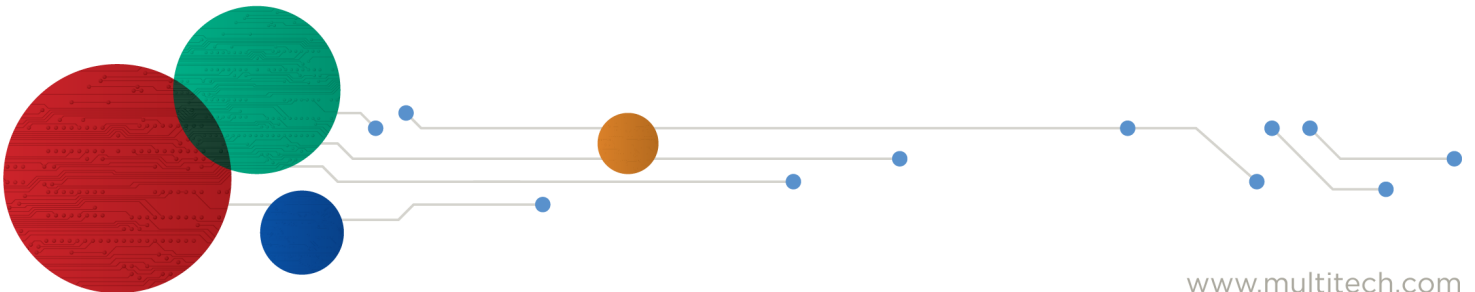




xDot[®] Developer Guide

for AT Commands



xDot Developer Guide for AT Commands

Models: MTMDK-XDOT-CN1-B10, MTMDK-XDOT-CN1-B14, MTUDK-XDOT-NA1-B10, MTUDK-XDOT-WW1-B10, MTXDOT-CN1-B10-TR-250, MTXDOT-CN1-B15-TR-250, MTXDOT-NA1-B10-TR-500, MTXDOT-NA1-B15-TR-500, MTXDOT-WW1-B10-TR-500, MTXDOT-WW1-B15-TR-500

Part Number:
S000820 Rev. 1.2

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Chapter 1 – Product Overview

Overview

The xDot (MTXDOT) is a programmable, low-power RF module that provides long-range, low bit rate M2M data connectivity to sensors, industrial and agricultural equipment, and remote appliances. The xDot is LoRaWAN® 1.0.4 capable communication up to 10 miles/15 km line-of-sight and 1-3 miles / 2 km into buildings using sub-GHz ISM bands in North America, Europe, and worldwide.

xDot Essential is a compact surface-mount device with enhanced security. It also includes a comprehensive AT command instruction set.

xDot Advanced has the features of xDot Essential plus internal memory, an Mbed enabled ARM® Cortex®-M4 processor, and Mbed™ compatible software library for developers to control, monitor, and bring edge intelligence to their Internet of Things (IoT) applications.

Note: If developing with Mbed, use *xDot Developer Kit Developer Guide for Mbed Developers (S000821)*.

xDot Developer Kit includes three USB developer boards with either xDot Advanced modules attached or three USB developer boards with xDot Essential modules attached.

*Actual distance depends on conditions, configuration, antennas, desired throughput, and usage frequency. In dense urban environments, a typical range is 1-2 miles.

Documentation Overview

This document includes:

- xDot Device Information: Mechanical drawings, specifications, safety and regulatory information, and other device-specific content for both xDot Essential and xDot Advanced.
- Developer Kit Information: Design considerations, schematics, and installation and operation information.

This current version of this manual is available at <https://multitech.com/product-manuals/>.

Note: If you have the xDot Advanced Developer Kit and wish to use Mbed, refer to the *xDot Developer Guide for Mbed Developers (S000821)*.

Related Documentation

- xDot AT Command Guide: (S000768) Includes details on the AT commands available for xDots.
- MultiTech Developer Site: This site includes information on using the Conduit with xDots. Go to www.multitech.net
- Documentation for related products, such as the Conduit gateways and LoRa accessory cards are available at <https://multitech.com/product-manuals/>

Product Build Options

Product	Description	Region
MTXDOT-CN1-B10-TR-250	xDot Advanced, UFL/TRC antenna. Tape and Reel, 250 pack.	China
MTXDOT-NA1-B10-TR-250	xDotAdvanced, UFL/TRC antenna. Tape and Reel, 250 pack.	North America
MTXDOT-WW1-B10-TR-250	xDotAdvanced, UFL/TRC antenna. Tape and Reel, 250 pack.	Worldwide
MTXDOT-CN1-B15-TR-250	xDot Essential, TRC antenna. Tape and Reel, 250 pack.	China
MTXDOT-NA1-B15-TR-250	xDot Essential, TRC antenna. Tape and Reel, 250 pack.	North America
MTXDOT-WW1-B15-TR-250	xDot Essential, TRC antenna. Tape and Reel, 250 pack.	Worldwide
Developer Kits		
MTMDK-XDOT-CN1-B10	xDot Advanced LoRa Developer Kit.	China
MTMDK-XDOT-NA1-B10	xDot Advanced LoRa Developer Kit.	North America
MTMDK-XDOT-WW1-B10	xDot Advanced LoRa Developer Kit.	Worldwide
MTMDK-XDOT-CN1-B14	xDot Essential LoRa Developer Kit.	China
MTMDK-XDOT-NA1-B14	xDot Essential LoRa Developer Kit.	North America
MTMDK-XDOT-WW-B14	xDot Essential LoRa Developer Kit.	Worldwide

Note: The complete product code may end in .Rx, where R is revision and x is the revision number. For example, MTXDOT-NA1-B10-TR-250.R1.

Important: Worldwide xDot models do not have a default frequency band. You must set the frequency band to use the device.

Developer Kit Package Contents

Your xDot Developer Kit includes the following:

Developer Board	3 - xDot Developer Boards with xDot modules attached.
Customer Notices	Quick Start Guide for each xDot Developer board.

Chapter 2 – Getting Started with the xDot Developer Kit

This example uses the xDot Developer kit, for more information on the Developer kit see Chapter 6. It ships with pre-installed firmware that supports AT Commands. For AT Commands, refer to the separate [xDot AT Command Reference Guide](#).

Two serial interfaces are available through the USB interface, one is used to send AT commands to the xDot and the other is for debug messages. Refer to [MTXDOT Specifications](#) for pin information.

To send AT commands to the xDot:

1. Plug the developer board into a USB port.
2. Open communications software, such as TeraTerm, Putty, or Minicom.
3. Set the following:
 - Baud rate = 115,200
 - Data bits = 8
 - Parity = None
 - Stop bits = 1
 - Flow control = Off

COM Port Enumeration by Operating System

xDots create an AT Commands port and a debug port.

Linux

The following COM ports are created on Linux systems:

- /dev/ttyACMx
- /dev/ttyACMy

Where x and y may be 0 and 1, 3, 4, etc.

The COM port with the lower number is the AT command port and COM port with the higher number is the debug port.

Windows

On Windows systems, COM ports appear in the Device Manager:

- Debug Port: USB Serial Device
- AT Command Port: XR21V1410 USB UART

Mac

On Mac systems, COM ports appear in the Device Manager as:

- /dev/cu.usbmodemx

Where x is a string of numbers and possibly letters, ending in a number.

The COM port with the lower number is the AT command port and the COM port with the higher number is the debug port.

AT Commands

- Once the above ports are setup, issue an AT<carriage return> on the AT command port and you should receive an OK response.
- See the [xDot AT Command Reference Guide](#) for a dictionary of the AT commands. In the AT command reference guide, you will also find a chapter with some examples demonstrating basic functions.
- See Appendix A of this manual for an example setup that ends with sending and receiving data using our LoRaWAN gateway and RadioBridge console.
- See Appendix B for Application recommendations.

Chapter 3 – Updating Firmware

Use one of the following methods to update xDot firmware:

- [Drag and drop firmware](#) onto the xDot on the developer board.
- [Ymodem over serial port](#) using the xDot bootloader either on the developer board or in the system.
- [In system/circuit programming](#) via SWD or JTAG.
- *[xDot Advanced only]* [Updating Firmware with FOTA](#) on the xDot either on the developer board or in the system.

Firmware Files

Firmware files for the xDot-ES are available at: <https://www.multitech.net/developer/downloads/#xdot-es>

Firmware files for the xDot-AD are available at: <https://www.multitech.net/developer/downloads/#xdot-ad>

Memory Map for Updating Firmware with an External Programmer

```
xDot ES / AD Memory Map
MAX32670
384K FLASH (0x60000) @ 0x10000000
160KB RAM (0x28000) @ 0x20000000
```

```
xDot ES Memory Map
FLASH Layout
Bootloader (64KB):      0x00000 - 0x0FFFF
Application: (256KB): 0x10000 - 0x4FFFF
Configuration (64KB): 0x50000 - 0x5FFFF
```

```
xDot AD Memory Map
FLASH Layout
Bootloader (64KB):      0x00000 - 0x0FFFF
Application: (320KB): 0x10000 - 0x5FFFF
```

Updating Firmware via Drag and Drop

To use the drag and drop method of updating firmware:

1. Plug the Developer Kit into a computer. A drive will be enumerated.
2. Wait for enumeration to complete.
3. Drag and drop the firmware file onto the enumerated drive on the device.

When the progress bar reaches 100%, the window closes and reopens once the update is complete.

Updating Firmware Using Ymodem

Make sure the firmware file has the bootloader removed and a CDC appended. You can use the `mtsmultitool` to remove the bootloader and append a CRC. Refer to: <https://pypi.org/project/mtsmultitool/>

To update firmware via ymodem in the xDot bootloader:

1. Enter the bootloader:
 - On the debug serial port, type any key on power up.
 - On the AT command port, on power up type the letters m t s.

You have 250 ms to enter each character.

2. At the bootloader command prompt, type upgrade.
3. Send the firmware file with CRC appended and bootloader removed via YModem.

Updating Firmware in the System

With the removal of R39, R42, R43, and R45 from the DK board and installation of R28, R29, and R36-38, the xDot on the DK board can be programmed via JP2 using a JTAG or SWD programming. Provide the same connections on a host board to support this programming option.

See Chapter 15 for more detail about in system programming.

Updating Firmware with FOTA

xDot Advanced only

Differential and Compressed Upgrade Files

Differential and compressed upgrade files can be used to reduce the size of firmware upgrades sent over-the-air (FOTA). Smaller files reduce the time required to deliver an update. Smaller FOTA sessions increase end-device battery life.

Creating Differential and Compressed Files

To package application firmware binaries for Dot devices with compression or deltas, use the mtsmultitool utility. The output is a binary file that can be sent to the bootloader over serial YModem or FOTA. For more details on the utility, see: <https://pypi.org/project/mtsmultitool/>

The utility requires Python v3.8 installed. To install the utility, open a command prompt and enter:

```
pip install mtsmultitool
```

Firmware Over the Air (FOTA) is a way to upgrade xDot end devices using multicast and file fragmentation packages defined in the LoRaWAN specification. FOTA allows the gateway to update the firmware on many xDots at once using multicast and error correction packets.

xDot Advanced includes flash memory for FOTA. Flash memory stores images for firmware updates.

File space is statically allocated. There is no traditional file system. The xDot reserves space for new application firmware, a backup of the current application, and an upgrade result file. A total of 436 KB (0x6A000 bytes) of free space is required.

Note: FOTA is enabled by default.

Conduit Gateway Configuration

1. In LoRaWAN > Network Settings:
 - a. Set LoRa Mode to Network Server.
 - b. Under LoRaWAN Network Server Configuration:

- i. Configure the channel plan, and frequency sub-band if applicable.
 - ii. Configure the xDot to match the conduit Network Mode and Join Delay.
2. In LoRaWAN > Key Management:
 - a. Configure Join Server > Location to Local Join Server.
 - b. Enable Local Network settings and configure the Network ID and Network Key.
 - c. Save settings and have the xDot join to the conduit.
3. In LoRaWAN > Operations:
 - a. In Operation Settings > Firmware Upgrade File select the file to FOTA.
 - b. Under Transmission Setup & Launch Date/Time Selection:
 - i. Configure the setup time and launch time. If the xDot is in class A mode, make sure there is enough time between setup and launch for a few uplinks to be sent to make sure setup packets are received by the xDot.

Note: FOTA can also be done using a Conduit with LENS.

To start the FOTA process, the Conduit sends two setup downlinks to the xDot:

1. First, the Conduit sends a multicast session setup request to the xDot.
2. The xDot responds with a multicast session setup answer.
3. The Conduit sends a fragmentation setup request.
4. The xDot responds by sending back a fragmentation setup answer.
5. Once the setup is complete, the xDot waits until the start of the multicast session.
6. At the start of the session, the xDot switches to class C with the specified data rate and frequency to receive the file fragments sent by the Conduit.

After the file fragments are sent, the Conduit starts sending parity fragments. At any point when the xDot is able to reconstruct the firmware file, the Cyclical Redundancy Check (CRC) is calculated, and the CRC message ID is sent in Class A. This could happen any time after the last fragment is sent to after the last parity is sent.

For details on the FOTA AT Commands, go to *xDot AT Command Reference Guide* (S000768).

FOTA Stages

A FOTA session has four stages:

1. [Session Setup](#)
2. [Fragmentation](#)
3. [Parity](#)
4. [Verification](#)

Session Setup

For a multicast session to work with class A devices, a start time must be agreed upon by the network server and each device. This requires the devices to synchronize their time with the server. These critical tasks are done during session setup.

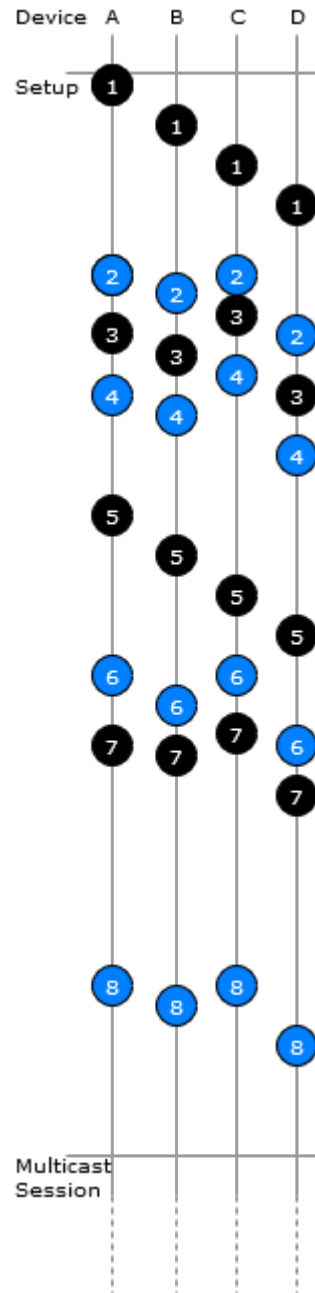
Class A devices must periodically send uplinks to open downlink windows making the time required to complete an operation setup directly tied to the frequency of device uplinks. For each device involved in the operation, some extra time should be added to the total setup time to account for latency in queuing each device's message.

Setup messages are sent up to 3 times. Worst-case timing for operation setup would be:

$$((3 * \text{device_uplink_period} * 2) + (\text{overhead} * \text{number_of_devices}))$$

The included diagram illustrates the events that occur during a best-case setup with no messages missed and well-timed device uplinks. Each device follows these steps:

1. FOTA operation queues Multicast setup message with network server.
2. Device sends an uplink.
3. Multicast setup message is downlinked to the device.
4. Device sends a multicast setup response.
5. FOTA operation queues fragmentation setup message.
6. Device sends an uplink.
7. Fragmentation setup is downlinked to the device.
8. Device sends a fragmentation setup response from device.



Fragmentation

During this stage, the device should only send uplinks as necessary, too many can cause excessive fragment loss. Applications on the device should not perform heavy processing activities during FOTA. Doing so can cause fragments to overlap and excessive fragment loss. The number of fragments required to send a file depends on the Data Rate. The device clears the file system to ensure enough free space to save updated firmware and a backup copy of the current firmware saved by the bootloader. User files are removed when the fragmentation session is set up.

