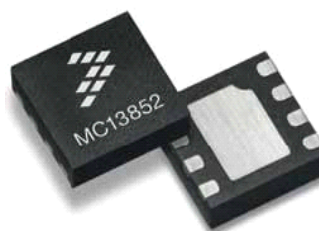




## MC13852

# MC13852

## General Purpose Low Noise Amplifier with Bypass Switch



**Package Information**  
Plastic Package: MLPD-8  
2.0 x 2.0 x 0.6 mm  
Case: 2128-01

### Ordering Information

| Device    | Device Marking | Package |
|-----------|----------------|---------|
| MC13852EP | 852            | MLPD-8  |

## 1 Introduction

The MC13852 is a cost-effective high gain LNA with low noise figure. This is the lower application frequency version of the MC13851.

An integrated bypass switch is included to preserve high input intercept performance in variable signal strength environments and boosts dynamic range. On-chip bias circuitry offers low system cost. The input and output match are external to allow maximum design flexibility. The external resistor used to set device current enables balancing required linearity with low current consumption. Gain is optimized for applications <1000 MHz.

The MC13852 is fabricated with an advanced RF BiCMOS process using the eSiGe:C module and is available in the 2 × 2 mm MLPD-8 leadless package, offering a small, low height, easy-to-solder solution for applications with tight printed circuit board placement requirements.

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This document contains information on a new product. Specifications and information herein are subject to change without notice.

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## 1.1 Features

- The MC13852 is intended for applications from 400 to 1000 MHz; the MC13851 is for applications >1000 MHz.
- Gain: 20.3 dB (typ) at 434 MHz, 18.7 dB (typ) at 900 MHz.
- Output third order intercept point (OIP3): 10.6 dBm at 434 MHz, 14.2 dBm (typ) dBm at 900 MHz.
- Noise Figure (NF): 1.65 dB (typ) at 434 MHz, 1.2 dB at 900 MHz.
- Output 1 dB compression point (P1dB): 7.8 dBm (typ) at 434 MHz, 9.6 dBm (typ) at 900 MHz.
- IP3 Boost Circuitry.
- Bypass mode return losses are comparable to active mode, for use in systems with filters and duplexers.
- Bypass mode improves dynamic range in variable signal strength environments.
- Integrated logic-controlled standby mode with current drain < 1uA.
- Total supply current variable from 3–6 mA using an external bias resistor.
- Average current drain <0.6mA in a receiver lineup with 20% active / 80% bypass mode operation.
- On-chip bias sets the bias point.
- Bias stabilized for device and temperature variations.
- MLPD-8 leadless package with low parasitics.
- 434 MHz and 900 MHz application circuit evaluation boards with characterization data are available.
- Available in tape and reel packaging.

## 1.2 Applications

Ideal for use in any RF product that operates between 400 MHz and 1 GHz, and may be applied in:

- Buffer amplifiers
- Mixers
- IF amplifiers
- Voltage-controlled oscillators (VCOs)
- Use with transceivers requiring external LNAs
- RF smart metering
- Mobile: Cellular front-end LNA, 2-way radios
- Auto: RKE, key fob, TPMS
- Low current drain/long standby time for extended battery life applications

Figure 1 shows a simplified block diagram, with the pinouts and the location of the pin 1 marking on the package.

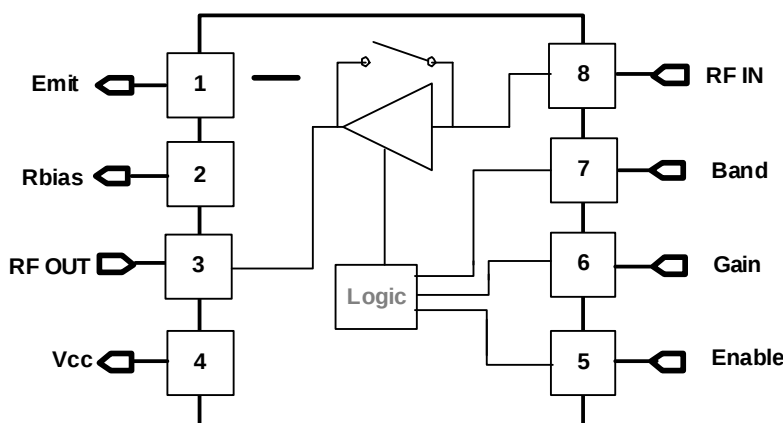


Figure 1. Simplified Block Diagram

## 2 Electrical Specifications

Table 1 lists the maximum ratings for the device.

Table 1. Maximum Ratings

| Ratings                                                | Symbol          | Value      | Unit |
|--------------------------------------------------------|-----------------|------------|------|
| Supply Voltage                                         | $V_{CC}$        | 3.3        | V    |
| Storage Temperature Range                              | $T_{stg}$       | -65 to 150 | °C   |
| Operating Ambient Temperature Range                    | $T_A$           | -30 to 85  | °C   |
| RF Input Power                                         | $P_{rf}$        | 10         | dBm  |
| Power Dissipation                                      | $P_{dis}$       | 100        | mW   |
| Thermal Resistance, Junction to Case                   | $R_{\theta JC}$ | 24         | C/W  |
| Thermal Resistance, Junction to Ambient, 4 Layer Board | $R_{\theta JA}$ | 90         | C/W  |

**NOTES:** 1. Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the Recommended Operating Conditions and Electrical Characteristics tables.  
 2. ESD (electrostatic discharge) immunity meets Human Body Model (HBM)  $\leq 200$  V, Charge Device Model (CDM)  $\leq 450$  V, and Machine Model (MM)  $\leq 50$  V. Additional ESD data available upon request.

Table 2 lists the recommended operating conditions.

Table 2. Recommended Operating Conditions

| Characteristic     | Symbol   | Min  | Typ  | Max      | Unit |
|--------------------|----------|------|------|----------|------|
| RF Frequency range | $f_{RF}$ | 400  | —    | 1000     | MHz  |
| Supply Voltage     | $V_{CC}$ | 2.3  | 2.75 | 3.0      | Vdc  |
| Logic Voltage      | —        | 1.25 | 1.8  | $V_{CC}$ | Vdc  |
| Input High Voltage | —        | 0    | —    | 0.8      | Vdc  |
| Input Low Voltage  | —        | 0    | —    | 0.8      | Vdc  |

Table 3 shows the use of the Gain, Enable and Band pins (along with the Vcc and RF out pins), to select Active mode (High Gain), Bypass mode (Low Gain), or Standby mode (Disable) operation.

Table 3. Truth Table

| Pin Function                                                                                                                                                                                                                                                                                   | Pin Name | Enable   |           | Disable  |           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|-----------|----------|-----------|
|                                                                                                                                                                                                                                                                                                |          | Low Gain | High Gain | Low Gain | High Gain |
| Logic Circuit Bias Vcc                                                                                                                                                                                                                                                                         | Vcc      | 1        | 1         | 1        | 1         |
| Toggles Gain Mode (Active or Bypass)                                                                                                                                                                                                                                                           | Gain     | 0        | 1         | 0        | 1         |
| Toggles LNA On/Off                                                                                                                                                                                                                                                                             | Enable   | 1        | 1         | 0        | 0         |
| Selects the LNA                                                                                                                                                                                                                                                                                | Band     | 1        | 1         | 1        | 1         |
| <b>NOTES:</b> 1. Logic state "1" equals Vcc voltage. Logic state of "0" equals ground potential.<br>2. Vcc is inductively coupled to LNA Out pin and Vcc pin.<br>3. Minimum logic state "1" for enable and gain pins is 1.25V.<br>4. Maximum logic state "0" for enable and gain pins is 0.8V. |          |          |           |          |           |

Table 4 lists electrical characteristics associated with noise performance measured in a 50Ω system. Additional noise parameters are listed in Table 14 and Table 15. Also listed are the typical Icc and RF turn-on times for the device.

Table 4. Electrical Characteristics (Vcc = 2.75 V, Ta = 25°C)

| Characteristic                                                                                                                                                                                                                                                | Symbol             | Min          | Typ                | Max        | Unit |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------|--------------------|------------|------|
| Insertion Gain<br>R1=1.2 kΩ, Freq=434 MHz<br>R1=1.2 kΩ, Freq=900 MHz                                                                                                                                                                                          | IS21I <sup>2</sup> | 20.4<br>16.4 | 21.9<br>18.3       | —          | dB   |
| Maximum Stable Gain and/or Maximum Available Gain [Note1]<br>R1=1.2 kΩ, Freq=434 MHz<br>R1=1.2 kΩ, Freq=900 MHz                                                                                                                                               | MSG, MAG           | 26.7<br>22   | 28.2<br>23.5       | —          | dB   |
| Minimum Noise Figure<br>R1=1.2 kΩ, Freq=434 MHz<br>R1=1.2 kΩ, Freq=900 MHz                                                                                                                                                                                    | NFmin              | —            | 0.92<br>0.84       | 1.2<br>1.1 | dB   |
| Associated Gain at Minimum Noise Figure<br>R1=1.2 kΩ, Freq=434 MHz<br>R1=1.2 kΩ, Freq=900 MHz                                                                                                                                                                 | Gnf                | 27.6<br>21   | 29.6<br>23         | —          | dB   |
| Icc and RF Turn On Time<br>Enable trigger total time of 1.8 usec from 0 to 2.75 V<br>Icc rise time from 0 to 76% of final current level<br>Icc rise time from 0 to 87% of final current level<br>RF on time from leading edge of enable trigger to RF turn-on | —                  | —            | 6.4<br>9.6<br>1.37 | —          | usec |
| <b>NOTES:</b> 1. Maximum Available Gain and Maximum Stable Gain are defined by the K factor as follows:<br>MAG=IS21/S12(K+/-sqrt(K <sup>2</sup> -1))), if K>1,<br>MSG =IS21/S12I, if K<1                                                                      |                    |              |                    |            |      |

Table 5 lists the electrical characteristics measured on evaluation boards that are tuned for typical application frequencies. Further details on the application circuits are shown in Section 4; details on the boards are shown in Section 5.

