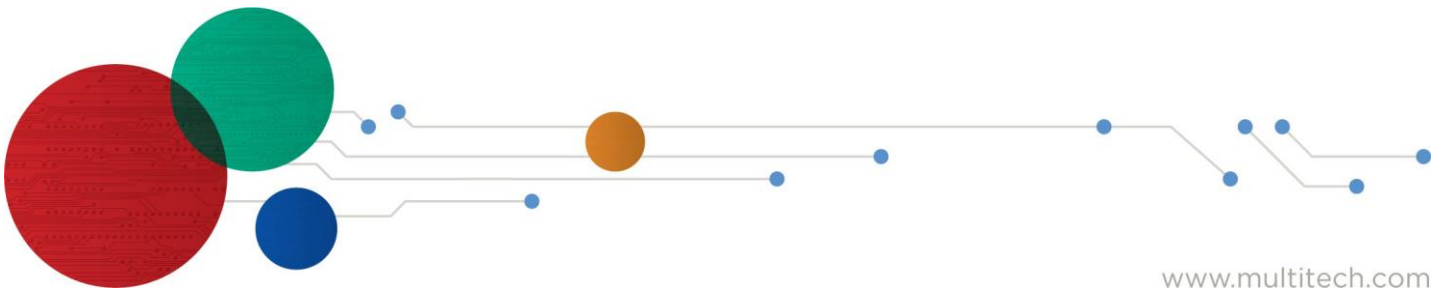


MTXDot[®] Developer Kit

Developer Guide



xDot Developer Guide

Models: MTXDOT-NA1 and MTXDOT-WW1

Part Number: S000820, Version 2.0 2023-12-11

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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.

MTXDOT-NA1 is for USA and Canada only and covered by FCC 15.247

MTXDOT-WW1 is for the Rest of the world

The xDot is a compact surface-mount device with enhanced security. Includes a comprehensive AT command instruction set.

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
- **Developer Kit information:** Design considerations, schematics, and installation and operation information.

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

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://www.multitech.com/resources/manuals>

Product Build Options

Product ordering part numbers	Description	Region
MTXDOT-NA1-B10-TR-500	xDot Advanced, UFL/Tace antenna support. Tape and Reel, 500 pack.	North America
MTXDOT-WW1-B10-TR-500	xDot Advanced, UFL/ Tace antenna support. Tape and Reel, 500 pack.	Worldwide
MTXDOT-NA1-B15-TR-500	xDot Essential, Tace antenna support. Tape and Reel, 500 pack.	North America
MTXDOT-WW1-B15-TR-500	xDot Essential, Tace antenna support. Tape and Reel, 500 pack.	Worldwide
Developer Kits		
MTMDK-XDOT-NA1-B10	xDot Advanced, LoRa Developer Kit.	North America
MTMDK-XDOT-WW1-B10	xDot Advanced LoRa Developer Kit.	Worldwide
MTMDK-XDOT-NA1-B14	xDot Essential LoRa Developer Kit	North America
MTMDK-XDOT-WW-B14	xDot Essential LoRa Developer Kit.	Worldwide

Note:

Important: **MTXDOT-WW1** xDot does not have a default frequency band. You must set the frequency band to use the device. **MTXDOT-NA1** defaults to US915 band and cannot be changed.

Developer Kit Package Contents

Your xDot Developer Kit includes the following:

Developer Board	3 - xDot Developer Boards with xDot modules attached.
Customer Notices	3 - Quick Start Guides

Chapter 2 – Getting Started with the xDot Developer Kit

The xDot Developer kit consists of an xDot module pre-attached to the USB developer board. 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 = N
 - Stop bits = 1
 - Flow control = Off

For steps on deploying xDots with a Conduit gateway or access point, refer to the [Appendix](#).

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 and 4, etc.

The COM port with 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

You may need to install a driver for the debug port to function properly. Go to: <https://developer.Mbed.org/handbook/Windows-serial-configuration>

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

Common Functions

This topic includes commands commonly used when getting started with the xDot. Consult the [xDot AT Command Reference Guide](#) for more information on these and other AT Commands.

Factory Default

To look at factory default settings:

```
AT&F
```

Setting Frequency Sub Band

With US915 and AU915 you usually need to set a Frequency Sub Band. Set this to match your LoRa network server's Frequency Sub Band

```
AT+FSB=1
```

Setting Up the xDot on a Network

1. **Set the Network ID (AppEUI/Join EUI) using AT+NI.**

```
AT+NI=<parameter1>,<parameter2>
```

Example setting:

```
AT+NI=0,0011223344556677
```

2. **Set the Network Key (AppKey)**

```
AT+NK=<parameter1>,<parameter2>
```

Example setting:

```
AT+NK=0,00112233445566778899AABBCCDDEEFF
```

3. **Save settings.**

```
AT&W
```

4. **Send a Join request to the server.**

```
AT+JOIN
```

Sending Text or Bytes

Once the xDot has successfully joined, you can send text or bytes.

To send text:

```
AT+SEND>HelloWorld
```

To send bytes:

AT+SENDB=01F4E25671

Chapter 3 – Updating Firmware

Use one of the following methods to update xDot firmware:

1. **Drag and drop firmware** onto the xDot on the developer board.
2. **Ymodem over serial port** using the xDot bootloader either on the developer board or in system.
3. **In system/circuit programming** (versus programming devices in production).
4. **xDot Advanced only** Updating Firmware with FOTA (FUOTA) on the xDot either on the developer board or in system.

Firmware Files

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

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`

Updating Firmware via Drag and Drop

To use the drag and drop method of updating firmware:

1. Plug the Developer Kit into a computer.
2. Wait for enumeration to complete.
3. Drag and drop the firmware file onto the device.

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

Updating Firmware Using the xDot Bootloader

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

mt s

2. At the bootloader command prompt, type
upgrade

3. Send firmware file with CRC appended via ymodem.

Updating Firmware with FOTA (FUOTA)

xDot Advanced only

Firmware Over the Air (FOTA) also known as Firmware Update Over the Air (FUOTA) is a way to upgrade xDot end devices using multicast and file fragmentation packages defined in the LoRaWAN specification. FOTA allows the Conduit 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. EEPROM stores device configuration and session information. Using EEPROM insures the Device EUI isn't lost if the internal flash is erased.

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.

To start the FOTA process, the Conduit sends two setup downlinks to the xDot. First, the Conduit then sends a multicast session setup request to the xDot. The xDot responds with a multicast session setup answer. The Conduit sends a fragmentation setup request. The xDot responds by sending back a fragmentation setup answer. Once setup is complete, the xDot waits until the start of the multicast session. 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 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, and 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.

