

GPS/Galileo/BeiDou/GLONASS multisystem single-band receiver

SPECIFICATION

1 FEATURES

- TSMC018 SiGe technology
- Single conversion superheterodyne receiver
- Active antenna detector
- Selectable front end modes: IQ GPS/Galileo/BeiDou/GLONASS, IQ GPS/Galileo/BeiDou only, IQ GLONASS only, GPS/Galileo/BeiDou and GLONASS with image-rejection
- Integrated LNA with output matching to 50 Ω
- Integrated mixer preamplifier with programmable operating current
- Image-rejection mixer
- Integrated IF filter with automatic passband adjustment
- Selectable channel output type: differential linear output or digital CMOS output with integrated 2-bit ADC
- Fully integrated frequency synthesizer with internal PLL filter and clock driver for correlator
- Fully integrated VCO with automatic adjustment system
- PLL lock indicator
- 3-wires serial peripheral interface for status monitoring, mode configuration and parameter adjustment
- «Stand-by» mode with minimum current consumption

2 APPLICATION

- Navigation systems
- Portable receivers
- Mobile communication
- Measuring equipment and etc.

3 OVERVIEW

The NT1020 is a multisystem receiver intended to perform a simultaneous reception, down conversion, filtering and amplifying of GNSS GPS/Galileo/BeiDou/GLONASS L1-band signals. IC is fabricated on SiGe BiCMOS TSMC 0.18 μm technology.

4 PAD DESCRIPTION

Pad number	Name	Description
1A	LNA_GND	Ground
1B		
2	LNA_OUT	LNA output
3	LNA_VCC	LNA supply voltage
4A	MIX_VCC	Mixer supply voltage
4B		
5	MIX_IN	Mixer input
6A	RF_GND	Ground
6B	MIX_GND	
7	VCO_GND	
8	VCO_VCC	VCO supply voltage
9A	DIG_GND	Voltage regulator and serial interface ground
9B		
10A	DIG_VCC	Voltage regulator and serial interface supply voltage
10B		
11	REF_IN	Reference frequency input
12	EN	Serial interface enable
13	DATA	Serial interface input/output data
14	CLK	Serial interface clock
15	CP_OUT	Not connected
16	PLL_VCC	Synthesizer supply voltage
17	PLL_GND	Charge pump ground
18	MIX_Q_VCC	Q channel LPF supply voltage
19	MIX_Q_OUTp	Not connected
20	MIX_Q_OUTn	
21A	LPF_Q_GND	Ground
21B	IFA_Q_GND	
22	IFA_Q_INn	Not connected
23	IFA_Q_INp	
24A	IFA_Q_VCC	Q channel IFA supply voltage
24B		
27	AGC_Q	Q channel AGC output
26	Q_OUT_P/sign	Q channel differential/digital output
27	Q_OUT_N/magn	
28A	BUF_Q_GND	Ground
28B	DET_Q_GND	
Sld	Sld	Serial interface defaults
29A	CLK_VCC	ADC and clock driver supply voltage
29B		
30	CLK_OUT_2	Clock driver differential output
31	CLK_OUT_1	

Table “Pad description” (continue).

Pad number	Name	Description
32A	CLK_GND	ADC and clock driver ground
32B		
33A	DET_I_GND	Ground
33B	BUF_I_GND	
34	I_OUT_N/magn	I channel differential/digital output
35	I_OUT_P/sign	
36	AGC_I	I channel AGC output
37A	IFA_I_VCC	I channel IFA supply voltage
37B		
38	IFA_I_INp	Not connected
39	IFA_I_INn	
40A	IFA_I_GND	Ground
40B	LPF_I_GND	
41	MIX_I_OUTn	Not connected
42	MIX_I_OUTp	
43	MIX_I_VCC	I channel LPF supply voltage
44	AA	Active antenna supply voltage
45	REF_CUR	Reference current source external resistor
46A	LNA_GND	LNA ground
46B		
47	LNA_IN	LNA input
48A	LNA_GND	LNA ground
48B		

