



Digi XBee[®] 3 Zigbee

RF Module

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Introduction

Digi has updated and ported its XBee Zigbee firmware from the XBee/XBee-PRO ZB (S2C) hardware based on the SiLabs EM357 SoC, to the Digi XBee 3 (Micro) hardware based on the SiLabs EFR32 SoC.

This guide will assist you with migration to the new platform. While basic functionality and communication are similar and compatible, there are some differences to consider. This newer platform provides several major advantages over the existing platform, which we describe in this guide, along with other migration considerations.

What's new

The Digi XBee 3 Zigbee 3.0 introduces some new features such as:

- Addition of the "Micro" (MMT) form factor
- Built on the latest Zigbee 3.0 specifications
- Capable of firmware migration to Zigbee, DigiMesh™ or Digi 802.15.4 protocols
- New, reliable and secure, firmware over-the-air (FOTA) update process based on the ZCL OTA update standard
- Lower operating receive current
- Power on channel 26 is increased on the PRO and power cap on channel 26 is removed for non-PRO
- Improved RF sensitivity and output power without the need for boost mode
- Bluetooth Low Energy (BLE) support for configuration, data transmission, and beaconing
- Supports MicroPython and a file system with OTA update support
- Support for I2C through MicroPython
- SRP authenticated remote access (Secure Session)

Specification considerations

Specification comparison between the legacy XBee/XBee-PRO ZB (S2C) and the new Digi XBee 3 Zigbee 3.0.

Low-Power (non-PRO) variant

Considerations	Legacy XBee ZB (S2C)	New Digi XBee 3 Zigbee	Comments
Indoor/urban range	Up to 60 m (200 ft)	Up to 60 m (200 ft)	Same
Outdoor RF line-of sight	Up to 1200 m (4000 ft)	Up to 1200 m (4000 ft)	Same
Transmit power output	6.3 mW (+8 dBm), boost mode 3.1 mW (+5 dBm), normal mode Channel 26 max power is +3 dBm	6.3 mW (+8 dBm)	No power cap on channel 26

Specification considerations

Considerations	Legacy XBee ZB (S2C)	New Digi XBee 3 Zigbee	Comments
Receive sensitivity	-102 dBm, boost mode -100 dBm, normal mode	-103 dBm	Comparable to boost mode
Operating current (transmit)	45 mA (+8 dBm, boost mode) 33 mA (+5 dBm, normal mode)	40 mA @ +3.3V, +8dBm	Lower operating current vs boost mode
Operating current (receive)	31 mA (boost mode) 28 mA (normal mode)	17 mA	Improved
Supply voltage	2.1 – 3.6 V	2.1 – 3.6 V	Same
FCC ID	MCQ-S2C	MCQ-XBEE3	Customer will need to change the label on the end product to show the appropriate regulatory ID for the XBee 3
Industry Canada (IC) ID	1846A-XBS2C	1846A-XBEE3	

High-Power (PRO) variant

Considerations	Legacy XBee-PRO ZB (S2C)	New Digi XBee 3 Zigbee Pro	Comments
Indoor/urban range	Up to 90 m (300 ft)	Up to 90 m (300 ft)	Same
Outdoor RF line-of sight	Up to 3200 m (2 mi)	Up to 3200 m (2 mi)	Same
Transmit power output	63 mW (+18 dBm) Channel 26 max power is +1 dBm	79 mW (+19 dBm) Channel 26 max power is +8 dBm	Power on channel 26 is increased
Receive sensitivity	-101 dBm	-103 dBm	Better sensitivity
Operating current (transmit)	120 mA @ 3.3 V, +18 dBm	135 mA @ +3.3 V, +19 dBm	Comparable
Operating current (receive)	31 mA (Boost mode) 28 mA (Normal mode)	17 mA	Improved
Supply voltage	2.7 – 3.6 V	2.1 - 3.6 V	Larger voltage range
FCC ID	MCQ-PS2C	MCQ-XBEE3	Customer will need to change the label on the end product to show the appropriate regulatory ID for the XBee 3
Industry Canada (IC) ID	1846A-PS2CSM	1846A-XBEE3	

Part number migration guide

The following table shows which Digi XBee 3 Zigbee 3.0 module to migrate to depending on which XBee/XBee-PRO ZB (S2C) module you are currently using.

