

GSM Receiver Circuit

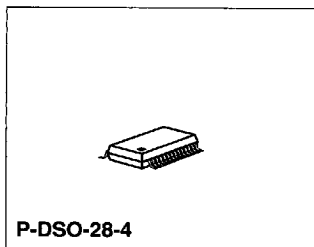
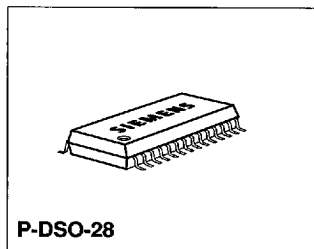
PMB 2401

Preliminary Data

Bipolar IC

Features

- Heterodyne receiver with demodulator
- Down mixing from 900 MHz receiver band to the base band
- Demodulation and generation of I/Q-baseband components
- Low mixer noise 10 dB (SSB)
- Input high intercept point + 2 dB
- Integrated 0° and 90° phase shifter
- 82 dB AGC-range
- On-chip second LO-oscillator with external tuning circuit
- Two differential operational amplifiers
- Low power consumption due to highly flexible power-down capability
- Wide input frequency range up to 1 GHz
- Wide IF-range from 35 MHz to 100 MHz
- P-DSO-28 package and P-DSO-28-4 shrink package
- Temperature range – 25 °C to 85 °C



Applications

- Digital mobile cellular systems as GSM, DAMPS, JDC
- Various demodulation schemes, such as PM, PSK, FSK, QAM, QPSK, GMSK
- Space and power saving optimizations of existing discrete demodulator circuits

Type	Version	Ordering Code	Package
PMB 2401T	V 2.1	Q67000-A6061	P-DSO-28 (SMD)
PMB 2401T	V 2.1	Q67006-A6061	P-DSO-28 (SMD, Tape + Reel)
PMB 2401S	V 2.1	Q67000-A6062	P-DSO-28-4 (Shrink, SMD)
PMB 2401S	V 2.1	Q67006-A6062	P-DSO-28-4 (Shrink, SMD, Tape + Reel)

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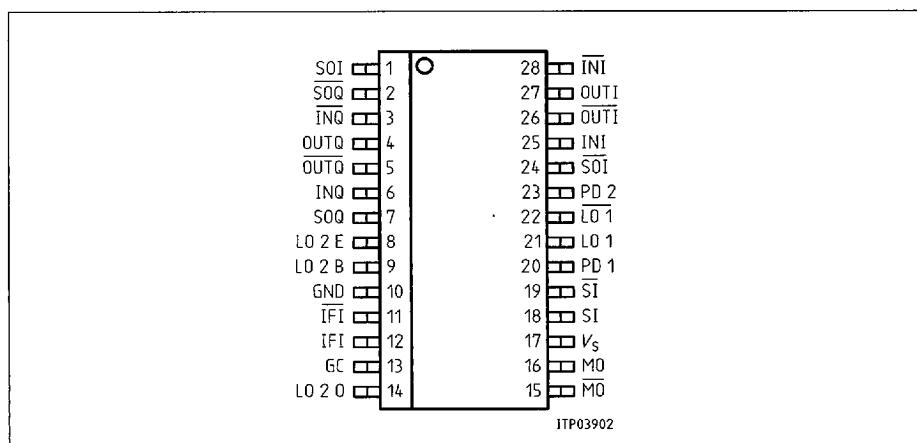
Functional Description

The PMB 2401 is a single-chip single-conversion heterodyn PM-receiver with phase shifting circuitry for the I/Q-phase baseband demodulation on chip. It also includes the second local oscillator, a gain controlled second IF-amplifier, two differential operational amplifiers for baseband filtering purposes and power down circuitry.

The PMB 2401 is designed for digital mobile telephones according to the GSM-standard and other digital systems.

Pin Configuration

(top view)



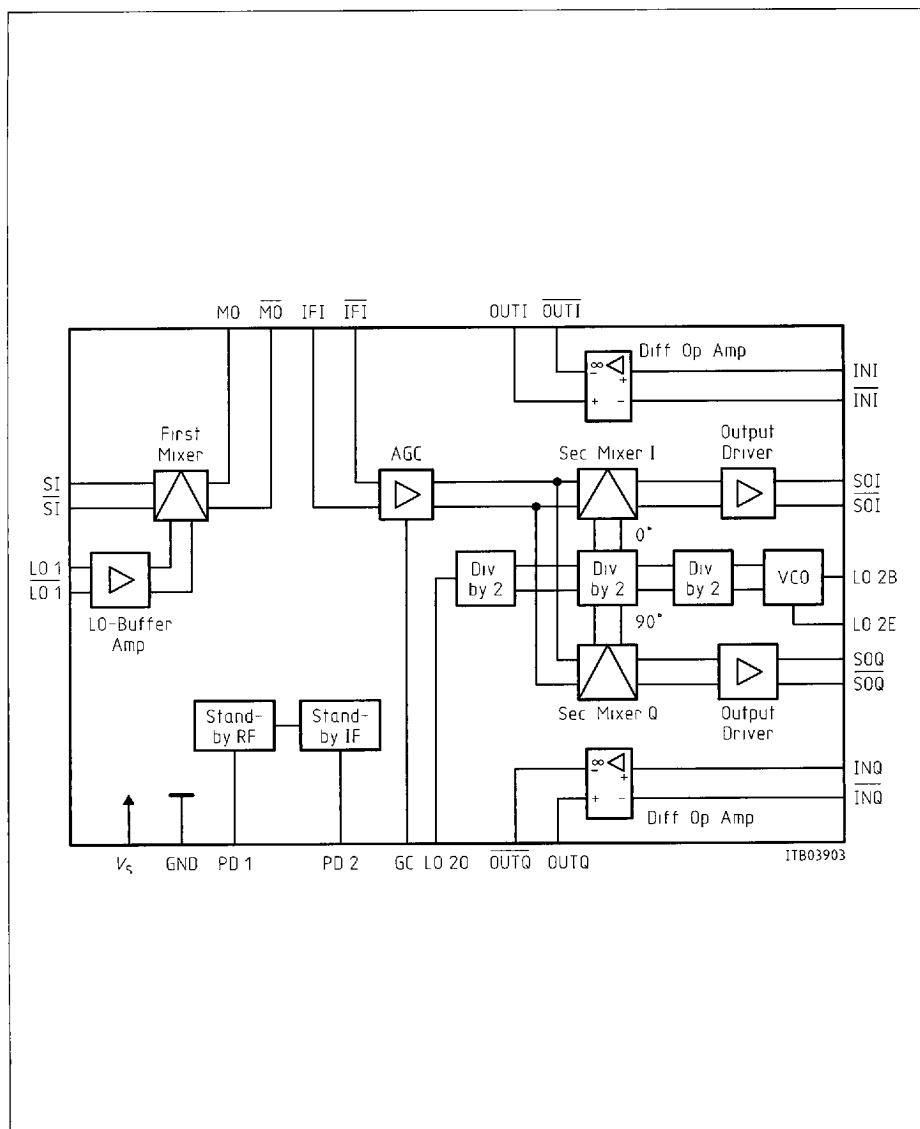
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Pin Definitions and Functions

