XB1301 LoRa Concentrator
User Guide

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1.1 References

Doc#	Title
HCI-005-DS	APANA XB1301 Datasheet
HCI-005-UG	APANA XB1301 User Guide
HCI-005-MECH	APANA XB1301 Mechanical Drawing
HCI-005-BD	APANA XB1301 Block Diagram
HCI-005-AT	APANA XB1301 AT Command Set
HCI-005-OD	APANA XB1301 Operational Description

Table 1. Reference documents.

1 Introduction

1.1 Purpose

The purpose of this document is to assist OEMs in integrating the APANA XB1301 into their equipment designs.

1.2 Orderable Part Numbers

Description	Part No.	Market	Frequency
LoRa Concentrator	XB1301-US915	N. America	902 to 928MHz
Programming Mule	XB1301-M		

1.3 Datasheet

For detailed electrical and mechanical specifications, see latest revision of **HCI-005-DS APANA XB1301 Datasheet**.

1.4 Block Diagram

For electrical block diagram, see latest revision of **HCI-005-BD APANA XB1301 Block Diagram**.

1.5 Mechanical

See **HCI-005-MECH APANA XB1301 Mechanical Drawing** for mechanical information.

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1.6 Installation

The APANA XB1301 is intended to be professionally integrated by OEMs into their equipment designs.

WARNING: Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment. The installer shall be responsible for ensuring that the proper antenna is employed so that the requirements of FCC § 15.203 are met and limits of § 15.247 are not exceeded.

2 Minimum Connections

2.1 UART

If UART is used, the minimum connections are VCC, GND, DIN, and DOUT.

2.2 USB

If USB is used, the minimum connections are VCC, GND, USB_D+, and USB_D-.

3 Firmware Updates

3.1 USB

To update firmware via USB, the minimum connections are VCC, GND, USB_D+, USB_D-, DTR, and RTS.

3.2 UART

To update firmware via UART, the minimum connections are VCC, GND, DIN, DOUT, DTR, and RTS.

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3.2.1 Example Schematic for UART Firmware Update

