Digi XBee 3® 802.15.4

RF Module

Migration Guide

Contents

Introduction

Digi has updated and ported our XBee 802.15.4 firmware from the XBee/XBee-PRO 802.15.4 (S2C) hardware based on the SiLabs EM357 SoC, to the Digi XBee 3 (Micro) hardware based on the SiLabs EFR32 SoC.

This guide assists 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 3 802.15.4 introduces some new features such as:

- Addition of the "Micro" (MMT) form factor
- 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
- Increased power on channel 26 on the PRO and removal of the power cap on channel 26 for the 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 I^2C through MicroPython
- SRP authenticated remote access (Secure Session)

Specification considerations

Specification comparison between the XBee/XBee-PRO 802.15.4 (S2C) and the new Digi XBee 3 802.15.4.

Low-Power (non-PRO) variant

Considerations	Legacy XBee 802.15.4 (S2C)	New Digi XBee 3 802.15.4	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

Considerations	Legacy XBee 802.15.4 (S2C)	New Digi XBee 3 802.15.4	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 802.15.4	New Digi XBee 3 802.15.4 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 3 802.15.4 to migrate to depending on which XBee/XBee-PRO 802.15.4 (S2C) module you are currently using.

Digi 802.15.4 is initially only available in the Micro form factor, however the XBee 3 with Zigbee firmware is available in a wide variety of form factors. The software can be updated to Digi 802.15.4 using a variety of options (contact sales or support for more information).

For the latest list of available XBee 3 802.15.4 modules, see the XBee 3 802.15.4 Part Numbers & Accessories page.

Legacy part number migration

S1 Part number	S2C part number	Description	Migrate to
XB24-API-001	XB24CAPIT-001	Digi XBee 3, 2.4 Ghz ZB 3.0, PCB Ant, TH MT	XB3-24Z8PT-J
XBP24-API-001	XBP24CAPIT-001	Digi XBee 3 PRO, 2.4 Ghz ZB 3.0, PCB Ant, TH MT	XB3-24Z8PT
XB24-ASI-001	XB24CASIT-001	Digi XBee 3, 2.4 Ghz ZB 3.0, SMA Ant, TH MT	XB3-24Z8ST-J
XBP24-ASI-001	XBP24CASIT-001	Digi XBee 3 PRO, 2.4 Ghz ZB 3.0, SMA Ant, TH MT	XB3-24Z8ST
XB24-AUI-001	XB24CAUIT-001	Digi XBee 3, 2.4 Ghz ZB 3.0, U.FL Ant, TH MT	XB3-24Z8UT-J
XBP24-AUI-001	XBP24CAUIT-001	Digi XBee 3 PRO, 2.4 Ghz ZB 3.0, U.FL Ant, TH MT	XB3-24Z8UT
XB24-AWI-001	XB24CAWIT-001	XBee 802.15.4 Wire whip	N/A
XBP24-AWI-001	XBP24CAWIT-001	XBee-Pro 802.15.4 wire whip	N/A
	XB24CARIS-001	Digi XBee 3, 2.4 Ghz ZB 3.0, RF Pad Ant, SMT	XB3-24Z8RS-J
	XBP24CARIS-001	Digi XBee 3 PRO, 2.4 Ghz ZB 3.0, RF Pad Ant, SMT	XB3-24Z8RS
	XB24CAPIS-001	Digi XBee 3, 2.4 Ghz ZB 3.0, PCB Ant, SMT	XB3-24Z8PS-J
	XBP24CAPIS-001	Digi XBee 3 PRO, 2.4 Ghz ZB 3.0, PCB Ant, SMT	XB3-24Z8PS
	XB24CAUIS-001	Digi XBee 3, 2.4 Ghz ZB 3.0, U.FL Ant, SMT	XB3-24Z8US-J
	XBP24CAUIS-001	Digi XBee 3 PRO, 2.4 Ghz ZB 3.0, U.FL Ant, SMT	XB3-24Z8US

Micro form factor - New to XBee 3

Part number	Description
XB3-24ARM-J	XBee 3, 2.4 GHz, 802.15.4, RF Pad Ant, MMT
XB3-24AUM-J	XBee 3, 2.4 GHz, 802.15.4, U.FL Ant, MMT
XB3-24ACM-J	XBee 3, 2.4 GHz, 802.15.4, Chip Ant, MMT
XB3-24ARM	XBee 3 PRO, 2.4 GHz, 802.15.4, RF Pad Ant, MMT
XB3-24AUM	XBee 3 PRO, 2.4 GHz, 802.15.4, U.FL Ant, MMT
XB3-24ACM	XBee 3 PRO, 2.4 GHz, 802.15.4, Chip Ant, MMT

Digi XBee 3 802.15.4 functional migration considerations

The following enhancements have been made to the Digi XBee 802.15.4 firmware for the XBee 3 platform:

Hardware 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.

