Linear Integrated Transceiver
2.4 - 2.5 GHz

MD58-0002

V 2.00

Features

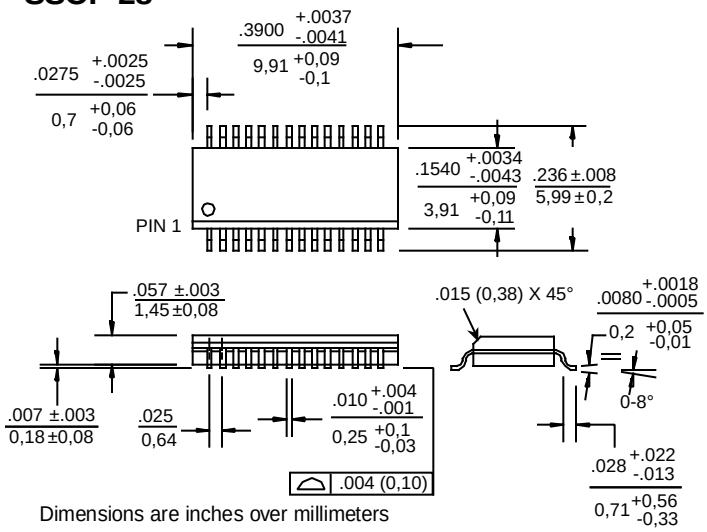
- Fully Integrated Transmit and Receive Functions
- High Linear Transmit Power: Output P_{1dB} = 9 dBm
- High Up/Down Conversion Gains (26 dB/16 dB)
- Generic Architecture with Single-Ended Input/Output Ports
- 4 dB, 8 dB and 12 dB Transmit Power Control
- Low Cost SSOP 28-Lead Plastic Package
- Integrated Image Reject Filter with 10 dB Rejection @ 200 MHz IF
- Offers Lower-Side-Band Suppression in Transmit Mode

Description

M/A-COM's MD58-0002 is a highly integrated RF front end transceiver with high linear transmit power. The transceiver is ideally suited for linear phase modulation systems in the 2.4 - 2.5 GHz ISM band. The receiver features an LNA, image reject filter, double balanced mixer and IF amplifier. The transmit chain includes IF amplifier, double balanced mixer, digital attenuator and two RF amplifiers. Applications include WLAN, portable data terminals and wireless PBX.

The MMIC is fabricated using an industry standard 1.0-µm MESFET process.

SSOP-28



Dimensions are inches over millimeters

Ordering Information

Part Number	Description
MD58-0002	SSOP 28-Lead Plastic Package
MD58-0002TR	Forward Tape & Reel*
MD58-0002RTR	Reverse Tape & Reel*
MD58-0002SMB	Designer's Kit

* If specific reel size is required, consult factory for part number assign-

Typical Electrical Specifications

Test Conditions: RF = 2484 MHz (-30 dBm), IF = 200 MHz (-30 dBm), LO = 2284 MHz (0 dBm), V_{DD} = +5 V ±5%, V_{GG} = -5 V ±10%, T_A = +25°C

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Receive Mode					
RF Frequency Range	IF port is matched to 50 Ω by LC network (see External Components section)	GHz	2.4		2.5
IF Frequency Range		MHz	200		400
Conversion Gain		dB	11	16	
SSB Noise Figure		dB		5.2	6.0
Input P_{1dB}		dBm		-15.5	
V_{DD} (+5V) Current		mA			50 75
V_{GG} (-5V) Current		mA		2.6	5.0
Transmit Mode					
RF Frequency Range	IF port is matched to 50 Ω by LC network (see External Components section)	GHz	2.4		2.5
IF Frequency Range		MHz	200		400
Conversion Gain		dB	20	26	
Output P_{1dB}		dBm	5	9	
LO Leakage		dBm		-2	
Power Control Accuracy For 4 dB, 8 dB and 12 dB states		dB		±1.5	
V_{DD} (+5 V) Current		mA		95	150
V_{GG} (-5 V) Current		mA			3.6 5.0

Absolute Maximum Ratings[1]

Parameter	Absolute Maximum
Max. Input Power[2]	+23 dBm
Operating Voltages[2]	V_{DD} = 7 V
	V_{GG} = -7 V
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

1.Exceeding these limits may cause permanent damage.
2.Ambient temperature (T_A) = +25°C

