

MRF89XAM8A
Data Sheet

868 MHz Ultra-Low Power
Sub-GHz Transceiver Module

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ISBN: 978-1-60932-637-1

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MRF89XAM8A

868 MHz Ultra-Low Power Sub-GHz Transceiver Module

Features

- Module designed from the MRF89XA integrated ultra low-power, sub-GHz transceiver IC.
- Supports proprietary sub-GHz wireless protocols
- Simple, SPI Interface with Interrupts
- Small size: 0.7" x 1.1" (17.8 mm x 27.9 mm), surface mountable
- Integrated crystal, internal voltage regulator, matching circuitry and Printed Circuit Board (PCB) antenna
- Easy integration into final product: minimize product development, quicker time to market
- Compatible with Microchip's Microcontroller families (PIC16, PIC18, PIC24, dsPIC33 and PIC32)
- Conforms to the following ETSI standards:
  - EN 300 220-2 V2.3.1 (2001–02)
  - EN 301 489-3 V1.4.1 (2002–08)

Operational

- Operating voltage: 2.1–3.6V (3.3V typical)
- Temperature range: -40°C to +85°C Industrial
- Low-current consumption:
  - Rx mode: 3 mA (typical)
  - Tx mode: 25 mA at +10 dBm (typical)
  - Sleep: 0.1 µA (typical)

RF/Analog Features

- 863–870 MHz operation
- Modulation: FSK and OOK
- Data rate (to conform to ETSI standards):
  - FSK: 40 kbps
  - OOK: 16 kbps
- Reception sensitivity
  - FSK: -107 dBm (typical) at 25 kbps
  - OOK: -113 dBm (typical) at 2 kbps
- +10 dBm typical output power with 21 dB Tx power control range

Media Access Controller (MAC)/Baseband Features

- Packet handling features with data whitening and automatic CRC generation
- Incoming sync word (pattern) recognition
- Built-in bit synchronizer for incoming data, and clock synchronization and recovery
- 64-byte transmit/receive FIFO with preload in stand-by mode
- Supports Manchester encoding/decoding techniques

Pin diagram

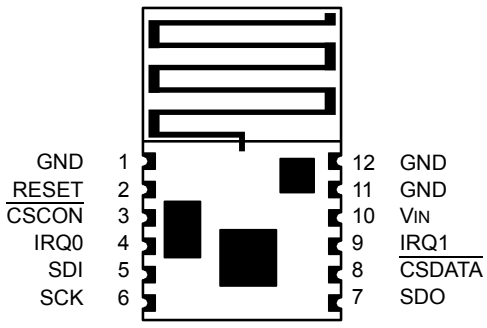


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1.0 DEVICE OVERVIEW

The MRF89XAM8A is an ultra-low power sub-GHz surface mount transceiver module with integrated crystal, internal voltage regulator, matching circuitry and PCB antenna. The MRF89XAM8A module operates in the European 863–870 MHz frequency band and is ETSI compliant. The integrated module design frees the integrator from the extensive RF and antenna design, and regulatory compliance testing, allowing quicker time to market.

The MRF89XAM8A module is compatible with Microchip's MiWi™ Development Environment software stacks. The software stacks are available as a free download, including source code, from the Microchip's web site http://www.microchip.com/wireless.

The MRF89XAM8A module has been tested and conforms to EN 300 220-2 V2.3.1 (2001–02) and EN 301 489-3 V1.4.1 (2002–08) European Standards. The module tests can be applied toward final product certification and Declaration of Conformity (DoC). To maintain conformance, refer to module settings in Section 1.3, Operation. Additional testing may be required depending on the end application.

1.1 Interface description

The simplified block diagram of the MRF89XAM8A module is illustrated in Figure 1-1. The module is based on the Microchip Technology MRF89XA ultra-low power sub-GHz transceiver Integrated Circuit (IC). The module interfaces to many popular Microchip PIC® microcontrollers through a 3-wire serial SPI interface, two chip selects (configuration and data), two interrupts Interrupt Request 0 (IRQ0) and Interrupt Request 1 (IRQ1), Reset, power and ground as illustrated in Figure 1-2. Table 1-1 provides the related pin descriptions.

Serial communication and module configuration are documented in the "*MRF89XA Ultra-Low Power, Integrated Sub-GHz Transceiver*" (DS70622) Data Sheet. Refer to the "*MRF89XA Data Sheet"* for specific serial interface protocol and general register definitions. Also, see Section 1.3, Operation for specific register settings that are unique to the MRF89XAM8A module operation to maintain regulatory compliance.

FIGURE 1-1: MRF89XAM8A BLOCK DIAGRAM

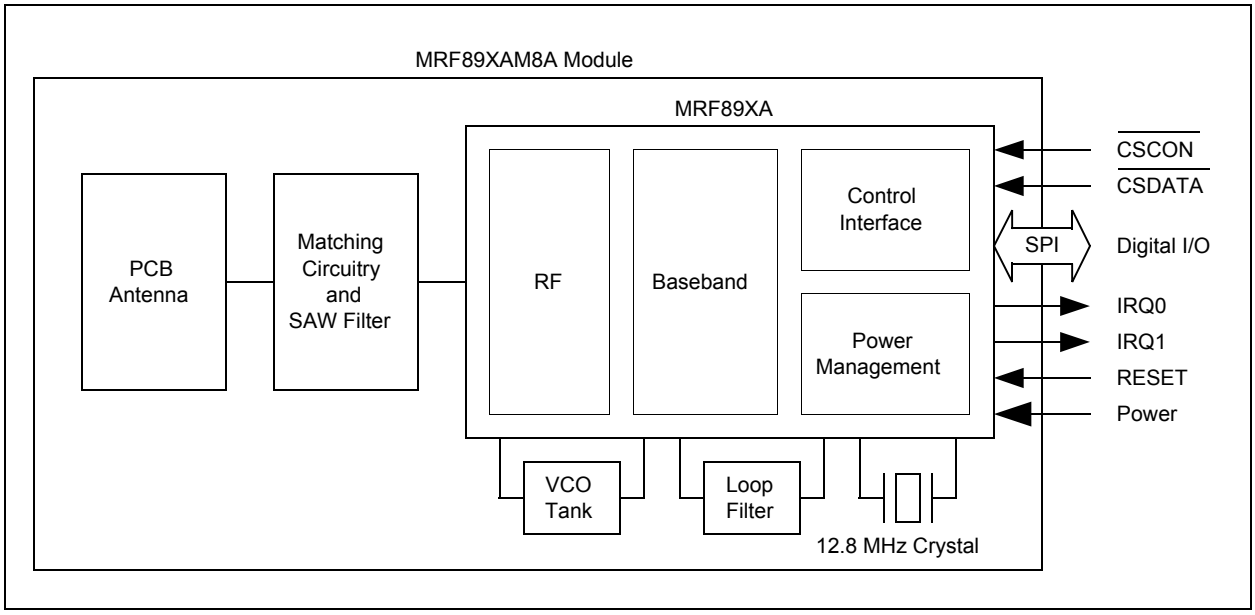
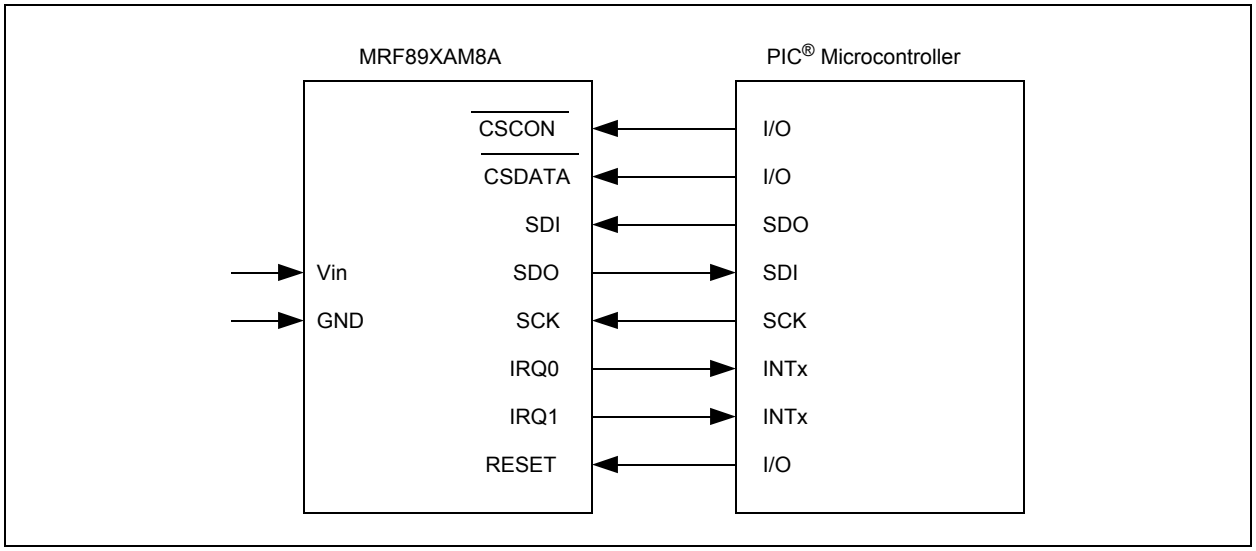


TABLE 1-1: PIN DESCRIPTION

Pin	Symbol	Type	Description
1	GND	Power	Ground
2	RESET	DI	Reset Pin
3	$\overline{\text{CSCON}}$	DI	Serial Interface Configure Chip Select
4	IRQ0	DO	Interrupt Request Output
5	SDI	DI	Serial Interface Data Input
6	SCK	DI	Serial Interface Clock
7	SDO	DO	Serial Interface Data Output
8	$\overline{\text{CSDATA}}$	DI	Serial Interface Data Chip Select
9	IRQ1	DO	Interrupt Request Output
10	Vin	Power	Power Supply
11	GND	Power	Ground
12	GND	Power	Ground

FIGURE 1-2: MICROCONTROLLER TO MRF89XAM8A INTERFACE



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1.2 Mounting Details

The MRF89XAM8A is a surface mountable module, the module dimensions are illustrated in Figure 1-3. The module PCB is 0.032" thick with castellated mounting holes on the edge. Figure 1-4 is the recommended host PCB footprint for the MRF89XAM8A.