**Table 5. Electrical Characteristics Measured in Frequency Specific Tuned Circuits**(V<sub>CC</sub> = 2.775 V, T<sub>A</sub> = 25°C, R<sub>bias</sub> = 2 kΩ, unless otherwise noted.)

| Characteristic                                     | Symbol           | Min   | Typ  | Max  | Unit |
|----------------------------------------------------|------------------|-------|------|------|------|
| <b>434 MHz</b>                                     |                  |       |      |      |      |
| Frequency                                          | f                | —     | 434  | —    | MHz  |
| Active RF Gain                                     | G                | 19.3  | 20.3 | —    | dB   |
| Active Noise Figure                                | NF               | —     | 1.65 | 1.95 | dB   |
| Active Input Third Order Intercept Point           | IIP3             | -10.7 | -9.7 | —    | dBm  |
| Active Output 1 dB Compression Point               | P <sub>1dB</sub> | 6.8   | 7.8  | —    | dBm  |
| Active Current @ 2.75 V, R <sub>bias</sub> =1.2 kΩ | I <sub>CC</sub>  | —     | 5.5  | 6.5  | mA   |
| Active Current @ 2.75 V, R <sub>bias</sub> =1.5 kΩ | I <sub>CC</sub>  | —     | 4.4  | 5.4  | mA   |
| Active Gain                                        | S21              | 19    | 20.1 | —    | dB   |
| Bypass RF Gain                                     | G                | -9.5  | -8.5 | —    | dB   |
| Bypass Noise Figure                                | NF               | —     | 8.9  | 9.9  | dB   |
| Bypass Input Third Order Intercept Point           | IIP3             | 24    | 25.1 | —    | dBm  |
| Bypass Current                                     | —                | —     | 4    | 20   | μA   |
| Bypass Gain                                        | S21              | -9.5  | -8.5 | —    | dB   |
| <b>900 MHz</b>                                     |                  |       |      |      |      |
| Frequency                                          | f                | —     | 900  | —    | MHz  |
| Active RF Gain                                     | G                | 17.6  | 18.6 | —    | dB   |
| Active Noise Figure                                | NF               | —     | 1.2  | 1.55 | dB   |
| Active Input Third Order Intercept Point           | IIP3             | -5.7  | -4.4 | —    | dBm  |
| Active Output 1 dB Compression Point               | P <sub>1dB</sub> | 8.5   | 9.6  | —    | dBm  |
| Active Current @ 2.75 V, R <sub>bias</sub> =1.2 kΩ | I <sub>CC</sub>  | —     | 5.5  | 6.5  | mA   |
| Active Current @ 2.75 V, R <sub>bias</sub> =1.5 kΩ | I <sub>CC</sub>  | —     | 4.4  | 5.4  | mA   |
| Active Gain                                        | S21              | 17.5  | 18.5 | —    | dB   |
| Bypass RF Gain                                     | G                | -6.7  | -5.7 | —    | dB   |
| Bypass Noise Figure                                | NF               | —     | 6.1  | 7.1  | dB   |
| Bypass Input Third Order Intercept Point           | IIP3             | 25    | 26.7 | —    | dBm  |
| Bypass Current                                     | —                | —     | 4    | 10   | μA   |
| Bypass Gain                                        | S21              | -6.7  | -5.7 | —    | dB   |

Figure 2 and Figure 3 show maximum stable and maximum available gain and forward insertion gain versus frequency for the packaged device in a 50Ω system using bias resistors of 1.5 kΩ and 1.2 kΩ.

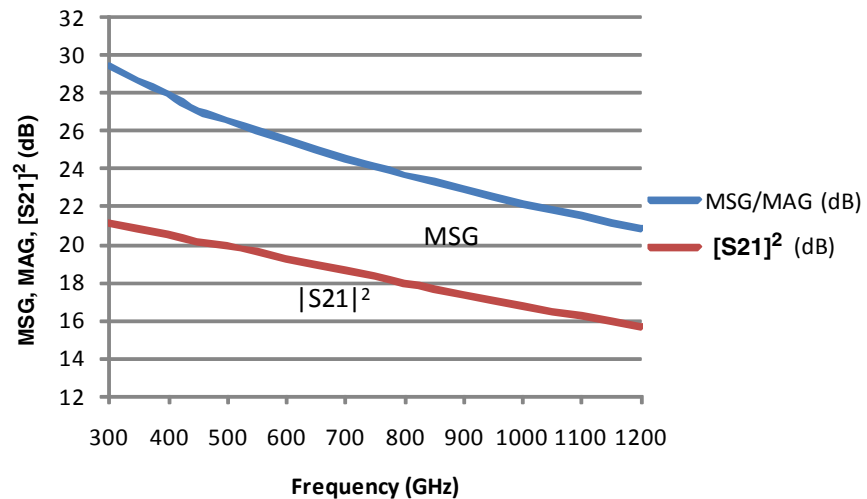


Figure 2. Maximum Stable/Available Gain and Forward Insertion Gain vs. Frequency, Rbias = 1.5 kΩ

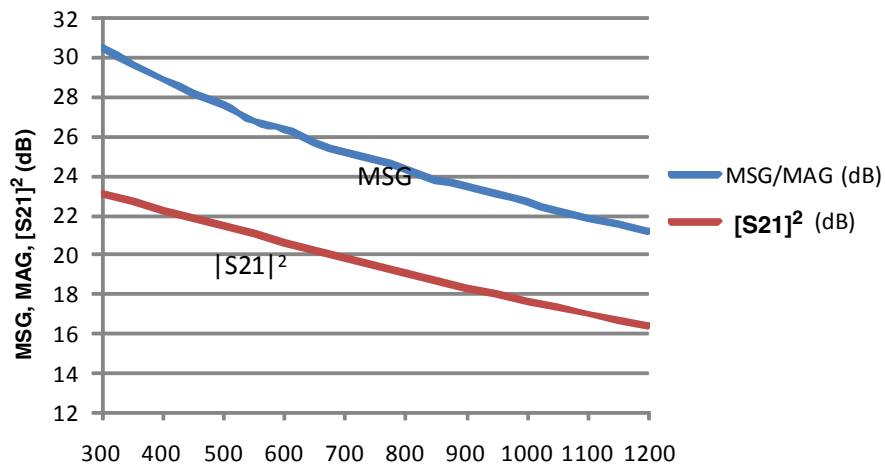


Figure 3. Maximum Stable/Available Gain and Forward Insertion Gain vs. Frequency, Rbias = 1.2 kΩ

Figure 4 and Figure 5 show minimum noise figure and associated gain versus frequency for the packaged device in a 50 $\Omega$  system using bias resistors of 1.5 k $\Omega$  and 1.2 k $\Omega$ .

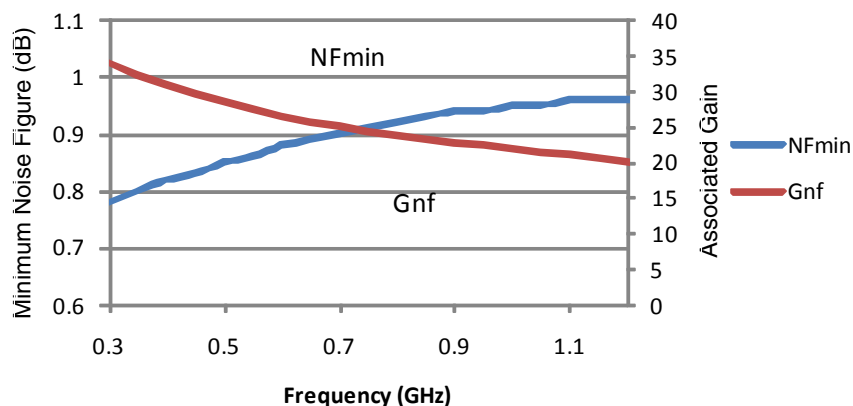


Figure 4. Minimum Noise Figure and Associated Gain vs. Frequency, R<sub>bias</sub> = 1.5 k $\Omega$

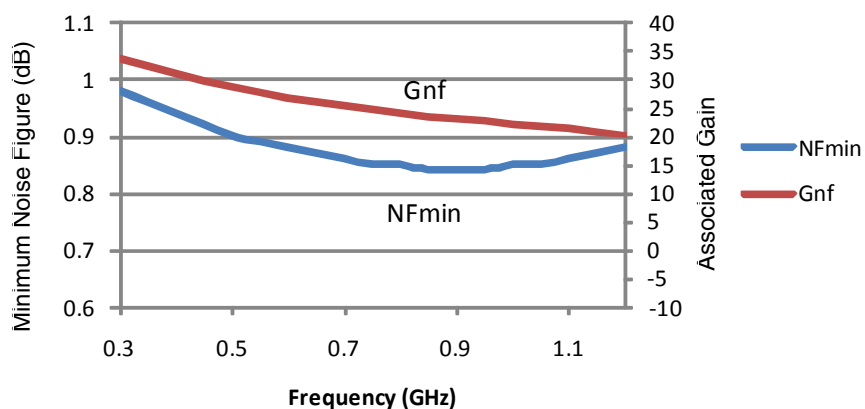


Figure 5. Minimum Noise Figure and Associated Gain vs. Frequency, R<sub>bias</sub> = 1.2 k $\Omega$

Figure 6 shows the  $I_{cc}$  current drain for a range of values for the external bias resistor  $R_{bias}$ .

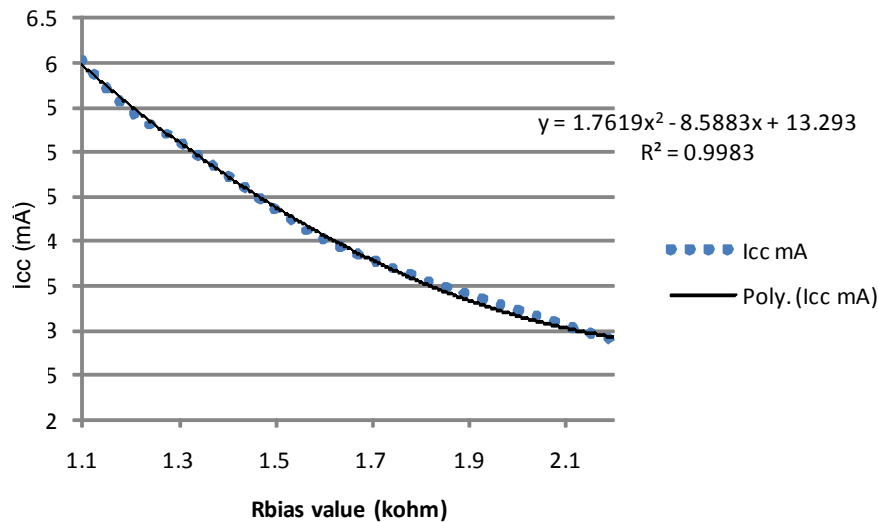


Figure 6.  $I_{cc}$  vs. Bias Resistor  $R_1$  Value

### 3 Applications Information

The MC13852 LNA is designed for applications in the 400 MHz to 1 GHz range. It has three different modes: High Gain, Low Gain (bypass) and Standby. The LNA is programmable through the Gain and Enable pins. The logic truth table is given in Table 3. The internal bypass switch is designed for broadband applications.

