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XBee-PRO 900HP/XSC RF Modules

S3 and S3B

User Guide

Revision history—90002173

Revision	Date	Description
P	December 2014	Editorial changes. Added a related publications table. Updated the timestamp information for the Route information packet.
R	May 2015	Removed the Warranty section and added a link. Updated the **SY** command information. Corrected the **GT** parameter range. Added Mexico IFETEL information.
S	October 2016	Replaced the Programmable bootloader section with the Programmable XBee SDK section. Updated the indoor range spec. Corrected the **SP** and **ST** parameter default values.
T	May 2018	Added note on range estimation. Changed IC to ISED.
U	July 2018	Added the 0x00, 0x80 and 0x89 frames for the 900HP.

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About the XBee-PRO 900HP RF Module

The XBee-PRO 900HP RF Modules consist of firmware loaded onto XBee-PRO S3B hardware. These embedded RF devices provide wireless connectivity to end-point devices in mesh networks.

You can build networks up to 128 nodes using the XBee devices. For larger networks of up to 1,000 or more nodes, we offer RF optimization services to assist with proper network configuration.

For more information network configuration, contact Digi Technical Support.

Note The XBee-PRO 900HP RF Module is not backward compatible with the legacy XBee-PRO 900 (Part Number: XBP09-DP…) or XBee-PRO DigiMesh 900 (Part Number: XBP09-DM…) RF modules.

The XBee-PRO S3B hardware consists of:

- One Energy Micro EFM®32G230F128 microcontroller
- One Analog Devices ADF7023 radio transceiver
- One RF power amplifier
- One NXP MC9S08QE32® microcontroller, only in the programmable version of the XBee

User guide structure

This user guide contains documentation for two RF protocols: XStream Compatible (XSC) and 900HP. The XSC firmware is provided for customers who need compatibility with existing networks that need to be 9XStream compatible. Customers who do not require this compatibility should not use the XSC firmware, but rather the newer 900HP firmware.

The XSC firmware section at the back of this user guide contains documentation for the XSC firmware only. All other firmware documentation in the user guide is applicable to the 900HP firmware only. For more information about XSC firmware see the XSC firmware section.

The XBee-PRO 900HP RF Module is not backward compatible with the legacy XBee-PRO 900 (Part Number: XBP09-DP…) or XBee-PRO DigiMesh 900 (Part Number: XBP09-DM…) RF Modules.

The following table describes how to use this user guide based on the Digi part number for the module:

Digi Part Numbers	FCC ID	Hardware Platform	Pre-installed Firmware	Firmware Available	Regulatory Information
XBP09-XC…	MCQ-XBEEXSC	S3[1]	XSC	XSC	Legacy S3B hardware certifications
XBP9B-XC*T-001 (revision G and earlier) XBP9B-XC*T-002 (revision G and earlier) XBP9B-XC*T-021 (revision F and earlier) XBP9B-XC*T-022 (revision F and earlier)	MCQ-XBPS3B	S3B	XSC	XSC	Legacy S3B hardware certifications
XBP9B-XC*T-001 (revision H and later) XBP9B-XC*T-002 (revision H and later) XBP9B-XC*T-021 (revision G and later) XBP9B-XC*T-022 (revision G and later) all other part numbers beginning XBP9B-XC...	MCQ-XB900HP	S3B	XSC	XSC / 900HP	
XBP9B-D…	MCQ-XB900HP	S3B	900HP	XSC / 900HP	

[1]The S3 hardware variant is a legacy design that is obsolete. New and old designs should use the S3B hardware variant.

Technical specifications

Performance specifications

This table describes the performance specifications for the devices.

Note Range figure estimates are based on free-air terrain with limited sources of interference. Actual range will vary based on transmitting power, orientation of transmitter and receiver, height of transmitting antenna, height of receiving antenna, weather conditions, interference sources in the area, and terrain between receiver and transmitter, including indoor and outdoor structures such as walls, trees, buildings, hills, and mountains.