The MRF89XAM8A has an integrated PCB antenna. For the best performance, follow the mounting details as illustrated in Figure 1-5. It is recommended that the module be mounted on the edge of the host PCB and an area around the antenna, approximately 3.4" (8.6 cm), be kept clear of metal objects for best performance. A host PCB ground plane around the MRF89XAM8A acts as a counterpoise to the PCB antenna. Extend the host PCB top copper ground plane under and to the left and right side of the module at least 0.4 inches (1 cm) for best antenna performance.

FIGURE 1-3: MODULE DETAILS

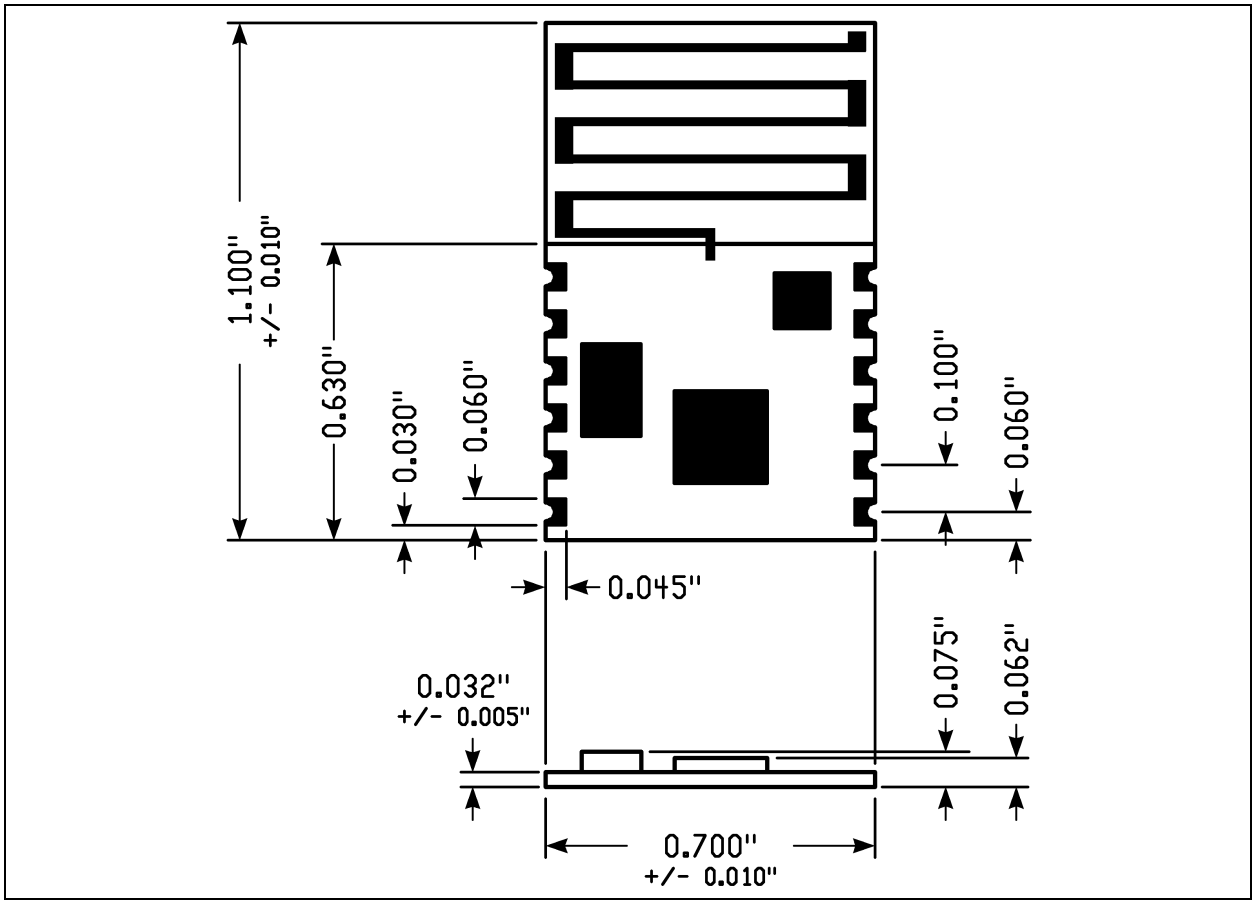
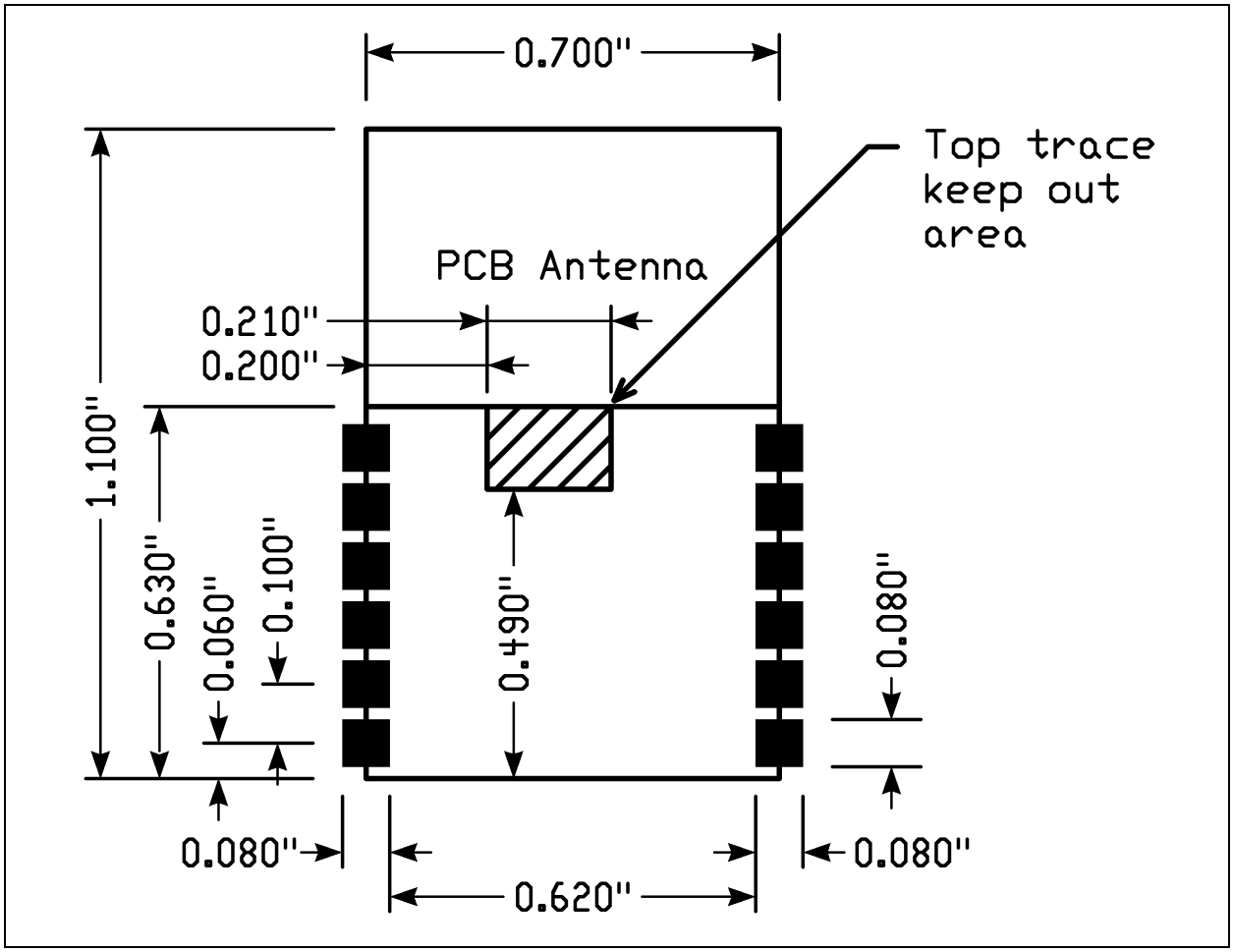
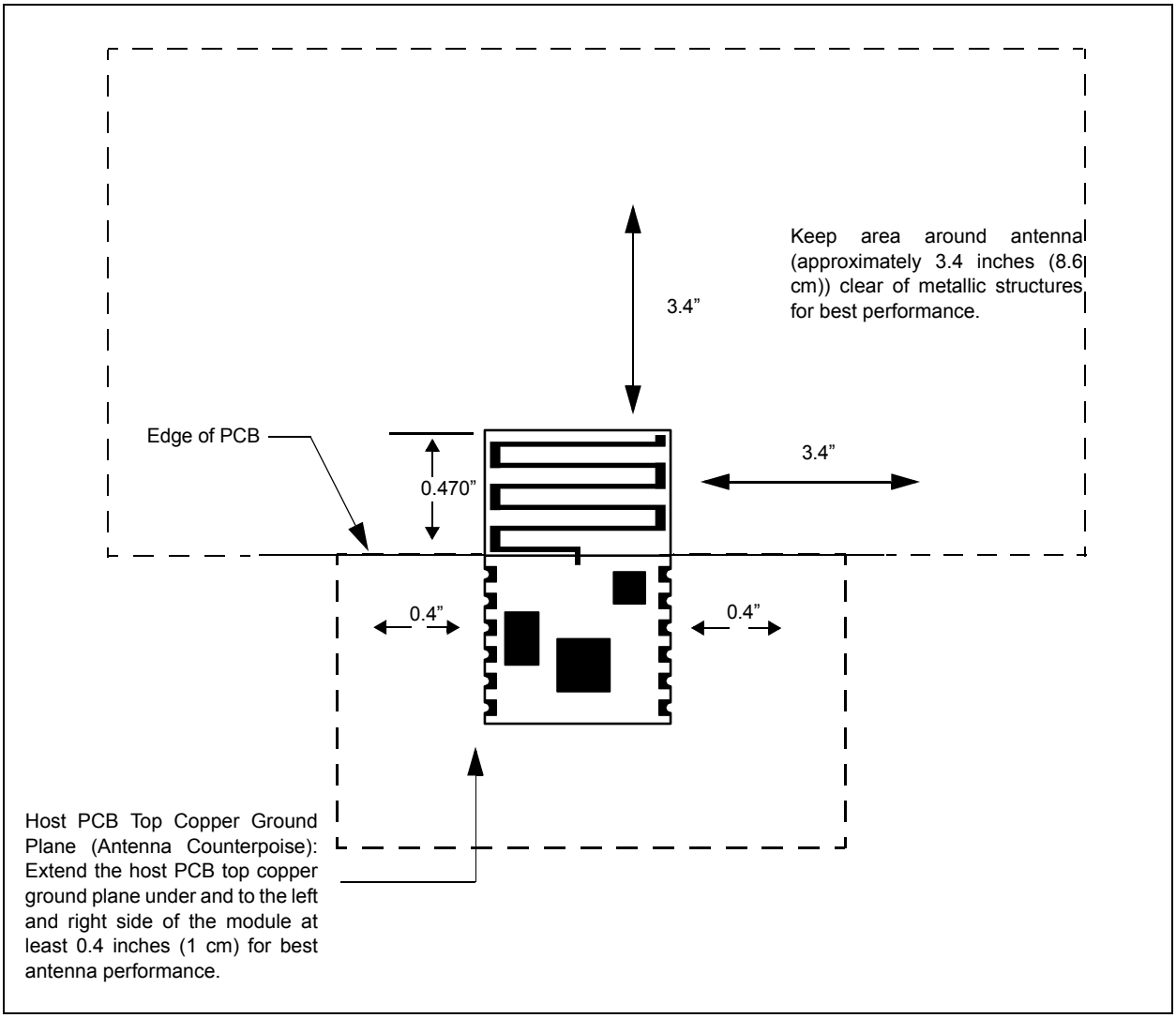


