

IMCP HTSXMO32L-22 SIP MODULE

Evaluation Board V2.0 Manual and Hardware Integration Guide

Classification: PUBLIC

Doc. Type: User Manual

Revision: v.06

Date: 27/06/2023

Code: EVB-SXF-02

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DOCUMENT INFO

This document provides the hardware integration guidelines for devices based on iMCP HTSXMO32L-22 SiP Module and technical information about the EVb-SXF-02, its Evaluation Board. This is a reference for the customers of HT Micron Semicondutores, especially device manufacturers and hardware engineers.

1. HT32SX - DEVICE OVERVIEW

The iMCP HTSXMO32L-22 SiP Module is a Multicomponent Integrated Circuit (MCO) designed to provide a general ready-to-use connectivity solution for Internet of Things (IoT) applications. Its small dimensions, high performance and low power consumption targets the best experience for IoT developers. Detailed information about this device can be found on its [datasheet](#).

1.1. EVALUATION BOARD KEY FEATURES

- Frequency bands:
 - 413-479 MHz
 - 452-527 MHz
 - 826-958 MHz
 - 904-1055 MHz
- Modulation schemes:
 - DBPSK, 2(G)FSK, OOK, ASK
- 64kB of flash memory
- 8kB of RAM
- 32.768kHz external crystal for RTC applications
- Voltage regulator ranging from 2.7 to 6V
- USB to Serial converter
- External LiPoly Battery connector
- Compatibility with Adafruit Feather Wings
- SWD interface
- MCU bootloader
- 20 GPIOs
- 12-bit ADC
- 12-bit 1 channel DAC
- 2 USART, LPUART, USB 2.0, I²C

1.2. OPERATIONAL DESCRIPTION

The HT32SX's evaluation board contains a voltage regulator with a voltage range of 2.7 to 6V, ensuring stable power supply to the system, it features a built-in USB to Serial converter, enabling easy communication with external devices and computers terminals. A LiPoly Battery Connector allow portable and wireless operation. Regarding to the radio, HTSXMO32L integrates an ultra-low power RF transceiver, intended for RF wireless applications in the sub-1 GHz band. It supports different modulation schemes, but due to the MCO main target application (Sigfox Network), only DBPSK (for TX) and GFSK (for RX) schemes are enabled in the provided software.

1.3. SUPPORTED FCC RULES

The iMCP HTSXMO32L-22 SiP Module has been certified to comply with the following FCC rules, when operating according to Sigfox RC2 requirements:

- 47 CFR Part 15.247
- 47 CFR Part 15B
- 47 CFR part 2.1091

These certifications can be applied to the host device if the device manufacturer implements the integration and test instructions of this document into the host device, except for FCC Part 15 Subpart B which needs to be retested. The host manufacturer can use iMCP HTSXMO32L-22 SiP Module FCC ID if the device meets the conditions of the FCC certificate. Commonly required conditions can be:

- A minimum of 20 cm distance from the human body.
- No collocation with other transmitters (this condition generally needs to be reviewed by an FCC lab).
- Antenna gain below the requirements.

It is mandatory for the host device manufacturer to assure the final device's compliance with FCC Part 15 Subpart B, even if certification has been granted to iMCP HTSXMO32L-22 SiP Module. The host device manufacturer is also responsible for compliance with any other FCC rules that apply to the host device not covered by the iMCP HTSXMO32L-22 SiP Module grant of certification.

1.4. BLOCK DIAGRAM

The following block diagram illustrates the iMCP HTSXMO32L-22 SiP Module. It features an ARM Cortex M0+ 32bit (STM32L052x8) and the S2-LP low-power transceiver from ST Microelectronics combined with the SKY66420 from Skyworks Solutions which provide all the performance advantages, integration, and convenience of advanced semiconductor packaging technology into a single chip.

