

## 1000-MHz Quadrature Modulator

## Description

U2790B is a 1000-MHz quadrature modulator that uses TEMIC Semiconductors' 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.

## Features

- Supply voltage 5 V (typical)
- Very low power consumption: 150 mW (typical) 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 (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 result in cost and board space saving

### Block Diagram

U2790B-FP

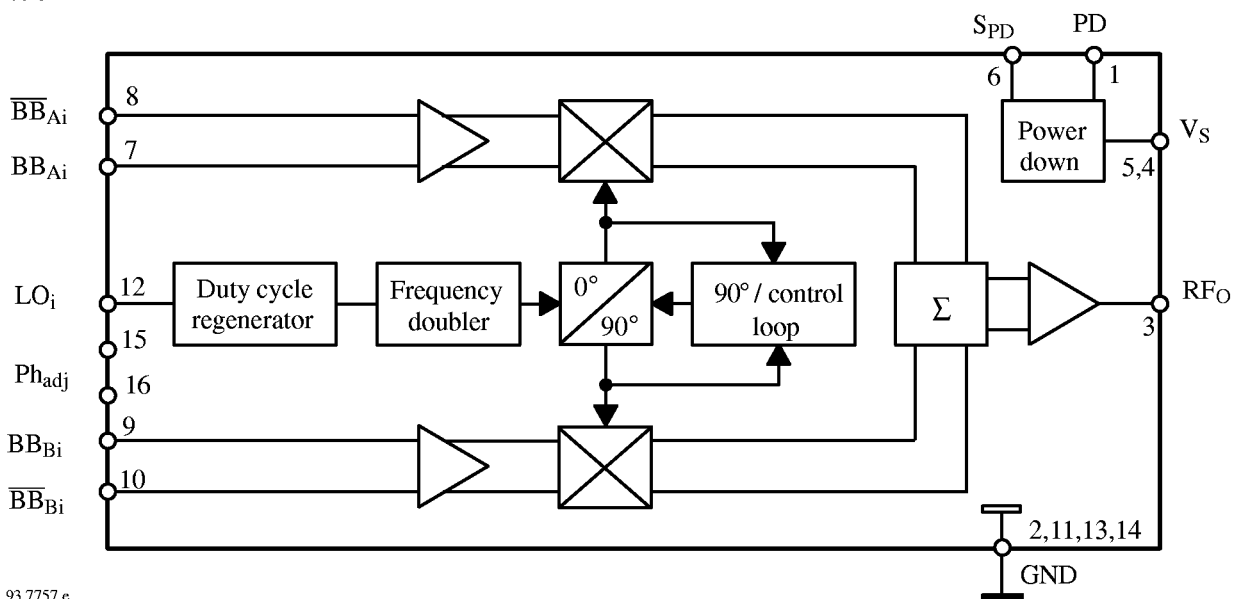
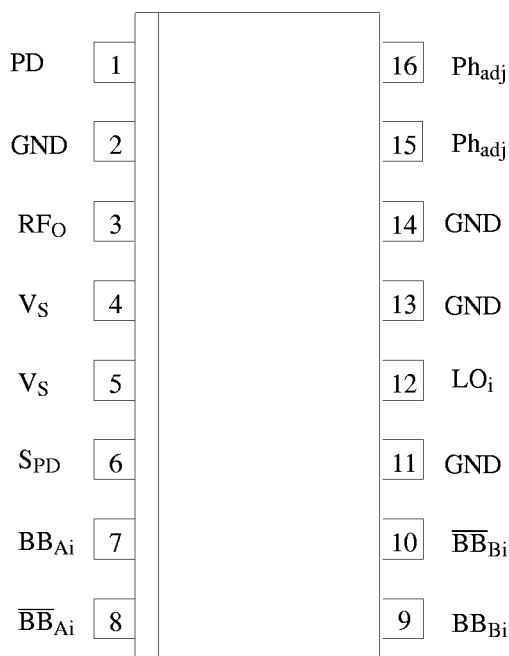


Figure 1.

