

## 1000-MHz Quadrature Demodulator

### Description

The U2794B silicon monolithic integrated circuit is a quadrature demodulator which is manufactured using Atmel Wireless & Microcontrollers' advanced UHF technology. This demodulator features a frequency range from 70 MHz to 1000 MHz, low current consumption, selectable gain, power-down mode and adjustment-free handling. The IC is suitable for direct conversion and

image rejection applications in digital radio systems up to 1 GHz such as cellular radios, cordless telephones, cable TV and satellite TV systems.

Electrostatic sensitive device.  
Observe precautions for handling.



### Features

- Supply voltage 5 V (typ.)
- Very low power consumption 125 mW (typ.)
- Very good image rejection by means of phase control loop for precise 90° phase shifting
- Duty-cycle regeneration for single ended LO input signal
- Low LO input level -10 dBm (typ.)
- LO frequency from 70 MHz to 1 GHz
- Power-down mode
- 25 dB gain control
- Very low I/Q output DC offset voltage typ. < 5 mV

### Block Diagram

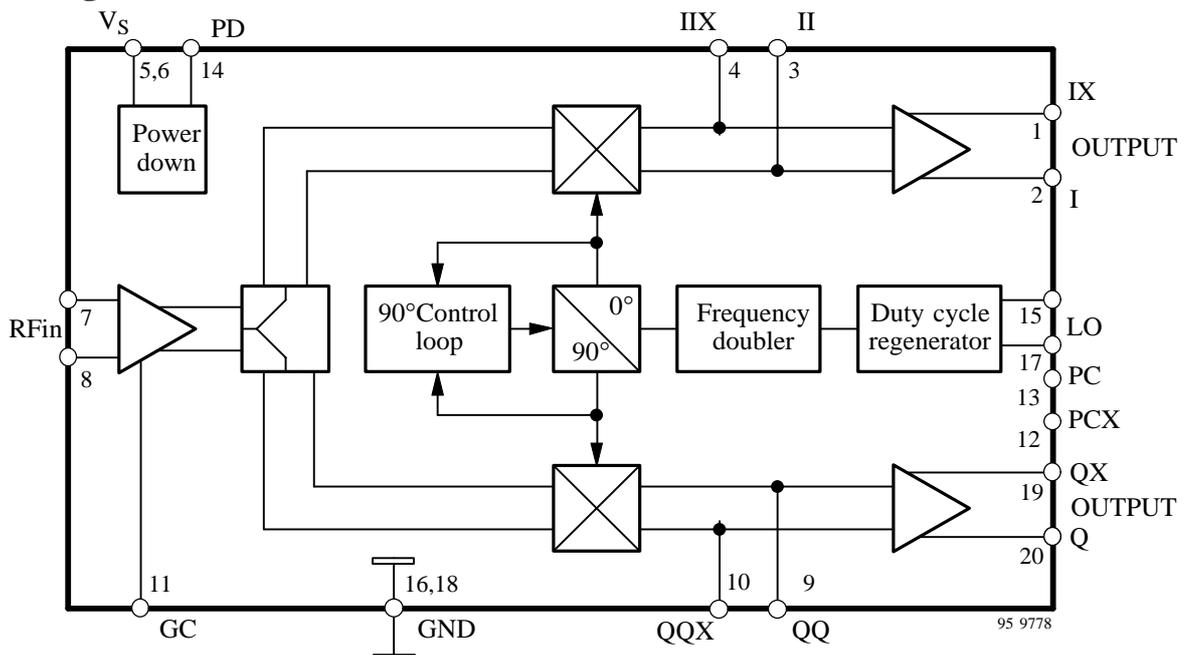


Figure 1. Block diagram

### Ordering Information

Extended Type Number	Package	Remarks
U2794B-MFS	SSO20	Tube, MOQ 830 pcs.
U2794B-MFSG3	SSO20	Taped and reeled, MOQ 4000 pcs.

