Advance Information

MC13190/D
Rev. 1.2, 08/2003

2.4 GHz Short-Range, Low-Power Transceiver

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MC13190



Package Information
Plastic Package
Case 1311
(QFN-32, 5x5 mm)

Ordering Information

Device	Device Marking	Package
MC13190FC	13190	QFN-32

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1 Introduction

The MC13190 is a Short-Range, Low-Power 2.4 GHz ISM band transceiver. Together with an appropriate microprocessor or DSP for a Baseband Controller, it provides cost effective solutions for short-range (up to 10 meters), battery-powered data links. Applications include remote control, wire replacement, wireless audio, and wireless game control. The receiver includes a low noise amplifier (LNA), AM demodulator, band pass filter and limiting IF. The transmitter includes modulation control, baseband filtering and AM modulator. An on-chip PLL/VCO derives the RF frequency from a fixed 256 multiplication of the reference frequency. The device is fabricated using Motorola's RF BiCMOS process and is housed in a 32 lead QFN package with backside ground.

1.1 Features

- Typical Receiver Sensitivity: -71 dBm for $2x10^{-4}$ Bit Error Rate (BER)
- Typical Output Power = 4.8 dBm
- Fully Differential RF Input and Output

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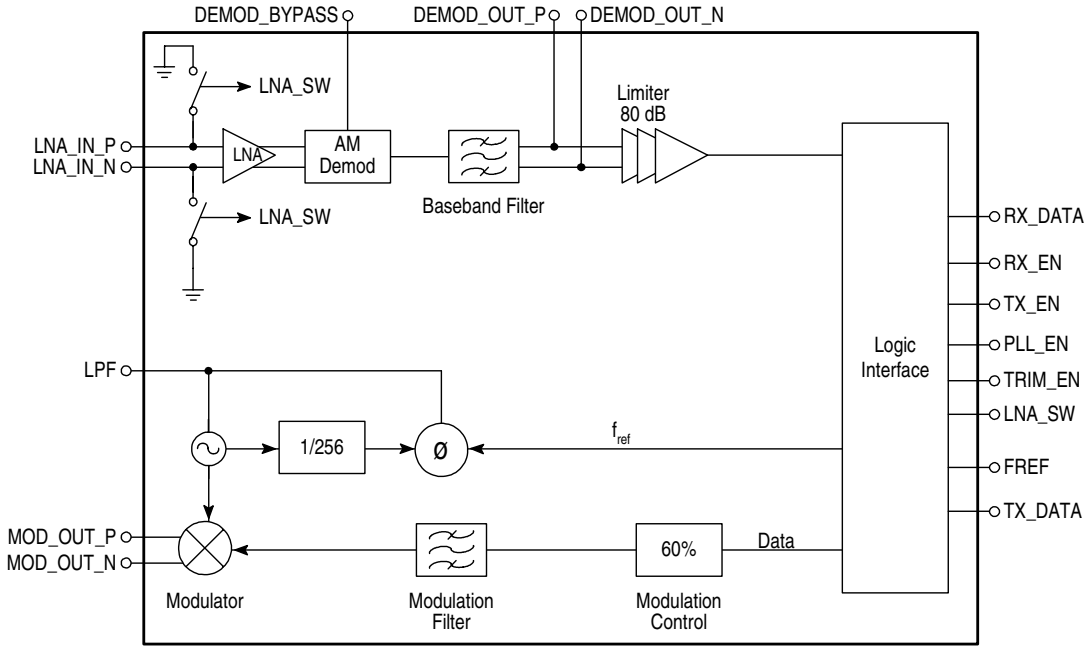


Figure 1. Simplified Block Diagram

2 Electrical Specifications

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}, V_{DD}	3.2	V
Signal and Control IC Contacts		3.2	V
Demodulator Supply Voltage	Demod_VCC	4.1	V
CW Input Power		7.0	dBm
Gnd IC Contacts Voltage		0.3	V
Capacitance Load at RX_DATA		10	pF
Storage Temperature	T_{stg}	-65 to 150	°C
Operating Temperature	T_A	0 to 50	°C

NOTES: 1. Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the Electrical Characteristics or Recommended Operating Conditions tables.
2. Meets Human Body Model (HBM)) ≤2.0 kV and Machine Model (MM) ≤200 V except RFand Limiter circuit contacts. Limiter circuit contacts (contacts 19 and 17) = 900 V HBM, 125 V MM. RF Contacts = 80 V HBM, 50V MM. RF contacts have no ESD protection. Additional ESD data available upon request.