Pin Description

Pin No.	Pin Name	Description
1	GND	DC and RF Ground
2	V_{GG}	Negative supply voltage (-5 V) for receive and transmit
3	GND	DC and RF Ground
4	RF IN	Receive input to LNA.Signal is internally AC coupled. Z_{in} = 50 Ω
5	V_{DD}	Positive supply voltage (+5 V) for receive and transmit
6	GND	DC and RF Ground
7	GND	DC and RF Ground
8	$T2V_{DD}$	Positive supply voltage (+5 V) for transmit
9	TxV_{DD}	Positive supply voltage (+5 V) for transmit
10	GND	DC and RF Ground
11	IF IN	Transmit input to IF amplifier. Signal is internally AC coupled.Z_{in} = 140 Ω + 12 pF
12	GND	DC and RF Ground
13	LOV_{DD}	Positive supply voltage (+5 V) for LO amplifier should be ON for receive and transmit.
14	A0	Logic control signal for 4 dB attenuator. CMOS level compatible.
15	A1	Logic control signal for 8 dB attenuator. CMOS level compatible.
16	GND	DC and RF Ground
17	GND	DC and RF Ground
18	LO IN	Input of LO signal.Signal is internally AC coupled. Z_{in} = 50 Ω
19	LOSEL	Logic control signal for LO switch. CMOS level compatible.
20	IF OUT	Receive output from IF amplifier. Signal is internally AC coupled. Z_{out} = 140 Ω + 12 pF
21	RxV_{DD}	Positive supply voltage (+5 V) for receive
22	RxV_{DD}	Positive supply voltage (+5 V) for receive
23	GND	DC and RF Ground
24	$T3V_{DD}$	Positive supply voltage (+5 V) for transmit
25	RF OUT	Transmit output from RF amplifier. Signal is internally AC coupled. Z_{out} = 50 Ω
26	GND	DC and RF Ground
27	$R1V_{DD}$	Positive supply voltage (+5V) for receive
28	GND	DC and RF Ground

Transceiver Truth Table

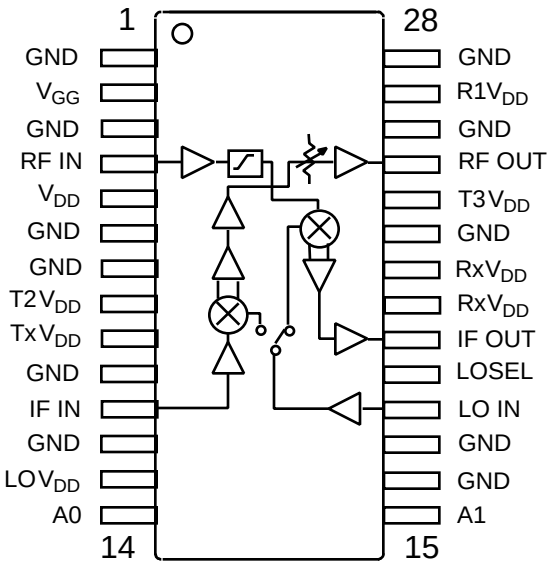
Pins	Receive	Transmit
LOSEL	1	0
$R1V_{DD}$, RxV_{DD}	5 V	0 V
TxV_{DD}, $T2V_{DD}$, $T3V_{DD}$	0 V	5 V

Digital Attenuator Truth Table

Attenuation	A1	A0
0 dB	1	1
4 dB	1	0
8 dB	0	1
12 dB	0	0

"0" = 0 V to 0.5 V @ 3 µA Typ.
"1" = V_{DD} to V_{DD} - 0.5 V @ 3 µA Typ.

Functional Diagram



General Information

The MD58-0002 is a highly integrated MMIC transceiver designed for 2.4 - 2.5 GHz ISM band operation. Its generic architecture and complete up/down conversion functions make this device suitable for low cost, small size and light weight portable radio systems.

The transceiver is composed of a low noise receive chain and a high linearity transmit chain. The receive chain consists of an LNA, on-chip image rejection filter, double balanced mixer and an IF amplifier. The transmit chain consists of IF amplifier, double balanced mixer, two common source RF amplifiers and a digital attenuator with 4- and 8-dB step size. All signal ports, IF input/output, LO input, RF input/output, are terminated single-ended to reduce the complexity of the off-chip component design and ease the interface to other components in the system, such as IF SAW filters and voltage controlled oscillators (VCO).

