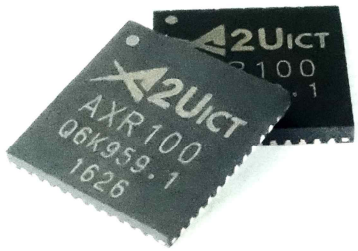
DATA SHEET

Wi-SUN/LECIM Compliant Transceiver

AXR100



DEVICE SPECIFICATION Ver.0.6

General Features

- Programmable Output Power up to +13.5dBm
- Receive Sensitivity Down to -107dBm (@ 12.5kbps, 128 packet length)
- Data rate: 12.5/25/50/150/200 kbps
- Frequency Bands: 902 ~ 928MHz (include KOREAN RFID/USN)
- HW AES128 Security Engine
- Automatic CCA and ACK
- MAX Payload size: 2048Bytes
- Package: QPN 48 pin package, 7mm X 7mm
- Temperature range: -25°C to +80°C
- Dual PHY:

  IEEE802.15.4g (SUN, Smart Utility Network)

  IEEE802.15.4k (LECIM, Low Energy Critical Infra structure Monitoring)
- Certificated with Wi-SUN Alliance

Applications

- Low-Power Wireless Applications Operating in the 902-928MHz ISM Band
- Automated Meter Reading
- Home and Building Automation
- Industrial Monitoring and Control
- Wireless Alarm and Security Systems
- IoT(Internet of Things)

Revision History

Author	Description of Changes	Date
A2U	Initial Draft	Oct. 2016
A2U	Add Test Result	Feb. 2017
A2U	Revision format	Sep. 2017

Disclaimer

Contents

Abbreviations

AXR100	A2UICT RF Transceiver
AXP100	A2UICT Processor for IOT
AXT100	A2UICT Wi-SUN Antenna
AXM100	IEEE802.15.4g/k Compliant LPWAN Module
ACLR	Adjacent channel leakage ratio
AES	Advanced encryption standard
AGC	Automatic gain control
AFC	Automatic frequency control
FSK	frequency shift keying
CAP	contention access period
CCA	clear channel assessment
CSMA-CA	carrier sense multiple access with collision avoidance
FFD	full-function device
GTS	guaranteed time slot
ED	energy detection
MAC	medium access control
PHY	physical layer
RSSI	Received signal strength indicator
RF	radio frequency
SAP	service access point
SFD	start-of-frame delimiter
WPAN	wireless personal area network

1 Introduction

The AXR100 is a cost optimized sub-1 GHz RF transceiver for the 902–928 MHz frequency bands. The RF transceiver is integrated with a highly configurable baseband modem. The modem supports various data rates and has a configurable data rate up to 200 kbps.

1.1 Functional Block Diagram

Figure 1 shows a functional block diagram of the device.

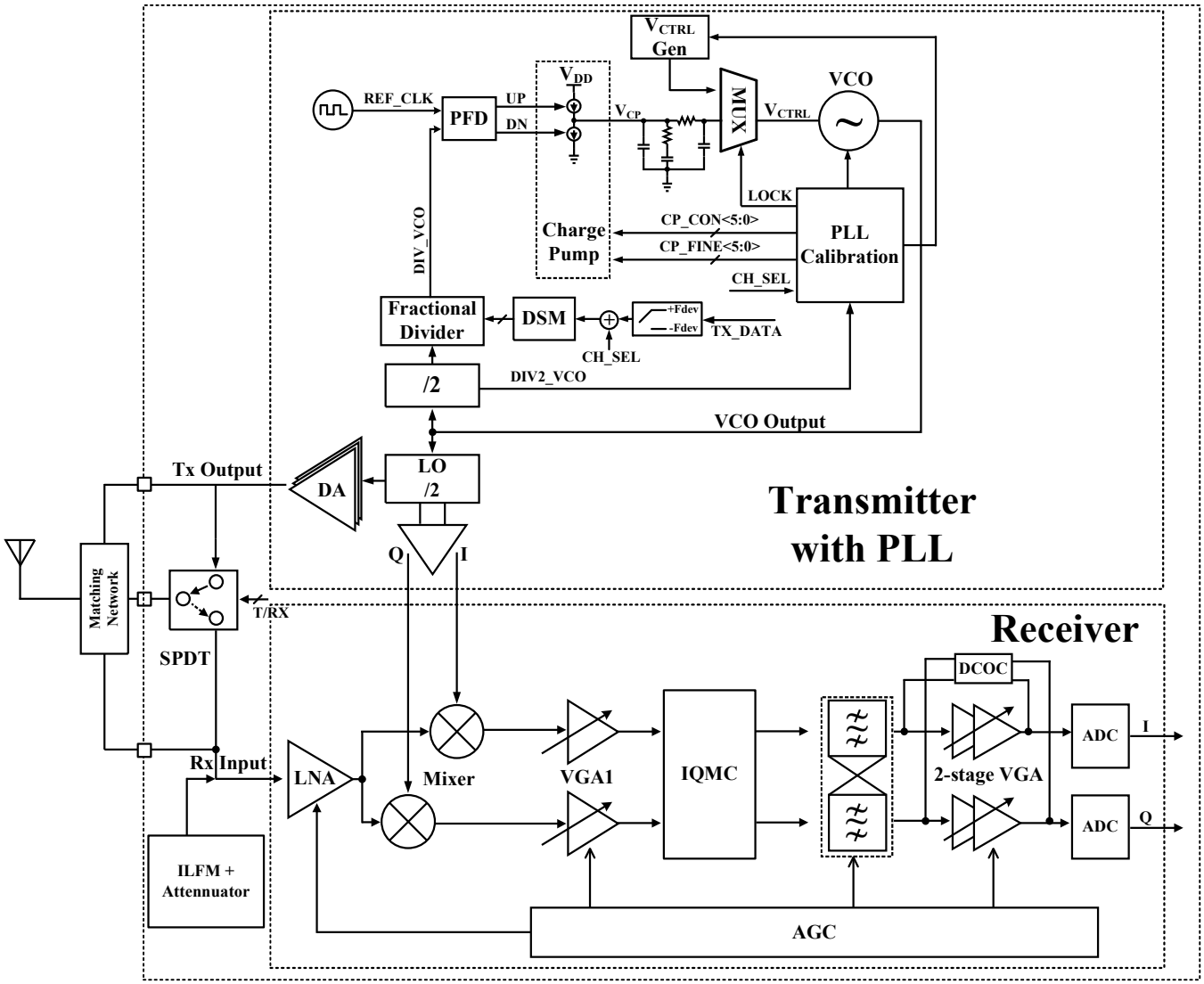


Figure 1 Functional Block Diagram

2 Terminal Configuration and Functions

2.1 Pin Diagram

Figure 2 shows pin names and locations for the AXR100 device.

