

RF Front End

SPECIFICATION

1 FEATURES

- TSMC CMOS 65 nm
- Operating frequency range 75...3000 MHz
- Single differential input
- High linearity
- High dynamic range
- Wide range variable gain -25...+20 dB
- Supply voltage 2.5 V
- Temperature compensation mode
- Adjusted gain
- Supported foundries: TSMC, UMC, Global Foundries, SMIC

2 APPLICATION

- High frequency front-end signal amplification in receivers

3 OVERVIEW

Low-noise amplifier (LNA) amplifies weak signal at receiver input and has low noise figure over the wide bandwidth.

LNA has a commutator to select necessary frequency sub-band and adjustable resonant circuit to fine-tune. After LNA, the RF signal is fed to the A-MIX (75...750 MHz) or BCD-MIX (750...3000 MHz). A-MIX consists of LO-buffers, outputs IQ-preamplifier with gain control and IQ harmonic-rejection mixer (HRM). BCD-MIX includes intermediate and output buffers with gain control, separated quadrature mixers and LO-buffers.

LO-buffers and IQ-preamp are used to improve channel-to-channel isolation, improve harmonic rejection and reduce intermodulation distortions.

HRM includes three Gilbert cells in parallel with 1: $\sqrt{2}$:1 Gm-ratio to perform multiphase (0°/45°/90°) mixing. HRM converts RF frequency to a low intermediate frequency (IF) and reject the 3rd and 5th harmonic distortions that may fall inside the band.

FrontEnd includes integrated inductors and uses minimum off-chip components.

4 STRUCTURE

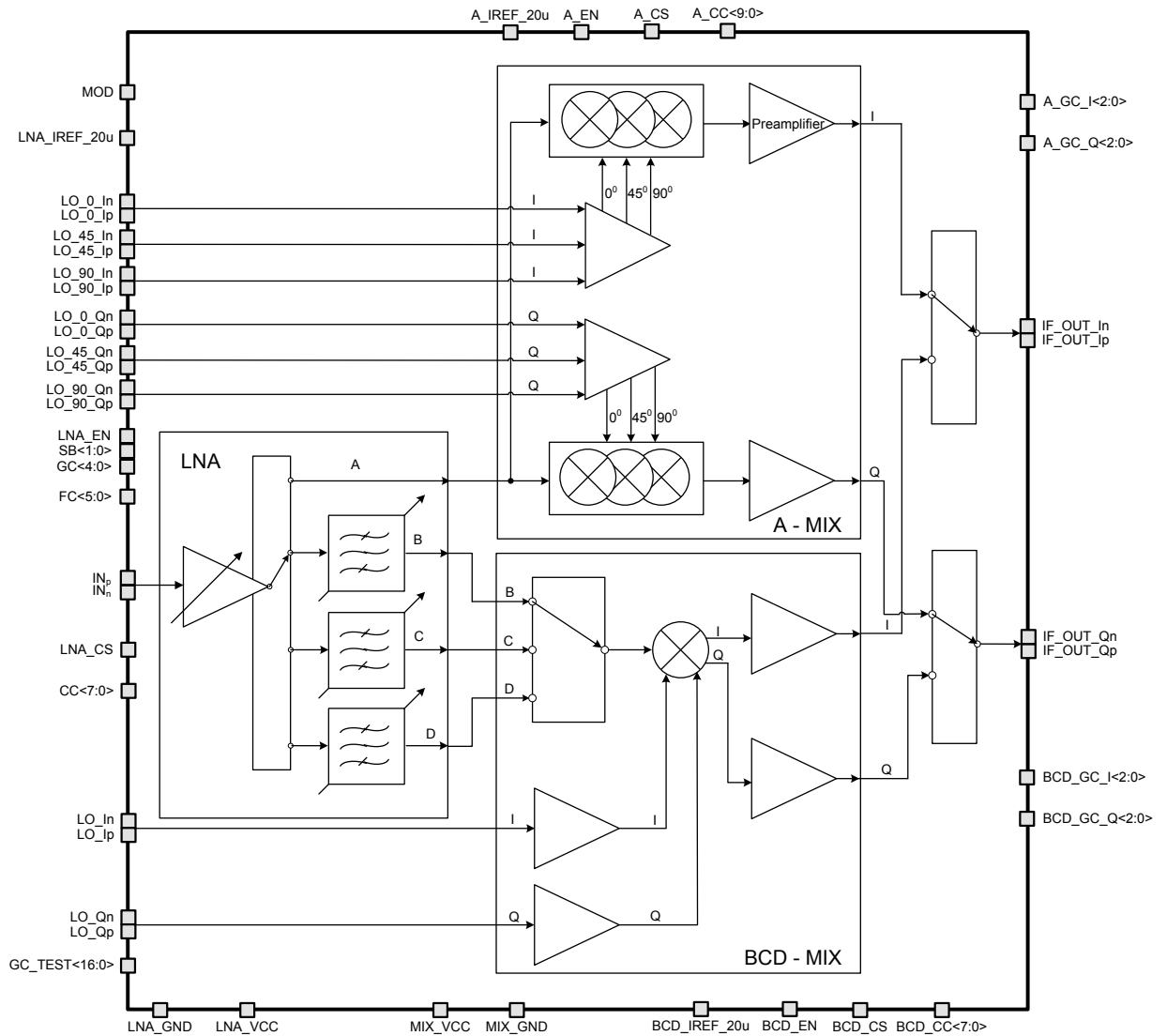


Figure 1: RF Front End structure

5 PIN DESCRIPTION

Name	Direction	Description
LNA_IREF_20u	IO	LNA reference current 20 μ A
BCD_IREF_20u	IO	MIX-BCD reference current 20 μ A
A_IREF_20u	IO	MIX-A reference current 20 μ A
LNA_EN	I	LNA enable
BCD_EN	I	MIX-BCD enable
MOD	I	LNA test gain control mode
GC<4:0>	I	LNA gain control
GC_TEST<16:0>	I	Test mode gain control
SB<1:0>	I	Frequency sub-band select
FC<5:0>	I	Resonant circuit adjustment
CC<7:0>	I	LNA current control
A_CC<9:0>	I	MIX-A current control
BCD_CC<7:0>	I	MIX-BCD current control
A_GC_I<2:0>	I	MIX-A I channel output buffer gain control
A_GC_Q<2:0>	I	MIX-A Q channel output buffer gain control
BCD_GC_I<2:0>	I	MIX-BCD I channel gain control
BCD_GC_Q<2:0>	I	MIX-BCD Q channel gain control
A_CS	I	MIX-A current source type (temperature independent/ temperature dependent)
BCD_CS	I	MIX-BCD current source type (temperature independent/ temperature dependent)
LNA_CS	I	LNA current source type (temperature independent/ temperature dependent)
IN _p	I	Differential input (F = 75...3000 MHz)
IN _n	I	
LO_In	I	Local-oscillator quadrature signal I channel differential input
LO_Ip	I	
LO_Qn	I	Local-oscillator quadrature signal Q channel differential input
LO_Qp	I	
LO_0_In	I	Local-oscillator 0° quadrature signal I channel differential input
LO_0_Ip	I	

Table “Pin description” (continue).

LO_0_Qn	I	Local-oscillator 0° quadrature signal Q channel differential input
LO_0_Qp	I	
LO_45_In	I	Local-oscillator 45° quadrature signal I channel differential input
LO_45_Ip	I	
LO_45_Qn	I	Local-oscillator 45° quadrature signal Q channel differential input
LO_45_Qp	I	
LO_90_In	I	Local-oscillator 90° quadrature signal I channel differential input
LO_90_Ip	I	
LO_90_Qn	I	Local-oscillator 90° quadrature signal Q channel differential input
LO_90_Qp	I	
IF_OUT_Ip	O	I channel differential IF output
IF_OUT_In	O	
IF_OUT_Qp	O	Q channel differential IF output
IF_OUT_Qn	O	
MIX_VCC	IO	MIX supply voltage
MIX_GND	IO	MIX ground
LNA_VCC	IO	LNA supply voltage
LNA_GND	IO	LNA ground

6 LAYOUT DESCRIPTION

FrontEnd dimensions are given in the table 1.

Table 1: Block dimension.

