TOSHIBA Bipolar Linear Integrated Circuit SiGe Monolithic

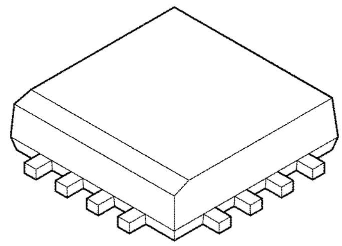
# TA4500F

1.9 GHz Band RX Front-End IC

PHS, Digital Cordless Telecommunication Applications

## Features

- Low-noise amplifier / down-conversion mixer
- Integrated local buffer amplifier
- Single positive power supply: $V_{CC}$ = 3.0 V
- Large conversion gain: $G_{LNA}$ = 17.5 dB (typ.)
  $G_{MIX}$ = 5.0 dB (typ.)
- High input IP3: $IIP3_{LNA}$ = -7.5 dBmW (typ.)
  $IIP3_{MIX}$ = 7.0 dBmW (typ.)
- High 1/2 IF reduction ratio: $1/2IFR_{MIX}$ = 45 dB (typ.)
- Small package: QS16 (2.5 mm × 2.5 mm × 0.55 mm)



QS16

Weight: 0.0065 g (typ.)

## Absolute Maximum Ratings (Ta = 25°C)

| Characteristic | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ (Note 1) | 4.5 | V |
| Input power | $P_{IN}$ (RF_IN) | 10 | dBmW |
| | $P_{IN}$ (LO_IN) | 0 | dBmW |
| | $P_{IN}$ (MIX_IN) | 0 | dBmW |
| Power dissipation | $P_d$ (Note 2) | 500 | mW |
| Operating temperature range | Topr | −40 to +85 | °C |
| Storage temperature range | Tstg | −55 to +150 | °C |

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: VCC = VCC1 = VCC2 = VCC3

Note 2: When mounted on a 30 mm × 35 mm × 0.6 mm FR4 substrate at Ta = 25°C (double-sided substrate: the reverse side is ground connection)

## Caution

This device is sensitive to electrostatic discharge. When handling this product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer.

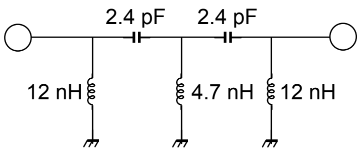
## Electrical Characteristics

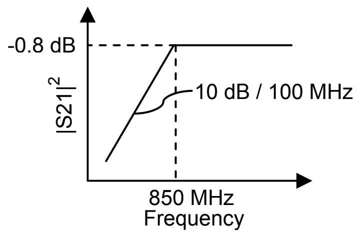
**$V_{CC}$ = 3.0 V, Ta = 25°C, Zg = Zl = 50 Ω**

| Characteristic | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| Operating frequency | f | — | 1.884 | — | 1.920 | GHz |
| Operating supply voltage | $V_{CC}$ | — | 2.7 | 3.0 | 3.3 | V |
| Supply current | $I_{CC}$ | pRF_IN = pLO_IN = pMIX_IN = 0 mW (no signal) | — | 15.0 | 22.0 | mA |
| **Low Noise Amplifier (LNA) Block** | | | | | | |
| Power gain | $G_{LNA}$ | fRF_IN = 1.9 GHz, pRF_IN = -35 dBmW | 15.0 | 17.5 | 22.0 | dB |
| Noise figure | $NF_{LNA}$ | Measured at 1.9 GHz | — | 2.2 | 3.0 | dB |
| Input IP3 | $IIP3_{LNA}$ | (Note 3) | -13.5 | -7.5 | — | dBmW |
| **Down Conversion Mixer (MIX) Block** | | | | | | |
| Conversion gain | $G_{MIX}$ | fMIX_IN = 1.9 GHz, pMIX_IN = -25 dBmW, fLO_IN = 1.66 GHz, pLO_IN = -15 dBmW, measured at IF_OUT1, IF_OUT2 terminated via 50 Ω and vice versa | 2.8 | 5.0 | 7.0 | dB |
| Noise figure | $NF_{MIX}$ | fLO_IN = 1.66 GHz, pLO_IN = -15 dBmW, measured at IF_OUT1, IF_OUT2 terminated via 50 Ω and vice versa, fIF_OUT = 240 MHz, DSB (Note 4) | — | 13.0 | 17.5 | dB |
| Input IP3 | $IIP3_{MIX}$ | fLO_IN = 1.66 GHz, pLO_IN = -15 dBmW, measured at IF_OUT1, IF_OUT2 terminated via 50 Ω and vice versa (Note 5) | -1.0 | 7.0 | — | dBmW |
| 1/2 IF reduction ratio | $1/2IFR_{MIX}$ | fMIX_IN = 1.9 GHz, 1.78 GHz, pMIX_IN = -25 dBmW, fLO_IN = 1.66 GHz, pLO_IN = -15 dBmW, measured at IF_OUT1, IF_OUT2 terminated via 50 Ω and vice versa, fIF_OUT = 240 MHz | — | 45.0 | — | dB |
| Local leak power | $P_{LK}$ | fLO_IN = 1.66 GHz, pLO_IN = -15 dBmW, measured at MIX_IN, IF_OUT1, 2 terminated via 50 Ω | — | -40.0 | — | dBmW |

Note 3: IIP3 of the LNA block is converted from IM3 when RF1 = 1.900 GHz / –35 dBmW, RF2 = 1.9006 GHz / –35 dBmW are input to RF_IN.

