XENO+ WIFI+BLE NANO CPU MODULE
ARM CORTEX M23 BASED
DATASHEET

Eoxys Systems

Revision History		
Version	Date	Description of change
1.0	27-JUN-2022	Initial version

Table of Contents

1 Overview

XENO+ WiFi+BLE Nano CPU Module is a solderable module and can be used as core CPU module of new Battery powered IOT devices of customers so that customers can focus only on adding sensors and Battery power circuits around this CPU module for building their new IOT devices in short time.

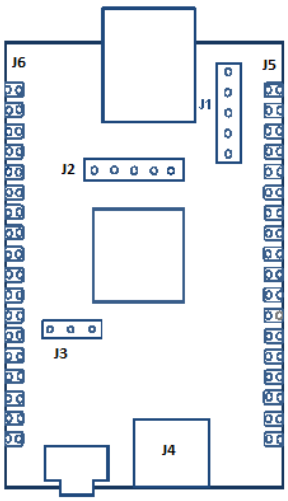
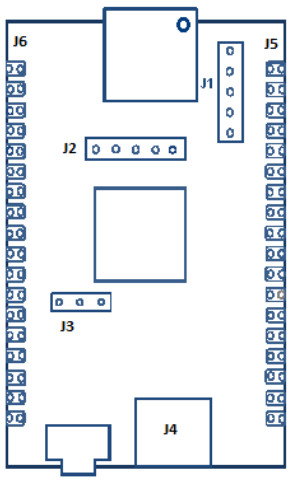
The module has smallest possible size with secure IoT MCU with Nuvoton ARM Cortex-M23 (M2354) Trust Zone series MCU @ 96MHz, 1MB Flash, 256KB SRAM, UART/SPI/I2C ports and GPIOs. This module has USB Type C based 5V Power input with serial debug port and Battery power input options. This module has 3 pin SWD pins for SW development and SW debug via KEIL IDE for Embedded SW development for the device by the users.

This Nano module is suitable for Trusted Execution Environment (TEE) with Trusted Applications (TAs). The key security features are,

- Tamper-resistant key storage in Flash and SRAM,
- TrustZone for Armv8-M Technology,
- 8 regions MPU_NS (for normal world) and 8 regions MPU_S (for secure world),
- Hardware Crypto Accelerators (AES, ECC and RSA), CRC calculation unit,
- Up to 6 tamper detection pins and
- Arm Platform Security Architecture (PSA Certified Level 2 /Level 3) supported.

2 CPU Module Overview

The below table shows the brief overview of modules:

	XNO-W102N	XNO-W112N
Module Image		
Wireless Interface	WiFi 2.4 b/g/n and BLE5.0	WiFi 2.4 b/g/n and BLE5.0
Antenna	PCB Antenna	UFL Antenna
Sensor Interface	UART, SPI, I2C, ADC, DAC, PWM and GPIOs	UART, SPI, I2C, ADC, DAC, PWM and GPIOs
Pins	18x18 Castellated Pins	18x18 Castellated Pins
Size in mm	60 x 35 mm	60 x 35 mm

3 Product Features and Specifications

The XENO+ module product features and specifications are listed below:

Table-1: The Product features and specifications

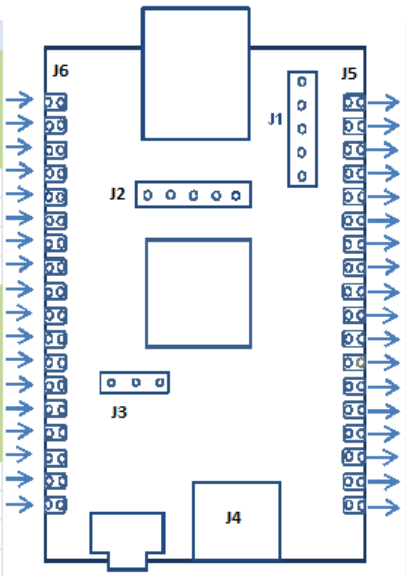
No.	Features	Specifications
Electro – Mechanical specification		
1	Boards Mounting	18x18 Castellated Pins
2	Wired interface	1x USB Type C for 5V Power and Serial debug UART interface for debug messages and user inputs.
3	Antenna	Chip antenna or uFL connector for external antenna supports 2.4G
4	User SW programming	3 pin SWD pins for SW programming and debug via KEIL IDE
5	Operating temperature	-40 ~ + 85 ℃
6	Operating humidity	95% or less
7	Size	60x35 mm
8	Weight	7 grams
Power Specifications		
1	Module input voltage	5V from USB Type C connector * MOSFET based switch to auto cut-off battery power when USB 5V is present.
2	Battery input voltage	2.5V to 5V Battery power from non-rechargeable (or) re-chargeable battery. The battery options are listed below: * Two 1.5V AA Type Alkaline/Drycell non-rechargeable batteries connected in series for non-restricted transport. * 3.6V AA type (Li-SOCl2) non-rechargeable battery for Industrial applications. * 4.2V LiFePO4 18650rechargeable battery. The recharging circuit to be added in carrier board by customer.
WiFi/BLE Specifications		
1	WiFi	2.4GHz b/g/n * PCB Antenna or uFL connector for external Antenna
2	BLE	BLE5.0 with 2Mbps PHY, LE Coded and Extended Advertising
3	WiFi/BLE Data interface	UART based AT command interface (or) SPI based AT Command interface
4	WiFi Active Mode Power	31mA (Rx Mode @ 1Mbps 802.11b), 178mA (Tx Mode @ 1Mbps 802.11b +17.5dBm)
5	Wi-Fi Power Save Mode Power at 802.11b, 1Mbps (Clean Environment, @3.3V)	57uA (DTIM10)
6	Deep Sleep Mode Power (@3.3V, Memory Retained)	11-19uA (RTC, memory retained, depends on amount of SRAM retained)
7	Module Standby Power	X uA (ARM Cortex-M23 in standby and WiFi module is in shut-down mode)
8	WiFi Power Shutdown	WiFi Power can be shut down by MCU GPIO control signal
9	Antenna	PCB Antenna (or) UFL Antenna Connector
CPU & Other Specifications		