Dimension	Value	Unit
Height	3110	um
Width	3070	um

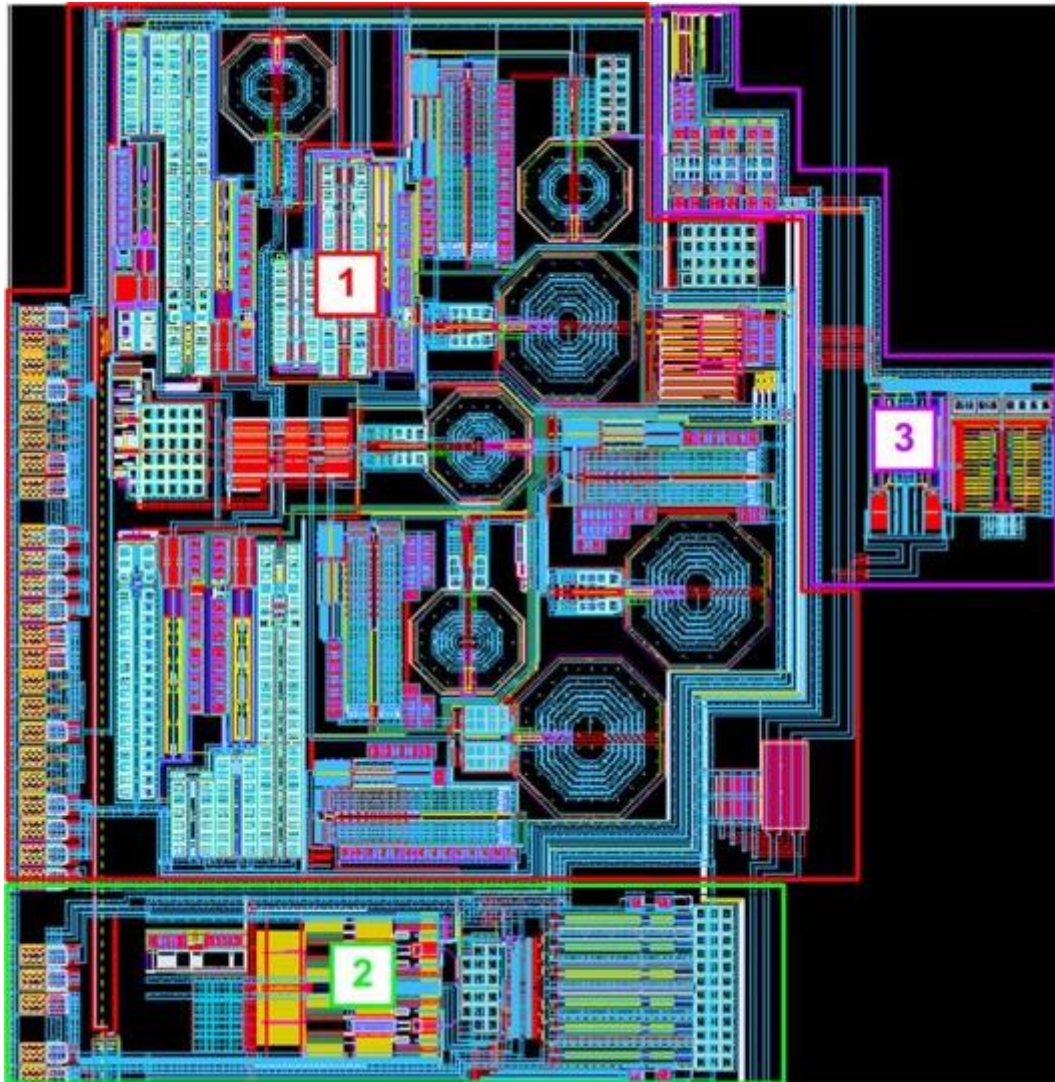


Figure 2: Front End layout view

1. LNA
2. MIX_A
3. MIX_BCD

7 OPERATING CHARACTERISTICS

7.1 TECHNICAL CHARACTERISTICS

Technology _____ TSMC CMOS 65 nm
 Status _____ silicon proven
 Area _____ 7.3mm²

7.2 ELECTRICAL CHARACTERISTICS

The values of electrical characteristics are specified for $V_{cc25} = 2.375 \div 2.625$ V and $T = -40 \div +125^\circ\text{C}$. Typical values are at $V_{cc25} = 2.5\text{V}$, $T = +85^\circ\text{C}$, unless otherwise specified.

Parameter	Symbol	Condition	Value			Unit	
			min	typ	max		
Over all							
Supply voltage	V_{cc25}	-	2.375	2.5	2.625	V	
Operating temperature range	T	-	-40	+85	+125	$^\circ\text{C}$	
Operating input frequency	F_A	-	75	-	750	MHz	
	F_B	-	750	-	1400		
	F_C	-	1400	-	2400		
	F_D	-	2400	-	3000		
Local-oscillator frequency	F_{osc}	-	75	-	3000	MHz	
Peak-to-peak voltage at local-oscillator input	$A_{in\ p-p}$	-	-	600	-	mV	
Bandwidth	B_w	-	-	-	200	MHz	
Output frequency range	F_{out}	-	0	-	100	MHz	
Input impedance	R_{in}	-	-	75	-	Ω	
Output impedance	R_{out}	-	-	50	-	Ω	
Conversion power gain	G_{pA}	GC_LNA="11111", GC_MIX="101"	26.8	30.7	33.2	dB	
	G_{pB}		25.3	29.8	31.7		
	G_{pC}		23.4	28.6	29.9		
	G_{pD}		22.3	26.1	28.4		
Input matching	S_{11}	Input impedance 75 Ω	F_A	-9	-8	-5	dB
			F_B	-13	-11	-8	
			F_C	-13	-10	-6	
			F_D	-11	-9	-5	
Output matching	S_{22}	Output impedance 50 Ω	-17	-18	-20	dB	
Noise figure	NF	-	-	4.8	6.5	dB	
		-	-	5.3	7.6		
		-	-	5.3	8.0		
		-	-	6.8	9.2		
Third order intermodulation	IM3	Input power -40dBm GC_LNA="11111", GC_MIX="101"	F_A	-	-59.1	-	dB
			F_B	-	-60.2	-	
			F_C	-	-59.0	-	
			F_D	-	-58.3	-	
Input 1dB compression point	P_{1dB}	GC_LNA="11111", GC_MIX="101"	F_A	-	-23	-	dBm
			F_{BCD}	-	-22	-	
3 rd order intercept point A-Band F_A	IIP3	In frequency range (75-750) MHz	-	-16	-	dBm	
3 rd order intercept point A-Band F_{BCD}	IIP3	In frequency range (750-3000) MHz	-	-20	-	dBm	
Maximum input power	P_{max}	-	-	-	10	dBm	
Current consumption in an active mode	I_{cc}	F_A	-	346.4	-	mA	
		F_{BCD}	-	319.4	-		

Table “Electrical characteristics” (continue).

Parameter	Symbol	Condition	Value			Unit	
			min	typ	max		
Current consumption in a standby mode	I_{stb}	-	-	-	2.2	uA	
LNA							
LNA Gain	G_{LNA}	GC="11111", 75Ω	F _A	15.8	18.6	19.2	dB
			F _B	15.2	19.0	20.1	
			F _C	14.3	19.1	20.1	
			F _D	14.1	18.2	19.6	
LNA Gain control range	GC _{LNA}	F _A	39.8	41.6	44.1	dB	
		F _B	38.9	42.8	44.7		
		F _C	39.3	43.4	45.2		
		F _D	42.7	47.1	47.9		
LNA Noise figure	NF _{LNA}	GC="11111", Input 75Ω	F _A	3.4	3.7	4.5	dB
			F _B	3.7	4.5	5.2	
			F _C	4.6	5.2	6.0	
			F _D	4.9	6.7	7.5	
LNA current consumption in an active mode	I_{ccLNA}	A-Band	-	62.9	72.3	mA	
LNA current consumption in an active mode	I_{ccLNA}	BCD-Band	-	88.1	97.5	mA	
LNA current consumption in a standby mode	I_{stbLNA}	-	-	-	692	nA	
MIX							
A_MIX current consumption in an active mode	I_{ccA_MIX}	A-Band	-	283.8	-	mA	
BCD_MIX current consumption in an active mode	I_{ccBCD_MIX}	BCD-Band	-	231.5	-	mA	
A_MIX current consumption in a standby mode	$I_{stbAMIX}$	A-Band	-	-	889	nA	
BCD_MIX current consumption in a standby mode	$I_{stbBCDMIX}$	BCD-Band	-	-	613	nA	

8 TYPICAL CHARACTERISTICS

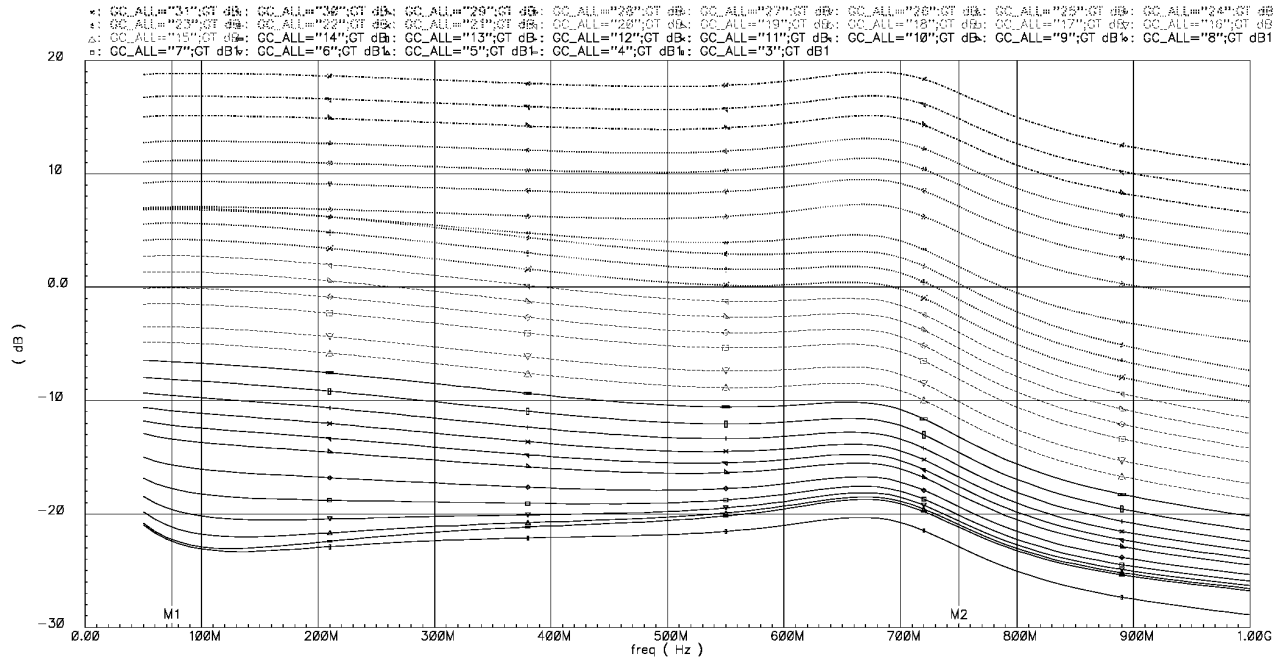


Figure 3: LNA gain vs gain control (GC) for F_A (75 – 750 MHz).

