# MRF89XAM9A Data Sheet

## 915 MHz Ultra Low-Power Sub-GHz Transceiver Module

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# MRF89XAM9A

## 915 MHz Ultra Low-Power Sub-GHz Transceiver Module

### Features

- Module designed from the MRF89XA Integrated Ultra Low-Power, Sub-GHz Transceiver IC.
- Supports MiWi™ Development Environment Proprietary Wireless Networking Protocols
- 4-Wire Serial Peripheral Interface (SPI) with Interrupts
- Small Size: 0.7" x 1.1" (17.8 mm x 27.9 mm), Surface Mountable — Pin compatible with MRF89XAM9A
- 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)
- Radio Regulation Certified for United States (FCC), Canada (IC) and Australia/New Zealand (C-TICK)

### 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)

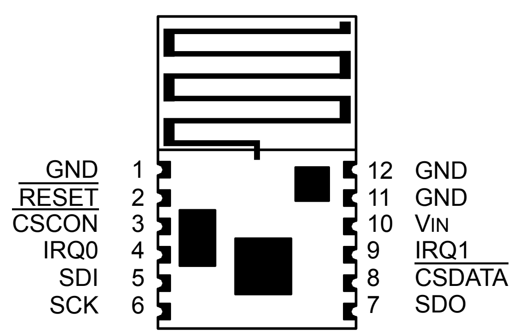
### RF/Analog Features

- ISM Band 902–928 MHz Operation
- Modulation: FSK and OOK
- Data Rate (to conform to FCC and IC regulations):
  - FSK: 50–200 kbps
  - OOK: 16 kbps
- Reception sensitivity
  - FSK: -107 dBm (typical) at 50 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 feature 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 MRF89XAM9A is an Ultra Low-Power Sub-GHz surface mount transceiver module with integrated crystal, internal voltage regulator, matching circuitry and PCB antenna. The MRF89XAM9A module operates in the United States/Canada 902–928 MHz ISM frequency band. The integrated module design frees the integrator from extensive RF and antenna design, and regulatory compliance testing, allowing quicker time to market.

The MRF89XAM9A 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 MRF89XAM9A module has received regulatory approvals for modular devices in the United States (FCC) and Canada (IC). Modular approval removes the need for expensive RF and antenna design, and allows the end user to place the MRF89XAM9A module inside a finished product and not require regulatory testing for an intentional radiator (RF transmitter). To maintain conformance, refer to module settings in Section 3.1.1, MRF89XAM9A SETTINGS for the United States and Section 3.2.1, MRF89XAM9A SETTINGS for Canada.

## 1.1 Interface description

The simplified block diagram of the MRF89XAM9A module is shown 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 shown in Figure 1-2. Table 1-1 provides the pin descriptions.

Data communication and module configuration are documented in the "*MRF89XA Ultra Low-Power, Integrated Sub-GHz Transceiver*" (DS70622) Data Sheet. For more information on specific serial interface protocol and general register definitions, refer to the "*MRF89XA Data Sheet*" and see Section 1.3, Operation for specific register settings unique to the MRF89XAM9A module operation to maintain regulatory compliance.

**FIGURE 1-1: MRF89XAM9A BLOCK DIAGRAM**

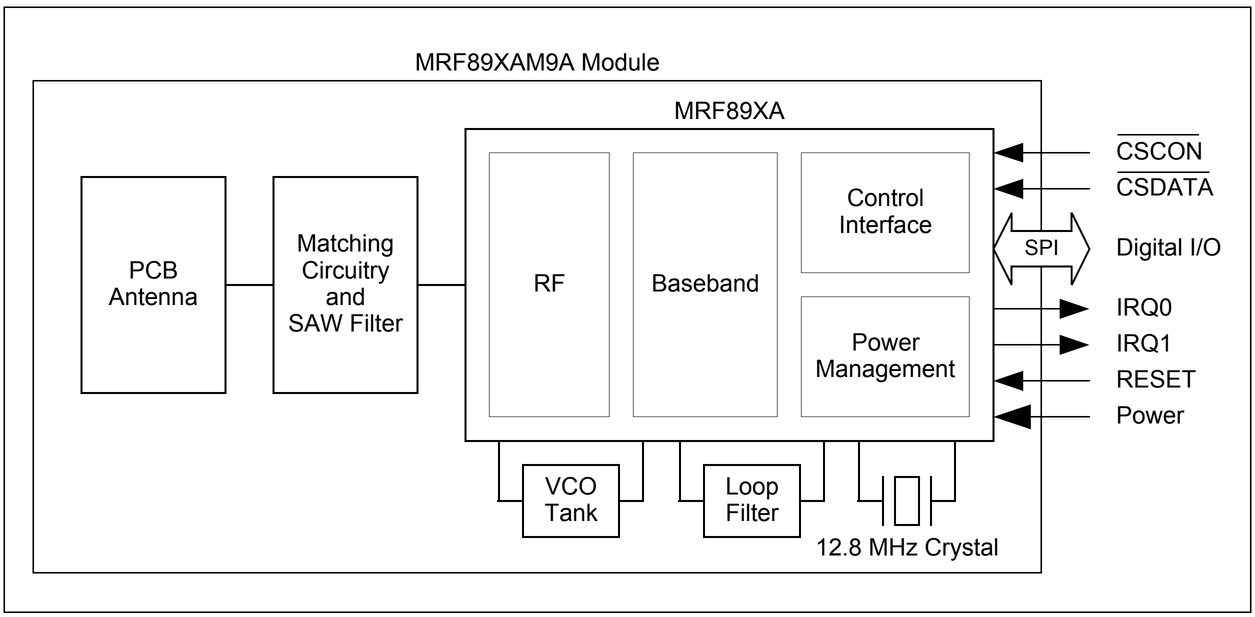
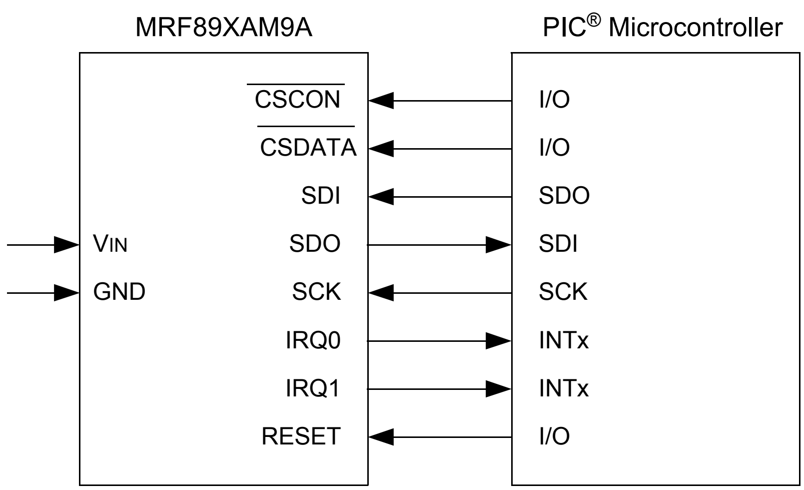


**TABLE 1-1: PIN DESCRIPTION**

| 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 MRF89XAM9A INTERFACE**





Preliminary

## 1.2 Mounting Details

The MRF89XAM9A is a surface mountable module. Module dimensions are shown 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 MRF89XAM9A.

The MRF89XAM9A has an integrated PCB antenna. For the best performance, follow the mounting details shown 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 MRF89XAM9A acts as a counterpoise to the PCB antenna. It is recommended to extend the ground plane at least 0.4" (1 cm) around the module.