5 TYPICAL APPLICATION CIRCUIT

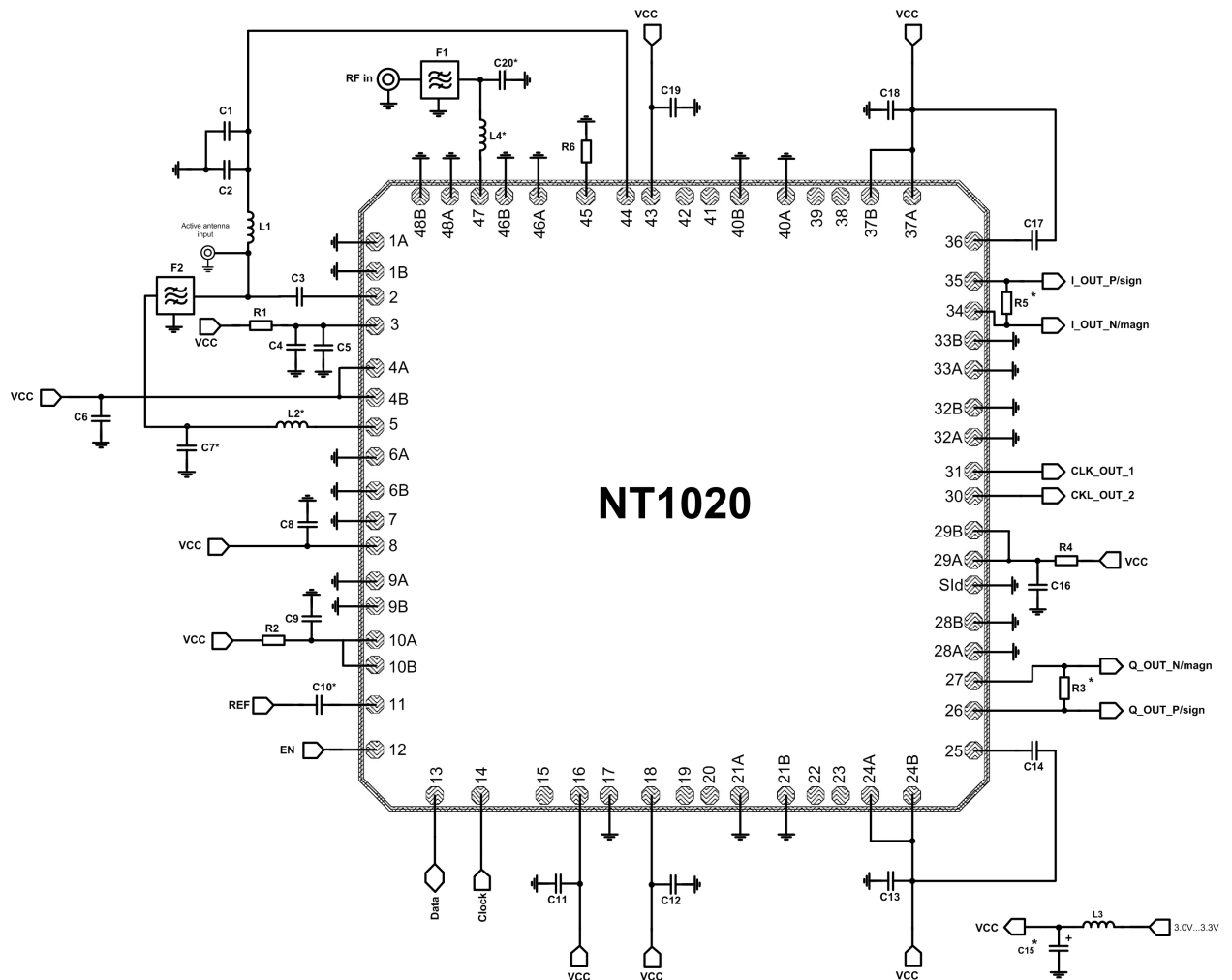


Figure 1: NT1020 application circuit.

Table 1: External component description.

Component	Nominal value	Tolerance	Notes
C1	1 uF	±10%	Supply voltage filter capacitor
C2	1 nF	±10%	Supply voltage filter capacitor
C3	3 pF	±5%	Blocking capacitor
C4	0.1 uF	±10%	Supply voltage filter capacitor
C5	100 pF	±10%	Supply voltage filter capacitor
C6	0.1 uF	±10%	Supply voltage filter capacitor
C7*	2.4 pF	±5%	Matching network element
C8	0.1 uF	±10%	Supply voltage filter capacitor
C9	0.1 uF	±10%	Supply voltage filter capacitor
C10*	47 pF	±10%	Blocking capacitor
C11	0.1 uF	±10%	Supply voltage filter capacitor
C12	0.1 uF	±10%	Supply voltage filter capacitor
C13	0.1 uF	±10%	Supply voltage filter capacitor
C14	0.01 uF	±10%	AGC filter capacitor
C15	100 uF	±20%	Supply voltage filter capacitor
C16	0.1 uF	±10%	Supply voltage filter capacitor
C17	0.01 uF	±10%	AGC filter capacitor
C18	0.1 uF	±10%	Supply voltage filter capacitor
C19	0.1 uF	±10%	Supply voltage filter capacitor
C20*	-	±5%	Matching network element
L1	56 nH (Q > 30)	±5%	Matching network element
L2*	5.1 nH (Q > 30)	±5%	Matching network inductance
L3	120 Ω/ 100 MHz	±10%	Supply voltage filter inductance
L4*	8.2 nH (Q > 30)	±5%	Matching network inductance
R1	10 Ω	±10%	Supply voltage filter resistor
R2	10 Ω	±10%	Supply voltage filter resistor
R3**	510 Ω	±5%	Load resistor
R4	10 Ω	±10%	Supply voltage filter resistor
R5**	510 Ω	±5%	Load resistor
R6	61.9 kΩ	±1%	High precision resistor
F1	B39162-B9000-C710	-	GPS/Galileo/GLONASS L1-band SAW filter (special part for BeiDou support required)
F2	DSF1590.0B01-TS22	-	GPS/Galileo/GLONASS L1-band SAW filter (special part for BeiDou support required)

Note: * – defined depending on PCB construction and purpose

** – the elements are mounted only in case of using the configuration with differential linear outputs I_OUT_P and I_OUT_N, Q_OUT_P and Q_OUT_N.

6 LAYOUT DESCRIPTION

IC dimensions are given in the table 2.

Table 2: Block dimensions.