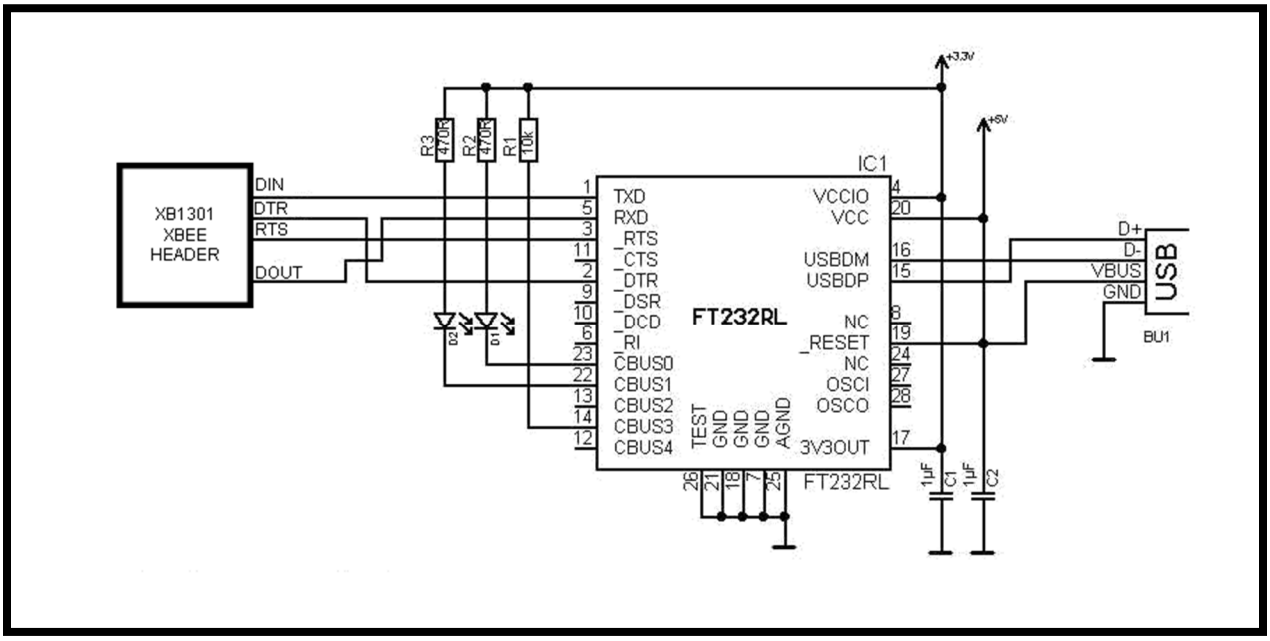

Figure 1. Example XB1301 reprogramming using FTDI FT232RL.

Figure 1 above show connects on XB1301 (FT232RL): DIN (TXD), DOUT (RXD), DTR (DTR), and RTS (RTS).

3.3 Flash Loader Demonstrator

For software to assist updating the STM32 using USB or UART bootloader, see the STMicroelectronics UM0462 User Manual Flash Loader Demonstrator.

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4 In-System Debug

To facilitate custom designs the XB1301 provides access to the SWD and JTAG connections via the XBEE header.

Table 294. SWJ debug port pins

SWJ-DP pin name	JTAG debug port		SW debug port		Pin assignment
	Type	Description	Type	Debug assignment	
JTMS/SWDIO	I	JTAG Test Mode Selection	IO	Serial Wire Data Input/Output	PA13
JTCK/SWCLK	I	JTAG Test Clock	I	Serial Wire Clock	PA14
JTDI	I	JTAG Test Data Input	-	-	PA15
JTDO/TRACESWO	O	JTAG Test Data Output	-	TRACESWO if async trace is enabled	PB3
NJTRST	I	JTAG Test nReset	-	-	PB4

Table 2. JTAG and SWJ debug port pins[1].

Table 295. Flexible SWJ-DP pin assignment

Available debug ports	SWJ IO pin assigned				
	PA13 / JTMS / SWDIO	PA14 / JTCK / SWCLK	PA15 / JTDI	PB3 / JTDO	PB4 / NJTRST
Full SWJ (JTAG-DP + SW-DP) - Reset State	X	X	X	X	X
Full SWJ (JTAG-DP + SW-DP) but without NJTRST	X	X	X	X	
JTAG-DP Disabled and SW-DP Enabled	X	X			
JTAG-DP Disabled and SW-DP Disabled	Released				

Table 3. Flexible programming pin assignments[1].

[1] Table taken directly from STMicroelectronics RM0090 Reference Manual

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4.1 Cortex Debug Connector

The XB1301 was designed assuming the use of the 10-pin Cortex Debug Connector, shown below.

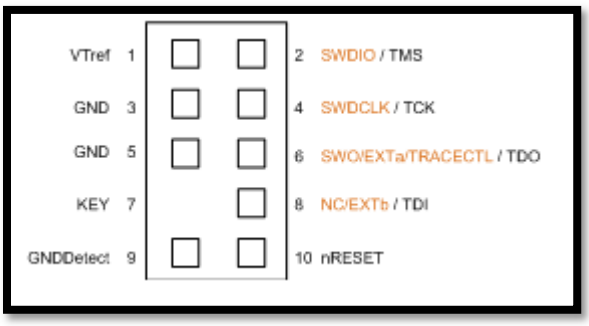

Figure 2. 10-Pin Cortex Debug Connector

The 10-Pin Cortex Debug Connector pinout is known to be supported by:

- STMicroelectronics ST-LINK/V2 with Olimex ARM-JTAG-20-10 20-pin 0.1" to 10-pin 0.05" Adapter[2]
- ULINK
- ULINK2
- Segger (?)

4.2 Serial Wire Debug (SWD) (2 connections)

To perform in-system debug using serial wire debug (SWD), the minimum connections are shown in the table below.