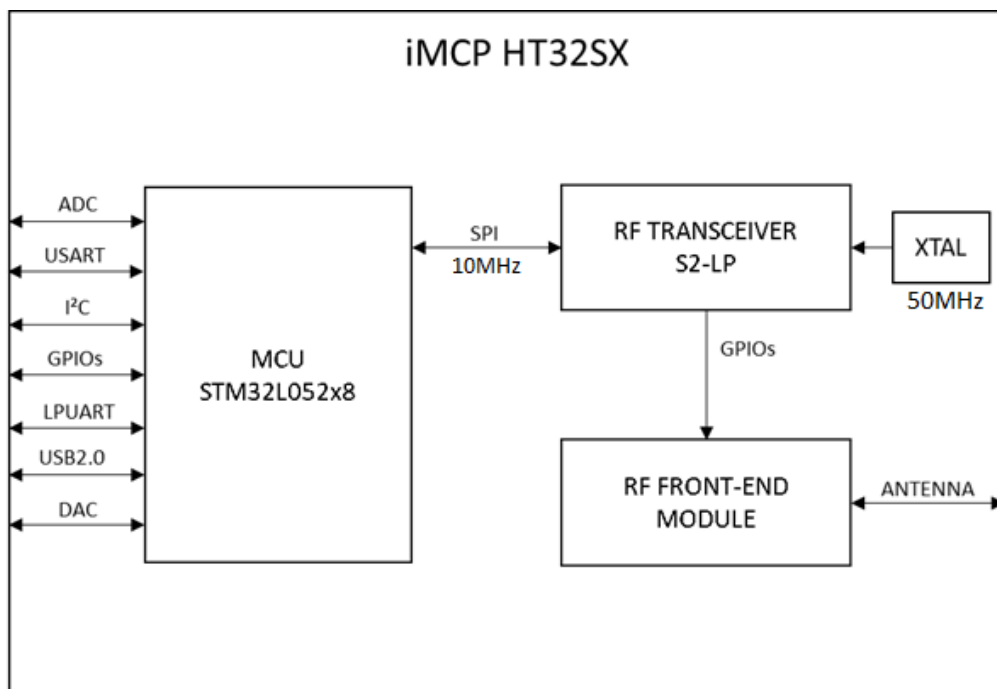


Figure 1: Block Diagram

2. EVALUATION BOARD

The EVB-SXF-02 Evaluation Board was designed to be a development platform, facilitating new users first contact and providing to advanced users limitless possibilities of developing your own products. All the iMCP HTSXMO32L-22 SiP features are available on the evaluation board. Two supply options can be used: a USB connection or an external battery. The evaluation board will automatically switch to USB power when it is available. The external battery makes the evaluation board portable, so it becomes easy to test the Sigfox connectivity anywhere you go.

2.1. PIN ASSIGNMENT

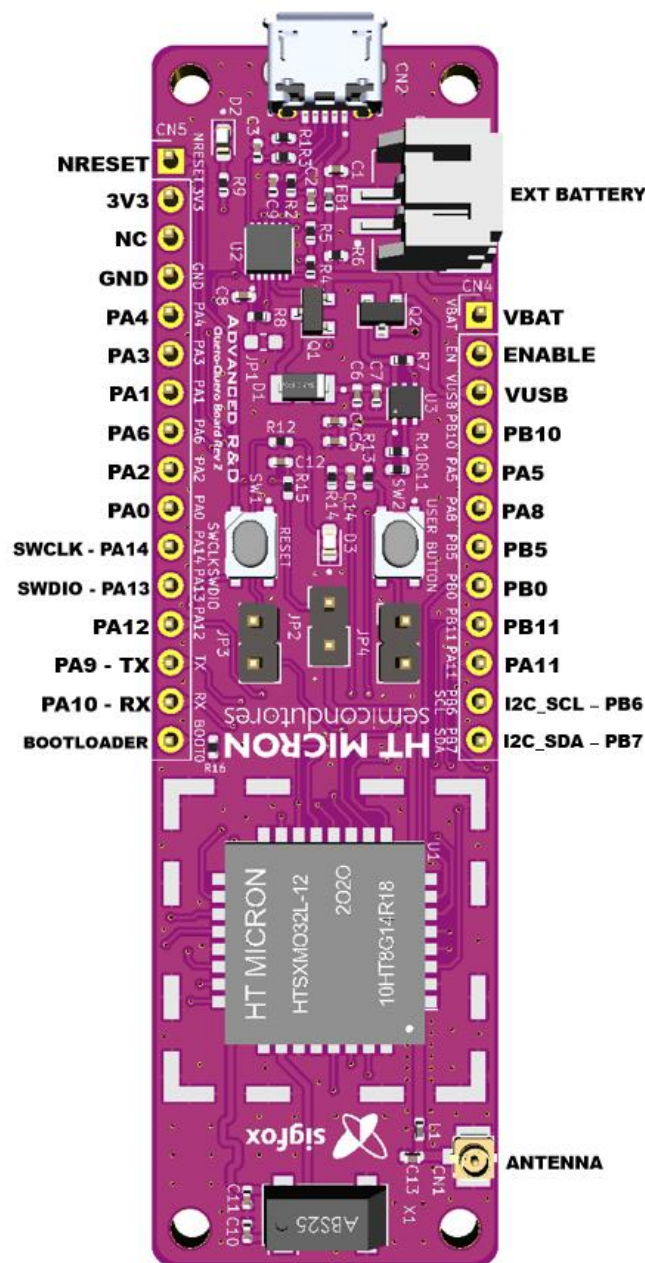


Figure 2: Pin Assignment

2.2. CONNECTIONS DESCRIPTION

Table 1: Detailed pin functions.