Dimension	Value	Unit
Height	2540.53	μm
Width	2540.53	μm

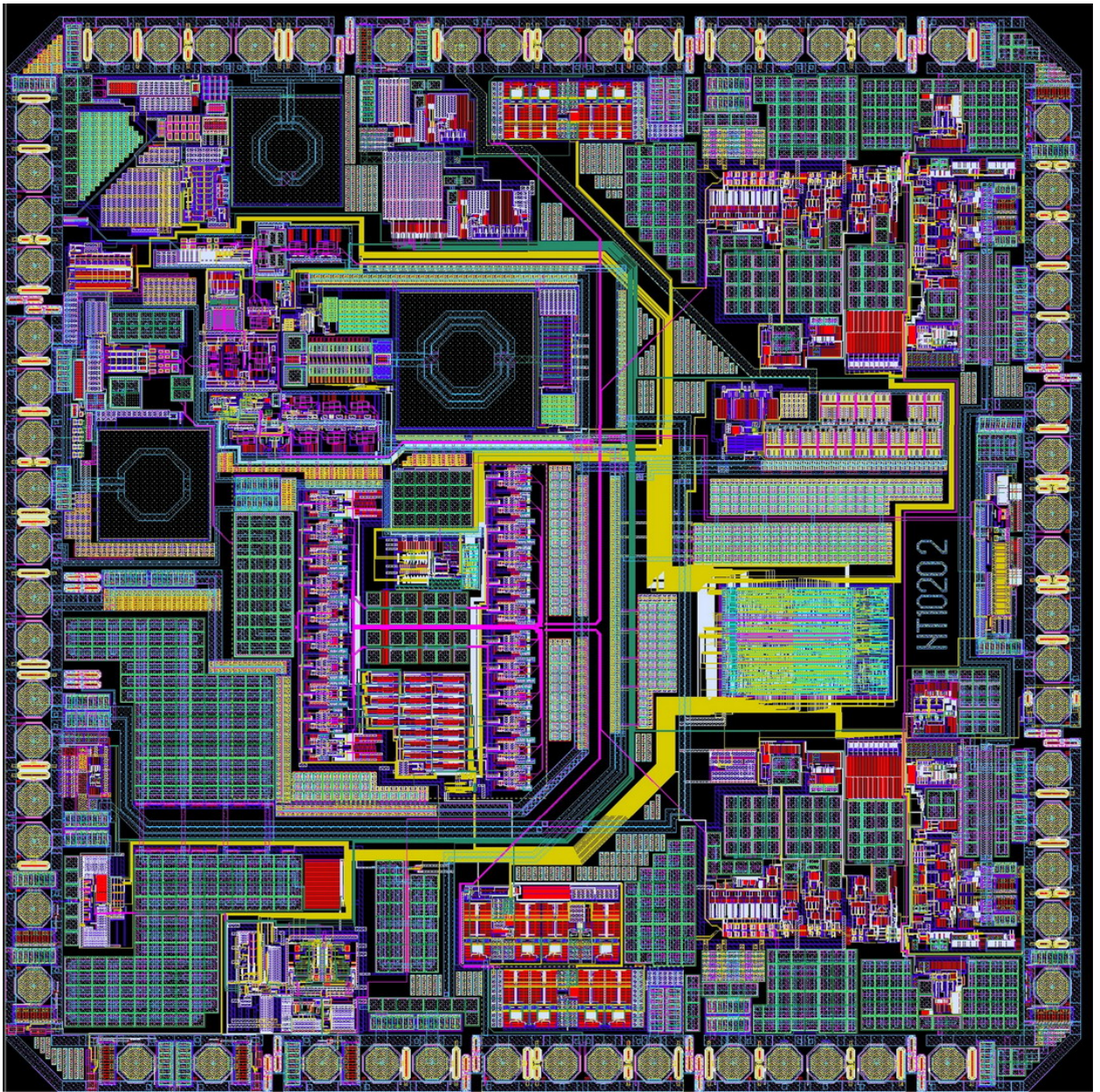


Figure 2:Block layout view.

7 OPERATING CHARACTERISTICS

7.1 TECHNICAL CHARACTERISTICS

Technology _____ BiCMOS SiGe TSMC 0.18 μm
 Status _____ silicon proven
 Area _____ 7.64 mm²

7.2 DC ELECTRICAL CHARACTERISTICS

The values of electrical characteristics are specified for $V_{cc} = 3.0 \text{ V}$ to 3.3 V , $T = -40 \dots +85^\circ\text{C}$. Typical values are at $V_{cc} = 3.15 \text{ V}$, $T = +25^\circ\text{C}$, unless otherwise specified.

Parameter	Symbol	Condition	Value			Unit
			min	typ	max	
Supply voltage	V_{cc}	-	3.0	3.15	3.3	V
Supply current	$I_{cc\ 3}$	Mode 1	-	32.1	-	mA
	$I_{cc\ GPS}$	Mode 2	-	31.0	-	
	$I_{cc\ GLO}$	Mode 3	-	31.0	-	
	I_{cc}	Mode 4	-	40.1	-	
	$I_{cc\ 3\ dig}$	Mode 5	-	31.9	-	
	$I_{cc\ GPS\ dig}$	Mode 6	-	30.9	-	
	$I_{cc\ GLO\ dig}$	Mode 7	-	30.9	-	
	$I_{cc\ dig}$	Mode 8	-	39.9	-	
Stand-by current	I_{stb}	-	-	-	1	μA
Voltage drop at AA supply voltage from V_{cc}	ΔV_{AA}	Nominal value. Note 1	-	0.16	-	V
Short-circuit protection current	I_{AS}	Nominal value. Note 2	-	16.5	-	mA
AA detection current	I_{AW}	Nominal value. Note 3	-	3.6	-	mA
DC operating point	$V_{IFA\ dif}$	IFA outputs, linear mode	-	$V_{cc}-1.17$	-	V
	V_{CLK}	Clock frequency outputs	-	$V_{cc}-0.4$	-	
Output logic-level low (digital outputs)	V_{OH_dig}	For outputs I_OUT_P, I_OUT_N, Q_OUT_P, Q_OUT_N. Load current 2 mA	$V_{cc}-0.5$	$V_{cc}-0.15$	V_{cc}	V
Output logic-level high (digital outputs)	V_{OL_dig}	For outputs I_OUT_P, I_OUT_N, Q_OUT_P, Q_OUT_N. Load current 2 mA	0	0.04	0.2	V
Input logic-level low	V_{IL}	-	-0.25	-	0.3	V
Input logic-level high	V_{IH}	-	$0.7V_{cc}$	-	$V_{cc}+0.25$	V

7.3 AC ELECTRICAL CHARACTERISTICS

The values of electrical characteristics are specified for $V_{CC} = 3.0\text{ V to }3.3\text{ V}$, $T_A = -40\dots+85^\circ\text{C}$. Typical values are at $V_{CC} = 3.15\text{ V}$, $T_A = +25^\circ\text{C}$, unless otherwise specified.

