

# VHF/UHF Low-Noise Amplifiers

## General Description

The MAX2664 and MAX2665 are ultra-compact LNAs for VHF/UHF applications. These devices incorporate a broadband LNA with an integrated bypass switch. The MAX2664 covers the UHF frequency range from 470MHz to 860MHz, and the MAX2665 covers the VHF frequency range from 75MHz to 230MHz.

Each device has a zero-power bypass mode for improved high-signal-level handling conditions. Additionally, the output port is internally matched to 50Ω while a single external inductor is used to match the input port to 50Ω.

The MAX2664 and MAX2665 are available in a 4-bump (0.8mm x 0.8mm x 0.64mm), lead-free, wafer-level package (WLP).

## Applications

Smartphones/Handsets  
MP3 Players  
Home Audio/Video  
Portable Navigation Devices  
Automotive

## Features

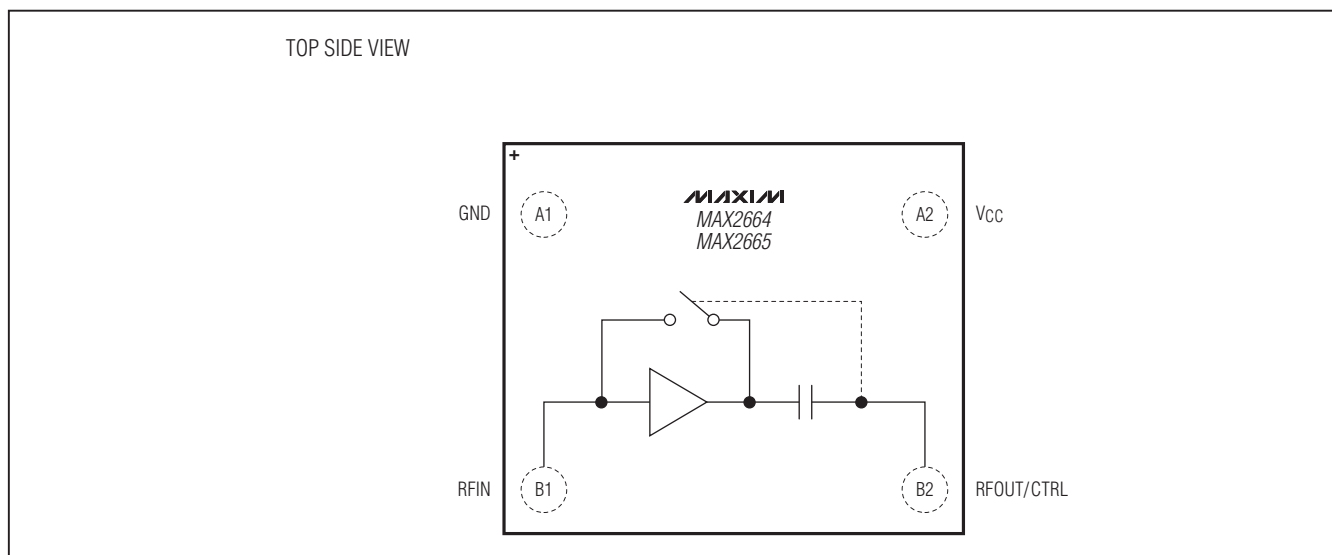
- ◆ **UHF and VHF Frequency Range**  
MAX2664: 470MHz to 860MHz  
MAX2665: 75MHz to 230MHz
- ◆ **Low Noise Figure**  
MAX2664: 1.2dB  
MAX2665: 1.1dB
- ◆ **High Gain: 15dB**
- ◆ **Zero-Power Bypass Mode**
- ◆ **Single +2.4V to +3.5V Supply Voltage**
- ◆ **Low Current: 3.3mA**
- ◆ **Small Footprint: 0.8mm x 0.8mm**
- ◆ **Thin Profile: 0.64mm**

## Ordering Information

| PART        | TEMP RANGE     | PIN-PACKAGE |
|-------------|----------------|-------------|
| MAX2664EWS+ | -40°C to +85°C | 4 WLP       |
| MAX2665EWS+ | -40°C to +85°C | 4 WLP       |

+Denotes a lead(Pb)-free/RoHS-compliant package.

## Functional Diagram



# VHF/UHF Low-Noise Amplifiers

## ABSOLUTE MAXIMUM RATINGS

V<sub>CC</sub> to GND.....-0.3V to +3.6V  
 Other Pins to GND..... -0.3V to (Operating V<sub>CC</sub> + 0.3V)  
 Maximum RF Input Power..... +10dBm  
 Short-Circuit Duration: RFIN, RFOUT/CTRL..... 10s  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
     WLP (derates 9.7mW/°C above +70°C).....776mW

Operating Temperature Range..... -40°C to +85°C  
 Junction Temperature.....+150°C  
 Storage Temperature Range.....-65°C to +160°C  
 Soldering Temperature (reflow).....+260°C



**CAUTION!** ESD SENSITIVE DEVICE

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.

## DC ELECTRICAL CHARACTERISTICS

(MAX2664 and MAX2665 EV kits. V<sub>CC</sub> = 2.4V to 3.5V, T<sub>A</sub> = -40°C to +85°C, no RF signals are applied, RFIN and RFOUT/CTRL are open circuit. Typical values are at V<sub>CC</sub> = 2.7V and T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER                | CONDITIONS                  | MIN                   | TYP | MAX                   | UNITS |
|--------------------------|-----------------------------|-----------------------|-----|-----------------------|-------|
| Supply Voltage           |                             | 2.4                   | 2.7 | 3.5                   | V     |
| Supply Current           | Active mode                 |                       | 3.3 |                       | mA    |
|                          | Bypass mode, logic-low = 0V |                       | 1   |                       | μA    |
| Digital Input Logic-High |                             | 0.7 x V <sub>CC</sub> |     |                       | V     |
| Digital Input Logic-Low  |                             |                       |     | 0.3 x V <sub>CC</sub> | V     |
| Digital Input Current    |                             | -10                   |     | +10                   | μA    |