## Pin Description

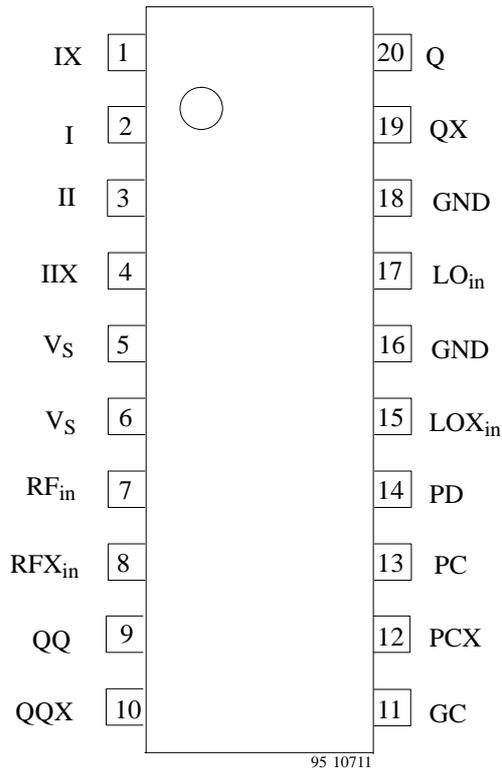


Figure 2. Pinning

Pin	Symbol	Function
1	IX	IX output
2	I	I output
3	II	II lowpass filter I
4	IIX	IIX lowpass filter I
5	V <sub>S</sub>	Supply voltage
6	V <sub>S</sub>	Supply voltage
7	RF <sub>in</sub>	RF input
8	RFX <sub>in</sub>	RFX input
9	QQ	QQ lowpass filter Q
10	QQX	QQX lowpass filter Q
11	GC	GC gain control
12	PCX	PCX phase control
13	PC	PC phase control
14	PD	PD power down
15	LOX <sub>in</sub>	LOX input
16	GND	Ground
17	LO <sub>in</sub>	LO input
18	GND	Ground
19	QX	QX output
20	Q	Q output

## Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage Pins 5 and 6	V <sub>S</sub>	6	V
Input voltage Pins 7, 8 and 17	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 5 and 6	V <sub>S</sub>	4.75 to 5.25	V
Ambient-temperature range	T <sub>amb</sub>	-40 to 85	°C

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient SSO 20	R <sub>thJA</sub>	140	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  $Z_O = 50\ \Omega$ ,  $f_{\text{iLO}} = 950\text{ MHz}$ ,  $P_{\text{iLO}} = -10\text{ dBm}$

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply-voltage range	Pins 5 and 6	$V_S$	4.75		5.25	V
Supply current	Pins 5 and 6	$I_S$		30		mA
<b>Power-down mode, PD</b>						
“OFF” mode supply current	$V_{\text{PD}} \leq 0.5\text{ V}$ Pins 5 and 6 $V_{\text{PD}} = 1.0\text{ V}$ Pin 14 Note 1	$I_{\text{SPD}}$		$\leq 1$ 20		$\mu\text{A}$
<b>Switch voltage</b> Pin 14						
“Power ON”		VPON	4			V
“Power DOWN”		VPOFF			1	V
<b>LO input, <math>LO_{\text{in}}</math></b> Pin 17						
Frequency range		$f_{\text{iLO}}$	70		1000	MHz
Input level	Note 2	$P_{\text{iLO}}$	-12	-10	-5	dBm
Input impedance	See figure 11	$Z_{\text{iLO}}$		50		$\Omega$
Voltage standing wave ratio	See figure 4	VSWRLO		1.2	2	
Duty-cycle range		LODCR	0.4		0.6	
<b>RF input, <math>RF_{\text{in}}</math></b>						
Noise figure (DSB) symmetrical output	@ 950 MHz Note 3 @ 100 MHz Pins 7 and 8	NF		12 10		dB
Frequency range	Pins 7 and 8	$f_{\text{iRF}}$			$>f_{\text{iLO}}$	
-1 dB input compression point	High gain Pins 7 and 8 Low gain	ICPHG ICPLG		-8 +3.5		dBm
Second order IIP	Note 4 Pins 7 and 8	IIP2HG		35		dBm
Third order IIP	High gain Pins 7 and 8 Low gain	IIP3HG IIP3LG		+3 +13		dBm
LO leakage	Pins 7 and 8 Symmetric input Asymmetric input	LOL		$\leq -60$ $\leq -55$		dBm
Input impedance	Pins 7 and 8 see figure 11	$Z_{\text{iRF}}$		$500\parallel 0.8$		$\Omega\parallel\text{pF}$