FIGURE 1-4: RECOMMENDED PCB FOOTPRINT



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FIGURE 1-5: MOUNTING DETAILS



1.3 Operation

The MRF89XAM8A module is based on the Microchip Technology MRF89XA ultra-low power, integrated ISM band sub-GHz transceiver IC. Serial communication and module configuration are documented in the "*MRF89XA Ultra-Low Power, Integrated ISM Band Sub-GHz Transceiver Data Sheet*" (DS70622).

This section emphasizes operational settings that are unique to the MRF89XAM8A module design that must be followed in order for the module to conform to the tested European standards summarized in Section 3.0, Regulatory Approval.

Note:	To maintain conformance to tested ETSI standards, the module shall not be modified and settings in Section 1.3, Operation must be observed.

1.3.1 RESET

Pin 2 of the module, RESET, enables an external reset of the MRF89XA IC. RESET is connected to the TEST8 pin of the MRF89XA IC. During normal operations of the MRF89XAM8A, the RESET pin should be held in a high impedance state. For more information on assertion of the RESET pin, refer to "*Section 3.1.2 Manual Reset*" of "*MRF89XA Data Sheet*" (DS70622).

1.3.2 CRYSTAL FREQUENCY

When calculating frequency deviation, bit rate, receiver bandwidth, and PLL R, P and S values, use crystal frequency f_{xtal} = 12.8 MHz.

1.3.3 CLOCK OUTPUT (CLKOUT)

The CLKOUT pin 19 of the MRF89XA IC is not used on the module. Ensure that the CLKOUT signal is disabled to minimize current consumption.

1.3.4 FREQUENCY SHIFT KEYING MODULATION (FSK)

The following settings must be followed for FSK modulation mode to conform to the European standards summarized in Section 3.0, Regulatory Approval.

- Bit Rate Maximum Setting: 40 kbps
- Frequency Deviation Maximum Setting: 40 kHz
- Transmit Bandwidth Maximum Setting: 125 kHz
- Lower Frequency Setting: 863.5 MHz
- Upper Frequency Setting: 869.5 MHz

1.3.5 ON-OFF KEYING MODULATION (OOK)

The following settings must be followed for OOK modulation mode to conform to the European standards summarized in Section 3.0, Regulatory Approval.

- Bit Rate Maximum Setting: 16 kbps
- Frequency Deviation Maximum Setting: 80 kHz
- Transmit Bandwidth Maximum Setting: 125 kHz
- Lower Frequency Setting: 863.5 MHz
- Upper Frequency Setting: 869.5 MHz

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2.0 CIRCUIT DESCRIPTION

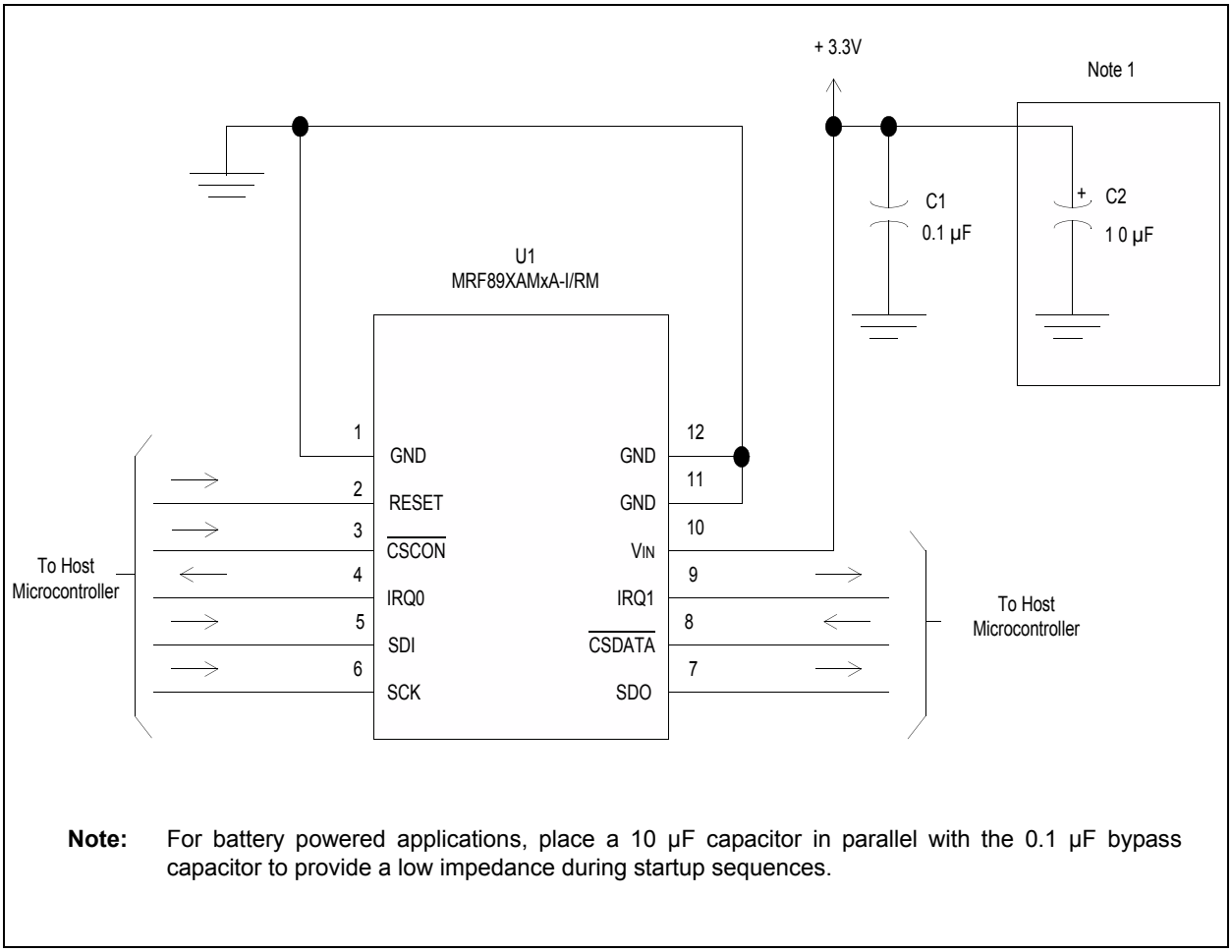
The MRF89XAM8A module interfaces to Microchip's PIC16, PIC18, PIC24, dsPIC33 and PIC32 microcontrollers with a minimum of external components through digital only connections. An example application schematic is illustrated in Figure 2-1.

2.1 Module Schematic

The MRF89XAM8A module is based on the Microchip Technology MRF89XA Ultra-Low Power, Integrated ISM Band sub-GHz Transceiver IC. The serial I/O (CSCON, CSDATA, SCK, SDO and SDI), RESET, IRQ0 and IRQ1 pins are brought to the module pins. Crystal X1 is a 12.8 MHz crystal with a frequency tolerance of ±10 ppm at 25°C. The RFIO output is matched to the SAW filter FL1 and further matched to the PCB trace antenna.