## AC ELECTRICAL CHARACTERISTICS

(MAX2664 EV kit. V<sub>CC</sub> = 2.4V to 3.5V, T<sub>A</sub> = -40°C to +85°C, UHF f<sub>RFIN</sub> = 670MHz. Typical values are at V<sub>CC</sub> = 2.7V and T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER                                | CONDITIONS           | MIN  | TYP  | MAX | UNITS |
|------------------------------------------|----------------------|------|------|-----|-------|
| <b>MAX2664</b>                           |                      |      |      |     |       |
| Power Gain                               | Normal mode          | 11.8 | 14.8 | 18  | dB    |
|                                          | Bypass mode          | -8   | -6   | -3  |       |
| Noise Figure                             | Normal mode          |      | 1.2  |     | dB    |
|                                          | Bypass mode          |      | 6    |     |       |
| Third-Order Input Intercept Point (IIP3) | Normal mode (Note 2) |      | -10  |     | dBm   |
|                                          | Bypass mode (Note 3) |      | +26  |     |       |
| Input 1dB Compression Point              | Normal mode          |      | -5   |     | dBm   |
|                                          | Bypass mode          |      | +7   |     |       |

# VHF/UHF Low-Noise Amplifiers

## AC ELECTRICAL CHARACTERISTICS

(MAX2665 EV kit.  $V_{CC} = 2.4V$  to  $3.5V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , VHF  $f_{RFIN} = 150MHz$ . Typical values are at  $V_{CC} = 2.7V$  and  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Note 1)

| PARAMETER                                | CONDITIONS           | MIN  | TYP  | MAX | UNITS |
|------------------------------------------|----------------------|------|------|-----|-------|
| <b>MAX2665</b>                           |                      |      |      |     |       |
| Power Gain                               | Normal mode          | 11.8 | 15.1 | 18  | dB    |
|                                          | Bypass mode          | -8   | -5.5 | -3  |       |
| Noise Figure                             | Normal mode          |      | 1.1  |     | dB    |
|                                          | Bypass mode          |      | 5.5  |     |       |
| Third-Order Input Intercept Point (IIP3) | Normal mode (Note 4) |      | -12  |     | dBm   |
|                                          | Bypass mode (Note 5) |      | +26  |     |       |
| Input 1dB Compression Point              | Normal mode          |      | -11  |     | dBm   |
|                                          | Bypass mode          |      | +6   |     |       |

**Note 1:** Min and max limits guaranteed by test at  $T_A = +25^{\circ}C$  and guaranteed by design and characterization at  $T_A = -40^{\circ}C$  and  $T_A = +85^{\circ}C$ .

**Note 2:** Tone-1 = 670MHz (-25dBm), Tone-2 = 676MHz (-25dBm).

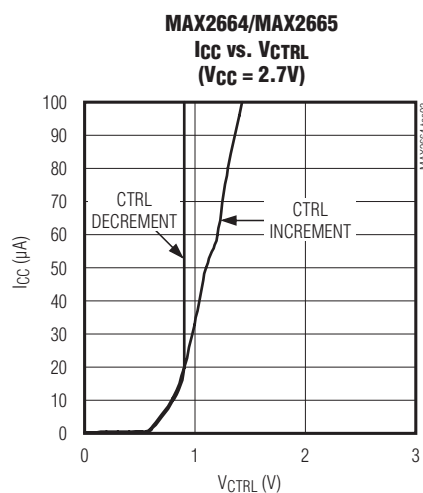
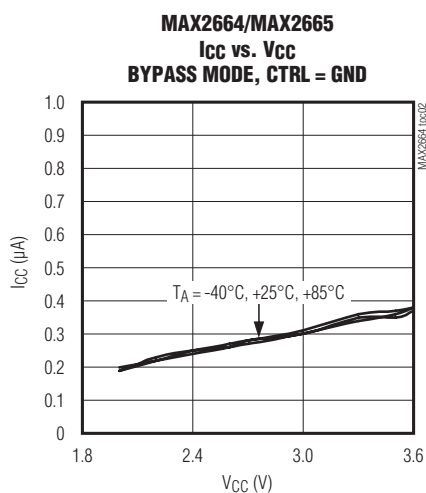
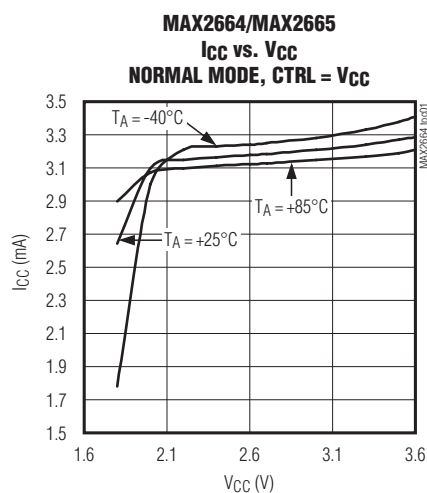
**Note 3:** Tone-1 = 670MHz (0dBm), Tone-2 = 676MHz (0dBm).

