

## 1000-MHz Quadrature Modulator

### Description

The U2790B is a 1000-MHz quadrature modulator using Atmel Wireless & Microcontrollers' 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.

Electrostatic sensitive device.

Observe precautions for handling.



### Features

- Supply voltage 5 V (typical)
- Very low power consumption: 150 mW (typical) for -1dBm 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: -10dBm (typical)
- 50-Ω single-ended LO and RF port
- LO frequency from 100 MHz to 1 GHz
- SO16 package

### Benefits

- No external components required for phase shifting
- Adjustment free, hence saves time
- Only three external components necessary, this results in cost and board space saving

### Block Diagram

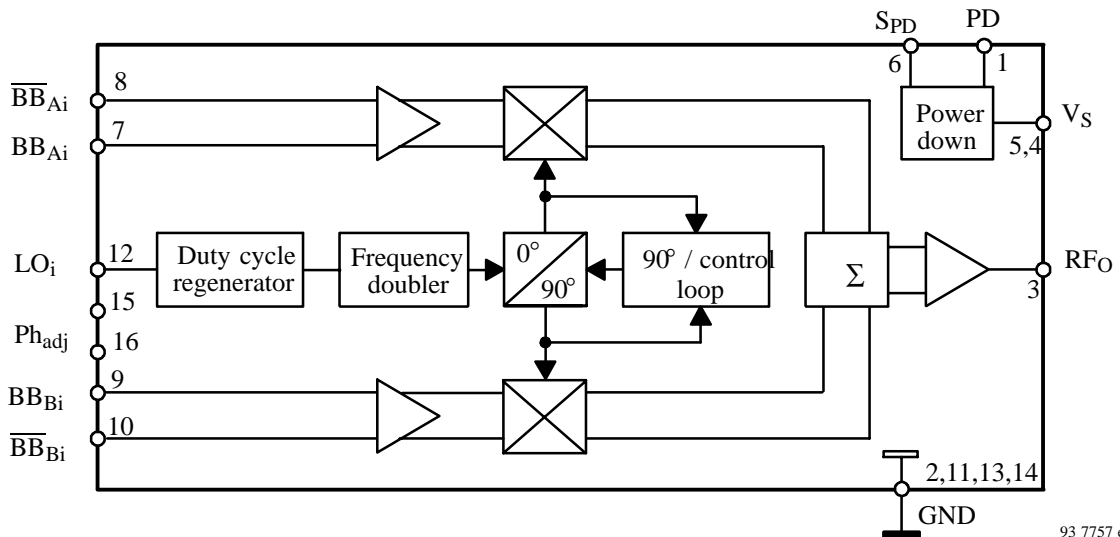


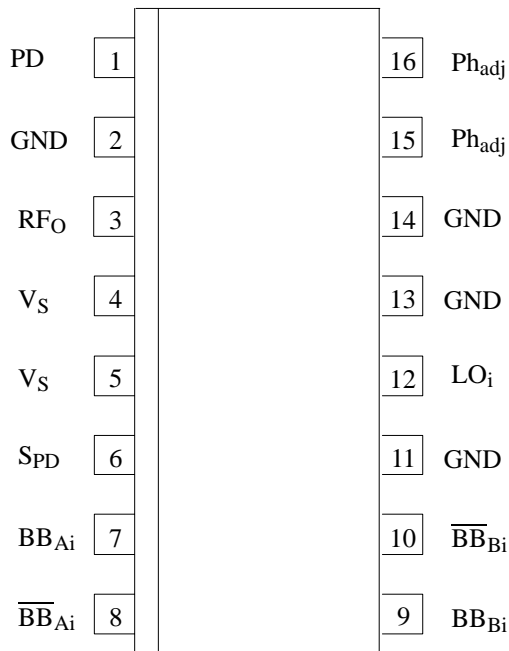
Figure 1. Block diagram

### Ordering Information

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

## Pin Description

SO16



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Pin	Symbol	Function
1	PD	Power-down port
2, 11, 13, 14	GND	Ground
3	RF <sub>o</sub>	RF output
4, 5	V <sub>S</sub>	Supply voltage
6	S <sub>PD</sub>	Settling time power down
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 Pins 4 and 5	V <sub>S</sub>	6	V
Input voltage Pins 7, 8, 9, 10 and 12	V <sub>i</sub>	0 to V <sub>S</sub>	V
Junction temperature	T <sub>j</sub>	125	°C
Storage-temperature range	T <sub>stg</sub>	-40 to +125	°C

