

## Features

- 700 MHz to 2700 MHz Operating Frequency
- Very Low Noise Floor Performance
- Very Good Sideband and Carrier Suppression
- Supports Wideband Baseband Input
- Very High Linearity
- Very Low LO Leakage
- 50  $\Omega$  Impedance on RF and LO Port
- Low LO Drive Requirements
- No External IF Filter
- Supply Voltage 5 V
- Small SSOP16 Package

## Applications

- Infrastructure Digital Communication Systems
- GSM/TDMA/CDMA2000/W-CDMA/UMTS/ISM Band Transceivers
- RF Radio Links
- Wireless Modem Access Points
- High Performance RF Instrumentation

Electrostatic sensitive device.  
Observe precautions for handling.



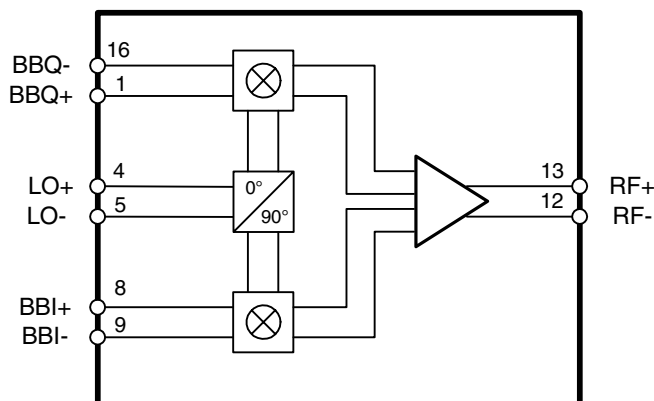
## Description

The T0790 is a direct quadrature modulator using Atmel's Silicon-Germanium (SiGe) process.

This modulator features a frequency range of 700 to 2700 MHz with excellent carrier and sideband suppression and a very low noise floor. It operates from a single 5 V supply and provides -11 dBm of power while requiring only 0 dBm input to the integrated LO driver. An RF and an LO amplifier are also included.

The T0790 incorporates internal matching on each RF, IF and LO port to enhance ease of use and to reduce the external components required. The LO input can be driven differentially or single ended.

Figure 1. Block Diagram



700 MHz -  
2700 MHz  
Direct  
Quadrature  
Modulator

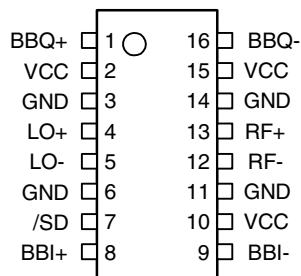
T0790

Preliminary



## Pin Configuration

Figure 2. Pinning SSOP16



## Pin Description

| Pin | Symbol | Function   |
|-----|--------|--|
| 1   | BBQ+   | Baseband Q-axis positive input   |
| 2   | VCC    | Supply voltage   |
| 3   | GND    | Ground   |
| 4   | LO_IN+ | Positive local oscillator input, nominal DC voltage is 2.0 V internally biased; input should be AC-coupled |
| 5   | LO_IN- | Negative local oscillator input, nominal DC voltage is 2.0 V internally biased; input should be AC-coupled |
| 6   | GND    | Ground   |
| 7   | /SD    | Shutdown control   |
| 8   | BBI+   | Baseband I-axis positive input   |
| 9   | BBI-   | Baseband I-axis negative input   |
| 10  | VCC    | Supply voltage   |
| 11  | GND    | Ground   |
| 12  | RF_IN- | Negative RF output; nominal DC voltage is 2.4 V internally biased; input should be AC-coupled              |
| 13  | RF_IN+ | Positive RF output; nominal DC voltage is 2.4 V internally biased; input should be AC-coupled              |
| 14  | GND    | Ground   |
| 15  | VCC    | Supply voltage   |
| 16  | BBQ-   | Baseband Q-axis negative input   |
| –   | Paddle | Device ground and heat sink, requires good thermal path; RF reference plane                                |

## Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

| Parameters                    | Symbols                | Value       | Unit |
|-------------------------------|------------------------|-------------|------|
| Supply voltage, no RF applied | $V_{CC}$               | 5.5         | V    |
| LO input signals              | LO_IN-, LO_IN+         | +10.0       | dBm  |
| Input voltage                 | BBI+, BBI-, BBQ+, BBQ- | 3           | V    |
| Operating case temperature    | $T_C$                  | -40 to +85  | °C   |
| Storage temperature           | $T_{STG}$              | -55 to +150 | °C   |

