

# LTC5564

## 15GHz RF Power Detector with Comparator

### DESCRIPTION

The demonstration circuit 1646A features the LTC<sup>®</sup>5564, an UltraFast™ RF peak detector with a built in gain-selectable high speed operational amplifier and comparator.

The 1646A demo circuit includes a simple impedance matching network that provides better than 10dB return loss for working frequencies ranging from 5.2GHz and from 14.7GHz to 16.5GHz. The input matching circuit can be easily changed for other working frequency

plans. The Demo Circuit Modification page provides the design information required for modifying with this demo circuit 1646A.

**Design files for this circuit board are available at <http://www.linear.com/demo>**

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### PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C), V<sub>CC</sub> = V<sub>CCRF</sub> = V<sub>CCA</sub> = V<sub>CCP</sub> = 5V

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage		3		5.5	V
Supply Current			44		mA
<b>Amplifier Characteristics</b>					
V <sub>OUT</sub> Output Offset	Supply Voltage = 5V, No RFIN		290		mV
	Gain1		295		mV
	Gain2		315		mV
	Gain4		360		mV
	Gain8				mV
	Supply Voltage = 3.3V, No RFIN		280		mV
	Gain1		280		mV
	Gain2		290		mV
	Gain4		315		mV
	Gain8				mV
Demodulation Bandwidth	Gain1, V <sub>OUT</sub> = 500mV		75		MHz
	Gain2, V <sub>OUT</sub> = 500mV		52		MHz
	Gain4, V <sub>OUT</sub> = 500mV		35		MHz
	Gain8, V <sub>OUT</sub> = 500mV		15		MHz
V <sub>OUT</sub> Output Voltage Swing	Supply Voltage = 3V to 5V	0.3		V <sub>CCA</sub> - 1.6	V
<b>Comparator Characteristics</b>					
V <sub>COMP</sub> Low	Supply Voltage = 5V		0.2		V
V <sub>COMP</sub> High	Supply Voltage = 5V		4.8		V
Comparator Response Time	10dBm RFIN Step to V <sub>COMP</sub> 50%		9		ns
Comparator Hysteresis			10		mV
<b>RF Characteristics</b>					
RFIN Frequency Range		0.6		15	GHz
RFIN AC Input Resistance	Frequency = 1000MHz, Power Level = 0dBm		135		Ω
RFIN Input Shunt Capacitance	Frequency = 1000MHz, Power Level = 0dBm		0.77		pF
RFIN Input Power Range		-24		16	dBm
<b>Digital I/O</b>					
	LOW = 0.8V (Max), HIGH = V <sub>CCA</sub> - 0.8V (Min)				
LEN	Comparator Enable			0.8	V
	Comparator Disable	V <sub>CCA</sub> - 0.8			V

dc1646af

## QUICK START PROCEDURE

### Operation

The demonstration circuit 1646A is preconfigured to work for applications at frequencies of 5.8GHz and 15GHz. It has better than 15dB return loss at these targeted frequencies. The input dynamic range at 5.8GHz is 40dB (from -24dBm to 16dBm) and slightly lower sensitivity at 15GHz.

### Comparator

The high speed comparator compares the external reference voltage on the  $V_{REF}$  pin to the internal signal voltage  $V_P$  from the peak detector and produces the output logic signal  $V_{COMP}$ .  $V_P$  is the internal comparator positive input as shown in Figure 1 Simplified Block Diagram.

The demo board has a typical 10mV hysteresis for its comparator and its response time can be as fast as 9ns (10dBm input power step to  $V_{COMP}$  50%) through out its supporting frequencies.

The, 1646A demo board's, LEN test point provides latch enable/disable functionality of the comparator. The comparator is always enabling with the pulling down 10k resistor (R8) to ground. Connecting The LEN test point to  $V_{CC}$  will place the comparator in the disable mode.

The R1 and R2 footprints are optional for configuring DC voltage of the  $V_{REF}$  test point. The C1 is the ground coupling capacitor of the, R1 and R2, voltage divider.

The VCC\_COMP (E11) test point is an alternative output of  $V_{COMP}$  (J2 SMA connector). Install a  $0\Omega$  resistor or a jumper to R3 will have the comparator Output at VCC-COMP test point.

