Order this document by MRFIC0954/D

MOTOROLA

# MRFIC0954

*Advance Information*

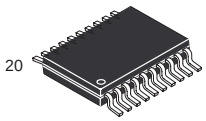
# 800 MHz CDMA Upmixer/Exciter

The MRFIC0954 is an integrated upmixer and exciter amplifier designed specifically for dual–mode CDMA/AMPS digital cellular radios. The exciter amplifier incorporates a temperature compensated linear gain control. The design utilizes Motorola's RF BiCMOS1 process to yield superior performance in a cost effective monolithic device.

- Designed for Dual–Mode Operation
  - Total Supply Current CDMA Mode = 55 mA Typical
  - Total Supply Current FM Mode = 35 mA Typical
- 30 dB Dynamic Range Gain Control on Exciter
- Upmixer Output $IP_3$ = 11 dBm Typical
- Exciter Output $IP_3$ = 28 dBm Typical
- Supply Voltage Range = 2.7 to 3.6 V
- Cascaded Adjacent Channel Power ($P_{out}$ = 6.0 dBm)
  - @ 885 kHz Offset = –60 dBc Typical
  - @ 1.98 MHz Offset = –72 dBc Typical

**800 MHz**
**DUAL–MODE CDMA/AMPS**
**UPMIXER/EXCITER**

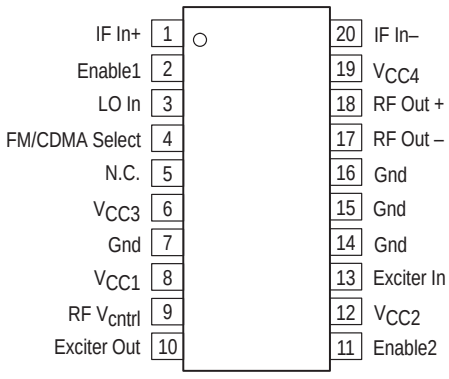
**SEMICONDUCTOR**
**TECHNICAL DATA**



(Scale 2:1)

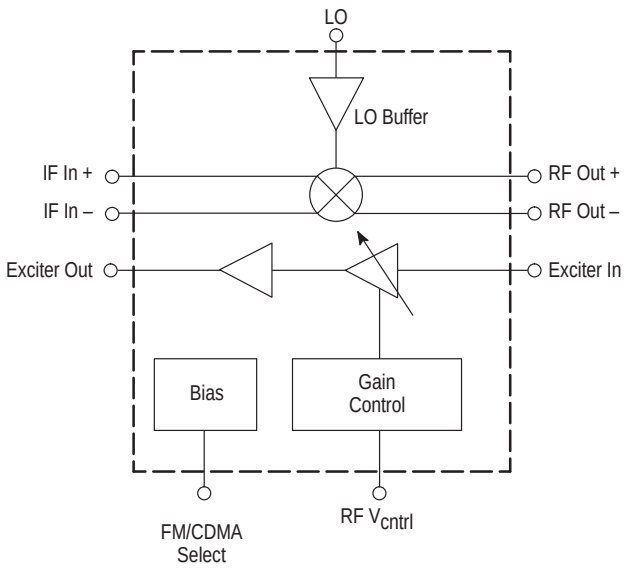
PLASTIC PACKAGE
CASE 948M
(TSSOP–20EP, Tape & Reel Only)

**PIN CONNECTIONS**



(Top View)

**Simplified Block Diagram**




This device contains 305 active transistors.

**ORDERING INFORMATION**

| Device | Operating Temp Range | Package |
|---|---|---|
| MRFIC0954R2 | $T_A$ = –40 to 85°C | TSSOP–20EP |

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

© Motorola, Inc. 2000

## MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 5.0 | V |
| IF Input | IF In+, IF In– | 10 | dBm |
| LO Input | LO | 10 | dBm |
| Operating Temperature | $T_A$ | –40 to 85 | °C |
| Storage Temperature | $T_{stg}$ | –65 to 150 | °C |

**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 or Pin Descriptions section.
2. Meets Human Body Model (HBM) ≤50 V and Machine Model (MM) ≤40 V. This device is rated Moisture Sensitivity Level (MSL) 4. ESD data available upon request.

## RECOMMENDED OPERATING CONDITIONS

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 2.7 | – | 3.6 | V |
| RF Frequency Range | $f_{RF}$ | 800 | – | 960 | MHz |
| IF Frequency Range | $f_{IF}$ | 70 | – | 250 | MHz |
| LO Frequency Range | $f_{LO}$ | 600 | – | 1200 | MHz |
| Gain Control Voltage Range | $V_{cntrl}$ | 0.1 | – | 1.7 | V |