**Note 4:** Tone-1 = 150MHz (-25dBm), Tone-2 = 156MHz (-25dBm).

**Note 5:** Tone-1 = 150MHz (0dBm), Tone-2 = 156MHz (0dBm).

## Typical Operating Characteristics

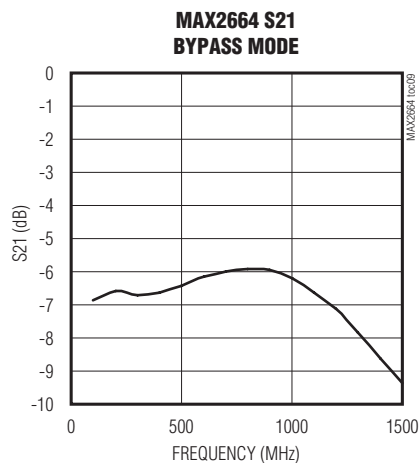
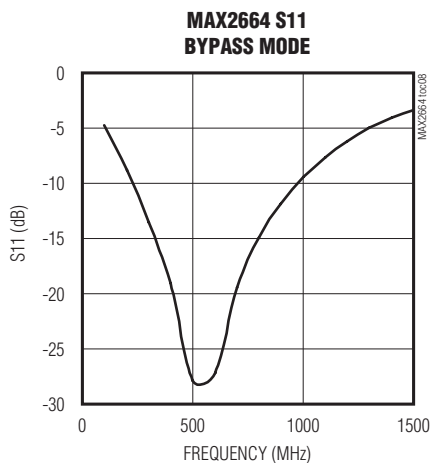
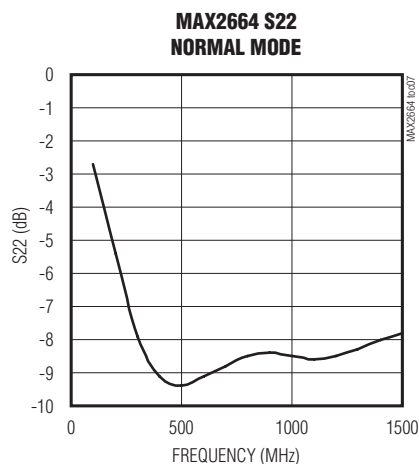
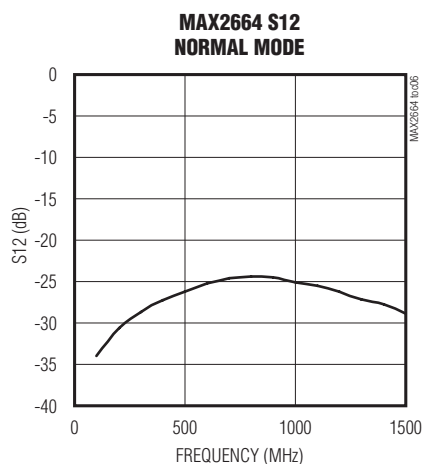
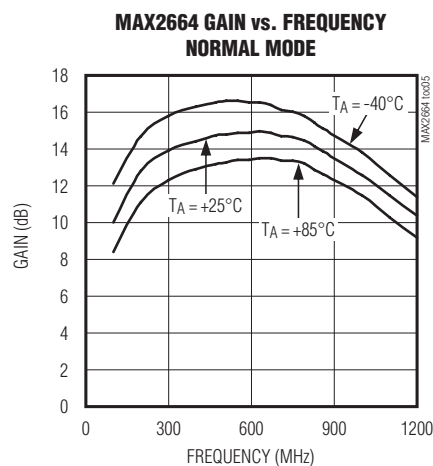
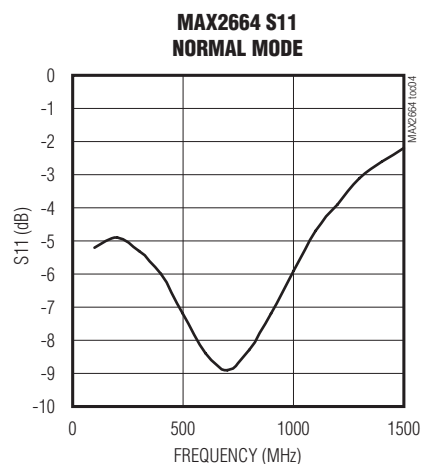
( $T_A = +25^{\circ}C$ , unless otherwise noted. MAX2664 and MAX2665 EV kits.)



# VHF/UHF Low-Noise Amplifiers

## Typical Operating Characteristics (continued)

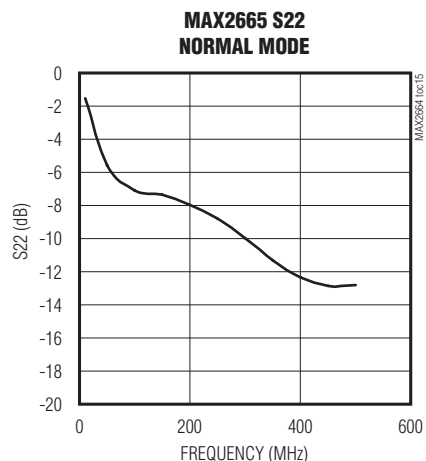
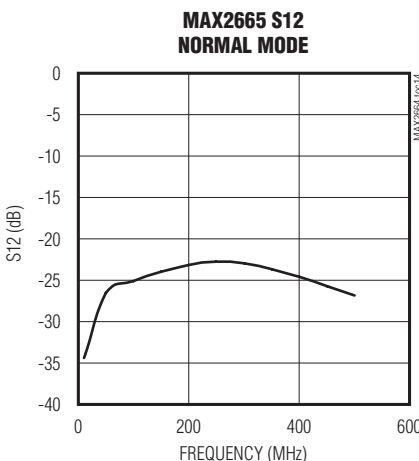
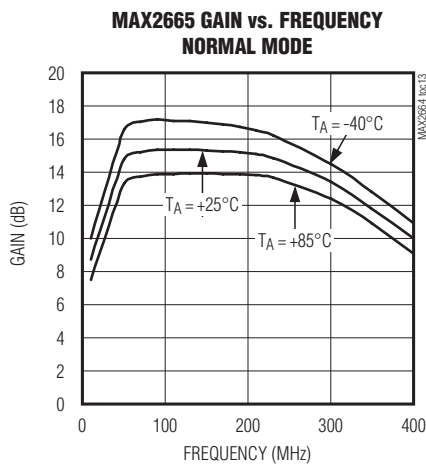
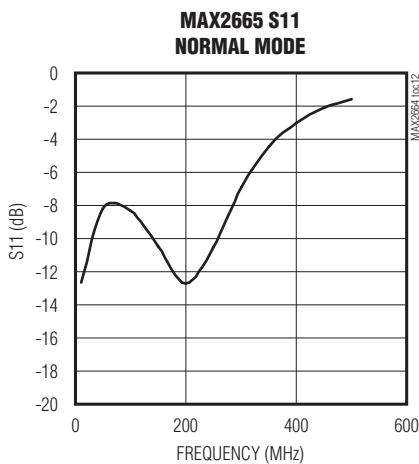
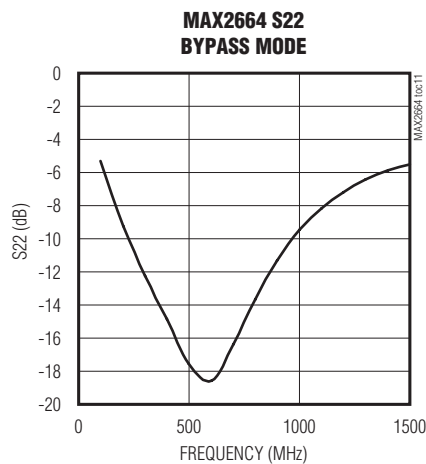
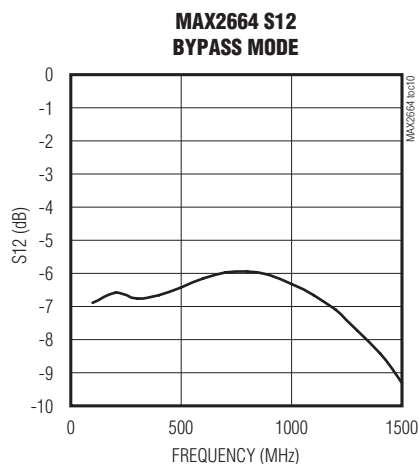
( $T_A = +25^\circ\text{C}$ , unless otherwise noted. MAX2664 and MAX2665 EV kits.)