Table 4. Connections required for serial wire debug (SWD)

Function	XBEE Pin No	XBEE Pin Name	MCU Pin	Type
SWDIO	17	SWDIO/TMS	PA13	I/O
SWDCLK	18	SWDCLK/TCK	PA14	I

4.3 Serial Wire Debug (SWD) with Trace via Serial Wire Viewer (SWV) (3 connections)

To perform in-system debug using serial wire debug (SWD), the minimum connections are shown in the table below.

Table 5. Connections required for serial wire debug (SWD) with serial wire viewer (SWV) capability

Function	XBEE Pin No	XBEE Pin Name	MCU Pin	Type
SWDIO	17	SWDIO/TMS	PA13	I/O
SWDCLK	18	SWDCLK/TCK	PA14	I
TRACESWO	19	SWO/TDO	PB3	-

[2] Recommended

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4.4 JTAG without Reset (4 connections)

To perform in-system debug using joint test action group (JTAG), without reset, the minimum connections are shown in the table below.

Table 6. Connections for JTAG without Reset

Function	XBEE Pin No	XBEE Pin Name	MCU Pin	Type
JTMS	17	SWDIO/TMS	PA13	I
JTCK	18	SWDCLK/TCK	PA14	I
JTDI	20	TDI	PA15	I
JTDO	19	SWO/TDO	PB3	O

4.5 JTAG with Reset (5 connections)

To perform in-system debug using joint test action group (JTAG), with reset, the minimum connections are shown in the table below.

Table 7. Connections for JTAG with Reset

Function	XBEE Pin No	XBEE Pin Name	MCU Pin	Type
JTMS	17	SWDIO/TMS	PA13	I
JTCK	18	SWDCLK/TCK	PA14	I
JTDI	20	TDI	PA15	I
JTDO	19	SWO/TDO	PB3	O
NJTRST[3]	5	NJRST	PB4	I

5 Power Supply Considerations

The power consumption estimates provided here assume that only one RF transmitter channel is active at any given time. In the event that the application requires both RF transmitters active simultaneously, simply double these numbers.

The absolute worst-case power consumption of the XB1301 is 5 Watts (1A at VCC=5V, 2A at VCC=2.5V). For design purposes, this author recommends you provide the XB1301 with a 5V supply capable of a sustained 1 Amp load.

5.1 RF transmit = 1W

For applications that want to transmit maximum RF power of 1W, a maximum of 1A (VCC=3V) or 0.5A (VCC=5V).

5.2 RF transmit = 0.5W

For applications that want to transmit maximum RF power of 0.5W, a maximum of 0.5A (VCC=3V) or 0.25A (VCC=5V).

[3] NJRST is the JTAG Test nReset

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5.3 RF transmit = 0.1W

For applications that want to transmit maximum RF power of 0.1W, a maximum of 0.25A (VCC=3V) or 0.125A (VCC=5V).

5.4 Maximizing Efficiency

The XB1301 contains many internal power supplies, each with its own ideal maximum efficiency input voltage, which changes on based upon load current. The power dissipation of the XB1301 is dominated by the RF power amplifier for higher transmit duty cycles. For applications with low transmit duty cycles, typically the XB1301 power consumption is dominated by the RF receiver, demodulation circuitry, and host processor.

The XB1301 is designed to operate with VCC between 2.5V and 5.5V. For applications where power consumption is a concern, and the designer is able to select the VCC voltage, the table below provides recommended VCC voltage to maximize efficiency.

Table 8. Recommended VCC to maximize device efficiency

RF TX Power		**VCCPA[4]**	**VCC for maximum efficiency**	
			Duty Cycle < 10%	**Duty Cycle >50%**
0.1W	20dBm	3V	3.3V	3V
0.5W	27dBm	3.7V	3.5V	4V
1.0W	30dBm	5V	5V	5V

[4] The voltage provided to the RF power amplifier is dynamically-controllable to ensure amplifier operation at maximum efficiency

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6 LEDs

The XB1301 has ten LEDs visible externally, as shown in below.