Pin No.	Symbol	Function
1	SOI	Non-inverting in-phase signal output
2	SOQ	Non-inverting quadratur signal output
3	INQ	Inverting op. amp. signal output (Q)
4	OUTQ	Non-inverting op. amp. signal output (Q)
5	OUTQ	Inverting op. amp. signal output (Q)
6	INQ	Non-inverting op. amp. signal input (Q)
7	SOQ	Inverting quadratur signal output
8	LO2E	External capacitors for oscillator
9	LO2B	VCO-tuning circuit
10	GND	Ground
11	IFI	Inverting IF input
12	IFI	Non-inverting IF input
13	GC	Gain control input
14	LO2O	VCO-signal output
15	MO	Inverted output of first mixer
16	MO	Non-inverted output of first mixer
17	V _s	Supply voltage
18	SI	Non-inverted signal input of first mixer
19	SI	Inverted signal input of first mixer
20	PD1	Power-down input 1
21	LO1	Non-inverting input for first local oscillator
22	LO1	Inverting input for first local oscillator
23	PD2	Power-down input 2
24	SOI	Inverting in-phase signal output
25	INI	Non-inverting op. amp. signal input (I)
26	OUTI	Inverting op. amp. signal output (I)
27	OUTI	Non-inverting op. amp. signal output (I)
28	INI	Inverting op. amp. signal input (I)



Block Diagram

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Circuit Description

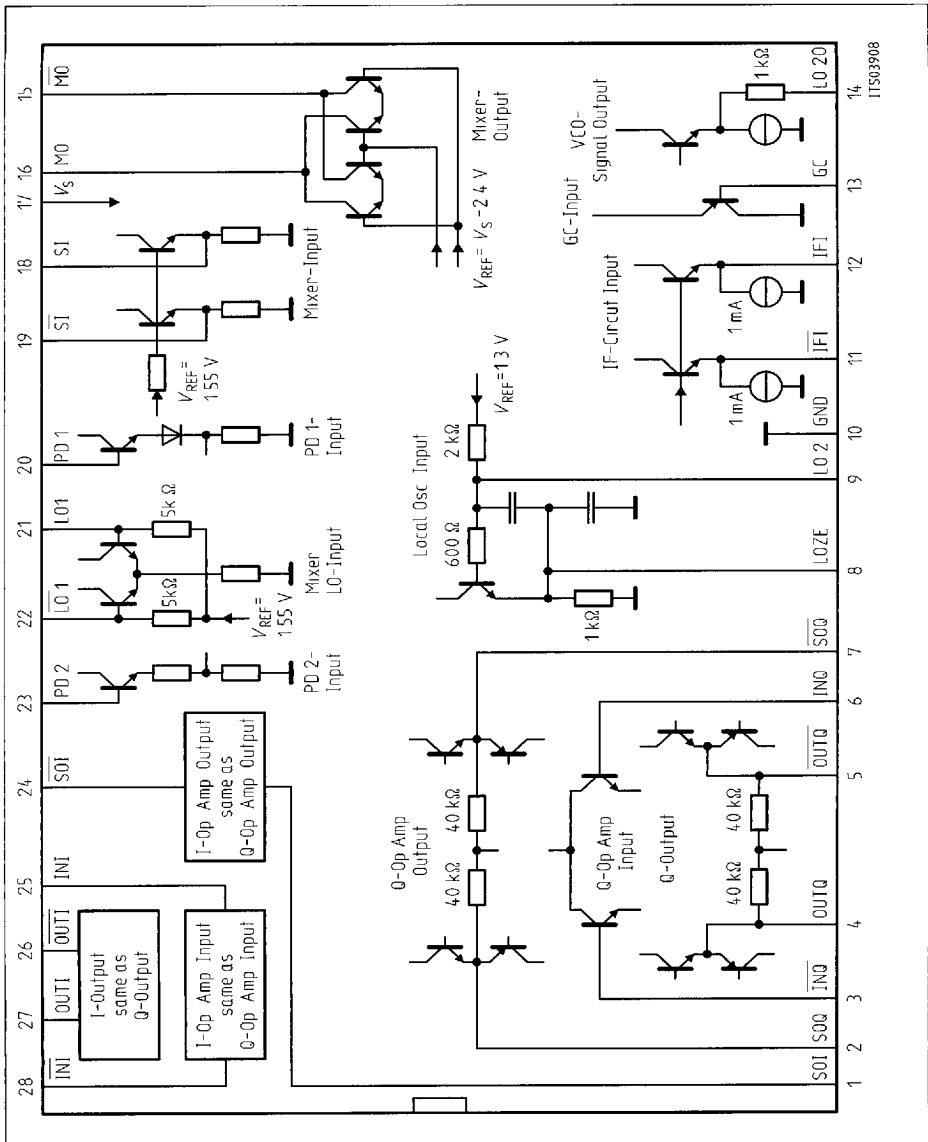
The input signal $SI/\overline{SI}$ and the amplified first local oscillator signal $LO1/\overline{LO1}$ are mixed down to an intermediate frequency (IF). The open collector output of the mixer generates a differential current at pins $MO/\overline{MO}$ which is filtered by an external resonant circuit. The resulting voltage drives an external SAW-filter.