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Table 2. Recommended Operating Conditions

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{CC}	2.5	2.75	3.0	V
Digital Supply	V_{DD}	2.0	2.75	3.0	V
Signal and Control Contacts		80% V_{DD}	-	V_{DD}	V
Demodulator Supply Voltage		2.47	3.1	3.6	V
Input Operating Frequency		2.411	-	2.473	GHz
Maximum Input Power into LNA_IN		-	-	0	dBm
Differential Load Impedance for Transmitter (MOD_OUT)		-	50	-	Ω
Differential Source Impendance for Receiver (LNA_IN)		-	25	-	Ω
Transmit Data Rate (Manchester Encoded)		4	5	6	Mbits/s
Transmit Data Encoding		Manchester, 50% Duty Cycle			

Table 3. System Characteristics

(V_{CC} = 2.75 V, T_A = 25°C, RF Receiver Frequency = 2.442 GHz, 60% AM, Bit Rate = 5.0 Mbps Manchester coded, tested in circuit shown in Figure 3, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Receiver Sensitivity for $2x10^{-4}$ Bit Error Rate		-65	-71	-	dBm
Baseband Filter Lower Corner Frequency		-	0.35	-	MHz
Baseband Filter Upper Corner Frequency		-	6.0	-	MHz
Receiver Recovery Time from a 7.0 dBm Burst		-	-	15	µs
AM Modulation Depth		50	60	88	%
Transmit Power (modulated)		3.0	4.8	6.7	dBm
Receive Supply Current (P_{in} = -50 dBm)	I_{CC}	-	11	15	mA
Transmit Supply Current Logic 1 Logic 0 50% Duty Cycle	I_{CC}	 - - -	 54 27 40.5	 - - 50	mA
Standby Supply Current		-	51	215	µA

NOTE: Characterization data and design simulations guarantee functional operation from 2.3 to 3.2 V for V_{CC}.

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Table 4. Receiver Section

(V_{CC} = 2.75 V, T_A = 25°C, RF Receiver Frequency = 2.442 GHz, 60% AM, Bit Rate = 5.0 Mbps Manchester coded, tested in circuit shown in Figure 3, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Low Noise Amplifier and Am Demodulator					
Current Consumption Active Disabled		 - -	 11 7.0	 - -	 mA µA
Recovered Signal Level at -65 dBm		-	5.0	-	mVpp
Limiter and Level Shifter					
Current Consumption Active Disabled		 - -	 240 3.0	 - -	µA
RX_DATA Drive Capability (5.0 MHz)		-	-	10	pF
Output High with respect to VDD_RX_DATA @ -100 µA		80% V_{DD}			V
Output Low with respect to GND @ -100 µA				0.2	V

NOTE: Characterization data and design simulations guarantee functional operation from 2.3 to 3.2 V for V_{CC}.

Table 5. Transmit Section

(V_{CC} = 2.75 V, T_A = 25°C, RF Transmit Frequency = 2.442 GHz, 60% AM, Bit Rate = 5.0 Mbps Manchester coded, tested in circuit shown in Figure 3, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Synthesizer (V_{CC} = 2.75 V, T_A = 25°C, unless otherwise noted.)					
Total Current Consumption when active Active Disabled		 - -	 10.2 1.1	 - -	 mA µA
Frequency Range (FREF x 256)		2.4	-	2.484	GHz
Reference Input Frequency	f_{ref}	9.375	-	9.704	MHz
RF Frequency Divide Ratio	N	-	256	-	
Trim Time (using fixed clock derived from reference)		-	-	100	µs
Time required to turn on and lock after trim (250 kHz Loop Bandwidth)		-	25	-	µs
Reference Input Level Ref Low Ref High		 - V_{DD} x 80%	 - -	 V_{DD} x 20% -	V