Parameter	Symbol	Condition	Value			Unit
			min	typ	max	
Overall						
Operating frequency range	F_{IN}	L1 band for GNSS GLONASS	1593	-	1606	MHz
		L1 band for GNSS GPS and SBAS	1571		1587	
		L1 band for GNSS Galileo	1571		1587	
		L1 band for GNSS BeiDou	1559		1564	
Noise figure (DSB)	NF	Mode 1	-	1.75	3.0	dB
		Mode 4		1.8	3.0	
AA noise figure	NF_{AA}	-	-	8.0	10.5	dB
Input VSWR	$VSWR_{IN}$	50 Ω	-	1.45	2.0	dB
AA input VSWR	$VSWR_{IN_AA}$	50 Ω	-	2.0	2.5	dB
Input 1dB compression point	P_{1dB}	Note 4	-	-62	-	dBm
AA input 1dB compression point	P_{1dB_AA}	Note 5	-	-41	-	dBm
3 rd order input intercept point (out of band)	IIP3	Note 5	-	-23	-	dBm
3 rd order AA input intercept point (out of band)	IIP3 _{AA}	Note 5	-	+37	-	dBm
Overall voltage gain	G_{MAX}	500 Ω	-	80	-	dB
IQ phase accuracy	$\Delta\phi$	-	-	± 0.2	± 5	degrees
IQ amplitude accuracy	ΔA	-	-	± 0.2	± 1	dB
LNA						
LNA noise figure	NF_{LNA}	-	-	1.4	1.7	dB
LNA gain	G_{LNA}	-	-	19.5	-	dB
LNA input VSWR	$VSWR_{LNA_IN}$	50 Ω	-	1.4	-	-
LNA output VSWR	$VSWR_{LNA_OUT}$	50 Ω	-	1.2	-	-
LNA input 1dB compression point	P_{1dB_LNA}	Note 6	-	-30	-	dBm
3 rd order input intercept point	IIP3 _{LNA}	Note 7	-	-21	-	dBm
Mixer						
Mixer noise figure	NF_{MIX}	-	-	3.7	4.2	dB
Mixer input VSWR	$VSWR_{MIX_IN}$	50 Ω	-	1.1	-	-
Image rejection	IR	GPS	30.0	35.0	-	dB
		GLONASS	28.0	33.0	-	
LPF&IFA						
Output frequency range	F_{IF}	-	3.0	-	18.0	MHz
Sinusoidal/noise signal peak-to-peak voltage at the differential linear outputs	V_m	500 Ω	-	200/480	-	mV
LPF cut-off frequency	F_{cut_LPF}	-1dB	-	15	-	MHz
		-3 dB		17		
AGC range	ΔG	-	50	-	-	dB
ADC						
ADC output signal level	V_{OUT}	-	-	CMOS	-	-

Table “AC electrical characteristics” (continue).

Parameter	Symbol	Condition	Value			Unit
			min	typ	max	
Resolution	R_{ADC}	-	-	2	-	bit
Synthesizer						
PLL dividing ratio	DR_{PLL}	-	-	128	-	-
LO phase noise	PN_{LO}	At 10 kHz offset relative to carrier frequency	-	-91.6	-	dBc/Hz
		At 100 kHz offset relative to carrier frequency	-	-92.8	-	
		At 1 MHz offset relative to carrier frequency	-	-114.9	-	
Peak-to-peak voltage at the differential clock outputs	V_{CLK}	4 k Ω	400	-	-	mV
Comparison frequency suppression	S_{FC}	-	80	-	-	dB
Clock frequency	F_{CLK}	-	-	49.68	-	MHz
Reference frequency	F_{REF}	-	-	24.84	-	MHz
LO frequency	F_{LO}	-	-	1589.76	-	MHz

Modes:

1. IQ GPS/Galileo/BeiDou/GLONASS mode, differential linear output.
2. GPS/Galileo/BeiDou mode, differential linear output
3. GLONASS mode, differential linear output
4. GPS/Galileo/BeiDou and GLONASS with image-rejection mode, differential linear output
5. IQ GPS/Galileo/BeiDou/GLONASS mode, digital CMOS output
6. GPS/Galileo/BeiDou mode, digital CMOS output
7. GLONASS mode, digital CMOS output
8. GPS/Galileo/BeiDou and GLONASS with image-rejection mode, digital CMOS output

Notes:

1. Voltage drop value is evaluated from the equation $\Delta V = 0.1 + (2 \times I_{nom})$, nominal current (I_{nom}) of an active antenna
2. Current value is evaluated from the equation $I_{AS} = 2 \times I_{nom}$, nominal current (I_{nom}) of an active antenna
3. Current value is evaluated from the equation $I_{AW} = 0.5 \times I_{nom}$, current (I_{nom}) of an active antenna
4. Minimum IFA gain
5. Under conditions:
 - minimum IFA gain;
 - the LNA output connects to the mixer input with a SAW filter between them.
 - two tones are located at 1375 MHz and 1175 MHz at -60dBm/tone. Passive pole at the output is programmed to be 14.76 MHz.
6. Harmonic signal at a LNA input is 1580 MHz
7. Two tones are located at 1375 MHz and 1175 MHz at -60dBm/tone

8 TYPICAL OPERATING CHARACTERISTIC

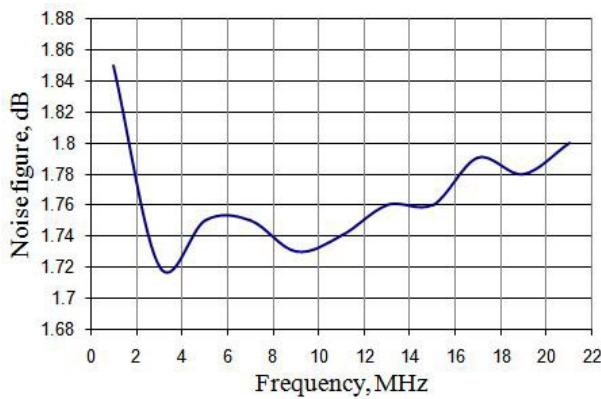


Figure 3: Front-end noise figure referred to LNA input in [mode 1](#).

