*Evaluation Board Documentation*

# *TRF1015 RF Downconverter*

*APPLICATION BRIEF: SWRA003*

*Wireless Communications Business Unit*

*Digital Signal Processing Solutions*
*21 November 1997*

TEXAS INSTRUMENTS

## IMPORTANT NOTICE

## TRADEMARKS

**CONTACT INFORMATION**

| | |
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# TRF1015 RF Downconverter

## Abstract

The evaluation board documentation for the TRF1015 RF Downconverter is primarily for device assessment. The TRF1015 RF Downconverter is suitable for portable 900mhz cellular and cordless telephones. Included in this documentation are the following tables and schematic diagrams with instructions.

**Diagrams:**

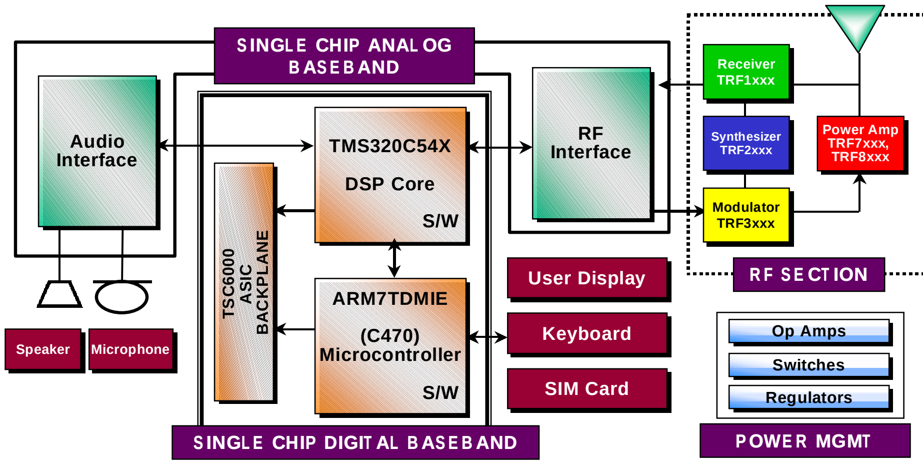
- ❑ A Functional Block Diagram
- ❑ An Evaluation Board Mechanical Outline
- ❑ An Evaluation Board Schematic of the TRF1015
- ❑ A Noise Figure Test Bench Schematic Diagram
- ❑ A Conversion Gain Test Bench Schematic Diagram
- ❑ A 1db Compression Point Test Bench Schematic Diagram
- ❑ LO Feedthrough to RF Test Bench Schematic Diagram
- ❑ 3rd Order Intermodulation (IP3) Test Bench Schematic Diagram

**Tables:**

- ❑ Terminal Functions Table. The table includes the Pin, I/O, and description.
- ❑ A Component List describing the resistors, inductors, and capacitors.

# Product Support

## The TI Advantage Extends Beyond RF to Every Other Major Wireless System Block




### Digital Baseband

TI's single-chip Digital Baseband Platform, combines two high-performance core processors – a digital signal processor tailored for digital wireless applications and a microcontroller designed specifically for low-power embedded systems. The customizable platform helps wireless digital telephone manufacturers lower component counts, save board space, reduce power consumption, introduce new features, save development costs and achieve faster time to market, at the same time giving them flexibility and performance to support any standard worldwide.

### Analog Baseband

TI analog baseband components provide a Mixed-signal bridge between the real world of analog signals and digital signal processors, the key enabling technology of the digital wireless industry. Using a seamless architecture for wireless communications technology, TI matches its baseband interfaces, radio frequency ICs and power management ICs to digital signal processing engines to create complete DSP Solutions for digital wireless systems.

### Power Management

TI provides power management solutions with integration levels designed to meet the needs of a range of wireless applications. From discrete LDOs and voltage supervisors to complete power supplies for the baseband section, TI power management solutions play an important role in increasing wireless battery life, time-to-market and system functionality.

***For more information visit the Wireless Communications web site at www.ti.com/sc/docs/wireless/home.htm.***

## Related Documentation

The following list specifies product names, part numbers, and literature numbers of corresponding TI documentation.

- *RF Downcoverter*, Literature number SLWS021B
- *TRF1015 Product Bulletin*, Literature number SLWT004

## World Wide Web

Our World Wide Web site at www.ti.com contains the most up to date product information, revisions, and additions. Users registering with TI&ME can build custom information pages and receive new product updates automatically via email.

