MRF24WG0MA/MB

MRF24WG0MA/MB Data Sheet
2.4 GHz IEEE 802.11b/g™

Features:

- IEEE 802.11-compliant RF transceiver
- Serialized unique MAC address
- Data rate: 1 to 11 Mbps for 802.11b / 6 to 54 Mbps for 802.11g
- Compatible with IEEE 802.11b/g/n networks
- Small size: 21 mm x 31 mm 36-pin Surface Mount module
- Integrated PCB antenna (MRF24WG0MA)
- External antenna option (MRF24WG0MB) with ultra-miniature coaxial (U.FL) connector
- Easy integration into final product – accelerates product development, provides quicker time to market
- Radio regulation certification for United States (FCC), Canada (IC), and Europe (ETSI)
- Designed for use with Microchip microcontroller families (PIC18, PIC24, dsPIC33, and PIC32) with downloadable Microchip TCP/IP Stack

Operational:

- Single operating voltage: 2.8V to 3.6V (3.3V typical)
- Temperature range: -40°C to +85°C
- Simple, four-wire SPI interface with interrupt
- Low-current consumption:
  - RX mode – 95 mA (typical)
  - TX mode – 240 mA (+18 dBm typical)
  - PS mode – 4 mA (typical)
  - Hibernate mode – 0.1 mA (typical)

RF/Analog Features:

- ISM Band 2.400 to 2.484 GHz operation
- 14 Channels selectable individually or domain-restricted
- DSSS/OFDM modulation
- Application throughput: 4500 kbps
- -95 dBm Typical sensitivity at 1 Mbps
- +18 dBm Typical 802.11b TX power with control
- +16 dBm Typical 802.11g TX power with control
- Integrated low phase noise VCO, RF frequency synthesizer, PLL loop filter and PA
- Integrated RSSI ADC and I/Q DACs, RSSI readings available to host
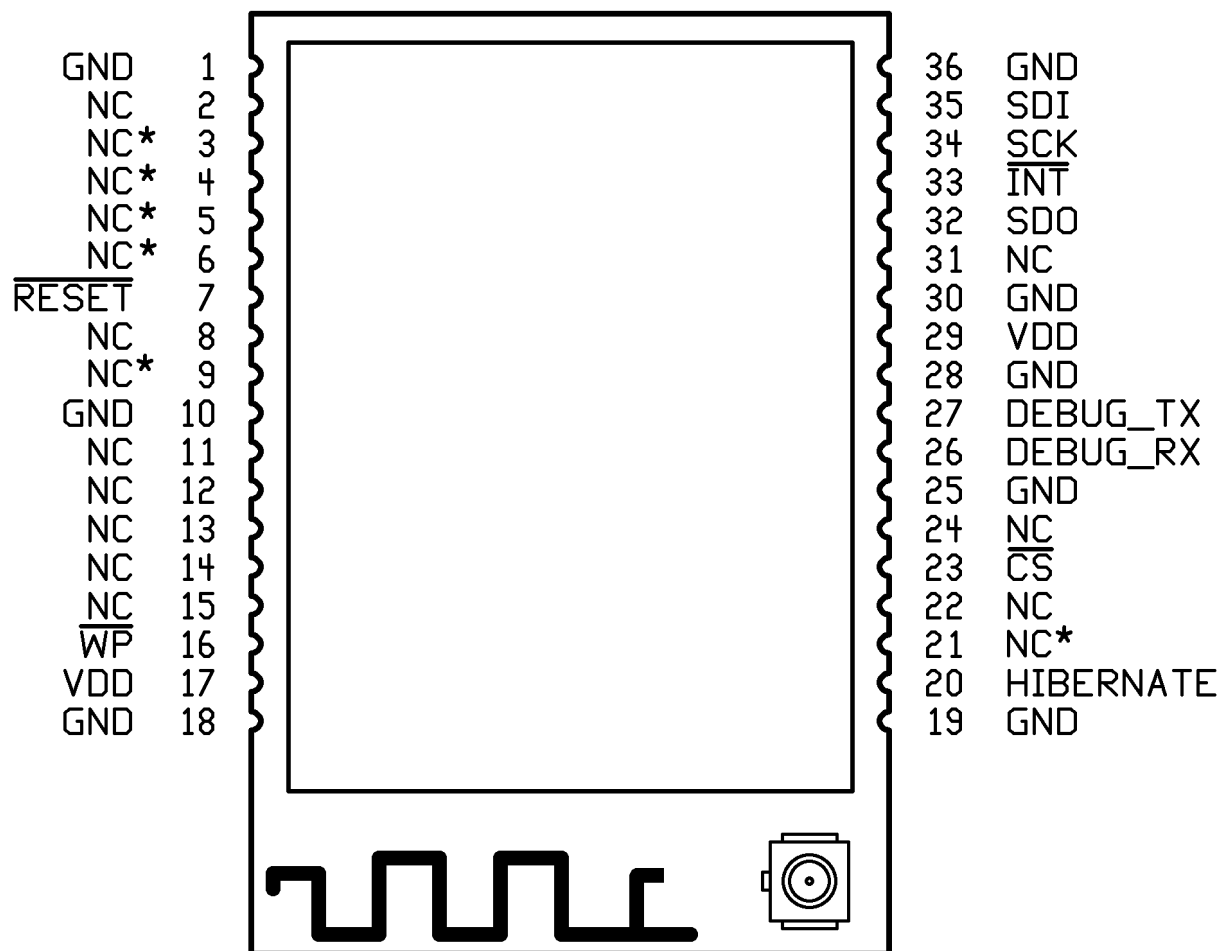
MAC/Baseband Features:

- Hardware CSMA/CA access control, automatic ACK, and FCS creation and checking
- Automatic MAC packet retransmit
- Hardware Security Engine for AES and RC4-based ciphers
- Supports 802.1x, 802.1i security: WEP, WPA-PSK, and WPA-2-PSK.

Applications:

- Utility and Smart Energy:
  - Thermostats
  - Smart Meters
  - White Goods
  - HVAC
- Consumer Electronics:
  - Remote Control
  - Internet Radio
  - Home Security
  - Toys
- Industrial Controls:
  - Chemical Sensors
  - HVAC
  - Security Systems
  - M2M Communication
- Remote Device Management:
  - Location and Asset Tracking
  - Automotive
  - Code Update
- Retail:
  - POS Terminals
  - Wireless Price Tags
  - Digital Remote
- Medical, Fitness, and Health Care:
  - Glucose Meters
  - Fitness Equipment
  - Patient Asset Tracking

MRF24WG0MA/MB

Pin Diagram

GND	1			36	GND
NC	2			35	SDI
NC*	3			34	SCK
NC*	4			33	$\overline{\text{INT}}$
NC*	5			32	SDO
NC*	6			31	NC
$\overline{\text{RESET}}$	7			30	GND
NC	8			29	VDD
NC*	9			28	GND
GND	10			27	DEBUG_TX
NC	11			26	DEBUG_RX
NC	12			25	GND
NC	13			24	NC
NC	14			23	$\overline{\text{CS}}$
NC	15			22	NC
$\overline{\text{WP}}$	16			21	NC*
VDD	17			20	HIBERNATE
GND	18			19	GND

Note: Antenna connector on MRF24WG0MB only.

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NOTES:

1.0 DEVICE OVERVIEW

The MRF24WG0MA and MRF24WG0MB are low-power, 2.4 GHz, IEEE 802.11-compliant, surface mount modules with all associated RF components – crystal oscillator, bypass and bias passives with integrated MAC, baseband, RF and power amplifier, and built-in hardware support for AES, and TKIP (WEP, WPA, WPA2 security). The modules also provide acceleration for hosts running WPA-EAP application security. The integrated module design frees the designer from RF and antenna design tasks and regulatory compliance testing, ultimately providing quicker time to market.

The MRF24WG0MA module is approved for use with the integrated PCB meander antenna.

The MRF24WG0MB module comes with an ultra-miniature coaxial connector (U.FL) and is approved for use with a list of antenna types that are certified with the module. See **Section 2.7 "External Antenna"** for specific recommendations.

The MRF24WG0MA/MB modules are designed to be used with Microchip's TCP/IP software stack. The software stack has an integrated driver that implements the API that is used in the modules for command and control, and for management and data packet traffic.

The Microchip TCP/IP software stack is available in the free *Microchip Application Libraries* download (including example applications and source code) from the Microchip web site, http://www.microchip.com/wireless.

The combination of the module and a PIC running the TCP/IP stack results in support for IEEE Standard 802.11 and IP services. For example, this allows the immediate implementation of a wireless web server and e-mail clients.

The MRF24WG0MA/MB modules have received regulatory approvals for modular devices in the United States (FCC), Canada (IC), and Europe (ETSI). The modular approval removes the need for expensive RF and antenna design, and allows the end user to place the modules inside a finished product and not require regulatory testing for an intentional radiator (RF transmitter). See **Section 3.0 "Regulatory Approval"**, for the specific requirements that should be adhered to by the integrator.

1.1 Interface Description

The block diagram in Figure 1-1 represents a MRF24WG0MA/MB module. It interfaces to Microchip PIC18, PIC24, dsPIC33, or PIC32 microcontrollers through a four-wire serial slave SPI interface – interrupt, hibernate, reset, power and ground signals. The module runs on a single supply voltage of nominally 3.3V. The serial trace port operates at 3.3V and requires a level shifter for operation with RS-232 devices. This port provides a serial output of module status messages and is helpful for debugging purposes. Figure 1-2 shows a simplified example connection between a Microchip PIC MCU and the module. Table 1-1 lists the pin descriptions.

Data communications with the MRF24WG0MA/MB are through the SPI interface that is detailed in **Section 2.0 "Circuit Description"**. The Microchip PIC microcontroller communicates with the module through a command API from within the Microchip TCP/IP stack. The command API is detailed in the Microchip TCP/IP stack online Help that is included in the free *Microchip Application Libraries* download.

