Texas Instruments

Application Brief
SWRA018

TRF1020 GSM Receiver EVM

Wireless Communication Business Unit

This document describes the Texas Instruments (TI™) TRF1020 evaluation module (EVM) board and associated EVM software, which allows the evaluation and the demonstration of the TRF1020 GSM Receiver.

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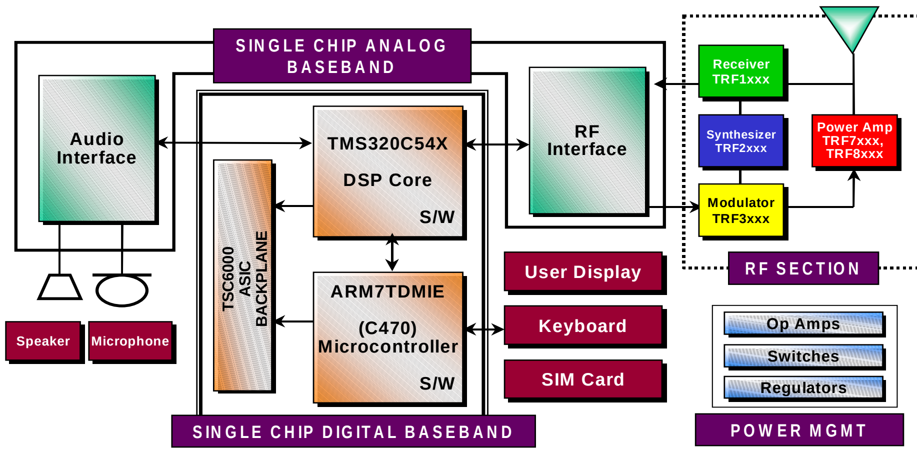
Product Support

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

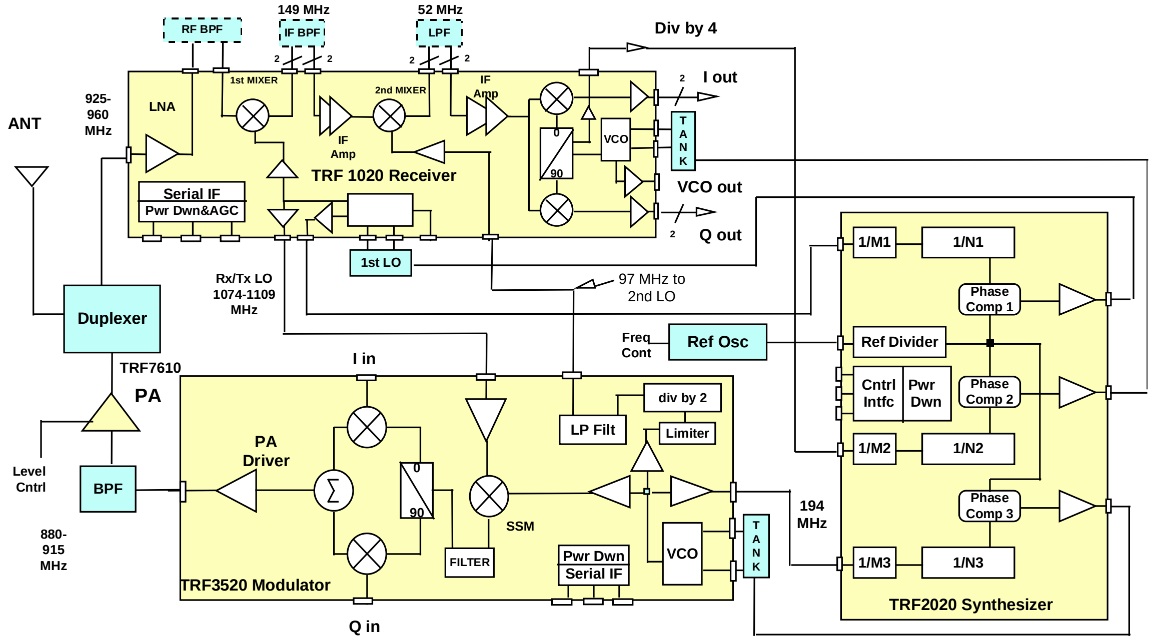
TI analog baseband components provide a Mixed-signal bridge between the real world of analog signals and digital signal processors, the key enabling technology of the digital wireless industry. Using a seamless architecture for wireless communications technology, TI matches its baseband interfaces, radio 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.

GSM RF System Block Diagram



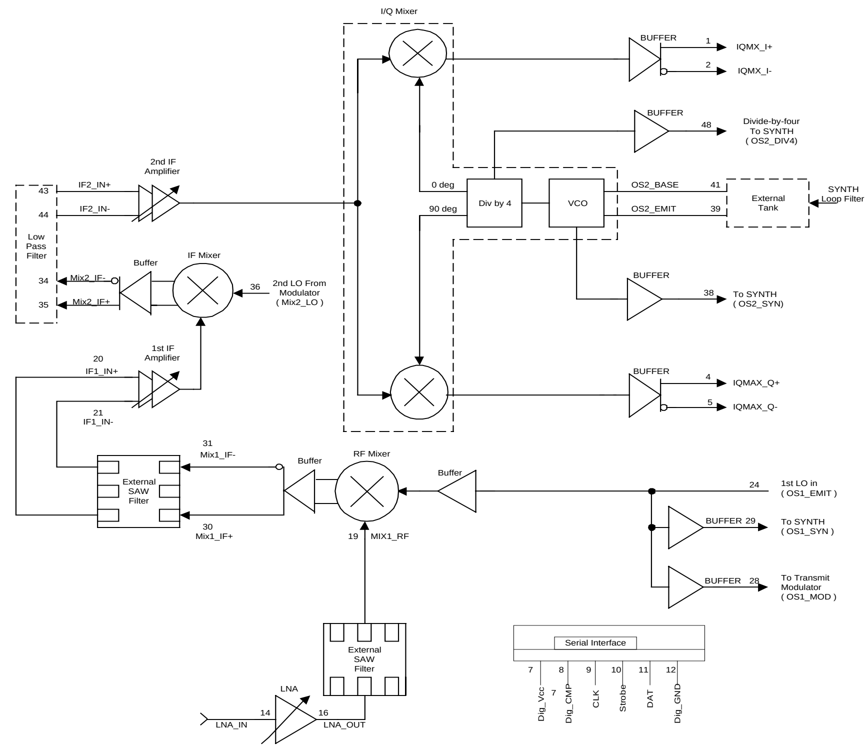
The TRF1020 is used in conjunction with the TRF3520 Modulator, the TRF2020 Synthesizer, and the TRF7610 Power Amplifier to create a complete GSM solution.

