

## Features

- Supply Voltage 5 V (Typically)
- Very Low Power Consumption: 150 mW (Typically) for -1 dBm Output Level
- Very Good Sideband Suppression by Means of Duty Cycle Regeneration of the LO Input Signal
- Phase Control Loop for Precise 90° Phase Shifting
- Power-down Mode
- Low LO Input Level: -10 dBm (Typically)
- 50-Ω Single-ended LO and RF Port
- LO Frequency from 100 MHz to 1 GHz
- SO16 Package01/03

## Benefits

- No External Components Required for Phase Shifting
- Adjustment Free, Hence Saves Manufacturing Time
- Only Three External Components Necessary, this Results in Cost and Board Space Saving

Electrostatic sensitive device.

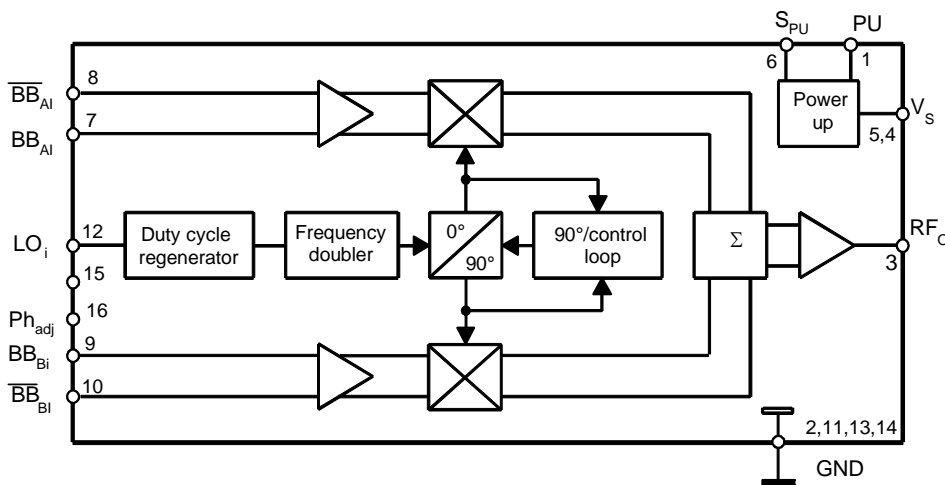
Observe precautions for handling.



## Description

The U2790B is a 1000-MHz quadrature modulator using Atmel's advanced UHF process. It features a frequency range from 100 MHz up to 1000 MHz, low current consumption, and single-ended RF and LO ports. Adjustment-free application makes the direct converter suitable for all digital radio systems up to 1000 MHz, e.g., GSM, ADC, JDC.

Figure 1. Block Diagram

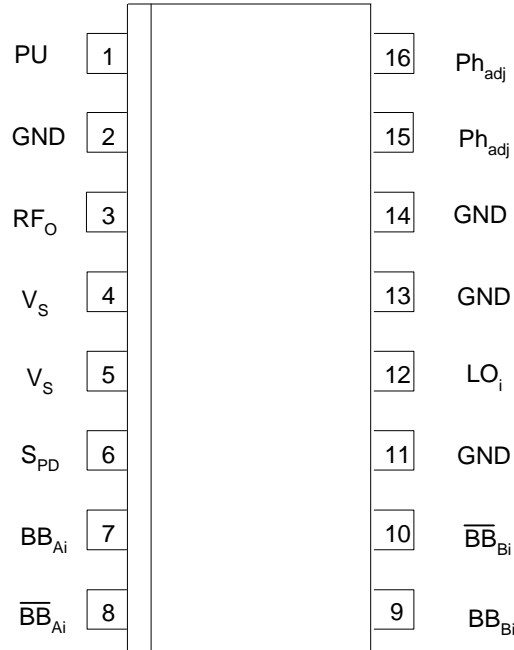


# 1000-MHz Quadrature Modulator

## U2790B

## Pin Configuration

Figure 2. Pinning SO16



## Pin Description

Pin	Symbol	Function
1	PU	Power-up input
2, 11, 13, 14	GND	Ground
3	RF <sub>O</sub>	RF output
4, 5	V <sub>S</sub>	Supply voltage
6	S <sub>PU</sub>	Settling time power-up
7	BB <sub>Ai</sub>	Baseband input A
8	$\overline{\text{BB}}_{\text{Ai}}$	Baseband input A inverse
9	BB <sub>Bi</sub>	Baseband input B
10	$\overline{\text{BB}}_{\text{Bi}}$	Baseband input B inverse
12	LO <sub>i</sub>	LO input
15, 16	Ph <sub>adj</sub>	Phase adjustment (not necessary for regular applications)

## Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	$V_S$	6	V
Input voltage	$V_i$	0 to $V_S$	V
Junction temperature	$T_j$	125	°C
Storage temperature range	$T_{Stg}$	-40 to +125	°C

## Operating Range

Parameters	Symbol	Value	Unit
Supply voltage range	$V_S$	4.5 to 5.5	V
Ambient temperature range	$T_{amb}$	-40 to +85	°C

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient SO16	$R_{thJA}$	110	K/W