## ELECTRICAL CHARACTERISTICS ($V_{CC}$ = 2.7 V, $P_{LO}$ = –15 dBm @ 967 MHz, $P_{IF}$ = –21 dBm (differential) @ 130 MHz, $V_{Enable}$ = $V_{TxEnable}$ = 2.4 V, $T_A$ = 25°C, Test Circuit in Figure 1, unless otherwise noted.)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **CASCADE PERFORMANCE** (Filter included between RF Out and Exciter input. Filter has an insertion loss of 4.0 dB) For CDMA mode FM/CDMA Select = 2.7 V. For FM mode FM/CDMA Select = 0 V. | | | | | |
| Output Power | $P_{out}$ | | | | dBm |
| CDMA Mode ($V_{cntrl}$ = 1.7 V) | | 6.0 | 10 | – | |
| FM Mode ($P_{IF}$ = –12 dBm (differential) ) | | 11 | 14 | – | |
| CDMA Mode ($V_{cntrl}$ = 1.3 V) | | 3.0 | 7.0 | – | |
| Dynamic Range ($RF_{Vcntrl}$ = 0.1 to 1.7 V) | DR | 25 | 38 | – | dB |
| Adjacent Channel Power (CDMA Mode, $P_{out}$ = 6.0 dBm, $P_{IF}$ = –21 dBm (differential) ) | ACPR | | | | dBc |
| @ 885 kHz Offset | | – | –60 | –52 | |
| @ 1.98 MHz Offset | | – | –72 | –62 | |
| Supply Current | $I_{CC}$ | | | | mA |
| CDMA Mode, $P_{IF}$ = –21 dBm (differential), $P_{out}$ = 6.0 dBm (set by $V_{cntrl}$) | | – | 55 | 70 | |
| FM Mode, $P_{IF}$ = –12 dBm (differential), $P_{out}$ = 11 dBm (set by $V_{cntrl}$) | | – | 35 | 50 | |
| **MIXER SECTION** | | | | | |
| Conversion Gain | GC | – | 7.0 | – | dB |
| Noise Figure | NF | – | 15 | – | dB |
| Output Third Order Intercept Point | OIP3 | – | 11 | – | dBm |
| **EXCITER SECTION** | | | | | |
| Gain (No Attenuation) | GC | – | 28 | – | dB |
| Noise Figure | NF | – | 5.0 | – | dB |
| AGC Dynamic Range | DR | 25 | 38 | – | dB |
| Output Third Order Intercept Point | OIP3 | – | 25 | – | dBm |