Connector	Number	Name	Alt. Functions	Type	Description
CN1	-	Antenna	-	RF I/O	RF input and output signal
CN2	-	Micro USB	-	-	USB connection for power and communication
CN3	-	Battery	-	Power	Input power from external battery
CN4	1	VBAT	-	Power	Battery output power
	2	ENABLE	-	Input	Voltage regulator Enable
	3	VUSB	-	Power	Output power from USB Bus
	4	PB10	LPUART1_TX	Digital I/O	USART interface
			TIM2_CH3	Digital I/O	General-purpose timer
	5	PA5	ADC_IN5	Analog I	ADC external input 5
			TIM2_CH1	Digital I/O	General-purpose timer
			TIM2_ETR	Digital I/O	General-purpose timer
			COMP1_INM5	Analog I	Comparator input
	6	PA8	USART1_CK	Digital I/O	USART interface
			USB_CSR_SYNC	Digital I/O	USB
			EVENT_OUT	Digital I/O	
	7	PB5	I2C1_SMBA	Digital I/O	I2C interface
			LPTIM1_IN1	Digital I/O	Low-power timer
			TIM22_CH2	Digital I/O	General-purpose timer
	8	PB0	ADC_IN0	Analog I	ADC external input 0
			VREF_OUT	Analog I/O	Output reference voltage
	9	PB11	LPUART1_RX	Digital I/O	Low-power USART interface
			TIM2_CH4	Digital I/O	General-purpose timer
			EVENTOUT	Digital I/O	
	10	PA11	USART1_CTS	Digital I/O	USART interface
			USB_DM	Digital I/O	USB
			COMP1_OUT	Analog O	Comparator output
			EVENT_OUT	Digital I/O	
	11	PB6	I2C1_SCL	Digital I/O	I2C interface
			USART1_TX	Digital I/O	USART interface
			LPTIM1_ETR	Digital I/O	Low-power timer
	12	PB7	I2C1_SDA	Digital I/O	I2C interface
			USART1_RX	Digital I/O	USART interface
			LPTIM1_IN2	Digital I/O	Low-power timer
CN5	1	NRESET	-	I/O	Bidirectional reset pin with embedded weak pull-up resistor
	2	3V3	-	Power	-
	3	NC	-	-	-
	4	GND	-	Ground	-
	5	PA4	DAC_OUT	Analog O	DAC analog output
			ADC_IN4	Analog I	ADC external input 4
			USART2_CK	Digital I/O	USART interface

			TIM22_ETR	Digital I/O	General-purpose timer
			COMP1_INM4	Analog I	Comparator input
	6	PA3	ADC_IN3	Analog I	ADC external input 3
			USART2_RX	Digital I/O	USART interface
			TIM2_CH4	Digital I/O	General-purpose timer
			TIM21_CH2	Digital I/O	General-purpose timer
	7	PA1	ADC_IN1	Analog I	ADC external input 1
			USART2_RTS_DE	Digital I/O	USART interface
			COMP1_INP	Analog I	Comparator input
			TIM21_ETR	Digital I/O	General-purpose timer
			EVENT_OUT	Digital I/O	
	8	PA6	ADC_IN6	Analog I	ADC external input 6
			LPUART1_CTS	Digital I/O	USART interface
			TIM22_CH1	Digital I/O	General-purpose timer
			COMP1_OUT	Analog O	Comparator output
			EVENT_OUT	Digital I/O	
	9	PA2	ADC_IN2	Analog I	ADC external input 2
			USART2_TX	Digital I/O	USART interface
			TIM21_CH1	Digital I/O	General-purpose timer
			TIM2_CH3	Digital I/O	General-purpose timer
	10	PA0	ADC_IN0	Analog I	ADC external input 0
			WKUP1	Digital I	MCU external wakeup input
			USART2_CTS	Digital I/O	USART interface
			TIM2_CH1	Digital I/O	General-purpose timer
	11	PA14	SWCLK	Digital O	Serial wire clock output
			USART2_TX	Digital I/O	USART interface
	12	PA13	SWDIO	Digital I/O	Serial wire
			USB_NOE	Digital I/O	USB
	13	PA12	USART1_RTS_DE	Digital I/O	USART interface
			USB_DP	Digital I/O	USB
			EVENT_OUT	Digital I/O	
	14	PA9	USART1_TX	Digital I/O	Serial wire
	15	PA10	USART1_RX	Digital I/O	Serial wire
	16	BOOT0	-	Digital I	Boot selection

2.3. POWER PINS

Table 2: Power pins description.

Pins	Description
VBAT	Positive voltage is available from external battery or an external power supply can be used
VUSB	Positive 5V from USB is available when the USB cable is connected
EN	This pin is pulled up to enable voltage regulator. If connected to the ground the voltage regulator is turned off
CN3	JST-PH connector for external Lipoly battery
3V3	Output voltage from voltage regulator. A peak of 500mA can be supplied
GND	Common ground for the board and components.