Note 4: Measured with the high pass filter shown below connected to MIX_IN.

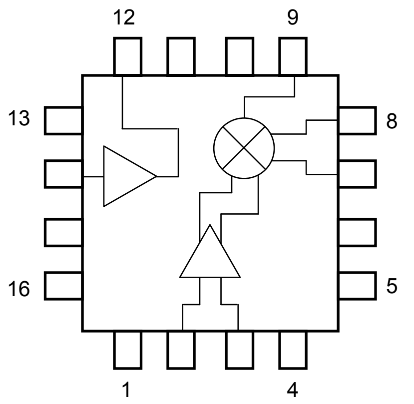


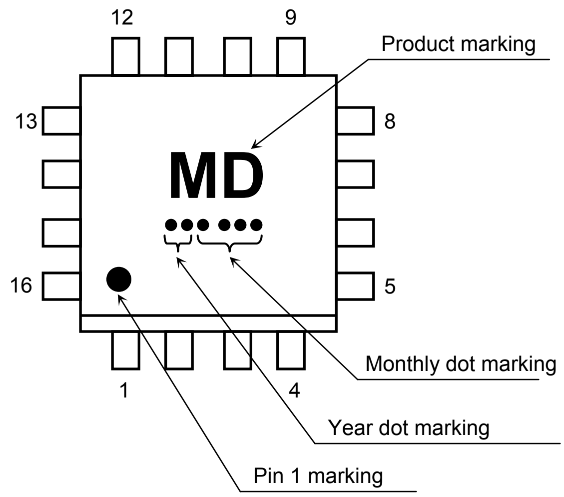




Note 5: IIP3 of the MIX block is converted from IM3 when RF1 = 1.900 GHz / –25 dBmW, RF2 = 1.9006 GHz / –25 dBmW are input to MIX_IN.

Note 6: All tests for electrical characteristics are performed using the test board shown on page 4.

