ICs for Communications

Mixer DC - 1.6GHz and Vector Modulator with AGC 1.4-1.6GHz

PMB 2212

Specification 05.99

Edition 05.99

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Ausgabe 05.99

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PMB 2212 **Revision History:** **Current Version: 05 .99**		
Previous Version: Preliminary Specification 12/98		
Page (previous version)	Page (current version)	Subjects (major changes since last revision)
13	13	#13: Operational Range of Gain Control Voltage V_{GC}=0.3V to 2.0V
14	14	#1: Supply Current of Low Gain Mode V_{GC}=0.4V
17	17	#21: Output Power of Low Gain Mode V_{GC}=0.4V, Limits: min. and max.
17	17	#30: Gain Control Voltage $V_{GC\ min}$=0.4V
17	17	#31: Gain Control Input Current V_{GC}=0.4V, Limits: min. and max.
20	20	Optimized Application Circuit

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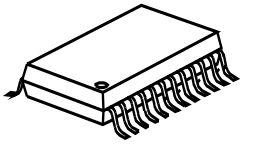
Version 3.1 **Bipolar IC**

1 Overview



P-TSSOP-24

1.1 Features

- Up-conversion mixer, direct quadrature modulator and AGC on one chip
- Mixer:
- double-balanced Gilbert cell
- low noise
- Modulator and AGC:
- single ended AGC output
- LO input frequency range from 1.4 to 1.6 GHz
- generation of orthogonal carriers without external elements and without trimming
- maximum AGC output power -2dBm
- analog gain control with a dynamic range of 40dB
- low current consumption regulated over the dynamic range
- 40dB carrier suppression with $1V_{pp}$ baseband level
- 45dB SSB suppression
- 45dB rejection of third-order intermodulation products with $1V_{pp}$ baseband level
- Supply voltage range from 2.7 to 4.5V
- Power-down mode separate for mixer, modulator with AGC
- P-TSSOP-24 package with 0.5 pitch
- Temperature range -30 to 85°C

1.2 Applications for the PMB 2212

- Vector-modulated digital mobile cellular systems, such as PDC-1.5 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 2212		P-TSSOP-24

1.3 Functional Description

The PMB 2212 contains an up-conversion mixer, a direct quadrature modulator and an AGC (Analog Gain Control).

The mixer combines the signals at the LOIN and IFIN inputs. The inverted inputs can be blocked to the external ground.The resulting signal is available at the MIXOUT / MIXOUTX output. In a typical application, the wanted mixer output product is band-pass filtered and fed to the modulator input MODIN / MODINX or to an external load.

The modulator generates two orthogonal carriers, which are mixed with the baseband modulation signals A / AX and B / BX in Gilbert multipliers. The outputs of the multipliers are added and fed to the AGC internally.

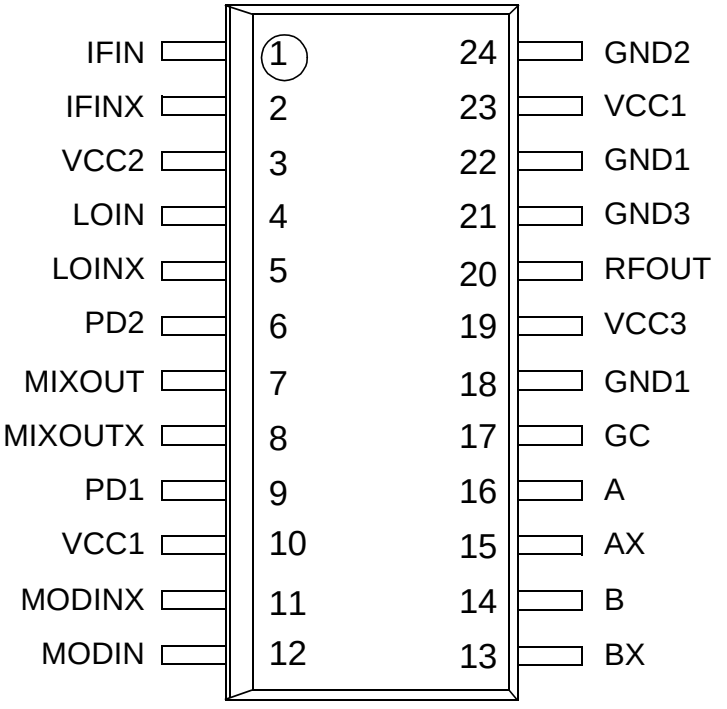
The output power of the AGC is continuously adjustable by a gain-control voltage connected to the GC pin.

The mixer, the modulator including the AGC core and the output stage of the AGC have separate power supplies.

The mixer, the modulator and the AGC can be powered down independently. The power-down concept enables the modulator / AGC to be used with or without the mixer.