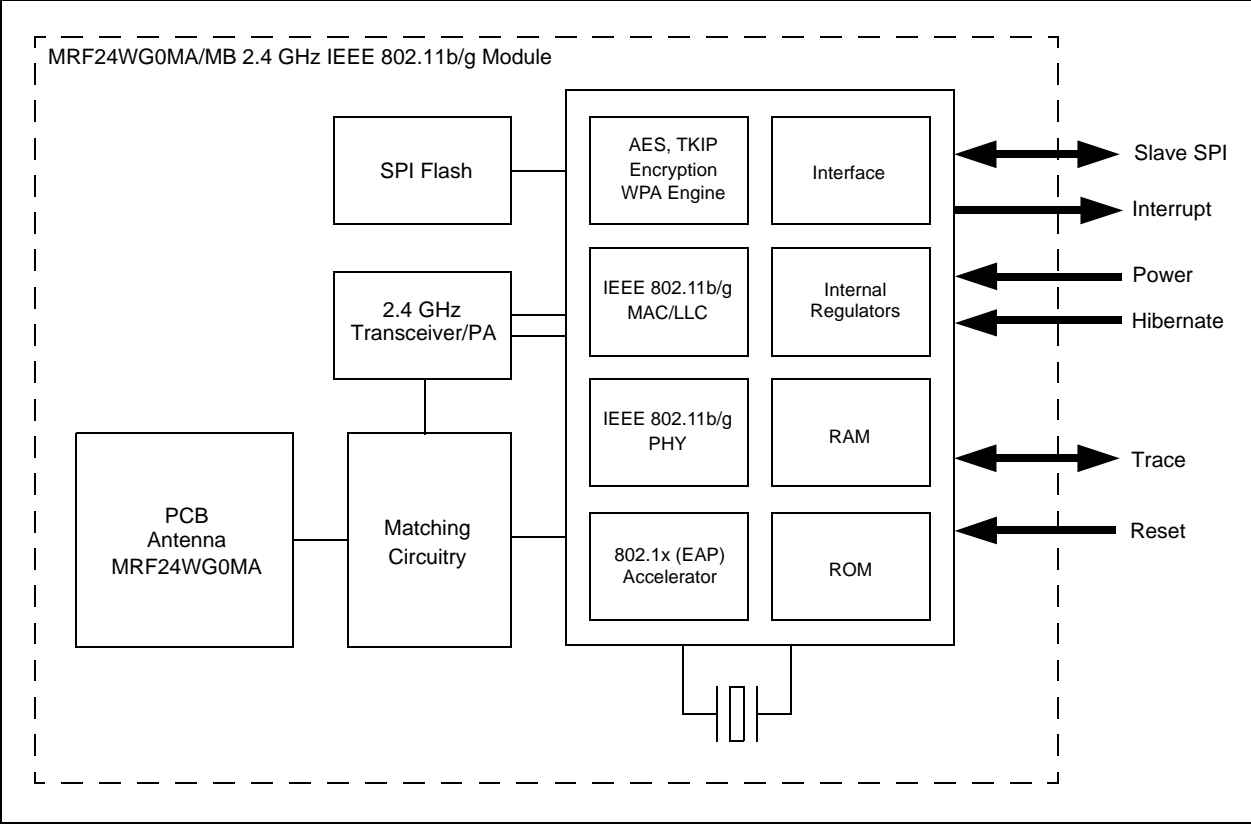# MRF24WG0MA/MB

FIGURE 1-1: **MRF24WG0MA/MB BLOCK DIAGRAM**

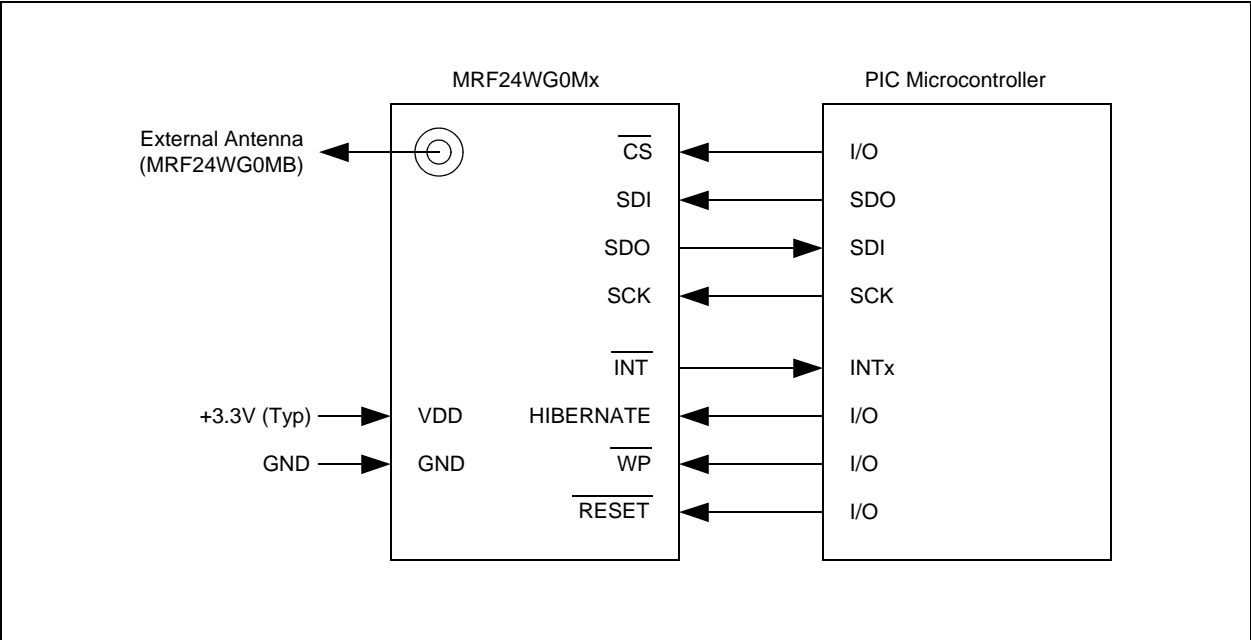
FIGURE 1-2: **MICROCONTROLLER TO MRF24WG0MA/MB INTERFACE**

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TABLE 1-1: Pin Description

Pin	Symbol	Type	Description
1	GND	P	Ground
2	NC*	NC*	No connect[3]
3	NC*	NC*	No connect[3]
4	NC*	NC*	No connect[3]
5	NC*	NC*	No connect[3]
6	NC*	NC*	No connect[3]
7	$\overline{\text{RESET}}$	I: Constant[1]	Module Reset input
8	NC	NC	Do not connect
9	NC*	NC*	No connect[3]
10	GND	P	Ground
11	NC	NC	Do not connect
12	NC	NC	Do not connect
13	NC	NC	Do not connect
14	NC	NC	Do not connect
15	NC	NC	Do not connect
16	$\overline{\text{WP}}$[2]	I	Write protect (this pin is used to enable FLASH update)
17	V_{DD}	P	Power
18	GND	P	Ground
19	GND	P	Ground
20	HIBERNATE	I	Hibernate mode enable (high input will disable the module)
21	NC*	NC*	No connect[3]
22	NC	NC	Do not connect
23	$\overline{\text{CS}}$	I: Constant[1]	SPI Chip Select input, constant drive or pull-up required
24	NC	NC	Do not connect
25	GND	P	Ground
26	DEBUG$_{RX}$	I	Serial debug port input (see **Section 2.0 "Circuit Description"**)
27	DEBUG$_{TX}$	O	Serial debug port output (see **Section 2.0 "Circuit Description"**)
28	GND	P	Ground
29	V_{DD}	P	Power
30	GND	P	Ground
31	NC	NC	Do not connect
32	SDO	O	SPI data out
33	$\overline{\text{INT}}$	O	Interrupt output (open drain – requires a pull-up)
34	SCK	I	SPI clock input
35	SDI	I	SPI data in
36	GND	P	Ground

Legend: Pin type abbreviation: P = Power Input, I = Input, O = Output, NC = Do Not Connect, NC* = No Connect

Note 1: Signals of Type "I: Constant" must either be constantly driven by the host or have a pull-up or pull-down (in case the host is likely to tri-state the signal during power down modes). The constant drive is used to ensure defined operation of the part and to minimize leakage current during low power modes.

2: $\overline{\text{WP}}$ is used as write-protect for the internal module SPI Flash. For production use, this pin should be pulled low. This pin can be controlled by the host microcontroller to enable in field Flash updates.

3: Signals of Type "NC*" were JTAG function pins on previous family devices. Signals on these pins will have no functional affect and will not impact the operation of this device.

1.2 Mounting Details

The MRF24WG0MA/MB is a surface mountable module. Module dimensions are shown in Figure 1-3. The module Printed Circuit Board (PCB) is 1 mm thick with castellated mounting points on two sides.