The transceiver typically consumes 50 mA in receive mode and 95 mA in transmit mode from a +5 V supply. The negative supply current from a -5 V source is typically 2.6 mA for receive mode and 3.6 mA in transmit mode.

Power Management

Power supply lines of the MD58-0002 are configured flexibly so that different modes of operation can be achieved. There are eight supply lines which can be grouped into three categories: (1) Standby Group - V_{DD}, V_{GG}, LOV_{DD}; (2) Receive Group - $R1V_{DD}$, RxV_{DD}; and (3) Transmit Group - TxV_{DD}, $T2V_{DD}$, $T3V_{DD}$.

When the radio is disabled, the MD58-0002 is in a sleep mode where all the groups are 0 V. During standby mode, the LO amplifier and some other bias circuitry need to be ready for receive/transmit modes. The standby group should be ON at all times during standby, receive and transmit modes. The following table summarizes the operation:

Group	Pins	Sleep Mode	Standby Mode	Rx Mode	Tx Mode
Standby	V_{DD}	0 V	+5 V	+5 V	+5 V
	V_{GG}	0 V	-5 V	-5 V	-5 V
	LOV_{DD}	0 V	+5 V	+5 V	+5 V
Receive	$R1V_{DD}$	0 V	0 V	+5 V	0 V
	RxV_{DD}	0 V	0 V	+5 V	0 V
Transmit	TxV_{DD}	0 V	0 V	0 V	+5 V
	$T2V_{DD}$	0 V	0 V	0 V	+5 V
	$T3V_{DD}$	0 V	0 V	0 V	+5 V

To guarantee safe operation, the negative supply V_{GG} should be applied prior to any positive supplies.

Control Signals

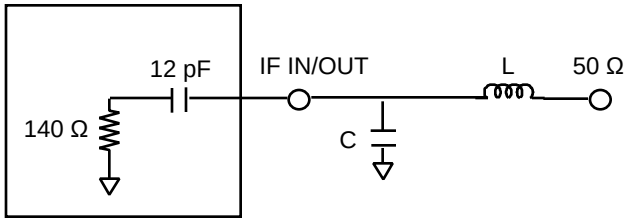
All the control signals (LO switch select, LOSEL and digital attenuator, A0 and A1) are CMOS compatible single positive logic (0 V and V_{DD}).

External Components

The MD58-0002 integrates all passive components required for transceiver functions. The only passive components which cannot be absorbed into MMIC are (1) AC bypass capacitors of 22 pF & 1000 pF and (2) single LC matching section for IF ports.

The AC bypass capacitors are designed to bypass both high (GHz) and low (MHz) frequencies. The absolute values are not critical, but they need to be the right order of magnitude. The placement of these capacitors needs to be as close to the package as possible in order to serve their purpose. (See printed circuit board layout for example.)

The IF input and output ports have an impedance equivalent to a series RC (R = 140Ω , C = 12 pF) network. This impedance can be matched to 50Ω by using a single LC section, as shown below.



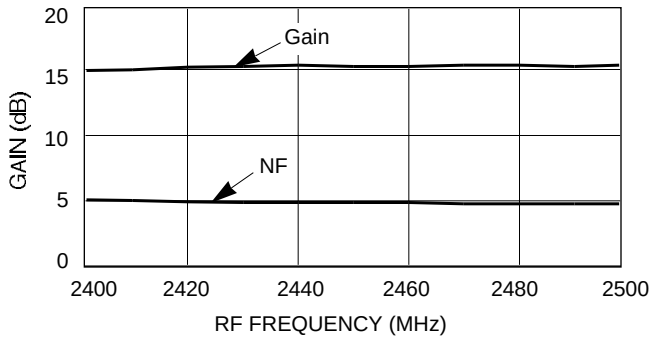
The values of inductance (L) and capacitance (C) are determined by the IF frequency and the length of 50 Ω line between the package and the LC section. The L & C values for the layout depicted in the sample board layout are listed below for a variety of IF frequencies.

