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XTend vB

Radio Frequency (RF) Module

User Guide

Revision history—90001478

Revision	Date	Description
A	December, 2015	Baseline release of the document.
B	May, 2016	Added information on the Australian variant. Updated cyclic sleep numbers. Added the **HS** command.

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XTend vB RF Module User Guide

The XTend vB RF Module was engineered to provide customers with an easy-to-use radio frequency (RF) solution that provides reliable delivery of critical data between remote devices. The module transfers a standard asynchronous serial data stream, operates within the ISM 900 MHz frequency band and offers two RF data rates of 10 kb/s and 125 kb/s for the United States and Canada variant. It offers two RF data rates of 10 kb/s and 105 kb/s for the Australia variant.

Applicable firmware and hardware

As the name suggests, the XTend vB RF Module is form factor and over the air compatible with our XTend module.

This manual supports firmware versions 2xxx for XTend DigiMesh.

XTend replacement numbers

The following table provides the part numbers you can use to replace XTend devices with the XTend vB RF Module.

Legacy part number	Replacement part number
XT09-MI	XTP9B-DPM-001
XT09-SI	XTP9B-DPS-001
XT09-MI-MESH	XTP9B-DMM-001
XT09-SI-MESH	XTP9B-DMS-001

Certification overview

The XTend vB RF Module contains an FCC/IC approved RF module. A separate variant of the XTend vB RF Module contains an Australian approved RF module. For usage requirements, see Certifications.

ISM (Industrial, Scientific and Medical) license-free 902-928 MHz frequency band.

Manufactured under ISO 9001:2000 registered standards.

Technical specifications

The following tables provide the device's technical specifications.

WARNING! When operating at 1 W power output, observe a minimum separation distance of 6 ft (2 m) between devices. Transmitting in close proximity of other devices can damage the device's front end.

General specifications

The following table provides the general specifications for the device.

Specification	Value
Dimensions (RF/pin connectors not included)	3.70 x 6.10 x 0.48 cm (1.457 x 2.402 x 0.190 in)
Weight	16 g
RoHS	Compliant
Manufacturing	ISO 9001:2000 registered standards
Connector	20 pin 2 mm pitch header
Antenna connector options	MMCX or RPSMA
Antenna impedance	50 ohms unbalanced
Operating temperature	-40°C to 85°C
Maximum input RF level at antenna port	6 dBm
Digital outputs	2 output lines

Performance specifications

The following table provides the performance specifications for the device.

Specification	Value	
Frequency range	902 to 928 MHz US/Canada 915 to 928 MHz Australia	
RF data rate (software selectable)	10 kb/s to 125 kb/s US/Canada 10 kb/s to 105 kb/s Australia	
Transmit power (software selectable)	Up to 30 dBm (see Power requirements)	
Channels	10 hopping sequences share 50 frequencies	
Outdoor line of sight	10 kb/s	Up to 40 miles[1]
	125 kb/s	Up to 7 miles
Indoor range line of sight	10 kb/s	Up to 1,000 feet (300 m)
	125 kb/s	Up to 500 feet (150 m)
Receiver sensitivity	10 kb/s	-110 dBm
	125 kb/s	-100 dBm
UART data rate	1200-230400 baud	

[1]Estimated based on a 9 mile range test with dipole antennas.

Networking specifications

The following table provides the general specifications for the device.

Specification	Value
Modulation	Frequency Shift Keying
Spread Spectrum	Frequency Hopping Spread Spectrum (FHSS)
Supported Network Topologies (software selectable)	Peer-to-peer (master/slave relationship not required), point-to-point/point-to-multipoint, mesh
Encryption	256-bit or 128-bit AES CBC encryption depending on region. 256-bit is only available on the North America variant. 128-bit is only available on international variants.

Power requirements

The following table provides the power requirements for the device. Specifications are given at 5 V, 25°C unless otherwise noted.

