TRF3722 EVM User's Guide

TRF3722 is a high performance direct conversion quadrature modulator with exceptional linearity and low noise performance. The TRF3722 converts low frequency baseband signals to high frequency RF signals and integrates PLL and VCO to provide the local oscillator (LO) to the integrated modulator. This document provides the operating procedures of the TRF3722 evaluation module (EVM).

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1 Introduction

TRF3722 is a quadrature modulator with integrated PLL and VCO. The typical 0.25-V baseband common mode voltage supports seamless interface with current sourcing DACs. The PLL and VCO provides excellent phase noise. The device also provides additional LO output for driving a second modulator or down converting mixer. The modulator features a high gain mode along with a low power mode when power optimization is desired. Figure 1 shows the TRF3722 EVM.

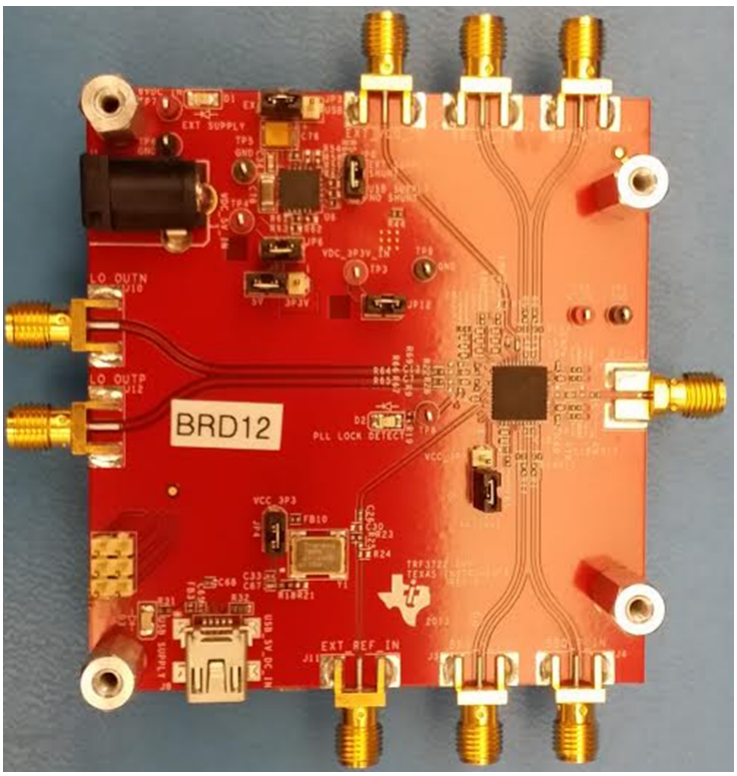

Figure 1. TRF3722EVM Board Photo

2 GUI Installation

Install the GUI using the following steps:

1. This is a one-time installation. Download the TRF3722 GUI (SLOC306) from the TI website.
2. Run *SETUP* from the *TRF3722GUI_Installer/Volume* folder.
3. The window in Figure 2 appears.

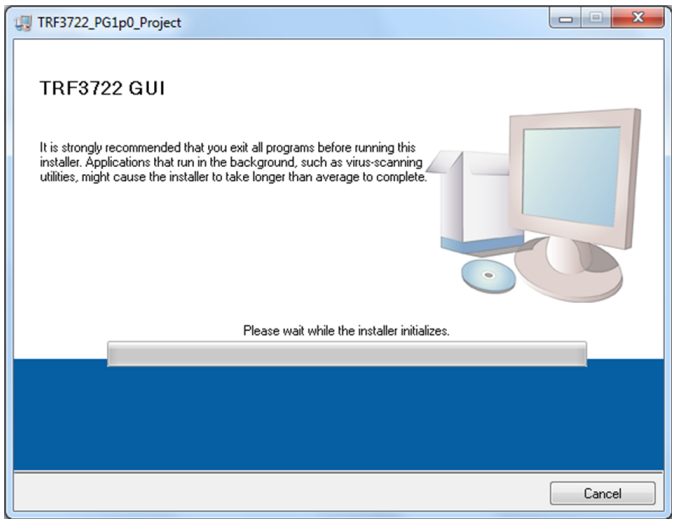

Figure 2. GUI Installer Initialization

4. When the destination directory installation windows appear (Figure 3), click the **Next >>** buttons.

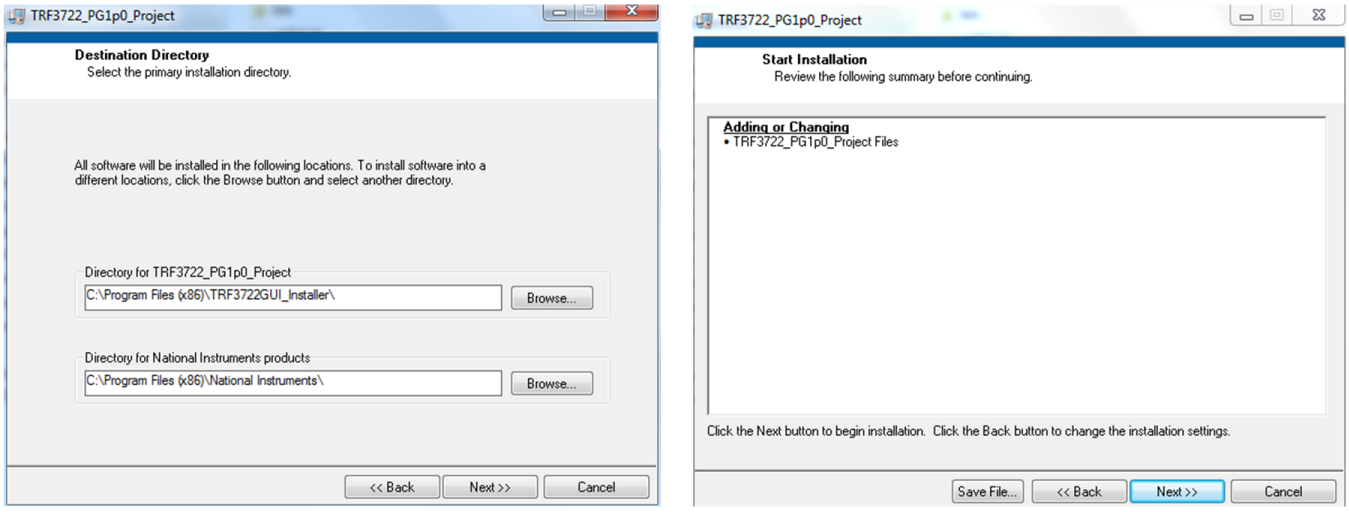

Figure 3. Directory Installation Windows

5. Once the installation is complete, select **Finish**
6. Go to *Start → All Programs → TRF3722_PG1p0_Project* to launch the **TRF3722 GUI**.

