MRF24J40MA Data Sheet

2.4 GHz IEEE Std. 802.15.4™ RF Transceiver Module

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MRF24J40MA

2.4 GHz IEEE Std. 802.15.4™ RF Transceiver Module

Features:

- IEEE Std. 802.15.4™ Compliant RF Transceiver
- Supports ZigBee®, MiWi™, MiWi™ P2P and Proprietary Wireless Networking Protocols
- Small size: 0.7" x 1.1" (17.8 mm x 27.9 mm) Surface Mountable
- Integrated crystal, internal voltage regulator, matching circuitry and PCB antenna
- Easy integration into final product - minimize product development, quicker time to market
- Radio regulation certified for United States (FCC), Canada (IC) and Europe (ETSI)
- Compatible with Microchip Microcontroller families (PIC18F, PIC24F/H, dsPIC33 and PIC32)

Operational:

- 20/10/5/2.5 MHz Clock Output:
  - Available to drive microcontroller clock
- Operating Voltage: 2.4 - 3.6V (3.3V typical)
- Temperature Range: -40°C to +85°C Industrial
- Simple Four-Wire SPI Interface
- Low-Current Consumption:
  - RX mode: 18 mA (typical)
  - TX mode: 22 mA (typical)
  - Sleep: 2 μA (typical)
- Supports Power-Save mode

RF/Analog Features:

- ISM Band 2.405 - 2.48 GHz Operation
- Data Rate: 250 Kbps
- -95 dBm Typical Sensitivity and 0 dBm Maximum Input Level
- +0 dBm Typical Output Power and 40 dB TX Power Control Range
- Integrated, Low Phase Noise VCO, Frequency Synthesizer and PLL Loop Filter
- Digital VCO and Filter Calibration
- Integrated RSSI ADC and I/Q DACs
- Integrated LDO
- High Receiver and RSSI Dynamic Range

MAC/Baseband Features:

- Hardware CSMA-CA Mechanism, Automatic ACK Response and FCS Check
- Independent Beacon, Transmit and GTS FIFO
- Hardware Security Engine (AES-128) with CTR, CCM and CBC-MAC modes
- Supports all CCA modes and RSS/LQI
- Automatic Packet Retransmit Capable
- Supports In-Line or Stand-Alone modes for both Encryption and Decryption

FIGURE 1:   PIN DIAGRAM

MRF24J40MA

Table of Contents

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An errata sheet, describing minor operational differences from the data sheet and recommended workarounds, may exist for current devices. As device/documentation issues become known to us, we will publish an errata sheet. The errata will specify the revision of silicon and revision of document to which it applies.

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1.0   DEVICE OVERVIEW

The MRF24J40MA is a 2.4 GHz IEEE Std. 802.15.4™ compliant, surface mount module with integrated crystal, internal voltage regulator, matching circuitry and PCB antenna. The MRF24J40MA module operates in the non-licensed 2.4 GHz frequency band and is FCC, IC, and ETSI compliant. The integrated module design frees the end user from extensive RF, antenna design, and regulatory compliance testing and allows quicker time to market.

Figure 1-1 shows a simplified block diagram of the MRF24J40MA module. The module is based on the Microchip Technology MRF24J40 IEEE 802.15.4™ 2.4 GHz RF Transceiver chip. The module interfaces to many popular Microchip PIC® microcontrollers via a 4-wire serial SPI interface, interrupt, wake, reset, power and ground. The module has an integrated PCB antenna and matching circuitry all in a compact size.

The MRF24J40MA module is compatible with Microchip's ZigBee®, MiWi, and MiWi P2P software stacks. Each software stack is available as a free download, including source code, from the Microchip web site http://www.microchip.com/wireless.

The MRF24J40MA module has received regulatory approvals for modular devices in the United States (FCC), Canada (IC) and Europe (ETSI). Modular approval removes the need for expensive RF and antenna design and allows the end user to place the MRF24J40MA module inside a finished product and not require testing for an intentional radiator (RF transmitter). See **Section 4.0 "Regulatory Approval"** for specific requirements to be followed by the end user.

This user's guide describes the installation, pin out, and voltage requirements for optimum operation of the module. Data communications with the MRF24J40MA module is documented in the MRF24J40 IEEE 802.15.4™ 2.4 GHz RF Transceiver Data Sheet (DS39776). Refer to the MRF24J40 data sheet for specific serial interface protocol and register definitions.