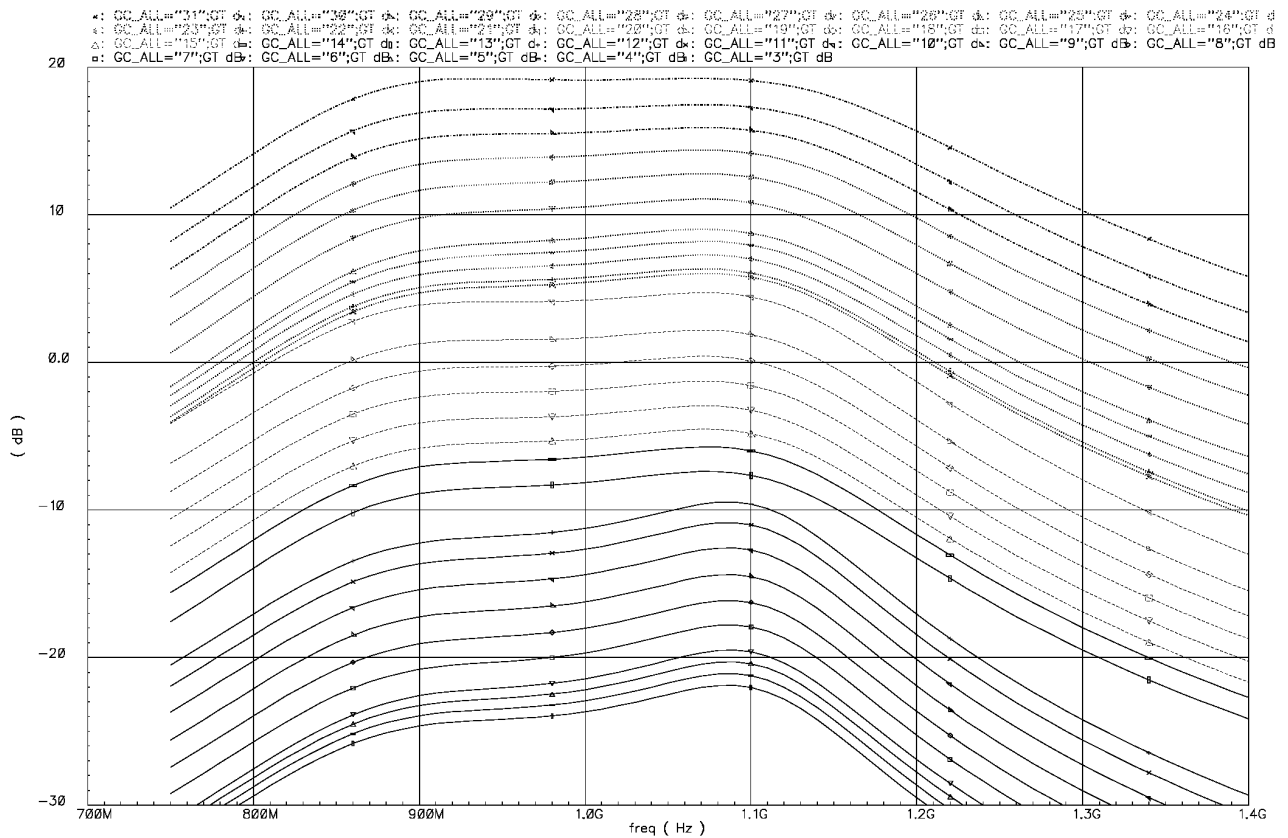


Figure 4: LNA gain vs gain control (GC) for F_B (750 – 1400 MHz).

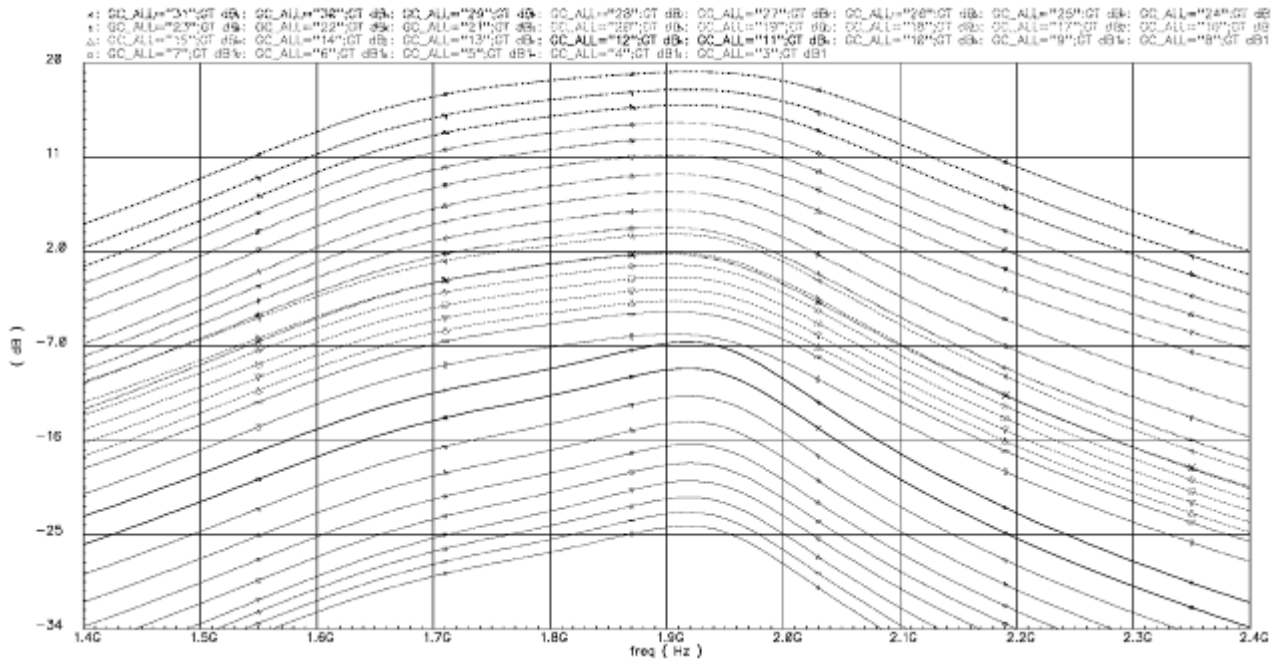


Figure 5: LNA gain vs gain control (GC) for F_C (1400 – 2400 MHz).

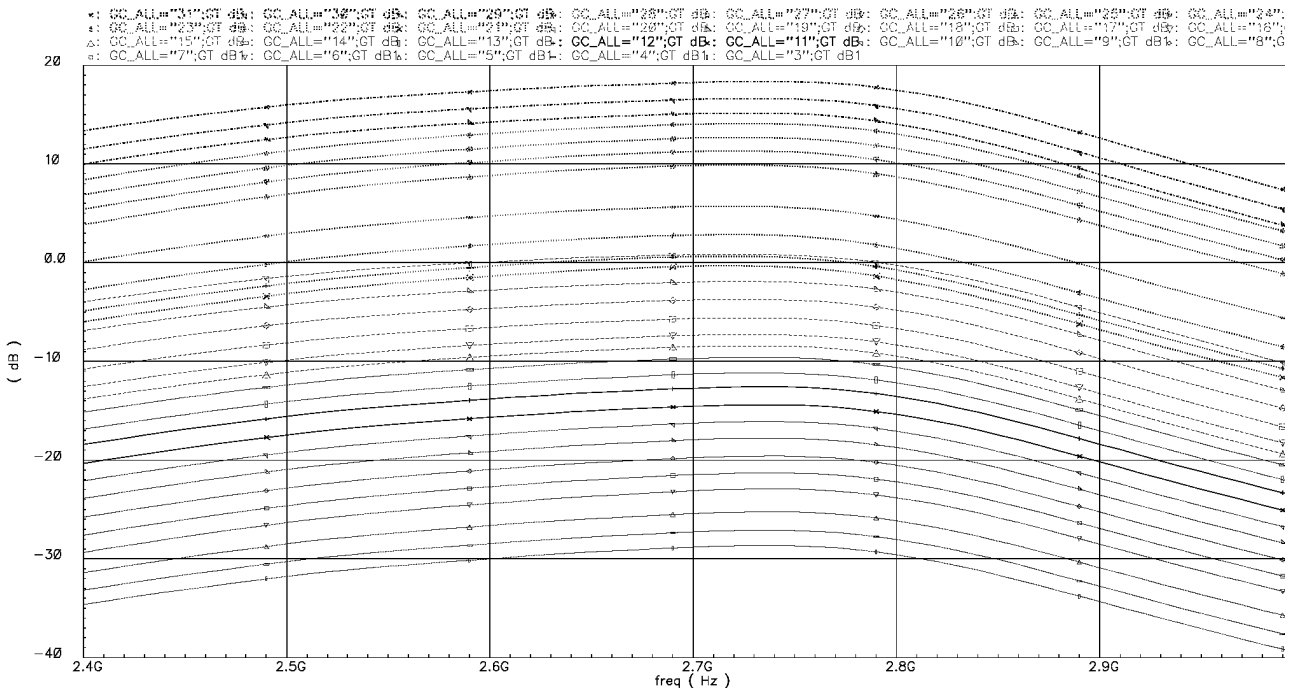


Figure 6: LNA Gain vs gain control (GC) for F_D (2400 – 3000 MHz).