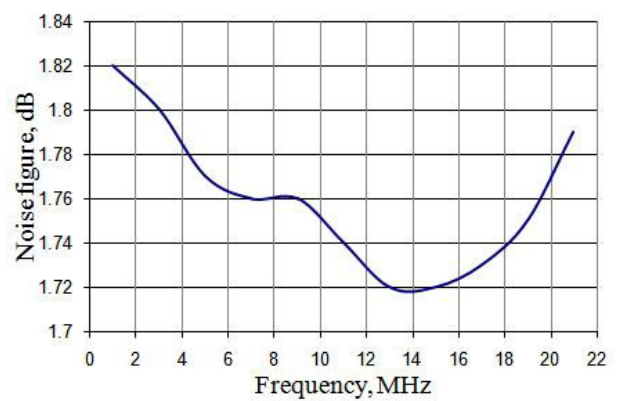


Figure 4: Front-end noise figure referred to LNA input in [mode 4](#).

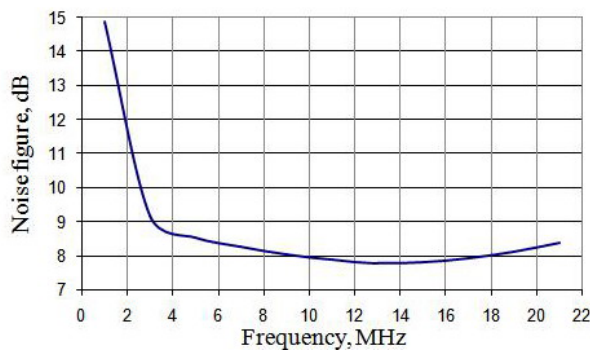


Figure 5: Front-end noise figure referred to active antenna input in [mode 1](#).

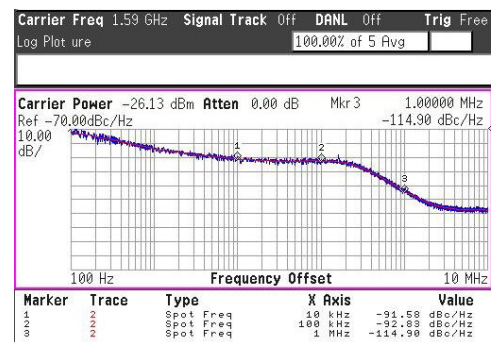


Figure 6: LO phase noise.

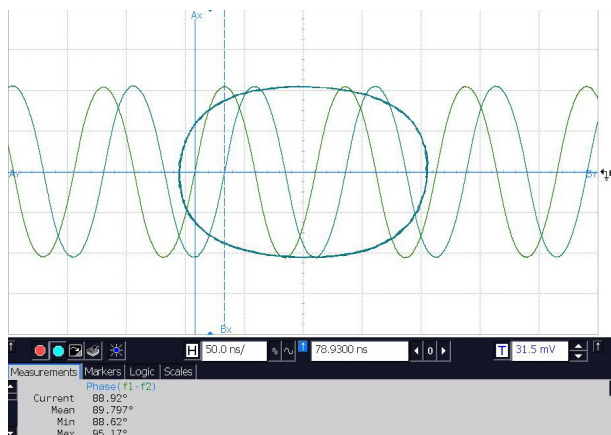


Figure 7: Quadrature output signals.

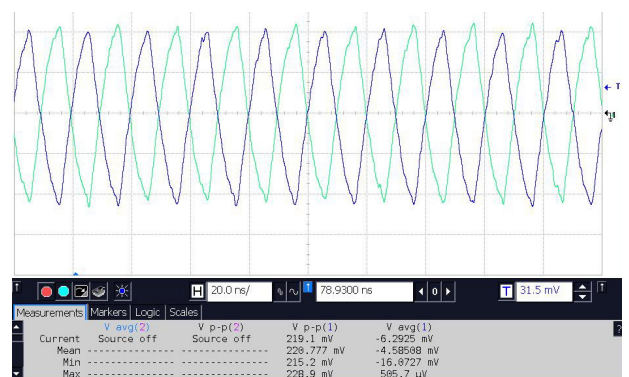


Figure 8: Clock output signal.

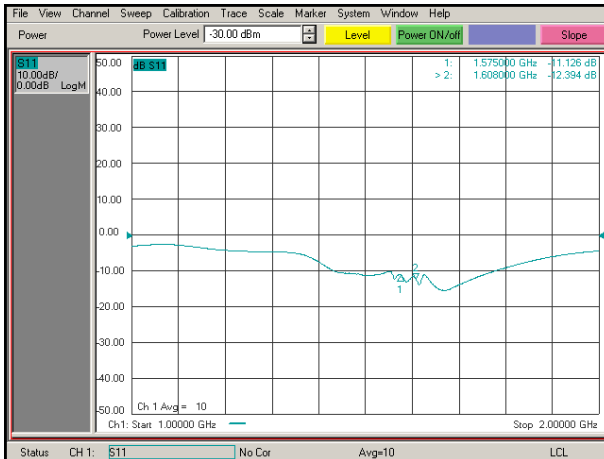


Figure 9: LNA input matching.



Figure 10: Active antenna input matching.