One of the advantages of the MC13852 is the simplification of the matching network in both bypass and amplifier modes. The bypass switch is designed so that changes of input and output return losses between bypass mode and active mode are minimized and the matching network design is simplified.

In these application examples, a balance is made between the competing RF performance characteristics of  $I_{cc}$ , NF, gain, IP3, and return losses with unconditional stability. Conjugate matching is not used for the input or output. Instead, matching which achieves a trade-off in RF performance qualities is used. For a particular application or specification requirement, the matching can be changed to achieve enhanced performance of one parameter.

Measurements are made at a bias of  $V_{cc} = 2.75$  V. Frequency spacing for IP3 measurements is 200 kHz. Non-linear measurements are made at  $P_{in} = -30$  dBm. Typical application circuits are provided for 434 MHz and 900 MHz applications. Typical RF performance is shown for two values of bias resistor  $R_1$ : 1.2 k $\Omega$  and 1.5 k $\Omega$ . These two current drain levels offer variations in intercept point, gain and noise figure. Included with each application are the schematics and electrical performance.

- Section 4 provides the evaluation board layout and Bill of Material for the circuits.
- Section 5 provides Smith charts with gain and noise circles for each application frequency.

### 3.1 434 MHz Application

This application was designed to provide typical NF = 1.65 dB, S21 gain = 20 dB, OIP3 = 10.6 dBm at 434 MHz. Typical performance that can be expected from this circuit at 2.75 V is listed in Table 6. The component values can be changed to enhance the performance of a particular parameter, but usually at the expense of another. Two values of bias resistor R1 are shown to demonstrate performance for different IP3 and Icc requirements.

- Values of external resistor R1 are varied to adjust Icc and IP3.
- Inductor L3 provides bias to the logic circuit.

Figure 7 is the 434 MHz application schematic with package pinouts and the circuit component topology.

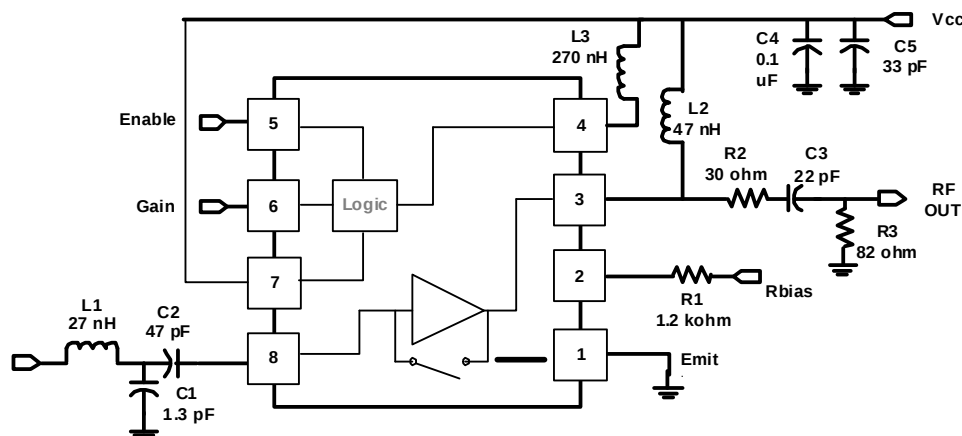


Figure 7. 434 MHz Application Schematic

Table 6. Typical 434 MHz Evaluation Board Performance (Vcc = 2.75V, TA = 25°C)

| Characteristic                                            | Symbol  | Min          | Typ          | Max    | Unit |
|-----------------------------------------------------------|---------|--------------|--------------|--------|------|
| <b>R1 = 1.2 kΩ</b>                                        |         |              |              |        |      |
| Frequency                                                 | f       | —            | 434          | —      | MHz  |
| RF Gain<br>High Gain<br>Bypass                            | G       | 19.3<br>-9.5 | 20.3<br>-8.5 | —<br>— | dB   |
| Output Third Order Intercept Point<br>High Gain<br>Bypass | OIP3    | 9.5<br>15.5  | 10.6<br>16.6 | —<br>— | dBm  |
| Input Third Order Intercept Point<br>High Gain<br>Bypass  | IIP3    | -10.7<br>24  | -9.7<br>25.1 | —<br>— | dBm  |
| Out Ref P1dB<br>High Gain                                 | P1dBout | 6.8          | 7.8          | —      | dBm  |
| In Ref P1dB<br>High Gain                                  | P1dBin  | -13.5        | -12.5        | —      | dBm  |

Table 6. Typical 434 MHz Evaluation Board Performance (Vcc = 2.75V, TA = 25°C) (continued)

| Characteristic                                            | Symbol          | Min          | Typ            | Max           | Unit     |
|-----------------------------------------------------------|-----------------|--------------|----------------|---------------|----------|
| Noise Figure<br>High Gain<br>Bypass                       | NF              | —<br>—       | 1.65<br>8.9    | 1.95<br>9.9   | dB       |
| Current Draw<br>High Gain<br>Bypass                       | I <sub>CC</sub> | —<br>—       | 5.5<br>4       | 6.5<br>20     | mA<br>μA |
| Rbias R1 Value                                            | —               | —            | 1.2            | —             | kΩ       |
| Input Return Loss<br>High Gain<br>Bypass                  | S11             | —<br>—       | -6.7<br>-17    | -5.5<br>-15   | dB       |
| Gain<br>High Gain<br>Bypass                               | S21             | 19<br>-9.5   | 20.1<br>-8.5   | —<br>—        | dB       |
| Reverse Isolation<br>High Gain<br>Bypass                  | S12             | —<br>—       | -35.5<br>-8.6  | -33.5<br>-6.5 | dB       |
| Output Return Loss<br>High Gain<br>Bypass                 | S22             | —<br>—       | -14.5<br>-20.4 | -12<br>-17    | dB       |
| <b>R1 = 1.5 kΩ</b>                                        |                 |              |                |               |          |
| Frequency                                                 | f               | —            | 434            | —             | MHz      |
| RF Gain<br>High Gain<br>Bypass                            | G               | 18.5<br>-9.4 | 19.5<br>-8.4   | —<br>—        | dB       |
| Output Third Order Intercept Point<br>High Gain<br>Bypass | OIP3            | 6.8<br>15.4  | 7.9<br>16.5    | —<br>—        | dBm      |
| Input Third Order Intercept Point<br>High Gain<br>Bypass  | IIP3            | -12.6<br>23  | -11.6<br>24.9  | —<br>—        | dBm      |
| Out Ref P1dB<br>High Gain                                 | P1dBout         | 5.2          | 6.2            | —             | dBm      |
| In Ref P1dB<br>High Gain                                  | P1dBin          | -14.3        | -13.3          | —             | dBm      |
| Noise Figure<br>High Gain<br>Bypass                       | NF              | —<br>—       | 1.6<br>8.7     | 1.9<br>9.7    | dB       |
| Current Draw<br>High Gain<br>Bypass                       | I <sub>CC</sub> | —<br>—       | 4.4<br>4       | 5.4<br>20     | mA<br>μA |
| Rbias R1 Value                                            | —               | —            | 1.5            | —             | kΩ       |

**Table 6. Typical 434 MHz Evaluation Board Performance ( $V_{CC} = 2.75V$ ,  $T_A = 25^{\circ}C$ ) (continued)**

| Characteristic     | Symbol | Min  | Typ   | Max   | Unit |
|--------------------|--------|------|-------|-------|------|
| Input Return Loss  |        |      |       |       |      |
| High Gain          | S11    | —    | -5.5  | -4.5  | dB   |
| Bypass             |        | —    | -17.2 | -15.5 |      |
| Gain               |        |      |       |       |      |
| High Gain          | S21    | 18.3 | 19.3  | —     | dB   |
| Bypass             |        | -9.3 | -8.3  | —     |      |
| Reverse Isolation  |        |      |       |       |      |
| High Gain          | S12    | —    | -35   | -32   | dB   |
| Bypass             |        | —    | -8.3  | -7.3  |      |
| Output Return Loss |        |      |       |       |      |
| High Gain          | S22    | —    | -13.9 | -11   | dB   |
| Bypass             |        | —    | -20.4 | -19   |      |

## 3.2 900 MHz Application

This application circuit is designed to demonstrate performance at 900 MHz. Typical results of NF = 1.2 dB, S21 gain = 18.5 dB, and OIP3 of 14.2 dBm.

By varying the value of resistor R1, the current draw and IP3 performance of the device can be tailored for a particular application. Two values of bias resistor R1 are shown to demonstrate performance for different IP3 and Icc requirements.

- Resistor R3 is used to de-Q output inductor L2 and adjust gain and return losses. Reducing R3 lowers gain and improves return losses.
- Inductor L1 can be raised in value at lower current operation to improve return losses.

Typical performance that can be expected from this circuit at 2.75 V is listed in [Table 7](#).

[Figure 8](#) is the 900 MHz application schematic with package pinouts and the circuit component topology.