### Loading Bypass Capacitors

The LTC5564 has been designed to directly drive a capacitive load of 10pF at  $V_{OUT}$ . When driving a capacitive load greater than 10pF a series resistance should be added between  $V_{OUT}$  and the load to maintain good stability. This resistance should be placed as close to  $V_{OUT}$  as possible.

The demo board 1646A is loaded with R series = R6 =  $0\Omega$ . Refer to Table 2 for typical series resistor (R6) values for various capacitive loads.

**Table 2. Typical Series Resistor (R6) Values for  $V_{OUT}$  Capacitive Loading**

LOAD	R SERIES(R6)
Up to 10pF	$0\Omega$
11pF to 20pF	$40\Omega$
21pF to 100pF	$68\Omega$
Greater Than 100pF	$100\Omega$

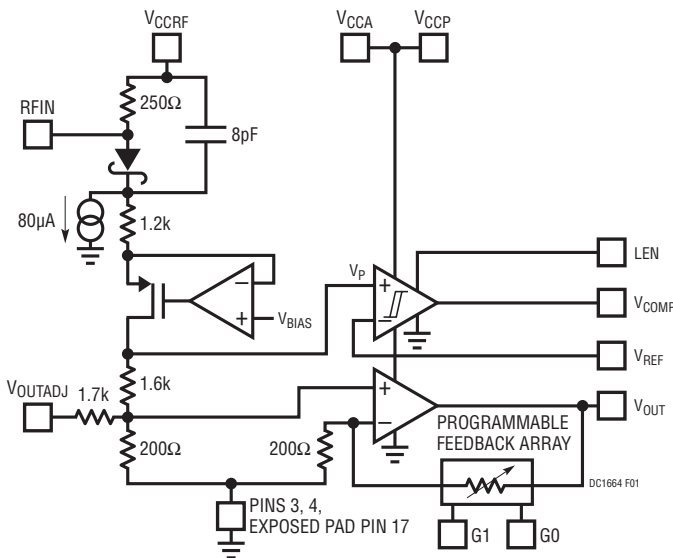
### Amplifier

The high speed amplifier offers four gain settings and is capable of driving a 1.7mA load with an output swing range of approximately 295mV to  $V_{CC} - 1.6V$ .

The standard demonstration circuit 1646A has a unity gain. Therefore, the pins G0 and G1 (or the test point Gain0 and Gain1) are pulling down for the logical Low with R10 = R11 = 10k resistors. The pins can be connected to  $V_{CC}$  forming the logical High for others gains setting. Refer to Table 3 for gain setting operation.

The  $V_{OUTADJ}$  pin provides output DC offset adjustment to satisfy various interface requirements. Setting  $V_{OUT}$  to 500mV also provides the maximum demodulation bandwidth in each gain mode.

The R9, R12 and C13 footprints are provided on the demo board to configure the  $V_{OUTADJ}$  DC voltage. The R9 and R12 are forming voltage divider topology and the C13 is the ground coupling capacitor. Refer to the LTC5564



**Figure 1. Simplified Block Diagram**

## QUICK START PROCEDURE

data sheet for Typical Performance Characteristics curve or Table 3 for the typical  $V_{OUTADJ}$  voltage for the desired  $V_{OUT}$  DC output offset in each gain setting.

The VCC\_OUT (E12) test point is an alternative output of  $V_{OUT}$  (J3 SMA CONNECTOR). Install a  $0\Omega$  resistor or a jumper at R5 will have the  $V_{OUT}$  at this VCC\_OUT test point.

The R7 and C12 footprints are provided for output loading at designed resistance and capacitance.

Demonstration circuit 1646A is easy to setup for evaluating the performance of the LTC5564. Refer to Figure 2 for measurement equipment set-up and follow the procedure below:

### A. Measure Detector Output Power ( $V_{OUT}$ ):

Connect DC power supply's negative (-) lead to demo board GND test point and positive (+) lead (between 3V to 5.5V) to  $V_{CC}$  test point.

Connect a DC volt meter to the  $V_{OUT}$  port (SMA connector J3) to measure the DC detector output voltage.

Connect signal generator's output to demo board RFIN (SMA connector J1) via coaxial cable. It is common practice to include a 2dB or 3dB attenuation pad to minimize reflections back into the signal generator. (Typical 540mV  $V_{OUT}$  with 0dBm input power at 5.8GHz)

### B. Measure Comparator Output ( $V_{COMP}$ ):

Connect DC power supply's negative (-) lead to demo board GND test point and positive (+) lead (between 3V to 5.5V) to  $V_{CC}$  test point.

