MRF89XAM8A
Data Sheet

868 MHz Ultra-Low Power
Sub-GHz Transceiver Module

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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)

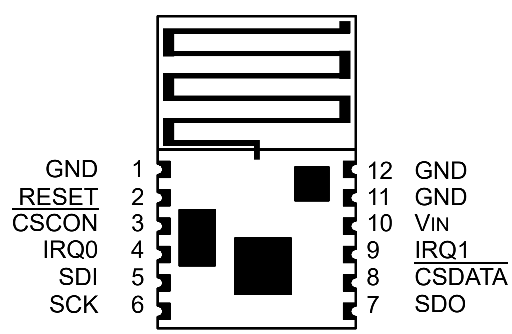
RF/Analog Features

- 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 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 the 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 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 lists the related pin descriptions.

Data 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 and 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

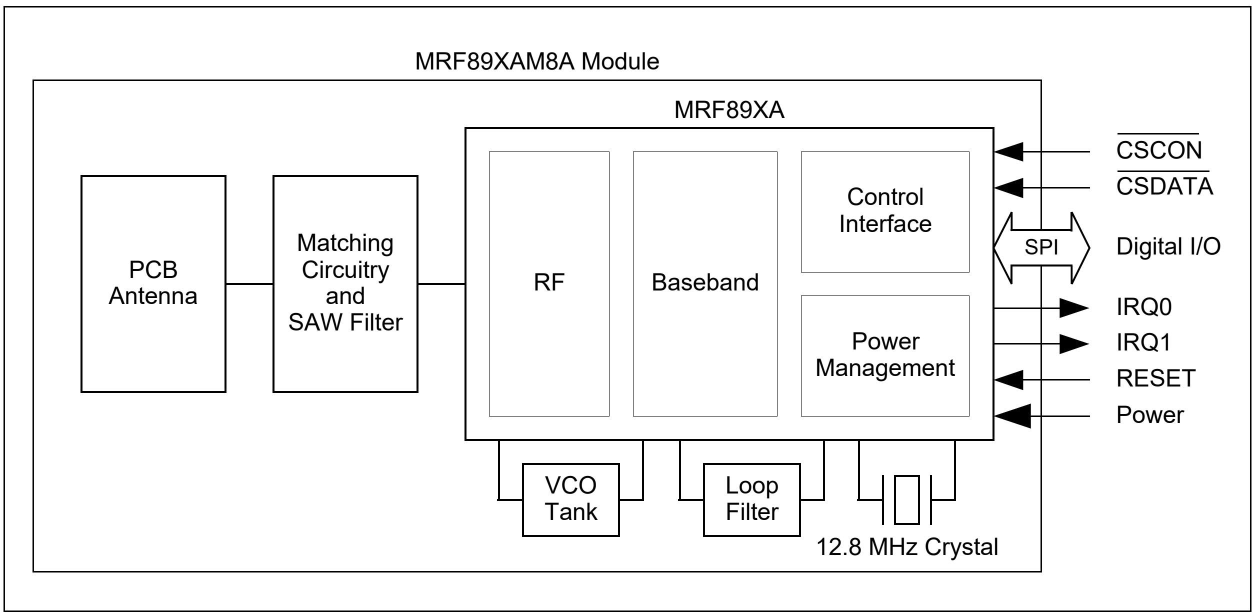
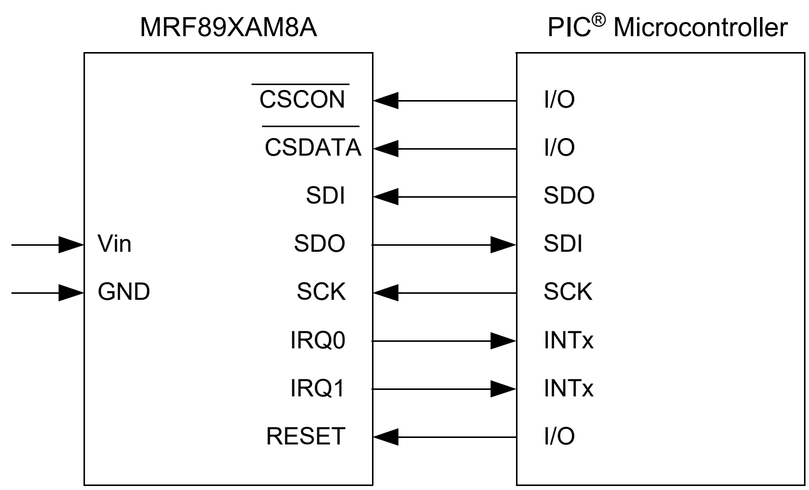


TABLE 1-1: PIN DESCRIPTION

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



 Preliminary

1.2 Mounting Details

The MRF89XAM8A 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 MRF89XAM8A.

The MRF89XAM8A 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 MRF89XAM8A 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