Specification	Value
Ideal RF line-of-sight range	10 kb/s: up to 9 miles (15.5 km) 200 kb/s: up to 4 miles (6.5 km) (with 2.1 dB dipole antennas)
Transmit power output	24 dBm (250 mW) (software selectable)
RF data rate (high)	200 kb/s
RF data rate (low)	10 kb/s
Serial UART interface	Complementary metal–oxide–semiconductor (CMOS) Serial universal asynchronous receiver/transmitter (UART), baud rate stability of <1%
Serial interface data rate (software selectable)	9600-230400 baud
Receiver sensitivity (typical)	-101 dBm, high data rate -110 dBm, low data rate

Power requirements

The following table describes the power requirements for the XBee-PRO 900HP RF Module.

Specification	Value
Supply voltage	2.1 to 3.6 VDC[1]
Transmit current	**PL** = 4: 215 mA typical, (290 mA max) **PL** = 3: 160 mA typical **PL** = 2: 120 mA typical **PL** = 1: 95 mA typical **PL** = 0: 60 mA typical
Idle/receive current	29 mA typical at 3.3 V (35 mA max)
Sleep current	2.5 µA (typical)

[1]Supply voltages of less than 3.0 V may reduce performance. Output power and receiver sensitivity may degrade.

General specifications

The following table describes the general specifications for the devices.

Specification	Value
Operating frequency band[1]	902 to 928 MHz (software selectable channels)
Dimensions	3.29 cm x 2.44 cm x 0.546 cm (1.297" x 0.962" x 0.215) Dimensions do not include connector/antenna or pin lengths
Weight	5 to 8 grams, depending on the antenna option
Operating temperature	-40 ºC to 85 º C (industrial)
Antenna options	Integrated wire, U. FL RF connector, reverse-polarity SMA connector
Digital I/O	Fifteen (15) I/O lines,
Analog-to-digital converter (ADC)	Four (4)10-bit analog inputs

Networking specifications

The following table provides the networking specifications for the device.

Specification	Value
Supported network topologies	Mesh, point-to-point, point-to-multipoint, peer-to-peer
Number of channels, user selectable channels	64 channels available
Addressing options	Personal Area Network identifier (PAN ID), Preamble ID, and 64-bit addresses
Encryption	128 bit Advanced Encryption Standard (AES)

Regulatory conformity summary

This table describes the agency approvals for the devices.

Country	Approval
United States (FCC Part 15.247)	MCQ-XB900HP
Innovation, Science and Economic Development Canada (ISED)	1846A-XB900HP

[1]Supply voltages of less than 3.0 V may reduce performance. Output power and receiver sensitivity may degrade.

Country	Approval
Australia	RCM
Brazil	ANATEL 3727-12-1209
Singapore	License No. DA105737 (XB900HP only)
Mexico	IFETEL (XB900HP only)
RoHS2	Compliant

Serial communication specifications

The XBee-PRO 900HP RF Module supports both Universal Asynchronous Receiver / Transmitter (UART) and Serial Peripheral Interface (SPI) serial connections.

UART pin assignments

UART pins	Device pin number
DOUT	2
DIN / $\overline{\text{CONFIG}}$	3
$\overline{\text{CTS}}$ / DIO7	12
$\overline{\text{RTS}}$ / DIO6	16

SPI pin assignments

SPI pins	Device pin number
SPI_SCLK / DIO18	18
SPI_$\overline{\text{SSEL}}$ / DIO17	17
SPI_MOSI / DIO16	11
SPI_MISO / DIO15	4
SPI_$\overline{\text{ATTN}}$ / DIO1	19

GPIO specifications

XBee devices have 15 General Purpose Input/Output (GPIO) ports available. The precise list depends on the device configuration as some devices use the GPIO pins for purposes such as serial communication. The following table shows the electrical specifications for the GPIO pins.

GPIO electrical specification	Value
Voltage - supply	2.1 - 3.6 V (3.0 V or higher required for optimal performance)
Low Schmitt switching threshold	0.3 x V_{DD}
High Schmitt switching threshold	0.7 x V_{DD}
Input pull-up resistor value	40 kΩ
Input pull-down resistor value	40 kΩ
Output voltage for logic 0	0.05 x V_{DD}
Output voltage for logic 1	0.95 x V_{DD}
Output source current	2 mA
Output sink current	2 mA
Total output current (for GPIO pins)	48 mA

Note For information about Mexico IFETEL, see Mexico IFETEL. Only the XBee-PRO 900HP devices listed are approved by IFETEL.

Secondary processor specifications

If the device has the programmable secondary processor, add the values from the following tables to the specifications listed in the Power requirements specifications. For more information about transmit, receive, and sleep currents, see Power requirements.