## Pin Description

SO16



94 8023 e

U2790B–FP (SO 16)

| 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 (differential)      |   | $V_{\text{BBi}}$          |          | 1000         | 1500 | mV <sub>pp</sub>     |
| Input impedance (single ended)          |   | $Z_{\text{BBi}}$          |          | 3.2          |      | k $\Omega$           |
| Input frequency range                   |   | $f_{\text{BBi}}$          | 0        |              | 200  | MHz                  |
| Internal bias voltage                   |   | $V_{\text{BBb}}$          | 2.35     | 2.5          | 2.65 | V                    |
| Temperature coefficient                 |   | $\text{TC}_{\text{BB}}$   |          | 0.1          | <1   | mV/ $^\circ\text{C}$ |
| <b>LO input</b>                         |   | Pin 12                    |          |              |      |                      |
| Frequency range                         |   | $f_{\text{LOi}}$          | 100      |              | 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>             | $f_{\text{LO}} = 900\text{ MHz}$<br>$f_{\text{LO}} = 150\text{ MHz}$  | $\text{LO}_{\text{RFo}}$  | 30<br>32 | 35<br>35     |      | dB                   |
| Sideband suppression <sup>2,3</sup>     | $f_{\text{LO}} = 900\text{ MHz}$<br>$f_{\text{LO}} = 150\text{ MHz}$  | $\text{SBS}_{\text{RFo}}$ | 35<br>30 | 40<br>35     |      | dB                   |
| Phase error <sup>4</sup>                |   | $P_e$                     |          | < 1          |      | deg.                 |
| Amplitude error                         |   | $A_e$                     |          | < $\pm 0.25$ |      | dB                   |
| Noise floor                             | $V_{\text{BBi}} = 2\text{ V}$ , $\bar{V}_{\text{BBi}} = 3\text{ V}$<br>$V_{\text{BBi}} = \bar{V}_{\text{BBi}} = 2.5\text{ V}$ | $N_{\text{FL}}$           |          | -132<br>-144 |      | dBm/Hz               |
| VSWR                                    |   | $\text{VSWR}_{\text{RF}}$ |          | 1.6          | 2    |                      |
| 3rd order baseband harmonic suppression |   | $S_{\text{BBH}}$          | 35       | 45           |      | dB                   |
| RF harmonic suppression                 |   | $S_{\text{RFH}}$          |          | 35           |      | dB                   |
| <b>Power down mode</b>                  |   |                           |          |              |      |                      |
| Supply current                          | $V_{\text{PD}} \leq 0.5\text{ V}$ Pins 4, 5<br>$V_{\text{PD}} = 1\text{ V}$   | $I_{\text{PD}}$           |          | 10           | 1    | $\mu\text{A}$        |
| Settling time                           | $C_{\text{SPD}} = 100\text{ pF}$<br>$C_{\text{LO}} = 100\text{ pF}$<br>$C_{\text{RFo}} = 1\text{ nF}$ 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 a 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  $5.5\text{ V}$

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

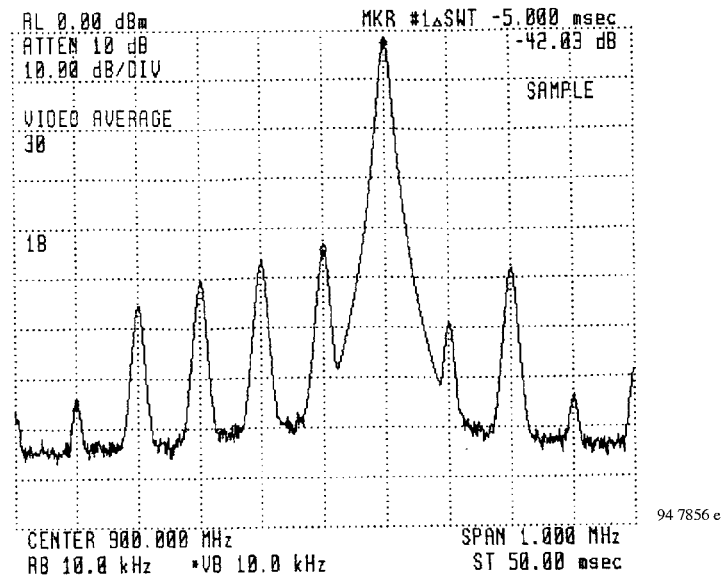


Figure 2.

## Typical GMSK Output Spectrum

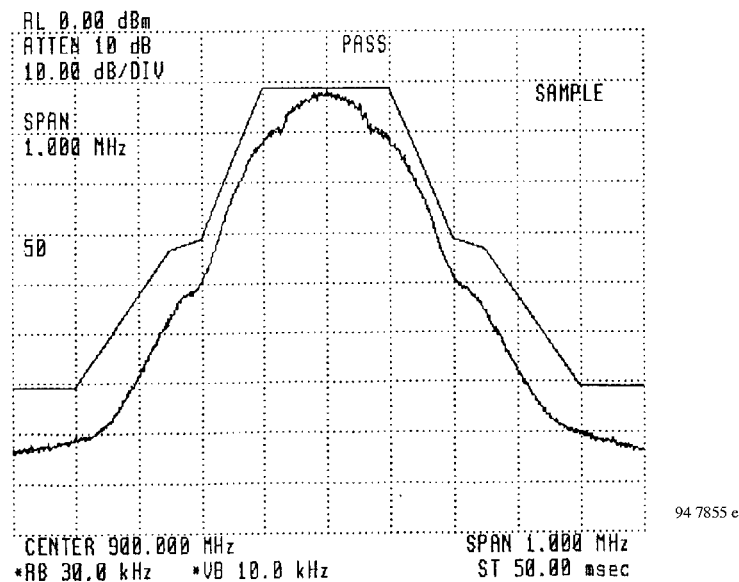


Figure 3.

