

## 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.



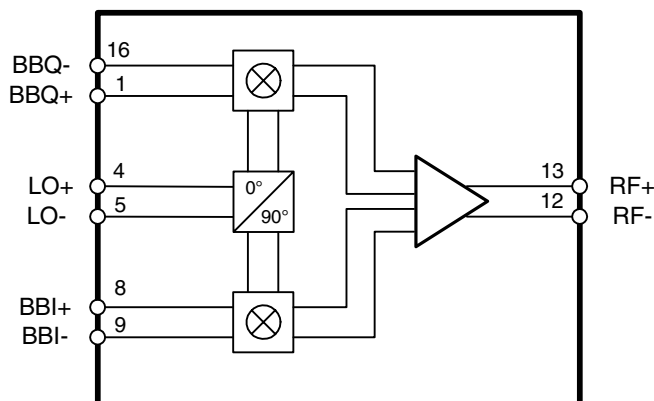
## Description

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

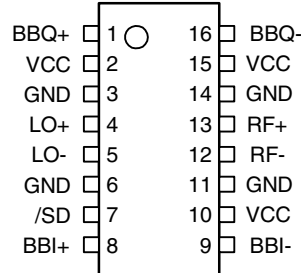
## Preliminary

Rev. 4555C-SIGE-11/03



## Pin Configuration

Figure 2. Pinning SSOP16



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## 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	$P_{1dB}$	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	$P_{1dB}$	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;  $P_{LO} = -5\text{ dBm}$

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
	Broadband noise floor		12, 13	$P_{NOISE}$		-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

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### 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;  $P_{LO} = -5\text{ dBm}$

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
<b>RF Output Port</b>									
	RF frequency		12, 13	$f_{RF}$	2300		2700	MHz	B
	Output power		12, 13	$P_{RFout}$	-18	-14.5	-13	dBm	A
	RF return loss	Matched to 50 Ω	12, 13	$P_{LORL}$		15		dB	D
	1-dB output compression point		12, 13	$P_{1dB}$		TBD		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	$A_{IM3}$		TBD		dB	D
	Broadband noise floor		12, 13	$P_{NOISE}$		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

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Figure 3. SSB Power versus LO Frequency

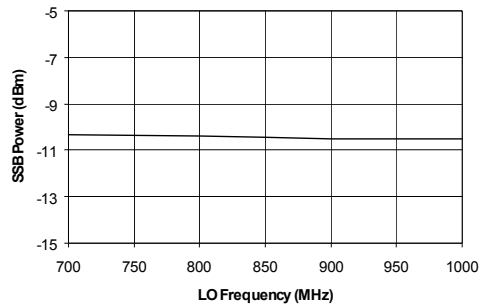


Figure 4. Output P1dB versus LO Frequency

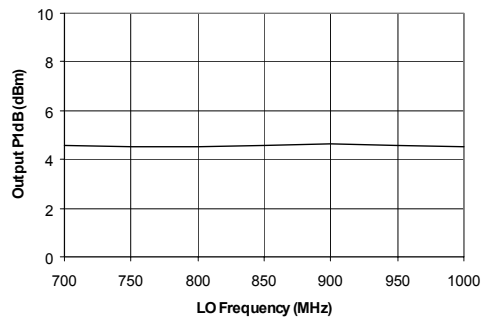


Figure 5. Carrier Feedthrough versus LO Frequency

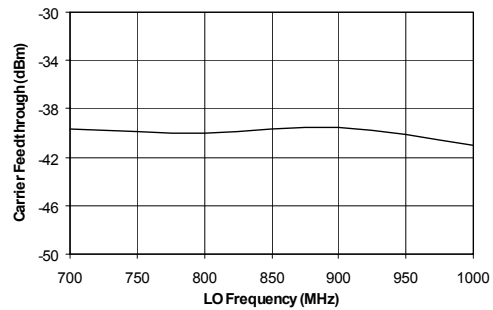
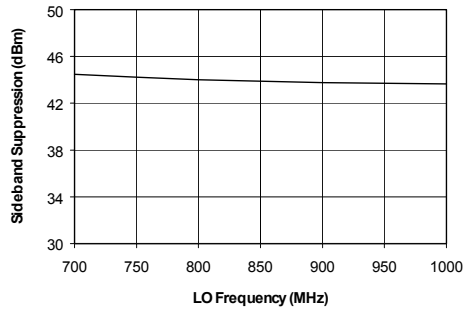