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Table 5. Transmit Section (Continued)
(V_{CC} = 2.75 V, T_A = 25°C, RF Transmit Frequency = 2.442 GHz, 60% AM, Bit Rate = 5.0 Mbps Manchester coded, tested in circuit shown in Figure 3, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
AM Modulator					
Current Consumption Active Disabled		 - -	 16.4 3.0	 - -	 mA µA
AM Modulation Depth Range		50	60	88	%
Output Power		3.0	4.8	6.7	dBm
Occupied Bandwidth (99% Signal Energy) [Note 1]		-	18	24	MHz
Out of Band Spurious at Antenna Port [Note 1] 30 MHz to 2.4 GHz 2.5 to 12.75 GHz		 - -	 -65 -60	 -50 -45	dBm
Acceptable Duty Cycle for TX_DATA Signal (Manchester Encoded)		48	-	52	%

NOTES: 1. Guaranteed by design, not tested.
2. Characterization data and design simulations guarantee functional operation from 2.3 to 3.2 V for V_{CC}.

Table 6. Enable Logic Levels
(V_{CC} = 2.75 V, T_A = 25°C)

Symbol	Characteristic	Min	Max
V_{IH}	High Level Input Voltage	80% V_{DD}	-
V_{IL}	Low Level Input Voltage	-	20% V_{DD}
I_{IH}	High Level Input Current	-	1.0 µA
I_{IL}	Low Level Input Current	-	1.0 µA

NOTE: Characterization data and design simulations guarantee functional operation from 2.3 to 3.2 V for V_{CC}.

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3 Contact Connections

Table 7. Contact Function Description

Contact #	Contact Name	Type	Description
	Ground Flag		Ground
1	MOD_VCC	DC Input	Modulator Supply Voltage
2	MOD_BUFF_VCC	DC Input	Modulator Buffer Supply Voltage
3	PLL_VCC	DC Input	PLL Supply Voltage
4	LOGIC_VDD	DC Input	Digital Supply Voltage
5	TX_DATA	Digital Input	Transmit Data Input
6	TX_EN	Digital Input	Enables TX Filter, Modulation Control and PA/Modulator circuitry
7	PLL_EN	Digital input	Enables Frequency Synthesizer and VCO
8	FREF	Analog Input	Reference frequency for PLL
9	TRIM_EN	Digital Input	Enables VCO Trimming
10	VDD_RX_DATA	DC Input	Limiter Output Supply Voltage
11	GND		Ground
12	VCO_VCC	DC Input	VCO Supply Voltage
13	LPF		PLL Loop filter
14	LIM_GND_2		Ground
15	LNA_SW	Digital Input	Switches LNA Inputs to Ground in TX Mode
16	RX_OUT_DRVR_GND		Ground
17	RX_DATA	Digital Output	Received data output
18	RX_EN	Digital Input	Enables LNA, Demod and Limiter
19	LIM_VCC	DC Input	Limiter Voltage Supply
20	DEMOD_OUT_N	Analog Output	Negative output of Demodulator prior to Limiter
21	DEMOD_OUT_P	Analog Output	Positive output of Demodulator prior to Limiter
22	DEMOD_BYPASS		Bypass Capacitor for Demod Circuit
23	DEMOD_VCC	DC Input	Demodulator Circuit Supply Voltage
24	LNA_VCC	DC Input	LNA Circuit Supply Voltage
25	LAN_IN_N	Analog Input	Negative Input to LNA
26	GND		Ground

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Table 7. Contact Function Description (Continued)

27	MOD_OUT_N	Analog Output	Negative output of Modulator
28	GND		Ground
29	GND		Ground
30	MOD_OUT_P	Analog Output	Positive output of Modulator
31	GND		Ground
32	LNA_IN_P	Analog Input	Positive Input to LNA