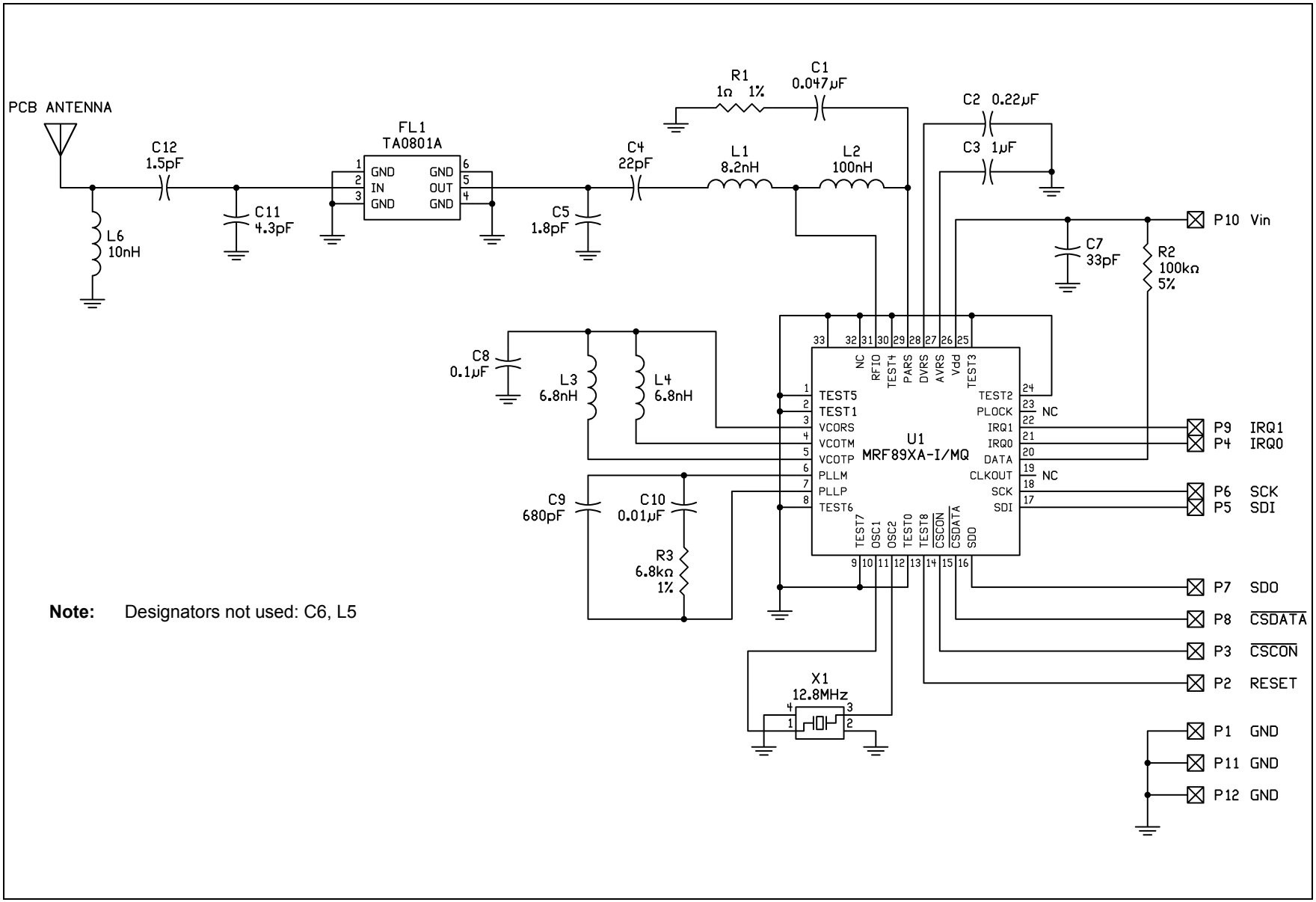
Figure 2-2 illustrates the MRF89XAM8A schematics. Table 2-1 details the Bill of Materials (BOM).

FIGURE 2-1: MRF89XAM8A APPLICATION SCHEMATIC



Note: For battery powered applications, place a 10 µF capacitor in parallel with the 0.1 µF bypass capacitor to provide a low impedance during startup sequences.

FIGURE 2-2: MRF89XAM8A SCHEMATIC



Note: Designators not used: C6, L5

Preliminary

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TABLE 2-1: MRF89XAM8A BILL OF MATERIALS

Designator	Value	Description	Manufacturer	Part Number
C1	0.047 µF	Capacitor, Ceramic, 10V, ±10%, X7R, SMT 0402	Murata	GRM155R71A473KA 01D
C2	0.22 µF	Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402	Murata	GRM155R71C224KA 12D
C3	1 µF	Capacitor, Ceramic, 6.3V, ±10%, X5R, SMT 0603	Murata	GRM188R60J105KA 01D
C4	22 pF	Capacitor, Ceramic, 50V, ±5%, UHI-Q NP0, SMT 0402	Johanson Technology	500R07S220JV4
C5	1.8 pF	Capacitor, Ceramic, 50V, ±0.1 pF, UHI-Q NP0, SMT 0402	Johanson Technology	500R07S1R8BV4
C6	—	Designator not used	—	—
C7	33 pF	Capacitor, Ceramic, 50V, ±5%, C0G, SMT 0402	Murata	GRM1555C1H330JZ 01D
C8	0.1 µF	Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402	Murata	GRM155R71C104KA 88D
C9	680 pF	Capacitor, Ceramic, 50V, ±5%, C0G, SMT 0402	Murata	GRM1555C1H681JA 01D
C10	0.01 µF	Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402	Murata	GRM155R71C103KA 01D
C11	4.3 pF	Capacitor, Ceramic, 50V, ±0.1 pF, UHI-Q NP0, SMT 0402	Johanson Technology	500R07S4R3BV4
C12	1.5 pF	Capacitor, Ceramic, 50V, ±0.1 pF, UHI-Q NP0, SMT 0402	Johanson Technology	500R07S1R5BV4
FL1	TA0801A	Filter, SAW, 863–870 MHz	Tai-saw Technology	TA0801A
L1	8.2 nH	Inductor, Ceramic, ±5%, SMT 0402	Johanson Technology	L-07C8N2JV6T
L2	100 nH	Inductor, Ceramic, ±5%, SMT 0402	Johanson Technology	L-07CR10JV6T
L3	6.8 nH	Inductor, Wirewound, ±5%, SMT 0402	Johanson Technology	L-07W6N8JV4T
L4	6.8 nH	Inductor, Wirewound, ±5%, SMT 0402	Johanson Technology	L-07W6N8JV4T
L5		Designator not used		
L6	10 nH	Inductor, Ceramic, ±5%, SMT 0402	Johanson Technology	L-07C10NJV6T
R1	1 Ω	Resistor, 1%, ±100 ppm/^{0}C, SMT 0402	Vishay/Dale	CRCW04021R00FKE D
R2	100K Ω	Resistor, 5%, ±100 ppm/^{0}C, SMT 0402	Yageo	RC0402JR-07100KL
R3	6.8K Ω	Resistor, 1%, ±100 ppm/^{0}C, SMT 0402	Yageo	RC0402FR-076K8L
U1	MRF89XA	Transceiver, Ultra-Low Power, Integrated sub-GHz	Microchip Technology	MRF89XA-I/MQ
X1	12.8 MHz	Crystal, ±10 ppm, 15 pF, ESR 100 ohms, SMT 5 x 3.2mm	Abracon	ABM3B-155-12.800MHz-T

2.2 Printed Circuit Board

The MRF89XAM8A module PCB is constructed with high temperature FR4 material, 4 layers and 0.032 inches thick. These layers are shown in Figure 2-3 through Figure 2-8. The stack up of the PCB is shown in Figure 2-9