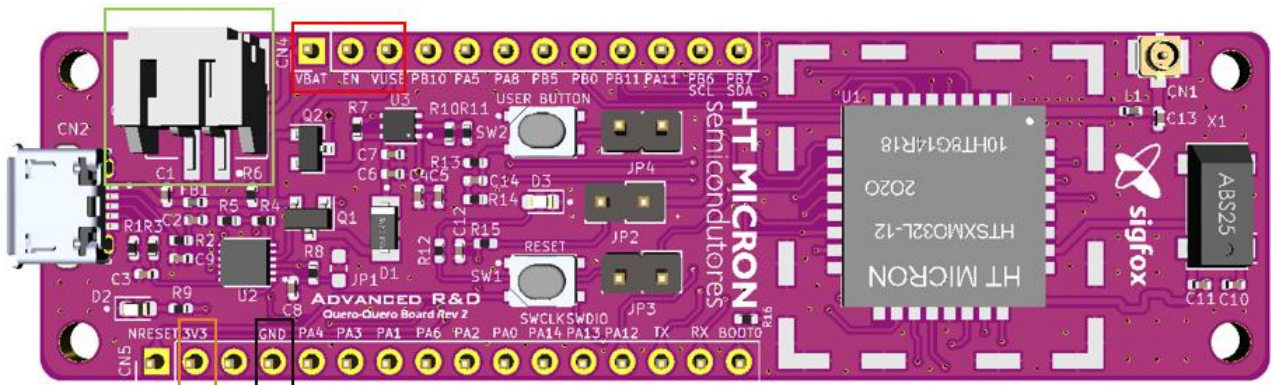


Figure 3: Power pins

2.4. OTHER PINS

Table 3: Other pins description.

Pins	Description
I ² C	Serial interface. Alternative functions are also available on these pins. These pins can also be used as GPIO
SWD	Serial Wire Debug interface to programming and debug the iMCP HTSXMO32L-22 SiP Module. These pins can also be used as GPIO
TX/RX	These pins can be used to communicate with iMCP HTSXMO32L-22 SiP Module through Serial 1. Alternative functions are also available on these pins. These pins can also be used as GPIO
Boot0	This pin is pulled down. When connected to VDD during iMCP HTSXMO32L-22 SiP Module powering up allow access to programming its flash memory through the serial interface.

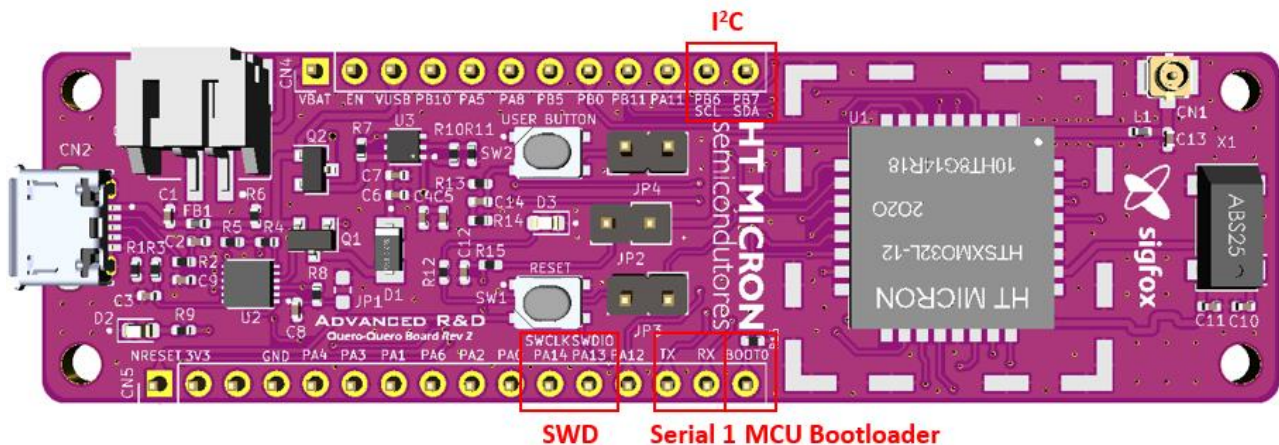


Figure 4: Other pins.

2.5. STATIC CHARACTERISTICS - GENERAL OPERATING RANGE

Table 4: General operating conditions.

Parameter	Conditions	Min	Typ.	Max	Unit
Supply Voltage	-	2.7	3.3	6.0	V
Supply Current	-	-	-	500	mA
Operating Temperature	-	-20	-	70	°C

External XTAL Frequency	-	-	-	32.768	kHz
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Remark: the voltage regulator can handle an input ranging from 1.5 to 6.0V. However, the iMCP HTSXMO32L-22 SiP Module operation voltages range is from 2.7 to 3.6V. The evaluation board is provided with a resistor pair that sets the voltage regulator output to 3.3V, therefore, consider the supply voltage informed above to get a proper operation from the iMCP HTSXMO32L-22.

2.6. POWER CONSUMPTION

Characteristics measured over recommended operating conditions unless otherwise specified. Typical values are referred to 25 °C temperature, output regulator voltage 3.3 V.

Table 5: Power Consumption.

Parameter	Conditions	Min	Typ.	Max	Unit
Supply current	JP2 Open (iMCP HTSXMO32L-22 SiP Module turned off)	-	1.4	-	mA

The iMCP HTSXMO32L-22 SiP Module current consumption depends on the operation mode, to get complete information about it, please refer to [datasheet](#).