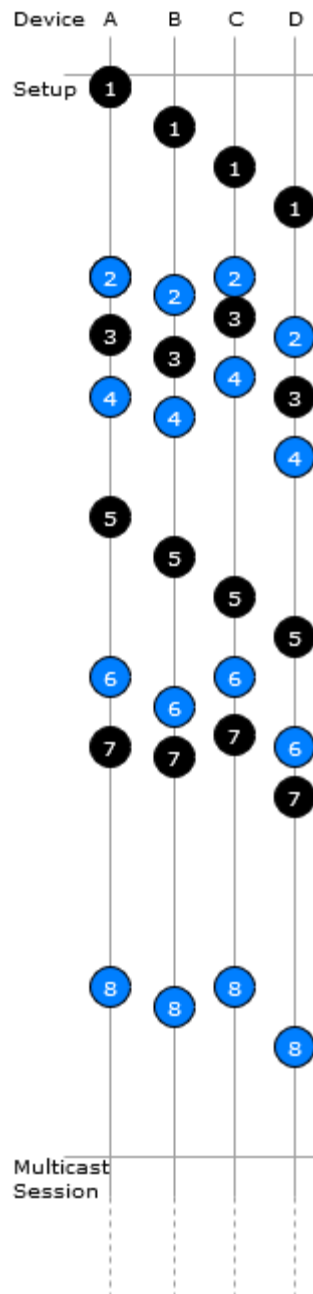
Class A devices must periodically send uplinks to open downlink windows making the time required to complete an operation setup directly tied to the frequency of device uplinks. For each device involved in the operation, some extra time should be added to the total setup time to account for latency in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

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 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 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.

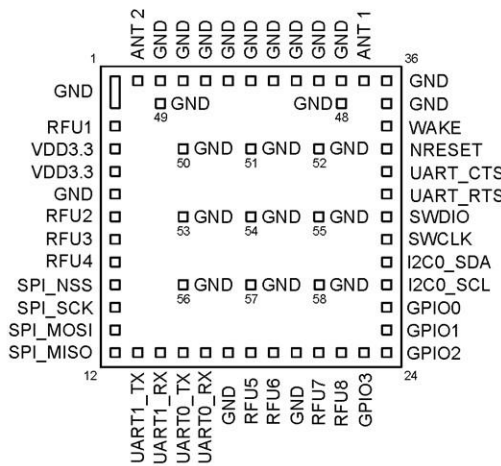
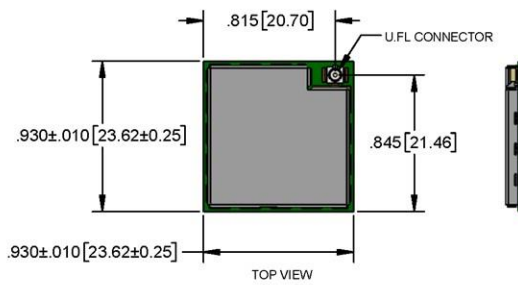
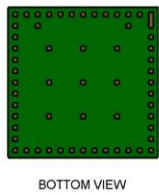
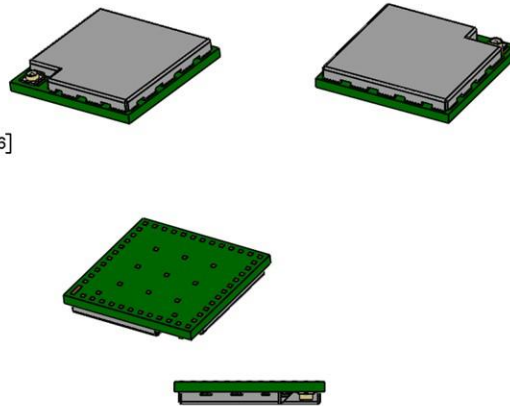
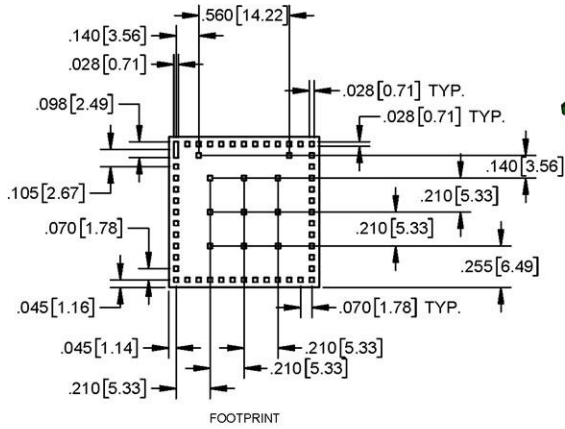
Problem: Stop FOTA Session / FOTA Session won't start (FOTA in progress) / Stop Multicast Session

Troubleshooting:

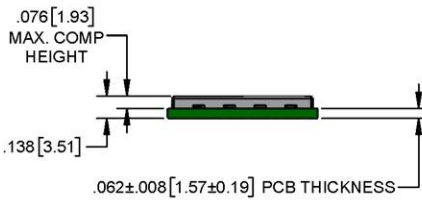
- To end a FOTA session that is in progress, send 'ps -A | grep fota'. Find the PID associated with lora-fota (not lora-fota-demo). Then send 'kill (pid of lora-fota)'.
- Also send 'rm -r -f ~/.fota/'. Devices may be in Class C or Class A depending on the FOTA session status before it ended. Make sure 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 future FOTA/multicast sessions scheduled that have not setup.

Chapter 4 – Mechanical Drawings with Pinouts

xDot



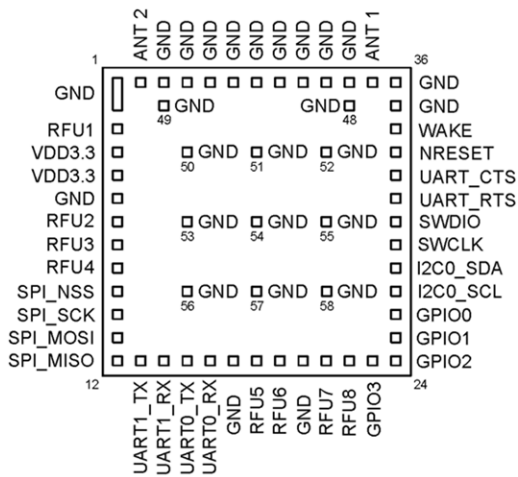
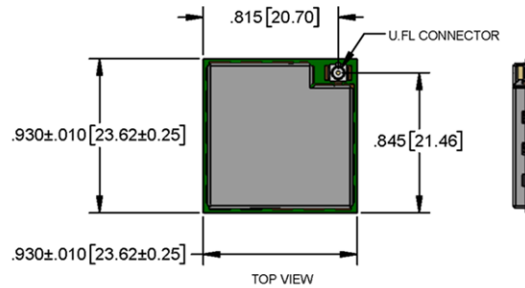
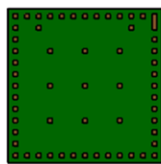
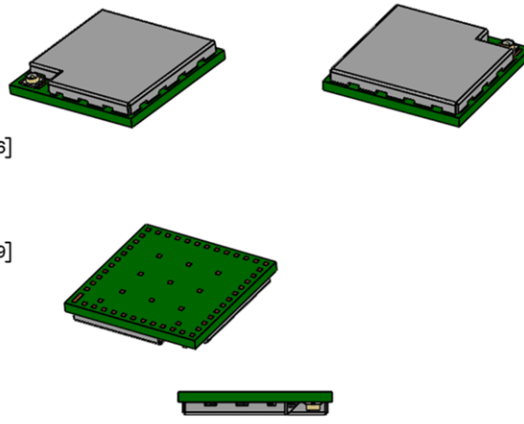
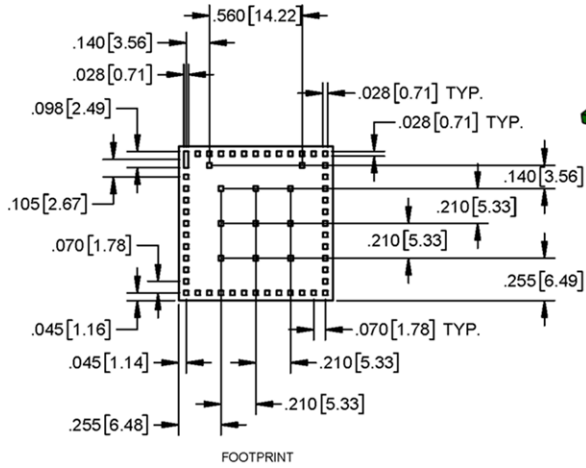
AS VIEWED FROM THE TOP
SCALE 2 : 1



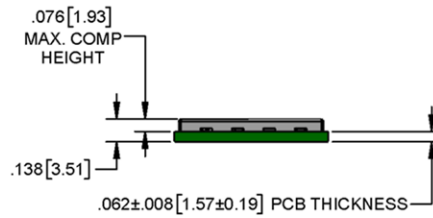
DIMENSIONS IN In [mm]

XDOT-1.5

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.