## Typical RF-Harmonic Output Spectrum

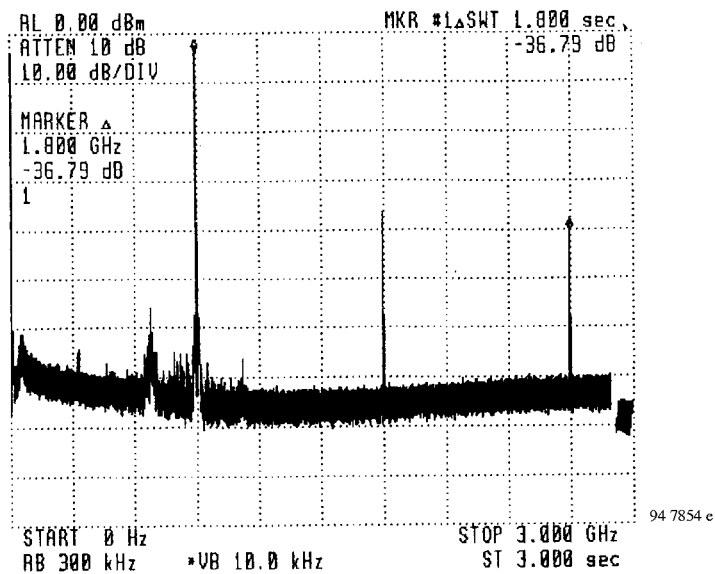


Figure 4.