## Electrical Characteristics

Test conditions (unless otherwise specified):  $V_S = 5\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$ , referred to test circuit, system impedance  $Z_O = 50\ \Omega$ ,  $f_{LO} = 900\text{ MHz}$ ,  $P_{LO} = -10\text{ dBm}$ ,  $V_{BBi} = 1\text{ V}_{pp}$  differential.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
1.1	Supply voltage range		4, 5	$V_S$	4.5		5.5	V	A
1.2	Supply current		4, 5	$I_S$	24	30	37	mA	A
<b>2</b>	<b>Baseband Inputs</b>								
2.1	Input-voltage range (differential)		7–8, 9–10	$V_{BBi}$		1000	1500	$\text{mV}_{pp}$	D
2.2	Input impedance (single ended)			$Z_{BBi}$		3.2		$\text{k}\Omega$	D
2.3	Input-frequency range <sup>(5)</sup>			$f_{BBi}$	0		250	MHz	D
2.4	Internal bias voltage			$V_{BBb}$	2.35	2.5	2.65	V	A
2.5	Temperature coefficient			$TC_{BB}$		0.1	<1	$\text{mV}/^\circ\text{C}$	D
<b>3</b>	<b>LO Input</b>								
3.1	Frequency range		12	$f_{LOi}$	50		1000	MHz	D
3.2	Input level <sup>(1)</sup>			$P_{LOi}$	- 12	- 10	- 5	dBm	D
3.3	Input impedance			$Z_{iLO}$		50		$\Omega$	D

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

- Notes:
- The required LO level is a function of the LO frequency.
  - In reference to an RF output level  $\leq -1\text{ dBm}$  and I/Q input level of  $400\text{ mV}_{pp}$  differential.
  - Sideband suppression is tested without connection at Pins 15 and 16. For higher requirements a potentiometer can be connected at these pins.
  - For  $T_{amb} = -30^\circ\text{C}$  to  $+85^\circ\text{C}$  and  $V_S = 4.5$  to  $5.5\text{ V}$ .
  - By low impedance signal source.

## Electrical Characteristics (Continued)

Test conditions (unless otherwise specified):  $V_S = 5\text{ V}$ ,  $T_{\text{amb}} = 25^\circ\text{C}$ , referred to test circuit, system impedance  $Z_O = 50\ \Omega$ ,  $f_{\text{LO}} = 900\text{ MHz}$ ,  $P_{\text{LO}} = -10\text{ dBm}$ ,  $V_{\text{BBi}} = 1\text{ V}_{\text{pp}}$  differential.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
3.4	Voltage standing wave ratio			$\text{VSWR}_{\text{LO}}$		1.4	2		D
3.5	Duty cycle range			$\text{DCR}_{\text{LO}}$	0.4		0.6		D
<b>4</b>	<b>RF Output</b>								
4.1	Output level		3	$P_{\text{RFo}}$	-5	-1	+2	dBm	B
4.2	LO suppression <sup>(2)</sup>	$f_{\text{LO}} = 900\text{ MHz}$ $f_{\text{LO}} = 150\text{ MHz}$		$\text{LO}_{\text{RFo}}$	30 32	35 35		dB	B
4.3	Sideband suppression <sup>(2,3)</sup>	$f_{\text{LO}} = 900\text{ MHz}$ $f_{\text{LO}} = 150\text{ MHz}$		$\text{SBS}_{\text{RFo}}$	35 30	40 35		dB	B
4.4	Phase error <sup>(4)</sup>			$P_e$		<1		deg.	D
4.5	Amplitude error			$A_e$		< ±0.25		dB	D
4.6	Noise floor	$V_{\text{BBi}} = 2\text{ V}$ , $\overline{V_{\text{BBi}}} = 3\text{ V}$ $V_{\text{BBi}} = \overline{V_{\text{BBi}}} = 2.5\text{ V}$		$N_{\text{FL}}$		-132 -144		dBm/Hz	D
4.7	VSWR			$\text{VSWR}_{\text{RF}}$		1.6	2		D
4.8	3rd-order baseband harmonic suppression			$S_{\text{BBH}}$	35	45		dB	D
4.9	RF harmonic suppression			$S_{\text{RFH}}$		35		dB	D
<b>5</b>	<b>Power-up Mode</b>								
5.1	Supply current	$V_{\text{PU}} \leq 0.5\text{ V}$ , $V_{\text{PU}} = 1\text{ V}$	4, 5	$I_{\text{PU}}$		10	1	$\mu\text{A}$	D
5.2	Settling time	$C_{\text{SPU}} = 100\text{ pF}$ , $C_{\text{LO}} = 100\text{ pF}$ $C_{\text{RFo}} = 1\text{ nF}$	6 to 3	$t_{\text{SPU}}$		10		$\mu\text{s}$	D
<b>6</b>	<b>Switching Voltage</b>								
6.1	Power-on		1	$V_{\text{PUon}}$	4			V	D
6.2	Power-up		1	$V_{\text{PUdown}}$			1	V	D

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

- Notes:
1. The required LO level is a function of the LO frequency.
  2. In reference to an RF output level  $\leq -1\text{ dBm}$  and I/Q input level of  $400\text{ mV}_{\text{pp}}$  differential.
  3. Sideband suppression is tested without connection at Pins 15 and 16. For higher requirements a potentiometer can be connected at these pins.
  4. For  $T_{\text{amb}} = -30^\circ\text{C}$  to  $+85^\circ\text{C}$  and  $V_S = 4.5$  to  $5.5\text{ V}$ .
  5. By low impedance signal source.

