# MAX2612–MAX2616 40MHz to 4GHz Linear Broadband Amplifiers

## General Description

The MAX2612–MAX2616 is a family of high-performance broadband gain blocks designed for use as a PA predriver, low-noise amplifier, or as a cascadable 50Ω amplifier with up to +19.5dBm output power. These devices are suited for many applications that include cellular infrastructure, private or commercial microwave radios, and CATV or cable modems. The operating frequency range extends from 40MHz to 4000MHz. The amplifier operates on a +3V to a +5.25V supply with input and output ports internally matched to 50Ω. The device family is available in a pin-to-pin compatible, compact 2mm x 3mm TDFN lead-free package.

## Applications

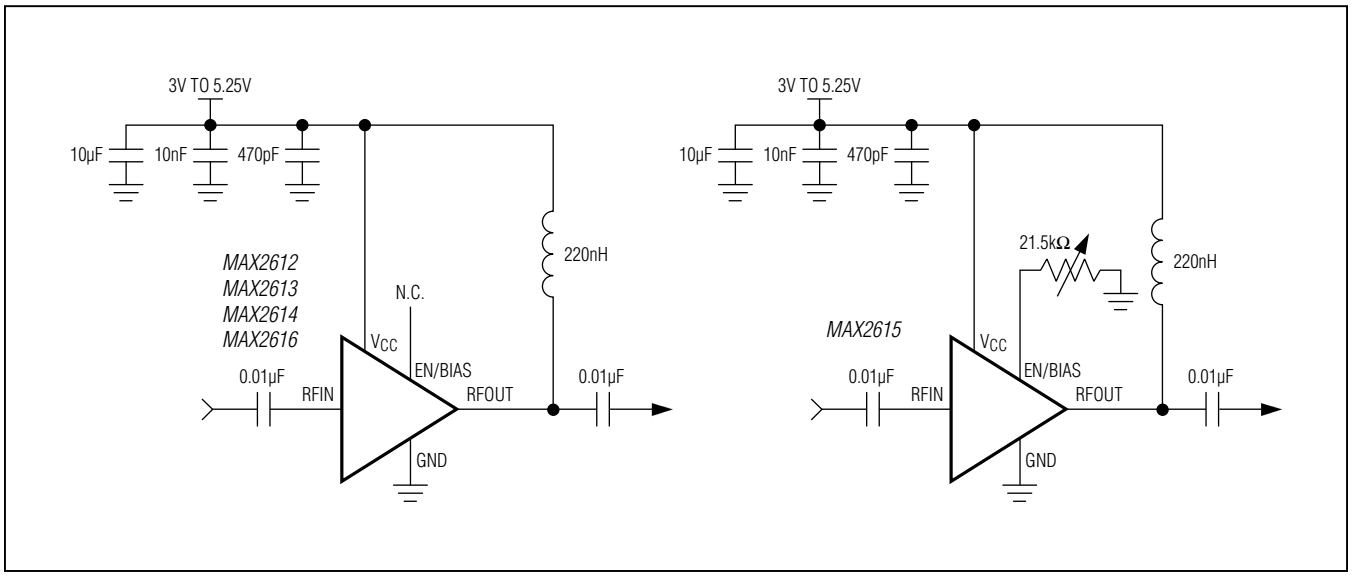
- Cellular Infrastructure
- Microwave Radio
- Wireless LAN
- Test and Measurement
- Automotive

***Ordering Information* appears at end of data sheet.**

## Benefits and 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
- AEC-Q100 Qualified—Refer to Ordering Information for List of /V Parts

## Typical Application Circuits






maxim integrated™

## Absolute Maximum Ratings

$V_{CC}$,EN/RBIAS, RFOUT to GND ..... -0.3V to +6.0V
Maximum Input Power (RFIN) ..... +20dBm
Continuous Power Dissipation ($T_A$ = +70°C)
TDFN (derates 16.7mW/°C above +70°C) ..... 1333.3mW
Operating Temperature Range ..... -40°C to +85°C
Junction Temperature ..... +150°C
Storage Temperature Range ..... -65°C to +160°C
Lead Temperature (soldering, 10s) ..... +300°C
Soldering Temperature (reflow) ..... +260°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## Package Thermal Characteristics (Note 1)

TDFN
Junction-to-Ambient Thermal Resistance ($\theta_{JA}$) ..... 60°C/W
Junction-to-Case Thermal Resistance ($\theta_{JC}$) ..... 11°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