AS VIEWED FROM THE TOP
SCALE 2 : 1



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	Note that pin functions are multiplexed.
	Up to 19 digital I/O
	I2C
	SPI
	Wake pin
	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/FUOTA	
Max Clock	32 MHz
Flash Memory	8 MB
EEPROM	16 KB
Physical Description	
Weight	0.0001 oz. (0.003g)
Dimensions	Refer to Mechanical Drawings for Dimensions.
RF Connectors	
-UFL	U.FL
-Trace	Trace Connection
Environment	
Operating Temperature	-40° C to +85° C
Storage Temperature	-40° C to +85° C
Humidity	20%-90% RH, non-condensing
Power Requirements¹	

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

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: EN55032 Class B
	EU: EN55035/CISPR35
Radio	EU: EN 300 220-1 V3.1.1
	EU: EN 301 489-03 V2.1.1
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	

Category	Description
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 15.247:2022 / CA: RSS-247 2:2017
	US: FCC 15.109:2023
	US: FCC 15.107:2023
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
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 current meter across JP30 on the developer board.

3. Plug the xDot developer board back into the computer.
4. Set wake pin to wake, **AT+WP=6**.
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 current draw.
9. Press the **S2** button on the developer board to wake the xDot

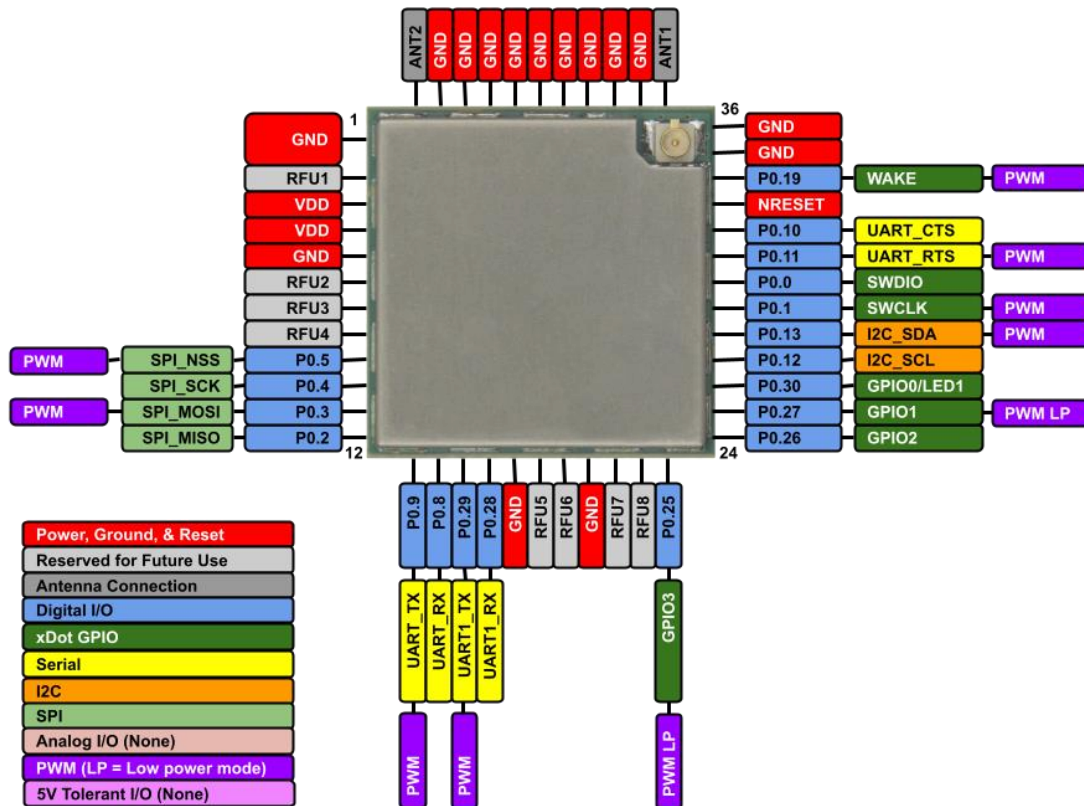
Power Draw

Note:

- Inrush charge is the highest observed value from took 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
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

xDot Pin Number	xDot Pin Name	MAX32670 Pin Number	MAX32670 Pin Name	MAX32670 Net Name
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
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 - Reserved	NC	N/A	N/A	N/A
47 - RFU (ANT2)	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
PD	11	P0.3	SPI_MOSI	100K
PD	10	P0.4	SPI_SCK	100K
PD	N/A	P0.15	MOSI for LoRa Radio	100K

PU/PD	xDot Pin	Pin Name	SW Name	Value
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
P0.20	LORA_RESET
P0.21	LORA_BUSY
P0.22	LORA_DIO1

Sleep and 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

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 [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 = N
- Stop bits = 1
- Flow control = Off

LoRa

Throughput Rates

Theoretical maximum speeds for LoRa mode with ACKs off are:

- Using spreading factor 7 at 125kHz, the throughput rate is 5470 bps (5.47 kbps).
- Using spreading factor 7 at 500kHz 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, earth's curvature. Use the following formula to calculate the maximum range:

$$Range_{Miles} = 10^{\left(\frac{TxPower + Antenna\ gain\ total - RX\ Sensitivity - Fade\ Margin - 36.56}{20} - LOG_{10}(F_{MHz})\right)}$$

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 T_{NRESET} .
2. Select either:
 - Allow RESET to float. The internal pull-up resistor pulls it up.
 - Drive the RESET line high.

The processor starts executing code after the RESET line is 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.