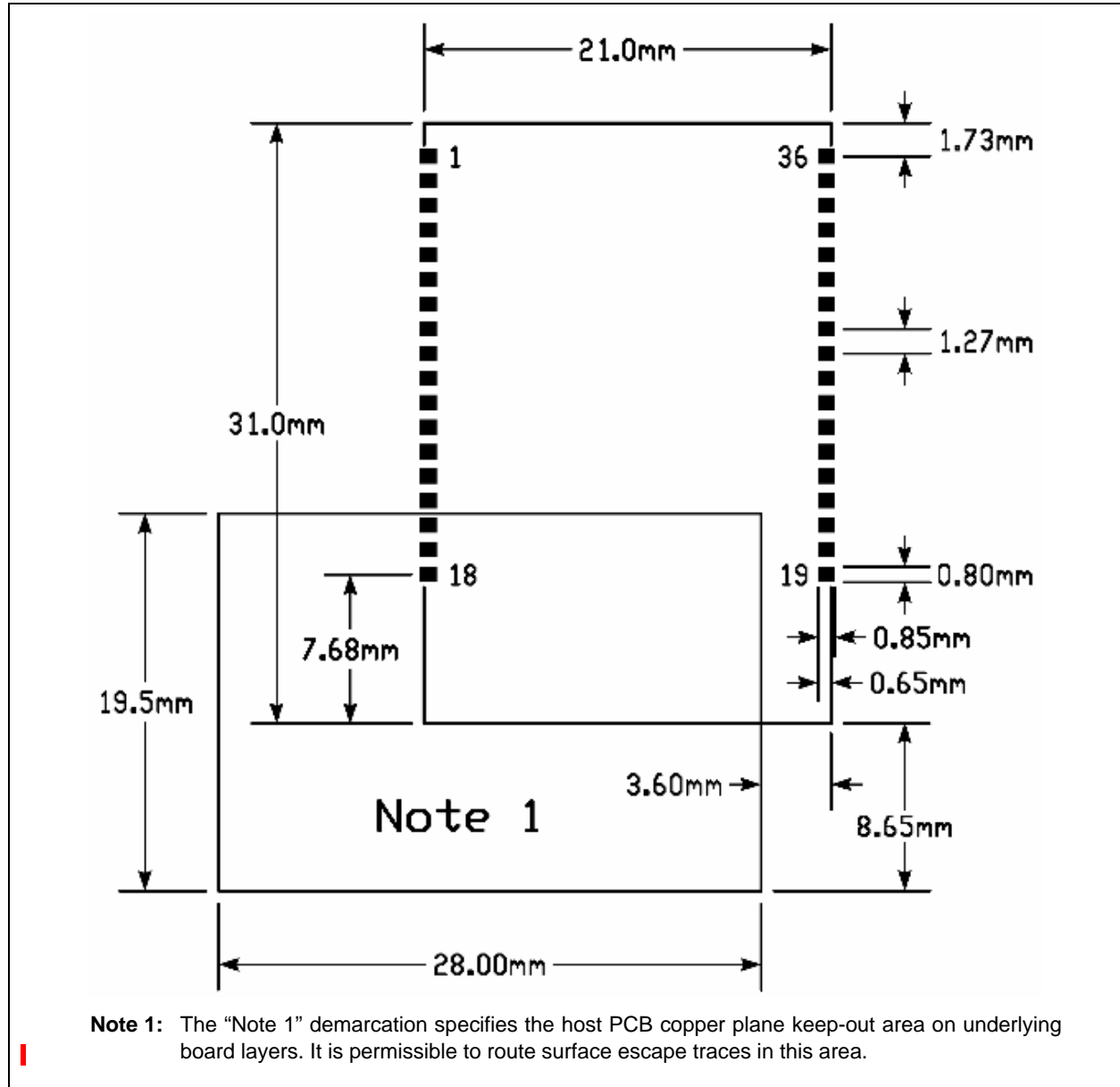**FIGURE 1-3:** **MRF24WG0MA/MB MODULE PHYSICAL DIMENSIONS**
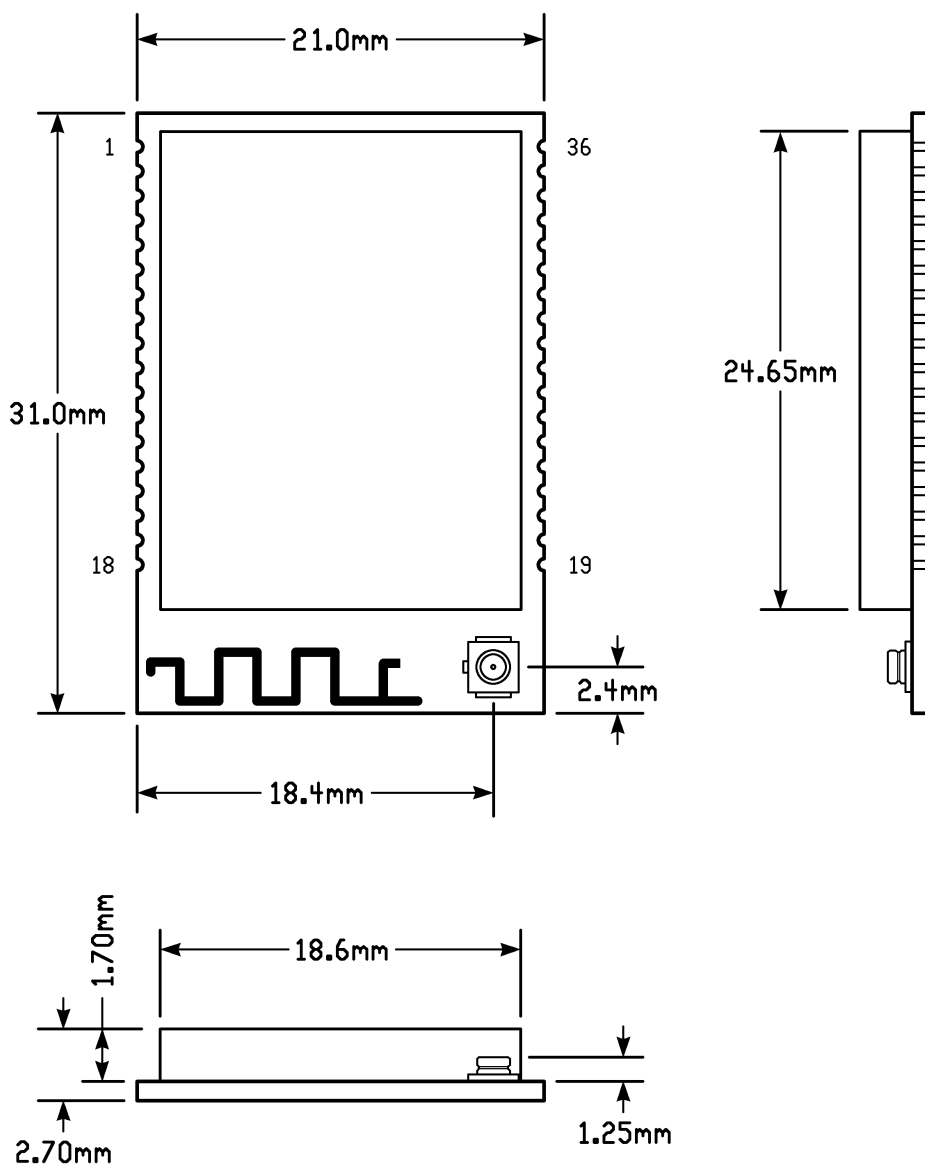
Note: Antenna connector on MRF24WG0MB only.

Figure 1-4 shows the recommended host PCB footprint for the module.

The MRF24WG0MA has an integrated PCB antenna. For best performance, follow the mounting details shown in Figure 1-4.

For best performance, mount the module on the PCB without metal obstructions in the keep out area of Figure 1-4. The antenna is tuned to have FR4 PCB material underneath the module. Do not "cut-out" host PCB material under the antenna.

FIGURE 1-4:   RECOMMENDED HOST PCB FOOTPRINT

Note 1: The "Note 1" demarcation specifies the host PCB copper plane keep-out area on underlying board layers. It is permissible to route surface escape traces in this area.

MRF24WG0MA/MB

Figure 1-5 illustrates the module reflow profile that is recommended for mounting the device onto the host PCB.

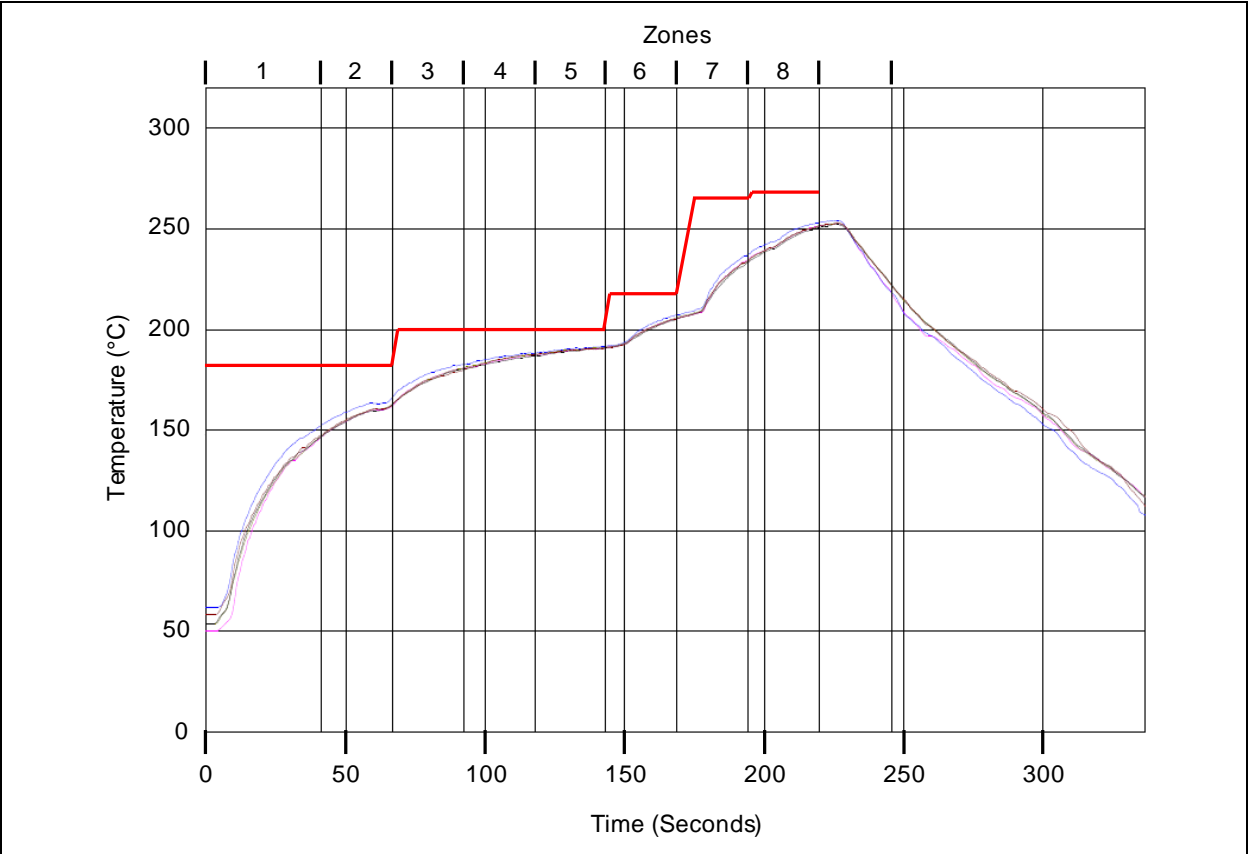**FIGURE 1-5:** **PRELIMINARY MODULE REFLOW PROFILE AND SETPOINTS**

TABLE 1-2: **MODULE REFLOW PROFILE[1]**

Zone	1	2	3	4	5	6	7	8
Temperature (°C)	180°	180°	200°	200°	200°	220°	265°	270°

Note 1: Conveyor Speed: 90 cm/min

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2.0   CIRCUIT DESCRIPTION

The MRF24WG0MA/MB interfaces to Microchip PIC18, PIC24, dsPIC33, and PIC32 microprocessors with a minimal of external components through digital-only connections. This section details use of the module, starting with an example host connection as shown in Figure 2-1.