## Package Information

### 8 TDFN

| PACKAGE CODE | T823+1 |
|---|---|
| Outline Number | 21-0174 |
| Land Pattern Number | 90-0091 |
| **Thermal Resistance, Single-Layer Board:** | |
| Junction to Ambient ($\theta_{JA}$) | 60°C/W |
| Junction to Case ($\theta_{JC}$) | 11°C/W |
| **Thermal Resistance, Four-Layer Board:** | |
| Junction to Ambient ($\theta_{JA}$) | 60°C/W |
| Junction to Case ($\theta_{JC}$) | 11°C/W |

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

## DC Electrical Characteristics

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{CC}$ = +5.0V, no RF input signals at RFIN, $T_A$ =-40°C to +85°C, unless otherwise noted. Typical values are at $V_{RFOUT}$ = +5V, $T_A$ = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Supply Voltage | DC voltage at RFOUT | 3 | 5 | 5.25 | V |
| Supply Current | MAX2612 | | 69 | | mA |
| | MAX2613 | | 51.2 | | |
| | MAX2614 | | 40.6 | | |
| | MAX2615, RBIAS = 21.5kΩ | | 81.5 | | |
| | MAX2616 | | 80.6 | | |
| Shutdown Supply Current | EN logic-low | | 7 | | µA |
| RBIAS Minimum | MAX2615 | | 10 | | kΩ |

## AC Electrical Characteristics

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{CC}$ = +5V, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{RFOUT}$ = +5V, $T_A$ = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| RFIN Frequency Range | | | 40 | | 4000 | MHz |
| Power Gain | fRFIN = 1000MHz (Note 3) | MAX2612 | | 18.3 | | dB |
| | | MAX2613 | | 18.6 | | |
| | | MAX2614 | | 18.6 | | |
| | | MAX2615 | | 18.5 | | |
| | | MAX2616 | | 18.4 | | |
| | fRFIN = 4000MHz (Note 3) | MAX2612 | | 17.5 | | |
| | | MAX2613 | | 18.1 | | |
| | | MAX2614 | | 17.5 | | |
| | | MAX2615 | | 18.0 | | |
| | | MAX2616 | | 18.0 | | |

## AC Electrical Characteristic (continued)

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{CC}$ = +5V, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{RFOUT}$ = +5V, $T_A$ = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Gain Flatness Across Band | fRFIN = 1000MHz < fRFOUT < 3000MHz (Note 3) | MAX2612 | | 0.2 | | dB |
| | | MAX2613 | | 0.1 | | |
| | | MAX2614 | | 0.15 | | |
| | | MAX2615 | | 0.15 | | |
| | | MAX2616 | | 0.1 | | |
| | fRFIN = 1000MHz < fRFOUT < 4000MHz (Note 3) | MAX2612 | | 0.8 | | |
| | | MAX2613 | | 0.5 | | |
| | | MAX2614 | | 1.1 | | |
| | | MAX2615 | | 0.5 | | |
| | | MAX2616 | | 0.4 | | |
| Noise Figure | fRFIN = 2000MHz (Note 3) | MAX2612 | | 2.1 | 2.65 | dB |
| | | MAX2613 | | 2 | 2.42 | |
| | | MAX2614 | | 2 | 2.35 | |
| | | MAX2615 | | 2.2 | 2.95 | |
| | | MAX2616 | | 2.2 | 2.85 | |
| OIP3 | Input tones at 1000MHz and 1001MHz at -15dBm/tone | MAX2612 | | 35.2 | | dBm |
| | | MAX2613 | | 31.2 | | |
| | | MAX2614 | | 29.7 | | |
| | | MAX2615 | | 37.6 | | |
| | | MAX2616 | | 37.2 | | |
| Output P1dB | fRFIN = 1000MHz (Note 3) | MAX2612 | | 18.2 | | dBm |
| | | MAX2613 | | 15.5 | | |
| | | MAX2614 | | 13.6 | | |
| | | MAX2615 | | 19.5 | | |
| | | MAX2616 | | 19.5 | | |
| Reverse Isolation | 40MHz < fRFOUT < 4000MHz | | | 20 | | dB |
| RFIN Input Return Loss | 40MHz < fRFOUT < 1000MHz | MAX2612 | | 15 | | dB |
| | | MAX2613 | | 15 | | |
| | | MAX2614 | | 12 | | |
| | | MAX2615 | | 15 | | |
| | | MAX2616 | | 15 | | |
| | 1000MHz < fRFOUT < 4000MHz | MAX2612 | | 12 | | |
| | | MAX2613 | | 8 | | |
| | | MAX2614 | | 8 | | |
| | | MAX2615 | | 12 | | |
| | | MAX2616 | | 12 | | |