For example, if the secondary processor runs at 20 MHz and the primary processor is in receive mode, then the new current value is:

$$I_{total} = I_{r2} + I_{rx} = 14\ mA + 9\ mA = 23\ mA$$

where I_{r2} is the runtime current of the secondary processor and I_{rx} is the receive current of the primary processor.

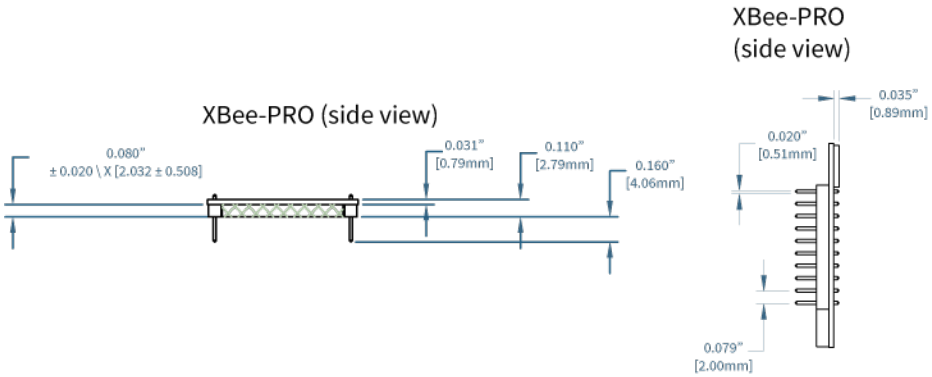
Optional secondary processor specification	Add these numbers to power requirement specifications (add to RX, TX, and sleep currents depending on mode of operation)
Runtime current for 32 k running at 20 MHz	+14 mA
Runtime current for 32 k running at 1 MHz	+1 mA
Sleep current	+0.5µ A typical
For additional specifications see the NXP datasheet and manual	MC9S08QE32
Voltage requirement for secondary processor to operate at maximum clock frequency	2.4 to 3.6 VDC

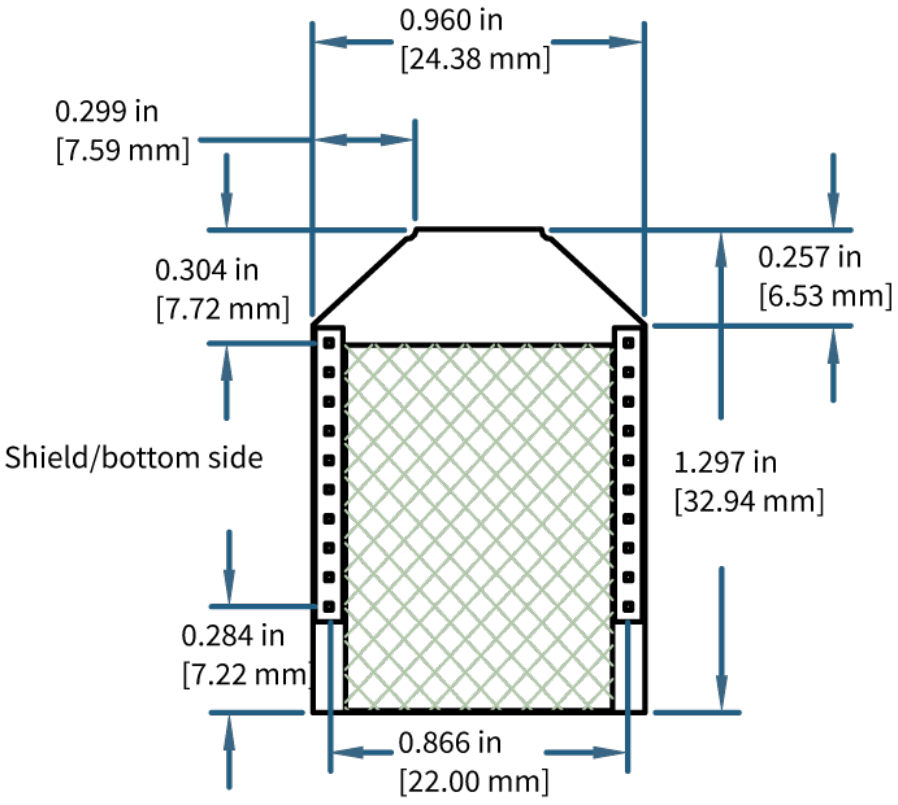
Optional secondary processor specification	Add these numbers to power requirement specifications (add to RX, TX, and sleep currents depending on mode of operation)
Minimum reset pulse for programmable variant	100 nS
Minimum reset pulse to radio	50 nS
Voltage reference (VREF) range	1.8 VDC to VCC