## Email

For technical issues or clarification on switching products, please send a detailed email to sc-infomaster@ti.com. Questions receive prompt attention and are usually answered within one business day.

# Functional Block Diagram and Evaluation Board Mechanical Outline

*Figure 1. Functional Block Diagram*

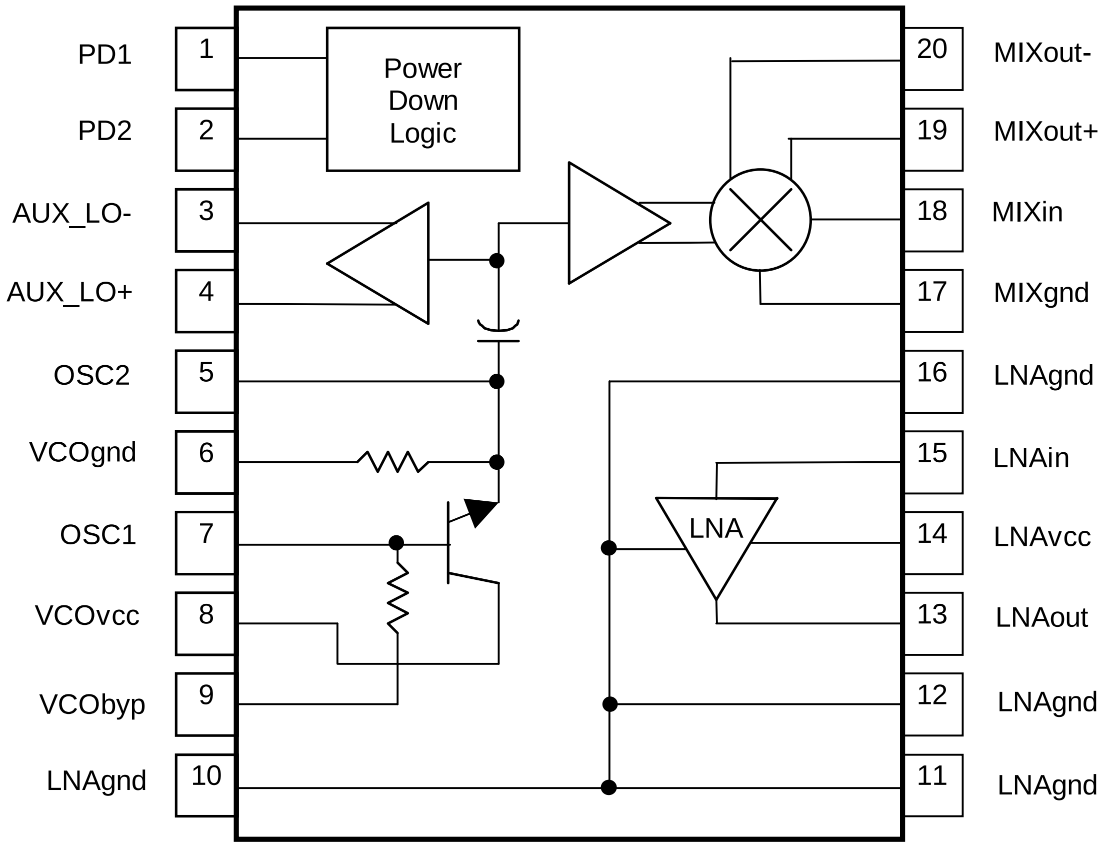
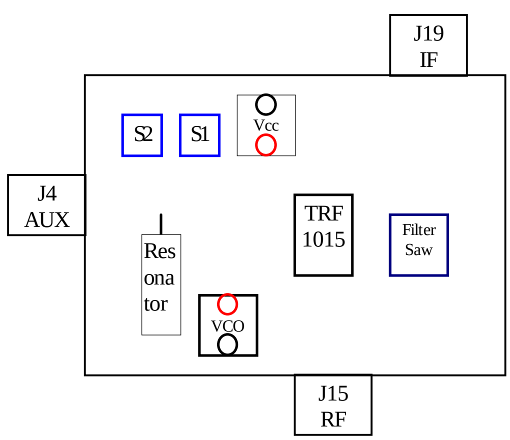