2.1 GUI Details

The TRF3722 GUI has two tabs, a *Top Level* tab and an *Advanced Settings* tab. The *Top Level* tab has two ON/OFF buttons which turn the LO section and IQ modulator section ON or OFF individually. When only the IQ modulator is turned ON, make sure a LO signal is provided at the *EXT_VCO_IN* SMA connector.

The TRF3722 has seven registers (registers 0–6). Register 0 is a read-back register. The yellow circle in Figure 4 illustrates the *Device Communication Failure* warning that appears when the GUI doesn't talk to the device. Whenever this happens, make sure the FTDI FT245RL device drivers are installed on your computer, reconnect the USB cable, and press the **USB Reset** button.

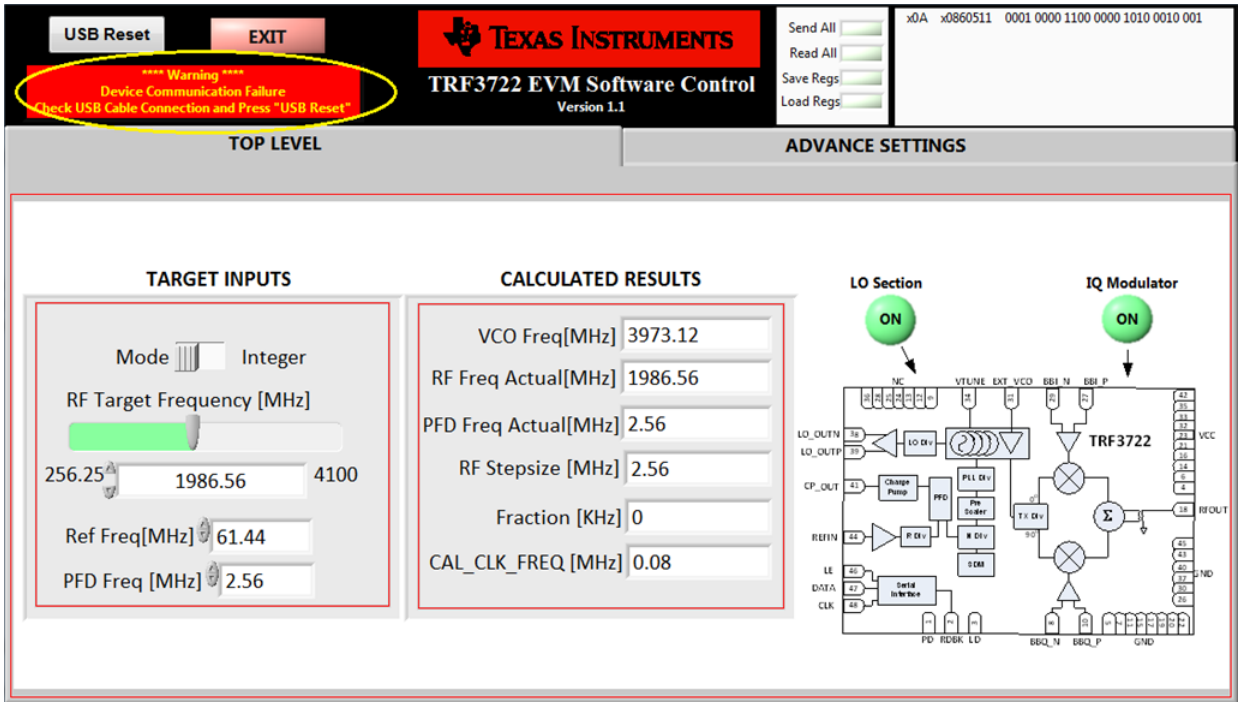

Figure 4. GUI Warning

3 EVM Jumper Configuration

The default EVM jumper installation is listed in Figure 5.

Table 1. Default Jumper Connections

Jumper	Description	Default Connection	Notes
JP2	Power save	Pins 2-3	Typical Operating Mode (1-2, power save mode)
JP4	Crystal supply	Pins 1-2	On-board crystal (make sure R23 is populated and R25 is DNI)
JP3	Ext/USB supply	Pins 1-2	External supply
JP8	5-V LDO (U6) load	Pins 1-2	External supply
JP6	5 V from LDO (U6)	Pins 1-2	LDO supply
JP8	3.3 V from LDO (U5)	Pins 1-2	LDO supply

3.1 Board Power-up

Power up the board using the following steps:

1. Make sure the jumpers are properly placed as shown in Table 1.
2. The board can be powered up either by using a single 6-V DC power supply (either using connecter jack J1 or test point TP7) or using 3.3- and 5-V DC supplies. To obtain optimum phase noise performance, TI recommends operating the board using clean 3.3- and 5-V linearDC supplies without engaging the LDOs.
3. Power up the board using a single 6-V DC supply by connecting a 6-V DC supply either at the *J1* power connector jack or at the test point (TP7) as shown in Figure 5.
4. When the 6-V DC supply is applied, red LED D1 turns ON.
5. When the 6-V DC supply is connected, the voltage at TP3 should read 3.3 V and the voltage at TP4 should read 5 V.
6. Power the board using 3.3- and 5-V DC supplies by removing jumpers JP12 and JP6. Directly connect a 3.3-V DC supply at test point TP3 and a 5-V DC supply at test point TP4.
7. At initial power up (before the device is programmed), typical consumption from a 3.3-V DC supply is around 55 mA (±15 mA) and typical consumption from a 5-V DC supply is around 20 mA (±7 mA). Figure 5 shows the voltage supply inputs.

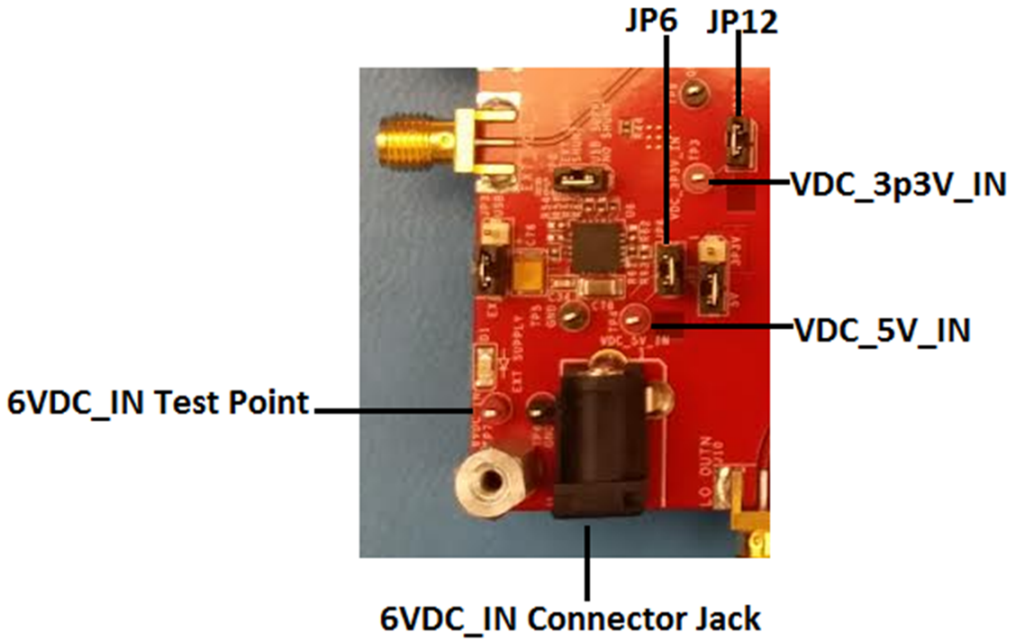

Figure 5. Voltage Supply Inputs

3.2 Modulator Linearity Validation

Validate modular linearity using the following steps:

1. Connect the J7 RFOUT SMA connector to a Spectrum analyzer.
2. Connect the baseband in-phase positive signal to SMA connector J6 and in-phase negative signal to SMA connector J5. Connect positive quadrature signal to SMA connector J4 and negative quadrature signal to SMA connector J3.
3. Connect a mini-USB cable from the computer to J8. This should turn ON the blue LED (D3).
4. Terminate any unused SMA connectors to 50-Ω load.
5. Connect 6-V power adaptor. This should turn ON the red LED (D1).
6. Launch the TRF3722 GUI.
7. As an example, this guide now considers an RF target frequency of 1986.56 MHz.
8. Set the GUI as shown in Figure 6 and Figure 7.

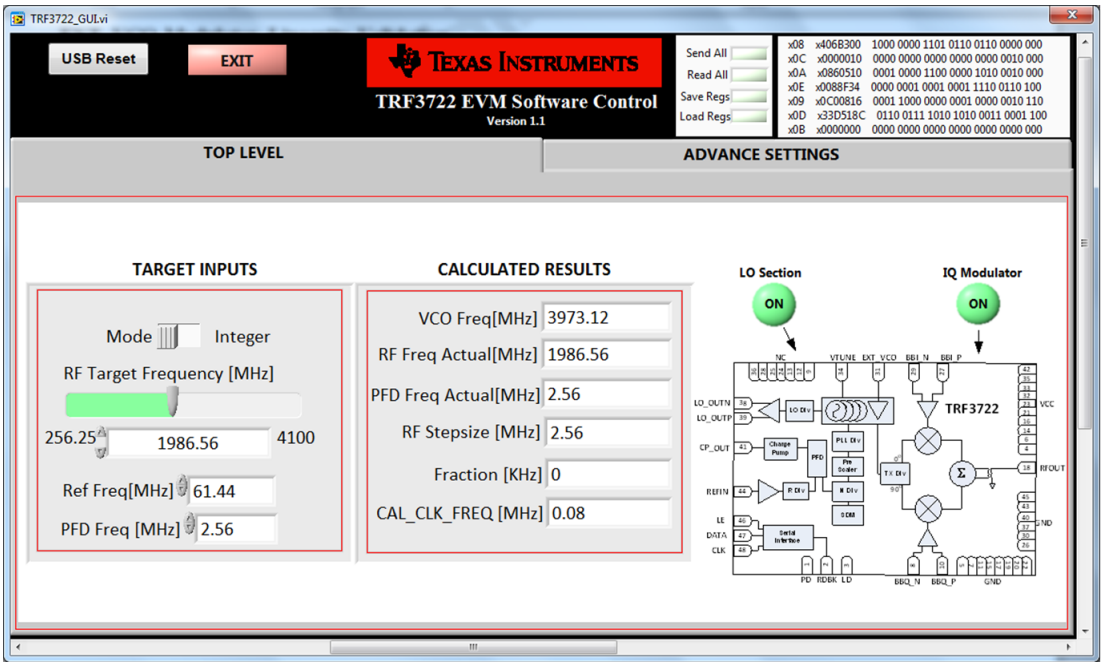

Figure 6. GUI Settings (a)

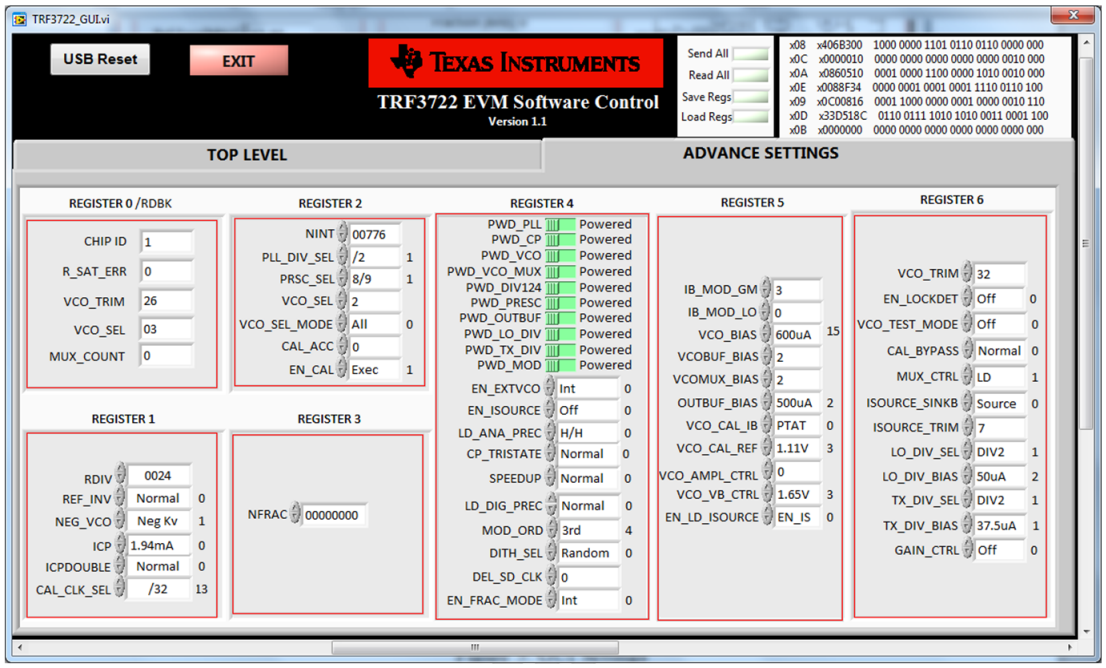

Figure 7. GUI Settings (b)

9. After setting proper register settings, click the **Send All** button. When the device is programmed, the green LED (D2) should turn ON which indicates PLL is locked as shown in Figure 8.