The second local oscillator signal $LO2$ is generated in an on chip VCO and is fed to two dividers, which generate orthogonal signals at a quarter of VCO-frequency. The internal LO-signal is fed to an additionally divider, whose output signal $LO2O$ is fed to the RF-signal of PLL-synthesizer. The filtered IF-signal reenters the chip at the $IFI/\overline{IF}$ input, where it is amplified and demodulated to the final baseband output frequency with each of the orthogonal signals. The resulting in-phase and quadrature signals pass through differential output drivers and appear at $SOI/\overline{SOI}$ and $SOQ/\overline{SOQ}$ outputs, respectively. The amplification of the IF-signal before the second mixer stage is performed by a gain-controlled amplifier, the gain being determined by the voltage at the gain control input GC .

Two differential operational amplifiers with the input signals $INI/\overline{INI}$ ($INQ/\overline{INQ}$) and the output signals $OUTI/\overline{OUTI}$ ($OUTQ/\overline{OUTQ}$) can be used as active filters.

Differential signals and symmetrical circuitry are used throughout, except at the signal output. Bias drivers generate internal temperature- and supply voltage-compensated reference voltages required by various circuit blocks. Switching the power down inputs $PD1$ and $PD2$ from high to low (**see table**) sets the circuit from its normal operating mode into a mode with reduced supply current.

PD1	PD2	RF-Part	IF-Part	VCO/Dividers
L	L	OFF	OFF	ON
L	H	OFF	ON	ON
H	L	ON	OFF	ON
H	H	ON	ON	ON



Internal Input / Output Circuits

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Electrical Characteristics

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.

$T_A = -25\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		
Supply voltage	V_S	-0.5	7	V	
Input/output voltage (any except open collector)	V_{IO}	-0.5	$V_S + 0.5$	V	$V_S \leq 7\text{ V}$
		-0.5	7.5	V	$V_S \leq 7\text{ V}$
Open collector output voltage (MO/MO)	V_{OC}	-0.5	$V_S + 2.5$	V	$V_S \geq 5\text{ V}$
		-0.5	7.5	V	$V_S \geq 5\text{ V}$
Differential input voltage (any differential input)	V_I	-3	3	V	
Junction temperature	T_J		125	$^{\circ}\text{C}$	
Storage temperature	T_{stg}	-55	125	$^{\circ}\text{C}$	
Thermal resistance (junction to ambient)	$R_{th JA}$		55	K/W	P-DSO-28
				K/W	P-DSO-28-4

The pins 15, 16, 18, 19 have no additional internal ESD protection circuitry

Operational Range

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

$V_S = 4.5 \text{ V to } 5.5 \text{ V}$; $T_A = -25 \text{ }^\circ\text{C to } 85 \text{ }^\circ\text{C}$; refer to test circuit 1.

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		
SI/ $\overline{\text{SI}}$ input level	P_{SI}		- 11	dBm	
SI/ $\overline{\text{SI}}$ input frequency	f_{SI}		1000	MHz	
LO1/ $\overline{\text{LO1}}$ input level	P_{LO1}	- 11	3	dBm	
LO1/ $\overline{\text{LO1}}$ input frequency	f_{LO1}		1100	MHz	
Intermediate frequency	f_{IF}	35	100	MHz	
IFI/ $\overline{\text{IFI}}$ input level	P_{IFI}		- 24	dBm	
IFI/ $\overline{\text{IFI}}$ input frequency	f_{IFI}	35	100	MHz	
LO2 input level	P_{LO2}	- 20	0	dBm	VCO external
LO2 input frequency	f_{LO2}	140	400	MHz	
VCO frequency range	f_{VCO}	120	250	MHz	with ext. capacitors
LO2O output level	P_{LO2O}	120	180	mVpp	
LO2O output frequency	f_{LO2O}	15	50	MHz	
SOI/ $\overline{\text{SOI}}$, SOQ/ $\overline{\text{SOQ}}$ output Bandwidth	B_{SO}	0	0.8	MHz	- 3 dB roll off
GC input voltage	V_{GC}	0	2	V	
L-PD1/PD2 voltage	V_{PDL}	0	1	V	
H-PD1/PD2 voltage	V_{PDH}	4	V_S	V	

Note: Power levels are referred to resistance of 50 Ω

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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.

$V_S = 4.75$ to 5.25 V; $T_A = 25$ °C;

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Supply current	I_S	3.1	5.5	6.8	mA	PD1 = L PD2 = L	1
		12	15.5	19	mA	PD1 = L PD2 = H	
		11.5	15	18.5	mA	PD1 = H PD2 = L	
		20	24.5	30	mA	PD1 = H PD2 = L	

First Mixer Signal Input SI/ $\overline{SI}$

Input resistance	R_{SI}	17	25	33	Ω		2a
Input inductance	L_{SI}	3.5	5	6.5	nH	In series to R_{SI}	2a
Max. input level	P_{SI}	-13	-11		dBm	1 dB compr. at MO/ $\overline{MO}$	1
Input intercept Point	P_{IP1}	0	2	3	dBm	$G_{MO} = 14$ dB	1
Blocking level	P_B	-16	-14	-12	dBm	3 dB attenuation of wanted Signal at MO	1
Input interference level at $f = f_{int}$	P_{int}	-38			dBm	-98 dBm interference at $f = (f_{int} \pm f_{LO1}) \times 2$ at MO	3
Input frequency	f_{SI}			960	MHz		1
Noise figure	N_{SI}	7.5	8	9.5	dB	DSB-noise, $f_c = 900$ MHz	1
	N_{SI}	9.5	10	11.5	dB	SSB-noise, $f_c = 900$ MHz including optimum noise matching	

Output of First Mixer MO/ $\overline{MO}$ (open collector)

Output resistance	R_{MO}	11.2	16	20.8	k Ω	$f_{MO} = 45$ MHz	2c
	R_{MO}	7	10	13	k Ω	$f_{MO} = 71$ MHz	2c
Output capacitance	C_{MO}	0.7	1	1.3	pF	parallel to R_{MO}	2c
Total output current	$I_{MO + \overline{MO}}$	3.5	5	6.5	mA		1
Power gain from Signal input	G_{MO}		13	14	dB		1
Intermediate frequency	f_{IF}	35		100	MHz		1

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AC/DC Characteristics (cont'd)