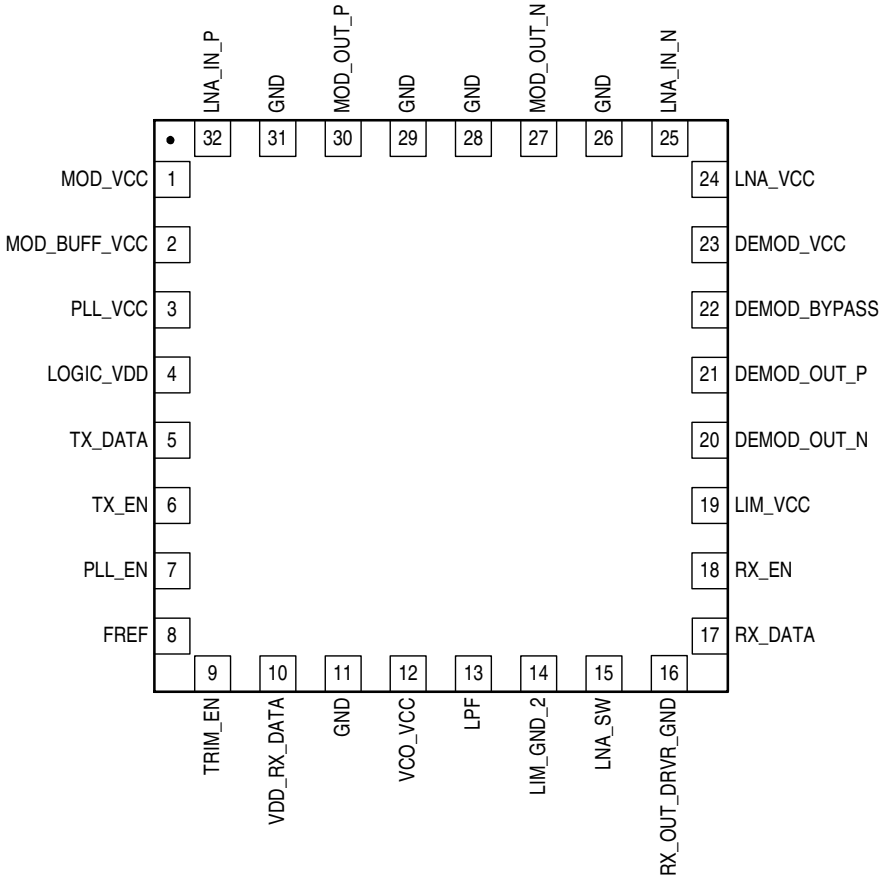


Figure 2. Contact Connections

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4 Application Information

Figure 3 shows the basic transceiver evaluation board circuit schematic with reference oscillator and Figure 4 shows the optional external LNAs. Figures 5 and 6 show the evaluation board printed circuit board layout details.

This realization is intended for device evaluation and has been designed with a 50 Ω interface. C19, C20, L10 and L12 form a lumped-element balun. In equipment applications a differential antenna can be interfaced through matching elements directly to the LNA and Modulator contacts. A PCB dipole antenna board with balun and SMA connector is available for link evaluations. A version of the board which includes a dipole antenna is also available. The RF circuit layout is critical and should be duplicated exactly. In normal applications, the entire transceiver should be shielded and control lines from the baseband should be as short as possible.

The optional external LNA circuits require an external differential switch that is implemented with PIN diodes D1, D2, D3 and D4. T1 and T2 are quarter wave lines for isolation. IC Contact 15, LNA_SW, is grounded since the internal switch is not used. If the LNA are used, C25 and C30 are not placed and “zero Ohm” resistors R5, R9, R13 and R14 insert the LNAs into the receive path.

Voltage supply Contacts 1, 2, 3, 12, 19, 23 and 24 require bypass capacitors as close as possible to the device. Logic supply Contact 4 can directly interface to the baseband supply in equipment applications. The DEMOD_BYPASS (Contact 22) bypasses the demodulator bias circuitry for both RF signals and low frequency signals. The differential demodulator output from contacts 20 and 21 is available at TP1 and TP2. The PLL loop filter is the standard R+C // C network and connects between contacts 12 and 13.