2.7. EXTERNAL CLOCK RESONATOR

The external clock resonator can be of high speed (1-25MHz) or low speed (32.768kHz), which can be connected to pins 25 and 26 of the iMCP HTSXMO32L-22 SiP Module. On the Evaluation Board, it is provided a 32.768kHz clock resonator, which can be changed by a high speed one, according to the application necessity. The connection diagram is shown below. For CL10 and CL11, it is recommended to use high-quality ceramic capacitors in the 5pF to 25 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator. CL1 and CL2 include PCB and the MCU pin capacitances.

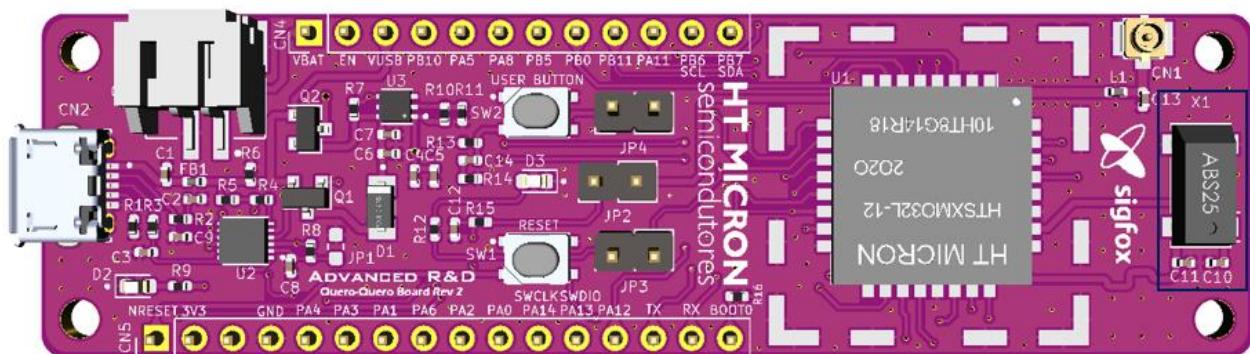


Figure 5: Oscillator position.

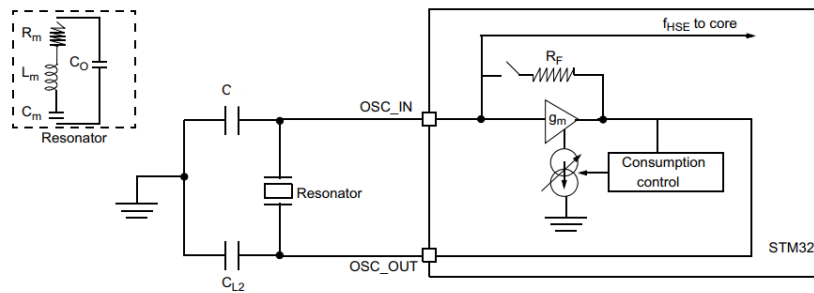


Figure 6: Oscillator circuit diagram.

2.8. BOARD SCHEMATICS

Is highly recommended to use the iMCP HTSXMO32L-22 SiP Module's [evaluation board schematic diagram](#) as a reference circuitry when designing PCBs. The PCB layout, list of materials and all the documentation are provided at HT Micron's [git hub page](#). In this context this reference circuitry (i.e. EVB-SXF-02) is applicable for the iMCP HTSXMO32L-22 SiP Module granted the FCC certifications . The given reference circuitry is a valid generic example of an iMCP HTSXMO32L-22 based final device but does not limit it uses in any way.

2.9. JUMPERS

Table 6: Jumpers' identification.

Jumper	Identification	Description
JP1	USB/Serial Converter Reset	This jumper provides the reset function for the USB to Serial converter when short-circuited.
JP2	iMCP HTSXMO32L-22 SiP Module Supply / Current Measurement	This jumper provides the supply to the iMCP HTSXMO32L-22 SiP Module and can be used to open the circuit and measure the current consumption drained only by it in different operation conditions.
JP3	User LED	This jumper allows the disconnection of User LED from PA5 to avoid disturbances when using this Pin as GPIO for other purposes.
JP4	User Button	This jumper allows the disconnection of User Button from PA6 to avoid disturbances when using this Pin as GPIO for other purposes.