Figure 6. Sideband Suppression versus LO Frequency



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Figure 7. Intermodulation Distortion versus SSB Output Power

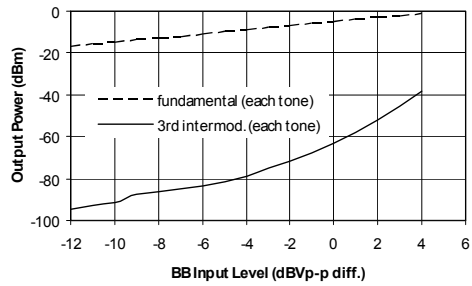
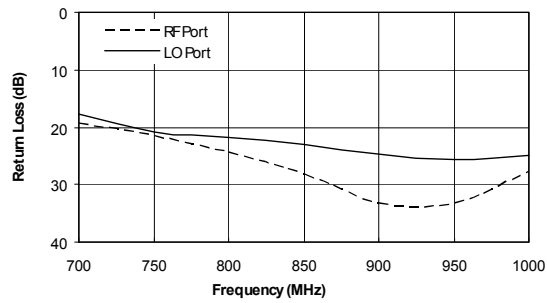


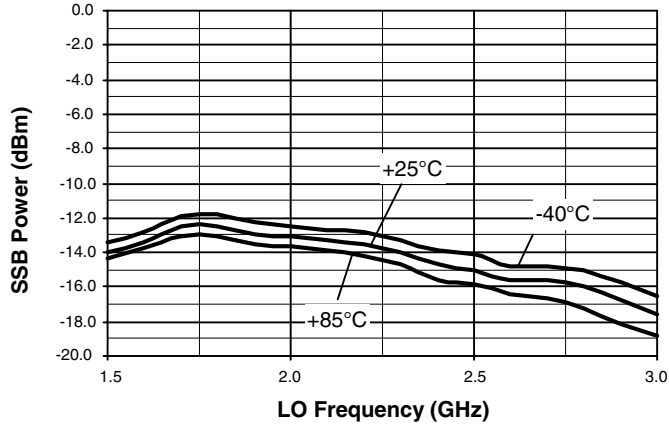
Figure 8. RF and LO Return Losses



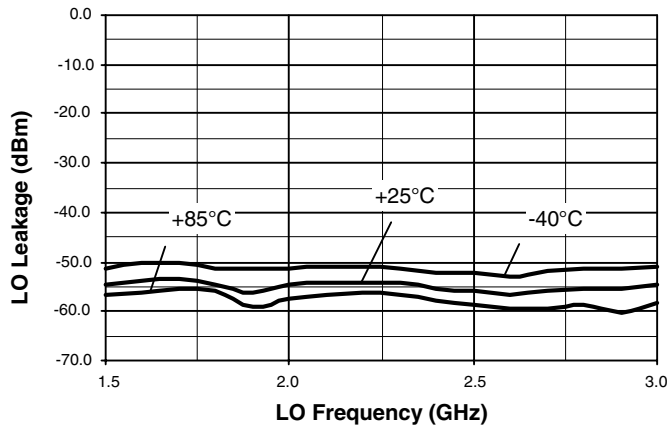
# 1500 MHz to 2500 MHz: Typical Device Performance

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

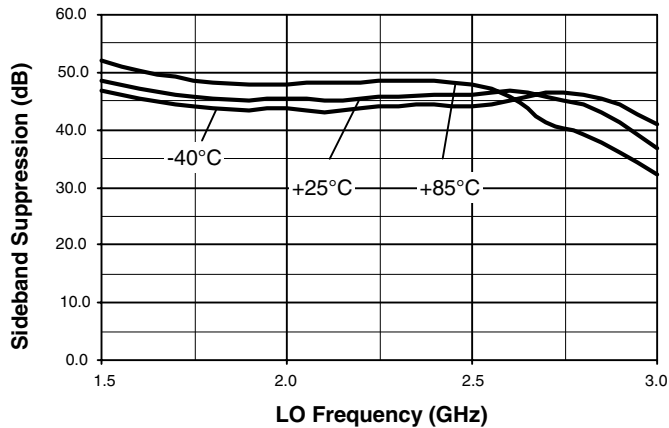
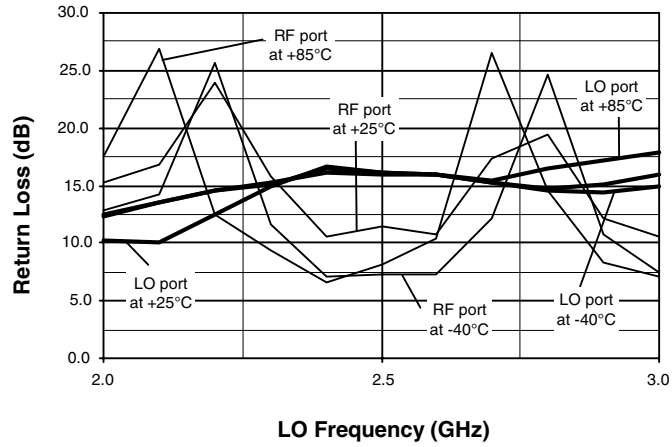