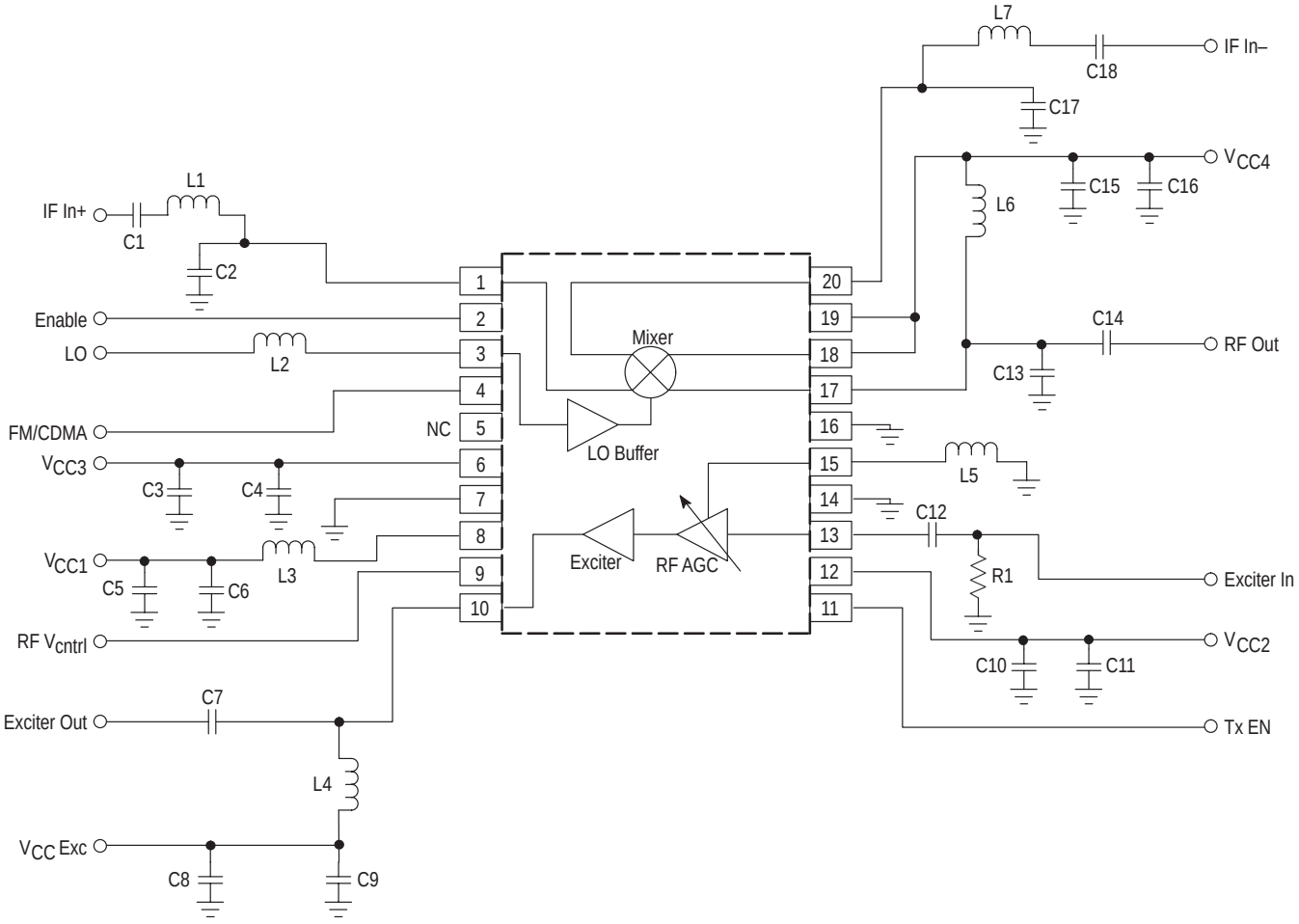
## PIN FUNCTION DESCRIPTION

| Pin | Function | Description | Voltage On (V) | Voltage Off (V) |
|---|---|---|---|---|
| 1 | IF In+ | Mixer IF input pin. Input impedance is 500 Ω. | –24 dBm (Typ) | |
| 2 | Enable 1 (See Table 1) | Enable pin. A logic ″High″ (>2.4 V) enables entire chip and ″Low″ (<0.4 V) **disables chip.** | 2.4 to 3.6 | 0 to 0.4 |
| 3 | LO In | Mixer LO input pin. | –15 dBm (Typ) | |
| 4 | FM/CDMA Select | FM/CDMA select pin. Logic ″High″ (>2.4 V) selects CDMA mode for increased linearity and output power. ″Low″ (<0.4 V) selects FM mode for reduced current consumption. | | |
| 5 | N.C. | No Connection | | |
| 6 | $V_{CC3}$ | Supply Voltage. | 2.7 to 3.6 | |
| 7 | Gnd | Ground connection. | – | |
| 8 | $V_{CC1}$ | Supply Voltage | 2.7 to 3.6 | |
| 9 | RF AGC Control Voltage | RF AGC control pin. A 30 dB dynamic range can be acheived by adjusting voltage from 0.1 V (low gain) to 1.7 V (high gain). | 0.1 to 1.7 | |
| 10 | Exciter Out | RF exciter amplifier output pin. | – | |
| 11 | Enable 2 (See Table 1) | Tx Enable pin. A logic ″High″ (>2.4 V) enables Tx path and ″Low″ (<0.4 V) **disables Tx path except LO Buffer**. | 2.4 to 3.6 | 0 to 0.4 |
| 12 | $V_{CC2}$ | Supply Voltage | 2.7 to 3.6 | |
| 13 | Exciter In | RF exciter amplifier input pin. | – | |
| 14 | Gnd | Ground connection. | – | |
| 15 | Gnd | Ground connection. | – | |
| 16 | Gnd | Ground connection. | – | |
| 17 | RF Out– | Mixer RF output pin. | | |
| 18 | RF Out+ | Mixer RF output pin. | | |
| 19 | $V_{CC4}$ | Supply Voltage | 2.7 to 3.6 | |
| 20 | IF In– | Mixer IF input pin. Input impedance is 500 Ω. | –24 dBm (Typ) | |

**Table 1. Enable Truth Table**

| Enable 1 | Enable 2 | Mode |
|---|---|---|
| 0 | 0 | Disabled |
| 0 | 1 | Not Applicable |
| 1 | 0 | Standby Mode: Disables mixer/exciter, except LO buffer |
| 1 | 1 | Tx Enabled |

**Figure 1. Applications Circuit**




| | | | |
|---|---|---|---|
| C1, C18 | 1.0 nF | L1, L7 | 220 nH |
| C2, C17 | 4.7 pF | L2 | 15 nH |
| C3 , C5, C8, C11, C16 | 10 nF | L3 , L4, L6 | 6.8 nH |
| C4, C6, C9, C10, C12, C15 | 100 pF | L5 | 1.0 nH |
| C7 | 4.3 pF | | |
| C13 | 1.6 pF | R1 | 100 Ω |
| C14 | 1.3 pF | | |

**NOTES:** 1. IF ports matched to 50 Ω for testing purposes.
2. L3 and C6 form part of RFAGC/Exciter interstage match.
3. L5 can be varied to change gain.