Connect a DC volt meter (or an oscilloscope) to the  $V_{COMP}$  port (SMA connector J2) to measure the  $V_{COMP}$  switch point voltages.

Set  $V_{REF}$  to desired reference voltage. (with 10dBm input power at RFIN, the typical  $V_{REF}$  tripped point is 1.23V)

Increase The RF input power level to the point when the  $V_{COMP}$  output voltage will go to a high level. (typically  $V_{CC} - 0.2V$ )

Optional measurements can be done by increasing  $V_{REF}$  reference level. During the measurements, when  $V_{COMP}$  is HIGH, connect LEN to  $V_{CC}$ . Remove the RF input signal and the  $V_{COMP}$  will continue to stay high.

**Table 3. Gain Mode and Typical  $V_{OUTADJ}$  Operation**

PIN		GAIN MODE	DESCRIPTION	REQUIRED $V_{OUTADJ}$ FOR A GIVEN DC OUTPUT OFFSET
G1	G0			
GND	GND	GAIN1	Minimum Gain Setting ( $V_{OUT}/RFIN \approx 1.5dB$ )	$V_{OUTADJ} = 0.95 \cdot V_{OUT} - 0.174$
GND	$V_{CCA}$	GAIN2	$V_{OUT}/RFIN$ Increased 6dB	$V_{OUTADJ} = (V_{OUT} - 0.07)/2.10$
$V_{CCA}$	GND	GAIN4	$V_{OUT}/RFIN$ Increased 12dB	$V_{OUTADJ} = (V_{OUT} + 0.05)/3.16$
$V_{CCA}$	$V_{CCA}$	GAIN8	$V_{OUT}/RFIN$ Increased 18dB	$V_{OUTADJ} = (V_{OUT} + 0.25)/5.26$