Requirement	Value	
Supply voltage	2.8 to 5.5 VDC, 5 V typical	
Receive current	@ 5 V	35 mA
Transmit current	See the following table	
Shutdown mode current	1 µA	
Sleep current	< 147 µA	

Cyclic sleep current (mA, average)

Sleep mode	Cycle time	RF data rate	Cyclic sleep current (mA, average)
SM = 8	16 seconds	**BR** = 0	0.65
		BR = 1	0.23
SM = 7	8 seconds	**BR** = 0	1.13
		BR = 1	0.31
SM = 6	4 seconds	**BR** = 0	2.06
		BR = 1	0.46
SM = 5	2 seconds	**BR** = 0	3.77
		BR = 1	0.77

Sleep mode	Cycle time	RF data rate	Cyclic sleep current (mA, average)
SM = 4	1 second	**BR** = 0	6.68
		BR = 1	1.36

Transmit power level	21.5 dBm	27 dBm	30 dBm
Supply voltage range	2.8 to 5.5 V	3.2 to 5.5 V	4.75 to 5.5 V
Transmit current (5 V, typical)	260 mA	470 mA	710 mA
Transmit current (3.3 V, typical)	340 mA	615 mA	N/A

Regulatory approvals

The following table provides the regulatory approvals for the device.

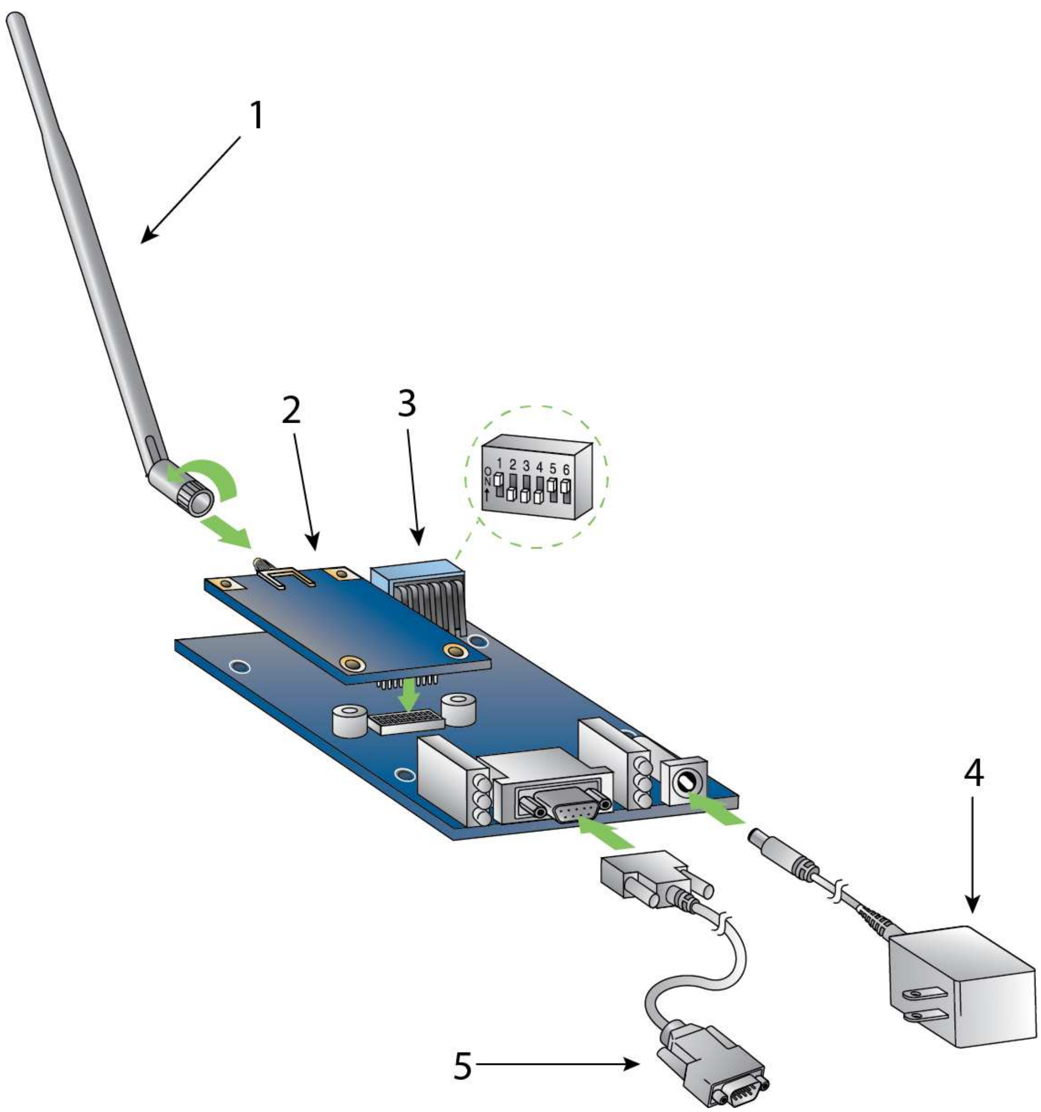
Nation	Approval
United States	Contains FCC ID: MCQ-XBPSX
Canada	Contains IC: 1846A-XBPSX
Australia	RCM