## Operating Range

Parameters	Symbol	Value	Unit
Supply-voltage range Pins 4 and 5	V <sub>S</sub>	4.5 to 5.5	V
Ambient temperature range	T <sub>amb</sub>	-40 to +85	°C

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient SO16	R <sub>thJA</sub>	110	K/W

## Electrical Characteristics

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

Parameters	Test Conditions / Pin	Symbol	Min.	Typ.	Max.	Unit
Supply-voltage range	Pins 4 and 5	$V_S$	4.5		5.5	V
Supply current	Pins 4 and 5	$I_S$		30		mA
<b>Baseband inputs</b>		Pins 7-8, 9-10				
Input-voltage range (diff.)		$V_{\text{BBi}}$		1000	1500	mV <sub>pp</sub>
Input impedance (single ended)		$Z_{\text{BBi}}$		3.2		k $\Omega$
Input-frequency range <sup>5</sup>		$f_{\text{BBi}}$	0		250	MHz
Internal bias voltage		$V_{\text{BBb}}$	2.35	2.5	2.65	V
Temperature coefficient		$\text{TC}_{\text{BB}}$		0.1	<1	mV/°C
<b>LO input</b>		Pin 12				
Frequency range		$f_{\text{LOi}}$	50		1000	MHz
Input level <sup>1</sup>		$P_{\text{LOi}}$	-12	-10	-5	dBm
Input impedance		$Z_{\text{iLO}}$		50		$\Omega$
Voltage standing wave ratio		$\text{VSWR}_{\text{LO}}$		1.4	2	-
Duty-cycle range		$\text{DCR}_{\text{LO}}$	0.4		0.6	-
<b>RF output</b>		Pin 3				
Output level		$P_{\text{RFo}}$	-5	-1		dBm
LO suppression <sup>2</sup>	$f_{\text{LO}} = 900\text{ MHz}$ $f_{\text{LO}} = 150\text{ MHz}$	$\text{LOR}_{\text{Fo}}$	30 32	35 35		dB
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
Phase error <sup>4</sup>		$P_e$		< 1		deg.
Amplitude error		$A_e$		< ±0.2 5		dB
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
VSWR		$\text{VSWR}_{\text{RF}}$		1.6	2	
3rd-order baseband harmonic suppression		$\text{S}_{\text{BBH}}$	35	45		dB
RF harmonic suppression		$\text{S}_{\text{RFH}}$		35		dB
<b>Power-down mode</b>						
Supply current	$V_{\text{PD}} \leq 0.5\text{ V}$ Pins 4, 5 $V_{\text{PD}} = 1\text{ V}$	$I_{\text{PD}}$			1	$\mu\text{A}$
Settling time	$C_{\text{SPD}} = 100\text{ pF}$ , $C_{\text{LO}} = 100\text{ pF}$ $C_{\text{RFo}} = 1\text{ nF}$ Pin 6 to 3	$t_{\text{sPD}}$		10		$\mu\text{s}$
<b>Switching voltage</b>		Pin 1				
Power on		$V_{\text{PDon}}$	4			V
Power down		$V_{\text{PDdown}}$			1	V

Note: 1 The required LO level is a function of the LO frequency.

Note: 2 In reference to an RF output level  $\leq -1\text{ dBm}$  and I/Q input level of  $400\text{ mV}_{\text{pp}}$  diff

Note: 3 Sideband suppression is tested without connection at Pins 15 and 16.

For higher requirements a potentiometer can be connected at these pins.

Note: 4 For  $T_{\text{amb}} = -30$  to  $+85^\circ\text{C}$  and  $V_S = 4.5$  to  $5.5\text{ V}$

Note: 5 By low-impedance signal source

**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)  $T_{amb} = 25^\circ\text{C}$**

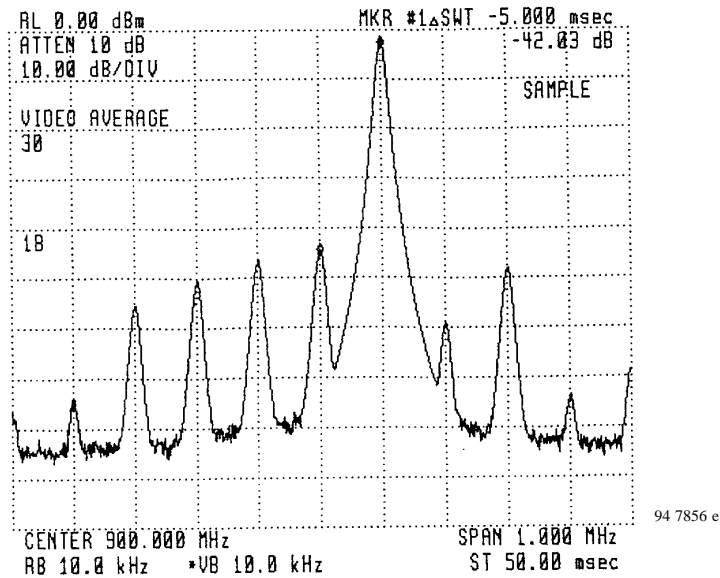


Figure 2.