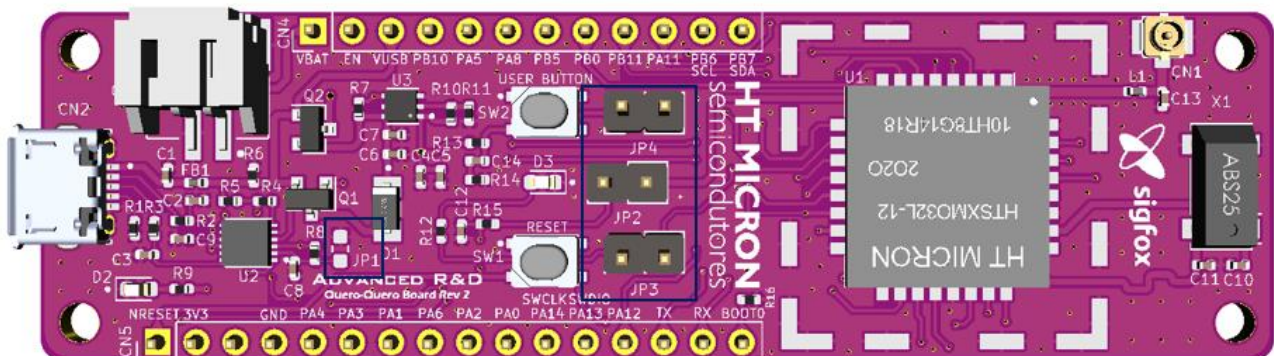


Figure 7: Jumpers' positioning.

2.10. PCB LAYOUT

The PCB layout shown in Figure 6 are part of the iMCP HTSXMO32L-22 SiP Module Evaluation Board (EVB-SXF-02) [reference layout](#), it shows the details of the area where the antenna connector is located.

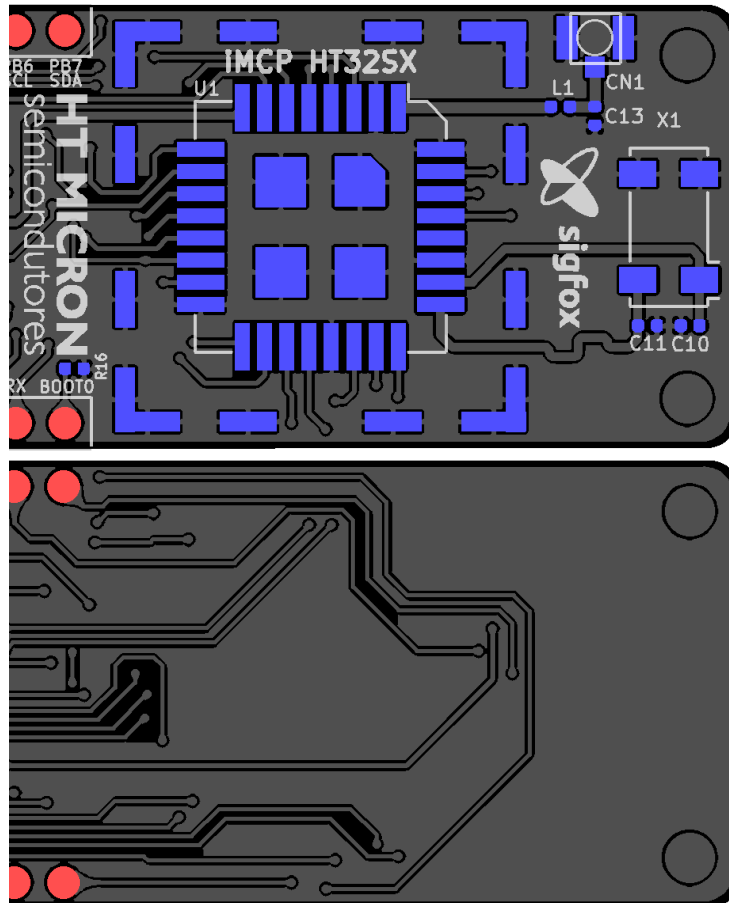


Figure 8: HT32SX reference layout on top and bottom layer

2.11. PCB SPECIFICATION

The Evaluation Board EVB-SXF-02 PCB stack-up and layer materials are shown in Figure 7. The reference PCB material is a two-layer FR4, 1.5mm core thickness and 1 Oz copper.

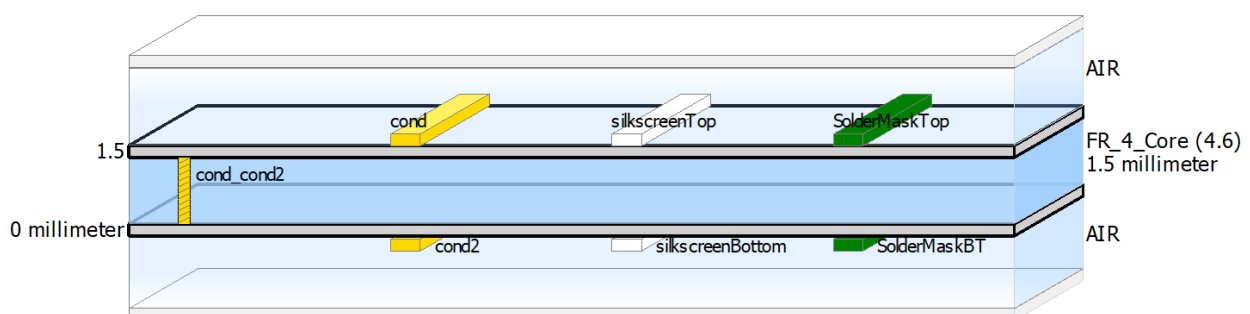


Figure 9: HT32SX reference PCB stack up.