**FIGURE 1-3: MODULE DETAILS**

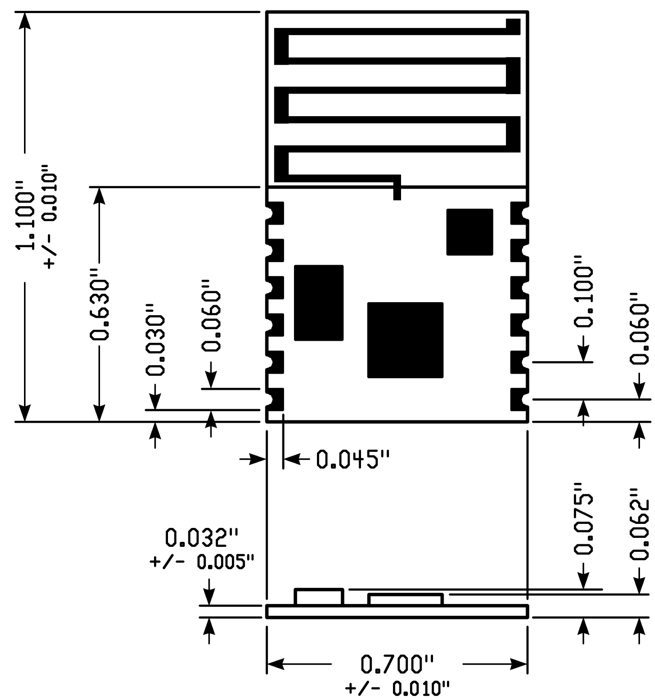



**FIGURE 1-4: RECOMMENDED PCB FOOTPRINT**

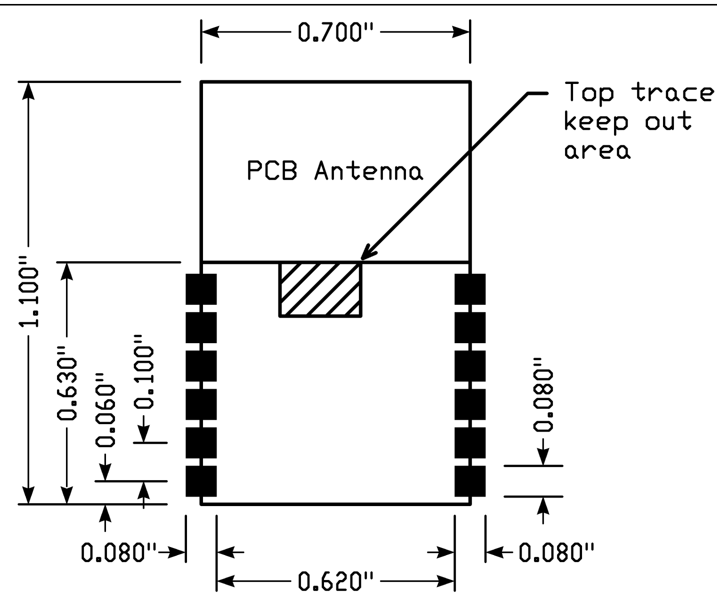
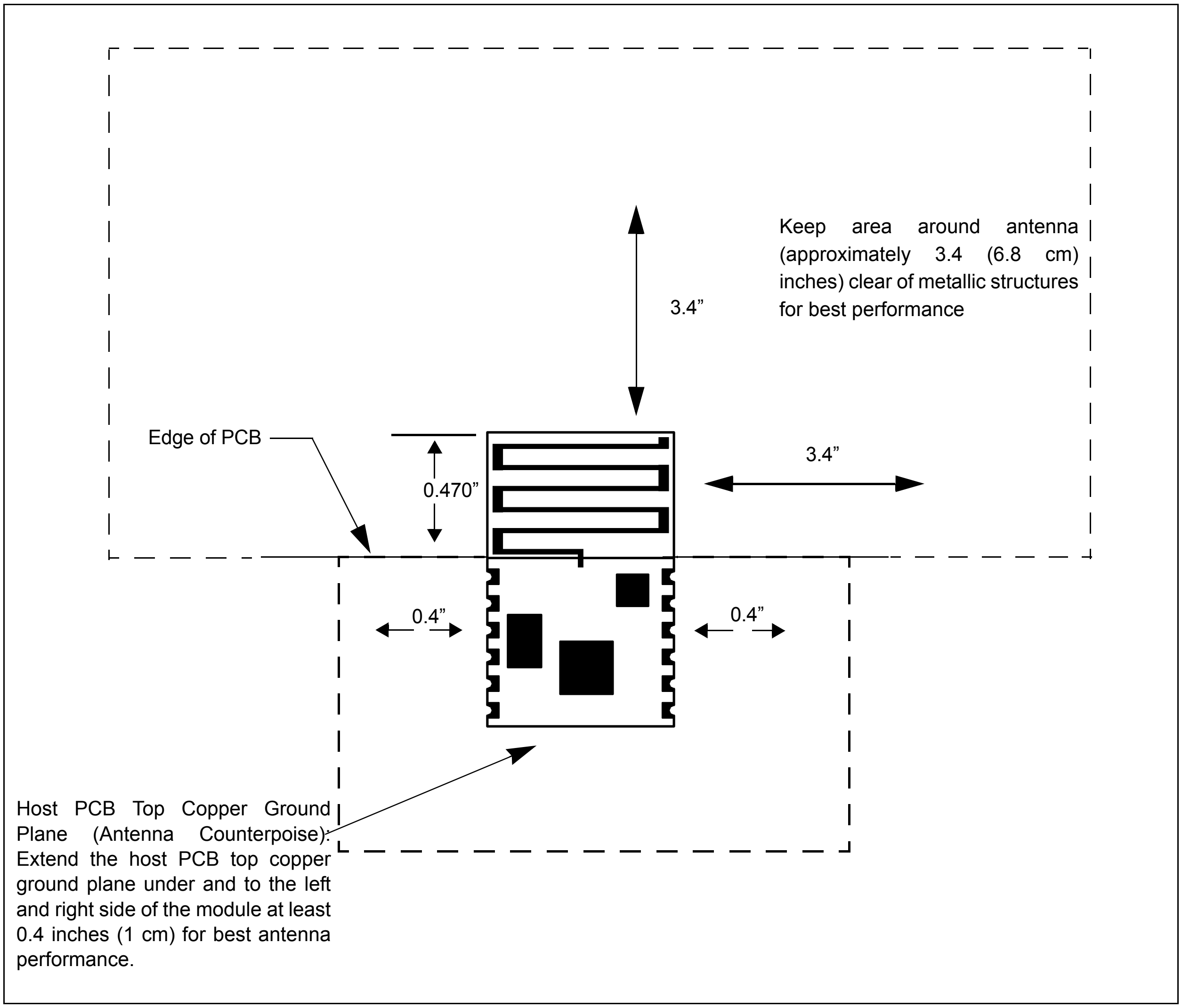


**FIGURE 1-5: MOUNTING DETAILS**



## 1.3 Operation

The MRF89XAM9A module is based on the Microchip Technology MRF89XA Ultra Low-Power, Integrated ISM Band Sub-GHz Transceiver IC. Data 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 MRF89XAM9A module design that must be followed for proper operation.

### 1.3.1 RESET

Pin 2 of the module, RESET, allows for an external reset of the MRF89XA IC. RESET is connected to the TEST8 pin of the MRF89XA IC. During normal operations of the MRF89XAM9A, the RESET pin should be held in a high impedance state. For more information on Assertion of the RESET pin, refer to the “*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 the current consumption.

### 1.3.4 FREQUENCY BAND SELECT

The Frequency Band Select (FBS<1:0>) bits in the GCONREG<4:3> should be set for target channel range 902–915 MHz FBS<1:0> = '00' or 915–928 MHz FBS<1:0> = '01'.

### 1.3.5 VCO TANK TRIM VALUE

The VCO Trim (VCOT<1:0>) bits in the GCONREG<2:1> should be set for VCOT<1:0> = '11' for the inductor values of the module.