FIGURE 1-1:   MRF24J40MA BLOCK DIAGRAM
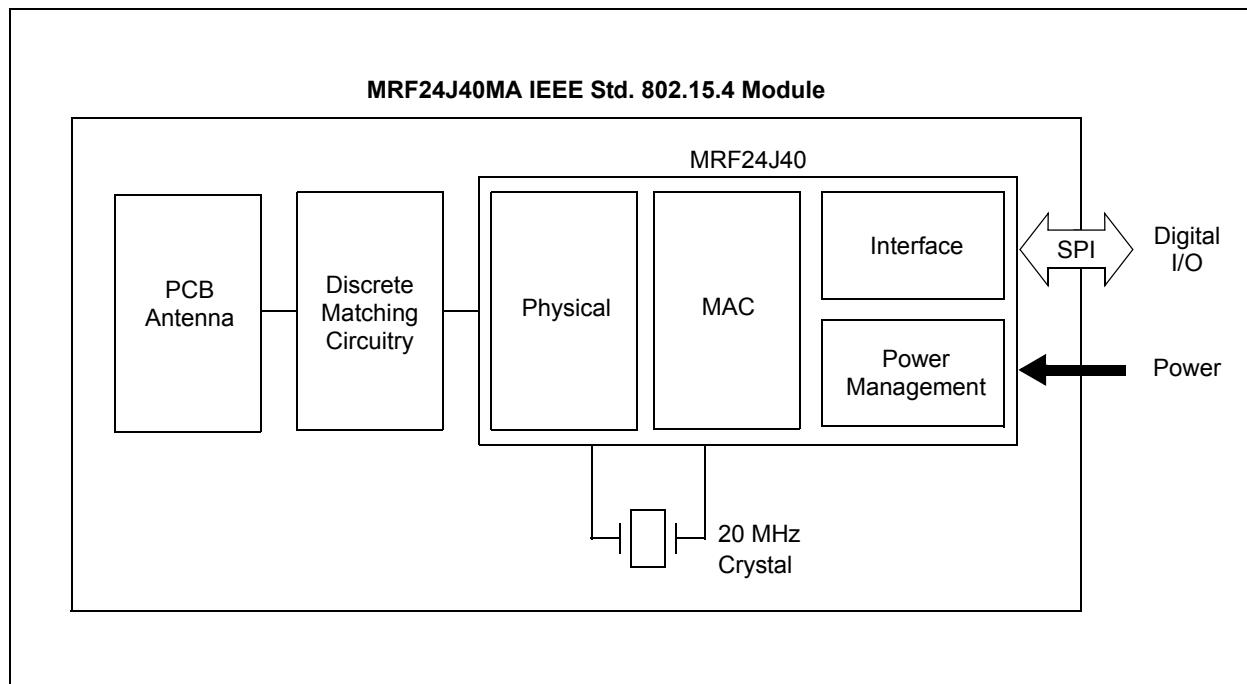
MRF24J40MA

TABLE 1-1: PIN DESCRIPTION

Pin	Symbol	Type	Description
1	GND	Power	Ground
2	$\overline{\text{RESET}}$	DI	Global hardware reset pin
3	WAKE	DI	External wake-up trigger
4	INT	DO	Interrupt pin to microcontroller
5	SDI	DI	Serial interface data input
6	SCK	DI	Serial interface clock
7	SDO	DO	Serial interface data output from MRF24J40
8	$\overline{\text{CS}}$	DI	Serial interface enable
9	CLKOUT	DO	20/10/5/2.5 MHz clock output
10	VIN	Power	Power supply
11	GND	Ground	Ground
12	GND	Ground	Ground

Legend: Pin type abbreviation: A = Analog, D = Digital, I = Input, O = Output

FIGURE 1-2: MOUNTING DETAILS

Keep area around antenna (approximately 1.2 inches) clear of metalic structures for best performance

1.2"

Edge of PCB

0.470"

1.2"

0.4"

0.4"

0.4"

PCB Ground Plane (Counterpoise)
Extend as far as possible to the sides and below the module (at least 0.4 inches on each side) for best performance