For the latest list of available XBee 3 Zigbee modules, see the [XBee 3 Zigbee Part Numbers & Accessories](#) page

Legacy part number migration

Legacy part number	Description	Migrate to
XB24CZ7SIT-004	XBee 3, 2.4 GHz ZB 3.0, SMA Ant, TH MT	XB3-24Z8ST-J
XB24CZ7UIT-004	XBee 3, 2.4 GHz ZB 3.0, U.FL Ant, TH MT	XB3-24Z8UT-J
XB24CZ7PIT-004	XBee 3, 2.4 GHz ZB 3.0, PCB Ant, TH MT	XB3-24Z8PT-J
XBP24CZ7SIT-004	XBee 3 PRO, 2.4 GHz ZB 3.0, SMA Ant, TH MT	XB3-24Z8ST
XBP24CZ7UIT-004	XBee 3 PRO, 2.4 GHz ZB 3.0, U.FL Ant, TH MT	XB3-24Z8UT
XBP24CZ7PIT-004	XBee 3 PRO, 2.4 GHz ZB 3.0, PCB Ant, TH MT	XB3-24Z8PT
XB24CZ7RIS-004	XBee 3, 2.4 GHz ZB 3.0, RF Pad Ant, SMT	XB3-24Z8RS-J
XB24CZ7UIS-004	XBee 3, 2.4 GHz ZB 3.0, U.FL Ant, SMT	XB3-24Z8US-J
XB24CZ7PIS-004	XBee 3, 2.4 GHz ZB 3.0, PCB Ant, SMT	XB3-24Z8PS-J
XBP24CZ7RIS-004	XBee 3 PRO, 2.4 GHz ZB 3.0, RF Pad Ant, SMT	XB3-24Z8RS
XBP24CZ7UIS-004	XBee 3 PRO, 2.4 GHz ZB 3.0, U.FL Ant, SMT	XB3-24Z8US
XBP24CZ7PIS-004	XBee 3 PRO, 2.4 GHz ZB 3.0, PCB Ant, SMT	XB3-24Z8PS

Micro form factor - New to XBee 3

Part number	Description
XB3-24Z8RM-J	XBee 3, 2.4 GHz ZB 3.0, RF Pad Ant, MMT
XB3-24Z8UM-J	XBee 3, 2.4 GHz ZB 3.0, U.FL Ant, MMT
XB3-24Z8CM-J	XBee 3, 2.4 GHz ZB 3.0, Chip Ant, MMT
XB3-24Z8RM	XBee 3 PRO, 2.4 GHz ZB 3.0, RF Pad Ant, MMT
XB3-24Z8UM	XBee 3 PRO, 2.4 GHz ZB 3.0, U.FL Ant, MMT
XB3-24Z8CM	XBee 3 PRO, 2.4 GHz ZB 3.0, Chip Ant, MMT

Pin signals

The Digi XBee 3 Zigbee 3.0 is available in three different form factors, Surface Mount (SMT), Through Hole (TH), and the newly introduced XBee 3 Micro (MMT). The SMT and TH versions are pin compatible with existing XBee/XBee-PRO ZB (S2C) SMT and TH hardware. This hardware is drop-in replaceable. In order to fit all necessary pin connections on the XBee 3 Micro, three pins on the SMT were removed and the remaining pins were shifted. These pins were unused on the SMT module. These pins were unused on the SMT module. See the [XBee 3 Hardware Reference Manual](#) for more information.

Configuration

Using XCTU, you can load the appropriate firmware to fit your current needs within the regulatory guidance of the region of deployment. See the [XBee 3 Zigbee User Guide](#) for more information.

Digi XBee 3 Zigbee 3.0 functional migration considerations

The following enhancements have been made to the Digi XBee Zigbee firmware for the XBee 3 platform:

Hardware and I/O considerations

Pin signals

Digi XBee 3 is available in three different form factors: Surface Mount (SMT), Through Hole (TH), and the newly introduced XBee 3 Micro (MMT).