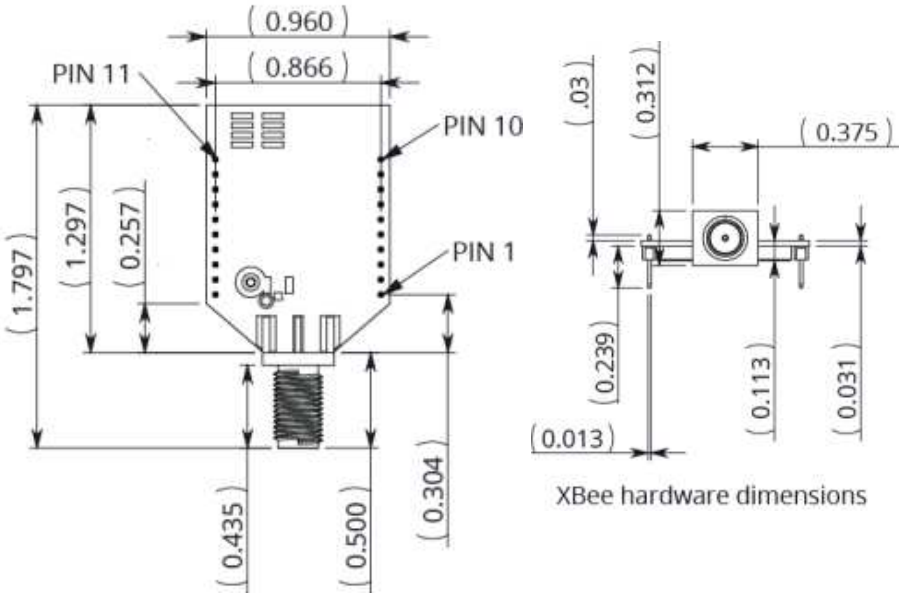
Hardware

Mechanical drawings

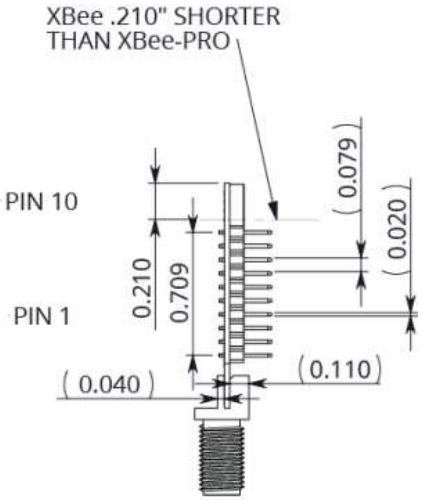
The following figures show the mechanical drawings for the XBee-PRO 900HP RF Module. The drawings do not show antenna options.







XBee hardware dimensions



XBee hardware
(side view)

Pin signals

The following table shows the pin signals and their descriptions. The table specifies signal direction with respect to the device. For more information on pin connections, see Design notes.