Introduction

The TRF1020 evaluation board is comprised of a multi-layer printed circuit board and required components. The following information is included to aid in the assessment of this device:

- ❑ Block Diagram and Functional Description
- ❑ Schematic
- ❑ Parts List
- ❑ PCB Layout
- ❑ EVM Design notes
- ❑ Impedance Matching
- ❑ EVM Tests
- ❑ Typical Performance
- ❑ EVM Software

Figure 1.   TRF1020 Functional Block Diagram



Functional Description

The TRF1020 is a single-chip Radio Frequency (RF) receiver suitable for 900 MHz wireless Global Systems for Mobile communications (GSM) applications. It combines a Low Noise Amplifier, an RF Mixer, an IF Mixer, two IF AGC Amplifiers, an I/Q Mixer and a buffered VCO into one small package. These functions are described in the following sections. Ample terminals have been reserved to provide for a high degree of signal grounding and to minimize cross talk.

Low Noise Amplifier

The low noise amplifier (LNA) receives the Gaussian-filtered minimum shift keying (GMSK) modulated carrier signal and boosts the level. Nominal gain of the LNA is 12.4 dB with a Noise Figure of 2.1 dB. The LNA is also capable of switching from +12.4 dB gain state to a -5.8 dB attenuation state. Control of this switching is accomplished using the LNA Gain Control (LNAP) bit of the serial control word. When true, the bias of the LNA to the high gain state is enabled and when false, the amplifier is unbiased. Attenuation is achieved by the off-state isolation of the structure.

RF Mixer

The RF mixer utilizes an external oscillator to translate the receive frequency signal to the first intermediate frequency (IF). The mixer's output is differential open-collector. This enables relatively simple matching to an external high impedance SAW filter. The Applications Evaluation Board uses high side frequency injection for a first intermediate frequency (IF) frequency of 149 MHz.

First IF Amplifier and IF Mixer

The second downconverter group consists of the first IF amplifier whose output feeds the IF mixer. Because the first IF amplifier output is not brought out to the device terminals, the two functions are specified together.

In order to provide for cascaded operation of the first and second IF amplifiers, it is possible to bypass the IF mixer function. Mixer bypassing is accomplished by using the MX2BYP bit (1 = mixer bypassed, 0 = normal operation).

The gain for this stage is variable from 0 to 42 dB and is selected by command of the serial control word bits D06 to D11. After amplification, the signal is down converted to 52 MHz using an external local oscillator (LO) frequency of 97 MHz.

I/Q VCO

The I/Q VCO generates a tone in the 208 MHz range which can be controlled by the voltage applied to the varactor diode on the external tank circuit. A buffered sample of the oscillator output is provided at the OSC2_SYN terminal. The 208 MHz signal is converted to 52 MHz using an on-chip divide-by-4 network then routed to the I/Q Mixer. The divide-by-4 signal is also available through a buffer amplifier at the OSC2_DIV4 terminal.

Second IF Amplifier and I/Q Mixer

This block provides an additional 42 dB of gain, then down converts the 2nd IF signal to baseband utilizing the on-chip Voltage Controlled Oscillator (I/Q VCO). Gain is variable from 0 to 42 dB and is controlled by the serial word bits D14 through D19. Differential outputs are provided for both the I and Q signals.

Serial Control Interface

All TRF1020 functional blocks can be individually powered up or down via the serial interface.

The TRF1020 device register is manipulated via a synchronous serial data port. The Serial Control Interface provides power up / power down capability for each one of the functional blocks. One 24 bit word is clocked into a temporary holding register with the least significant bit clocked first. The operation register is loaded with the new data residing in the temporary registers using the rising edge of the STROBE input.

Table 1 lists the format of the control word.