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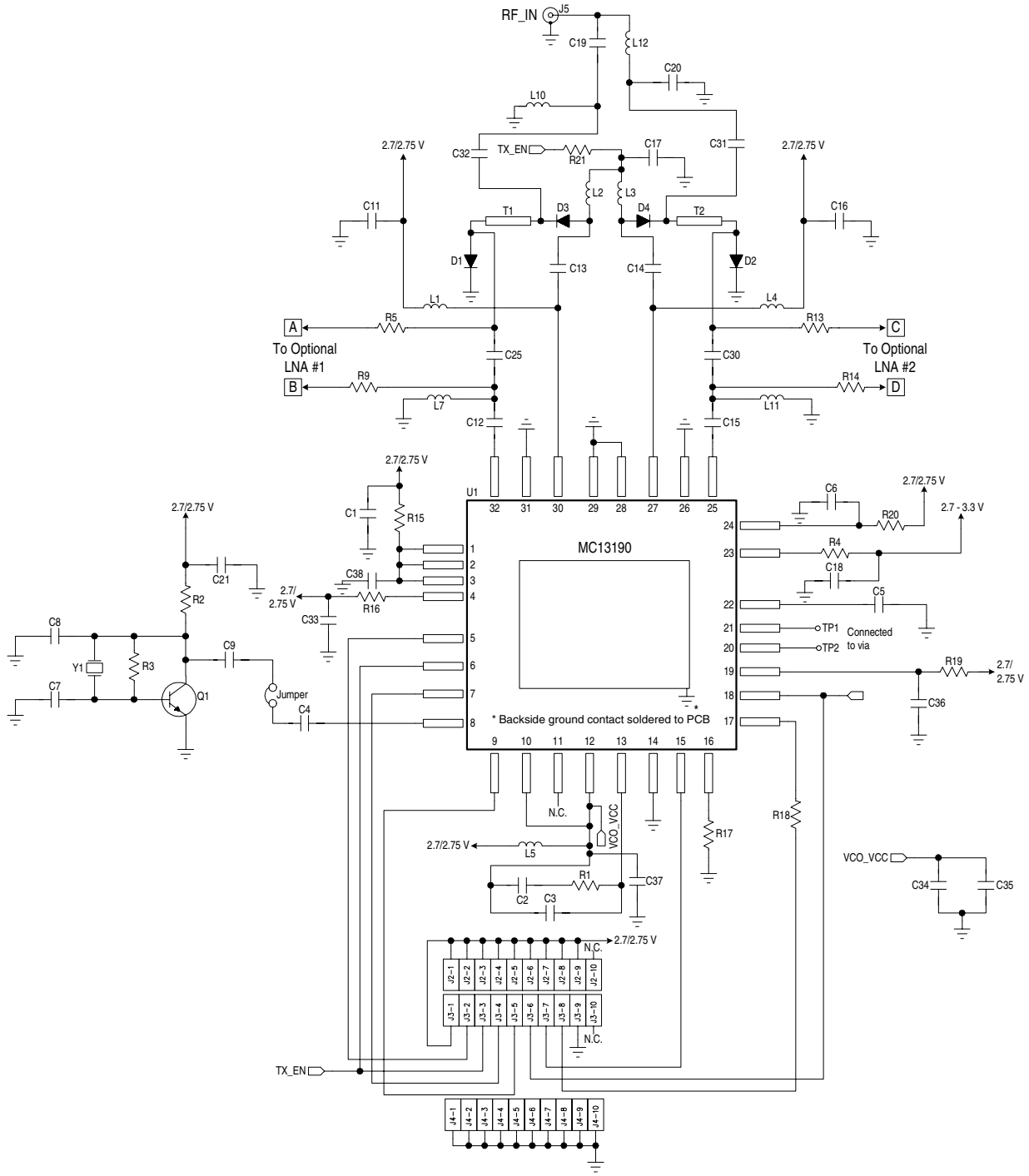


Figure 3. Transceiver Application Circuit Schematic

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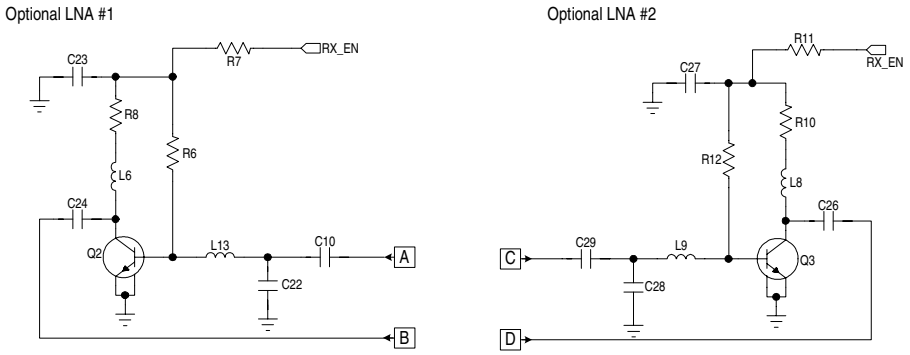