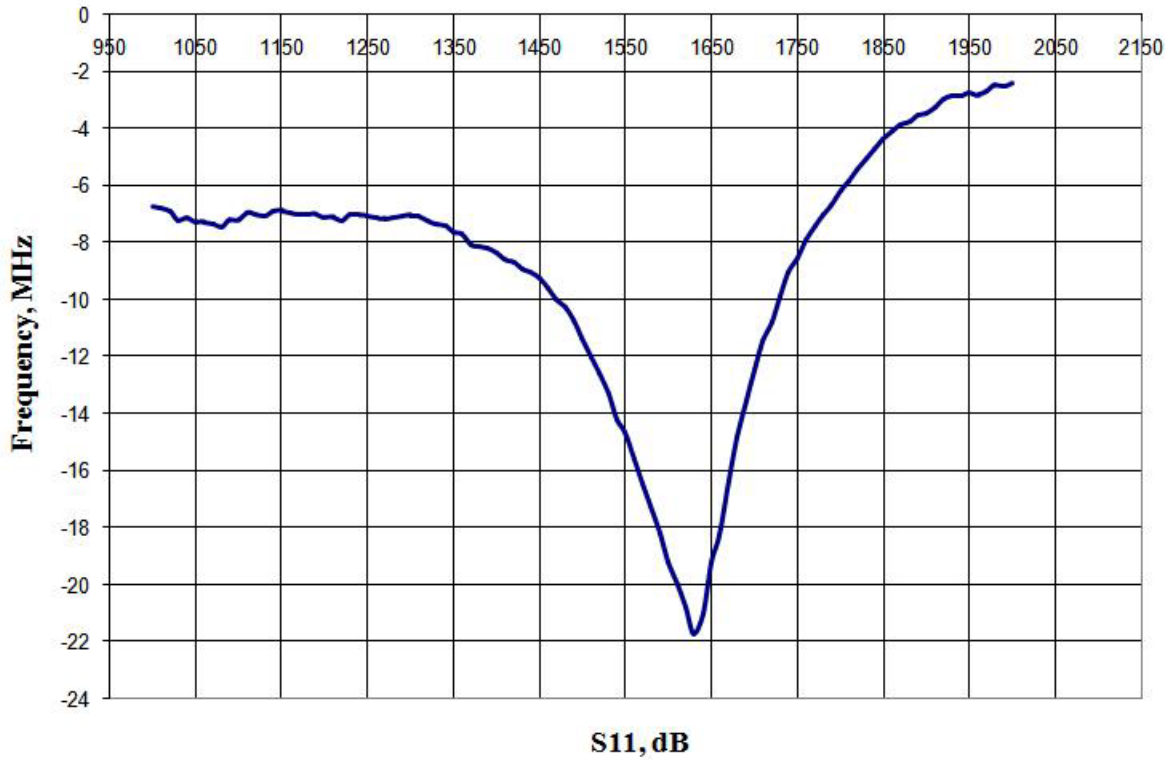


Figure 11: Mixer input.

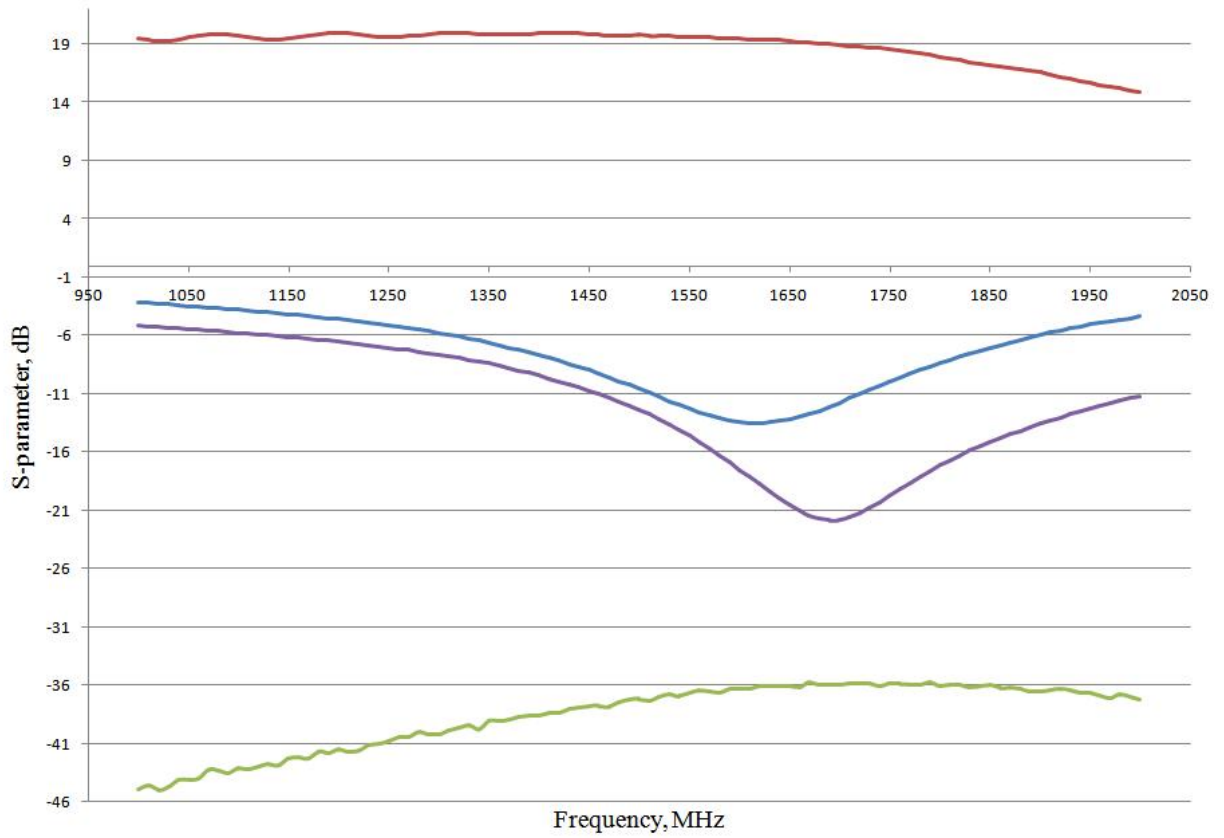


Figure 12: LNA S-parameter.