Note: Valid range for  $V_{OUT} \approx 0.195V \leq V_{OUT} \leq V_{CC} - 1.6$

## QUICK START PROCEDURE

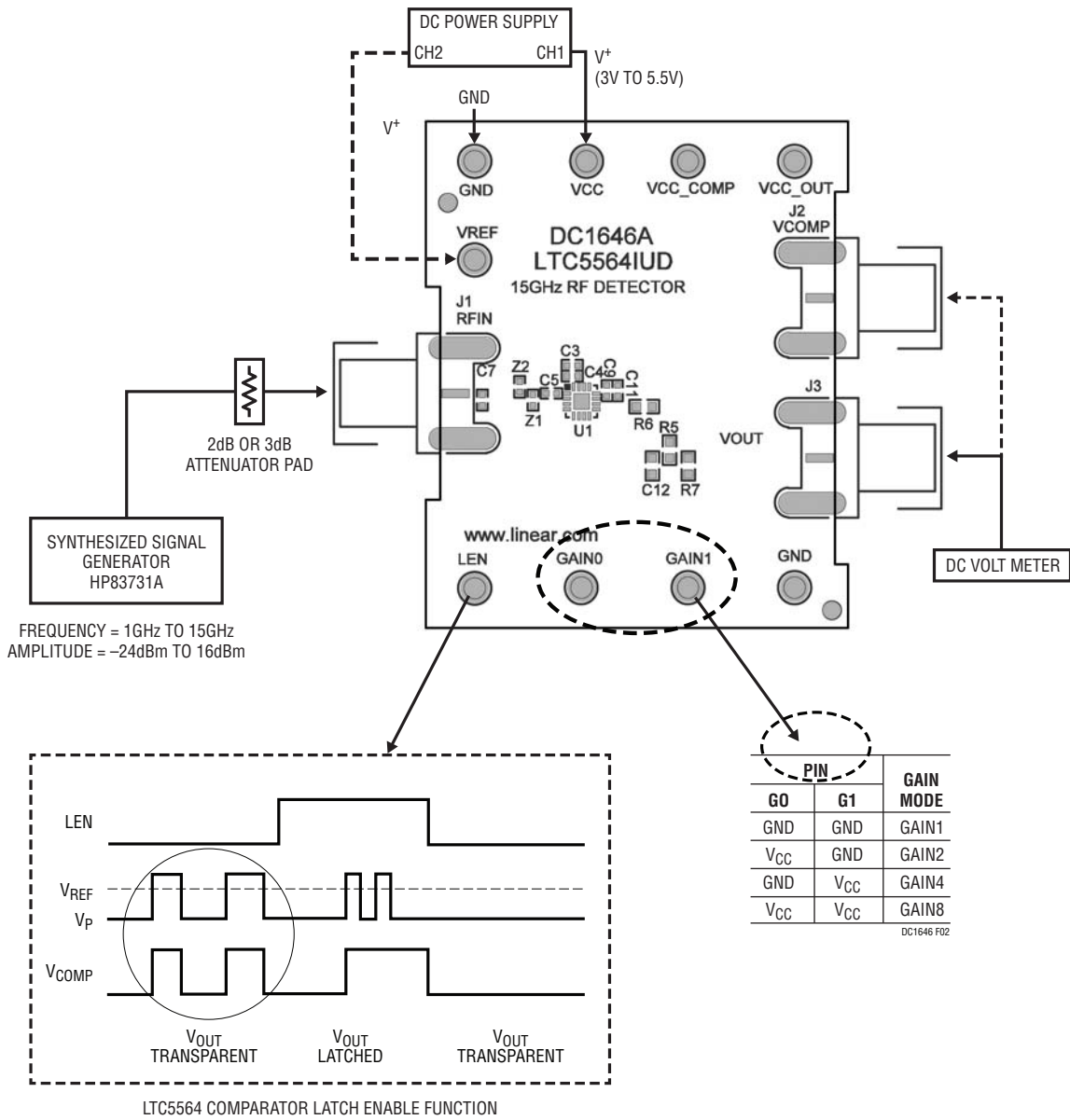
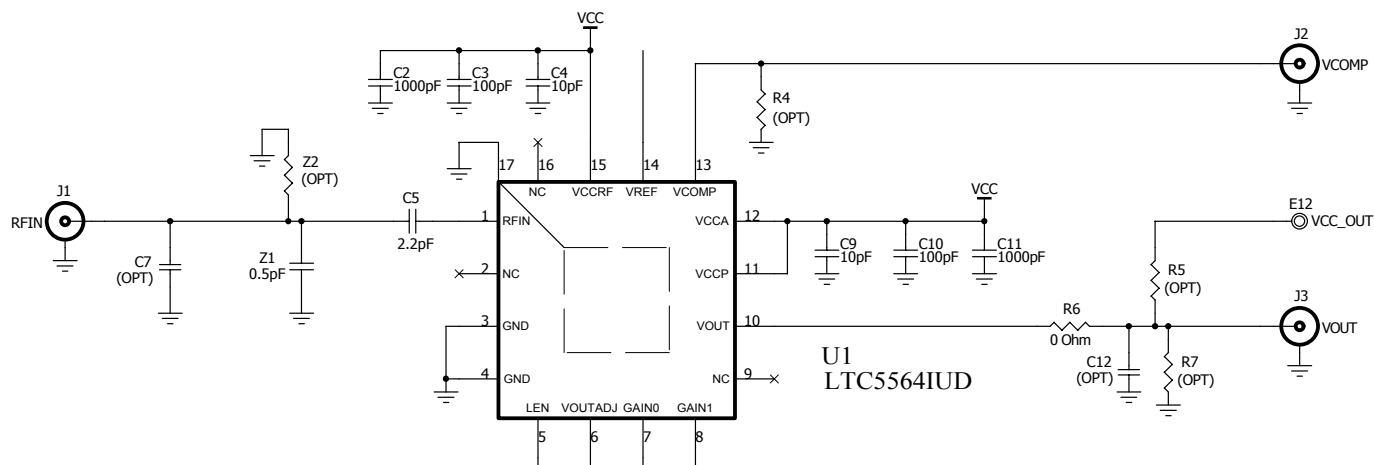