# VHF/UHF Low-Noise Amplifiers

## Typical Operating Characteristics (continued)

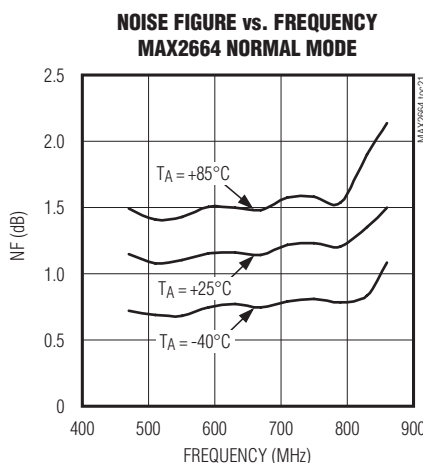
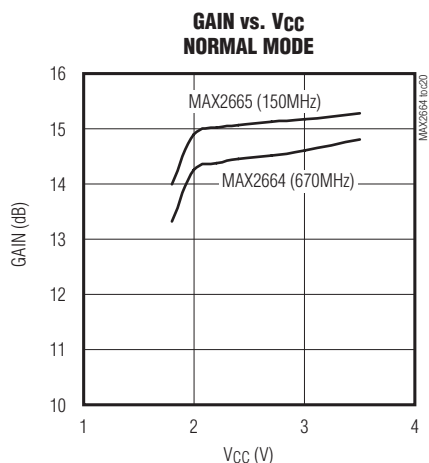
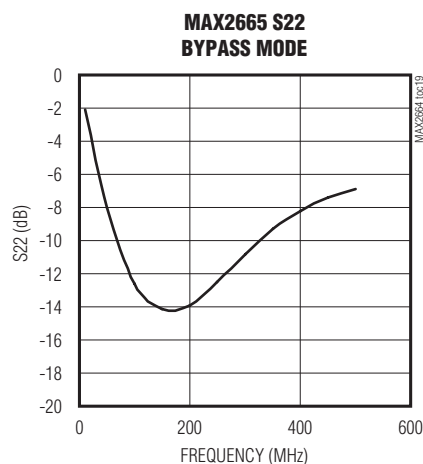
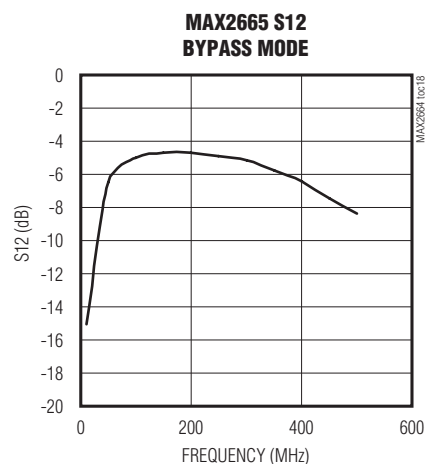
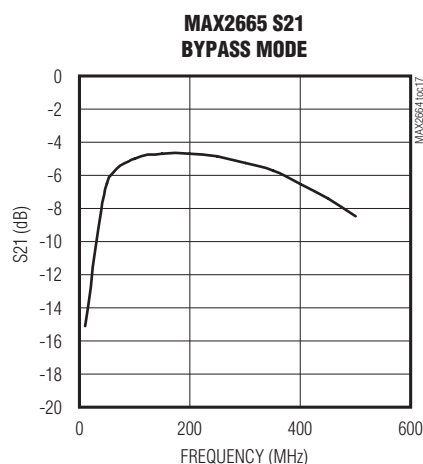
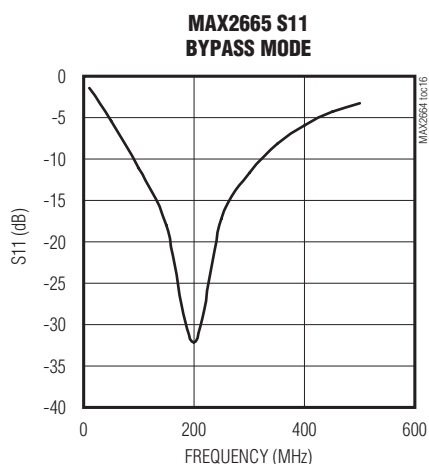
( $T_A = +25^\circ\text{C}$ , unless otherwise noted. MAX2664 and MAX2665 EV kits.)



# VHF/UHF Low-Noise Amplifiers

## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted. MAX2664 and MAX2665 EV kits.)