1.4 Pin Configuration

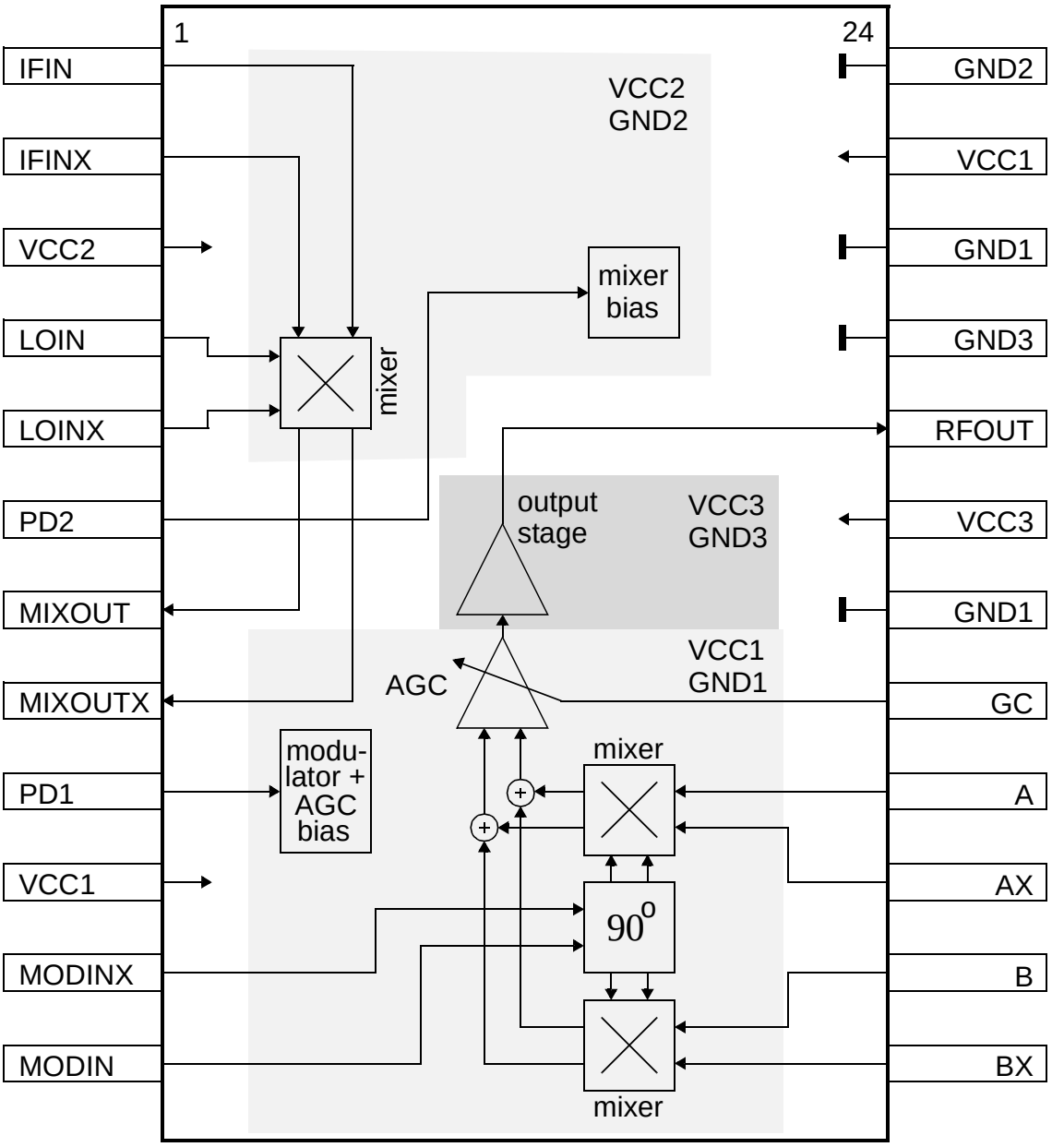
(top view)



1.5 Pin Definitions and Functions

Pin No.	Symbol	Function
1	IFIN	mixer IF input
2	IFINX	mixer IF input (inverted)
3	VCC2	supply voltage of mixer
4	LOIN	mixer LO input
5	LOINX	mixer LO input (inverted)
6	PD2	power down for mixer
7	MIXOUT	mixer output
8	MIXOUTX	mixer output (inverted)
9	PD1	power down for modulator and AGC
10	VCC1	supply voltage of modulator and AGC core
11	MODINX	modulator input (inverted)
12	MODIN	modulator input
13	BX	modulation input BX (inverted)
14	B	modulation input B
15	AX	modulation input AX (inverted)
16	A	modulation input A
17	GC	gain control input
18	GND1	ground of modulator and AGC core
19	VCC3	supply voltage of AGC output stage
20	RFOUT	AGC output
21	GND3	ground of AGC output stage
22	GND1	ground of modulator and AGC core
23	VCC1	supply voltage of modulator and AGC core
24	GND2	ground of mixer

1.6 Functional Block Diagram



1.7 Circuit Description

The up-conversion mixer is a fully-balanced Gilbert cell with symmetrical inputs and output.

The inputs are high impedanced and biased internally. The LOIN / LOINX input is ac-coupled. In a typical application the inputs IFIN and LOIN can be driven single ended by blocking the inverted inputs IFINX and LOINX against ground. The transfer function from the IFIN input to the mixer output is linear for input levels below the 1dB compression point. The input level at LOIN has to be high enough to ensure proper switching of the differential transistor pairs.

The mixer output MIXOUT / MIXOUTX is a high impedanced open collector output which has to be connected to the supply rail externally.

The modulator with AGC performs a direct quadrature modulation. The output power of the modulated signal is continuously adjustable.

The differential modulator input MODIN / MODINX is high impedanced and biased internally.

The baseband signals are fed to the modulation inputs A / AX / B / BX. These inputs are the high impedanced inputs of an emitter coupled transistor pair with no internal biasing.