The SMT and TH versions are pin compatible with existing XBee/XBee-PRO (S2C) SMT and TH hardware. This hardware is drop-in replaceable.

In order to fit all necessary pin connections on the XBee 3 Micro, three pins on the SMT were removed and the remaining pins have been shifted. These pins were unused on the SMT module. See the [XBee 3 Hardware Reference Manual](#) for more information.

ADC voltage reference and resolution

The default ADC voltage reference changed from 1.2 V to 1.25 V. The ADC internal voltage reference can be set to 1.25 V, 2.5 V or VDD using the **AV** command.

The VREF pin from the XBee Series 1 is not supported by the XBee 3 hardware and has been removed from the Micro (MMT) form factor.

The ADCs on the XBee 3 are 10-bit when sampled from the XBee application (**IS, IR, IC**), if sampled through MicroPython, the resolution is increased to 12-bit.

Overvoltage detection

An overvoltage 0x8A modem status frame with a 0x0D status byte will warn the user of VCC input voltages exceeding the maximum rated 3.6 Volts with a 0.1 Volt margin. API mode (**AP** set to **1** or **2**) must be enabled to see this status message. When an overvoltage occurs the module will continue to operate with the RF power limited to max value of **PL = 3** to meet FCC requirements.

Module temperature

The **TP** command (module temperature) is available on both Pro and Non-Pro variants. On the S2C, this command was only available on the PRO variant.

Boot time

The boot time of the XBee 3 Zigbee module has increased compared to the previous XBee S2C Zigbee. This is due to enhanced functionality compared to the previous hardware platform as well as a secure boot operation.

Measured time from power-on to CTS asserting:

- XBee S2C Zigbee: ~75 ms
- XBee 3 Zigbee: ~290 ms

PWM output

The RSSI PWM period on the S2C was 200 μ S, this has been changed to match other XBee firmwares and now outputs a signal with a 64 μ S period. The **M0** and **M1** commands can be used to output a fixed duty cycle PWM signal on **P0** and **P1** if configured as a PWM output.

SPI pins - non-peripheral behavior

On the SMT and Micro (MMT) form factors, the SPI lines (**P5, P6, P7, P8, P9**) can now be set as digital output High and Low.

UART considerations

UART parity

The XBee 3 802.15.4 supports the following serial communication parity bit modes:

- No parity bit (**NB** = 0)
- Even parity bit (**NB** = 1)
- Odd parity bit (**NB** = 2)

Support for mark parity has been removed.

Expanded baud rate

The XBee S2C only supported standard baud rates up to 230400. For the XBee 3, standard UART baud rates 460800 (**BD** = **0x9**) and 921600 (**BD** = **0xA**) have been added.

When setting a custom baud rate, **BD** now accepts a value up to 0x0EC400 (967680 baud).

Maximum payload command (**NP**)

The XBee 3 has expanded support for the **NP** command compared to previous XBee Zigbee modules. When operating in Transparent Mode (**AP** = **0**), the **NP** command returns the maximum size of a non-fragmented payload based on current configuration (**EE**, **DH+DL**, and **TO** are considered). On the S2C, **NP** would return a fixed 84-bytes, which represents an encrypted unicast. In other operating modes (API and MicroPython), **NP** returns a fixed 255 byte maximum.

Serial break upon boot

If a serial break signal is sent during boot or reset, the module will enter command mode. If the module is configured for API operation, modem status API frames are suppressed and will not be output.

The CTS line will assert while in serial-break initiated command mode even if CTS is disabled (**D7** = **0**). Previously, CTS would remain disabled when entering command mode via a serial-break.

Sleep considerations

Cyclic Sleep with Pin Wake

The behavior of Cyclic sleep with pin wake (**SM** = 5) has been updated for XBee 3. While nDTR is deasserted (high), the module will operate in a cyclic sleep pattern. If nDTR is asserted (low), the module will wake and remain awake until the pin is deasserted. If nDTR is deasserted momentarily, the module will minimally wake for a period defined by the **ST** parameter.