## Block Diagram and Marking (Top View)

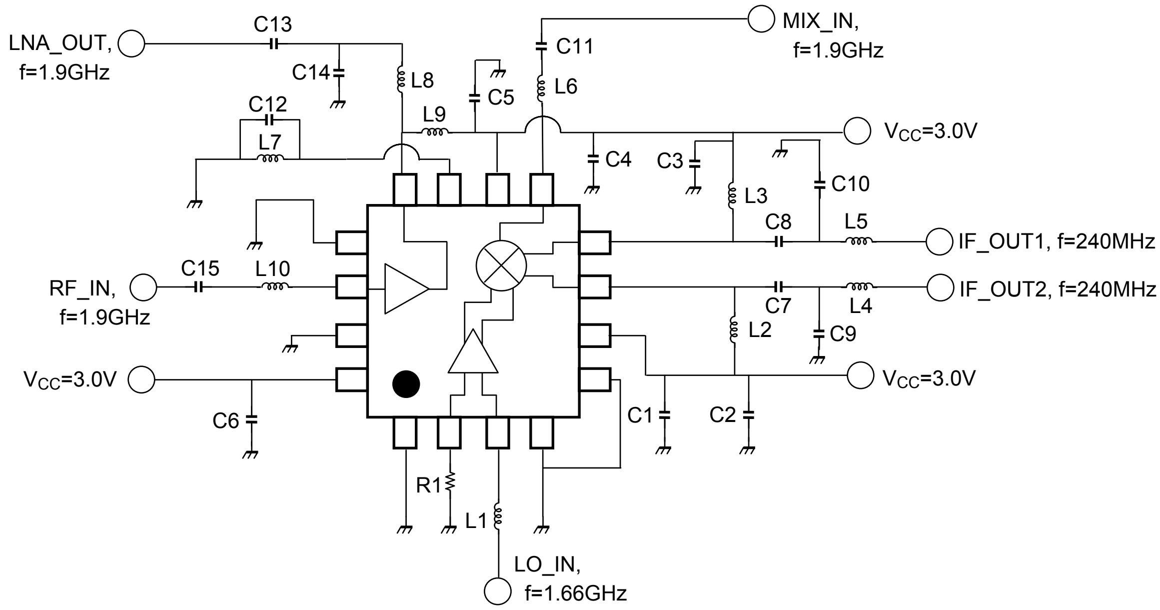



## Pin Configuration

| Pin number | Pin name | Description |
|---|---|---|
| 1 | N.C. | Not connected to the pellet. Connect to ground. |
| 2 | LO_term | MIX local input termination pin. To be terminated. |
| 3 | LO_IN | MIX local input |
| 4 | GND1 | Ground. |
| 5 | GND2 | Ground. |
| 6 | $V_{CC2}$ | Supply pin for MIX. |
| 7 | IF_OUT2 | MIX IF output. Biasing circuit is necessary. |
| 8 | IF_OUT1 | MIX IF output. Biasing circuit is necessary. |
| 9 | MIX_IN | MIX RF input. |
| 10 | $V_{CC1}$ | Supply pin for LNA and biasing circuits. |
| 11 | LNA_ind | LNA emitter. Connect to ground via 1 nH inductance // 1 pF capacitance. |
| 12 | LNA_OUT | LNA output. Biasing circuit is necessary. |
| 13 | GND3 | Ground. |
| 14 | RF_IN | LNA input. |
| 15 | GND4 | Ground. |
| 16 | $V_{CC3}$ | Supply pin for MIX. |

## Circuit Diagram of Test Board

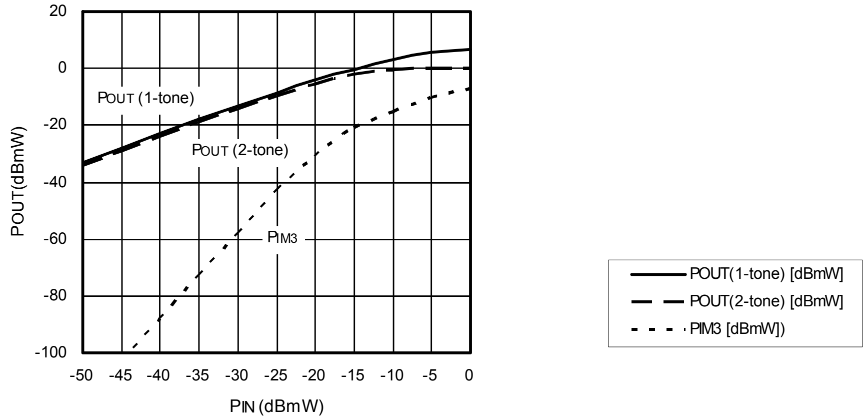



## List of External Chip Components

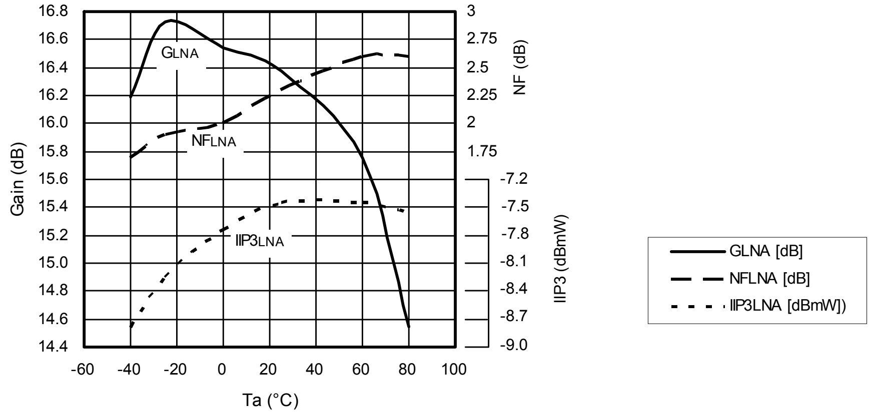
| Part | Value | Chip Series | Description |
|---|---|---|---|
| C1 | 1000 pF | GRM15 series MURATA | Decoupling capacitor |
| C2 | 1000 pF | GRM15 series MURATA | Decoupling capacitor |
| C3 | 1000 pF | GRM15 series MURATA | Decoupling capacitor |
| C4 | 1000 pF | GRM15 series MURATA | Decoupling capacitor |
| C5 | 1000 pF | GRM15 series MURATA | Decoupling capacitor |
| C6 | 1000 pF | GRM15 series MURATA | Decoupling capacitor |
| C7 | 1000 pF | GRM15 series MURATA | DC blocking capacitor |
| C8 | 1000 pF | GRM15 series MURATA | DC blocking capacitor |
| C9 | 5 pF | GRM15 series MURATA | IF_OUT matching |
| C10 | 5 pF | GRM15 series MURATA | IF_OUT matching |
| C11 | 39 pF | GRM15 series MURATA | MIX_IN matching |
| C12 | 1 pF | GRM15 series MURATA | Determining LNA gain |
| C13 | 82 pF | GRM15 series MURATA | LNA_OUT matching |
| C14 | 1.2 pF | GRM15 series MURATA | LNA_OUT matching |
| C15 | 3 pF | GRM15 series MURATA | RF_IN matching |
| L1 | 8.2 nH | LQG15HN series MURATA | LO_IN matching |
| L2 | 120 nH | LQG15HN series MURATA | MIX output load |
| L3 | 120 nH | LQG15HN series MURATA | MIX output load |
| L4 | 120 nH | LQG15HN series MURATA | IF_OUT matching |
| L5 | 120 nH | LQG15HN series MURATA | IF_OUT matching |
| L6 | 8.2 nH | LQG15HN series MURATA | MIX_IN matching |
| L7 | 1 nH | LQG15HN series MURATA | Determining LNA gain |
| L8 | 10 nH | LQG15HN series MURATA | LNA_OUT matching |
| L9 | 15 nH | LQG15HN series MURATA | LNA output load |
| L10 | 6.8 nH | LQG15HN series MURATA | LNA_IN matching |
| R1 | 51 Ω | MCR01 series ROHM | LO termination load |