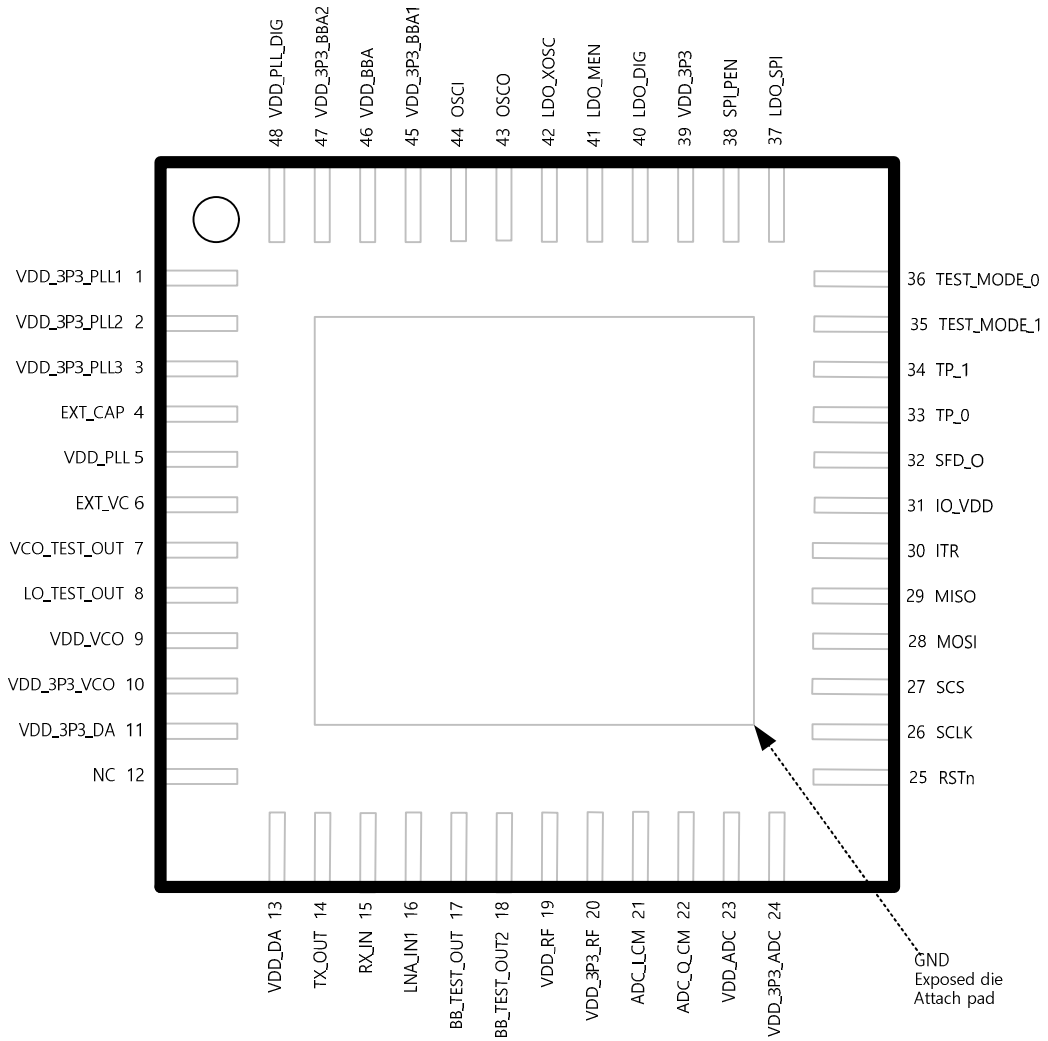


Figure 2 Pinout(Top View)

2.2 Pin Description

Pin No.	Pin Name	Signal Type (I/O/IO/P/G)	Descriptions
1	VDD_3P3_PLL1	P	Power for PLL 3.3V
2	VDD_3P3_PLL2	P	Power for PLL 3.3V
3	VDD_3P3_PLL3	P	Power for PLL 3.3V
4	EXT_CP	IO	External Loop Filter component
5	VDD_PLL	IO	Power for PLL
6	EXT_VC	IO	External Loop Filter component

7	VCO_TEST_OUT	O	Test output port for VCO
8	LO_TEST_OUT	O	Test output port for LO
9	VDD_VCO	IO	Decoupling Cap for VCO LDO
10	VDD_3P3_VCO	P	Power for VCO 3.3V
11	VDD_3P3_DA	P	Power for DA 3.3V
12	N.C	-	No connect
13	VDD_DA	IO	Decoupling Cap for DA LDO
14	TX_OUT	O	TX output port
15	RX_IN	I	Input for RX
16	LNA_IN	I	LNA Input
17	BB_TEST_OUTI	O	BB test signal out for Mixer, VGA1, BPF,VGA2, VGA3
18	BB_TEST_OUTIB	O	BB test signal out for Mixer, VGA1, BPF,VGA2, VGA3
19	VDD_RF	IO	Decoupling Cap for Power for RF
20	VDD_3P3_RF	P	Power for RF 3.3V
21	ADC_I_CM	O	Decoupling cap for ADC I common mode voltage
22	ADC_Q_CM	O	Decoupling cap for ADC Q common mode voltage
23	VDD_ADC	IO	Decoupling cap for ADC LDO
24	VDD_3P3_ADC	P	Power for ADC 3.3V
25	RSTn	I	Reset (Active Low)
26	SCLK	I	Serial Port Clock
27	SCS	I	Serial Port Chip Select (Active Low)
28	MOSI	I	Serial Port Master Out/Slave In
29	MISO	IO	Serial Port Master In/Slave Out
30	INTR	IO	MAC HW Interrupt (Active High)
31	IO_VDD	P	Power for IO interface
32	SFD_OUT	O	Tx/Rx SFD Signal
33	TP[0]	O	Test Point 0
34	TP[1]	O	Test Point 1
35	TEST_MODE[1]	I	SCAN/BIST Mode Selection
36	TEST_MODE[0]	I	SCAN/BIST Mode Selection
37	LDO_SPI	IO	Decoupling cap for SPI LDO
38	SPI_PEN	IO	SPI LDO Enable
39	VDD_3P3	P	Power for digital parts, XOSC
40	LDO_DIG	IO	Decoupling cap for SPI LDO
41	LDO_MEM	IO	Decoupling cap for Memory LDO
42	LDO_XOSC	IO	Decoupling cap for XOSC LDO
43	OSCO	IO	Crystal driver

44	OSCI	IO	Crystal driver
45	VDD_3P3_BBA	P	Power for BBA 3.3V
46	VDD_BBA	IO	Decoupling cap for BBA LDO
47	VDD_3P3_BBA	P	Power for BBA 3.3V
48	VDD_PLL_DIG	IO	Decoupling cap for PLL digital parts

*Signal type definition (I: Input, O: Output, IO: Input Output, P: Power)

3 Specification

3.1 General Characteristics

PARAMETER	MIN	TYP.	MAX	UNIT	CONDITION
Frequency Range	902		928	MHz	NA-ISM, KOREA RFID/USN
Frequency Resolution		5.7		Hz	
Data rate	12.5		200	kbps	GFSK/2FSK(12.5/25/50/150/200)