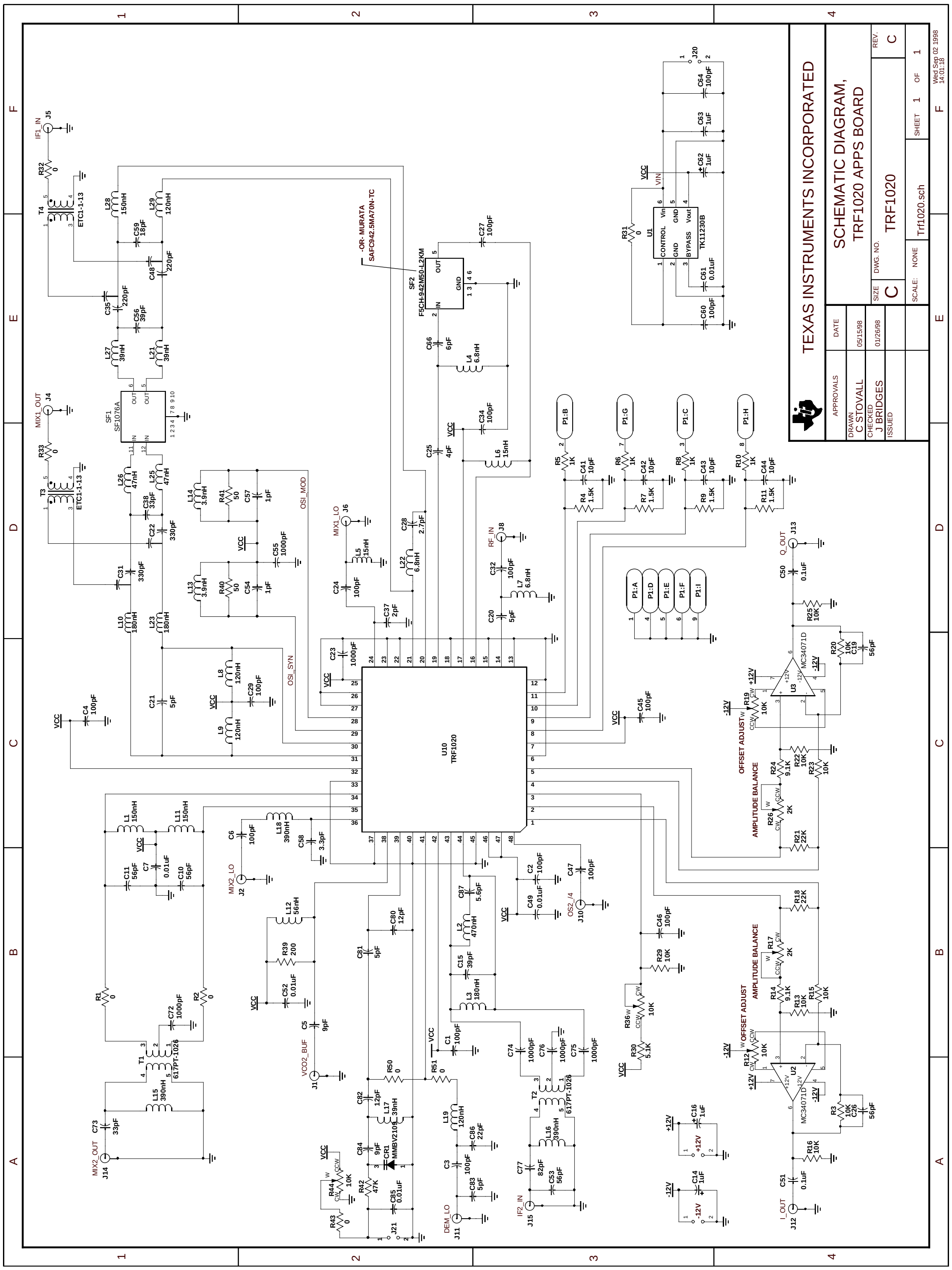
Table Formats and Styles

Table 1. Control Word Bit Assignment

Bit	FUNCTION	Signal Name
D0	LNA power control	LNAP
D1	LNA gain control	LNAG
D2	RF mixer standby	MX1STBY
D3	RF mixer power	MX1P
D4	IF mixer power	MX2P
D5	IF mixer bypass	MIX2BYP
D6	IF amp 1, gain control bit 1	IF1AGC1
D7	IF amp 1, gain control bit 2	IF1AGC2
D8	IF amp 1, gain control bit 3	IF1AGC3
D9	IF amp 1, gain control bit 4	IF1AGC4
D10	IF amp 1, gain control bit 5	IF1AGC5
D11	IF amp 1, gain control bit 6	IF1AGC6
D12	Demod power control	DMODP
D13	Demod standby	DMODSTBY
D14	IF amp 2, gain control bit 1	IF2AGC1
D15	IF amp 2, gain control bit 2	IF2AGC2
D16	IF amp 2, gain control bit 3	IF2AGC3
D17	IF amp 2, gain control bit 4	IF2AGC4
D18	IF amp 2, gain control bit 5	IF2AGC5
D19	IF amp 2, gain control bit 6	IF2AGC6
D20	Demod DC correction	DMDISABLE
D21	<not used>	<not used>
D22	<not used>	<not used>
D23	<not used>	<not used>

TRF1020 Schematic

Figure 2. TRF1020 Schematic



Parts List

Table 2. Parts List

Ref. Designator	Value	Description	QTY	Part Number	Manufacturer
C1,2,3,4,6,24,27,29,32, 34,45,46,47,60, 64	100pF	Capacitor	15	GRM36COG Series	Murata
C5, 84	9 pF	Capacitor	2	GRM36COG Series	Murata
C7,49,52,61,85	0.01 µF	Capacitor	5	GRM36COG Series	Murata
C10,11,19,26,53	56 pF	Capacitor	5	GRM36COG Series	Murata
C14,16,62	1 µF	Capacitor	3	TA025TCM105KAR	Venkel
C15	39 pF	Capacitor	1	GRM36COG Series	Murata
C56	39 pF	Capacitor	1	GRM42-6COG Series	Murata
C20, 21, 81, 83	5 pF	Capacitor	4	GRM36COG Series	Murata
C22,31	330 pF	Capacitor	2	GRM42-6COG Series	Murata
C23, 55, 72, 74, 75, 76	1000 pF	Capacitor	6	GRM36COG Series	Murata
C25	4 pF	Capacitor	1	GRM36COG Series	Murata
C28	2.7 pF	Capacitor	1	GRM36COG Series	Murata
C35, 48	220 pF	Capacitor	2	GRM36COG Series	Murata
C37	2 pF	Capacitor	1	GRM36COG Series	Murata
C38, 73	33 pF	Capacitor	2	GRM36COG Series	Murata
C41,42,43,44	10 pF	Capacitor	4	GRM36COG Series	Murata
C50,51	0.1 µF	Capacitor	2	GRM36COG Series	Murata
C54, 57	1 pF	Capacitor	2	GRM36COG Series	Murata
C58	3.3 pF	Capacitor	1	GRM36COG Series	Murata
C59	18 pF	Capacitor	1	GRM42-6 Series	Murata
C63	1 µF	Capacitor	1	GRM42-6Y5V Series	Murata
C66	6 pF	Capacitor	1	GRM36COG Series	Murata
C77	82 pF	Capacitor	1	GRM36COG Series	Murata
C80, C82	12 pF	Capacitor	2	GRM36COG Series	Murata
C86	22 pF	Capacitor	1	GRM36COG Series	Murata
C87	5.6 pF	Capacitor	1	GRM39COG Series	Murata
L1,11	150 nH	Inductor	2	1008CS Series	Coilcraft
L2	470 nH	Inductor	1	LL2012-FR47K	Toko
L3,10, 23	180 nH	Inductor	3	805HS Series	Coilcraft
L4, 7	6.8 nH	Inductor	2	603HS Series	Coilcraft
L5, 6	15 nH	Inductor	2	603HS Series	Coilcraft
L8, 9, 29	120 nH	Inductor	3	603HS Series	Coilcraft
L12	56 nH	Inductor	1	603HS Series	Coilcraft
L13, 14	3.9 nH	Inductor	2	603HS Series	Coilcraft
L15, 16, 18	390 nH	Inductor	3	1008CS Series	Coilcraft
L17	39 nH	Inductor	1	603HS Series	Coilcraft
L19	120 nH	Inductor	1	1008HS Series	Coilcraft
L21, 27	39 nH	Inductor	2	805HS Series	Coilcraft
L22	6.8 nH	Inductor	1	LL1005 Series	Toko

L25, 26	47 nH	Inductor	2	603HS Series	Coilcraft
L28	150 nH	Inductor	1	805HS Series	Coilcraft
R1, 2, 31, 32, 33, 43, 50, 51	0 Ω	Resistor	8	ERJ-2GEJ0R00	Panasonic
R3, 13, 15, 16, 20, 22, 23, 25, 29	10 KΩ	Resistor	9	ERJ-2GEJ103	Panasonic
R4, 7, 9, 11	1.5K Ω	Resistor	4	ERJ-2GEJ152	Panasonic
R5, 6, 8, 10	1K Ω	Resistor	4	ERJ-2GEJ102	Panasonic
R14, 24	9.1K Ω	Resistor	2	ERJ-2GEJ912	Panasonic
R18, 21	22K Ω	Resistor	2	ERJ-2GEJ223	Panasonic
R30	5.1K Ω	Resistor	1	ERJ-2GEJ512	Panasonic
R39	200 Ω	Resistor	1	ERJ-2GEJ201	Panasonic
R40, 41	50 Ω	Resistor	2	ERJ-2GEJ500	Panasonic
R42	47K Ω	Resistor	1	ERJ-2GEJ473	Panasonic
R12, 19, 36	10K Ω	Adjustable Resistor	3	3214W-103	Bourns
R17, 26	2K Ω	Adjustable Resistor	2	3214W-202	Bourns
R44	10K Ω	Adjustable Resistor	1	3296-Y-1-103	Bourns
P1	Serial	9-Pin Connector	1	745990-4	Amp
J1,2,4,5,6,8,10,11, 12,13,14,15		SMA Connector	12	142-0701-801	EF Johnson
J20,21		DC Voltage Connector	2	4-103239-0	Amp
U1		Voltage Regulator	1	TK11230	Toko
U10		GSM Receiver	1	TRF1020	T. I.
U11, 12		Operational Amplifiers	2	MC34071D	Motorola
CR1		Varactor Diode	1	MMBV2109	Motorola
F1		Differential SAW Filter	1	RFM_SF 1076A	RF Monolithics
F2		Image Reject SAW Filter	1	SAFC942.5MA70N	Murata
T1, 2		Balun Transformer 9:1	2	617PT-1026	Toko
T3,4		Balun Transformer 1:1	2	ECT1-1-13	MA/COM