Advance Information
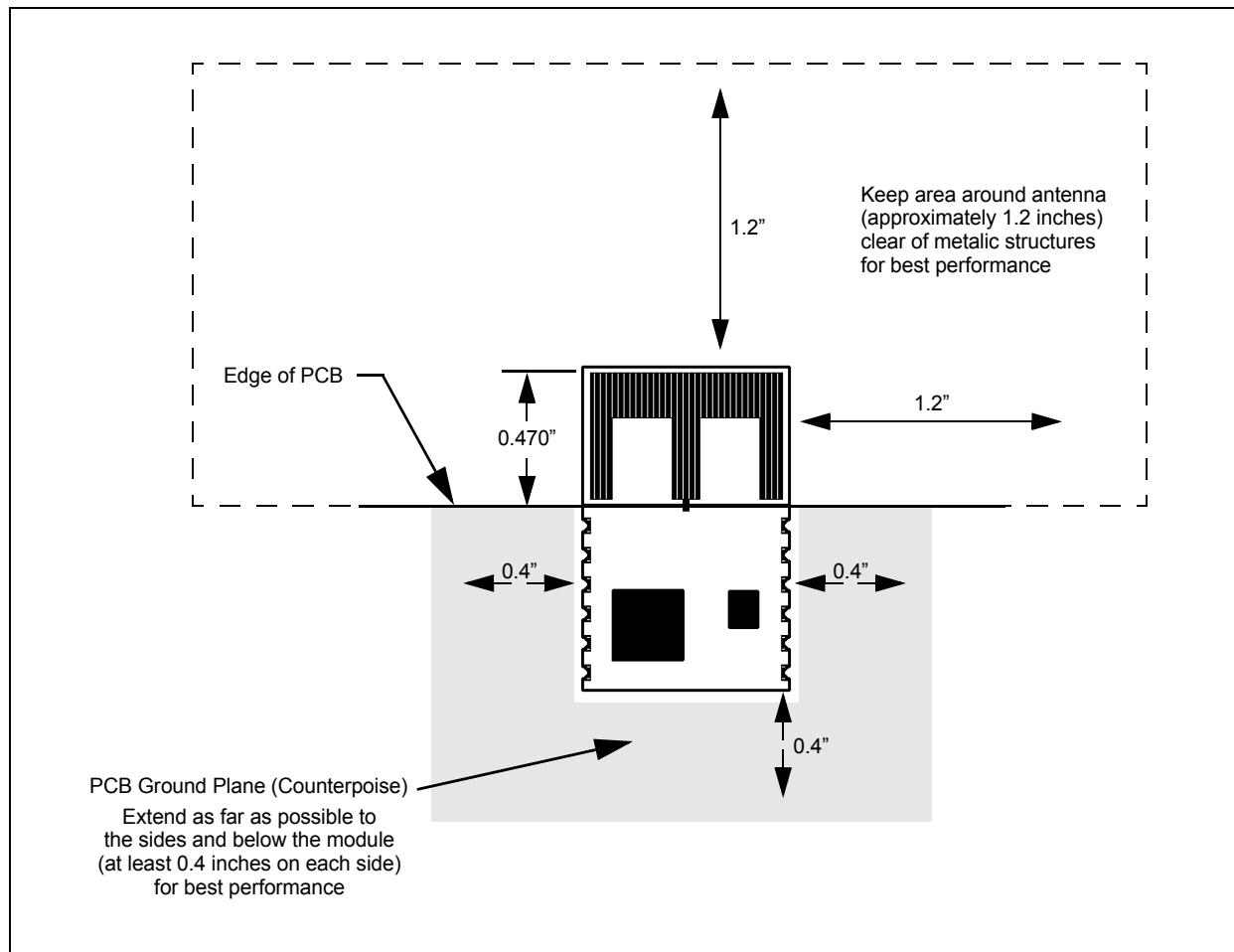
FIGURE 1-3: RECOMMENDED PCB FOOTPRINT
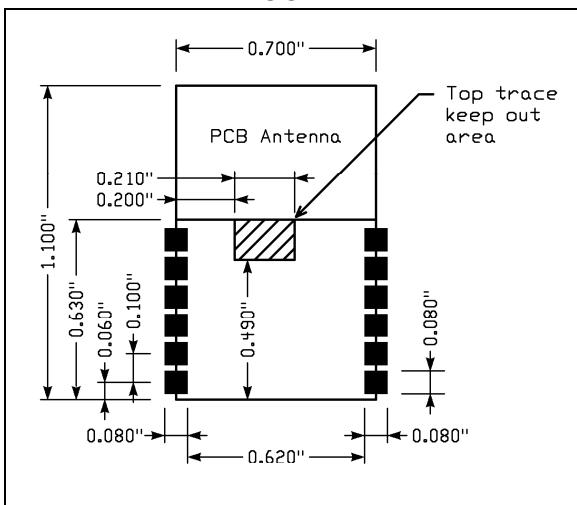
**FIGURE 1-4:** MODULE DETAILS