*Figure 2. Evaluation Board Mechanical Outline (Top View)*



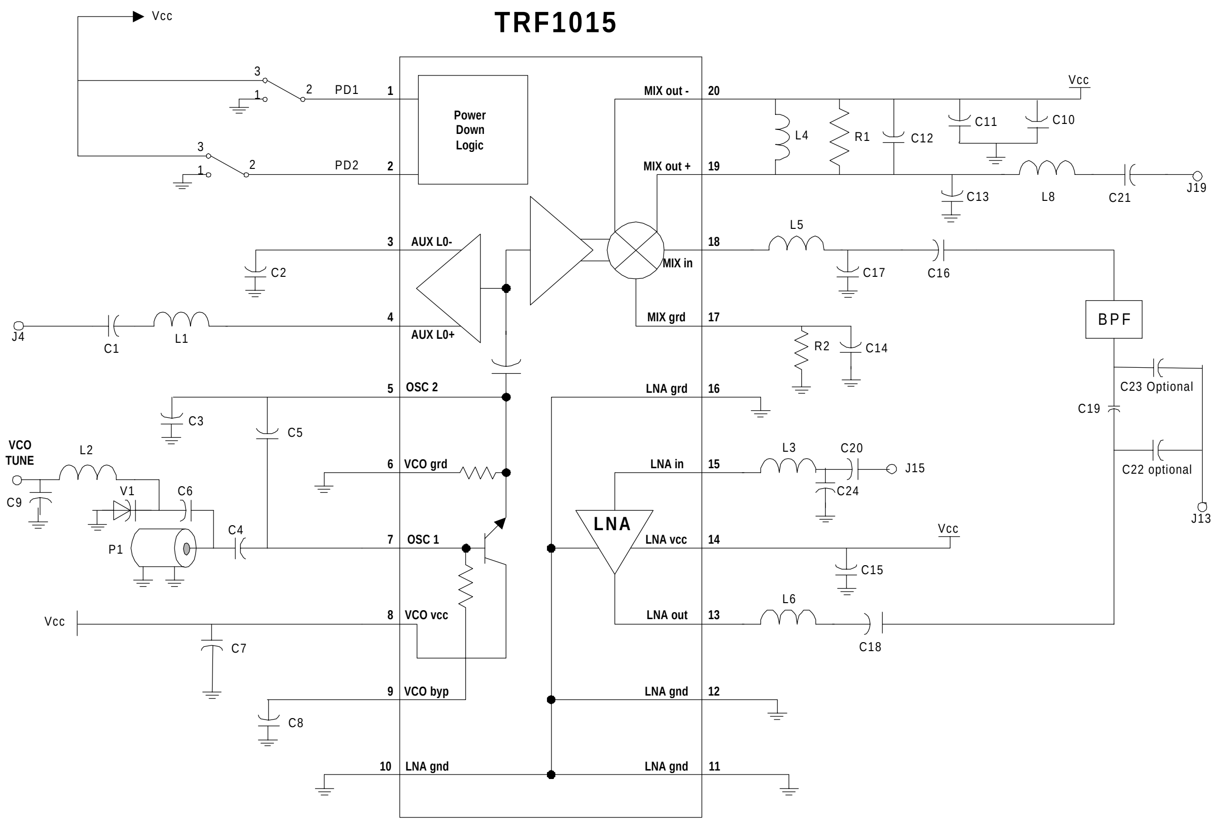
# Terminal Functions

*Table 1. Terminal Functions*

| PIN NUMBER | PIN NAME | I/O | DESCRIPTION |
|---|---|---|---|
| 1 | PD1 | I | Power Down LSB |
| 2 | PD2 | I | Power Down MSB |
| 3 | AUX_LO- | O | PLL Auxiliary LO Output (Inverting) |
| 4 | AUX_LO+ | O | PLL Auxiliary LO Output (Non-Inverting) |
| 5 | OSC2 | I | External Oscillator input |
| 6 | VCO GND | | VCO ground |
| 7 | OSC1 | | VCO Tank port |
| 8 | VCO_VCC | | VCO Power Supply |
| 9 | VCO_BYPASS | | VCO Bypass Port (External Capacitor) |
| 10 | LNA_GND | | LNA Ground |
| 11 | LNA_GND | | LNA Ground |
| 12 | LNA_GND | | LNA Ground |
| 13 | LNA_OUT | O | LNA RF Output |
| 14 | LNA_VCC | | LNA Power Supply |
| 15 | LNA_IN | I | LNA RF Input |
| 16 | LNA_GND | | LNA Ground |
| 17 | MIX_GND | | Mixer Ground |
| 18 | MIX_IN | I | Mixer RF Input |
| 19 | MIX_OUT+ | O | Mixer IF Output (Non-Inverting) |
| 20 | MIX_OUT- | O | Mixer IF Output (Inverting) |