**Typical GMSK Output Spectrum**

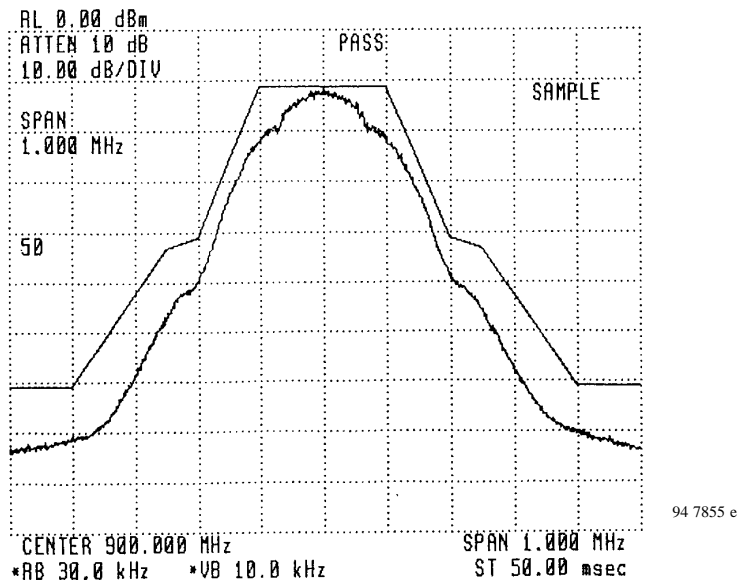


Figure 3.

**Typical RF-Harmonic Output Spectrum**

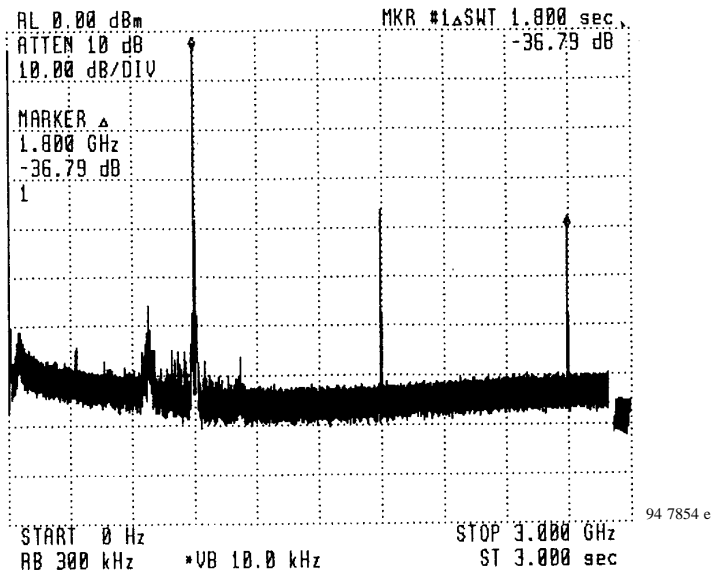
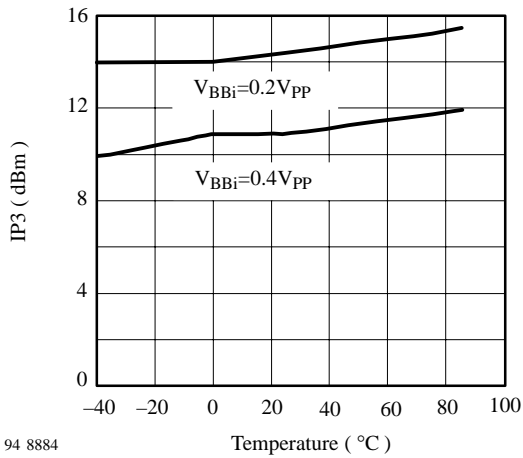
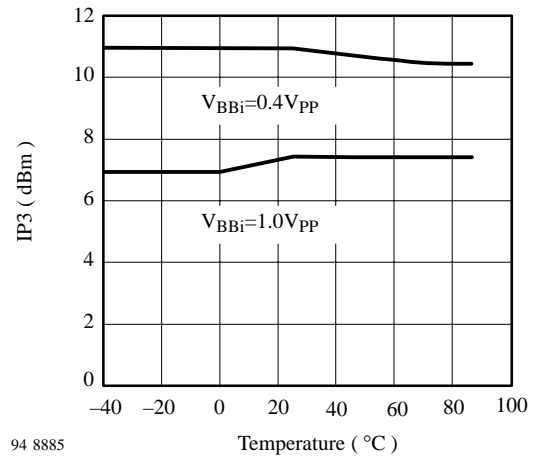


Figure 4.