3.2 Absolute Maximum Ratings

PARAMETER	MIN	MAX	UNIT	CONDITION
Supply Voltage	-0.3	3.9	V	All supply pins must have the same voltage
Voltage on any digital pin	-0.3	3.9	V	
Voltage on the pins(RF Port)	-0.3	3.9	V	
Input RF Level		+10	dBm	

3.3 Handling Ratings

PARAMETER		MIN	MAX	UNIT
Storage temperature range, Tstg	(Default)	-40	125	℃
Voltage on any digital pin	Human Body Model(HBM)	-2	2	kV
	Machine Model (MM)	-200	200	V

3.4 Recommended Operation Conditions

PARAMETER	MIN	TYP	MAX	UNIT	CONDITION
Voltage supply range	2.7		3.6	V	All supply pins must have the same voltage
Voltage on digital inputs	0		VDD	V	VDD=3.3V
Temperature range	-40		85	°C	

3.5 Current Consumption

T_A=25°C, VDD=3.3V, fc= 920.1 MHz, if nothing else stated. All measurement results are obtained using user guide of AXR100.

PARAMETER	MIN	TYP	MAX	UNIT	CONDITION
PHY SLEEP MODE		0.8		mA	
DEEP SLEEP MODE		-		mA	SPI
SLEEP MODE		-		mA	SPI, Memory, XOSC
IDLE MODE		-		mA	SPI, Memory, XOSC, Digital Core

READY MODE		19.5		mA	SPI, Memory, XOSC, Digital Core, PLL
RX MODE		32.3		mA	SPI, Memory, XOSC, Digital Core, PLL, RX (In wait state for packet reception)
TX MODE		20.6		mA	SPI, Memory, XOSC, Digital Core, PLL, TX (In wait state for packet transmission)

3.6 Tx Current Consumption

PARAMETER	MIN	TYP	MAX	UNIT	CONDITION
TX Current Consumption		20.6		mA	In wait state for packet transmission
TX Current Consumption @ +13.5 dBm		56.1		mA	At maximum transmit power
DA_CONT : 0x3074 [31:28] = [1111],					
DA_LDO : 0x3D28 [25:22] =[1111]					
TX Current Consumption @ +10 dBm		44.5		mA	DA_CONT : 0x3074 [31:28] = [1111],

3.7 RX Current Consumption

PARAMETER	MIN	TYP	MAX	UNIT	CONDITION
RX Current		32.3		mA	In wait state for packet reception
RX Peak Current		32.5		mA	Peak current consumption during packet reception at the sensitivity level.

3.8 RF Receive Section

TA = 25°C, VDD = 3.3 V, fc = 920.1 MHz, if nothing else stated. All RX measurements are made at the antenna connector, to a packet error rate (PER) limit of 10% with 250 bytes of packet length. Selectivity and blocking are measured with input power of desired signal 3dB greater than the sensitivity level of IEEE 802.15.4g/k standard.

3.8.1 General Receive Parameters

PARAMETER	MIN	TYP	MAX	UNIT	CONDITION
Saturation		+10		dBm	RF frequency = 920.1 MHz
Channel Filter Programmable Bandwidth	90		200	kHz	
IIP3 (LNA and Mixer)		-16.4		dBm	At maximum gain

			11		dBm	At minimum gain
P1dB (LNA and Mixer)			-25		dBm	At maximum gain
			2		dBm	At Minimum gain
Spurious Emission	< 1GHz		-63		dBm	
	> 1GHz		-58		dBm	
Optimum Source Impedance			52-j16		Ω	RF_freq=920.1 MHz

3.8.2 Receive Performance in 920.1 MHz bands

Parameter	Min	Typ	Max	Units	Condition
Sensitivity		-105		dBm	12.5kbps, 2-GFSK, DEV= 12.5 KHz, CHF= 100 KHz
		-103		dBm	25kbps, 2-GFSK, DEV= 12.5 KHz, CHF= 100 KHz
		-101		dBm	50kbps, 2-GFSK, DEV= 25KHz, CHF= 100KHz
		-93		dBm	150kbps, 2-GFSK, DEV= 37.5KHz, CHF= 165KHz
		-92		dBm	200kbps, 2-GFSK, DEV= 50KHz, CHF= 200KHz
Selectivity and Blocking 12.5 kbps, 2-GFSK, 12.5 kHz deviation, 100 kHz channel filter		33		dB	CW Interferer, - 200 kHz (adjacent channel)
		33		dB	CW Interferer, + 200 kHz (adjacent channel)
		40		dB	CW Interferer,- 400 kHz (alternate channel)
		42		dB	CW Interferer, + 400 kHz (alternate channel)
		33		dB	Modulated Interferer, - 200 kHz (adjacent channel)
		33		dB	Modulated Interferer, + 200 kHz (adjacent channel)
		40		dB	Modulated Interferer, - 400 kHz (alternate channel)
		42		dB	Modulated Interferer, + 400 kHz (alternate channel)
		51		dB	CW Interferer, ± 1 MHz
		52		dB	CW Interferer, ± 2 MHz
		71		dB	CW Interferer, ± 10 MHz
		51		dB	Modulated Interferer, ± 1MHz
		52		dB	Modulated Interferer, ± 2MHz
		71		dB	Modulated Interferer, ± 10 MHz
Selectivity and Blocking 25 kbps, 2-GFSK, 12.5 kHz deviation, 100 kHz channel filter		31		dB	CW Interferer, - 200 kHz (adjacent channel)
		31		dB	CW Interferer, + 200 kHz (adjacent channel)
		38		dB	CW Interferer,- 400 kHz (alternate channel)
		40		dB	CW Interferer, + 400 kHz (alternate channel)
		31		dB	Modulated Interferer, - 200 kHz (adjacent channel)
		31		dB	Modulated Interferer, + 200 kHz (adjacent channel)
		38		dB	Modulated Interferer, - 400 kHz (alternate channel)
		40		dB	Modulated Interferer, + 400 kHz (alternate channel)
		49		dB	CW Interferer, ± 1 MHz