**NOTES:**

## 2.0 CIRCUIT DESCRIPTION

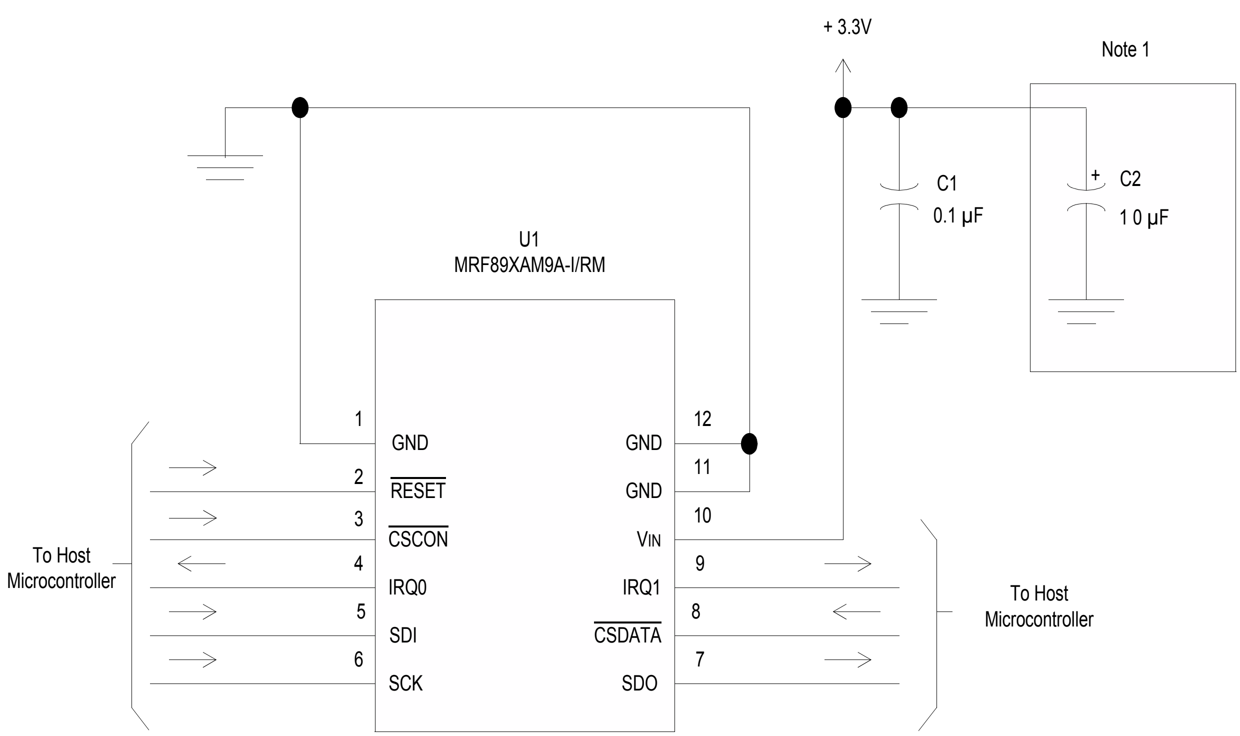
The MRF89XAM9A module interfaces to Microchip's PIC16, PIC 18, PIC24, dsPIC33 and PIC32 microcontrollers with a minimum of external components through digital only connections. An example application schematic is shown in Figure 2-2.

## 2.1 Module Schematic

The MRF89XAM9A 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 out 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.

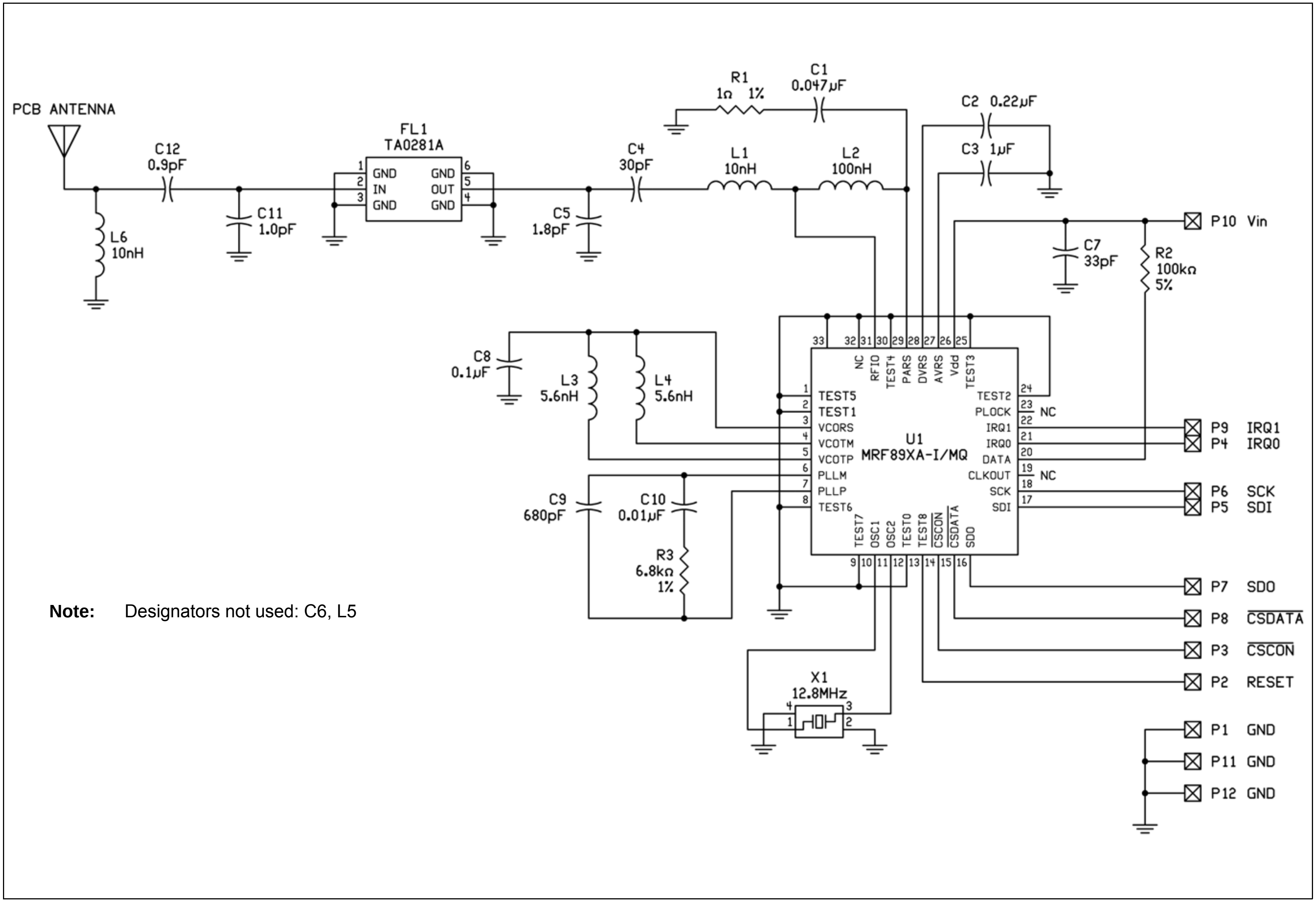
Figure 2-2 illustrates the MRF89XAM9A schematics. Table 2-1 details the Bill of Materials (BOM).