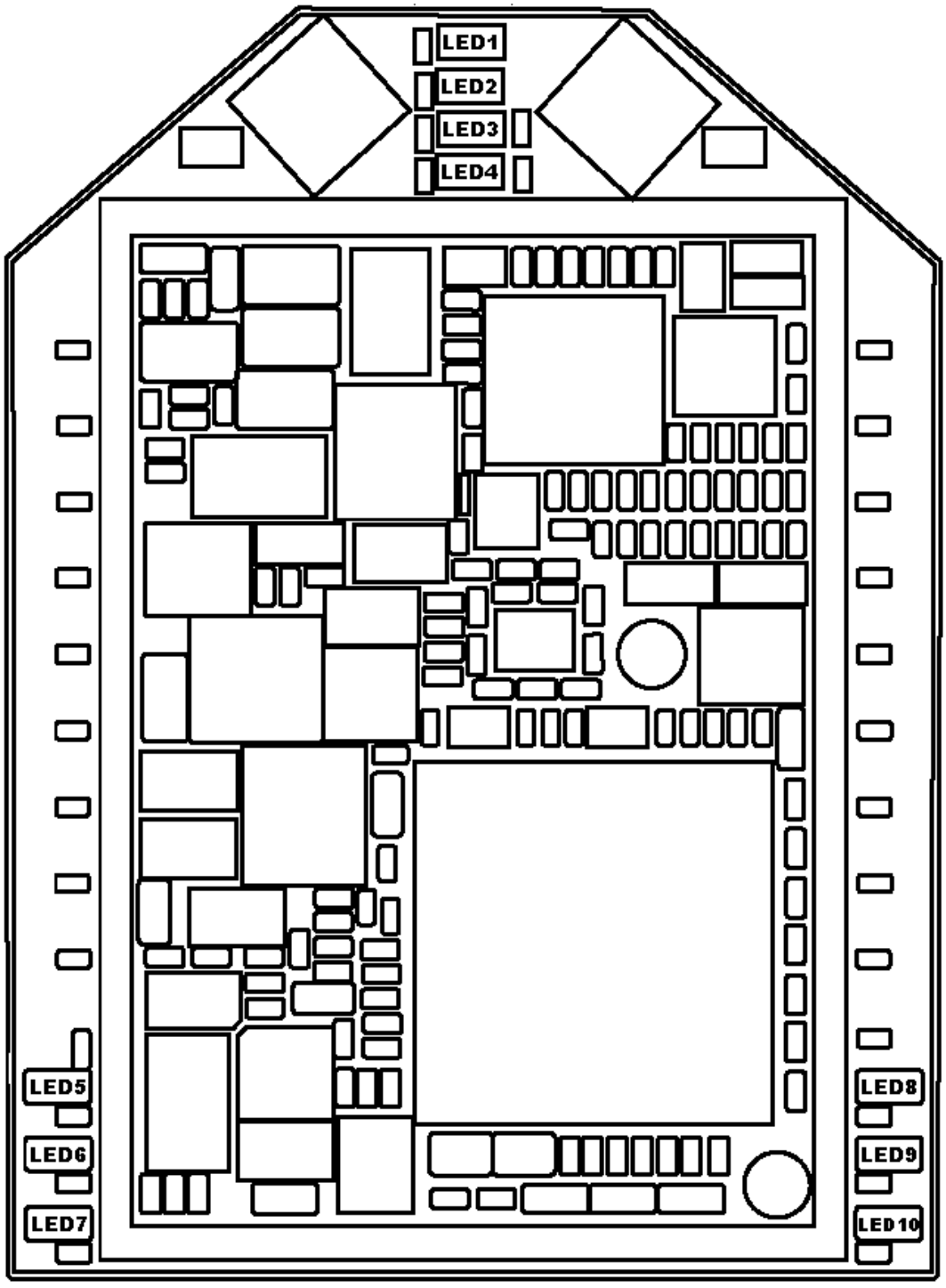

Figure 3. XB1301 LED locations

Four User LEDs are controlled directly by the MCU (STM32F4) are LED1, LED2, LED3, and LED4.