Diagrams

Figure 3. Typical Single Sideband Output Spectrum at  $V_S = 4.5\text{ V}$  and  $V_S = 5.5\text{ V}$ ,  $f_{LO} = 900\text{ MHz}$ ,  $P_{LO} = -10\text{ dBm}$ ,  $V_{BBI} = 1\text{ V}_{PP}$  (differential)  $T_{amb} = 25^\circ\text{C}$

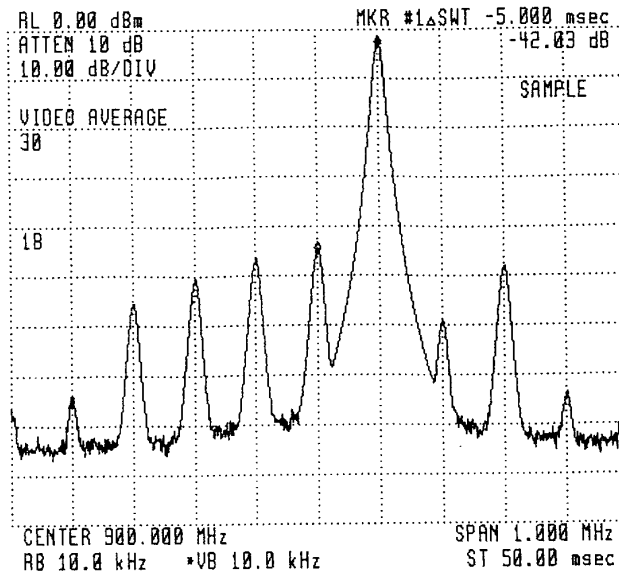


Figure 4. Typical GMSK Output Spectrum

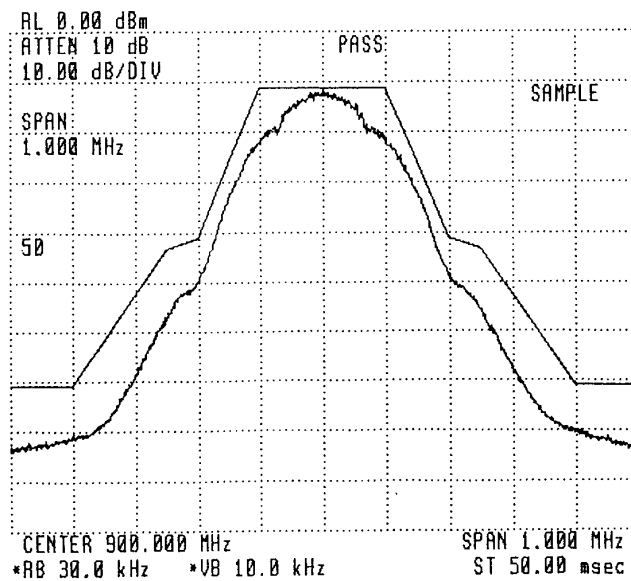


Figure 5. Demo Board Layout

