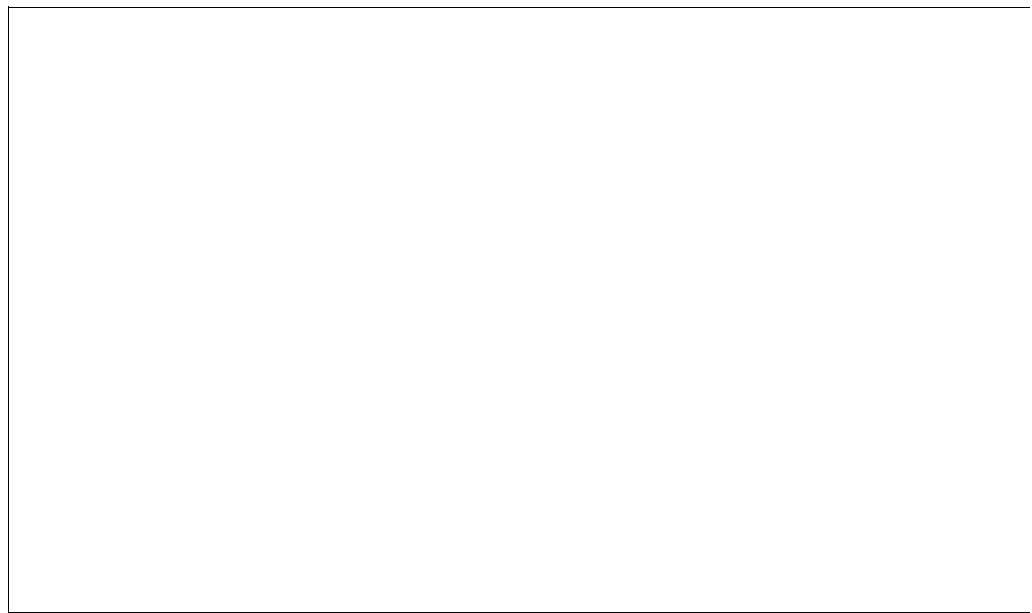


SIEMENS



ICs for Communications

Mixer DC - 2.5GHz and Vector Modulator 1.4 - 2.5GHz

PMB 2202 Version 1.2

Preliminary Data Sheet 08.97

Edition 08.97

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Revision History

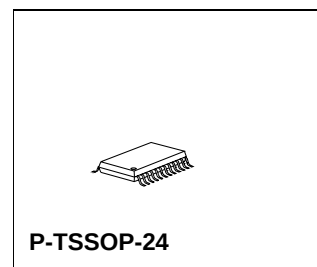
#	Subject	Preliminary Data Sheet 8.95		Preliminary Data Sheet 8.97		Change
		Page	Item	Page	Item	
1	Features	5	1.1	5	1.1	Revised
2	Thermal resistance	13	8	13	8	Revised
3	ESD integrity			13	9	Added
4	A,AX,B,BX input level	14	12	14	13	Revised
5	Supply current	15	1, 2	15	1, 2	Revised
6	Input impedances	15	4, 6			Omitted
7	Mixer output	16		16		Revised
8	Modulator inputs	17	18-21	17	12-15	Revised
9	Modulator output	18	27-33	18	22-27	Revised
10	S-Parameters and input/output impedances			19	2.4	Added
11	Test circuit 1	19	2.4	28	2.5.1	Revised
12	Test circuit 2, Evaluation circuit	20, 21				Omitted
13	Application circuit	22		29	2.5.2	Revised

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1 Overview

1.1 Features

- Direct quadrature modulator with separate additional double balanced active mixer
- Direct quadrature modulation
- LO frequency range from 1.4 to 2.5 GHz
- Generation of orthogonal carriers without external elements and without trimming
- Typ. 35 dB carrier rejection
- Typ. 45 dB SSB rejection
- Typ. 50 dB rejection of third order products at 1 Vpp A/B drive level and $f_{LO} = 2.2$ GHz
- 1 dBm output power with appropriate output power matching network and at 1 Vpp A/B baseband drive level
- Double balanced Gilbert cell mixer
- RF and IF frequency range from DC to 2.5 GHz
- Typ. 39 dB carrier rejection
- Low noise
- Supply voltage range from 2.7 V to 4.5 V
- Power down mode
- P-TSSOP-24 package
- Temperature range -30° to 85°C



1.2 Applications:

- Vector modulated digital mobile cellular systems as PDC-1.5, DCS-1800, DCS-1900, WLAN etc.
- Various modulation schemes, such as PM, PSK, FSK, QAM, QPSK, GMSK etc.
- Analog systems with FM and AM modulation
- Space and power saving optimizations of existing discrete transmitter circuits

Type	Ordering Code	Package
PMB 2202		P-TSSOP-24

1.3 Functional Description

The PMB2202 is a modulator and mixer circuit with high integration level. It includes a direct quadrature modulator and a double balanced Gilbert cell mixer with according bias circuitry.

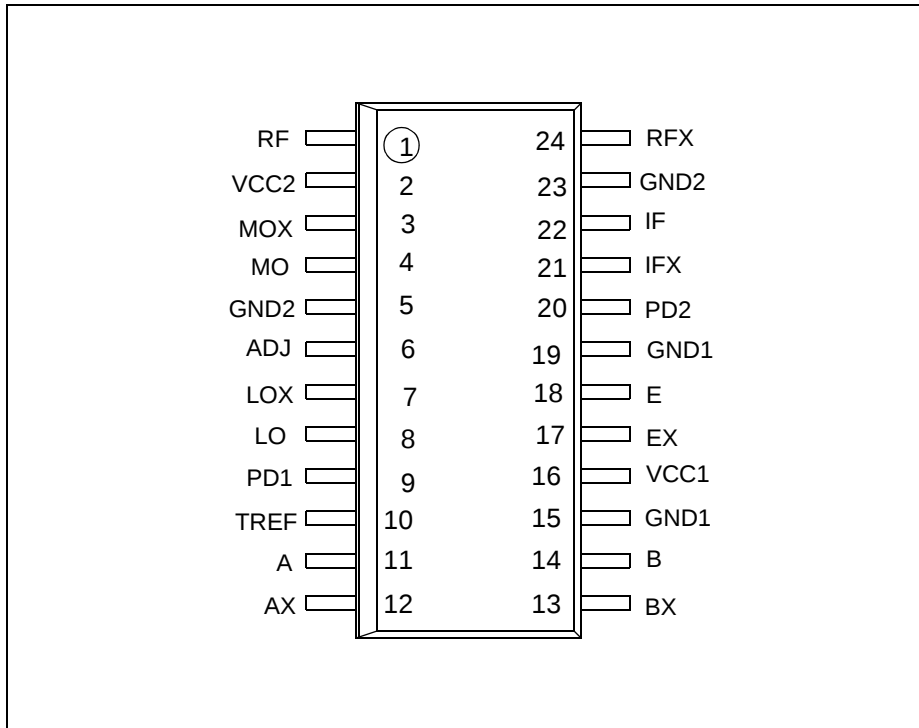
The up/down conversion mixer combines two external signals at the RF and IF inputs. The IF input is suited for the lower frequency signal because of its linear transfer function to the mixer output. The higher frequency signal is fed to the RF input to switch the Gilbert cell mixer. In a typical application the wanted mixer output product is bandpass filtered and then fed to the modulator LO input. The mixer may also be used to convert the modulator output signal from E/EX via the IF/IFX input by mixing with a local oscillator signal RF/RFX to higher frequencies up to 2.5 GHz.