Developer Kit Package Contents

Your Developer Kit includes the following:

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

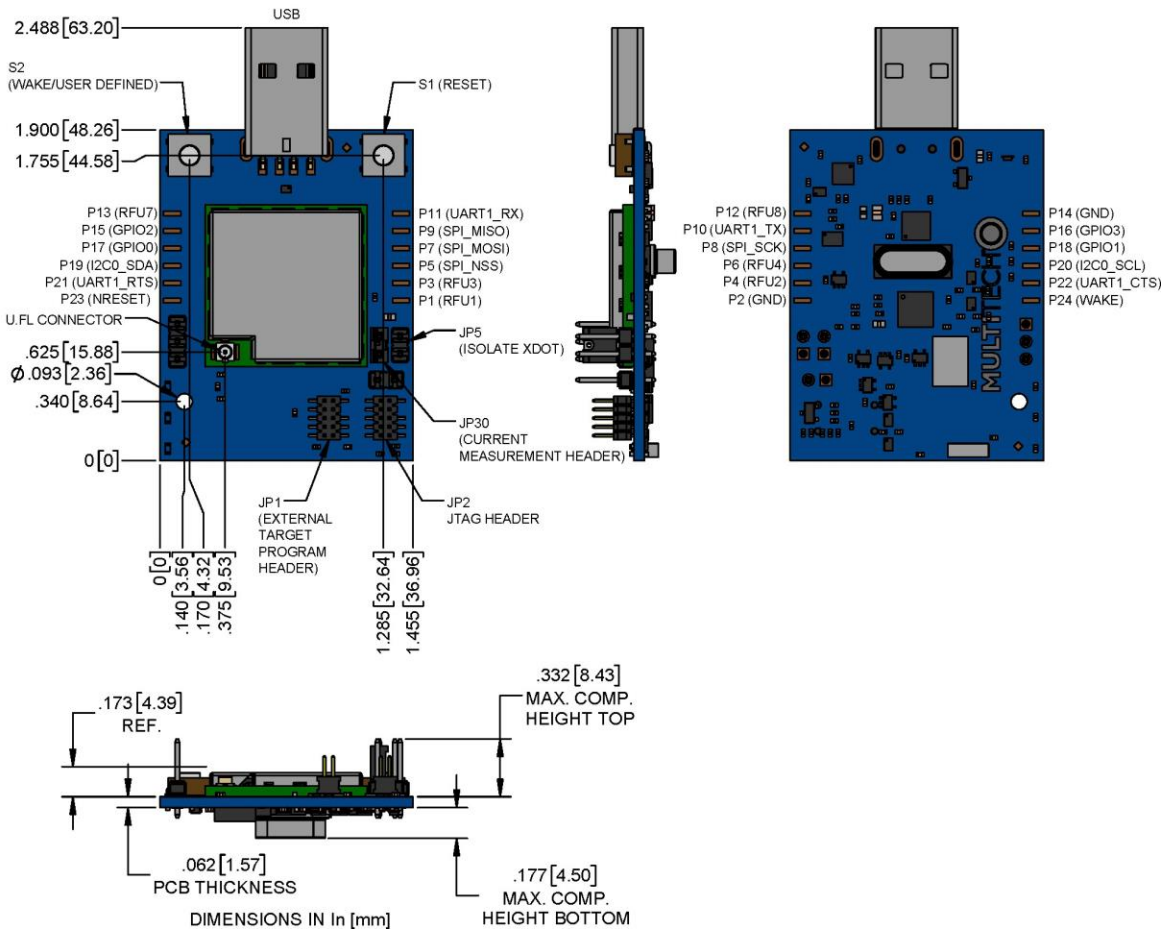
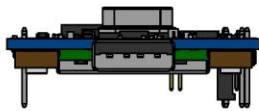
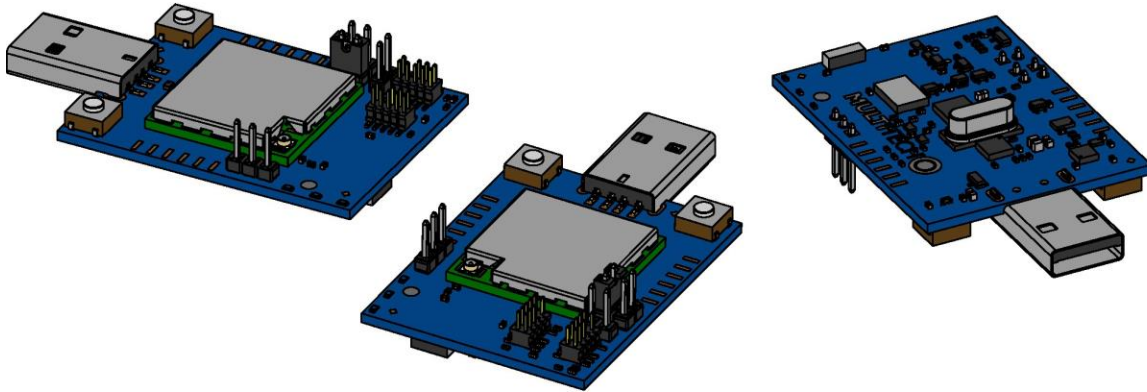
Firmware Updates

Before starting your project development, make sure you have the latest firmware for the Developer Kit and xDot. Go to the xDot mbed page for firmware. <https://developer.mbed.org/platforms/MTS-xDot-32670/>

Programming Devices in Production

Consult [In-System Programming of xDot](#) for programming options.

xDot Developer Kit Mechanical Drawings



Note: The Reset and Wake buttons reset and wake the xDot processor.

Micro Developer Board LEDs

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

Chapter 7 – Antennas

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. Antennas having a greater gain than the maximum gain indicated for the listed type, are strictly prohibited for use with this device.

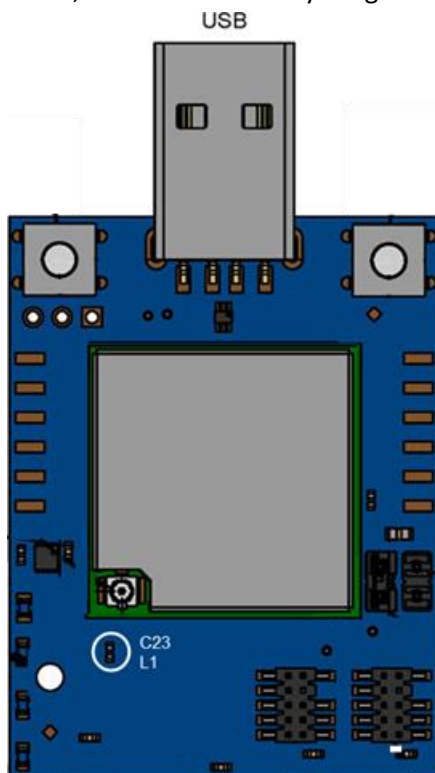
A C2PC will be needed to use a trace Antenna.

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 50ohm impedance controlled transmission line.. Use the developer board schematics for a reference circuit for the trace antenna.
- **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 connector on the xDot, do not connect anything to ANT1 (pin 37) or ANT2 (pin 47).



LoRa Antenna

Manufacturer:	Pulse Larsen 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
Radiation	Omni
Polarization	Vertical

RSMA-to-U.FL Coaxial Cables

Coaxial Cable Specifications

Optional antenna cables can be ordered from MultiTech.

Cable Type	Coaxial Cable
Attenuation	<1.0db
Connector Impedance	50 ohm
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. Text of first list item.