## Thermal Resistance

| Parameters       | Symbols    | Value | Unit |
|------------------|------------|-------|------|
| Junction ambient | $R_{thJA}$ | 35    | K/W  |

## Electrical Characteristics

Test conditions:

Unless otherwise noted, the following conditions apply to typical performance specification under static conditions:

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$ ; baseband inputs: 1.9 V DC bias, 200 kHz frequency, 300 mV<sub>P-P</sub> 600 mV<sub>P-P</sub> differential drive, I/Q signals in quadrature, LO = 1960 MHz;  $P_{LO} = -5\text{ dBm}$

| No.                        | Parameters                     | Test Conditions   | Pin         | Symbol    | Min. | Typ.     | Max. | Unit       | Type* |
|----------------------------|--------------------------------|---|-------------|-----------|------|----------|------|------------|-------|
| <b>General Performance</b> |                                |   |             |           |      |          |      |            |       |
|                            | Supply voltage                 |   | 2, 10, 15   | $V_{CC}$  | 4.75 | 5.0      | 5.25 | V          | A     |
|                            | Supply current                 |   | 2, 10, 15   | $I_{CC}$  |      | 73       | 82   | mA         | A     |
| <b>LO Input</b>            |                                |   |             |           |      |          |      |            |       |
|                            | LO drive                       |   | 4, 5        | $P_{LO}$  | -8   | -5       | -2   | dBm        | D     |
|                            | LO frequency                   |   | 4, 5        | $f_{LO}$  | 700  |          | 2700 | MHz        | B     |
|                            | LO return loss                 | Matched to 50 $\Omega$  | 4, 5        | $RL_{LO}$ |      | 16       |      | dB         | C     |
| <b>Baseband Inputs</b>     |                                |   |             |           |      |          |      |            |       |
|                            | Baseband input frequency range | -3 dB bandwidth, baseband inputs, terminated with 50 $\Omega$ | 1, 8, 9, 16 | $f_{BB}$  | DC   |          | 500  | MHz        | D     |
|                            | Baseband input resistance      | Per pin   | 1, 8, 9, 16 | $R_{BB}$  |      | 4.4      |      | k $\Omega$ | D     |
|                            | Baseband input capacitance     | Per pin   | 1, 8, 9, 16 | $C_{BB}$  |      | 4        |      | pF         | D     |
| <b>Miscellaneous</b>       |                                |   |             |           |      |          |      |            |       |
|                            | Shutdown attenuation           |   | 7           | $A_{SD}$  |      | 60       |      | dB         | D     |
|                            | Shutdown pin resistance        | At 1 MHz  | 7           | $R_{SD}$  |      | 11.9     |      | k $\Omega$ | D     |
|                            | Shutdown pin capacitance       | At 1 MHz  | 7           | $C_{SD}$  |      | 5.2      |      | pF         | D     |
|                            | Shutdown input thresholds      | Shutdown disabled (normal operation)                          | 7           | 3.75      |      | $V_{CC}$ |      | V          | D     |
|                            |                                | Shutdown enabled  | 7           | 0         |      | 1.5      |      | V          | D     |

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## RF Electrical Characteristics (700 to 1000 MHz)

Test conditions:

Unless otherwise noted, the following conditions apply to typical performance specification under static conditions:

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25^{\circ}\text{C}$ ; baseband inputs: 1.9 V DC bias, 200 kHz frequency, 300 mV<sub>P-P</sub> 600 mV<sub>P-P</sub> differential drive, I/Q signals in quadrature, LO = 900 MHz;  $P_{LO} = -5\text{ dBm}$

