

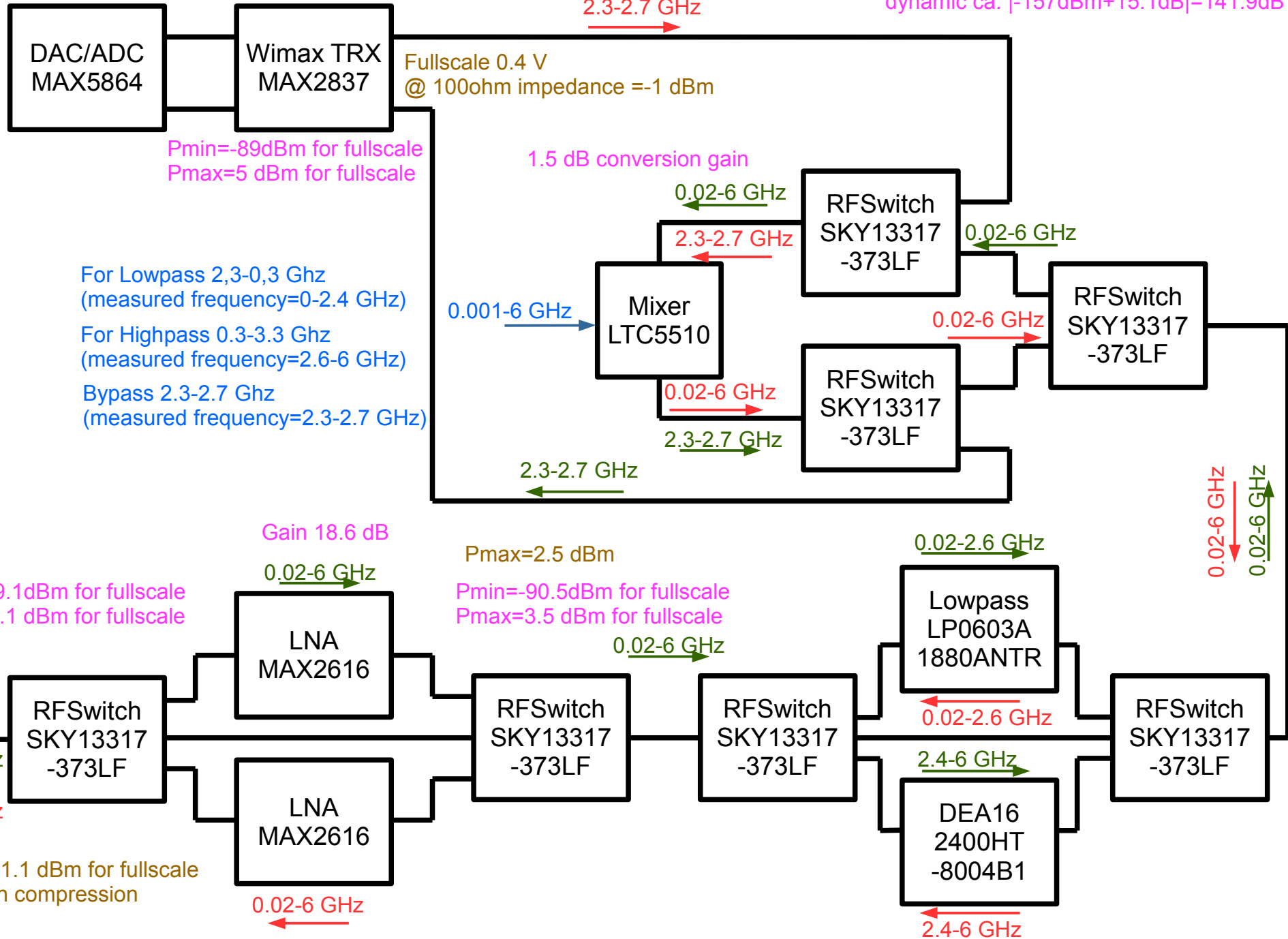
RX level analysis

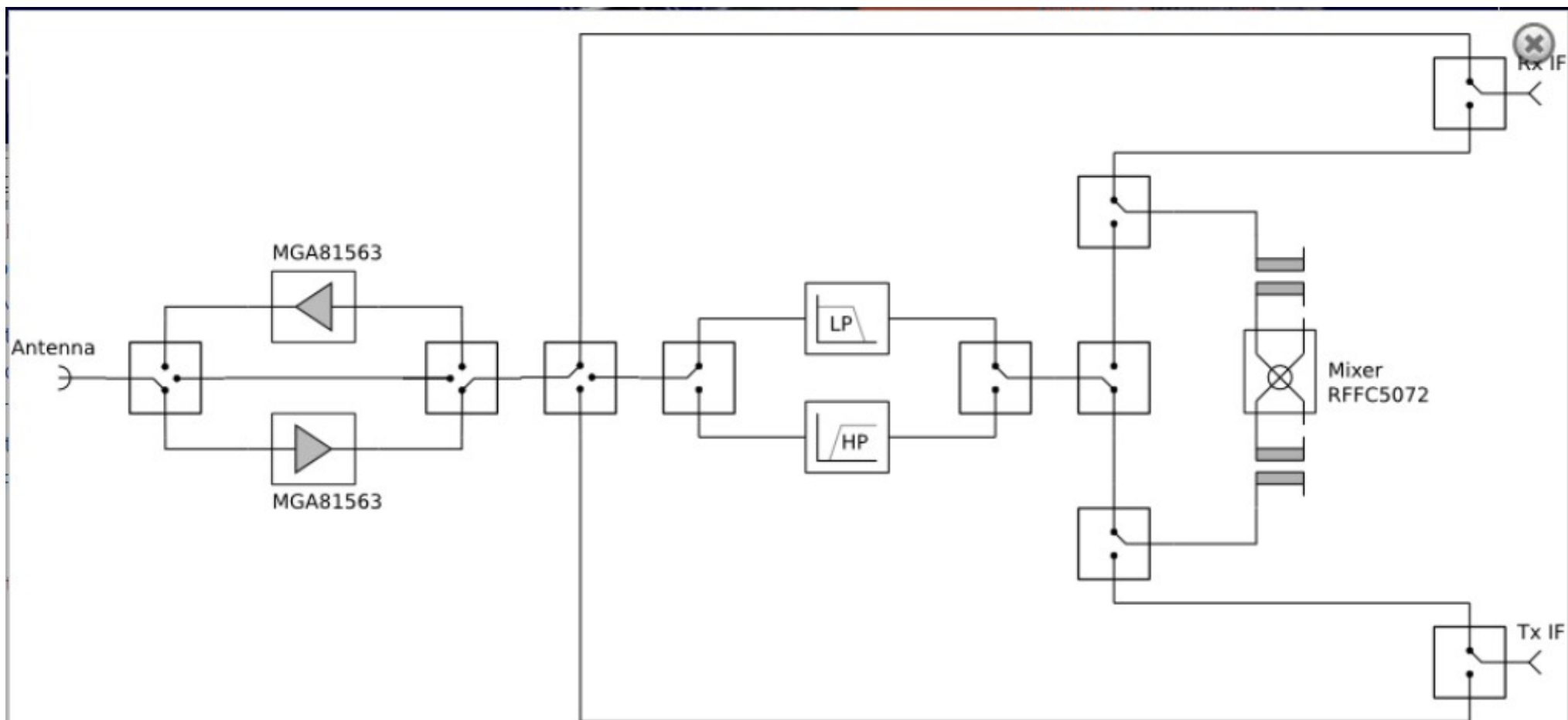
TX level analysis

Voltage gain 5-99dB (RF0-32dB; BB 0-62dB)  
P1dB=-37dBm @RFATT0dB  
100ohm impedance

Noise floor ca. -109dBm-48dB=-157dBm  
dynamic ca. |-157dBm+15.1dB|=141.9dB

1V fullscale





### HackRF One Frontend Block diagram

based on frontend schema dated 13. Feb. 2014

(C) Ekkie Plicht, DF4OR WiMo

## Current consumption

	mA	V
Mixer	105	3.3/5
LNA	2x81	3-5.5
Tranceiver	RX110 TX170	2.7-3.6
ADC	14	1.8-3.3
LPC4300	100	3.3
Switch	-	3.3/5
SUMRX	410mA	
SUMTX	470mA	

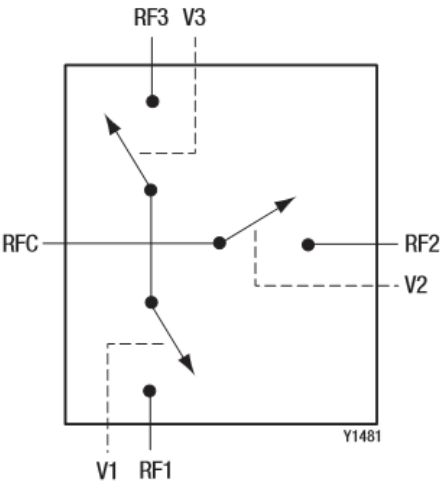
# SKY13317-373LF: 20 MHz to 6.0 GHz pHEMT GaAs SP3T Switch

## Applications

- 802.11 a/b/g/n WLAN networks
- Bluetooth® systems

## Features

- Positive low voltage control: 0/1.8 to 5.0 V
- Low insertion loss: 0.5 dB @ 2.5 GHz, 0.9 dB @ 6 GHz
- High isolation: 25 dB up to 6 GHz
- Excellent linearity performance: P1dB = +29 dBm
- Miniature, ultra-thin MLP (8-pin, 1.5 x 1.5 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



3 <sup>rd</sup> Order Input Intercept Point	IIP3	900 to 2450 MHz, $\Delta F = 1$ MHz, $P_{IN} = +17$ dBm/tone $V_{LOW} = 0$ V, $V_{HIGH} = 2.1$ V $V_{LOW} = 0$ V, $V_{HIGH} = 3.3$ V	+33 +50	dBm dBm
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Table 4. SKY13317-373LF Truth Table

Low Insertion Loss Path	V1 (Pin 3)	V2 (Pin 6)	V3 (Pin 7)
RFC to RF1	High	Low	Low
RFC to RF2	Low	High	Low
RFC to RF3	Low	Low	High

Note: "High" = 1.8 to 5.0 V. "Low" = 0 to 0.25 V. Any state other than described in this Table places the switch into an undefined state. An undefined state will not damage the device.