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

Input of First Mixer Local Oscillator LO1/ $\overline{\text{LO1}}$

Input resistance	R_{LO1}	490	700	910	Ω	$f_{\text{LO1}} = 900 \text{ MHz}$	2a
Input capacitance	C_{LO1}	0.7	1	1.3	pF	parallel to R_{LO1}	2a
Input level	P_{LO1} V_{LO1}	-11 178		3 890	dBm mVpp	see diagram 1	1 1
Input frequency	f_{LO1}			1100	MHz		1

Isolation of First Mixer

From SI to MO	$A_{\text{SI-MO}}$	30			dB	$f_{\text{SI}} = 945 \text{ MHz};$ $f_{\text{LO1}} = 900 \text{ MHz}$	1
SI to LO1	$A_{\text{SI-LO1}}$	60			dB	$f_{\text{SI}} = 945 \text{ MHz};$ $f_{\text{LO1}} = 900 \text{ MHz}$	1
LO1 to MO	$A_{\text{LO1-MO}}$	50			dB	$f_{\text{SI}} = 945 \text{ MHz};$ $f_{\text{LO1}} = 900 \text{ MHz}$	1
LO1 to SI	$A_{\text{LO1-SI}}$	60			dB	$f_{\text{SI}} = 945 \text{ MHz};$ $f_{\text{LO1}} = 900 \text{ MHz}$	1
MO to SI	$A_{\text{MO-SI}}$	50			dB	$f_{\text{SI}} = 945 \text{ MHz};$ $f_{\text{LO1}} = 900 \text{ MHz}$	1
MO to LO1	$A_{\text{MO-LO1}}$	65			dB	$f_{\text{SI}} = 945 \text{ MHz};$ $f_{\text{LO1}} = 900 \text{ MHz}$	1

IF Input IFI/ $\overline{\text{IF1}}$

Input resistance	R_{IFI}	63	90	117	Ω		2a
Input capacitance	C_{IFI}	0.35	0.5	0.65	pF	parallel to R_{IFI}	2a
Max. input level	P_{IFI} V_{IFI}		-17 89		dBm mVpp	$V_{\text{GC}} = 2 \text{ V}, 1 \text{ dB compr. at SO};$ see diagram 4	1 1
Input intercept point	P_{IP1}	see diagram 5					1
Input frequency	f_{SI}	35		100	MHz		1
Noise figure	N_{SI}	10	11	14	dB	SSB-noise	1

Input for Second Local Oscillator LO2 (VCO external)

Input resistance	R_{LO2}	1.9 1.3	2.4 1.8	3.1 2.3	k Ω k Ω	$f_{\text{LO2}} = 180 \text{ MHz}$ $f_{\text{LO2}} = 360 \text{ MHz}$	2b 2b
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AC/DC Characteristics (cont'd)

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Input capacitance	C_{LO2}	0.7	1	1.3	pF		2b
Input level	P_{LO2} V_{LO2}	-20 63		0 630	dBm mVpp	into 50 Ω	1.1 1.1
Input frequency	f_{LO2}	140		400	MHz		1.1

Voltage Controlled Oscillator VCO (LO2)

VCO-frequency	f_{VCO}	120		250	MHz	with ext. capacitors	1.2
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VCO Output LO2O

Output resistance	R_{LO2O}	0.9	1.2	1.5	k Ω		
Output capacitance	C_{LO2O}	0.7	1	1.3	pF		
Output level	V_{LO2O}	150 120	160 140		mVpp mVpp	IF $\leq$ 75 MHz IF $\geq$ 75 MHz	1 1
Output frequency	f_{LO2O}	15		50	MHz		1

Signal Outputs SOI/ $\overline{SOI}$, SOQ/ $\overline{SOQ}$

Output resistance	R_{SO}	175	250	325	Ω		
Output capacitance	C_{SO}	0.7	1	1.3	pF		
SO frequency roll off	f_{SO}		800		kHz	see diagram 6	
DC output level	V_{SO}	2.0		2.5	V		1
Diff. output offset voltage	$V_{SO/\overline{SO}}$			28	mV	between I/ $\overline{I}$ or Q/ $\overline{Q}$	1
Voltage gain from IF to I/Q-output	G_{SO}	70 -12	74 -8	78 -4	dB dB	$V_{GC} = 0$ V $V_{GC} = 2$ V	see diagram 2 + 3 1

Gain Control Input GC

GC-input voltage	V_{GC}	0		2	V		1
GC-input current	$-I_{GC}$			1	μ A	0 V $\leq V_{GC} \leq 2$ V	1
Gain control factor	F_{GC}		40		dB/V	$F_{GC} = dG_{SO}/dV_{GC}$ see diagram 3	1

AC/DC Characteristics (cont'd)