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Figure 5. OIP3 vs. T<sub>amb</sub>, LO = 150 MHz, level – 20 dBm



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Figure 6. OIP3 vs. T<sub>amb</sub>, LO = 900 MHz, level – 10 dBm

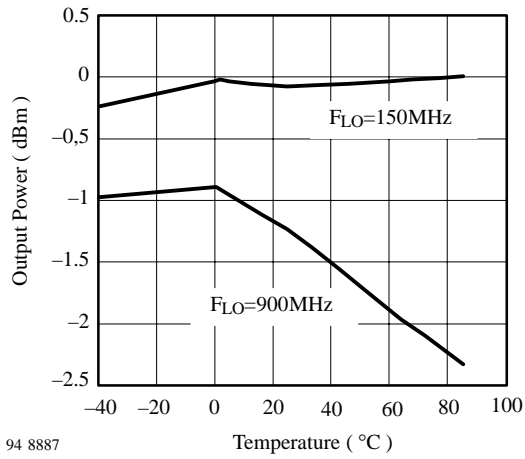


Figure 7. Output power vs.  $T_{amb}$

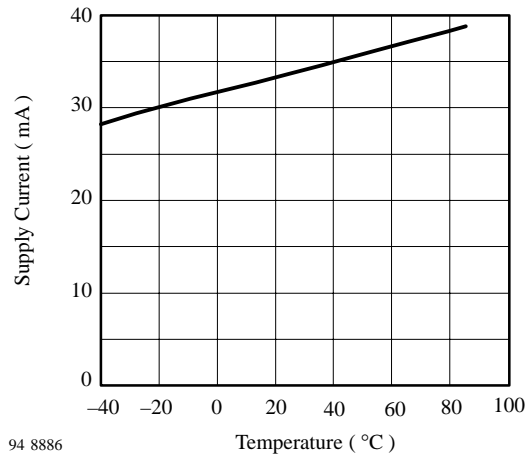


Figure 8. Supply current vs.  $T_{amb}$

## Typical S11 Frequency Response of the RF Output

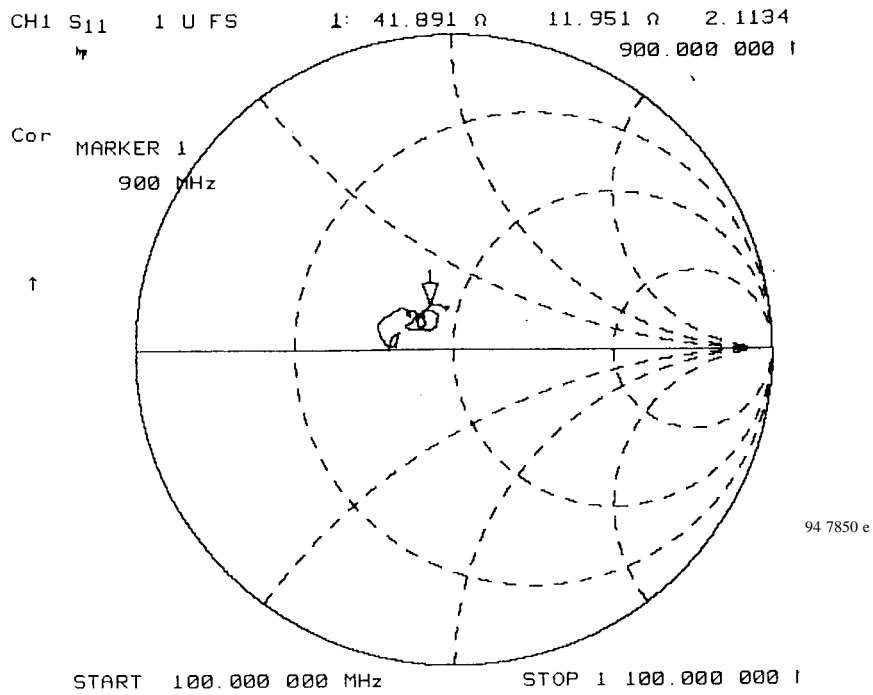


Figure 9.