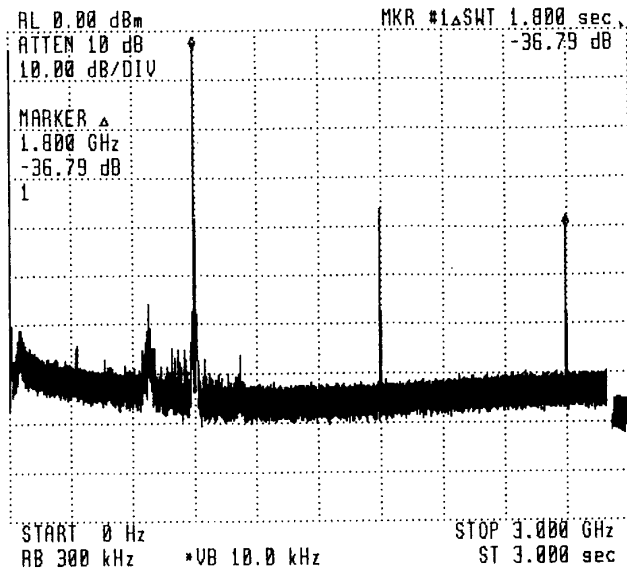


Figure 6. OIP3 versus  $T_{amb}$ , LO = 150 MHz, Level -20 dBm

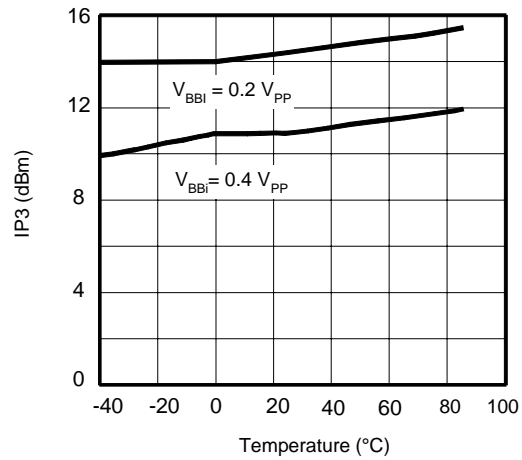


Figure 7. OIP3 versus  $T_{amb}$ , LO = 900 MHz, Level - 10 dBm

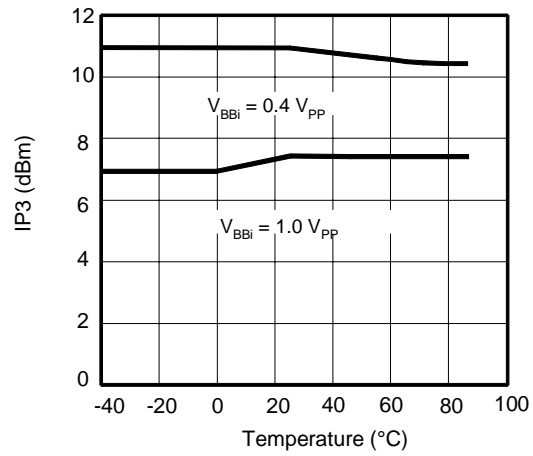


Figure 8. Output Power versus  $T_{amb}$

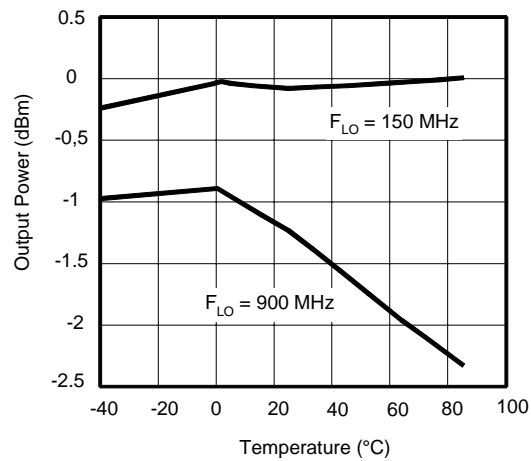
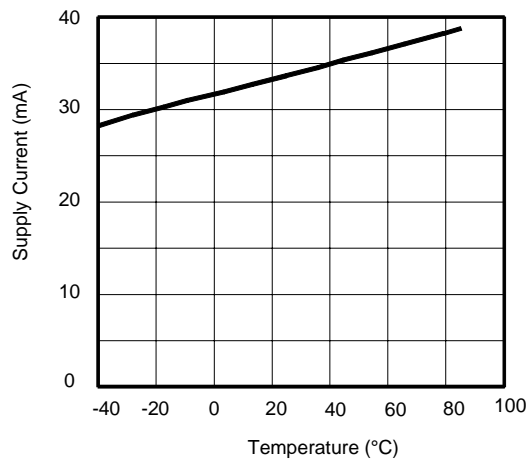
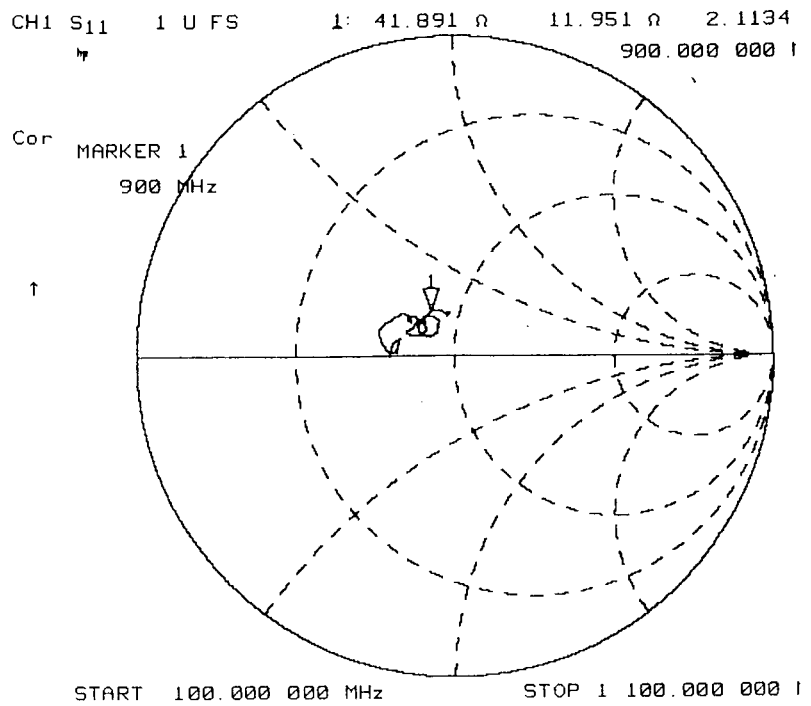