# Evaluation Board Schematic

*Figure 3. Evaluation Board Schematic*



# Component List

*Table 2. Component List*

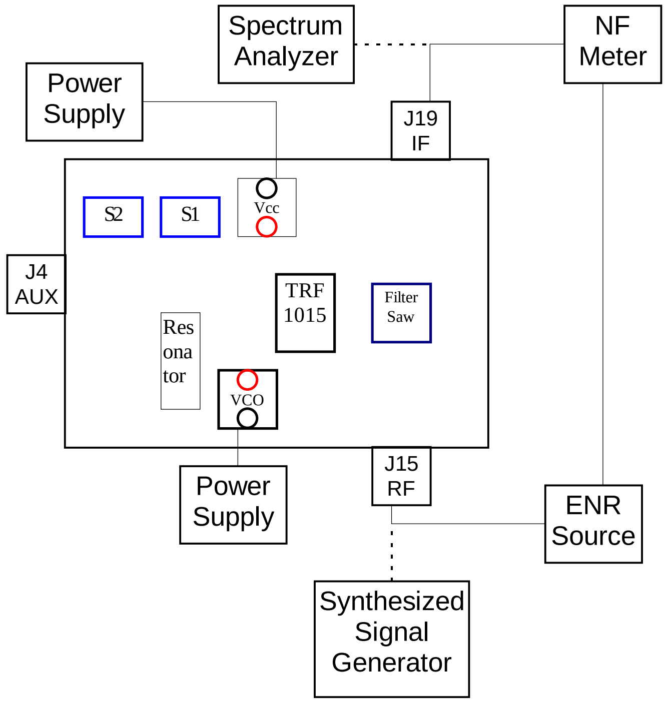
| Resistors | Capacitors | Inductors | Other |
|---|---|---|---|
| R1 = 1.5Ω | C1 = 22pF | L1 = 10.0nH | RS1 = Coaxial Resonator – Transtech SR8800LPQ1050BY |
| R2 = 22Ω | C2 = 10pF | L2 = 10.0nH | V1 = Varactor – Siemens BBY5103 |
| | C3 = 1.0pF | L3 = 12.0nH | U1 = TRF1015 |
| | C4 = 1.0pF | L4 =220nH | U2 = Saw Filter – Murata SAFC881.5MA70N |
| | C5 = 0.5pF | L5 = 12.0nH | |
| | C6 = 1.5pF | L6 = 12.0nH | |
| | C7 = 100pF | L7 = Not in use | |
| | C8 = 100pF | L8 = 680nH | |
| | C9 = 68pF | | |
| | C10 = 1000pF | | |
| | C11 = 100pF | | |
| | C12 = 56pF | | |
| | C13 = 22pF | | |
| | C14 = 12pF | | |
| | C15 = 100pF | | |
| | C16 = 22pF | | |
| | C17 = 3.0pF | | |
| | C18 = 22pF | | |
| | C19 = 100pF | | |
| | C20 = 22pF | | |
| | C21 = 68pF | | |
| | C22 = 100pF | | |
| | C23 = 100pF | | |
| | C24 = 1.0pF | | |

Note

C19, C22 and C23 are interchangable.  C19 is used to test the cascaded performance, C22 for the LNA output and C23 for the Mixer input.

## Noise Figure Test Bench Schematic Diagram

*Figure 4. Noise Figure Test Bench Schematic Diagram*




The cascaded Noise Figure (NF) is measured at the IF output port, J19. The measurement is performed using an HP8790B Noise Figure Meter. The noise figure meter requires a special setup and calibration since the RF source and receive (IF) frequencies are different.

Set up the noise figure meter as follows:

1) Special Function 1.3 sets the noise figure meter to measure swept LO and fixed IF.

2) The LO start, stop, and step size frequencies are set to 914MHz, 938MHz, and 12 MHz, respectively.