2.1   Schematic

FIGURE 2-1:   MRF24WG0MA/MB EXAMPLE APPLICATION SCHEMATIC
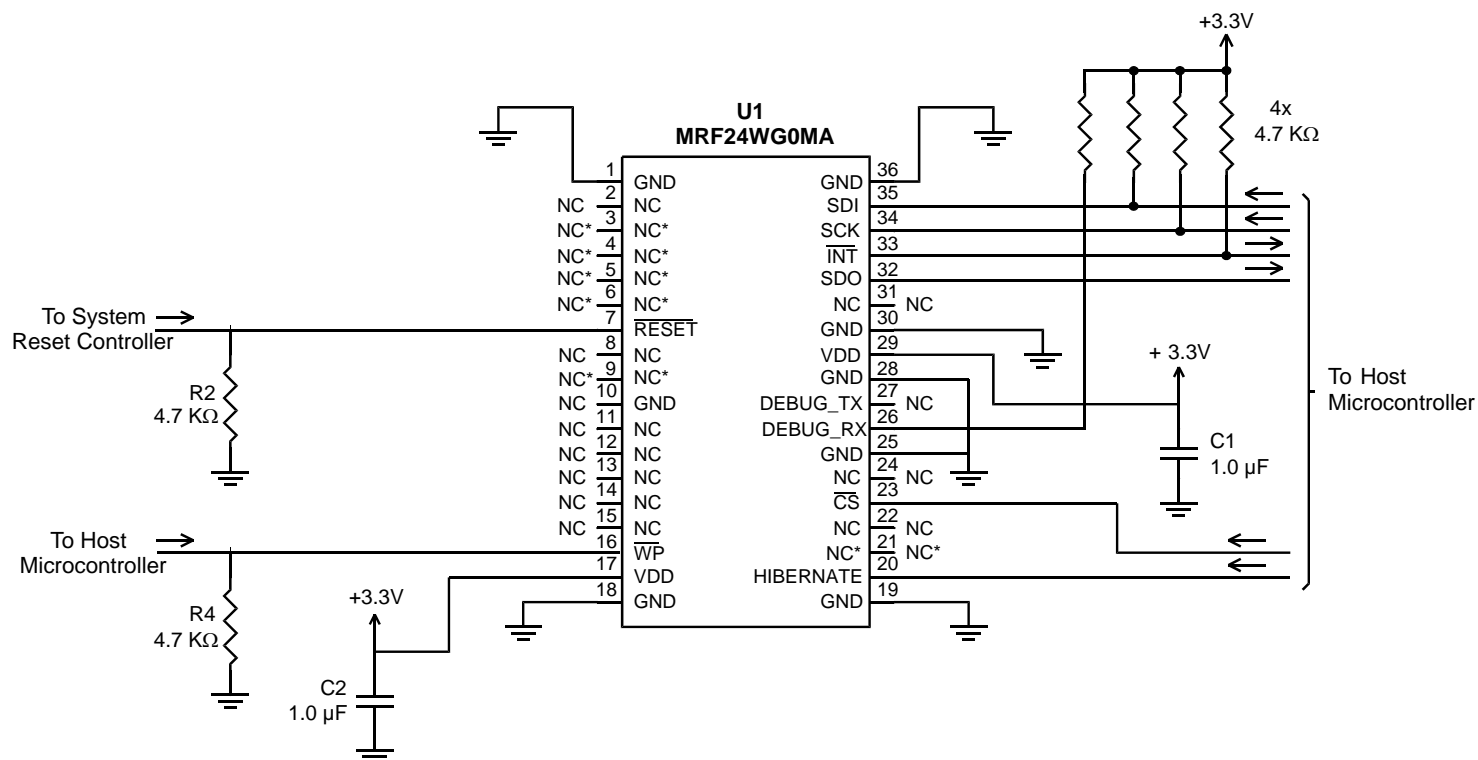
Note: The example application schematic is for suggested design purposes. Please refer to Table 1-1 in **Section 1.0 "Device Overview"** for the module pin descriptions.

MRF24WG0MA/MB

2.2   Power-On Sequence

The internal regulators for the digital and analog core power supplies are disabled by driving the HIBERNATE pin high. Figure 2-2 shows the power up sequence for the MRF24WG0MA/MB.

There is an internal Power-on-Reset (POR) circuit which keeps the module in reset until V_{DD} is within specification. The Hibernate and Reset signals are also used to control startup. In Figure 2-2, section A is controlled by the internal POR and section B is an allowance for the SPI bus to stabilize when the module supplies are enabled. Once Hibernate is disabled, the host software provides 1mS of startup to allow the SPI to stabilize. This time is pre-programmed into the host driver, and may need to be increased if sufficient initial drive current is not provided to the MRF24WG0MA/MB module. Section C is the driver controlled release from Reset period. This takes approximately 300 mS and is monitored by the stack driver. No additional time needs to be provided by user software for startup.

FIGURE 2-2:   MRF24WG0MA/MB POWER-ON SEQUENCE TIMING

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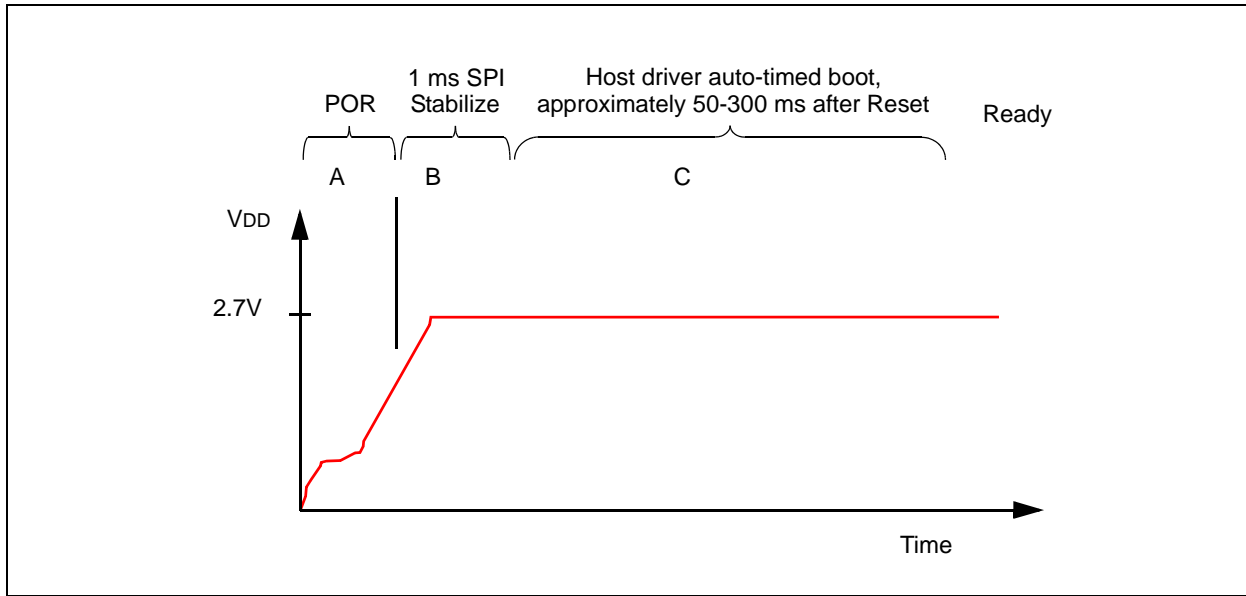
2.3 Power States

The MRF24WG0MA/MB has several power states. These are Hibernate, Sleep and Active (two sub-states), as shown in Figure 2-3. The selection of power state directly affects system behavior, and overall power consumption or battery life. There is also a "Stand-by" state that is not user-controlled.

2.3.1 HIBERNATE STATE

An "Off" state is defined as no power applied to the device. The Hibernate mode is the closest to controlled off that the module can approach. It is controlled through the HIBERNATE pin (high input puts the module into Hibernate). When in Hibernate, the module only consumes leakage current, but does not maintain state. Hibernate has to be fully controlled by the PIC MCU and requires the TCP/IP stack to restart on an awake.

The module contains about 70 µF of internal bulk capacitance. Supplies should be provisioned to supply sufficient charge on release of hibernate for desired start time or sufficient delay must be provided in software after hibernate release and before releasing reset.

This state provides the best battery life for embedded products. Entering Hibernate for intervals of less than 30 seconds is not likely to save power. Battery life expectation can be more than a year for devices operating on AA cells that would be in Hibernate except to wake up every hour for a small data transfer (<500 Bytes).

2.3.2 POWER SAVE (PS) MODE

The PS mode is a low-power dynamic state that automatically implements the 802.11 Power Save feature. In this mode, if enabled, the module will enter PS mode when all activity is complete.