## AC Electrical Characteristic (continued)

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{CC}$ = +5V, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{RFOUT}$ = +5V, $T_A$ = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| RFOUT Output Return Loss | 40MHz < fRFOUT < 1000MHz | MAX2612 | | 20 | | dB |
| | | MAX2613 | | 15 | | |
| | | MAX2614 | | 12 | | |
| | | MAX2615 | | 20 | | |
| | | MAX2616 | | 20 | | |
| | 1000MHz < fRFOUT < 4000MHz | MAX2612 | | 12 | | |
| | | MAX2613 | | 10 | | |
| | | MAX2614 | | 10 | | |
| | | MAX2615 | | 12 | | |
| | | MAX2616 | | 12 | | |

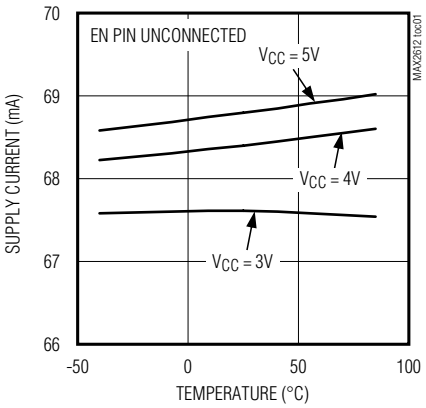
**Note 2:** Min and max values are production tested at $T_A$ = +25°C. Min and max limits at $T_A$ = +85°C and $T_A$ = -40°C are guaranteed by design and characterization.

**Note 3:** Min and max values are guaranteed by design and characterization at $T_A$ = +25°C.

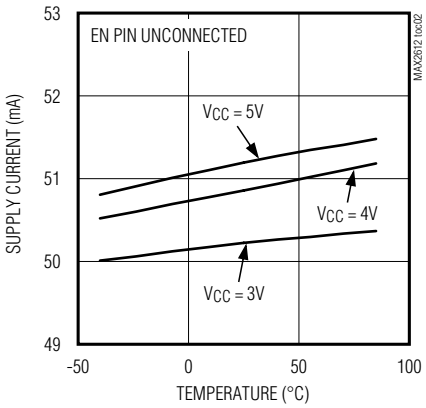
## Typical Operating Characteristics

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{RFOUT}$ = +5V, $T_A$ = +25°C .)

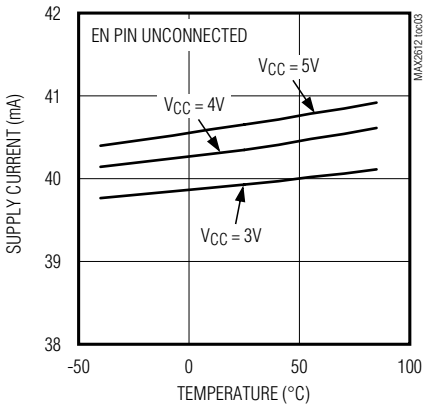
**MAX2612 SUPPLY CURRENT vs. TEMPERATURE**




**MAX2613 SUPPLY CURRENT vs. TEMPERATURE**



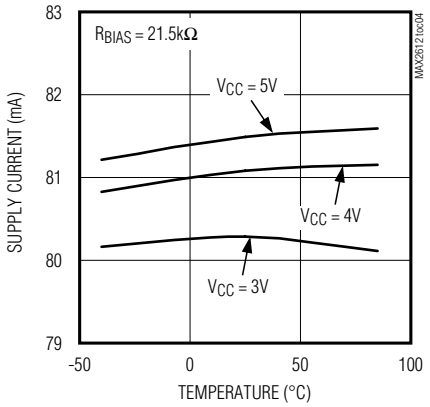

**MAX2614 SUPPLY CURRENT vs. TEMPERATURE**



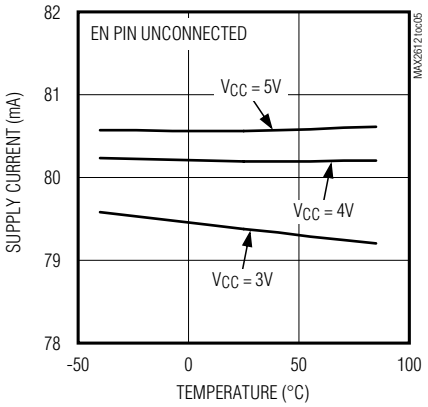
## Typical Operating Characteristics (continued)

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{RFOUT}$ = +5V, $T_A$ = +25°C .)