## Typical Operating Characteristics of Low-Noise Amplifier Block

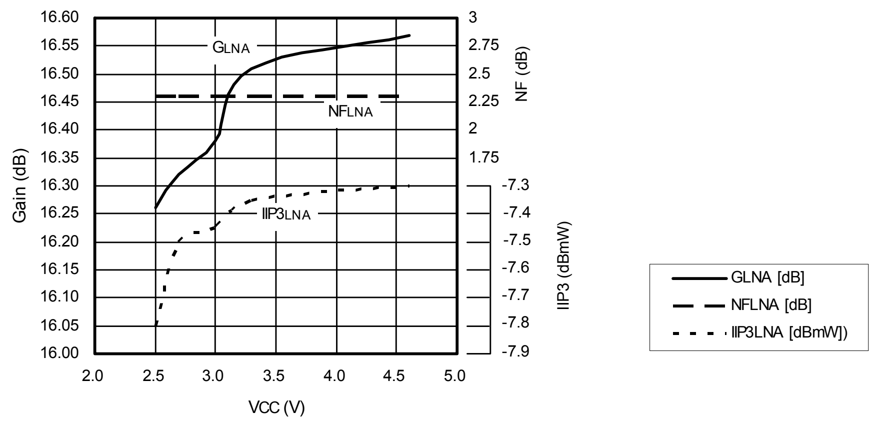
**LNA Block**
POUT(1-,2-tone),PIM3 vs PIN
VCC = 3 V, Ta = 25 °C,
RF1 = 1.9000 GHz,
RF2 = 1.9006 GHz for 2-tone, IM3 measurement



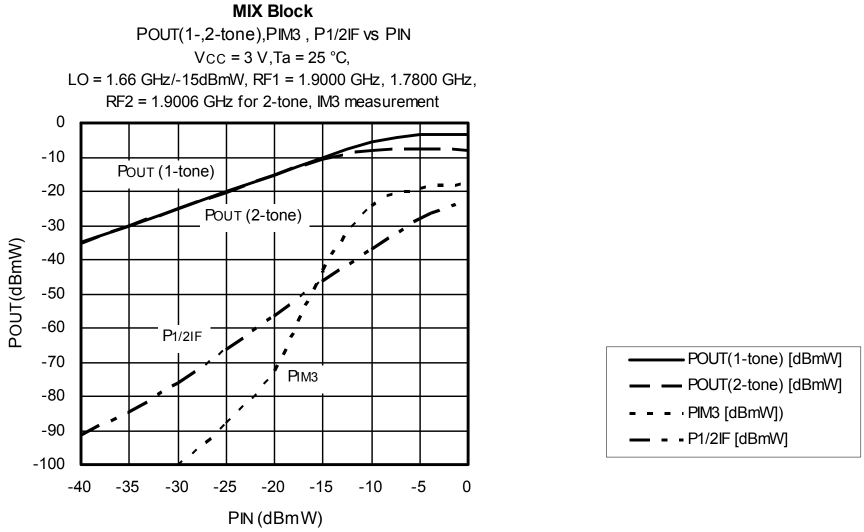

**LNA Block**
GLNA, IIP3LNA, NFLNA vs Temperature
VCC = 3 V,
RF1 = 1.9000 GHz/-35 dBmW,
RF2 = 1.9006 GHz/-35 dBmW for IIP3 measurement