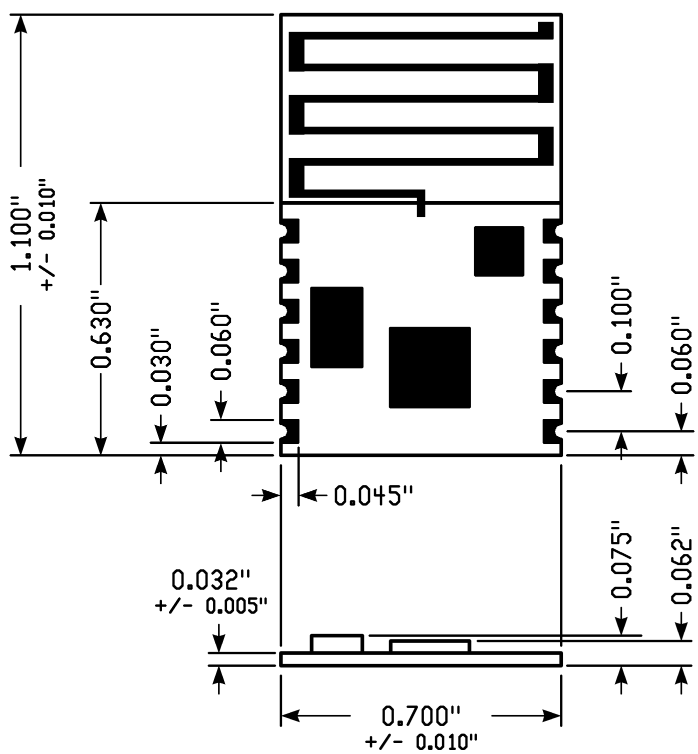


FIGURE 1-4: RECOMMENDED PCB FOOTPRINT

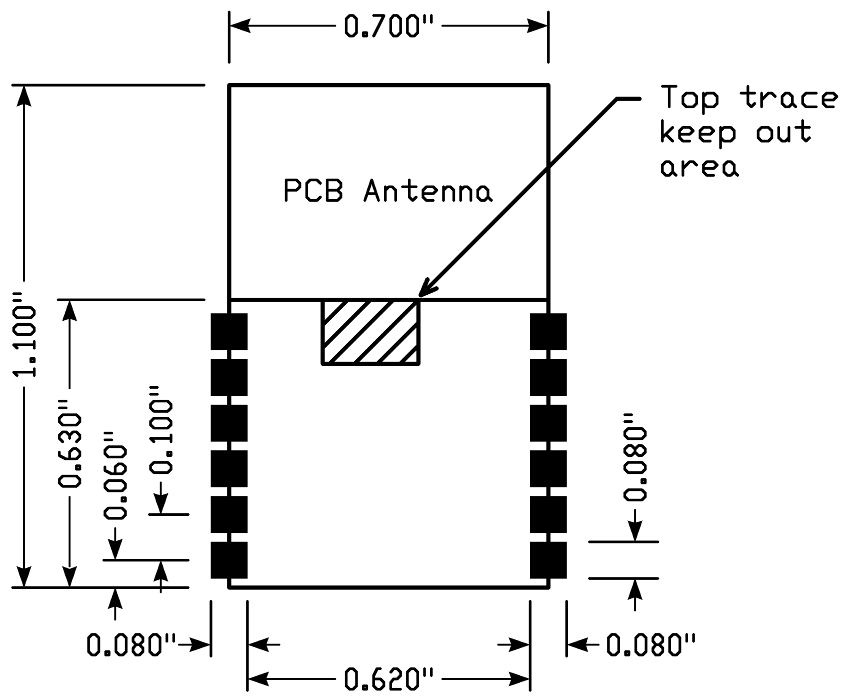
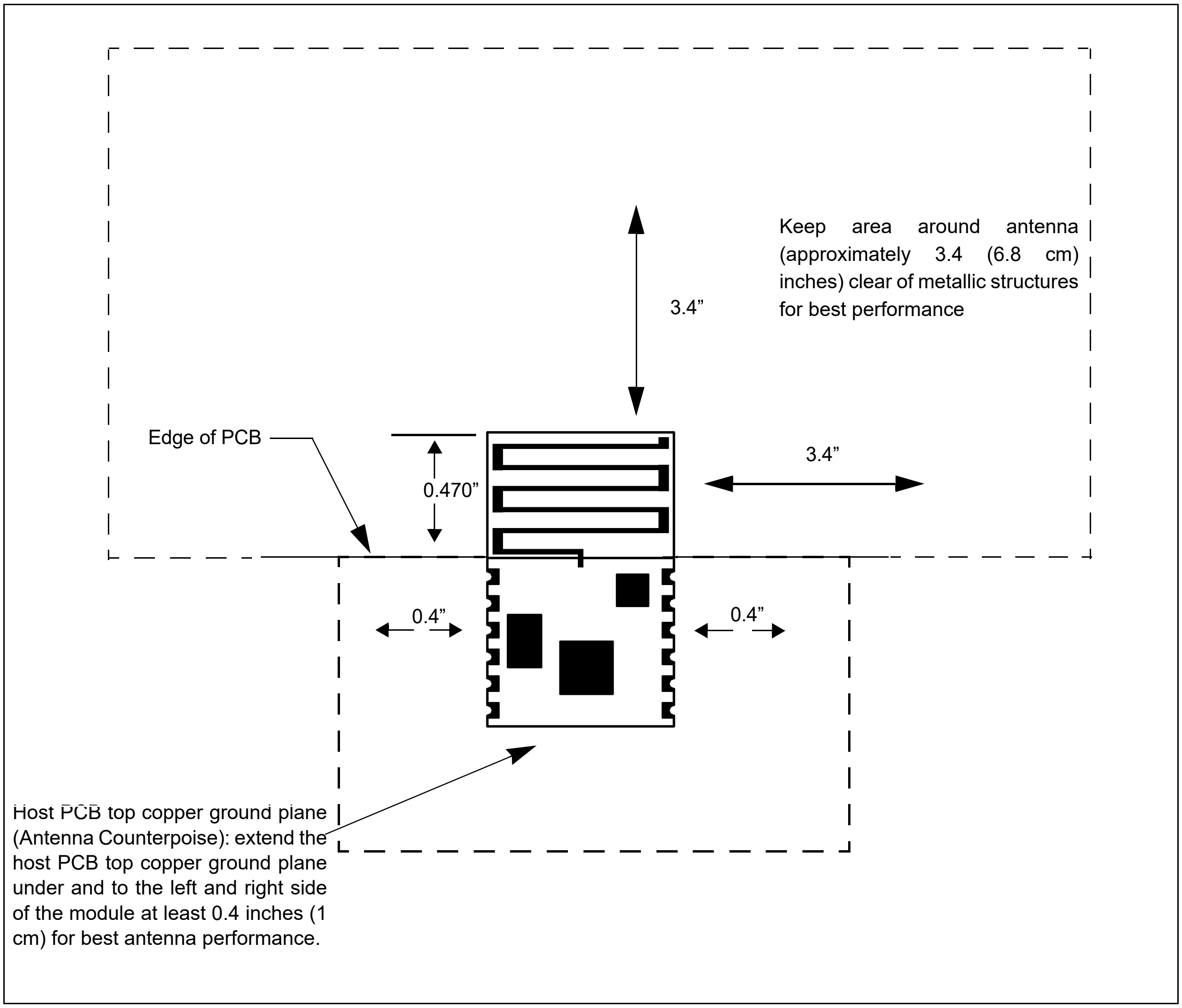


FIGURE 1-5: MOUNTING DETAILS



1.3 Operation

The MRF89XAM8A 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 MRF89XAM8A module design that must be followed in order for the module to conform to the tested European Standards that are 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 the 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: 863.4 MHz
- Upper Frequency Setting: 869.7 MHz