3) Set the IF frequency by pressing 3.0, the Special Function Key and then entering 45 MHz.

   a) Set the smoothing to 16 or above.

4) Ensure that the Excess Noise Ratio(ENR) Table on the Noise Source head in use is entered into the noise figure meter.

   a) On the front panel, press the ENR button.

b) Check the ENR value by pressing the Enter button or enter the ENR value for each frequency and then press Enter.

c) After entering the ENR for the desired frequency, press the Frequency button on the front panel to exit.

5) To calibrate the NF Meter, connect the Noise Source directly to the NF meter on the front panel and press the Calibration button twice.

a) On the front panel, press Noise Figure and Gain Button. The Corrected LED just above the button should be lit. Calibration is complete.

Next, the external equipment loss is considered (RF cable, Transmission line, filter and circulator).

1) The losses are entered into the Noise Figure Meter by using Special Function 34.x.

a) Special Function 34.1 turns on the loss compensation factor.

b) Special Function 34.2 is used to enter the loss before the device under test (DUT).

c) Special Function 34.3 is used to enter the room temperature in Kelvin (300$^{o}$K).

d) Finally, Special Function 34.4 is used to enter the loss after the DUT.

The Noise Figure is measured as follows:

1) Set the Vcc power supply to 3.75v.

2) Set S1 and S2 to the (0,1) mode.

3) Set the synthesized signal generator to the desired RF frequency (869, 881 or 893 MHz) and input power to -40dBm at the J15 port.

4) Set the spectrum analyzer to measure the IF frequency at 45 MHz.

a) Adjust the VCO power supply to achieve maximum amplitude injection lock at the IF frequency of 45MHz.

5) Turn off the synthesized signal generator and disconnect the cable from the J15 port of the evaluation board.

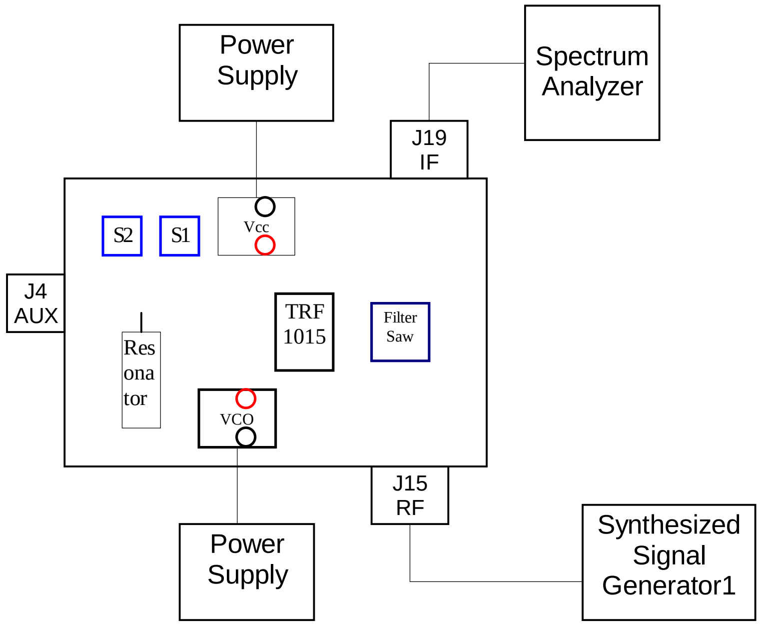
6) Connect the J19 port of the evaluation board to the noise figure meter and the ENR noise source to the J15 port of the evaluation board.

7) Measure the Cascaded Noise Figure.

a) A circulator between the ENR noise source and RF input port may help minimize any mismatches between the EVM board and test equipment.

# Conversion Gain Test Bench Schematic Diagram

*Figure 5. Conversion Gain Test Bench Schematic Diagram*




The cascaded gain is measured using an RF source at the J15 RF port and a spectrum analyzer at the J19 IF output port. The gain (in dB) is equal to the measured power (in dBm) at the IF frequency minus the RF source power (in dBm).

1) Set the Vcc power supply to 3.75V and S1 and S2 to the (0,1) mode.

2) Set the synthesized signal generator to the desired RF frequency (869, 881 or 894 MHz) and the input power (RF Pin) to -40 dBm at the RF input port J15.

3) Set the spectrum analyzer to measure the IF frequency at 45 MHz.