2.12. ANTENNA TYPE

The external hinged antenna used in EVB-SXF-02 is Ethertronics X9000984-4GDSMB, as shown in the Figure 8. For further details on the antenna, see the antenna supplier [datasheet](#).

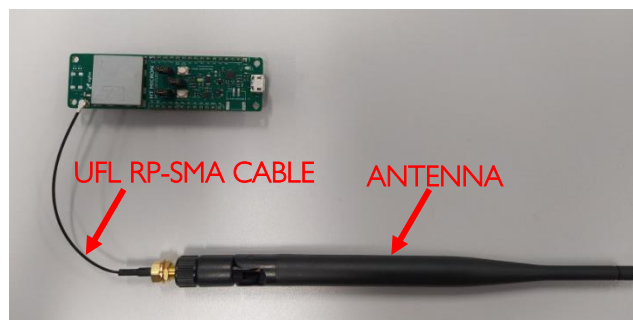


Figure 10: HT32SX Evaluation Board antenna.

2.13. ANTENNA CHARACTERISTICS

The Ethertronics X9000984-4GDSMB antenna has 196 mm height and 6 mm diameter, a peak gain of 2.2dBi and an efficiency greater than 40% over the 790-960MHz frequency band. The radiation pattern plots can be found at the antenna [datasheet](#).

3. RF CIRCUITS AND ANTENNA

The iMCP HTSXMO32L-22 SiP Module support all the Sigfox radio configurations frequency bands. It has been certified only with the antenna solution presented in previous section. It is possible to use other antennas with iMCP HTSXMO32L-22 SiP Module but testing and certification will always be required from the end device, regardless of antenna selection.

3.1. ANTENNA INTERFACE

The Evaluation Board EVB-SXF-02 has a single-ended 50 Ω uFL antenna connector, where the antenna solution shall be connected. The antenna impedance and the characteristic impedance of the transmission line (planar and cable) connecting to the antenna must be 50 Ω . It is recommended to reserve space for a matching network (as in the EVB-SXF-02) because antennas are typically tuned on a supplier reference board and some differences may impact the antenna impedance, matching components can be used to compensate a possible mismatch to the antenna impedance and avoid performance degradation. The recommended minimum return loss is 10 dB but 6.0 dB can still be accepted in the end device. The length of the transmission line from the antenna connector to the matching network should be kept as short as possible to minimize losses.

3.2. MATCHING NETWORK

An external LC matching network (series inductor and shunt capacitor) was applied on the EVB-SXF-02 to improve the output power level of the antenna pin in the iMCP HTSXMO32L-22 SiP Module. For detailed information about iMCP HTSXMO32L-22 SiP Module RF characteristics, please refers to [datasheet](#). The recommended values and specifications are given below:

- SMD ceramic inductor L1: 5.6nH $\pm$ 0.3nH 0402 size
- SMD ceramic capacitor C13: 4.7pF $\pm$ 0.1pF 0402 size

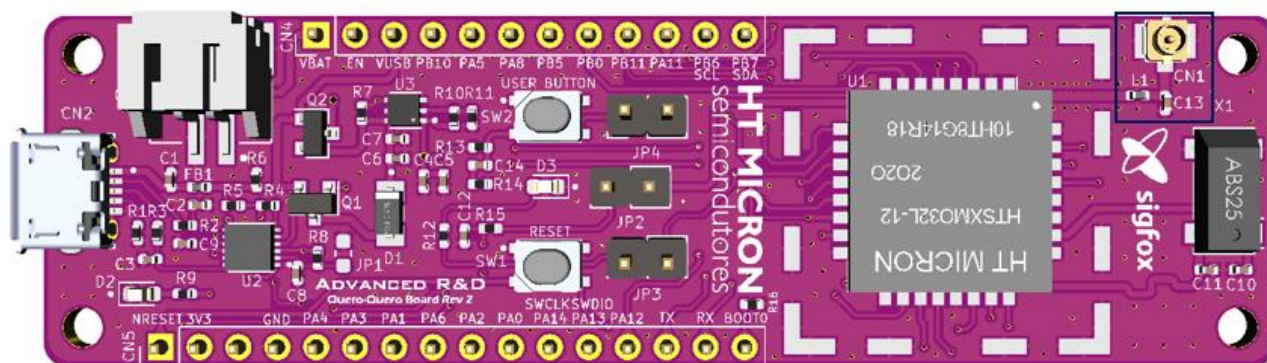


Figure 11: uFL connector positioning.

4. REGULATORY INFORMATION

This section contains information on certified bands and FCC/ISED regulatory notices for iMCP HTSXM032L-22 SiP Module.