Pin #	Name	Direction	Default state	Description
1	VCC			Power supply

Pin #	Name	Direction	Default state	Description
2	DOUT/DIO13	Both	Output	GPIO/UART data out
3	DIN/$\overline{\text{CONFIG}}$ /DIO14	Both	Input	GPIO/UART data in
4	DIO12/SPI_ MISO	Both	Output	GPIO/SPI slave out
5	$\overline{\text{RESET}}$	Input		Device reset. Drive low to reset the device. This is also an output with an open drain configuration with an internal 20 kΩ pull-up (never drive to logic high, as the device may be driving it low). The minimum pulse width is 1 mS.
6	DIO10/PWM0	Both		GPIO/RX signal strength indicator
7	DIO11/PWM1	Both		GPIO/pulse width modulator
8	Reserved		Disabled	Do not connect
9	$\overline{\text{DTR}}$/SLEEP_ RQ/DIO8	Both	Input	GPIO/pin sleep control line (DTR on the development board)
10	GND			Ground
11	DIO4/SPI_MOSI	Both		GPIO/SPI slave in
12	$\overline{\text{CTS}}$/DIO7	Both	Output	GPIO/clear-to-send flow control
13	ON_$\overline{\text{SLEEP}}$ /DIO9	Output	Output	GPIO/module status indicator
14	VREF	Input		Internally used for the programmable secondary processor. For compatibility with other XBee devices, we recommend connecting this pin to the voltage reference if you desire analog sampling. Otherwise, connect to GND.
15	Associate/DIO5	Both	Output	GPIO/associate indicator
16	$\overline{\text{RTS}}$ /DIO6	Both	Input	GPIO/request-to-send flow control
17	$\underline{\text{AD3}}$/DIO3/SPI_ SSEL	Both		GPIO/analog input/SPI slave select
18	AD2/DIO2/SPI_ CLK	Both		GPIO/analog input /SPI clock
19	$\underline{\text{AD1}}$/DIO1/SPI_ ATTN	Both		GPIO/analog input /SPI attention
20	AD0/DIO0	Both		GPIO/analog input

Design notes

The XBee modules do not require any external circuitry or specific connections for proper operation. However, there are some general design guidelines that we recommend to build and troubleshoot a robust design.

Power supply design

A poor power supply can lead to poor radio performance, especially if you do not keep the supply voltage within tolerance or if the noise is excessive. To help reduce noise, place a 1.0 µF and 47 pF capacitor as near as possible to pin 1 on the PCB. If you are using a switching regulator for the power supply, switch the frequencies above 500 kHz. Limit the power supply ripple to a maximum 50 mV peak to peak.

For designs using the programmable modules, we recommend an additional 10 µF decoupling cap near pin 1 of the device. The nearest proximity to pin 1 of the three caps should be in the following order:

1. 47 pf
2. 1 µF
3. 10 µF

Board layout

We design XBee modules to be self-sufficient and have minimal sensitivity to nearby processors, crystals or other printed circuit board (PCB) components. Keep power and ground traces thicker than signal traces and make sure that they are able to comfortably support the maximum current specifications. There are no other special PCB design considerations to integrate XBee modules, with the exception of antennas.

Antenna performance

Antenna location is important for optimal performance. The following suggestions help you achieve optimal antenna performance. Point the antenna up vertically (upright). Antennas radiate and receive the best signal perpendicular to the direction they point, so a vertical antenna's omnidirectional radiation pattern is strongest across the horizon.

Position the antennas away from metal objects whenever possible. Metal objects between the transmitter and receiver can block the radiation path or reduce the transmission distance. Objects that are often overlooked include:

- Metal poles
- Metal studs
- Structure beams
- Concrete, which is usually reinforced with metal rods

If you place the device inside a metal enclosure, use an external antenna. Common objects that have metal enclosures include:

- Vehicles
- Elevators
- Ventilation ducts
- Refrigerators

- Microwave ovens
- Batteries
- Tall electrolytic capacitors

Use the following additional guidelines for optimal antenna performance:

- Do not place XBee modules with the chip antenna inside a metal enclosure.
- Do not place any ground planes or metal objects above or below the antenna.
- For the best results, mount the device at the edge of the host PCB. Ensure that the ground, power, and signal planes are vacant immediately below the antenna section.

Recommended pin connections

The only required pin connections for two-way communication are VCC, GND, DOUT and DIN. To support serial firmware updates, you must connect VCC, GND, DOUT, DIN, RTS, and DTR.

Do not connect any pins that are not in use. Use the **PR** and **PD** commands to pull all inputs on the radio high with internal pull-up resistors. Unused outputs do not require any specific treatment.

For applications that need to ensure the lowest sleep current, never leave unconnected inputs floating. Use internal or external pull-up or pull-down resistors, or set the unused I/O lines to outputs.

You can connect other pins to external circuitry for convenience of operation including the Associate LED pin (pin 15) and the Commissioning pin (pin 20). The Associate LED pin flashes differently depending on the state of the module, and a pushbutton attached to pin 20 can enable various deployment and troubleshooting functions without you sending UART commands. For more information, see Commissioning pushbutton and associate LED.

Only the programmable versions of these devices use the VREF pin (pin 14). For compatibility with other XBee modules, we recommend connecting this pin to a voltage reference if you want to enable analog sampling. Otherwise, connect to GND.