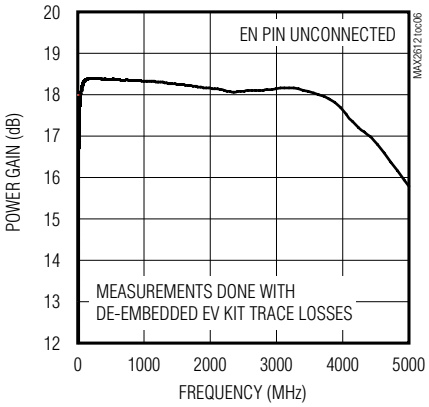
**MAX2615 SUPPLY CURRENT vs. TEMPERATURE**



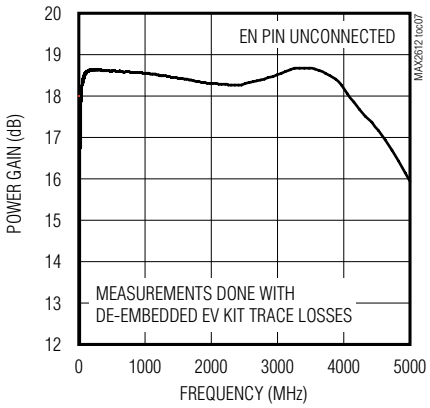

**MAX2616 SUPPLY CURRENT vs. TEMPERATURE**



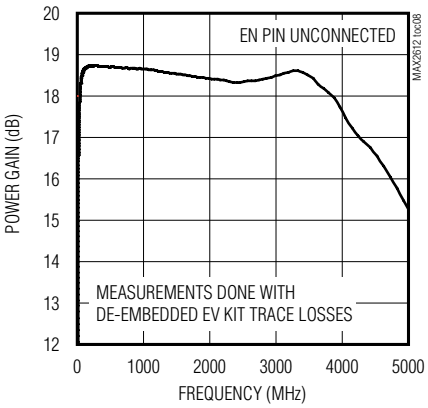

**MAX2612 GAIN vs. FREQUENCY**



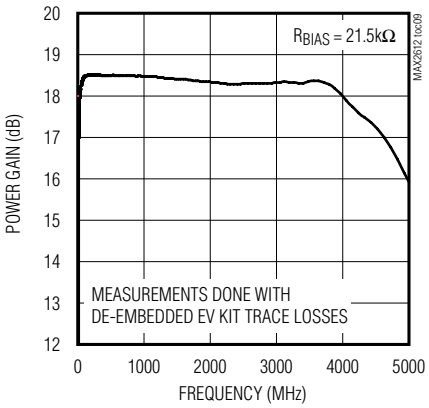

**MAX2613 GAIN vs. FREQUENCY**



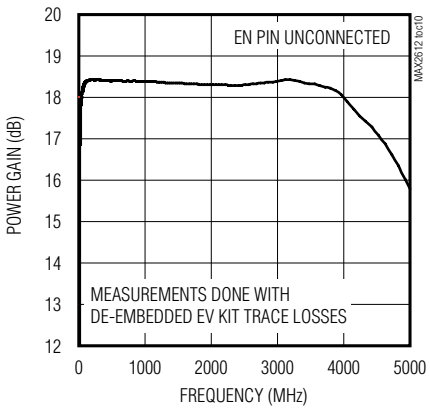

**MAX2614 GAIN vs. FREQUENCY**



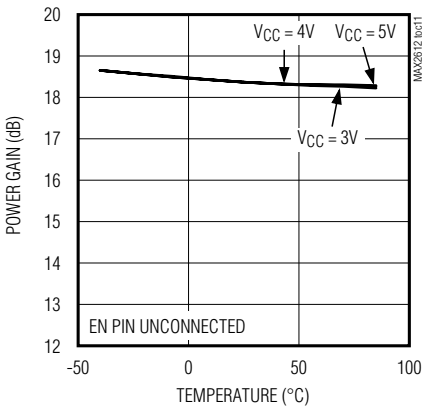

**MAX2615 GAIN vs. FREQUENCY**



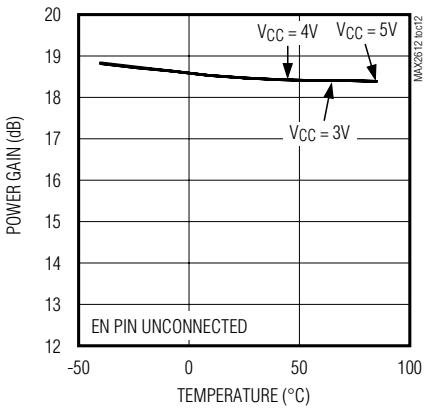

**MAX2616 GAIN vs. FREQUENCY**




**MAX2612 GAIN vs. TEMPERATURE**



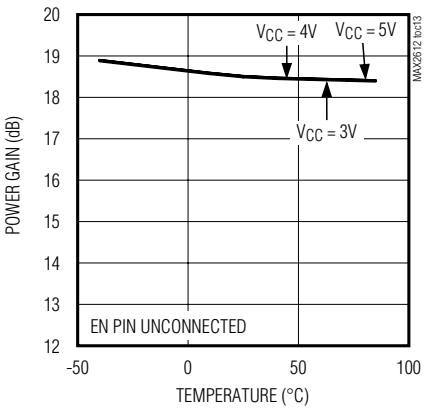

**MAX2613 GAIN vs. TEMPERATURE**



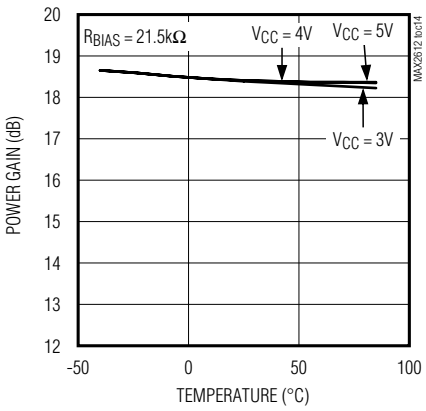
## Typical Operating Characteristics (continued)

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{RFOUT}$ = +5V, $T_A$ = +25°C .)