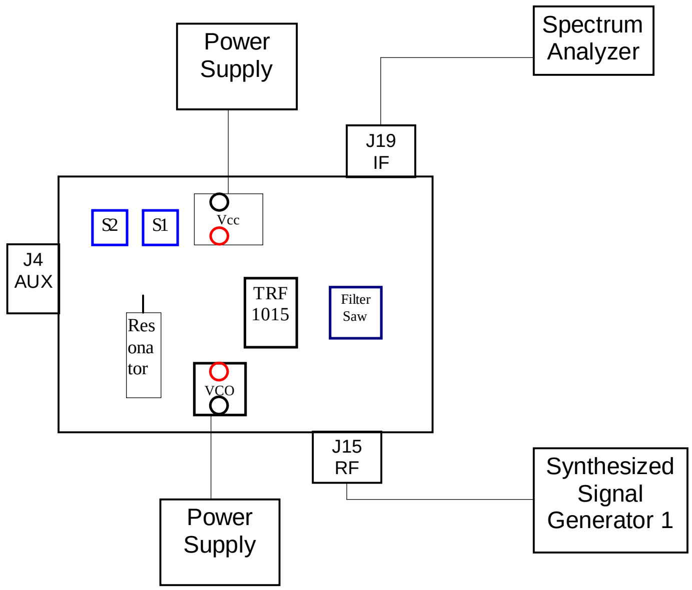
    a) Adjust the VCO power supply to achieve maximum amplitude injection lock at the IF frequency of 45 MHz.

4) Measure the IF output power (IF Pout) with the spectrum analyzer.

5) Calculate the Conversion Gain as: Gain = (IF Pout - RF Pin)

# 1 dB Compression Point Test Bench Schematic Diagram

*Figure 6. 1 dB Compression Point Test Bench Schematic Diagram*




The 1dB input compression point is measured at the IF output port J19. The 1 dB input compression point is the RF input power at which the gain compresses by 1 dB. This measurement is performed using an RF source and a spectrum analyzer.

1) Set the Vcc power supply to 3.75V and S1 and S2 to the (0,1) mode.

2) Set the RF synthesized signal generator frequency to 881 MHz and the input power (RF Pin) to -40 dBm at the J15 input port.

3) Set the spectrum analyzer to measure the output power at the IF frequency of 45MHz.

   a) Adjust the VCO power supply to achieve maximum amplitude injection lock at the IF frequency of 45 MHz.

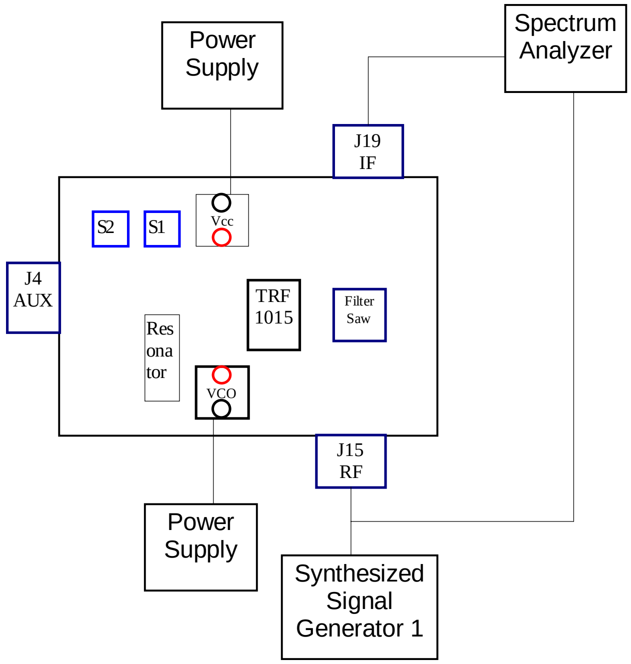
4) To determine the 1 dB compression point, the RF input power (RF Pin) is increased in steps of 1 dB until the gain compresses by 1 dB.

   a) Gain compression is when an increase in the RF input power (RF Pin) causes no further increase in the output power (IF Pout).

      i) Gain is calculated for each RF frequency step as: Gain = (IF Pout – RF Pin)

## LO Feedthrough to RF Test Bench Schematic Diagram

*Figure 7. LO Feedthrough to RF Test Bench Schematic Diagram*




The LO feedthrough to the RF port is measured at the RF input port J15. Feedthrough is a measure of the LO power (in dBm) that couples to the RF port. The measurement is performed using an RF source and a spectrum analyzer.