Figure 9. Supply Current versus  $T_{amb}$



**Figure 10.** Typical S11 Frequency Response of the RF Output



**Figure 11.** Typical VSWR Frequency Response of the RF Output

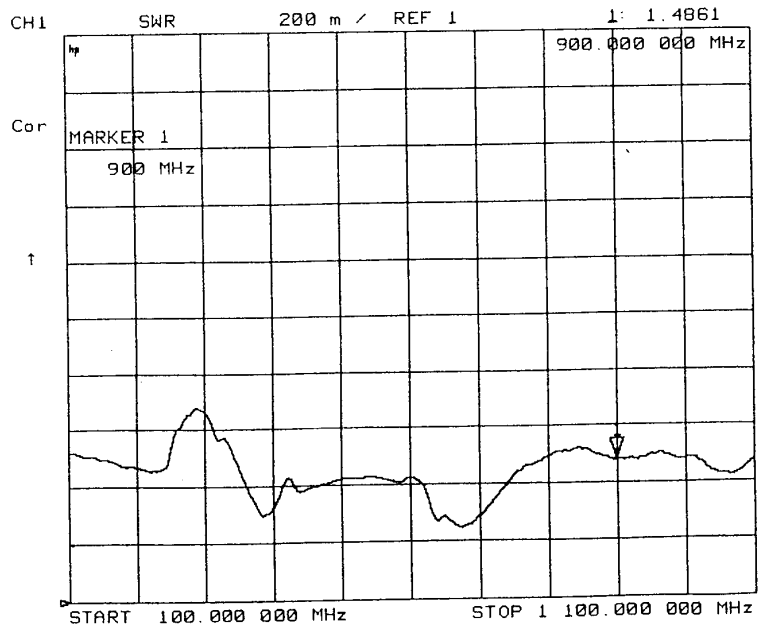




Figure 12. Typical S11 Frequency Response of the LO Input

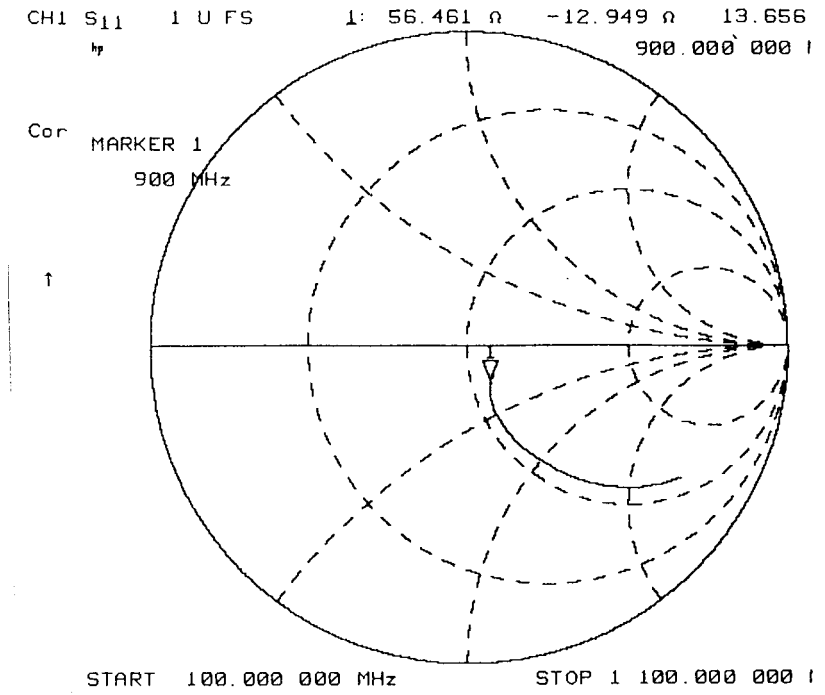
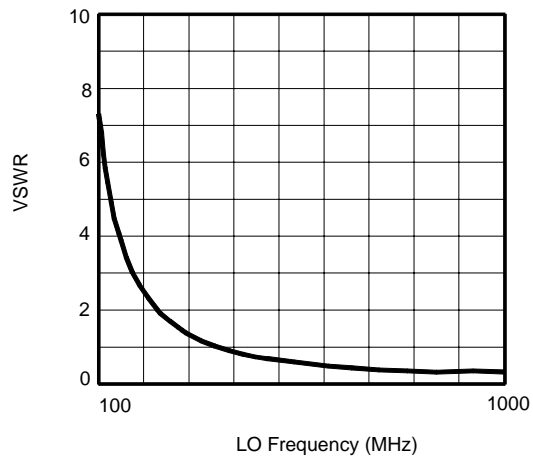
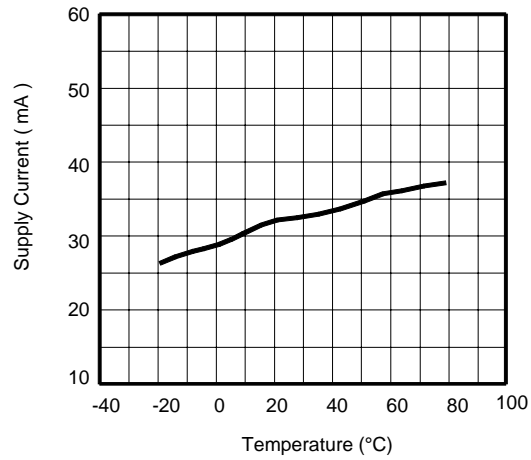