Hardware

Connect the hardware

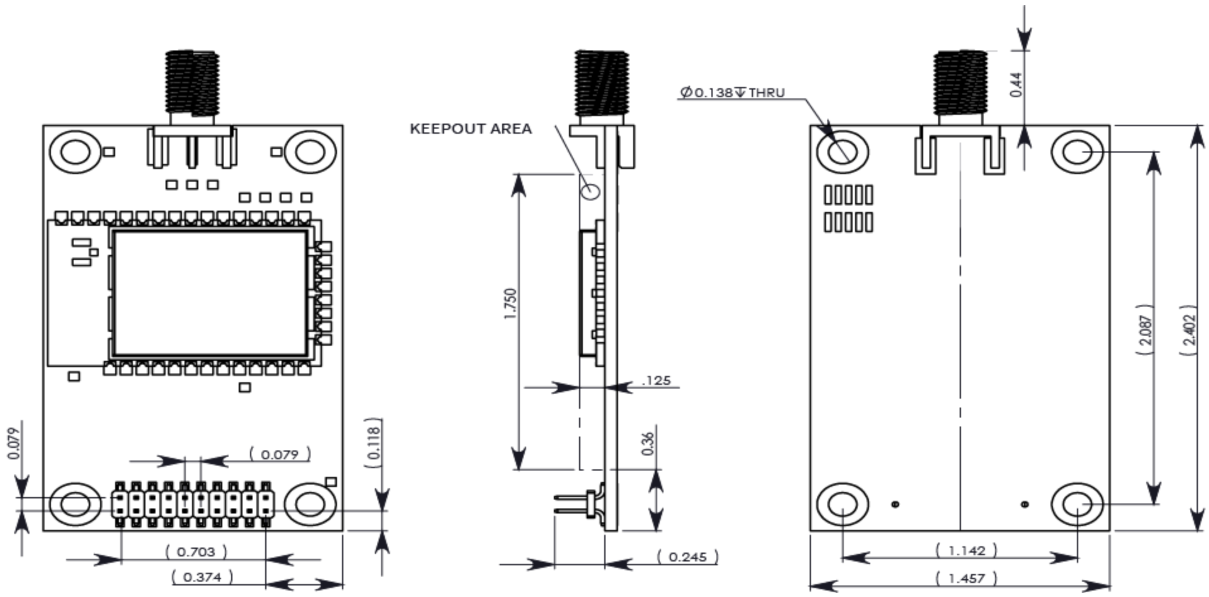
The following figure shows the XTend vB RF Module and accessories you need to get started and how to connect them. The accessories are in the XT09-DK development kit.

Item	Description
1	Antenna, RPSMA (female)
2	XTend vB module, RPSMA version shown
3	DIP switches
4	9 V power supply
5	DB9 serial cable



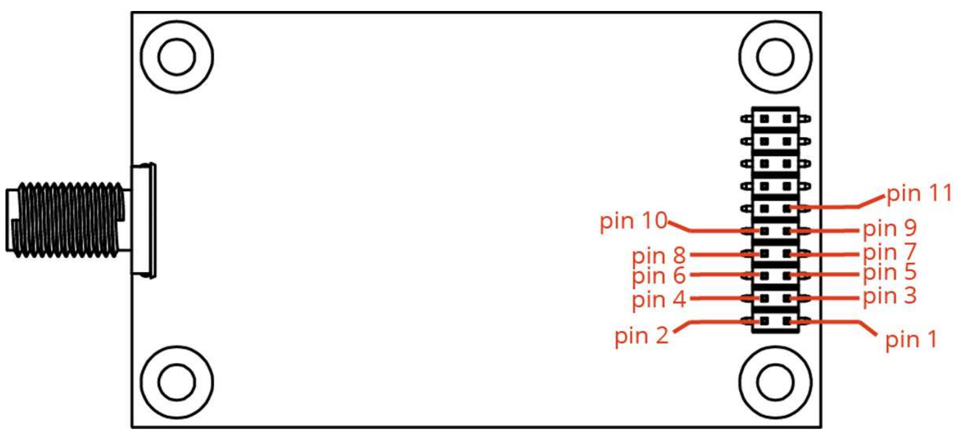
Mechanical drawings

The following drawings show the dimensions of the device.