IF Frequency	Inductor (L)	Capacitor (C)
200 MHz	68 nH	3 pF
250 MHz	68 nH	3 pF
350 MHz	33 nH	0.5 pF
400 MHz	33 nH	0.5 pF

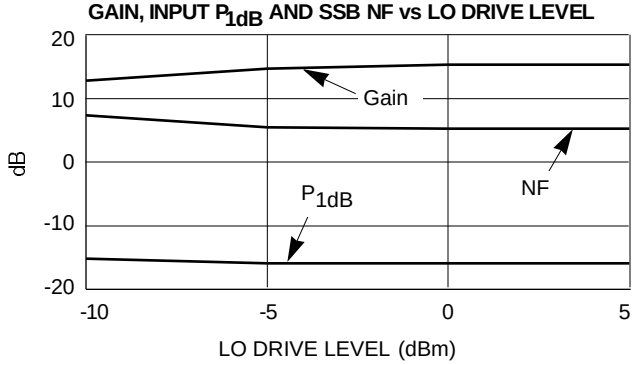
There are several vendors available to supply chip inductors and capacitors.

Typical Receiver Performance Characteristics[1]

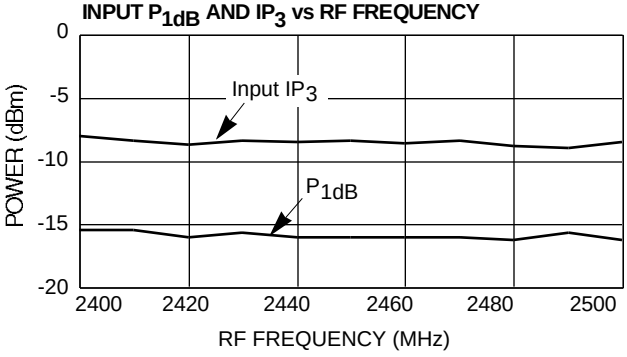
GAIN AND SSB NOISE FIGURE vs RF FREQUENCY



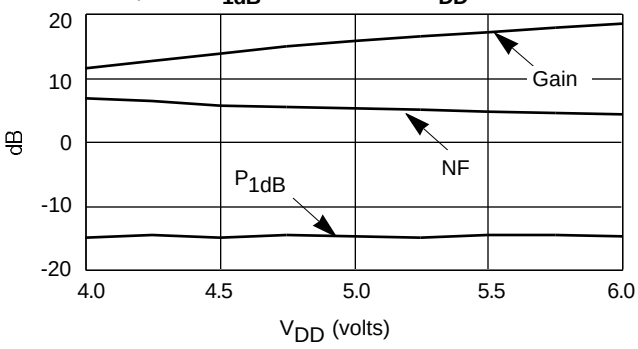
GAIN, INPUT P_{1dB} AND SSB NF vs LO DRIVE LEVEL



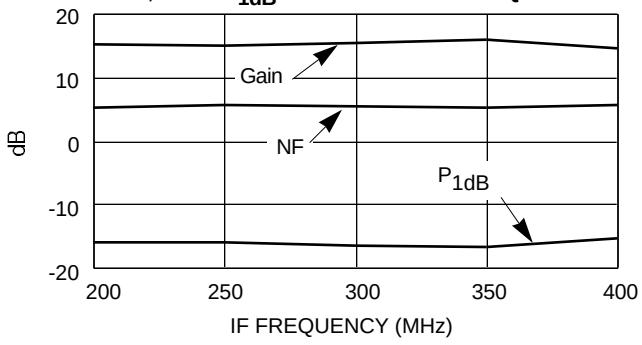
INPUT P_{1dB} AND IP_3 vs RF FREQUENCY



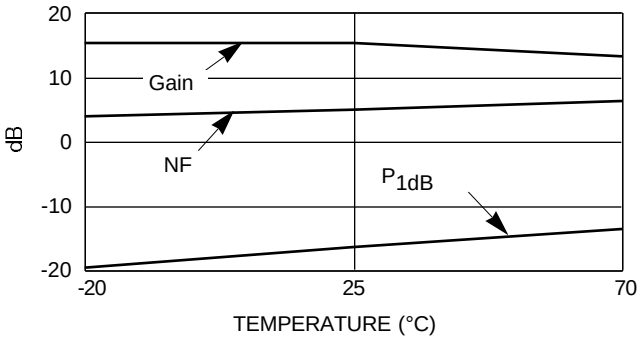
GAIN, INPUT P_{1dB} AND SSB NF vs V_{DD}