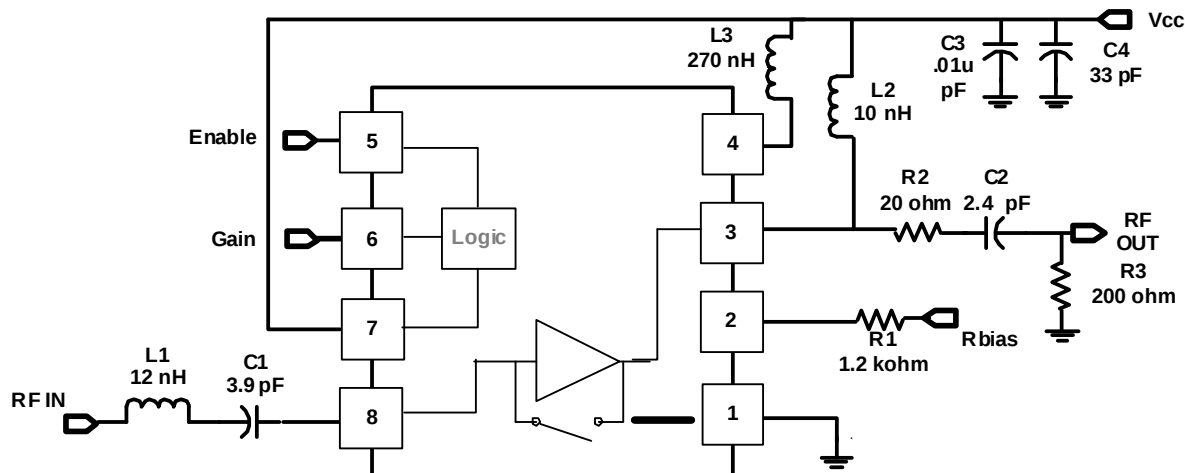
**Figure 8. 900 MHz Application Schematic**

Table 7. Typical 900 MHz Evaluation Board Performance (Vcc = 2.75V, TA = 25°C)

| Characteristic                                            | Symbol          | Min          | Typ          | Max           | Unit     |
|-----------------------------------------------------------|-----------------|--------------|--------------|---------------|----------|
| <b>R1 = 1.2 kΩ</b>                                        |                 |              |              |               |          |
| Frequency                                                 | f               | —            | 900          | —             | MHz      |
| RF Gain<br>High Gain<br>Bypass                            | G               | 17.6<br>-6.7 | 18.6<br>-5.7 | —<br>—        | dB       |
| Output Third Order Intercept Point<br>High Gain<br>Bypass | OIP3            | 13<br>19.5   | 14.2<br>21   | —<br>—        | dBm      |
| Input Third Order Intercept Point<br>High Gain<br>Bypass  | IIP3            | -5.4<br>25   | -4.4<br>26.7 | —<br>—        | dBm      |
| Out Ref P1dB<br>High Gain                                 | P1dBout         | 8.5          | 9.6          | —             | dBm      |
| In Ref P1dB<br>High Gain                                  | P1dBin          | -9.9         | -8.9         | —             | dBm      |
| Noise Figure<br>High Gain<br>Bypass                       | NF              | —<br>—       | 1.2<br>6.1   | 1.55<br>7.1   | dB       |
| Current Draw<br>High Gain<br>Bypass                       | I <sub>CC</sub> | —<br>—       | 5.5<br>4     | 6.5<br>20     | mA<br>μA |
| Rbias R1 Value                                            | —               | —            | 1.2          | —             | kΩ       |
| Input Return Loss<br>High Gain<br>Bypass                  | S11             | —<br>—       | -8.8<br>-11  | -7<br>-9      | dB       |
| Gain<br>High Gain<br>Bypass                               | S21             | 17.5<br>-6.7 | 18.5<br>-5.7 | —<br>—        | dB       |
| Reverse Isolation<br>High Gain<br>Bypass                  | S12             | —<br>—       | -28<br>-5.7  | -26.5<br>-4.7 | dB       |
| Output Return Loss<br>High Gain<br>Bypass                 | S22             | —<br>—       | -13<br>-25   | -10<br>-20    | dB       |
| <b>R1 = 1.5 kΩ</b>                                        |                 |              |              |               |          |
| Frequency                                                 | f               | —            | 900          | —             | MHz      |
| RF Gain<br>High Gain<br>Bypass                            | G               | 17.2<br>-7.7 | 18.2<br>-5.7 | —<br>—        | dB       |
| Output Third Order Intercept Point<br>High Gain<br>Bypass | OIP3            | 12.1<br>19.8 | 13.1<br>21   | —<br>—        | dBm      |

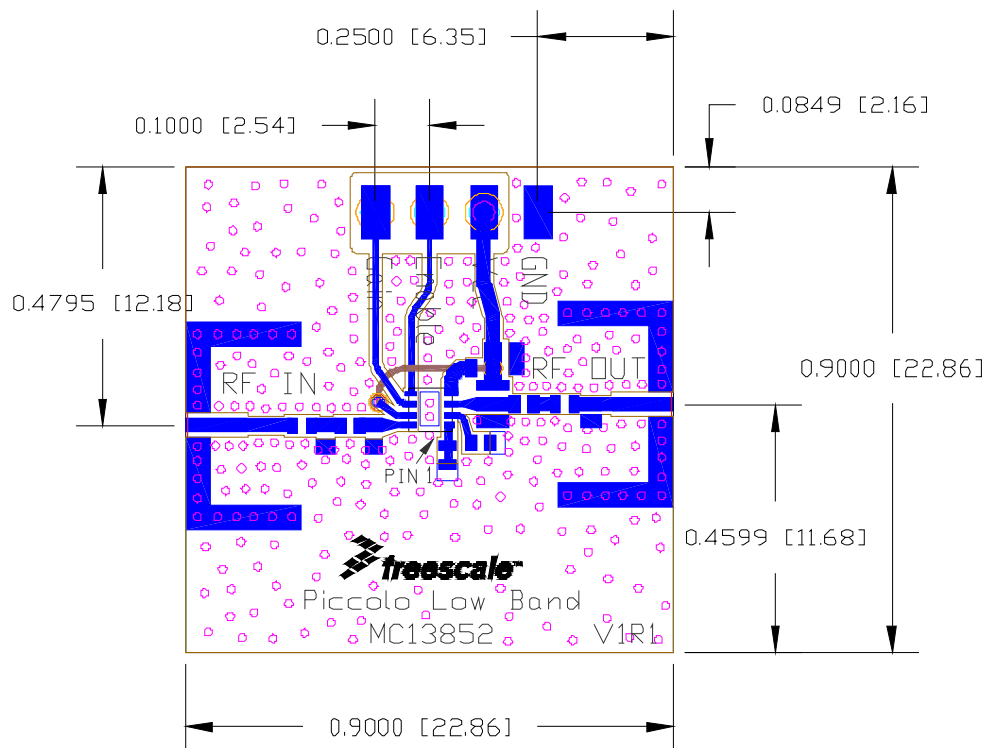
**Table 7. Typical 900 MHz Evaluation Board Performance (Vcc = 2.75V, TA = 25°C) (continued)**

| Characteristic                                           | Symbol          | Min          | Typ           | Max           | Unit     |
|----------------------------------------------------------|-----------------|--------------|---------------|---------------|----------|
| Input Third Order Intercept Point<br>High Gain<br>Bypass | IIP3            | -6.2<br>25.5 | -5.1<br>26.7  | —<br>—        | dBm      |
| Out Ref P1dB<br>High Gain                                | P1dBout         | 8.5          | 9.9           | —             | dBm      |
| In Ref P1dB<br>High Gain                                 | P1dBin          | -10          | -8.4          | —             | dBm      |
| Noise Figure<br>High Gain<br>Bypass                      | NF              | —<br>—       | 1.18<br>6.1   | 1.5<br>7.1    | dB       |
| Current Draw<br>High Gain<br>Bypass                      | I <sub>CC</sub> | —<br>—       | 4.4<br>4      | 5.4<br>20     | mA<br>μA |
| Rbias R1 Value                                           | —               | —            | 1.5           | —             | kΩ       |
| Input Return Loss<br>High Gain<br>Bypass                 | S11             | —<br>—       | -7.6<br>-11   | -6.2<br>-9    | dB       |
| Gain<br>High Gain<br>Bypass                              | S21             | 17.2<br>-6.7 | 18.2<br>-5.7  | —<br>—        | dB       |
| Reverse Isolation<br>High Gain<br>Bypass                 | S12             | —<br>—       | -27.7<br>-5.7 | -26.7<br>-4.7 | dB       |
| Output Return Loss<br>High Gain<br>Bypass                | S22             | —<br>—       | -12.5<br>-25  | -10<br>-20    | dB       |

## 4 Printed Circuit Board and Bills of Materials

Figure 9 is the drawing of the printed circuit board. Figure 11 and Figure 12 are drawings of the evaluation boards used for each of the application frequency designs described in Section 3. These drawings show the boards with the circuit matching components placed and identified.

The Bill of Materials for the application frequency circuit boards is listed in Table 8 and Table 9. The value, case size, manufacturer and circuit function of each component is shown.



Note: Dimensions are in inches and [mm].

Soldering Note: The center flag under the part must be soldered down to ground on the board.

**Figure 9. Printed Circuit Board**

Figure 10 is a picture of a typical assembled evaluation board similar to the ones in the evaluation kits.

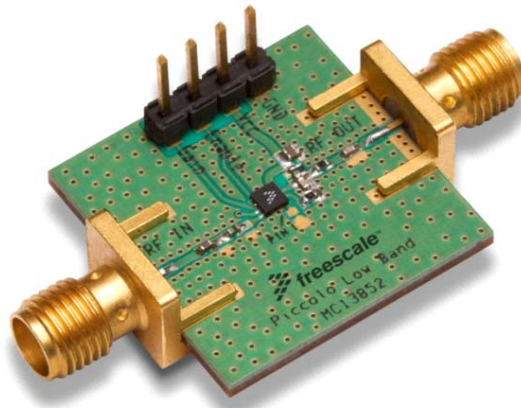


Figure 10. Typical Assembled Evaluation Board with SMA Connectors

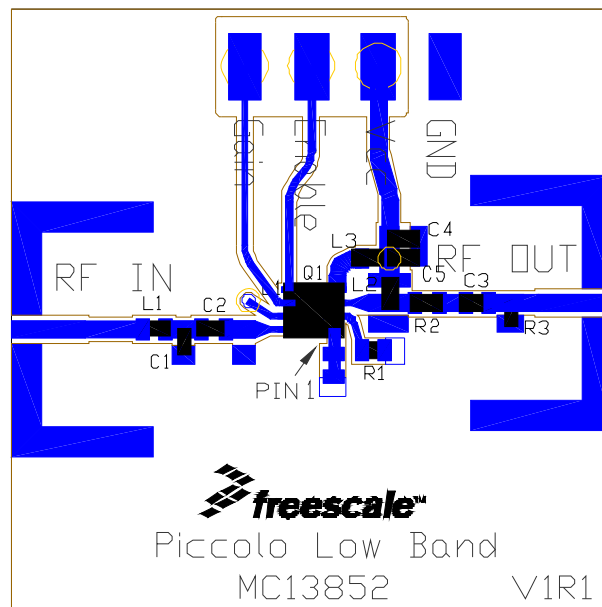


Figure 11. 434 MHz Application Board

Table 8. Bill of Materials for 434 MHz Application Board

| Component | Value  | Case | Manufacturer | Comments              |
|-----------|--------|------|--------------|-----------------------|
| C1        | 1.3 pF | 402  | Murata       | DC block, input match |
| C2        | 47 pF  | 402  | Murata       | DC block, input match |
| C3        | 22 pF  | 402  | Murata       | Output match          |
| C4        | 0.1 uF | 402  | Murata       | Low frequency bypass  |
| C5        | 33 pF  | 402  | Murata       | RF bypass             |