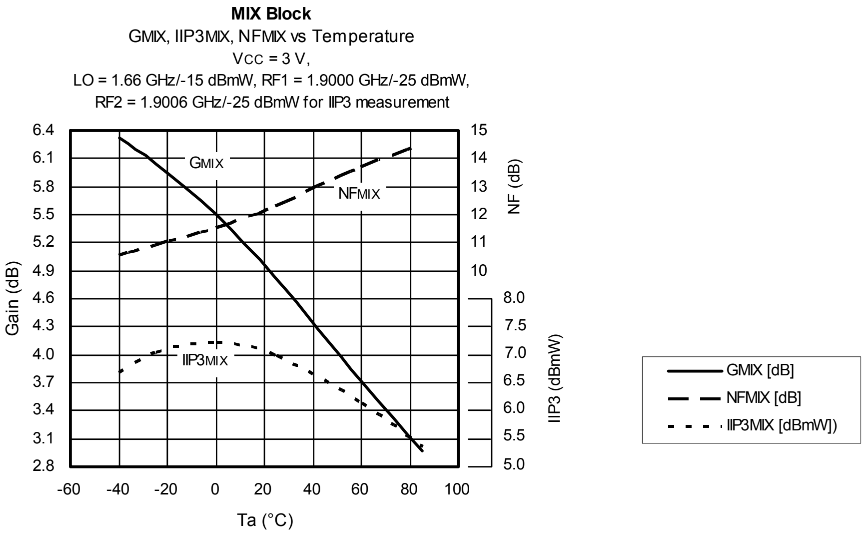


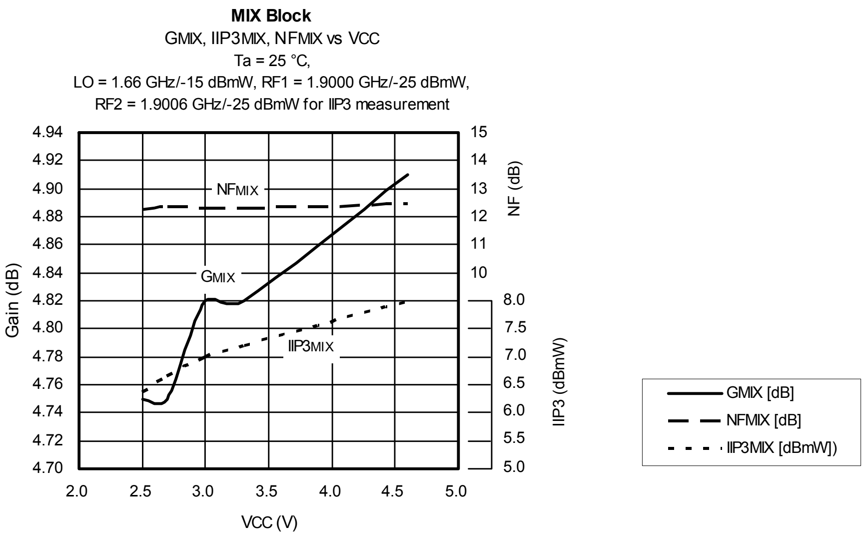

**LNA Block**
GLNA, IIP3LNA, NFLNA vs VCC
Ta = 25 °C,
RF1 = 1.9000 GHz/-35 dBmW,
RF2 = 1.9006 GHz/-35 dBmW for IIP3 measurement



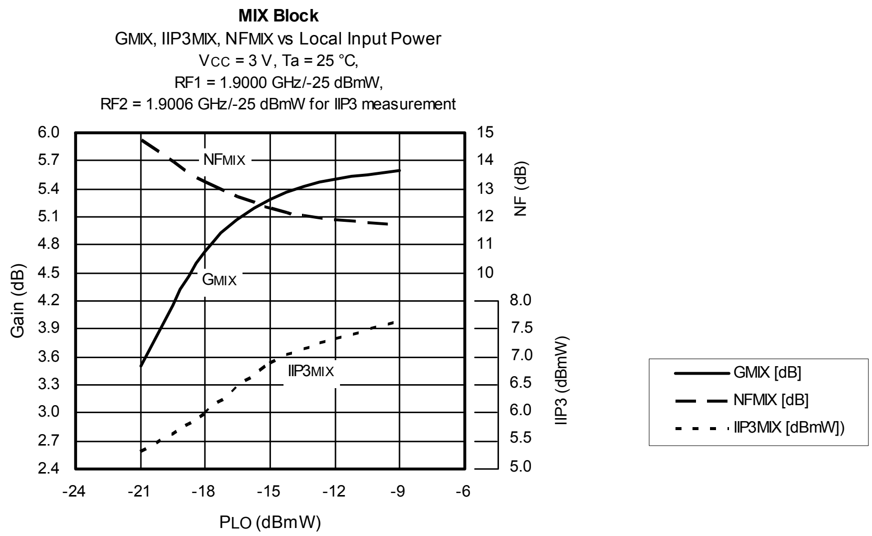
## Typical Operating Characteristics of Down Conversion Mixer Block