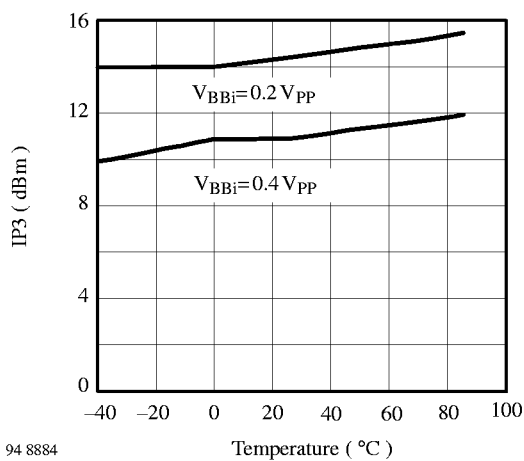


Figure 5. OIP3 vs.  $T_{amb}$ , LO = 150 MHz, level -20 dBm

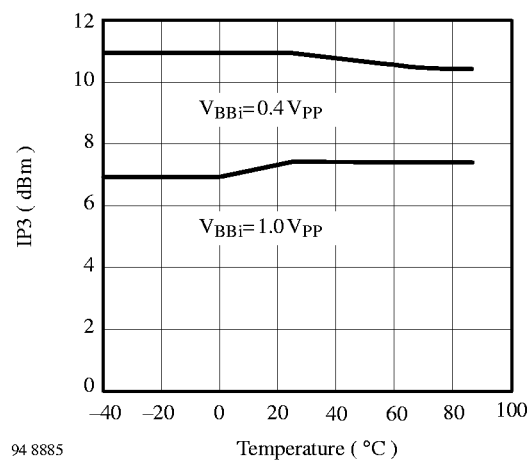


Figure 6. OIP3 vs.  $T_{amb}$ , LO = 900 MHz, level -10 dBm

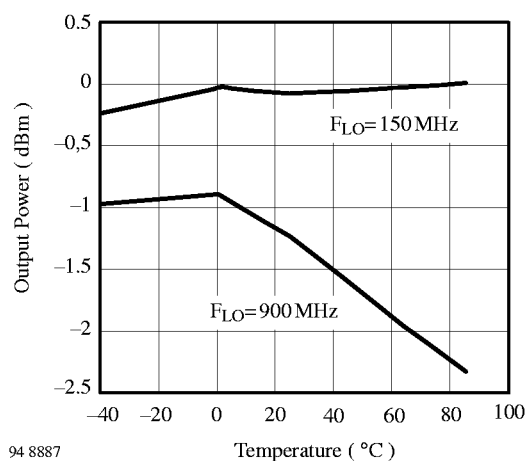


Figure 7. Output power vs.  $T_{amb}$

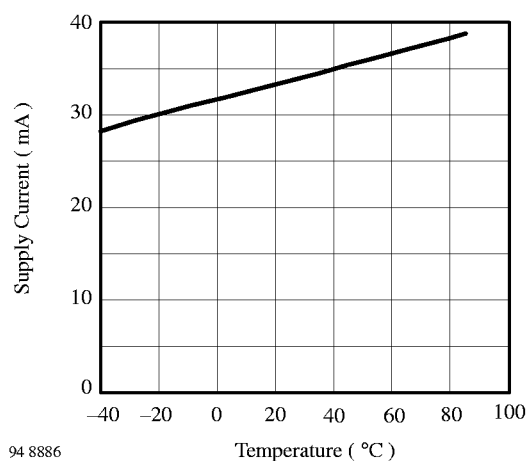


Figure 8. Supply current vs.  $T_{amb}$

## Typical S11 Frequency Response of the RF Output

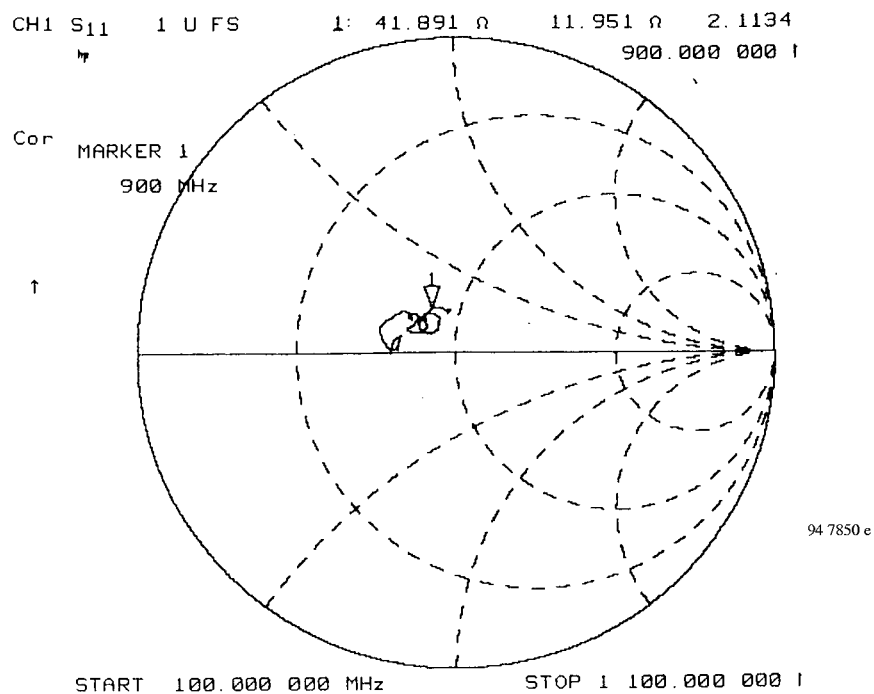


Figure 9.

## Typical VSWR Frequency Response of the RF Output

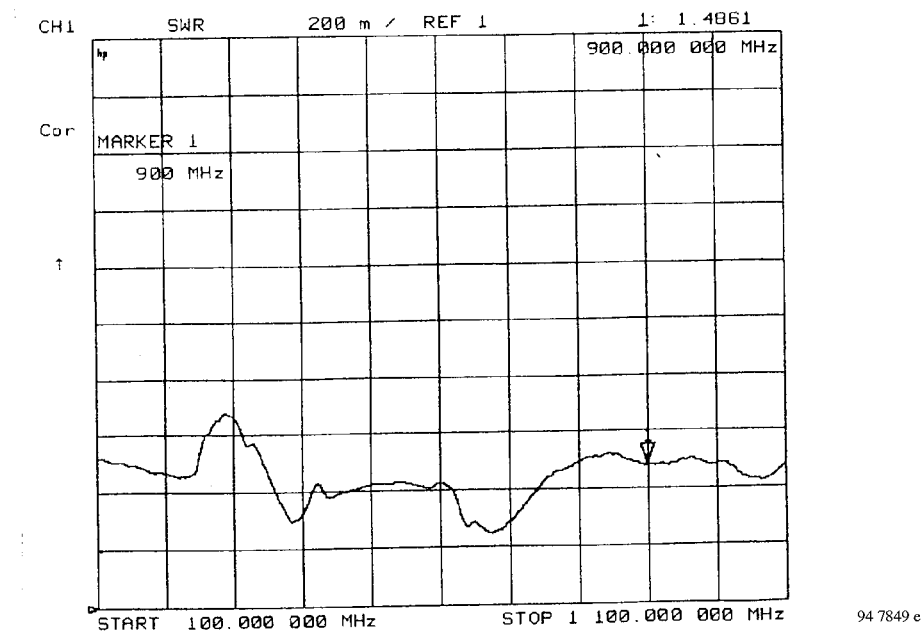


Figure 10.