Table 8. Bill of Materials for 434 MHz Application Board (continued)

| Component | Value          | Case    | Manufacturer | Comments                    |
|-----------|----------------|---------|--------------|-----------------------------|
| L1        | 27 nH          | 402     | Murata       | Input match                 |
| L2        | 47 nH          | 402     | Murata       | Output match, bias decouple |
| L3        | 270 nH         | 402     | Murata       | Bias couple to logic        |
| R1        | 1.2 k $\Omega$ | 402     | KOA          | Bias set point              |
| R2        | 30 $\Omega$    | 402     | KOA          | Stability, lower gain       |
| R3        | 82 $\Omega$    | 402     | KOA          | L2 de-Q, gain adjust        |
| Q1        | MC13852        | MLP 2x2 | Freescale    | SiGe LNA                    |

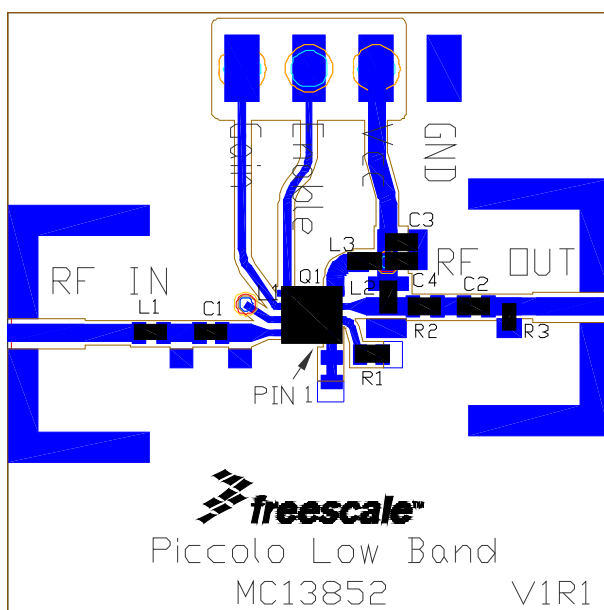


Figure 12. 900 MHz Application Board

Table 9. Bill of Materials for 900 MHz Application Board

| Component | Value       | Case | Manufacturer | Comments             |
|-----------|-------------|------|--------------|----------------------|
| C1        | 3.9 pF      | 402  | Murata       | Input match          |
| C2        | 2.4 pF      | 402  | Murata       | Output match         |
| C3        | 0.1 $\mu$ F | 402  | Murata       | Low frequency bypass |
| C4        | 33 pF       | 402  | Murata       | RF bypass            |
| L1        | 12 nH       | 402  | Murata       | Input match          |
| L2        | 10 nH       | 402  | Murata       | Output match         |

**Table 9. Bill of Materials for 900 MHz Application Board (continued)**

| Component | Value          | Case    | Manufacturer | Comments                  |
|-----------|----------------|---------|--------------|---------------------------|
| L3        | 270 nH         | 402     | Murata       | Bias couple to logic      |
| R1        | 1.2 k $\Omega$ | 402     | KOA          | LNA bias                  |
| R2        | 20 $\Omega$    | 402     | KOA          | Stability, lower gain     |
| R3        | 200 $\Omega$   | 402     | KOA          | De-Q L2, adjust gain, RLs |
| Q1        | MC13852        | MLP 2x2 | Freescale    | SiGe LNA                  |

## 5 Scattering and Noise Parameters

Table 10 through Table 13 list the S parameters for the packaged part in a 50  $\Omega$  system for each of the modes of operation and for two values of the external bias resistor.

**Table 10. Scattering Parameters, Active Mode, R<sub>bias</sub> = 1.2 k $\Omega$   
(V<sub>cc</sub> = 2.75V, 25°C, 50  $\Omega$  system)**

| f (MHz) | S11   |       | S21    |       | S12   |      | S22   |      |
|---------|-------|-------|--------|-------|-------|------|-------|------|
|         | Mag   | Ang   | Mag    | Ang   | Mag   | Ang  | Mag   | Ang  |
| 300     | 0.842 | -6.5  | 14.329 | 149.3 | 0.013 | 88.9 | 0.952 | -2.0 |
| 350     | 0.821 | -7.5  | 13.624 | 146.1 | 0.015 | 89.9 | 0.939 | -2.0 |
| 400     | 0.801 | -8.1  | 12.975 | 143.0 | 0.017 | 90.0 | 0.927 | -1.9 |
| 450     | 0.779 | -8.6  | 12.343 | 140.3 | 0.019 | 90.2 | 0.915 | -1.8 |
| 500     | 0.739 | -11.2 | 11.895 | 136.6 | 0.021 | 89.5 | 0.909 | 1.5  |
| 550     | 0.728 | -11.9 | 11.296 | 134.4 | 0.024 | 90.1 | 0.891 | 2.4  |
| 600     | 0.710 | -12.2 | 10.764 | 132.4 | 0.025 | 90.3 | 0.882 | 3.1  |
| 650     | 0.691 | -12.3 | 10.269 | 130.4 | 0.028 | 91.1 | 0.874 | 3.6  |
| 700     | 0.677 | -12.1 | 9.820  | 129.0 | 0.030 | 91.4 | 0.863 | 4.3  |
| 750     | 0.662 | -12.0 | 9.403  | 127.4 | 0.031 | 92.4 | 0.856 | 4.9  |
| 800     | 0.649 | -12.1 | 8.955  | 126.3 | 0.033 | 92.9 | 0.849 | 5.8  |
| 850     | 0.636 | -12.6 | 8.605  | 125.0 | 0.036 | 93.2 | 0.842 | 6.5  |
| 900     | 0.623 | -11.8 | 8.263  | 123.9 | 0.037 | 93.7 | 0.832 | 7.0  |
| 950     | 0.610 | -11.5 | 7.937  | 122.9 | 0.039 | 94.2 | 0.827 | 7.5  |
| 1000    | 0.599 | -11.4 | 7.637  | 121.9 | 0.041 | 94.9 | 0.820 | 8.2  |
| 1050    | 0.588 | -10.8 | 7.359  | 121.1 | 0.044 | 95.4 | 0.813 | 8.5  |
| 1100    | 0.576 | -10.9 | 7.100  | 120.3 | 0.046 | 95.8 | 0.808 | 9.3  |
| 1150    | 0.565 | -10.2 | 6.857  | 119.7 | 0.048 | 96.2 | 0.800 | 9.5  |
| 1200    | 0.554 | -10.0 | 6.642  | 118.7 | 0.050 | 96.5 | 0.794 | 9.8  |

**Table 11. Scattering Parameters, Active Mode, R<sub>bias</sub> = 1.5 k $\Omega$   
(V<sub>cc</sub> = 2.75V, 25°C, 50  $\Omega$  system)**

| f (MHz) | S11   |      | S21    |       | S12   |      | S22   |      |
|---------|-------|------|--------|-------|-------|------|-------|------|
|         | Mag   | Ang  | Mag    | Ang   | Mag   | Ang  | Mag   | Ang  |
| 300     | 0.877 | -5.4 | 11.365 | 155.1 | 0.013 | 89.7 | 0.972 | -1.0 |
| 350     | 0.860 | -6.3 | 10.935 | 152.4 | 0.015 | 90.0 | 0.963 | -1.0 |
| 400     | 0.843 | -7.0 | 10.523 | 149.8 | 0.017 | 90.5 | 0.953 | -0.9 |

**Table 11. Scattering Parameters, Active Mode, R<sub>bias</sub> = 1.5 k $\Omega$  (continued)**  
**(V<sub>cc</sub> = 2.75V, 25°C, 50  $\Omega$  system)**

| f (MHz) | S11   |       | S21    |       | S12   |      | S22   |      |
|---------|-------|-------|--------|-------|-------|------|-------|------|
|         | Mag   | Ang   | Mag    | Ang   | Mag   | Ang  | Mag   | Ang  |
| 450     | 0.825 | -7.6  | 10.136 | 147.5 | 0.020 | 90.8 | 0.944 | -0.9 |
| 500     | 0.788 | -10.4 | 9.908  | 144.0 | 0.022 | 89.8 | 0.943 | 2.2  |
| 550     | 0.777 | -11.2 | 9.493  | 141.9 | 0.024 | 90.0 | 0.926 | 3.0  |
| 600     | 0.761 | -11.8 | 9.128  | 139.9 | 0.026 | 90.5 | 0.918 | 3.6  |
| 650     | 0.743 | -12.1 | 8.795  | 138.1 | 0.028 | 90.8 | 0.911 | 4.0  |
| 700     | 0.730 | -12.1 | 8.513  | 136.7 | 0.030 | 91.2 | 0.901 | 4.4  |
| 750     | 0.713 | -12.3 | 8.228  | 135.1 | 0.032 | 91.8 | 0.894 | 4.9  |
| 800     | 0.699 | -12.6 | 7.875  | 134.0 | 0.034 | 92.1 | 0.887 | 5.8  |
| 850     | 0.686 | -13.3 | 7.624  | 132.7 | 0.036 | 92.2 | 0.879 | 6.4  |
| 900     | 0.670 | -12.7 | 7.375  | 131.5 | 0.038 | 92.9 | 0.870 | 6.8  |
| 950     | 0.655 | -12.6 | 7.125  | 130.3 | 0.040 | 93.6 | 0.864 | 7.4  |
| 1000    | 0.642 | -12.5 | 6.885  | 129.2 | 0.042 | 93.7 | 0.856 | 8.0  |
| 1050    | 0.630 | -12.1 | 6.667  | 128.3 | 0.044 | 94.3 | 0.849 | 8.3  |
| 1100    | 0.616 | -12.2 | 6.457  | 127.4 | 0.046 | 95.0 | 0.845 | 9.1  |
| 1150    | 0.603 | -11.7 | 6.264  | 126.7 | 0.048 | 95.6 | 0.838 | 9.4  |
| 1200    | 0.592 | -11.5 | 6.084  | 125.6 | 0.050 | 95.8 | 0.831 | 9.7  |