1	CPU	ARM Cortex-M23 TrustZone @ 96MHz
2	Flash Memory	1MB with Preassigned FOTA section
3	RAM	256KB SRAM
4	Sensor Interfaces	On Function-A pins: 1x SPI 3x UART 2x I2C 1x CAN 3x ADC 2x DAC 2x PWM 7x GPIOs
5	RTOS	FreeRTOS

4 Module Pinouts:

This module has 18x18 Castellated pins. The Left side 18 pins mapping and Right side 18 pins mapping are listed below. The MCU port pins can be assigned with 2 predefined module functions: Function-A and Function-B. The users can also map custom functions as per MCU native GPIO functions on these pins.

J6	MCU Pins	Function A	Function B
1	PC7	SPI1_MISO	TM0
2	PC6	SPI1_MOSI	TM1
3	PA7	SPI1_CLK	TM4/TM2
4	PA6	SPI1_SS	TM3/TM5
5	PA5	CAN0_TXD	CAN0_TXD
6	PA4	CAN0_RXD	CAN0_RXD
7	PA3	GPIO	GPIO
8	PA2	GPIO	GPIO
9	PA1	I2C2_SCL	GPIO
10	PA0	I2C2_SDA	GPIO
11	PC5	UART4_TXD	GPIO
12	PC4	UART4_RXD	GPIO
13	PC3	UART3_TXD	GPIO
14	PC2	UART3_RXD	GPIO
15	PD3	GPIO	GPIO
16	NRST	Active LOW RESET signal	
17	GND	GND	
18	VDD_3V3	Regulated 3V3 supply O/P	



J5	MCU Pins	Function A	Function B
1	PB7	EADC0_CH7	GPIO
2	PB8	UART0_RXD	UART0_RXD
3	PB9	UART0_TXD	UART0_TXD
4	PB10	I2C1_SDA	GPIO
5	PB11	I2C1_SCL	GPIO
6	PB12	DAC0_OUT	SPI0_MOSI
7	PB13	DAC1_OUT	SPI0_MISO
8	PB14	EADC0_CH14	SPI0_CLK
9	PB15	EADC0_CH15	SPI0_SS
10	PA15	GPIO	GPIO
11	PA14	GPIO	GPIO
12	PA13	BPWM1_CH3	GPIO
13	PA12	BPWM1_CH2	GPIO
14	PD1	GPIO	GPIO
15	PD2	GPIO	GPIO
16	GND	GND	
17	VBAT	Battery supply voltage I/P	
18	VBUS_5V	USB 5V supply voltage O/P	

4.1 Left side 18 pins connector signals

SNO	MCU Pins	Function A	Function B
1	PC7	SPI1_MISO	TM0
2	PC6	SPI1_MOSI	TM1
3	PA7	SPI1_CLK	TM4/TM2
4	PA6	SPI1_SS	TM3/TM5
5	PA5	CAN0_TXD	CAN0_TXD
6	PA4	CAN0_RXD	CAN0_RXD

7	PA3	GPIO	GPIO
8	PA2	GPIO	GPIO
9	PA1	I2C2_SCL	GPIO
10	PA0	I2C2_SDA	GPIO
11	PC5	UART4_TXD	GPIO
12	PC4	UART4_RXD	GPIO
13	PC3	UART3_TXD	GPIO
14	PC2	UART3_RXD	GPIO
15	PD3	GPIO	GPIO
16	NRST	Active LOW RESET signal to MCU. The Push button also asserts RESET signal to LOW.	
17	GND	GND pin of module.	
18	VDD_3V3	Regulated 3V3 supply output from module to other circuits of carrier board.	