FIGURE 2-3: TOP SILK SCREEN

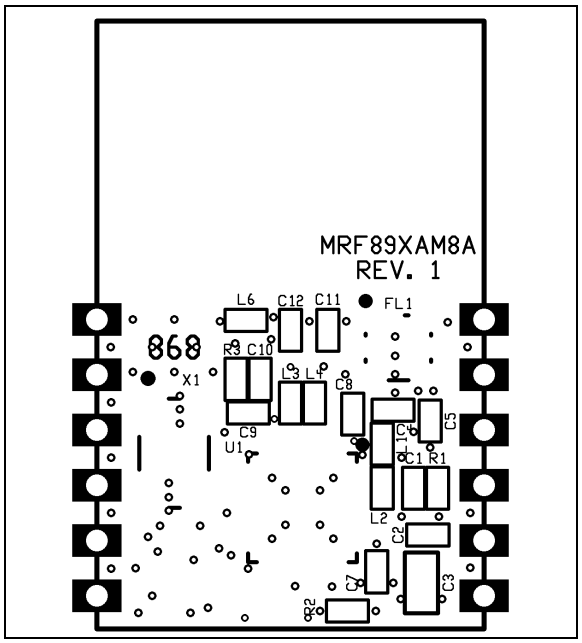


FIGURE 2-4: TOP COPPER

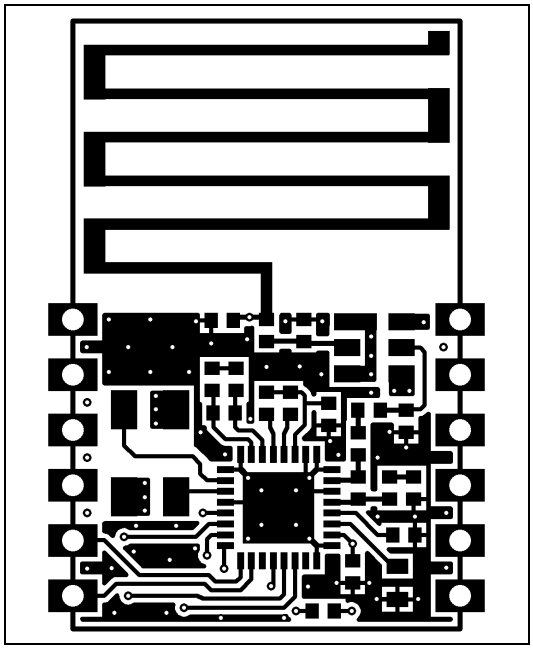


FIGURE 2-5: LAYER 2 — GROUND PLANE

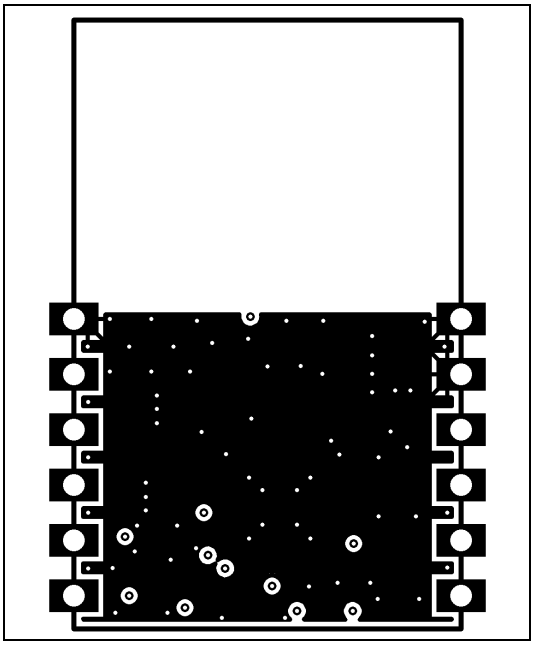
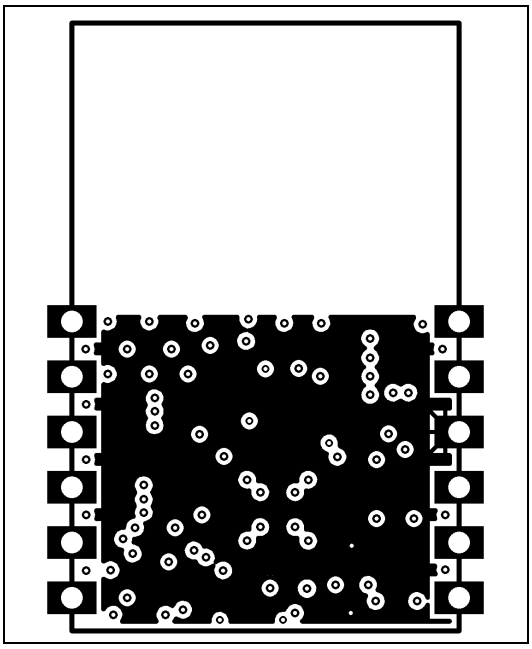


FIGURE 2-6: LAYER 3 — POWER PLANE



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FIGURE 2-7: BOTTOM COPPER

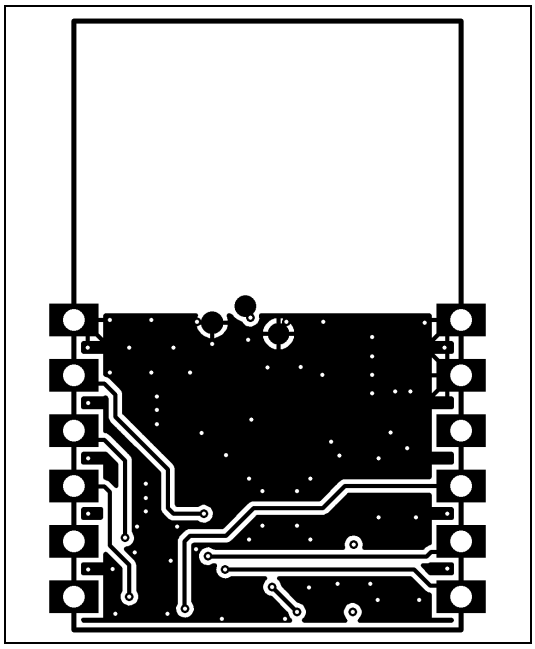


FIGURE 2-8: BOTTOM SILK SCREEN

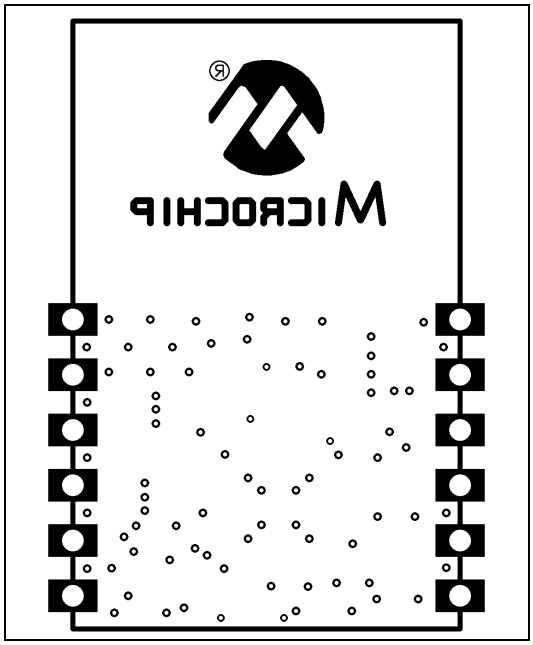
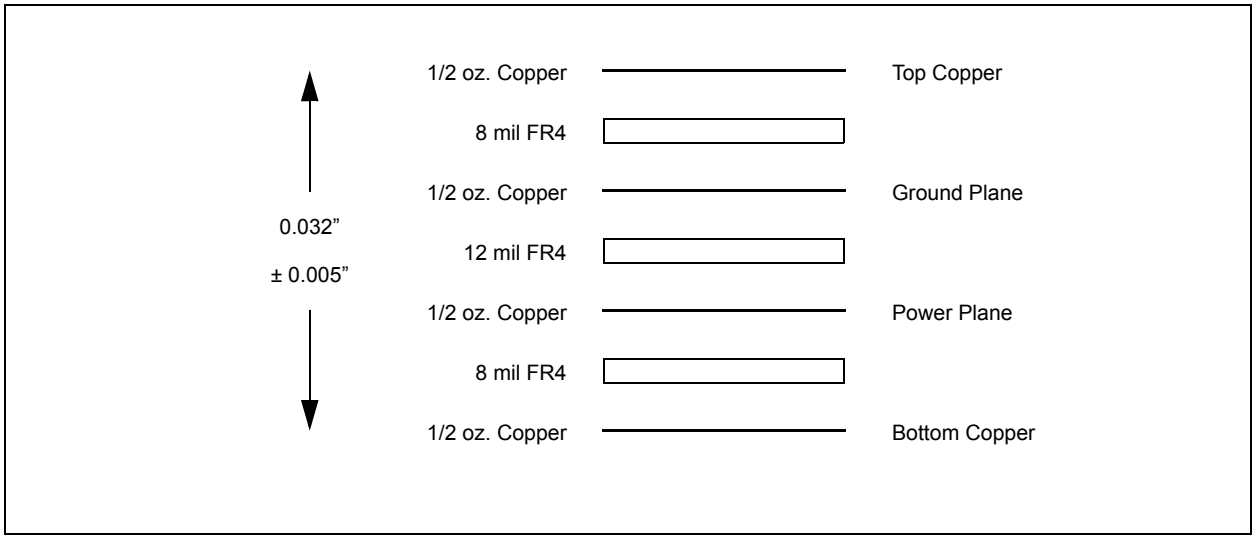


FIGURE 2-9: PCB LAYER STACK UP

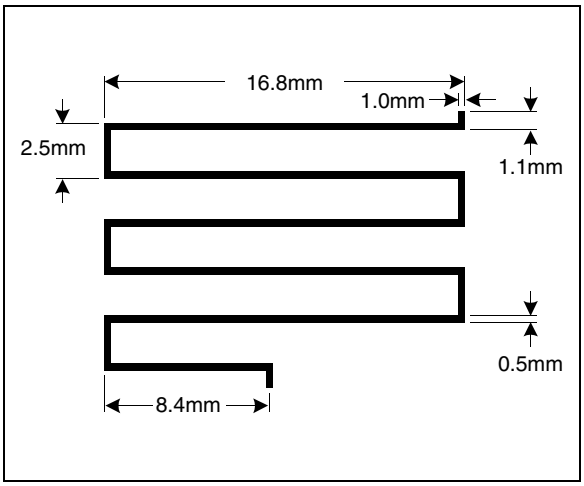


2.3 PCB Antenna

The PCB antenna is fabricated on the top copper trace. Figure 2-10 illustrates the trace dimensions. The layers below the antenna have no copper traces. The ground and power planes under the components serve as a counterpoise to the PCB antenna. Additional ground plane on the host PCB will substantially enhance the performance of the module. For best performance, place the module on the host PCB by following the recommendations given in the Section 1.2, Mounting Details.

The PCB antenna was designed and simulated using Ansoft Designer® and HFSS™ 3D full-wave solver software by ANSYS Inc. (www.ansoft.com). The goal of the design was to create a compact, low-cost antenna with the best radiation pattern. Figure 2-11 illustrates the simulation drawing and Figure 2-12 and Figure 2-13 illustrates the 2D and 3D radiation patterns. As shown by the radiation patterns, the performance of the antenna is dependant upon the orientation of the module. Figure 2-14 illustrates the impedance simulation and Figure 2-15 illustrates the simulated PCB antenna VSWR. The discrete matching circuitry matches the impedance of the antenna with the SAW filter and MRF89XA transceiver IC.