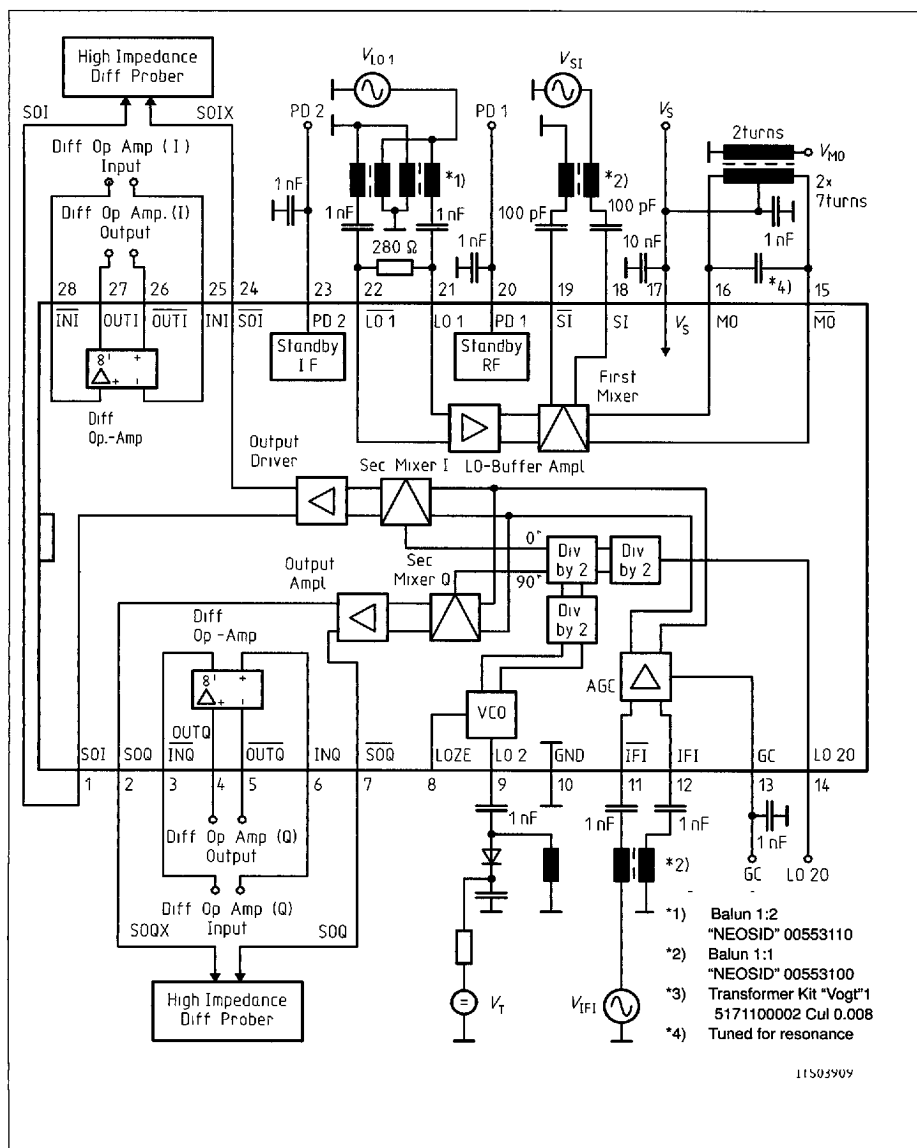
Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

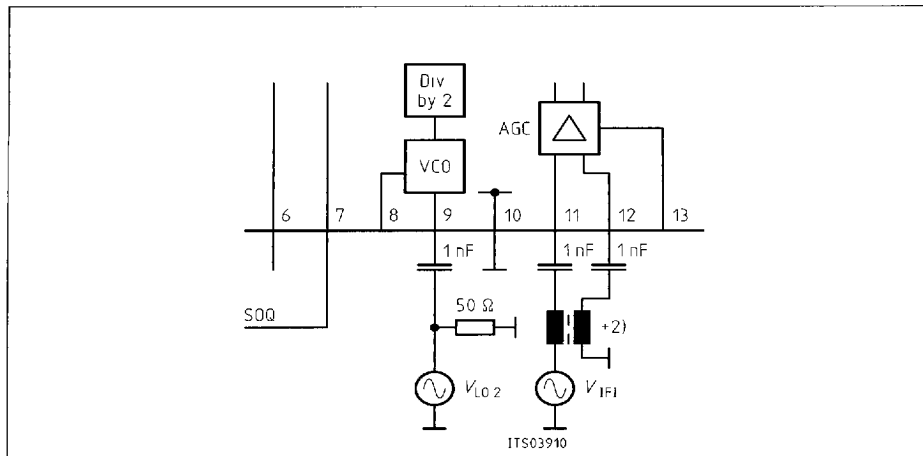
Power-Down Inputs PD1, PD2

L-PD input voltage	V_{PDL}	0		1	V		1
L-PD input current	I_{PD1L} I_{PD2L}			0.1 0.2	μA μA	$0 \leq V_{PD1,2L} \leq 1 V$	1
H-PD input voltage	V_{PDH}	4		V_S	V		1
H-PD input current	I_{PDH}			10	μA	$4 \leq V_{PD1,2L} \leq V_S$	1

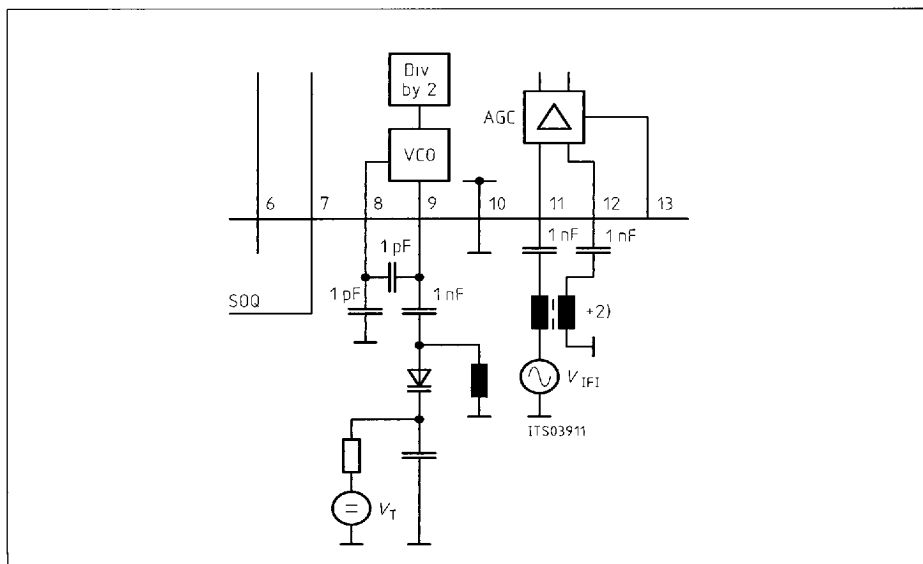
Differential Operational Amplifier (open loop)

Slew rate	SR		4.6		V/ μs		1
Gain Bandwidth Prod.	GBW		12		MHz		1
Voltage gain	A_{Vo}		55		dB		1
Phase margin	Φ_R		60		degr.		1
Gain margin	A_R		14		dB		1
Common mode Rejection Ratio	$CMRR$		58		dB		1
Offset voltage	V_{OFF}		1		mV		1
Output voltage	V_{OUT}	0.8		$V_S - 1$	V		1