Table 3. Evaluation Board Component Summary

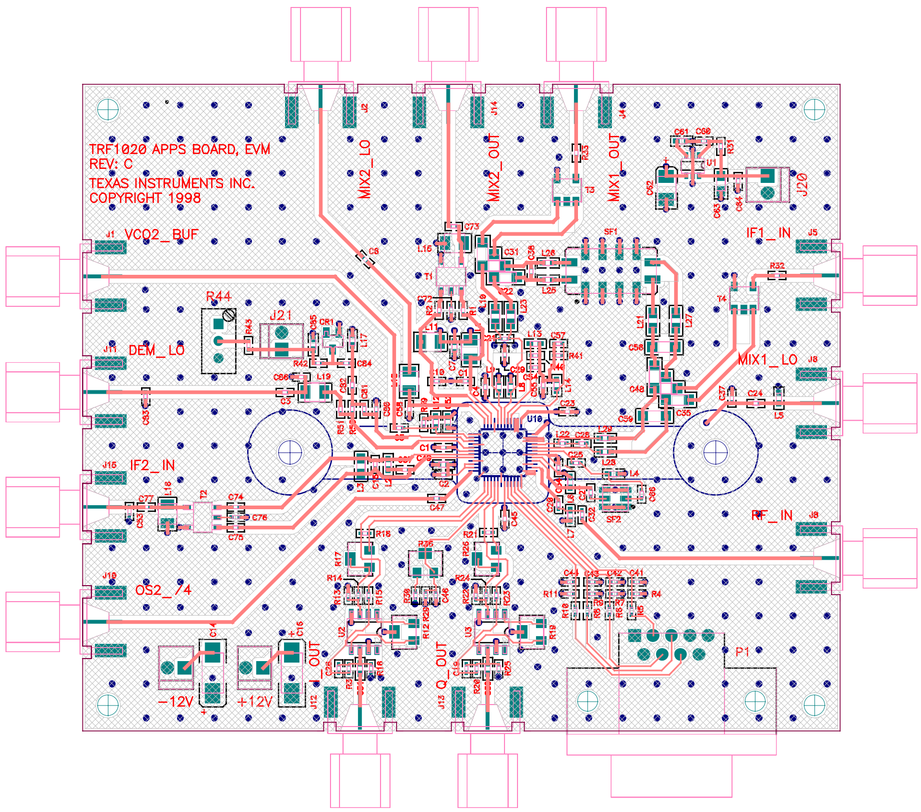
Description	Quantity Required
Capacitors	68
Inductors	27
Resistors	34
Potentiometers	6
Semiconductors	5
Balun Transformers	4
SAW Filters	2

NOTE: Many of the components used are to aid in taking measurements and injecting signals in a 50 Ohm environment. In actual use, the component count could be greatly reduced.

PCB Layout

The EVM board is comprised of a multi-layer printed circuit board, a TRF1020 device, SMA connectors, and the necessary peripheral discrete components.

Figure 3. PCB Layout

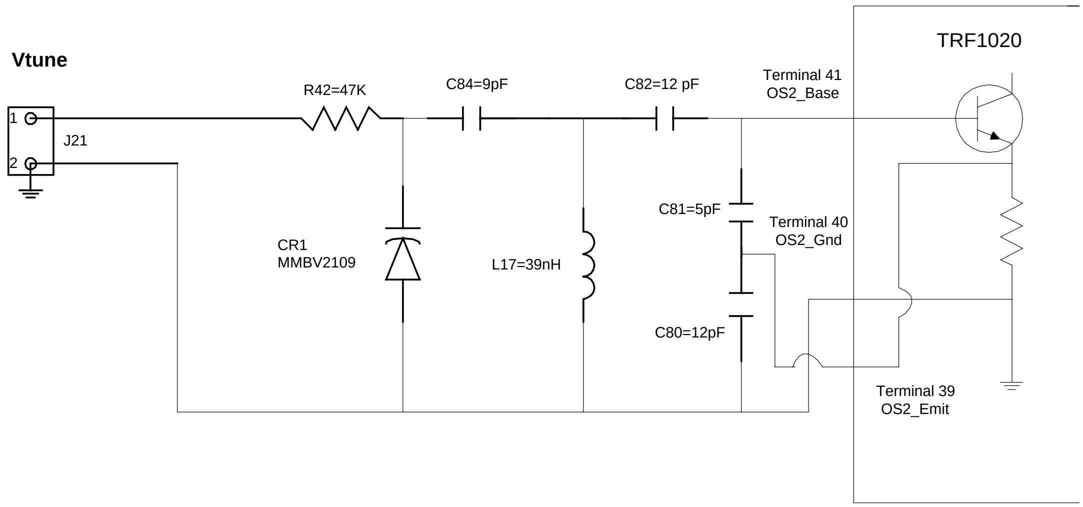


EVM Design Notes

Tank Circuit

The VCO generates a signal in the 208MHz range that is used in the downconversion of the IF2 signal to baseband. The 208 MHz signal is later translated to 52MHz through the on-chip divide-by-four circuit.

Figure 4. Varactor Controlled LC Tank Circuit



NOTE: The tank circuit in Figure 2 has been redrawn in Figure 4 for clarification.

The tank resonant frequency is defined by the following formula:

$$f_{resonance} = \frac{1}{2\pi\sqrt{L_{17}Ceq}}$$

where

$$Ceq = \left[\frac{1}{C_{84}} + \frac{1}{C_{CR1}}\right]^{-1} + \left[\frac{1}{C_{80}} + \frac{1}{C_{82}}\right]^{-1}$$, C_{CR1} = Varactor's capacitance

On the EVM board, the VCO was designed to operate at 208 MHz. The calculated resonance frequency is as follows:

C_{R1} = 50 pF (at 1.5V, measured on the EVM board)

$$Ceq = \left[\frac{1}{9\,pF} + \frac{1}{50\,pF}\right]^{-1} + \left[\frac{1}{12\,pF} + \frac{1}{12\,pF}\right]^{-1} = 13.627\,pF,$$

with L_{17}= 39nH

$$f_{resonance} = \frac{1}{2\pi\sqrt{L_{17}Ceq}} = 218.32\,MHz$$

The difference in frequency between the calculated and measured resonant frequencies is attributed to the actual varactor capacitance, component tolerances, board layout, and the interaction of the TRF1020 with C81. C81 is primarily used to adjust the output power of the oscillator by controlling the feedback current of the internal transistor, but it will have some small effect on the actual resonant frequency.

The oscillator frequency tuning range is approximately 6 MHz. The tuning range is controlled by the varactor changing in capacitance when the tuning voltage, (Vtune) is adjusted from 0V to 3.0 V. Vtune is adjusted from 0 to 3Vdc using R44 or can be applied externally at J24 if R43 is removed.