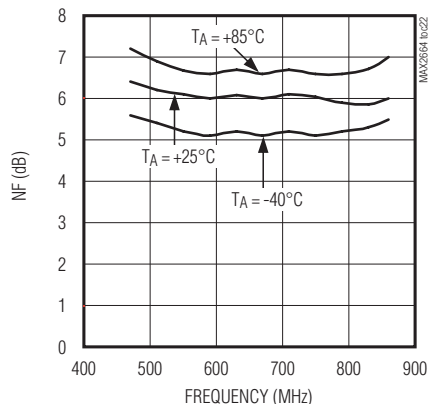


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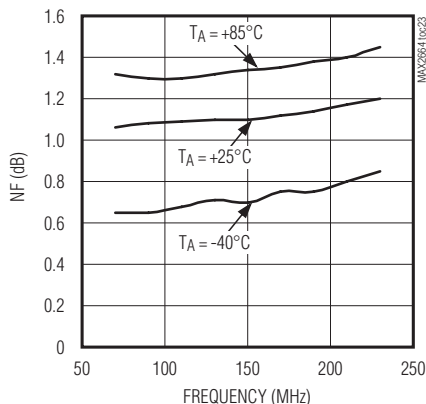
## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted. MAX2664 and MAX2665 EV kits.)

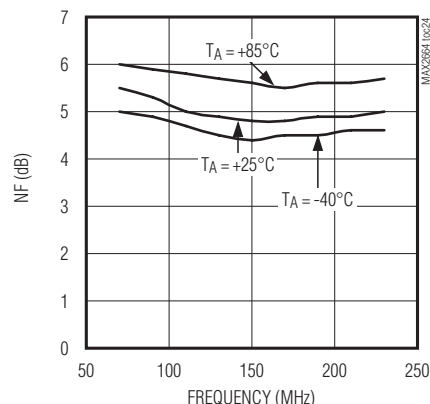
**NOISE FIGURE vs. FREQUENCY**  
**MAX2664 BYPASS MODE**



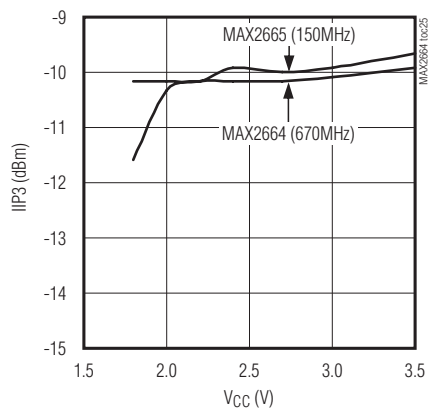
**NOISE FIGURE vs. FREQUENCY**  
**MAX2665 NORMAL MODE**



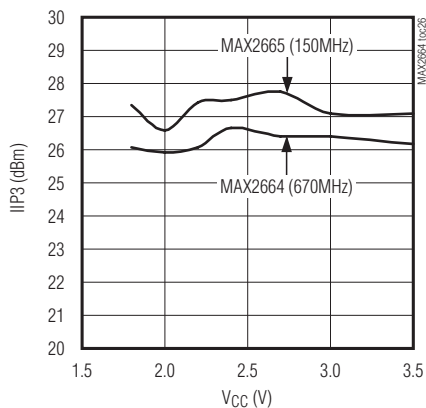
**NOISE FIGURE vs. FREQUENCY**  
**MAX2665 BYPASS MODE**



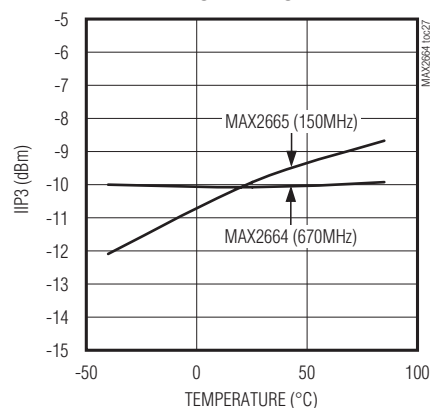
**IIP3 vs. VCC**  
**NORMAL MODE**



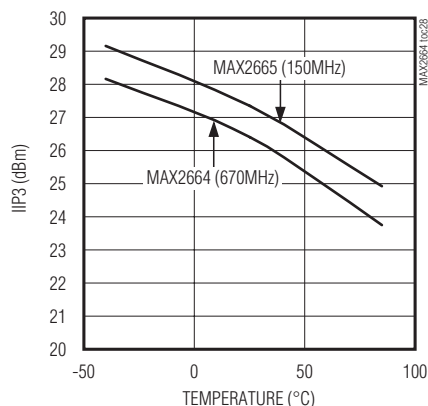
**IIP3 vs. VCC**  
**BYPASS MODE**



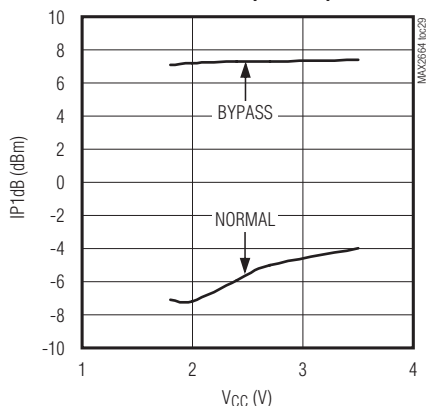
**IIP3 vs. TEMPERATURE**  
**NORMAL MODE**



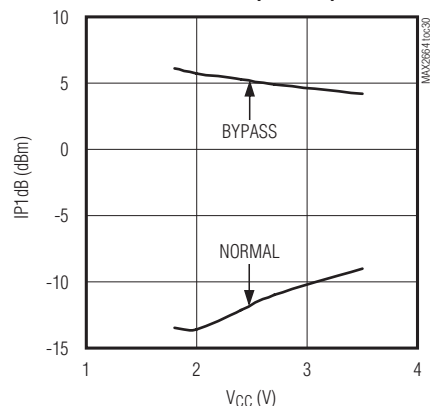
**IIP3 vs. TEMPERATURE**  
**BYPASS MODE**