Parity

Multicast messages are unconfirmed meaning some loss of fragments is expected. The device can recover a certain number of fragments through parity.

The xDot can tolerate up to 150 lost fragments.

Verification

Once a device completes its fragmented file, it calculates a CRC64 and sends a request to the server to verify the CRC. The server sends a response indicating if the CRC matches or not. If the CRC is verified, the device reboots and performs the upgrade. If the CRC does not match, the downloaded file is discarded.

Potential Problems

- If the xDot misses either setup message, the FOTA session will not be successful. The xDot attempts to receive both messages multiple times. If the xDot is unsuccessful, it resets the fragmentation sessions and multicast session.
- If the xDot does not receive a CRC response from the Conduit, it resets the fragmentation and multicast sessions and deletes the fragmentation file.
- The xDot can reset the multicast/fragmentation session at any time using AT+FOTA=2.
- When using AT+SLEEP, make sure to wake up the xDot before a scheduled FOTA session. Using AT+FOTA=3 will return the time in seconds before the FOTA session is scheduled to start.
- If AT+SLEEP is used during the FOTA session, the xDot will miss packets and the session will likely fail.
- The FOTA session sends down packets every 1.5 seconds (assuming no duty cycle) and parity packets every 3 seconds by default. For best results, MultiTech recommends users suspend all normal xDot operations until the FOTA session is complete.

Troubleshooting FOTA

The xDot must not sleep during FOTA.

Problem: xDot does not receive any file fragments.

Troubleshooting:

- The xDot must receive two setup messages for the FOTA session to work, fragmentation setup request, and multicast setup request.
 Verify if the xDot received the fragmentation setup request. This comes down on port 201. When the xDot receives this request, it sends an answer. Check the xDot debug log for *Sending Fragmentation Response*.
 After sending the fragmentation response, the xDot receives a multicast setup request. Check for this message on port 201. The xDot responds with a multicast setup answer. Check the xDot debug log for *Sending Multicast Response*.
- Make sure the xDot is in Class C at the start of the FOTA session (AT+DC). The xDot must also be awake and will not wake up to start the FOTA/Multicast session. The command AT+FOTA=3 displays the time before a FOTA session starts.
- Make sure the Conduit is sending the fragments by checking the Conduit logs in /var/log/log_fota*.

Problem: xDot cannot complete the FOTA session.

Troubleshooting:

- If the xDot misses too many packets, the FOTA session cannot be completed.

- If the xDot was able to reconstruct the file using parity fragments, it sends a CRC check to the Conduit. Check the xDot debug log for *Sending CRC*. If the Dot does not receive a response or the Conduit responds with CRC not correct, the xDot discards the file.

Problem: xDot fails to process parity fragments.

Troubleshooting:

- If the Conduit sends parity fragments faster than the xDot can process them, the xDot starts failing to properly receive the fragments. This results in failed MIC checks or the wrong address, which is noted in the xDot debug log.
- To correct this, increase the delay between parity fragments on the Conduit.

Problem: xDot is in an unexpected state.

Troubleshooting:

- If the xDot is in a bad or unknown state, use ATZ to reset the xDot and clear the multicast and FOTA states. AT+FOTA=2 also resets FOTA and Multicast states.

Troubleshooting FOTA on the Conduit

Problem: FOTA Session not starting.

Troubleshooting:

- Verify that there is not a current FOTA session. If there is no current FOTA session and a FOTA session will not start, reboot the Conduit.
- If the Conduit does not receive at least one response from an xDot, the FOTA session will not start. The process will go from SETUP (10%) to TEARDOWN (90%). Check the log (/var/log/log_fota*) to make sure the Conduit is receiving the setup answers.

Problem: FOTA Session not successful.

Troubleshooting:

- For a FOTA Session to be successful, the xDot has to be able to reconstruct the file. If the xDot misses too many packets, the FOTA session will not be successful and the xDot will not send a CRC to the Conduit.
- If the Conduit receives a CRC from an xDot check the FOTA log (/var/log/log_fota*) to make sure the CRC matches the Conduit and the CRC correct answer is sent back to the xDot. Check the xDot debug log to verify if the device received the CRC answer.

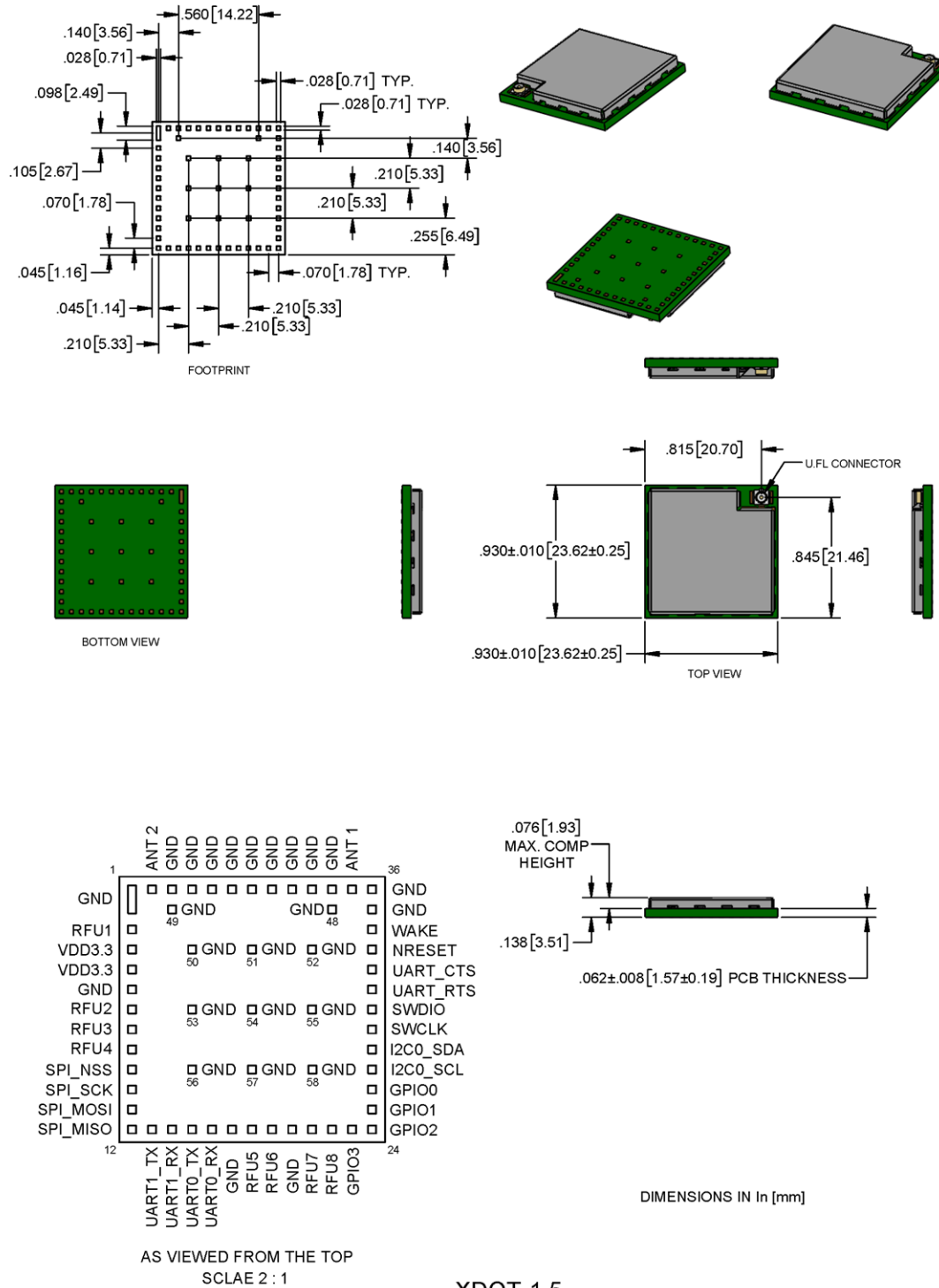
Problem: Stop FOTA Session / FOTA Session won't start (FOTA in progress) / Stop Multicast Session

Troubleshooting:

- To end a FOTA session that is in progress, send `ps -A | grep fota`. Find the PID associated with lora-fota (not lora-fota-demo). Then send `kill (pid of lora-fota)`.
- Also send `rm -r -f ~/.fota/`. Devices may be in Class C or Class A depending on the FOTA session status before it ended. Make sure to change the devices back to their appropriate class. Make sure the FOTA daemon is running by `/etc/init.d/fotad restart`.
- To end a Multicast session that is in progress, use `ps -A | grep mcm`. Find the PID associated with lora-mcm. Then use `kill (pid of lora-mcm)`. Also send `rm -r -f ~/.fota/`.
- Wiping out the .fota directory removes any scheduled future FOTA/multicast sessions that have not been setup.

Chapter 4 – Mechanical Drawings with Pinouts

xDot Mechanical Drawing



Note: The xDot development board uses a land pattern that matches the xDot land pattern in the previous image. All pads are 0.028 inches square except the large one, which is 0.098 inches x 0.028 inches.

Chapter 5 – Specifications and Pin Information

MTXDOT Specifications

Category	Description	
General		
Compatibility	LoRaWAN 1.1 specifications	
Interfaces	AT firmware	xDot-AD custom app
	AT UART (TX, RX, CTS, RTS)	Up to 19 digital I/O
	Debug UART (TX, RX)	I2C
	6 wake pin options	SPI
	Reset pin	6 wake pin options
	Programming interface	Reset pin
		Full UART
		Simple UART (RX & TX only)
		Programming interface
CPU Performance		
CPU	100 MHz	
CPU SRAM	160 KB	
CPU Flash	384 KB	
FOTA		
Max Clock	32 MHz	
Flash Memory	8 Mb <i>Advanced only</i>	
EEPROM	128 Kb <i>Advanced only</i>	
Physical Description		
Weight	0.0001 oz. (0.003g)	
Dimensions	Refer to Mechanical Drawings for Dimensions.	
RF Connectors		
-UFL Models	U.FL	
-TRC Models	Trace Connection (all models support a trace connection)	
Environment		
Operating Temperature	-40° C to +85° C	
Storage Temperature	-40° C to +85° C	

Category	Description
Humidity	20%-90% RH, non-condensing
Power Requirements ¹	

¹Operating range is 2.4-3.57V. When operating voltage is below 3.3V, radio power is affected as shown in the following table:

SX1262	+22 dBm	VBAT = 2.7 V -2dB
SX1262	+22 dBm	VBAT = 2.4 V -3dB

470 MHz ISM Band Specifications and Approvals

Category	Description
Radio Frequency	
ISM Bands	China: 470-510 MHz

470 MHz Receive Sensitivity

Spreading Factor	Receive Sensitivity (dBm)	Link Budget (dB)
7	-125	-131
8	-129	-135
9	-132	-138
10	-134	-140
11	-137	-143

868 MHz ISM Band Specifications and Approvals

Category	Description
Radio Frequency	
ISM Bands	Europe: 863-870 MHz
	United Kingdom: 863-870 MHz
Certifications and Compliance	
EMC	EU: EN55022 Class B
	EU: EN55024
	EU: CISPR 22:2008
Radio	EU: EN 300 220-1 V4.1:2012
	EU: EN 301 489-03 V1.6.1:2013
Safety	EU: IEC 62368-1 2 nd Edition
ROHS	EU: EN IEC 63000:2018

868 MHz Receive Sensitivity

Note: RFS_L125: RF sensitivity, Long-Range Mode, highest LNA gain, LNA boost, 125 kHz bandwidth using split Rx/Tx path.

Spreading Factor	Receive Sensitivity (dBm)	Link Budget (dB) ¹
5	-116	122
6	-118	124
7	-123	129
8	-126	132
9	-129	135
10	-132	138
11	-134.5	140.5
12	-137	143

¹Greater link budget is possible with higher gain antenna.

915 MHz ISM Band Specifications and Approvals

Category	Description
Radio Frequency	
ISM Bands	North America: US902-928 MHz
	Other Asia-Pacific: AS920-923 MHz ("AS1")
Certifications and Compliance	
EMC	US: FCC Part 15 Class B
	CA: ICES-003
Radio	US: FCC 15.247:2015
	US: FCC 15.109:2015
	US: FCC 15.107:2015
Safety	US: UL 60950-1 2nd Edition
	CA: cUL 60950-1 2nd Edition
	US: UL/cUL 62368-1 2nd Edition
	IEC 62368-1:2014

915 MHz Receive Sensitivity

Note: RFS_L500: RF sensitivity, Long-Range Mode, highest LNA gain, LNA boost, 500 kHz bandwidth using split Rx/Tx path.

Spreading Factor	Receive Sensitivity (dBm)	Link Budget (dB) ¹
5	-111	117
6	-112	118

Spreading Factor	Receive Sensitivity (dBm)	Link Budget (dB) ¹
7	-117	123
8	-120	126
9	-123	129
10	-126	132
11	-128.5	134.5
12	-131	137

¹Greater link budget is possible with higher gain antenna.

Electrical and Timing Characteristics

For electrical and timing characteristics, refer to the MAX32670 datasheet

<https://www.analog.com/media/en/technical-documentation/data-sheets/MAX32670-MAX32671.pdf>

Measuring the Power Draw

To measure the power draw on an xDot developer board:

1. Unplug the xDot developer board from the computer.
2. Connect the current meter across JP30 on the developer board.
3. Plug the xDot developer board back into the computer.
4. Set wake pin to WAKE, internal pulldown, rising edge trigger, AT+WP=6,2,1. The wake button on the xDot-DK will pull the pin high when pressed.
5. Set wake mode to interrupt, AT+WM=1.
6. Put the xDot to sleep, AT+SLEEP=0|1.
7. Put jumper across JP5.
Note: After this step, AT command and debug ports no longer work.
8. Measure the current draw.
9. Press the S2/WAKE button on the developer board to wake the xDot.

Power Draw

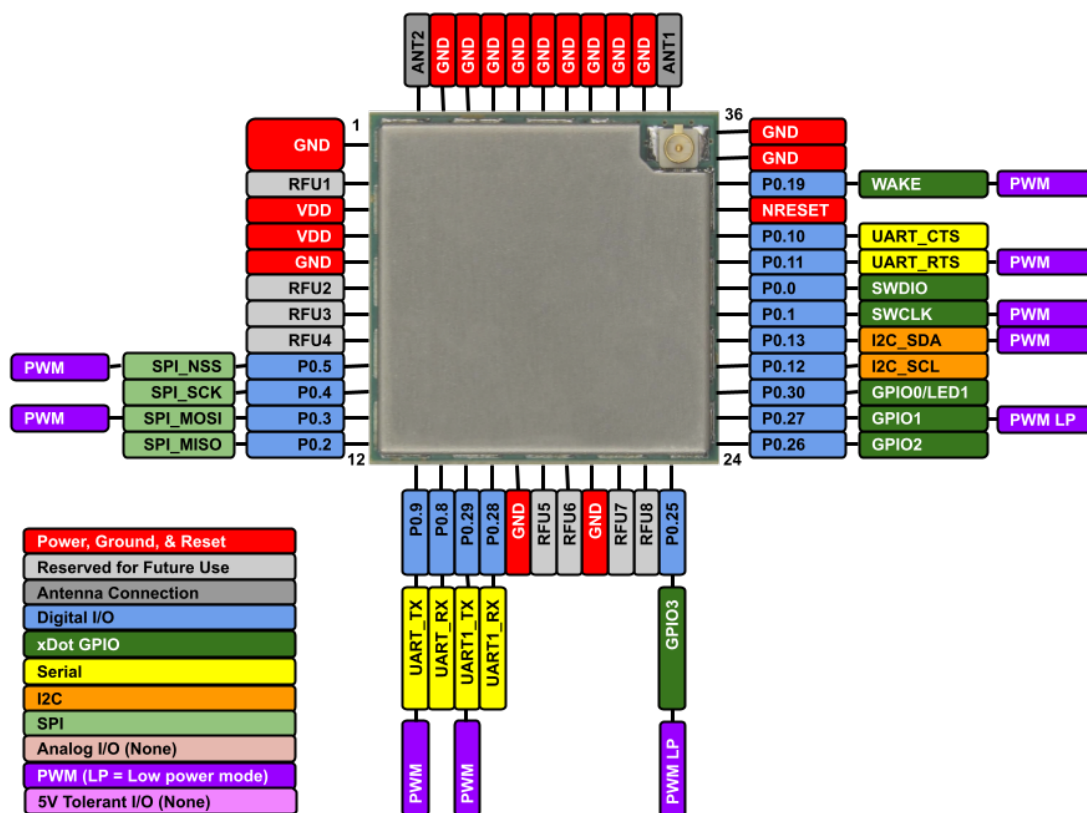
Note:

- Inrush charge is the highest observed value taken from five separate measurements. Power measurements are similar for all models.
- Power measurements are the same for packet sizes of 11 bytes and 53 bytes.
- Multi-Tech Systems, Inc. recommends that you incorporate a 10% buffer into the power source when determining product load.