Figure 4. Optional LNA Circuits

Table 8. Bill of Materials

Reference	Value	Description
C1, C6, C11, C16, C18, C21, C33, C35, C36, C37	0.1 µF	0402 Ceramic, Murata
C2	82 pF	0402 NPO Ceramic, Murata
C3	12 pF	0402 NPO Ceramic, Murata
C4, C23, C27	1000 pF	0402 Ceramic, Murata
C5	1.0 µF	0603 Ceramic, Murata
C7, C8	27 pF	0402 NPO Ceramic, Murata
C9, C34	100 pF	0402 NPO Ceramic, Murata
C10, C13, C14, C29	6.0 pF	0402 NPO Ceramic, Murata
C12, C15	3.0 pF	0402 NPO Ceramic, Murata
C17	10 pF	0402 NPO Ceramic, Murata
C19, C20	1.5 pF	0402 NPO Ceramic, Murata
C22, C28	0.5 pF	0402 NPO Ceramic, Murata
C24, C26	2.0 pF	0402 NPO Ceramic, Murata
C25, C30, C31, C32, C38	33 pF	0402 NPO Ceramic, Murata
D1, D2, D3, D4	BAR63-03W	Pin Diode, Siemans
J2, J3, J4		1 x 10 Header Strip
J5		SMA Right Angle
L1, L4	2.2 nH	0402 Toko
L2, L3	15 nH	0402 Toko
L5	2.7 nH	0603 Toko
L6, L7, L8, L11	3.0 nH	0402 Toko
L9, L13	0.5 nH	0402 Toko

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Table 8. Bill of Materials (Continued)

Reference	Value	Description
L10, L12	1.8 nH	0402 Toko
Q1		MMBT3904
Q2, Q3		MBC13900
R1	12 kΩ	0402 5%
R2	560 Ω	0402 5%
R3	68 kΩ	0402 5%
R4	51Ω	0402 5%
R5, R9, R13, R14	0 Ω	0402
R6, R12	49 kΩ	0402 5%
R7, R11	130 Ω	0402 5%
R16, R17, R18	180 Ω	0402 5%
R8, R10, R15, R19, R20	10 Ω	0402 5%
R21	270 Ω	0402 5%
T1, T2	Z_0 = 25 Ω, ℓ = 0.72	Microstrip Transmission line, ε_r = 4.5 mils, t = 10 mils
U1		MC13190
Y1	9.357 MHz	Temex