| No.                   | Parameters                    | Test Conditions  | Pin    | Symbol      | Min.  | Typ.      | Max. | Unit       | Type* |
|-----------------------|-------------------------------|--|--------|-------------|-------|-----------|------|------------|-------|
| <b>RF Output Port</b> |                               |  |        |             |       |           |      |            |       |
|                       | RF frequency                  |  | 12, 13 | $f_{RF}$    | 700   |           | 1000 | MHz        | B     |
|                       | Output power                  |  | 12, 13 | $P_{RFout}$ | -13.0 | -10.5     | -9.0 | dBm        | A     |
|                       | RF return loss                | Matched to 50 $\Omega$   | 12, 13 | $P_{LORL}$  |       | 20        |      | dB         | D     |
|                       | 1-dB output compression point |  | 12, 13 | P1dB        | 3     | 4         |      | dBm        | A     |
|                       | LO-RF leakage                 |  | 12, 13 | $P_{LORF}$  |       | -40       | -34  | dBm        | D     |
|                       | Sideband suppression          |  | 12, 13 | $A_{SB}$    | 34    | 40        |      | dB         | D     |
|                       | IM3 suppression               | Two tone baseband input at 600 mV <sub>P-P</sub> differential per tone | 12, 13 | $A_{IM3}$   | 58    | 62        |      | dB         | D     |
|                       | Broadband noise floor         |  | 12, 13 | $P_{NOISE}$ |       | -154      | -148 | dBm/Hz     | C     |
|                       | Quadrature phase error        |  | 12, 13 |             | -2    | $\pm 0.5$ | +2   | $^{\circ}$ | B     |
|                       | I/Q amplitude balance         |  | 12, 13 |             | -0.2  | $\pm 0.5$ | +0.2 | dB         | B     |

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## RF Electrical Characteristics (1700 to 2000 MHz)

Test conditions:

Unless otherwise noted, the following conditions apply to typical performance specification under static conditions:

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25^{\circ}\text{C}$ ; baseband inputs: 1.9 V DC bias, 200 kHz frequency, 300 mV<sub>P-P</sub> 600 mV<sub>P-P</sub> differential drive, I/Q signals in quadrature, LO = 1960 MHz;  $P_{LO} = -5\text{ dBm}$

| No.                   | Parameters                    | Test Conditions  | Pin    | Symbol      | Min.  | Typ.  | Max.  | Unit | Type* |
|-----------------------|-------------------------------|--|--------|-------------|-------|-------|-------|------|-------|
| <b>RF Output Port</b> |                               |  |        |             |       |       |       |      |       |
|                       | RF frequency                  |  | 12, 13 | $f_{RF}$    | 1700  |       | 2000  | MHz  | B     |
|                       | Output power                  |  | 12, 13 | $P_{RFout}$ | -15.0 | -11.5 | -10.0 | dBm  | A     |
|                       | RF return loss                | Matched to 50 $\Omega$   | 12, 13 | $P_{LORL}$  |       | 16    |       | dB   | D     |
|                       | 1-dB output compression point |  | 12, 13 | P1dB        | 2     | 3     |       | dBm  | A     |
|                       | LO-RF leakage                 |  | 12, 13 | $P_{LORF}$  |       | -40   | -32   | dBm  | D     |
|                       | Sideband suppression          |  | 12, 13 | $A_{SB}$    | 34    | 40    |       | dB   | D     |
|                       | IM3 suppression               | Two tone baseband input at 600 mV <sub>P-P</sub> differential per tone | 12, 13 | $A_{IM3}$   | 58    | 62    |       | dB   | D     |

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

### RF Electrical Characteristics (1700 to 2000 MHz) (Continued)

Test conditions:

Unless otherwise noted, the following conditions apply to typical performance specification under static conditions:

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$ ; baseband inputs: 1.9 V DC bias, 200 kHz frequency, 300 mV<sub>P-P</sub> 600 mV<sub>P-P</sub> differential drive, I/Q signals in quadrature, LO = 1960 MHz; P<sub>LO</sub> = -5 dBm

| No. | Parameters             | Test Conditions | Pin    | Symbol             | Min. | Typ. | Max. | Unit   | Type* |
|-----|------------------------|-----------------|--------|--------------------|------|------|------|--------|-------|
|     | Broadband noise floor  |                 | 12, 13 | P <sub>NOISE</sub> |      | -155 | -148 | dBm/Hz | C     |
|     | Quadrature phase error |                 | 12, 13 |                    | -2   | ±0.5 | +2   | °      | B     |
|     | I/Q amplitude balance  |                 | 12, 13 |                    | -0.2 | ±0.5 | +0.2 | dB     | B     |