## 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

MAX2837

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### Features

- ◆ 2.3GHz to 2.7GHz Wideband Operation
- ◆ Complete RF Transceiver, PA Driver, and Crystal Oscillator
  - 0dBm Linear OFDM Transmit Power
  - 70dBm Tx Spectral Emission Mask
  - 2.3dB Rx Noise Figure
  - Tx/Rx I/Q Error and LO Leakage Detection
  - Monolithic Low-Noise VCO with -39dBc Integrated Phase Noise
  - Programmable Tx I/Q Lowpass
  - Anti-Aliasing Filter
  - Sigma-Delta Fractional-N PLL with 20Hz Step Size
  - 45dB Tx Gain-Control Range
  - 94dB Receive Gain-Control Range
  - 60dB Analog RSSI Instantaneous Dynamic Range
  - 4-Wire SPI™ Digital Interface
  - I/Q Analog Baseband Interface
  - Digitally Tuned Crystal Oscillator
  - On-Chip Digital Temperature Sensor Read-Out
- ◆ +2.7V to +3.6V Transceiver Supply
- ◆ Low-Power Shutdown Current
- ◆ Small 48-Pin Thin QFN Package (6mm x 6mm x 0.8mm)

## Lowpass

# Thin-Film Low Pass Filter

## LP0603 Lead-Free LGA Type

### GENERAL DESCRIPTION

The LP0603 ITF (Integrated Thin Film) Lead-Free LGA Low Pass Filter is based on thin-film multilayer technology. The technology provides a miniature part with excellent high frequency performance and rugged construction for reliable automatic assembly.

The ITF Low Pass Filters are offered in a variety of frequency bands compatible with various types of high frequency wireless systems.

### FEATURES

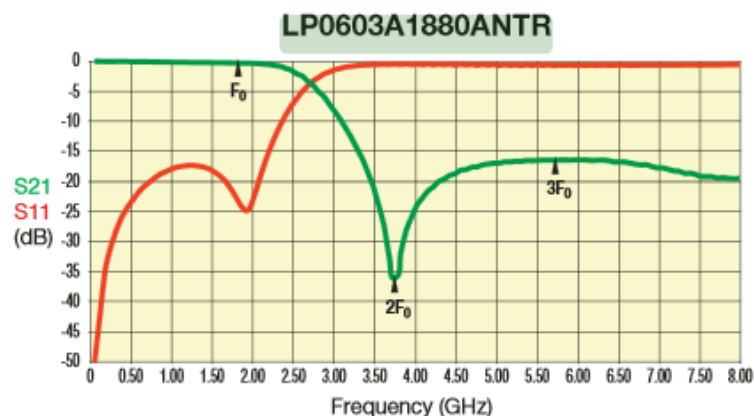
- Miniature Size: 0603
- Frequency Range: 900MHz-5.5GHz
- Characteristic Impedance: 50 Ohm
- Operating/Storage Temperature: -40°C to +85°C
- Power Rating: 3W Continuous
- Low Profile
- Rugged Construction
- Lead Free
- Taped and Reeled