## Typical S11 Frequency Response of the LO Input

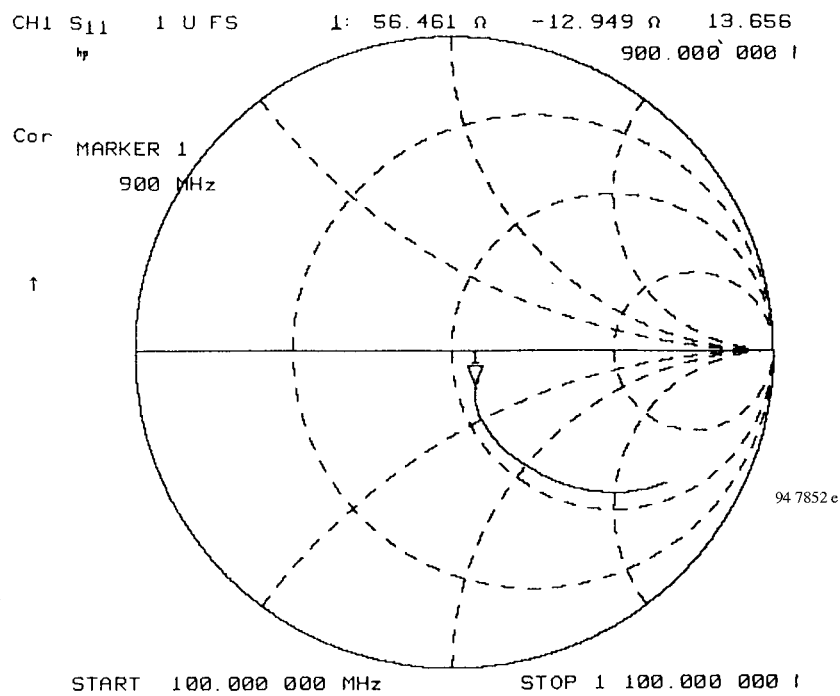


Figure 11.

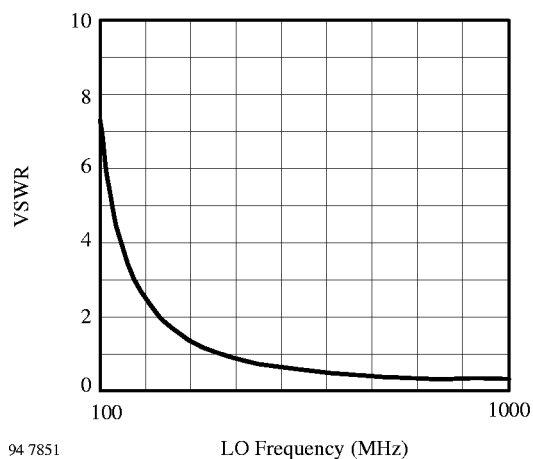


Figure 12. Typical VSWR frequency response of the LO input

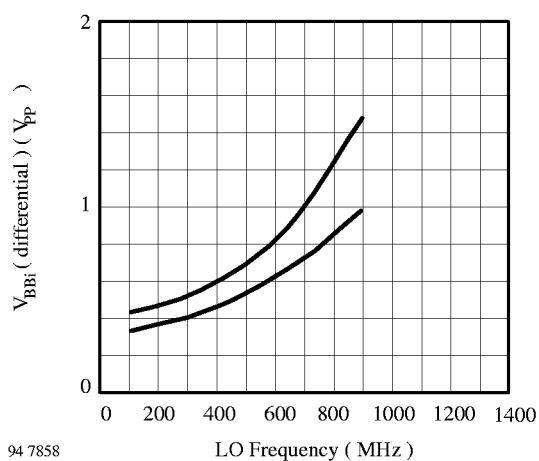


Figure 15. Typical required  $V_{BBi}$  input signal (differential) vs. LO frequency for  $P_O = 0$  dBm and  $P_O = -2$  dBm