2.0 CIRCUIT DESCRIPTION

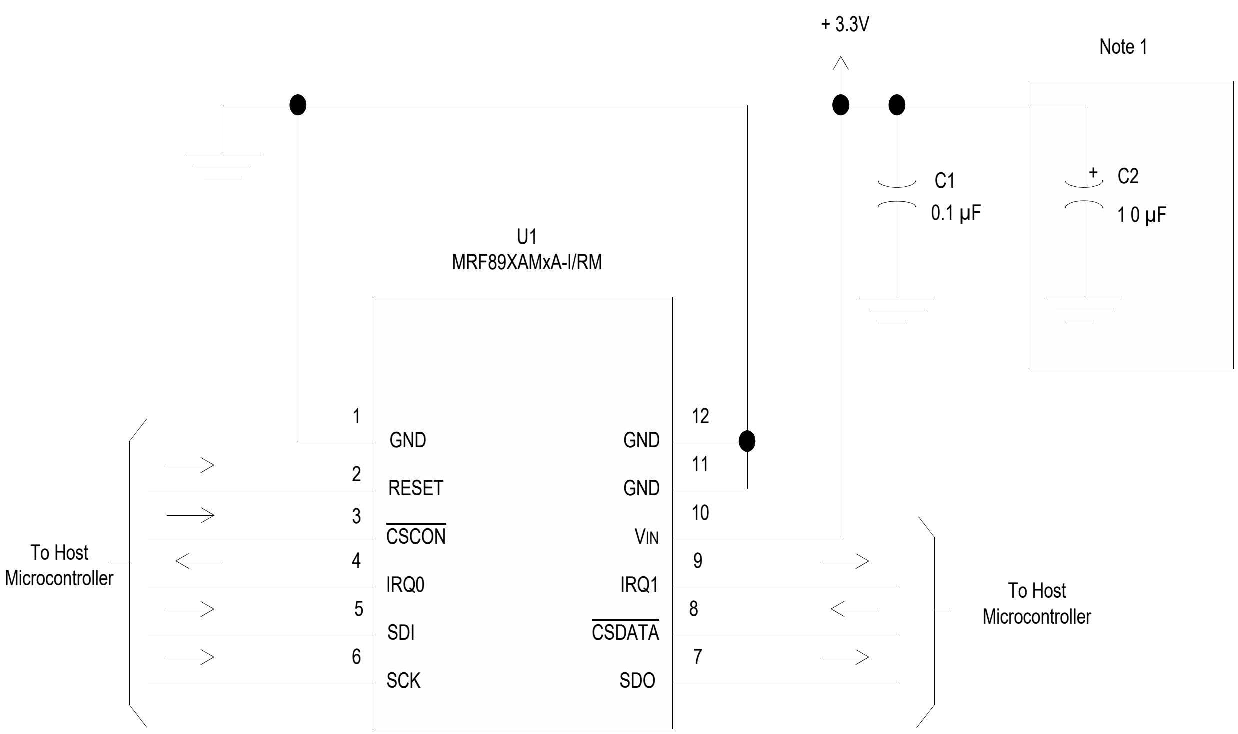
The MRF89XAM8A module interfaces to Microchip's PIC16, PIC18, PIC24, dsPIC33 and PIC32 microcontrollers with a minimum of external components through digital only connections. An example application schematic is shown in Figure 2-2.

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.

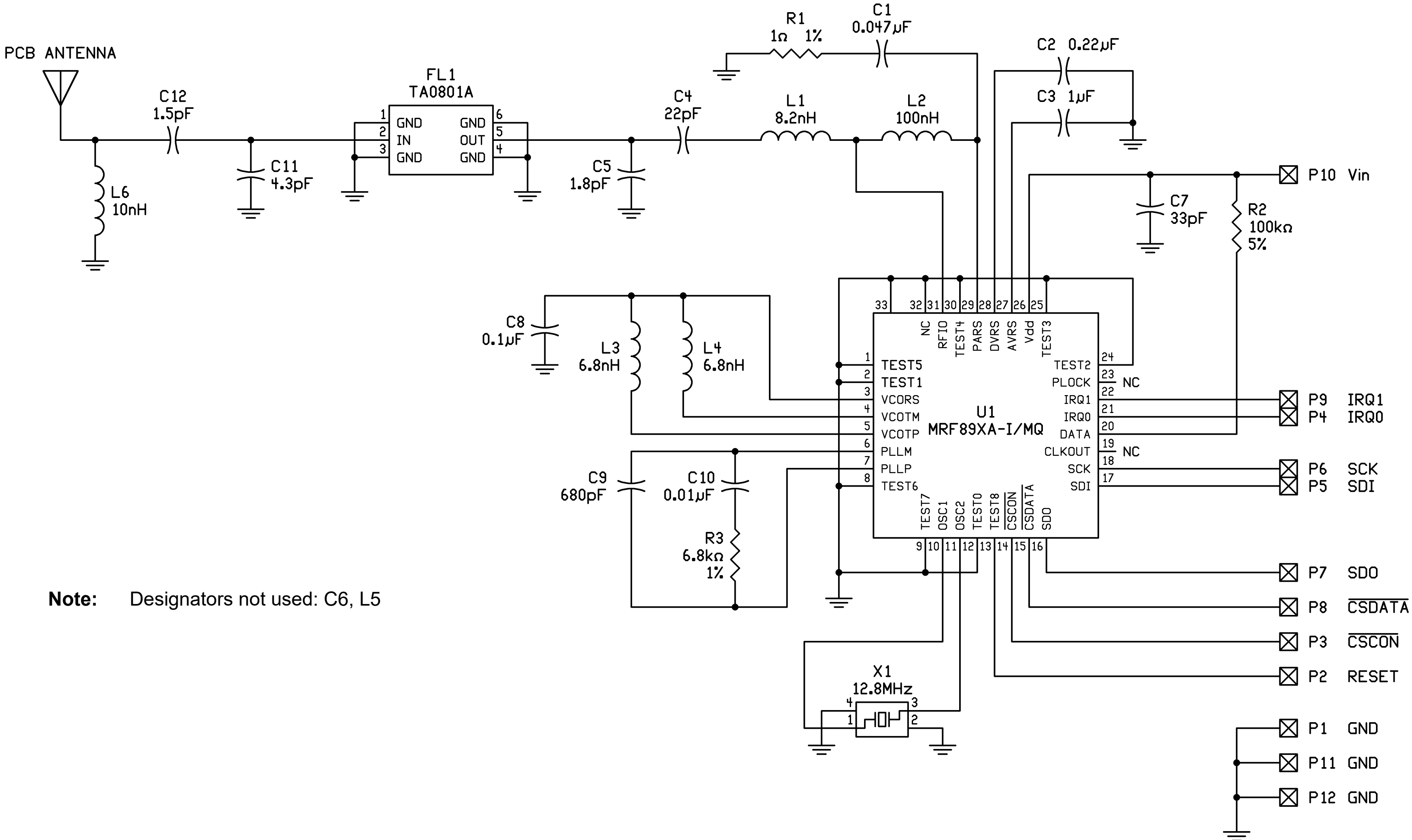
Figure 2-2 illustrates the MRF89XAM8A schematics. Table 2-1 lists the Bill of Materials (BOM).