**Typical VSWR Frequency Response of the RF Output**

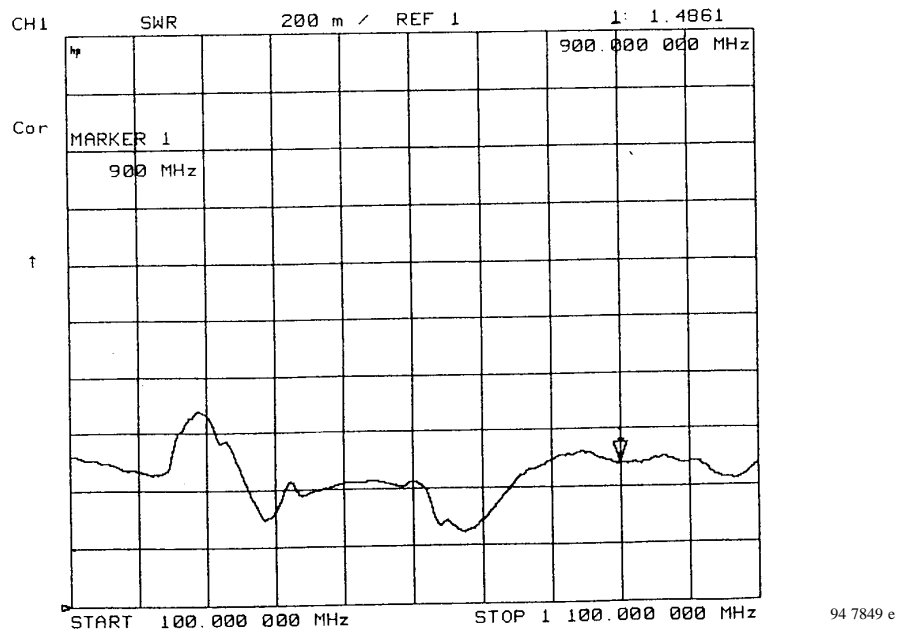


Figure 10.

**Typical S11 Frequency Response of the LO Input**

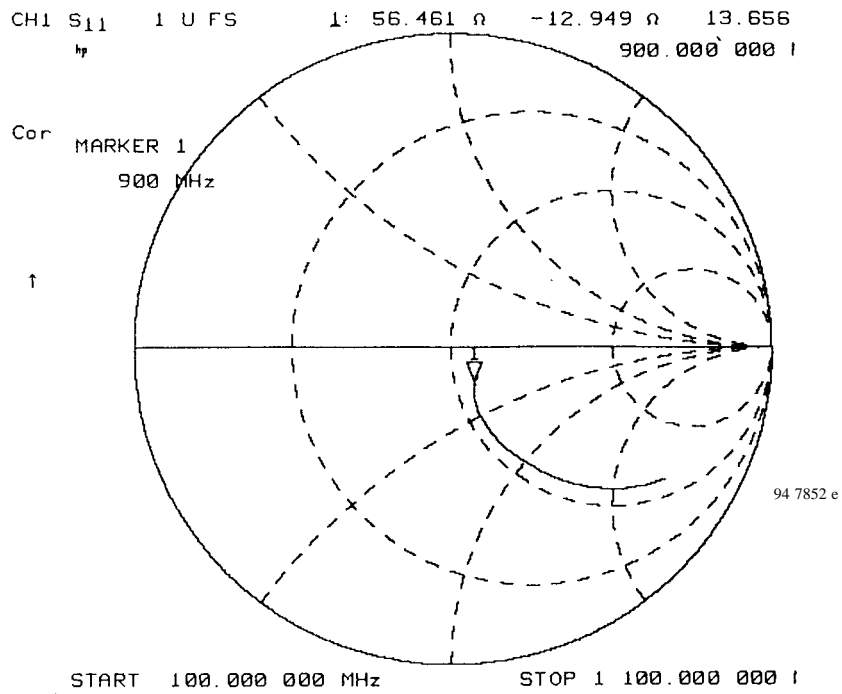


Figure 11.