Pin signals

The following drawing shows the location of the pins.



When integrating the module with a Host PC board, all lines not used should be left disconnected (floating).

Pin number	Name	I/O	High impedance during shutdown	Must connect	Function
1	GND	-	-	yes	Ground

Pin number	Name	I/O	High impedance during shutdown	Must connect	Function
2	VCC	I	-	yes	Power: 2.8 - 5.5 VDC
3	GPO2 / RX LED	O	-	yes	GPO2: General Purpose Output. Default (**CD** = 2) drives this pin low. RX LED: Pin is driven high during RF data reception; otherwise, the pin is driven low. To enable this pin, see CD (GP02 Configuration).
4	TX _PWR	O	yes	-	Transmit_Power: Pin pulses low during RF transmission; otherwise, the pin is driven high to indicate power is on and the device is not in Sleep or Shutdown Mode.
5	DIN	I	yes	yes	Data In: Serial data entering the device (from the UART host). For more information, see .
6	DOUT	O	yes	-	Data Out: Serial data exiting the module (to the UART host). For more information, see .
7	SHDN	I	no	yes	Shutdown: Drive this pin high to enable normal operation and low during Shutdown. Shutdown enables the lowest power mode available to the module.
8	SLEEP	I	yes	-	SLEEP: By default, SLEEP is not used. To configure this pin to enable Sleep modes, refer to Sleep modes, SM (Sleep Mode) and PW (Pin Wakeup).

Pin number	Name	I/O	High impedance during shutdown	Must connect	Function
9	GPO1 / CTS / RS-485 TX_EN	O	yes	-	GPO1: General Purpose Output. Pin can be driven low or high. CTS (Clear-to-Send): CTS is enabled by default. When the pin is driven low, the UART host is permitted to send serial data to the device. For more information, see and CS (GP01 Configuration). RS-485 Transmit Enable: Enables RS-485 half and full-duplex communications. For more information, see and CS (GP01 Configuration).
10	RTS / CMD	I	yes	-	RTS (Request-to-Send): Not used by default. This pin can be configured to allow the UART host to regulate the flow of serial data exiting the module. For more information, see and RT (GPI1 Configuration).
11	CONFIG / RSSI	I[1]	no	-	Configuration: Pin can be used as a backup method for entering Command mode during power-up.
		O[2]	no	-	Receive Signal Strength Indicator: By default, pin is used as an RSSI PWM output after at the conclusion of the power-up sequence. The PWM output is 2.8 V-level. For more information, see RP (RSSI PWM Timer).
12-20	Reserved / do not connect				

[1]The RF module has a 10 kΩ internal pull-up resistor.

[2]The RF module has a 10 kΩ internal pull-up resistor.

Modes

The RF device is in Receive Mode when it is not transmitting data. The device shifts into the other modes of operation under the following conditions:

- Transmit Mode (Serial data in the serial receive buffer is ready to be packetized)
- Sleep Mode
- Command Mode (Command Mode Sequence is issued, not available when using the SPI port)

Transparent and API operating modes

The firmware operates in several different modes. Two top-level modes establish how the device communicates with other devices through its serial interface: Transparent operating mode and API operating mode.

Transparent operating mode

Devices operate in this mode by default. The device acts as a serial line replacement when it is in Transparent operating mode. The device queues all UART data it receives through the DIN pin for RF transmission. When a device receives RF data, it sends the data out through the DOUT pin. You can set the configuration parameters using the AT Command interface.

API operating mode

API operating mode is an alternative to Transparent mode. API mode is a frame-based protocol that allows you to direct data on a packet basis. It can be particularly useful in large networks where you need control over the operation of the radio network or when you need to know which node a data packet originated from. The device communicates UART data in packets, also known as API frames. This mode allows for structured communications with serial devices. It is helpful in managing larger networks and is more appropriate for performing tasks such as collecting data from multiple locations or controlling multiple devices remotely.