MRF24J40MA

NOTES:

Advance Information
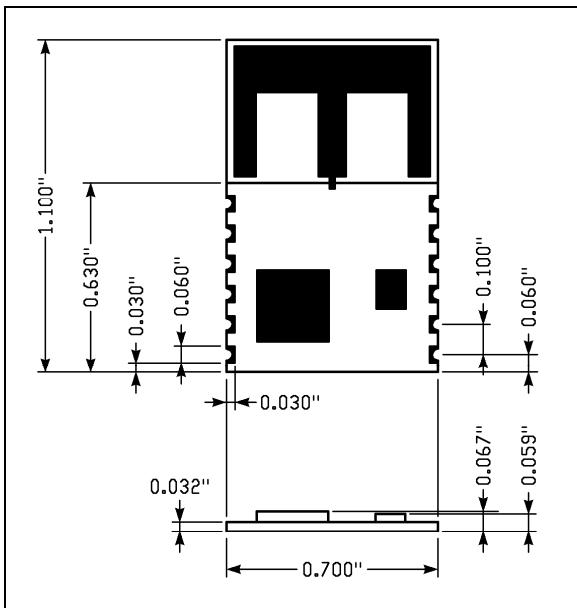
2.0 MICROCONTROLLER INTERFACE

FIGURE 1: **MICROCONTROLLER TO MRF24J40MA INTERFACE**
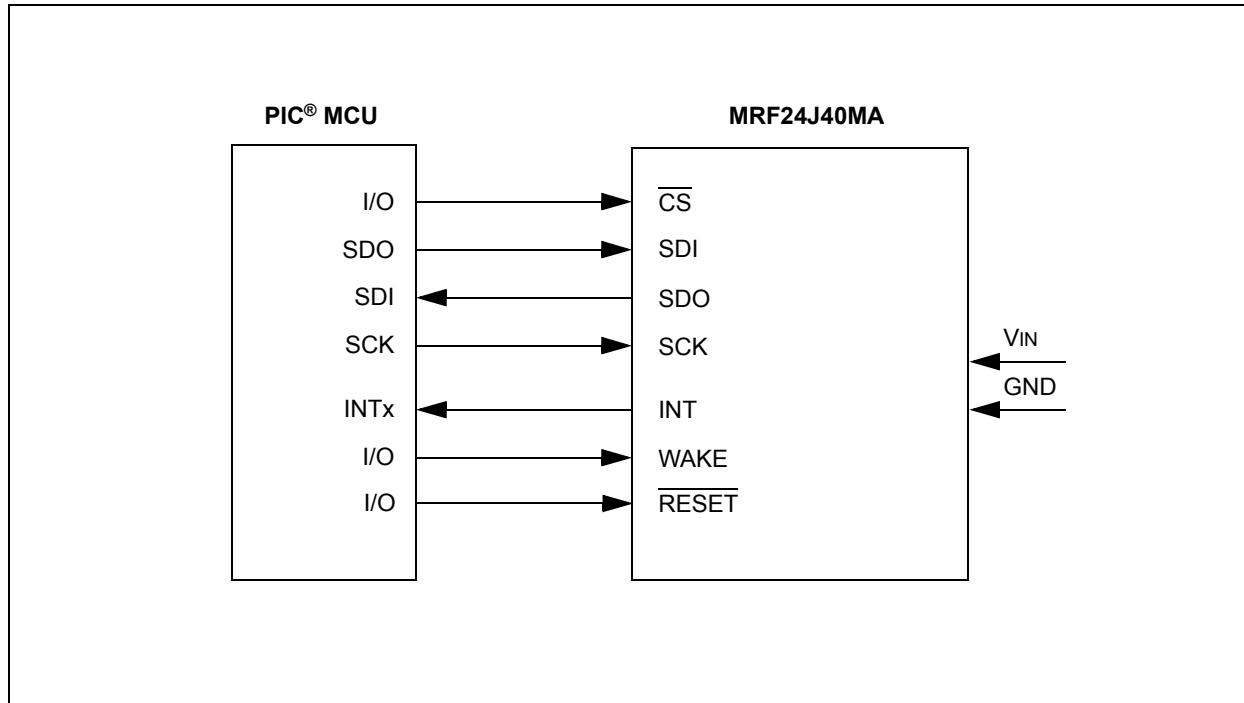
NOTES:

3.0   CIRCUIT INTERFACE

MRF24J40MA

FIGURE 3-1:

Note: NP = Not Placed.