Note 1: During power-down status a load circuitry with DC-isolation to GND is assumed, otherwise a current of  $I \approx (V_S - 0.8\text{ V}) / R_I$  has to be added to the above power-down current for each output I, IX, Q, QX.

Note 2: The required LO-Level is a function of the LO frequency (see figure 7).

Note 3: Measured with input matching. For 950 MHz, the optional transmission line T3 at the RF input may be used for this purpose. Noise figure measurements without using the differential output signal result in a worse noise figure.

Note 4: Using Pins 7 and 8 as a symmetric RF input, the second-order IIP can be improved.

## 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  $Z_O = 50\ \Omega$ ,  $f_{\text{iLO}} = 950\text{ MHz}$ ,  $P_{\text{iLO}} = -10\text{ dBm}$

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
<b>I/O outputs (I, IX, Q, QX) Emitter follower I = 0.6 mA</b>						
3-dB bandwidth w/o external C	Note 5 Pins 1, 2, 19 and 20	BWI/Q	$\geq 30$			MHz
I/Q amplitude error	Pins 1, 2, 19 and 20	AII/Q		$\leq \pm 0.2$		dB
I/Q phase error	Pins 1, 2, 19 and 20	QEI/Q		$\leq \pm 1.5$		Deg
I/Q maximum output swing	Pins 1, 2, 19 and 20 Symm. output $R_L > 5\text{ k}\Omega$	Max I/Q			2	$V_{\text{PP}}$
DC output voltage	Pins 1, 2, 19 and 20	VOUT		2.8		V
DC output offset voltage	Note 6 Pins 1, 2, 19 and 20	VOFSI/Q I/IX Q/QX		$< 5$		mV
Output impedance	Pins 1, 2, 19 and 20 see figure 11	Zout		50		$\Omega$
<b>Gain control, GC</b>						
Control range power gain, gain high/gain low	Note 7 Pin 11	GCR PGH/GGL		25 23/-2		dB
<b>Switch voltage</b>						
“Gain high”	Pin 11	GCVHigh			1	V
“Gain low”	Note 8 Pin 11	GCVLow				V
<b>Settling time, ST</b>						
Power “OFF” – “ON”		STON		$< 4$		$\mu\text{s}$
Power “ON” – “OFF”		STOFF		$< 4$		$\mu\text{s}$

Note 5: Due to test board parasitics, this bandwidth is reduced and not equal for I, IX, Q, QX.