Voltage	Standby Mode Current Sleep = 0, WM=1	Standby Mode Current Sleep = 0, WM=0	Stop Mode Current (Sleep =1), WM=0	Stop Mode Current (Sleep =1), WM=1	Idle Current Average	Spreading Factor Setting
3.3 V	1.0 uA	3.0 uA	7.7 uA	5.6 uA	4.4 mA	DR1 - SF9BW125

Peak Transmit Power at TXP = 2	Peak Transmit Power at TXP = 11	Peak Transmit Power at TXP = 21	Total Inrush Charge measured in MilliCoulombs (mC)	Total Inrush Charge DURATION during Powerup (INRUSH Duration)
24.3 mA	53.2 mA	111 mA	.029 mC	65 uS

Pin Information



Pin Information

Note:

- Using the mbed platform expands your pin functionality options.
- Pins are on a 0.07 inch grid, and are 0.028 inches square (except for upper left).
- The xDot is 0.045 x 0.045, board is 0.93 x 0.93.

xDot Pin Number	xDot Pin Name	MAX32670 Pin Number	MAX32670 Pin Name	MAX32670 Net Name
30	SWDIO	4	P0.0	SWDIO
29	SWDCLK	5	P0.1	SWDCLK
12	SPI_MISO	6	P0.2	SPI_MISO
11	SPI_MOSI	7	P0.3	SPI_MOSI

xDot Pin Number	xDot Pin Name	MAX32670 Pin Number	MAX32670 Pin Name	MAX32670 Net Name
10	SPI_SCK	8	P0.4	SPI_SCK
9	SPI_NSS	9	P0.5	SPI_NSS
N/A		10	P0.6	EEPROM_SE_I2C_SCL
N/A		11	P0.7	EEPROM_SE_I2C_SDA
14	UART_RX	20	P0.8	UART_RX
13	UART_TX	21	P0.9	UART_TX
32	UART_CTS	22	P0.10	UART_CTS
31	UART_RTS	23	P0.11	UART_RTS
27	I2C_SCL	24	P0.12	I2C_SCL
28	I2C_SDA	25	P0.13	I2C_SDA
N/A		26	P0.14	LORA_MISO
N/A		27	P0.15	LORA_MOSI
N/A		28	P0.16	LORA_SCK
N/A		29	P0.17	LORA_NSS
N/A		30	P0.18	RF_SW_CTRL
34	WAKE	31	P0.19	WAKE
N/A		1	P0.20	LORA_RESET
N/A		2	P0.21	LORA_BUSY
N/A		3	P0.22	LORA_DIO1
N/A		12	P0.23	FLASH_CS
N/A		13	P0.24	MEM_PWR_EN
23	GPIO3	14	P0.25	GPIO3
24	GPIO2	15	P0.26	GPIO2
25	GPIO1	16	P0.27	GPIO1
16	UART1_RX	17	P0.28	MBED_RX
15	UART1_TX	18	P0.29	MBED_TX
26	GPIO0	19	P0.30	GPIO0
33	NRESET	35	RSTN	NRESET
N/A		40	VCORE	NC
N/A		32	VREG1	NC
3,4 -VDD	VDD3_3	37	VDD	VDD3_3

xDot Pin Number	xDot Pin Name	MAX32670 Pin Number	MAX32670 Pin Name	MAX32670 Net Name
1, 5, 17, 20, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58	GND	36	VSS	GND
N/A		38	32KOUT	32KOUT
N/A		39	32KIN	32KIN
N/A		33	HFXIN	HFXIN
N/A		34	HFXOUT	HFXOUT
37 - ANT1	ANT1	N/A	N/A	N/A
2, 6, 7, 8, 18, 19, 21, 22, 47, RFU	NC	N/A	N/A	N/A

Pull-Up/Down

PU/PD	xDot Pin	Pin Name	SW Name	Value
PU	33	RESET		10K
PU	N/A	P0.17	NSS to LORA radio	100K
PU	N/A	P0.24	MEM_PWR_EN	10K
PU	N/A	P0.6	EEPROM_SE_I2C_SCL	10K
PU	N/A	P0.7	EEPROM_SE_I2C_SDA	10K
PU	N/A	P0.23	FLASH_CS	100K
PU	29	P0.1	SWCLK	100K
PD	11	P0.3	SPI_MOSI	100K
PD	10	P0.4	SPI_SCK	100K
PD	N/A	P0.15	MOSI for LoRa Radio	100K
PD	N/A	P0.16	SCK for LoRa Radio	100K

LoRa

Pin	Function
P0.14	LORA_MISO
P0.15	LORA_MOSI
P0.16	LORA_SCK
P0.17	LORA_NSS

Pin	Function
P0.20	LORA_RESET
P0.21	LORA_BUSY
P0.22	LORA_DIO1

Wake Pins

Pin	xDot Pin	Description
P0.8	14	UART1_RX
P0.30	26	GPIO0
P0.27	25	GPIO1
P0.26	24	GPIO2
P0.25	23	GPIO3
P0.19	34	Wake

Internal Memory Interface: Flash and EEPROM Pins (Advanced Only)

Pin	xDotPin	Description	Function
P0.24	--	MEM_PWR_EN	Enables power to EEPROM & FLASH, active low
P0.6	--	EEPROM_SE_I2C_SCL	EEPROM Clock
P0.7	--	EEPROM_SE_I2C_SDA	EEPROM Data
P0.23	--	FLASH_CS	Dedicated chip select for Flash
P0.2	11	SPI_MISO	Shared SPI MISO line for Flash
P0.3	12	SPI_MOSI	Shared SPI MOSI line for Flash
P0.4	10	SPI_SCK	Shared SPI Clock line for Flash

xDot Pinout Design Notes

Refer to the mechanical drawing for your model for pin locations.

- All I/O pins that go off board are directly connected to the processor
- Refer to the [Pin Information](#) table for pull up and pull down information.
- xDots allow you to program pins depending on your application:
 - Serial: Available out of the box. See [Serial Pinout Notes](#) for details.
 - mbed: Designed with the MAX32670GTL processor. This option provides the most flexibility. For more information about processor capabilities, see the processor datasheet.

Serial Pinout Notes

These pins are available for serial applications. If using AT firmware, serial pins are the AT command port. If writing an app, you need to configure the UART before using.

Refer to the pinout image for pin locations.

- xDot 13 P0.9 UART_TX
- xDot 14 P0.8 UART_RX
- xDot 15 P0.29 UART1_TX
- xDot 16 P0.28 UART1_RX
- xDot 31 P0.11 UART_RTS
- xDot 32 P0.10 UART_CTS

Serial Settings

When creating a serial connection with the device on the developer board, open communications software (such as TeraTerm, Putty, or Minicom), and use the following settings:

- Baud rate = 115,200
- Data bits = 8
- Parity = None
- Stop bits = 1
- Flow control = Off

LoRa

Throughput Rates

Theoretical maximum speeds for LoRa mode with ACKs off are:

- Using spreading factor 7 at 125 kHz, the throughput rate is 5470 bps (5.47 kbps).
- Using spreading factor 7 at 500 kHz the receiving throughput rate is 21900 bps (21.9 kbps).

Note: Data rates in the LoRaWAN specification vary by geographic region.

Range

Variables effecting the range include TX power, antenna gain, RX sensitivity, fade margin¹, and earth's curvature. Use the following formula to calculate the maximum range:

$$\text{Range}_{\text{Miles}} = 10^{\left(\frac{\text{Tx Power} + \text{Antenna Gain total} - \text{Rx Sensitivity} - \text{Fade Margin} - 36.56}{20} - \text{LOG}_{10}(\text{F}_{\text{MHz}})\right)}$$

¹Fade margin is an allowance used to account for unknown variables. The higher the fade margin, the better the overall link quality will be. With a fade margin set to zero, the link budget is still valid, but only in LOS conditions, which is not practical for most designs. The amount of fade margin to include in a calculation depends on the environment in which you will deploy the system. A fade margin of 12 dBm is good, but a better number would be 20 to 30 dBm.

Resetting the xDot

To reset the xDot

1. Drive the RESET signal low for at least 6 system clock cycles, if the device is in a low power state this will be:

$$T_{\text{NRESET}} = \frac{6}{32,768 \text{ Hz}} = 183 \mu\text{s}$$

2. Select one of the following. The processor starts executing code after RESET line is high.
 - Allow RESET to float. The internal pull-up resistor pulls it up.
 - Drive the RESET line high.

Chapter 6 – Developer Kit Overview

xDot Developer Kit

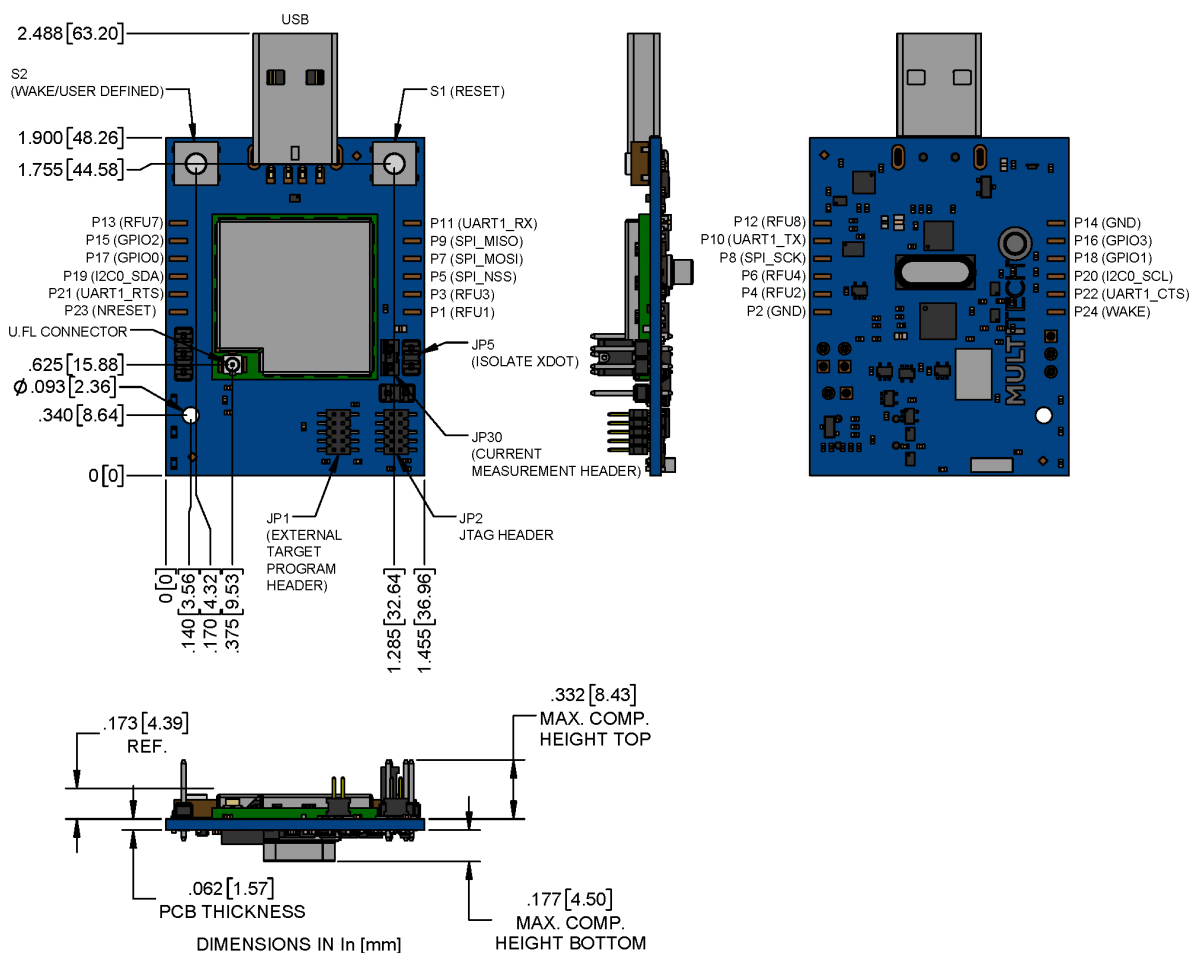
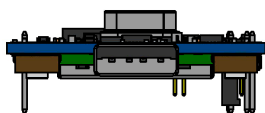
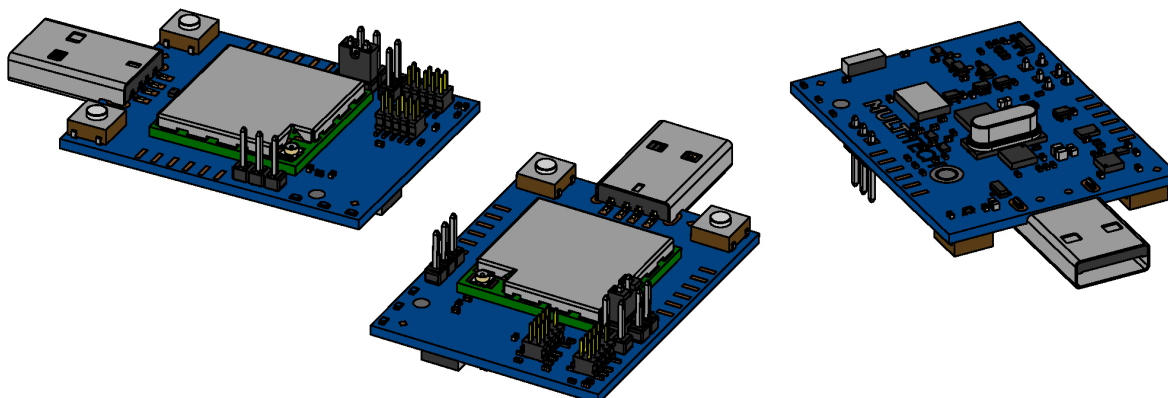
The xDot developer kit comes with an xDot already mounted on the developer board. Simply plug the developer kit into a USB port on your computer to test, program, and evaluate your application. The board allows for testing of applications and IO before you deploy the xDot in your design.