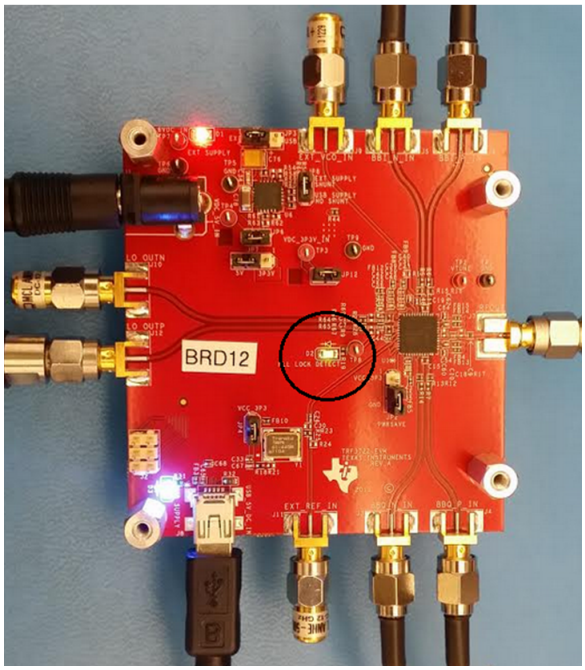

Figure 8. TRF3722 EVM

10. Current consumption from the 3.3-V DC supply should now change to 390 mA (±20 mA), and the 5-V DC supply should change to 27 mA (±7 mA).
11. This is the typical current consumption with the GUI settings shown in Figure 6 and Figure 7, adjusting various bias settings in register 5 and register 6 change this current.
12. Use a DAC or an arbitrary waveform generator to generate two-tone I/Q baseband input signals. For example, consider 4.5 MHz and 5.5 MHz.

13. A typical setup using Agilent's E4438C ESG vector signal generator to provide I/Q signals is as follows:
    (a) Press Preset.
    (b) Press Mode → More (1 of 2) → Multitone
    (c) Press Initialize Table → Number of Tones → 12 → Enter.
    (d) Press Freq Spacing → 1 → MHz.
    (e) Press Done.
    (f) Highlight each of the first 10 rows and press Toggle State to turn OFF the first 10 frequencies and only keep the last two rows with the BB frequency 4.5 MHz and 5.5 MHz ON.
    (g) Press Multitone Off/On to ON to generate the multitone waveform.
    (h) Adjust the differential I or Q voltage level by pressing Mode → I/Q → I/Q Output Control → I/Q Output Atten → Enter 9 → Press dB.
    (i) Set the common mode voltage to 0.25 V by pressing Mode → I/Q → I/Q Output Control → Common Mode I/Q Offset → 250 → mV. Use a DC voltage meter to monitor the DC common voltage at the inputs of I and Q and fine-tune the common mode voltage setting until it measures 250 mV.
14. Measure the TRF3722 output OIP3. The OIP3 at LO 1986.56 MHz should be around 28.5 ±2 dBm, as shown in Figure 9.

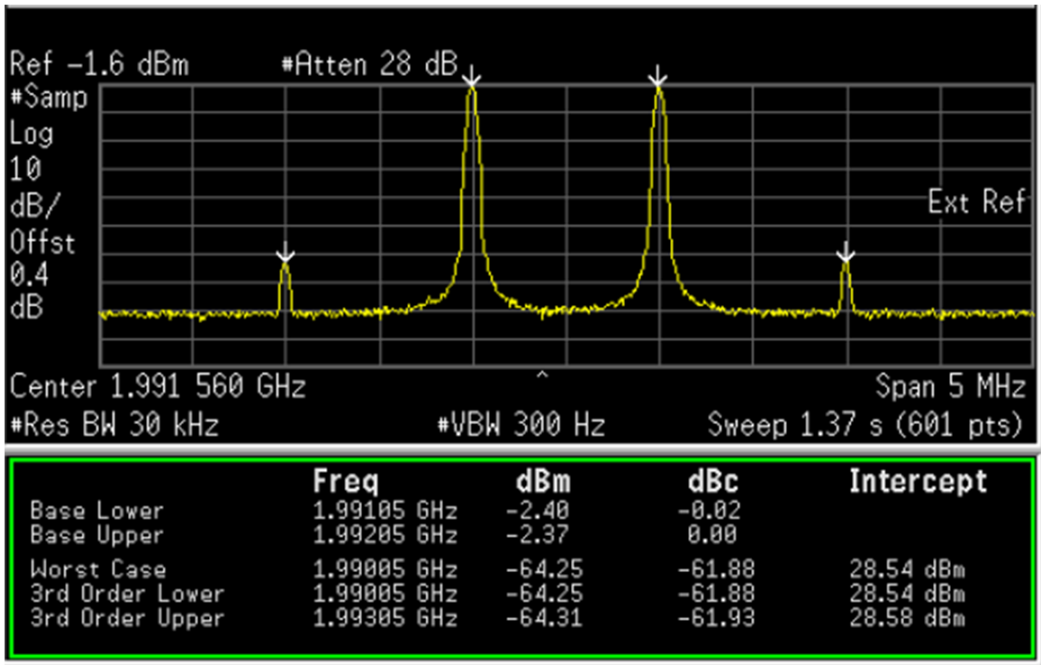

Figure 9. TRF3722 OIP3

4 EXT_VCO Modulator Linearity Validation

To test the external VCO / LO, turn off the LO section and apply LO signal at the EXT_VCO SMA connector. As an example, consider a frequency of 1986.56 MHz:

1. Use the GUI settings as shown in Figure 10 and Figure 11.
2. Since LO_DIV_SEL is Div2, apply a 3973.12-MHz signal at the EXT_VCO_IN SMA connector.
3. Use a DAC or an arbitrary waveform generator to generate two tone I/Q baseband input signals. As an example, consider 4.5 MHz and 5.5 MHz.
4. A typical setup using Agilent's E4438C ESG vector signal generator to provide I/Q signals is as follows:
   (a) Press Preset.
   (b) Press Mode → More (1of 2) → Multitone
   (c) Press Initialize Table → Number of Tones → 12 → Enter.
   (d) Press Freq Spacing → 1 → MHz.
   (e) Press Done.
   (f) Highlight each of the first 10 rows and press 'Toggle State' to turn OFF the first 10 frequencies and only keep the last two rows with the BB frequency 4.5 MHz and 5.5 MHz ON.
   (g) Press Multitone Off/On to ON to generate the multitone waveform.
   (h) Adjust the differential I or Q voltage level by pressing Mode → I/Q → I/Q Output Control → I/Q Output Atten → Enter 9 → Press dB.
   (i) Set the common mode voltage to 0.25 V by pressing Mode → I/Q → I/Q Output Control → Common Mode I/Q Offset → 250 → mV. Use a DC voltage meter to monitor the DC common voltage at the inputs of I and Q and fine-tune the common mode voltage setting until it measures 250 mV.

5. Measure the TRF3722 output OIP3. The OIP3 at LO 1986.56 MHz should be around 28.5 dBm as shown in Figure 10 and Figure 11.