		50		dB	CW Interferer, ± 2 MHz
		69		dB	CW Interferer, ± 10 MHz
		49		dB	Modulated Interferer, ± 1MHz
		50		dB	Modulated Interferer, ± 2MHz
		69		dB	Modulated Interferer, ± 10 MHz
Selectivity and Blocking 50 kbps, 2-GFSK, 25 kHz deviation, 100 kHz channel filter (Same modulation format as 802.15.4g Mandatory Mode)		30		dB	CW Interferer, - 200 kHz (adjacent channel)
		30		dB	CW Interferer, + 200 kHz (adjacent channel)
		36		dB	CW Interferer,- 400 kHz (alternate channel)
		37		dB	CW Interferer, + 400 kHz (alternate channel)
		29		dB	Modulated Interferer, - 200 kHz (adjacent channel)
		29		dB	Modulated Interferer, + 200 kHz (adjacent channel)
		35		dB	Modulated Interferer, - 400 kHz (alternate channel)
		36		dB	Modulated Interferer, + 400 kHz (alternate channel)
		46		dB	CW Interferer, ± 1 MHz
		48		dB	CW Interferer, ± 2 MHz
		66		dB	CW Interferer, ± 10 MHz
		46		dB	Modulated Interferer, ± 1MHz
		48		dB	Modulated Interferer, ± 2MHz
		66		dB	Modulated Interferer, ± 10 MHz
Selectivity and Blocking 150 kbps, 2-GFSK, 37.5 kHz deviation, 165 kHz channel filter		16		dB	CW Interferer, - 400 kHz (adjacent channel)
		21		dB	CW Interferer, + 400 kHz (adjacent channel)
		32		dB	CW Interferer,- 800 kHz (alternate channel)
		35		dB	CW Interferer, + 800 kHz (alternate channel)
		16		dB	Modulated Interferer, - 400 kHz (adjacent channel)
		21		dB	Modulated Interferer, + 400 kHz (adjacent channel)
		31		dB	Modulated Interferer, - 800 kHz (alternate channel)
		35		dB	Modulated Interferer, + 800 kHz (alternate channel)
		33		dB	CW Interferer, ± 1 MHz
		34		dB	CW Interferer, ± 2 MHz
		59		dB	CW Interferer, ± 10 MHz
		33		dB	Modulated Interferer, ± 1MHz
		34		dB	Modulated Interferer, ± 2MHz
		59		dB	Modulated Interferer, ± 10 MHz
Selectivity and Blocking 200 kbps, 2-GFSK,				dB	CW Interferer, - 400 kHz (adjacent channel)
		-		dB	CW Interferer, + 400 kHz (adjacent channel)
		-		dB	CW Interferer,- 800 kHz (alternate channel)
		-		dB	CW Interferer, + 800 kHz (alternate channel)

50 kHz deviation, 200 kHz channel filter		-		dB	Modulated Interferer, - 400 kHz (adjacent channel)
		-		dB	Modulated Interferer, + 400 kHz (adjacent channel)
		-		dB	Modulated Interferer, - 800 kHz (alternate channel)
		-		dB	Modulated Interferer, + 800 kHz (alternate channel)
		-		dB	CW Interferer, ± 1 MHz s
		-		dB	CW Interferer, ± 2 MHz
		-		dB	CW Interferer, ± 10 MHz
		-		dB	Modulated Interferer, ± 1MHz
		-		dB	Modulated Interferer, ± 2MHz
		-		dB	Modulated Interferer, ± 10 MHz
Image Channel Attenuation		25		dB	Measured as image attenuation at the IF filter output, carrier wave interferer at 500 kHz below the channel frequency, 100 kHz IF filter bandwidth

3.9 RF Transmit Section

T_A = 25°C, VDD = 3.3 V, fc = 920.1 MHz, if nothing else stated. All TX measurements are made at the antenna connector. Adjacent channel leakage ratio (ACLR) is measured when transmitter outputs +10 dBm of signal power.

3.9.1 General Transmit Parameters

Parameter	Typ	Units	Condition
Max. Output Power	13.5	dBm	RF freq = 920.1 MHz,
Min. Output Power	-33.5	dBm	RF freq = 920.1 MHz
Output Power Step Size	0.5	dB	Within fine step size range
Clock-Related Spur Level	-52	dBc	TX output power = +10 dBm, Clock freq=24 MHz
Spurious Emissions (Excluding harmonics) < 1GHz > 1GHz	 -55 -52	 dBm dBm	TX output power = +10 dBm,
Harmonics Second Harmonic Third Harmonic Fourth Harmonic	 -37.9 -51.5 -49.3	 dBm dBm dBm	TX output power = +10 dBm,
Optimum Load Impedance	25+j4	Ω	RF_freq=920.1 MHz

3.9.2 Adjacent Channel Leakage Ratio

Parameter	Typ	Units	Condition

ACLR (12.5kbps, 2-GFSK, 12.5 KHz deviation, 200-kHz channel BW)	-36.0	dBc	- 200 kHz (adjacent channel)
	-36.0	dBc	+ 200 kHz (adjacent channel)
	-45.4	dBc	- 400 kHz (alternate channel)
	-45.4	dBc	+ 400 kHz (alternate channel)
ACLR (25kbps, 2-GFSK, 12.5 KHz deviation, 200-kHz channel BW)	-36.7	dBc	- 200 kHz (adjacent channel)
	-36.6	dBc	+ 200 kHz (adjacent channel)
	-45.2	dBc	- 400 kHz (alternate channel)
	-45.6	dBc	+ 400 kHz (alternate channel)
ACLR (50kbps, 2-GFSK, 25 KHz deviation, 200-kHz channel BW)	-37.0	dBc	- 200 kHz (adjacent channel)
	-37.1	dBc	+ 200 kHz (adjacent channel)
	-45.6	dBc	- 400 kHz (alternate channel)
	-45.5	dBc	+ 400 kHz (alternate channel)
ACLR (150kbps, 2-GFSK, 37.5 KHz deviation, 400-kHz channel BW)	-36.2	dBc	- 400 kHz (adjacent channel)
	-36.3	dBc	+ 400 kHz (alternate channel)
	-45.3	dBc	- 800 kHz (alternate channel)
	-45.5	dBc	+ 800 kHz (alternate channel)
ACLR (200kbps, 2-GFSK, 50 KHz deviation, 400-kHz channel BW)	-34.8	dBc	- 400 kHz (adjacent channel)
	-34.9	dBc	+ 400 kHz (adjacent channel)
	-45.8	dBc	- 800 kHz (alternate channel)
	-45.5	dBc	+ 800 kHz (alternate channel)

3.10 Crystal Oscillator

T_A=25°C, VDD=3.3V if nothing else stated. All measurement results are obtained using user guide

Parameter	Min	Typ.	Max	Units	Condition
Crystal frequency		24		MHz	
Load Capacitance (CL)		17		pF	
ESR			80	Ω	
Start-up time		5		ms	Excluding LDO settling time

3.11 PLL Characteristics

T_A = 25°C, VDD = 3.3 V, fc = 920.1 MHz if nothing else stated

Parameter	Typ	Units	Condition
Phase Noise in 920.1 MHz Bands 100-KHz Loop Bandwidth setting	-79	dBc/Hz	± 1KHz offset
	-84	dBc/Hz	± 10KHz offset
	-89	dBc/Hz	± 100KHz offset
	-108	dBc/Hz	± 1MHz offset

	-134	dBc/Hz	± 10MHz offset
Phase Noise in 920.1 MHz Bands 300-KHz Loop Bandwidth setting	-80	dBc/Hz	± 1KHz offset
	-85	dBc/Hz	± 10KHz offset
	-92	dBc/Hz	± 100KHz offset
	-102	dBc/Hz	± 1MHz offset
	-132	dBc/Hz	± 10MHz offset
Frequency resolution	5.7	Hz	

3.12 Wake-up and Timing

TA = 25°C, VDD = 3.3 V, fc = 920.1 MHz if nothing else stated.