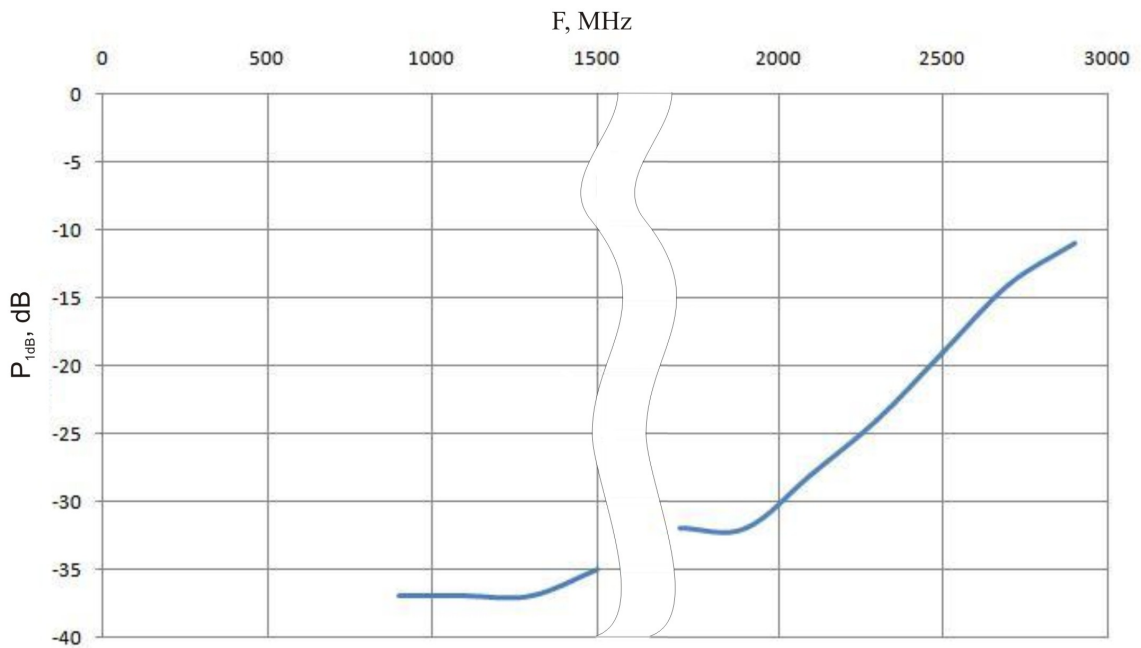


Figure 13: 1 dB cascaded gain desensitization vs. jammer frequency.

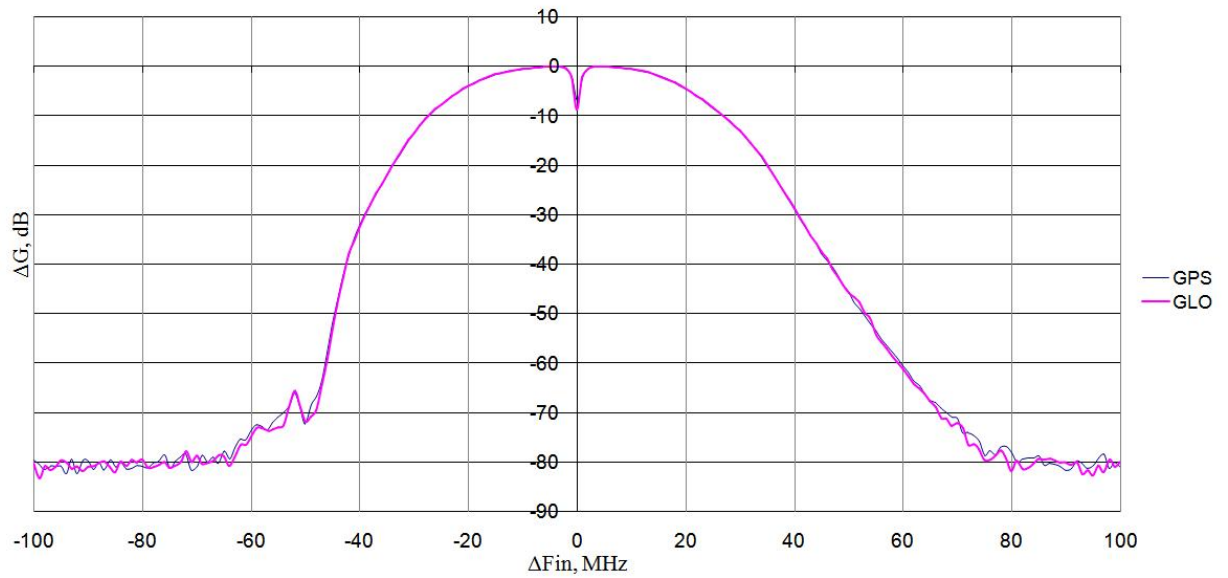


Figure 14: Relative front-end amplitude-frequency characteristic in [mode 1](#).