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's 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. QR code contains the Node ID

Example xDot example Device Labels

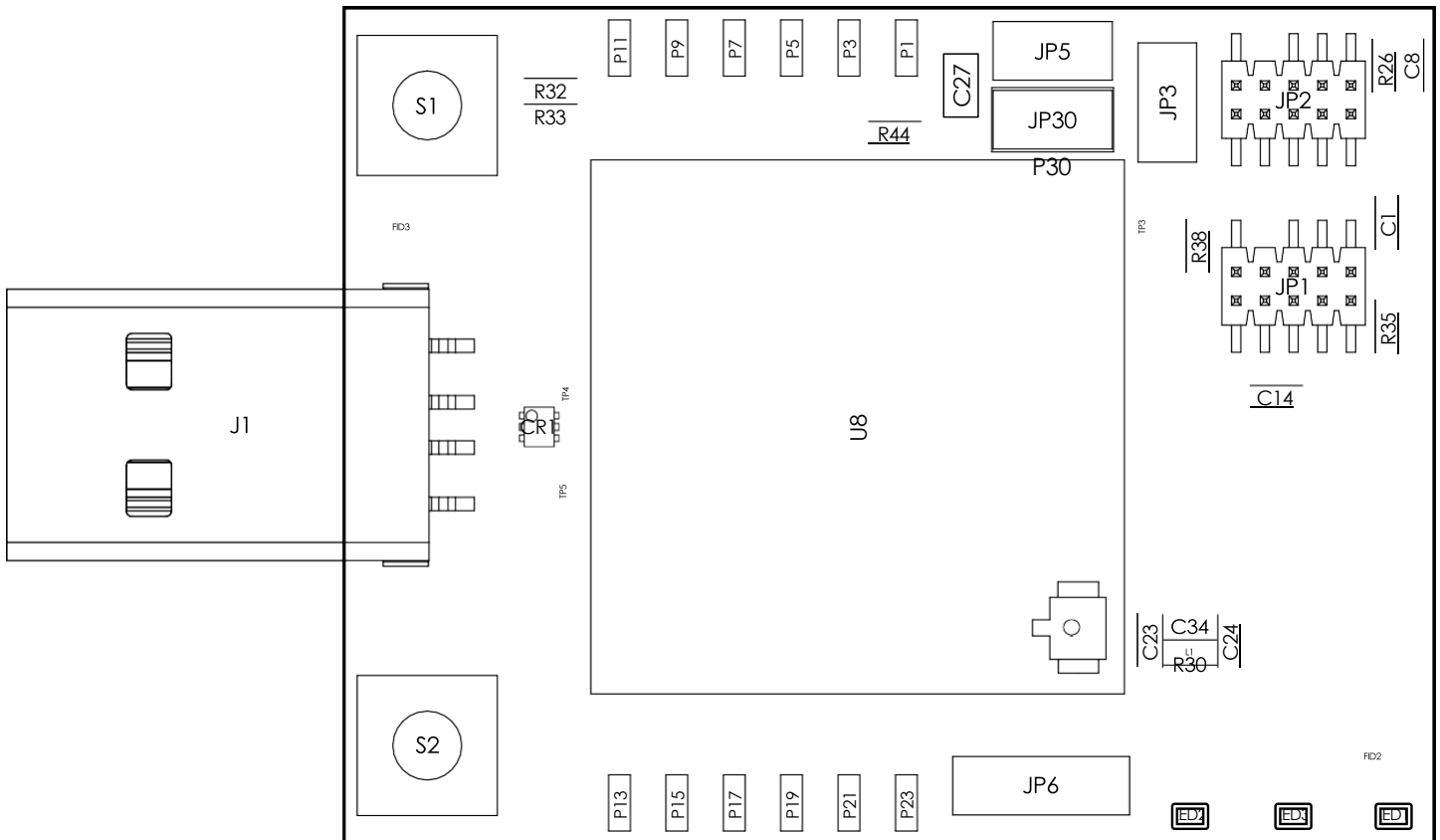


Chapter 10 – Developer Board Assembly Diagram and Schematics

Assembly Diagram - Top

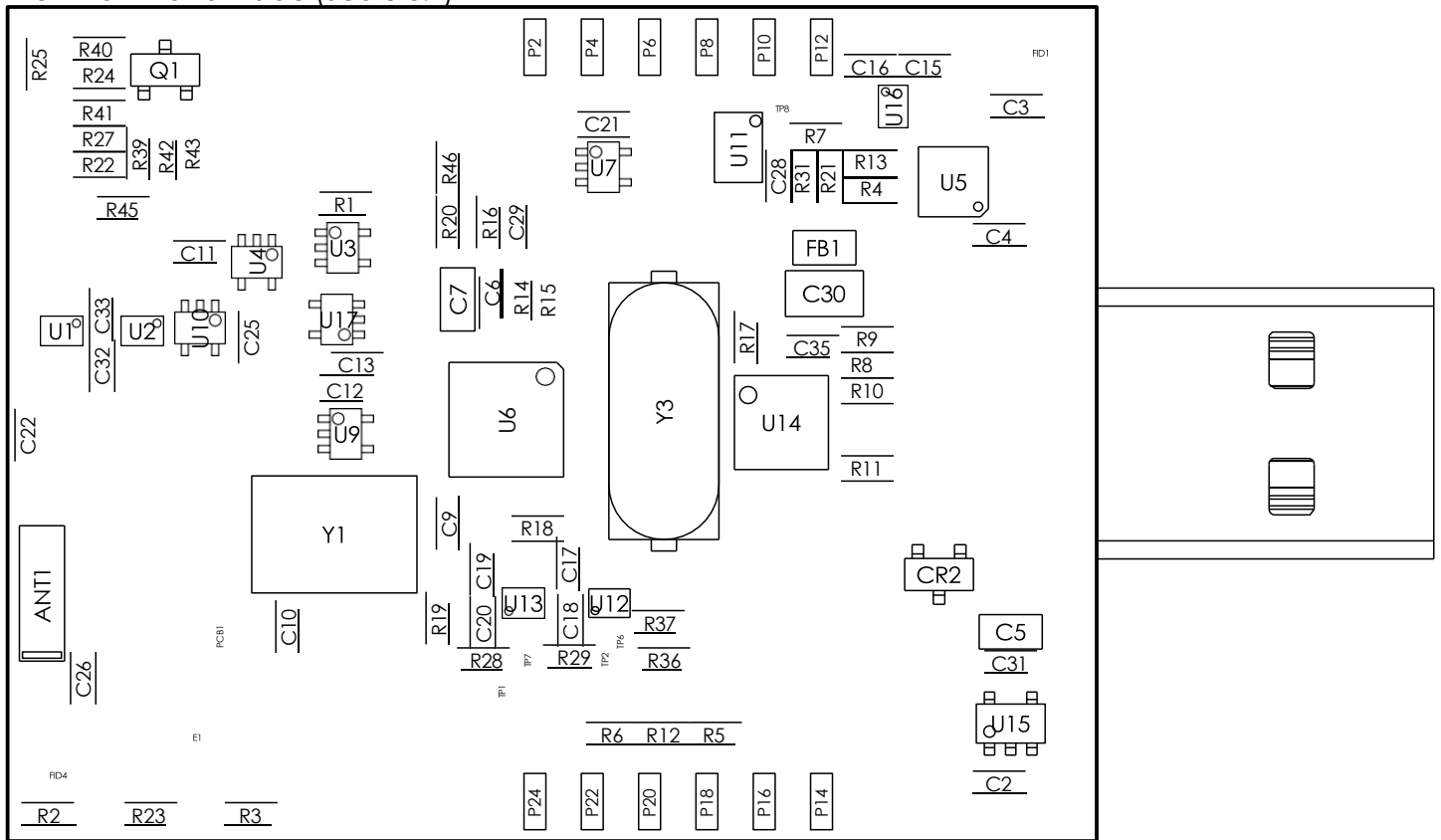
L1 C34 and R30 share the same spot

View from Top side (Scale 3:1)