The turnaround behavior to and from RX and/or TX is highly configurable, and the time it takes will depend on how the device is set up.

Parameter	Typ	Units	Condition
PHY SLEEP to DEEP Sleep	6	ms	SPI ON
DEEP SLEEP to SLEEP	5	ms	DEEP SLEEP + XOSC + Register
SLEEP to IDLE	450	us	SLEEP + Digital Core
IDLE to READY	470	us	IDEL+PLL/Calibration disabled
	500	us	IDEL+PLL/Calibration enabled
IDLE to RX	450	us	
IDLE to TX	450	us	
RX to IDLE	0	us	
TX to IDLE	0	us	
Minimum required number of preamble bytes	1.5	Bytes	AGC settling time
Time from start RX until valid RSSI Including gain settling (function of channel bandwidth. Programmable for trade-off between speed and accuracy)	260	ms	AGC settling time + 1 symbol timing, 50kbps mode

3.13 I/O and Reset

TA = 25°C, VDD = 3.3 V, fc = 920.1 MHz if nothing else stated

Parameter	Min	Typ	Max	Unit	Condition
Logic Input High Voltage	0.8*VDD			V	
Logic Input Low Voltage			0.2*VDD	V	
Logic Output High Voltage	0.8*VDD			V	

Logic Output Low Voltage			0.2*VDD	V	

4 Typical Performance characteristics

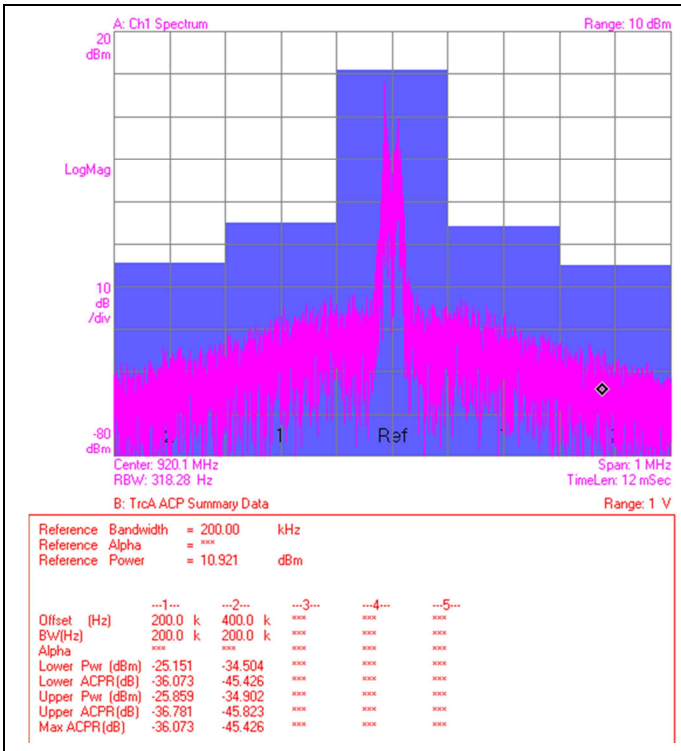


Figure 3

Transmit spectrum and ACLR at 920.1 MHz, 2-GFSK, Data Rate=12.5 kbps, Frequency Deviation=12.5 kHz.

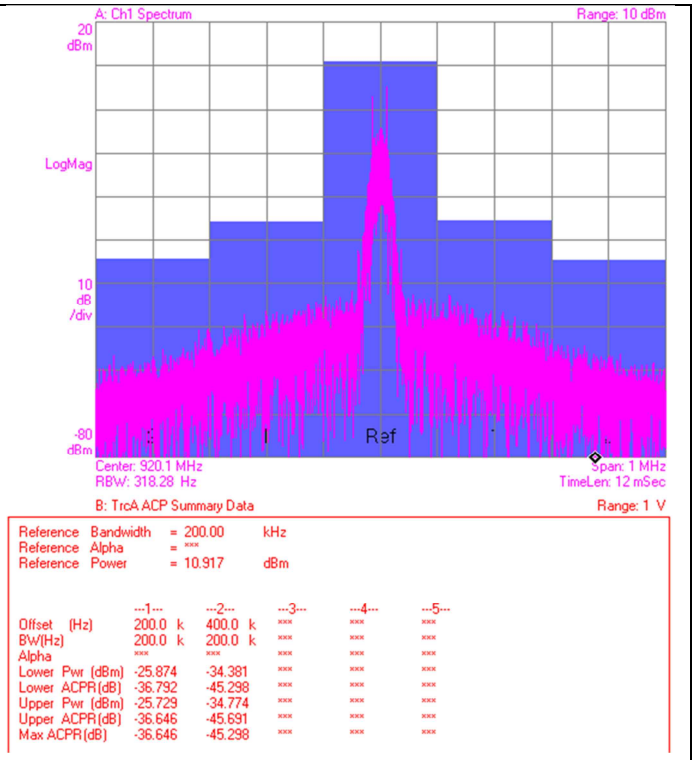


Figure 4

Transmit spectrum and ACLR at 920.1 MHz, 2-GFSK, Data Rate=25 kbps, Frequency Deviation=12.5 kHz.

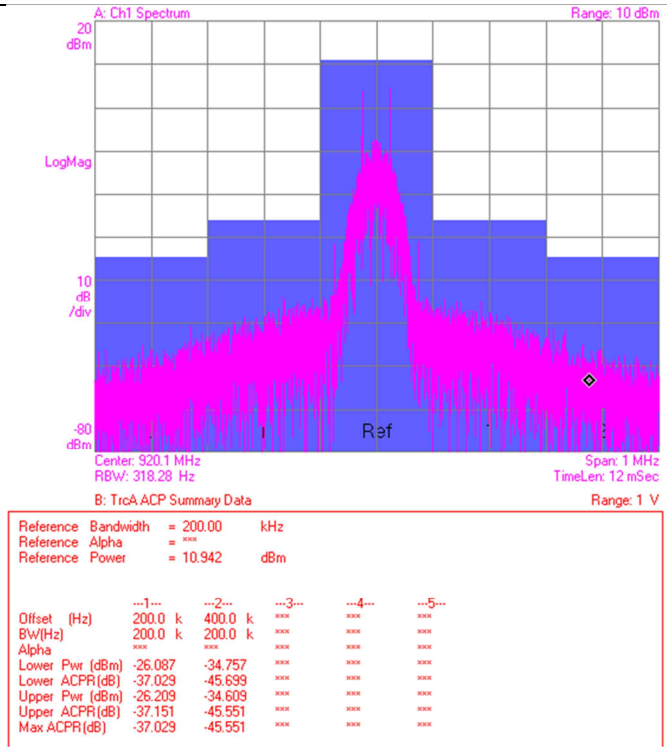


Figure 5

Transmit spectrum and ACLR at 920.1 MHz, 2-GFSK, Data Rate=50 kbps, Frequency Deviation=25 kHz.