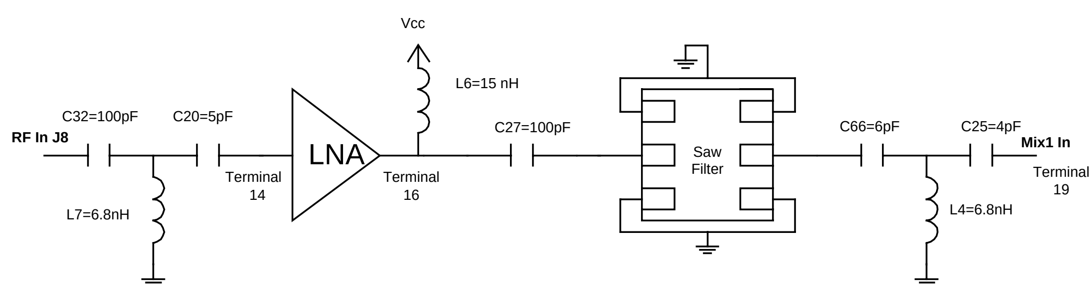
The use of high Q components in the tank circuit is required as they affect the impedance seen by the TRF1020. The Q's of the inductor (L17), the capacitors, and varactors are very critical, as the selection of these components affects the attenuation that the tank circuit will provide. An increase in attenuation reduces the tank resonant signal level and, if not designed properly, can degrade the oscillator start up properties. See the TRF3520 GSM RF Modulator/Driver Amplifier EVM Application Brief, (TI Literature Number SWRA020), for a detailed description of Q and how it can affect oscillator circuits.

Impedance Matching

Low Noise Amplifier and SAW Filter Matching

The diagram below shows the matching circuitry used on the TRF1020 LNA input and image-reject SAW filter. The LNA input impedance matching network primarily determines the gain, noise figure and input return loss performance. A series-C (C32), shunt-L (L7), series-C (C20) matching network is used to obtain optimum noise figure performance. The trade-off for this optimization is degraded input return loss and lower gain. Components L6 and C27 provide a matching network between the LNA output and SAW Filter input. The output of the SAW Filter is matched to the input of Mixer1 with another series-C (C66), shunt-L (L4), series-C (C25) circuit. The two series capacitors, (C66 and C25) are critical to the cascaded input 3rd-order intercept point performance. The circuitry depicted is a compromise between the best gain, noise figure, input return loss, and input 3rd-order intercept point.

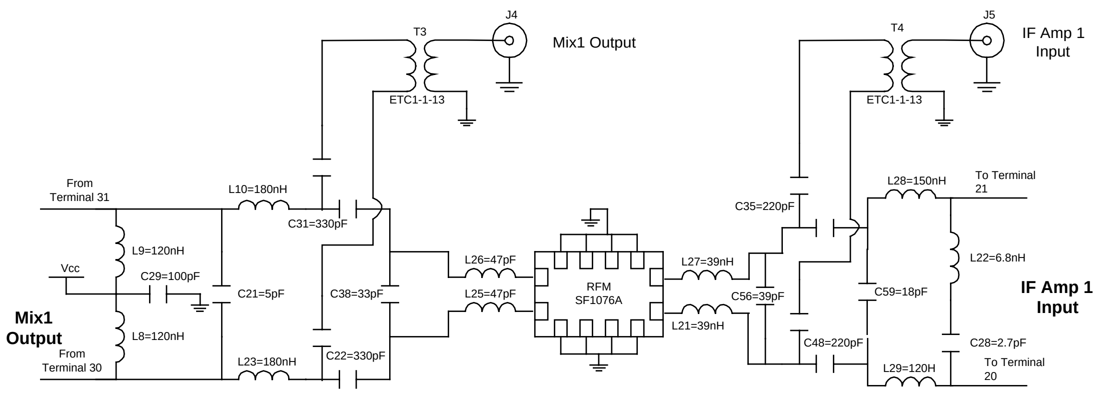
Figure 5. LNA Input/Output &SAW Filter Match



Mixer 1 Output and IF Amplifier 1 Input Matching

The output of Mixer 1 is differential and has a real impedance component of 2000 Ohms. This impedance is transformed from 2000 Ohms to 50 Ohms at capacitors C22/C31 using components L8, L9, C21, L10, and L23. The value of C21 is critical for both noise figure and input 3rd -order intercept point. Depending on the placement of C22 and C31, the signal can either continue through the SAW filter or brought out to measurement point J4 (Mix1 Output), using a 1:1 balun transformer, (T3).

Figure 6. Mix1 Output to IF Amp1 Input Match



The SAW filter provides 149 MHz filtering and has an input impedance of approximately 850 Ohms. Starting at capacitors C22 and C31, the impedance is transformed from 50 Ohms to 850 Ohms using components C38, L25, and L26. After the filter, the impedance is transformed back from 850 Ohms to 50 Ohms at capacitors C35 and C48 using components C56, L21 and L27. Depending on the placement of C35 and C48, the signal can either continue on to the input of IF Amplifier1 or brought out to connection point J5 (IF1_In), using a 1:1 balun transformer, (T4).

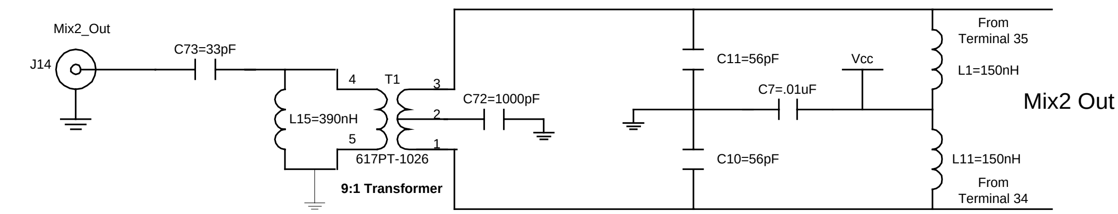
With the signal path connected to J5, the IF Amplifier1 can be driven externally. This allows for individual testing of IF Amp1/Mixer2. When cascaded together, Mix1 output, the differential SAW filter, and IF Amp1 input are very sensitive. Small changes in the values of components C21 and C59 will greatly affect the path's gain, noise figure, and input 3rd order intercept point.

Finally, components L22 and C28 are used to create a resonant trap circuit for the Mix1 LO signal, (Frequency Range 1079-1109), which can couple into the receiver at this point and interfere with proper performance. Again, the tuning utilized is a compromise between the best gain, noise figure, and input 3rd-order intercept point.

NOTE: Much of the impedance matching shown in Figure 6 was to aid in taking measurements and injecting signals in a 50 Ohm environment. In actual use, the cascaded matching circuitry could be greatly simplified.