**IP1dB vs. VCC**  
**MAX2664 (670MHz)**



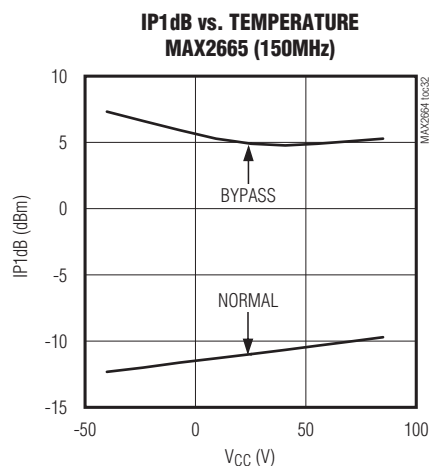
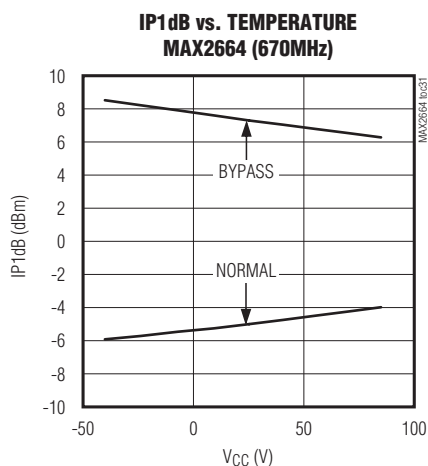
**IP1dB vs. VCC**  
**MAX2665 (150MHz)**



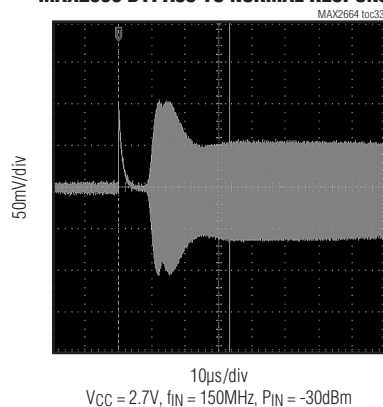
# VHF/UHF Low-Noise Amplifiers

## Typical Operating Characteristics (continued)

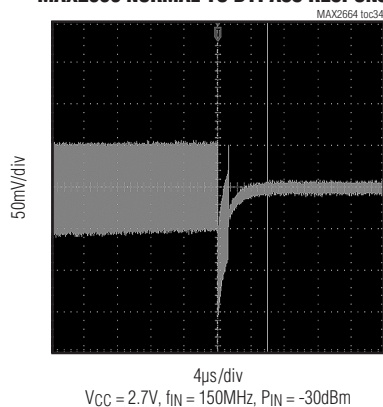
( $T_A = +25^\circ\text{C}$ , unless otherwise noted. MAX2664 and MAX2665 EV kits.)



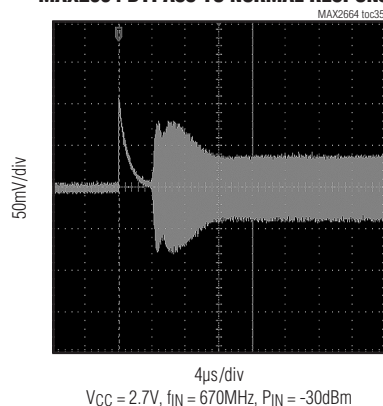
**MAX2665 BYPASS TO NORMAL RESPONSE**



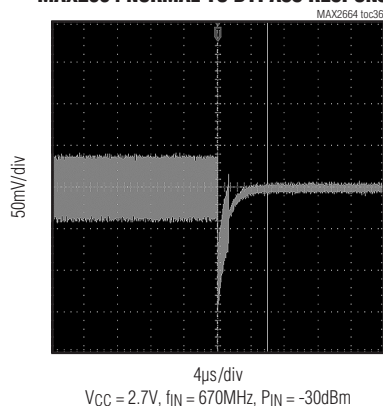
**MAX2665 NORMAL TO BYPASS RESPONSE**



**MAX2664 BYPASS TO NORMAL RESPONSE**



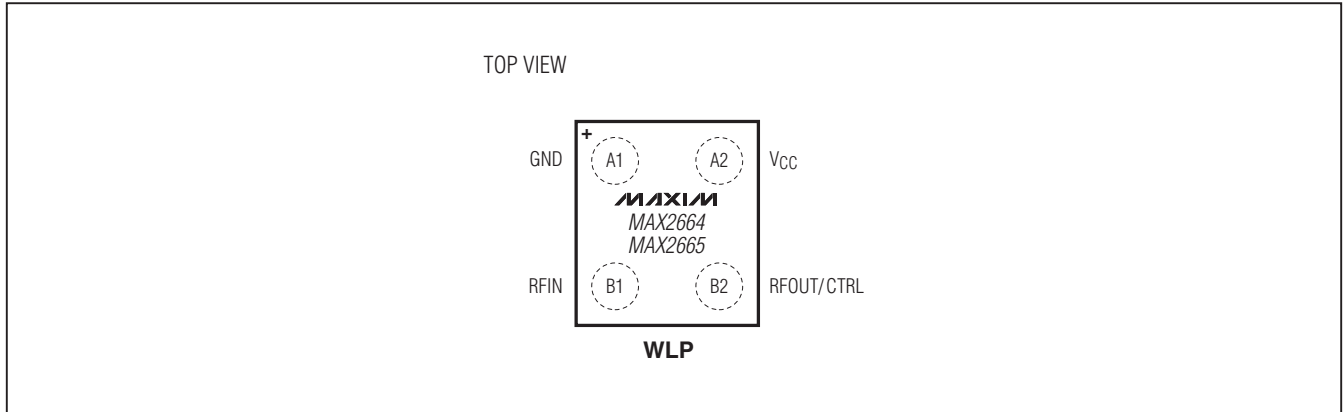
**MAX2664 NORMAL TO BYPASS RESPONSE**





# VHF/UHF Low-Noise Amplifiers

## Bump Configuration



## Bump Description

| BUMP | NAME       | FUNCTION                                                                                                                                                               |
|------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1   | GND        | Ground. Connect to the PCB ground plane with minimal trace inductance.                                                                                                 |
| A2   | VCC        | Supply Voltage. Bypass to ground with a 1000pF capacitor as close as possible to the IC.                                                                               |
| B1   | RFIN       | RF Input. Requires an external matching inductor and DC-blocking capacitor. The nominal internal DC voltage is 750mV.                                                  |
| B2   | RFOUT/CTRL | RF Output and Bypass Control (see the <i>Applications Information</i> section). RFOUT is internally matched to 50Ω and incorporates an internal DC-blocking capacitor. |

## Detailed Description

The MAX2664/MAX2665 are low-power LNAs designed for VHF/UHF applications. The devices feature an internal LNA bypass control mode for better linearity under high-input-signal power conditions. The devices are offered in a small WLP package.