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

### RF Electrical Characteristics (2300 to 2700 MHz)

Test conditions:

Unless otherwise noted, the following conditions apply to typical performance specification under static conditions:

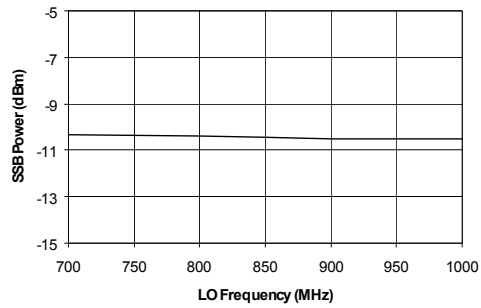
$V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$ ; baseband inputs: 1.9 V DC bias, 200 kHz frequency, 300 mV<sub>P-P</sub> 600 mV<sub>P-P</sub> differential drive, I/Q signals in quadrature, LO = 2600 MHz; P<sub>LO</sub> = -5 dBm

| No.                   | Parameters                    | Test Conditions  | Pin    | Symbol             | Min. | Typ.  | Max. | Unit   | Type* |
|-----------------------|-------------------------------|--|--------|--------------------|------|-------|------|--------|-------|
| <b>RF Output Port</b> |                               |  |        |                    |      |       |      |        |       |
|                       | RF frequency                  |  | 12, 13 | f <sub>RF</sub>    | 2300 |       | 2700 | MHz    | B     |
|                       | Output power                  |  | 12, 13 | P <sub>RFout</sub> | -18  | -14.5 | -13  | dBm    | A     |
|                       | RF return loss                | Matched to 50 Ω  | 12, 13 | P <sub>LORL</sub>  |      | 15    |      | dB     | D     |
|                       | 1-dB output compression point |  | 12, 13 | P1dB               |      | TBD   |      | dBm    | A     |
|                       | LO-RF leakage                 |  | 12, 13 | P <sub>LORF</sub>  |      | -40   | -32  | dBm    | D     |
|                       | Sideband suppression          |  | 12, 13 | A <sub>SB</sub>    | 34   | 40    |      | dB     | D     |
|                       | IM3 suppression               | Two tone baseband input at 600 mV <sub>P-P</sub> differential per tone | 12, 13 | A <sub>IM3</sub>   |      | TBD   |      | dB     | D     |
|                       | Broadband noise floor         |  | 12, 13 | P <sub>NOISE</sub> |      | TBD   |      | dBm/Hz | C     |
|                       | Quadrature phase error        |  | 12, 13 |                    | -2   | ±0.5  | +2   | °      | B     |
|                       | I/Q amplitude balance         |  | 12, 13 |                    | -0.2 | ±0.5  | +0.2 | dB     | B     |

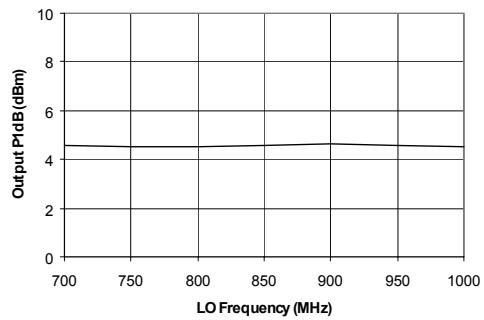
\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