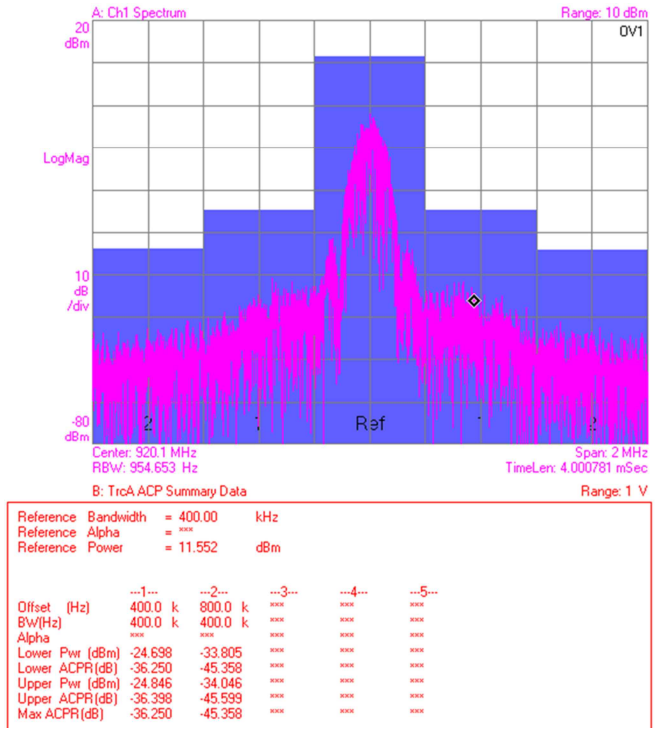


Figure 6

Transmit spectrum and ACLR at 920.1 MHz, 2-GFSK, Data Rate=150 kbps, Frequency Deviation=37.5 kHz.

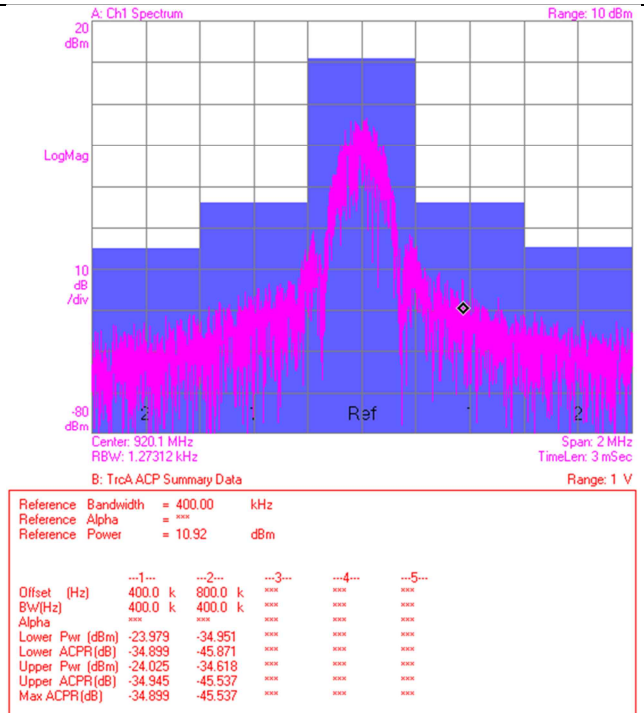


Figure 7

Transmit spectrum and ACLR at 920.1 MHz, 2-GFSK, Data Rate=200 kbps, Frequency Deviation=50 kHz.

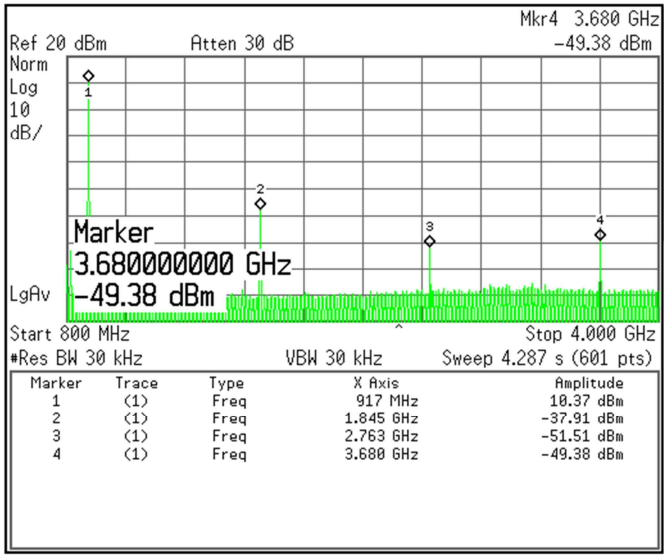


Figure 8

Transmitter Output Signal Spectrum with Harmonics.

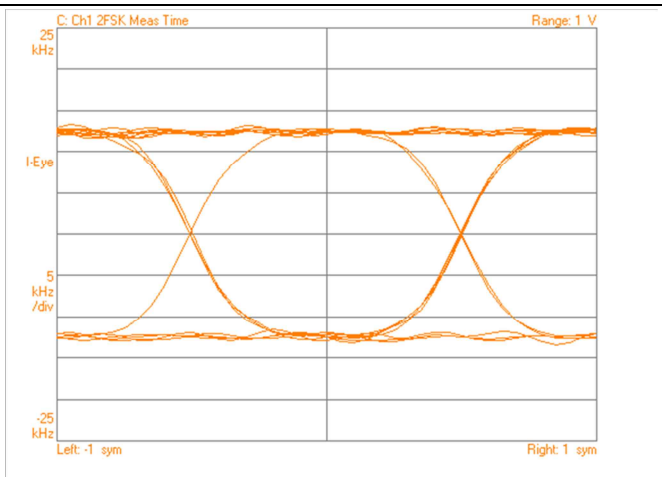


Figure 9

Transmit Eye at 920.1 MHz, 2-GFSK, Data Rate=12.5 kbps, Frequency Deviation=12.5 kHz.

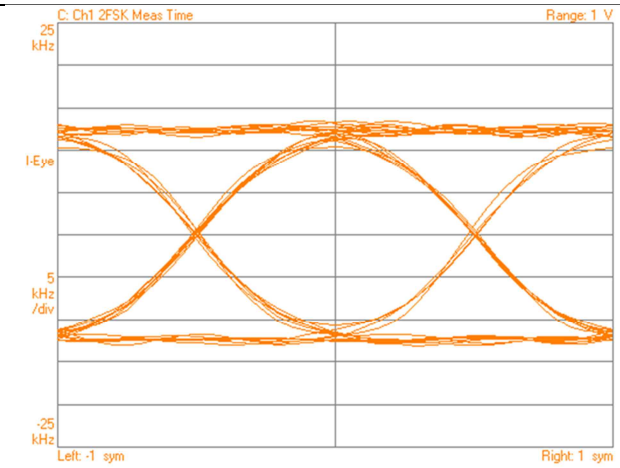


Figure 10

Transmit Eye at 920.1 MHz, 2-GFSK, Data Rate=25 kbps, Frequency Deviation=12.5 kHz.