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

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	GRM155R71A473-KA01D
C2	0.22 µF	Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402	Murata	GRM155R71C224-KA12D
C3	1 µF	Capacitor, Ceramic, 6.3V, ±10%, X5R, SMT 0603	Murata	GRM188R60J105-KA01D
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	GRM1555C1H330-JZ01D
C8	0.1 µF	Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402	Murata	GRM155R71C104-KA88D
C9	680 pF	Capacitor, Ceramic, 50V, ±5%, C0G, SMT 0402	Murata	GRM1555C1H681-JA01D
C10	0.01 µF	Capacitor, Ceramic, 16V, ±10%, X7R, SMT 0402	Murata	GRM155R71C103-KA01D
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	CRCW04021R00FKED
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, 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

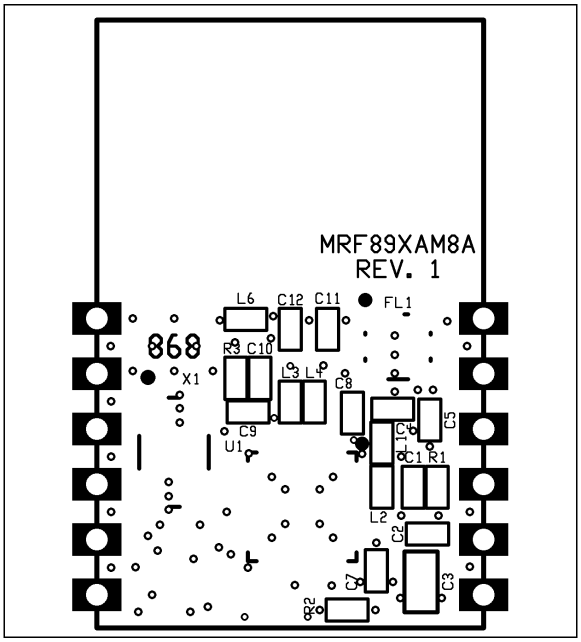


FIGURE 2-4: TOP COPPER

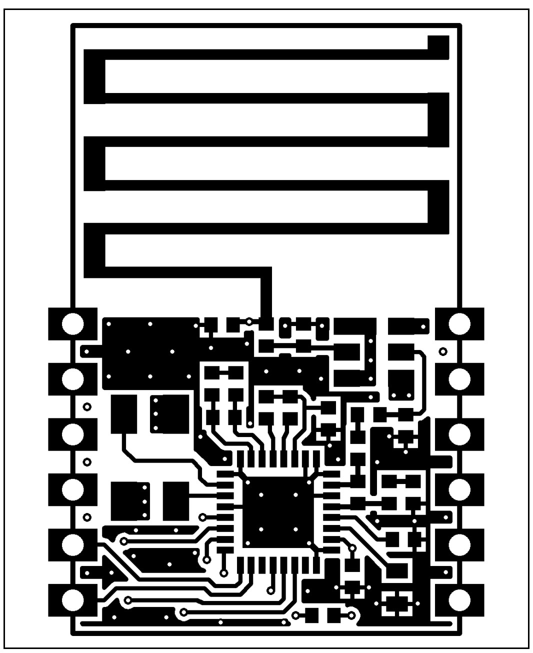


FIGURE 2-5: LAYER 2 — GROUND PLANE

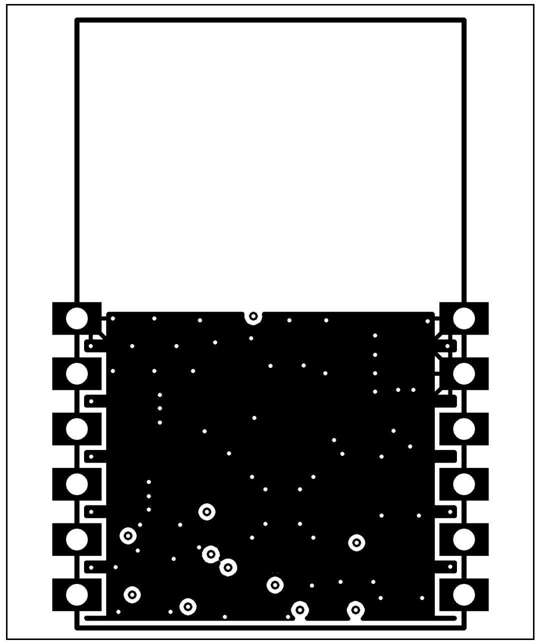


FIGURE 2-6: LAYER 3 — POWER PLANE

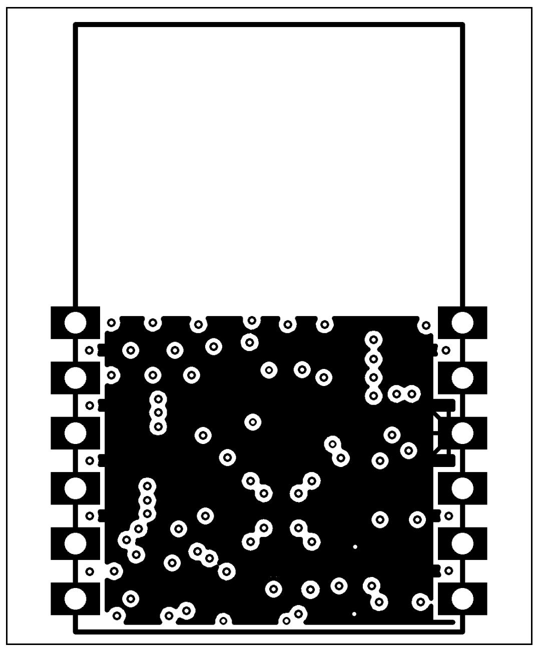


FIGURE 2-7: BOTTOM COPPER

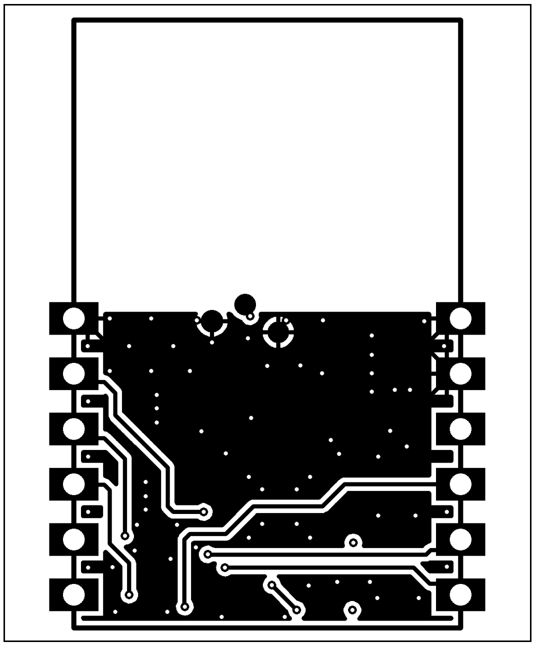


FIGURE 2-8: BOTTOM SILK SCREEN

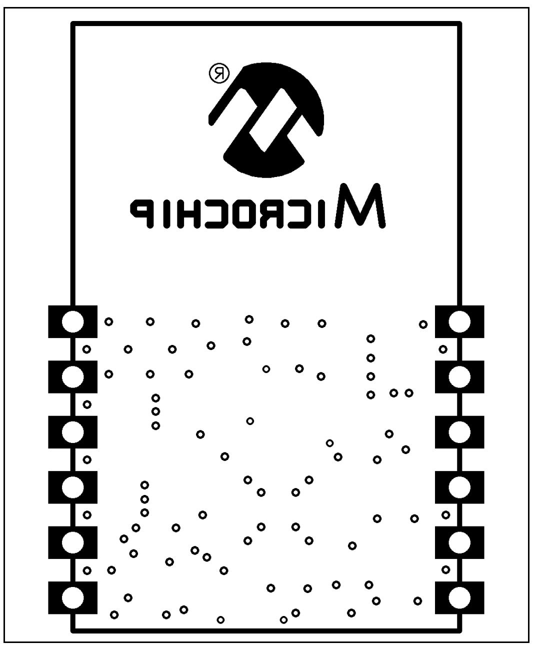
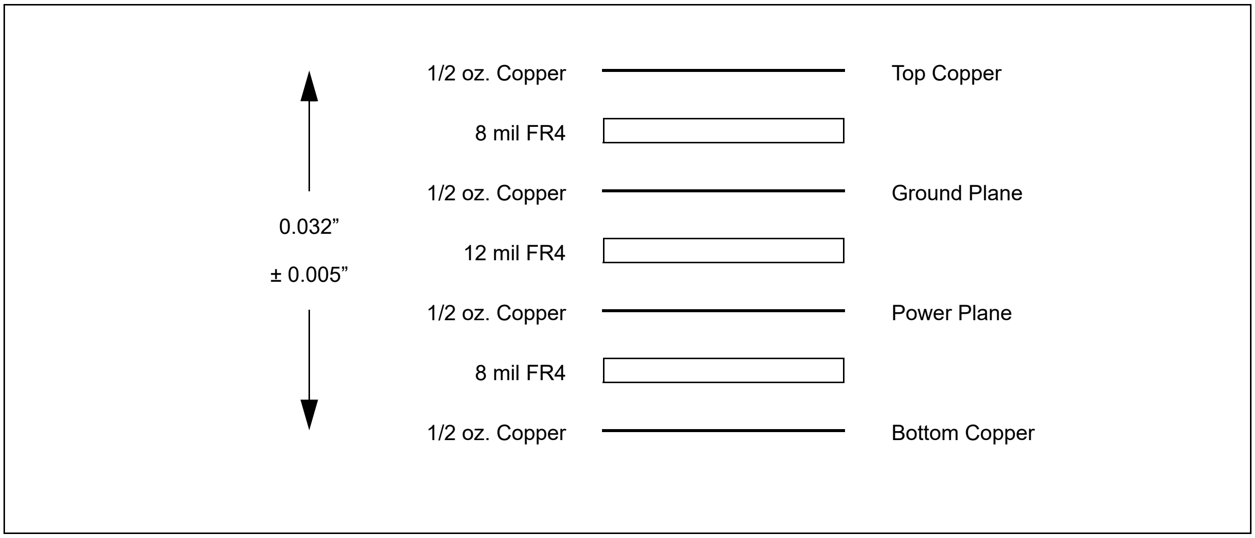


FIGURE 2-9: PCB LAYER STACK UP



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 given in Section 1.2, Mounting Details.

The PCB antenna is designed and simulated using Ansoft Designer® and HFSS™ 3D full-wave solver software by ANSYS, Inc. (www.ansoft.com). The goal of the design is 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. 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 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