The module will wake autonomously to any PIC intervention so it can check DTIM beacons from the Access Point. If any traffic is listed as queued for the module, then it will awaken and get the data from the Access Point on the next possible opportunity. When data is acquired, the module will interrupt the PIC microcontroller on a normal "data available" indication. If no data is available on a DTIM check, the module reenters the Power Save state until the next DTIM. The DTIM interval is programmed at the Access Point. This state can provide "as if on" behavior of the radio with a significant power savings versus "always on". The battery life expectation of this mode is several days to several weeks. This mode is characterized by a very low latency (as low as 200 ms) to begin data transfer from the state.

2.3.3 ACTIVE STATE

The Active state is identified as one of two states where the radio circuitry is fully on. The two active states are the Receive state (RX ON) and the Transmit state (TX ON).

2.3.4 STAND-BY STATE

The Stand-by state is not user-controlled but is noted as it helps identify and track certain operations of the module during power tracing.

TABLE 2-1: MRF24WG0MA/MB POWER STATE DEFINITIONS

State	V$_{DD}$	$\overline{CS}$	Description
Off	0V	0V	Power is completely disconnected
Hibernate	3.3V	3.3V	All internal power regulators are OFF – enabled by HIBERNATE pin
Power Save	3.3V	0V	Enabled by TCP/IP driver
RX ON	3.3V	0V	Receive circuits are on and receiving
TX ON	3.3V	0V	Transmit circuits are on and transmitting
Stand-by	3.3V	0V	State machine transition state only – not user controlled

FIGURE 2-3: **MRF24WG0MA/MB POWER-STATE DIAGRAM**
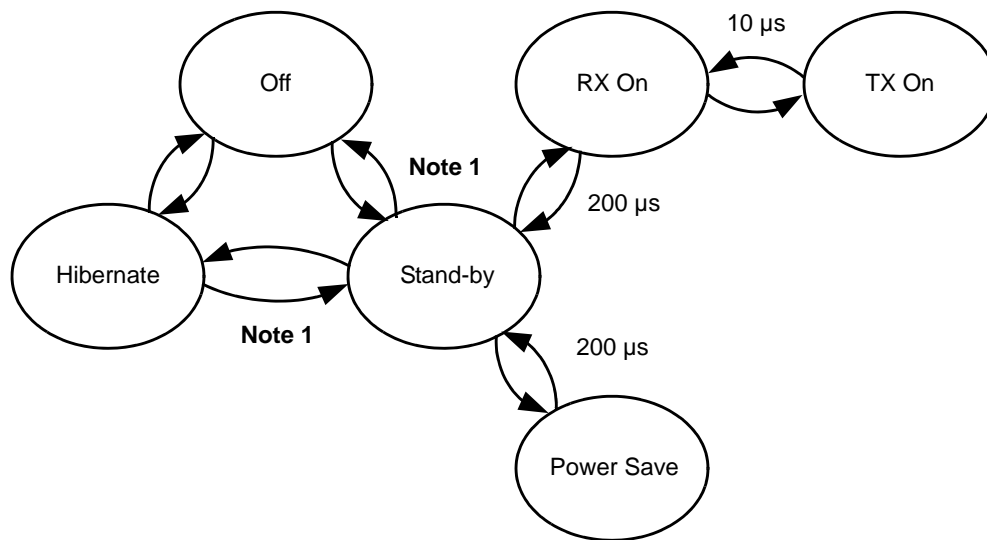
Note 1: See **Section 2.2 "Power-On Sequence"**.

2.4   Serial Trace Port Interface

The MRF24WG0MA/MB incorporates a Transmit Data pin (DEBUGTX) and a Receive Data pin (DEBUGRX) for serial debugging purposes. These pins can be connected to commercially available RS-232 line drivers/receivers with appropriate external level shifters. The serial interface operates at 19200, 8, N, 1, N.

2.5   SPI Interface

The slave Serial Peripheral Interface (SPI) is used to interface with the host PIC microcontroller. The slave SPI interface works with the Interrupt line ($\overline{INT}$). When data is available for the PIC microcontroller during operation, the $\overline{INT}$ line is asserted (logic low) by the MRF24WG0MA/MB module. The $\overline{INT}$ line is de-asserted (logic high) by the MRF24WG0MA/MB after the data is transferred to the host PIC microcontroller. The SPI SCK frequency can be up to 25 MHz.

The slave SPI interface implements the [CPOL = 0; CPHA = 0] and [CPOL = 1; CPHA = 1] modes (0 and 3) of operation. That is, data is clocked in on the first rising edge of the clock after Chip Select ($\overline{CS}$) is asserted.

Data is placed on the bus with most significant bit (MSb) first.

The $\overline{CS}$ pin must be toggled with transfer blocks and cannot be held low permanently. The falling edge of $\overline{CS}$ is used to indicate the start of a transfer. The rising edge of $\overline{CS}$ is used to indicate the completion of a transfer.

Figure 4-1 in **Section 4.0 "Electrical Characteristics"** shows the SPI timing diagram. Table 4-7 details the SPI timing AC characteristics.

2.6   PCB Antenna

For the MRF24WG0MA, the PCB antenna is fabricated on the top copper layer and covered in solder mask. The layers below the antenna have no copper trace.

It is recommended that the module be mounted on the edge of the host PCB. It is permitted for PCB material to be below the antenna structure of the module as long as no copper traces or planes are on the host PCB in that area. For best performance, place the module on the host PCB according to the details shown in Figure 1-4 in **Section 1.0 "Device Overview"**.

The antenna patterns shown in the following plots are simulated results of the PCB antenna. Figure 2-4 illustrates the simulation drawing and Figure 2-5 and Figure 2-6 illustrate the two-dimensional (2D) and three-dimensional (3D) radiation patterns.

The calculated average of the radiated field is shown in Figure 2-5, highlighted in yellow. The radiation pattern for the XZ plane is shown in red, and the YZ plane is shown in black. As shown, the most powerful radiation occurs in the XY plane (the red pattern).

Figure 2-6 shows the relative position of the 3D radiation "donut" with reference to the module orientation. This is a very useful guide for placement of the module to obtain the maximum range.

Figure 2-7 shows the 3D radiation pattern with the colored distribution of the radiation magnitude. The values range from -9 dB to +0.3 dB. This is very useful in interpreting the 2D radiation pattern.
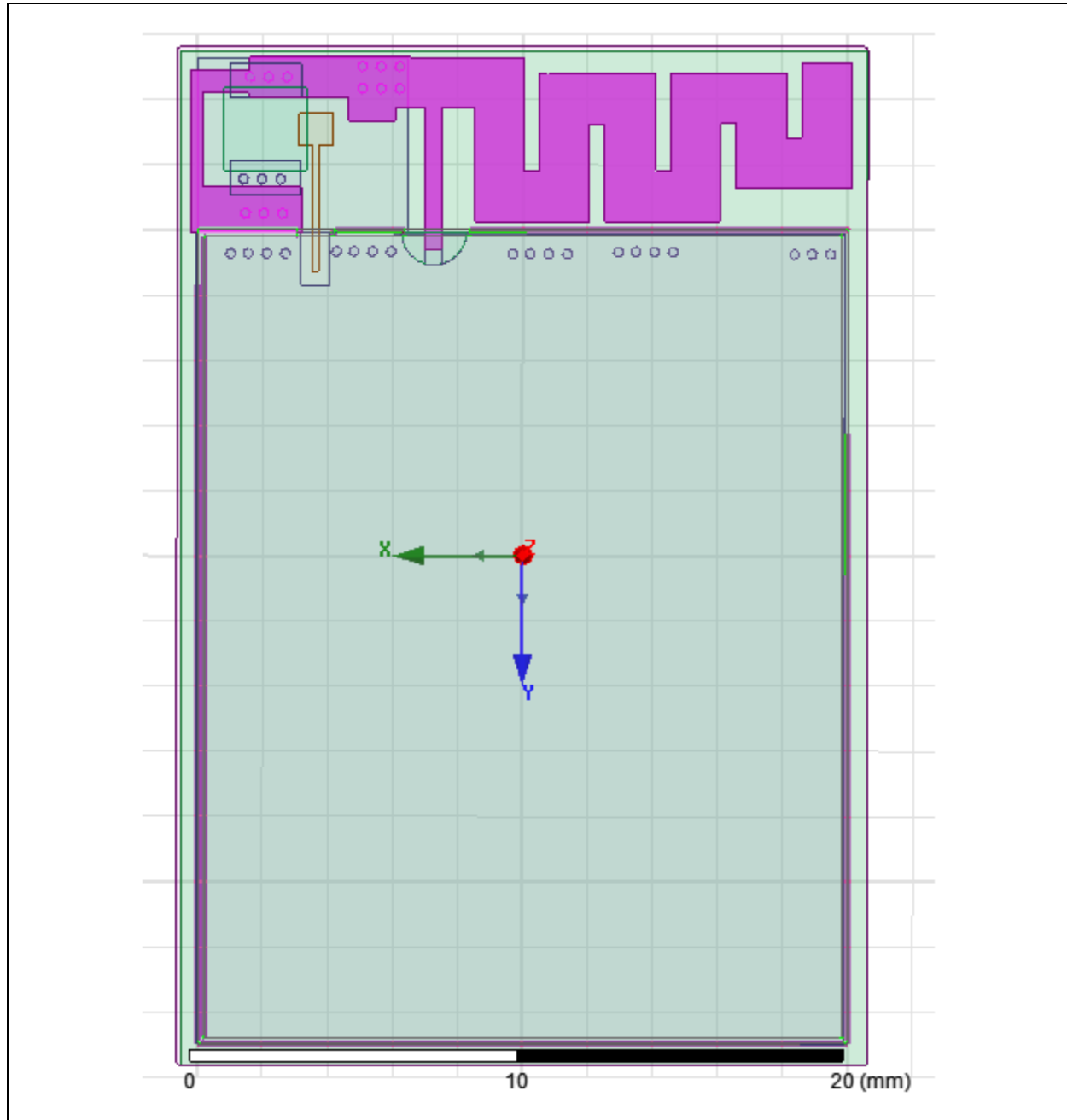
FIGURE 2-4: PCB ANTENNA SIMULATION DRAWING