Figure 2. Proper Measurement Equipment Set-Up

## QUICK START PROCEDURE

### Modification of RFIN Port for Other Frequency Ranges



### Impedance Matching Circuits Components and Values at Selected Frequency Ranges

FREQUENCY RANGE <sup>(1)</sup>	C5 VALUE/PART# <sup>(2)</sup>	Z1 VALUE/PART# <sup>(2)</sup>	Z2 VALUE/PART# <sup>(2)</sup>
1.6GHz to 3.4GHz	100pF/GJM1555C1H101JZ01	6.8nH/0402CS-6N8XGL	No Placement
7GHz to 8.5GHz	0.5pF/GJM1555C1HR50BB01	0.3pF/GJM1555C1HR30BB01	No Placement
8.6GHz to 10.7GHz	0.2pF/GJM1555C1HR20BB01	0.1pF/GJM1555C1HR10BB01	No Placement
11.7GHz to 12.2GHz	10pF/GJM1555C1H100JB01	No Placement	2.2pF/GJM1555C1H2R2CB01
0.5GHz to 1.9GHz and 5.7GHz to 11.3GHz <sup>(3)</sup>	20pF/GJM1555C1H200JB01	137Ω/RK73H1ETTP1370F	137Ω/RK73H1ETTP1370F
5.2GHz to 6.2GHz and 14.7GHz to 16.5GHz <sup>(4)</sup>	2.2pF/GJM1555C1H2R2CB01	0.5pF/GJM1555C1HR50BB01	No Placement

(1) The impedance matching networks at stated frequency ranges have 10dB or better return loss.

(2) Capacitors, inductors and resistors are manufacture by MURATA, COILCRAFT or KOA respectively.

(3) Resistive matching has wider frequency ranges at the expense of degraded sensitivity by 6dB to 8dB.

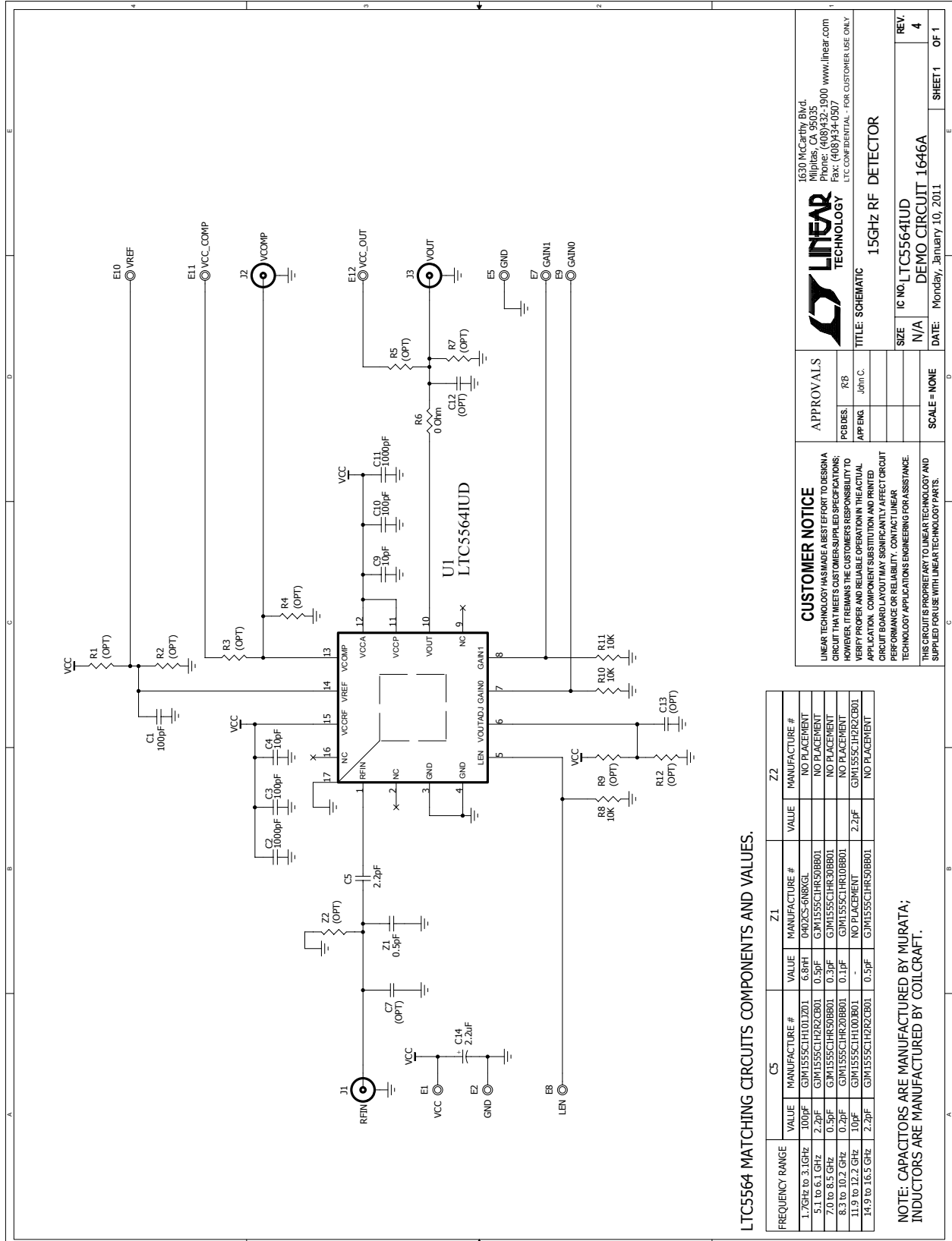
(4) Default DC1646A demo board frequencies ranges.