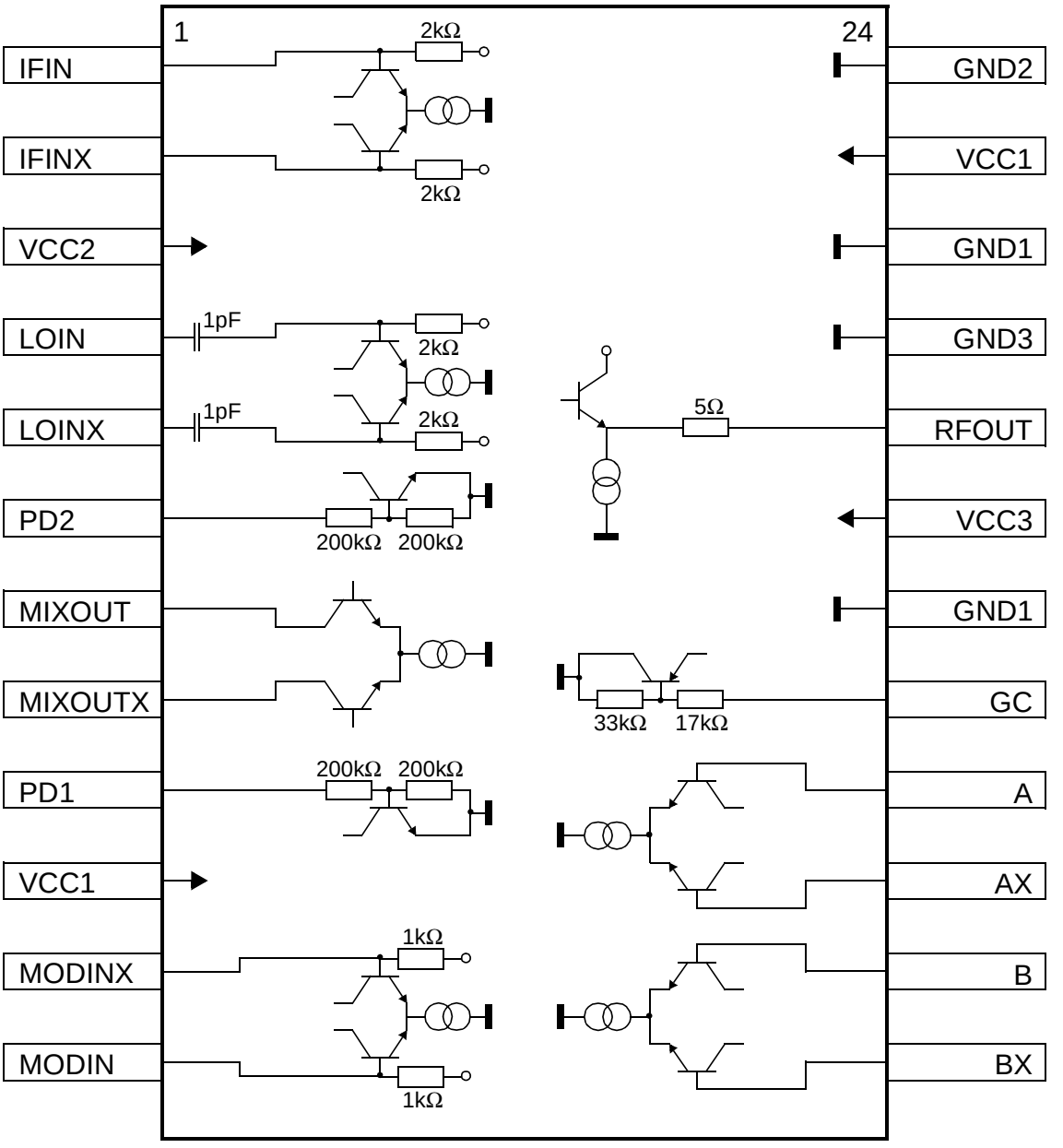
The input resistance of the gain control voltage pin GC is typically 50kΩ.

The AGC has a low impedanced, single ended output RFOUT. The output has to be ac-coupled externally.

The mixer is connected to the supply pins GND2 and VCC2. The modulator and the AGC core have the same supply pins GND1 and VCC1. The output stage of the AGC has the separated supply pins GND3 and VCC3.

Applying a logic LOW to PD1 powers down the modulator and the AGC, including their bias circuit. Applying a logic LOW to PD2 powers down the mixer, including its bias circuit. Depending on the application, the power-down pins can be combined or separately fixed to supply rails.

1.8 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}	-0.3	5.0	V	
2	Input voltage	V_I	-0.3	V_{CC}+0.3 5.0	V	$V_{CC} \leq 4.7V$ $V_{CC} > 4.7V$
3	Differential input voltage	$V_I - V_{IX}$	-0.8 -2.0	0.8 2.0	V	DC stress AC stress
4	Output voltage MIXOUT	V_{MIXOUT}	-0.5	V_{CC}+0.5	V	
5	Output voltage RFOUT	V_{RFOUT}	-0.3 V_{CC}-3.5 V_{CC}-3.5	V_{CC}+0.3 V_{CC}+0.3 5.0	V	$V_{CC} \leq 3.2V$ $V_{CC} > 3.2V$ $V_{CC} \leq 4.7V$ $4.7V < V_{CC}$
6	Junction temperature	T_j		125	°C	
7	Storage temperature	T_S	-55	125	°C	
8	Thermal resistance (junction to lead)*	R_{thJL}		180	K/W	
9	Thermal resistance (junction to ambient)*	R_{thJA}		165	K/W	
10	ESD integrity	V_{ESD}	-1	1	kV	according MIL-STD 883D, method 3015.7 and EOS/ ESD assn. standard S5.1-1993

* Application hint

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_{CC} = 2.7 to 4.5V, ambient temperature T_A = -30 to 85°C

#	Parameter	Symbol	Limit Values		Units	Remarks
			Min	Max		
Control inputs PD1, PD2						
1	LOW input voltage	V_{IL}	0	0.8	V	
2	HIGH input voltage	V_{IH}	2.1	V_{CC}	V	
Mixer						
3	LO input frequency	f_{LOIN}	0	1.8	GHz	
4	LO input level	P_{LOIN}	-10	0	dBm	
5	IF input frequency	f_{IFIN}	0	200	MHz	
6	IF input level	P_{IFIN}		-9	dBm	
7	MIXOUT output frequency	f_{MIXOUT}	0	1.6	GHz	
Modulator						
8	MODIN input frequency	f_{MODIN}	1.4	1.6	GHz	
9	MODIN input level	P_{MODIN}	-15	0	dBm	
10	A, AX, B, BX input frequency	f_A, f_B	0	10	MHz	
11	A, AX, B, BX input level	V_A, V_{AX}, V_B, V_{BX}	1.4	V_{CC}–0.6	V	DC+AC
12	A-AX, B-BX differential input level	$V_{A\text{-}AX}$, $V_{B\text{-}BX}$		1	V_{pp}	AC
AGC						
13	GC	V_{GC}	0.3	2.0	V	

Note: Power levels are meant to be voltage at pin referred to an impedance of 50Ω.