**700 MHz to  
1000 MHz: Typical  
Device Performance**

**Figure 3. SSB Power versus LO Frequency**



**Figure 4. Output P1dB versus LO Frequency**



**Figure 5. Carrier Feedthrough versus LO Frequency**

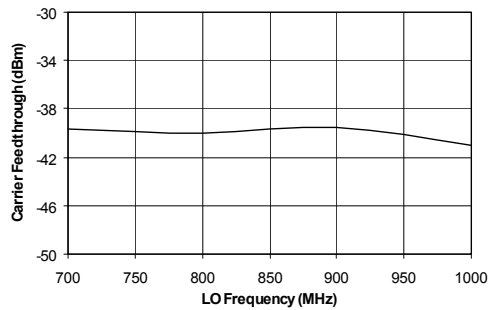


Figure 6. Sideband Suppression versus LO Frequency

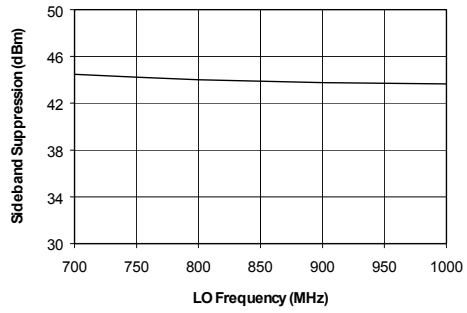


Figure 7. Intermodulation Distortion versus SSB Output Power

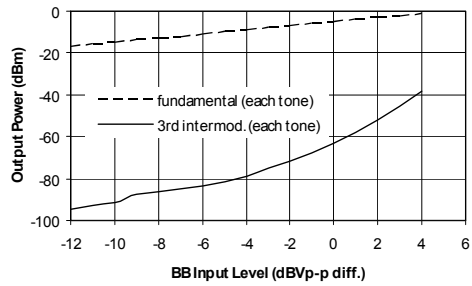
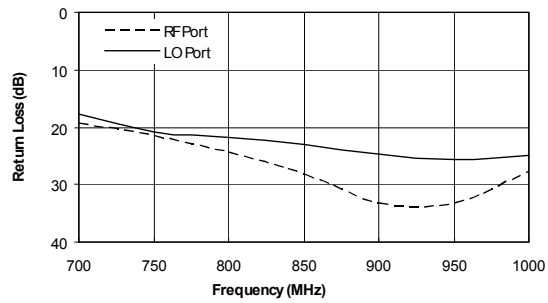


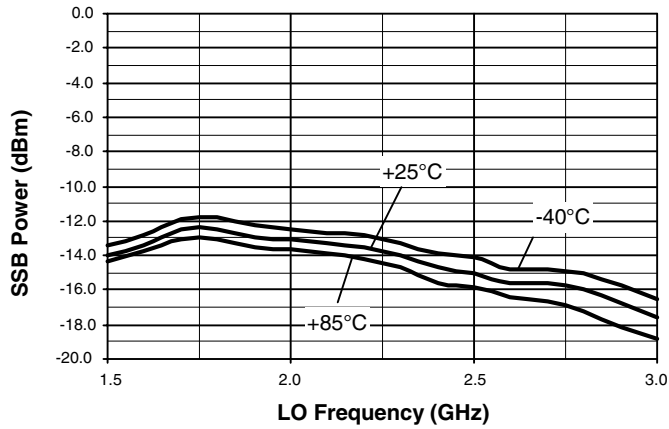
Figure 8. RF and LO Return Losses



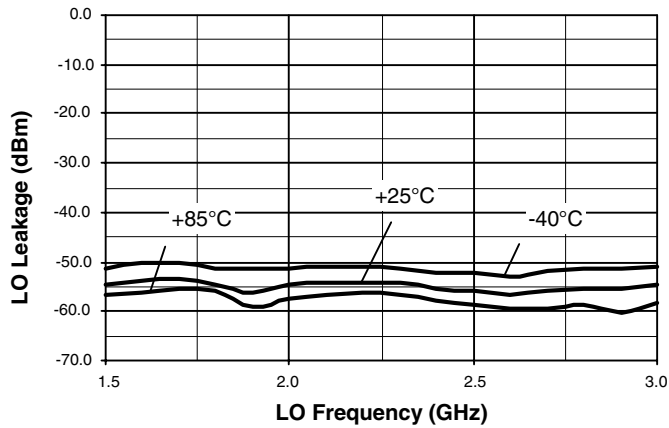
# 1500 MHz to 2500 MHz: Typical Device Performance

All tests have been done on a testboard with LO and RF matching to 2600 MHz (see "Application Bard Schematic" description on page 10). Test in a clima chamber required long cables, which added additional loss and affected the output power.