**Table 12. Scattering Parameters, Bypass Mode, R<sub>bias</sub> = 1.2 k $\Omega$  and 1.5 k $\Omega$**

| f (MHz) | S11   |       | S21   |      | S12   |      | S22   |       |
|---------|-------|-------|-------|------|-------|------|-------|-------|
|         | Mag   | Ang   | Mag   | Ang  | Mag   | Ang  | Mag   | Ang   |
| 300     | 0.593 | -32.3 | 0.573 | 36.7 | 0.573 | 36.7 | 0.615 | -27.7 |
| 350     | 0.540 | -32.9 | 0.601 | 32.8 | 0.601 | 32.8 | 0.561 | -27.6 |
| 400     | 0.496 | -32.8 | 0.621 | 29.8 | 0.621 | 29.7 | 0.517 | -26.8 |
| 450     | 0.459 | -32.2 | 0.636 | 27.2 | 0.636 | 27.2 | 0.480 | -25.6 |
| 500     | 0.413 | -33.1 | 0.648 | 24.3 | 0.648 | 24.3 | 0.451 | -20.2 |
| 550     | 0.391 | -32.5 | 0.656 | 22.6 | 0.656 | 22.6 | 0.424 | -17.7 |
| 600     | 0.368 | -31.5 | 0.663 | 21.2 | 0.663 | 21.2 | 0.403 | -15.3 |
| 650     | 0.348 | -30.2 | 0.668 | 20.0 | 0.668 | 20.0 | 0.387 | -13.1 |
| 700     | 0.333 | -28.9 | 0.672 | 19.0 | 0.672 | 19.0 | 0.373 | -10.8 |
| 750     | 0.318 | -27.7 | 0.675 | 18.2 | 0.675 | 18.2 | 0.363 | -8.4  |

**Table 12. Scattering Parameters, Bypass Mode, R<sub>bias</sub> = 1.2 k $\Omega$  and 1.5 k $\Omega$  (continued)**

| f (MHz) | S11   |       | S21   |      | S12   |      | S22   |      |
|---------|-------|-------|-------|------|-------|------|-------|------|
|         | Mag   | Ang   | Mag   | Ang  | Mag   | Ang  | Mag   | Ang  |
| 800     | 0.305 | -26.7 | 0.678 | 17.4 | 0.678 | 17.4 | 0.353 | -5.9 |
| 850     | 0.292 | -25.8 | 0.68  | 16.8 | 0.679 | 16.7 | 0.345 | -3.4 |
| 900     | 0.282 | -24.4 | 0.682 | 16.2 | 0.682 | 16.2 | 0.337 | -1.3 |
| 950     | 0.272 | -23.2 | 0.683 | 15.8 | 0.683 | 15.7 | 0.332 | 0.6  |
| 1000    | 0.263 | -22.3 | 0.685 | 15.3 | 0.684 | 15.3 | 0.327 | 2.8  |
| 1050    | 0.256 | -21.1 | 0.685 | 15.0 | 0.685 | 15.0 | 0.323 | 4.5  |
| 1100    | 0.247 | -20.3 | 0.686 | 14.6 | 0.686 | 14.6 | 0.320 | 6.5  |
| 1150    | 0.239 | -19.2 | 0.687 | 14.3 | 0.687 | 14.3 | 0.316 | 8.1  |
| 1200    | 0.231 | -18.4 | 0.688 | 14.1 | 0.688 | 14.1 | 0.314 | 9.5  |

**Table 13. Scattering Parameters, Standby Mode, R<sub>bias</sub> = 1.2 k $\Omega$  and 1.5 k $\Omega$   
(V<sub>cc</sub> = 2.75V, 25°C, 50  $\Omega$  system)**

| f (MHz) | S11   |      | S21   |      | S12   |      | S22   |      |
|---------|-------|------|-------|------|-------|------|-------|------|
|         | Mag   | Ang  | Mag   | Ang  | Mag   | Ang  | Mag   | Ang  |
| 300     | 0.974 | -0.3 | 0.013 | 95.0 | 0.014 | 94.8 | 0.996 | 3.5  |
| 350     | 0.973 | -0.2 | 0.016 | 95.5 | 0.016 | 95.1 | 0.994 | 4.1  |
| 400     | 0.972 | -0.2 | 0.018 | 96.2 | 0.018 | 95.5 | 0.993 | 4.7  |
| 450     | 0.971 | -0.1 | 0.020 | 96.7 | 0.021 | 96.5 | 0.992 | 5.2  |
| 500     | 0.956 | -2.7 | 0.023 | 95.1 | 0.023 | 95.1 | 1.007 | 8.5  |
| 550     | 0.960 | -3.2 | 0.026 | 95.8 | 0.026 | 96.0 | 0.999 | 9.6  |
| 600     | 0.958 | -3.6 | 0.028 | 96.2 | 0.028 | 95.9 | 1.000 | 10.4 |
| 650     | 0.953 | -3.7 | 0.031 | 96.7 | 0.031 | 96.6 | 1.001 | 11.0 |
| 700     | 0.952 | -3.9 | 0.033 | 97.1 | 0.033 | 97.0 | 0.997 | 11.7 |
| 750     | 0.949 | -4.1 | 0.036 | 97.5 | 0.036 | 97.5 | 0.998 | 12.4 |
| 800     | 0.946 | -4.6 | 0.039 | 97.7 | 0.039 | 97.7 | 0.998 | 13.2 |
| 850     | 0.940 | -5.2 | 0.041 | 98.1 | 0.041 | 97.9 | 0.998 | 14.0 |
| 900     | 0.941 | -5.1 | 0.044 | 98.3 | 0.044 | 98.2 | 0.994 | 14.5 |
| 950     | 0.937 | -5.3 | 0.047 | 98.8 | 0.047 | 98.8 | 0.994 | 15.0 |
| 1000    | 0.934 | -5.7 | 0.049 | 98.9 | 0.049 | 98.8 | 0.993 | 15.6 |

**Table 13. Scattering Parameters, Standby Mode,  $R_{bias} = 1.2\text{ k}\Omega$  and  $1.5\text{ k}\Omega$  (continued)**  
**( $V_{cc} = 2.75\text{V}$ ,  $25^\circ\text{C}$ ,  $50\text{ }\Omega$  system)**

| f (MHz) | S11   |      | S21   |      | S12   |      | S22   |      |
|---------|-------|------|-------|------|-------|------|-------|------|
|         | Mag   | Ang  | Mag   | Ang  | Mag   | Ang  | Mag   | Ang  |
| 1050    | 0.931 | -5.8 | 0.052 | 99.2 | 0.052 | 99.1 | 0.992 | 15.9 |
| 1100    | 0.925 | -6.3 | 0.055 | 99.3 | 0.055 | 99.3 | 0.993 | 16.6 |
| 1150    | 0.923 | -6.4 | 0.058 | 99.6 | 0.058 | 99.6 | 0.990 | 16.9 |
| 1200    | 0.919 | -6.7 | 0.061 | 99.7 | 0.061 | 99.6 | 0.989 | 17.2 |

Table 14 and Table 15 list the noise parameters for the packaged part, as measured in a  $50\text{ }\Omega$  system for active mode operation for two values of the external bias resistor.

**Table 14. Active Mode Noise Parameters,  $R_{bias} = 1.2\text{ k}\Omega$**   
**( $V_{cc} = 2.75\text{V}$ ,  $25^\circ\text{C}$ ,  $50\text{ }\Omega$  System,  $I_{cc} = 4.8\text{ mA}$ )**

| Freq | Fmin | Gamma Opt |       | Rn   | Ga    |
|------|------|-----------|-------|------|-------|
| MHz  | dB   | Mag       | Angle |      | dB    |
| 400  | 0.94 | 0.244     | 4.2   | 10.0 | 30.86 |
| 450  | 0.92 | 0.261     | 1.5   | 10.0 | 29.62 |
| 500  | 0.90 | 0.273     | -0.5  | 10.0 | 28.51 |
| 700  | 0.86 | 0.289     | -4.2  | 10.0 | 25.18 |
| 800  | 0.85 | 0.283     | -4.6  | 9.5  | 23.99 |
| 900  | 0.84 | 0.274     | -4.9  | 9.5  | 22.99 |
| 1000 | 0.85 | 0.265     | -5.8  | 9.5  | 22.09 |
| 1200 | 0.88 | 0.262     | -12.3 | 9.5  | 20.16 |

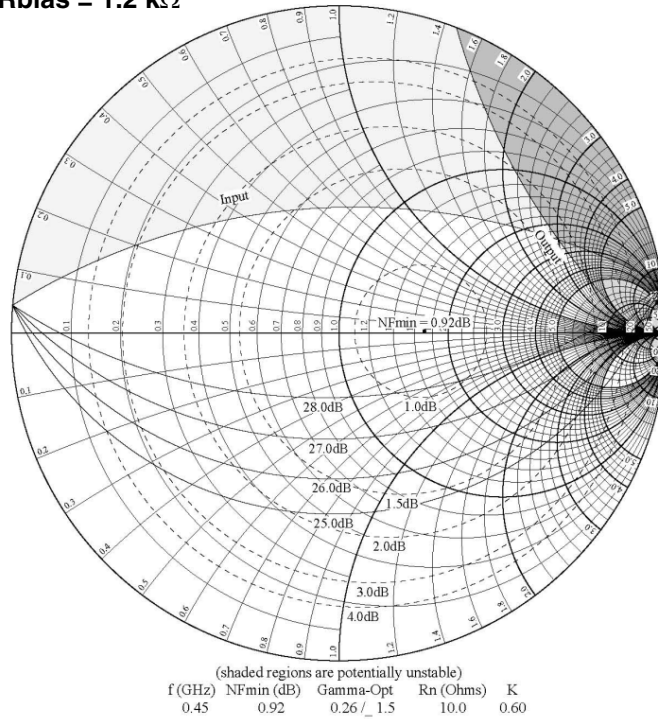
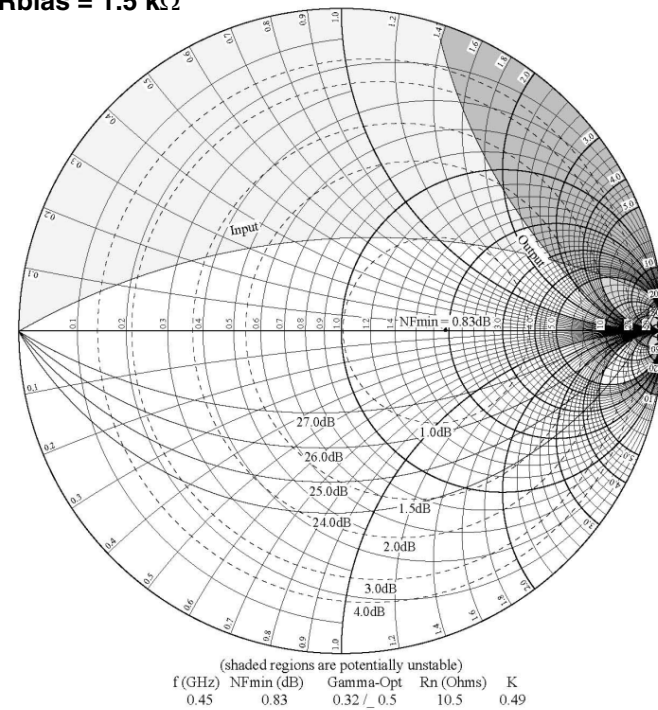
**Table 15. Active Mode Noise Parameters,  $R_{bias} = 1.5\text{ k}\Omega$**   
**( $V_{cc} = 2.75\text{V}$ ,  $25^\circ\text{C}$ ,  $50\text{ }\Omega$  System,  $I_{cc} = 3.8\text{ mA}$ )**

| Freq | Fmin | Gamma Opt |       | Rn   | Ga    |
|------|------|-----------|-------|------|-------|
| MHz  | dB   | Mag       | Angle |      | dB    |
| 400  | 0.82 | 0.313     | 0.23  | 10.5 | 30.82 |
| 450  | 0.83 | 0.323     | 0.5   | 10.5 | 29.52 |
| 500  | 0.85 | 0.331     | -1.0  | 10.5 | 28.37 |
| 700  | 0.90 | 0.337     | -4.3  | 10.5 | 24.94 |
| 800  | 0.92 | 0.331     | -5.0  | 10.5 | 23.75 |
| 900  | 0.94 | 0.322     | -5.7  | 10.5 | 22.76 |