Mixer2 Output Matching

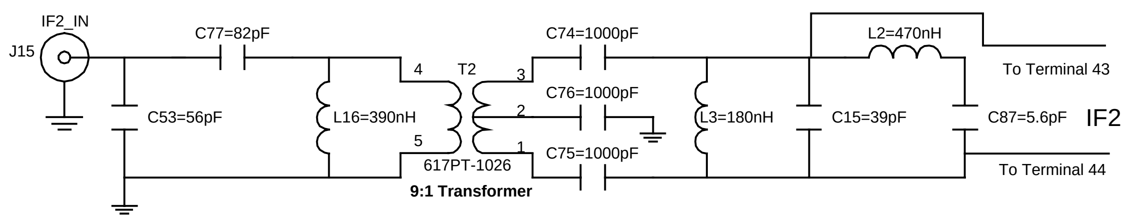
Figure 7. Mixer2 Output



Mixer 2 translates the 149 MHz signal to a 2nd IF frequency of 52 MHz. Components L1, L11, C10, and C11 create a resonant circuit at approximately 52 MHz. Mixer2 was specified to have a load impedance of 2500 Ohms. The 9:1 balun transformer, (3:1 turns ratio) together with L15 and C73 provide a load impedance of 2500 Ohms to the Mixer2 output while presenting a 50 Ohm impedance to the test environment at connector J14. In particular, the 9:1 balun transforms the 2500 Ohm impedance to approximately 277 Ohms. Finally, L15 and C73 were adjusted to obtain the best gain and complete the impedance transformation to 50 Ohms.

IF2 Amplifier/Demodulator Input Matching

Figure 8. IF2 Amplifier/Demodulator Input



The IF2 Amplifier/Demodulator has a specified input impedance of 2500 Ohms. C53, C77 and L16, combined with the 9:1 balun transformer present a 50 Ohm impedance to the test environment at connector J15 and provide a load impedance of 2500 Ohms to the input of the IF2 Amplifier/Demodulator. L3 and C15 form a resonant tank at approximately 52 MHz. L2 and C87 are used to create a 97 MHz trap, (care should be taken as the 97 MHz trap will affect the 52 MHz tank circuit). This trap is necessary to attenuate the Mix2 LO which can couple into the circuit at this point.

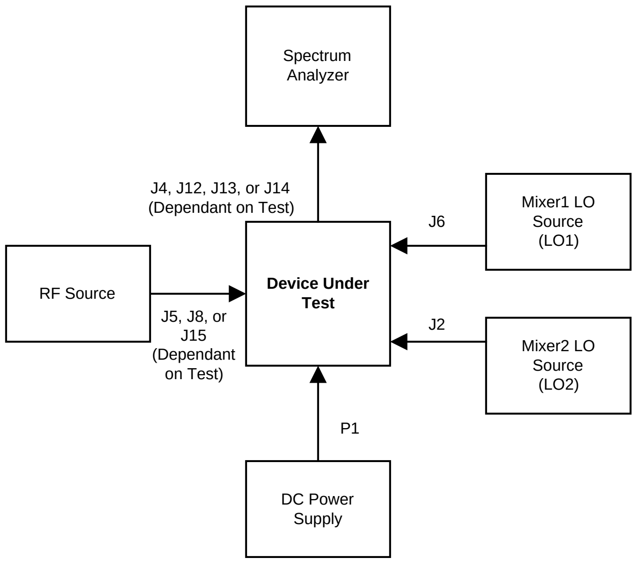
LO1 Buffered Outputs

Os1_ Mod and Os1_Syn, (TRF1020 terminals 28 and 29) are the two available buffered outputs for the 1st local oscillator input, (LO1). These outputs are not brought out to test points on the TRF1020 EVM. Components L14, R41, C57, L13, R40, and C54 represent typical tuning elements if the outputs are to be used.

EVM Tests

Typical Test Setup

Figure 9. Typical Test Setup for the TRF1020 EVM



Test Conditions

The tests are performed at room temperature.

- Vcc = +3.0
- RF Input = 940 MHz
- LO1=1098 MHz @ -5 dBm
- LO2=97 MHz @ -10 dBm
- I/Q VCO Frequency=208 MHz

Table 4. First IF Amplifier Gain Control (see Note 1)

IF1AGC6	IF1AGC5	IF1AGC4	IF1AGC3	IF1AGC2	IF1AGC1	GAIN (dB)
0	0	0	0	0	0	0
0	0	0	0	0	1	3.0
0	0	0	0	1	1	6.0
0	0	0	1	1	1	9.0
0	0	1	0	0	0	12.0
0	0	1	0	0	1	14.5
0	0	1	0	1	1	17.5
0	0	1	1	1	1	20.5
0	1	1	0	0	0	23.0
0	1	1	0	0	1	26.0
0	1	1	0	1	1	29.0
0	1	1	1	1	1	32.0
1	1	1	0	0	0	34.5
1	1	1	0	0	1	37.0
1	1	1	0	1	1	39.5
1	1	1	1	1	1	42.0

NOTE: See Table 1, Control Data BIT/Signal Name Map

Table 5. Second IF Amplifier Gain Control

IF2AGC6	IF2AGC5	IF2AGC4	IF2AGC3	IF2AGC2	IF2AGC1	GAIN (dB)
0	0	0	0	0	0	0
0	0	0	0	0	1	3.0
0	0	0	0	1	1	6.0
0	0	0	1	1	1	8.5
0	0	1	0	0	0	12.0
0	0	1	0	0	1	15.0
0	0	1	0	1	1	18.0
0	0	1	1	1	1	21.0
0	1	1	0	0	0	24.0
0	1	1	0	0	1	27.0
0	1	1	0	1	1	30.0
0	1	1	1	1	1	33.0
1	1	1	0	0	0	36.0
1	1	1	0	0	1	39.0
1	1	1	0	1	1	40.0
1	1	1	1	1	1	42.5

Typical Performance

Test Data

LNA/Mix1 (Cascaded Operation) *RF = 940 MHz @ -50 dBm, LO1 = 1089 MHz @ -5 dBm, IF1=149 MHz, (Measurements include filter loss)*

Test No	Parameter	Conditions	Typical Test Results			Units
			Min	Typ	Max	
1	Gain	Max LNA Gain	25	27	29	dB
		Min LNA Gain		6.8		dB
2	Noise Figure	Max LNA Gain		3.8	4.5	dB
		Min LNA Gain		6.8		dB
3	3rd-order Intercept Point	Max LNA Gain		-9.0		dBm
	(200 kHz tone separation)	Min LNA Gain		9.0		dBm

NOTE: Input RF power level may need to be increased in order to measure 3rd-order Intercept point.

IF1/Mix 2 *Input Frequency = 149 MHz @ -75 dBm, LO2 = 97 MHz @ -10 dBm, IF2 = 52 MHz*

Test No	Parameter	Conditions	Typical Test Results			Units
			Min	Typ	Max	
4	Gain Delta	Max Gain	39	42.5	46	dB
5	Gain Step Error	See Table 2		± 1		dB
6	Noise Figure (SSB)			9.4	15	dB
7	Input 3rd-order Intercept Point	Max Gain		-52.5		dBm
	(200 kHz tone separation)	Min Gain		-9.6		dBm

NOTE: Gain error relative to gain state in Table 2.