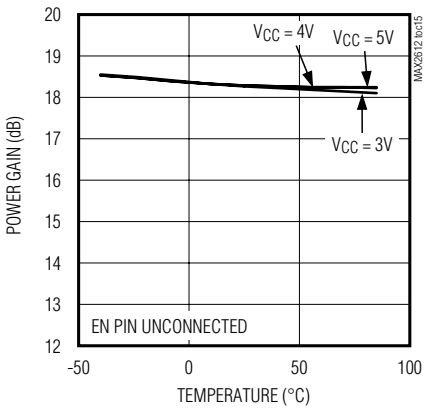
**MAX2614 GAIN vs. TEMPERATURE**



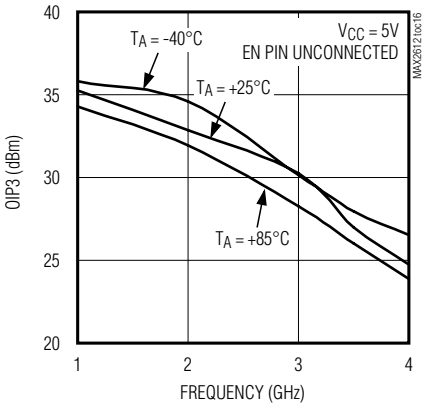

**MAX2615 GAIN vs. TEMPERATURE**



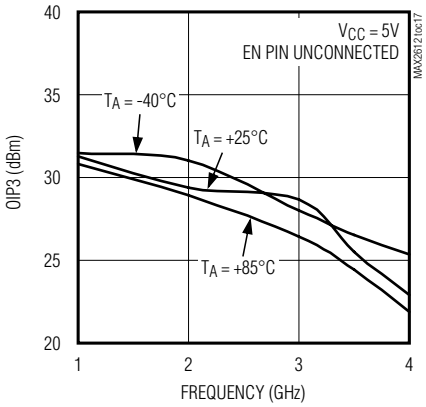

**MAX2616 GAIN vs. TEMPERATURE**



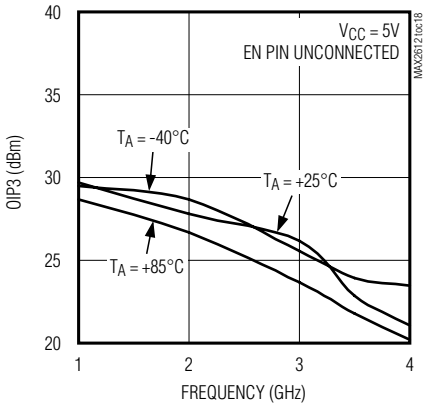

**MAX2612 OIP3 vs. FREQUENCY**



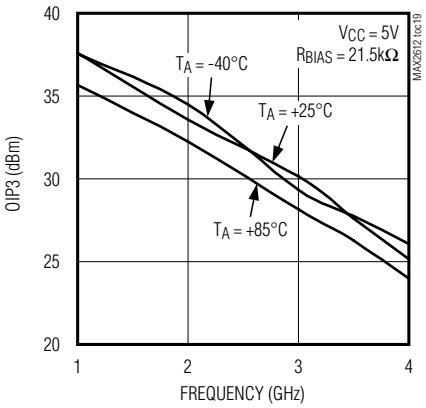

**MAX2613 OIP3 vs. FREQUENCY**



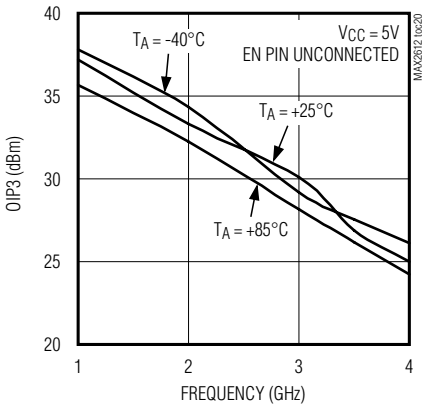