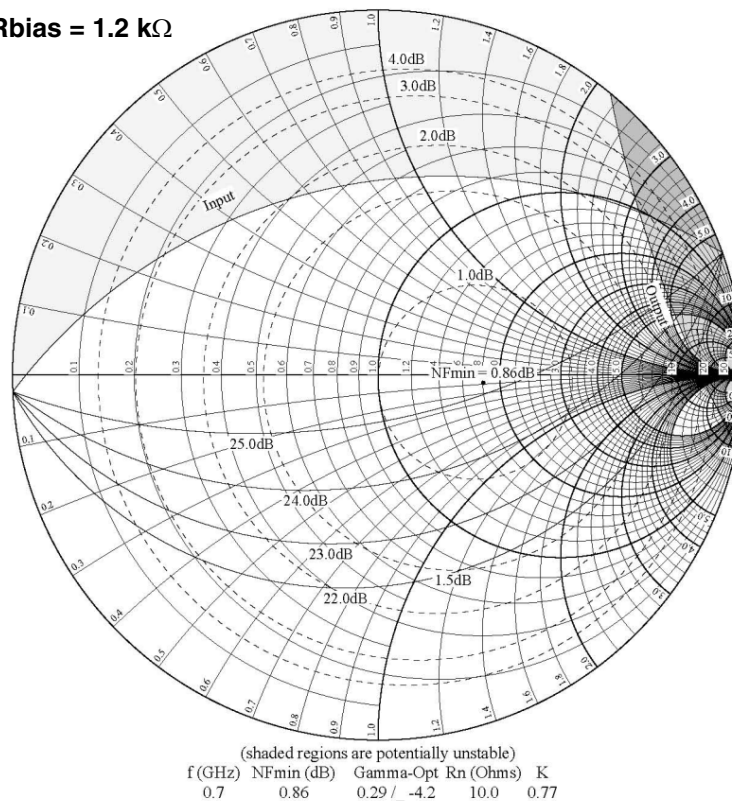
**Table 15. Active Mode Noise Parameters,  $R_{bias} = 1.5\text{ k}\Omega$   
 $(V_{cc} = 2.75\text{V}, 25^\circ\text{C}, 50\Omega\text{ System}, I_{cc} = 3.8\text{ mA})$**

|      |      |       |       |      |       |
|------|------|-------|-------|------|-------|
| 1000 | 0.95 | 0.313 | -6.8  | 10.5 | 21.87 |
| 1200 | 0.96 | 0.304 | -11.7 | 10.5 | 19.94 |

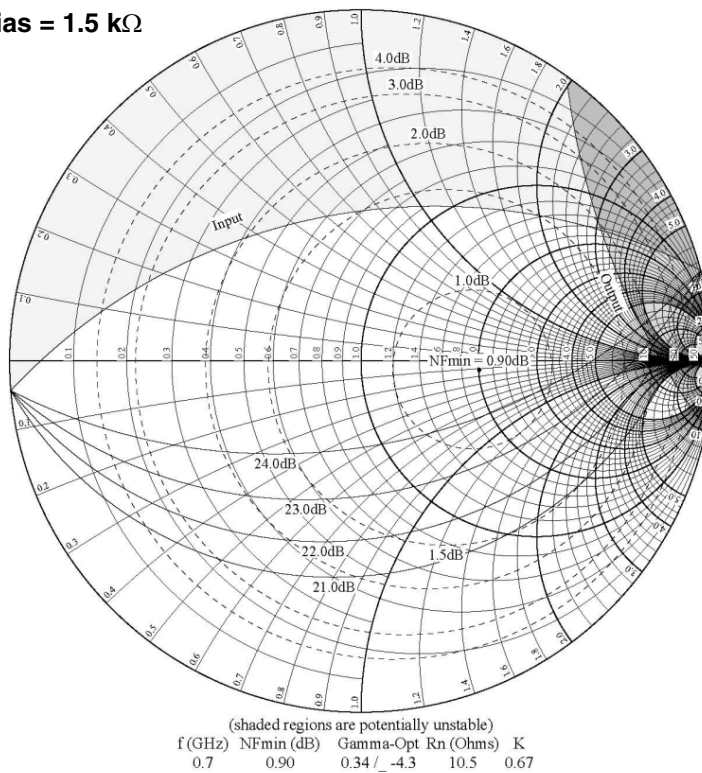
Figure 13 through Figure 16 are the constant noise figure and gain circles with input and output stability regions shown on Smith charts.  $\Gamma_{opt}$ , noise resistance and stability at the frequency are shown for two values of the external bias resistor at 450, 700, 900 and 1000 MHz.

**Rbias = 1.2 k $\Omega$** **Rbias = 1.5 k $\Omega$** **Figure 13. Constant Noise Figure and Gain Circles, 450 MHz**

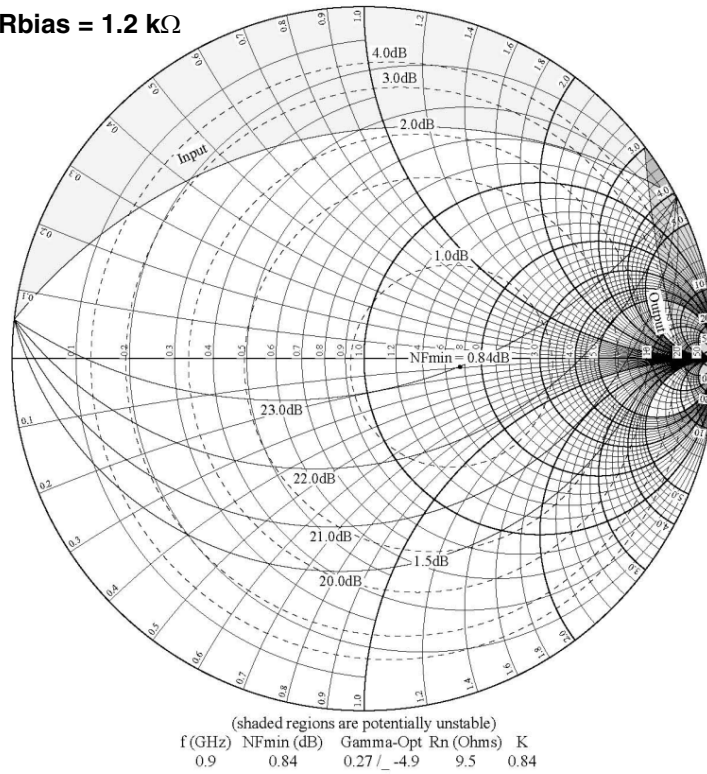
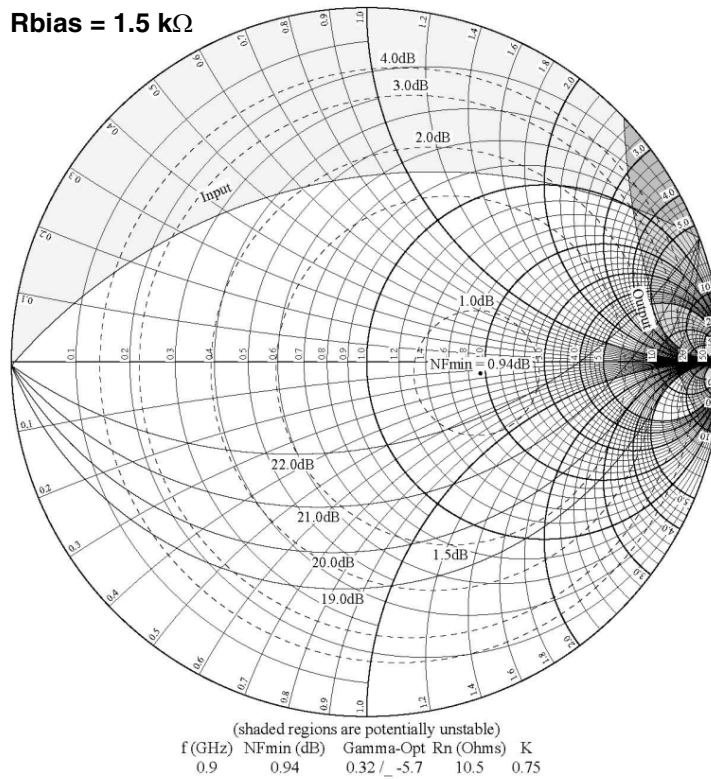
**R<sub>bias</sub> = 1.2 k $\Omega$**