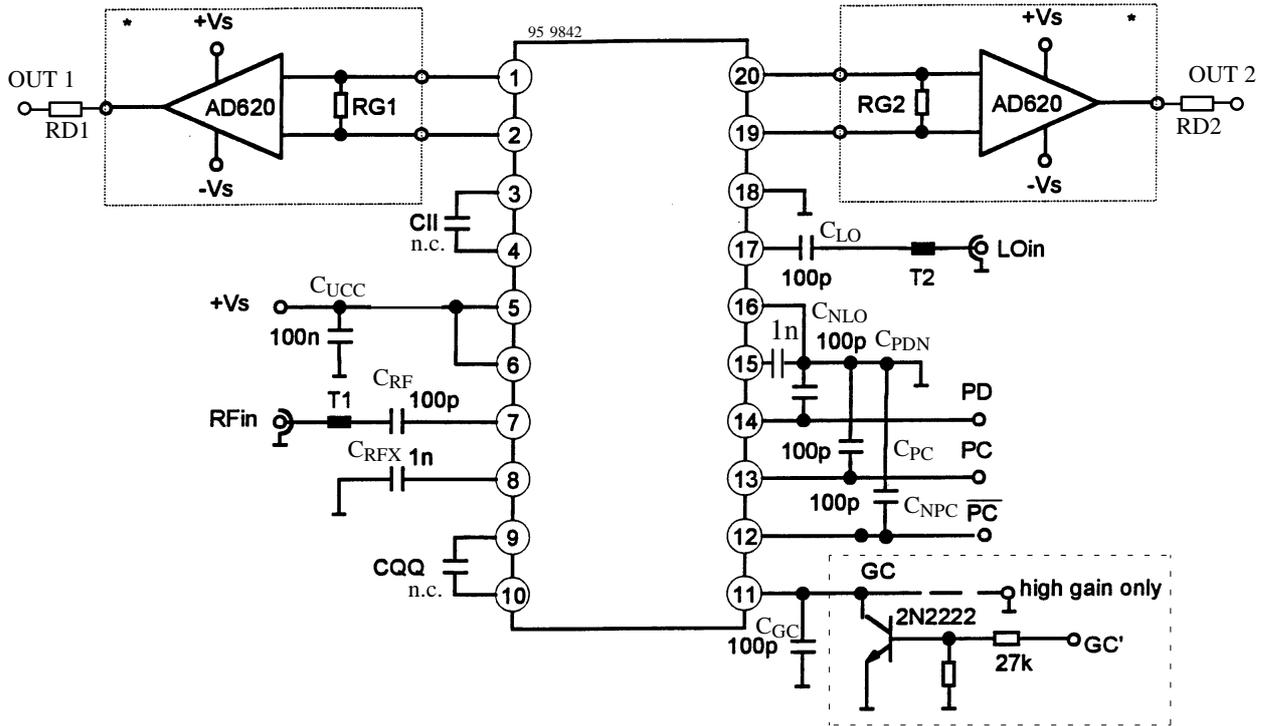
If symmetry and full bandwidth is required, the lowpass Pins 3, 4 and 9, 10 should be isolated from the board. The bandwidth of the I/Q outputs can be increased further by using a resistor between Pins 3, 4, 9 and 10. These resistors shunt the internal loads of  $R_I \sim 5.4\text{ k}\Omega$ . The decrease in gain here has to be considered.

Note 6: Output emitter follower internal, a current  $I = 0.6\text{ mA}$  allows only small voltage swing with a  $50\ \Omega$  load. For low signal distortion the load impedance should be  $R_I \geq 5\text{ k}\Omega$

Note 7: Referred to the level of the output vector  $\sqrt{I^2 + Q^2}$ .

Note 8: The low-gain status is achieved with an open or high-ohmic Pin 11. A recommended application circuit for switching between high and low gain status is shown in figure 3.

**Test Circuit**



- \* optional for single ended tests (notice 3 dB bandwidth of AD620)
- T1, T2 = transmission line  $Z_0 = 50 \Omega$
- If no GC function is required, connect Pin 11 to GND.
- For high and low gain status GC' is to be switched to GND respectively to  $V_S$ .

Figure 3.