2.3 AC/DC Characteristics

Supply voltage V_{CC} = 2.7 to 4.5V, ambient temperature T_A = +25°C

#	Parameter	Symbol	Limit Values			Units	Test Conditions	Test Circuit
			Min	Typ	Max			
Supply currents: T_A =+25°C, V_{CC}=3.6V								
1	Supply current PD1=PD2=high High gain mode V_{GC}=1.8V	I_{VCC1} I_{VCC2} I_{VCC3}	18 9.5 6.5	22 12 8.5	27.5 15 10.5	mA mA mA	PD1/2=H	
	Supply current PD1=PD2=high Low gain mode V_{GC}=0.4V	I_{VCC1} I_{VCC2} I_{VCC3}	15.5 9.5 1.5	19 12 2	23.5 15 2.5	mA mA mA	PD1/2=H	
	Supply current PD1=high, PD2=low High gain mode V_{GC}=1.8V	I_{VCC1} I_{VCC2} I_{VCC3}	18 6.5	22 8.5	27.5 10 10.5	mA uA mA	PD1=H PD2=L	
	Supply current PD1=low, PD2=high High gain mode V_{GC}=1.8V	I_{VCC1} I_{VCC2} I_{VCC3}	 9.5	 12	10 15 10	uA mA uA	PD1=L PD2=H	
2	Supply current PD1=low, PD2=low	I_{VCC1} I_{VCC2} I_{VCC3}			10 10 10	µA µA µA	PD1/2=L	
Control inputs PD1and PD2								
3	LOW input current	I_{IL}		2	4	µA	V_{IL}=0.8V	
4	HIGH input current	I_{IH}		9	18	µA	V_{IH}=2.1V	
5	Power-up settling time for modulator / AGC*	t_{PU}		4		µs		app. cct.

* Application hint

AC/DC Characteristics (cont'd)

Supply voltage V_{CC} = 2.7 to 4.5V, ambient temperature T_A = +25°C

#	Parameter	Symbol	Limit Values			Unit	Test Conditions	Test Circuit
			Min	Typ	Max			
Mixer input IFIN:								
6	Single ended Input Impedance*	R_{IFIN} || C_{IFIN}		1.2 1.6		kΩ pF	*f*=178MHz	app. cct.
Mixer input LOIN:								
7	Single ended Input Impedance*	R_{LOIN} || C_{LOIN}		0.32 1.1		kΩ pF	*f*=1.619GHz	app. cct.
Mixer output MIXOUT: P_{IF}= -12dBm, P_{LO}= -5dBm								
8	Differential Output Impedance*	R_{MIXOUT} || C_{MIXOUT}		8.8 0.6		kΩ pF	*f*=1.441GHz	app. cct.
9	Output power**	P_{MIXOUT}	-13	-9.5	-6.5	dBm		
10	Gain*	G_{MIXOUT}		2.5		dB		app. cct.
11	1dB compression point refer to IF input level*	P_{IF1dB}		-8		dBm		app. cct.
12	Noise figure*	N_{IF_MIX}		13.3		dB	DSB	app. cct.
13	Carrier suppression	a_{C_MIX}	20	25		dBc		app. cct.

* Application hint
** Application hint: output power with power matching

Note: Power levels are meant to be voltage at pin referred to an impedance of 50Ω.

AC/DC Characteristics (cont'd)

Supply voltage V_{CC} = 2.7 to 4.5V, Ambient temperature T_A =+25°C

#	Parameter	Symbol	Limit Values			Unit	Test Conditions	
			Min	Typ	Max			
Modulator input MODIN:								
14	Differential Input Impedance*	$R_{MODIN-MODINX}$ || $C_{MODIN-MODINX}$		1.1 0.55		kΩ pF	*f*=1.441GHz	app. cct.
15	Single ended Input Impedance*	$R_{MODIN/MODINX}$ || $C_{MODIN/MODINX}$		0.4 0.9		kΩ pF	*f*=1.441GHz	app. cct.
16	Internal DC voltage	V_{MODIN} V_{MODINX}	V_{CC}-0.9	V_{CC}-0.8	V_{CC}-0.7	V		
Modulator inputs A/AX and B/BX: $V_A = V_{AX} = V_B = V_{BX}$ = 1.75V								
17	Differential Input Impedance*	R_{A-AX}, R_{B-BX} || C_{A-AX}, C_{B-BX}		250 1		kΩ pF	*f*=100kHz	app. cct.
18	Input DC current	I_A, I_{AX}, I_B, I_{BX}		4	8	µA	$V_{A-AX}=V_{B-BX}$ =0V	

* Application hint

AC/DC Characteristics (cont'd)

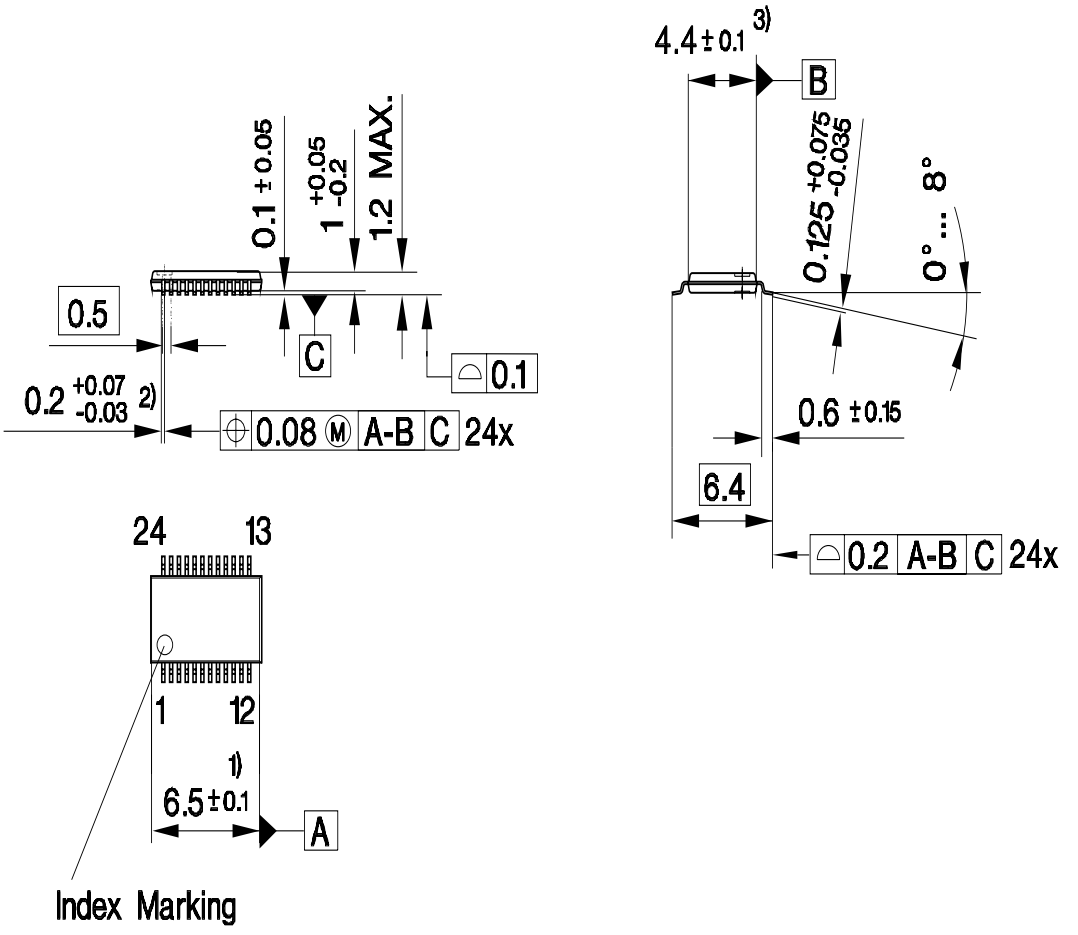
Supply voltage V_{CC} = 2.7 to 4.5V, Ambient temperature T_A = +25°C