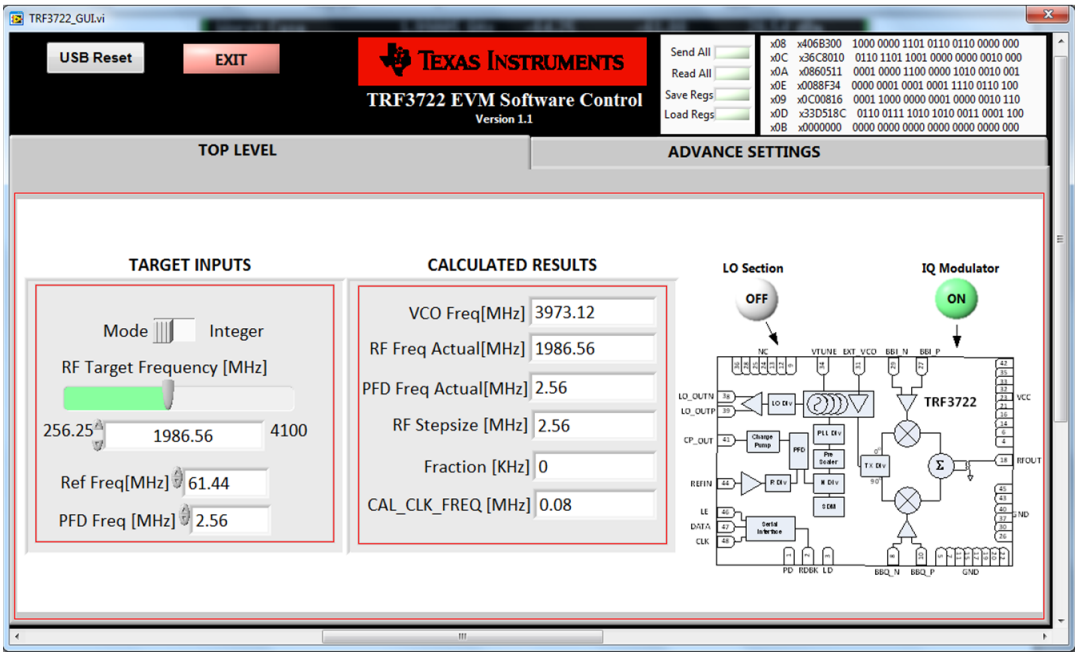

Figure 10. TRF3722 GUI, Ext VCO Configuration (a)

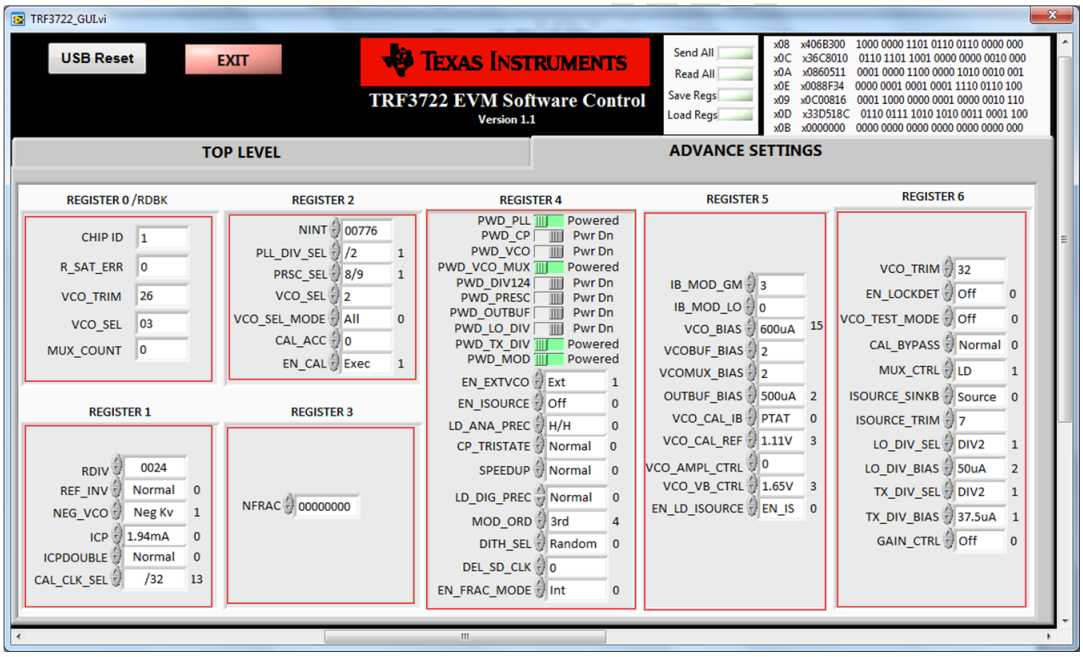

Figure 11. TRF3722 GUI, Ext VCO Configuration (b)

5 Phase Noise Validation - Integer Mode

Validate integer mode phase noise using the following steps:

1. The default loop filter populated on the TRF3722 EVM is an integer mode loop filter.
2. A 40-kHz bandwidth and 2.56-MHz Fpfd loop filter has been designed using the loop filter calculator tool, available from www.ti.com.
3. Figure 12 shows the screen shot of a loop filter.