FIGURE 2-10: PCB ANTENNA DIMENSIONS



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FIGURE 2-11: PCB ANTENNA SIMULATION DRAWING

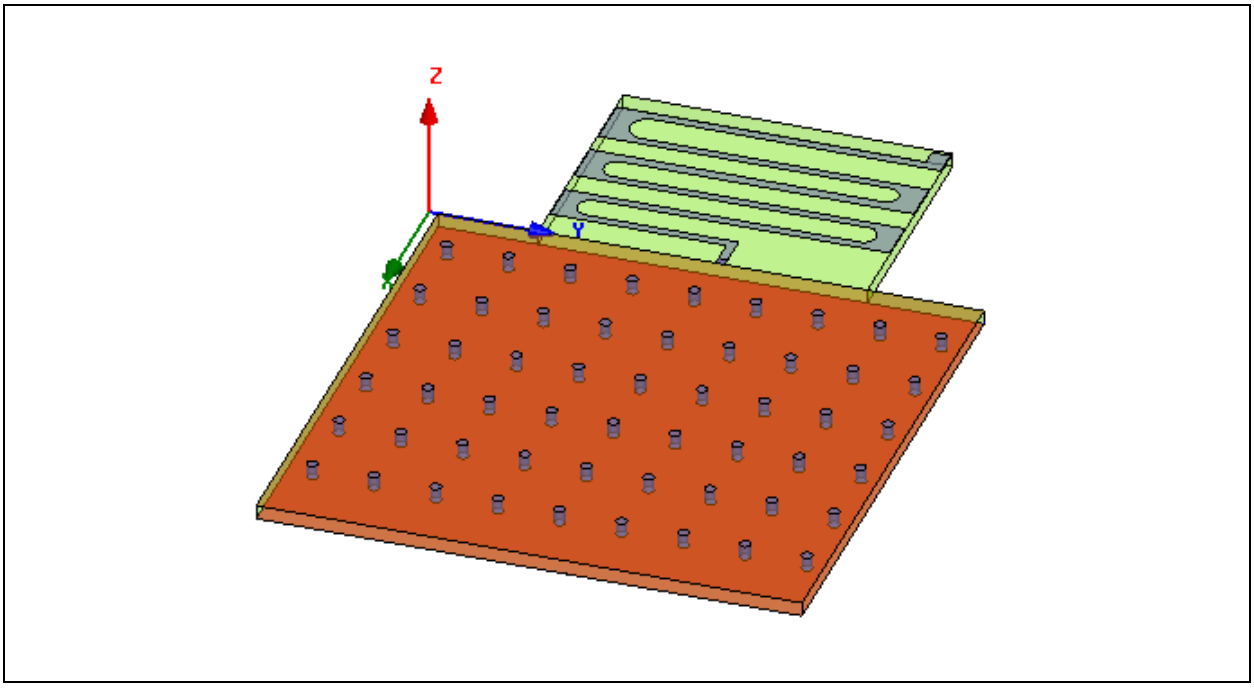


FIGURE 2-12: SIMULATED 2D RADIATION PATTERN

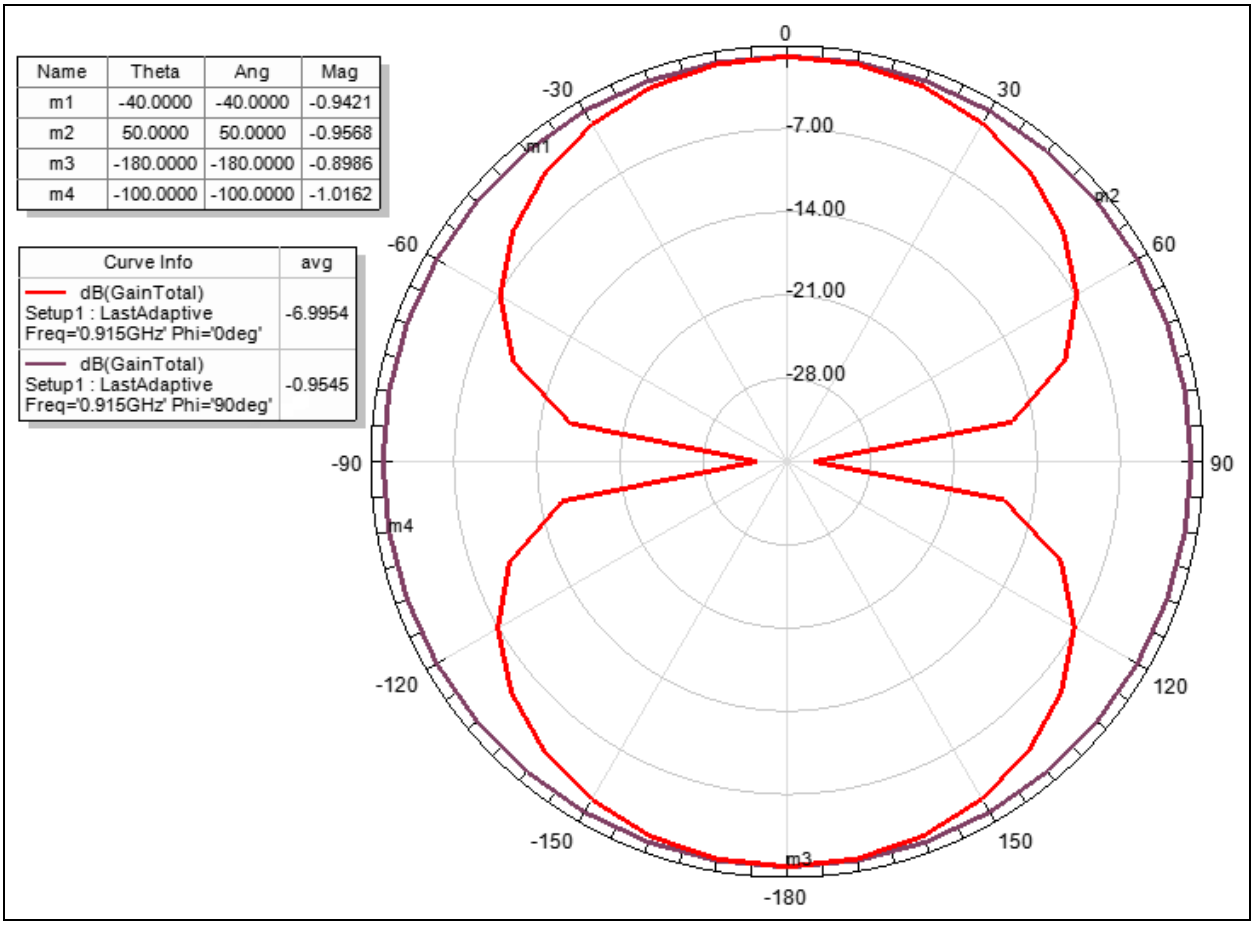


FIGURE 2-13: SIMULATED 3D RADIATION PATTERN

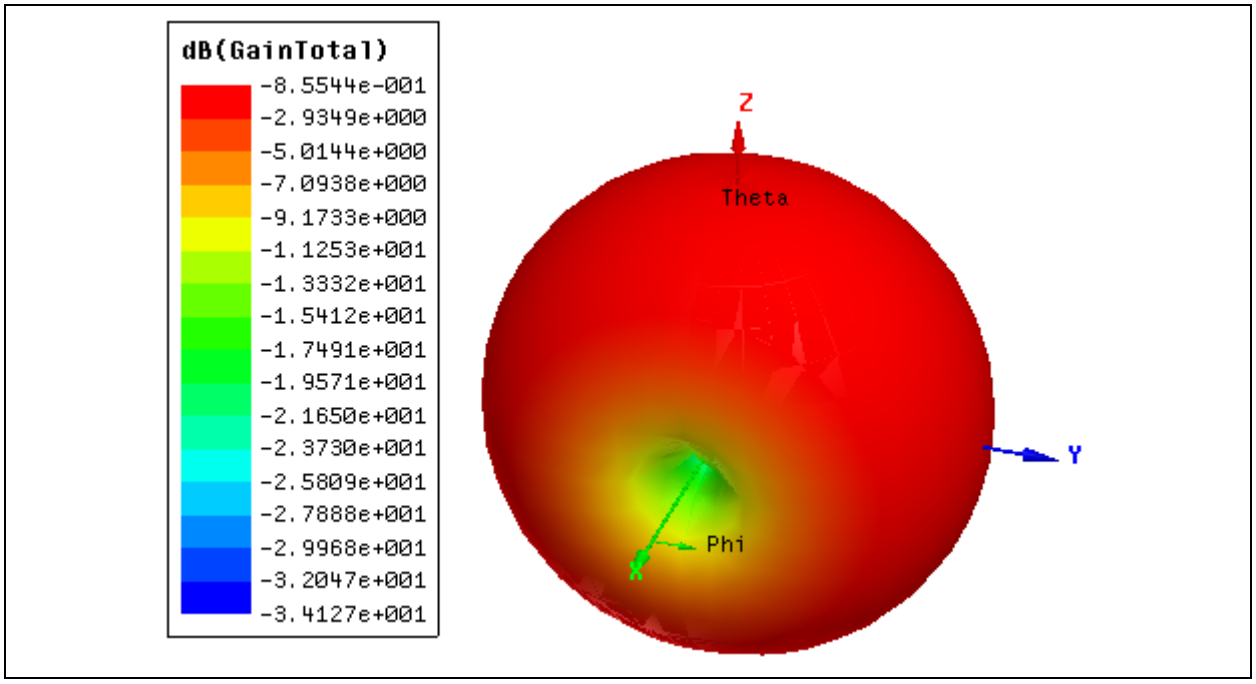
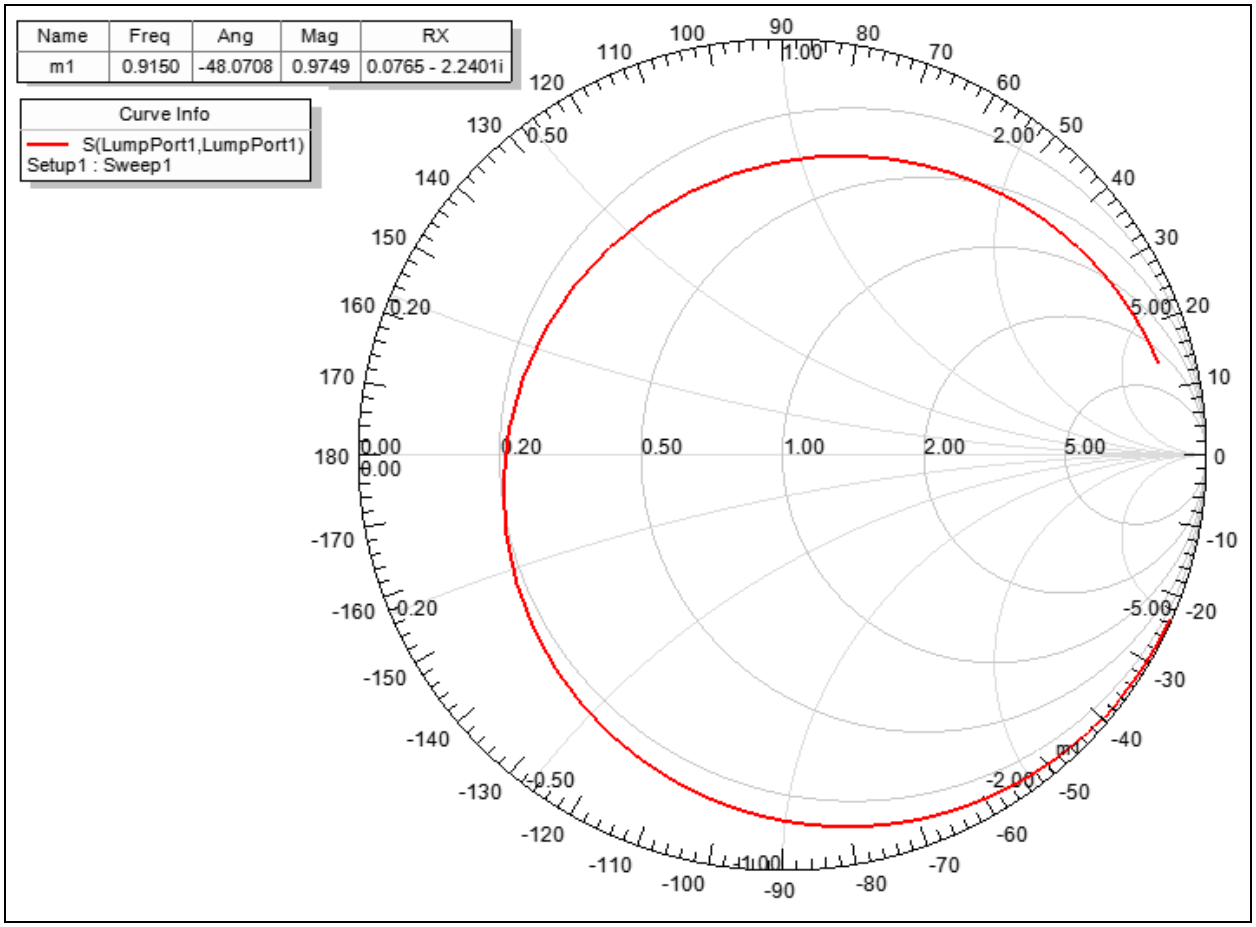
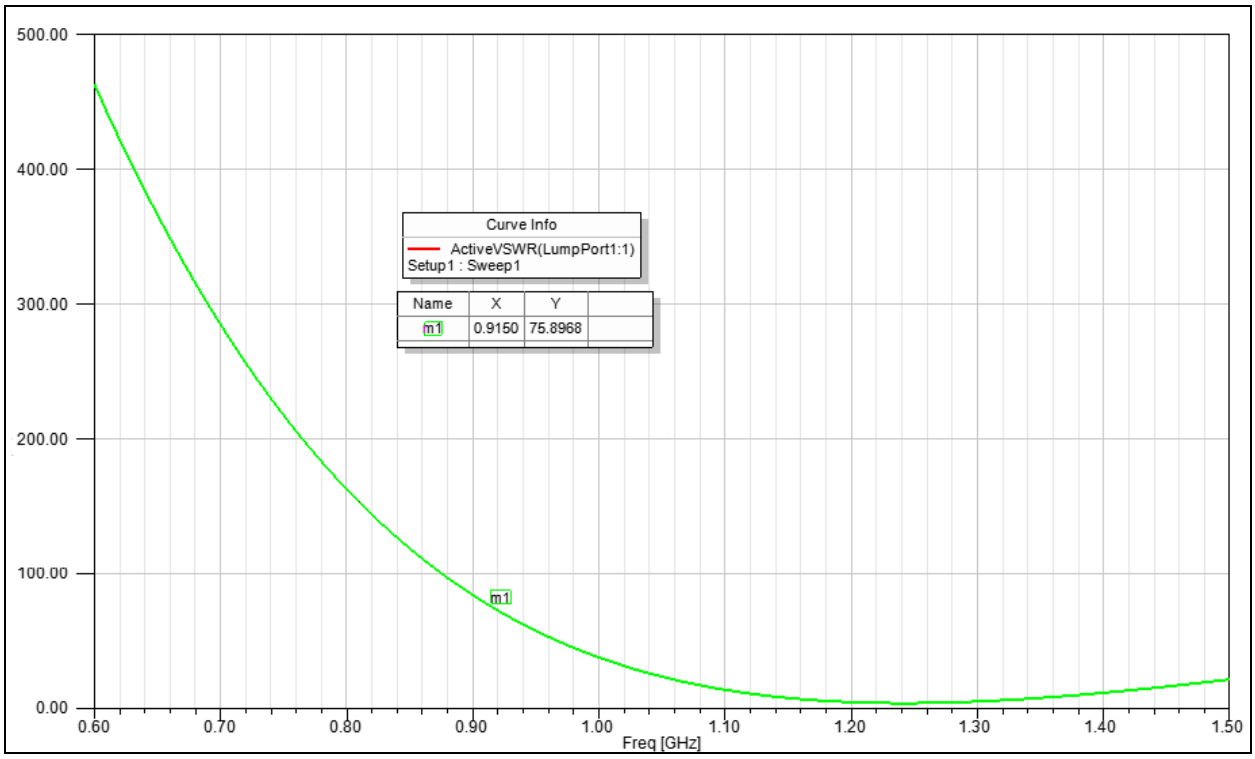


FIGURE 2-14: SIMULATED PCB ANTENNA IMPEDANCE



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FIGURE 2-15: SIMULATED PCB ANTENNA VSWR



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3.0 REGULATORY APPROVAL

3.1 Europe

The MRF89XAM8A module conforms to the emission and immunity standards summarized in Table 3-1. The module tests can be applied toward final product certification and DoC.

Note:	To maintain conformance tested ETSI standards, the module shall not be modified and settings in Section 1.3, Operation must be observed.

The European Standards do not provide a modular approval similar to the USA (FCC) and Canada (IC). However, the completed compliance testing can be used as part of the customer's application for product certification. The module test report data can be included in the customer's product test plan and can significantly lower customer's certification burden.

Depending on the end application, additional testing may be required. The integrator is responsible for testing the end product for any additional compliance requirements that become necessary with this module installed (for example, digital device emission, PC peripheral requirements and so on) in the specific country where end device is marketed.

3.1.1 HELPFUL WEB SITES

A helpful document that can be used as a starting point in understanding the use of Short Range Devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, can be downloaded from the following websites:

- European Radio Communications Office (ERO): http://www.ero.dk.