Figure 12. RF and LO Return Losses



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Figure 13. Phase Error versus LO Frequency

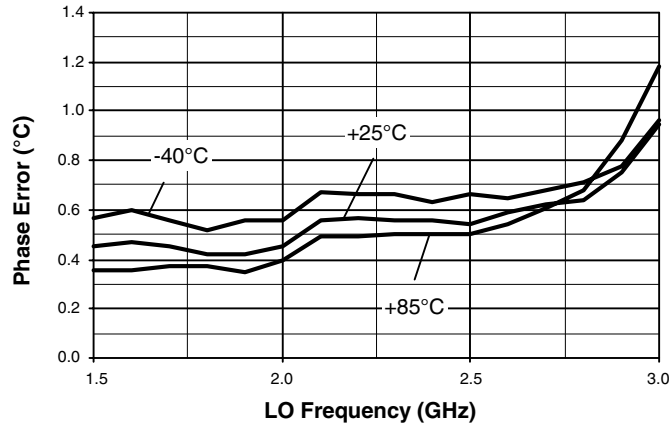
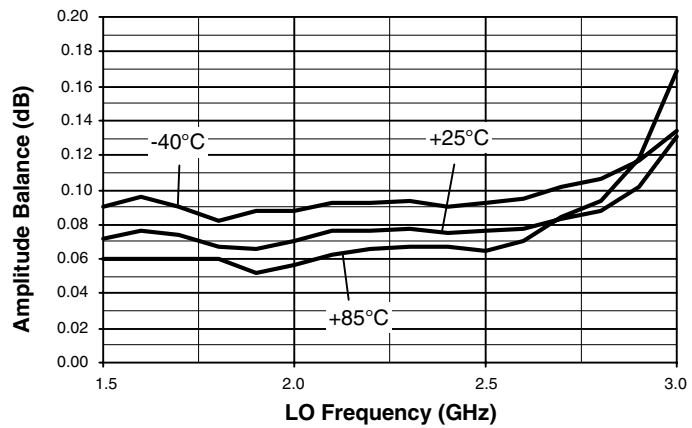
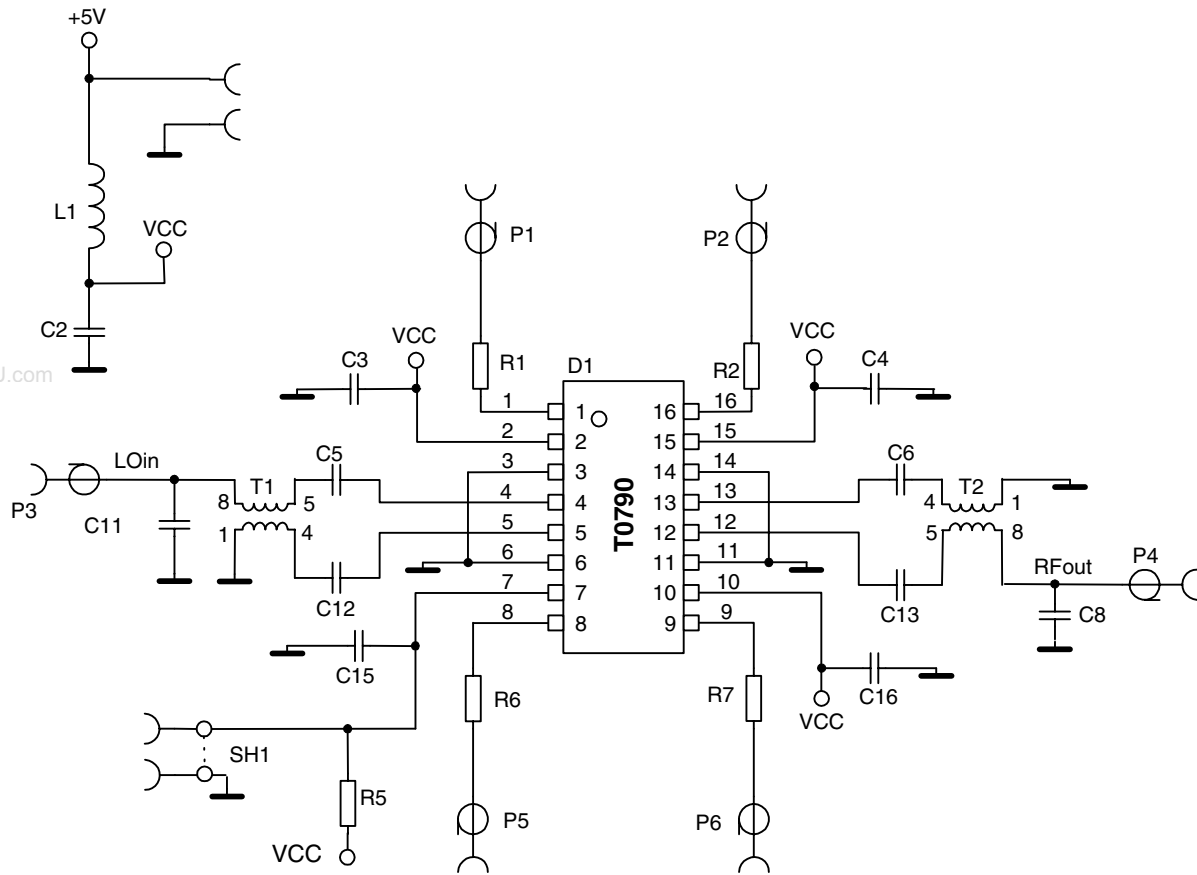