Test Circuit 1.1

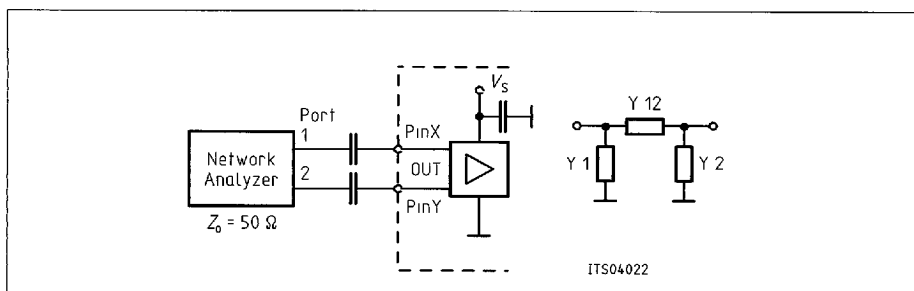


Test Circuit 1.2

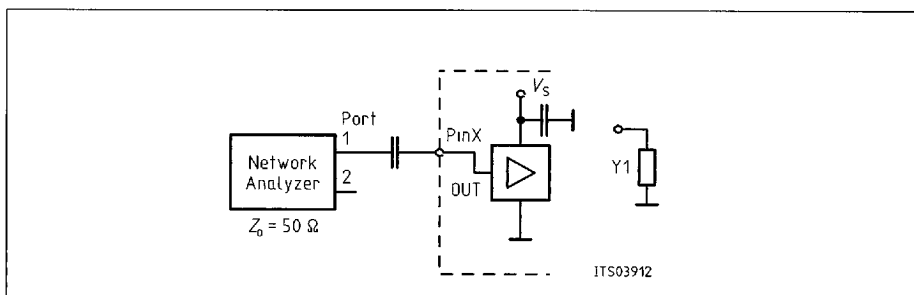
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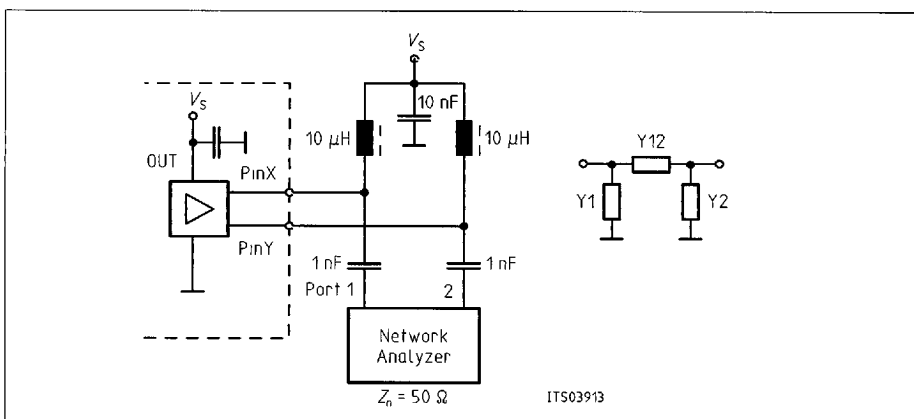
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Test Circuit 2a



Test Circuit 2b



Test Circuit 2c

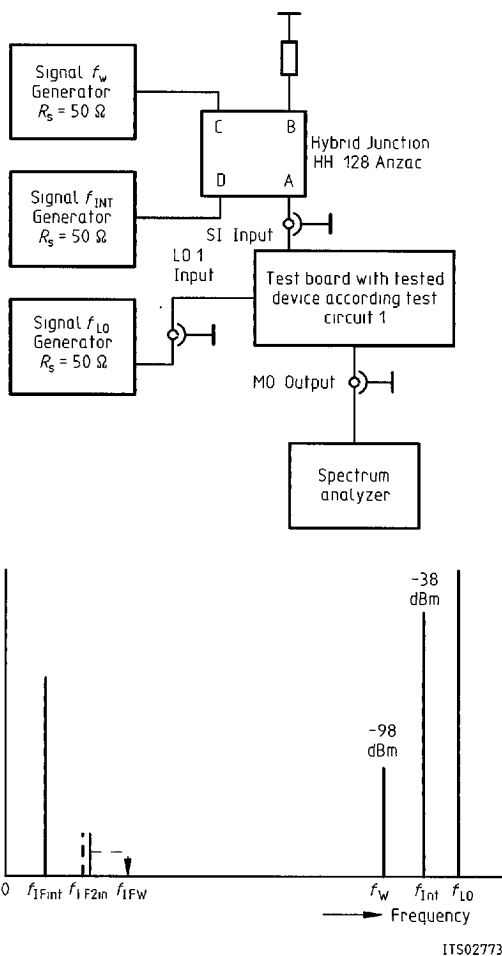
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The S-parameters are tested at the indicated frequency and the equivalent parallel or series circuit is calculated on this base.

Test Point	Test Circuit	Test Frequency / MHz	Pin x	Pin y
LO1-input impedance	2a	900	21	22
SI-input impedance	2a	900	18	19
IFI-input impedance	2a	45 ... 90	11	12
LO2-input impedance	2b	180, 360	9	—
MO-output impedance	2c	45, 71	15	16

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Test Circuit 3

f_W = wanted input signal from received channel

f_{int} = unwanted interfering signal within band : $f_{int} = f_{LO} - f_{IF} / 2$

f_{LO} = local oscillator signal

f_{IFW} = wanted IF signal from received channel = $f_{LO} - f_W$

f_{IF1} = unwanted IF / 2 signal from interfering channel: $f_{IF1} = f_{LO} - f_{int}$

f_{IF2n} = unwanted harmonic signal of f_{IF1} : $f_{IF2n} = 2 \times f_{IF1}$

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Diagram 1

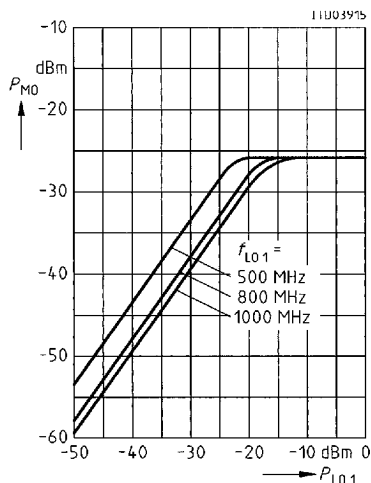
First Mixer Gain versus LO-Level P_{LO1} $P_{SI} = -40$ dBm, $f_{MO} = 45$ MHz