### APPL

- Mobil
- Satelli
- GPS
- Vehicl
- Wirele
- RFID

### LANC

- Inhere
- Self A
- Excell
- Low F
- Better

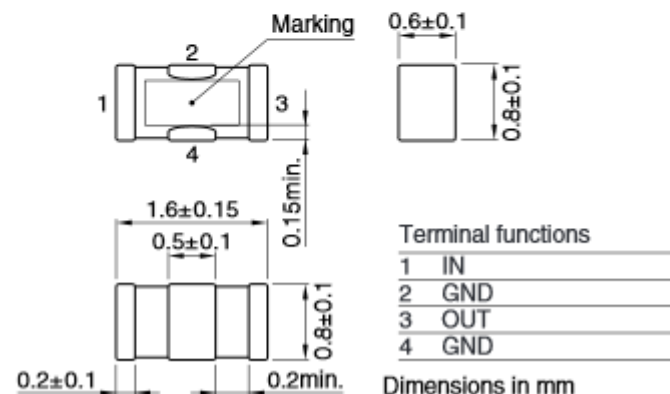


## Highpass

# Multilayer Chip High Pass Filters For Bluetooth & 2.4GHz W-LAN

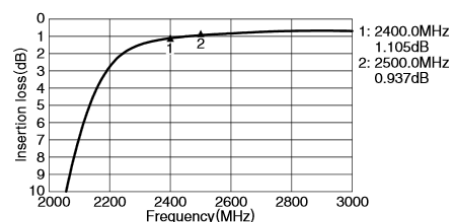
## DEA Series DEA162400HT-8004B1

### SHAPES AND DIMENSIONS

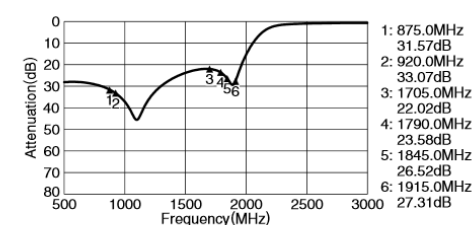


### FREQUENCY CHARACTERISTICS

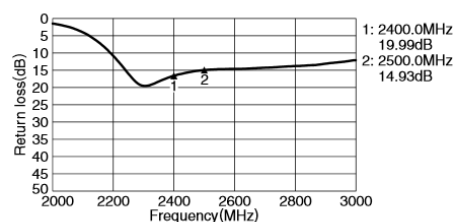
#### INSERTION LOSS



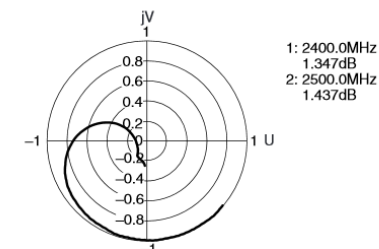
#### ATTENUATION



#### RETURN LOSS



#### VSWR



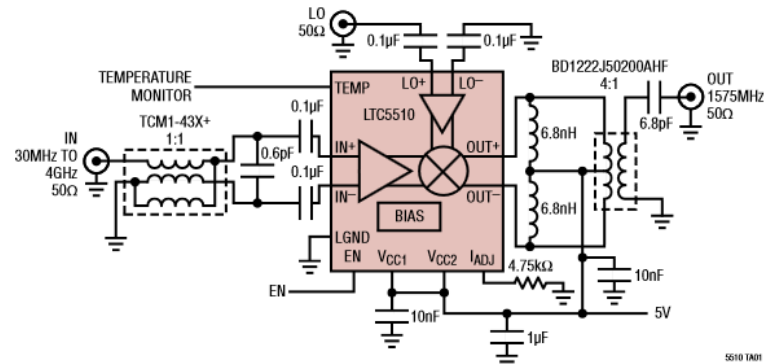
# LTC5510

## 1MHz to 6GHz Wideband High Linearity Active Mixer

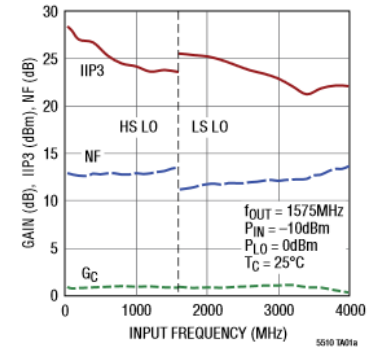
### FEATURES

- Input/LO Frequency Range to 6GHz
- 50Ω Matched Input from 30MHz to >3GHz
- Capable of Up- or Down-Conversion
- **OIP3: 27dBm at  $f_{OUT} = 1575\text{MHz}$**
- **1.5dB Conversion Gain**
- **Noise Figure: 11.6dB at  $f_{OUT} = 1575\text{MHz}$**
- **High Input P1dB: 11dBm at 5V**
- **5V or 3.3V Supply at 105mA**
- Shutdown Control
- LO Input Impedance Always Matched
- 0dBm LO Drive Level
- On-Chip Temperature Monitor
- -40°C to 105°C Operation ( $T_C$ )
- 16-Lead (4mm × 4mm) QFN Package

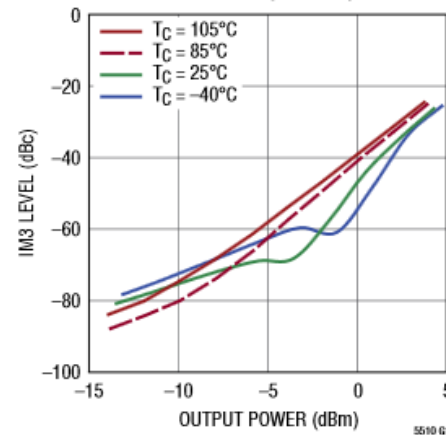
30MHz to 4GHz Up/Down Mixer for Wideband Receiver



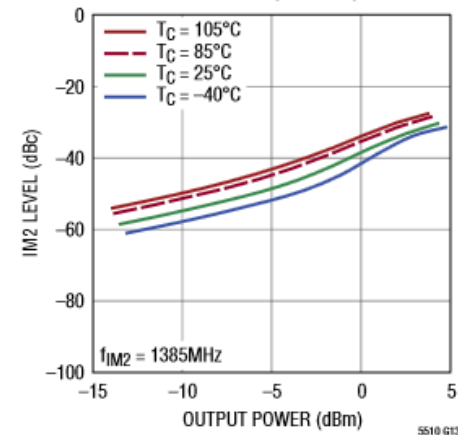
Conversion Gain, IIP3 and NF vs Input Frequency



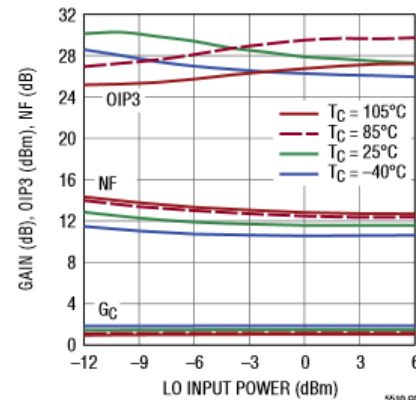
IM3 Level vs Output Power (2-Tone)



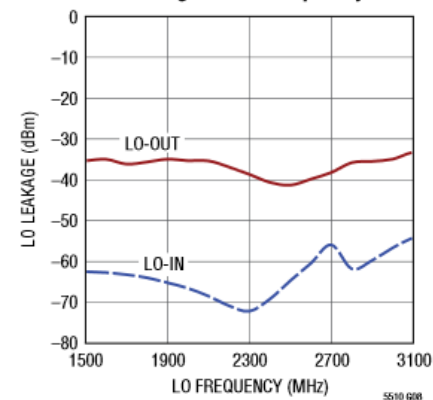
IM2 Level vs Output Power (2-Tone)



Conversion Gain, OIP3 and NF vs LO Power



LO Leakage vs LO Frequency



# MAX2612-MAX2616

## 40MHz to 4GHz Linear Broadband Amplifiers

### General Description

MAX2616 is a family of high-performance in blocks designed for use as a PA predriver amplifier, or as a cascable 50Ω amplifier 9.5dBm output power. These devices are for applications that include cellular infrastructure or commercial microwave radios, and modems. The operating frequency range is 40MHz to 4000MHz. The amplifier operates from a 3.0V to 5.25V supply with input and output ports matched to 50Ω. The device family is available in a compact, compact 2mm x 3mm TDFN package.