GAIN, INPUT P_{1dB} AND SSB NF vs IF FREQUENCY



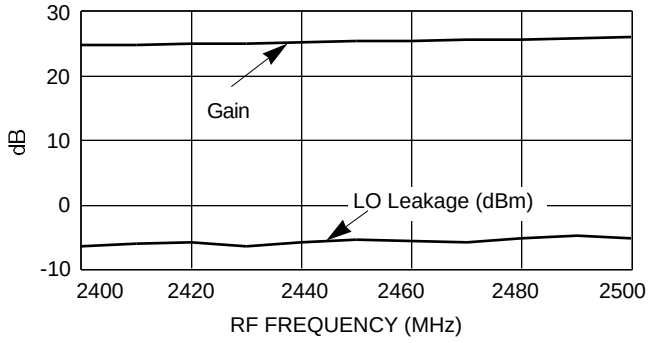
GAIN, INPUT P_{1dB} AND SSB NF vs TEMPERATURE



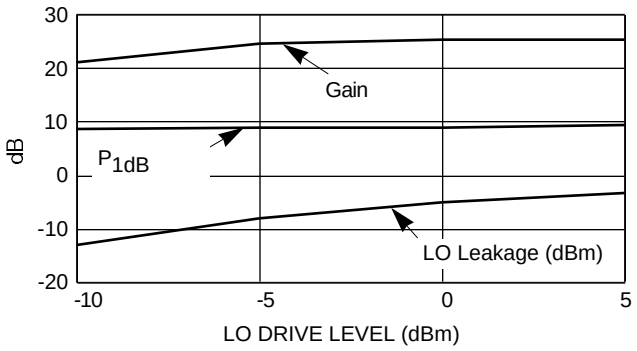
1. Test conditions (unless otherwise specified):
   RF = 2450 MHz, IF = 200 MHz, LO = 2250 MHz, 0 dBm, V_{DD} = +5 V, V_{GG} = -5 V, T_A = +25°C

Typical Transmitter Performance Characteristics[1]

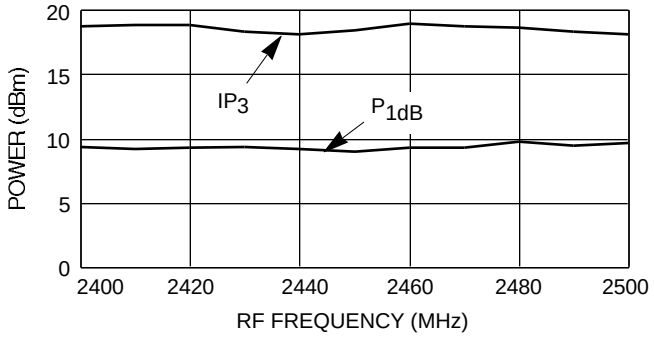
GAIN and LO LEAKAGE vs RF FREQUENCY



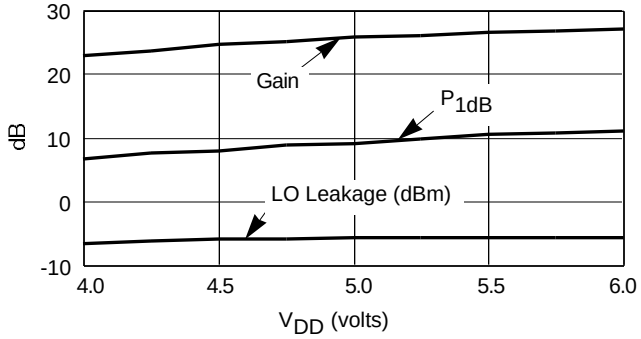
GAIN, P_{1dB} and LO LEAKAGE vs LO DRIVE LEVEL