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FIGURE 2-5: SIMULATED TWO-DIMENSIONAL RADIATION PATTERN

Name	Theta	Angle	Mag.
m1	-60.0000	-60.0000	0.6323
m2	-20.0000	-20.0000	0.3962
m3	30.0000	30.0000	-0.1038
m4	100.0000	100.0000	-0.9490
m5	170.0000	170.0000	-0.1414

	Curve Information	Average
——	db(GainTotal) Setup 1: LastAdaptive Freq. = "2.44 GHZ" Phi = "0 deg"	0.0097
——	dB(GainTotal) Setup 2: LastAdaptive Freq. = "2.44 GHz" Phi = "0 deg"	-3.2020

Radiation Pattern 1
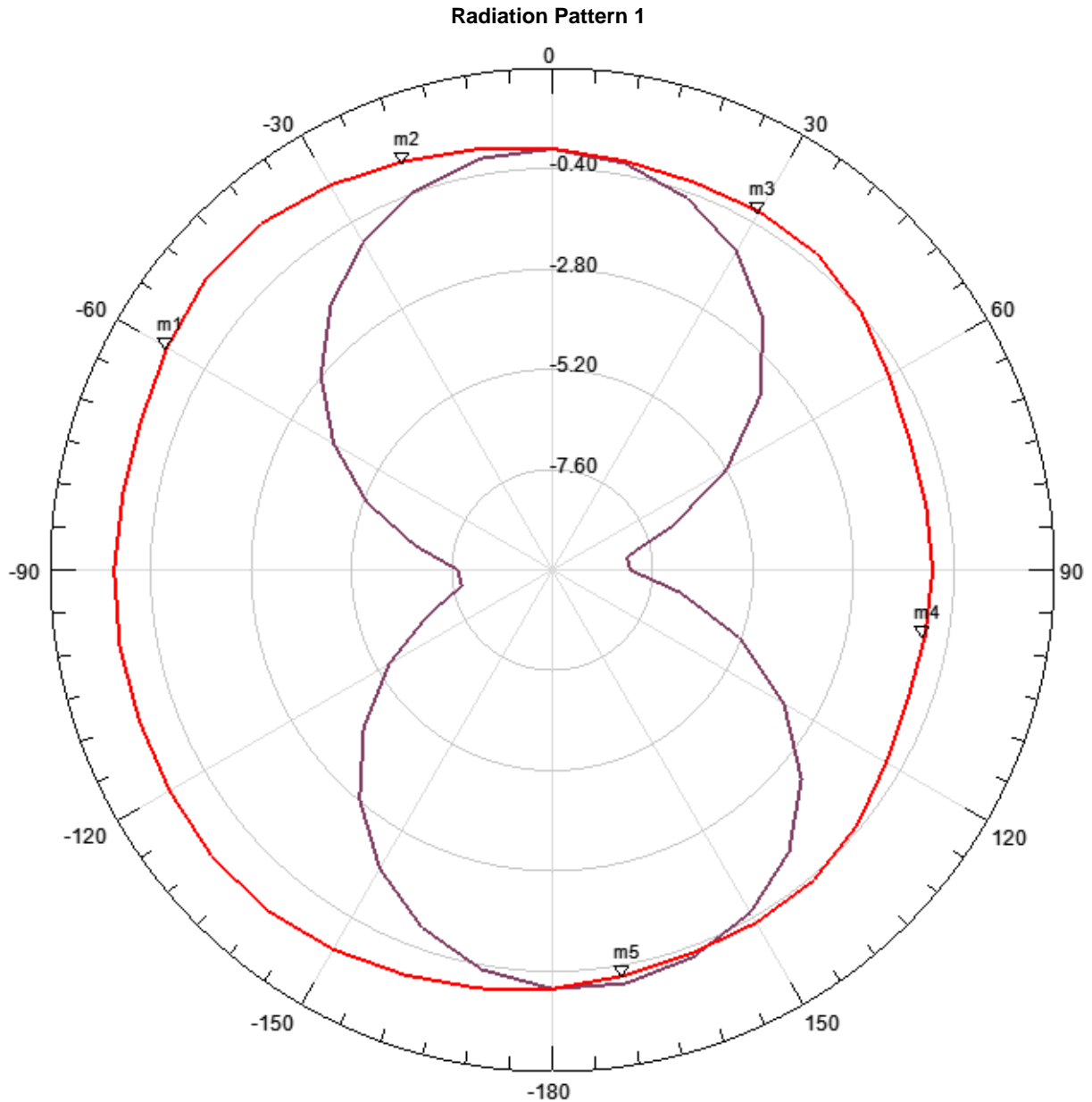
Two-dimensional (2D) pattern, including the average on main radiation planes (Phi = 0 and 90 degrees).