Sleep Request operation

When configured for pin sleep (**SM** = 1) or cyclic sleep with pin wake (**SM** = 5), the DIO8/DTR/sleep_request (**D8**) line can only be used to control sleep when configured as a peripheral (**D8** = 1). On the S2C, the **D8** line could be used for sleep control regardless of the pin's configuration (e.g. DTR could still be used, even if the line is disabled).

RF considerations

Expanded channel selection

The IEEE 802.15.4 standard allows for 16 channels to be used for communication: from 2.405 GHz (Channel 11) through 2.480 GHz (Channel 26). On the previous XBee-PRO S2 and S2B, the range of available channels (via the **SC** and **CH** commands) was restricted on the PRO variant. This restriction is alleviated on the S2C and XBee 3, all 16 channels are available for use regardless of the variant.

Expanded power cap on channel 26

The power cap on IEEE 802.15.4 channel 26 has been increased on XBee 3 and restrictions on the coordinator have been alleviated.

On the XBee S2C, output power on channel 26 is capped to +3 dBm for all device roles. Additionally, Including channel 26 in the scan channel mask (**SC**) of the coordinator would reduce the output power on all channels to +3 dBm.

The power cap on channel 26 of the XBee 3 is increased to +8 dBm. Including channel 26 in the scan channel mask has no impact to other channels. The default value for **SC** is 0x7FFF (Channels 11 through 25).

Display output power and boost mode

The **PP** AT Command will return the operating power level of the device in dBm based on the current operating configuration. On the previous S2C, **PP** would return the maximum power at **PL** = 4, regardless of the configuration and was only useful in identifying whether the module is a Pro or Non-PRO variant.

Boost Mode (**PM**) is no longer available, as both the Pro and Non-PRO variants of the XBee 3 hardware have enhanced output power and receive sensitivity.

LQI calculations

Modules prior to the XBee3 use a different scale to represent LQI (Link Quality Indicator). On the S2C, the LQI curve is more flat and trends towards the top of the scale; where the LQI curve on the XBee 3 is linear and lower scale. As a result, if operating in a network with a mixture of XBee 3 and S2C modules, the S2C modules will have higher priority when determining route costs.

An LQI compatibility mode was introduced in XBee 3 Zigbee version 1009, which can optionally have the XBee 3 operate with a similar LQI curve as the S2C. **C8** bit 4 (**C8** | 0x10) on XBee 3 enables the LQI

compatibility mode. Networks that contain a mix of XBee3 Zigbee and legacy XBee Zigbee modules should enable this feature.

Enabling or disabling LQI compatibility causes all current parameters to be written to persistent storage and the module restarts; this is equivalent to issuing **WR** and **FR** commands. No modem status is generated, however CTS will also de-assert during this period, so flow control is advised. If hardware flow control is not being used, a 1 second delay after exiting Command mode (or applying changes if using API) may be necessary to avoid data loss.

Zigbee network considerations

The Digi XBee 3 Zigbee 3.0 module was designed to provide support for the Zigbee 3.0 specification. Some of the default configurations have changed to comply with Zigbee 3.0 requirements. See the [XBee 3 Zigbee User Guide](#) for details.

End Device timeout

On the S2C, the parent node determines how long an end device exists in the child timeout table. The timeout value was based on the **SP** and **SN** parameters on the parent node.

With XBee 3, the end device controls this timeout value. A new **ET** command (which is only set on an End Device) sets the child table timeout when it joins its parent. The timeout is a minimum of 2 minutes, but can be set as long as 273 hours.

Out-of-band commissioning

Install Codes are supported on XBee 3. In order to read the install code from a module, query the **I?** command. This install code can be used during out-of-band commissioning by deriving a join key based on install code. See the user guide for more information and examples.

Enable Joiner Global Link Key (**DC** bit 0) has been removed for Zigbee 3.0 security, and this bit now enables deriving a link key based on the install code for joining devices.