#	Parameter	Symbol	Limit Values			Unit	Test Conditions	Test Circuit
			Min	Typ	Max			
AGC output RFOUT: V_{GC}=1.8V, $V_{A\text{-}AX}$=$V_{B\text{-}BX}$=1V$_{pp}$, P_{MODIN}=-10dBm, $f_{A\text{-}AX}$=$f_{B\text{-}BX}$=450kHz								
19	Single ended Output Impedance*	R_{RFOUT} + L_{RFOUT}		58 3.9		Ω nH	f=1.441GHz V_{GC}=1.8V	app. cct.
20	Dynamic range	DR		40		dB		
21	Output Power**	P_{RFOUT}	-6 -47	-2 -42	1 -37	dBm dBm	V_{GC}=1.8V V_{GC}=0.4V	
22	Carrier suppression	a_{C_MOD}	30	40		dB		
23	Single-sideband supression	a_{SSB}	35	45		dB		
24	Suppression of third-order intermodulation products	a_{IM3}	35	45		dB		
25	Output noise floor***	P_{N_MOD}		-139		dBm/ Hz	20MHz from carrier	app. cct.
26	ACPR****			66 70		dB dB	50kHz 100kHz	app. cct.
27	Vector error****			1.1		%rms		app. cct.
28	Magnitude error**** Phase error****			0.77 0.46		%rms ° rms		app. cct.
Gain control input GC:								
29	Input Resistance***	R_{GC}	40	50	60	kΩ		app. cct.
30	Gain control voltage	V_{GC}	0.4		1.8	V		
31	Input current	I_{GC}	25 3	36 8	45 13	µA	V_{GC}=1.8V V_{GC}=0.4V	

* Application hint: meant to be R in series with L
** Application hint: output power for optimum power matching
*** Application hint
****Application hint: according PDC-Specification RCR STD-27F

Note: Power levels are meant to be voltage at pin referred to an impedance of 50Ω.

3 Package Outlines



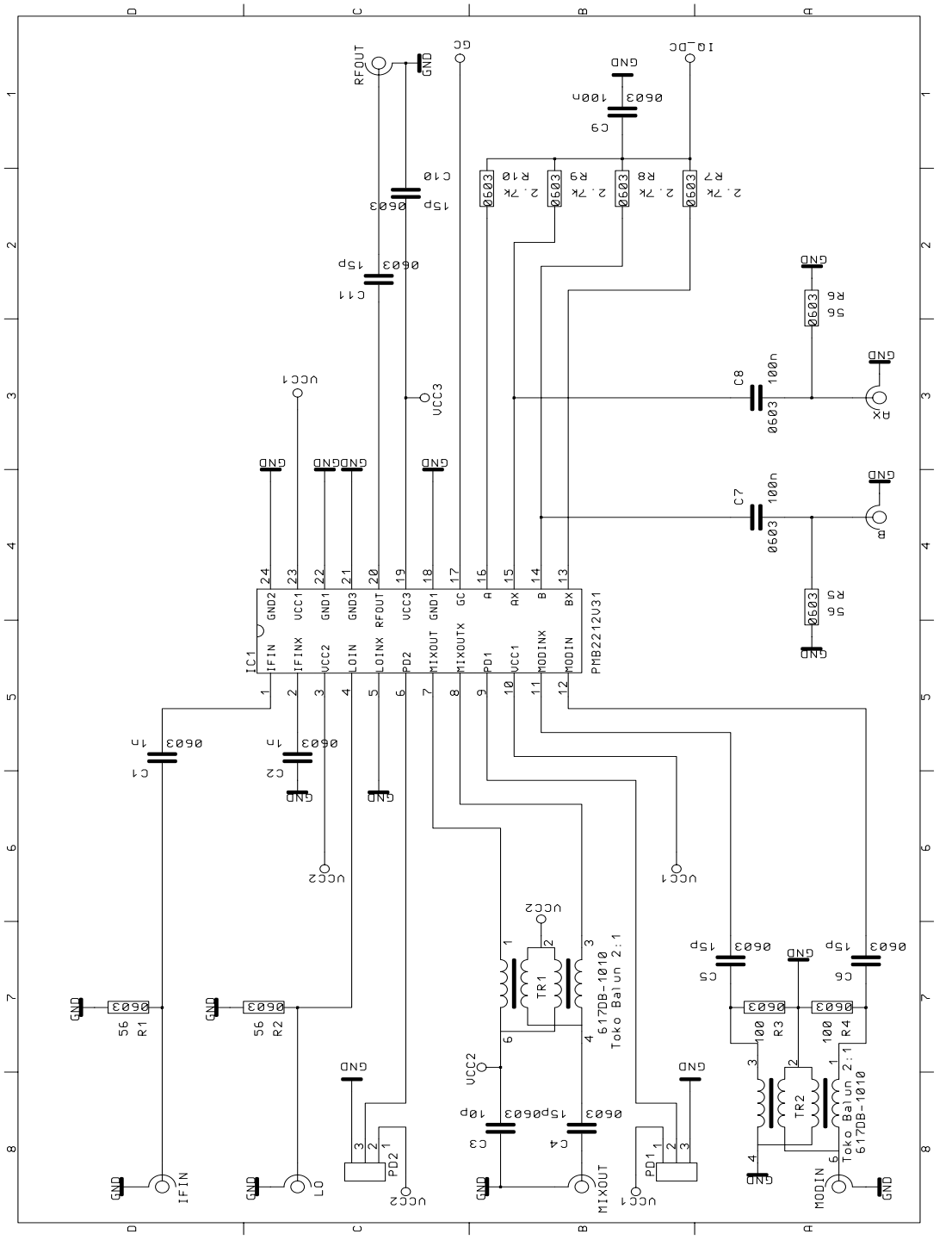
1) Does not include plastic or metal protrusion of 0.15 max. per side