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The one Power LED is simply on when external power is applied, off otherwise, which is called LED5.

The five Radio LEDs are controlled directly by the Semtech SX1301 chip are LED6, LED7, LED8, LED9, and LED10.

Table 9. LED description

Type	Name	Controlled By	Pin	Color	Description
User	LED1	STM32F4	PE14	RED	LoRa Init Failure
User	LED2	STM32F4	PE13	GRN	Heartbeat (1Hz)
User	LED3	STM32F4	PE11	ORG	TBD
User	LED4	STM32F4	PE9	YLW	TBD
Power	LED5	VIN	Pin 1	GRN	On when external power applied >2V
Radio	LED6	SX1301	GPIO3	RED	fsk_pkt (FSK rx IF9)
Radio	LED7	SX1301	GPIO2	YLW	bh_pkt (LoRa rx on IF8)
Radio	LED8	SX1301	GPIO0	GRN	rx_buffer_not_empty
Radio	LED9	SX1301	GPIO4	GRN	tx_on
Radio	LED10	SX1301	GPIO1	RED	sensor_pkt (Lora rx on IF0 to IF7)

See Semtech SX1301 datasheet §3.6.1 for more information on LED functions.

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7 Alternate Functions

7.1 Overview

The XB1301 includes multiple alternate functions, available to the user through custom configuration.

Table 10. Summary of alternate functions by pin

Label				Default			Reconfigurable as:				
XBEE Pin No.	**Name**	**FUNC**	**MCU**	**Type**	**Function**	**Dir**	**GPIO**	**SPI1**	**UART3**	**UART4**	**I2C2**
1	VCC	VCC	N/A	Power Input	Power Input	I	Dedicated VCC pin				
2	DOUT	UART3_TX/I2C2_SCL	PB10	UART TX	UART3_TX	O	GPIO (I/O)		UART3_TX		I2C2_SCL
3	DIN	UART3_RX/I2C2_SDA	PB11	UART RX	UART3_RX	I	GPIO (I/O)		UART3_RX		I2C2_SDA
4	1PPS	1PPS	PD15	GPIO	1PPS	I	Dedicated 1PPS signal from GPS/GNSS				
5	NJRST	NJRST	PB4	GPIO	None	I	GPIO (I/O)				
6	PWM0/RSSI	TIM2_CH2/TIM5_CH2/DAC_OUT2/UART4_RX	PA5,PA1	PWM (TIM2_CH2)	RSSI Output	O	GPIO (I/O)			UART4_RX	
7	USB_D+	OTG_FS_DP	PA12	OTG_FS_DP	USB_FS_DP	I/O	GPIO (I/O)				
8	USB_D-	OTG_FS_DM	PA11	OTG_FS_DM	USB_FS_DM	I/O	GPIO (I/O)				
9	DTR	BOOT0	PB12,BOOT0	BOOT0	BOOT0	I	Dedicated field firmware update pin (BOOT0)				
10	GND	GND	N/A	Ground	Ground	I	Dedicated ground pin				
11	AD4/DIO4	TIM3_CH1/ADC12_IN6	PA6	GPIO	None	I	GPIO (I/O)	SPI1_MISO			
12	CTS	USART3_CTS	PB13,PB6	GPIO	None	I	GPIO (I/O)				
13	ON/nSLEEP	UART4_TX	PA0	SW Reset	ON/nSLEEP	I	GPIO (I/O)			UART4_TX	
14	SHDN	SHDN	N/A	HW Reset	SHDN	I	Dedicated asynchronous shutdown input pin				
15	AD5/DIO5	TIM14_CH1/TIM3_CH2/ADC12_IN7/SPI1_MOSI	PA7	GPIO	None	I	GPIO (I/O)	SPI1_MOSI			
16	RTS	NRST	NRST	NRST	NRST	I	Dedicated field firmware update pin (NRST)				
17	SWDIO/TMS	SWDIO/TMS	PA13	SW Prog	SWDIO	I/O	GPIO (I/O)				
18	SWDCLK/TCK	SWDCLK/TCK	PA14	SW Prog	SWDCLK	I	GPIO (I/O)				
19	SWO/TDO	SWO/TDO/SPI1_SCK	PB3	GPIO	None	I	GPIO (I/O)	SPI1_SCK			
20	TDI	TDI/SPI1_NSS	PA15	GPIO	None	I	GPIO (I/O)	SPI1_NSS			