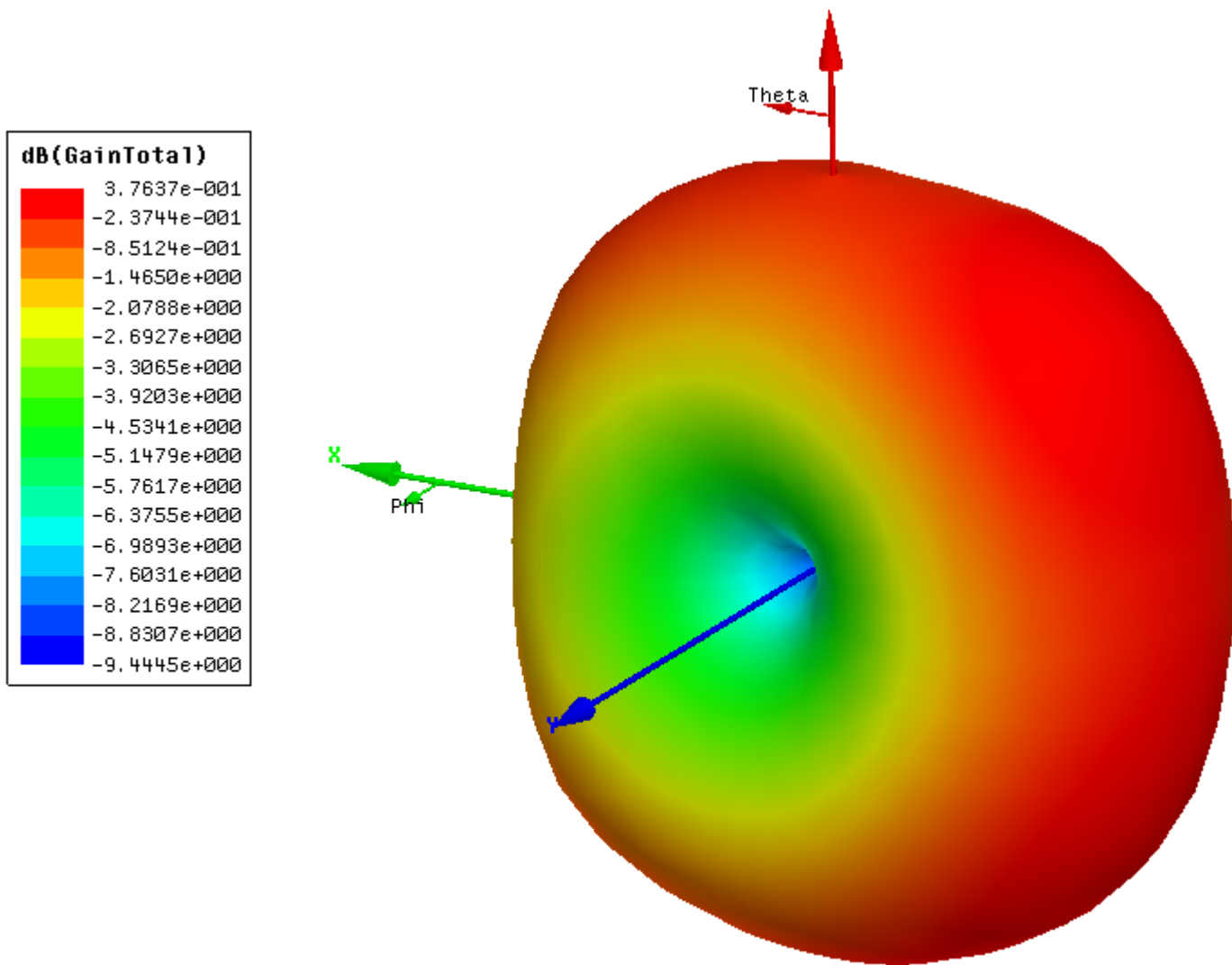**FIGURE 2-6:**   **SIMULATED THREE-DIMENSIONAL RADIATION PATTERN**

Radiation pattern against the module dimensions
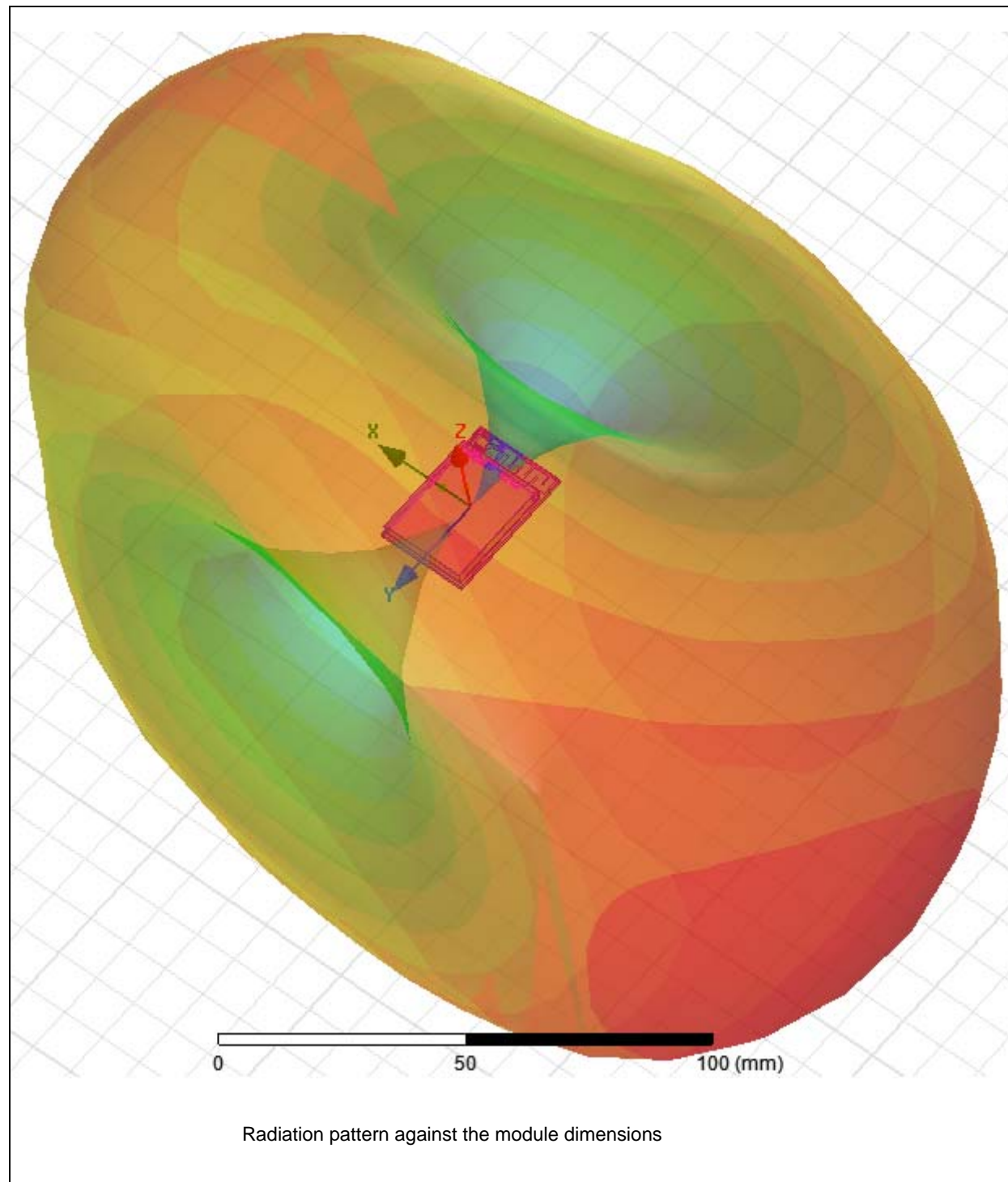
FIGURE 2-7: SIMULATED THREE-DIMENSIONAL RADIATION PATTERN

MRF24WG0MA/MB

Three-dimensional (3D) pattern and magnitude distribution

2.7 External Antenna

The MRF24WG0MB module has a 50Ω ultra-miniature coaxial (U.FL) connector to connect to an external 2.4 GHz antenna.

> **Caution:** The U.FL connector is fragile and can only tolerate a very limited number of insertions.

The choice of antenna is limited to the antenna types the module has been tested with. Refer to the respective country in **Section 3.0 "Regulatory Approval"** for a list of tested and approved antenna types that may be used with the MRF24WG0MB module.

A list of antennas approved for use with the module is provided in Table 2-2.

TABLE 2-2: APPROVED EXTERNAL ANTENNA TYPES

Type	Manufacturer	Part Number	Gain
Dipole	Aristotle	RFA-02-C2M2-D034	2 dBi
PCB	Aristotle	RFA-02-P33-D034	1 dBi
PCB	Aristotle	RFA-02-P05-D034	2 dBi
PIFA	Aristotle	RFA-02-G03-D034	0 dBi

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3.0 REGULATORY APPROVAL

The MRF24WG0MA/MB module has received regulatory approvals for modular devices in the United States and Canada. Modular approval allows the end user to place the MRF24WG0MA/MB 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 MRF24WG0MA/MB module has been tested and conforms to EN 300 328 V1.7.1 (2006-10), European Standards. The module tests can be applied toward final product certification and Declaration of Conformity (DoC). Additional testing may be required depending on the end application.

The integrator may still be 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, etc.) in the specific country that the end device will be marketed.

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

3.1 United States

The MRF24WG0MA/MB has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" 15.247 and modular approval in accordance with Part 15.212 Modular Transmitter approval. The MRF24WG0MA/MB module can be integrated into a finished product without obtaining subsequent and separate FCC approvals for intentional radiation.

The MRF24WG0MA/MB 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 follows:

Contains Transmitter Module FCC ID:

W7OMRF24WG0MAMB

or

Contains FCC ID:

W7OMRF24WG0MAMB

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.

A user's manual for the product 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.

MRF24WG0MA/MB

3.1.1 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 Radio Frequency (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 MRF24WG0MA/MB module is used in a portable application (i.e., the 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.

3.1.2 APPROVED EXTERNAL ANTENNA TYPES

To maintain modular approval in the United States, only the antenna types that have been tested shall be used. It is permissible to use different antenna manufacturer provided the same antenna type and antenna gain (equal to or less than) is used.

Testing of the MRF24WG0MB module was performed with the antenna types listed in Table 2-2 in **Section 2.0 "Circuit Description"**.

3.1.3 HELPFUL WEB SITES

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

3.2 Canada

The MRF24WG0MA/MB 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-24WG0MAMB

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 APPROVED EXTERNAL ANTENNA TYPES

Transmitter Antenna (from Section 7.1.2 RSS-Gen, Issue 3, December 2010):

The MRF24WG0MB module can only be sold or operated with antennas with which it was approved. Transmitter may be approved with multiple antenna types. An antenna type comprises antennas having similar in-band and out-of-band radiation patterns. Testing shall be performed using the highest gain antenna of each combination of transmitter and antenna type for which approval is being sought, with the transmitter output power set at the maximum level. Any antenna of the same type having equal or lesser gain as an antenna that had been successfully tested with the transmitter, will also be considered approved with the transmitter, and may be used and marketed with the transmitter.

When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on measurement or on data from the antenna manufacturer. For transmitters of output power greater than 10 milliwatts, the total antenna gain shall be added to the measured RF output power to demonstrate compliance to the specified radiated power limits. User manuals for transmitters shall display the following notice in a conspicuous location:

> Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.
>
> Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

The above notice may be affixed to the device instead of displayed in the user manual.

User manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:

> This radio transmitter (identify the device by certification number, or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.
>
> Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi) and required impedance for each.

Approved external antenna types for the MRF24WG0MA/MB module are listed in Table 2-2 in **Section 2.0 "Circuit Description"**.

3.2.2 HELPFUL WEB SITES

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

MRF24WG0MA/MB

3.3   Europe

The MRF24WG0MA/MB module conforms to the emission standards summarized in Table 3-1. The module tests can be applied toward product certification and Declaration of Conformity (DoC).

> **Note:**   To maintain conformance tested ETSI standards, the module shall not be modified.

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 compliance approvals. The module test report data can be used as part of the customer's product test plan and can significantly lower customer's compliance 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).

3.3.1   EXTERNAL ANTENNA REQUIREMENTS

European conformance testing was performed using the antenna types listed in Table 2-2 in **Section 2.0 "Circuit Description"**.

3.3.2   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 Radio Communications Office (ERO) at: http://www.ero.dk/.

Additional helpful web sites are:

- 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

- European Radio Communications Office (ERO):

  http://www.ero.dk

TABLE 3-1:   EMISSIONS STANDARDS TESTED

Specification			Test Method
Emission Standards			
EN 300 328 V1.7.1 (2006-10)	4.3.1	Maximum Transmit Power	5.7.2
EN 300 328 V1.7.1 (2006-10)	4.3.2	Maximum EIRP Spectral Density	5.7.3
EN 300 328 V1.7.1 (2006-10)	4.3.3	Frequency Range	5.7.4
EN 300 328 V1.7.1 (2006-10)	4.3.6	Transmitter Spurious Emissions	5.7.5
EN 300 328 V1.7.1 (2006-10)	4.3.7	Receiver Spurious Emissions	5.7.6

Advance Information

3.4 Other Regulatory Jurisdictions

Should other regulatory jurisdiction certification be required by the customer, or the customer need to recertify the module for other reasons, a certification utility is available. The utility runs on a Window's PC and utilizes a USB to SPI converter to interface to the MRF24WG0MA/MB module. In order to use the utility, the MRF24WG0MA/MB module must be out of reset and not accessed by the system host. That is, the SPI signals to the MRF24WG0MA/MB module must be tri-state, with Reset and Hibernate deasserted. The following signals will need to be brought from the MRF24WG0MA/MB module for connection to the PC (through the USB adapter):

- SDO
- SDI
- $\overline{\text{CS}}$
- SCK
- $\overline{\text{INT}}$
- GND

For further regulatory Certification Utility and documentation, contact your local Microchip salesperson.

3.5 Wi-Fi® Alliance

Wi-Fi Alliance Certification focuses on interoperability testing of devices based on 802.11 standards.

Historically, when the certification process and programs were developed by Wi-Fi Alliance members, the vast majority of the 802.11 clients were PC-centric, and certification testing adequately addressed those types of devices. In subsequent years, the number of Wi-Fi devices that are not PC-centric has grown significantly.

These non-standard devices, as a class of products, have been dubbed Application Specific Devices (ASDs) by the Wi-Fi Alliance. ASDs are 802.11 devices, for example clients or access points (APs), which cannot be tested under a standard Alliance test plan because they do not comply with the standard test configuration and/or because they are designed to perform a specific application. Examples include, but are not limited to: bar code scanners, pagers, recording devices, monitoring equipment, and cable modems.

The APs or clients that are used to validate ASD compliance (from the standard test bed) will meet all of the requirements specified in the applicable System Interoperability Test Plans (referred to as the "standard test plan"), unless specifically exempted. The MRF24WG0MA/MB modules are in the ASD category.