**Figure 2. Gain versus Frequency (FM Mode)**

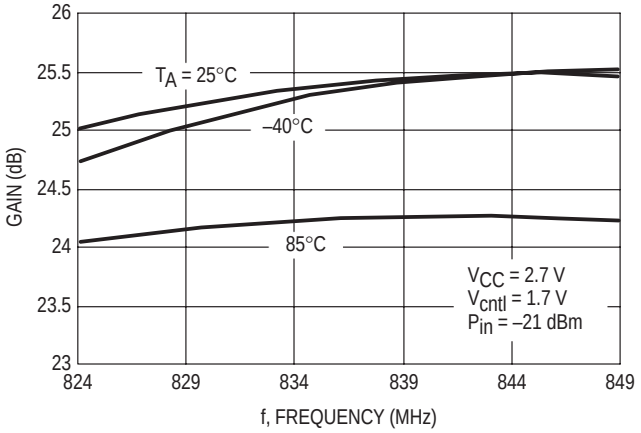



**Figure 3. Gain versus Frequency (CDMA Mode)**

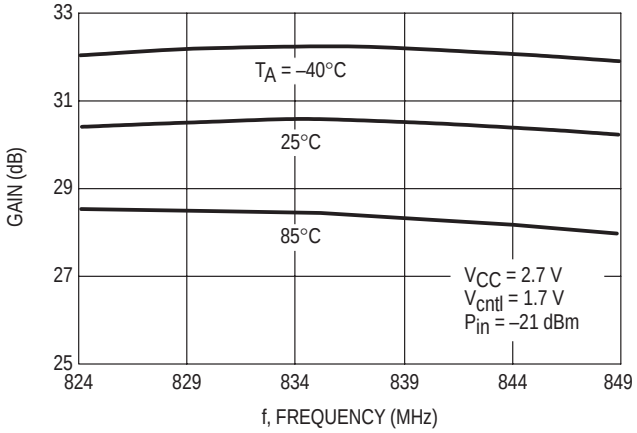



**Figure 4. Gain versus LO Power (FM Mode)**

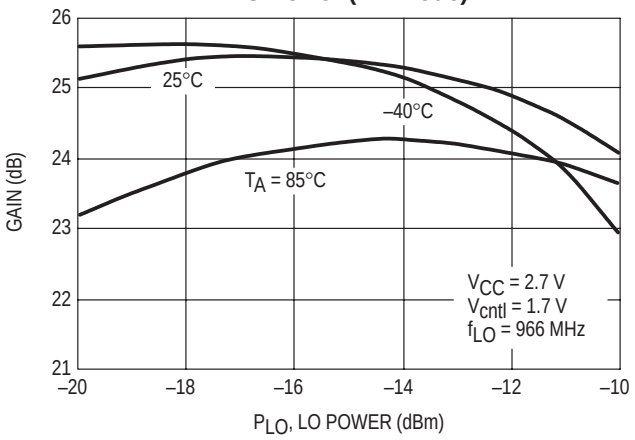



**Figure 5. Gain versus LO Power (CDMA Mode)**

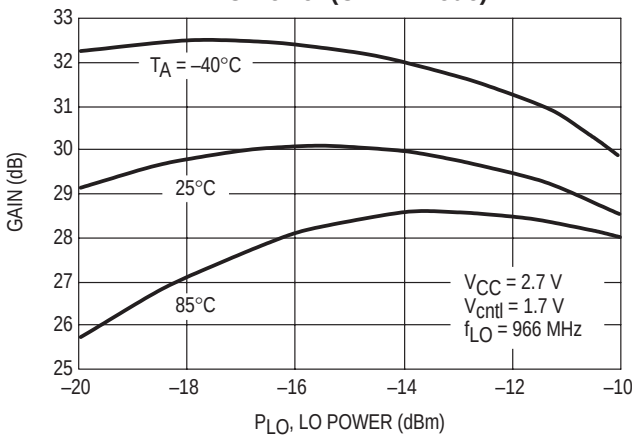



**Figure 6. LO Feedthrough versus Control Voltage (FM Mode)**

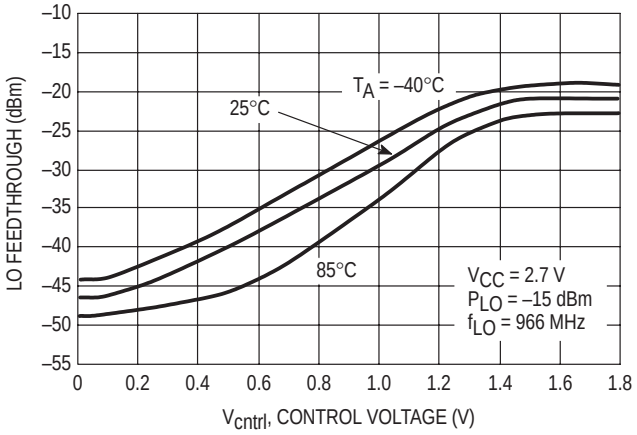



**Figure 7. LO Feedthrough versus Control Voltage (CDMA Mode)**

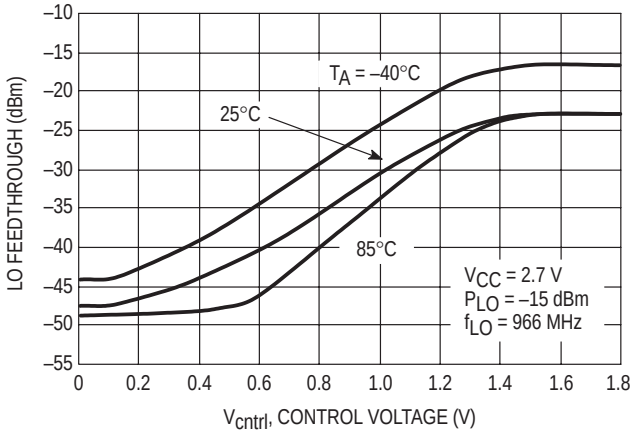


**Figure 8. Output Power versus Control Voltage (FM Mode)**

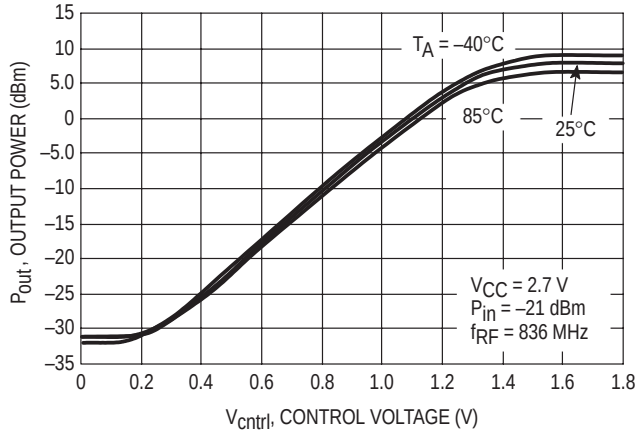



**Figure 9. Output Power versus Control Voltage (CDMA Mode)**

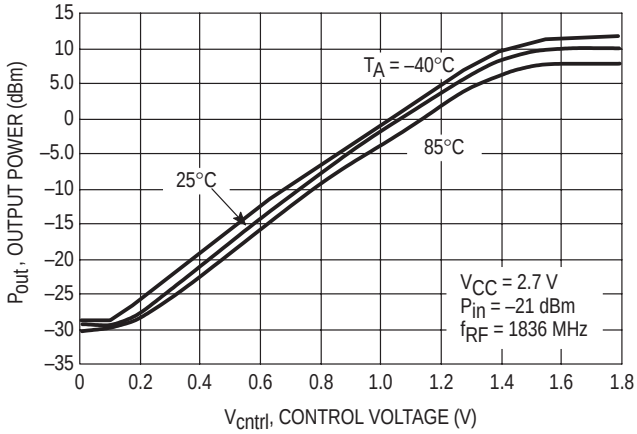



**Figure 10. Adjacent Channel Power versus Control Voltage (CDMA Mode)**

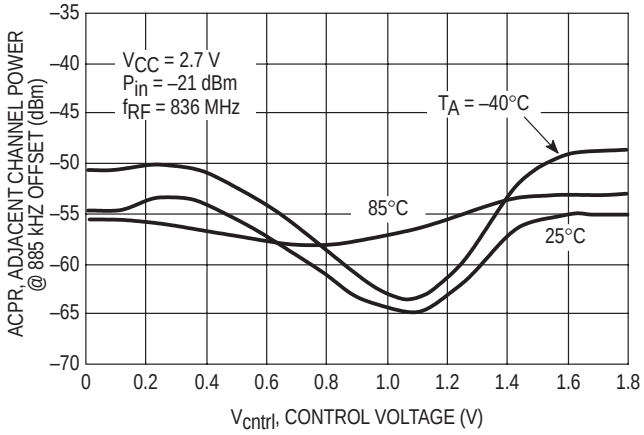
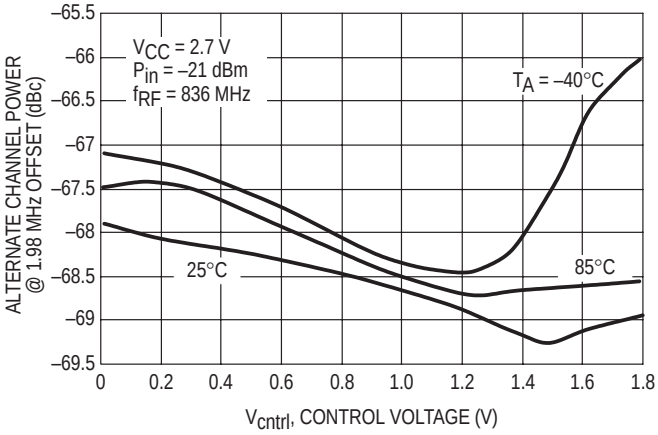



**Figure 11. Alternate Channel Power versus Control Voltage (CDMA Mode)**



## APPLICATIONS INFORMATION

### Design Philosophy

The MRFIC0954 has three operating states, enable, standby, and disable. These states are controlled by the truth table shown in Table 1. The device is fully operational during the enable state and the bias level can be selected. A high bias current for CDMA or a lower bias current for Analog (or CDMA at lower powers) can be selected via the FM/CDMA pin. In the high current CDMA mode, the quiescent current is increased to maximize the linearity of the device. In the lower current bias, the quiescent current is optimized for efficiency in the Analog mode. This lower bias point is also useful in lower power CDMA operation. The standby mode can be used to reduce current consumption during Voice Activity Factoring. In the standby mode, the LO buffer remains on to prevent VCO pulling and the bandgap reference bias circuit remains on to assure rapid device turn on. Current consumption in standby mode is 10 mA typical. The disable mode is used to turn the MRFIC0954 completely off. Leakage current in this mode is only a few microamps.