VCO

Test No	Parameter	Conditions	Typical Test Results Min	Typ	Max	Units
8	Frequency Range			206-212		MHz
9	Output power			-14.5		dBm
10	Phase Noise	200 kHz Offset		-120		dBc/Hz

NOTE: The EVM is configured to use the on-board Vcc and R44 for frequency tuning. To apply an external tuning voltage, R43 must be removed.

IF2/Demodulator *Input Frequency = 52.1 MHz @ -75 dBm*

Test No	Parameter	Conditions	Typical Test Results Min	Typ	Max	Units
11	Gain Delta	Max IF Gain	37	42	47	dB
12	Gain Error	See Table 3		± 1		dB
13	Amplitude Balance			± .7		dB
14	Phase Balance			± 1		deg

NOTE: Gain error relative to gain state in Table 3.

LNA/Mix2 (Cascaded Operation) *RF = 940 MHz @ -85 dBm, LO1 = 1089 MHz @ -5 dBm, LO2 = 97 MHz @ -10 dBm, (Measurements include filter losses)*

Test No	Parameter	Conditions	Typical Test Results Min	Typ	Max	Units
15	Gain	Max IF Gain		56		dB
16	Noise Figure	IF1 Gain=42 dB IF2 Gain=42 dB		4.8		dB

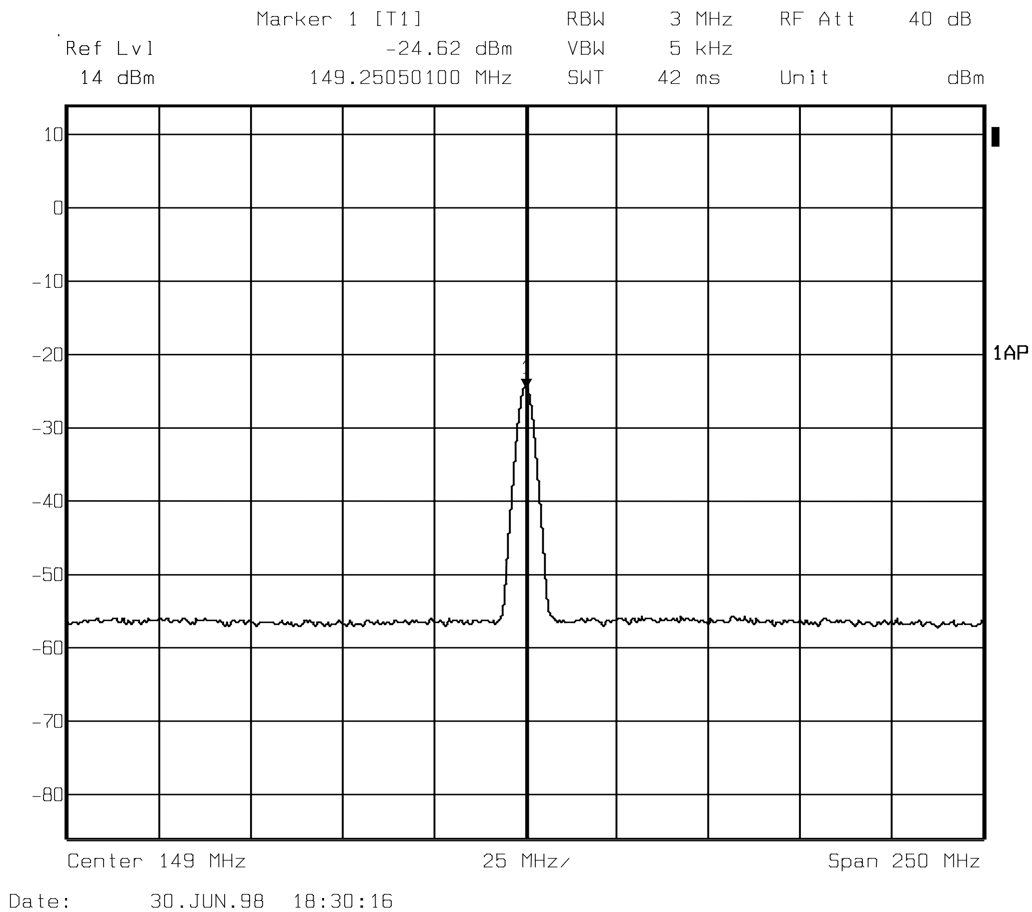
NOTE: For maximum IF Gain control range, C28 should be changed to 4 pF. C22, C31, C35, and C48 must be properly oriented for cascaded operation.

LNA/Demodulator (Cascaded Operation) *RF = 940.1 MHz @ -108 dBm, LO1 = 1089 MHz @ -5 dBm, LO2 = 97 MHz @ -10 dBm, VCO enabled (Measurements include filter losses)*

Test No	**Parameter**	**Conditions**	**Typical Test Results**			**Units**
			Min	**Typ**	**Max**	
17	IF Amplifier Gain Control Range			0 to 80		dB
18	Noise Figure	IF1 Gain=42 dB IF2 Gain=30 dB		5.5		dB

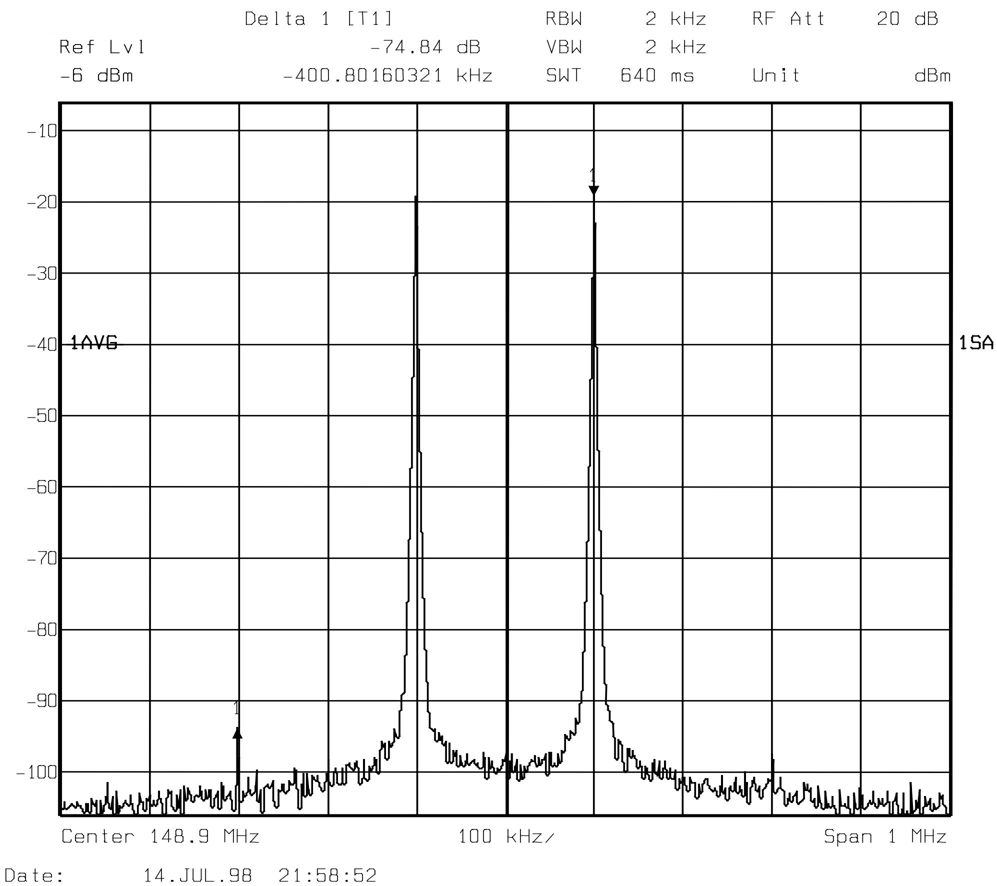
NOTE: For maximum IF Gain control range, C28 should be changed to 4 pF. C22, C31, C35, and C48 must be properly oriented for cascaded operation.