When operating with a centralized trust center, the **KT** command lets you set the Trust Center link key registration timeout. This dictates how long an entry will persist in the transient link key table.

Network Manager

In a Distributed Trust Center configuration (**EO**=0), the coordinator role is deprecated. The network is formed by a router, but it will operate as a 'Network Manager'; in most circumstances, this device role is equivalent to a coordinator and can be treated as such.

If operating with a Distributed Trust Center, when a joining device sends a Device Announce, the network manager (**CE** = 1) will respond by broadcasting a Manager Update. This broadcast is what the joining device uses to correlate the reserved 0 address to the network manager's actual address.

Device Options

The options in the **DO** and **DC** commands have been rearranged or deprecated. **DC** is now primarily focused on the behavior of joining devices. Refer to the release notes or command options in XCTU for more information.

The **DO** command now defaults to 0x40 to enable a high RAM concentrator for use with source routing. Use this setting for networks of 40 nodes or less. When using Many-to-One and Source routing (**AR**<0xFF), routes will be stored on the module instead of requiring the use of an external micro to store route records. Concentrator mode is only enabled when **AR** is set to less than 0xFF; to disable concentrator mode and revert to AODV routing, set **AR** = 0xFF.

PAN ID conflict

The CR command is used to determine how many PAN ID conflicts must be detected in a 1 minute period before a new PAN will be formed. On XBee 3, the ability to disable PAN ID change due to a conflict has been added. Setting **CR=0** on XBee 3 will still cause a PAN ID conflict to be detected (a 0x42 modem status will be emitted if this occurs), but a PAN ID change will not be triggered. On S2C, setting **CR=0** would use the default value of 3 instead.

Security considerations

Digi makes it easy to find the right level of security for your specific application, ranging from a completely open and unencrypted network, to a high security model with out-of-band commissioning. The Zigbee 3.0 standard default requires a higher security model than what is currently default on the XBee/XBee-PRO ZB (S2C). In order to better support Zigbee 3.0, the default configurations have changed.

Join window is not persistently open

Zigbee 3.0 does not support an open joining model. To meet this requirement, the **NJ** command has a new default setting of **NJ=0xFE**. This generous joining window still allows other devices to join to the network, but the join window will close after 254s. The join window can be reopened again at any time by pressing the commissioning button twice, or issuing a **CB2** AT Command.

To keep the join window open indefinitely, you must explicitly set **NJ = FF**.

Join Window indicators

On the XBee 3, when the Zigbee Network Join Window is opened, the Associate LED will blink rapidly (100ms blink rate) to indicate that joining is allowed. This can be useful when deploying networks to identify if a join attempt will be successful. This can also be useful in visually identifying potential vulnerabilities in a normally closed network (e.g. a device is erroneously allowing joining due to misconfiguration or recent power cycle).

If the device is operating in API mode (**AP = 1** or **2**), [Modem Statuses](#) will be emitted when the join window opens and closes:

- 0x43 - Open Join Window
- 0x44 - Closed Join Window

Centralized Trust Center

Once encryption is enabled via the **EE=1** command, the level of security employed will primarily depend on the **EO** setting. The Digi XBee 3 Zigbee 3.0 default for **EO** has changed to 2, which enables a Centralized Trust Center for key management.

The default for XBee/XBee-PRO ZB (S2C) is **EO=0**, which is a Distributed Trust Center model.

XBee S2 and S2B modules have limited capabilities when used in a Centralized Trust Center network. These legacy ZigBee modules are able to associate and join the secure network, but will not open the join window to adjacent devices if the window was opened from the trust center. It's recommended to utilize Distributed Trust Center if interoperating with S2 or S2B modules.

XBee Secure Session

Secure Session is an extension to Digi TrustFence that was introduced on XBee 3 Zigbee in version 1008. Secure Session allows XBee modules to create an end-to-end communication channel that can be used to securely send data and perform authorized remote configuration. Authentication is provided through the [SRP protocol](#), the same authentication method used by BLE. When a Secure Session is successfully established, the SRP Client can send encrypted data packets ([AES-128](#)) to the SRP Server.