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 device will continue to operate with the RF power limited to maximum value of **PL**=**3** to meet FCC requirements.

Detection

An overvoltage 0x8A modem status has been added to warn the user of VCC input voltages exceeding the maximum rated 3.6 Volts. API mode—**AP** is set to **1** or **2**—must be enabled to see this status message.

Boot time

The boot time of the XBee 3 802.15.4 module has increased compared to the previous XBee S2C 802.15.4. 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 802.15.4: ~65 ms
- XBee 3 802.15.4: ~260 ms

I/O considerations

Enhanced I/O pin support

Due to the wide-sweeping changes made to I/O on the XBee 3 802.15.4 firmware, please refer to the I/O support portion of the user guide for more information on compatibility and how to use the enhanced I/O support: https://www.digi.com/resources/documentation/digidocs/90002273/Default.htm Highlights are included below:

- Every I/O line (**D0** through **D9**, **P0** through **P9**) can now be set as a Digital Output high (4) or low (5).
- XBee 3 802.15.4 now has support for up to 15 Digital Inputs.
- The number of analog inputs is unchanged from the S2C 802.15.4. The four 10-bit ADC lines are **D0** through **D3** when set to 2.

- **D0** through **D9** and **P0** through **P4** can be set as Digital Inputs for I/O sampling and/or Digital I/O line passing.
  - In order to take advantage of these inputs for sampling, **AO** must be set to 0 or 1 on the sampling radio. The receiving radio must be an XBee 3 in order to interpret the enhanced I/O sample data packet.
  - The API frame that gets output on the receiver is a 0x92 API frame when configured in this way.
  - S1 and S2C compatible support is enabled by default (the **AO** command is set to 2) which will allow seamless integration of the XBee 3 into a mixed network or application that was designed for these devices. This does, however, restrict the digital inputs to **D0** through **D8**.

Expanded internal resistor coverage

Internal pull-up/down resistors are expanded to cover the entire range of I/O lines. On the S1 and S2C firmware, the **PR** and **PD** commands only allow for internal pull-up/down resistors to cover the first 8 I/O lines. This has been expanded to cover all 20 I/O lines on the XBee 3. Be aware that instead of an 8-bit value (max of 0xFF), **PR** and **PD** on the XBee 3 support a 32-bit range of up to 0xFFFFF.

I/O sample output behavior

The XBee S1 and S2C 802.15.4 modules would output API frames for incoming I/O samples even when operating in transparent interface mode (**AP** = 0). I/O sample frames on the XBee 3 are suppressed when in transparent mode. To output incoming I/O samples with the XBee 3 802.15.4, an API interface mode (**AP** = 1) or (**AP** = 2) must be used.

It is possible to suppress I/O sample frames when using I/O line passing if **IU** = 0. In this case if the source address of the incoming sample matches **IA** or (**IA** = 0xFFFF) then the I/O frame will be suppressed as its being used to affect I/O lines. On the S1 and S2C, the **IU** command would suppress all I/O samples regardless of whether they were being utilized for line passing or not.

ADC voltage reference and accuracy

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.

Input voltage sampling

The **%V** AT command has been added and detects the input voltage over the range of hardware supported input voltages (2.1V to 3.6V). If VCC input voltages exceed the maximum rated 3.6 volts, an overvoltage modem status will be continuously emitted (API mode must be enabled) and the module will be inoperable.

Module temperature sampling

The **TP** AT command has been added to return the current module temperature in degrees Celsius. This command is available on both the PRO and non-PRO variants.

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.

The UART lines (**P3** and **P4**) can now be configured for I/O (peripheral, digital input, or digital output).

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 S1 802.15.4 and XBee-PRO S2C 802.15.4 modules, the range of available channels (via the CH command) was restricted on the PRO variant. This restriction is alleviated on the XBee 3 and all 16 channels are available for use regardless of the variant.

If you are designing an application that will be interoperating with legacy S1 and/or S2C PRO modules, the **CH** parameter on the XBee 3 needs to be within 0x0C and 0x17 to communicate.

Clear Channel Assessment

CCA (clear channel assessment) can now be disabled by setting the **CA** parameter to 0. Doing so will reduce latency in noisy environments at a risk of data loss and causing interference.
The CCA threshold is set upon device initialization. Any change made to the **CA** parameter value must be written to flash using the **WR** command and the written value will be used upon the next power cycle.

Display output power and boost mode

The **PP** AT Command will return the operating power level of the XBee 3 in dBm based on the current operating configuration.