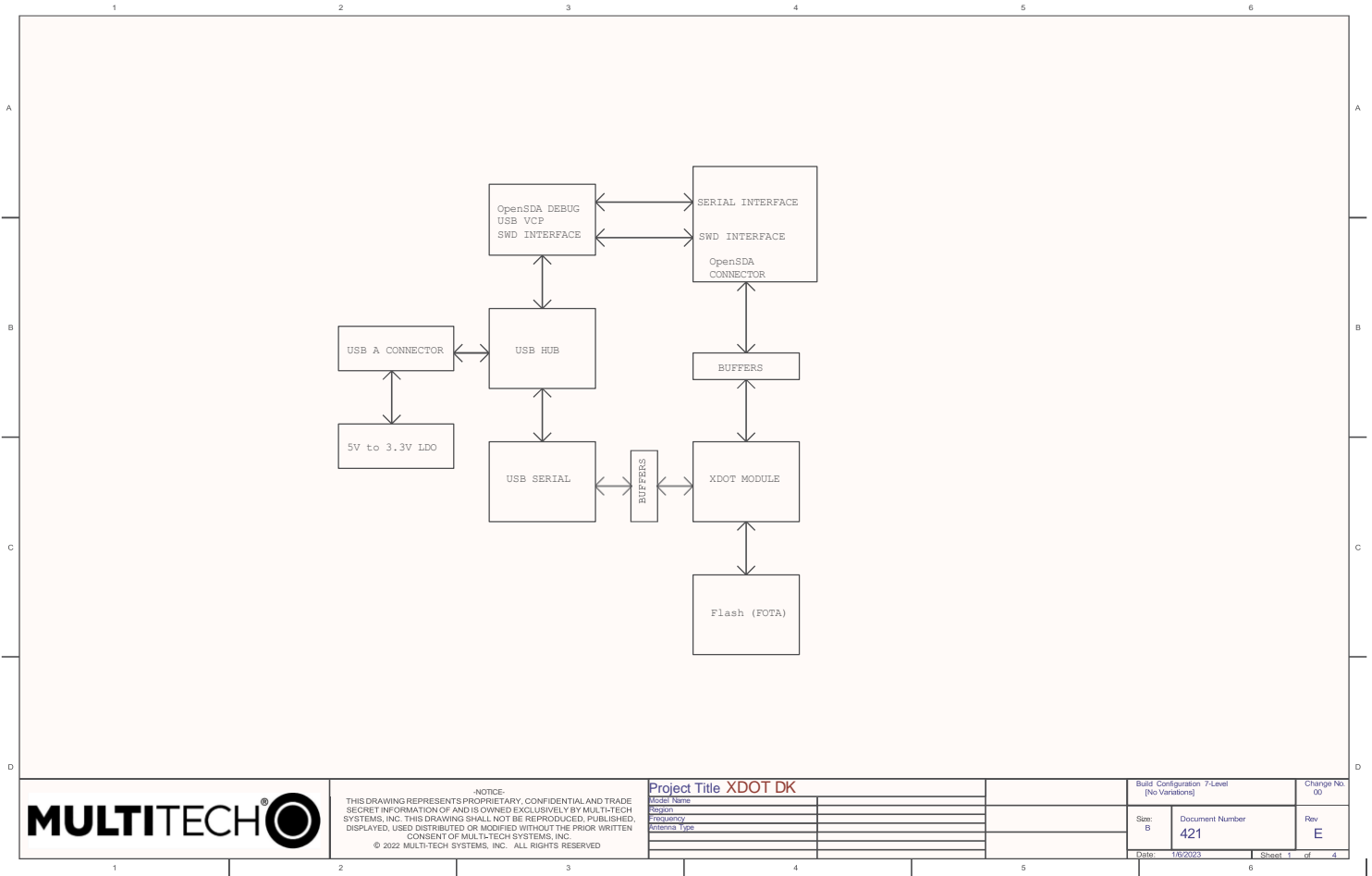


Assembly Diagram - Bottom

View from Bottom side (Scale 3:1)



Block Diagram



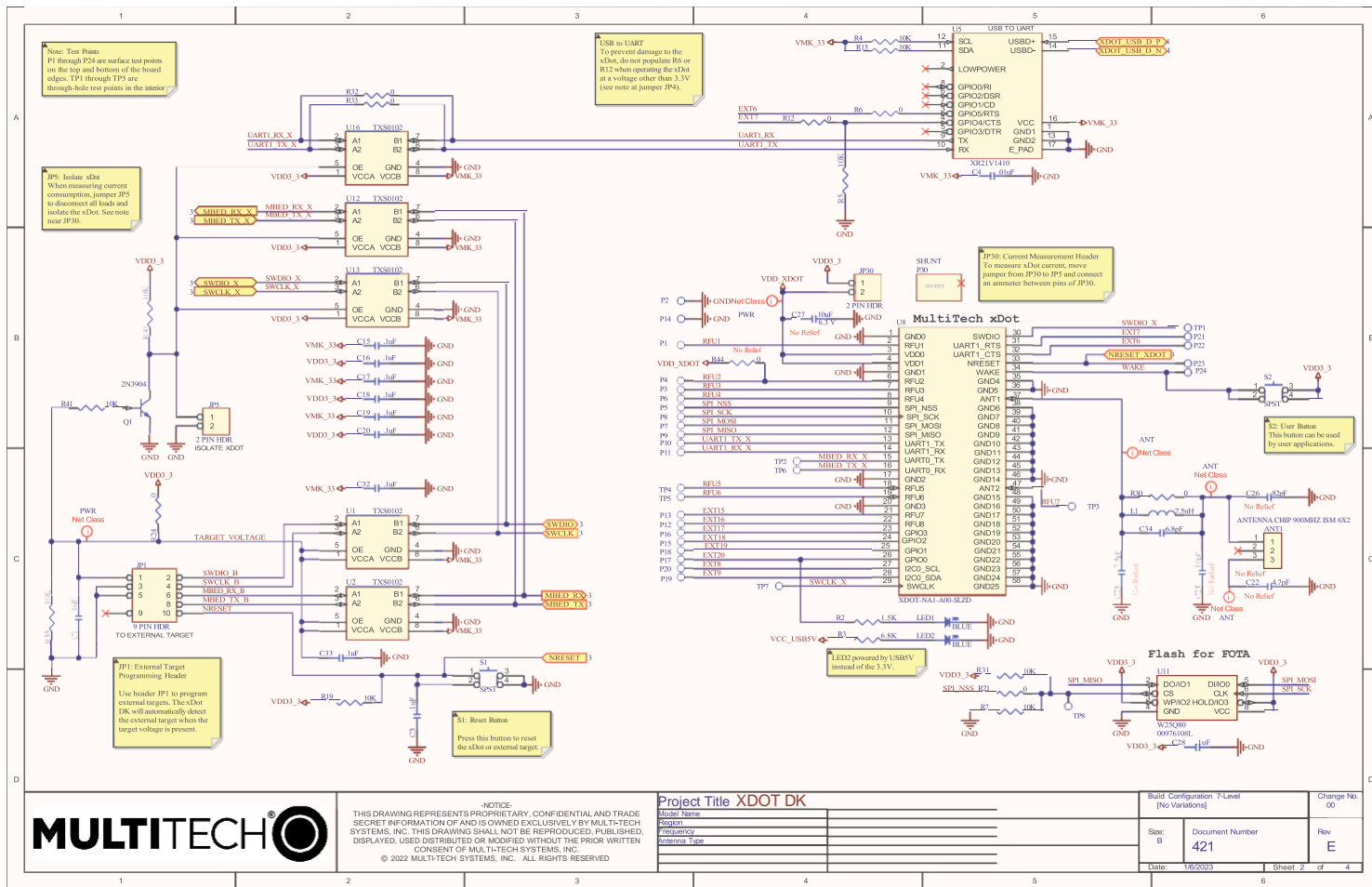
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Project Title **XDOT DK**