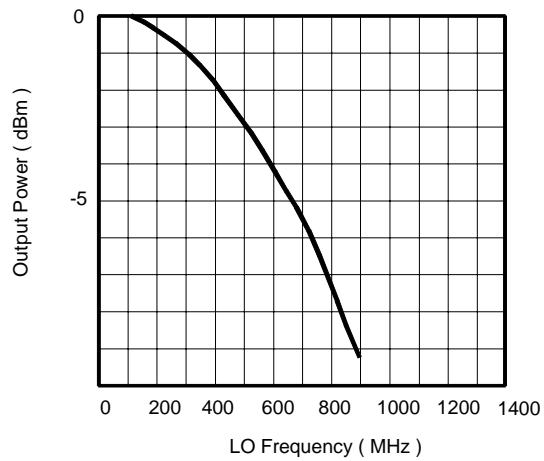
Figure 13. Typical VSWR Frequency Response of the LO input



**Figure 14.** Typical Supply Current versus Temperature at  $V_S = 5\text{ V}$



**Figure 15.** Typical Output Power versus LO-Frequency at  $T_{amb} = 25^\circ\text{C}$ ,  $V_{BBI} = 230\text{ mV}_{PP}$  (differential)



**Figure 16.** Typical required  $V_{BBI}$  Input Signal (differential) versus LO Frequency for  $P_O = 0\text{ dBm}$  and  $P_O = -2\text{ dBm}$

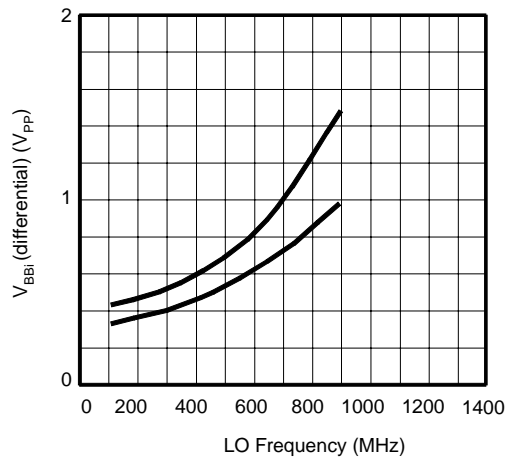


Figure 17. Typical useful LO Power Range versus LO Frequency at  $T_{amb} = 25^{\circ}\text{C}$

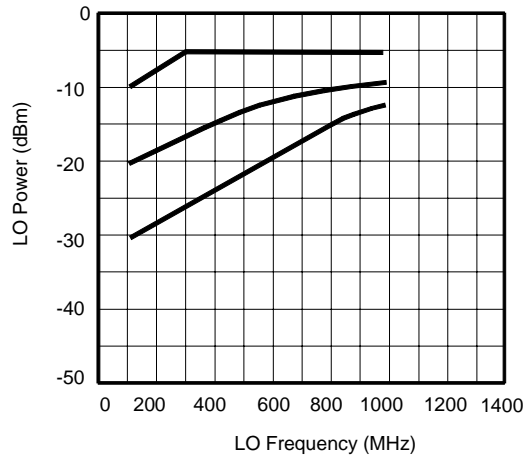


Figure 18. Application Circuit

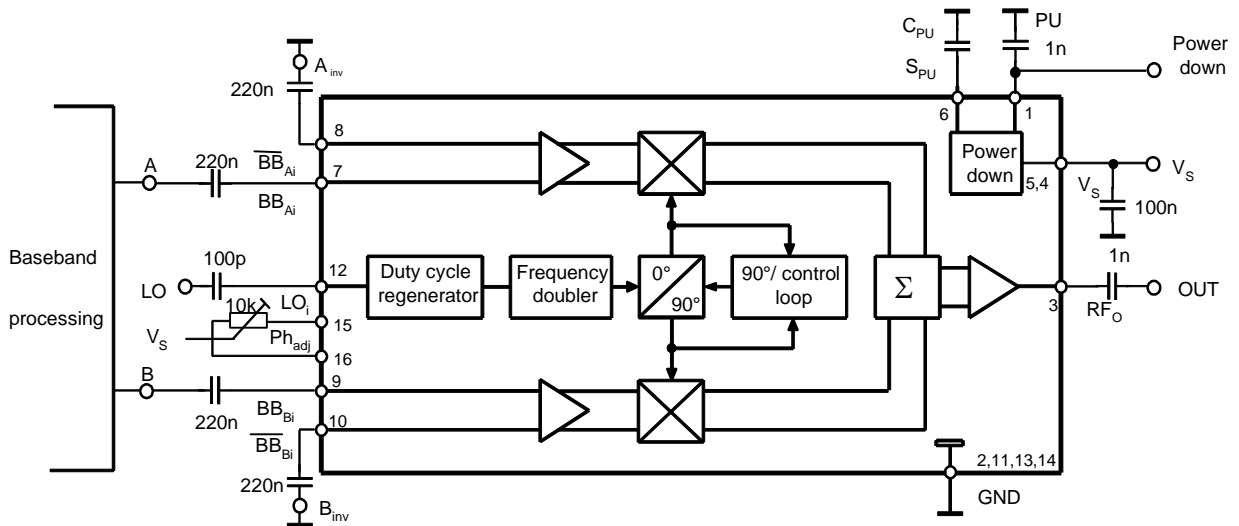
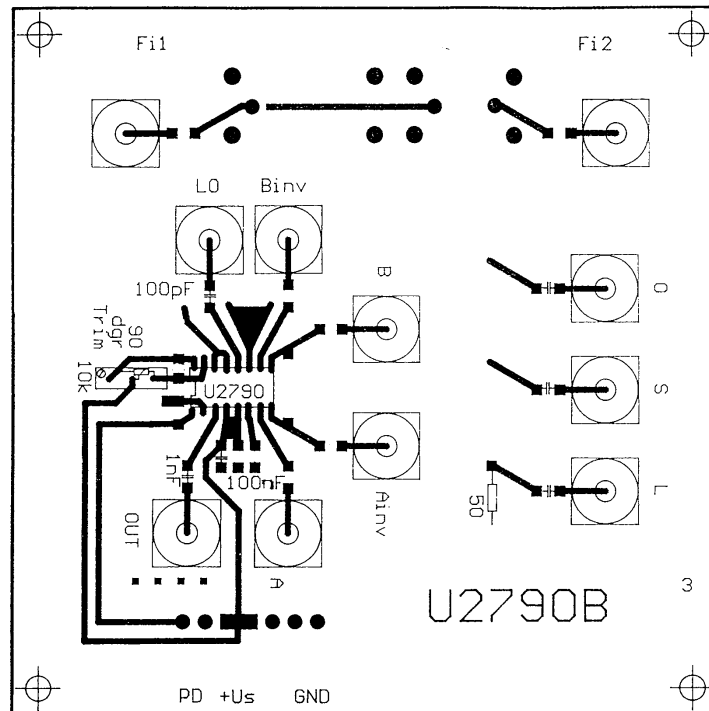