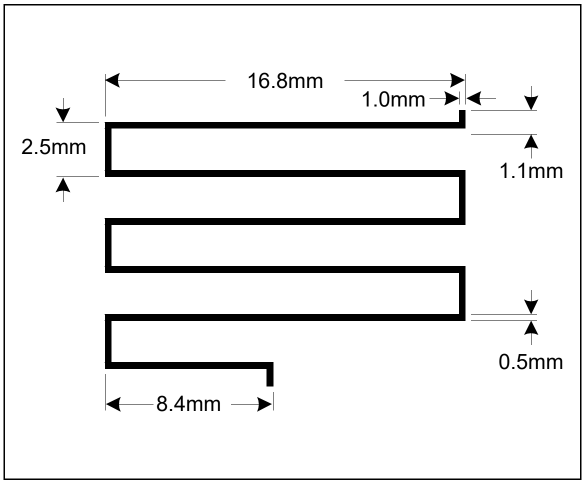


FIGURE 2-11: PCB ANTENNA SIMULATION DRAWING

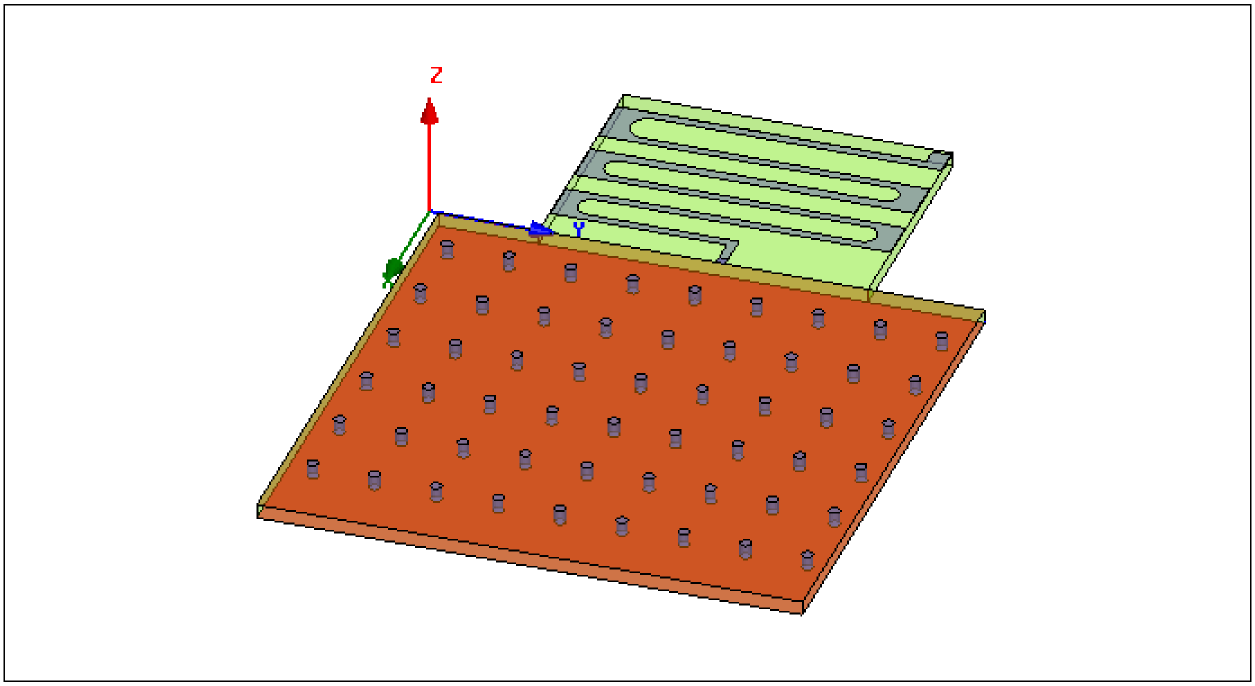