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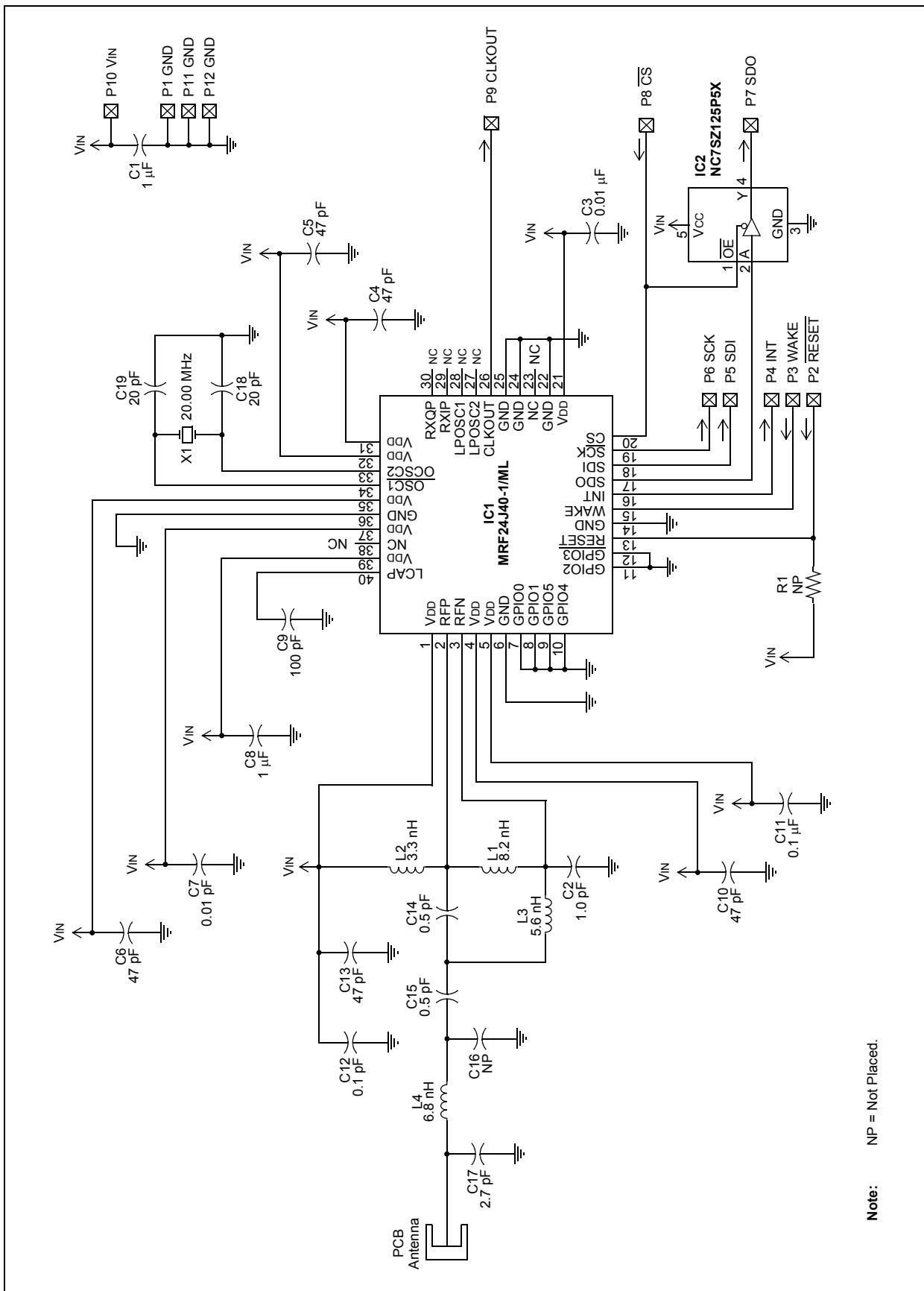
4.0   REGULATORY APPROVAL

The MRF24J40MA module has received regulatory approvals for modular devices in the United States, Canada and European countries. Modular approval allows the end user to place the MRF24J40MA module inside a finished product and not require 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 end user may still be responsible for testing the end product for any additional compliance requirements required with this module installed (for example: digital device emission, PC peripheral requirements, etc.) in the specific country that the end device will be marketed.