The modulator generates two orthogonal carriers which are mixed with the baseband modulation signals A and B in Gilbert multipliers. The outputs of the Gilbert cells are added and amplified by a linear output stage. The modulated signal is available at the open collector output E,EX. The voltage TREF can be used for DC biasing of the modulation inputs A, AX, B, BX externally.

The modulator and the mixer have separate power supplies and grounds. They can be powered down independently. Due to the power down concept the modulator can be used without or in conjunction with the up/down conversion mixer part.

For applications in the frequency range from 800MHz to 1.5GHz the derivative PMB2201 is offered.

1.4 Pin Configuration (top view)

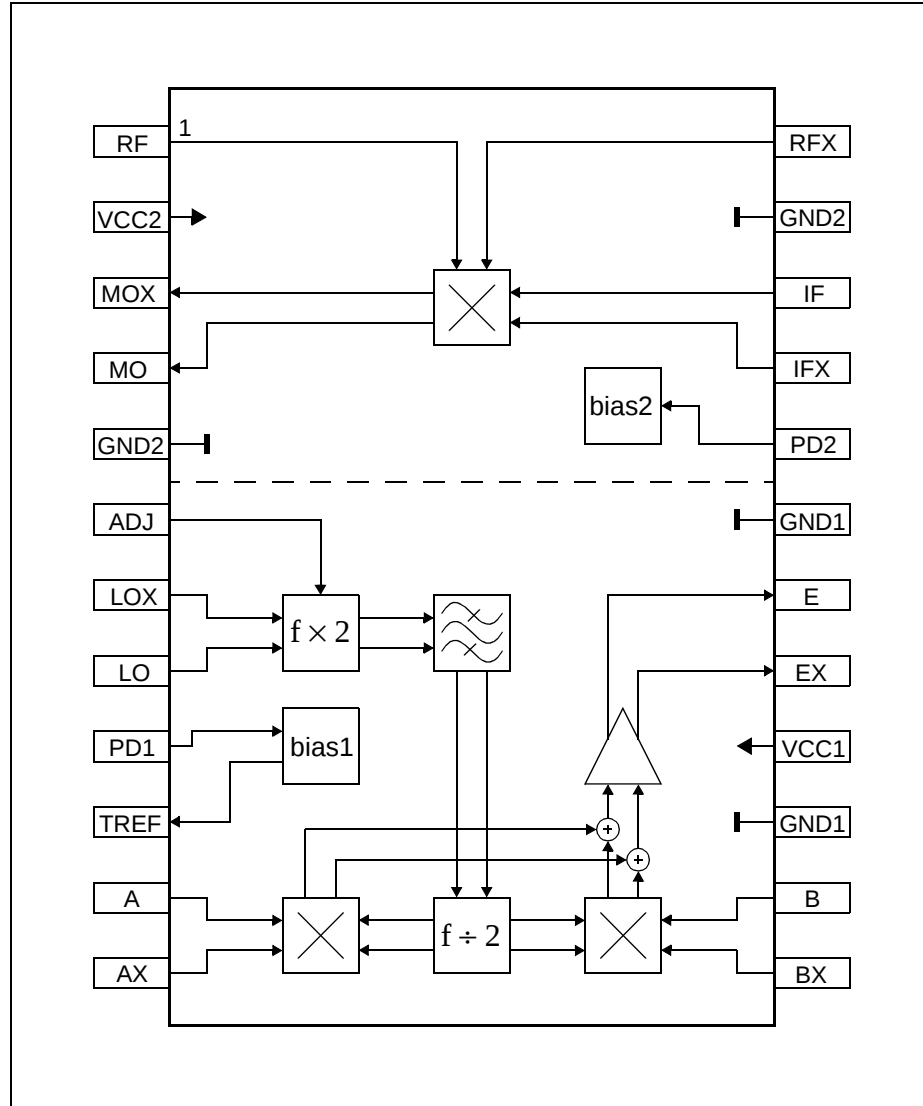


P-TSSOP-24

1.5 Pin Definitions and Functions

Pin No.	Symbol	Function
1	RF	RF input, base input
2	VCC2	Supply voltage for mixer
3	MOX	Mixer output inverted, open collector
4	MO	Mixer output, open collector
5,23	GND2	Ground for mixer
6	ADJ	Phase adjust input
7	LOX	Modulator LO input inverted
8	LO	Modulator LO input
9	PD1	Power down for modulator
10	TREF	DC bias voltage for modulation inputs A, AX, B, BX
11	A	Modulation input A
12	AX	Modulation input A inverted
13	BX	Modulation input B inverted
14	B	Modulation input B
15, 19	GND1	Ground for modulator
16	VCC1	Supply voltage for modulator
17	EX	Modulator output inverted, open collector
18	E	Modulator output, open collector
20	PD2	Power down for mixer
21	IFX	IF input inverted, emitter input
22	IF	IF input, emitter input
24	RFX	RF input inverted, base input

1.6 Functional Block Diagram



1.7 Circuit Description

Block Level Description

The PMB2202 includes an up/down conversion mixer and a direct quadrature modulator on one chip.

The mixer is a fully balanced Gilbert cell. The IF, IFX pins are low impedance inputs. The transfer function from this input to the mixer output is linear for input levels below the 1dB compression point. For improved intermodulation the mixer current can be increased with external resistors to GND2 at IF, IFX. The RF, RFX pins are high impedance inputs and are DC coupled to the bases of the transistors in the Gilbert cell. The input level at RF, RFX should be high enough to ensure proper switching of the differential transistor pairs. The mixer output pins MO, MOX are high impedance open collector outputs. The wanted mixer output product can be band pass filtered and fed to the LO, LOX input of the modulator or to an external load.