2) Does not include dambar protrusion of 0.08 max. per side

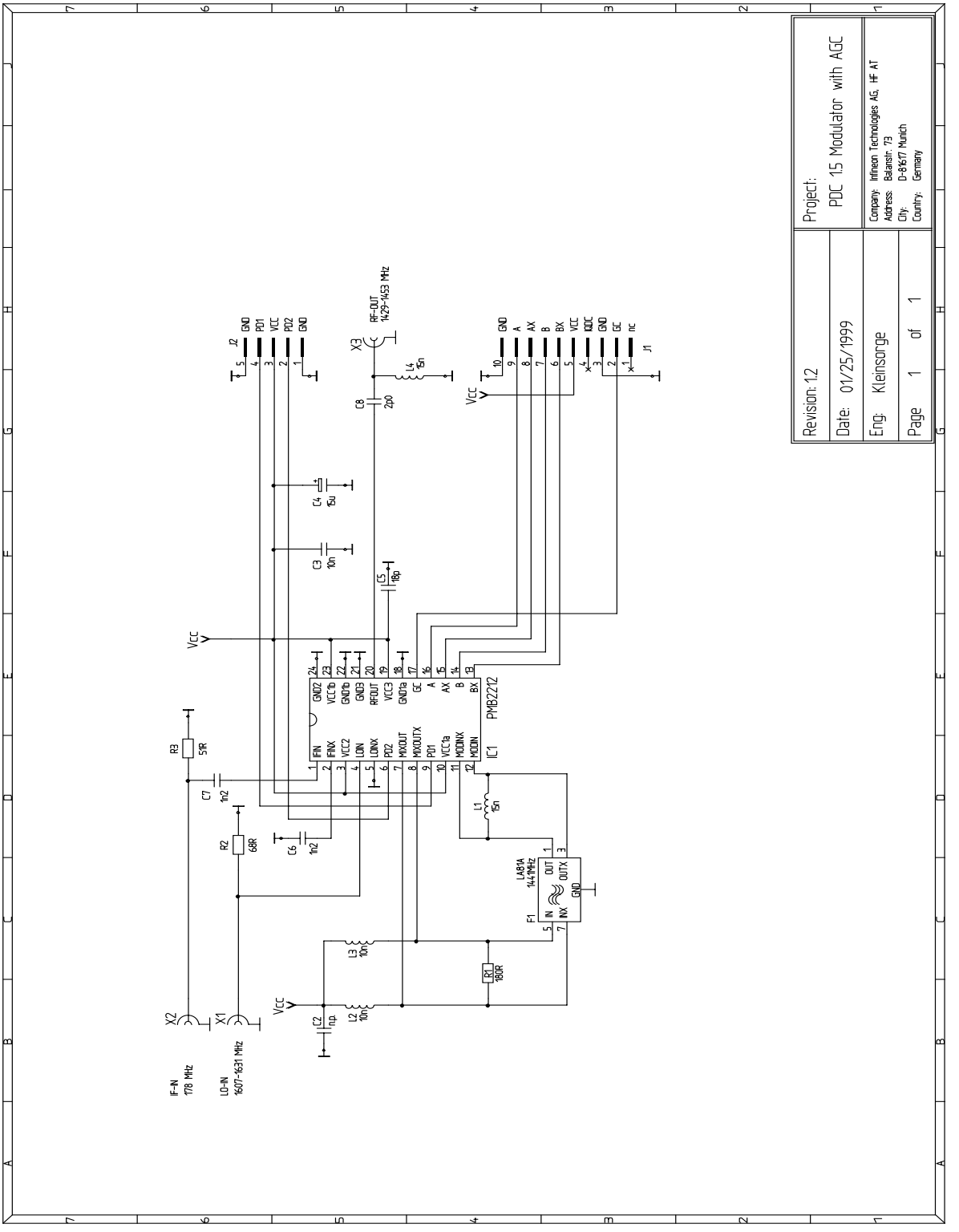
3) Does not include plastic or metal protrusion of 0.25 max. per side

4 Circuits

4.1 Evaluation Circuit



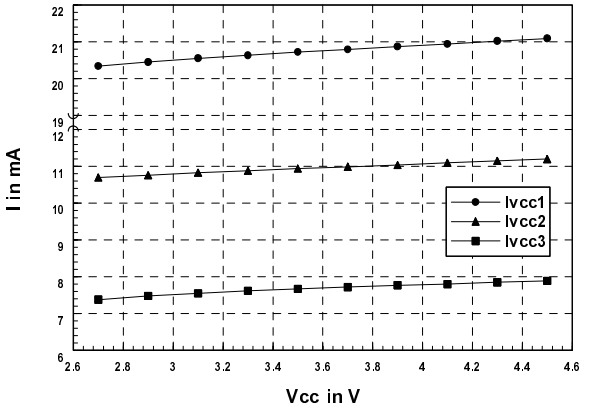
4.2 Application Circuit



5 Typical Measurement Results (Evaluation Board)

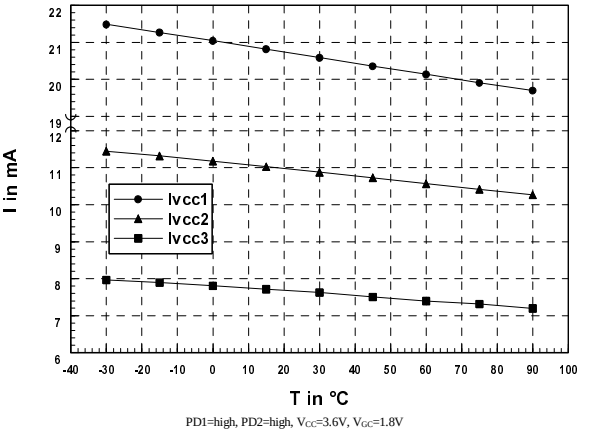
5.1 Current Consumption

Current Consumption vs. Supply Voltage:



PD1=high, PD2=high, T=25°C, V_{GC}=1.8V

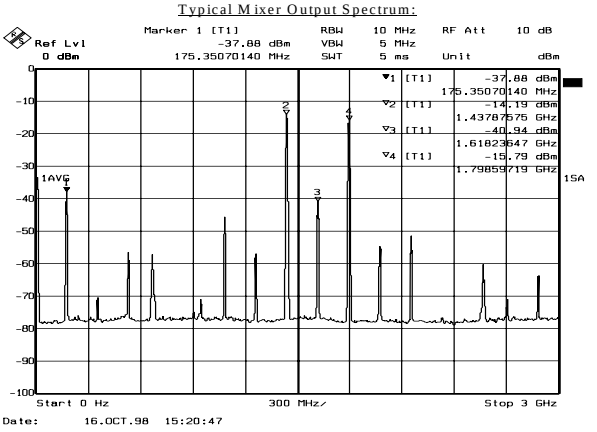
Current Consumption vs. Temperature:



PD1=high, PD2=high, V_{CC}=3.6V, V_{GC}=1.8V

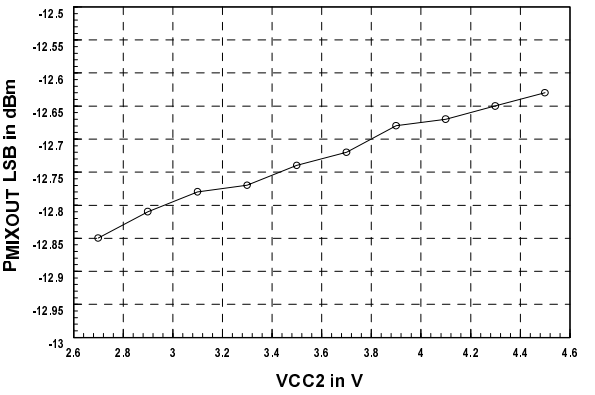
5.2 Mixer

Typical Mixer Output Spectrum:



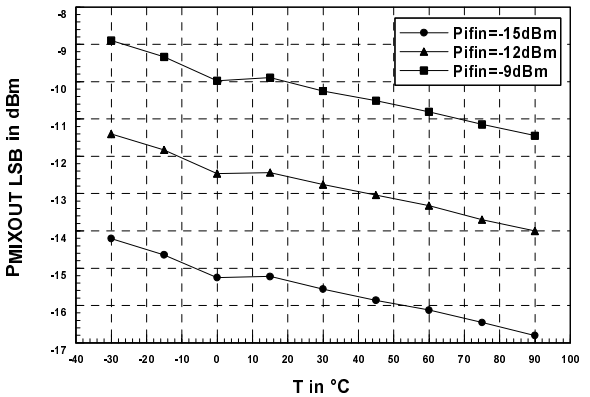
PD1=low, PD2=high, V_{CC}=3.6V, T=25°C,
P_{LOIN}=-5dBm, f_{LOIN}=1.619GHz, P_{IFIN}=-12dBm, f_{IFIN}=178MHz,
(about 1.5dB attenuation due to cable loss)

Output Power P_{MIXOUT} vs. Supply Voltage:



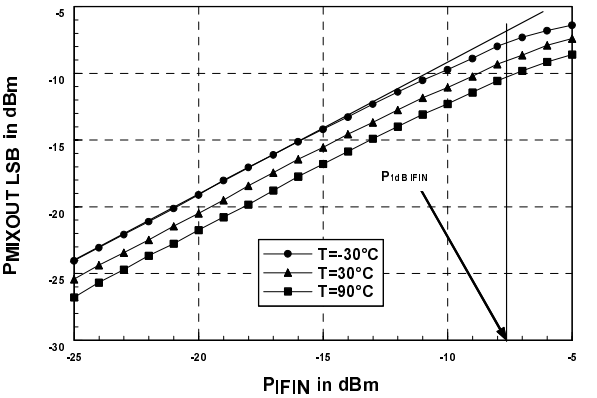
PD1=low, PD2=high, T=25°C,
P_{LOIN}=-5dBm, f_{LOIN}=1.619GHz, P_{IFIN}=-12dBm, f_{IFIN}=178MHz

Output Power P_{MIXOUT} vs. Temperature:



PD1=low, PD2=high, V_{CC}=3.6V,
P_{LOIN}=-5dBm, f_{LOIN}=1.619GHz, f_{IFIN}=178MHz

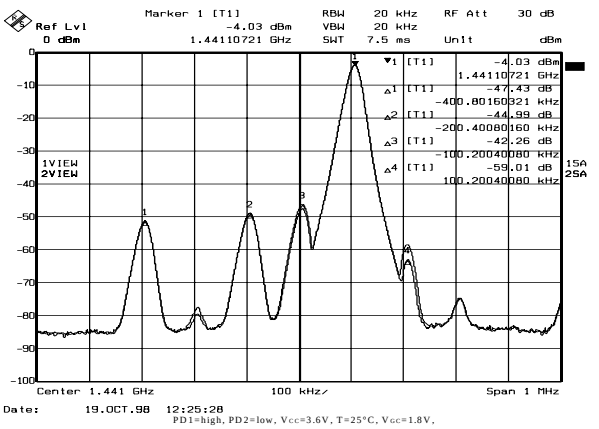
1dB-Compression Point vs. Temperature:



PD1=low, PD2=high, V_{CC}=3.6V,
P_{LOIN}=-5dBm, f_{LOIN}=1.619GHz, f_{IFIN}=178MHz