Developer Kit Package Contents

Your Developer Kit includes the following:

Developer Board	1 - xDot Developer Board with xDot
Customer Notices	Quick Start

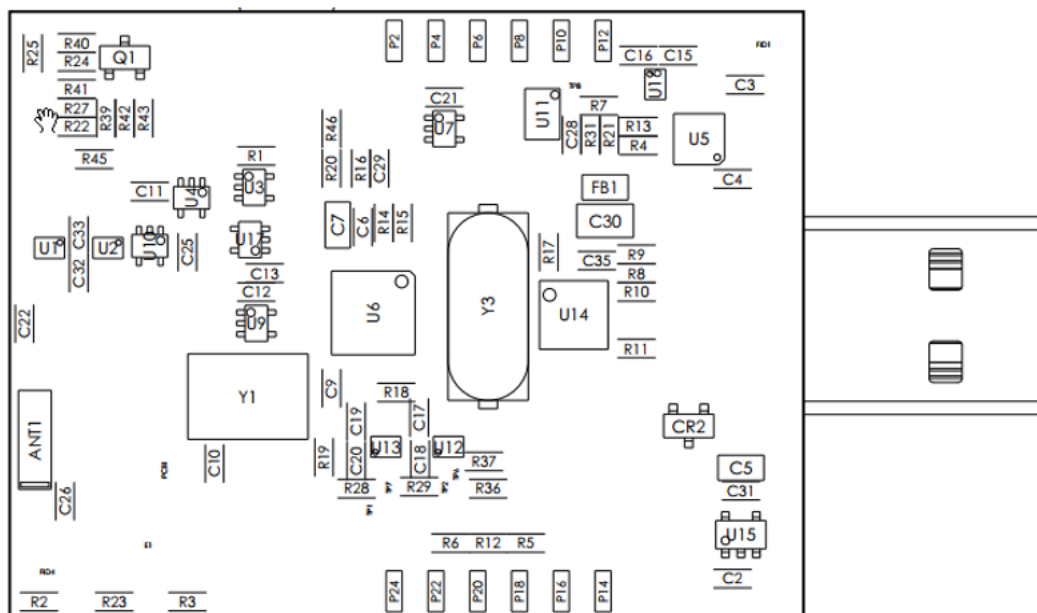
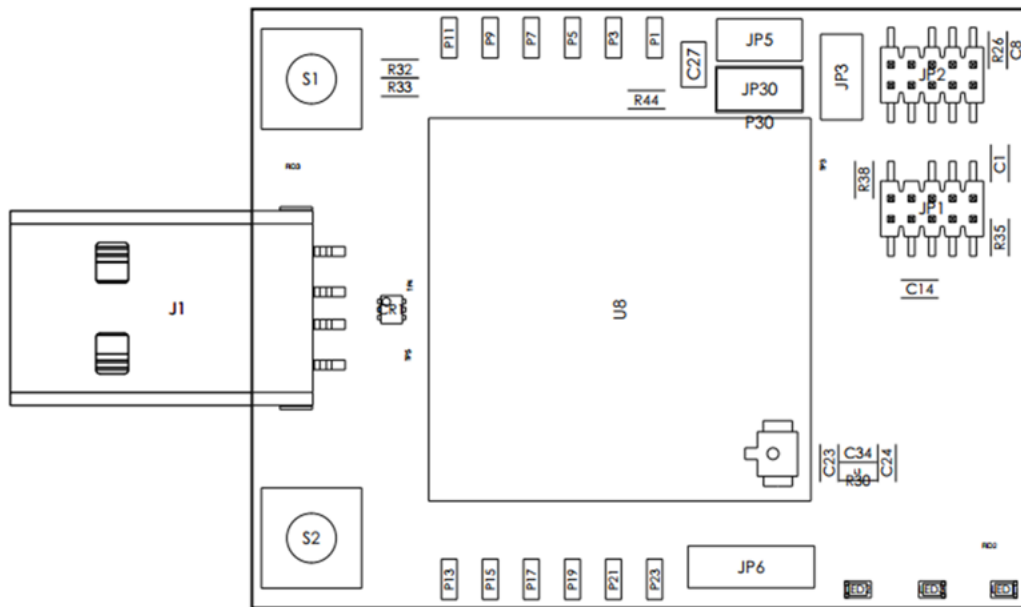
xDot Developer Kit Mechanical Drawings



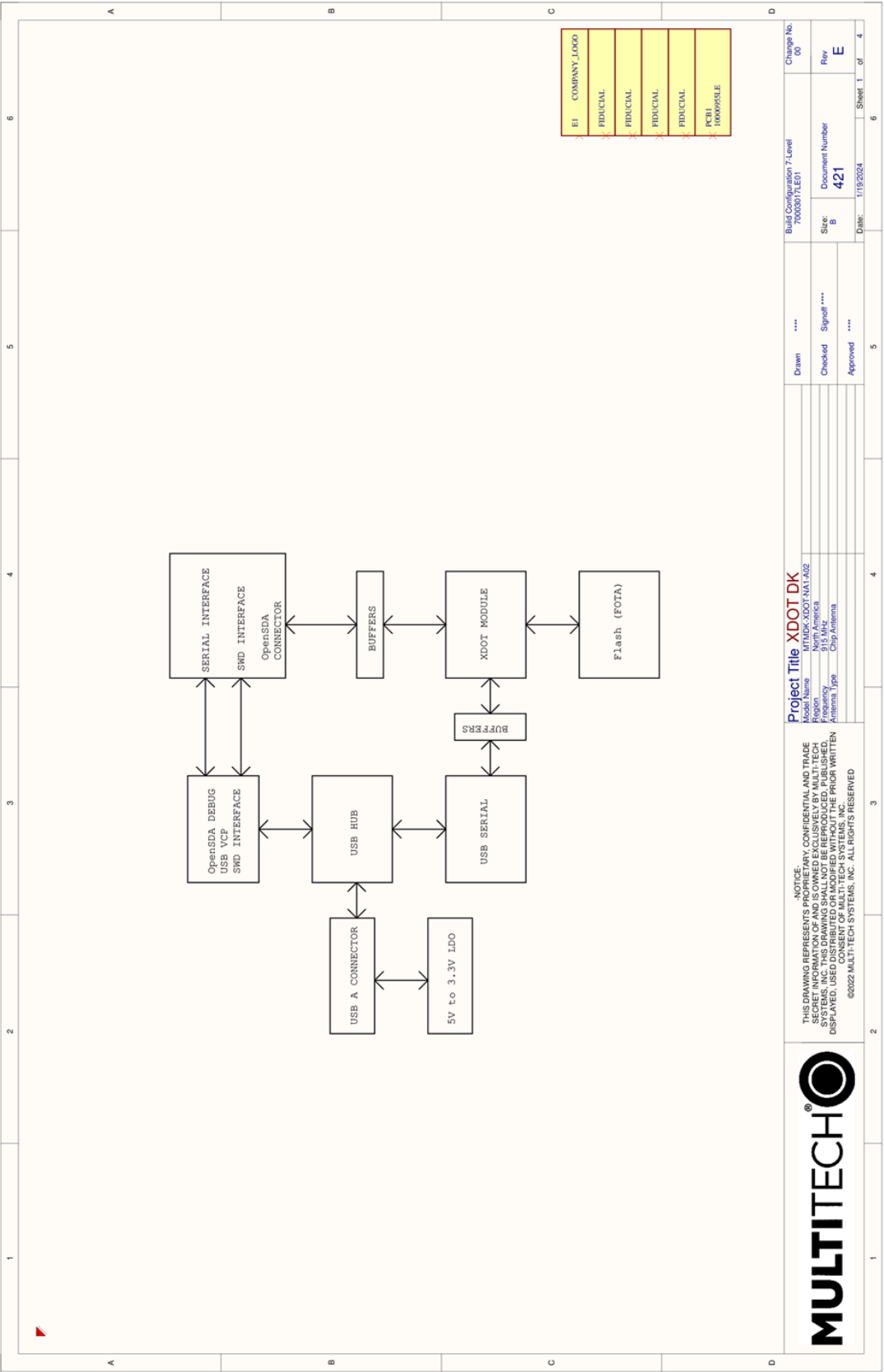
xDot Developer Board LEDs

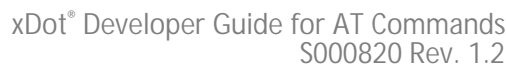
LED	Description
LED1	User-definable LED
SDA	Programming Status
PWR	Power, blue light when the board has power

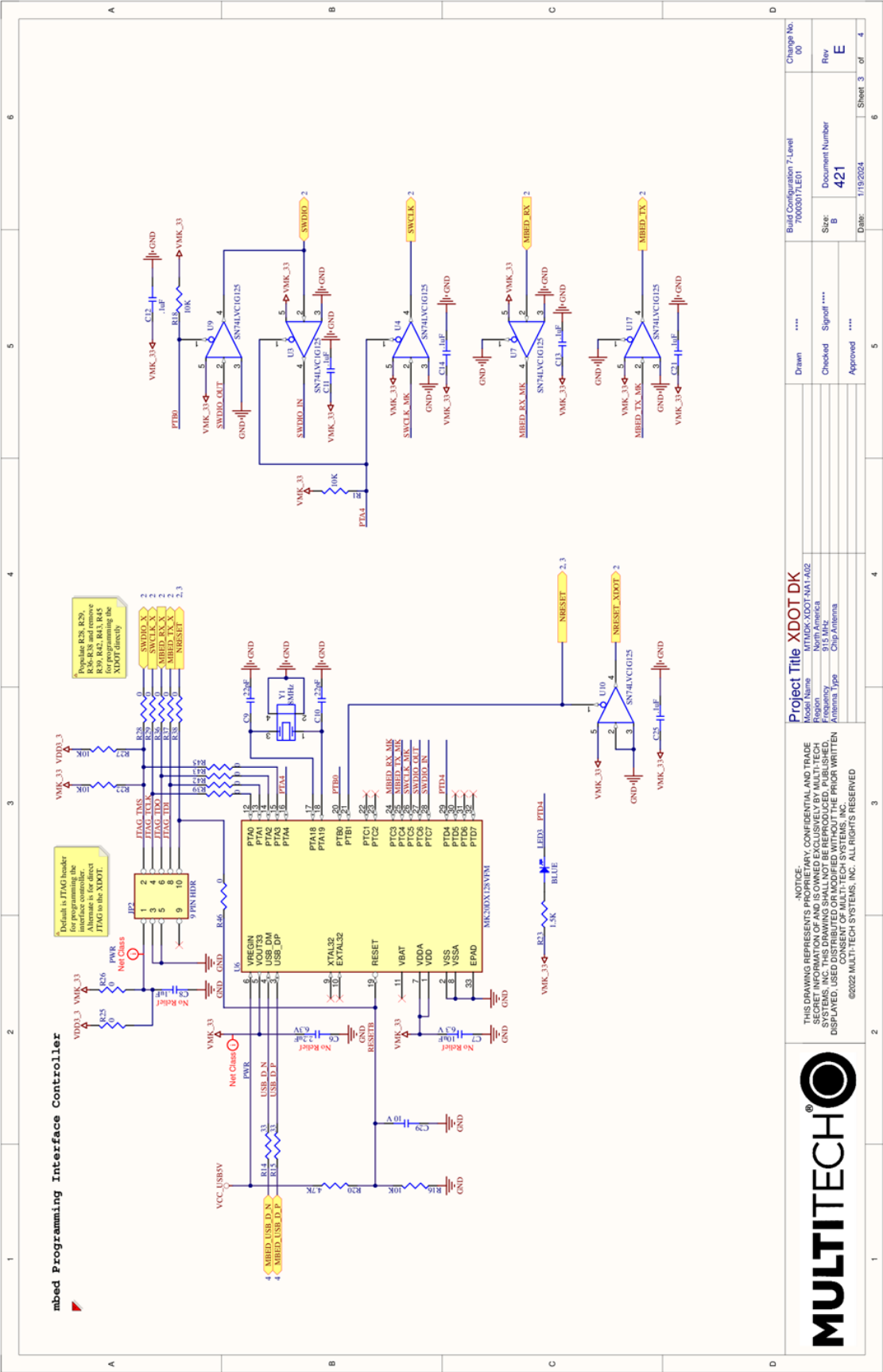
xDot Developer Board Assembly Drawings



xDot Developer Board Schematics



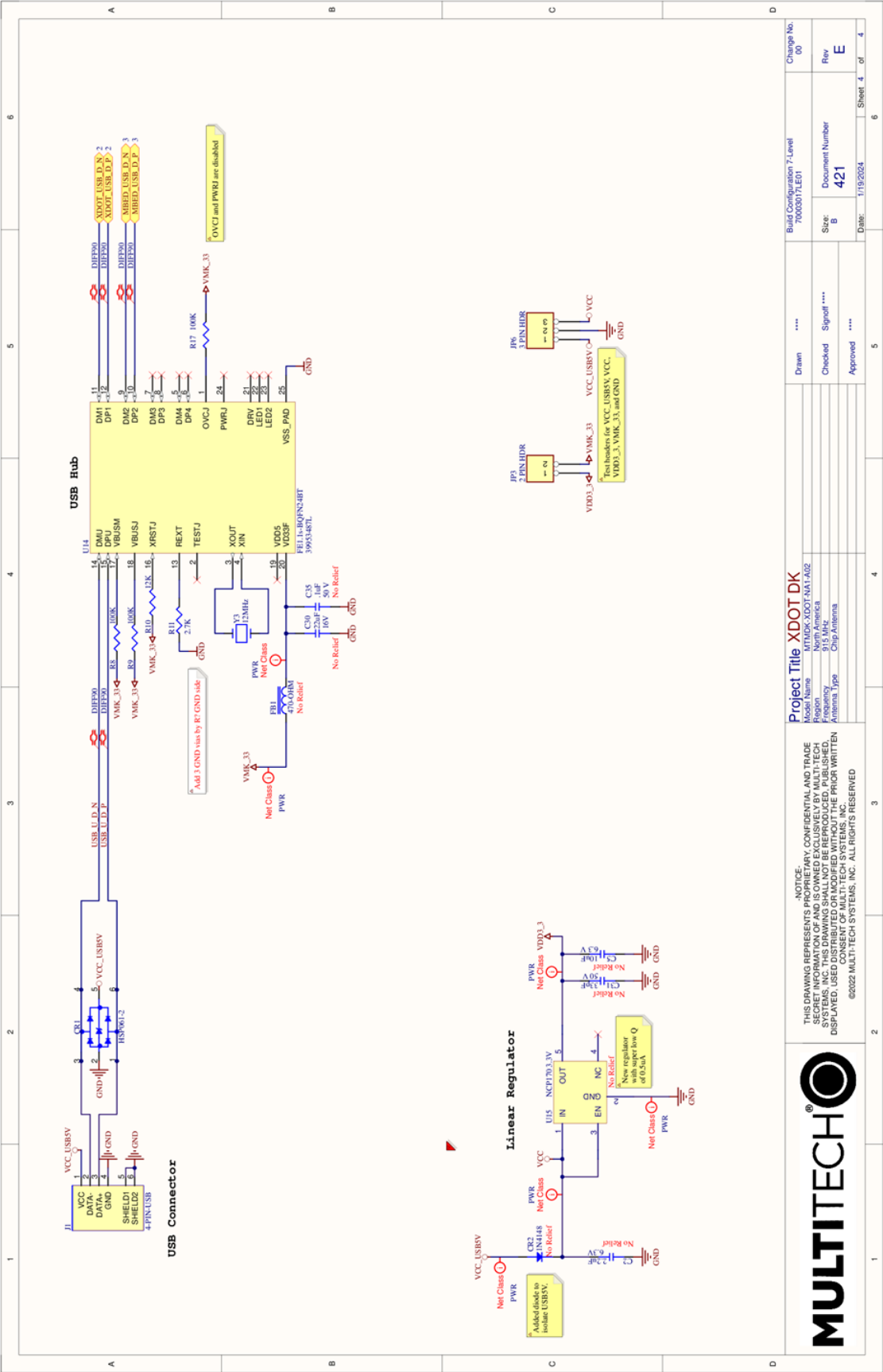




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Project Title XDOT DK
Model Name MULTITECH-XDOT-NAL-A02
Manufacturer Multitech
Frequency 915 MHz
Antenna Type Chip Antenna

Drawn	....	Build Configuration 7-Level	70002017LE01	Change No.	80
Checked	....	Size	B	Rev	E
Approved	....	Document Number	421	Sheet	3 of 4
		Date:	1/19/2024		



Project Title xDOT DK		Model Name	MTDK-XDOT-N1-A02	Build Configuration	7-Level	Change No.	80
		Manufacturer	Multitech	Size	B	Document Number	421
		Frequency	915 MHz	Checked	Signal	Rev	E
		Antenna Type	Chip Antenna	Approved	Sheet	4	of 4
		Date:		1/19/2024		Sheet 4 of 4	

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Chapter 7 – Antenna Information

Antenna System

The LoRa antenna performance depends on the implementation and antenna design. The integration of the antenna system into the product is a critical part of the design process; therefore, it is essential to consider it early so the performance is not compromised. If changes are made to the device's certified antenna system, then recertification will be required.

This radio transmitter has been tested with the Pulse antenna listed below. If you follow our design guidelines, you do not need to re-certify your design. The antenna you use must maintain the same specifications. It must be of the same type, with similar in-band and out-of-band radiation patterns. Antennas having a greater gain than the maximum gain indicated for the listed type are strictly prohibited for use with this device.