See the [user guide](#) for more information on how to secure devices against insecure remote access.

Firmware update considerations

XBee file system

XBee 3 Zigbee RF Module firmware versions 1006 and later include support for storing files in internal flash memory. Through the XBee application, the file system is accessed through the **FS** command, however the file system is primarily used to support MicroPython applications. XCTU has full support for local and remote file system access and can be used to generate and sign

FOTA (firmware over-the-air) updates are stored in the same memory location as the file system. Initiating an OTA update will erase the contents of the file system. A bundled file system image can be sent over the air using the same mechanism as FOTA updates; this should be utilized in order to restore device operation after a firmware update is completed. In order to allow remote images to be uploaded, a File system public key (**FK** command) must be set on the target device and the bundled image signed before it can be validated and applied by the remote node. To ensure unauthorized code cannot be arbitrarily uploaded to devices on the network, the **FK** command must be set locally.

OTA firmware update process

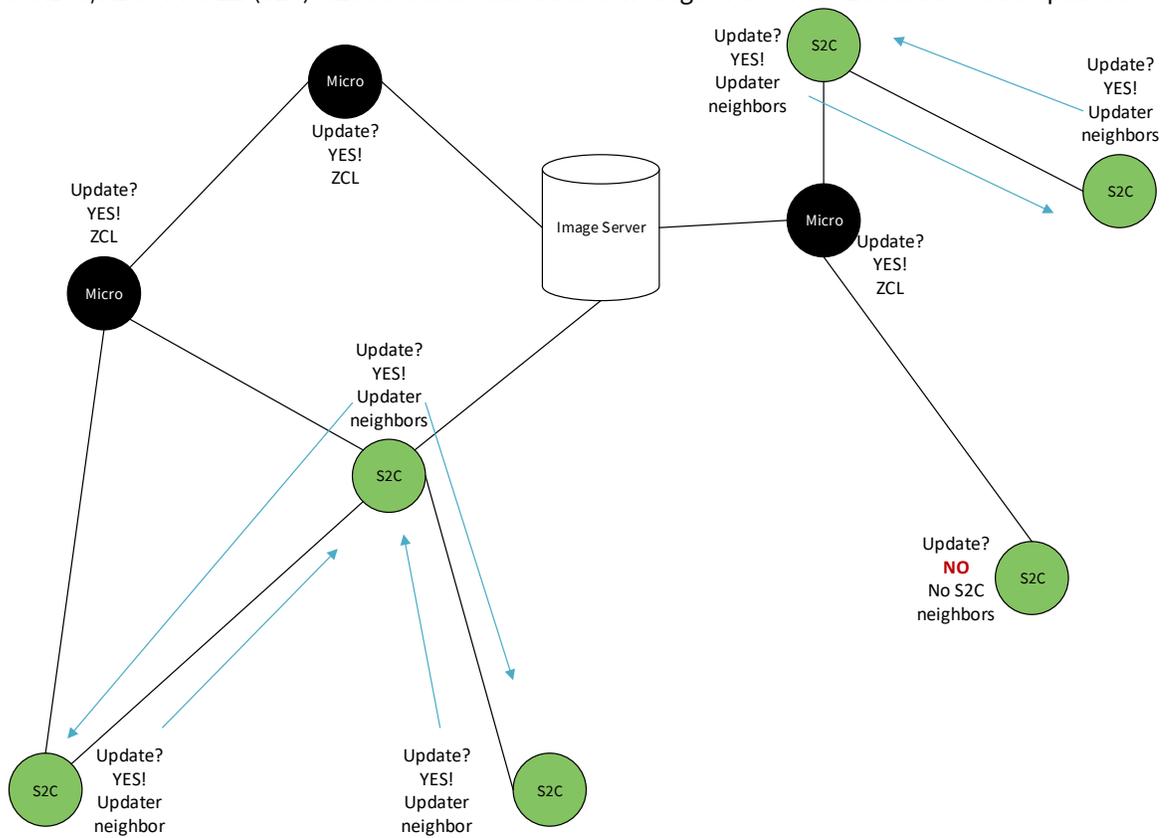
The firmware update process has changed on the Digi XBee 3 Zigbee 3.0. The XBee/XBee-PRO ZB (S2C) module required a source, updater, and target node. Under certain circumstances, nodes could be put in bootloader mode, and were therefore unavailable on the network. Additionally, if the firmware upload was interrupted at any point in the update process, the target module would then need to be "recovered". This can be very taxing on a network, especially across multiple hops.