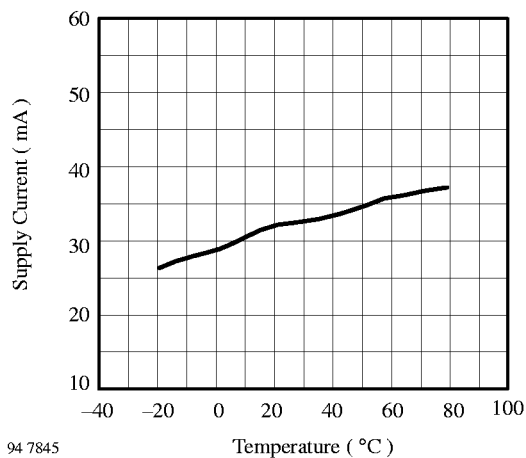


Figure 13. Typical supply current vs. temperature at  $V_S = 5$  V

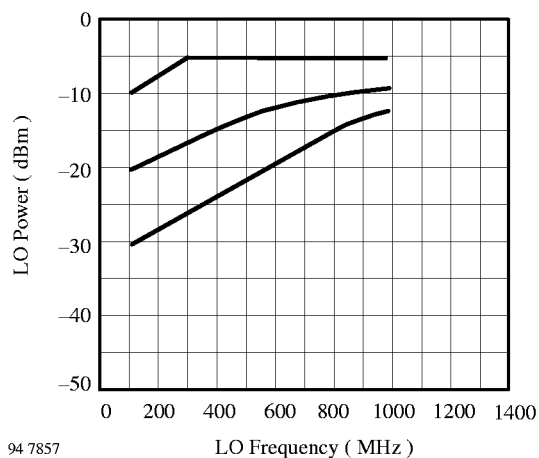


Figure 16. Typical useful LO power range vs. LO frequency at  $T_{amb} = 25$  °C

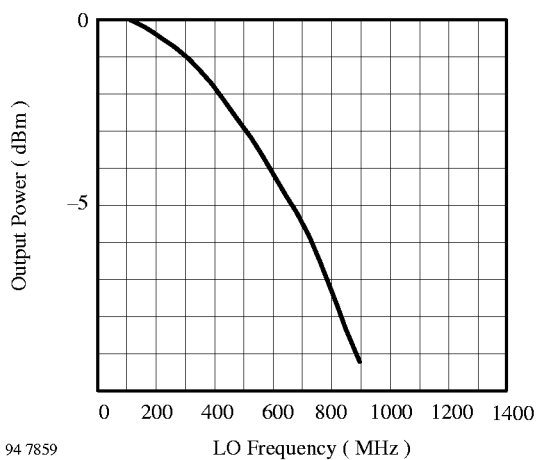


Figure 14. Typical output power vs. LO-frequency at  $T_{amb} = 25$  °C,  $V_{BBi} = 230$  mV<sub>pp</sub> (differential)



## Application Circuit

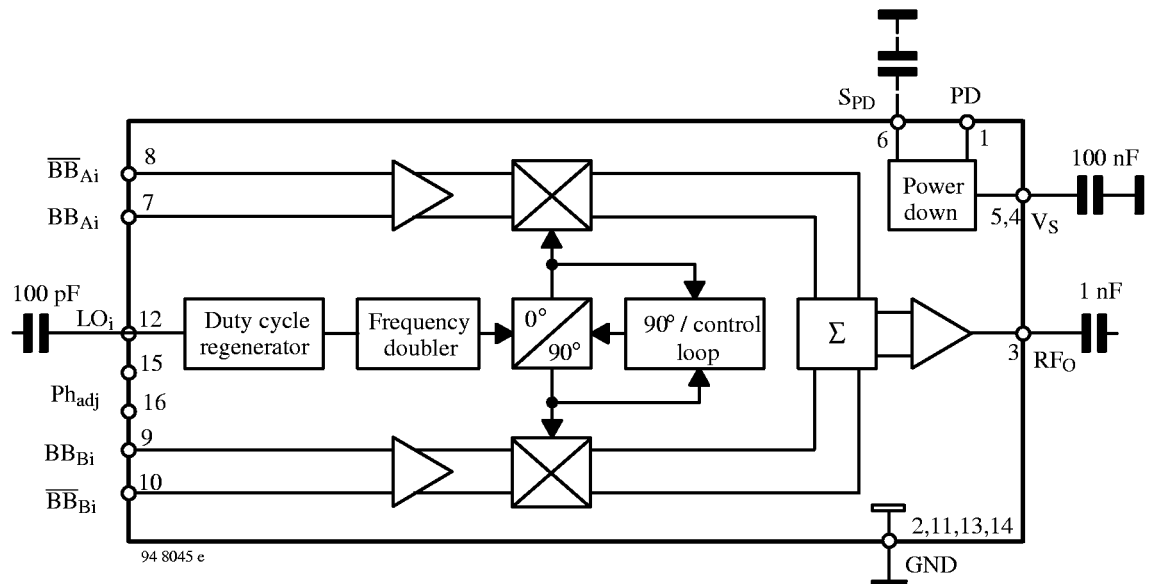


Figure 17.