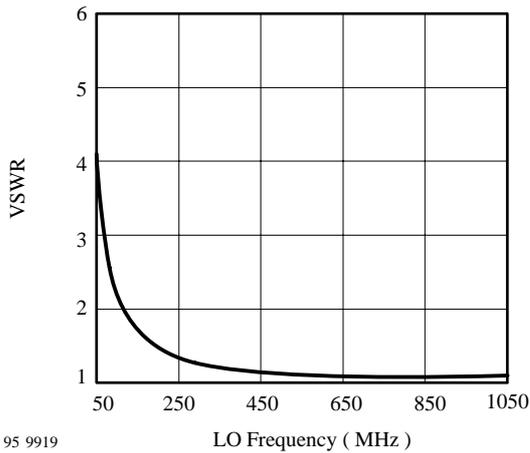


Figure 4. Typical VSWR frequency response of the LO input

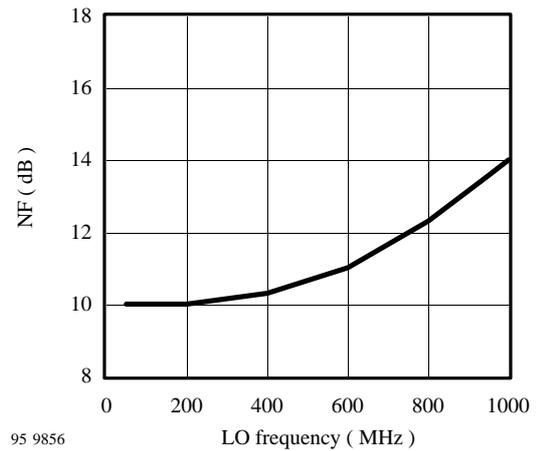


Figure 5. Noise figure vs. LO frequency; o: value at 950 MHz with RF input matching with T3

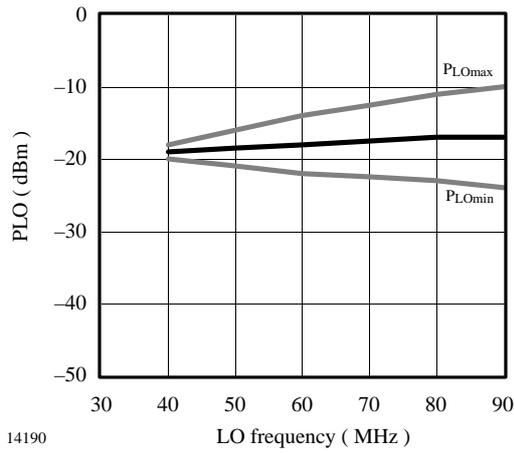


Figure 6. Typical suitable LO power range vs. frequency

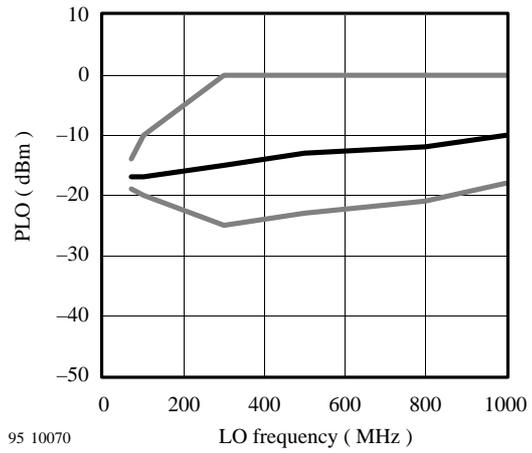


Figure 9. Typical suitable LO power range vs. frequency

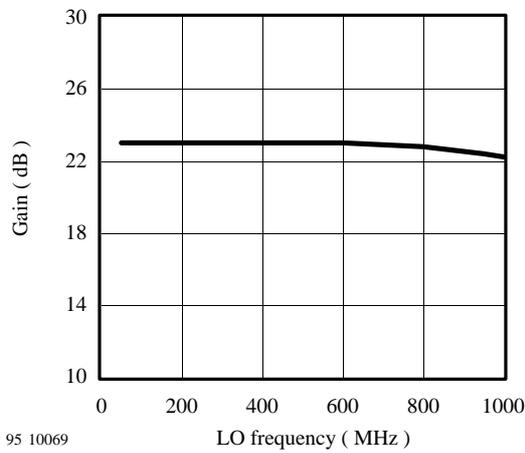


Figure 7. Gain vs. LO frequency;  
x: value at 950 MHz with RF input matching with T3

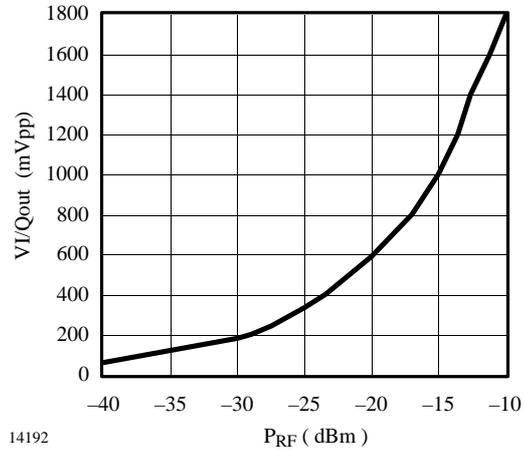


Figure 10. Typical output voltage (single ended) vs.  $P_{RF}$   
at  $T_{amb} = 25^{\circ}C$  and  $P_{LO} = -15$  dBm