## Input and Output Matching

Only an inductor in series with a DC-blocking capacitor is needed to form the input-matching network. The *Typical Application Circuit* shows the recommended input-matching network. These values are optimized for the best simultaneous gain, noise figure, and return loss performance. Tables 1 and 2 list typical device S-parameter values. The devices integrate an on-chip 50Ω output-matching network, eliminating the need for external matching components.

## VHF/UHF Low-Noise Amplifiers

Table 1. MAX2664 Typical Device S-Parameter at VCC = 2.7V, TA = +25°C, Z0 = 50Ω

| FREQUENCY (MHz) | IS11I  | S11<br>ANGLE | IS21I | S21<br>ANGLE | IS12I  | S12<br>ANGLE | IS22I  | S22<br>ANGLE |
|-----------------|--------|--------------|-------|--------------|--------|--------------|--------|--------------|
| 470             | 0.6664 | -55.7        | 4.945 | 167.1        | 0.0449 | 36.7         | 0.2847 | -65.8        |
| 500             | 0.6675 | -58.9        | 4.964 | 163.9        | 0.0462 | 35.5         | 0.2795 | -64.5        |
| 530             | 0.6674 | -62.0        | 4.979 | 160.8        | 0.0474 | 34.9         | 0.2769 | -63.2        |
| 560             | 0.6674 | -65.0        | 4.978 | 157.8        | 0.0484 | 33.6         | 0.2787 | -62.2        |
| 590             | 0.6673 | -67.8        | 4.972 | 154.8        | 0.0500 | 32.4         | 0.2819 | -61.3        |
| 620             | 0.6667 | -70.6        | 4.958 | 152.0        | 0.0507 | 31.0         | 0.2858 | -60.9        |
| 650             | 0.6651 | -73.4        | 4.938 | 149.1        | 0.0523 | 30.8         | 0.2937 | -60.7        |
| 680             | 0.6662 | -75.9        | 4.916 | 146.3        | 0.0528 | 29.5         | 0.3011 | -60.7        |
| 710             | 0.6651 | -78.4        | 4.885 | 143.7        | 0.0539 | 27.9         | 0.3098 | -61.2        |
| 740             | 0.6639 | -80.9        | 4.852 | 140.9        | 0.0550 | 26.6         | 0.3185 | -61.6        |
| 770             | 0.6624 | -83.2        | 4.810 | 138.2        | 0.0560 | 25.6         | 0.3276 | -62.5        |
| 800             | 0.6610 | -85.5        | 4.764 | 135.7        | 0.0570 | 25.1         | 0.3372 | -63.5        |
| 830             | 0.6598 | -87.7        | 4.714 | 133.1        | 0.0573 | 24.0         | 0.3478 | -64.7        |
| 860             | 0.6600 | -89.7        | 4.667 | 130.7        | 0.0579 | 22.1         | 0.3571 | -66.1        |

Table 2. MAX2665 Typical Device S-Parameter at VCC = 2.7V, TA = +25°C, Z0 = 50Ω

| FREQUENCY (MHz) | IS11I  | S11<br>ANGLE | IS21I | S21<br>ANGLE | IS12I  | S12<br>ANGLE | IS22I  | S22<br>ANGLE |
|-----------------|--------|--------------|-------|--------------|--------|--------------|--------|--------------|
| 60              | 0.4608 | -13.9        | 5.505 | -176.6       | 0.0519 | 27.3         | 0.5060 | -32.8        |
| 90              | 0.4944 | -29.2        | 5.564 | 172.6        | 0.0546 | 21.5         | 0.4518 | -33.6        |
| 120             | 0.5160 | -42.2        | 5.507 | 164.2        | 0.0571 | 19.2         | 0.4270 | -35.0        |
| 150             | 0.5368 | -53.0        | 5.366 | 156.6        | 0.0593 | 16.5         | 0.4181 | -38.4        |
| 180             | 0.5601 | -62.9        | 5.173 | 150.4        | 0.0612 | 15.9         | 0.4036 | -41.7        |
| 210             | 0.5800 | -71.6        | 4.979 | 144.7        | 0.0630 | 14.3         | 0.3948 | -45.0        |
| 240             | 0.6006 | -79.3        | 4.783 | 139.5        | 0.0649 | 13.1         | 0.3870 | -48.4        |

Table 3. MAX2664 Simulated Device Noise Parameters at VCC = 2.7V, TA = +25°C, Z0 = 50Ω

| FREQUENCY (MHz) | FMIN (dB) | ΓOPT   | ΓOPT ANGLE | rn*    |
|-----------------|-----------|--------|------------|--------|
| 470             | 1.014     | 0.2673 | 47.4       | 0.1724 |
| 500             | 1.017     | 0.2680 | 50.1       | 0.1709 |
| 530             | 1.021     | 0.2691 | 52.8       | 0.1695 |
| 560             | 1.024     | 0.2703 | 55.4       | 0.1681 |
| 590             | 1.028     | 0.2718 | 58.0       | 0.1667 |
| 620             | 1.032     | 0.2735 | 60.6       | 0.1653 |
| 650             | 1.036     | 0.2753 | 63.1       | 0.1639 |
| 680             | 1.040     | 0.2774 | 65.5       | 0.1626 |
| 710             | 1.045     | 0.2796 | 67.9       | 0.1612 |
| 740             | 1.049     | 0.2820 | 70.3       | 0.1599 |
| 770             | 1.054     | 0.2845 | 72.6       | 0.1586 |
| 800             | 1.059     | 0.2871 | 74.9       | 0.1573 |
| 830             | 1.064     | 0.2899 | 77.1       | 0.1560 |
| 860             | 1.070     | 0.2927 | 79.3       | 0.1547 |

\*rn is normalized.