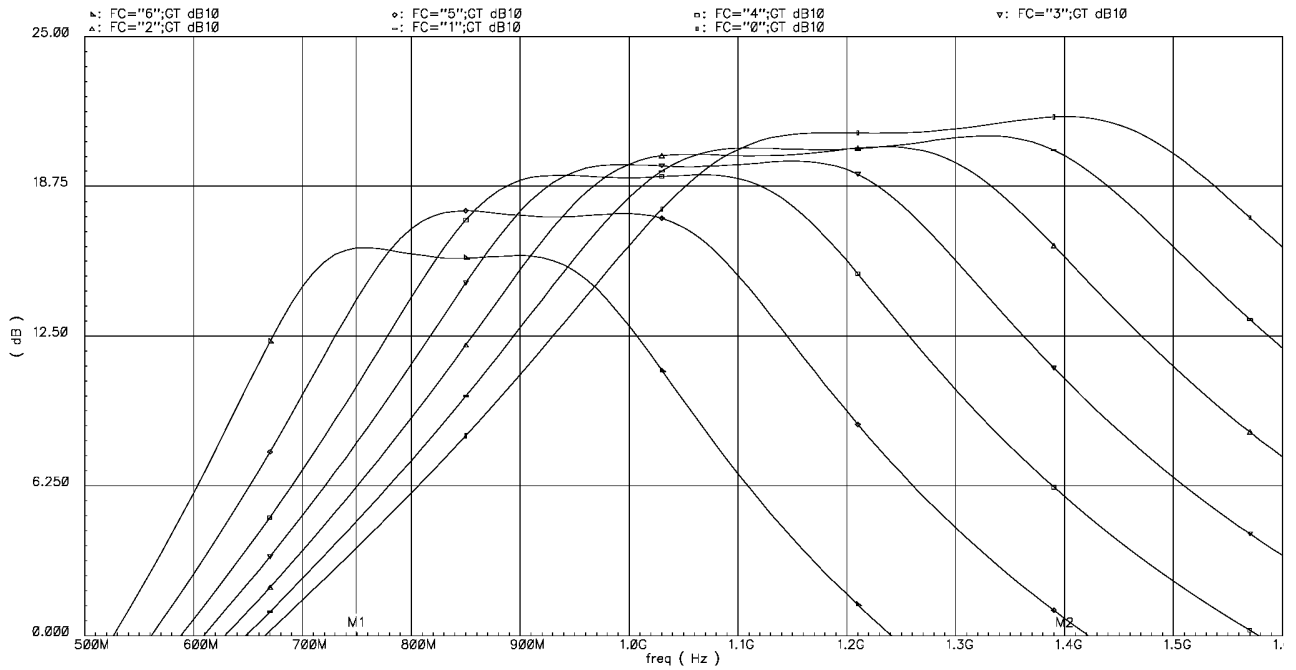


Figure 7: LNA Gain vs resonant circuit adjustment (FC) for F_B (750 – 1400 MHz).

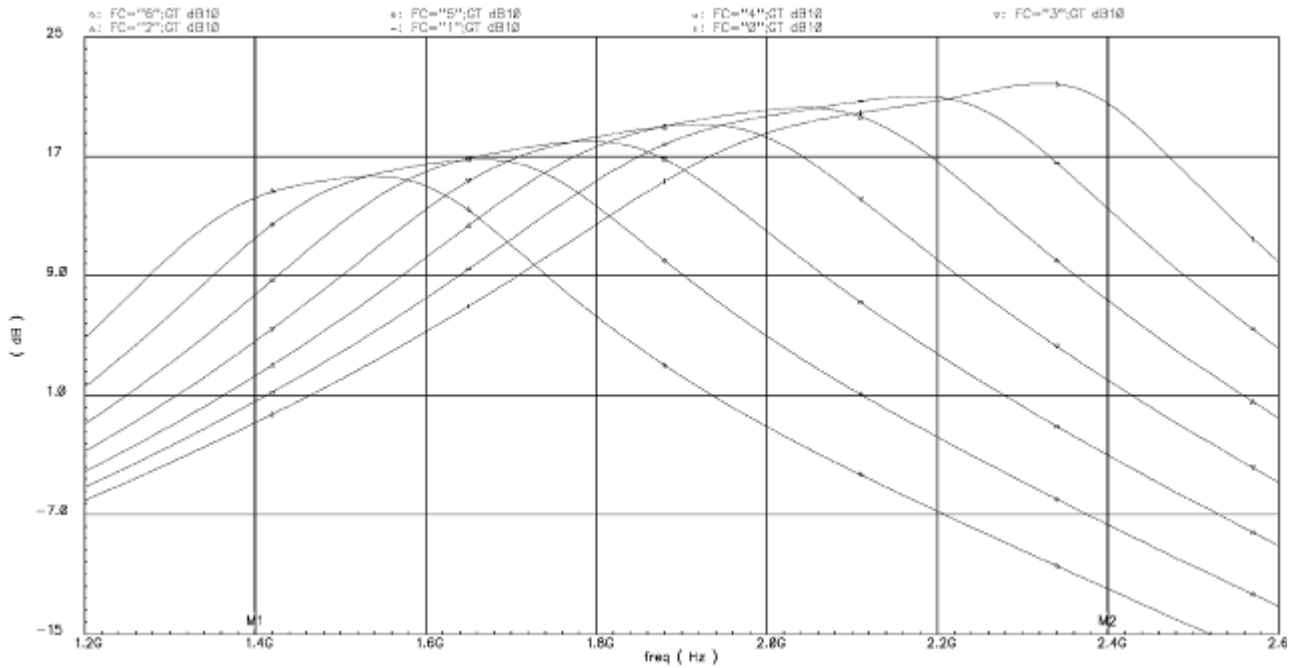


Figure 8: LNA Gain vs resonant circuit adjustment (FC) for F_C (1400 – 2400 MHz).

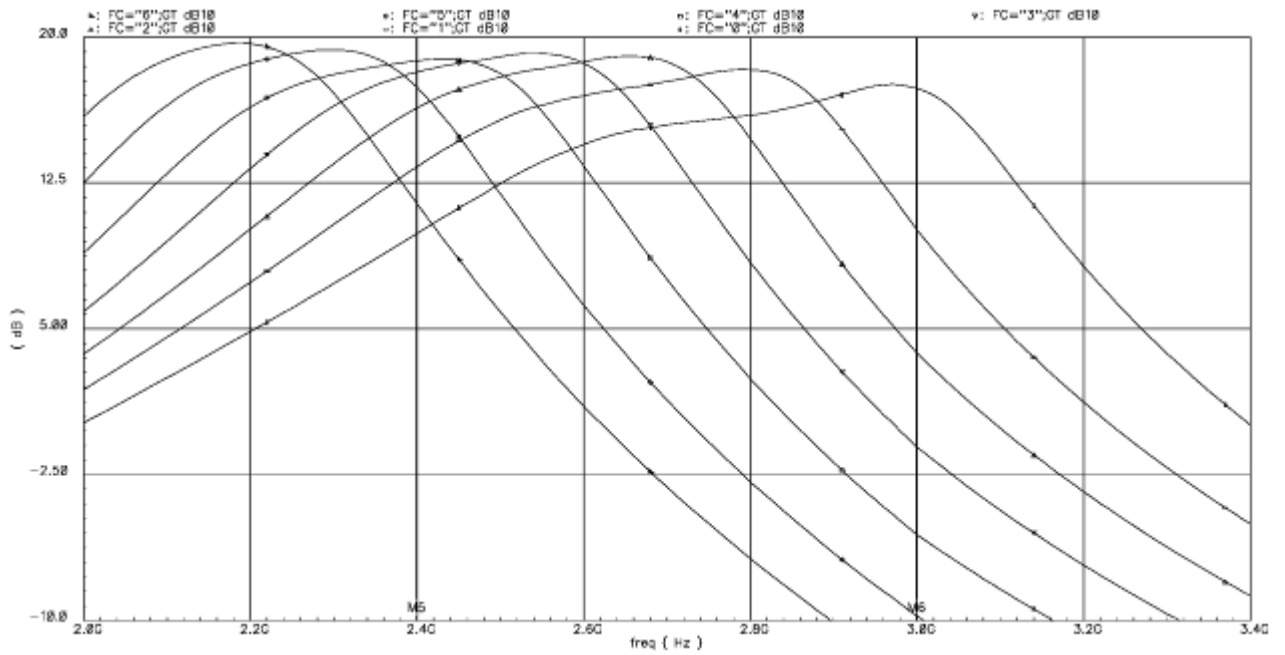


Figure 9: LNA Gain vs resonant circuit adjustment (FC) for F_D (2400 – 3000 MHz).