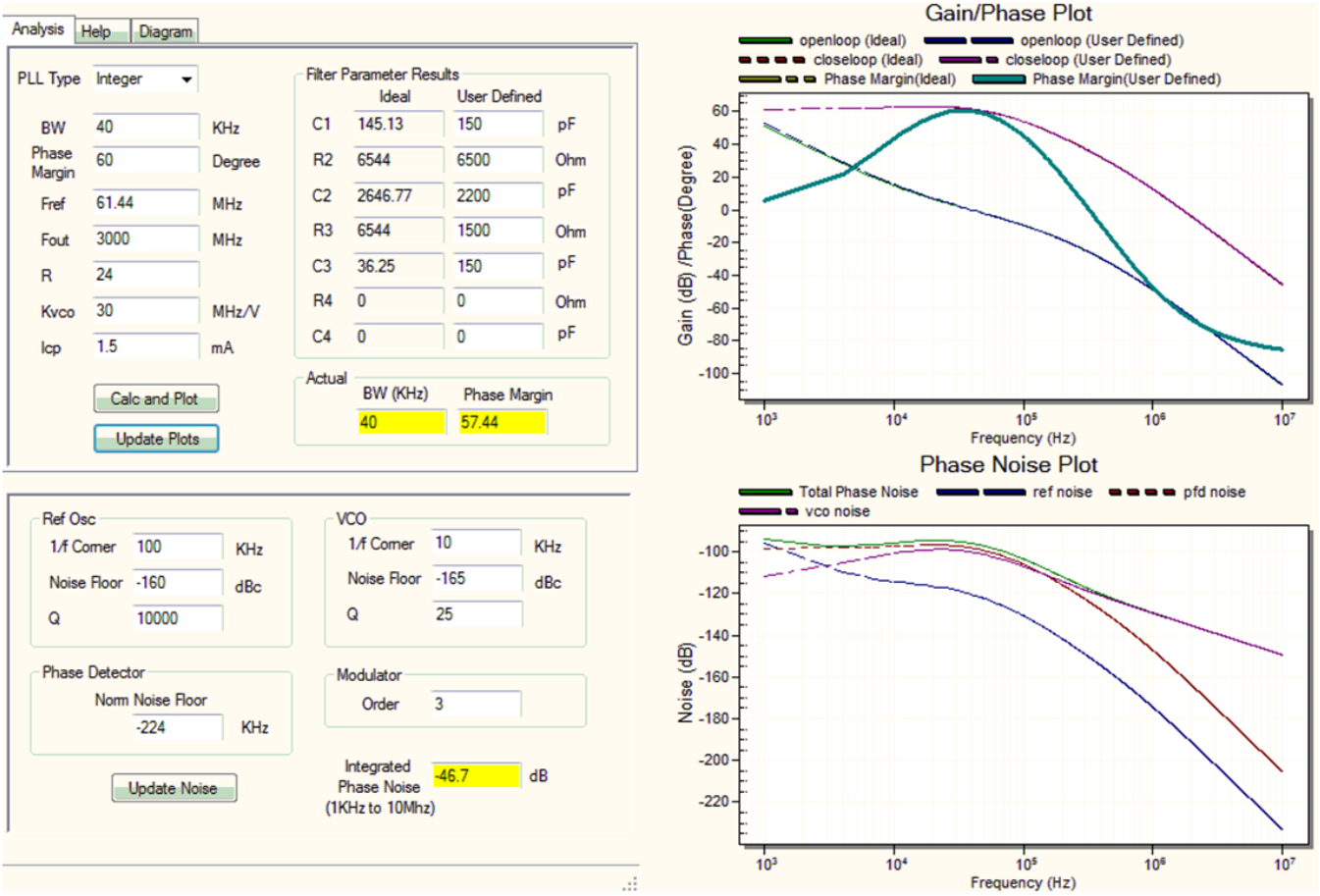

Figure 12. Integer Mode Loop Filter

4. As an example, consider an 1800-MHz target frequency.

5. Set the GUI as shown in Figure 13 and Figure 14.

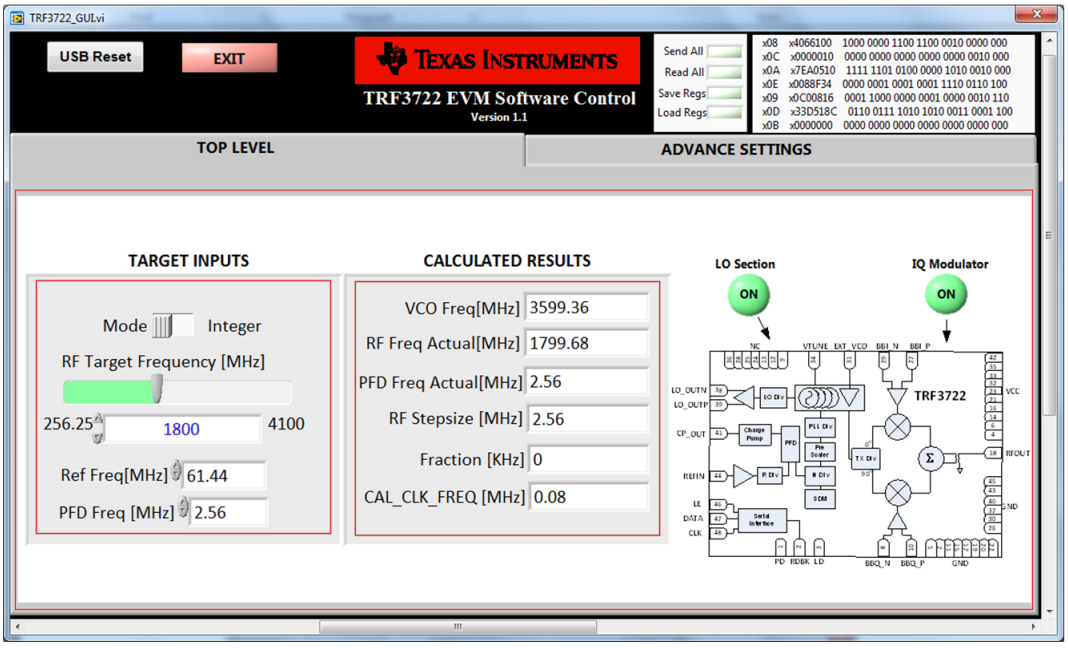

Figure 13. Integer Mode Loop Filter (a)

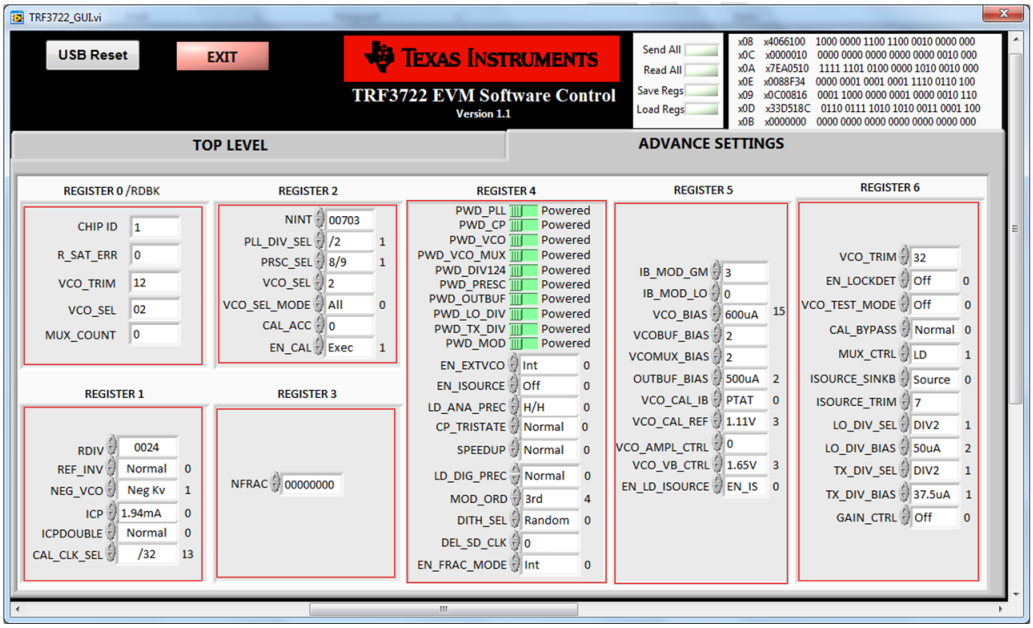

Figure 14. Integer Mode Loop Filter (b)