The FOTA update process for the Digi XBee 3 Zigbee 3.0 module is improved over the S2C. First, the firmware update requires only the use of a server (node sending the firmware file), and a client node (node receiving the firmware file). The firmware image is sent in blocks using standard Zigbee Cluster Library (ZCL) frames as described in [Zigbee document 07-5123-06](#) chapter 11. These frames are supported using the 0x11 Explicit Transmit Frame. The client device never goes offline. The image is simply stored in an internal flash slot of the module's memory. Note that this slot is utilized by the XBee file system, the act of initiating an FOTA update will irreversibly erase the file system. Once the entire firmware file has been uploaded, the client can switch to the new firmware image. If at any point in the process the transfer was interrupted, the image will simply not pass a security check and the module will not boot into the new image.

The radio serving up the firmware image can be either a Digi XBee 3 Zigbee 3.0 or XBee/XBee-PRO ZB (S2C). However, since the XBee/XBee-PRO ZB (S2C) requires that another XBee/XBee-PRO ZB (S2C) be a nearest neighbor to act as the updater node, there is some limitation as to how nodes can be updated in a mixed network.

The image below describes how it is determined whether nodes in a mixed network arrangement can be updated from a single firmware image server. The image server can be either Digi XBee 3 Zigbee 3.0

or XBee/XBee-PRO ZB (S2C). S2C modules must be within range of another S2C module to be updated.



Security

Bootloader update support

The bootloader of the XBee 3 can be updated in addition to the XBee application. The bootloader update can be performed serially or over the air. When the bootloader is updated serially, the XBee application is erased and must be reinstalled. If updating from bootloader version 118 or earlier to version 166 or newer, the memory layout was updated in order to support the file system. In this instance, device configuration will be lost. If running version 166 or newer, when performing a bootloader update, the device configuration is retained. As long as the same firmware type (e.g. Zigbee to Zigbee) is installed and ran after the bootloader update, the device configuration will be retained.

The bootloader version can be read using the **VH** command. If using XCTU to update your device, you will be prompted to update the bootloader if an update is needed. The bootloader can never be downgraded.

The bootloader can be updated over the air if the target device is running application version 1005 and bootloader version 166. This is done by performing an FOTA update using a combined image that contains the XBee application and bootloader; the image type for this is an *.otb file format.

Configuration retention with AT Command invoked bootloader

On the S2C, when using the **%P** AT command to invoke the bootloader, if a parameter value of 0x5441 is not provided, then configuration is not retained through the subsequent update and the device will boot into a factory default state. On XBee 3, the additional parameter is not required, and configuration will always be retained if it is possible to do so.

Additionally, the **%P** command is now documented in the user guide. This command cannot be executed remotely in order to avoid accidental soft-bricking of remote devices.

Other considerations

Custom defaults

The XBee 3 supports custom defaults. This allows you to specify the parameter values that are loaded into configuration when defaults are restored using the **RE** command or 4-button presses of the commissioning button.

On the S2C, in order to facilitate devices remaining on the network through the restoration of defaults, the **KY** value is not restored when defaults are loaded (either through the **RE** command or commissioning button [**CB4**]). In order to provide equivalent support on the XBee 3, it's encouraged to save encryption keys as a custom default.

Enhanced XCTU support

To improve usability within XCTU, AT commands have been rearranged and additional categories have been created.

Legacy X-CTU (5.2.8.10 and older) can be used for serial firmware updates only; no bootloader update or module configuration is available.

Future updates

For the most up-to-date information on what features and enhancements have been added in the XBee software, refer to the release notes that are included with each software update.