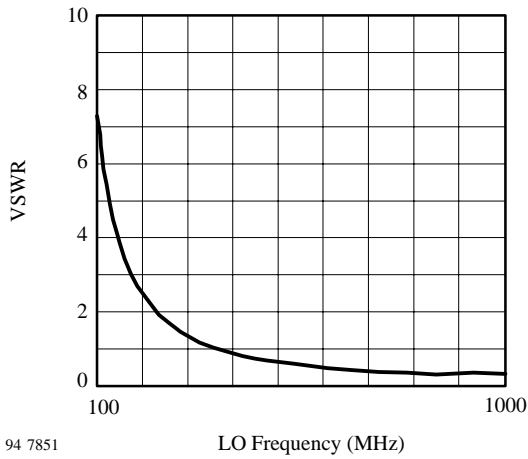


Figure 12. Typical VSWR frequency response of the LO input

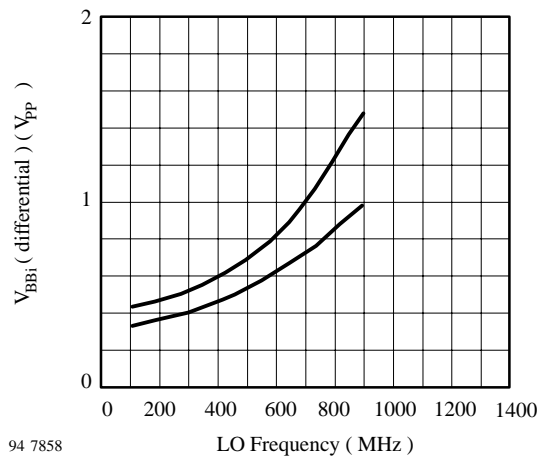


Figure 15. Typical required  $V_{BBi}$  input signal (differential) vs. LO frequency for  $P_O = 0$  dBm and  $P_O = -2$  dBm

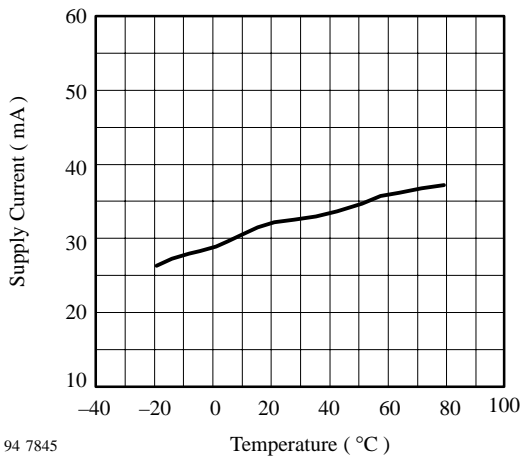


Figure 13. Typical supply current vs. temperature at  $V_S = 5$  V

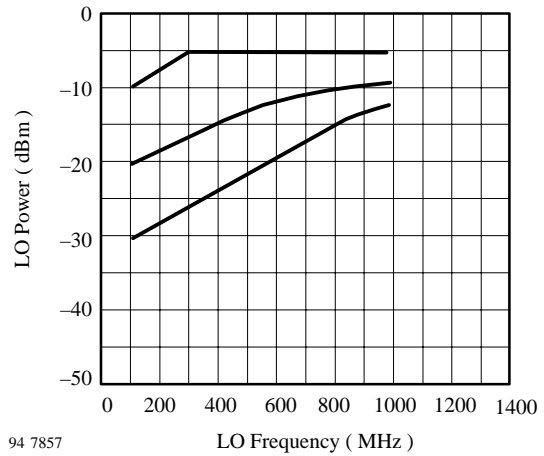


Figure 16. Typical useful LO power range vs. LO frequency at  $T_{amb} = 25$  °C

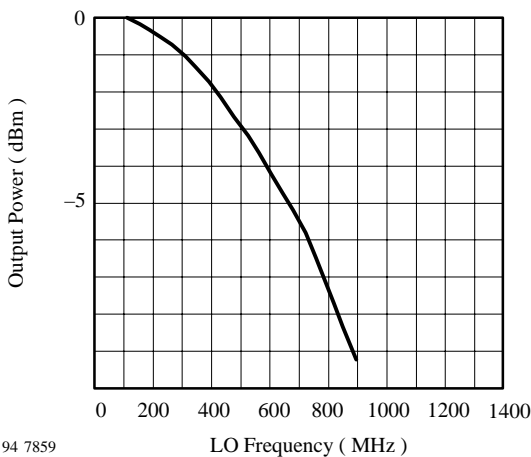


Figure 14. Typical output power vs. LO-frequency at  $T_{amb} = 25$  °C,  $V_{BBi} = 230$  mV<sub>PP</sub> (differential)