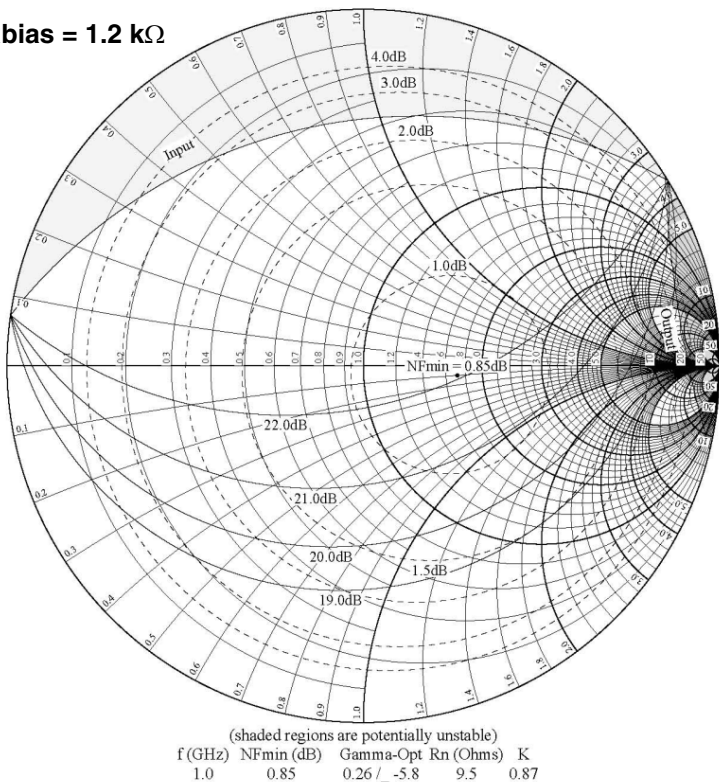
**R<sub>bias</sub> = 1.5 k $\Omega$**



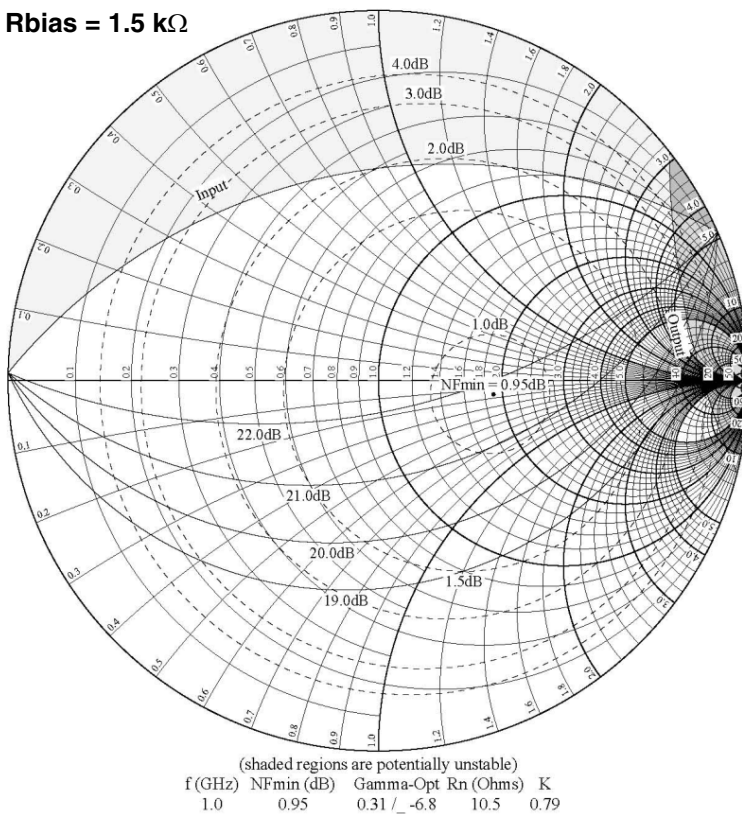
**Figure 14. Constant Noise Figure and Gain Circles, 700 MHz**

**R<sub>bias</sub> = 1.2 k $\Omega$** **R<sub>bias</sub> = 1.5 k $\Omega$** **Figure 15. Constant Noise Figure and Gain Circles, 900 MHz**

**Rbias = 1.2 kΩ**



**Rbias = 1.5 kΩ**



**Figure 16. Constant Noise Figure and Gain Circles, 1000 MHz**

## 6 Packaging

Figure 17 and Figure 18 are the package drawings with dimensions for the MLPD-8,  $2 \times 2 \times 0.6$  mm, package.

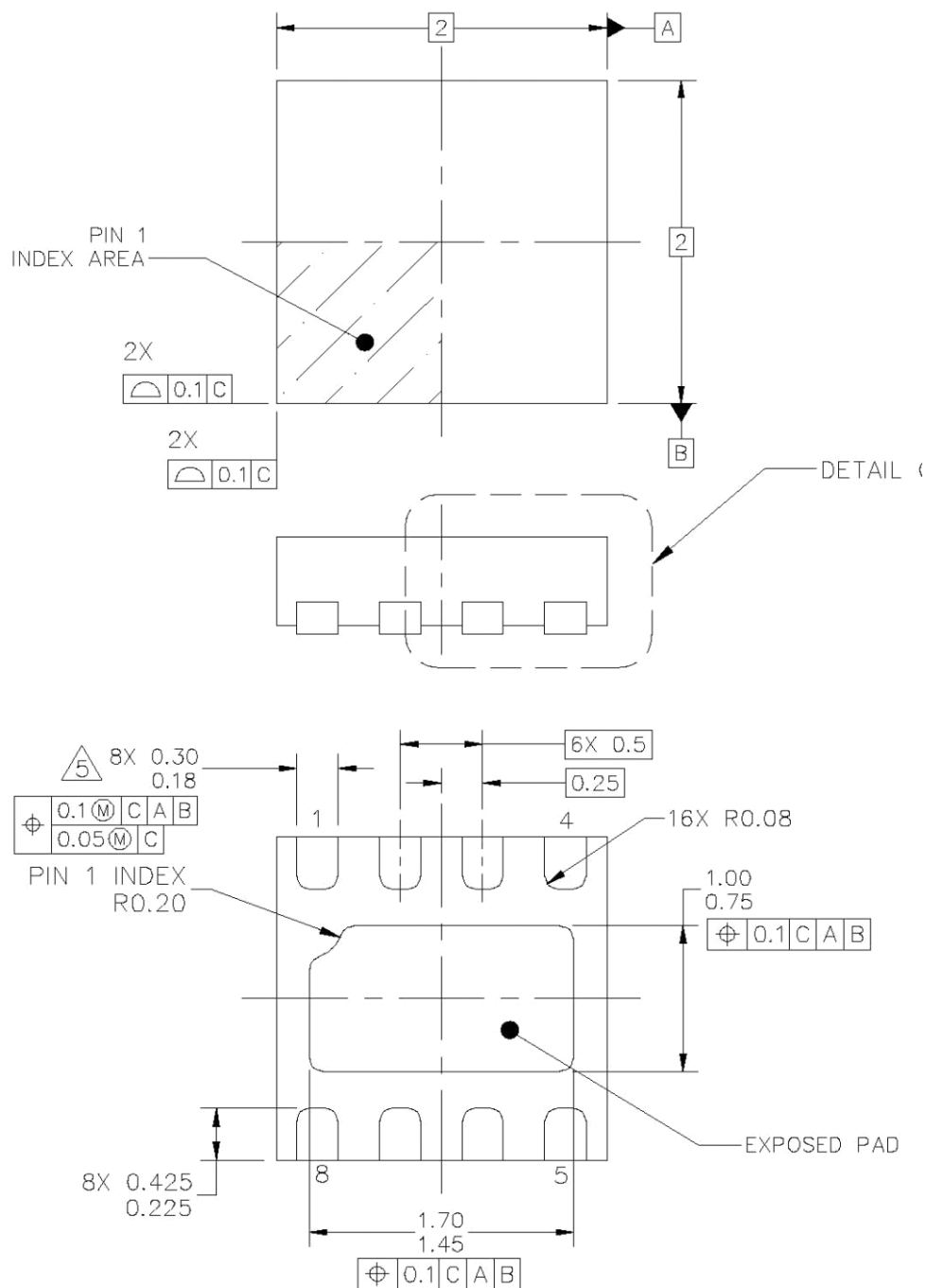
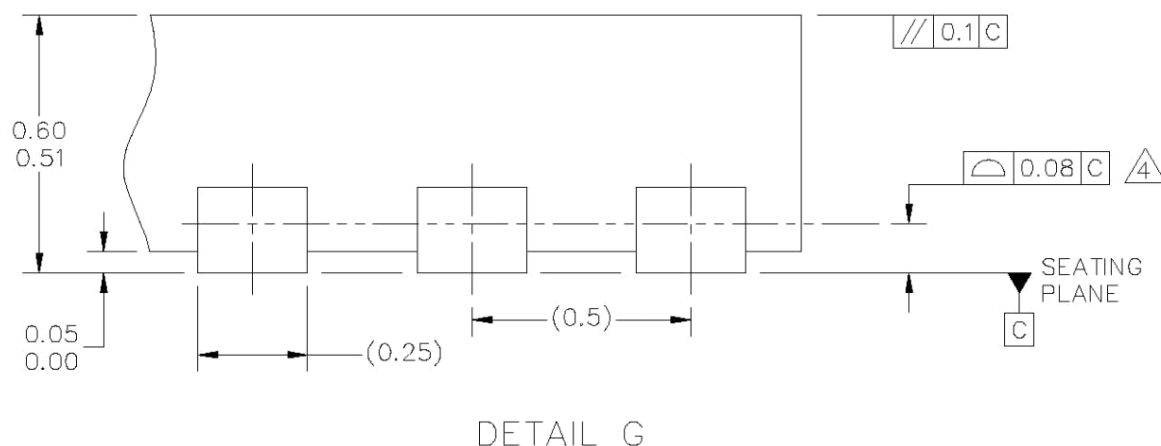


Figure 17. Outline Dimensions for MLPD-8



## NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. THIS IS NON JEDEC REGISTERED PACKAGE.

4. COPLANARITY APPLIES TO THE TERMINALS AND ALL OTHER BOTTOM SURFACE METALLIZATION.

5. THIS DIMENSION APPLIES TO METALLIZED TERMINAL AND IS MEASURE BETWEEN 0.15 AND 0.25 FROM THE TERMINAL TIP. IF THE TERMINAL HAS THE OPTIONAL RADIUS ON THE OTHER END OF THE TERMINAL, THIS DIMENSION SHALL NOT BE MEASURED IN THE RADIUS AREA.

Figure 18. Packaging Details

## 7 Product Documentation

This data sheet is labeled as a particular type: Product Preview, Advance Information, or Technical Data. Definitions of these types are available at: <http://www.freescale.com>.

## 8 Revision History

Table 16 summarizes revisions to this document since the last revision.

Table 16. Revision History

| Revision | Description of Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2.0      | <ul style="list-style-type: none"> <li>Updated entire document for changes due to increased operating frequency range (now 400–1000 MHz, was 800–1000 MHz) and increased operating ambient temperature range (now -40 to 85°C, was -30 to 85°C), and to the change in packaging from MLF8 to MLPD-8 (Section 6).</li> <li>Electrical characteristics (Section 2) were updated.</li> <li>New application examples (Section 3) for 434 and 900 MHz replace previous examples for 880 and 950 MHz.</li> <li>For the new application examples (Section 3), printed circuit board layouts were added and bills of materials were updated (Section 4).</li> <li>Scattering and noise parameters (with Smith charts for 450, 700, 900, and 1000 MHz) were added in Section 5.</li> </ul> |



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