Figure 19. Demo Board Layout



## Application Notes

### Noise Floor and Settling Time

In order to reduce noise on the power-up control input and improve the wide-off noise floor of the 900-MHz RF output signal, capacitor  $C_{PU}$  should be connected from Pin 6 to ground in the shortest possible way.

The settling time has to be considered for the system under design. For GSM applications, a value of  $C_{PU} = 1$  nF defines a settling time,  $t_{sPU}$ , equal or less than 3 ms. This capacitance does not have any influence on the noise floor within the relevant GSM mask. For mobile applications the mask requirements can be achieved very easily without  $C_{PU}$ .

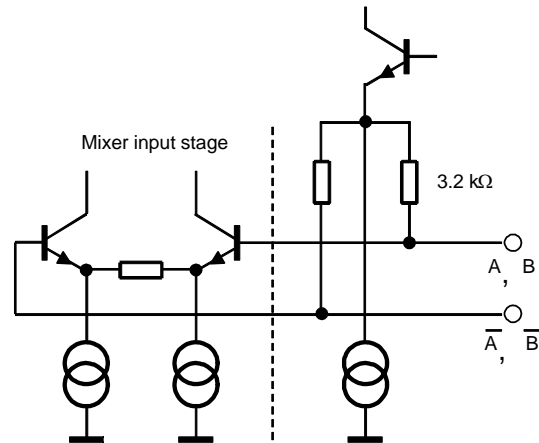
A significant improvement of the wide-off noise floor is obtainable with  $C_{PU}$  greater than 100 nF. Such values are recommended for applications where the settling time is not critical such as in base stations. Coupling capacitors for  $L_{O_i}$  and  $R_{F_o}$  also have a certain impact on the settling time. The values used for the measurements are  $C_{L_{O_i}} = 100$  pF and  $C_{R_{F_o}} = 1$  nF.

### Baseband Coupling

The U2790B-FP (SO16) has an integrated biasing network which allows AC coupling of the baseband signal at a low count of external components. The bias voltage is  $2.5 \text{ V} \pm 0.15 \text{ V}$ .

Figure 19 shows the baseband input circuitry with a resistance of 3.2 kΩ for each asymmetric input. The internal DC offset between A and A, and B and B is typically  $< \pm 1$  mV with a maximum of  $\pm 3$  mV. DC coupling is also possible with an external DC voltage of  $2.5 \pm 0.15 \text{ V}$ .

Figure 20. Baseband Input Circuitry



RF Output Circuitry LO Input Circuitry

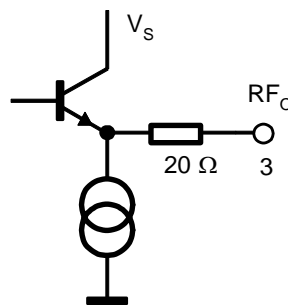
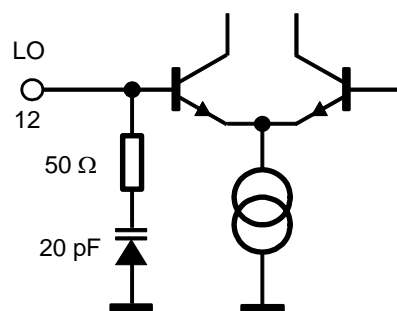