LNA to Mixer 1 Gain



- **RF In = 940 MHz @ -50dBm**
- **LO = 1089 MHz @ -5 dBm**
- **Cable/Balun Transformer Loss = 1.7 dB**
- **LNA/Mix1 Gain = |-50 - (-24.62)| +1.7 dB = 27.08 dB**

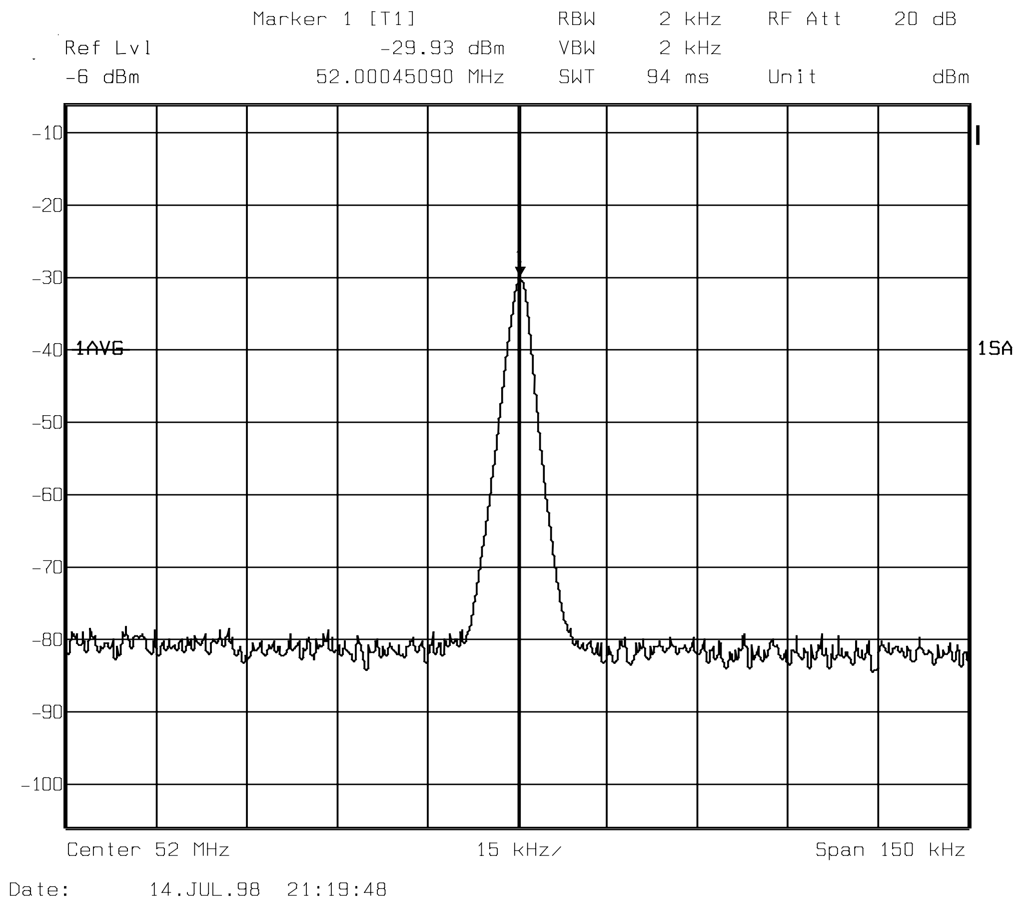
LNA to Mixer 1 Input 3rd Order Intercept Point



- **RF1 In = 940 MHz @ -45dBm, RF2 In = 940.20 MHz @ -45dBm**
- **LO = 1089 MHz @ -5 dBm**
- **Cable/Balun Transformer Loss = 1.7 dB**
- **IIP3 = |(-74.8/2)| - 45 = -7.6 dBm**

NOTE: Input power was increased from the specified –50 dBm to –45 dBm in order to measure the 3rd order product above the noise floor.

LNA to Mixer 2 Gain



- **RF In = 940MHz @ -85dBm**
- **LO1 = 1089 MHz @ -5 dBm**
- **LO2 = 97 MHz @ -10 dBm**
- **Cable/Balun Transformer Loss = 1.7 dB**
- **LNA/Mix2 Gain = |-85 - (-29.93)| +1.7 dB = 56.8 dB**

EVM Software

Windows-based software is supplied with the evaluation board. The software is intended for use in a Windows environment, 3.11or later version, Windows 95 or Windows NT. No special memory is required to use the software.

- ❑ TRF1020.EXE

The TRF1020.exe file may be copied to the system hard drive or may be executed directly from the disk provided. To execute the program from the provided disk, simply type the following.

A:\TRF1020 ↵ (*Enter)*

The program executes from the TRF1020.EXE file.

Connect the interface cable to the computer LPT port, then connect the cable to the EVM. The EVM software allows you to select the correct LPT port. Port selection is found under the Options menu.

The TRF1020 functional blocks can be activated or deactivated individually by selecting the corresponding button on the EVM software display. Available selections are First Mixer Power, First Mixer Standby, Second Mixer Power, Second Mixer Standby, DeModulator Power, DeModulator Standby, LNA Bias, IF1 Gain, and IF2 Gain. To activate or deactivate a block, simply click on the desired state with the mouse.

Once the functional blocks have been selected, select ***SEND*** with the mouse to enable the selected device state. ***SEND*** can be found at the top/center of the EVM software window.

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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References

TRF1020 GSM Receiver, Literature number SLWS028

TRF3520 GSM RF Modulator/Driver Amplifier EVM, Literature number SLWA020

TRF2020 Frequency Synthesizer, Literature number SWRA012

TRF7610 Silicon Mosfet Power Amplifier IC for GSM, Liter

ature number SLW5059

European Telecom Standards Institute Specification, 05.05 Radio Transmission & Reception

European Telecom Standards Institute Specification, 11.10 Mobile Station Conformity Specifications