**FIGURE 2-1: MRF89XAM9A 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: MRF89XAM9A SCHEMATIC**




**Note:** Designators not used: C6, L5



Preliminary

**TABLE 2-1: MRF89XAM9A BILL OF MATERIALS**

| Designator | Value | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| C1 | 0.047 µF | Capacitor, Ceramic, 10V, ±10%, X7R, SMT 0402 | Murata | GRM155R71A473KA01D |
| C2 | 0.22 µF | Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402 | Murata | GRM155R71C224KA12D |
| C3 | 1 µF | Capacitor, Ceramic, 6.3V, ±10%, X5R, SMT 0603 | Murata | GRM188R60J105KA01D |
| C4 | 30 pF | Capacitor, Ceramic, 50V, ±5%, UHI-Q NP0, SMT 0402 | Johanson Technology | 250R07S300JV4T |
| 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 | GRM1555C1H330JZ01D |
| C8 | 0.1 µF | Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402 | Murata | GRM155R71C104KA88D |
| C9 | 680 pF | Capacitor, Ceramic, 50V, ±5%, C0G, SMT 0402 | Murata | GRM1555C1H681JA01D |
| C10 | 0.01 µF | Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402 | Murata | GRM155R71C103KA01D |
| C11 | 1.0 pF | Capacitor, Ceramic, 50V, ±0.1 pF, UHI-Q NP0, SMT 0402 | Johanson Technology | 500R07S1R0BV4 |
| C12 | 0.9 pF | Capacitor, Ceramic, 50V, ±0.1 pF, UHI-Q NP0, SMT 0402 | Johanson Technology | 500R07S0R9BV4 |
| FL1 | TA0281A | Filter, SAW, 902–928 MHz | Tai-saw Technology | TA0281A |
| L1 | 10 nH | Inductor, Ceramic, ±5%, SMT 0402 | Johanson Technology | L-07C10NJV6T |
| L2 | 100 nH | Inductor, Ceramic, ±5%, SMT 0402 | Johanson Technology | L-07CR10JV6T |
| L3 | 5.6 nH | Inductor, Wirewound, ±5%, SMT 0402 | Johanson Technology | L-07W5N6JV4T |
| L4 | 5.6 nH | Inductor, Wirewound, ±5%, SMT 0402 | Johanson Technology | L-07W5N6JV4T |
| L5 | — | Designator not used | — | — |
| L6 | 10 nH | Inductor, Ceramic, ±5%, SMT 0402 | Johanson Technology | L-07C10NJV6T |
| R1 | 1Ω | Resistor, 1%, ±100 ppm/$^0$C, SMT 0402 | Vishay/Dale | CRCW04021R00FKED |
| R2 | 100KΩ | Resistor, 5%, ±100 ppm/$^0$C, SMT 0402 | Yageo | RC0402JR-07100KL |
| R3 | 6.8KΩ | 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 MRF89XAM9A module PCB is constructed with high temperature FR4 material, four layers and 0.032 inches thick. The 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**