### Applications

Infrastructure  
Wireless Radio  
LAN  
Measurement

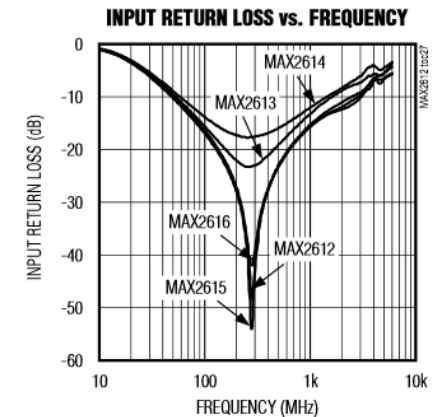
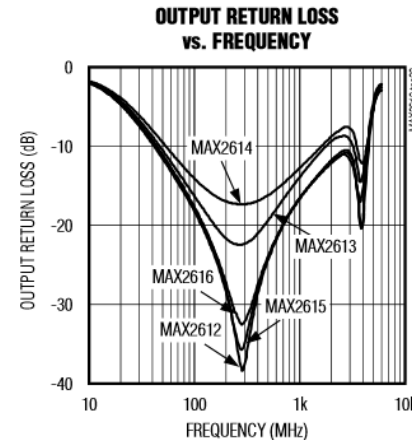
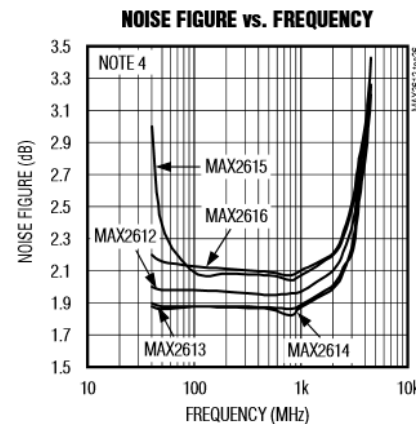
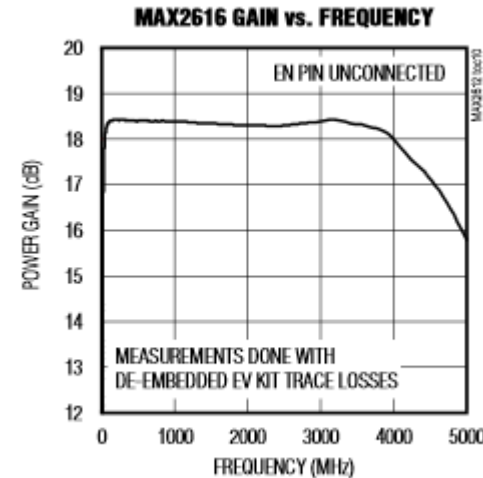
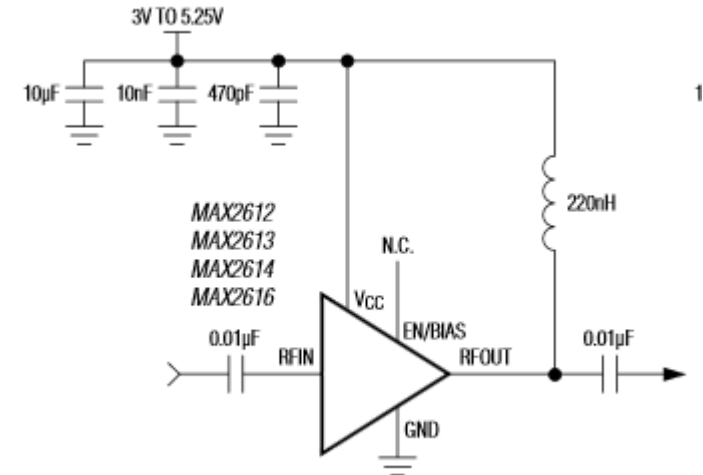
[MAX2612](#) appears at end of data sheet.

and recommended products to use with this part,  
<http://www.maximintegrated.com/MAX2612.related>.

Current 80.6 mA

### Features

- Extremely Flat Frequency Response
  - < 0.5dB, 1GHz to 4GHz
- Low Noise Figure: 2.0dB at  $f_{RFIN} = 2.0GHz$
- 40MHz to 4000MHz Frequency Range
- Industry's Highest Max  $P_{IN}$  Rating
- Large OIP3 Ranges
  - MAX2615/MAX2616: +37dBm
  - MAX2612: +35.2dBm
  - MAX2613: +31.2dBm
  - MAX2614: +30dBm
- Output P1dB: +19.5dBm (MAX2615/MAX2616)
- High Gain: 18.6dB
- Shutdown Mode (MAX2612/MAX2613/MAX2614/MAX2616)
- Adjustable Bias Current for Improved OIP3 (MAX2615)
- 3.0V to 5.25V Supply Range
- Compact 2mm x 3mm TDFN Package
- Industry-High ESD Rating: 2.5kV HBM