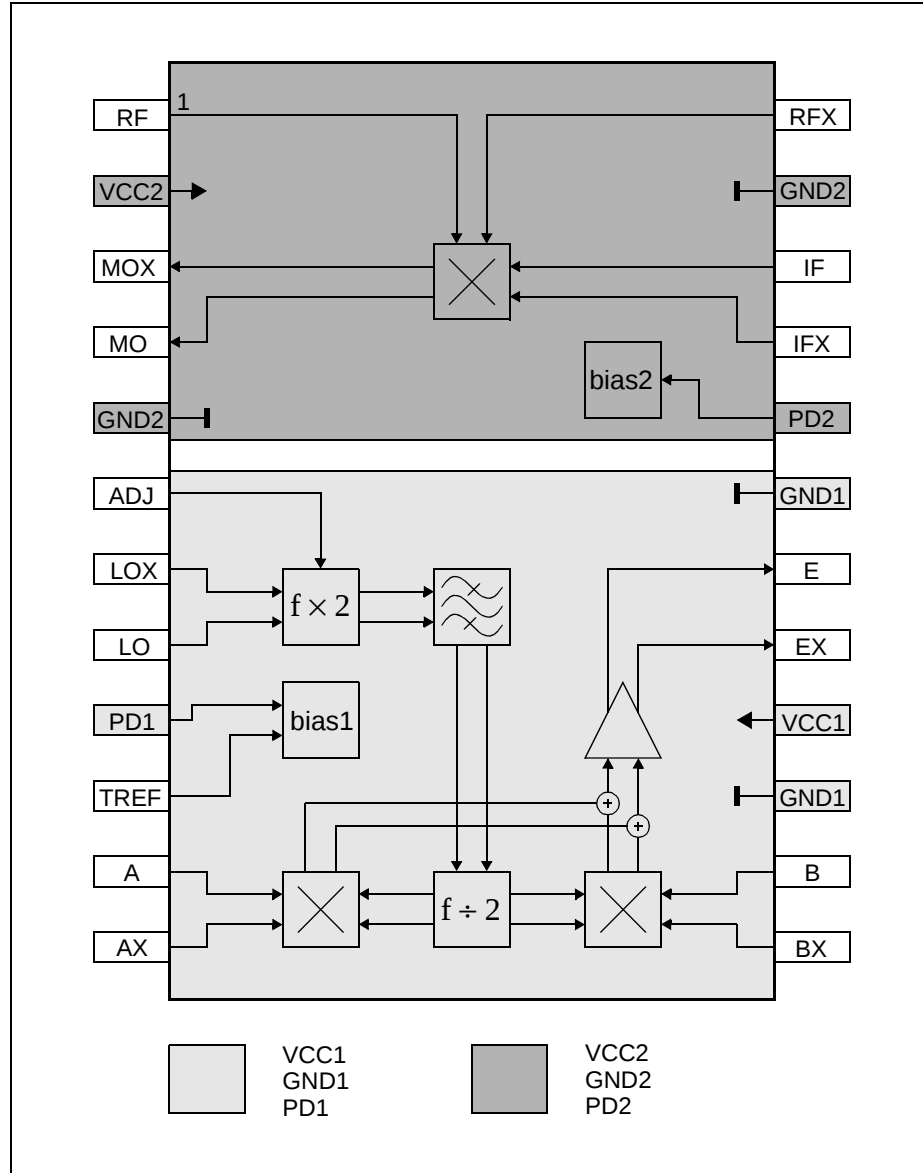
The LO, LOX pins are the high impedance inputs of an emitter coupled differential pair. The LO signal is internally divided into two orthogonal carriers at the transmit frequency. The modulator has two Gilbert cell multipliers, in which the modulation signals A(t) and B(t) are mixed with the orthogonal carriers. The outputs of both Gilbert cells are added and amplified by a linear output stage. The modulated transmit signal is available at the high impedance open collector outputs E/EX and can be fed to a power amplifier.

At the output TREF a DC voltage for biasing the modulation inputs A, AX, B, BX is available, which should be capacitively decoupled to ground. The modulation inputs can be connected externally via bias resistors to TREF. Due to the low voltage concept a balanced drive of the differential modulator inputs is recommended to obtain the best second and third order spurious suppression.

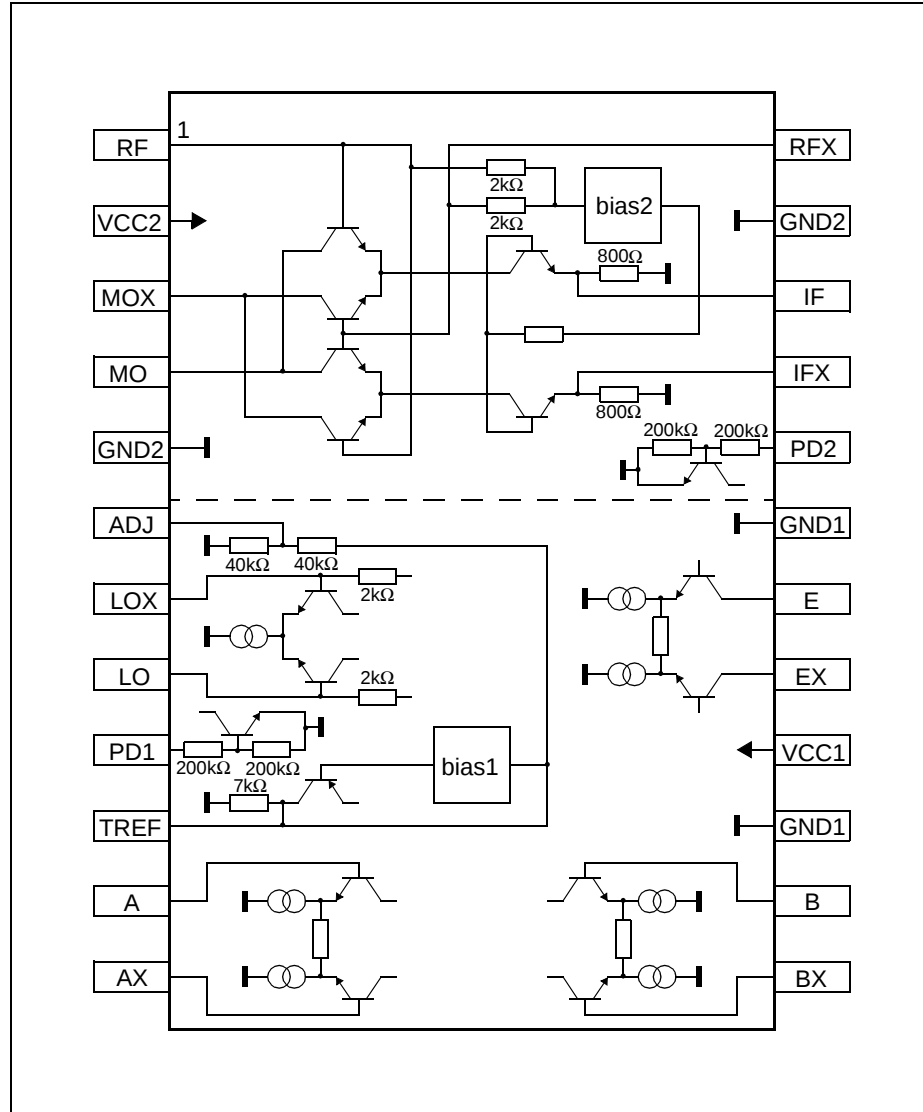
The phase adjust input ADJ allows the single sideband suppression of the modulator to be optimized for a particular application. If the specified sideband suppression is sufficient, ADJ should only be capacitively decoupled to ground, in which case the voltage at ADJ is set internally to half the TREF voltage. If a higher suppression is required, the voltage at ADJ can be adjusted to the optimum value by a pull-up resistor to TREF, a pull-down resistor to GND1 or a potentiometer between TREF and GND1.