1) Set the Vcc power supply to 3.75V and S1 and S2 to the (0,1) mode.

2) Set the RF synthesized signal generator frequency to 881 MHz and the input power to -40 dBm at the J15 input port.

3) Set the spectrum analyzer to measure the output power at the IF frequency (45MHz) at port J19.

4) Adjust the VCO power supply to achieve maximum amplitude injection lock at the IF frequency of 45MHz.

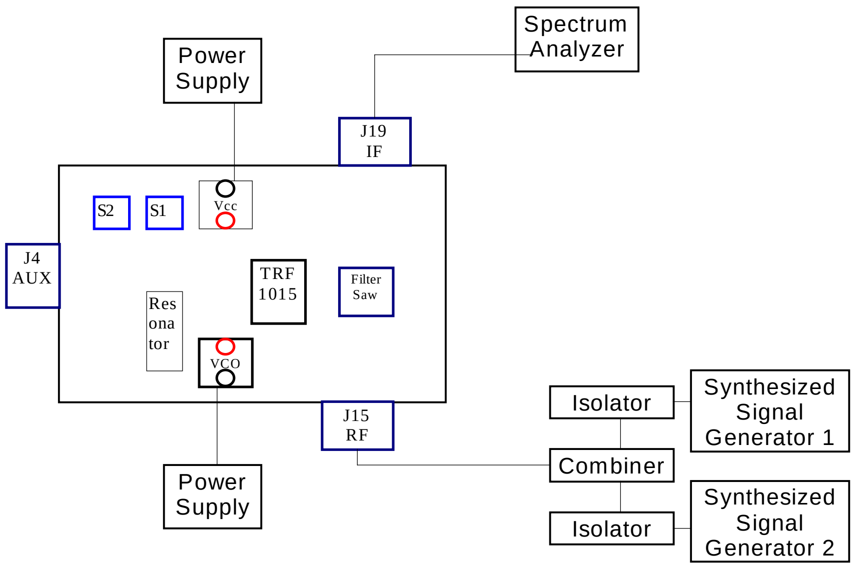
5) Disconnect the evaluation board from the spectrum analyzer and the RF synthesized signal generator.

6) Connect the RF input port, J15, to the spectrum analyzer.

   a) Set the spectrum analyzer to measure the LO feedthrough at the RF frequency plus IF frequency: (881MHz + 45Mhz = 926MHz).

# $3^{rd}$ Order Intermodulation (IP3) Test Bench Schematic Diagram

*Figure 8. 3rd Order Intermodulation (IP3) Test Bench Schematic Diagram*




The third order intercept point is measured at the IF port, port J19. The third order input intercept point is the level of the RF input power at which the output power levels of the undesired intermodulation products and desired IF products are equal. The measurement is performed using two RF sources and a spectrum analyzer.

1) Set Synthesized Signal Generator 1 to the desired RF frequency (869, 881 or 894MHz) and to -40 dBm (RF Pin) at the board.

2) Set Synthesized Generator 2 to the desired RF frequency plus 60 kHz.

3) Set the spectrum analyzer to measure at the IF frequency (45MHz) at port J19.

   a) Adjust the VCO power supply to achieve maximum amplitude injection lock at the IF frequency of 45MHz.

4) The powers of the third-order intermodulation products, ($2f_2$-$f_1$ and $2f_1$-$f_2$), are then measured and compared to the fundamental to obtain the intermodulation suppression.

   a) Suppression (dB) = [RF Pin (dBm)] – [$2f_2 – f_1$ (dBm)]

5 ) The Input Third-Order Intercept is then calculated as:
Input Third-Order Intercept (dB) = Suppression/2 (dB) + RF Pin (dBm)

## Evaluation Board Disclaimer

Please note that the enclosed evaluation boards are experimental Printed Circuit Boards and are therefore only intended for device evaluation.

We would like to draw your attention to the fact that these boards have been processed through one or more of Texas Instruments' external subcontractors which have not been production qualified.

Device parameters measured, using these boards, are not representative of any final datasheet or of a final production version. Texas Instruments does not represent or guarantee that a final version will be made available after device evaluation.

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