Figure 21. LO Input Circuitry

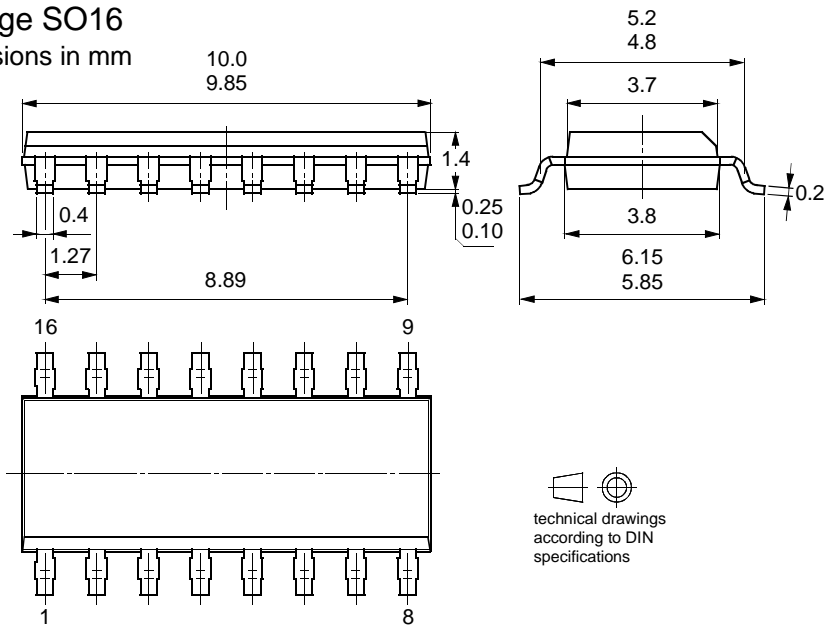


## Ordering Information

Extended Type Number	Package	Remarks
U2790B-MFP	SO16	Tube
U2790B-MFPG3	SO16	Taped and reeled

## Package Information

Package SO16  
Dimensions in mm





## Atmel Headquarters

### *Corporate Headquarters*

2325 Orchard Parkway  
San Jose, CA 95131  
TEL 1(408) 441-0311  
FAX 1(408) 487-2600

### *Europe*

Atmel Sarl  
Route des Arsenaux 41  
Case Postale 80  
CH-1705 Fribourg  
Switzerland  
TEL (41) 26-426-5555  
FAX (41) 26-426-5500

### *Asia*

Room 1219  
Chinachem Golden Plaza  
77 Mody Road Tsimhatsui  
East Kowloon  
Hong Kong  
TEL (852) 2721-9778  
FAX (852) 2722-1369

### *Japan*

9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
TEL (81) 3-3523-3551  
FAX (81) 3-3523-7581

## Atmel Operations

### *Memory*

2325 Orchard Parkway  
San Jose, CA 95131  
TEL 1(408) 441-0311  
FAX 1(408) 436-4314

### *Microcontrollers*

2325 Orchard Parkway  
San Jose, CA 95131  
TEL 1(408) 441-0311  
FAX 1(408) 436-4314

La Chantrerie  
BP 70602  
44306 Nantes Cedex 3, France  
TEL (33) 2-40-18-18-18  
FAX (33) 2-40-18-19-60

### *ASIC/ASSP/Smart Cards*

Zone Industrielle  
13106 Rousset Cedex, France  
TEL (33) 4-42-53-60-00  
FAX (33) 4-42-53-60-01

1150 East Cheyenne Mtn. Blvd.  
Colorado Springs, CO 80906  
TEL 1(719) 576-3300  
FAX 1(719) 540-1759

Scottish Enterprise Technology Park  
Maxwell Building  
East Kilbride G75 0QR, Scotland  
TEL (44) 1355-803-000  
FAX (44) 1355-242-743

### *RF/Automotive*

Theresienstrasse 2  
Postfach 3535  
74025 Heilbronn, Germany  
TEL (49) 71-31-67-0  
FAX (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.  
Colorado Springs, CO 80906  
TEL 1(719) 576-3300  
FAX 1(719) 540-1759

### *Biometrics/Imaging/Hi-Rel MPU/ High Speed Converters/RF Datacom*

Avenue de Rochepleine  
BP 123  
38521 Saint-Egreve Cedex, France  
TEL (33) 4-76-58-30-00  
FAX (33) 4-76-58-34-80

---

### *e-mail*

literature@atmel.com

### *Web Site*

<http://www.atmel.com>

### © Atmel Corporation 2003.

Atmel Corporation makes no warranty for the use of its products, other than those expressly contained in the Company's standard warranty which is detailed in Atmel's Terms and Conditions located on the Company's web site. The Company assumes no responsibility for any errors which may appear in this document, reserves the right to change devices or specifications detailed herein at any time without notice, and does not make any commitment to update the information contained herein. No licenses to patents or other intellectual property of Atmel are granted by the Company in connection with the sale of Atmel products, expressly or by implication. Atmel's products are not authorized for use as critical components in life support devices or systems.

Atmel® is the registered trademark of Atmel.

Other terms and product names may be the trademarks of others.



Printed on recycled paper.