U.FL and Trace Antenna Options

Note: The xDot on the Developer Kit uses an on-board chip antenna by default.

If using U.FL or trace antennas, note the following:

- For a simple trace to RF antennas: Routing must follow standard RF design rules and practices for a 50 ohm impedance controlled transmission line.
- For U.FL antennas: The antenna and cable combination in your design cannot exceed the performance of the SMA antenna as listed in the next topic.
- To use the U.FL on the xDot while it is on the Developer Kit, please remove C32 for best performance.

LoRa Antenna

Manufacturer:	PulseLarsen Antenna
Description:	868-928 MHz RP-SMA Antenna, 8"
Model Number:	W1063

MultiTech ordering information:

Ordering Part Number	Quantity
AN868-915A-1HRA	1
AN868-915A-10HRA	10
AN868-915A-50HRA	50

LoRa Antenna Specifications

Category	Description
Frequency Range	868-928 MHz
Impedance	50 Ohms
VSWR	≤ 2.0
Gain	1.0 dBi

Category	Description
Radiation	Omni
Polarization	Vertical

Recommended Antenna for China

Manufacturer:	TE Connectivity / Linx Technologies
Description:	Antenna 490 MHz Whip, 157.7 mm length, 216 mm cable with U.FL connector
Model Number:	ANT-490-PW-QW-UFL

RSMA-to-U.FL Coaxial Cables

Coaxial Cable Specifications

Optional antenna cables can be ordered from MultiTech.

Cable Type	Coaxial Cable
Attenuation	<1.0 db
Connector Impedance	50 ohms
Maximum Cable Length	16" (40 cm)

OEM Integration

FCC & IC Information to Consumers

The user manual for the consumer must contain the statements required by the following FCC and IC regulations: 47 C.F.R. 15.19(a)(3), 15.21, 15.105 and RSS-Gen Issue 4 Sections 8.3 and 8.4.

FCC Grant Notes

The OEM should follow all the grant notes listed below. Otherwise, further testing and device approvals may be necessary.

FCC Definitions

Portable: (§2.1093) — A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.

Mobile: (§2.1091) — A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.

Actual content pending Grant: This device is a mobile device with respect to RF exposure compliance. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons, and must not be collocated or operate in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product guidelines. Installers and end-users must be provided with specific information required to satisfy RF exposure compliance for installations and final host devices. (See note under Grant Limitations.) Compliance of this device in all final host configurations is the responsibility of the Grantee.

Note: Host design configurations constituting a device for portable use (<20 cm from human body) require separate FCC/IC approval.

Host Labeling

The following statements are required to be on the host label:

- This device contains FCC ID: AU792U23B16873
- This device contains equipment certified under IC: 125A-0070

For labeling examples, see Cellular Approvals and Labeling Requirements.

Integration Notes

- Once you've integrated the xDot into your device, spot check for excess emissions occurring due to the digital circuitry or physical properties of your final product.
- Refer to the *Testing and Compliance* chapter of the *xDot AT Command Reference Guide* for information on commands used for compliance testing.

Chapter 8 – Safety Information

Handling Precautions

To avoid damage due to the accumulation of static charge use proper precautions, such as an ESD strap, when handling any cellular device to avoid exposure to electronic discharge during handling and mounting the device.

Radio Frequency (RF) Safety

Due to the possibility of radio frequency (RF) interference, it is important that you follow any special regulations regarding the use of radio equipment. Follow the safety advice given below.

- Operating your device close to other electronic equipment may cause interference if the equipment is inadequately protected. Observe any warning signs and manufacturers' recommendations.
- Different industries and businesses restrict the use of cellular devices. Respect restrictions on the use of radio equipment in fuel depots, chemical plants, or where blasting operations are in process. Follow restrictions for any environment where you operate the device.
- Do not place the antenna outdoors.
- Switch OFF your wireless device when in an aircraft. Using portable electronic devices in an aircraft may endanger aircraft operation, disrupt the cellular network, and is illegal. Failing to observe this restriction may lead to suspension or denial of cellular services to the offender, legal action, or both.
- Switch OFF your wireless device when around gasoline or diesel-fuel pumps and before filling your vehicle with fuel.
- Switch OFF your wireless device in hospitals and any other place where medical equipment may be in use.

Sécurité relative aux appareils à radiofréquence (RF)

À cause du risque d'interférences de radiofréquence (RF), il est important de respecter toutes les réglementations spéciales relatives aux équipements radio. Suivez les conseils de sécurité ci-dessous.

- Utiliser l'appareil à proximité d'autres équipements électroniques peut causer des interférences si les équipements ne sont pas bien protégés. Respectez tous les panneaux d'avertissement et les recommandations du fabricant.
- Certains secteurs industriels et certaines entreprises limitent l'utilisation des appareils cellulaires. Respectez ces restrictions relatives aux équipements radio dans les dépôts de carburant, dans les usines de produits chimiques, ou dans les zones où des dynamitages sont en cours. Suivez les restrictions relatives à chaque type d'environnement où vous utiliserez l'appareil.
- Ne placez pas l'antenne en extérieur.
- Éteignez votre appareil sans fil dans les avions. L'utilisation d'appareils électroniques portables en avion est illégale: elle peut fortement perturber le fonctionnement de l'appareil et désactiver le réseau cellulaires. S'il ne respecte pas cette consigne, le responsable peut voir son accès aux services cellulaires suspendu ou interdit, peut être poursuivi en justice, ou les deux.
- Éteignez votre appareil sans fil à proximité des pompes à essence ou de diesel avant de remplir le réservoir de votre véhicule de carburant.
- Éteignez votre appareil sans fil dans les hôpitaux ou dans toutes les zones où des appareils médicaux sont susceptibles d'être utilisés.

Interference with Pacemakers and Other Medical Devices

Potential interference

Radio frequency energy (RF) from cellular devices can interact with some electronic devices. This is electromagnetic interference (EMI). The FDA helped develop a detailed test method to measure EMI of implanted cardiac pacemakers and defibrillators from cellular devices. This test method is part of the Association for the Advancement of Medical Instrumentation (AAMI) standard. This standard allows manufacturers to ensure that cardiac pacemakers and defibrillators are safe from cellular device EMI.

The FDA continues to monitor cellular devices for interactions with other medical devices. If harmful interference occurs, the FDA will assess the interference and work to resolve the problem.

Precautions for pacemaker wearers

If EMI occurs, it could affect a pacemaker in one of three ways:

- Stop the pacemaker from delivering the stimulating pulses that regulate the heart's rhythm.
- Cause the pacemaker to deliver the pulses irregularly.
- Cause the pacemaker to ignore the heart's own rhythm and deliver pulses at a fixed rate.

Based on current research, cellular devices do not pose a significant health problem for most pacemaker wearers. However, people with pacemakers may want to take simple precautions to be sure that their device doesn't cause a problem.

- Keep the device on the opposite side of the body from the pacemaker to add extra distance between the pacemaker and the device.
- Avoid placing a turned-on device next to the pacemaker (for example, don't carry the device in a shirt or jacket pocket directly over the pacemaker).

Device Maintenance

Do not attempt to disassemble the device. There are no user serviceable parts inside.

When maintaining your device:

- Do not misuse the device. Follow instructions on proper operation and only use as intended. Misuse could make the device inoperable, damage the device and/or other equipment, or harm users.
- Do not apply excessive pressure or place unnecessary weight on the device. This could result in damage to the device or harm to users.
- Do not use this device in explosive or hazardous environments unless the model is specifically approved for such use. The device may cause sparks. Sparks in explosive areas could cause explosion or fire and may result in property damage, severe injury, and/or death.
- Do not expose your device to any extreme environment where the temperature or humidity is high. Such exposure could result in damage to the device or fire. Refer to the device specifications regarding recommended operating temperature and humidity.
- Do not expose the device to water, rain, or spilled beverages. It is not waterproof. Exposure to liquids could result in damage to the device.
- Using accessories, such as antennas, that MultiTech has not authorized or that are not compliant with the device accessory specifications may invalidate the warranty.

If the device is not working properly, contact MultiTech Technical Support.

User Responsibility

- Respect all local regulations for operating your wireless device.
- Use the security features to block unauthorized use and theft.
- End user must operate product per country laws and rules.

Chapter 9 – Labels

Label Examples

Note: Actual labels vary depending on the regulatory approval markings and content.

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 label shown is not the actual size.

1. MultiTech Model Identification
2. MultiTech Ordering Part Number
3. Device Node Number



Chapter 10 – Design Considerations

Noise Suppression Design

Adhere to engineering noise-suppression practices when designing a printed circuit board (PCB). Noise suppression is essential to the proper operation and performance of the device and surrounding equipment.

Any OEM board design must consider both on-board and off-board generated noise that can affect digital signal processing. Both on-board and off-board generated noise that is coupled on-board can affect interface signal levels and quality. Noise in frequency ranges that affect device performance is of particular concern.

On-board generated electromagnetic interference (EMI) noise that can be radiated or conducted off-board is equally important. This type of noise can affect the operation of surrounding equipment. Most local government agencies have certification requirements that must be met for use in specific environments.

Proper PC board layout (component placement, signal routing, trace thickness and geometry, and so on) component selection (composition, value, and tolerance), interface connections, and shielding are required for the board design to achieve desired device performance and to attain EMI certification.

Other aspects of proper noise-suppression engineering practices are beyond the scope of this guide. Consult noise suppression techniques described in technical publications and journals, electronics and electrical engineering text books, and component supplier application notes.

PC Board Layout Guideline

In a 4-layer design, provide adequate ground plane covering the entire board. In 4-layer designs, power and ground are typically on the inner layers. Ensure that all power and ground traces are 0.05 inches wide.

Use spacers to hold the device vertically in place during the wave solder process. For an xDot the recommended landing pad size is the same as the xDot's pad size, 0.28 in (0.71 cm).

Electromagnetic Interference

The following guidelines are offered specifically to help minimize EMI generation. Some of these guidelines are the same as, or similar to, the general guidelines. To minimize the contribution of device-based design to EMI, you must understand the major sources of EMI and how to reduce them to acceptable levels.

- Keep traces carrying high frequency signals as short as possible.
- Provide a good ground plane or grid. In some cases, a multilayer board may be required with full layers for ground and power distribution.
- Decouple power from ground with decoupling capacitors as close to the device's power pins as possible.
- Eliminate ground loops, which are unexpected current return paths to the power source and ground.
- Locate high frequency circuits in a separate area to minimize capacitive coupling to other circuits.
- Locate cables and connectors to avoid coupling from high frequency circuits.
- Lay out the highest frequency signal traces next to the ground grid.
- If using a multilayer board design, make no cuts in the ground or power planes and be sure the ground plane covers all traces.
- Minimize the number of through-hole connections on traces carrying high frequency signals.

- Avoid right angle turns on high frequency traces. Forty-five degree corners are good; however, radius turns are better.
- On 2-layer boards with no ground grid, provide a shadow ground trace on the opposite side of the board to traces carrying high frequency signals. This will be effective as a high frequency ground return if it is three times the width of the signal traces.
- Distribute high frequency signals continuously on a single trace rather than several traces radiating from one point.

Electrostatic Discharge Control

Handle all electronic devices with precautions to avoid damage due to the static charge accumulation.

See the ANSI/ESD Association Standard (ANSI/ESD S20.20-1999) – a document “for the Development of an Electrostatic Discharge Control for Protection of Electrical and Electronic Parts, Assemblies and Equipment.” This document covers ESD Control Program Administrative Requirements, ESD Training, ESD Control Program Plan Technical Requirements (grounding/bonding systems, personnel grooming, protected areas, packaging, marking, equipment, and handling), and Sensitivity Testing.

MultiTech strives to follow these recommendations. Input protection circuitry is incorporated in MultiTech devices to minimize the effect of static buildup. Take precautions to avoid exposure to electrostatic discharge during handling.

MultiTech uses and recommends that others use anti-static boxes that create a faraday cage (packaging designed to exclude electromagnetic fields). MultiTech recommends that you use our packaging when returning a product and when you ship your products to your customers.

Chapter 11 – Regulatory Information

EMC, Safety, and Radio Equipment Directive (RED) Compliance



The CE mark is affixed to this product to confirm compliance with the following European Community Directives:

- Council Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment; and
- Council Directive 2014/53/EU on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity.

MultiTech declares that this device is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU. The declaration of conformity may be downloaded at <https://multitech.com/product-support/>.

EMC, Safety, and Radio Equipment Regulations (UKCA)

For models designated for use in the UK, the following applies:



The UKCA mark is to confirm conformity with the relevant UKCA harmonization legislation:

2017 No 1206	The Radio Equipment Regulations 2017
2016 No 1101	The Electrical Equipment Safety Regulations 2016
2016 No 1091	The Electromagnetic Compatibility Regulations 2016
2012 No 3032	The Restriction of the Use of Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

MultiTech declares that this device is in compliance with the essential requirements and other relevant provisions of the above regulations. The UKCA Declaration of Conformity may be requested at <https://multitech.com/product-support/>

47 CFR Part 15 Regulation Class B Devices

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.

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Notice

Per FCC 15.19(a)(3) and (a)(4) 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.

FCC Notice

The MultiTech Conduit is an open embedded development product. Configurations of this product may optionally contain a sub GHz radio technology which MultiTech has certified for compliance with US and Foreign compliance bodies including FCC, R&TTE and others. (e.g. FCC 15.247:2015 & IC RSS-210:2010).

Per FCC 15.19(a)(3) and (a)(4) 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 MTAC-LORA is open development based product that contains a sub GHz radio technology. MultiTech has certified for compliance with US and Foreign compliance bodies including FCC, R&TTE and others. (e.g. FCC 15.247:2015 & IC RSS-210:2010)

This device is open development based product that contains a sub GHz radio technology. MultiTech has certified for compliance with US and Foreign compliance bodies including FCC, R&TTE and others. (e.g. FCC 15.247:2015 & IC RSS-210:2010)

MTXDOT-x products are open development based products that contain a sub ghz radio technology. MultiTech has certified for compliance with US and Foreign compliance bodies including FCC, R&TTE and others. (e.g. FCC 15.247:2015 & IC RSS 247:2015)

Per FCC 15.19(a)(3) and (a)(4) 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.

This device is open development based product that contains a sub GHz radio technology. MultiTech has certified for compliance with US and Foreign compliance bodies including FCC, R&TTE and others. (e.g. FCC 15.247:2015 & IC RSS-210:2010)

MultiTech provides software code meant to operate the radio to a level that maintains compliance with the operating modes under which these radio devices were certified. To ensure this level of compliance, the software code is provided in binary form only. Users are prohibited from making any changes that affect the operation of the radio performance. Accessing or controlling the radio through any means other than the provided binary software will require the user to obtain their own intentional radiator license from the certification body governing their locality, as all pre-certification provided with Conduit IP67 Series 200 Base Station. Conduit Conduit Base Station IP67 MTAC-LORA xDot will have been made invalid.

Industry Canada Class B Notice

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement Canadien sur le matériel brouilleur.

This device complies with Industry Canada license-exempt RSS standard(s). The operation is permitted for the following two conditions:

1. the device may not cause interference, and
2. this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. l'appareil ne doit pas produire de brouillage, et
2. l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Chapter 12 – Environmental Notices

Waste Electrical and Electronic Equipment Statement

Note: This statement may be used in documentation for your final product applications.

WEEE Directive

The WEEE Directive places an obligation on EU-based manufacturers, distributors, retailers, and importers to take-back electronics products at the end of their useful life. A sister directive, ROHS (Restriction of Hazardous Substances) complements the WEEE Directive by banning the presence of specific hazardous substances in the products at the design phase. The WEEE Directive covers all MultiTech products imported into the EU as of August 13, 2005. EU-based manufacturers, distributors, retailers and importers are obliged to finance the costs of recovery from municipal collection points, reuse, and recycling of specified percentages per the WEEE requirements.

Instructions for Disposal of WEEE by Users in the European Union

The symbol shown below is on the product or on its packaging, which indicates that this product must not be disposed of with other waste. Instead, it is the user's responsibility to dispose of their waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling, contact your local city office, your household waste disposal service or where you purchased the product.