**MAX2614 OIP3 vs. FREQUENCY**



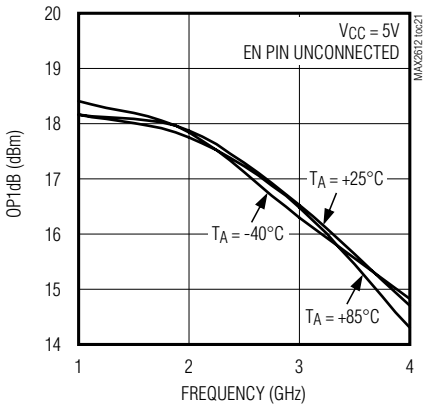

**MAX2615 OIP3 vs. FREQUENCY**




**MAX2616 OIP3 vs. FREQUENCY**



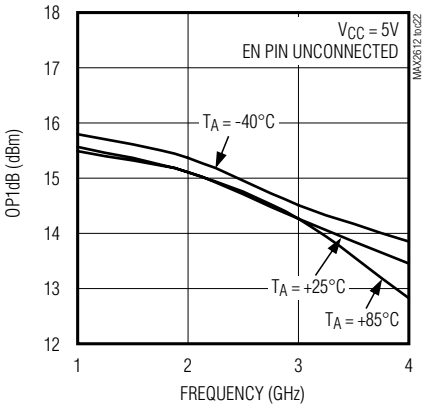

**MAX2612 OP1dB vs. FREQUENCY**



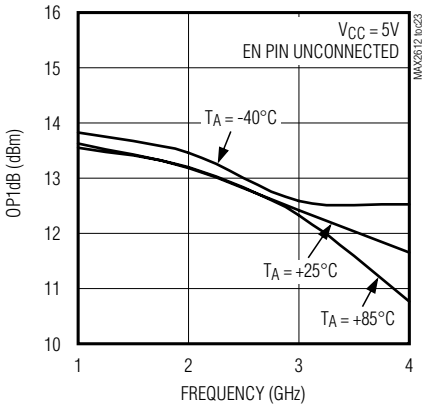
## Typical Operating Characteristics (continued)

(MAX2612/MAX2613/MAX2614/MAX2615/MAX2616 EV Kit, $V_{RFOUT}$ = +5V, $T_A$ = +25°C .)