Annex F of the IEEE Std. 802.15.4 document has a good summary of regulatory requirements in various countries concerning IEEE Std. 802.15.4 devices. The standard can be downloaded from the IEEE Standards web page: http://standards.ieee.org/getieee802/802.15.html.

Refer to the specific countries radio regulations for details on regulatory compliance.

4.1   United States

The MRF24J40MA has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" 15.247 and modular approval in accordance with FCC Public Notice DA 00-1407 Released: June 26, 2000, Part 15 Unlicensed Modular Transmitter Approval. The MRF24J40MA module can be integrated into a finished product with obtaining subsequent FCC approvals.

The MRF24J40MA 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 such as the following:

Contains Transmitter Module FCC ID: OA3MRF24J40MA

-or-

Contains FCC ID: OA3MRF24J40MA

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.

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.

4.1.1   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.

MRF24J40MA

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 MRF24J40MA module is used in a portable application (antenna is less than 20 cm from persons during operation), the end user is responsible for performing Specific Absorption Rate (SAR) testing in accordance with FCC rules 2.1091.

4.1.2   HELPFUL WEB SITES

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

4.2   Canada

The MRF24J40MA module has been certified for use in Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-210 and RSS-Gen.

From section 7.1.1 RSS-Gen, Issue 2, June 2007, Modular Transmitter Approval:

Host devices which contain separately certified modules do not need to be recertified, provided that they meet the following conditions:

a)   The host device, as a stand-alone unit without any separately certified modules, complies with all applicable Radio Standards Specifications.

b)   The host device and all the separately certified modules it contains jointly meet the RF exposure compliance requirements of RSS-102, if applicable.

c)   The host device complies with the certification labeling requirements of each of the modules it contains.

Note: Compliance of a module in its final configuration is the responsibility of the applicant. A host device will not be considered certified if the instructions regarding antenna configuration provided in the original description, of one or more separately certified modules it contains, were not followed

From section 5.2, RSS-Gen, Issue 2, June 2007, Equipment Labels:

All Category I radio equipment intended for use in Canada shall permanently display on each transmitter, receiver, or inseparable combination thereof, the applicant's name (i.e., manufacturer's name, trade name or brand name), model number and certification number. This information shall be affixed in such a manner as not to be removable except by destruction or defacement. The size of the lettering shall be legible without the aid of magnification, but is not required to be larger than 8-point font size. If the device is too small to meet this condition, the information can be included in the user manual upon agreement with Industry Canada.

Label:

Contains IC: 7693A-24J40MA

From section 7.1.6, RSS-Gen, Issue 2, June 2007, Digital Circuits:

If the device contains digital circuitry that is not directly associated with the radio transmitter, the device shall also have to comply with ICES-003, Class A or B as appropriate, except for ICES-003 labeling requirements. The test data obtained (for the ICES-003 tests) shall be kept by the manufacturer or importer whose name appears on the equipment label, and made available to Industry Canada on request, for as long as the model is being marketed in Canada.

4.2.1   HELPFUL WEB SITES:

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

4.3 Europe

The MRF24J40MA module has been certified for use in European countries. The following testing has been completed:

Test standard ETSI EN 300 328 V1.7.1 (2006-10)

- Maximum Transmit Power
- Maximum EIRP Spectral Density
- Frequency Range
- Radiated Emissions

Test standards ETSI EN 301 489-1:2008 and ETSI EN 301 489-17:2008

- Radiated Emissions
- Electro-Static Discharge
- Radiated RF Susceptibility

A helpful document that can be used as a starting point in understanding the use of short range devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, downloadable from the European Radio Communications Office (ERO) http://www.ero.dk.

The end user is responsible for ensuring compliance with harmonized frequencies and labeling requirements for each country the end device is marketed and sold.