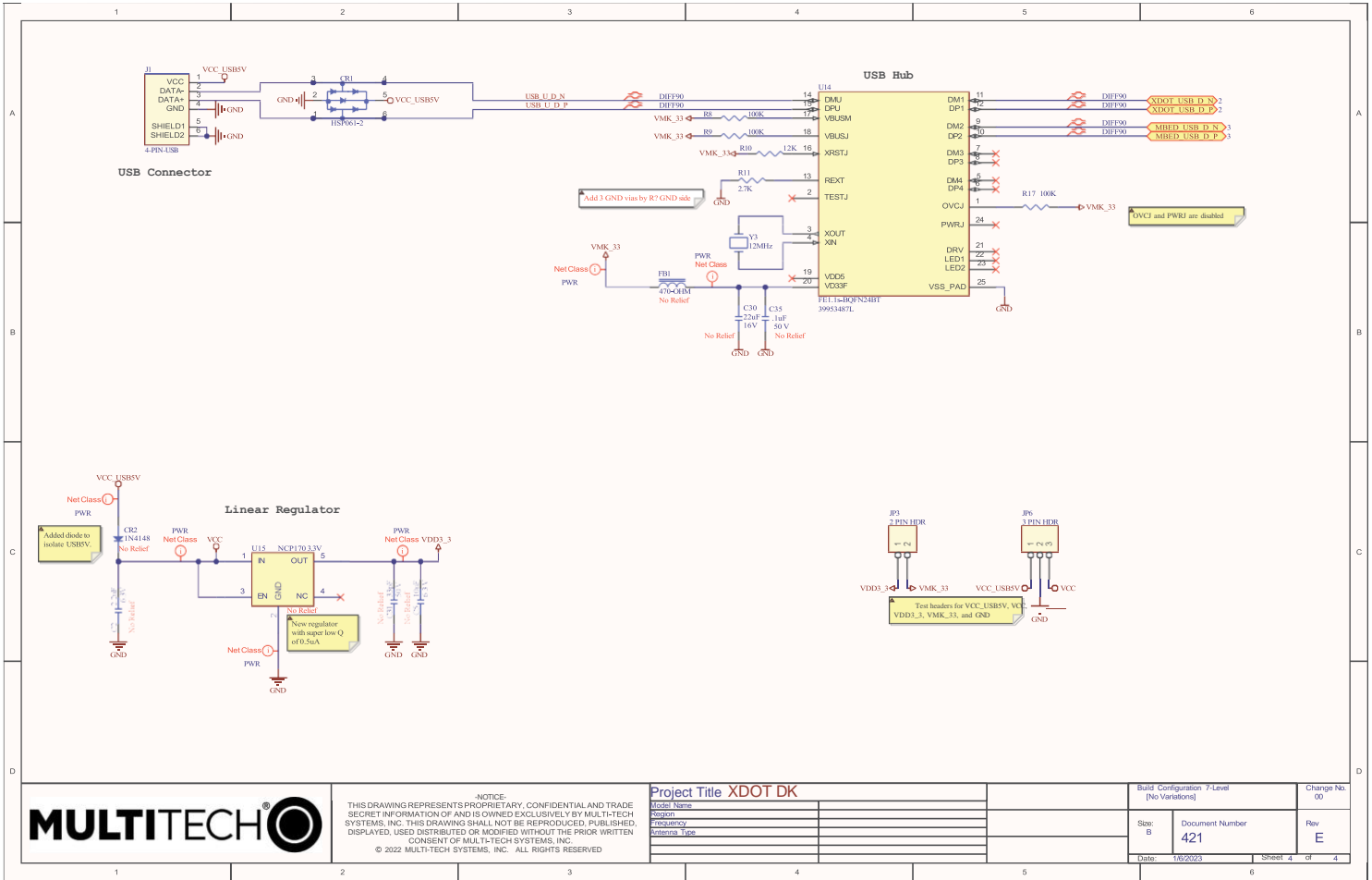
Model Name	
Region	
Frequency	
Antenna Type	

Build Configuration: 7-Level (No Variations)		Change No 00
Size B	Document Number 421	Rev E
Date: 1/8/2023	Sheet 1 of 4	

Power



USB Hub/Linear Regulator



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Project Title XDOT DK

Model Name	
Region	
Quantity	
Antenna Type	

Build Configuration 7-Level [No Variations]

Size: B	Document Number: 421	Rev: E
Date: 1/6/2023	Sheet: 4	of: 4

Chapter 11 – 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 12 – 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://www.multitech.com/red>

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://www.multitech.com/support/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

Per FCC KDB 996369, the Grantee of a transmitter seeking modular approval must provide integration instructions for host product manufacturers with each of the following items addressed:

2.2 List of applicable FCC rules

FCC 15.247

2.3 Summarize the specific operational use conditions:

The MTXDOT-NA1 is designed to be used for sensors or device tracking using the latest Lora Technology to communicate back to a Lora Gateway that could be nearby or many miles away depending on the install.

2.4 Limited module procedures

N/A

2.5 Trace antenna designs

The MTXDOT-NA1 allows for a customer to design in a trace antenna and will be left to the integrator to do C2PC if they decide they need or want to use a trace antenna that has different characteristics the antenna used with the ufl connection.

2.6 RF exposure considerations

See Chapter 7 of this guide.

2.7 Antennas

See Chapter 7 of this Guide.

2.8 Label and compliance information

See chapter 9

2.9 Information on test modes and additional testing requirements

See AT command section of this document.

2.10 Additional testing, Part 15 Subpart B disclaimer

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.

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 void the certification of this product.

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 13 – 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, refer to additional regulatory documents at:

<https://www.multitech.com/support/support>

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
- Diisobutyl 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 14 – Tape and Reel Specifications and Guidelines

Text of first paragraph.

Text of second paragraph.

Note: Text of note.

Text of third paragraph.

1. Text of first list item.
2. Text of second list item.
3. Text of third list item.

Chapter 15 – Mounting xDots and Programming External Targets

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.