FIGURE 2-12: SIMULATED 2D RADIATION PATTERN

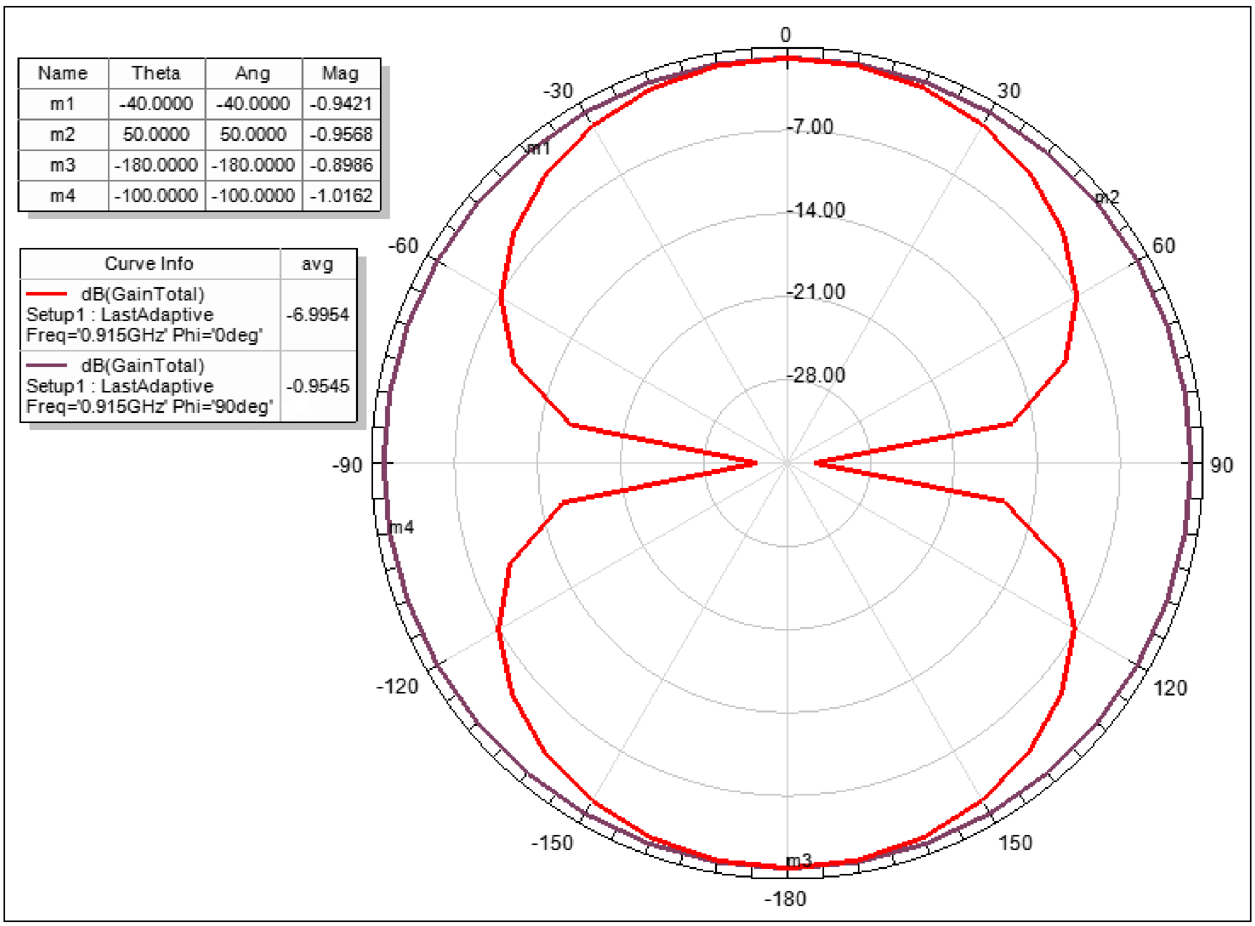


FIGURE 2-13: SIMULATED 3D RADIATION PATTERN

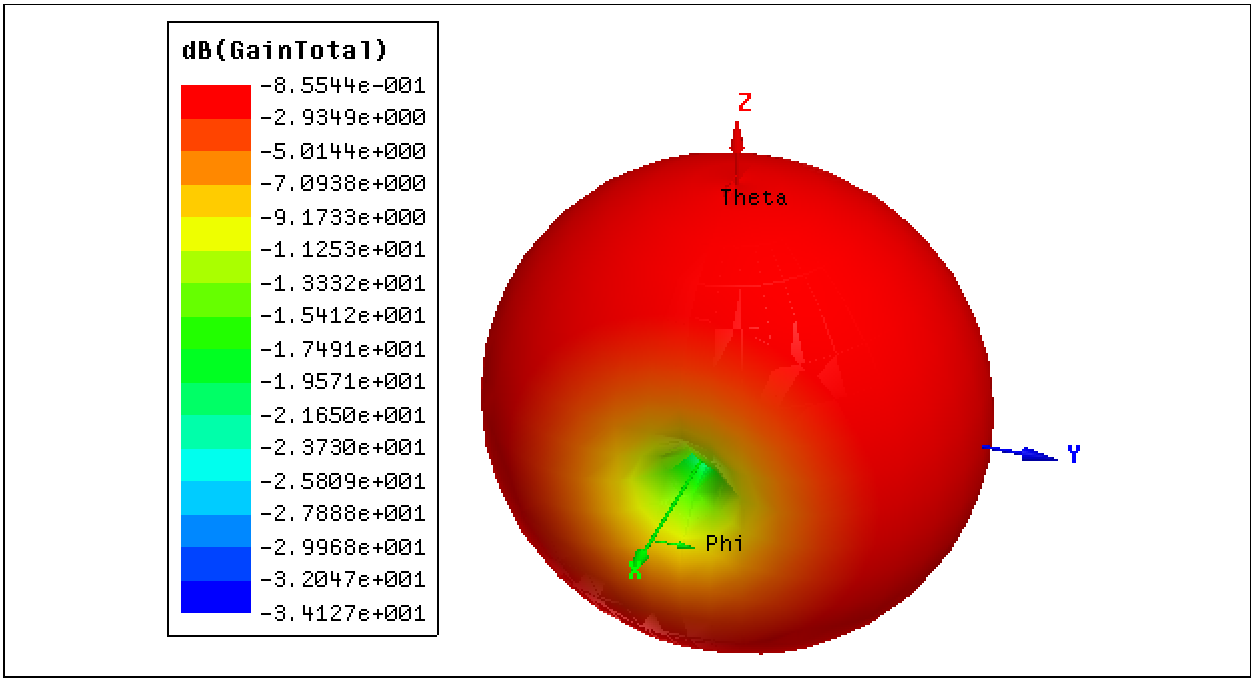