4.1. RF - FREQUENCY BANDS

Frequency bands based on Sigfox radio configurations:

- RC1: Europe, Middle East and Africa 868.034 ~ 868.226 MHz
- RC2: North America and Brazil 902.104 ~ 902.296 MHz
- RC3: Japan 923.104 ~ 923.296 MHz
- RC4: Latin America and Asia Pacific 920.704 ~ 920.896 MHz
- RC5: South Korea 923.204 ~ 923.396 MHz
- RC6: India 865.104 ~ 865.296 MHz
- RC7: Russia 868.704 ~ 868.896 MHz

4.2. FCC REGULATORY NOTICES

FCC regulatory notices cover modification and interference statements, wireless and FCC Class B digital device notices, permitted antennas and labeling requirements.

FCC Class B digital device notice

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

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.

Labeling requirements for the host device

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be always clearly visible when installed in the host device, otherwise the host device must be labelled to display the FCC ID of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows: Contains FCC ID: 2A7ZW-HTSXMO32L.

Interference statement

This device complies with Part 15 of the FCC. 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.

Wireless notice

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be collocated or operating in conjunction with any other antenna or transmitter.

Permitted antenna

This radio transmitter has been approved by FCC to operate with the antenna type described in this document, below the maximum permissible gain. The antenna peak gain is 2.2 dBi along the RC2 band cited in section 4.1. Antenna types not included in this list, having a gain greater than the maximum gain indicated, are strictly prohibited for use with this device.

Information on Test Modes

All the test modes information, codes and requirements can be found at HT Micron's [github](#) page.

4.3. PROFESSIONAL INSTALLATION INSTRUCTIONS

Due to the unique function provided by the iMCP HTSXMO32L-22 SiP Module, this device must use our software and licensed third-party only. The product will be distributed through controlled distribution channels, installed by trained professional and will not be sold directly to the public through retail stores.

4.3.1. Installation personal

This product is designed for specific application and needs to be installed by a qualified personal who has RF and related CFR rules knowledge. The general user shall not attempt to install or change the setting.

4.3.2. Installation location

The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

4.3.3. Installation procedure

The installation procedures are described along the chapters 2, 3 and 4 of this document, where all the information about the PCB layout and circuitry references can be found.

5. DIMMENSIONS

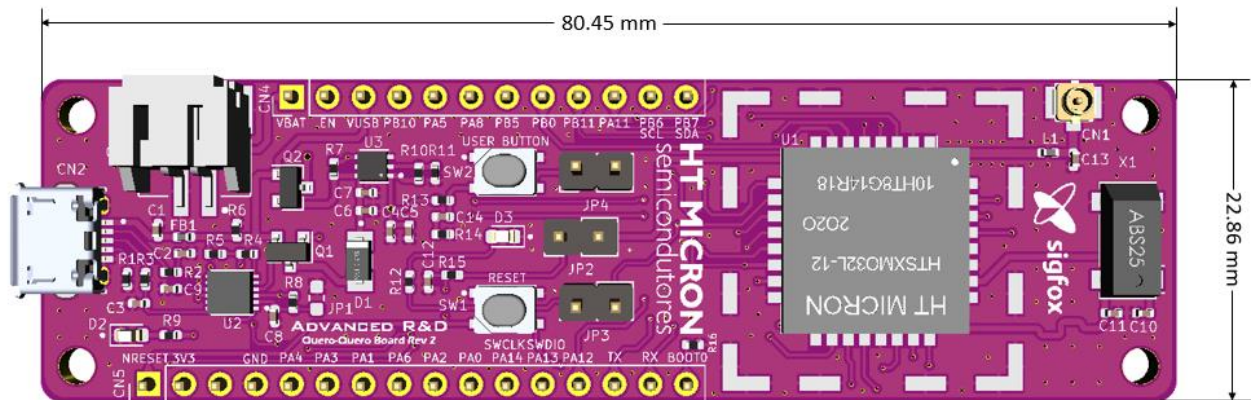


Figure 12: Board dimensions.

6. ORDERING INFORMATION

Table 7: Detailed pin functions.

Type number	Package		
	Name	Description	Version
EVB-SXF-02	Sigfox HT32SX-22 EVB	iMCP HTSXM032L-22 Evaluation Board	2.0

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REVISION HISTORY

Version	Date	Changes	Authors
00	03/12/2020	- Initial draft	MC
01	18/12/2020	- Review and updates	WH
02	12/01/2020	- Corrections and template update.	MC
03	26/01/2020	- Classification changed to Public	MC
04	07/06/2021	- Table 5 and Table 6 descriptions fixed.	MC
05	09/03/2022	- Regulatory Information and integration guide instructions	FK
06	27/06/2023	- Regulatory FCC ID and modulation schemes description update	

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DOCUMENT INFORMATION

Document Title: iMCP HTSXMO32L-22 SIP MODULE
Document Subtitle: Evaluation Board V2.0 Manual and Hardware Integration Guide
Classification: PUBLIC
Doc. Type: User Manual
Revision: v.06
Date: 27/06/2023
Code: EVB-SXF-02

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