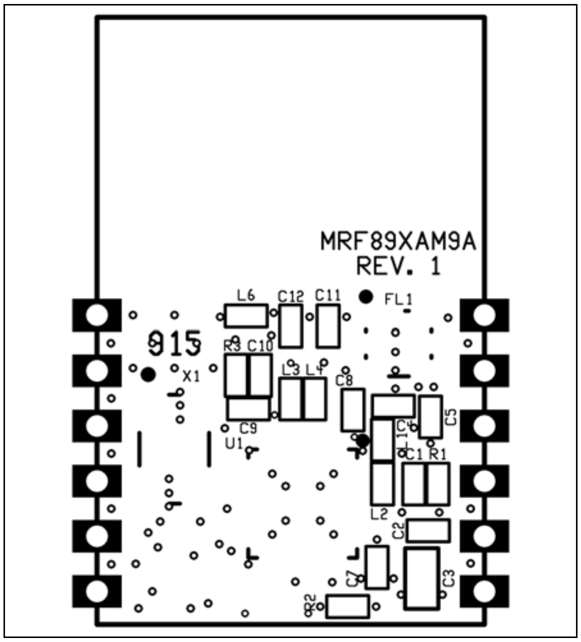



**FIGURE 2-4: TOP COPPER**

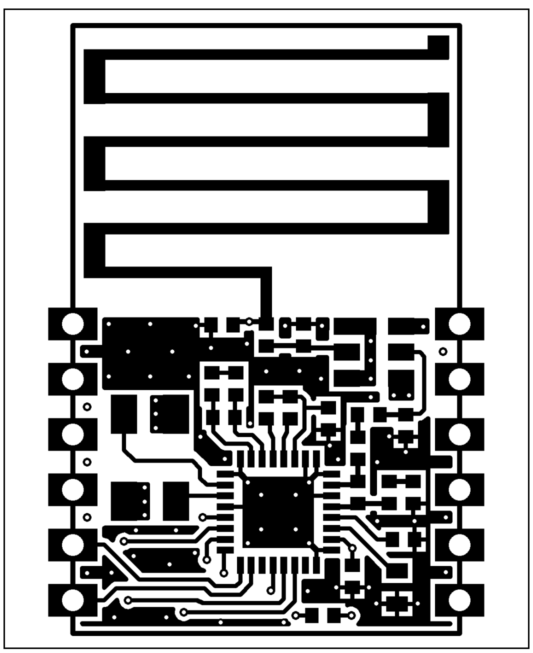


**FIGURE 2-5: LAYER 2 — GROUND PLANE**

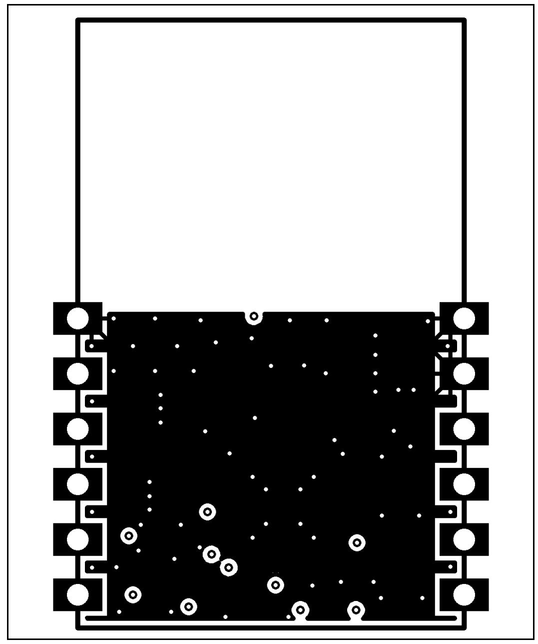


**FIGURE 2-6: LAYER 3 — POWER PLANE**

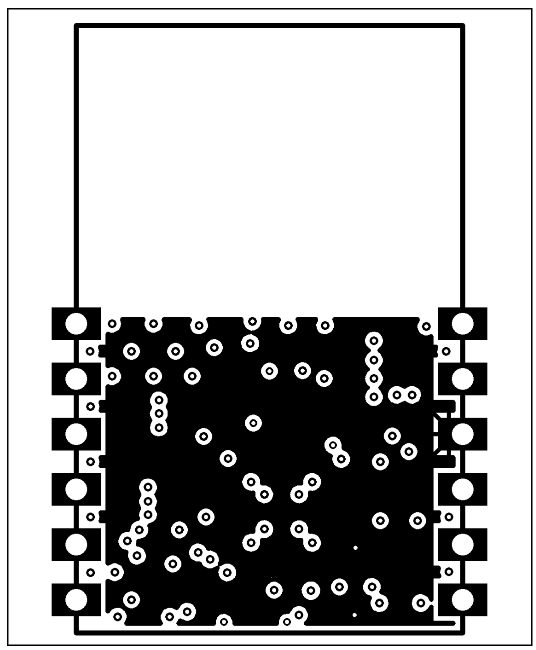


**FIGURE 2-7: BOTTOM COPPER**

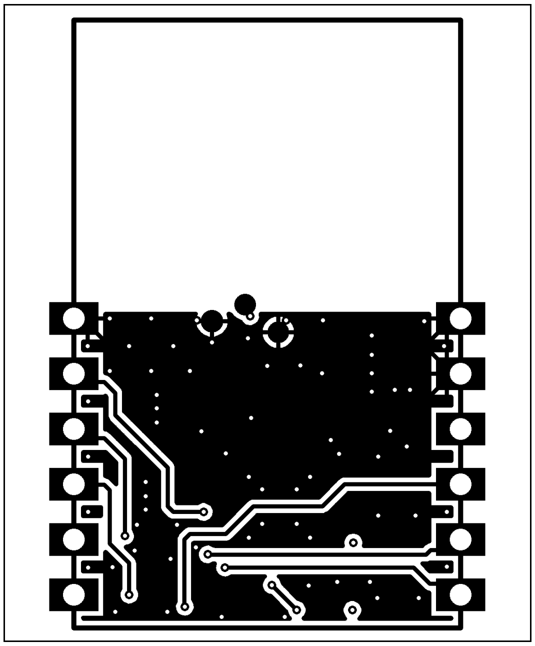


**FIGURE 2-8: BOTTOM SILK SCREEN**

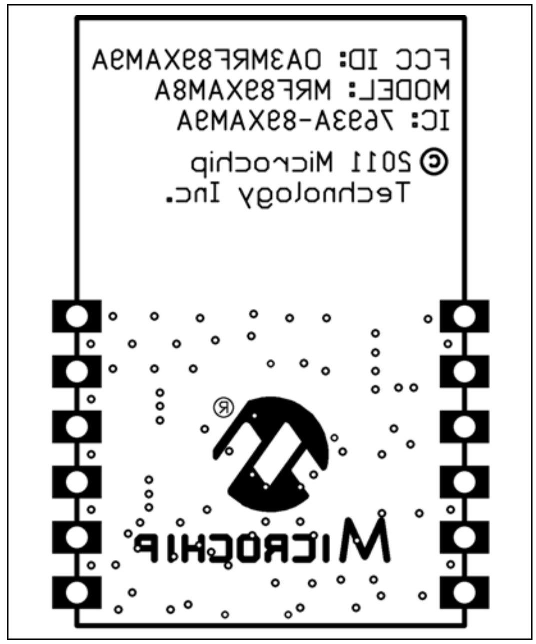
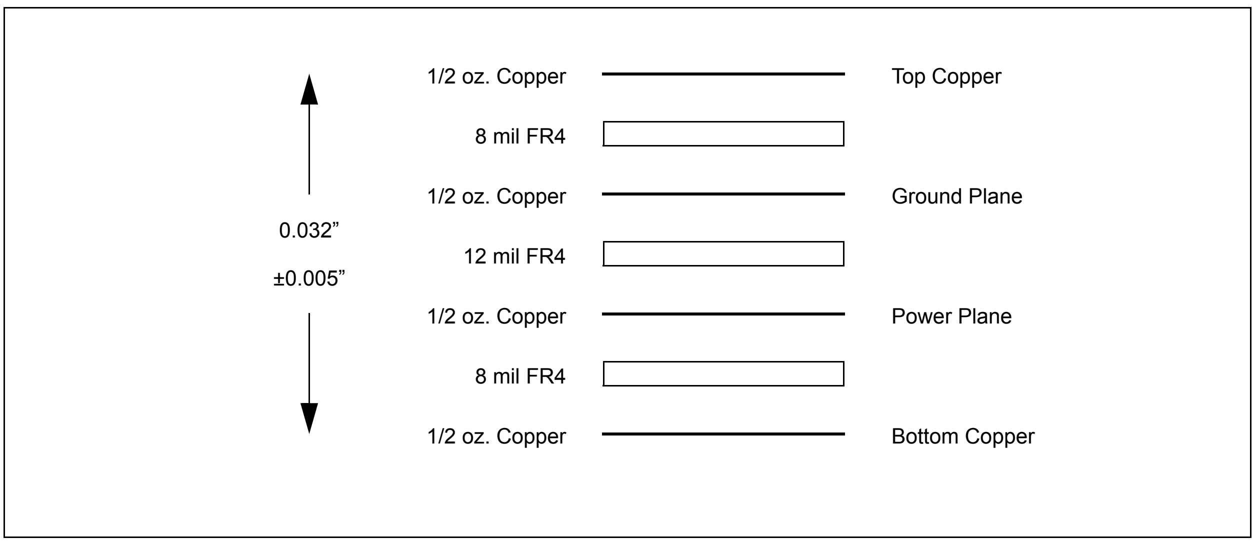



**FIGURE 2-9: PCB LAYER STACK UP**



## 2.3 PCB Antenna

The PCB antenna is fabricated on the top copper trace. Figure 2-11 shows 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 in 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 design goal was to create a compact, low-cost antenna with the best radiation pattern. Figure 2-11 shows the simulation drawing and Figure 2-12 and Figure 2-13 show the 2D and 3D radiation patterns, respectively. As shown by the radiation patterns, the performance of the antenna is dependant upon the orientation of the module. Figure 2-14 shows the impedance simulation and Figure 2-15 shows the actual impedance measurement. The discrete matching circuitry matches the impedance of the antenna with the SAW filter and MRF89XA transceiver IC.