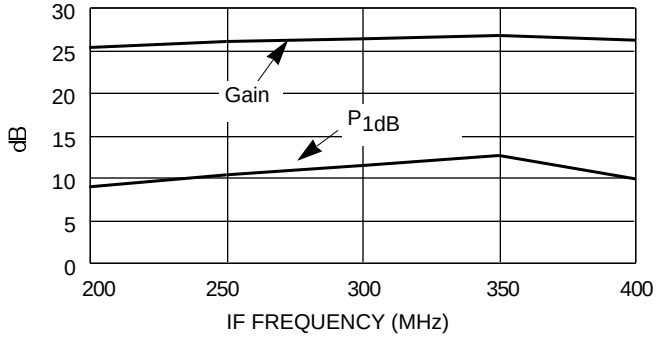
OUTPUT P_{1dB} and IP_3 vs RF FREQUENCY



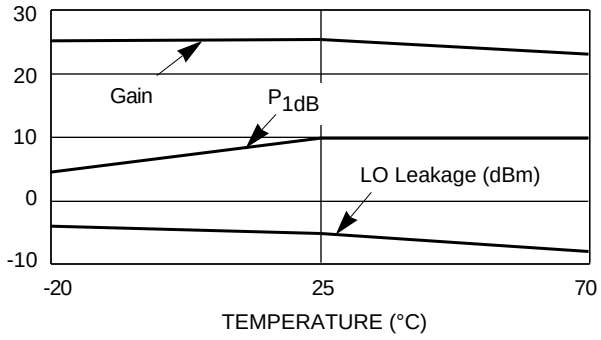
GAIN, OUTPUT P_{1dB} and LO LEAKAGE vs V_{DD}



GAIN and OUTPUT P_{1dB} vs IF FREQUENCY



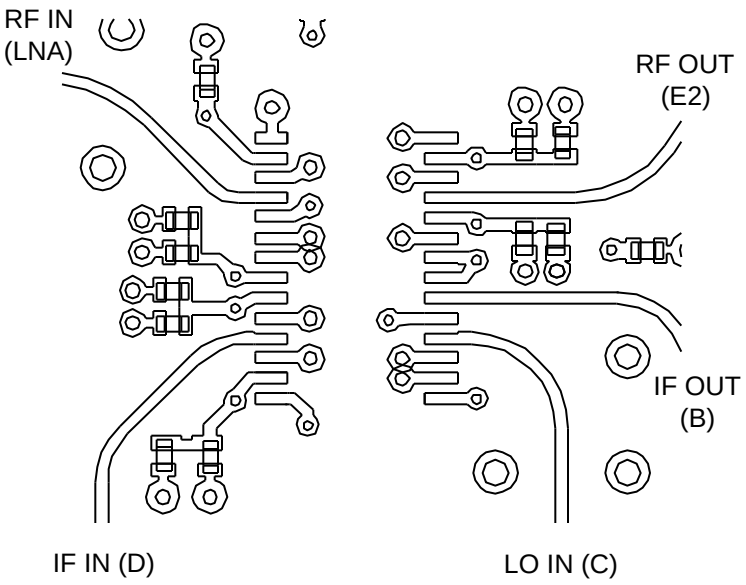
GAIN, OUTPUT P_{1dB} and LO LEAKAGE vs TEMPERATURE



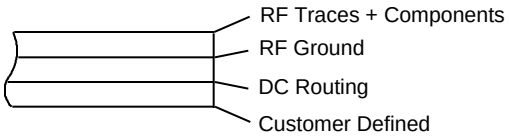
1. Test conditions (unless otherwise specified):
   RF = 2450 MHz, IF = 200 MHz, LO = 2250 MHz, 0 dBm, V_{DD} = +5 V, V_{GG} = -5 V, T_A = +25°C