**Application Circuit**

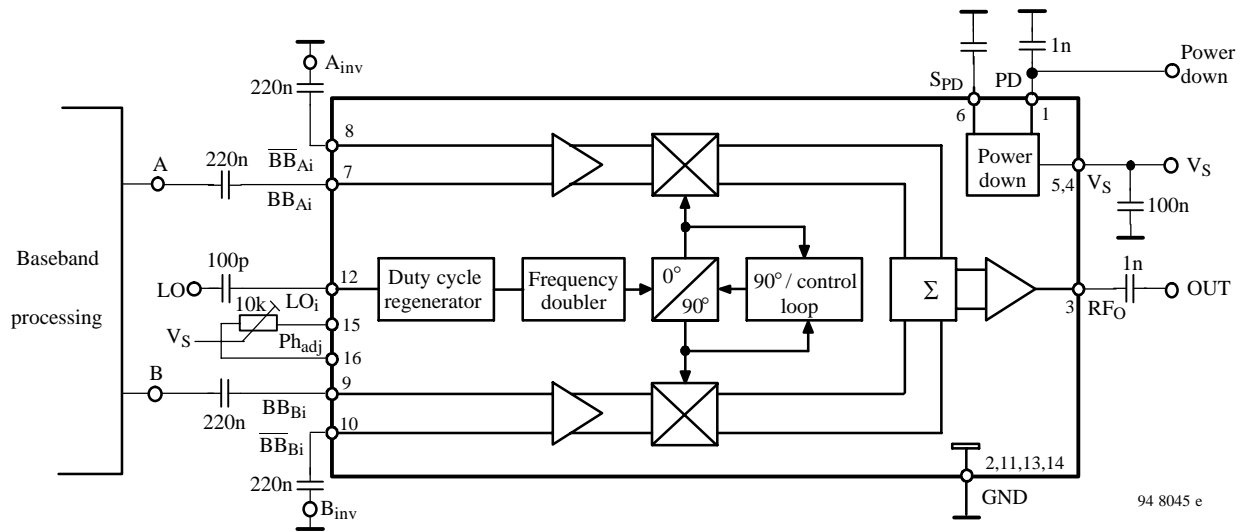


Figure 17.

**PCB Basic Layout**

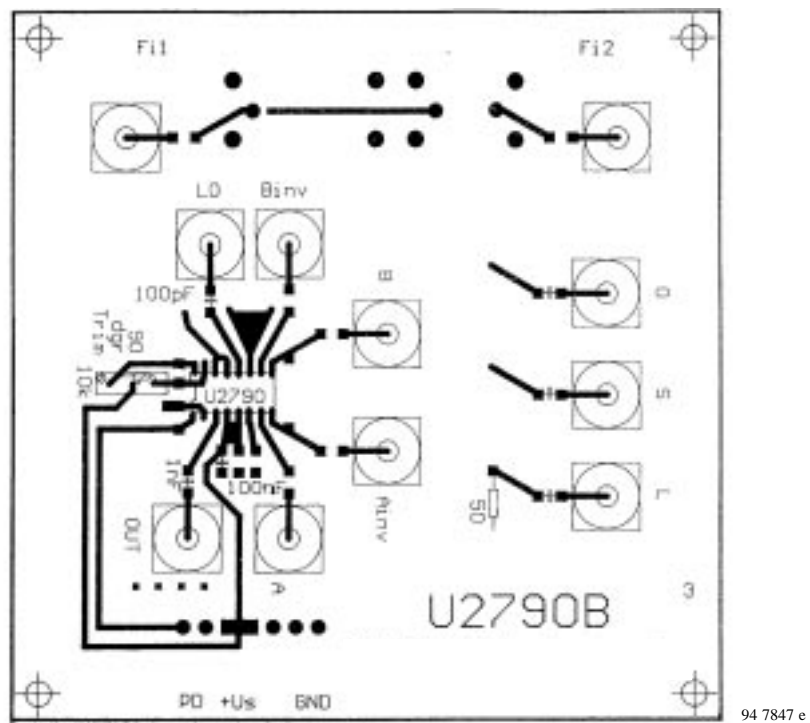


Figure 18. U2790B-FP (SO 16)

## Application Notes

### Noise Floor and Settling Time

In order to reduce noise on the power-down control input and improve the wide-off noise floor of the 900-MHz RF output signal, capacitor  $C_{PD}$  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  $C_{PD} = 1 \text{ nF}$  defines a settling time,  $t_{sPD}$ , equal or less than  $3 \mu\text{s}$ . 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  $C_{PD}$ .

A significant improvement of the wide-off noise floor is obtainable with  $C_{PD}$  greater than  $100 \text{ nF}$ . Such values are recommended for applications where the settling time is

not critical such as in base stations. Coupling capacitors for  $LO_i$  and  $RF_o$  also have a certain impact on the settling time. The values used for the measurements are  $C_{LO_i} = 100 \text{ pF}$  and  $C_{RF_o} = 1 \text{ nF}$ .

