1000pF</td>
<td>Murata</td>
<td>GRM1555C1H102JA01D</td>
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<tr>
<td>C3</td>
<td>Power Supply Decoupling (0402)</td>
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<td>Murata</td>
<td>GRM1555C1H100JZ01D</td>
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<td>C4</td>
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<td>0.01µF</td>
<td>Kemet</td>
<td>C0603C103K1RACTU</td>
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<td>C5</td>
<td>Power Supply Decoupling (Tantalum)</td>
<td>10µF</td>
<td>Kemet</td>
<td>T494A106M016AS</td>
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<tr>
<td>J1, J2</td>
<td>AC signal SMA connector</td>
<td></td>
<td>Emerson Connectivity (Johnson)</td>
<td>142-0701-851</td>
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<tr>
<td>J3</td>
<td>Terminals for VCC (Clip)</td>
<td>Red</td>
<td>Keystone</td>
<td>5005</td>
</tr>
<tr>
<td>J4</td>
<td>Terminal for GND (Clip)</td>
<td>Black</td>
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<td>5006</td>
</tr>
<tr>
<td>JP1</td>
<td>Terminals for PWDN</td>
<td></td>
<td></td>
<td>1.3 10 mil header</td>
</tr>
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<td>L1</td>
<td>DC biasing inductor (0603)</td>
<td>100nH</td>
<td>CoilCraft</td>
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<tr>
<td>R1</td>
<td>DC Biasing resistor (0603)</td>
<td>0 ohm</td>
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### TRF37A75-Specific BOM

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<tr>
<td>R2</td>
<td>DC biasing resistor (0603)</td>
<td>1.8 ohm</td>
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<tr>
<td>U1</td>
<td>TRF37A75</td>
<td>5V, 12dB gain</td>
<td>TI</td>
<td>TRF37A75</td>
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<tr>
<td>TRF37A75</td>
<td>0402 BOM Identification resistor</td>
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### TRF37B75-Specific BOM

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<td>U1</td>
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<td>5V, 15dB gain</td>
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<td>0402 BOM Identification resistor</td>
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### TRF37C75-Specific BOM

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<tr>
<td>U1</td>
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<td>5V, 18dB gain</td>
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<tr>
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### TRF37A73-Specific BOM

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<td></td>
</tr>
<tr>
<td>U1</td>
<td>TRF37A73</td>
<td>3.3V, 12dB gain</td>
<td>TI</td>
<td>TRF37A73</td>
</tr>
<tr>
<td>TRF37A73</td>
<td>0402 BOM Identification resistor</td>
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### TRF37B73-Specific BOM

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<td>R2</td>
<td>DC biasing resistor (0603)</td>
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<tr>
<td>U1</td>
<td>TRF37B73</td>
<td>3.3V, 15dB gain</td>
<td>TI</td>
<td>TRF37B73</td>
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<tr>
<td>TRF37B73</td>
<td>0402 BOM Identification resistor</td>
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### TRF37C73-Specific BOM

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<tr>
<td>U1</td>
<td>TRF37C73</td>
<td>3.3V, 18dB gain</td>
<td>TI</td>
<td>TRF37C73</td>
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<tr>
<td>TRF37C73</td>
<td>0402 BOM Identification resistor</td>
<td>0 ohm</td>
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</tbody>
</table>
### 2.3 General Usage Information

This section provides general usage information for the EVM.

1. Recommended power up sequence:
   - (a) Connect GND to J4 (black – GND)
   - (b) Connect Vcc to J3 (red – VCC)
   - (c) Connect RF input signal to J1 (RFIN)
   - (d) Connect measurement instrument to J2 (RFOUT)
   - (e) Ensure the device is not in power-down mode by shorting JP1 terminals 1 and 2 or simply remove JP1 to take advantage of the TRF37x73/75’s internal pull-down resistor.

2. Power supply options:
   - (a) For TRF37x73 devices, set VCC to 3.3 V
   - (b) For TRF37x75 devices, set VCC to 5.0 V

3. PWDN option:
   - (a) Short terminals 2 and 3 on JP1 to put the TRF37x73/75 in its power down state.

4. Tuning options:
   - (a) Solder mask has been removed along the RF signal paths and VCC path allowing an easy method to slide surface mount components along these traces for optimal tuning.

### 3 EVM Layout

#### 3.1 Description: Stack up and Material

The TRF37x73/75 EVM is a 62-mil, 4-layer board whose material type is Isola® 370HR. The top layer routes the power, ground, and signals to and from the device. The signal impedance is targeted at 49.9 Ω. The bottom 3 layers are ground layers.

#### 3.2 PCB Layers

Figure 2 through Figure 4 illustrate the PCB layers for this EVM.

![Figure 2. Top Layer](image-url)
Figure 3. Layers 2 and 3

Figure 4. Bottom Layer (Through Top Side)
4 EVM Board Loss

Performance plots of the TRF37x73/75 EVM board are illustrated in Figure 5 and Figure 6, with the following modifications to the BOM:

- U1 gain block uninstalled
- C1 and C2 removed, terminals shorted with strip of copper whose width equaled the trace width.

Figure 5 and Figure 6 show the S11 and S22 log magnitude responses to a –10-dBm input signal. These measurements were taken with an Agilent E5071B vector network analyzer calibrated from 1 MHz to 6 GHz to the end of the coaxial cables. The coaxial cables were connected directly to J1 and J2 on the EVM board. Port 1 refers to J1 in the schematic and Port 2 refers to J2 in the schematic.

Figure 5. S11, S22 (Open), U1 Uninstalled

Figure 6. S11, S22 (Open), U1 and L1 Uninstalled, Copper Tape Replaced C1 and C2
5 Test Block Diagrams

This section includes recommendations, comments, and test block diagrams for noise figure, gain and P1dB, and OIP3.

5.1 Noise Figure

Recommendations and comments:
1. Use the traditional Y-factor method
2. Take into account losses of coax to the EVM board
3. Take into account losses of traces on the board up to the input pin of the device under test (DUT)

5.2 Gain and P1dB

Recommendations and comments:
1. Take into account losses of coax and attenuators to and from the EVM board
2. Take into account losses of traces on the board up to the I/O pins of the DUT
3. Power meters are typically a few tenths of dB more accurate than a signal generator's level controls and spectrum analyzer measurement capability. For precise measurements, use a power meter to measure the output of the signal generator and output of the TRF37x73/75 EVM.
5.3 **OIP3**

Recommendations and comments:

1. This setup can also be used for gain and P1dB, if desired
2. For wideband measurements, the 30-dB gain stage and 10-dB attenuators are used to improve the input IP3 level that is created from the interaction of the 2 signal generators via the isolation of the combiner. For narrow band measurements, it maybe possible to create a setup with enough isolation using an isolator and/or combiner. In this case the 10-dB pads could be reduced or removed.
3. Power meter A is used to ensure the amplitude of the two tones at the input of the TRF37x73/75 EVM are within a certain tolerance. The gain stages will have unique gain characteristics and their gain can drift over time
4. Power meter B can be used for measuring the amplitude of individual tones for more accurate measurements.
5. Keep spectrum analyzer RBW and VBW settings identical for main tone and IM3 products
6. Take into account losses of coax and attenuators to and from the EVM board
7. Take into account losses of traces on the board up to the I/O pins of the DUT
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10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.

11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.

12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

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**Agreement to Defend, Indemnify and Hold Harmless.** User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 handling and/or use of EVMs. User’s indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

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For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. 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 TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 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 its 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. 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.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003. Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

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.
Canada Industry Canada Compliance (French)

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.

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.

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.

Important 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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