The mixer is a double–balanced “Gilbert–cell” design with a balanced LO buffer amplifier. The input and output of the mixer are differential. However, the linearity is high enough to tie one output to $V_{CC}$ and use the other as a single–ended output. Used this way it provides around 7.0 dB of gain and typically draws 20 mA quiescent current in CDMA mode and 16 mA in Analog Mode. An external filter is required between the mixer and RF AGC amplifier to reduce RX band noise.

Figure 1 shows the applications circuit for the MRFIC0954. In this circuit, the IF ports of the mixer have been matched to 50 Ω for testing purposes. In the actual application, the differential IF ports of the mixer would be impedance matched to an IF SAW filter. The differential impedance of the mixer IF ports is 1600 Ω. The RF output of the mixer is configured as a single ended output. DC current to the open collector output of the mixer is provided by inductor, L6 (6.8 nH). Inductor L6 is also part of the matching circuit with C13 (1.6 pF), C14 (1.3 pF) and C15 (100 p).

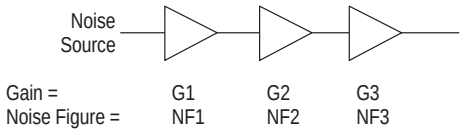
The RF AGC amplifier is a single–ended cascode design employing the standard “current steering” method of gain control. It’s ground is brought out through pin number 15 so inductance can be added to degenerate the gain for a lower noise floor. With 2.0 to 3.0 nH of external inductance, the maximum gain is around 13 dB. It typically draws 9.0 mA quiescent current in CDMA mode and 3.0 mA in Analog mode. The RF $V_{cntrl}$ signal is buffered with an on–chip OpAmp then preconditioned with temperature compensation and dB/V linearization before being applied to the RF AGC amplifier.

Inductor L3 (6.8 nH) and capacitor C6 (100 pF) are for the interstage match between the RF AGC and the exciter amplifier.

The exciter amplifier is a simple common emitter design. It is grounded directly to the exposed pad which results in 12 dB of gain. It typically draws 24 mA bias current in CDMA mode and 8.0 mA in Analog mode. Inductor L4 (6.8 nH), capacitor C7 (4.3 pF), and C9 (100 pF) provide the output matching. L4 also provides a DC current path for the open collector output.

### Noise Power Considerations

In CDMA systems, the handset is required to dynamically adjust its output power to specific levels. This requires a dynamic range of as much as 90 dB from the transmitter. Another key performance specification in CDMA systems is the output noise power, both in band and out of band. Noise power specifications has caused the noise figure of the transmitter to become an important system consideration. The cascaded noise figure of the transmitter can be analyzed with the same equation used in receiver analysis. The only difference is the noise source is from the transmitter (modulator) instead of the atmosphere.




$$NF_{cascaded} = NF_1 + \frac{NF_2 - 1}{G_1} + \frac{NF_3 - 1}{G_1 G_2}$$

This equation above shows that the cascaded noise figure is better if the gain is higher and the noise figure is lower for the stages close to the noise source. For this reason, it is advantageous to implement some of the gain control of a CDMA transmitter in the RF section. The MRFIC0954 integrates a RF AGC amplifier after the upmixer to improve the overall noise figure of the transmitter.

If better noise figure from the mixer is required, the mixer RF output can be operated differentially with the addition of a balun. Operating the mixer differentially will provide some noise cancellation and reduce the noise figure by 5.0 dB. Shown below is a lumped element balun that is effective in the cellular transmit band of 824 to 849 MHz.

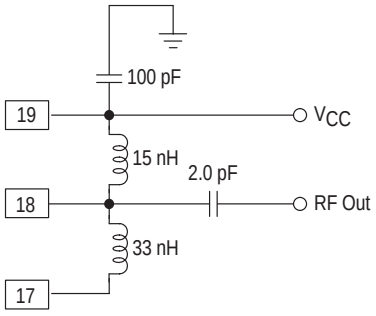


**Table 2. Scattering Parameters for Exciter Amplifier**
($V_{DD}$ = 2.7 V, $T_A$ = 25°C, RF $V_{cntrl}$ = 1.8 V, 50 Ω System)