The modulator and the mixer have separate supply, ground and power down pins: VCC1, GND1, PD1 for the modulator and VCC2, GND2, PD2 for the mixer. Applying a logic LOW to PD1 or PD2 powers down the corresponding part of the chip, including its bias circuitry. Depending on the application the power down pins can be combined or separately fixed to supply rails.

1.8 Blocks with separate supply, ground and power down pins



1.9 Internal Input/Output Circuits



2 Electrical Characteristics

2.1 Absolute Maximum Ratings

The maximum ratings may not be exceeded under any circumstances, not even momentarily and individually, as permanent damage to the IC will result.

#	Parameter	Symbol	Limit Values		Units	Remarks
			Min	Max		
1	Supply Voltage	V_{CC}	-0,5	4.5	V	
2	Input Voltage	V_{IO}	-0.5	$V_{CC} + 0.5$	V	of PD1, PD2
3	Open Collector Output Voltage (MO, MOX, E, EX)	V_{OC}	-0.5	$V_{CC} + 0.5$	V	
4	Differential Input Voltage (any differential Input)	V_I		2	V	AC stress
5	Input current (IF, IFX)	I_{IF}		10	mA	
6	Junction Temperature	T_j		125	°C	
7	Storage Temperature	T_S	-55	125	°C	
8	Thermal Resistance (junction to lead)	R_{thJL}		140	K/W	
9	ESD Integrity *	V_{ESD}	-1000	1000	V	according MIL-STD 883D, method 3015.7 and EOS/ESD assn. standard S5.1 - 1993

* The RF pins 3,4,17 and 18 are not protected against voltage stress > 300V (versus VS or GND).

The high frequency performance prohibits the use of adequate protective structures.

2.2 Operational Range

Within the operational range the IC operates as described in the circuit description.
The AC/DC characteristic limits are not guaranteed.

Supply voltage $V_{VCC} = 2.7V...4.5V$, Ambient temperature $T_{amb} = -30^{\circ}C...85^{\circ}C$

#	Parameter	Symbol	Limit Values		Units
			Min	Max	
1	VCC1, VCC2 Supply	V_{CC1}, V_{CC2}	2.7	4.5	V
2	PD-Signals Voltage-L	V_{PDL}	0	0.8	V
3	PD-Signals Voltage-H	V_{PDH}	2.1	V_{CC}	V

Mixer section

4	RF, RFX input frequency	f_{RF}	DC	2.5	GHz
5	RF, RFX input level	P_{RF}		0	dBm
6	IF, IFX input frequency	f_{IF}	DC	2.5	GHz
7	IF, IFX input Level	P_{IF}		0	dBm
8	MO, MOX output frequency	f_{MO}	DC	2.5	GHz
9	Minimum resistive load R2, R3 at IF, IFX to GND	R_2, R_3 in Test Circuit 1	33		Ω

Modulator section

10	LO, LOX input frequency	f_{LO}	1.4	2.5	GHz
11	LO, LOX input level ($f_{LO} = 1.4$ GHz $f_{LO} = 2.5$ GHz)	P_{LO}	-15 -10	0 0	dBm
12	A, AX, B, BX input frequency	f_A, f_B	DC	400	MHz
13	A, AX, B, BX input level	$V_A, V_{AX},$ V_B, V_{BX}	1.4	$V_{CC1}-0.6$	V
14	A-AX, B-BX differential input signal level	$V_{A-AX},$ V_{B-BX}		1	V_{pp}

Note: Power levels refer to 50 Ohms impedance

2.3 AC/DC Characteristics

AC/DC characteristics involve the spread of values guaranteed within the specified supply voltage and ambient temperature range. Typical characteristics are the median of the production.

Supply voltage $V_{VCC} = 2.7V \dots 4.5V$, Ambient temperature $T_{amb} = +25^{\circ}C$

#	Parameter	Symbol	Limit Values			Unit	Test Conditions	Test Circuit
			Min	Typ	Max			

Supply Current

1	Supply current with all powered up	I_{VCC1}	17	22	27	mA	PD1 & PD2 = H	1
		$I_E + I_{EX}$	9	12	15	mA		
		I_{VCC2}	0.3	0.6	1.0	mA		
		$I_{MO} + I_{MOX}^*$	5	7	9	mA		
2	Supply current with all powered down	I_{VCC1}			2	μA	PD1 & PD2 = L	1
		I_E, I_{EX}			2	μA		
		I_{VCC2}			2	μA		
		I_{MO}, I_{MOX}			2	μA		
3	Power up settling time **	t_{PU}		10		μs	10nF at TREF 100pF at ADJ Modulator inputs DC coupled	

Mixer section

Mixer input at IF/IFX

4	Internal DC voltage at IF/IFX***	V_{DCIF}		0.3		V		1
5	Internal DC voltage at RF/RFX	V_{DCRF}		2.0		V		1

* The mixer current decreases when no external resistors to ground are connected at IF and IFX.

** t_{DIL} is determined by the time needed to charge the external capacitors.

*** Note: There are external resistors (82 Ω) at IF and IFX to ground.

AC/DC Characteristics

AC/DC characteristics involve the spread of values guaranteed within the specified supply voltage and ambient temperature range. Typical characteristics are the median of the production.

Supply voltage $V_{VCC} = 2.7V$ to $4.5V$, Ambient temperature $T_{amb} = +25^{\circ}$

#	Parameter	Sym- bol	Limit Values			Unit	Test Conditions	Test Circuit
			Min	Typ	Max			

Mixer Output MO/MOX:

6	Power gain*	G		3		dB		Application Circuit
7	Output power	P_{MO}	-12	-9	-6	dBm	$P_{RFIN} = -5dBm$ $f_{RFIN} = 1.4 GHz$ $P_{IFIN} = -5dBm$ $f_{IFIN} = 400 MHz$	1
8	1dB compression point*	P_{IF1dB}		-7		dBm	$P_{RFIN} > -4dBm$	Application Circuit
9	Noise figure*	N_{IF}		8		dB	DSB Noise, $f=1GHz$	
10	Carrier suppression	a_C	25	39		dB	$P_{RFIN} = -5dBm$ $f_{RFIN} = 1.4 GHz$ $P_{IFIN} = -5dBm$ $f_{IFIN} = 400 MHz$	1

*Application hint

AC/DC Characteristics

AC/DC characteristics involve the spread of values guaranteed within the specified supply voltage and ambient temperature range. Typical characteristics are the median of the production.