Recommended PCB Configuration

Layout View



Cross-Section View

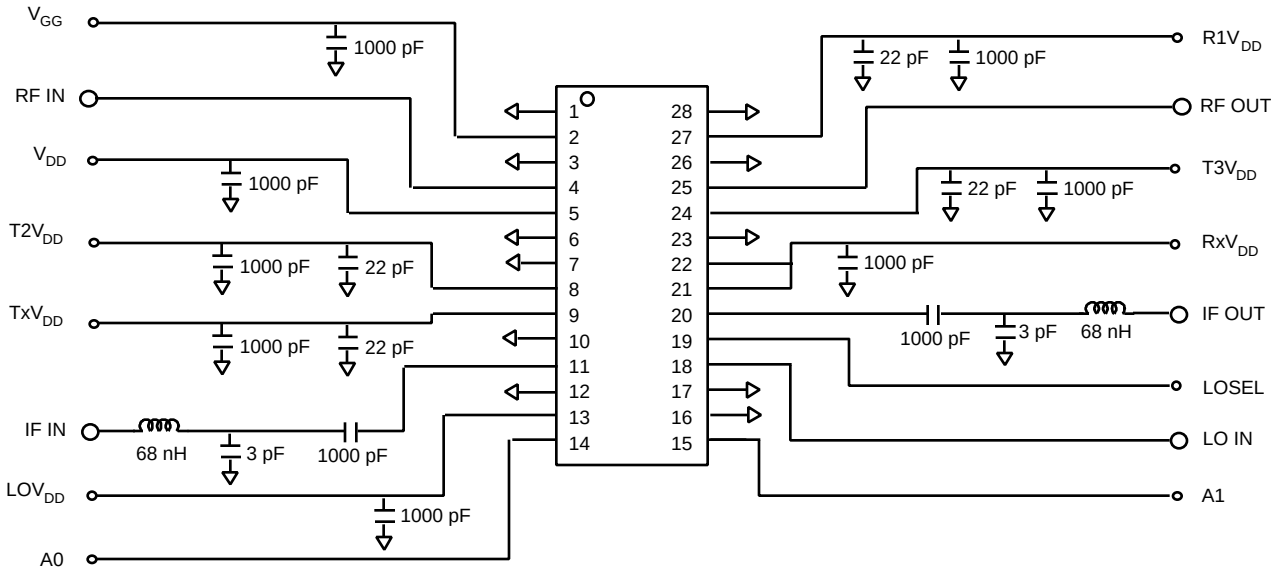


The PCB dielectric between RF traces and RF ground layers should be chosen to reduce RF discontinuities between 50-Ω lines and package pins. M/A-COM recommends an FR-4 dielectric thickness of 0.008 in. (0.2 mm), yielding a 50-Ω line width of 0.015 in. (0.38 mm). The recommened metalization thickness is 1 oz. copper.

Biasing Procedure

The MD58-0002 requires that V_{GG} bias be applied prior to ***any*** V_{DD} bias. Permanent damage may occur if this procedure is not followed. All FETs will draw excessive current and damage internal circuitry.

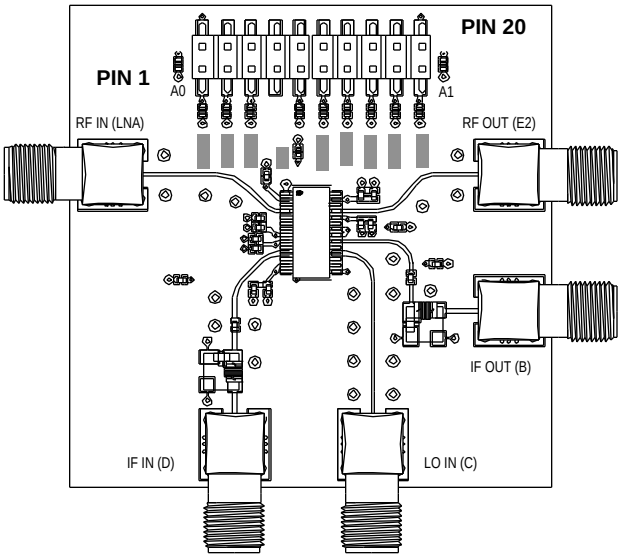
External Circuitry



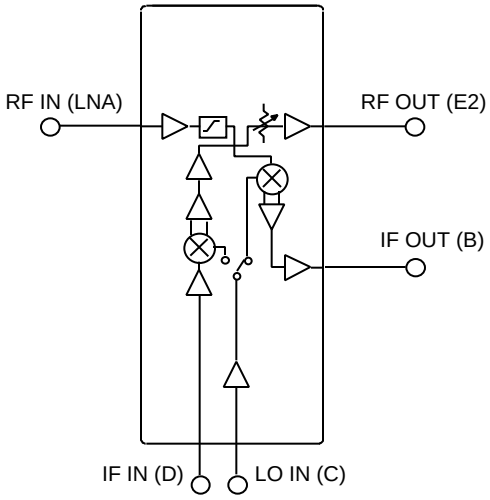
Designer's Kit (MD58-0002SMB)

The MD58-0002SMB Designer's Kit allows for immediate evaluation of M/A-COM's MD58-0002 integrated transceiver without the delays and cost of designing evaluation test boards. The evaluation board consists of an MD58-0002, recommended external surface mount circuitry, RF connectors and a DC multi-pin connector, all mounted to a multi-layer FR-4 PCB. Other items included in the Designer's Kit: a floppy disk (with typical performance data and a DXF file of the recommended PCB layout) and any additional Application Notes. The MD58-0002SMB integrated transceiver evaluation PCB and block diagram are illustrated below with all functional ports labeled.