**Figure 9.** SSB Power versus LO Frequency



**Figure 10.** Carrier Feedthrough versus LO Frequency



**Figure 11.** Sideband Suppression versus LO Frequency

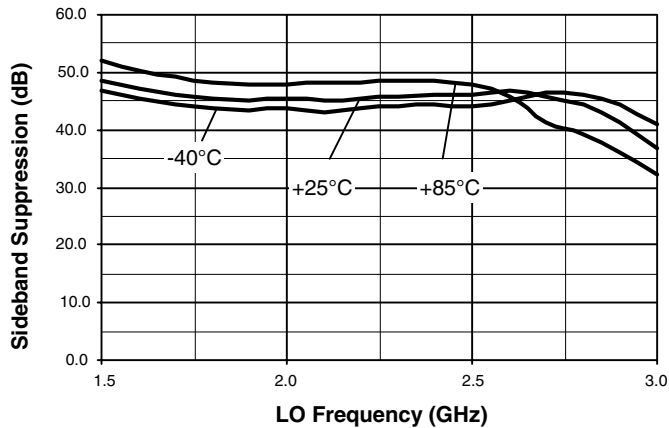




Figure 12. RF and LO Return Losses

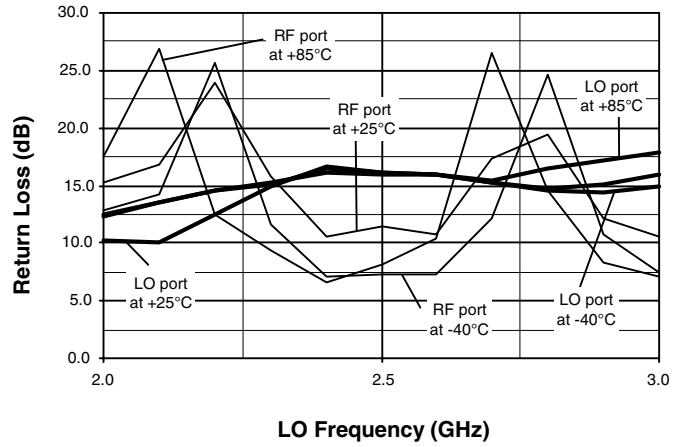


Figure 13. Phase Error versus LO Frequency

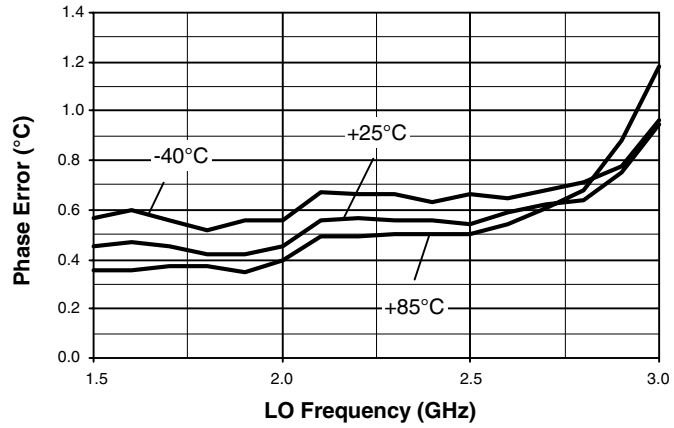
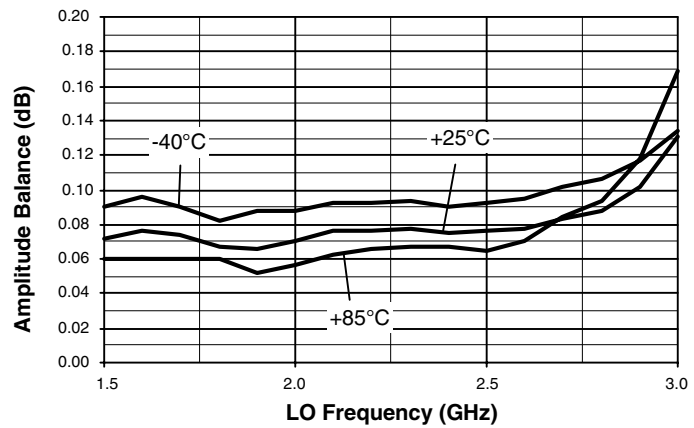