July, 2005



REACH-SVHC Statement

Registration of Substances

Multi-Tech Systems, Inc. confirms that none of its products or packaging contain any of the Substances of Very High Concern (SVHC) on the REACH Candidate List, in a concentration above the 0.1% by weight allowable limit.

For the current REACH-SVHC statement and additional regulatory documents, visit:

<https://multitech.com/approvals-and-certifications/>.

Restriction of the Use of Hazardous Substances (RoHS)

Multi-Tech Systems, Inc. Certificate of Compliance 2015/863

Multi-Tech Systems, Inc. confirms that its embedded products comply with the chemical concentration limitations set forth in the directive 2015/863 of the European Parliament (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment - RoHS 3).

These MultiTech products do not contain the following banned chemicals¹:

- Lead, [Pb] < 1000 PPM
- Mercury, [Hg] < 100 PPM
- Cadmium, [Cd] < 100 PPM
- Hexavalent Chromium, [Cr+6] < 1000 PPM Polybrominated Biphenyl, [PBB] < 1000 PPM
- Polybrominated Diphenyl Ethers, [PBDE] < 1000 PPM
- Bis(2-Ethylhexyl) phthalate (DEHP): < 1000 PPM
- Benzyl butyl phthalate (BBP): < 1000 PPM
- Dibutyl phthalate (DBP): < 1000 PPM
- Di-isobutyl phthalate (DIBP): < 1000 PPM

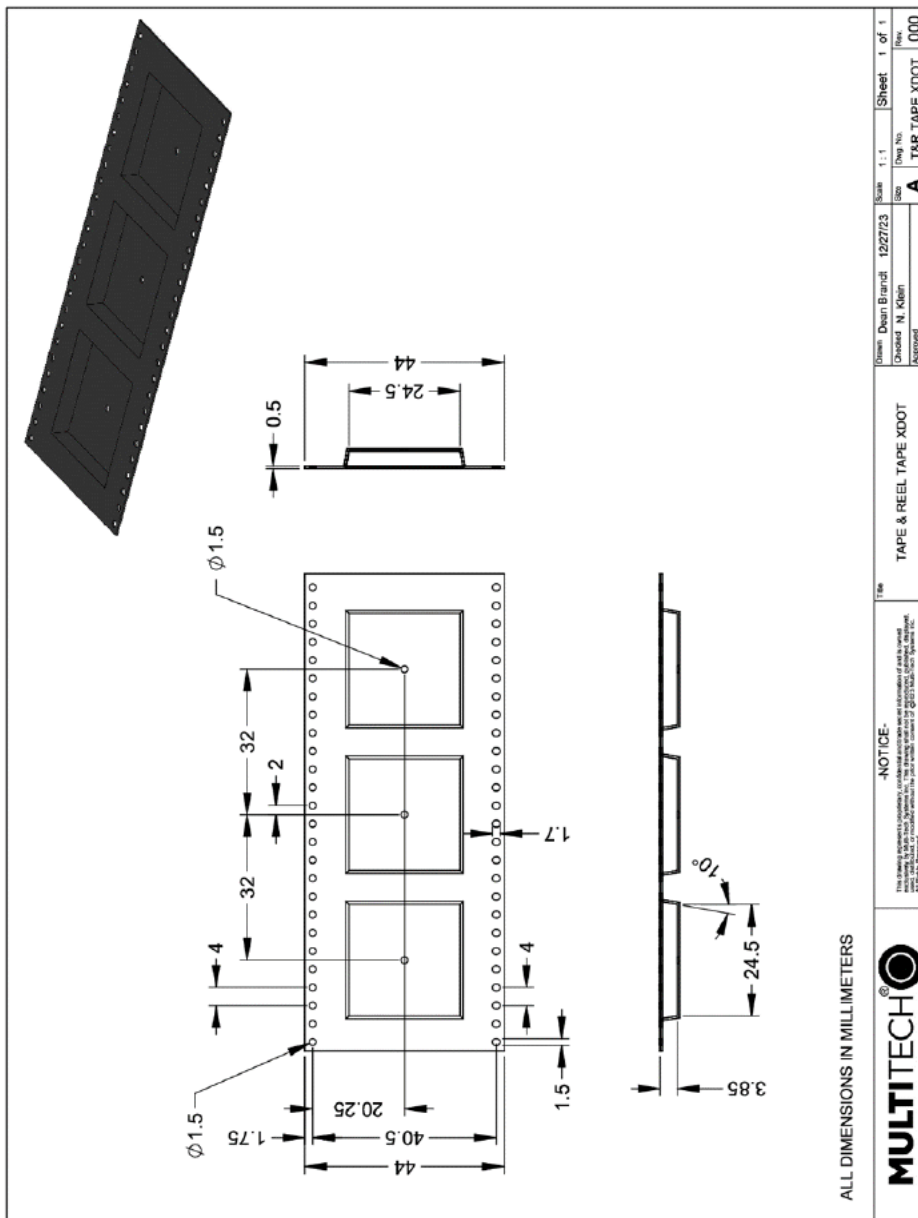
Environmental considerations:

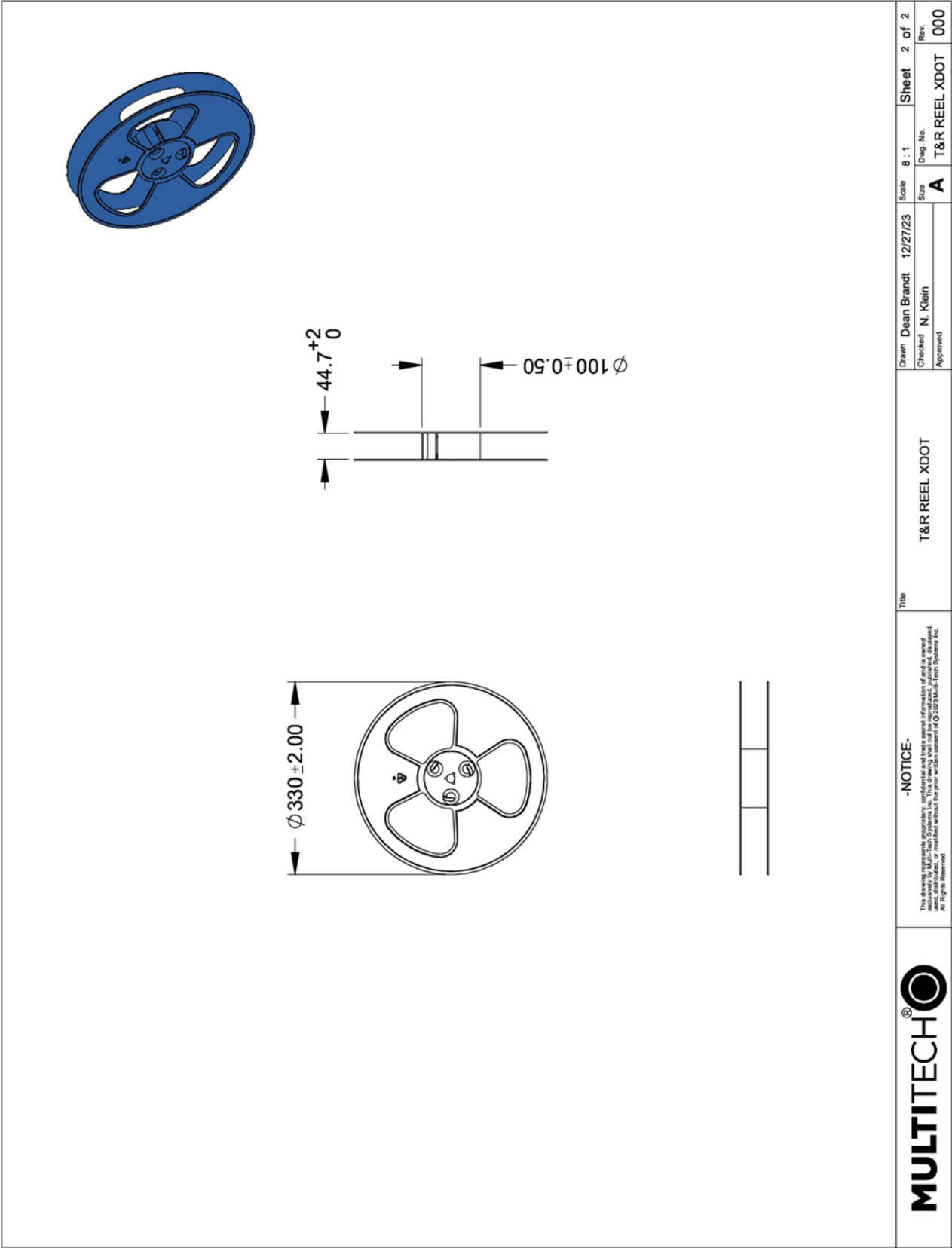
- Moisture Sensitivity Level (MSL) =1
- Maximum Soldering temperature = 260C (in SMT reflow oven)

¹Lead usage in some components is exempted by the following RoHS annex, therefore higher lead concentration would be found in some modules (>1000 PPM)

- Resistors containing lead in a glass or ceramic matrix compound.

Chapter 13 – Tape and Reel Specifications





Chapter 14 – Mounting xDots

Mounting the Device on Your Board

A footprint diagram is included on the [xDot Mechanical Drawing](#) in Chapter 4.

Stencil

Match the stencil aperture size and layout to the mechanical footprint of the xDot (1:1). We recommend a stencil thickness of 5 mil.

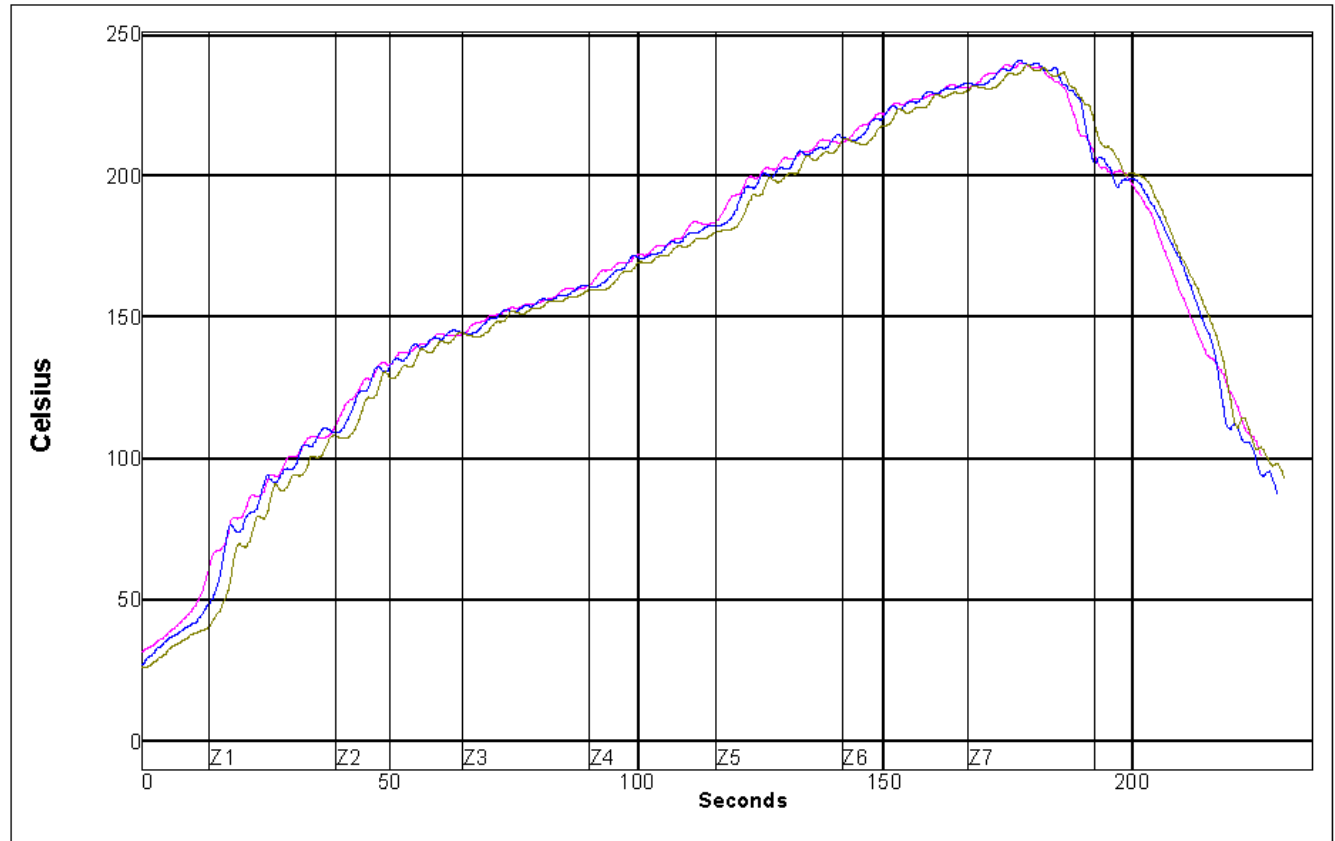
Solder Profile

Note: Because this device goes through a no-clean assembly process, if you perform additional reflow processes, we recommend using a no-clean process.

Solder Paste: AIM M8 Lead-Free

Note: Calculate slope over 120 seconds.

Name	Low Limit	High Limit	Units
Max Rising Slope (Target=1.0)	0	2	Degrees/Second
Max Falling Slope	-2	-0.1	Degrees/Second
Soak Time 150-170C	15	45	Seconds
Peak Temperature	235	250	Degrees Celsius
Total Time Above 218C	30	90	Seconds



Setpoints (Celsius)

Zone	1	2	3	4	5	6	7
Top	130	160	170	190	230	245	255
Bottom	130	160	170	190	230	245	255
Conveyer Speed	32.0 inch/minute						

TC	Position	Max Rising Slope		Max Falling Slope		Soak Time 150-170C		Peak Temp		Total Time /218C	
		Slope	PWI	Slope	PWI	Time	PWI	Temp	PWI	Time	PWI
1	<TC2>	1.38	38%	-0.63	45%	28.82	-8%	240.22	-30%	43.61	-55%
2	<TC3>	1.38	38%	-0.75	32%	26.75	-22%	241.21	-17%	43.66	-54%
3	<TC4>	1.38	38%	-0.70	36%	29.47	-4%	239.56	-39%	43.29	-56%
Delta		0.00		0.12		2.72		1.65		0.37	

Chapter 15 – Programming External Targets

In-System Programming of xDot

You can use the xDot developer board to in-system program an xDot on your custom board. To do this, your board must implement a 9-pin header for the JTAG SWD and Mbed debug serial signals. See the example schematic in this topic.

When the xDot developer board detects a target voltage on Pin 1 of JP1, it redirects the Mbed programming interface to the external xDot. You can use the Mbed programming environment as normal to program and debug the external xDot.

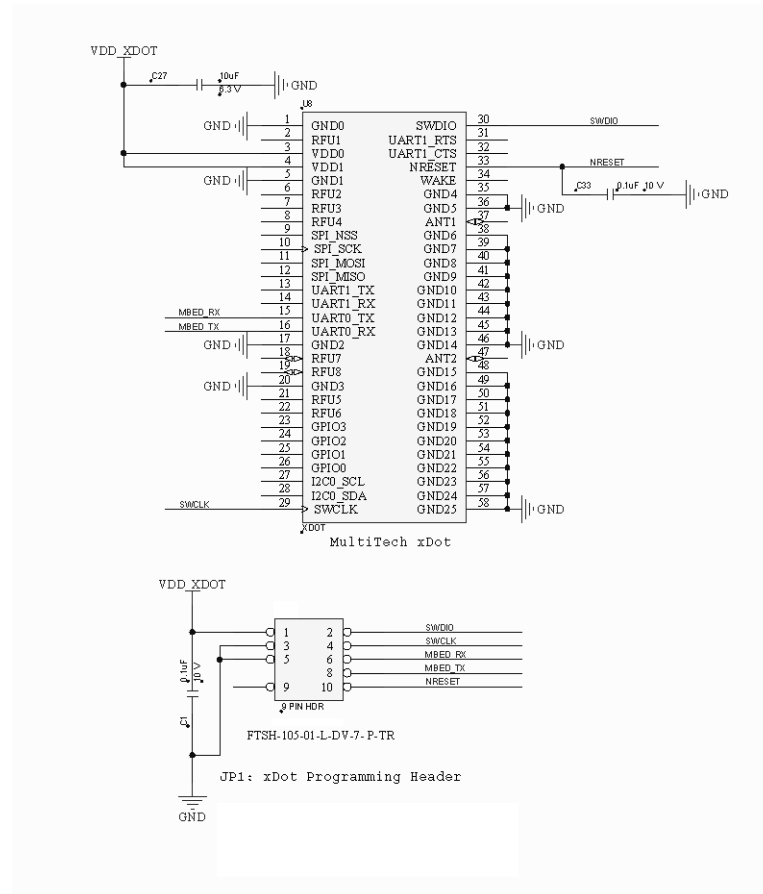
Warning: Electrostatic discharge (ESD) can damage the MTMDK-XDOT. Potential failure via ESD through the JTAG headers include the MTMDK-XDOT processor, level converters, and potentially the target device.