Supply voltage $V_{VCC} = 2.7V \dots 4.5V$, Ambient temperature $T_{amb} = +25^{\circ}C$

#	Parameter	Sym- bol	Limit Values			Unit	Test Condition	Test Circuit
			min.	typ.	max.			

Modulator section

Modulator LO input at LO/ LOX

11	Internal DC voltage at LO, LOX	V_{DCLO}		V_{CC1} -0.7V		V		1
----	--------------------------------	------------	--	--------------------	--	---	--	---

Modulator inputs A/AX and B/BX

12	Input DC current for A, AX, B, BX	I_A, I_{AX}, I_B, I_{BX}		5	10	μA	Differential input voltage = 0V	1
13	Differential input offset current	I_{OSA}, I_{OSB}	-1		1	μA		1
14	Differential input resistance*	$R_{A/AX}, R_{B/BX}$	125	250		k Ω	$f_{A,B} = 100 \text{ KHz}$	
15	Differential input capacitance*	$C_{A/AX}, C_{B/BX}$		1		pF	$f_{A,B} = 100 \text{ KHz}$	

DC bias TREF for A/AX and B/BX inputs

16	Reference voltage for A, B modulating inputs	V_{TREF}	1.65	1.75	1.85	V		1
17	Minimum decoupling capacitance at TREF*	C_{TREF}	10			nF		
18	Maximum load current at TREF*	I_{LMAX}			1.0	mA		

* Application hint

AC/DC Characteristics

AC/DC characteristics involve the spread of values guaranteed within the specified supply voltage and ambient temperature range. Typical characteristics are the median of the production.

Supply voltage $V_{VCC} = 2.7V \dots 4.5V$, Ambient temperature $T_{amb} = +25^{\circ}C$

#	Parameter	Sym- bol	Limit Values			Unit	Test Condition	Test Circuit
			min.	typ.	max.			

Phase adjust input ADJ

20	Open circuit voltage	V_{ADJ}		880		mV		
21	Input impedance	R_{ADJ}		20		k Ω		

Modulator output E/EX: $f_{A,B}=10MHz$; $V_{A,B}=1V_{PP}$; 90° phase shift; $P_{LO}=-10dBm$

22	Output power	$P_{E/EX}$	-8	-4	0	dBm		1
23	Output power for power matching *	$P_{E/EX}$		1		dBm	$f_{LO} = 1895 MHz$	Appl. Circuit
24	Carrier suppression **	a_C	25	35		dB		1
25	Single sideband suppression ***	a_{ssb}	35	45		dB		1
26	Suppression of third order distortion products ****	a_{IM3}	34 42	42 50		dB	$f_{LO} = 1400 MHz$ $f_{LO} = 2200 MHz$	1
27	Output noise floor *	P_N		-140		dBc /Hz	$f_{LO} = 1785MHz$ - $f_{meas} = 1805MHz$	

* Application hint

** The carrier suppression can be optimized for a particular application using offset voltages at the baseband inputs A/AX and B/BX. The optimum values can be found iteratively by adjusting the A/AX and B/BX offsets alternately until the carrier disappears into the noise floor. If the actual offset voltages differ from their optimum values by ΔV_{OSA} and ΔV_{OSB} , the carrier suppression in dB is given by

$$a_c = 20 \cdot \log_{10} \left[\frac{V_m}{\sqrt{(\Delta V_{OSA})^2 + (\Delta V_{OSB})^2}} \right]$$

where V_m is the peak value of the signal voltage at A/AX and B/BX.

*** Phase adjust pin ADJ not used.

**** a_{IM3} can be increased by reducing the amplitude of the modulator inputs V_{A-AX} and V_{B-BX} .

2.4 S-Parameters and Input/Output Impedances

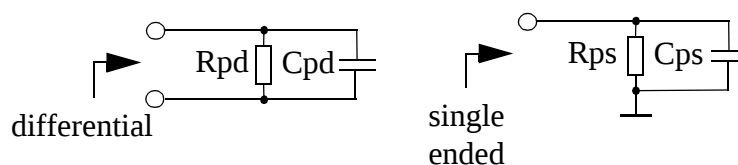
The S-parameters provided in this section are based on measurements at the supply voltage of $V_{CC} = 3.6V$. Via the internal bias tees of the NWA the capacitive coupling is done and the open collector pins are connected to VCC.

The S-parameters have to be considered as application hints.

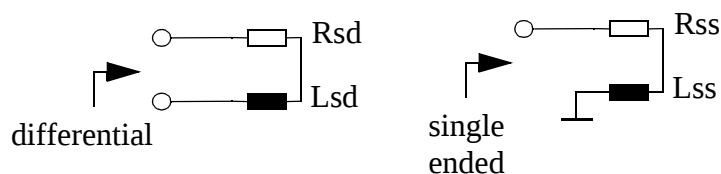
Test	Frequency [MHz]	Port 1	Port 2	Output levels
RF-Input impedance	25 - 2500	RF	RFX	-5 dBm
IF-Input impedance	25 - 2500	IF	IFX	-30 dBm
MO-Output impedance	25 - 2500	MO	MOX	-30 dBm
LO-Input impedance	1400 - 2500	LO	LOX	-5 dBm
E-Output impedances	1400 - 2500	E	EX	-30 dBm

The input/output impedances are calculated from these parameters. The impedances are given as equivalent circuit with lumped elements for differential and single ended in-/outputs.

As equivalent circuit for these in-/outputs (except IF) a resistor R_p parallel to a capacitance C_p is derived:

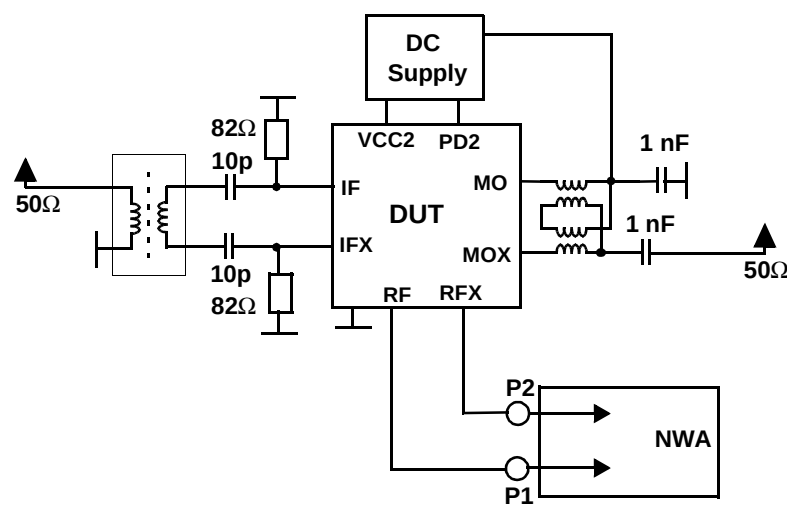


The IF-Input impedance is given as a equivalent circuit of a resistor R_s serial to a inductivity L_s .