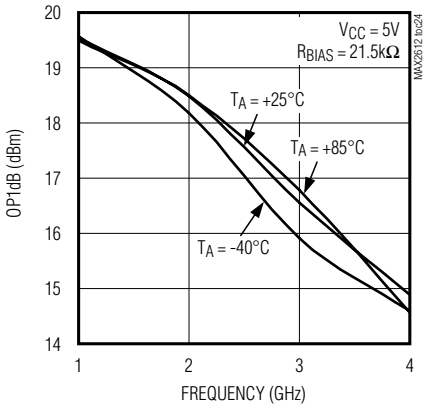
**MAX2613 OP1dB vs. FREQUENCY**



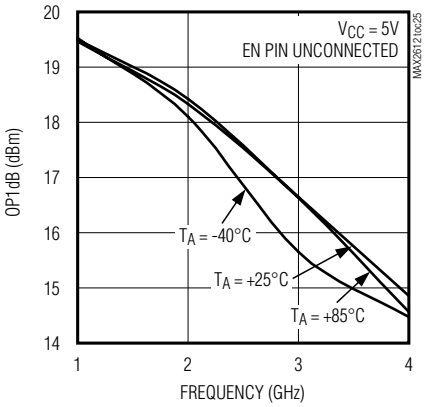

**MAX2614 OP1dB vs. FREQUENCY**



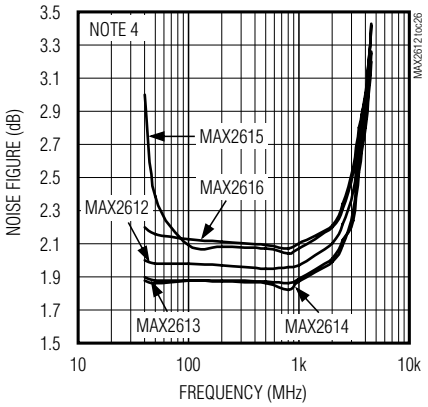

**MAX2615 OP1dB vs. FREQUENCY**



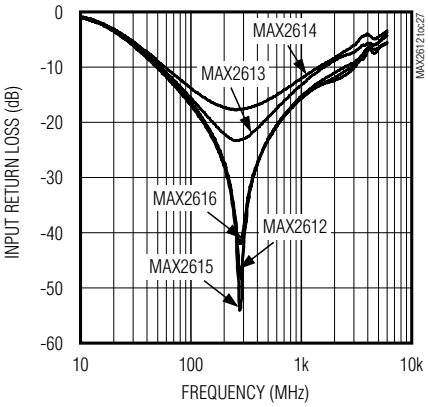

**MAX2616 OP1dB vs. FREQUENCY**



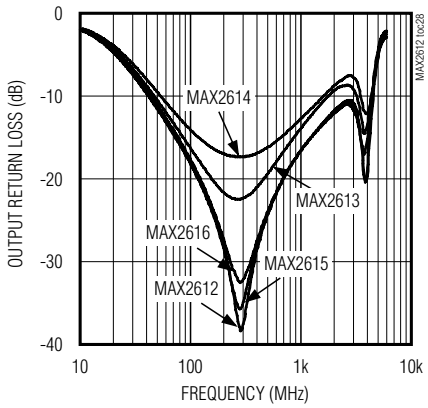

**NOISE FIGURE vs. FREQUENCY**



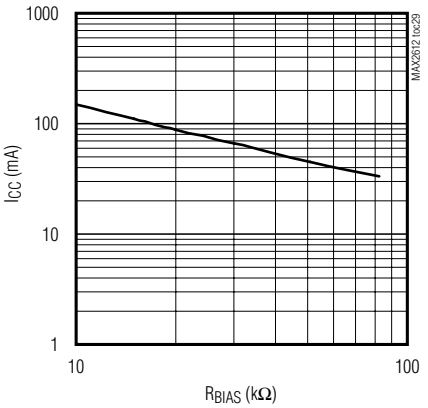

**INPUT RETURN LOSS vs. FREQUENCY**



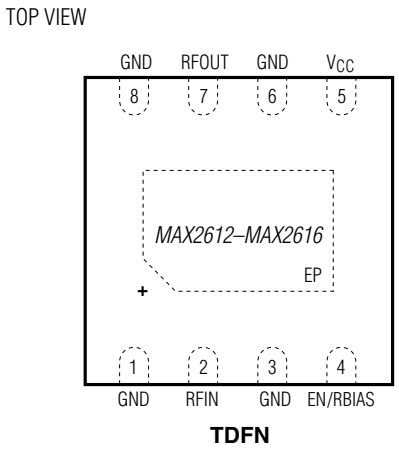

**OUTPUT RETURN LOSS vs. FREQUENCY**




**MAX2615 $R_{BIAS}$ RESISTANCE vs. SUPPLY CURRENT**



## Pin Configuration




**TDFN**

## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1, 3, 6, 8 | GND | Ground. Connect to PCB ground plane. |
| 2 | RFIN | RF Input. Connect to an RF source through a 0.01µF DC-blocking capacitor. Internally matched to 50Ω. |
| 4 | EN/RBIAS | Enable (MAX2612/MAX2613/MAX2614/MAX2616). Leave unconnected for normal operation or logic-low for disable mode operation. For applications that use the disable mode, it is recommended that the logic-high signal be derived from a high-impedance source such as an unterminated open-collector output or three-state (high-Z) output. Logic-low should be a low-impedance source or a switch to ground capable of sinking 10µA.<br>RBIAS (MAX2615). Connect to a 21.5kΩ bias resistor to ground. The value can be adjusted to trade off supply current for OIP3. See the *Applications Information* section for further detail. |
| 5 | VCC | DC Supply Input. Place 470pF and 10nF decoupling capacitors as close to pin as possible. Also place a 10µF bulk capacitor on VCC; this must be a tantalum capacitor with ESR > 2Ω and can be placed further away. |
| 7 | RFOUT | RF Output and DC Feed. Connect to DC supply through a 220nH inductor. Connect to output load through a 0.01µF DC-blocking capacitor. |
| — | EP | Exposed Pad. Connect to PCB ground plane by a 3 x 3 array of vias. Connect to ground lead (1, 3, 6, 8) land patterns and to layer 1 ground plane with thermal relief traces. |