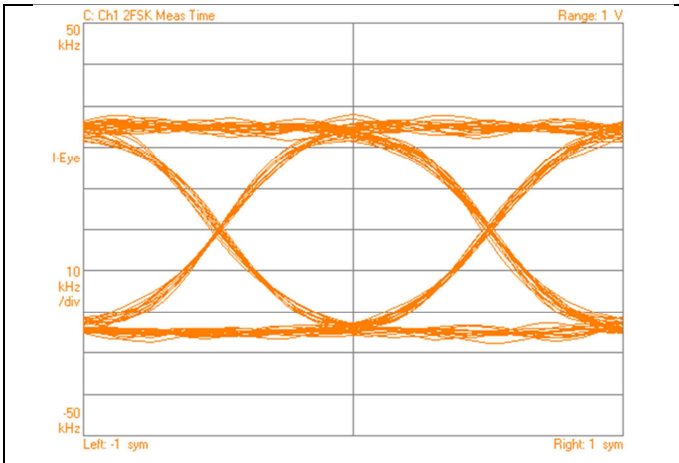


Figure 11

Figure 5-9. Transmit Eye at 920.1 MHz, 2-GFSK, Data Rate=50 kbps, Frequency Deviation=12.5 kHz.

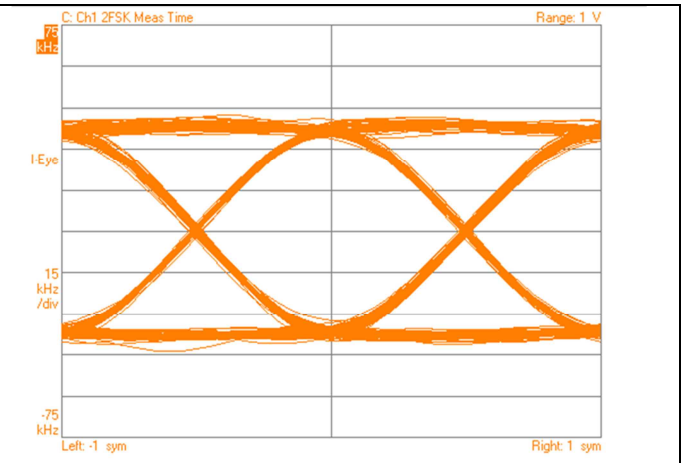


Figure 12

Figure 5-10. Transmit Eye at 920.1 MHz, 2-GFSK, Data Rate=150 kbps, Frequency Deviation=37.5 kHz.

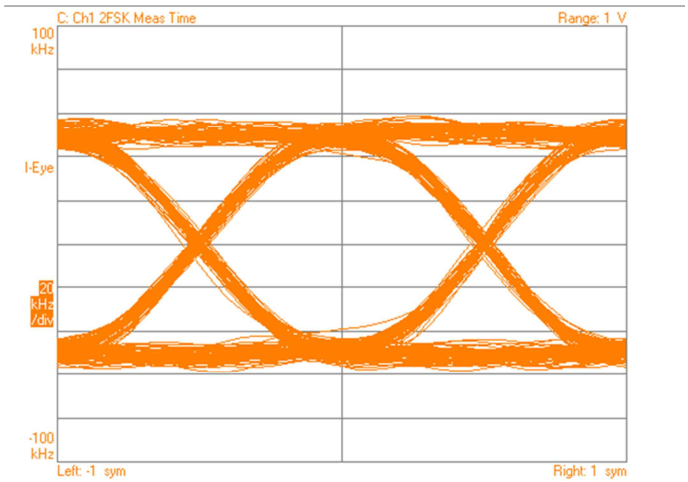


Figure 13

Transmit Eye at 920.1 MHz, 2-GFSK, Data Rate=200 kbps, Frequency Deviation=50 kHz.

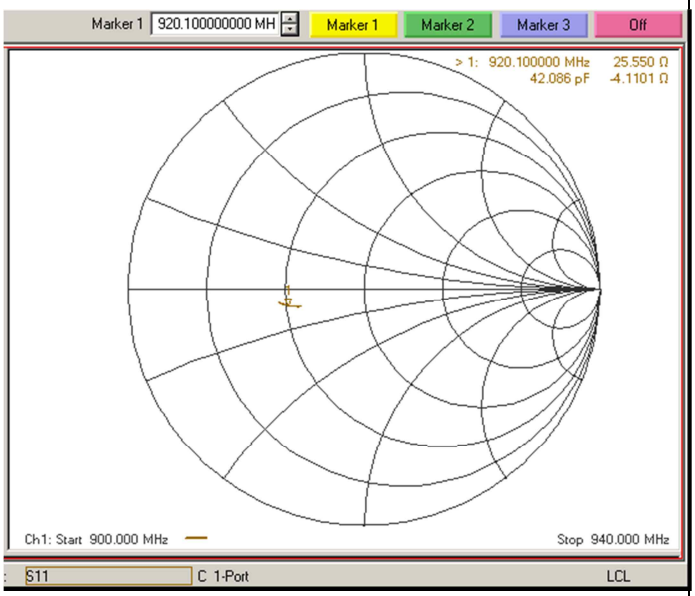


Figure 14

Transmitter Output Impedance at 920.1 MHz.

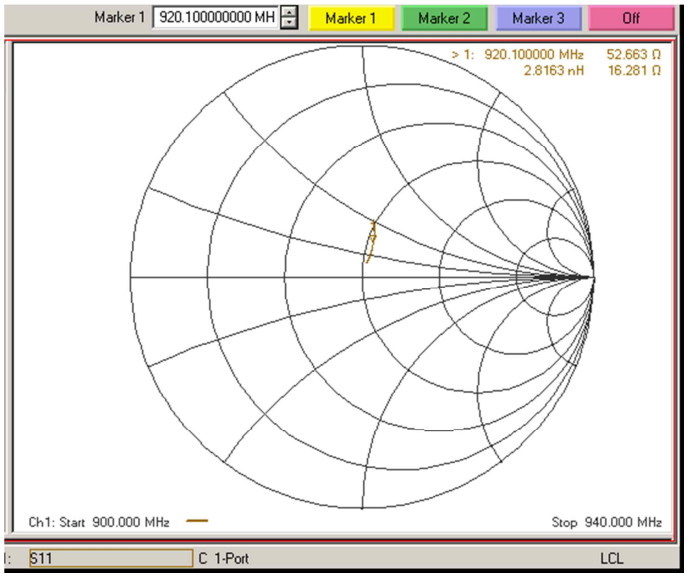


Figure 15

Receiver Input Impedance at 920.1 MHz.