## VHF/UHF Low-Noise Amplifiers

**Table 4. MAX2665 Typical Noise Parameters  $V_{CC} = 2.7V$ ,  $T_A = +25^\circ C$ ,  $Z_0 = 50\Omega$**

| FREQUENCY (MHz) | F <sub>MIN</sub> (dB) | $ \Gamma_{OPT} $ | $\Gamma_{OPT}$ ANGLE | $r_n^*$ |
|-----------------|-----------------------|------------------|----------------------|---------|
| 60              | 0.911                 | 0.1390           | 34.5                 | 0.1241  |
| 90              | 0.928                 | 0.1458           | 47.2                 | 0.1240  |
| 120             | 0.940                 | 0.1592           | 58.1                 | 0.1237  |
| 150             | 0.949                 | 0.1766           | 67.0                 | 0.1233  |
| 180             | 0.958                 | 0.1962           | 74.5                 | 0.1227  |
| 210             | 0.967                 | 0.2170           | 80.7                 | 0.1221  |
| 240             | 0.975                 | 0.2383           | 86.2                 | 0.1213  |

\* $r_n$  is normalized.

### Active Bypass Mode Control

The devices' RFOUT/CTRL pin is used to control the bypass mode of the LNA. When set to logic-high through an external  $1k\Omega$  resistor, the devices' active mode is enabled. Conversely, when connected to logic-low, the devices' bypass mode is enabled. An external DC-blocking capacitor should be used to isolate the control function of this dual-purpose pin (see the *Typical Application Circuit*).

### Applications Information

A properly designed PCB is essential to any RF microwave circuit. Use controlled-impedance lines on all high-frequency inputs and outputs. Bypass  $V_{CC}$  with decoupling capacitors located close to the device. For long  $V_{CC}$  lines, it might be necessary to add additional decoupling capacitors. Locate these additional capacitors further away from the device package. Proper grounding of the GND pin is essential. If the PCB uses a topside RF ground, connect it directly to the GND pin. For a board where the ground is not on the component layer, connect the GND pin to the board with multiple vias close to the package.

Refer to [www.maxim-ic.com](http://www.maxim-ic.com) for the MAX2664/MAX2665 S-parameter download, MAX2664/MAX2665 EV kit schematic, gerbers, PADS layout file, and BOM information.

**Table 5. Logic Table**

| RFOUT/CTRL | MODE   |
|------------|--------|
| High       | Active |
| Low        | Bypass |

### Chip Information

PROCESS: SiGe BiCMOS

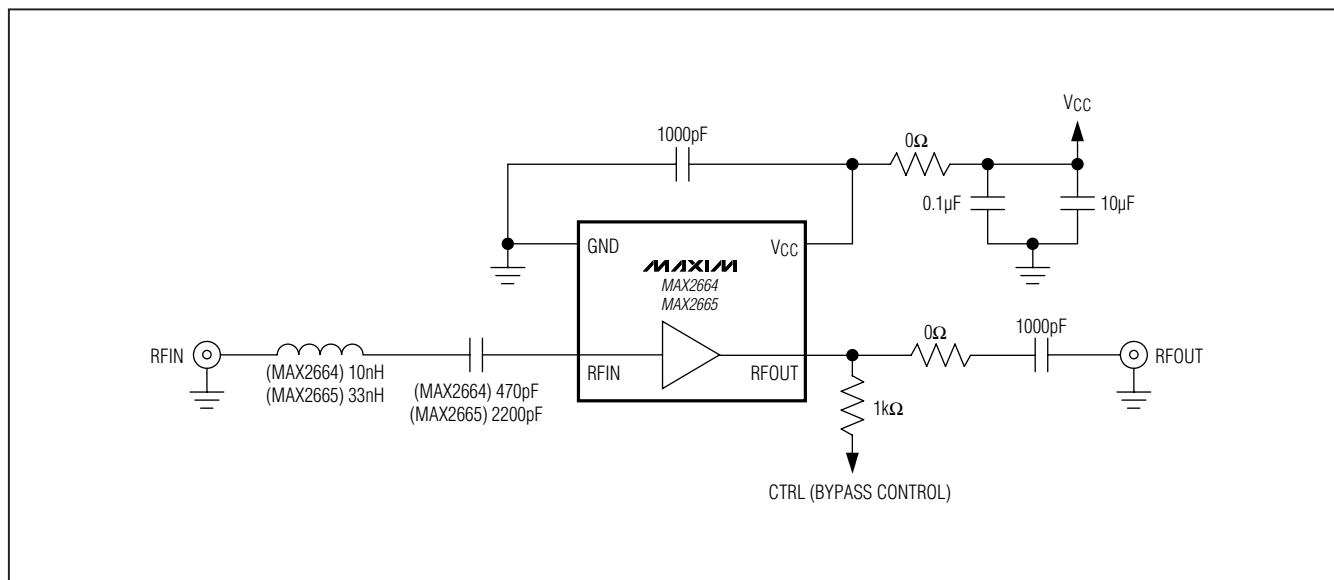
### Package Information

For the latest package outline information and land patterns, go to [www.maxim-ic.com/packages](http://www.maxim-ic.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 TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO. |
|--------------|--------------|-------------------------|------------------|
| 4 WLP        | W40A0+1      | <a href="#">21-0480</a> | —                |

## VHF/UHF Low-Noise Amplifiers

### Typical Application Circuit



# VHF/UHF Low-Noise Amplifiers

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION     | PAGES<br>CHANGED |
|--------------------|------------------|-----------------|------------------|
| 0                  | 8/10             | Initial release | —                |

MAX2664/MAX2665

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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