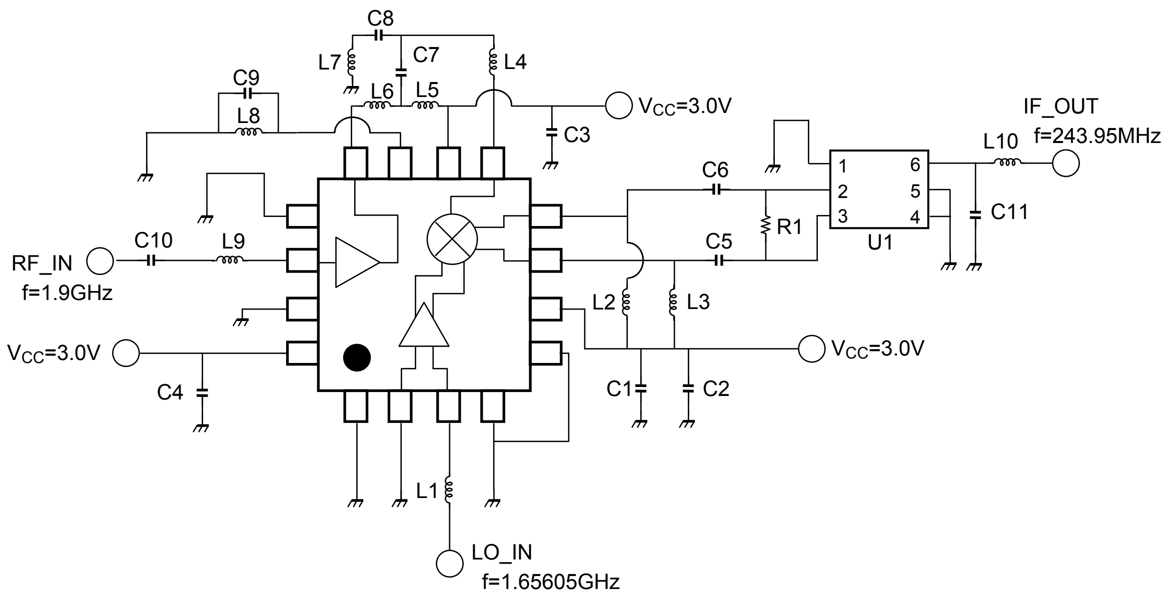



## Typical Operating Characteristics of Down Conversion Mixer Block (continued)



## Circuit Diagram of Evaluation Board




## List of External Chip Components on Evaluation Board

| Part | Value | Chip Series | Part | Value | Chip Series |
|---|---|---|---|---|---|
| C1 | 1000 pF | GRM15 series MURATA | L2 | 120 nH | LQG15HN series MURATA |
| C2 | 1000 pF | GRM15 series MURATA | L3 | 120 nH | LQG15HN series MURATA |
| C3 | 1000 pF | GRM15 series MURATA | L4 | 5.6 nH | LQG15HN series MURATA |
| C4 | 1000 pF | GRM15 series MURATA | L5 | 2.2 nH | LQG15HN series MURATA |
| C5 | 1000 pF | GRM15 series MURATA | L6 | 3.3 nH | LQG15HN series MURATA |
| C6 | 1000 pF | GRM15 series MURATA | L7 | 5.6 nH | LQG15HN series MURATA |
| C7 | 1 pF | GRM15 series MURATA | L8 | 1 nH | LQG15HN series MURATA |
| C8 | 2 pF | GRM15 series MURATA | L9 | 6.8 nH | LQG15HN series MURATA |
| C9 | 1 pF | GRM15 series MURATA | L10 | 100 nH | LQG15HN series MURATA |
| C10 | 3 pF | GRM15 series MURATA | R1 | 1.2 kΩ | MCR01 series ROHM |
| C11 | 2.7 pF | GRM15 series MURATA | U1 | 243.95 MHz | SAFDA243MRD9X00R00 MURATA |
| L1 | 8.2 nH | LQG15HN series MURATA | | | |

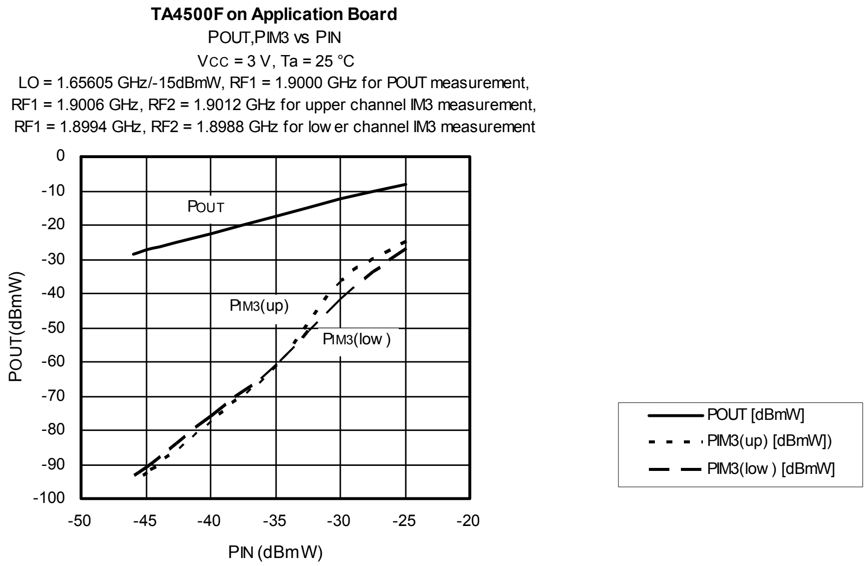
## Typical Electrical Characteristics of Evaluation Board (for Reference Only)