| f | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | $\lvert S_{11} \rvert$ | $\angle\phi$ | $\lvert S_{21} \rvert$ | $\angle\phi$ | $\lvert S_{12} \rvert$ | $\angle\phi$ | $\lvert S_{22} \rvert$ | $\angle\phi$ |
| 800 | 0.523 | –31.46 | 18.463 | –102.56 | 0.001 | 153.19 | 0.341 | –26.37 |
| 810 | 0.522 | –31.83 | 18.964 | –107.12 | 0.001 | 152.15 | 0.360 | –33.06 |
| 820 | 0.519 | –31.84 | 19.412 | –111.84 | 0.001 | 152.18 | 0.379 | –39.48 |
| 830 | 0.515 | –31.96 | 20.017 | –121.57 | 0.001 | 143.30 | 0.413 | –52.61 |
| 840 | 0.513 | –31.90 | 20.214 | –126.53 | 0.002 | 139.87 | 0.428 | –58.96 |
| 850 | 0.512 | –31.78 | 20.330 | –131.59 | 0.001 | 140.14 | 0.445 | –65.36 |
| 860 | 0.513 | –31.62 | 20.228 | –141.98 | 0.001 | 143.83 | 0.468 | –77.72 |
| 870 | 0.510 | –31.64 | 19.962 | –147.12 | 0.002 | 140.02 | 0.476 | –83.97 |
| 880 | 0.510 | –31.45 | 19.593 | –152.09 | 0.002 | 147.69 | 0.478 | –89.94 |
| 890 | 0.514 | –31.41 | 18.768 | –161.40 | 0.002 | 139.58 | 0.486 | –100.64 |
| 900 | 0.515 | –31.50 | 18.161 | –166.11 | 0.002 | 141.12 | 0.491 | –105.67 |
| 910 | 0.514 | –31.58 | 17.585 | –170.50 | 0.002 | 124.24 | 0.489 | –110.70 |
| 920 | 0.515 | –31.83 | 16.353 | –178.79 | 0.002 | 125.97 | 0.485 | –119.67 |
| 930 | 0.517 | –31.96 | 15.718 | 177.30 | 0.002 | 128.36 | 0.489 | –124.16 |
| 940 | 0.518 | –32.29 | 15.070 | 173.39 | 0.002 | 125.66 | 0.484 | –128.24 |
| 950 | 0.517 | –32.88 | 13.708 | 166.70 | 0.002 | 112.00 | 0.473 | –135.30 |
| 960 | 0.518 | –32.81 | 13.090 | 163.84 | 0.002 | 117.04 | 0.468 | –138.41 |

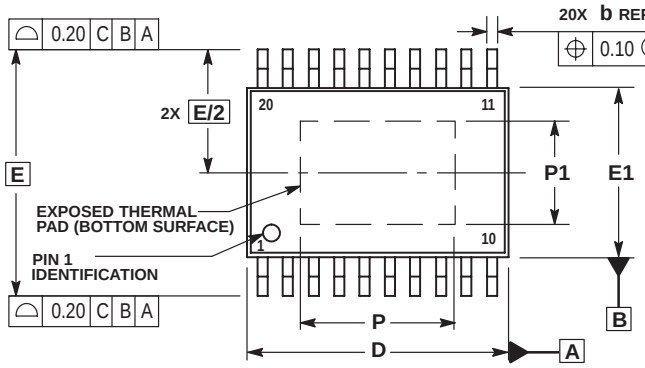
**Table 3. Scattering Parameters for Upmixer**
($V_{DD}$ = 2.7 V, $T_A$ = 25°C, 50 Ω System)

| f | IF In+ | | IF In– | | f | RF Out (Pin 17) | |
|---|---|---|---|---|---|---|---|
| (MHz) | $\lvert S_{11} \rvert$ | $\angle\phi$ | $\lvert S_{11} \rvert$ | $\angle\phi$ | (MHz) | $\lvert S_{11} \rvert$ | $\angle\phi$ |
| 70 | 0.886 | –5.66 | 0.885 | –5.12 | 800 | 0.488 | –60.15 |
| 80 | 0.883 | –5.79 | 0.882 | –5.29 | 810 | 0.487 | –60.56 |
| 90 | 0.884 | –6.15 | 0.881 | –5.73 | 820 | 0.487 | –61.04 |
| 100 | 0.879 | –6.26 | 0.878 | –5.74 | 830 | 0.488 | –61.82 |
| 110 | 0.881 | –6.74 | 0.881 | –6.19 | 840 | 0.490 | –62.20 |
| 120 | 0.877 | –7.20 | 0.878 | –6.43 | 850 | 0.487 | –62.85 |
| 130 | 0.880 | –7.23 | 0.879 | –6.64 | 860 | 0.491 | –63.72 |
| 140 | 0.876 | –7.89 | 0.876 | –7.20 | 870 | 0.492 | –64.03 |
| 150 | 0.876 | –8.11 | 0.875 | –7.28 | 880 | 0.493 | –64.38 |
| 160 | 0.878 | –8.51 | 0.877 | –7.57 | 890 | 0.497 | –65.56 |
| 170 | 0.879 | –8.84 | 0.879 | –8.07 | 900 | 0.501 | –65.98 |
| 180 | 0.877 | –9.28 | 0.880 | –8.26 | 910 | 0.503 | –66.50 |
| 190 | 0.876 | –9.81 | 0.878 | –8.81 | 920 | 0.504 | –68.66 |
| 200 | 0.876 | –10.15 | 0.877 | –9.21 | 930 | 0.504 | –69.70 |
| 210 | 0.875 | –10.52 | 0.876 | –9.44 | 940 | 0.502 | –69.91 |
| 220 | 0.877 | –10.83 | 0.880 | –9.78 | 950 | 0.503 | –71.15 |
| 230 | 0.877 | –11.58 | 0.877 | –10.41 | 960 | 0.502 | –70.74 |
| 240 | 0.878 | –11.59 | 0.877 | –10.41 | | | |
| 250 | 0.881 | –12.29 | 0.879 | –10.85 | | | |