2.4.1 Mixer Input RF/RFX

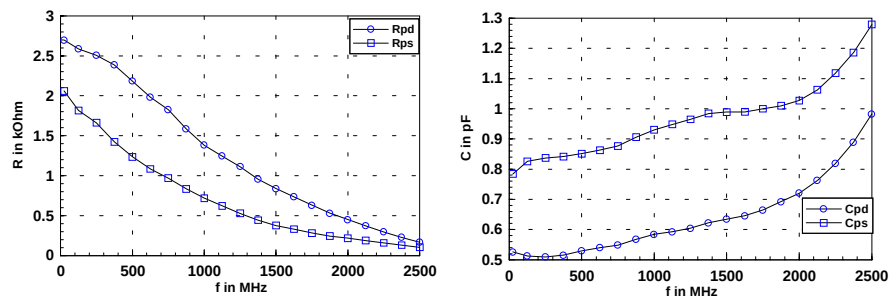
Circuit for measurement:



Mixer Input RF/RFX S-Parameters:

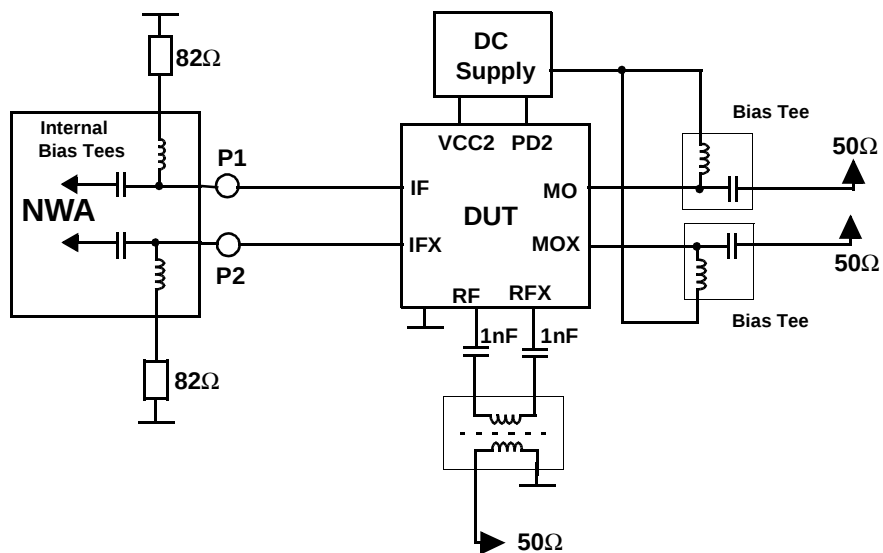
f	S11		S21		S12		S22	
MHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
25	0.953	-0.7	0.025	8.6	0.025	8.8	0.953	-0.7
250	0.942	-7.5	0.032	47.1	0.029	43.7	0.942	-7.8
500	0.922	-15.2	0.060	62.1	0.055	65.0	0.926	-15.6
750	0.902	-23.3	0.091	59.0	0.085	64.2	0.910	-23.7
1000	0.872	-32.5	0.123	50.7	0.119	57.0	0.887	-32.7
1250	0.836	-41.5	0.145	44.6	0.144	52.4	0.867	-41.4
1500	0.787	-50.1	0.171	37.5	0.177	46.5	0.840	-50.5
1750	0.738	-58.0	0.196	31.1	0.207	40.5	0.808	-59.7
2000	0.688	-66.0	0.233	22.5	0.253	30.9	0.769	-69.6
2250	0.635	-77.1	0.261	12.1	0.290	20.4	0.715	-82.5
2500	0.567	-92.0	0.276	1.1	0.321	9.7	0.636	-98.7

Mixer Input RF/RFX Impedances:



2.4.2 Mixer Input IF/IFX

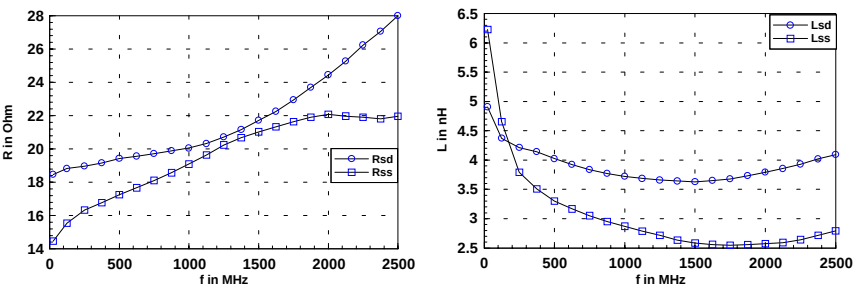
Circuit for measurement:



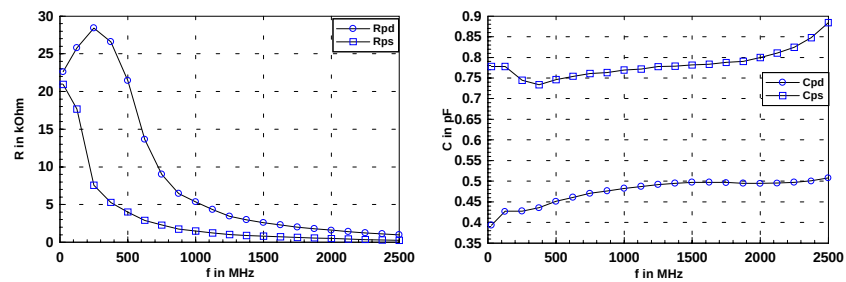
Mixer Input IF/IFX S-Parameters:

f	S11		S21		S12		S22	
MHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
25	0.445	174.3	0.248	7.5	0.247	7.9	0.444	174.3
250	0.314	150.0	0.408	8.7	0.410	9.3	0.314	149.9
500	0.280	144.9	0.426	-2.3	0.428	-1.8	0.279	145.3
750	0.285	139.6	0.417	-9.1	0.420	-8.6	0.287	141.1
1000	0.303	134.4	0.397	-14.7	0.402	-13.9	0.308	136.7
1250	0.327	128.8	0.372	-18.7	0.378	-18.4	0.335	131.0
1500	0.361	122.6	0.347	-21.6	0.353	-21.1	0.358	123.9
1750	0.401	115.0	0.322	-23.9	0.329	-23.0	0.383	116.1
2000	0.446	106.6	0.296	-24.8	0.307	-23.8	0.417	107.5
2250	0.501	98.0	0.275	-22.3	0.292	-22.3	0.461	97.4
2500	0.549	88.2	0.287	-19.1	0.305	-21.8	0.501	85.3

Mixer Input IF/IFX Impedances:

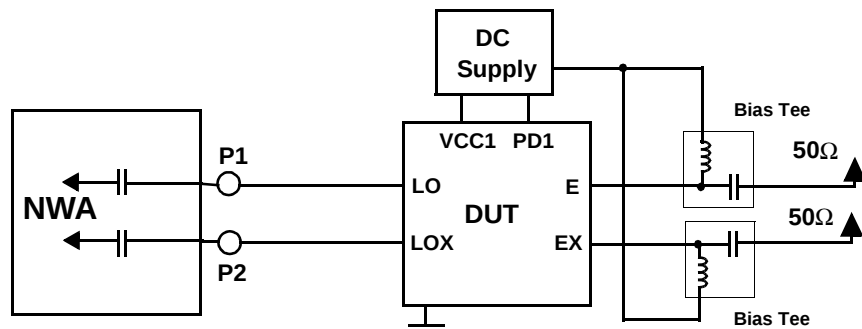


Mixer Output MO/MOX Impedances:



2.4.4 Modulator Input LO/LOX

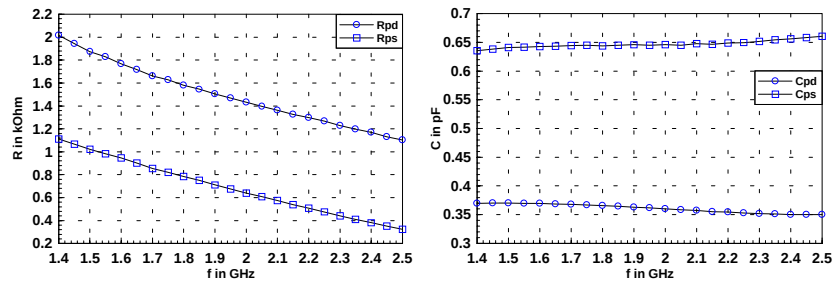
Circuit for measurement:



Modulator Input LO/LOX S-Parameters:

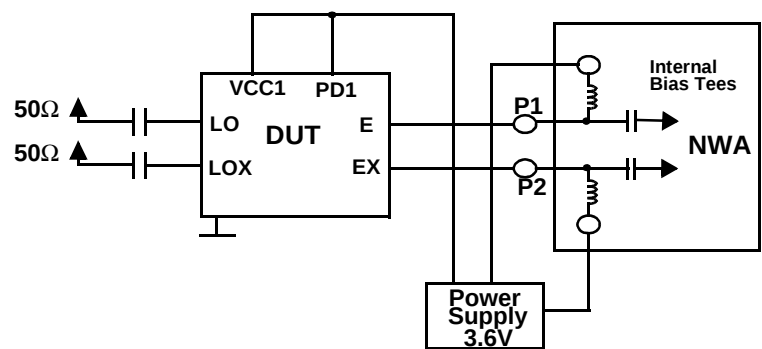
f	S11		S21		S12		S22	
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
1.4	0.915	-31.2	0.094	59.1	0.095	59.3	0.906	-29.2
1.5	0.909	-33.6	0.095	57.0	0.095	57.2	0.901	-31.6
1.6	0.904	-35.8	0.094	56.0	0.095	56.1	0.894	-34.0
1.7	0.896	-38.0	0.093	55.7	0.094	55.9	0.888	-36.2
1.8	0.889	-40.1	0.091	56.2	0.092	56.4	0.880	-38.4
1.9	0.880	-42.3	0.089	57.6	0.090	57.6	0.872	-40.5
2.0	0.870	-44.4	0.086	60.1	0.087	60.0	0.863	-42.5
2.1	0.859	-46.6	0.084	64.1	0.085	63.9	0.852	-44.5
2.2	0.845	-48.8	0.083	70.0	0.084	69.5	0.839	-46.5
2.3	0.828	-51.1	0.084	77.5	0.085	76.8	0.823	-48.4
2.4	0.808	-53.6	0.090	85.5	0.092	84.8	0.805	-50.3
2.5	0.783	-56.2	0.102	92.3	0.104	91.5	0.783	-52.3

Modulator Input LO/LOX Impedances:



2.4.5 Modulator Output E/EX

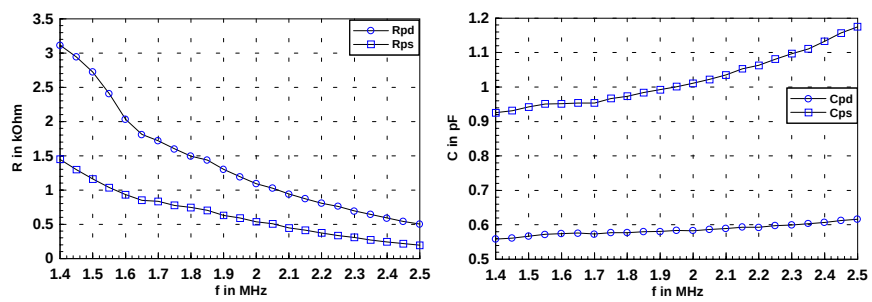
Circuit for measurement:



Modulator Output E/EX S-Parameters:

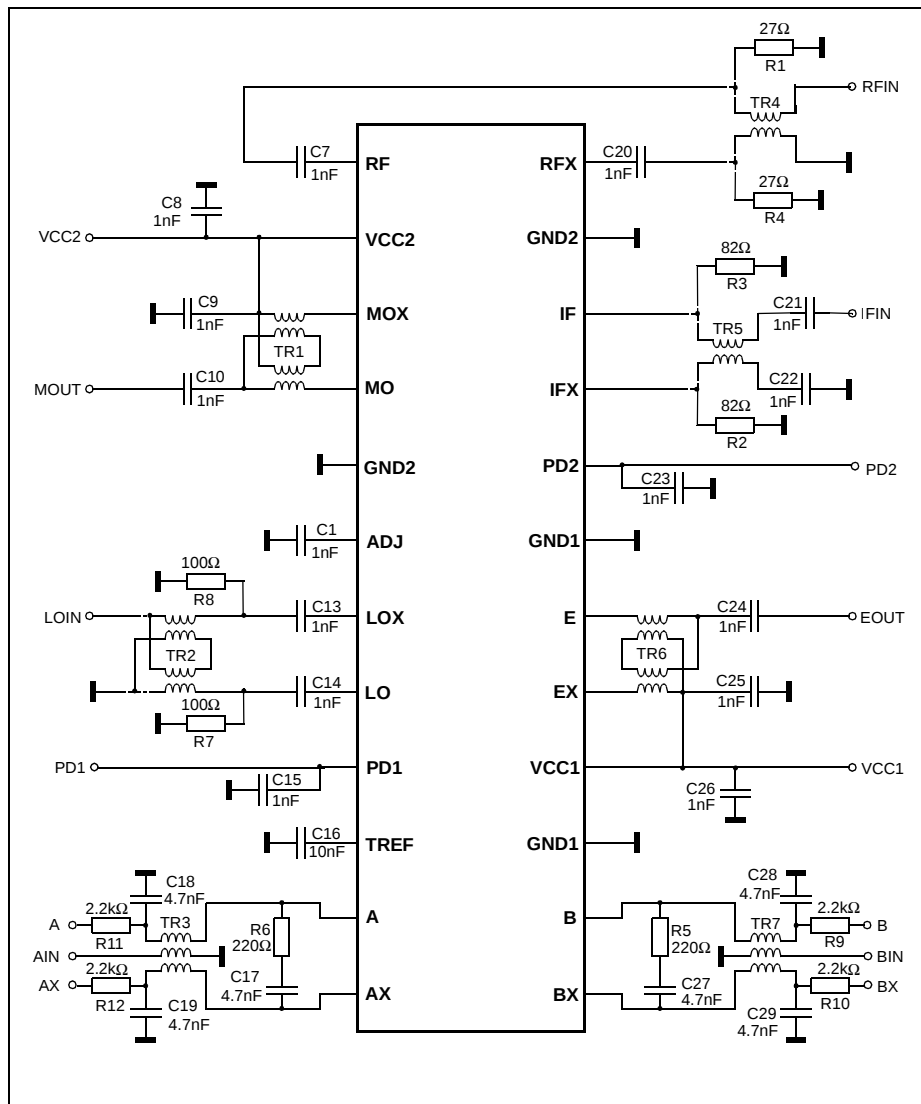
f	S11		S21		S12		S22	
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
1.4	0.933	-44.1	0.132	48.5	0.142	44.0	0.945	-44.1
1.5	0.920	-47.7	0.136	46.0	0.145	41.4	0.941	-47.8
1.6	0.906	-50.9	0.140	39.3	0.147	38.9	0.929	-51.6
1.7	0.899	-53.8	0.131	37.5	0.142	34.1	0.918	-55.3
1.8	0.893	-57.5	0.125	33.2	0.136	31.1	0.908	-58.9
1.9	0.881	-61.2	0.119	30.4	0.128	28.3	0.901	-62.4
2	0.869	-64.9	0.106	26.5	0.116	25.4	0.888	-66.2
2.1	0.852	-68.9	0.092	24.2	0.107	23.6	0.877	-70.3
2.2	0.837	-73.1	0.072	23.3	0.091	23.8	0.861	-74.5
2.3	0.817	-77.7	0.053	31.9	0.076	27.4	0.838	-79.0
2.4	0.787	-82.5	0.042	60.3	0.061	37.2	0.812	-83.8
2.5	0.759	-87.6	0.049	93.0	0.053	55.1	0.780	-88.9