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7.2 SPI1

Table 11. SPI1 Alternate Function Pins

Function	MCU Pin	Header Pin No.	Header Pin Name
SPI1_MISO	PA6	11	AD4/DIO4
SPI1_MOSI	PA7	15	AD5/DIO5
SPI1_SCK	PB3	19	SWO/TDO
SPI1_NSS	PA15	20	TDI

7.3 I2C2

Table 12. I2C2 Alternate Function Pins

Function	MCU Pin	Header Pin No.	Header Pin Name
I2C2_SCL	PB10	2	DOUT
I2C2_SDA	PB11	3	DIN

7.4 UART4

Table 13. UART4 Alternate Function Pins

Function	MCU Pin	Header Pin No.	Header Pin Name
UART4_RX	PA1	6	PWM0/RSSI
UART4_TX	PA0/WKUP	13	ON/nSLEEP

7.5 Summary by Function

Table 14. Summary of available peripherals by function

Function	Total	Notes
USB	1	OTG_FS
UART	2	UART3, UART4
SPI	1	SPI1
I2C	1	I2C2

8 MULE Board

8.1 Virtual COM Ports

Table 15. USB COM Ports when XB1301 is plugged into MULE board

Hub[5]	Manfr	Manfr PN	VID[6]	PID	VCP Order[7]	XBEE Header	MCU[8]	Notes
Port 1	FTDI	FT231XQ	0x0403	0x6015	1	DOUT[2], DIN[3], DTR[9], RTS[16], CTS[12]	UART3	Main comm (DIN/DOUT)
Port 2	FTDI	FT2232HQ	0x0403	0x6010	2	AD4/DIO4[11], AD5/DIO5[15], SWO/TDO[19], TDI[20]	SPI1	Channel A
					3	PWM0/RSSI[6], ON/nSLEEP[13]	UART4	Channel B
Port 3	ST	STM32F415OG	??	??	4	USB_D+[7], USB_D-[8]	OTG_FS	Direct to MCU

[5] Port number on the 3-port USB Hub integrated onto the MULE board
[6] Vendor ID, as assigned by usb.org
[7] The order in which the Virtual COM Ports (VCP) should appear in Windows
[8] The peripheral function connected on the MCU (see STM32F415OG datasheet)

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9 Safety and Security

9.1 For your safety

To prevent damage to your Product or injury to you or to others, please read the following safety precautions in their entirety before using the Product and visit our website at www.apana.com to obtain further safety and security information.

9.2 Do not disassemble

This Product is not intended to be disassembled. Do not attempt to open the enclosure. Any such attempt will void the warranty and may result in personal injury or permanent product damage.

9.3 Use only provided and/or recommended cables & accessories

Only use cables, antennas, and power sources provided with the Product, or recommended herein.

10 Certification and Compliance

10.1 FCC ID

The XB1301 FCC ID is 2AK5C-APANA-XB1301

10.2 IC ID

The XB1301 IC ID is 22417-APANAXB1301

10.3 Information to user

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

10.4 Radiation Exposure Statements

10.4.1 FCC

To satisfy FCC RF exposure requirements for mobile and base station transmission devices, a separation distance of 22 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

10.4.2 Industry Canada (IC)

Important Note for mobile device use
Radiation Exposure Statement:
This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 32cm between the radiator & your body.

Note Importante pour l'utilisation de dispositifs mobiles
Déclaration d'exposition aux radiations:

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Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 32 cm de distance entre la source de rayonnement et votre corps.

10.5 Interference Statements

10.5.1 FCC

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 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.