For more information, see API frame specifications.

Additional modes

In addition to the serial communication modes, several modes apply to how to configure devices and how devices communicate with each other.

Command mode

Command mode is a state in which the firmware interprets incoming characters as commands. Command mode allows you to modify the device's firmware using parameters you can set using AT commands. When you want to read or set any setting of the device, you have to send it an AT command. Every AT command starts with the letters "AT" followed by the two characters that identify the command the device issues and then by some optional configuration values. For more details, see Enter Command mode.

Binary Command mode

Binary Command mode allows you to configure a device at a faster rate than AT commands will allow. Using binary commands to send and receive parameter values is the fastest way to change the operating parameters of the device. Use binary commands to:

- Sample signal strength and/or error counts;
- Change device addresses and channels for polling systems when a quick response is necessary.

For more details, see Enter Binary Command mode and DB (Received Signal Strength).

Idle mode

When not receiving or transmitting data, the device is in Idle mode. During Idle mode, the device listens for valid data on the serial port.

Receive mode

If a destination node receives a valid RF packet, the destination node transfers the data to its serial transmit buffer. For the serial interface to report receive data on the RF network, that data must meet the following criteria:

- ID match
- Channel match
- Address match

Sleep modes

Sleep Modes enable the device to enter states of low-power consumption when not in use. The device support three software sleep modes:

- Pin Sleep: the host controls this
- Serial Port Sleep: wakes when it detects serial port activity
- Cyclic Sleep: wakes when it detects RF activity

For more information, see Sleep modes.

Shutdown mode

Shutdown mode offers the lowest power mode available to the device. This is helpful for applications that must keep power consumption to a minimum during idle periods.

When you drive the SHDN pin (pin 7) low, it forces the device into Shutdown mode. This halts any communication in progress (transmit or receive) and any buffered data is lost. For any other mode of operation, you must drive or pull SHDN high.

Immediately after the SHDN pin changes states from low to high, the device resets. After reset, the application must observe a delay time of <100 ms.

While SHDN is driven low, the device sets the following pins to high impedance: DCD, TX_PWR, RX LED, DO and CTS. The SHDN line is driven low during shutdown.

The following input pins may continue to be driven by external circuitry when in shutdown mode: RTS, DI and SHDN.

Because the DO pin is set to high impedance during Shutdown, if the XTend vB RF Module is connected to a processor, the UART receive pin could be floating. Place a weak pull-up between the device and the microcontroller so that the application does not misinterpret noise as data.

Transmit mode

When the device receives serial data and is ready to packetize it, the device exits Idle mode and attempts to transmit the serial data.

Enter Command mode

There are two ways to enter Command mode:

1. To get a device to switch into this mode, you must issue a unique string of text in a special way: +++ (default). When the device sees a full second of silence in the data stream followed by the string +++ (without Enter or Return) and another full second of silence, it knows to stop sending data through and start accepting commands locally.

   Do not press Return or Enter after typing +++ because it will interrupt the guard time silence and prevent you from entering Command mode.

2. Assert (low) the CONFIG pin. Turn the power going to the device off and back on.

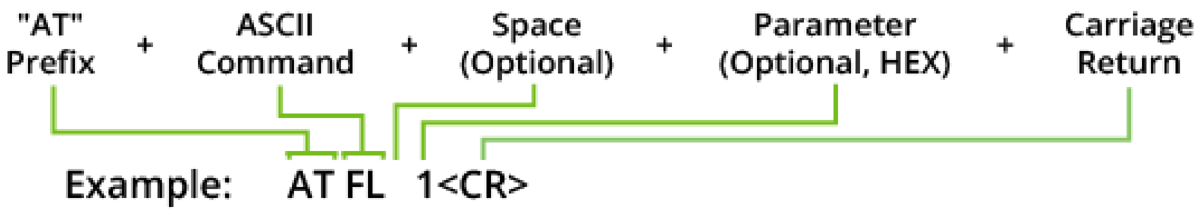
The device sends the letters **OK** followed by a carriage return out of the UART to indicate that it entered Command mode.

You can customize the guard times and timeout in the device's configuration settings. See CC (Command Sequence Character), BT (Guard Time Before) and AT (Guard Time After).

Send AT commands

Once the device enters Command mode, use the syntax in the following figure to send AT commands. Every AT command starts with the letters **AT**, which stands for "attention." The **AT** is followed by two characters that indicate which command is being issued, then by some optional configuration values.