Figure 14. Amplitude Balance versus LO Frequency





**Bill of Materials (1700 MHz to 2500 MHz Evaluation Board)**

| Component                           | Reference                  | Vendor             | Part Number/<br>Remark | Value <sup>(1)</sup> | Size/Package |
|-------------------------------------|----------------------------|--------------------|------------------------|----------------------|--------------|
| Direc Quadrature Modulator          | D1                         | Atmel              | T0790                  |                      | SSOP16       |
| Inductor                            | L1                         | Würth Elektronik   | 74476401               | 1 µH                 | 1210         |
| Resistor                            | R1, R2, R6, R7             |                    |                        | 180 Ω                | 0402         |
| Resistor                            | R5                         |                    |                        | 1 kΩ                 | 0402         |
| Capacitor                           | C3,C16                     |                    |                        | 6.8 pF               | 0402         |
| Capacitor                           | C4,C15                     |                    |                        | 1 nF                 | 0402         |
| Electrolytic capacitor              | C2                         |                    |                        | 10 µF                | Size A       |
| Capacitor                           | C5, C6, C12, C13           |                    |                        | 2.7 pF               | 0402         |
| Capacitor                           | C8, C11                    |                    |                        | n.c.                 | 0402         |
| RF transformer 1200 MHz to 2200 MHz | T1, T2                     | Panasonic          | EHF-FD1619             |                      | 3216         |
| RF connector                        | P8, P9, P10, P11, P12, P13 | Johnson Components | 142-0711-841           |                      | SMA          |

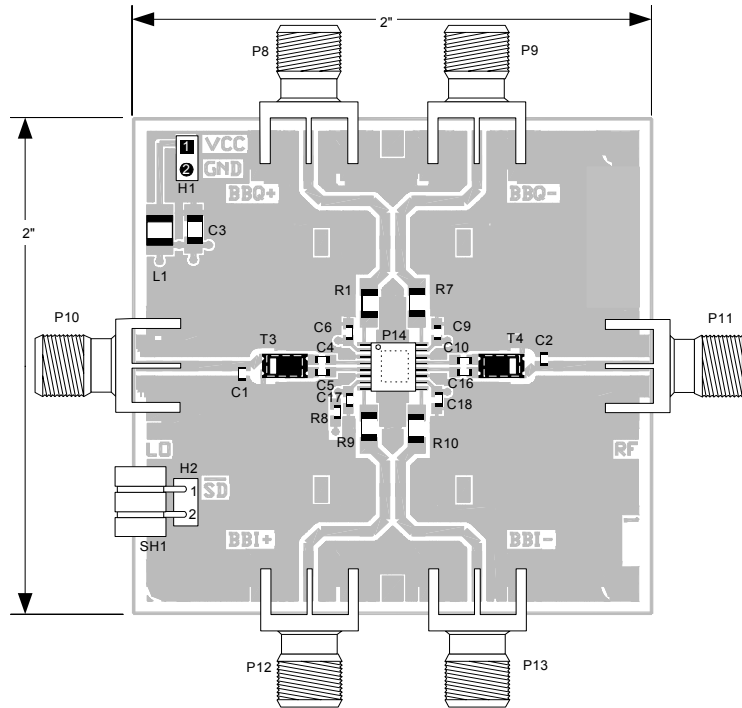
Note: 1. May vary due to printed board layout and material.