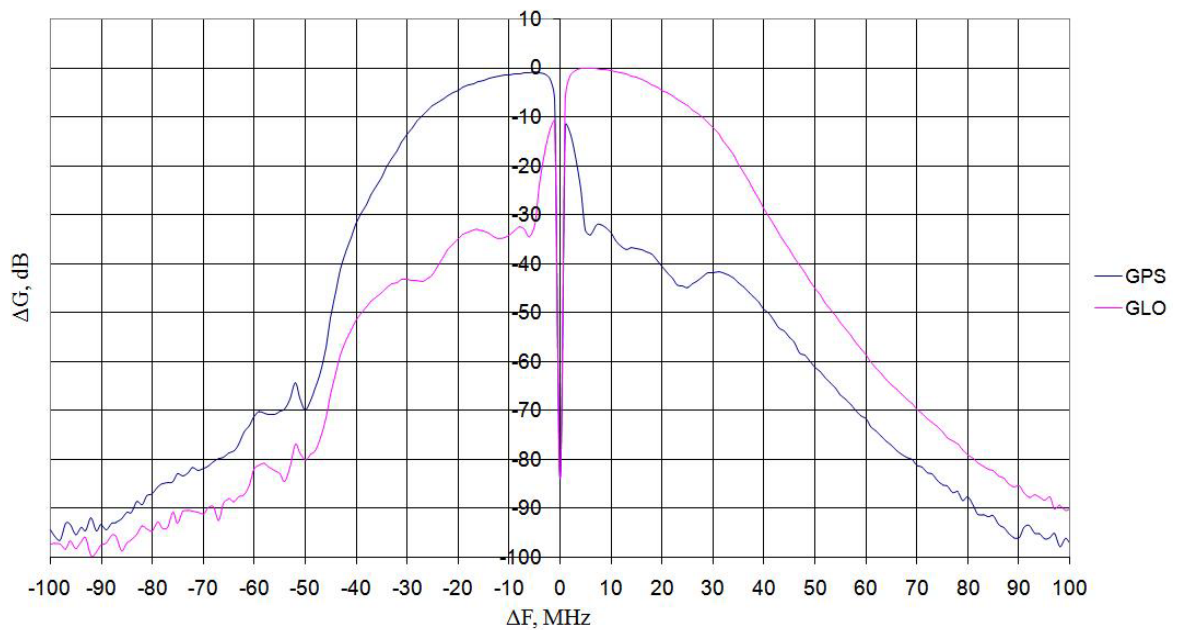


Figure 15: Relative front-end amplitude-frequency characteristic in [mode 4](#).

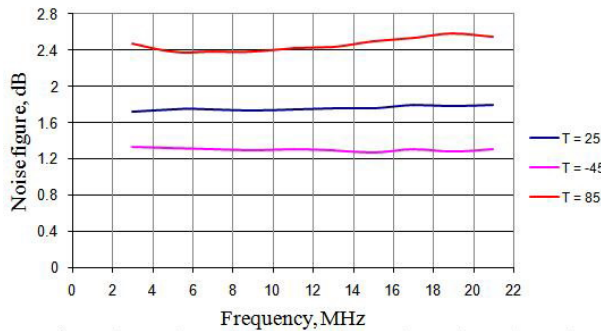


Figure 16: Front-end noise figure referred to LNA input in [mode 1](#) under different operating temperatures.

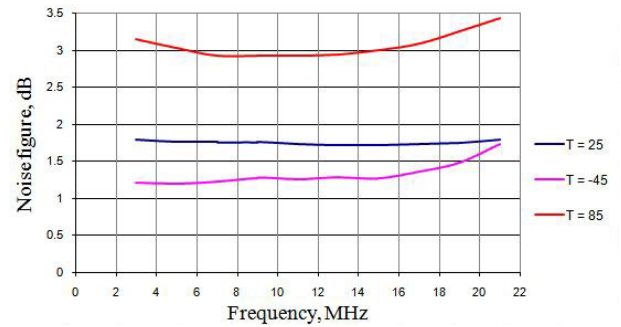


Figure 17: Front-end noise figure referred to LNA input in [mode 4](#) under different operating temperatures.

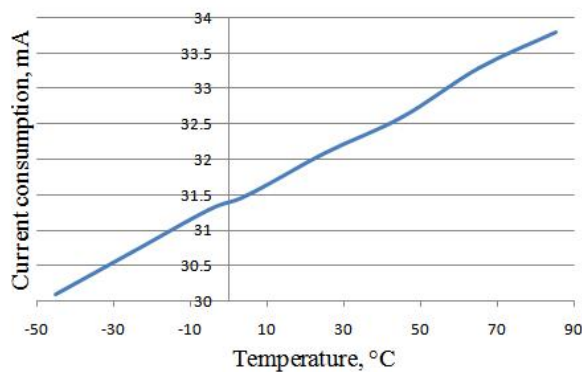


Figure 18: Current consumption vs. operating temperature in [mode 1](#).

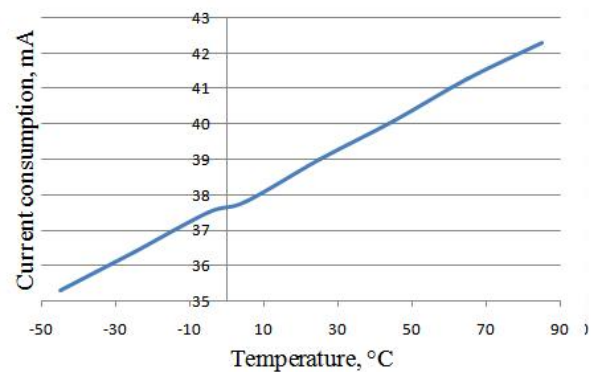


Figure 19: Current consumption vs. operating temperature in [mode 4](#).

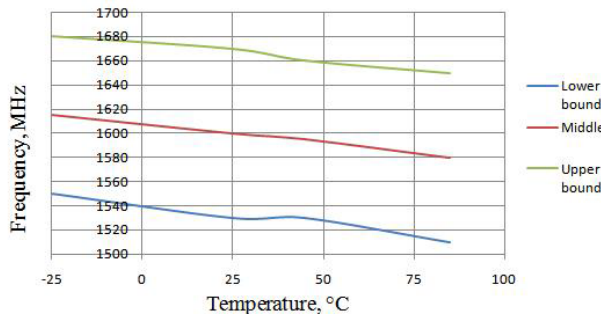


Figure 20: LO adjustment at 4 subband vs. operating temperature.

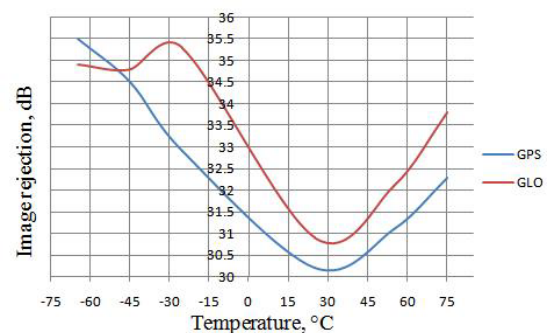


Figure 21: Image rejection vs. operating temperature.

9 DELIVERABLES

IP contents:

- Datasheet
- Layout View (GDSII)
- Evaluation kit based on packaged IC
- Characterization Report
- Behavioral Model
- SPICE netlist (.cdl)
- Integration Support

REVISION HISTORY

From version 1.0:

- Table 4.1 (refer to [page. 2](#))
- Figures 8.16 (refer to [page. 13](#)), 8.17 (refer to [page. 13](#))