To read a parameter value stored in the device's register, omit the parameter field.



The preceding example enables software flow control.

Respond to AT commands

When you send a command to the device, the device parses and runs the command. If the command runs successfully, the device returns an **OK** message. If the command errors, the device returns an **ERROR** message.

When reading parameters, the device returns the current parameter value instead of an **OK** message.

Exit Command mode

1. Send the **CN** (Exit Command Mode) command followed by a carriage return.

   or:

2. If the device does not receive any valid AT commands within the time specified by **CT** (Command Mode Timeout), it returns to Transparent or API mode. The default Command Mode Timeout is 20 seconds.

Enter Binary Command mode

To enter Binary Command mode, you must first be in Command mode:

1. Set **RT** to 1; see RT (GPI1 Configuration).
2. Assert CMD by driving pin 10 high to enter Binary Command mode.
3. Disable hardware flow control.

CTS (pin) is high when the firmware executes a command. That is why you must disable hardware flow control, because CTS holds off parameter bytes.

Exit Binary Command mode

To exit Binary Command mode, de-assert CMD by driving pin 10 low.

Binary Command mode FAQs

Since sending and receiving binary commands takes place through the same serial data path as live data, interference between the two types of data can be a concern. Some common questions about using binary commands are:

- What are the implications of asserting CMD while the device is sending or receiving live data?

You must assert the CMD pin (pin 10) in order to send binary commands to the device. You can assert the CMD pin to recognize binary commands anytime during the transmission or reception of data.

The device only checks the status of the CMD signal at the end of the stop bit as the byte shifts into the serial port.

The firmware does not allow control over when the device receives data, except by waiting for dead time between bursts of communication.

If the command is sent in the middle of a stream of payload data, the device executes the command in the order it is received. If the device is continuously receiving data, it waits for a break in the data it receives before executing the command.

- After sending serial data, is there a minimum time delay before you can assert CMD?
- Is a time delay required after CMD is de-asserted before payload data can be sent?

The host must observe a minimum time delay of 100 µs after sending the stop bit of the command byte before the host de-asserts the CMD pin. The command executes after the host sends all of its associated parameters. If the device does not receive all of these parameters within 0.5 seconds, the device returns to Idle mode.

Note When a host sends parameters, they are two bytes long with the least significant byte sent first. Binary commands that return one parameter byte must be written with two parameter bytes. Example: to set **PL** to 3, send the following data: 0x3A 0x03 0x00 (Binary Command, LSB, MSB).

- How do I discern between live data and data received in response to a command?

To query command parameters using Binary Command mode, set the most significant bit of the binary command. This can be accomplished by logically ORing (bit-wise) the binary command with hexadecimal 0x80. The parameter bytes are returned in hexadecimal bytes with the least significant bit first (if multiple bytes are returned).

Example: to query **HP** in Binary Command mode, instead of setting it, send 0x11 (**HP** binary command) as 0x91 with no parameter bytes.

The device must be in Binary Command mode in order for the device to recognize a binary command; see Enter Binary Command mode.

If the device is not in Binary Command mode (the **RT** parameter value is not 1), the device does not recognize that the CMD pin is asserted and therefore does not recognize the data as binary commands.

For an example of binary programming, see Send binary commands.

Sleep modes

For the device to enter one of the sleep modes, **SM** must have a non-zero parameter value, and it must meet one of the following conditions:

1. The device is idle (no data transmission or reception) for the amount of time defined by the **ST** parameter. **ST** is only active when **SM** = 4-5.
2. The host asserts SLEEP (pin 10). This only applies to the Pin Sleep option.

When in Sleep mode, the device does not transmit or receive data until it transitions to Idle mode.

Use the **SM** command to enable or disable all Sleep modes. The following table shows the transitions into and out of Sleep modes.