## PCB Layout

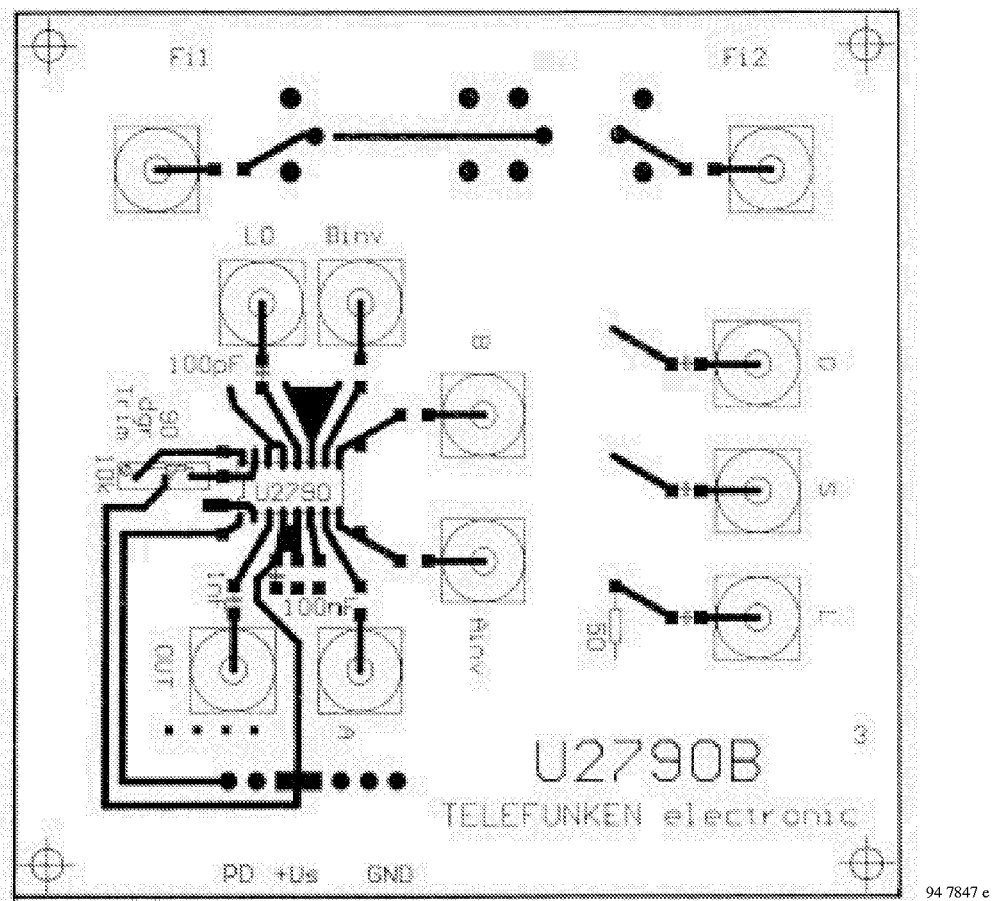


Figure 18. U2790B-FP (SO 16)

## Application Notes

### 1. 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 application

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  $C_{LOi} = 100 \text{ pF}$  and  $C_{RFo} = 1 \text{ nF}$