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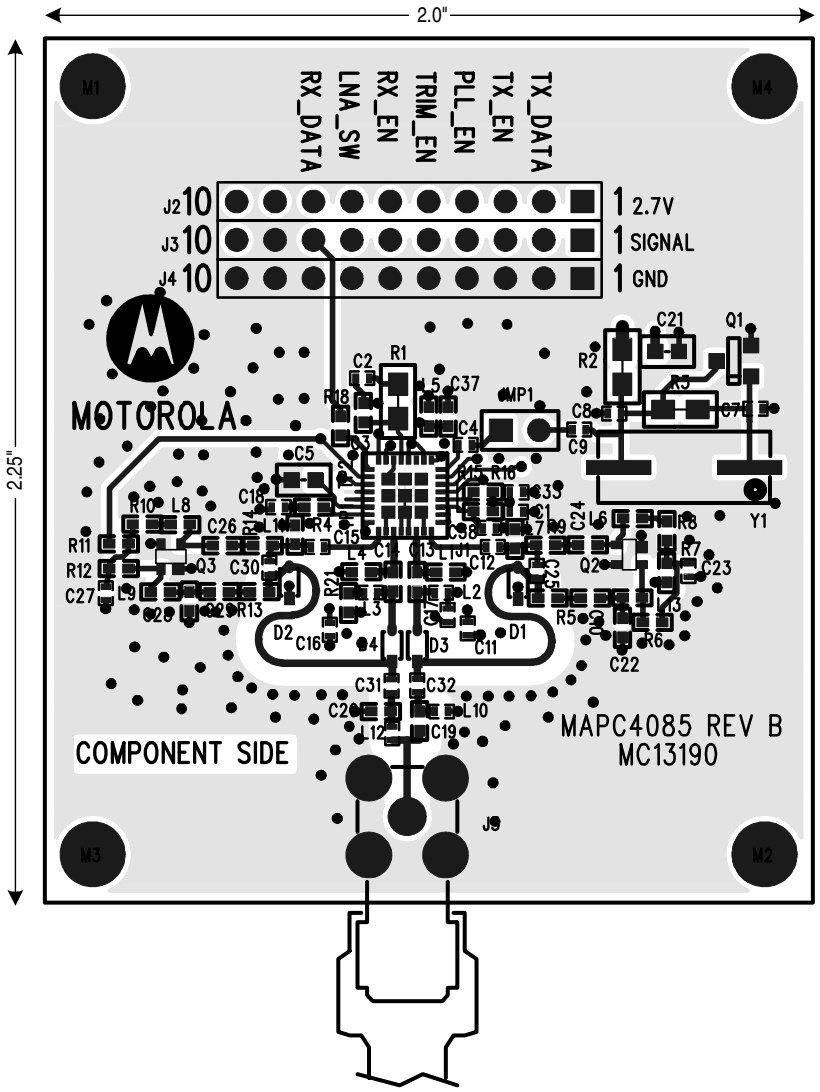


Figure 5. Transceiver Circuit PCB Topside
(Active Dielectric = 10 mil FR4, Total Board Thickness = 0.062”)

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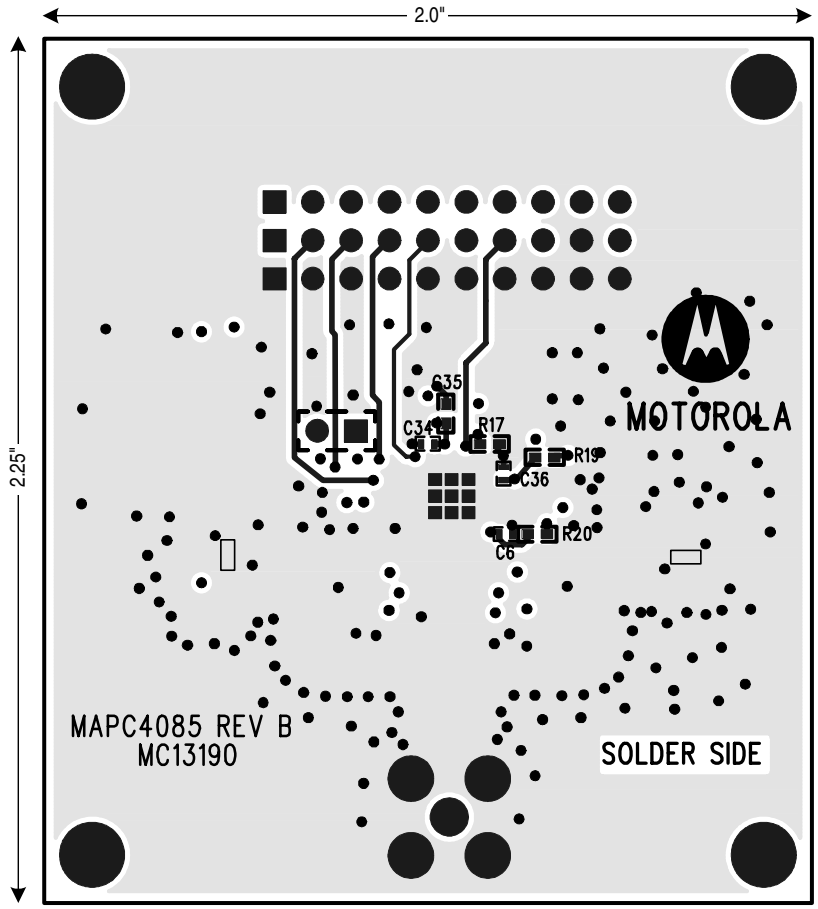