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 CAUTION: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This radio transmitter (FCC: 2AK5C-APANA-XB1301) has been approved by FCC to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Antenna Information: 902-928 MHz, linearly-polarized antenna, Gain: 12 dBi max

10.5.2 Industry Canada (IC)

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this 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) cet appareil doit accepter toute interférence, notamment les interférences qui peuvent affecter son fonctionnement..

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To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

This device has been designed to operate with the antennas listed in the filing, and having a maximum gain of 12 dBi. Antennas not included in this list or having a gain greater than 12 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

10.5.3 Japan (VCCI)

For operation in the 920-928MHz band, a maximum of 13dBm is permissible, assuming an antenna gain of 3dBi (EIRPmax is 16dBm). Operation above this limit is prohibited. Thus, for higher gain antennas, the output power of the device is necessarily reduced to maintain radiation within the specified limit.

10.6 U.S./Canada OEM Labeling Requirements for End-Product

The module is labeled with its own FCC ID and IC Certification Number. The FCC ID and IC Certification Numbers are not visible when the module is installed inside another device. As such the end device into which the module is installed must display a label referring to the enclosed module. The final end product must be labeled in a visible area with the following:

"Contains Transmitter Module FCC ID: 2AK5C-APANA-XB1301" and "Contains Transmitter Module IC: 22417-APANAXB1301"

or

"Contains FCC ID: 2AK5C-APANA-XB1301" and "Contains IC: 22417-APANAXB1301"

The OEM of the module must only use approved antenna(s) listed above, which have been certified with the module.

10.7 OEM End-Product User Manual Statements

The OEM integrator should not provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user manual of the end product.

Other user manual statements may apply.

10.7.1 FCC / IC Label Validity

Compliance statement only valid if used with certified antenna. See list of approved antenna(s).

Label requirements vary by country. See alternate compliance statements on www.apana.com.

Label must be placed on enclosure exterior and must be clearly visible.

10.8 RF Cable

10.8.1 Minimum Cable Loss

The minimum cable loss is 1 dB[9].

[9] Typical cable is U.FL to SMA bulkhead, which is 1 dB cable loss.

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10.8.2 Maximum Cable Loss

There is no regulatory maximum cable loss for the antenna cables. However, for best performance, a maximum of 5dB cable loss is recommended

10.9 Antenna

10.9.1 Antenna Gain

Antenna tested with the XB1301 were simple monopole with up to 3.5dBi gain, and Yagi antenna with up to 12dBi gain.

10.9.2 List of Approved Antenna

The following is a list of approved antenna:

10.9.2.1 External Antennas

Table 16. XB1301 List of FCC- and ISED-Approved External Antennas

Manfr	Manfr P/N	FREQ (MHz)	Max VSWR	Efficiency	Polarization	Max Gain	Indoor/Outdoor
Digi	A09-F2NF-M	902-928	1.5	???	Linear	2.1dBi	Indoor/Outdoor
Taoglas	TI.19.2113	902-928	1.9	82%	Linear	2.5dBi	Indoor
Taoglas	OMB.915.B03F21	902-928	1.5	61%	Linear	3.5dBi	Indoor/Outdoor
DMS Wireless	YA90012	902-928	1.4	???	Yagi	12.0dBi	Indoor/Outdoor

WARNING: Regulatory transmit limit is 36 dBm EIRP, which can be exceeded when using the DMS Wireless YA90012 Yagi antenna. It is the responsibility of the installer to ensure that the proper combination of transmit power (programmed in software) and cables are used to ensure the regulatory limit is not exceeded. Failure to do this could void the user's authority to operate the equipment. The installer shall be responsible for ensuring that the proper antenna is employed so that the requirements of FCC § 15.203 are met and limits of § 15.247 are not exceeded.

10.9.3 Maximum Transmit Power

In the U.S. (FCC) and Canada (ISED) the regulatory limit for RF power into the antenna (after cable losses) is 30 dBm (1W), which assumes an antenna maximum gain of 6 dBi. Referring to Table 16 above, the Yagi antenna (DMS Wireless YA90012) is the only antenna that exceeds this limit.