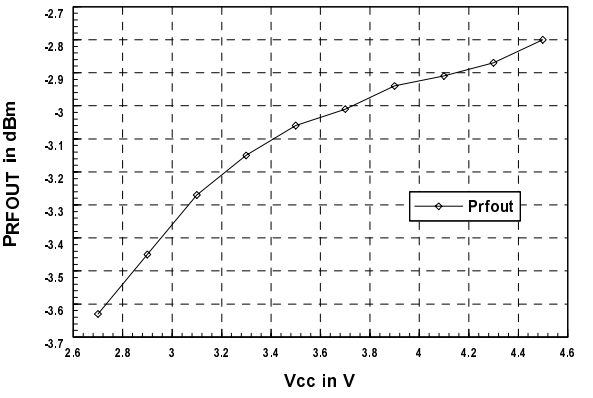
5.3 Modulator with AGC

Typical Modulator Output Spectrum:



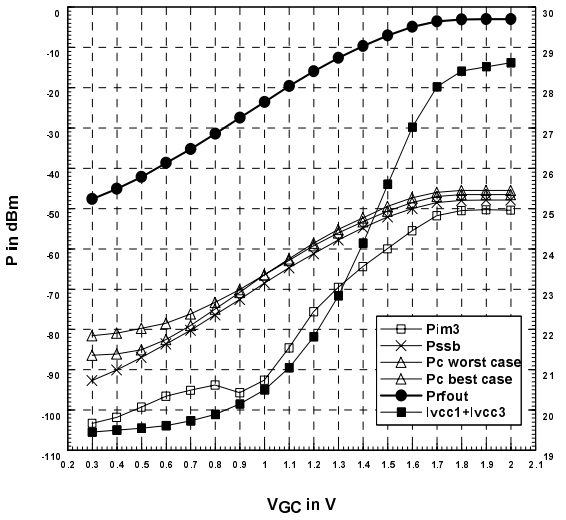
PD1=high, PD2=low, V_{CC}=3.6V, T=25°C, V_{GC}=1.8V,
$P_{MODIN-MODINX}$=-10dBm, $f_{MODIN-MODINX}$=1.441GHz, IQ_DC=1.75V, IQ_AC=$1V_{pp}$, f_m=100kHz
(about 1dB attenuation due to cable loss)

Output Power P_{RFOUT} vs. Supply Voltage:



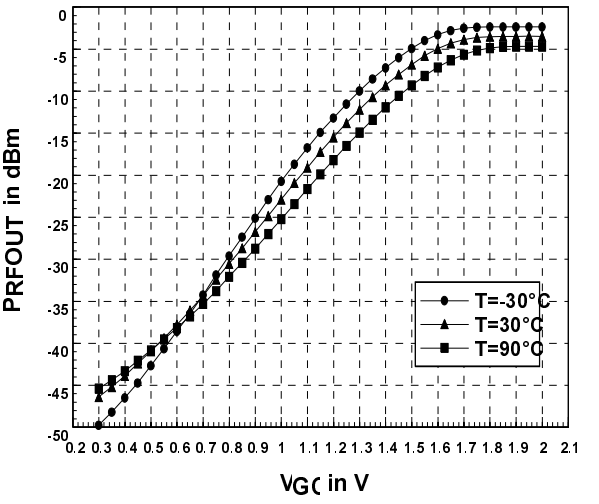
PD1=high, PD2=low, T=25°C, V_{GC}=1.8V,
$P_{MODIN-MODINX}$=-10dBm, $f_{MODIN-MODINX}$=1.441GHz, IQ_DC=1.75V, IQ_AC=$1V_{pp}$, f_m=100kHz

Modulator Performance over Dynamic Range of the AGC:



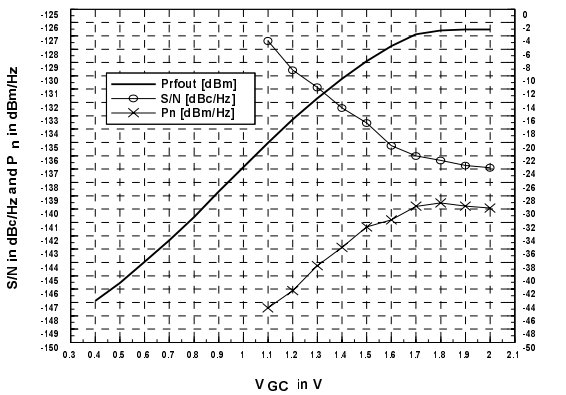
PD1=high, PD2=low, V_{CC}=3.6V, T=25°C,
$P_{MODIN-MODINX}$=-10dBm, $f_{MODIN-MODINX}$=1.445GHz, IQ_DC=1.75V, IQ_AC=$1V_{pp}$, f_m=100kHz

Output Power P_{RFOUT} over Dynamic Range of the AGC:



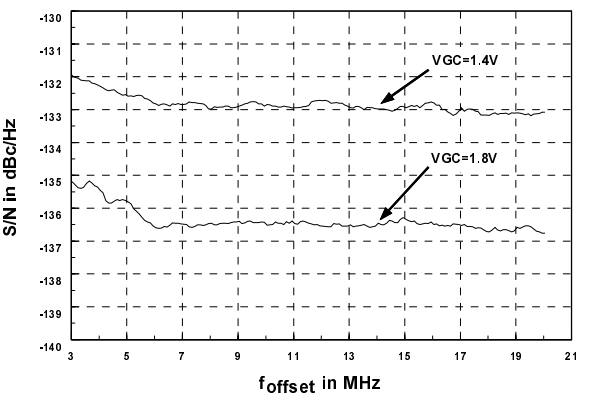
PD1=high, PD2=low, V_{CC}=3.6V,
$P_{MODIN-MODINX}$=-10dBm, $f_{MODIN-MODINX}$=1.445GHz, IQ_DC=1.75V, IQ_AC=$1V_{pp}$, f_m=100kHz

Noise Performance over Dynamic Range of the AGC:



PD1=high, PD2=low, V_{CC}=3.6V, T=25°C,
$P_{MODIN-MODINX}$=-10dBm, $f_{MODIN-MODINX}$=1.441GHz, IQ_DC=1.75V, IQ_AC=$1V_{pp}$, f_m=100kHz,
f_{offset}=20MHz

Noise Performance vs. Offset Frequency:



PD1=high, PD2=low, V_{CC}=3.6V, T=25°C,
$P_{MODIN-MODINX}$=-10dBm, $f_{MODIN-MODINX}$=1.441GHz, IQ_DC=1.75V, IQ_AC=$1V_{pp}$, f_m=10kHz