FIGURE 2-14: SIMULATED PCB ANTENNA IMPEDANCE

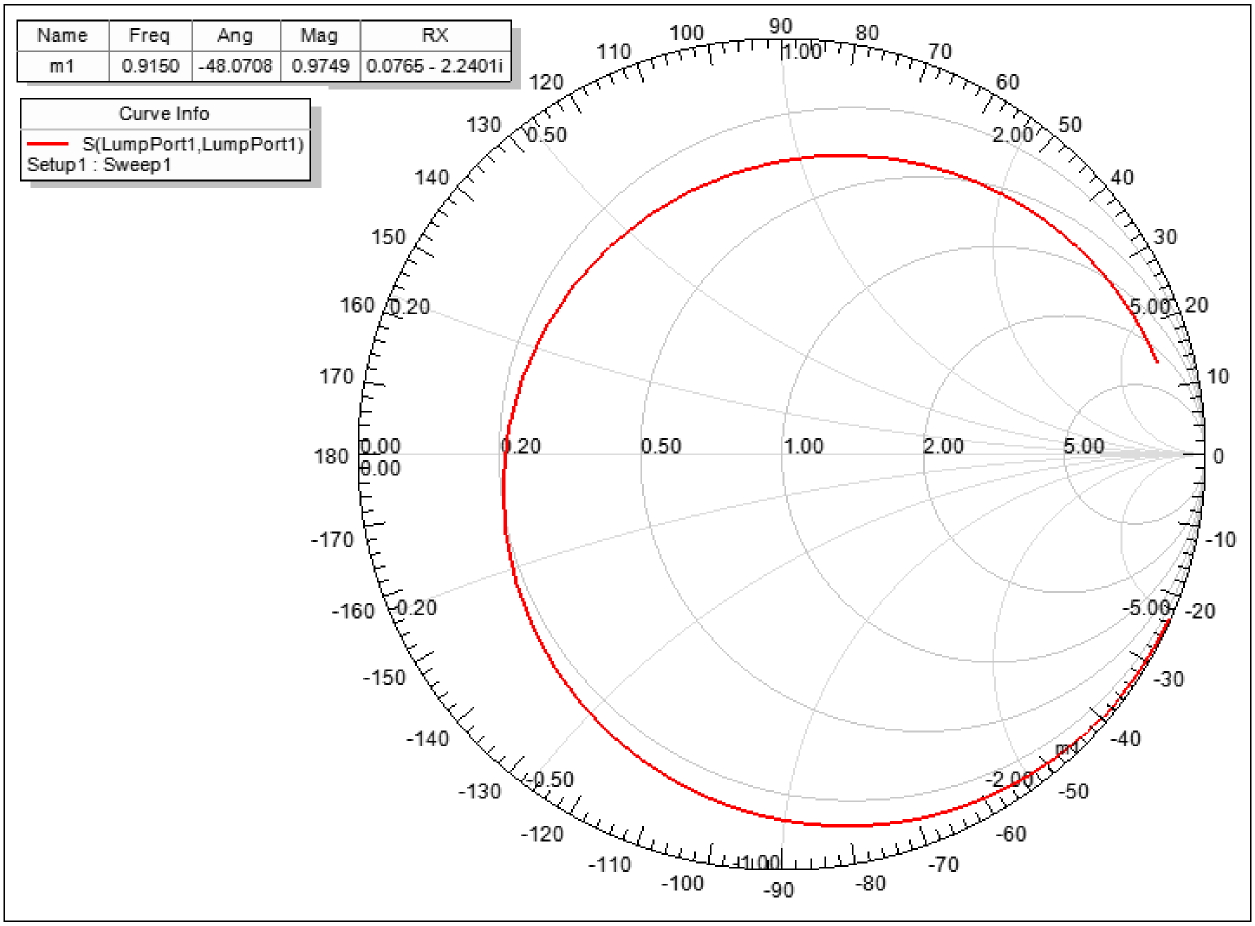
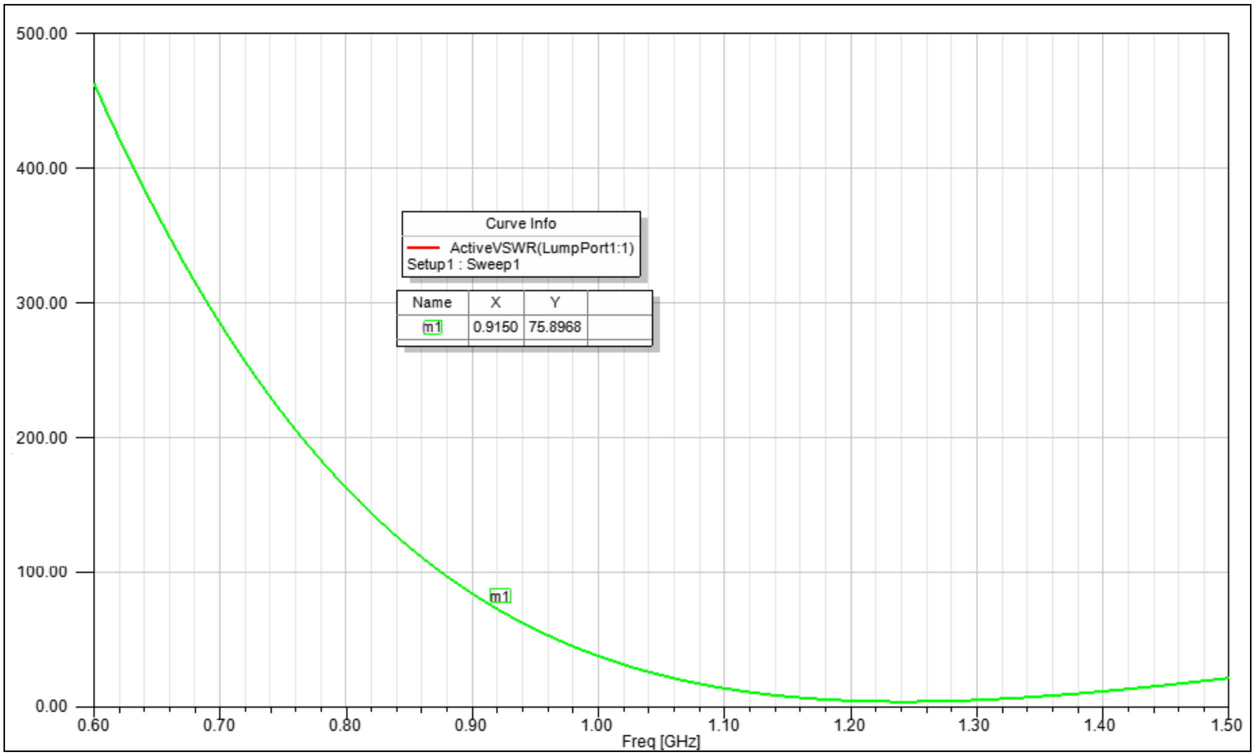