**Bill of Materials (2500 MHz to 2700 MHz Evaluation Board)**

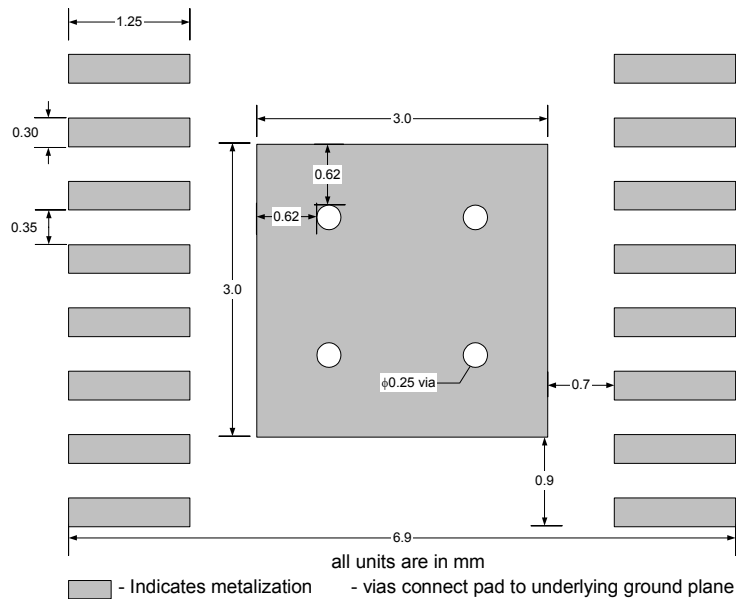
| Component                           | Reference                  | Vendor             | Part Number/<br>Remark | Value <sup>(1)</sup> | Size/Package |
|-------------------------------------|----------------------------|--------------------|------------------------|----------------------|--------------|
| Direc Quadrature Modulator          | D1                         | Atmel              | T0790                  |                      | SSOP16       |
| Inductor                            | L1                         | Würth Elektronik   | 74476401               | 1 µH                 | 1210         |
| Resistor                            | R1, R2, R6, R7             |                    |                        | 180 Ω                | 0402         |
| Resistor                            | R5                         |                    |                        | 1 kΩ                 | 0402         |
| Capacitor                           | C3,C16                     |                    |                        | 6.8 pF               | 0402         |
| Capacitor                           | C4,C15                     |                    |                        | 1 nF                 | 0402         |
| Electrolytic capacitor              | C2                         |                    |                        | 10 µF                | Size A       |
| Capacitor                           | C5, C12                    |                    |                        | 1.5 pF               | 0402         |
| Capacitor                           | C6, C13                    |                    |                        | 1.8 pF               | 0402         |
| Capacitor                           | C8, C11                    |                    |                        | n.c.                 | 0402         |
| RF transformer 1200 MHz to 2200 MHz | T1, T2                     | Panasonic          | EHF-FD1619             |                      | 3216         |
| RF connector                        | P8, P9, P10, P11, P12, P13 | Johnson Components | 142-0711-841           |                      | SMA          |

Note: 1. May vary due to printed board layout and material.

**Figure 16.** Demo Test Board (Fully Assembled PCB)



**Figure 17.** Recommended Package Footprint



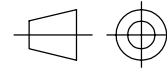
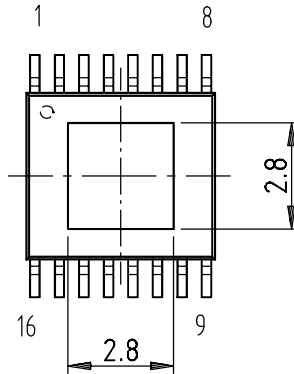
Note: Only ground signal traces are allowed directly under the package.  
 Heatslug must be soldered to GND.  
 Plugging of the ground vias under the heat slug is also recommended to avoid soldering problems.

### Ordering Information

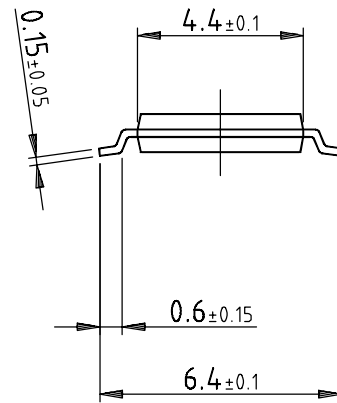
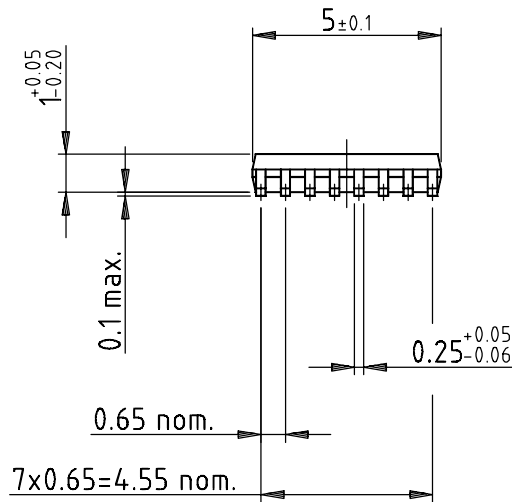
| Extended Type Number | Package | Remarks |
|----------------------|---------|---------|
| T0790-6C             | SSOP16  | -       |

### Package Information

Package: SSOP16  
 ( acc. JEDEC SMALL OUTLINE No. MO-153 )  
 Dimensions in mm



technical drawings  
 according to DIN  
 specifications



Drawing-No.: 6.543-5079.01-4  
 Issue: 1; 10.07.01



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Fax: (33) 4-42-53-60-01

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Fax: (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.  
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## Literature Requests

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