Amplitude-frequency characteristic

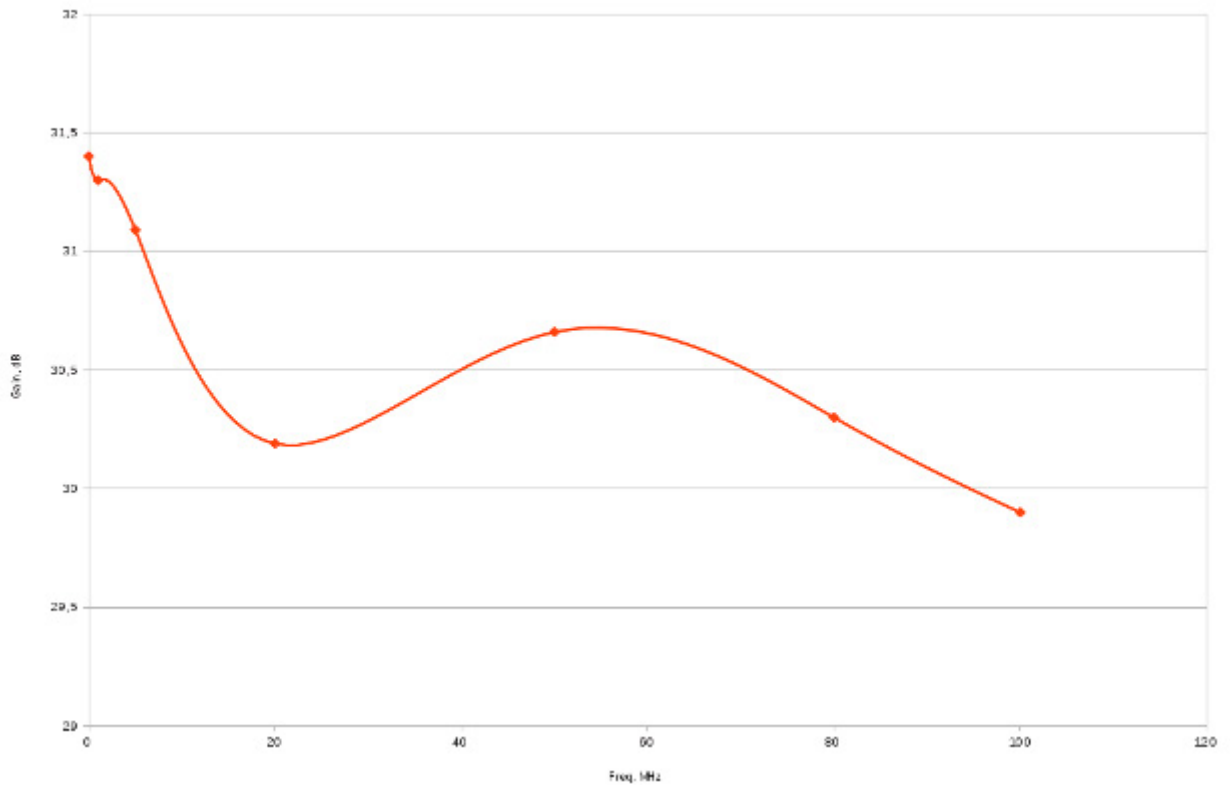


Figure 10: Amplitude-frequency characteristic for A-Band.

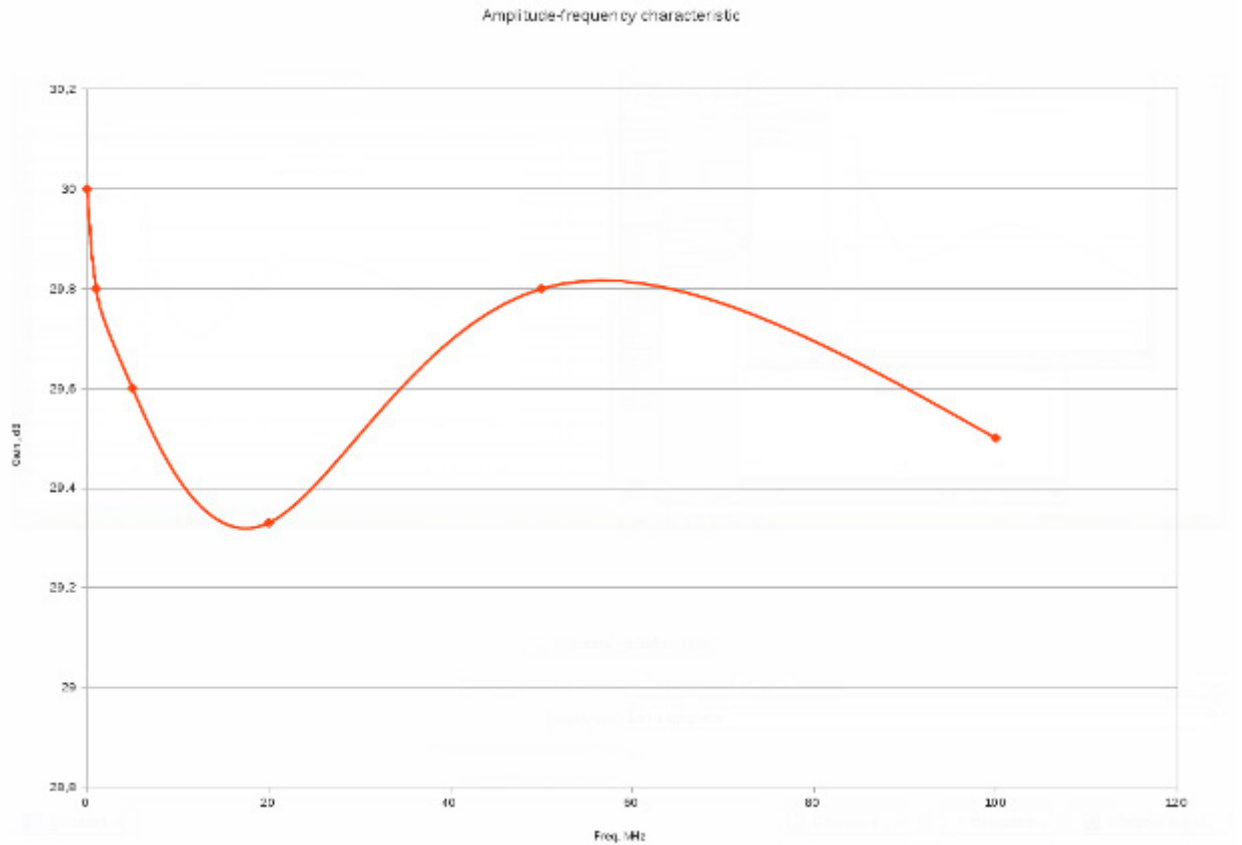


Figure 11: Amplitude-frequency characteristic for B-Band.

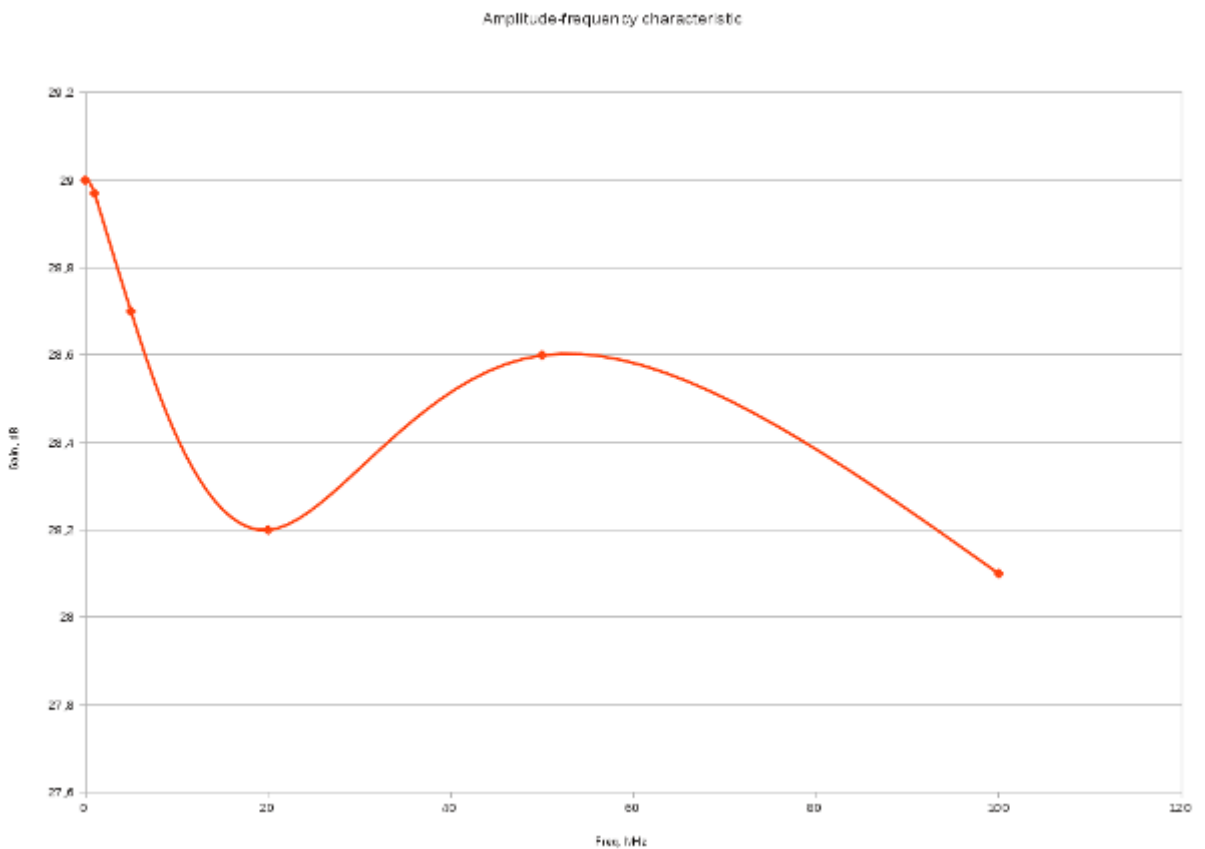


Figure 12: Amplitude-frequency characteristic for C-Band.