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

Energy Detect and Active Scan

The Energy Detect (**ED**) and Active Scan (**AS**) commands no longer have adjustable scan durations, so the **SD** command has been removed. As such, the **ED** and **AS** commands no longer accepts a parameter to specify the scan duration.

The **ED** command in transparent mode (**AP** = 0) also now returns the detected energy levels delimited by commas instead of carriage returns (as was done on legacy products). This matches the output of **ED** on other XBee protocols. Remote **ED** AT commands are also now fully functional.

Some of the unused fields in the **AS** superframe have been populated with 0xFF by default. On the S1 and S2C, these unused fields are populated with a 0 value.

MAC retries and timing optimization

On the previous XBee-PRO S1 802.15.4 and XBee-PRO S2C 802.15.4 modules, if a unicast transmission fails, there are up to 3 MAC-layer retries that can occur. The **RR** parameter defines how many of these retry attempts should be taken.

For XBee 3, the default number of retries has been increased from 3 to 5. If an application for S2C is designed with a high **RR** value, it should be adjusted for the XBee 3 to reduce the amount of potential RF traffic. In addition, the timing of these retries has been fine-tuned for optimal performance in a high-traffic environment.

UART considerations

Maximum payload command (NP)

Due to the complexity of determining the maximum payload size, an AT command was included to help facilitate this. The **NP** command can be queried to determine what the maximum achievable payload size is based on current configuration.
Note that this command assumes long addressing is used, which means utilizing short addressing will slightly increase the payload size.

Enhanced API frame support

Additional API frame support has been added and is configured with the **AO** command. When **AO** is configured as either 0 or 1, this will output an API frame format that matches XBee DigiMesh and XBee Zigbee firmwares. This allows for easy migration from these other software releases to the XBee 3 802.15.4.
API support for the S1 and S2C is enabled by setting **AO** to 2. This is the default configuration of the XBee 3 802.15.4, which allows it to act as a drop-in replacement for existing deployments.

AO affects API frame output as follows:

AO value	Incoming data packet	Incoming I/O sample data
0	0x90 – Rx Frame	0x92 – I/O Sample
1	0x91 – Explicit Rx Frame	0x92 – I/O Sample
2 (default)	0x80 – 64-bit Rx Frame 0x81 – 16-bit Rx Frame	0x82 – 64-bit I/O sample 0x83 – 16-bit I/O sample

The XBee 3 802.15.4 also supports receiving 0x10 and 0x11 transmit request frames. These frames are identical to XBee DigiMesh and XBee Zigbee firmwares, providing an easy migration path to 802.15.4 from applications built for those protocols.

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**=0xA) and 921600 (**BD**=0xB) have been added.

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

UART Stop bits

It is now possible to specify the number of Stop bits used for incoming and outgoing UART frames. The **SB** command can be used to specify either one or two stop bits.

RS-485 support

RS-485 support can be enabled via the **D7** pin. When enabled, this will cause the CTS pin to assert high or low whenever data is transmitted on the UART, facilitating the half-duplex nature of RS-485.

Sleep considerations

Sleep Request operation

The **D8** pin can now be set as a peripheral (1) to provide pin sleep support. When configured for pin sleep (**SM**=1) or cyclic sleep with pin wake (**SM**=5), the DIO8/DTR/sleep_request 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).

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. Previously, asserting nDTR would only momentarily wake the module (wake for the configured **ST** period, then return to sleep).

Momentary wake

Momentary wake has been added to **D0** as a commissioning button option (**D0** = 1). Pressing the commissioning button on a sleeping module will wake the device for 30 seconds.

Wake for entire ST period every cycle

The bit field for **SO** has been updated to match other XBee protocols. Setting bit 8 (**SO** | 0x100) will now cause the XBee to stay awake for the complete **ST** time when cyclic sleep modes are enabled after the expiration of every **SP** period.

Indirect messaging limitation

SP determines the asynchronous cyclic sleep period, the same as S1 and S2C 802.15.4. However, on the XBee 3, the indirect messaging coordinator will not hold messages for longer than 65 seconds, even if **SP** * 2.5 > 65 seconds.

Firmware update considerations

XBee file system

XBee 3 802.15.4 RF Module firmware versions 2003 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 OTA firmware update process for the XBee 3 802.15.4 is different than the process on the S2C. The XBee S1 did not have OTA firmware update capabilities. When performing an OTA firmware update, both the server and client nodes must be of the same type (XBee 3 to XBee 3, S2C to S2C).
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 and will continue operating using the existing image.

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. 802.15.4 to 802.15.4) 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 2002 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.

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.

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.

Configuration checksum

A configuration CRC has been added to XBee 3. This provides a checksum that can be used to easily identify if devices are configured properly. Note that the checksum may change on your device between firmware versions.

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.