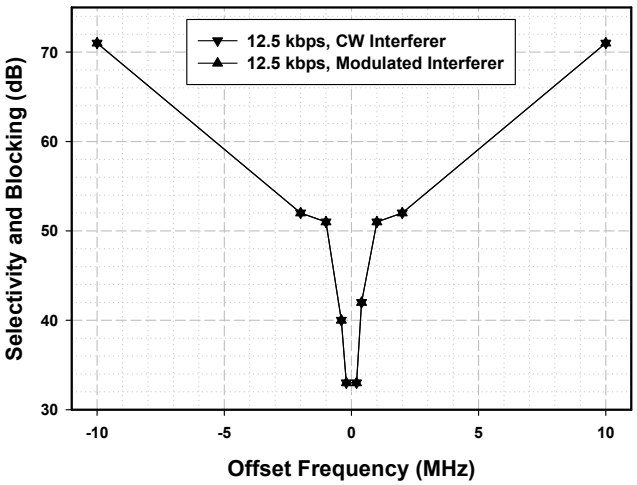


Figure 16

Selectivity and Blocking vs Offset Frequency (Data Rate=12.5 kbps, Frequency Deviation=12.5 kHz, IF=250 kHz, Channel Filter BW = 100 kHz)

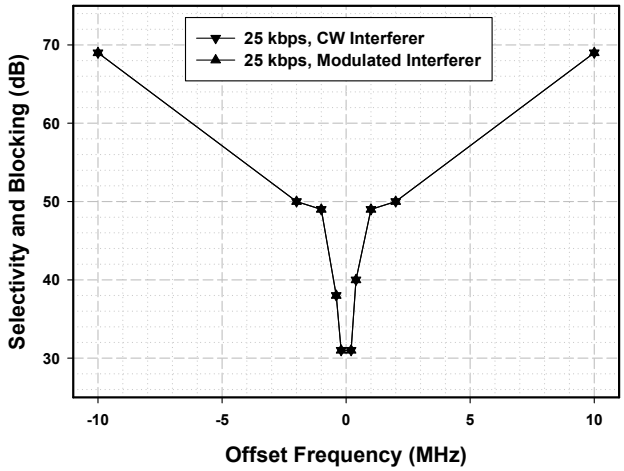


Figure 17

Selectivity and Blocking vs Offset Frequency (Data Rate=25 kbps, Frequency Deviation=12.5 kHz, IF=250 kHz, Channel Filter BW = 100 kHz)

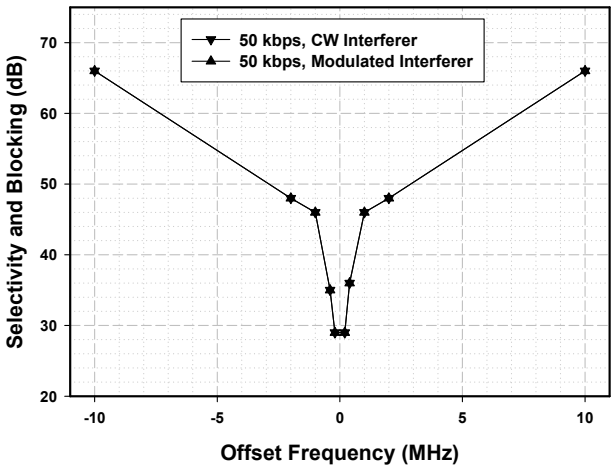


Figure 18

Selectivity and Blocking vs Offset Frequency (Data Rate=50 kbps, Frequency Deviation=25 kHz, IF=250 kHz, Channel Filter BW = 100 kHz)

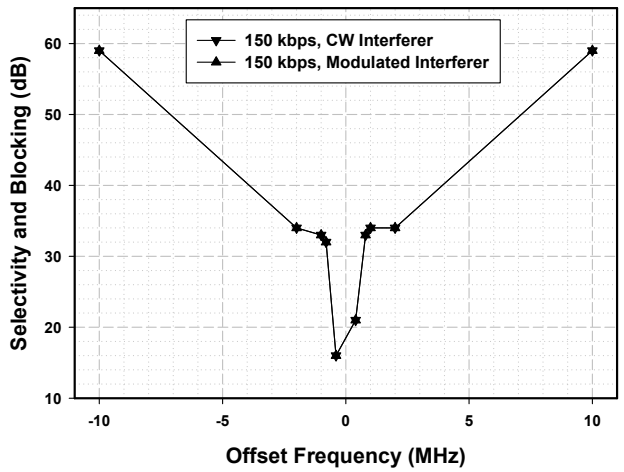


Figure 19

Selectivity and Blocking vs Offset Frequency (Data Rate=150 kbps, Frequency Deviation=37.5 kHz, IF=250 kHz, Channel Filter BW = 165 kHz)

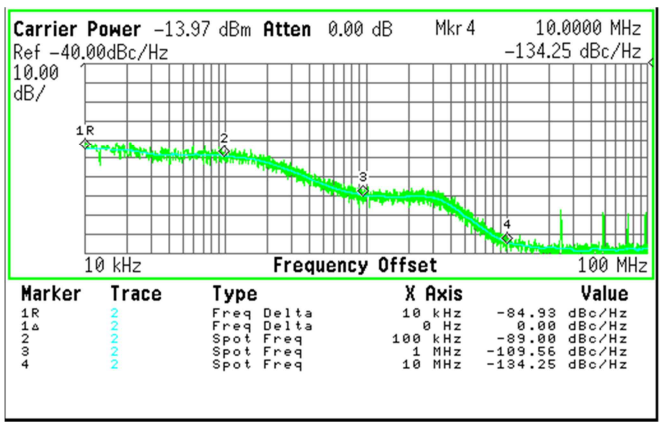


Figure 20

Phase Noise in 920.1 MHz Bands 100-KHz loop Bandwidth

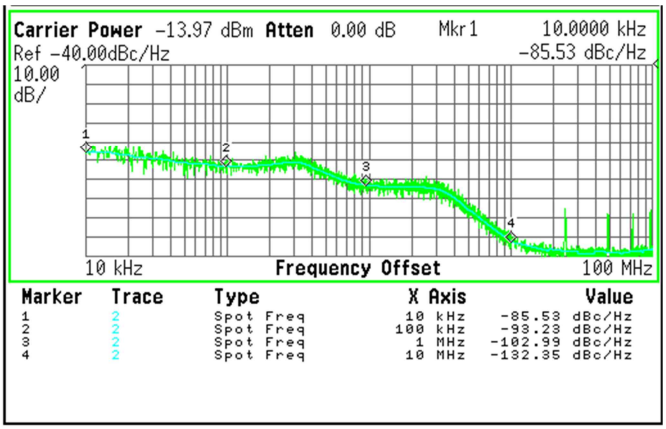


Figure 21

Phase Noise in 920.1 MHz Bands 300-KHz loop Bandwidth