To use the external target programming header:

1. Use a 10-position ribbon cable to connect xDot developer board header JP1 to the SWD programming header on your custom board.¹
2. Apply power to your target board.
3. Use the Mbed programming environment as normal.

Schematic Example

This schematic example shows programming header connections for xDot on a custom board:



¹MultiTech recommends the Samtec FFSD-05-D-06.00-01-N ribbon cable.

Recommended Programming Hardware for Production

Note: MultiTech does not recommend using the MTMDK-XDOT developer board for production programming. It doesn't have ESD protection, isn't enclosed, and wasn't tested to be a robust solution for production.

MultiTech recommends using the following programming hardware for production:

- J-Link 9-Pin Cortex-M Adapter - <https://www.segger.com/products/debug-probes/j-link/accessories/adapters/9-pin-cortex-m-adapter>
- SEGGER J-Link programmer - SEG-JLINK - <https://www.segger.com/products/debug-probes/j-link/>

Note: When programming the Essentials version, care needs to be taken to protect information stored in flash.

The last 64KB of the 384KB flash contains the settings including keys and device ID. 0x50000 is the first 320KB of flash.

J-link script for Segger programming:

```
device MAX32670
if SWD
speed 4000
connect

erase 0x10000000 0x1004ffff
loadfile C:\<path to file>\xdotes-firmware.bin 0x10000000
```

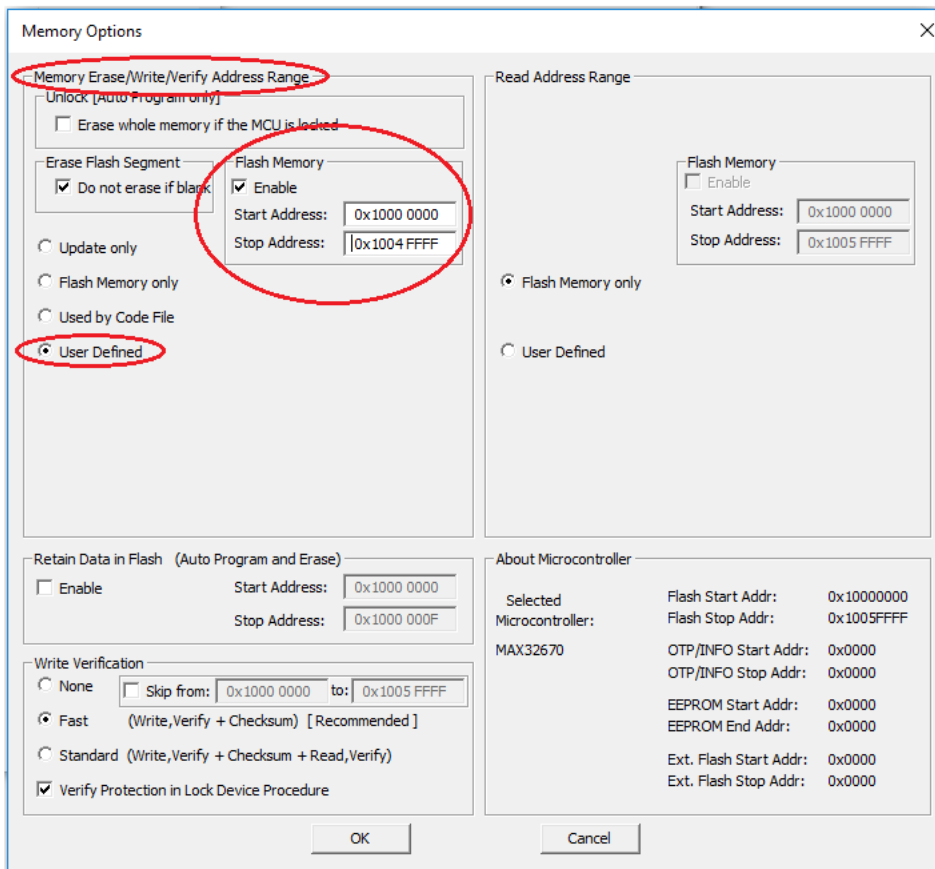

exit

Elprotronic programmer:

Note: If using an Elprotronic programmer, Elprotronic requires that it powers the target itself.

Under Setup > Memory Options in the Memory Erase/Write/Verify address Range section choose the User Defined radio button and check the Enable box in the Flash Memory section.

- For the Essentials version: Set the Start Address to 0x1000 0000 and the Stop Address to 0x1004 FFFF.
- For the Advanced version: Set the Start Address to 0x1000 0000 and the Stop Address to 0x1005 FFFF.



JTAG/SWD Connector

The developer board uses an unshrouded 9-pin header.

Suitable connector headers include:

- Harwin: M50-3500542
- Mouser: 855-M50-3500542
- Samtec shrouded header: FTSH-105-01-F-D-K

The Samtec FTSH-105 header dimensions are 0.25"x 0.188" (6.35mm x 4.78mm). Ensure that you connect your cable correctly, typically by matching the "1" marked on the board to the cable's red stripe.

Appendix A – Connecting the xDot with a Conduit and a LoRa Network

Overview

This section describes the setup needed to connect an xDot®, to a Conduit® gateway or Conduit AP and connect to the Radio Bridge Chirpstack server to get data to the cloud. Additionally, it includes setting up remote management with DeviceHQ.

Prerequisites

You need:

- A computer running Windows.
- A Conduit gateway or Conduit AP with the hardware setup. Hardware set up includes:
 - SIM card installed if the model has a cellular radio
 - All antennas connected
 - Ethernet cable connected to Conduit and computer
 - Powered up and status light shows ready

Consult the quick start or hardware guide for your model if the hardware is not ready.

- An xDot Developer Kit plugged in to the computer and powered up.
- A terminal program. For Windows, examples are:
 - Tera Term (<https://ttssh2.osdn.jp/index.html.en>) – This is one of the first serial based terminal apps for computers. Over time SSH and other protocols were added. It allows keyboard mapping and macros.
 - Putty (<https://www.putty.org/>) – This has become a standard for SSH connections to devices. It also supports a serial connection over a UART or USB emulated UART.

Setting up a Conduit

Note: For your Internet/WAN connection, you can use Ethernet or cellular if your Conduit has a cellular radio.

These steps use the First-Time Setup wizard. In most cases, you can accept the provided defaults. See First-Time Setup in the [Conduit mPower Software Guide](#) for more details.

1. Open a web browser and enter the Conduit's default IP address to access web management: 192.168.2.1. Most browsers display a warning about HTTP addresses being unsafe.



Your connection is not private

Attackers might be trying to steal your information (passwords, messages, or credit cards). [Learn more](#)

NET::ERR_CERT_AUTHORITY_INVALID

2. Click on Advanced and continue to 192.168.2.1.

[Proceed to 192.168.2.1 \(unsafe\)](#)

mPower opens in Commissioning Mode. The system requires you to set up an admin user. Enter your desired username and click OK.

3. Enter and confirm a password following the on screen rules.
4. Login using the new credentials. The First Time Setup wizard appears.
5. For Call Home accept all default settings (disabled) and click Next.
6. Set the date, time, and time zone. If the information is correct, accept the default values and click Next. Otherwise, update Date, Time, and/or Time Zone and click Next.
7. For LAN network interfaces Eth0 and Br0, accept default settings. Click Next.
Note: If using Ethernet with a LoRa Packet Forwarder, you will need to make additional configuration changes for Ethernet under Network Interfaces. See [Using Ethernet with LoRa Packet Forwarder](#).
8. If your Conduit has cellular capability, configure your device's cellular connection.
 - a. If your device does not have a cellular radio (Ethernet only) or you plan to use Ethernet with the LoRa packet forwarder, accept all defaults with Enabled deactivated (Cellular is disabled) and APN left blank.
 - b. If you have a cellular radio model and plan to use Cellular with the LoRa packet forwarder, select Enabled.
 - c. If required by your network carrier, enter your APN (Some carrier networks set APN automatically via OTA registration. Leave it blank in that case.)
 - d. Click Next.
9. For Cellular Authentication accept all defaults (NONE) and click Next.
10. For Remote Management accept all defaults (NONE) and click Next.
11. For HTTP/HTTPS Access, accept all defaults (NONE) and click Next.
12. For Bootloader Protection (setting a u-boot password).
 - a. Disable Bootloader Protection (defaults vary with firmware version).
 - b. Click Finish.
13. To save your changes, click Save and Apply.

Configuring the Network for the Conduit

This sets up the Conduit on the Radio Bridge Chirpstack.

1. Go to the [Radio Bridge console](https://console.radiobridge.com/login), <https://console.radiobridge.com/login>.
2. Create a new account if you do not already have one. If you do, login.
3. On the left side, select Gateways.
4. Click Add Gateway on the right side.
5. You should see a list of LoRa Network Servers. Select Chirpstack.
6. Complete the following information:
 - Gateway Name: Enter a user-defined Gateway name. Required. Example: TestGateway.
 - Gateway EUI: Enter the Gateway EUI that you copied earlier from LoRaWAN > LoRa Network Settings > LoRa Card Information. Paste the EUI into this field. Required.
Note: Remove any dashes.
 - Select Region: Required. Under 'Select Region' you can select US915 or EU868 for Europe. (If your channel plan is not for US but in the 900's, select US915. If your channel plan is not for Europe but in the 800's, select EU868.) Required.
 - IP Address: The IP Address allows you to have a quick link to the gateway interface. If the gateway is on a local LAN, enter the IP Address of that gateway. If you have a private cellular SIM, enter the private IP address of that SIM.
 - Description: Enter information to describe the gateway.
7. Click Register Gateway. You should receive a confirmation message that it's successful.
8. Close the window. The gateway appears in the Radio Bridge console and the last check-in date (under Last Seen) in the gateway list. If it is blank, click on the refresh icon on the far right.

Using Ethernet with LoRa Packet Forwarder

To use Ethernet with the LoRa Packet Forwarder, you must make the following configuration change before configuring and running Packet Forwarder.

If you are using a Cellular connection with LoRa, you can skip these steps.

1. In mPower, go to Network Interfaces.
2. Click the pencil for the eth0 interface.
3. Under Network Interface ETH0, change Direction to WAN.
4. Click Submit.
5. Go to Administration > Access Configuration > HTTPS.
6. Enable HTTPS via WAN.
7. Click Submit. Then, click Save and Apply.

Configuring the xDot

When the xDot developer board is plugged in to a USB port on your computer, configure the xDot:

1. Open the Windows Device Manager. (Press the Windows key and type Device Manager or open the Control Panel > Hardware and Sound > Devices and Printers > Device Manager.) It will show the COM ports added.
2. Open PuTTY or another terminal program.
3. Choose Serial Port connection and select the first port that matches.
4. Go to the serial port setup and make sure it is properly configured with the following:

- Speed: 115200
 - Data: 8 bit
 - Parity: None
 - Stop bits: 1 bit
 - Flow control: Off
5. Test the terminal connection, enter the AT Command AT. If it does not return an OK response, open another terminal connection and select the other xDot port. Enter AT again to verify. It returns an OK.
 6. Send the following commands. The notes explain what each command does and values:
 - AT+PN=1: Enables or disables public network mode: 0, 1, or 2.
 - AT+JD=5: Configures when the join receive window opens to listen for a join accept.
 - AT+FSB=2: For US/AU915, Set Frequency Sub-band: 1-8 (needs to match the gateway configuration LoRaWAN > Network Settings > Channel Config).
 - AT+NJM=1: Configure for OTA Network Join:
 - 0: Manual configuration
 - 1: OTA Network Join (default: 1)
 - 2: Join on Setup
 - 3: Peer-to- Peer mode
 - AT+NK=0,App Key: Network Key Configured network key (App Key in TTN) (16 bytes)
 - AT+NI=0,App EUI: Network ID Configured Network EUI (App EUI in TTN) (8 bytes)
 - AT&W: Save Configuration

Configuring the Network for the xDot

To configure the Network for the xDot, you need the device ID, network key, and App EUI network key. To get this information, in a terminal window connected to the xDot:

1. For the xDot Device ID, enter the AT Command:
AT+DI
2. For the Network Key, enter:
AT+NK
3. For the Join EUI, enter:
AT+NI
4. Use a text editor like Notepad++ or Notepad. Cut and paste these values into a text editor for later use. For example:
Device ID (AT+DI): 0080000000009ce4

Network Key (AT+NK): 01020304050607080910111213141516

App EUI or Join EUI (AT+NI): 0101010101010101
5. Log into the [Radio Bridge console](https://console.radiobridge.com/login), <https://console.radiobridge.com/login>
6. Go to Devices.
7. Click Add Device.
8. Select Chirpstack as the Network used.

9. Enter the end device information for the xDot (remove dots and dashes).
 - a. Device Name: Enter a user-defined Device Name to identify your xDot.
 - b. Device EUI: For Device EUI, enter the EUI from the AT+DI command.
 - c. App Key: Enter the Network Key from the AT+NK command.
 - d. Select Device Type: For Select Device Type, choose LoRa Generic Device.
 - e. Select/Enter Join EUI: Enter the Join EUI from the AT+NI command.
 - f. Select Region: For the Region, select US915 or EU868. (If your channel plan is not for US but in the 900's, select US915. If your channel plan is not for Europe but in the 800's, select EU868.) This must match the xDot AT+FREQ response and gateway LoRaWAN > Network Settings > Channel Plan.
10. Click Continue.
11. Click Confirm.
12. Review your device. Click View Device and the system will show the device.

Connecting xDot to Network and Sending and Receiving Data

To connect the xDot to the network:

- AT+JOIN
- AT+SEND=hello

This sends hello to the RadioBridge console. You can view the messages in the Message Log in the middle of the screen. To the right, in the Configure Sensor section, you can schedule a downlink to the xDot. Once you hit Submit, the downlink is queued. Since the default configuration is class A, an uplink is required for the downlink to be sent. After the downlink/"config" is sent, you can view it in the Config History box. At the time of this writing, you need to click the red cancel button to schedule another downlink or send a RadioBridge sensor config acknowledge packet with the command:

```
AT+SENDB=11ff02
```

Appendix B – Application Development

Overview

This section provides guidance for application development using the AT command firmware on the xDot which is interfaced to a host processor. The host processor sends AT commands via the AT command UART.

Basic Flow

1. If needed, join.
2. Read the sensor and send payload.
3. Process the downlink, if any.
4. Sleep.
5. Wake.
6. Repeat.

Link Assurance

This is a method of ensuring communication. The flow diagrams below use one of the following methods.