Diagram 2

Gain Control Characteristic Output Level

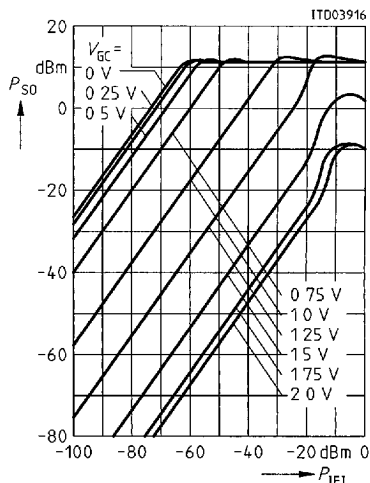
 P_{SO} versus input Level P_{IF1} 

Diagram 3

Gain Control Characteristic Voltage Gain

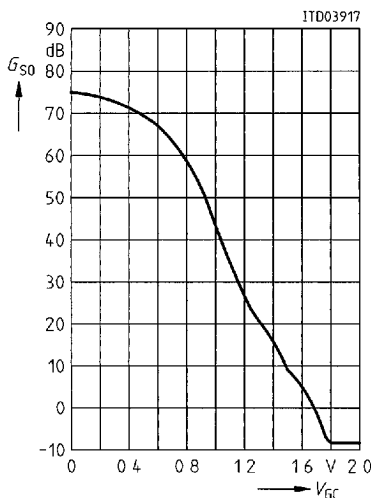
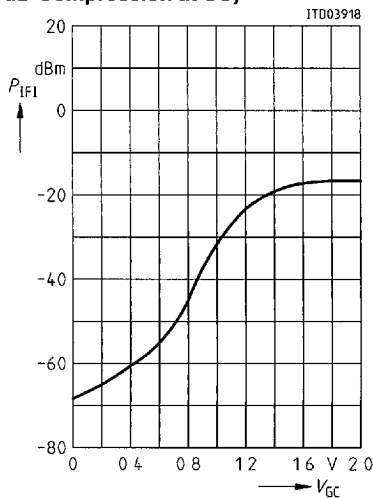
 G_{SO} versus GC-Voltage V_{GC} 

Diagram 4

Gain Control Characteristic

Max. Input Level P_{IF1} versus GC-Voltage V_{GC} :
(1 dB Compression at SO)

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Diagram 5
Gain-Control Characteristic Input Intercept
Point P_{IP1} versus GC-Voltage V_{GC}

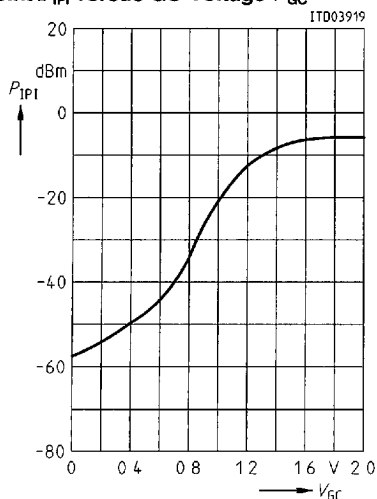
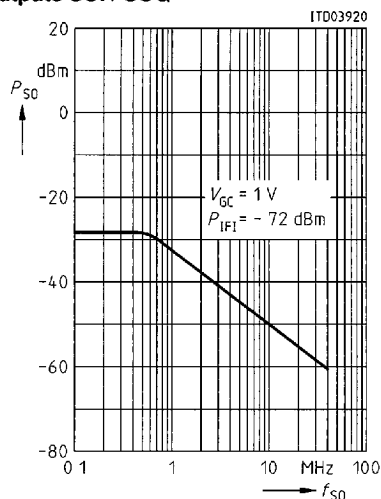


Diagram 6
Frequency Transfer Characteristic of
Outputs SOI / SOQ



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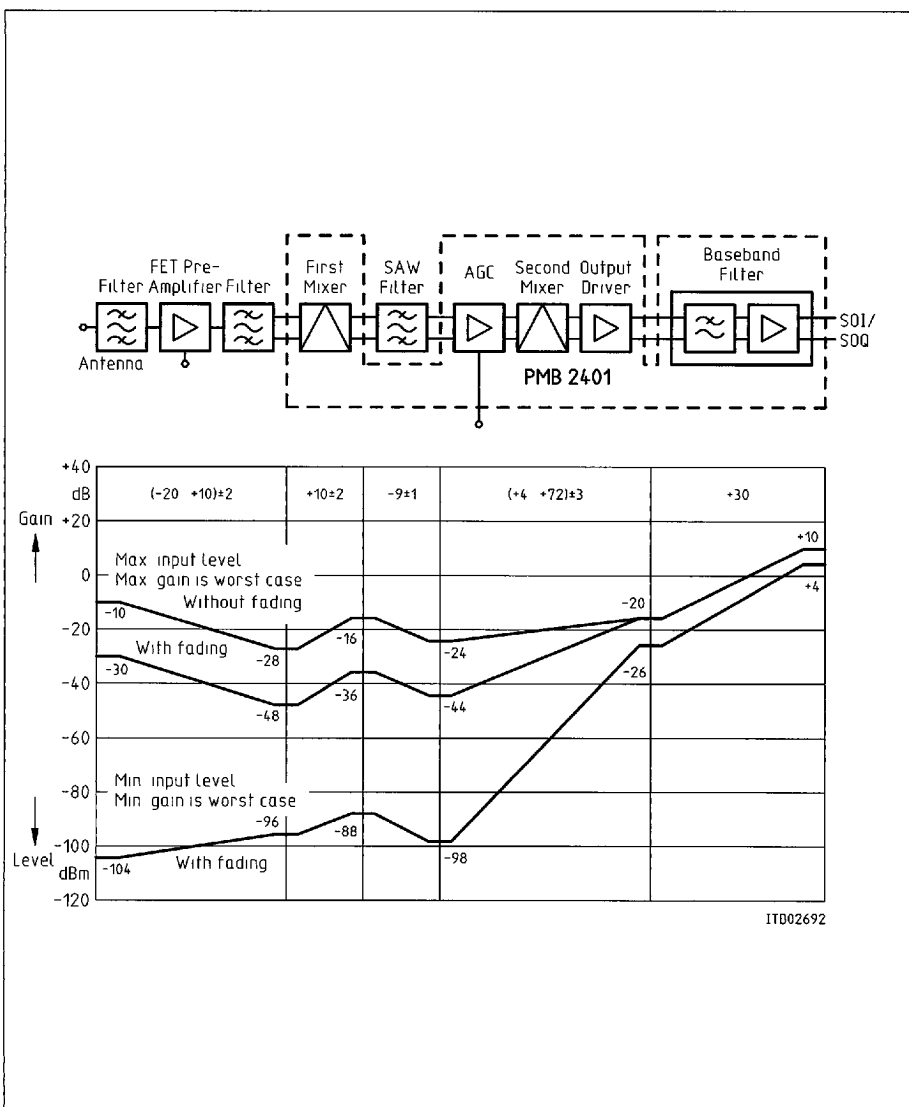