- Radio and Telecommunications Terminal Equipment (R&TTE): http://ec.europa.eu/enterprise/rtte/index_en.htm
- European Conference of Postal and Telecommunications Administrations (CEPT): http://www.cept.org/
- European Telecommunications Standards Institute (ETSI): http://www.etsi.org/

TABLE 3-1: EMISSIONS AND IMMUNITY STANDARDS TESTED

Specification			Test Method
Emission Standards			
EN 300 220-2 V2.3.1 (2001–02)	7.1.2	Frequency error and drift	5.1.3.1
EN 300 220-2 V2.3.1 (2001–02)	7.3.2	Effective Radiated Power	5.1.3.3
EN 300 220-2 V2.3.1 (2001–02)	7.5.2	Transient power	5.1.3.4
EN 300 220-2 V2.3.1 (2001–02)	7.7.2	Modulation bandwidth	5.1.3.6
EN 300 220-2 V2.3.1 (2001–02)	—	Unwanted emissions on the spurious domain	5.1.3.7
EN 300 220-2 V2.3.1 (2001–02)	8.6.4	Receiver spurious radiation	5.1.4.6
Immunity Standards			
EN 301 489-3 V1.4.1 (2002–08)	—	Conducted emissions	EN 55022:2007
EN 301 489-3 V1.4.1 (2002–08)	—	Radiated emissions	EN 55022:2007
EN 301 489-3 V1.4.1 (2002–08)	—	Radiated immunity	EN 61000-4-3

NOTES:

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4.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

Ambient temperature under bias ..... -40°C to +85°C
Storage temperature ..... -55°C to +125°C
Voltage on V_{IN} with respect to V_{SS} ..... -0.3V to 6V
Voltage on any combined digital and analog pin with respect to V_{SS} (except V_{IN}) .....-0.3V to (V_{IN} + 0.3V)
Input current into pin (except V_{IN} and V_{SS}) ..... -25 mA to 25 mA
Electrostatic discharge with human body model 1000V

NOTICE: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TABLE 4-1: RECOMMENDED OPERATING CONDITIONS

Parameter	Min	Typ	Max	Unit	Condition
Ambient Operating Temperature	-40	—	+85	°C	—
Supply Voltage for RF, Analog and Digital Circuits	2.1	—	3.6	V	—
Supply Voltage for Digital I/O	2.1	—	3.6	V	—
Input High Voltage (V_{IH})	0.5 * V_{IN}	—	V_{IN} + 0.3	V	—
Input Low Voltage (V_{IL})	-0.3V	—	0.2 * V_{IN}	V	—
AC Peak Voltage on Open Collector Outputs (IO)(1)	V_{IN} – 1.5	—	V_{IN} + 1.5	V	—

Note 1: At minimum, V_{IN} – 1.5V should not be lower than 1.8V.