Figure 14. Amplitude Balance versus LO Frequency



**Figure 15. Application Schematic**



**Bill of Materials (700 MHz to 1000 MHz Evaluation Board)**

Component	Reference	Vendor	Part Number/ Remark	Value <sup>(1)</sup>	Size/Package
Direct 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			33 pF	0402
Capacitor	C4, C15			1 nF	0402
Electrolytic capacitor	C2			10 µF	Size A
Capacitor	C5, C6, C12, C13			10 pF	0402
Capacitor	C8, C11			n.c.	0402
RF transformer 700 MHz to 1300 MHz	T1, T2	Panasonic®	EHF-FD1618		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 (1700 MHz to 2500 MHz Evaluation Board)**

Component	Reference	Vendor	Part Number/ 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

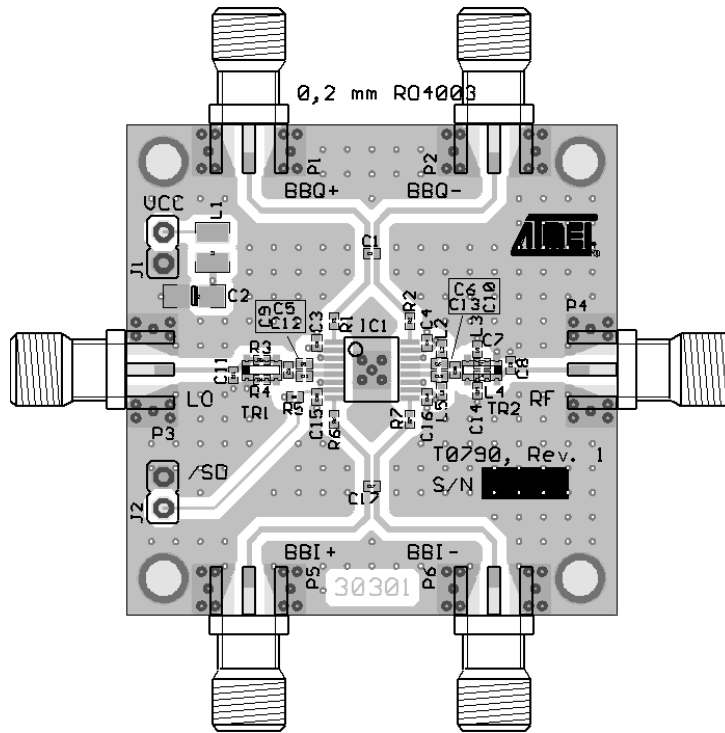
Note: 1. May vary due to printed board layout and material.