6. The TRF3722 phase noise at 1800-MHz frequency at the LO_OUTP SMA connector is shown in Figure 15.

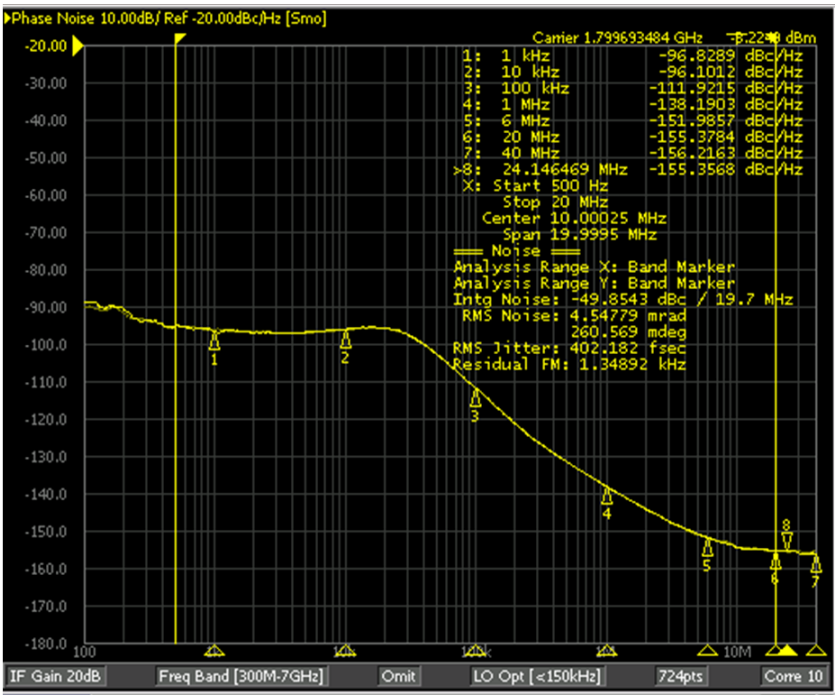

Figure 15. Integer Mode Phase Noise at 1800 MHz

7. Obtain optimum phase noise performance by using linear clean power supplies at TP3 3.3-V DC supply and TP4 5-V DC supply.
8. Obtain best close-in noise (below 500-Hz offset) by using a low phase noise reference signal at the J11 *EXT_REF_IN* SMA connector. When operating the board using an external reference, make sure to DNI R23, remove JP4, and populate R25.

5.1 Phase Noise Validation - Fractional Mode

Validate fractional mode phase noise using the following steps:

1. The default loop filter connected on the TRF3722 EVM is an integer mode loop filter. Change integer loop filter to fractional loop filter DNI R11 and DNI R40, and populate R8 and R10.
2. A 40-kHz bandwidth and 15.36-MHz Fpfd loop filter has been designed using the loop filter calculator tool, available on www.ti.com.
3. Figure 16 shows the screen shot of a loop filter tool.

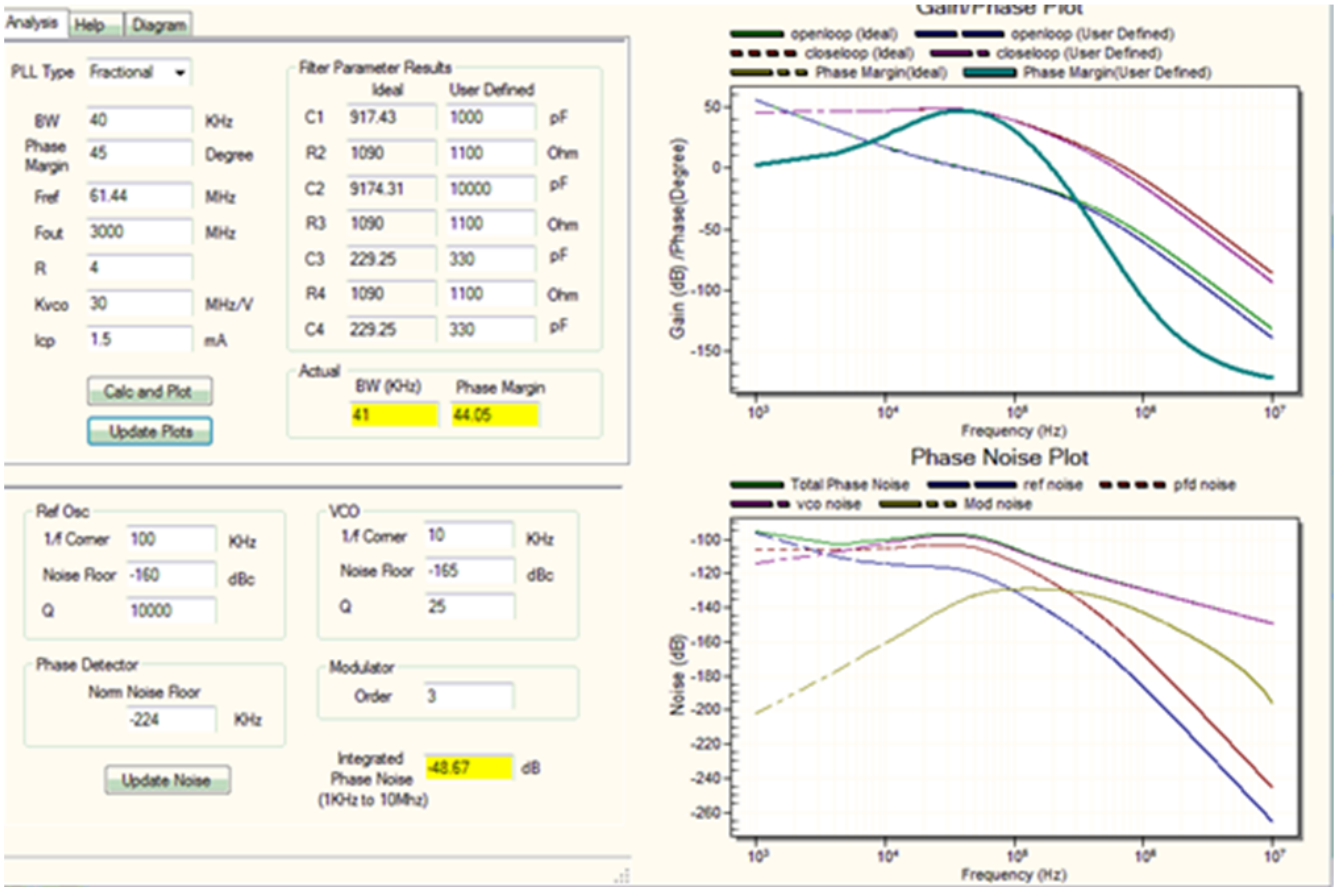

Figure 16. Fractional Mode Loop Filter

4. As an example, use a 3532.9 MHz target frequency.
5. An external reference of 153.6 MHz is used. To use an external reference, make sure to DNI R23, remove JP4, and populate R25.