Diagram 7
Worst-Case Signal Levels without Blocking Level

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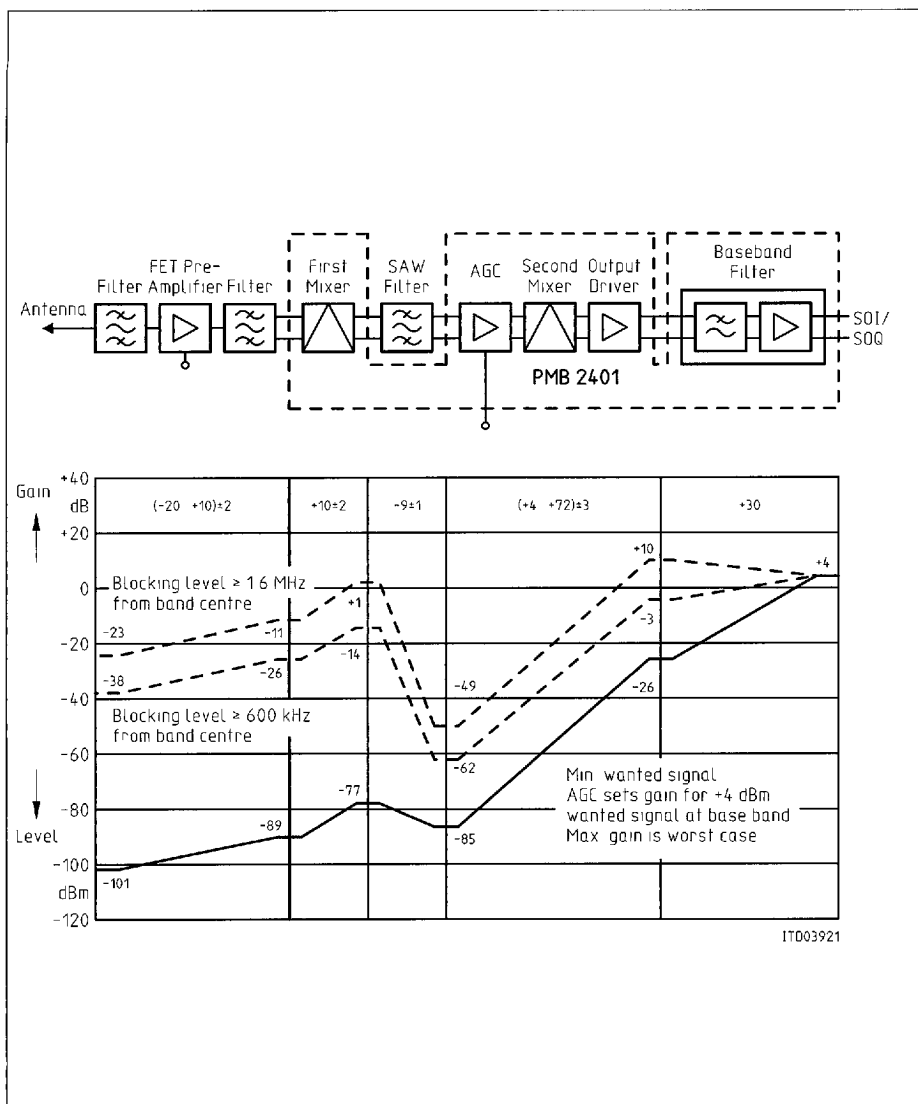


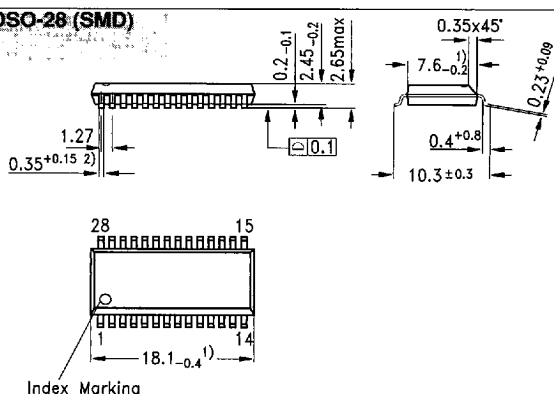
Diagram 8
Worst-Case Signal Levels with Blocking Level

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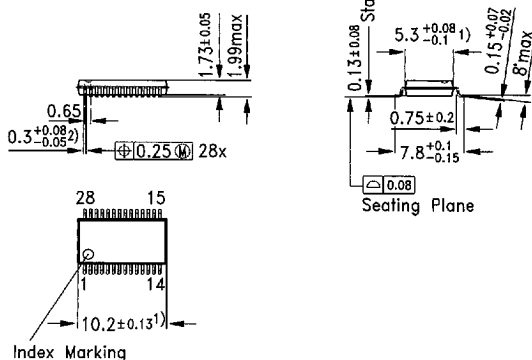
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Package Outlines

Plastic Package, P-DSO-28 (SMD)
(Dual-Small-Outlines)

- 1) Does not include plastic or metal protrusions of 0.15 max per side
2) Does not include dambar protrusion of 0.05 max per side

GPS05123

Plastic Package, P-DSO-28-4 (Shrink) (SMD)
(Dual-Small-Outlines)

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

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Sorts of Packing

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

SMD = Surface Mounted Device

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Dimensions in mm

B115-H6698-
G1-X-1600