Transceiver Sample Board



Functional Block Diagram



DC Connector Pinout

Pin	Function/DC Volt	Device Pin Number
1	LOV_{DD}/+5 V	13
2	GND/0 V	N/C
3	TxV_{DD}/+5 V	9
4	A0/0 V, +5 V	14
5	$T2V_{DD}$/+5 V	8
6	N/C	N/C
7	N/C	N/C
8	N/C	N/C
9	V_{GG}/-5 V	2
10	N/C	N/C

Pin	Function/DC Volt	Device Pin Number
11	V_{DD}/+5 V	5
12	N/C	N/C
13	$R1V_{DD}$/+5 V	27
14	N/C	N/C
15	$T3V_{DD}$	24
16	N/C	N/C
17	RxV_{DD}/+5 V	21, 22
18	A1/0V, +5 V	15
19	LOSEL/0 V, +5 V	19
20	GND/0 V	N/C

Note: 5% tolerance for +5 V, 10% tolerance for -5 V

The evaluation of MD58-0002 transceiver is greatly simplified by using this ready-to-measure Sample Board. There are five RF/IF ports: two for transmit input/output, two for receive input/output and one for LO signal input. All the RF/IF ports are AC coupled, either on the board or inside MMIC, and there is no need for any DC blocking. The RF and LO ports are designed to be 50 ohm and the IF ports are matched to 50 ohm on the board @ 200 MHz. The following test procedure will guide you to evaluate several key parameters of the highly integrated transceiver.

Transmit Mode Test Procedure

DC Bias Sequence:

1. Set V_{GG} pin to -5 V.
2. Set V_{DD}, LOV_{DD}, $T2V_{DD}$, $T3V_{DD}$, TxV_{DD}, A0, and A1 pins to +5 V.
3. Set LOSEL, $R1V_{DD}$, and RxV_{DD} pins to 0 V.

RF/IF Signals:

1. Apply LO signal of 2284 MHz, 0 dBm to LO IN (C) port.
2. Apply IF signal of 200 MHz, -30 dBm to IF IN (D) port.

Measurements:

1. Measure transmit upper-side-band conversion gain at 2484 MHz from RF OUT (E2) port.
2. Measure transmit lower-side-band conversion gain at 2084 MHz from RF OUT (E2) port.
3. Measure transmit LO leakage at 2284 MHz from RF OUT (E2) port.

Other Measurements:

1. Measure DC supply currents from both +5 V and -5 V source.
2. Set A0 pin to 0 V to obtain 4 dB attenuation. Set A1 pin to 0 V to obtain 8 dB attenuation.
3. Increase input IF power until 1-dB gain compression occurs.

Receive Mode Test Procedure

DC Bias Sequence:

1. Set V_{GG} pin to -5 V.
2. Set V_{DD}, LOV_{DD}, RxV_{DD}, $R1V_{DD}$, LOSEL, A0, and A1 pins to +5 V.
3. Set $T2V_{DD}$, $T3V_{DD}$, and TxV_{DD} pins to 0 V.

RF/IF Signals:

1. Apply LO signal of 2284 MHz, 0 dBm to LO IN (C) port.
2. Apply RF signal of 2484 MHz, -30 dBm to RF IN (LNA) port.

Measurements:

1. Measure receive conversion gain at 200 MHz from IF OUT (B) port.

RF/IF Signals:

1. Apply LO signal of 2284 MHz, 0 dBm to LO IN (C) port.
2. Apply RF image signal of 2084 MHz, -30 dBm to RF IN (LNA) port.

Measurements:

1. Measure receive image conversion gain at 200 MHz from IF OUT (B) port.

Other Measurements:

1. Measure DC supply currents from both +5 V and -5 V source.
2. Increase input RF power until 1-dB gain compression occurs.

Evaluation PCB and RF Connector Losses

Port Reference	Estimated Loss (dB)
RF IN (LNA)	0.28
RF OUT (E2)	0.28
LO IN (C)	0.29
IF IN (D)	0.10
IF OUT (B)	0.10

The DC connector on the Designer's Kit PCB allows selection of all the device's operating modes. It is accomplished by one or more of the following methods:

1. A mating female multi-pin connector (Newark Electronics Stock # 46F-4658, not included)
2. Wires soldered to the necessary pins (not included)
3. Clip leads (not included)
4. A combination of clip leads or wires and jumpers (jumpers included as required)