## Detailed Description

### Adjustable Bias Control for the MAX2615

While the MAX2612/MAX2613/MAX2614/MAX2616 are fixed biased for ease of use, the MAX2615 allows the current to be controlled by an external bias resistor connected from RBIAS (pin 4) to ground. In this configuration, the MAX2615 can be used over a range of current settings with an upper limit of ~150mA for an $R_{BIAS}$ of 10kΩ and a lower limit of 37.5mA for an $R_{BIAS}$ of 69kΩ. Values within this range allow optimized performance and power consumption for customer requirements.

## Applications Information

### Wideband Designs

For LTE designs, the MAX261x family is ideally suited to minimize gain compensation over frequency while providing low noise and high OIP3 in a small (2mm x 3mm TDFN) but thermally efficient package. The same device can be used for multiple frequency bands without adjusting for gain slope degradation, a common artifact among pHEMT, InGaP, and GaAs gain blocks.

### Input Overload Handling

As a result of its simple Darlington architecture and rugged bipolar process, the MAX261x family provides an industry-leading +20dBm maximum input power rating. This inherently reduces the need for input protection circuitry while greatly minimizing the potential for damage to the device from intermittent RF surges.

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX2612**ETA+ | -40°C to +85°C | 8 TDFN-EP* |
| **MAX2613**ETA+ | -40°C to +85°C | 8 TDFN-EP* |
| **MAX2614**ETA+ | -40°C to +85°C | 8 TDFN-EP* |
| **MAX2615**ETA+ | -40°C to +85°C | 8 TDFN-EP* |
| MAX2615ETA/V+ | -40°C to +85°C | 8 TDFN-EP* |
| **MAX2616**ETA+ | -40°C to +85°C | 8 TDFN-EP* |

*+Denotes a lead(Pb)-free/RoHS-compliant package.*
**EP = Exposed Pad.*
*/V Denotes an automotive qualified part.*

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 5/12 | Initial release | — |
| 1 | 2/14 | Revised *Electrical Characteristics* notes and added the automotive package to the *Ordering Information* | 4, 9 |
| 2 | 7/14 | Fixed *Typical Operating Characteristics* error and *Pin Description* | 6, 8 |
| 3 | 5/15 | Updated *Package Information* | 9 |
| 4 | 6/18 | Updated *Benefits and Features* section | 1 |
| 5 | 3/19 | Updated *Benefits and Features* and *Application* sections; added *Package Information* section | 1, 2 |

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