Sleep mode (setting)	Transition into Sleep mode	Transition out of Sleep mode (wake)	Related commands	Power consumption
Pin Sleep (**SM** = 1)	Assert (high) SLEEP pin. A microcontroller can shut down and wake devices via the SLEEP pin. The device completes a transmission or reception before activating Pin Sleep.	De-assert (low) SLEEP pin	**SM**	< 147 µA
Serial Port Sleep (**SM** = 2)	Automatic transition to Sleep Mode occurs after a user-defined period of inactivity (no transmitting or receiving of data). Period of inactivity is defined by the **ST** command.	When a serial byte is received on the DI pin	(**SM**), **ST**	7.3 mA
Cyclic Sleep (**SM** = 4 - 8)	The device transitions in and out of Sleep Mode in cycles (you set the sleep interval of time using the **SM** command). The cyclic sleep interval of time must be shorter than the interval of time that is defined by the **LH** command. You can for the device into Idle Mode using the SLEEP pin if you issue the **PW** command.		(**SM**), **ST**, **HT**, **LH**, **PW**	See Power requirements

The **SM** (Sleep Mode) command is central to setting all Sleep Mode configurations. By default, Sleep Modes are disabled (**SM** = 0) and the device remains in Idle/Receive Mode. When in this state, the device remains constantly ready to respond to serial or RF activity.

Pin Sleep (SM = 1)

After enabling Pin Sleep, the SLEEP pin controls whether the device is active or sleeping. When the host de-asserts SLEEP, the device is fully operational. When the host asserts SLEEP, the device transitions to Sleep mode and remains in its lowest power-consuming state until the host de-asserts the pin. This pin is only active if the device is setup to operate in this mode; otherwise the firmware ignores the pin.

Once in Pin Sleep, the device de-asserts (high) $\overline{\text{CTS}}$ (pin 9) , indicating that other devices should not send data to the device. The device also de-asserts (low) the TX_PWR line (pin 4) when the device is in Pin Sleep mode.

You cannot assert the SLEEP (pin9) until the transmission of the second byte has started.

Note The device completes a transmission or reception before activating Pin Sleep.

Serial Port Sleep (SM = 2)

- Wake on serial port activity

Serial Port Sleep is a Sleep mode in which the device runs in a low power state until it detects serial data on the DI pin.

The **ST** command determines the period of time that the device sleeps. Once it receives a character through the DI pin, the device returns to Idle mode and is fully operational.

Cyclic Sleep Mode (SM = 4-8)

Cyclic Sleep modes allow device wakes according to the times designated by the cyclic sleep settings. If the device detects a wake-up initializer during the time it is awake, the device synchronizes with the transmitting device and receives data after the wake-up initializer runs its duration. Otherwise, the device returns to Sleep mode and continues to cycle in and out of activity until a wake-up initializer is detected.

While the device is in Cyclic Sleep mode, it de-asserts (high) $\overline{\text{CTS}}$ (pin 9) to indicate not to send data to the device. When the device awakens to listen for data, it asserts $\overline{\text{CTS}}$ and transmits any data received on the DI pin. The device also de-asserts (low) the $\overline{\text{TX\_PWR}}$ (pin 4) when it is in Cyclic Sleep mode.

The device remains in Sleep mode for a user-defined period of time ranging from 1 second to 16 seconds (**SM** parameters 4 through 8). After this interval of time, the device returns to Idle mode and listens for a valid data packet. The listen time depends on the **BR** parameter setting. The default **BR** setting of 1 requires at least a 35 ms wake time, while the **BR** setting of 0 requires a wake time of up to 225 ms. If the device does not detect valid data on any frequency, it returns to Sleep mode. If it detects valid data, it transitions into Receive mode and receives the incoming RF packets. The device then returns to Sleep mode after a period of inactivity determined by the **ST** parameter.

You can also configure the device to wake from cyclic sleep when the SLEEP pin is de-asserted. To configure a device to operate in this manner, you must issue the **PW** (Pin Wake-up) command. When you de-assert the SLEEP pin, it forces the device into Idle mode and it can begin transmitting or receiving data. It remains active until it no longer detects data for the time that **ST** specifies, at which point it resumes its low-power cyclic state.

Cyclic scanning

Each RF transmission consists of an RF initializer and payload. The RF initializer contains initialization information and all receiving devices must wake during the wake-up initializer portion of data transmission in order to synchronize with the transmitting device and receive the data.

The cyclic interval time defined by the **SM** (Sleep Mode) command must be shorter than the interval time defined by **LH** (Wake-up Initializer Timer) command.

Correct configuration (LH > SM)

In the following figure, the length of the wake-up initializer exceeds the time interval of Cyclic Sleep. The receiver is guaranteed to detect the wake-up initializer and receive the accompanying payload data.