The modules are certified under Wi-Fi 802.11 with WPA2, WPA, and WEP System Interoperability ASD Model Test Plan with Test Engine For IEEE 802.11a, b, and g Devices (Version 1.0).

NOTES:

4.0   ELECTRICAL CHARACTERISTICS

TABLE 4-1:   DIGITAL ELECTRICAL CHARACTERISTICS (NOMINAL CONDITIONS: 25ºC, V$_{DD}$ = 3.3V)

Parameters	Min	Typ	Max	Units
V$_{IL}$ (Input low voltage)	-0.3	—	0.8	V
V$_{IH}$ (Input high voltage)	2	—	5.5	V
V$_{OL}$ (Output low voltage)	—	—	0.4	V
V$_{OH}$ (Output high voltage)	2.4	—	—	V
I$_{OL}$ (Output low level current at V$_{OL}$ Max)	—	8.5	—	mA
I$_{OH}$ (Output high level current at V$_{OH}$ Min)	—	15.4	—	mA

TABLE 4-2:   ABSOLUTE MAXIMUM RATINGS[1]

Parameters	Min	Max	Notes
Storage Temperature	-40ºC	+125ºC	—
V$_{DD}$	0V	3.60V	—
V$_{IN}$ on SDI, $\overline{CS}$, SCK	-0.3V	3.60V	—

Note 1:   The listed Absolute Maximum Ratings are not meant for functional operation. Operation exceeding these levels is not guaranteed, and may reduce the operating life of the component.

TABLE 4-3:   RECOMMENDED OPERATING CONDITIONS

Parameters	Min	Typ	Max	Units
Ambient Temperature	-40	—	+85	Degrees Celsius
V$_{DD}$ – for FCC and IC	2.80	3.3	3.60	Volts

TABLE 4-4:   CURRENT CONSUMPTION[1] (NOMINAL CONDITIONS: 25ºC, V$_{DD}$ = 3.3V)

Parameters	Min	Typ	Max	Units	Conditions
I$_{DD}$, Hibernate = 3.3V	—	0.1	—	µA	—
I$_{DD}$, Power Save (software enabled)	—	4[2]	—	mA	—
I$_{DD}$, RX on, Receive @ -91 dBm with 1 Mbps modulated signal at antenna port	—	85	—	mA	—
I$_{DD}$, TX on, 802.11b, +18 dBm	—	237	—	mA	Measured at 11 Mbps
I$_{DD}$, TX on, 802.11g, +16 dBm	—	226	—	mA	Measured at 6 Mbps

Note 1:   Current Consumption values represent Typical Peak currents, and the measured current conditions were done with 85% duty cycle modulated signal. Wi-Fi applications typically operate at less than 85% TX duty cycle. TX current is dependent on such criteria as transmit power setting, and transmit data rate and bandwidth being used. RX current is affected by connection distance.

2:   Power Save current is current consumed during periods of "stand-by" between DTIM beacons. The module will awake 2 ms before a DTIM and turn on its receiver, and possibly its transmitter (if data is available).

TABLE 4-5: **RECEIVER AC CHARACTERISTICS**[1]

Parameters	Min	Typ	Max	Units
Flo	2412	—	2484	MHz
RX Min Input Level Sensitivity, 1 Mbps, 8% PER	—	-95	—	dBm
RX Min Input Level Sensitivity, 2 Mbps, 8% PER	—	-88	—	dBm
RX Max Input Level (Power), 1 Mbps, 8% PER	—	-4	—	dBm
RX Max Input Level (Power), 2 Mbps, 8% PER	—	-4	—	dBm

Note 1: Nominal conditions: 25ºC, V_{DD} = 3.3V, Flo = 2437 MHz, measurements at antenna port.

TABLE 4-6: **TRANSMITTER AC CHARACTERISTICS**[1]

Parameters	Min	Typ	Max	Units
Flo	2412	—	2484	MHz
Average P_{OUT} (transmit spectrum mask compliant)	—	+18	—	dBm
Average P_{OUT} gain step resolution from +5 to +10 dBm[2]	—	0.5	—	dB
Average P_{OUT} gain step resolution from -5 to Max.[2]	—	1.0	—	dB

Note 1: Nominal conditions: 25ºC, V_{DD} = 3.3V, Flo = 2437 MHz, 2 Mbps. modulated signal measured at antenna port.

2: Gain step control is not calibrated. Steps are shown for planning purposes only.

FIGURE 4-1: SPI INPUT TIMING

Note 1: $\overline{CS}$ must be toggled for each SPI block transfer.
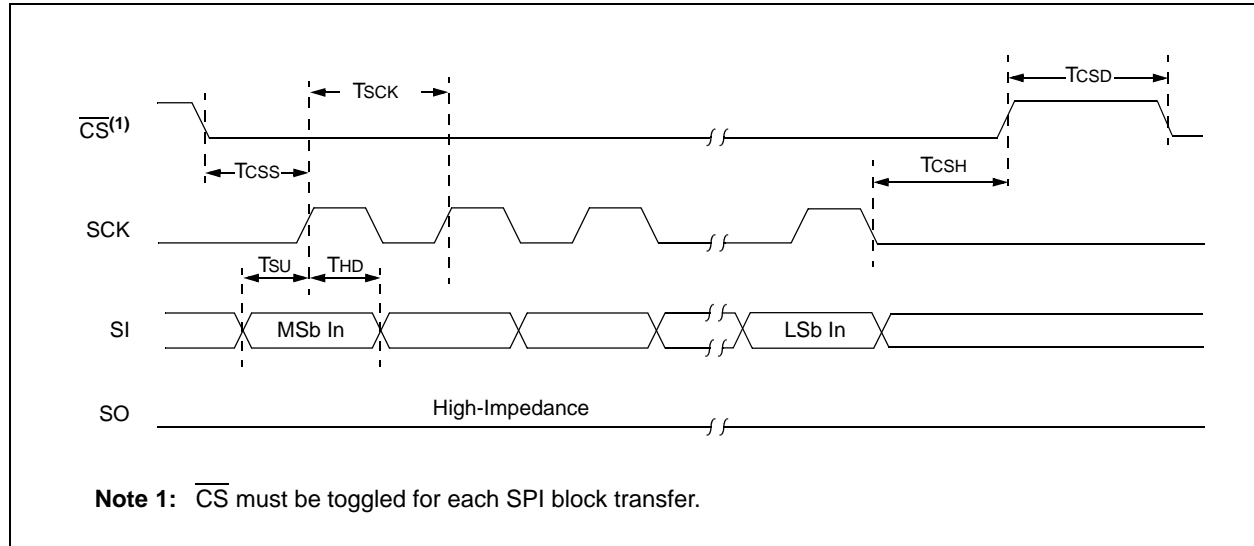
FIGURE 4-2: SPI OUTPUT TIMING
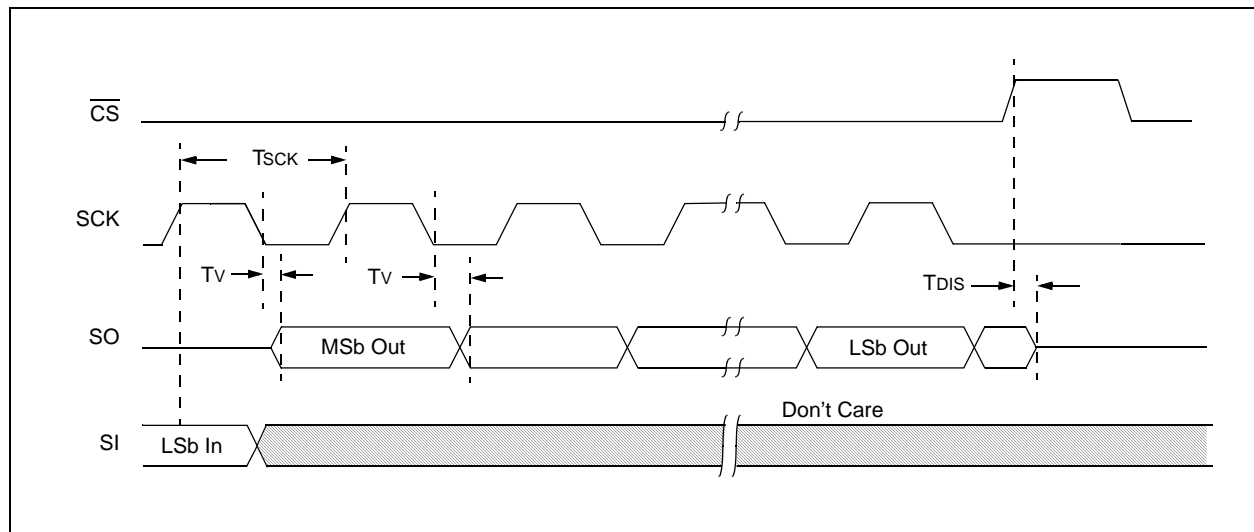
TABLE 4-7: SPI INTERFACE AC CHARACTERISTICS

Symbol	Parameters	Min	Max	Units
T_{SCK}	SCK Period	40	—	ns
T_{CSD}	$\overline{CS}$ High time	50	—	ns
T_{CSS}	$\overline{CS}$ Setup time	50	—	ns
T_{CSH}	$\overline{CS}$ Hold time	50	—	ns
T_{SU}	SDI Setup time	10	—	ns
T_{HD}	SDI Hold time	10	—	ns
T_{V}	SDO Valid time	—	15	ns

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (July 2012)

This is the initial released version of this document.

NOTES:

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   _____

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   _____

   _____

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PRODUCT IDENTIFICATION SYSTEM

To order parts, including industrial, or obtain information, for e.g., on pricing or delivery, refer to the factory or the listed sales office.

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

Device	MRF24WG0MA/MB; V$_{DD}$ range 2.7V to 3.6V
Temperature Range	I = -40°C to +85°C (Industrial Temperature)

Examples:

a)   MRF24WG0MA-I/RM = Industrial Temp

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