## 2.3GHz to 2.7GHz Wireless Broadband RF Transceiver

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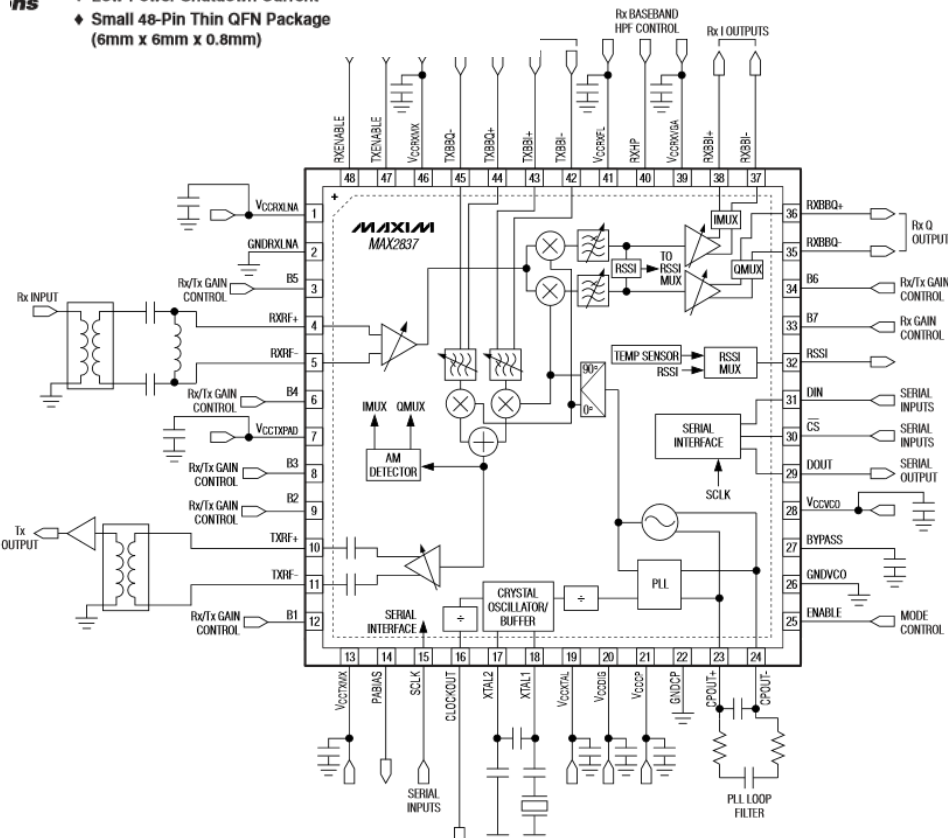
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## ***Features***

- ◆ 2.3GHz to 2.7GHz Wideband Operation
- ◆ Complete RF Transceiver, PA Driver, and Crystal Oscillator
  - 0dBm Linear OFDM Transmit Power
  - 70dBm Tx Spectral Emission Mask
  - 2.3dB Rx Noise Figure
  - Rx/Rx I/Q Error and LO Leakage Detection
  - Monolithic Low-Noise VCO with -39dBc Integrated Phase Noise
  - Programmable Tx I/Q Lowpass
  - Anti-Aliasing Filter
  - Sigma-Delta Fractional-N PLL with 20Hz Step Size
  - 45dB Tx Gain-Control Range
  - 94dB Receive Gain-Control Range
  - 60dB Analog RSSI Instantaneous Dynamic Range
  - 4-Wire SPI™ Digital Interface
  - I/Q Analog Baseband Interface
  - Digitally Tuned Crystal Oscillator
  - On-Chip Digital Temperature Sensor Read-Out
- ◆ +2.7V to +3.6V Transceiver Supply
- ◆ Low-Power Shutdown Current
- ◆ Small 48-Pin Thin QFN Package (6mm x 6mm x 0.8mm)

MAX2837



PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	VCC_	2.7		3.6	V
Supply Current	Shutdown mode, T <sub>A</sub> = +25°C		10		μA
	Standby mode		35	45	mA
	Rx mode		91	110	
	Tx mode, T <sub>A</sub> = +25°C		145	170	
	Rx calibration mode		135	160	
	Tx calibration mode		110	135	
Rx I/Q Output Common-Mode Voltage	D9:D8 = 00 in A4:A0 = 00100	0.85	1.0	1.20	V
	D9:D8 = 01 in A4:A0 = 00100		1.1		
	D9:D8 = 10 in A4:A0 = 00100		1.2		
	D9:D8 = 11 in A4:A0 = 00100		1.35		
Tx Baseband Input Common-Mode Voltage Operating Range	DC-coupled	0.5		1.2	V
Tx Baseband Input Bias Current	Source current		10	20	μA
<b>LOGIC INPUTS: ENABLE, TXENABLE, RXENABLE, SCLK, DIN, CS̄, B7:B1, RXHP</b>					
Digital Input-Voltage High, V <sub>IH</sub>		V <sub>CC</sub> - 0.4			V
Digital Input-Voltage Low, V <sub>IL</sub>				0.4	V
Digital Input-Current High, I <sub>IH</sub>		-1		+1	μA
Digital Input-Current Low, I <sub>IL</sub>		-1		+1	μA