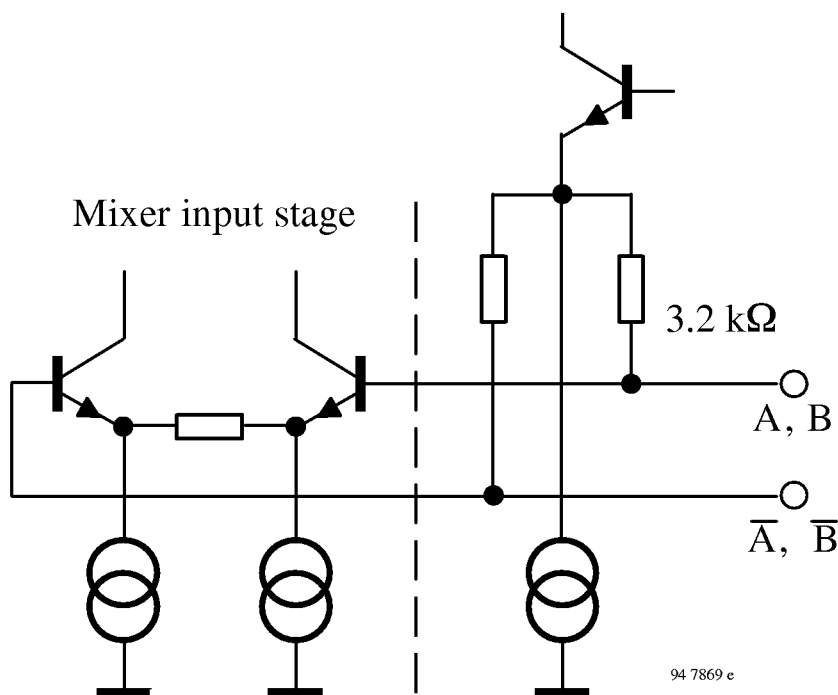


Figure 19. Baseband input circuitry

### 2. 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 1 shows the baseband input circuitry with a resis-

tance 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  $2.5 \pm 0.15 \text{ V}$ .

## 3. Circuitries

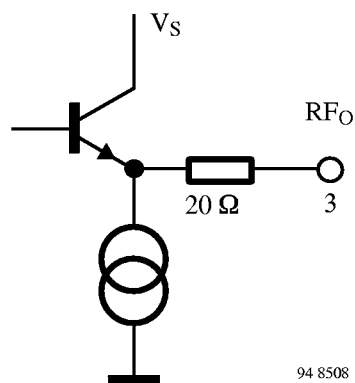


Figure 20. RF output circuitry

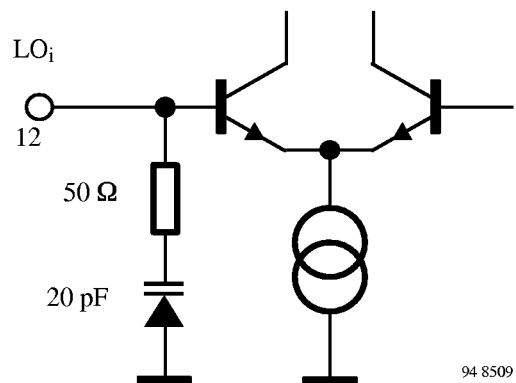


Figure 21.  $L_O$  input circuitry

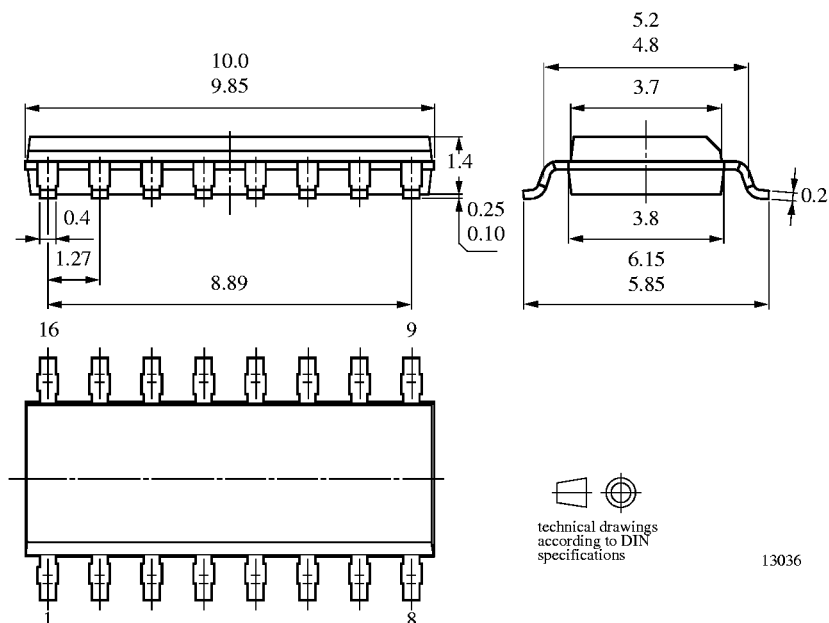
## Ordering Information

| Package | Part number |
|---------|-------------|
| SO16    | U2790B-FP   |

## Dimensions in mm

Package SO16

Dimensions in mm



## Ozone Depleting Substances Policy Statement

It is the policy of **TEMIC Semiconductor 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.

**TEMIC Semiconductor 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.

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TEMIC Semiconductor GmbH, P.O.B. 3535, D-74025 Heilbronn, Germany  
Telephone: 49 (0)7131 67 2594, Fax number: 49 (0)7131 67 2423