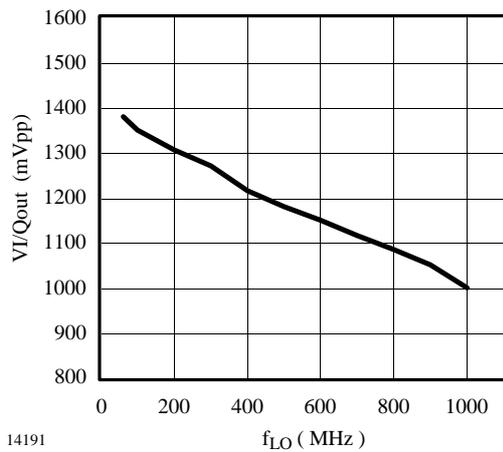


Figure 8. Typical output signal vs. LO frequency  
for  $P_{RF} = -15$  dBm and  $P_{LO} = -15$  dBm

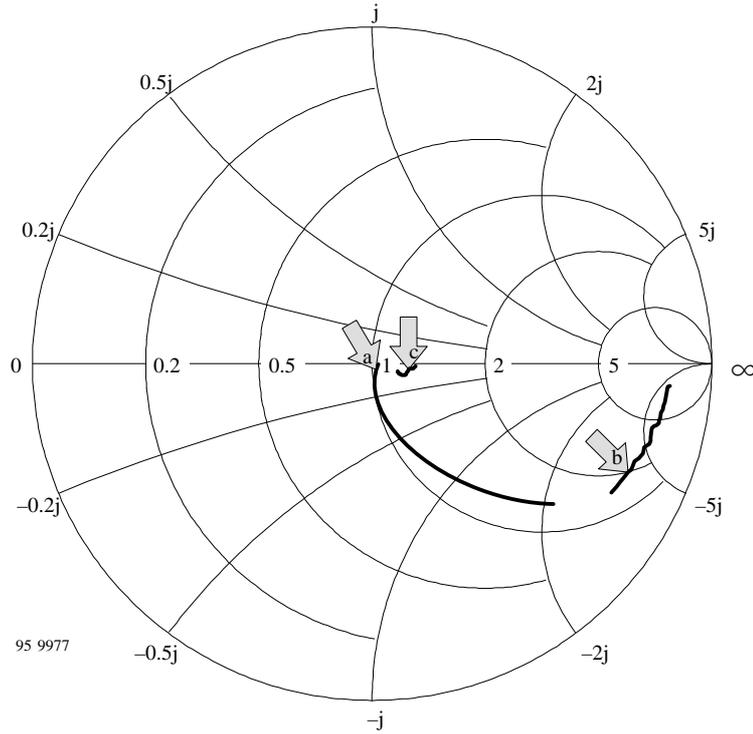


Figure 11. Typical S11 frequency response of the  
a: LO input, LO frequency from 100 MHz to 1100 MHz, marker: 950 MHz  
b: RF input, RF frequency from 100 MHz to 1100 MHz, marker: 950 MHz  
c: I/Q outputs, baseband frequency from 5 MHz to 55 MHz, marker: 25 MHz