**$V_{CC}$ = 3.0 V, Ta = 25°C, Zg = Zl = 50 Ω, fLO_IN = 1.65605 GHz, pLO_IN = -15 dBmW, fIF_OUT = 243.95 MHz**

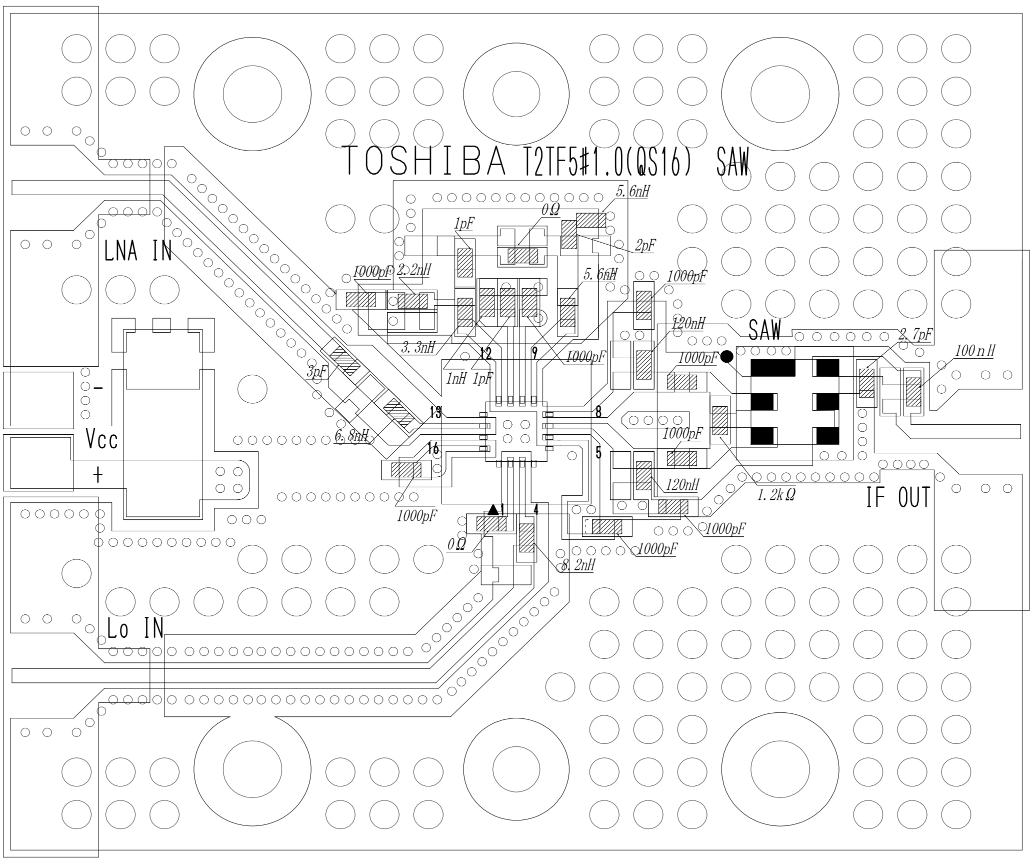
| Characteristic | Symbol | Test Condition | Typ | Unit |
|---|---|---|---|---|
| Conversion gain | $G_C$ | fRF_IN = 1.9 GHz, pRF_IN = -30 dBmW (Note 7) | 17.5 | dB |
| Noise figure | NF | DSB | 3.8 | dB |
| 3rd order intermodulation distortion | IM3 | IF output: fRF_IN = 1.9 GHz, pRF_IN = -46 dBmW,<br>3rd order: fRF_IN1 = 1.8994 GHz, fRF_IN2 = 1.8988 GHz,<br>pRF_IN1 = pRF_IN2 = -46 dBmW | 64.0 | dB |
| Image reduction ratio | IMR | fRF_IN = 1.9 GHz,1.4121 GHz, pRF_IN = -46 dBmW | 27.0 | dB |
| 1/2 IF reduction ratio | 1/2IFR | fRF_IN = 1.9 GHz,1.778025 GHz, pRF_IN = -46 dBmW | 48.0 | dB |

Note 7: Conversion gain in the above table includes the insertion loss (3.5 dB typical) of SAW filter, SAFDA243MRD 9X00R00.