6. Set the GUI as shown in Figure 17 and Figure 18.

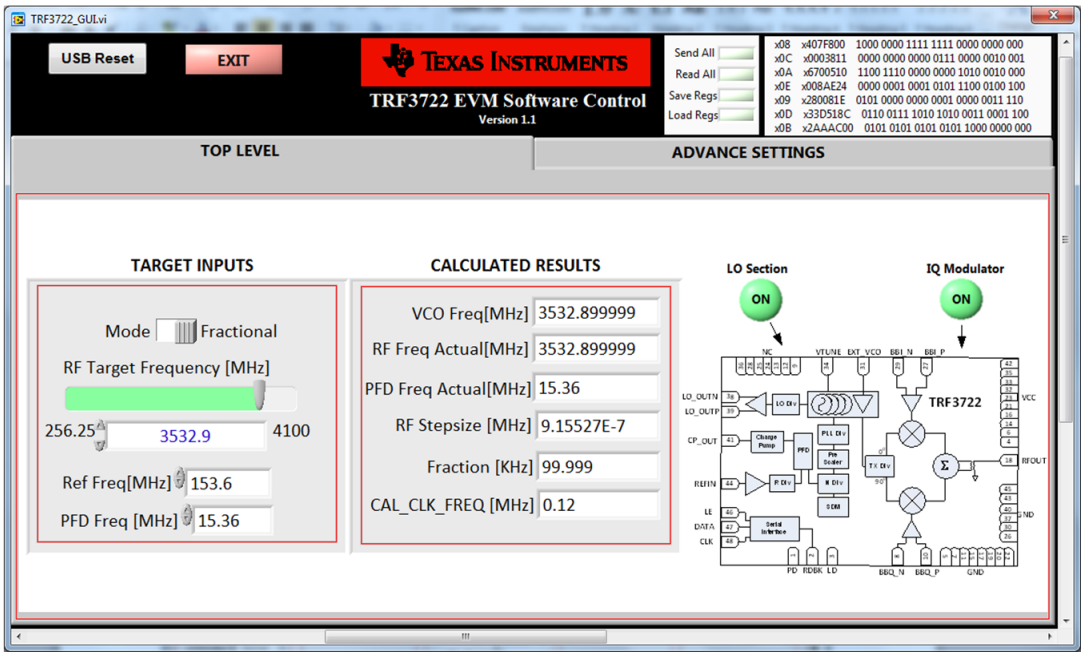

Figure 17. Fractional Mode Loop Filter (a)

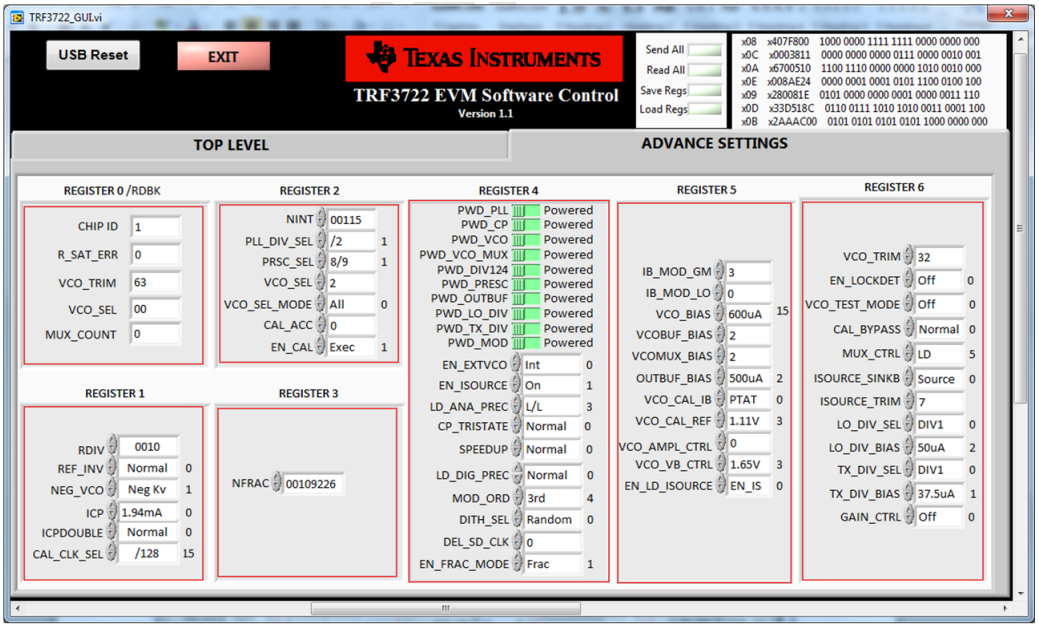

Figure 18. Fractional Mode Loop Filter (b)

7. TRF3722 phase noise at 3532.9-MHz frequency at LO_OUTP is shown in Figure 19.

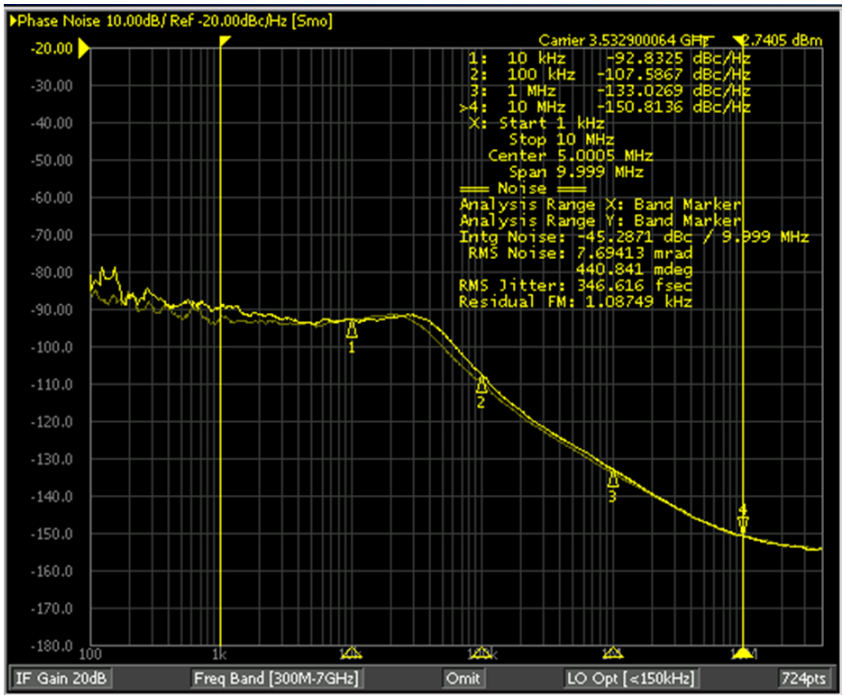

Figure 19. Fractional Phase Noise at 3532.9 MHz

8. To obtain optimum phase noise performance use linear clean power supplies at TP3 3.3-V DC supply and TP4 5-V DC supply.
9. To obtain best close-in noise (below 500-Hz offset), use a low phase noise reference signal at J11 *EXT_REF_IN* SMA connector.

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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.

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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.

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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.

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.

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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.

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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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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２４番１号
西新宿三井ビル
http://www.tij.co.jp

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(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

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