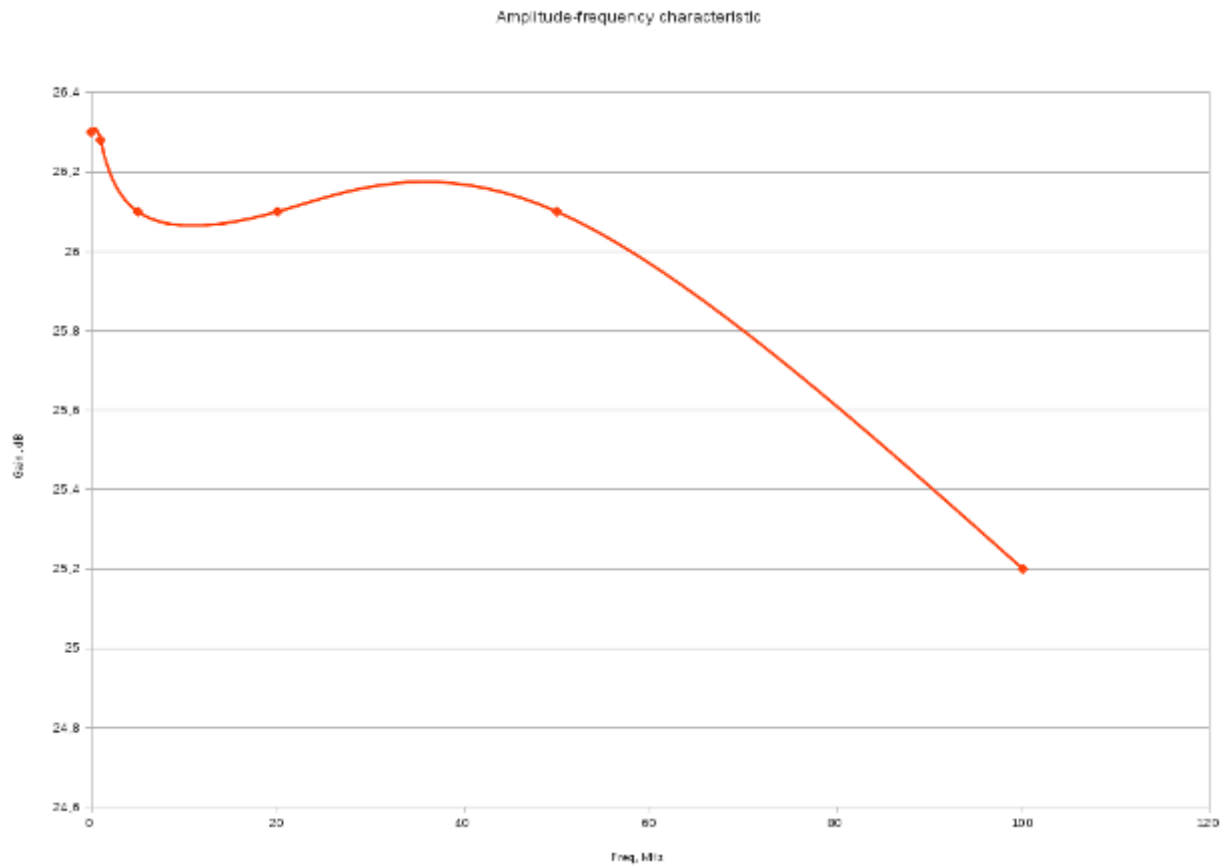


Figure 13: Amplitude-frequency characteristic for D-Band.

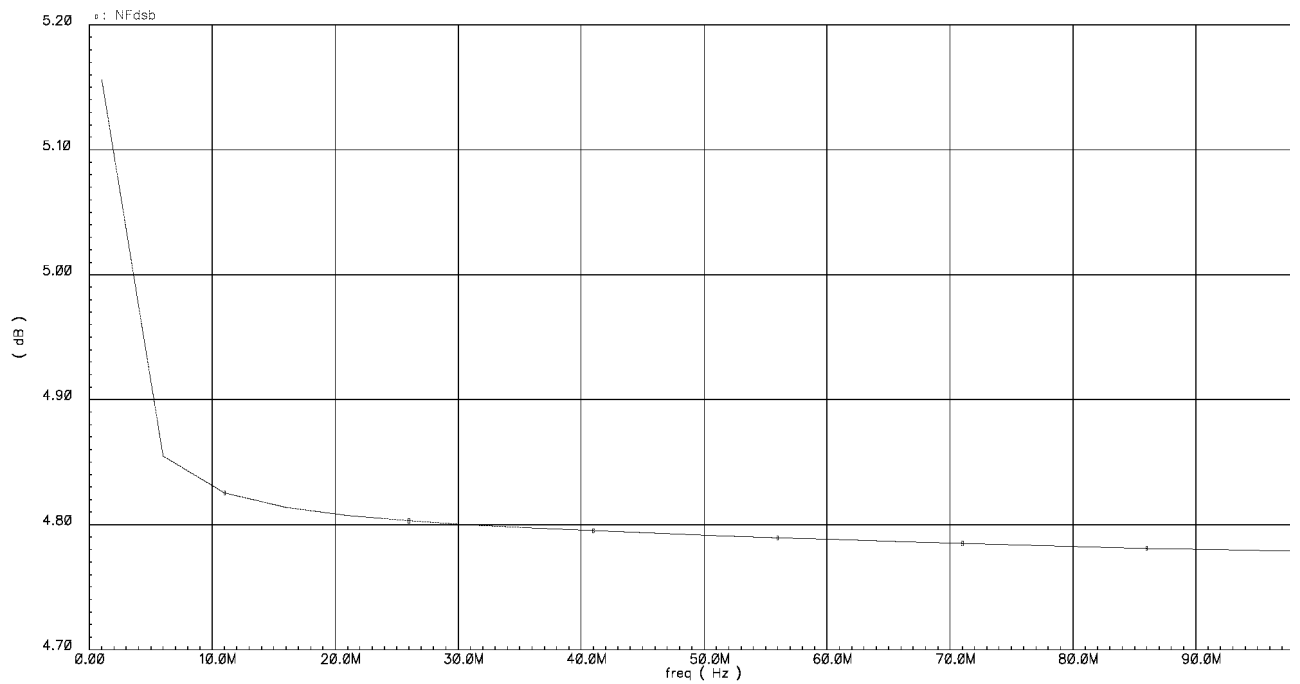


Figure 14: NFdsb for A-Band.

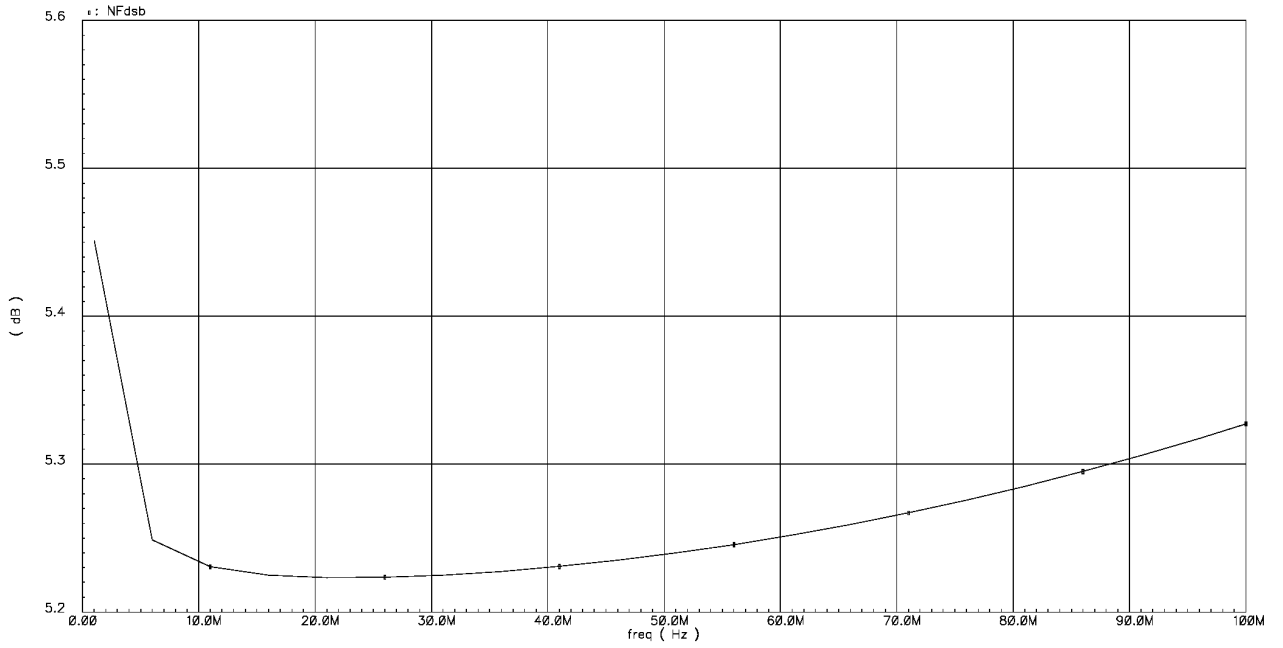


Figure 15: NFdsb B-Band.