## Typical Operating Characteristics of Evaluation Board




## Pattern Layout of Evaluation Board (Top Layer)



## Notice

The circuits and measurements contained in this document are given in the context of example applications of the product only.

Moreover, these example application circuits are not intended for mass production since the high-frequency characteristics (i.e., the AC characteristics) of the device will be affected by the external components that the customer uses, by the design of the circuit and by various other conditions.

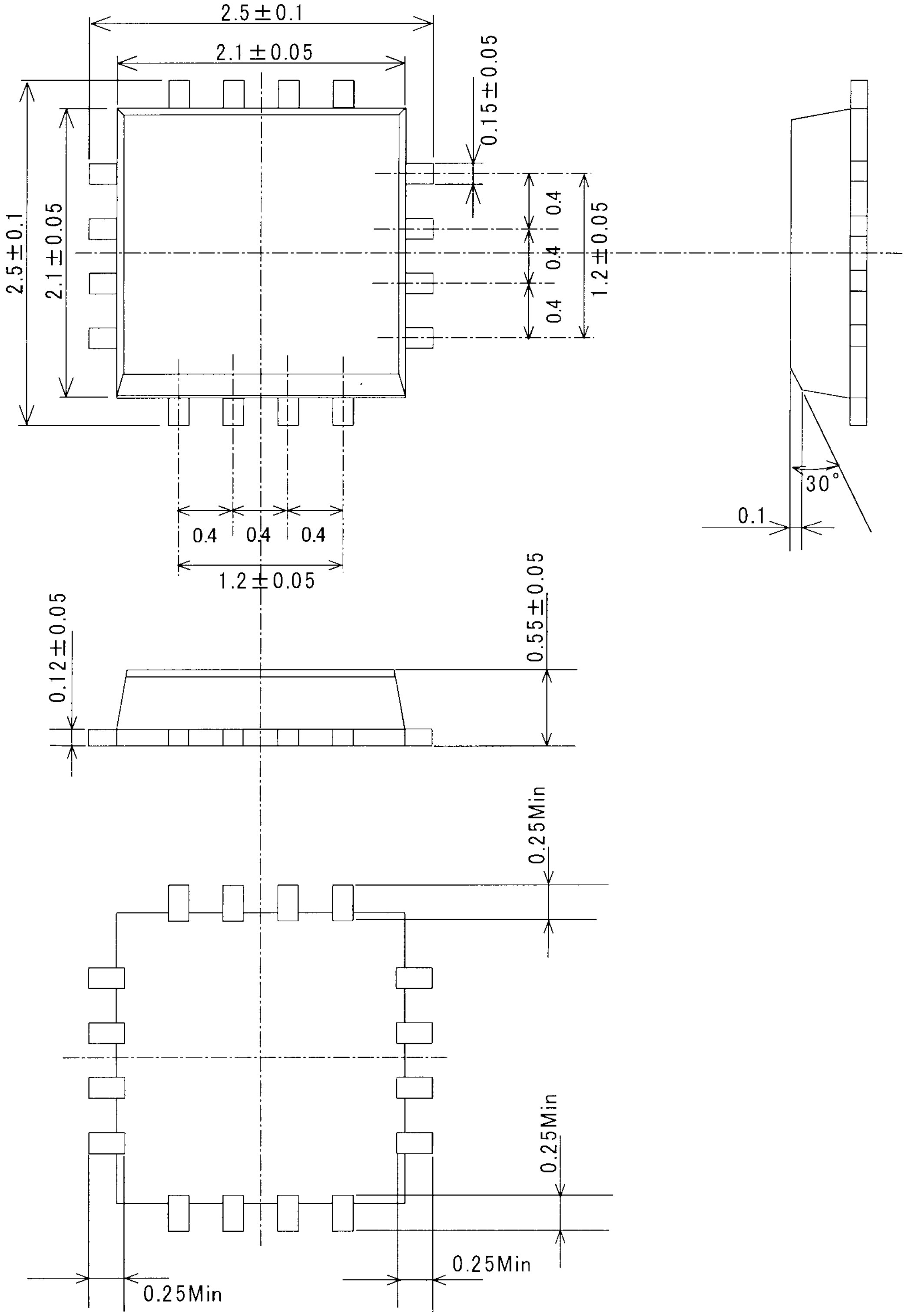
It is the responsibility of the customer to design external circuits that correctly implement the intended application and to check the characteristics of the design.

TOSHIBA assumes no responsibility for the integrity of customer circuit designs or applications.

## Package Physical Dimensions

QS16

Unit: mm




Weight: 0.0065 g (typ.)

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20070701-EN GENERAL

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