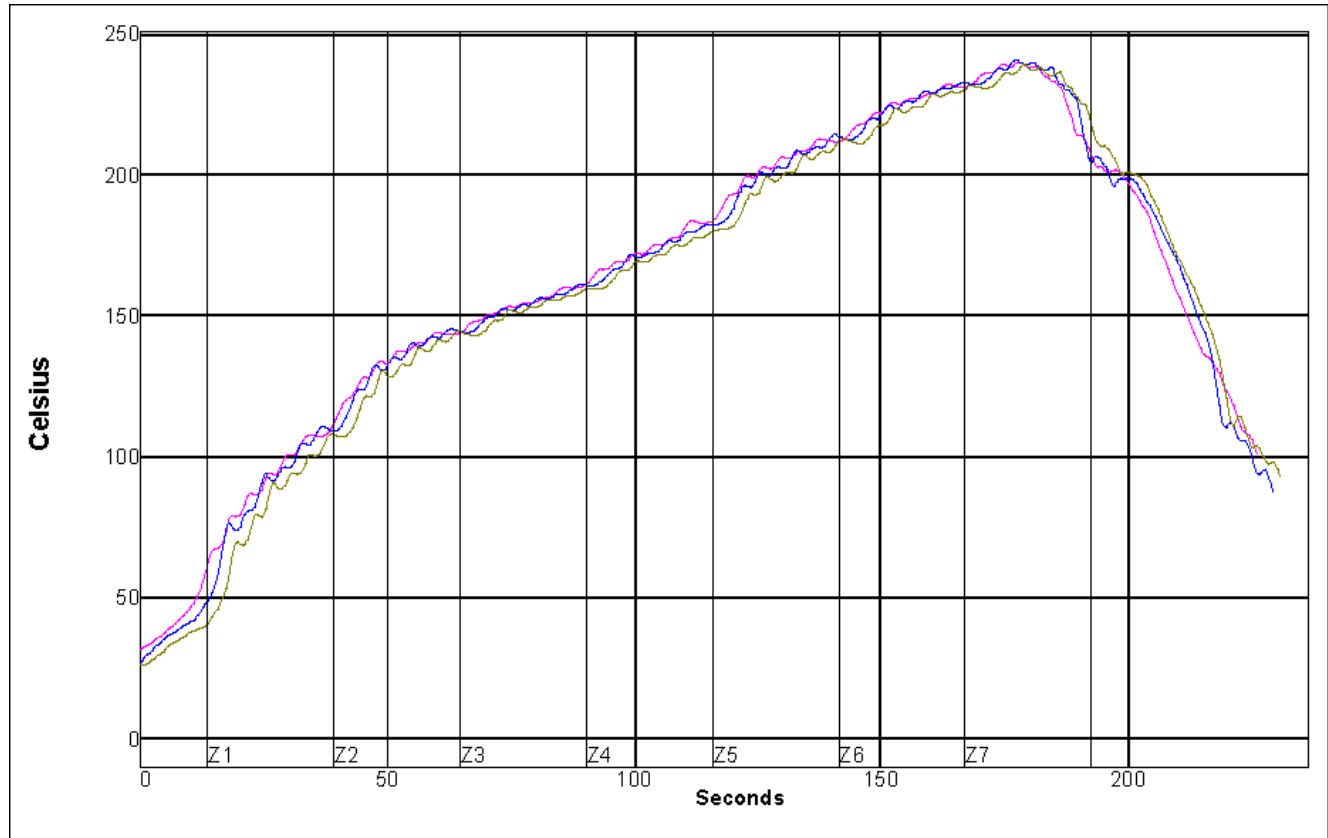
Solder Profile

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	

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.

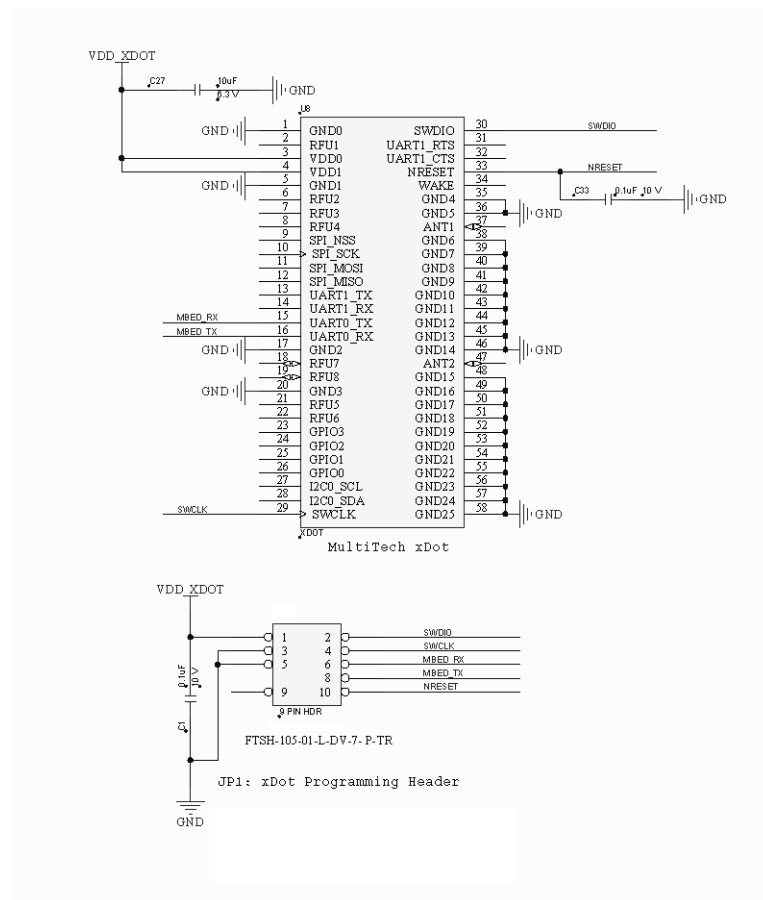
Warning: Electrostatic discharge (ESD) can damage the MTMDK-XDOT. Potential failure via ESD through the JTAG headers include the MTMDK-XDOT processor, level converters, and potentially the target device.

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

Schematic example shows programming header connections for xDot on 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:

- Segger J-Link programmer - SEG-JLINK <https://www.segger.com/products/debug-probes/j-link>

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

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, but the mPower First Time Setup not started. 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: You can use Ethernet or if your Conduit has a cellular radio, cellular for your LoRa connection.

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 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 and 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

Ethernet LoRa packet forwarder 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. Under **Mode**, select **DHCP Client**.
5. Click **Submit**.
6. Go to **Administration > Access Configuration > HTTPS**.
7. Enable **HTTPS via WAN**.
8. 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: none
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.

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 App EUI Network ID, 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>
6. Go to **Devices**.
7. Click **Add Device**.
8. Select **Chirpstack** as the **Network** used.
9. Enter the end device information for the xDot.
 - a. **Device Name:** Enter a user-defined **Device** Name to identify your xDot.
 - b. **Device ID:** For **Device ID**, enter the EUI from the AT+DI command.
 - c. **Device Key:** Enter the Network Key from the AT+NI command.
 - d. **Select Device Type:** For Select Device Type, choose LoRa xDot/mDot Sensor.
 - e. **Select/Enter Join EUI:** Accept the Join EUI as is.

- 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**.)

10. Click **Continue**.
11. Click **Confirm**.
12. Review your device. Click **View Device** and the system will show the device.

Connecting the xDot to the Network and Sending and Receiving Data

To connect the xDot to the network in a terminal window connected to the xDot:

1. Send the following commands. The notes explain what each command does and values.

- `AT+PN=`

Enables or disables public network mode: 0, 1, or 2

- `AT+FSB=2`

Sets Frequency Sub-band: 1-8

- `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+DI=devEUI`

Device ID Device EUI-64 (MSB) (8 bytes)

- `AT+NA=devAddr Network`

Address Network address (devAddr in TTN) (4 bytes)

- `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

- `AT+SEND=hello`

This sends hello to the ASW broker

For example, if you take the information from `AT+DI` and build your own set of AT commands in a text editor, just like this except the `AT+NI=` part. Your ID will be what you got back from `AT+DI`.

```
AT+PN=1
AT+NJM=1
AT+NI=0,00800000000009ce4
AT+NK=0,01020304050607080910111213141516
AT&W
AT+JOIN
AT+NJS
```


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