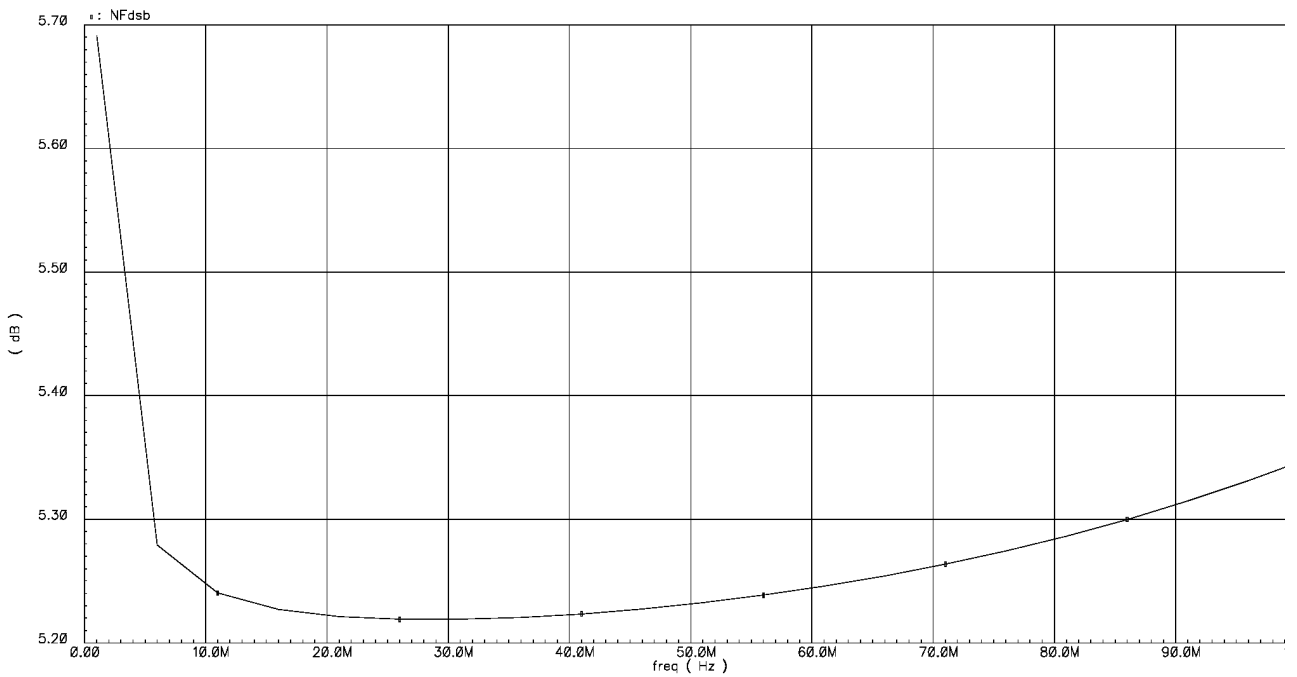


Figure 16: NFdsb for C-Band.

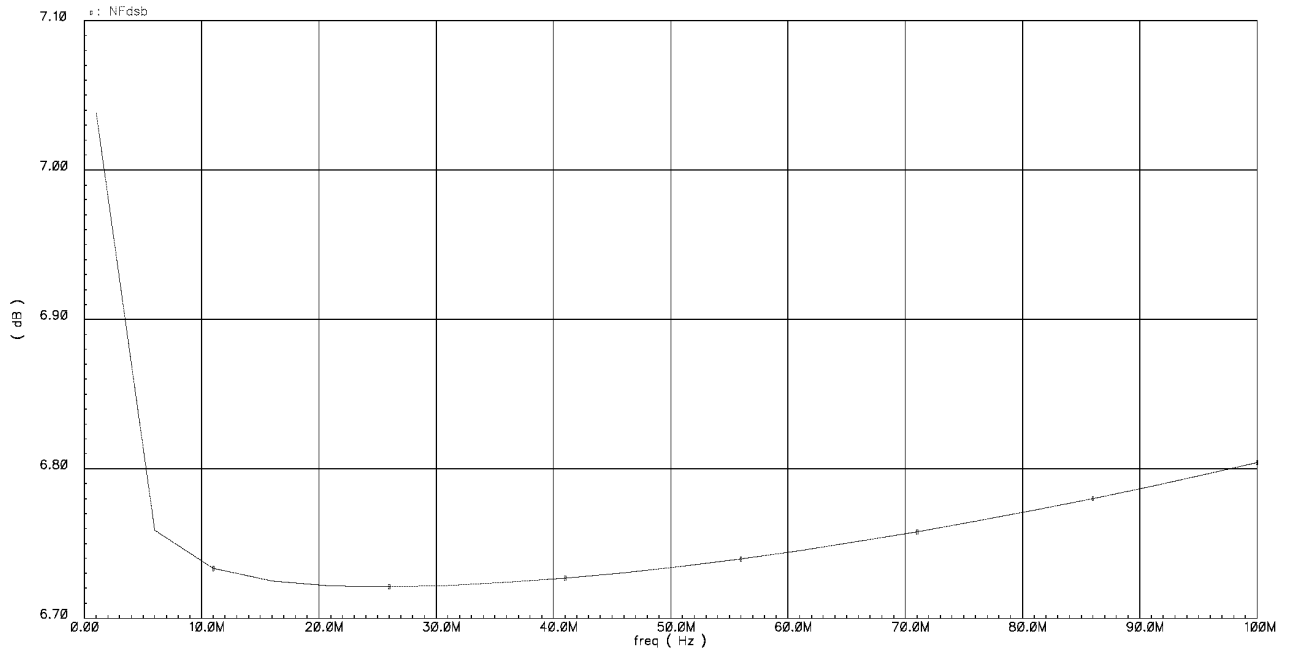


Figure 17: NFdsb for D-Band.

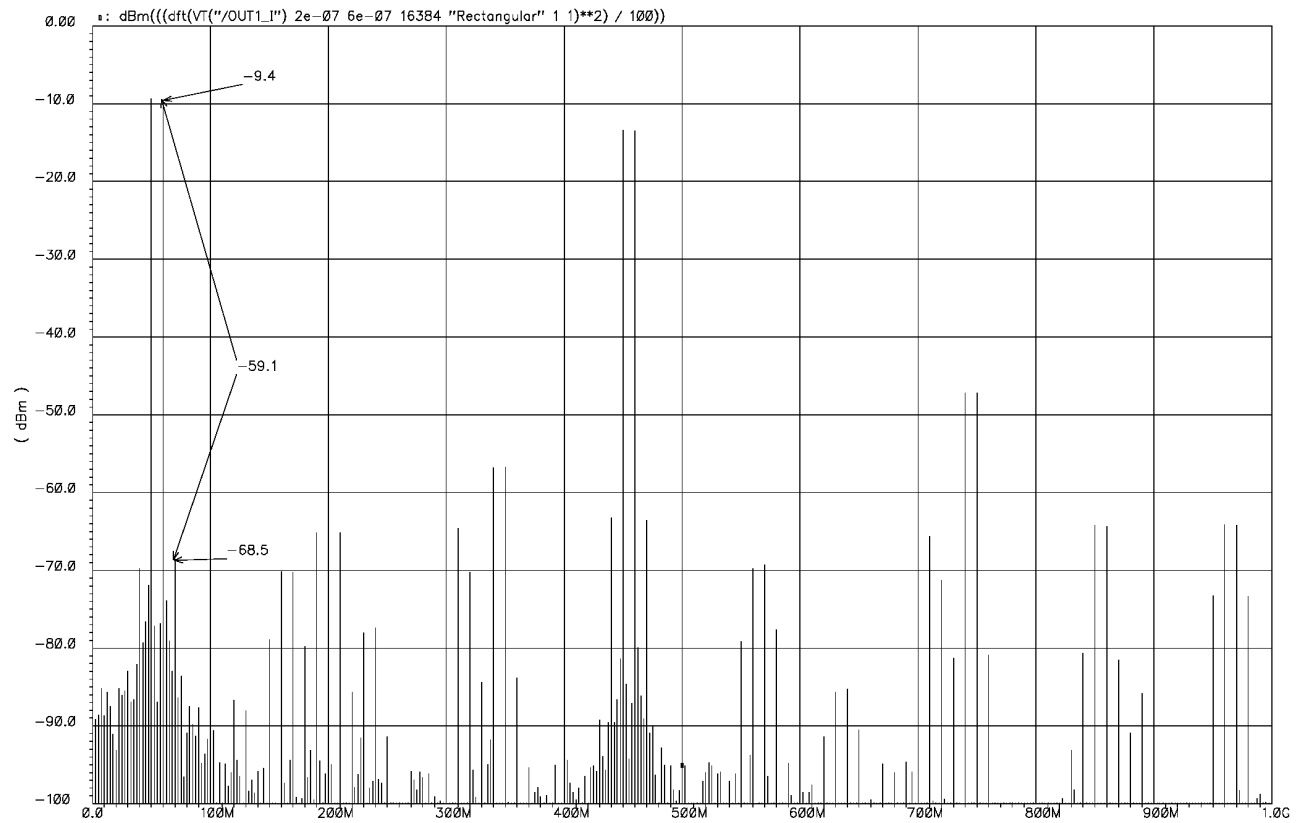


Figure 18: IM3 for A-Band.