**FIGURE 2-10: PCB ANTENNA DIMENSIONS**

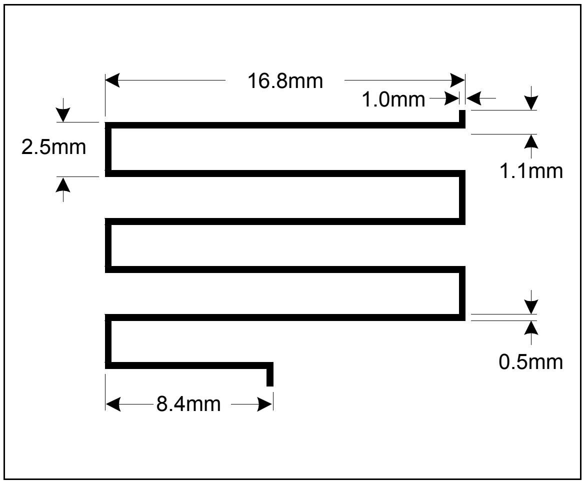



**FIGURE 2-11: PCB ANTENNA SIMULATION DRAWING**

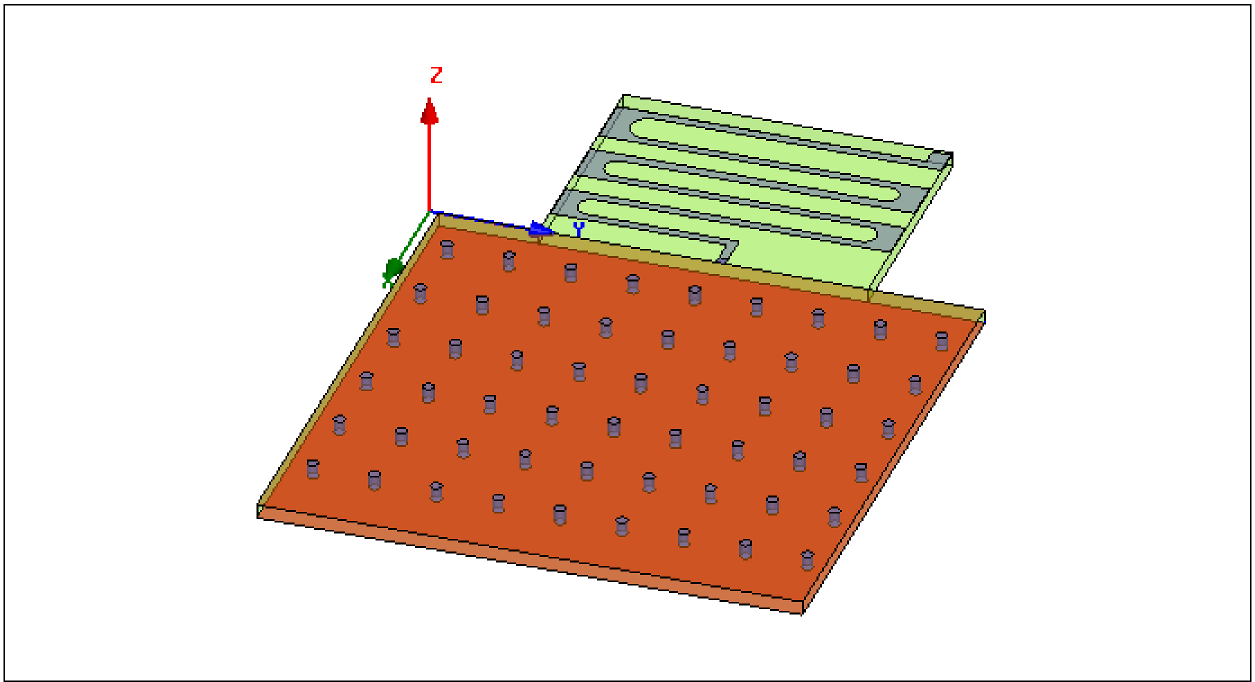


**FIGURE 2-12: SIMULATED 2D RADIATION PATTERN**

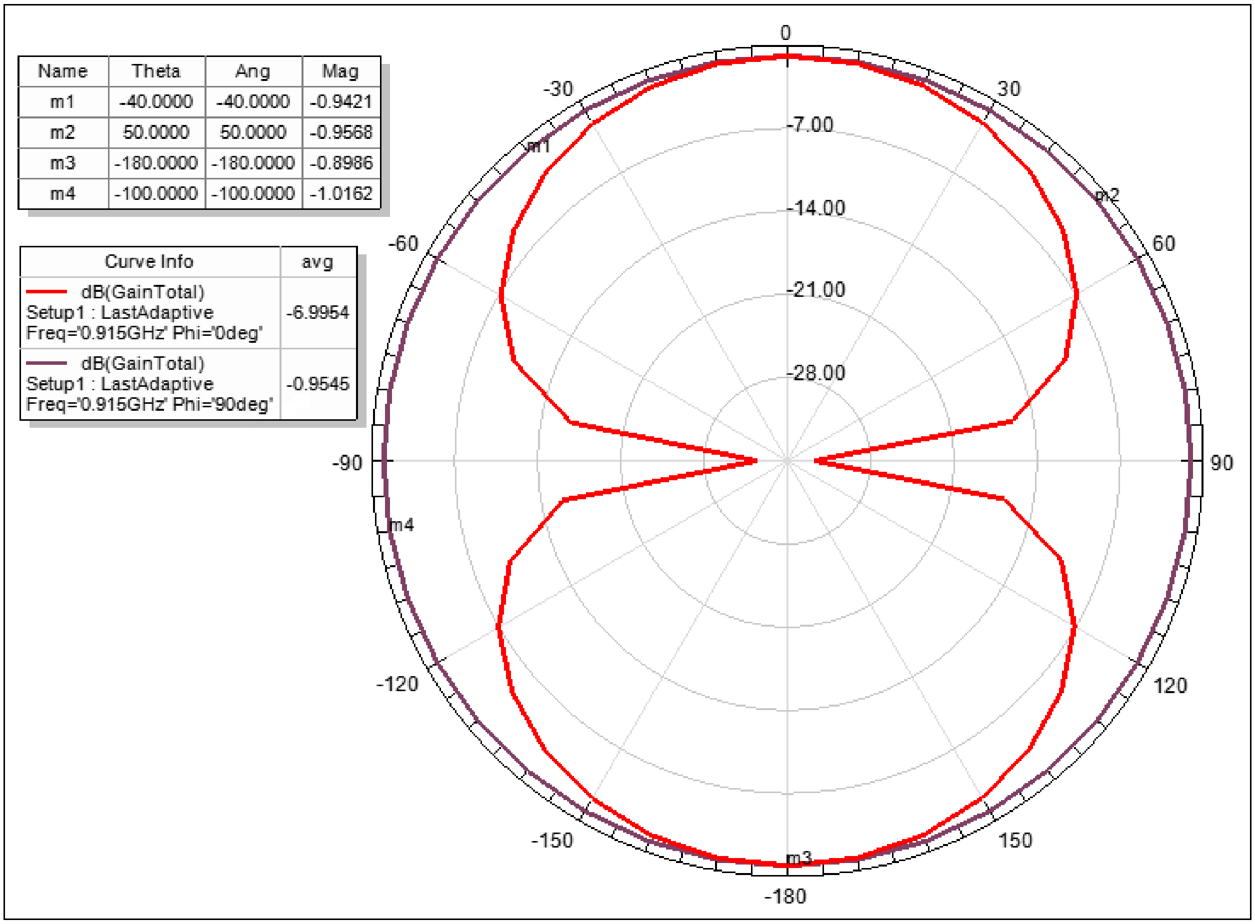



**FIGURE 2-13: SIMULATED 3D RADIATION PATTERN**

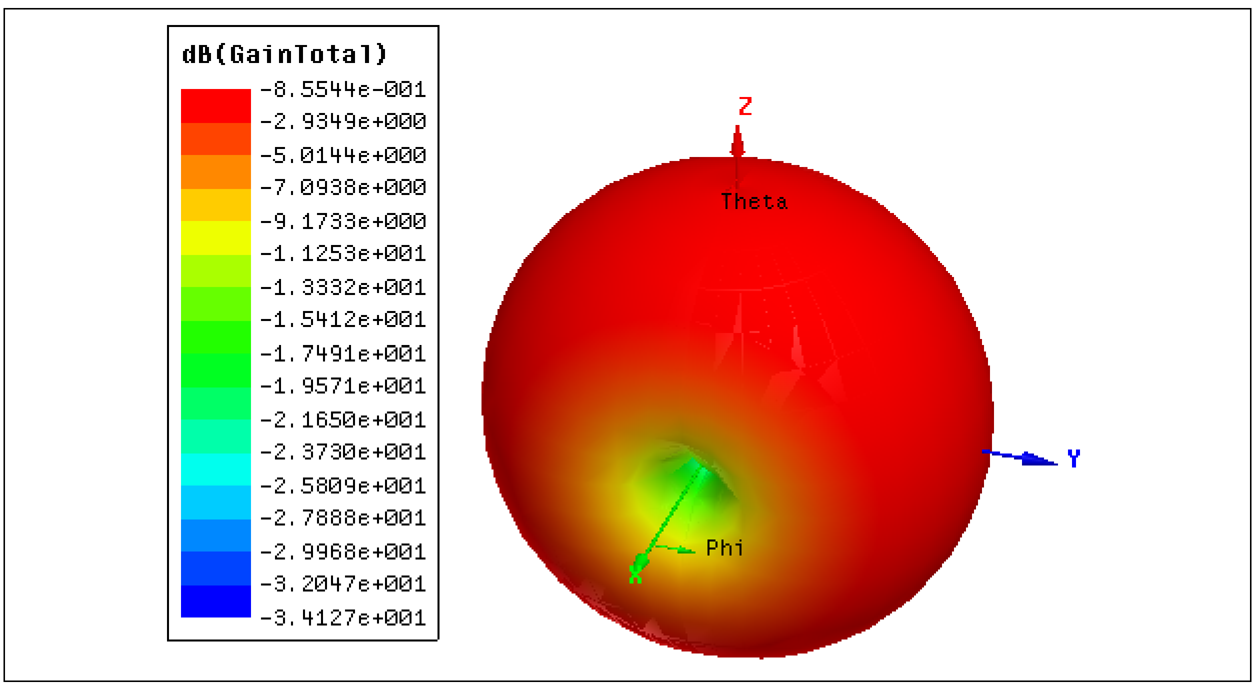


**FIGURE 2-14: SIMULATED PCB ANTENNA IMPEDANCE**

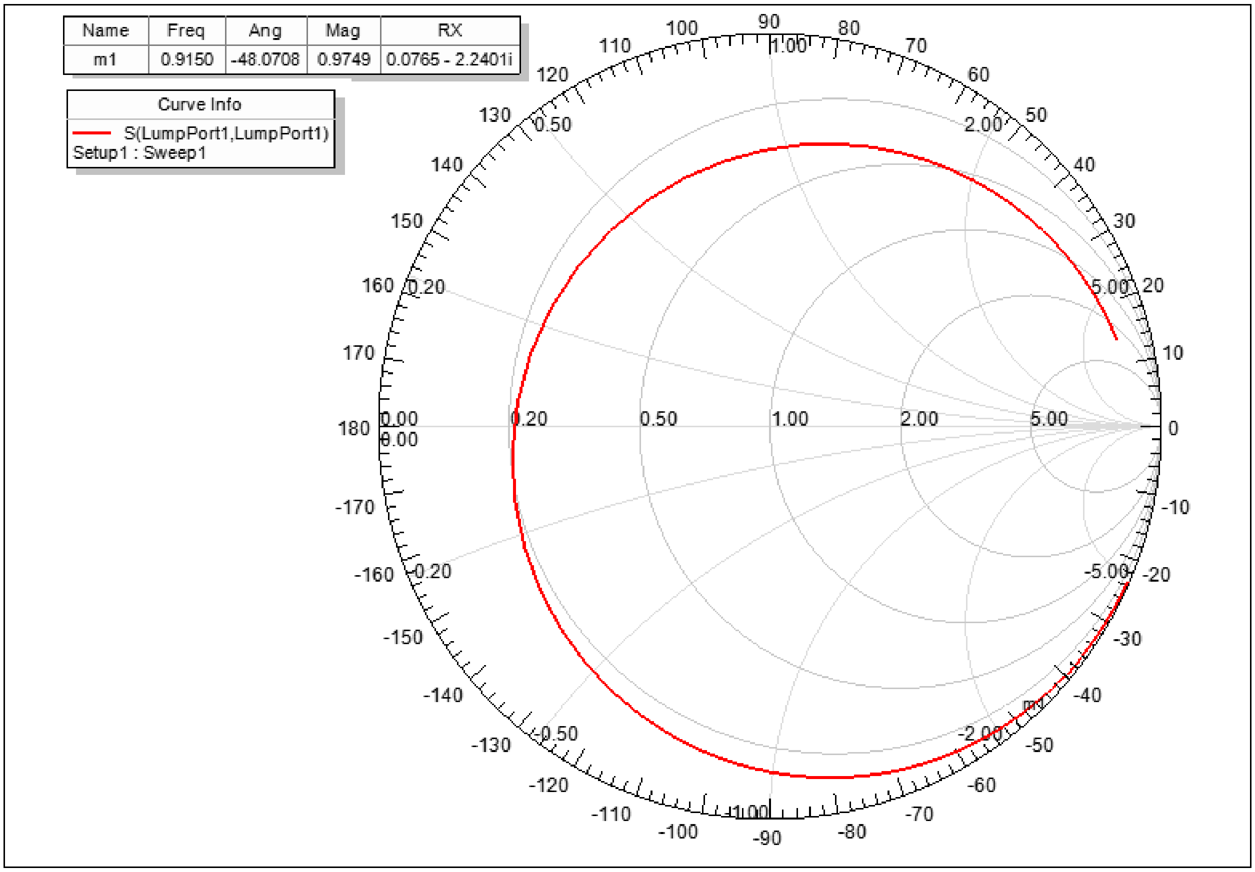
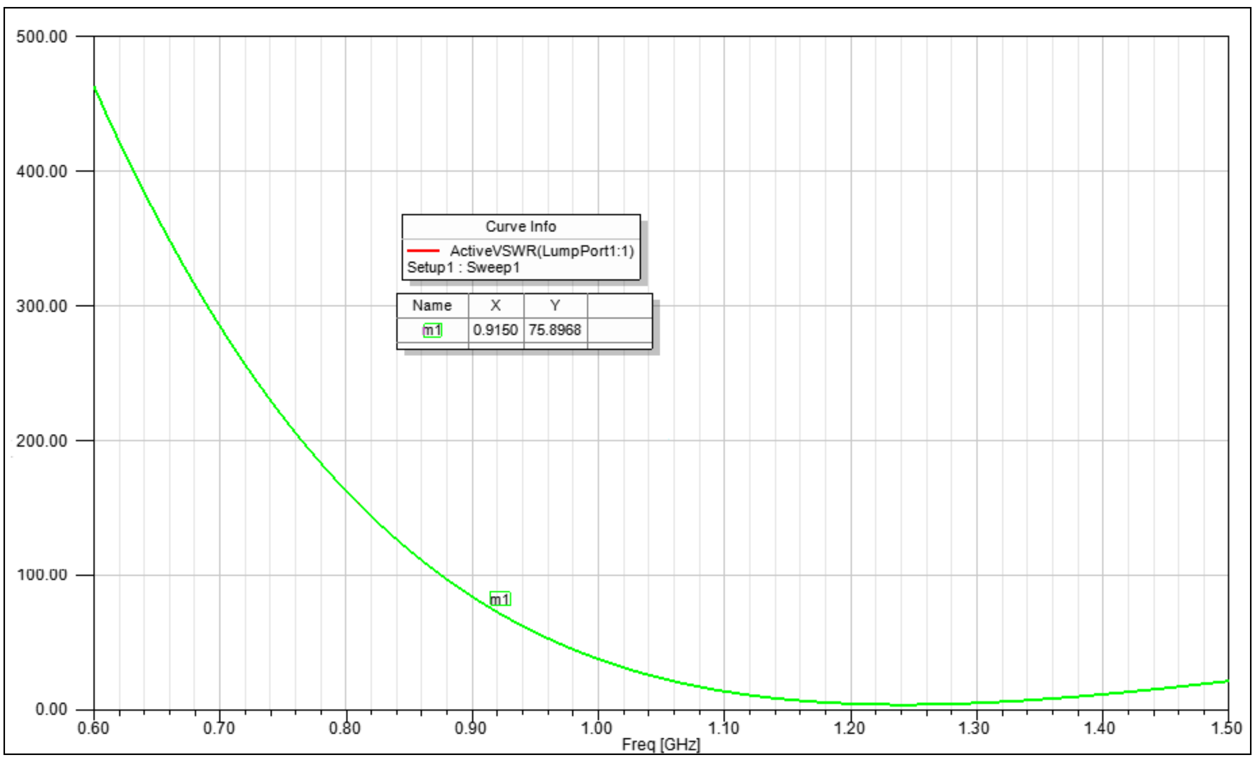



**FIGURE 2-15: SIMULATED PCB ANTENNA VSWR**



## 3.0 REGULATORY APPROVAL

The MRF89XAM9A module has received regulatory approvals for modular devices in the United States and Canada. Modular approval allows the end user to place the MRF89XAM9A module inside a finished product and not require regulatory testing for an intentional radiator (RF transmitter), provided no changes or modifications are made to the module circuitry. Changes or modifications could void the user's authority to operate the equipment. The end user must comply with all of the instructions provided by the Grantee, which indicate installation and/or operating conditions necessary for compliance.

The integrator is still responsible for testing the end product for any additional compliance requirements required with this module installed (digital device emission, PC peripheral requirements, etc.) in the specific country that the end device will be marketed.

For more information on details on regulatory compliance, refer to the specific country radio regulations in the following sections.