Modulator Output E/EX Impedances:

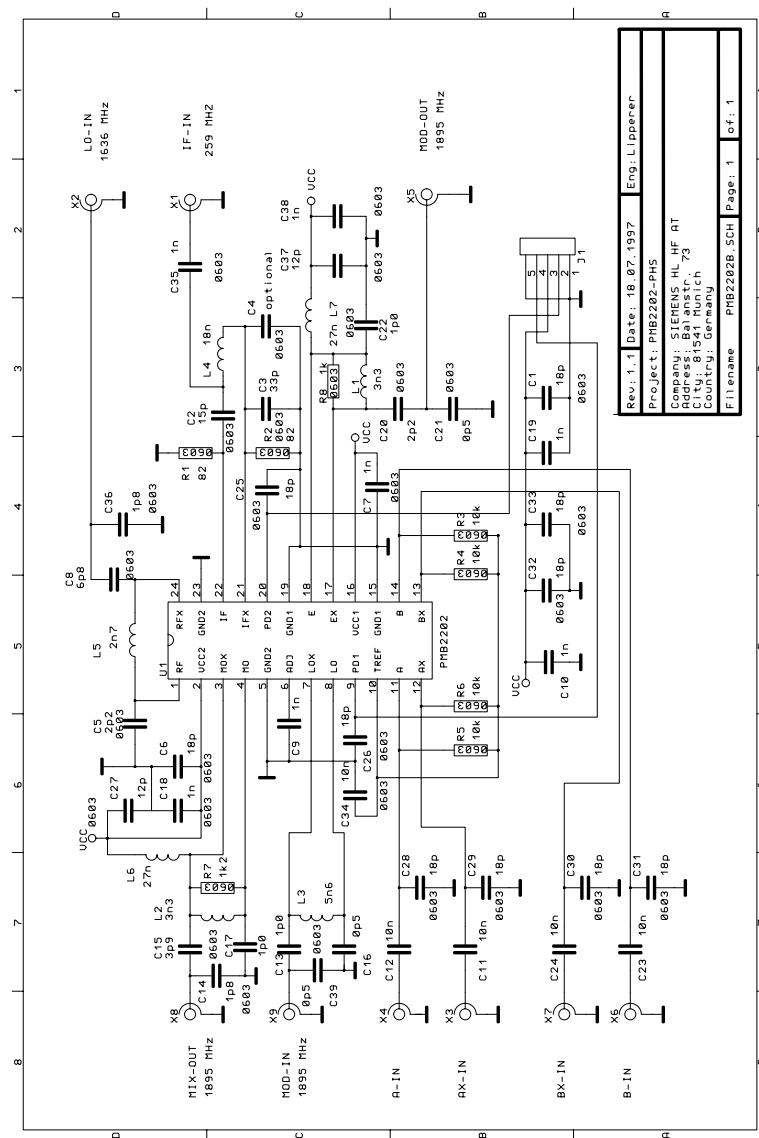


2.5 Circuits

2.5.1 Test Circuit 1



2.5.2 Application Circuit



The application circuit is designed for the following frequencies:

Mixer section:

$f_{\text{IF-IN}}$: 259 MHz

$f_{\text{LO-IN}}$: 1636 MHz - 1648 MHz

$f_{\text{MIX-OUT}}$: 1895 MHz - 1907 MHz

Modulator section:

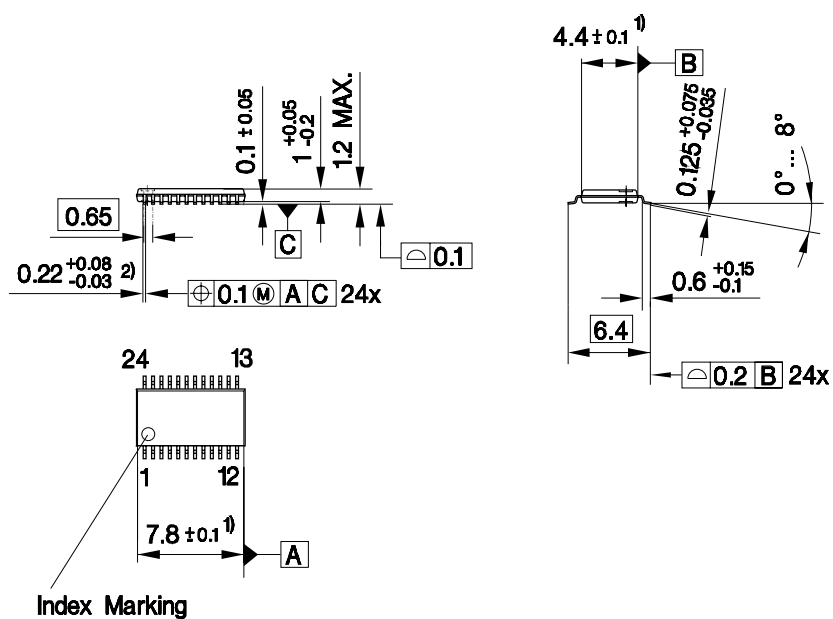
$f_{\text{MOD-IN}}$ = 1895 MHz - 1907 MHz

$f_{\text{MOD-OUT}}$ = 1895 MHz - 1907 MHz

3 Package Outlines

P-TSSOP-24

(Plastic Package)



Index Marking

- 1) Does not include plastic or metal protrusion of 0.15 max. per side
- 2) Does not include dambar protrusion of 0.08 max. per side

Sorts of Packing

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information".

SMD = Surface Mounted Device

Dimensions in mm