10.9.4 Determining EIRP

10.9.4.1 Calculation[10]

Equation 1 below is used to calculate EIRP for a given installation. As discussed above, the EIRP cannot exceed 36dBm.

[10] As an example, a good online calculator is the Pasternack EIRP Calculator

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Equation 1. EIRP Calculation

$$EIRP = P_t - L_C - Ga$$

Where:

P_t is the transmit power (dBm)

L_c is the cable loss (dB)

G_a is the antenna gain (dBi)

10.9.4.2 Lookup Table

Alternatively, to Equation 1 above, Table 17 below provides a convenient lookup table of output transmit power for various common antenna gains and cable losses. As of this writing, the only FCC- and ISED-approved antenna with antenna gain above 6 dBi is the DMS Wireless Yagi with 12dBi gain, however, the other values are provided as an example.

Table 17. Maximum transmit power for antenna gain and cable loss

G_a (dBi) [1]	L_c (dB) [2]	P_t (dBm) [3]
15	1	22
	2	23
	3	24
	4	25
	5	26
	6	27
	7	28
	8	29
	9	30
12	1	25
	2	26
	3	27
	4	28
	5	29
	6	30
9	1	28
	2	29
	3	30

Key

Note	Symbol	Explanation
[1]	G_a (dBi)	Antenna gain relative to isotropic radiator
[2]	L_c (dB)	Total cable loss between XB1301 U.FL connector and antenna

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[3]	P_t (dBm)	RF transmit power at the U.FL connector of the XB1301

10.9.5 Determining Cable Loss

To measure cable loss, use a network analyzer[11] to measure cable loss directly.

10.9.6 Adjusting RF Transmit Power

In order to adjust the XB1301 RF transmit power to below the regulatory limit, refer to the XB1301 AT Commands document, which details the console interface for both UART and USB communication.

11 Additional Information

11.1 References and Resources

The following document references are useful to assist in integration:

- Semtech
  - Semtech LoRa Website
  - Semtech GitHub Driver/HAL for SX1301 using SX1257/SX1255 RF Transceivers
  - Semtech SX1257 I/Q Transceiver (862-960MHz) Datasheet
  - Semtech SX1255 I/Q Transceiver (400-510MHz) Datasheet
  - Semtech SX1301 Datasheet[12]
  - Semtech SX1276/77/78/79 End Device Transceiver (137-1020MHz) Datasheet
  - Semtech SX1272/73 End Device Transceiver (860-1020MHz) Datasheet
- STMicroelectronics
  - STMicroelectronics STM32F415OG Product Page
  - STMicroelectronics DS8597 STM32F415OG Datasheet
  - STMicroelectronics RM0090 Reference Manual
  - STMicroelectronics PM0214 Cortex-M4 Programming Manual
- ARM
  - ARM Cortex-M4 Processor Website
  - ARM Developer Website
- LoRa Alliance Website

11.2 Disclaimer

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11.3 Licenses

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[11] Example Network Analyzer for Cable Loss Measurement: Hewlett Packard (Keysight) 8753D

[12] Contact Semtech for SX1301 datasheet (not publicly available as of the writing of this document)

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--- For the parson library used by the packet logger ---

Parson (http://kgabis.github.com/parson/)
Copyright (c) 2012 Krzysztof Gabis

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12 Document

12.1 Revision History

Rev	Date	Description
001	20 Feb 2017	Initial draft
002	20 Feb 2017	Updated French translation in 11.5.2 Industry Canada statement (2)
003	24 Feb 2017	Added warning for regulatory EIRP limit Added table of max tx power vs antenna Added reference to AT command set
004	13 June 2017	Changed RF exposure from 20cm to 22cm (FCC) and 32cm (Canada), based on MPE failure for Yagi antenna.
005	19 June 2017	Updated antenna list (dipole max from 5.1dBi to 3.5dBi)
006	6 April 2018	Formatting Updates.

13 Contact

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