# DEMO MANUAL DC1646A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	3	C1, C3, C10	CAP, NPO 100pF 25V 10% 0402	AVX 04023A101KAT2A
2	2	C2, C11	CAP, X7R 1000pF 50V 10% 0402	AVX 04025C102KAT2A
3	2	C4, C9	CAP, NPO 10pF 25V 10% 0402	AVX 04023A100KAT2A
4	1	C5	CAP, COG 2.2pF 50V ±0.25pF 0402	MURATA GJM1555C1H2R2CB01D
5	0	C7, C13 (OPT)	CAP, 0402	
6	0	C12 (OPT)	CAP, 0603	
7	1	C14	CAP, TANT 2.2µF 20V 20% 3216	AVX TPSA225M020R3000
8	9	E1, E2, E5, E7, E8, E9, E10, E11, E12	TURRET, TESTPOINT 0.063"	MILL MAX 2308-2-00-80-00-00-07-0
9	3	J1, J2, J3	CONN, SMA 50Ω	E. F. JOHNSON 142-0701-851
10	0	R1 to R5, R7, R9, R12 (OPT)	RES, 0603	
11	1	R6	RES/JUMPER, CHIP 0Ω 1/16W 1A 0603	VISHAY CRCW06030000Z0EA
12	3	R8, R10, R11	RES, CHIP 10K 0.06W 5% 0603	VISHAY CRCW060310K0JNEA
13	1	U1	I.C., PRECISION RF PWR DET QFN(16)(UD)3mm × 3mm	LINEAR TECHNOLOGY CORP LTC5564IUD
14	1	Z1	CAP, COG 0.50pF 50V ±0.1pF 0402	MURATA GJM1555C1HR50BB01D
15	0	Z2 (OPT)	RES, 0402	
16	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 1646A
17	1		STENCIL	STENCIL 1646A

SCHEMATIC DIAGRAM



LTC5564 MATCHING CIRCUITS COMPONENTS AND VALUES.

FREQUENCY RANGE	C5	Z1	Z2
1.7GHz to 3.1GHz	100pF	040ZCS-6NBXGCL	NO PLACEMENT
5.1 to 6.1 GHz	2.2pF	GJM1555CHR20B01	NO PLACEMENT
7.0 to 8.5 GHz	0.5pF	GJM1555CHR30B01	NO PLACEMENT
8.3 to 10.2 GHz	0.2pF	GJM1555CHR20B01	NO PLACEMENT
11.9 to 12.2 GHz	10pF	GJM1555CH100B01	2.2pF
14.9 to 16.5 GHz	2.2pF	GJM1555CHR20B01	NO PLACEMENT

NOTE: CAPACITORS ARE MANUFACTURED BY MURATA;  
INDUCTORS ARE MANUFACTURED BY COILCRAFT.

**CUSTOMER NOTICE**  
LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS; HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.

**APPROVALS**

POBDES	R8
APP ENG	John C.

SCALE = NONE

IC NO. LTC5564IUUD  
DEMO CIRCUIT 1646A

DATE: Monday, January 10, 2011

REV: 4

SHEET 1 OF 1

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**LINEAR TECHNOLOGY**

TITLE: SCHEMATIC  
15GHz RF DETECTOR

# DEMO MANUAL DC1646A

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