## 3.1 United States

The MRF89XAM9A has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" 15.247 and 15.249 and modular approval in accordance with FCC Public Notice DA 00-1407 Released: June 26, 2000, Part 15 Unlicensed Modular Transmitter Approval. The MRF89XAM9A module can be integrated into a finished product without obtaining subsequent and separate FCC certification.

The MRF89XAM9A module has been labeled with its own FCC ID number, and if the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording as following:

> Contains Transmitter Module FCC ID:
> OA3MRF89XAM9A
>
> -or-
>
> Contains FCC ID: OA3MRF89XAM9A
>
> This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Requirements for product labeling are given in Part 15.19 Labelling Requirements.

The user's manual should include the following statement:

> This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment OFF and ON, the user is encouraged to try to correct the interference by one or more of the following measures:
>
> - Reorient or relocate the receiving antenna.
> - Increase the separation between the equipment and receiver.
> - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
> - Consult the dealer or an experienced radio/TV technician for help.

### 3.1.1 MRF89XAM9A SETTINGS

To meet the FCC requirements, the following settings must be observed by the integrator:

#### 3.1.1.1 FSK Modulation

The following settings configure the MRF89XAM9A for wideband digital modulation techniques that conform to the requirements of Part 15.247. These settings allow for higher radio frequency (RF) output power and greater link budget:

- Bit Rate Setting: 50 - 200 kbps
  - Transmit Power Maximum Setting: 13 dBm
- Bit Rate Setting: 2 - 40 kbps
  - Transmit Power Maximum Setting: 7 dBm
- Frequency Deviation Setting: 200 kHz
- Data Whitening: On
- Transmit Bandwidth Setting: 400 kHz
- Lower Frequency Setting: 902.800 MHz
- Upper Frequency Setting: 926.500 MHz

#### 3.1.1.2 OOK Modulation

The following settings configure the MRF89XAM9A for narrowband operation that conform to the requirements of Part 15.249. Part 15.249 requires a much lower power setting than is allowed in Part 15.247. These settings are good for applications that require lower transmit power current consumption and shorter transmit distances:

- Transmit Power Maximum Setting: 1 dBm
- Bit Rate Maximum Setting: 16 kbps
- Frequency Deviation Setting: 200 kHz
- Transmit Bandwidth Setting: 400 kHz
- Lower Frequency Setting: 902.330 MHz
- Upper Frequency Setting: 927.500 MHz

### 3.1.2 RF EXPOSURE

All transmitters regulated by FCC must comply with RF exposure requirements. OET Bulletin 65 "*Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields*" provides assistance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to RF fields adopted by the Federal Communications Commission (FCC). The bulletin offers guidelines and suggestions for evaluating compliance.

If appropriate, compliance with exposure guidelines for mobile and unlicensed devices can be accomplished by the use of warning labels and by providing users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.

The following statement must be included as a CAUTION statement in manuals and OEM products to alert users of FCC RF Exposure compliance:

> To satisfy FCC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended.
>
> The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

If the MRF89XAM9A module is used in a portable application (antenna is less than 20 cm from persons during operation), the integrator is responsible for performing Specific Absorption Rate (SAR) testing in accordance with FCC rules 2.1091.

### 3.1.3 HELPFUL WEB SITES

Federal Communications Commission (FCC) http://www.fcc.gov

## 3.2 Canada

The MRF89XAM9A module has been certified for use in Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-210 and RSS-Gen. Modular approval permits the installation of a module in a host device without the need to recertify the device.

Labeling Requirements for the Host Device (from Section 3.2.1, RSS-Gen, Issue 3, December 2010):

The host device shall be properly labeled to identify the module within the host device.

The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labeled to display the Industry Canada certification number of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

| Contains transmitter module IC: 7693A-89XAM9A |
|---|

User Manual Notice for License-Exempt Radio Apparatus (from Section 7.1.3 RSS-Gen, Issue 3, December 2010):

User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual or alternatively on the device or both.

> This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.
>
> Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

### 3.2.1 MRF89XAM9A SETTINGS

To meet Industry Canada (IC) requirements, the following settings must be observed by the integrator:

#### 3.2.1.1 FSK Modulation

The following settings configure the MRF89XAM9A for wideband digital modulation techniques that conform to the requirements of RSS-210 Issue 8 Annex 8. These settings allow for higher radio frequency (RF) output power and greater link budget.

- Bit Rate Setting: 50 - 200 kbps
  - Transmit Power Maximum Setting: 13 dBm
- Bit Rate Setting: 2 - 40 kbps
  - Transmit Power Maximum Setting: 7 dBm
- Frequency Deviation Setting: 200 kHz
- Data Whitening: On
- Transmit Bandwidth Setting: 400 kHz
- Lower Frequency Setting: 902.800 MHz
- Upper Frequency Setting: 926.500 MHz

#### 3.2.1.2 OOK Modulation

The following settings configure the MRF89XAM9A for narrowband operation that conform to the requirements of RSS-Gen Issue 3. RSS-Gen Issue 3 requires a much lower power setting than is allowed in Part RSS-210 Issue 8 Annex 8. These settings are good for applications that require lower transmit power current consumption and shorter transmit distances.

- Transmit Power Maximum Setting: 1 dBm
- Bit Rate Maximum Setting: 16 kbps
- Frequency Deviation Setting: 200 kHz
- Transmit Bandwidth Setting: 400 kHz
- Lower Frequency Setting: 902.330 MHz
- Upper Frequency Setting: 927.500 MHz

### 3.2.2 HELPFUL WEB SITES

Industry Canada: http://www.ic.gc.ca/

**NOTES:**

# 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 | —<br>— | 25<br>16 | 30<br>21 | mA<br>mA | Output power = +10 dBm<br>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.

**TABLE 4-4: PLL PARAMETERS AC CHARACTERISTICS[1]**

| Symbol | Parameter | Min | Typ | Max | Unit | Condition |
|---|---|---|---|---|---|---|
| FRO | Frequency Ranges | 902 | — | 928 | 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 | 915 MHz, BR = 25 kbps, $f_{dev}$ = 50 kHz, $f_c$ = 100 kHz |
| | | — | -103 | — | dBm | 915 MHz, BR = 66.7 kbps, $f_{dev}$ = 100 kHz, $f_c$ = 200 kHz |
| RSO | Sensitivity (OOK) | — | -113 | — | dBm | 915 MHz, 2 kbps NRZ $f_c - f_o$ = 50 kHz, $f_o$ = 50 kHz |
| | | — | -106 | — | dBm | 915 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.

**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 | — |
| $\overline{CSCON}$ Low to SCK Rising Edge; SCK Falling Edge to $\overline{CSCON}$ High | 500 | — | — | ns | — |
| $\overline{CSDATA}$ Low to SCK Rising Edge; SCK Falling Edge to $\overline{CSDATA}$ High | 625 | — | — | ns | — |
| $\overline{CSCON}$ Rising to Falling Edge | 500 | — | — | ns | — |
| $\overline{CSDATA}$ 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.

**NOTES:**

# APPENDIX A: REVISION HISTORY

## Revision A (May 2011)

This is the Initial release of the document.

**NOTES:**

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## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, for example, on pricing or delivery, refer to the factory or the listed sales office.

PART NO — M — X — T — -X

- PART NO: Device
- M: Module
- X: Module Type
- T: Tape and Reel
- -X: Temperature Range

| | | |
|---|---|---|
| Device | MRF89XAM9A-I/RM: Ultra Low-Power, Integrated ISM Band Sub-GHz Transceiver module | |
| Temperature Range | I | = -40ºC to +85ºC (Industrial) |

**Example:**

a) MRF89XAM9A-I/RM: Industrial temperature tray.

b) MRF89XAM9AT-I/RM: Industrial temperature tape and reel,

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