## AC ELECTRICAL CHARACTERISTICS—Rx MODE

(MAX2837 evaluation kit:  $V_{CC-} = 2.8V$ ,  $f_{RF} = 2.502GHz$ ,  $f_{LO} = 2.5GHz$ ; receiver baseband I/Q outputs at  $90mV_{RMS}$  (-21dBV),  $f_{IF} = 40MHz$ ,  $ENABLE = RXENABLE = \overline{CS} = high$ ,  $TXENABLE = SCLK = DIN = low$ , with power matching for the differential RF pins using the typical applications and registers set to default settings and corresponding test mode,  $T_A = +25^{\circ}C$ , unless otherwise noted. Lowpass filter is set to 10MHz RF channel BW. Unmodulated single-tone RF input signal is used, unless otherwise indicated.) (Note 1)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
<b>RECEIVER SECTION: LNA RF INPUT TO BASEBAND I/Q OUTPUTS</b>						
RF Input Frequency Range			2.3		2.7	GHz
Peak-to-Peak Gain Variation over RF Input Frequency Range	Tested at band edges and band center			0.8		dB
RF Input Return Loss	All LNA gain settings			13		dB
Total Voltage Gain	T <sub>A</sub> = -40°C to +85°C	Maximum gain, B7:B1 = 0000000	90	99		dB
		Minimum gain, B7:B1 = 1111111		5	13	
RF Gain Steps	From max RF gain to max RF gain - 8dB			8		dB
	From max RF gain to max RF gain - 16dB			16		
	From max RF gain to max RF gain - 32dB			32		
Gain Change Settling Time	Any RF or baseband gain change; gain settling to within ±1dB of steady state; RXHP = 1			0.2		μs
	Any RF or baseband gain change; gain settling to within ±0.1dB of steady state; RXHP = 1			2		
Baseband Gain Range	From maximum baseband gain (B5:B1 = 00000) to minimum baseband gain (B5:B1 = 11111), T <sub>A</sub> = -40°C to +85°C		58	62	66	dB
Baseband Gain Minimum Step Size				2		dB
DSB Noise Figure	Voltage gain ≥ 65dB with max RF gain (B7:B6 = 00)			2.3		dB
	Voltage gain = 50dB with max RF gain - 8dB (B7:B6 = 01)			5.5		
	Voltage gain = 45dB with max RF gain - 16dB (B7:B6 = 10)			17		
	Voltage gain = 15dB with max RF gain - 32dB (B7:B6 = 11)			27		

**Ultra-Low-Power, High-Dynamic-Performance, 22Msps Analog Front End**

### General Description

low-power, highly integrated analog portable communication equipment. The AD9444 integrates dual 8-bit receive ADCs, 10-bit DACs while providing the high-linearity at ultra-low power. The ADCs' input amplifiers are fully differential and accept both single-ended and differential signals. Typical I-Q channel gain mismatch is  $\pm 0.1^\circ$  and amplitude matching is  $\pm 0.1\%$ . The feature 48.5dB SINAD and 69dBc SFDR range (SFDR) at  $f_{IN} = 5.5\text{MHz}$  and  $f_{CLK} = 22\text{MHz}$ . The DACs' analog I-Q outputs are fully differential with 1.4V full-scale output, and 1.4V common-mode output. Typical I-Q channel phase match is  $\pm 0.05\text{dB}$ . The DACs also provide resolution with 71.7dBc SFDR, and  $f_{CLK} = 22\text{MHz}$ .

operate simultaneously or independent-division duplex (FDD) and time-division) modes. A 3-wire serial interface and transceiver modes of operation. Operating power is 42mW at  $f_{CLK} =$

## ELECTRICAL CHARACTERISTICS

(V<sub>DD</sub> = 3V, OV<sub>DD</sub> = 1.8V, internal reference (1.024V), C<sub>L</sub> = 10pF on all digital outputs, f<sub>CLK</sub> = 22MHz, ADC input amplitude = -0.5dBFS, DAC output amplitude = 0dBFS, differential ADC input, differential DAC output, C<sub>REFP</sub> = C<sub>REFN</sub> = C<sub>COM</sub> = 0.33μF, Xcvr mode, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