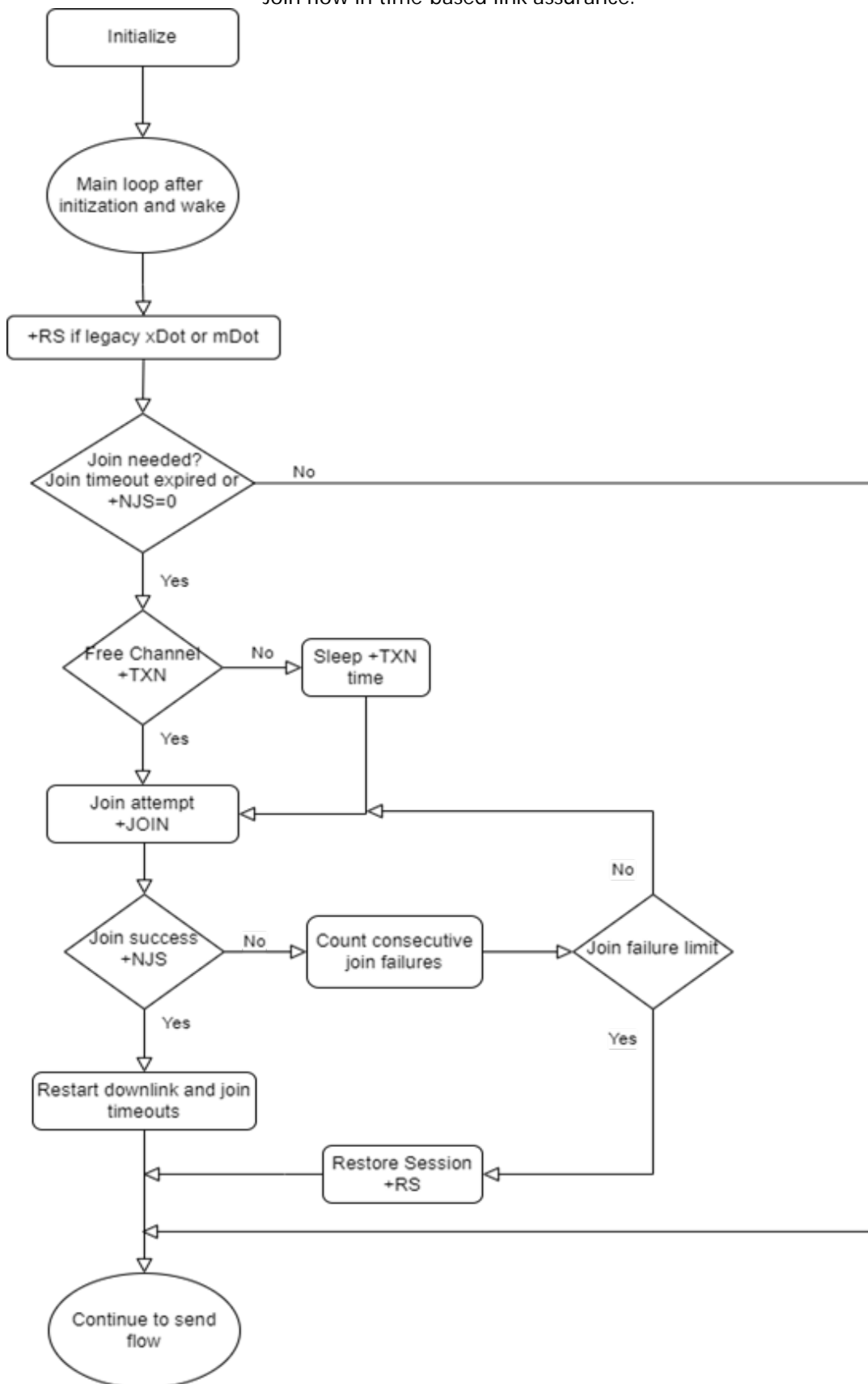
- Time-Based Link Assurance (TBLA)
- Link Check Threshold (LCT)

Time-Based Link Assurance (TBLA)

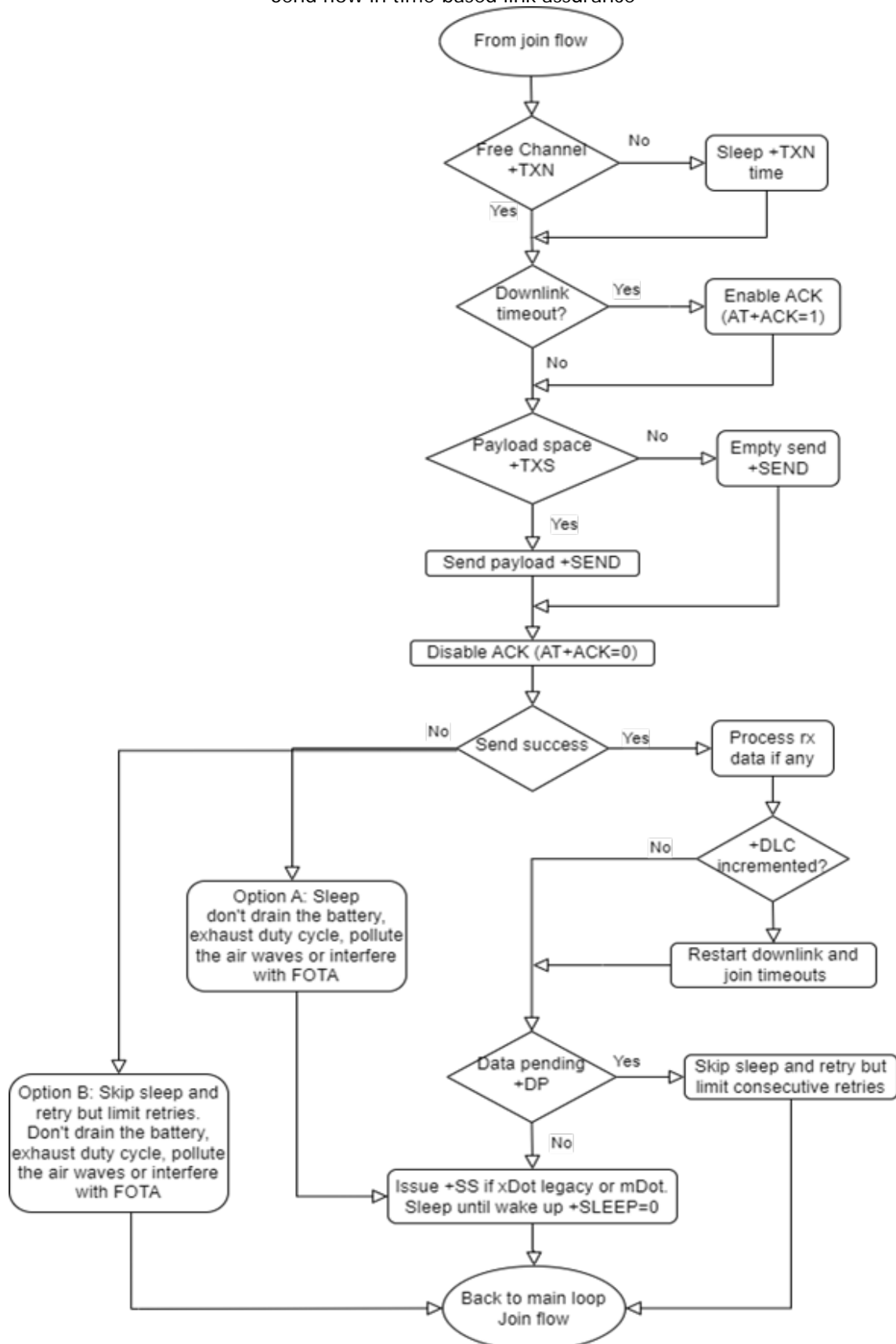
Time-based link assurance keeps track of the time since a downlink has been received. If no downlink has been received for a certain amount of time, an uplink is sent with ACKs enabled to trigger a downlink. If no downlinks are received after one or more such attempts, a rejoin is attempted. This time-based link assurance method is not currently built into the xDot firmware and relies on the host processor to manage timers, enabling ACKs, and rejoining.

- Downlink timeout: An uplink is sent with ACK enabled on each timeout.
- Join timeout: A join is attempted when this times out. This could also be a count of consecutive downlink timeouts.
- Both timeouts are restarted on a successful join or a downlink of any kind.

Join flow in time-based link assurance.



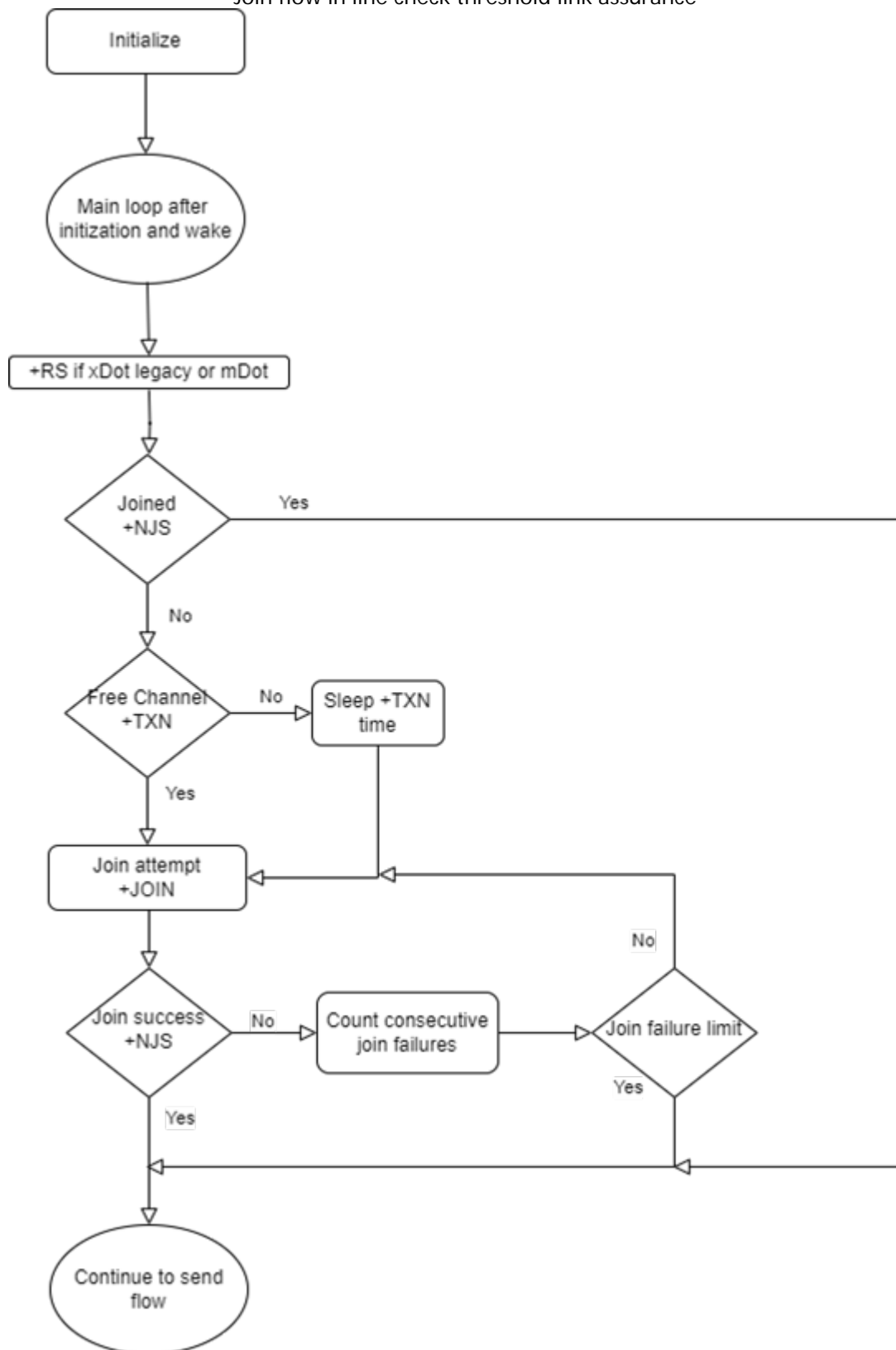
Send flow in time-based link assurance



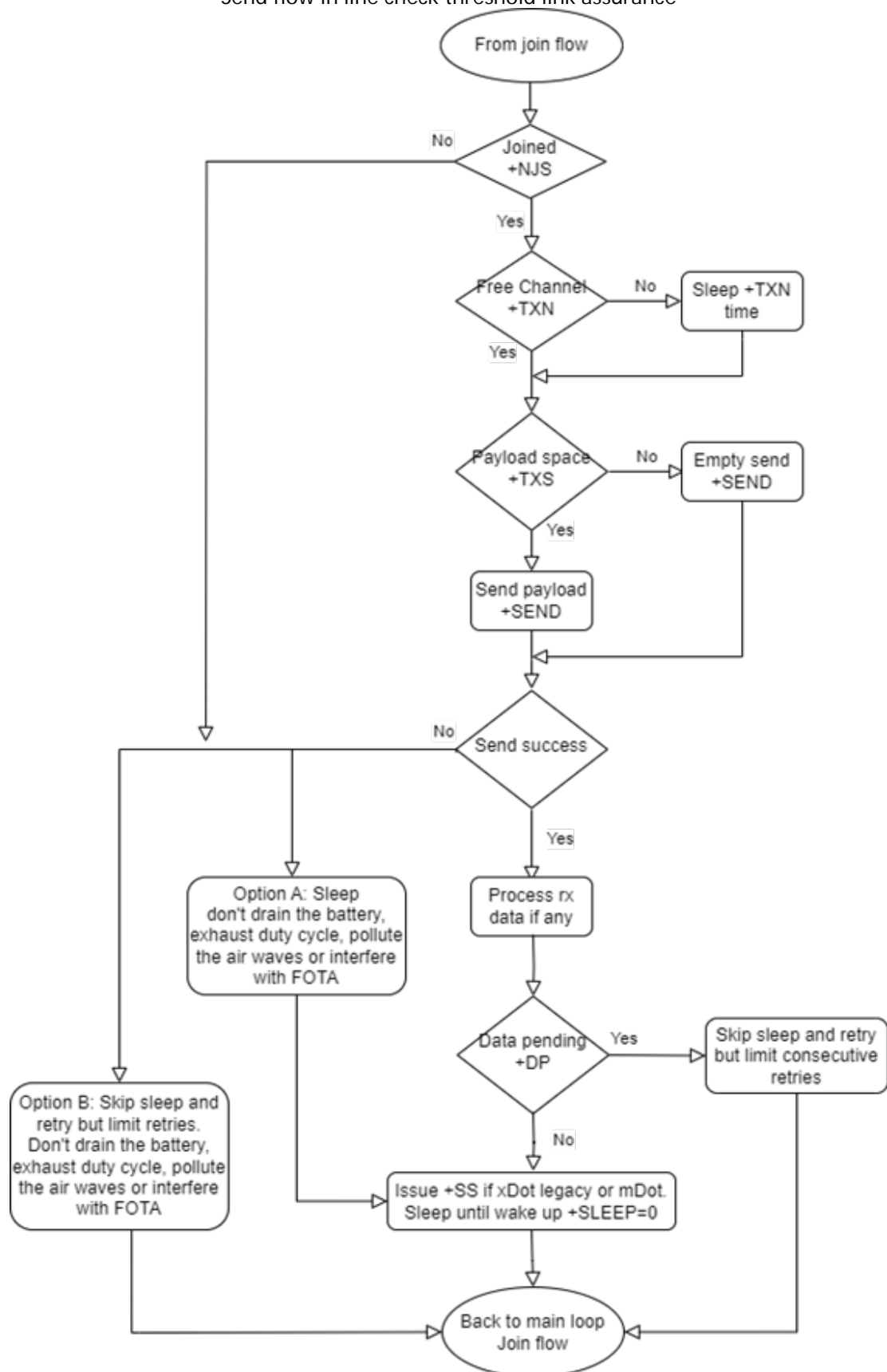
Link Check Threshold (LCT)

The command +LCT will count missed ACKs or missed link checks to ensure a connection. Once a predetermined number of ACKs or link checks have been missed, it sets the join status to not joined which indicates to the host processor to rejoin based on the +NJS command response.

Join flow in line check threshold link assurance



Send flow in line check threshold link assurance



Revision History

Revision Number	Description	Revision Date
1.2	Added support for MTXDOT-CN1- and MTMDK-XDOT-CN1-models.	October 2024
1.1	Added Appendix B - Application Development to include Time-Based Link Assurance (TBLA) and Link Check Threshold (LCT).	July 2024
1.0	Original publication.	May 2023