FIGURE 2-15: SIMULATED PCB ANTENNA VSWR



NOTES:

3.0 REGULATORY APPROVAL

3.1 Europe

The MRF89XAM8A modules are Radio Equipment Directive (RED) assessed, CE marked and are manufactured and tested with the intention of being integrated into a final product.

The MRF89XAM8A modules are tested to the RED 2014/53/EU Essential Requirements mentioned in the following European Compliance table.

TABLE 3-1: EUROPEAN COMPLIANCE

Certification	Standards	Article
Safety	EN 62368	3.1a
Health	EN 62311	
Electro Magnetic Compatibility (EMC)	EN 301 489-1	3.1b
	EN 301 489-3	
Radio	EN 300 220-1	3.2
	EN 300 220-2	

The ETSI provides guidance on modular devices in “Guide to the application of harmonized standards covering Article 3.1(b) and Article 3.2 of the Directive 2014/53/EU RED to multi-radio and combined radio and non-radio equipment” document available at http://www.etsi.org/deliver/etsi_eg/203300_203399/203367/01.01.01_60/eg_203367v010101p.pdf

Note:	To maintain conformance to the testing listed in Table 3-1, the module must be installed in accordance with the installation instructions in this data sheet and shall not be modified. When integrating a radio module into a completed product the integrator becomes the manufacturer of the final product and is therefore responsible for demonstrating compliance of the final product with the essential requirements against RED.

3.1.1 LABELING AND USER INFORMATION REQUIREMENTS

The label on the final product that contains the MRF89XAM8A modules must follow CE marking requirements.

3.1.2 CONFORMITY ASSESSMENT

From ETSI Guidance Note EG 203367, section 6.1

Non-radio products are combined with a radio product:

If the manufacturer of the combined equipment installs the radio product in a host non-radio product in equivalent assessment conditions (i.e. host equivalent to the one used for the assessment of the radio product) an d according to the installation instructions for the radio product, then no additional assessment of the combined equipment against article 3.2 of the RED is required.

3.1.2.1 SIMPLIFIED EU DECLARATION OF CONFORMITY

Hereby, Microchip Technology Inc. declares that the radio equipment type MRF89XAM8A is in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity, for this product, is available at:

https://www.microchip.com/wwwproducts/en/MRF89XAM8A

(available under Documents > Certifications)

3.1.3 APPROVED ANTENNAS

For MRF89XAM8A, the approval is received using the integral PCB antenna.

3.1.4 HELPFUL WEB SITES

A 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, which can be downloaded from the European Communications Committee (ECC) at: http://www.ecodocdb.dk/

Additional helpful web sites are:

- Radio Equipment Directive (2014/53/EU): https://ec.europa.eu/growth/single-market/euro
- European Conference of Postal and Telecommunications Administrations (CEPT): http://www.cept.org
- European Telecommunications Standards Institute (ETSI): http://www.etsi.org
- The Radio Equipment Directive Compliance Association (REDCA): http://www.redca.eu/

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	— —	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.

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.

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.

APPENDIX A: REVISION HISTORY

Revision B (April 2021)

Updated **Section 3.1 “Europe”**

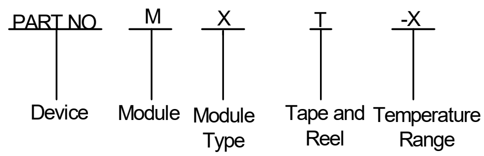
Revision A (October 2010)

This is the Initial release of the document

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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



Device	MRF89XAM8A-I/RM: Ultra Low-Power, Integrated ISM Band Sub-GHz Transceiver module
Temperature Range	I = -40ºC to +85ºC (Industrial)

Example:

a) MRF89XAM8A-I/RM: Industrial temperature tray.

b) MRF89XAM8AT-I/RM: Industrial temperature tape and reel,

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