4.3.1 HELPFUL WEB SITES:

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/

NOTES:

Advance Information

5.0 ELECTRICAL CHARACTERISTICS

TABLE 1: RECOMMENDED OPERATING CONDITIONS

Parameters	Min	Typ	Max	Units
Ambient Operating Temperature	-40	—	+85	°C
Supply Voltage for RF, Analog and Digital Circuits	2.4	—	3.6	V
Supply Voltage for Digital I/O	2.4	3.3	3.6	V
Input High Voltage (V_{IH})	0.5 x V_{DD}	—	V_{DD} + 0.3	V
Input Low Voltage (V_{IL})	-0.3	—	0.2 x V_{DD}	V

TABLE 2: CURRENT CONSUMPTION

(T_A = 25°C, V_{DD} = 3.3V)

Chip Mode	Condition	Min	Typ	Max	Units
Sleep		—	2	—	µA
TX	At maximum output power	—	22	—	mA
RX		—	18	—	mA

TABLE 3: RECEIVER AC CHARACTERISTICS

Typical values are at T_A = 25°C, V_{DD} = 3.3V, LO frequency = 2.445 GHz

Parameters	Condition	Min	Typ	Max	Units
RF Input Frequency	Compatible to IEEE Std. 802.15.4-2003	2.405	—	2.480	GHz
RF Sensitivity	At antenna input with O-QPSK signal and 3.5 dB front-end loss is assumed	—	-95	—	dBm
Maximum RF Input		+5	—	—	dBm
LO Leakage	Measured at balun matching network input at frequency 2.405-2.48 GHz	—	-60	—	dBm
Input Return Loss	External matched to 50 source by a balun matching network	-8	-12	—	dB
Noise Figure (including matching)		—	8	—	dB
Adjacent Channel Rejection	@ +/-5 MHz	30	—	—	dB
Alternate Channel Rejection	@ +/-10 MHz	40	—	—	dB
RSSI Range		—	50	—	dB
RSSI Error		-5	—	5	dB

MRF24J40MA

TABLE 4: TRANSMITTER AC CHARACTERISTICS

Typical values are at T_A = 25°C, V_{DD} = 3.3V, LO Frequency = 2.445 GHz

Parameters	Condition	Min	Typ	Max	Units
RF Carrier Frequency		2.405	—	2.480	GHz
Maximum RF Output Power		—	0	+3	dBm
RF Output Power Control Range		—	40	—	dB
TX Gain Control Resolution	Programmed by register	—	1.25	—	dB
Carrier Suppression		—	-30	—	dBc
TX Spectrum Mask for O-QPSK Signal	Offset frequency > 3.5 MHz, at 0 dBm output power	-33	—	—	dBm

Advance Information

6.0   PACKAGING INFORMATION

For packaging information, see the *XXX*.

NOTES:

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APPENDIX A: REVISION HISTORY

Revision A (August 2007)

Original data sheet for the MRF24J40MA device.

NOTES:

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Device: MRF24J40MA Family   Literature Number: DS00000A

Questions:

1. What are the best features of this document?

   _____

   _____

2. How does this document meet your hardware and software development needs?

   _____

   _____

3. Do you find the organization of this document easy to follow? If not, why?

   _____

   _____

4. What additions to the document do you think would enhance the structure and subject?

   _____

   _____

5. What deletions from the document could be made without affecting the overall usefulness?

   _____

   _____

6. Is there any incorrect or misleading information (what and where)?

   _____

   _____

7. How would you improve this document?

   _____

   _____

MRF24J40MA PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	X	/XX	XXX
Device	Temperature Range	Package	Pattern

Device[1][2]   PinLow, PinHigh,
                     V$_{DD}$ range 4.2V to 5.5V

                  MRF24J40MA,(
                     V$_{DD}$ range 2.0V to 5.5V

Temperature   I   =   -40°C to +85°C (Industrial)
Range   E   =   -40°C to +125°C (Extended)

Package   PT   =   TQFP (Thin Quad Flatpack)

Pattern   QTP, SQTP, Code or Special Requirements
               (blank otherwise)

Examples:

a)   MRF24J40MA-I/PT 301 = Industrial temp.,
     TQFP package, Extended V$_{DD}$
     limits, QTP pattern #301.

b)   MRF24J40MA-E/PT = Extended temp.,
     TQFP package, standard V$_{DD}$ limits.

Note 1:   F   =   Standard Voltage Range
              LF   =   Wide Voltage Range
        2:   T   =   in tape and reel TQFP
                     packages only.

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