### Evaluation Board Layout

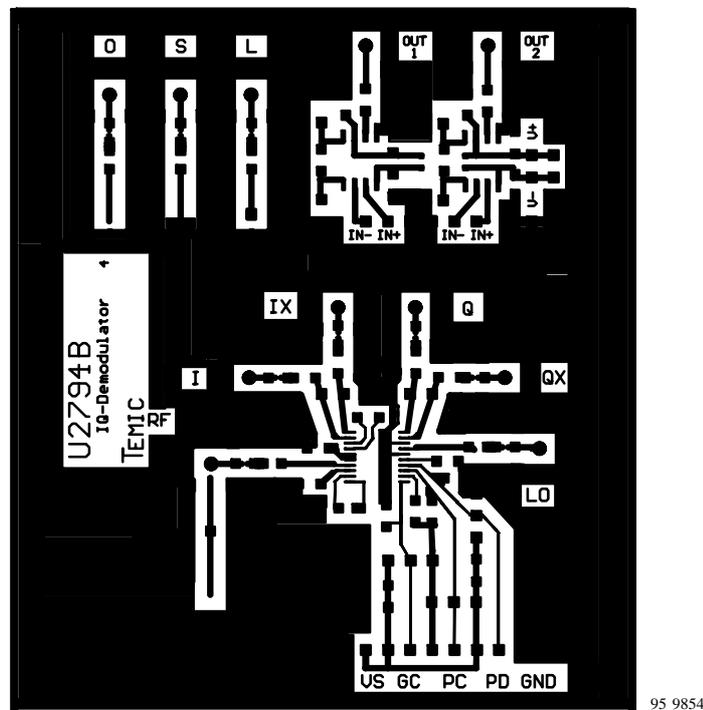
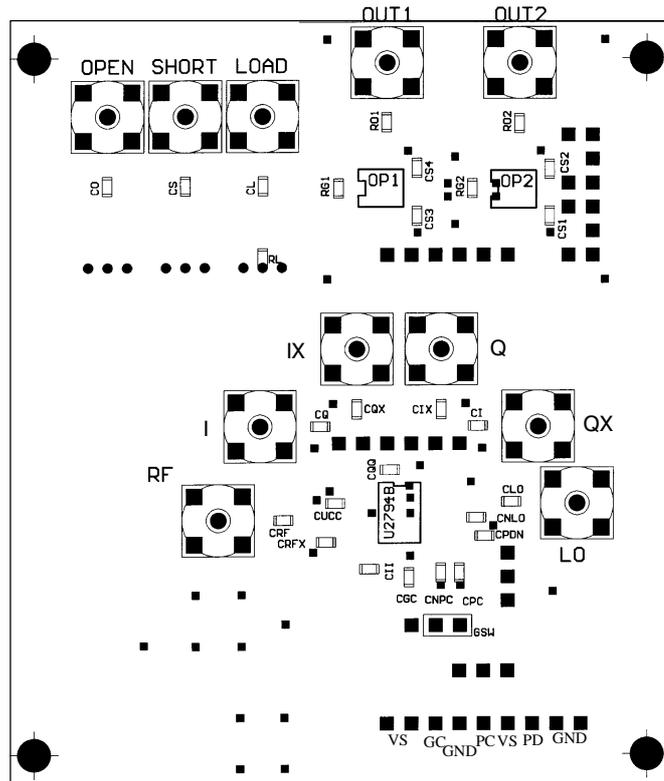


Figure 12.

## Evaluation Board



95 9853

Figure 13.

### External Components

CUCC 100 nF  
 CRFX 1 nF  
 CLO 100 pF  
 CNLO 1 nF  
 CRF 100 pF  
 CII, CQX optional external lowpass filters  
 T3 transmission line for RF-input matching,  
 to connect optionally  
 CI, CIX, optional for AC-coupling at  
 CQ, CQX baseband outputs  
 CPDN 100 pF – not connected  
 CGC 100 pF  
 CPC 100 pF – not connected  
 CNPC 100 pF – not connected  
 GSW gain switch

### Calibration Part

CO, CS, CL 100 pF  
 RL 50 Ω

### Conversion to Single Ended Output

(see data sheet of AD620)

OP1, OP2 AD620  
 RG1, RG2 prog. gain, see datasheet, for 5.6 kΩ a  
 gain of 1 at 50 Ω is achieved together  
 with RD1 and RD2.  
 RD1, RD2 450 Ω  
 CS1, CS2 100 nF  
 CS3, CS4, 100 nF

## Description of the Evaluation Board

Board material: epoxy;  $\epsilon_r = 4.8$ , thickness = 0.5 mm  
 transmission lines:  $Z_0 = 50 \Omega$