TABLE 4-2: CURRENT CONSUMPTION

Symbol	Chip Mode	Min	Typ	Max	Unit	Condition
I_{DDSL}	Sleep	—	0.1	2	µA	Sleep clock disabled, all blocks disabled
I_{DDST}	Idle	—	65	80	µA	Oscillator and baseband enabled
I_{DDFS}	Frequency Synthesizer	—	1.3	1.7	mA	Frequency synthesizer running
I_{DDTX}	Tx	— —	25 16	30 21	mA mA	Output power = +10 dBm Output power = +1 dBm(1)
I_{DDRX}	Rx	—	3.0	3.5	mA	—

Note 1: Guaranteed by design and characterization.

TABLE 4-3: DIGITAL I/O PIN INPUT SPECIFICATIONS(1)

Symbol	Characteristic	Min	Typ	Max	Unit	Condition
V_{IL}	Input Low Voltage	—	—	0.2 * V_{IN}	V	—
V_{IH}	Input High Voltage	0.8 * V_{IN}	—	—	V	—
I_{IL}	Input Low Leakage Current(2)	-0.5	—	0.5	µA	V_{IL} = 0V
I_{IH}	Input High Leakage Current	-0.5	—	0.5	µA	V_{IH} = V_{IN}, V_{IN} = 3.7
V_{OL}	Digital Low Output Voltage	—	—	0.1 * V_{IN}	—	I_{OL} = 1 mA
V_{OH}	Digital Low Output	0.9 * V_{IN}	—	—	V	I_{OH} = -1 mA

Note 1: Measurement Conditions: T_A = 25°C, V_{IN} = 3.3V, Crystal Frequency = 12.8 MHz, unless otherwise specified.

2: Negative current is defined as the current sourced by the pin.

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TABLE 4-4: PLL PARAMETERS AC CHARACTERISTICS(1)

Symbol	Parameter	Min	Typ	Max	Unit	Condition
FRO	Frequency Ranges	863	—	870	MHz	
BRFSK	Bit Rate (FSK)	1.56	—	40	kbps	NRZ
BROOK	Bit Rate (OOK)	1.56	—	16	kbps	NRZ
FDFSK	Frequency Deviation (FSK)	33	50	200	kHz	—
FXTAL	Crystal Oscillator Frequency	9	12.8	—	MHz	—
FSSTP	Frequency Synthesizer Step	—	2	—	kHz	Variable, depending on the frequency
TSOSC	Oscillator Wake-up Time	—	1.5	5	ms	From Sleep mode(1)
TSFS	Frequency Synthesizer Wake-up Time; at most, 10 kHz away from the target	—	500	800	µs	From Stand-by mode
TSHOP	Frequency Synthesizer Hop Time; at most, 10 kHz away from the target	—	180	—	µs	200 kHz step
		—	200	—	µs	1 MHz step
		—	250	—	µs	5 MHz step
		—	260	—	µs	7 MHz step
		—	290	—	µs	12 MHz step
		—	320	—	µs	20 MHz step
		—	340	—	µs	27 MHz step

Note 1: Guaranteed by design and characterization.

TABLE 4-5: RECEIVER AC CHARACTERISTICS(1)

Symbol	Parameter	Min	Typ	Max	Unit	Condition
RSF	Sensitivity (FSK)	—	-107	—	dBm	869 MHz, BR = 25 kbps, f_{dev} = 50 kHz, f_c = 100 kHz
		—	-103	—	dBm	869 MHz, BR = 66.7 kbps, f_{dev} = 100 kHz, f_c = 200 kHz
RSO	Sensitivity (OOK)	—	-113	—	dBm	869 MHz, 2 kbps NRZ $f_c - f_o$ = 50 kHz, f_o = 50 kHz
		—	-106	—	dBm	869 MHz, 16.7 kbps NRZ $f_c - f_o$ = 100 kHz, f_o = 100 kHz
CCR	Co-Channel Rejection	—	-12	—	dBc	Modulation as wanted signal
ACR	Adjacent Channel Rejection	—	27	—	dB	Offset = 300 kHz, unwanted tone is not modulated
		—	52	—	dB	Offset = 600 kHz, unwanted tone is not modulated
		—	57	—	dB	Offset = 1.2 MHz, unwanted tone is not modulated
BI	Blocking Immunity	—	-48	—	dBm	Offset = 1 MHz, unmodulated
		—	-37	—	dBm	Offset = 2 MHz, unmodulated, no SAW
		—	-33	—	dBm	Offset = 10 MHz, unmodulated, no SAW
RXBWF	Receiver Bandwidth in FSK Mode(2)	50	—	250	kHz	Single side BW, Polyphase Off
RXBWU	Receiver Bandwidth in OOK Mode(2)	50	—	400	kHz	Single side BW, Polyphase On
ITP3	Input Third Order Intercept Point	—	-28	—	dBm	Interferers at 1 MHz and 1.950 MHz offset
TSRWF	Receiver Wake-up Time	—	280	500	µs	From FS to Rx ready
TSRWS	Receiver Wake-up Time	—	600	900	µs	From Stand-by to Rx ready
TSRHOP	Receiver Hop Time from Rx Ready to Rx Ready with a Frequency Hop	—	400	—	µs	200 kHz step
		—	400	—	µs	1 MHz step
		—	460	—	µs	5 MHz step
		—	480	—	µs	7 MHz step
		—	520	—	µs	12 MHz step
		—	550	—	µs	20 MHz step
		—	600	—	µs	27 MHz step
RSSIST	RSSI Sampling Time	—	—	$1/f_{dev}$	s	From Rx ready
RSSTDR	RSSI Dynamic Range	—	70	—	dB	Ranging from sensitivity

Note 1: Guaranteed by design and characterization.

2: This reflects the whole receiver bandwidth, as described by conditions for active and passive filters.

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TABLE 4-6: TRANSMITTER AC CHARACTERISTICS(1)

Symbol	Description	Min	Typ	Max	Unit	Condition
RFOP	RF Output Power, Programmable with 8 Steps of typ. 3 dB	—	+12.5	—	dBm	Maximum power setting
		—	-8.5	—	dBm	Minimum power setting
PN	Phase Noise	—	-112	—	dBc/Hz	Measured with a 600 kHz offset at the transmitter output
TXSP	Transmitted Spurious	—	—	-47	dBc	At any offset between 200 kHz and 600 kHz, unmodulated carrier, f_{dev} = 50 kHz
Tx2	Second Harmonic	—	—	-40	dBm	No modulation, see Note(2)
Tx3	Third Harmonic					
Tx4	Fourth Harmonic					
Txn	Harmonics above Tx4					
FSKDEV	FSK Deviation	±33	±55	±200	kHz	Programmable
TSTWF	Transmitter Wake-up Time	—	120	500	µs	From FS to Tx ready
TSTWS	Transmitter Wake-up Time	—	600	900	µs	From Stand-by to Tx ready

Note 1: Guaranteed by design and characterization.

2: Transmitter in-circuit performance with SAW filter and crystal.

4.1 Timing Specification and Diagram

TABLE 4-7: SPI TIMING SPECIFICATION(1,2)

Parameter	Min	Typ	Max	Unit	Condition
SPI Configure Clock Frequency	—	—	6	MHz	—
SPI Data Clock Frequency	—	—	1	MHz	—
Data Hold and Setup Time	2	—	—	µs	—
SDI Setup Time for SPI Configure	250	—	—	ns	—
SDI Setup Time for SPI Data	312	—	—	ns	—
$\overline{\text{CSCON}}$ Low to SCK Rising Edge; SCK Falling Edge to $\overline{\text{CSCON}}$ High	500	—	—	ns	—
$\overline{\text{CSDATA}}$ Low to SCK Rising Edge; SCK Falling Edge to $\overline{\text{CSDATA}}$ High	625	—	—	ns	—
$\overline{\text{CSCON}}$ Rising to Falling Edge	500	—	—	ns	—
$\overline{\text{CSDATA}}$ Rising to Falling Edge	625	—	—	ns	—

Note 1: Typical Values: T_A = 25°C, V_{IN} = 3.3V, Crystal Frequency = 12.8 MHz, unless otherwise specified.

2: Negative current is defined as the current sourced by the pin.

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APPENDIX A: REVISION HISTORY

Revision A (November 2010)

This is the Initial release of the document.

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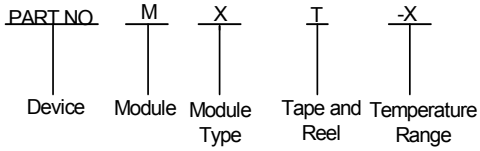
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Temperature Range	I = -40ºC to +85ºC (Industrial)

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