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

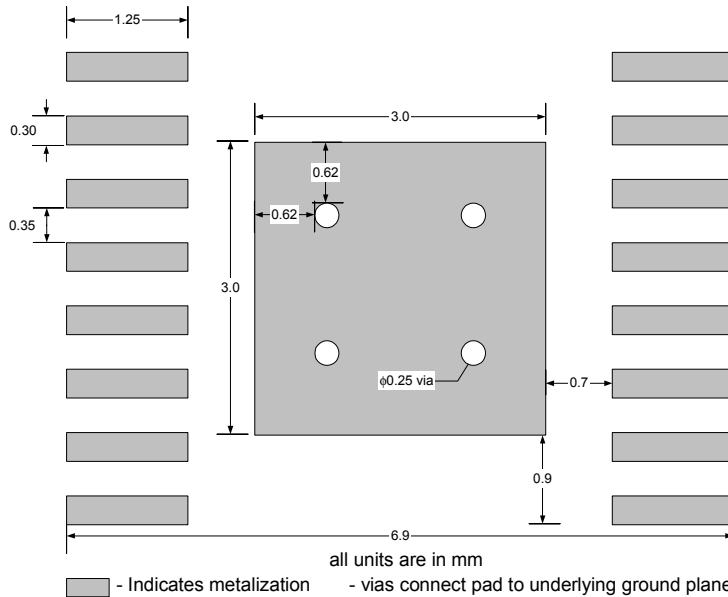
Component	Reference	Vendor	Part Number/ Remark	Value <sup>(1)</sup>	Size/Package
Direc Quadrature Modulator	D1	Atmel	T0790		SSOP16
Inductor	L1	Würth Elektronik	74476401	1 µH	1210
Resistor	R1, R2, R6, R7			180 Ω	0402
Resistor	R5			1 kΩ	0402
Capacitor	C3,C16			6.8 pF	0402
Capacitor	C4,C15			1 nF	0402
Electrolytic 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



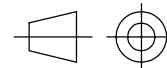
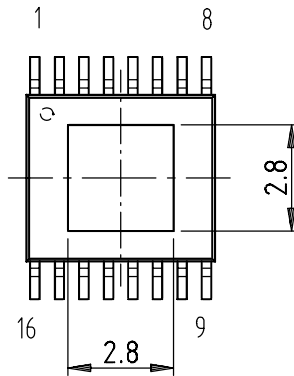
Note: Only ground signal traces are allowed directly under the package.  
 Heatslug must be soldered to GND.  
 Plugging of the ground vias under the heat slug is also recommended to avoid soldering problems.

### Ordering Information

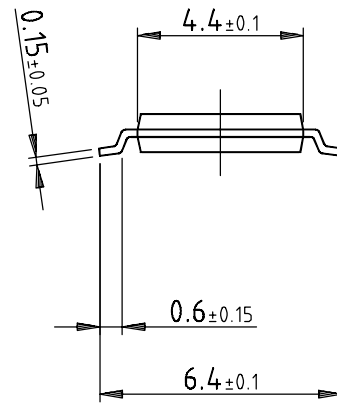
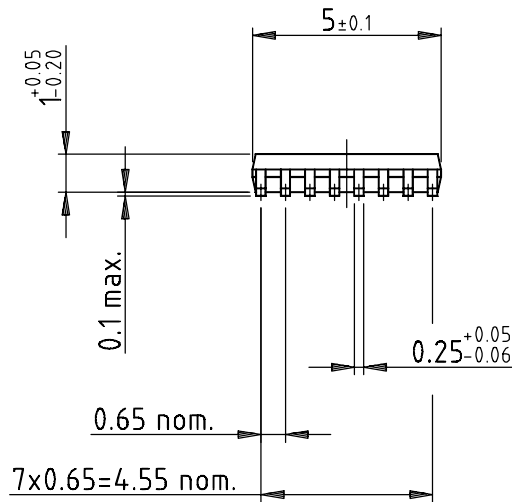
Extended Type Number	Package	Remarks
T0790-6C	SSOP16	-

### 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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Scottish Enterprise Technology Park  
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Fax: (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.  
Colorado Springs, CO 80906, USA  
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Fax: (33) 4-76-58-34-80

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