### Baseband Coupling

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  $3.2 \text{ k}\Omega$  for each asymmetric input. The internal DC offset between A and  $\bar{A}$ , and B and  $\bar{B}$  is typically  $< \pm 1 \text{ mV}$  with a maximum of  $\pm 3 \text{ mV}$ . DC coupling is also possible with an external DC voltage of  $2.5 \pm 0.15 \text{ V}$ .

### Circuitries

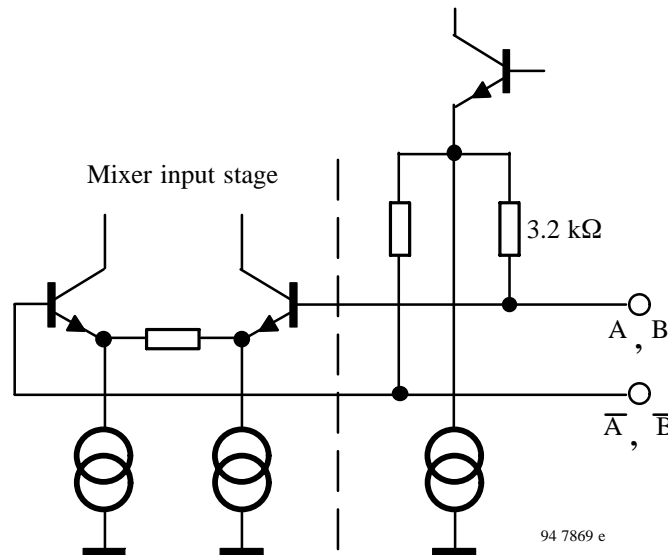


Figure 19. Baseband input circuitry

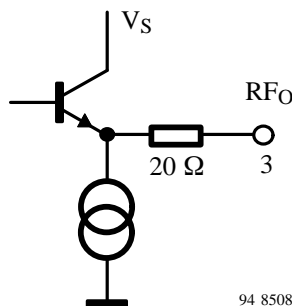


Figure 20. RF output circuitry

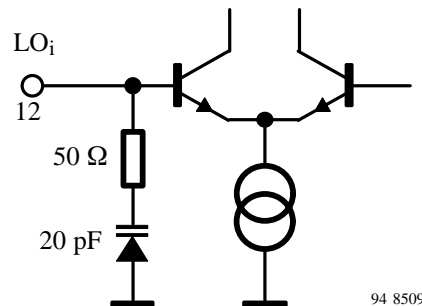
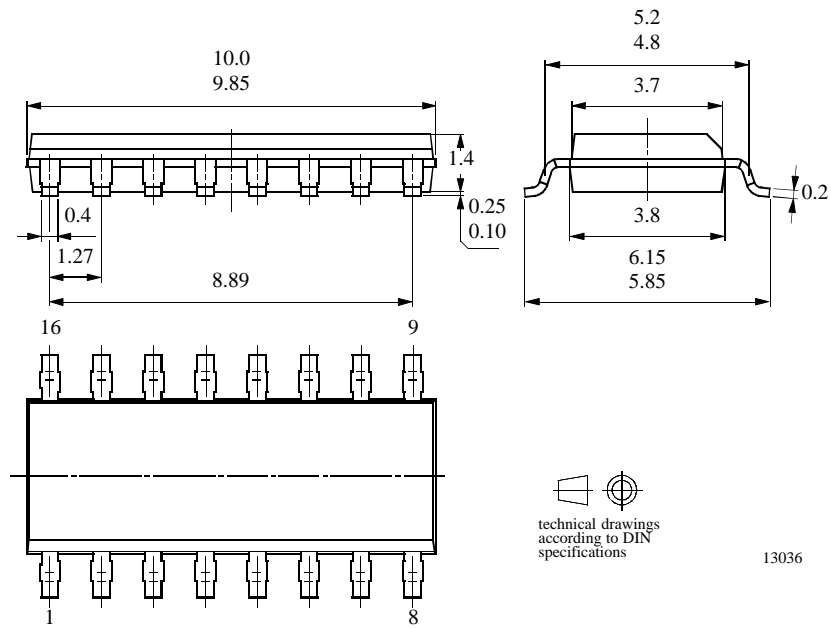


Figure 21.  $LO_i$  input circuitry

**Package Informaion**

Package SO16

Dimensions in mm



## Ozone Depleting Substances Policy Statement

It is the policy of **Atmel Germany GmbH** to

1. Meet all present and future national and international statutory requirements.
2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

**Atmel Germany GmbH** has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively
2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

**Atmel Germany GmbH** can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

**We reserve the right to make changes to improve technical design and may do so without further notice.**

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**Data sheets can also be retrieved from the Internet: <http://www.atmel-wm.com>**

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