Figure 6. Transceiver Circuit PCB Bottom Side
(Active Dielectric = 10 mil FR4, Total Board Thickness = 0.062”)

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5 Packaging

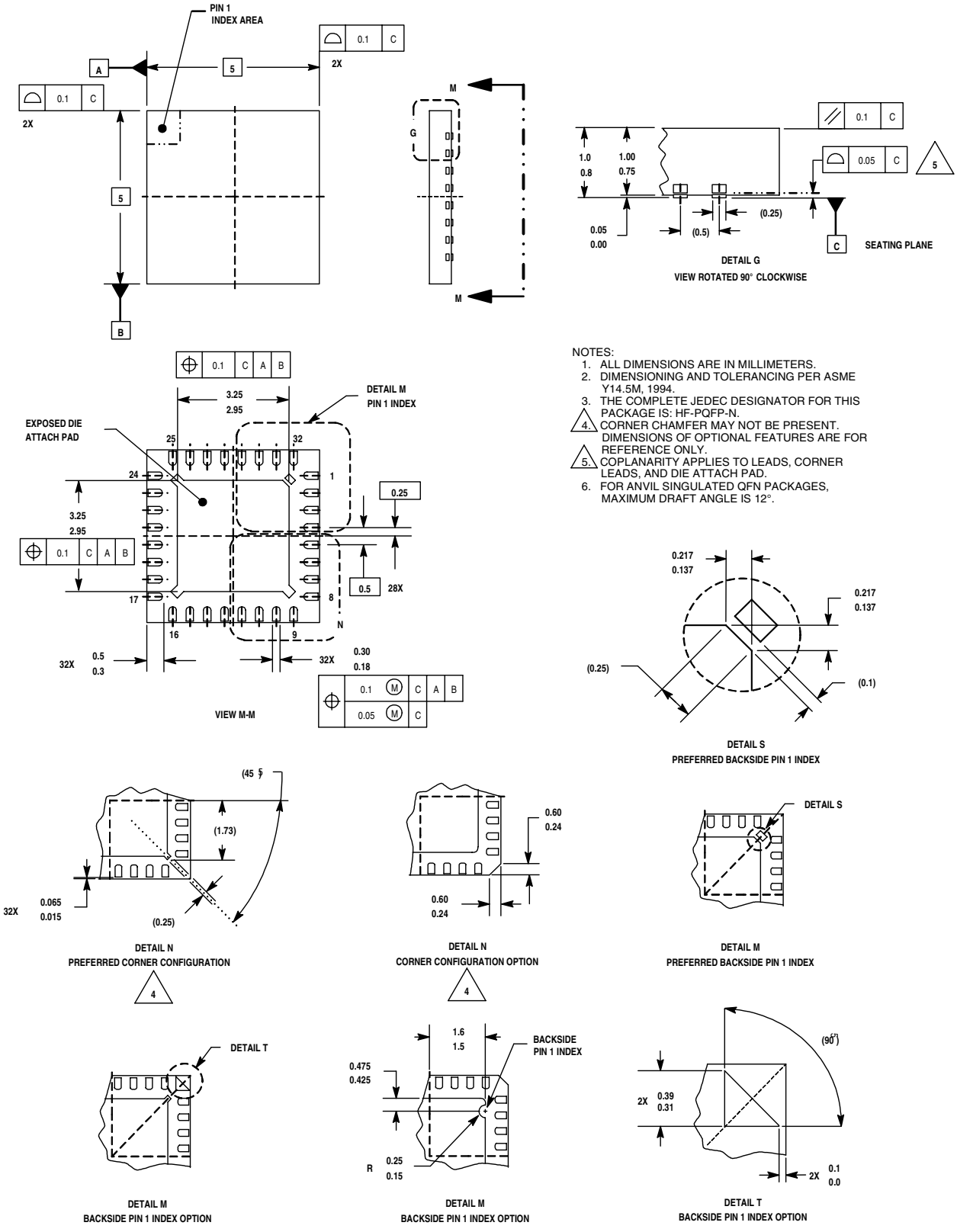


Figure 7. Outline Dimensions for QFN-32, 5x5 mm
(Case 1311-03, Issue E)

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