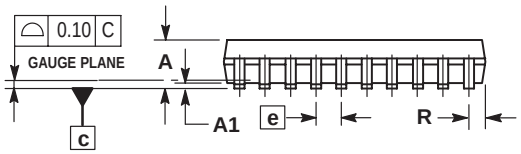
| f | LO In | | f | LO In | | f | LO In | |
|---|---|---|---|---|---|---|---|---|
| (MHz) | $\lvert S_{11} \rvert$ | $\angle\phi$ | (MHz) | $\lvert S_{11} \rvert$ | $\angle\phi$ | (MHz) | $\lvert S_{11} \rvert$ | $\angle\phi$ |
| 600 | 0.820 | –18.93 | 810 | 0.802 | –24.40 | 1020 | 0.785 | –30.28 |
| 610 | 0.819 | –19.00 | 820 | 0.800 | –24.55 | 1030 | 0.784 | –30.09 |
| 620 | 0.817 | –19.35 | 830 | 0.802 | –24.75 | 1040 | 0.786 | –30.63 |
| 630 | 0.815 | –19.60 | 840 | 0.804 | –25.22 | 1050 | 0.786 | –30.91 |
| 640 | 0.820 | –19.87 | 850 | 0.804 | –25.13 | 1060 | 0.784 | –31.10 |
| 650 | 0.814 | –20.06 | 860 | 0.802 | –25.86 | 1070 | 0.780 | –31.60 |
| 660 | 0.813 | –20.49 | 870 | 0.799 | –26.14 | 1080 | 0.783 | –31.85 |
| 670 | 0.816 | –20.61 | 880 | 0.801 | –26.36 | 1090 | 0.782 | –31.99 |
| 680 | 0.815 | –20.82 | 890 | 0.797 | –26.72 | 1100 | 0.775 | –32.54 |

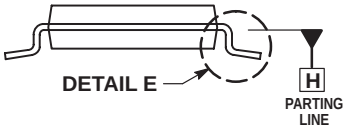
## OUTLINE DIMENSIONS

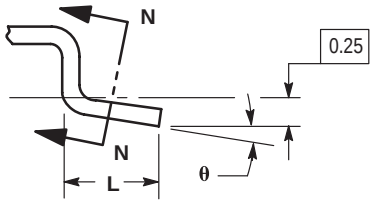
PLASTIC PACKAGE
CASE 948M–01
(TSSOP–20EP)
ISSUE O

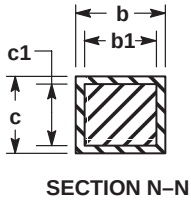



NOTES:
1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE.
4. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 PER SIDE.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSIONS D AND E1 ARE TO BE DETERMINED AT DATUM PLANE H.




| DIM | MILLIMETERS MIN | MAX |
|---|---|---|
| A | — | 1.20 |
| A1 | 0.00 | 0.10 |
| b | 0.19 | 0.30 |
| b1 | 0.19 | 0.25 |
| c | 0.09 | 0.20 |
| c1 | 0.09 | 0.16 |
| D | 6.40 | 6.60 |
| E | 6.40 BSC | |
| E1 | 4.30 | 4.50 |
| e | 0.65 BSC | |
| L | 0.50 | 0.75 |
| P | — | 4.80 |
| P1 | — | 3.00 |
| R | 0.27 | 0.37 |
| θ | 0° | 8° |

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. “Typical” parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including “Typicals” must be validated for each customer application by customer’s technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and Ⓜ are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

Mfax is a trademark of Motorola, Inc.

**How to reach us:**
**USA / EUROPE / Locations Not Listed**: Motorola Literature Distribution;
P.O. Box 5405, Denver, Colorado 80217. 1–303–675–2140 or 1–800–441–2447

**JAPAN**: Motorola Japan Ltd.; SPD, Strategic Planning Office, 141,
4–32–1 Nishi–Gotanda, Shinagawa–ku, Tokyo, Japan. 81–3–5487–8488

**Customer Focus Center: 1–800–521–6274**

**Mfax**™: RMFAX0@email.sps.mot.com – TOUCHTONE 1–602–244–6609
Motorola Fax Back System – US & Canada ONLY 1–800–774–1848
– http://sps.motorola.com/mfax/

**ASIA / PACIFIC**: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Centre,
2, Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong.
852–26668334

**HOME PAGE**: http://motorola.com/sps/