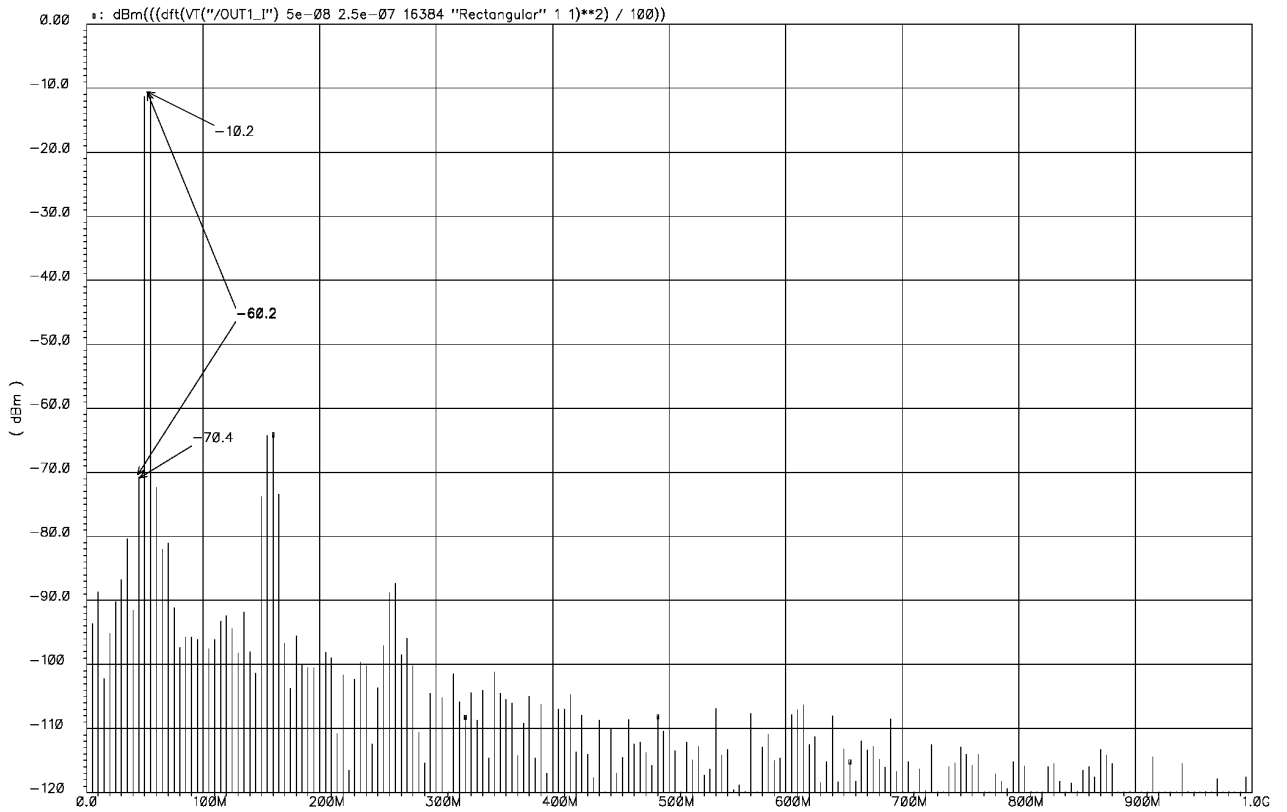


Figure 19: IM3 for B-Band.

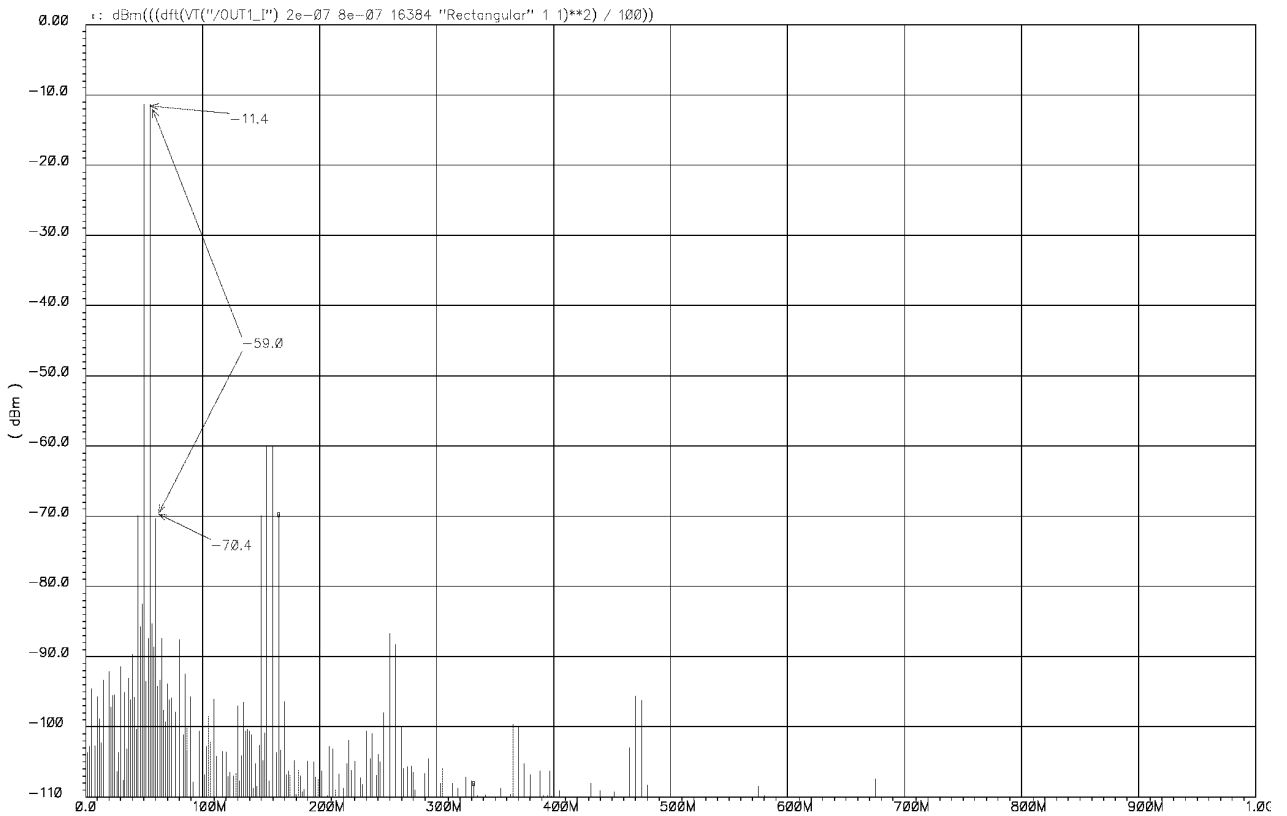


Figure 20: IM3 for C-Band.

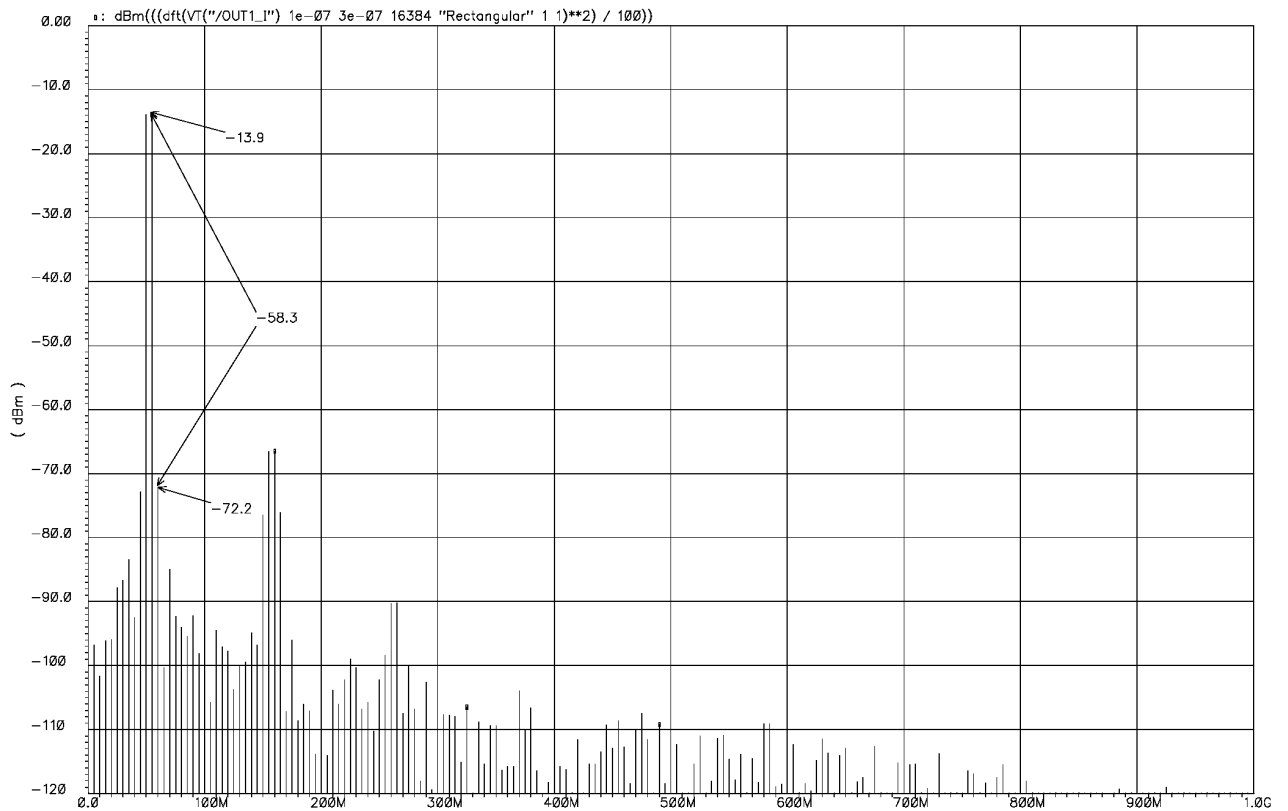


Figure 21: IM3 for D-Band.

9 DELIVERABLES

IP contents:

- Schematic or NetList
- Layout or blackbox
- Extracted view (optional)
- GDSII
- DRC, LVS, antenna report
- Test bench with saved configurations (optional)
- Documentation