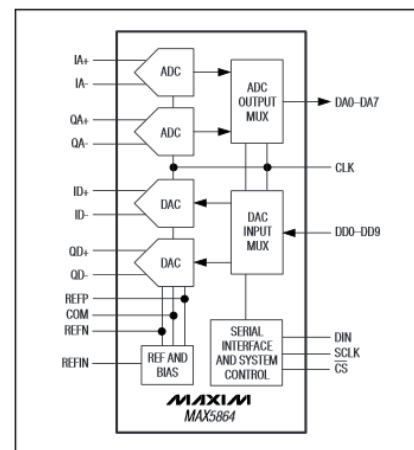
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>POWER REQUIREMENTS</b>						
Analog Supply Voltage	V <sub>DD</sub>		2.7	3.0	3.3	V
Output Supply Voltage	OV <sub>DD</sub>		1.8		V <sub>DD</sub>	V
V <sub>DD</sub> Supply Current		ADC operating mode, f <sub>IN</sub> = 5.5MHz, f <sub>CLK</sub> = 22MHz, DAC operating mode, f <sub>OUT</sub> = 2.2MHz		14	16.5	mA
		ADC operating mode, f <sub>IN</sub> = 5.5MHz, f <sub>CLK</sub> = 15.36MHz, DAC operating mode, f <sub>OUT</sub> = 2.2MHz		11.4		
		ADC operating mode (Rx), f <sub>IN</sub> = 5.5MHz, f <sub>CLK</sub> = 15.36MHz, DAC off, DAC digital inputs at zero or DV <sub>DD</sub>		8.25		
		DAC operating mode (Tx), f <sub>OUT</sub> = 2.2MHz, f <sub>CLK</sub> = 15.36MHz, ADC off		8		
		Standby mode, DAC digital inputs and CLK at zero or OV <sub>DD</sub>			2.0	
		Idle mode, DAC digital inputs at zero or OV <sub>DD</sub> , f <sub>CLK</sub> = 22MHz			6.7	
		Shutdown mode, digital inputs and CLK at zero or OV <sub>DD</sub> , CS = OV <sub>DD</sub>		1		μA
OV <sub>DD</sub> Supply Current		ADC operating mode, f <sub>IN</sub> = 5.5MHz, f <sub>CLK</sub> = 22MHz, DAC operating mode, f <sub>OUT</sub> = 2.2MHz		2.3		mA
		Idle mode, DAC digital inputs at zero or OV <sub>DD</sub> , f <sub>CLK</sub> = 22MHz		20.6		
		Shutdown mode, DAC digital inputs and CLK at zero or OV <sub>DD</sub> , CS = OV <sub>DD</sub>		1		μA

## Features

- ◆ Integrated Dual 8-Bit ADCs and Dual 10-Bit DACs
- ◆ Ultra-Low Power
  - 42mW at  $f_{CLK} = 22\text{MHz}$  (Transceiver Mode)
  - 34mW at  $f_{CLK} = 15.36\text{MHz}$  (Transceiver Mode)
  - Low-Current Idle and Shutdown Modes
- ◆ Excellent Dynamic Performance
  - 48.5dB SINAD at  $f_{IN} = 5.5\text{MHz}$  (ADC)
  - 71.7dB SFDR at  $f_{OUT} = 2.2\text{MHz}$  (DAC)
- ◆ Excellent Gain/Phase Match
  - $\pm 0.1^\circ$  Phase,  $\pm 0.03\text{dB}$  Gain at  $f_{IN} = 5.5\text{MHz}$  (ADC)
- ◆ Internal/External Reference Option
- ◆ +1.8V to +3.3V Digital Output Level (TTL/CMOS Compatible)
- ◆ Multiplexed Parallel Digital Input/Output for ADCs/DACs
- ◆ Miniature 48-Pin Thin QFN Package (7mm  $\times$  7mm)
- ◆ Evaluation Kit Available (Order MAX5865EVKIT)

MAX5864

### Functional Diagram



PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
ADC DC ACCURACY						
Resolution			8			Bits
Integral Nonlinearity	INL		±0.15			LSB
Differential Nonlinearity	DNL	No missing codes over temperature	±0.15			LSB
Offset Error		Residual DC offset error	±0.24	±5		%FS
Gain Error		Includes reference error	±0.77	±5		%FS
DC Gain Matching			±0.03	±0.25		dB
Offset Matching			±3			LSB
Gain Temperature Coefficient			±59			ppm/°C
Power-Supply Rejection	PSRR	Offset error (V <sub>DD</sub> ±5%)	±0.2			LSB
		Gain error (V <sub>DD</sub> ±5%)	±0.07			
ADC ANALOG INPUT						
Input Differential Range	V <sub>ID</sub>	Differential or single-ended inputs	±0.512			V
Input Common-Mode Voltage Range			V <sub>DD</sub> / 2			V
Input Impedance	R <sub>IN</sub>	Switched capacitor load	245			kΩ
	C <sub>IN</sub>		5			pF
ADC CONVERSION RATE						
Maximum Clock Frequency	f <sub>CLK</sub>	(Note 2)			22	MHz
Data Latency		Channel I	5			Clock cycles
		Channel Q	5.5			
ADC DYNAMIC CHARACTERISTICS (Note 3)						
Signal-to-Noise Ratio	SNR	f <sub>IN</sub> = 5.5MHz	47	48.6		dB
		f <sub>IN</sub> = 11MHz	48.6			
Signal-to-Noise and Distortion Ratio	SINAD	f <sub>IN</sub> = 5.5MHz	46.5	48.5		dB
		f <sub>IN</sub> = 11MHz	48.5			
Spurious-Free Dynamic Range	SFDR	f <sub>IN</sub> = 5.5MHz	58	69		dBc
		f <sub>IN</sub> = 11MHz	71.5			
Third-Harmonic Distortion	HD3	f <sub>IN</sub> = 5.5MHz	-70.3			dBc
		f <sub>IN</sub> = 11MHz	-75.5			
Intermodulation Distortion	IMD	f <sub>1</sub> = 2MHz, -7dBFS; f <sub>2</sub> = 2.01MHz, -7dBFS	-64			dBc
Third-Order Intermodulation Distortion	IM3	f <sub>1</sub> = 2MHz, -7dBFS; f <sub>2</sub> = 2.01MHz, -7dBFS	-67			dBc
Total Harmonic Distortion	THD	f <sub>IN</sub> = 5.5MHz	-68.2	-57		dBc

Bit-Dynamik  $20 \cdot \log(2^8) = 48 \text{ dB}$