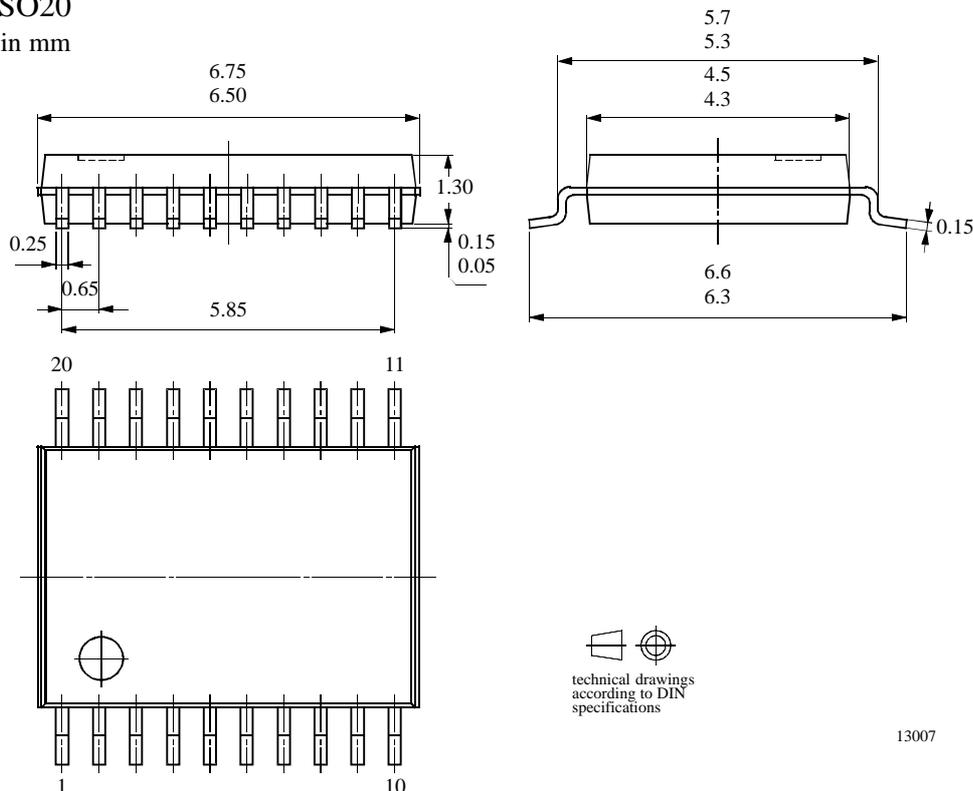
### The board offers the following functions

- The test circuit for the U2794B:
  - The supply voltage and the control inputs GC, PC and PD are connected via a plug strip. The control input voltages can be generated via external potentiometers; then the inputs should be AC-grounded (time requirements in burst mode for power up have to be considered).
  - The outputs I, IX, Q, QX are DC coupled via an plug strip or can be AC-connected via SMB plugs for high frequency tests e.g. noise figure or s-parameter measurement. The Pins II, IIX, QQ, QQQ allow user-definable filtering with 2 external capacitors CII, CQQ.
  - The offsets of both channels can be adjusted with two potentiometers or resistors.
- The LO- and the RF-inputs are AC-coupled and connected via SMB plugs. If transmission line T3 is connected to the RF-input and AC-grounded at the other end, gain and noise performance can be improved (input matching to  $50 \Omega$ ).
- The complementary RF-input is AC-coupled to GND (CRFX = 1 nF), the same appears to the complementary LO input (CNLO = 1 nF).
- A calibration part which allows to calibrate an s-parameter analyzer directly to the in- and output-signal ports of the U2794B.
- For single-ended measurements at the demodulator outputs, two OPs (e.g., AD620 or other) can be configured with programmable gain; together with an output-divider network  $R_D = 450 \Omega$  to  $R_L = 50 \Omega$ , direct measurements with  $50\text{-}\Omega$  load impedances are possible at frequencies  $< 100 \text{ kHz}$ .

## Package Information

### Package SSO20

Dimensions in mm



13007

## 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.

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

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