4.2 Right side 18 pins connector signals

SNO	MCU Pins	Function A	Function B
1	PB7	EADC0_CH7	GPIO
2	PB8	UART0_RXD	UART0_RXD
3	PB9	UART0_TXD	UART0_TXD
4	PB10	I2C1_SDA	GPIO
5	PB11	I2C1_SCL	GPIO
6	PB12	DAC0_OUT	SPI0_MOSI
7	PB13	DAC1_OUT	SPI0_MISO
8	PB14	EADC0_CH14	SPI0_CLK
9	PB15	EADC0_CH15	SPI0_SS
10	PA15	GPIO	GPIO
11	PA14	GPIO	GPIO
12	PA13	BPWM1_CH3	GPIO
13	PA12	BPWM1_CH2	GPIO
14	PD1	GPIO	GPIO
15	PD2	GPIO	GPIO
16	GND	GND pin of module	
17	VBAT	Battery supply voltage input to module with 2.5V to 5V range. If Battery is	

		connected, the module works with this battery supply.
18	VBUS_5V	USB 5V supply voltage output from module to other circuits of carrier board. This is USB 5V supply. When USB cable is removed, the module will switch to Battery supply on-the-fly, if battery is connected.

4.3 WiFi Control and Data signals

WiFI Control Signals:

SNO	MCU Pins	Pin name	Description	Behaviour
1	PB0	WIFI_RST_N	GPIO Output pin. Used to reset the WiFi Module. Need to keep LOW for 2500ms to reset.	Acts as a RESET push button to reset the module. Keep RESET signal LOW for at least 2500ms
2	PA11	WIFI_PWREN_N	GPIO Output pin. Used to enable the power to the WiFi module. By default, the WiFi module is powered down during the power-on time of module. The MCU SW need to power-up the module by making it LOW during its boot time	0 – ENABLE Power to WiFi 1 – SHUT DOWN Power to WiFi
3	PB6	WIFI2HOST_WAKEUP	GPIO Input pin. This signal will be interrupt signal to Host to wakeup from standby by WiFi module. This signal will be asserted with HI pulse to wakeup the Host. Default its kept at LOW.	Acts as Host Wake-up signal and is asserted by WiFi module. Default its kept at LOW. The HI pulse will be asserted to wakeup the MCU host.
4	PB1	HOST2WIFI_WAKEUP	GPIO Output pin. This signal will wake up the WiFi module from standby/sleep. Default its kept at LOW. HI pulse will wakeup the WiFi module.	Acts as WiFi module Wake-up signal and is asserted by host. . Default its kept at LOW. The HI pulse will be asserted to wakeup the WiFi module.

The WiFi module can be put into following low-power modes to save power for Battery operated applications. These low-power modes can be enabled from host SW via AT commands.

1. **Sleep/Suspend** - Puts system in suspend mode
2. **Listen Interval** - Specifies how often the device shall wake up and listen for Beacons
3. **Traffic Timeout** - Sets the time in millisecond that the device shall stay awake after incoming or outgoing traffic

4. **PS-Poll** - Sends PS-Poll if a Beacon is missed
5. **Dynamic listen interval** - Listen to each Beacon if there has been any traffic recently
6. **Receive Nap(Rx Nap)** - When the device has received the beginning of the frame it is possible to check if the frame is intended for this device or not. If the frame is not intended for this device Rx Nap function will turn off the receiver
7. **Only Broadcast -** Turn off the receiver for multicast frames
8. **Transmit PS (Tx PS) -** Send outgoing frames without leaving wifi power save
9. **Multicast don't care -** Turn off both multicast and broadcast frames

WiFi UART Data Signals:
The WiFi module supports either UART based AT interface. The WiFi module is flashed with UART AT interface binary, then below UART interface is used for AT command interface from host MCU.

SNO	MCU Pins	Pin name	Description	Behaviour
1	PB4	WIFI_TX	UART5_RX of host MCU	Acts as UART5 receive pin of host MCU
2	PB5	WIFI_RX	UART5_TX of host MCU	Acts as UART5 transmit pin of host MCU
3	PB3	WIFI_RTS	unused	-
4	PB2	WIFI_CTS	unused	-

5 SW Functional Specifications

5.1 Bootloader Application Functional Specifications

This module comes with Bootloader as a standalone Boot time application which is executed by default at the boot time. This Bootloader has capability to download following firmware from FOTA server:

1. Host MCU firmware
2. WiFi Module firmware

The Bootloader helps in management of the devices above 2 firmware image versions and auto updates this device firmware with latest version Over-The-Air (OTA).

1. The Bootloader offers OTA (Over-The-Air) capability for the deployed IOT devices.
2. The Bootloader uses TCP/IP protocol over WiFi via Socket commands for communicating with FOTA Server (Called as TUNE APP Server). The connection management (connect, disconnect and re-connect) is handled by the FOTA Downloader.
3. The TUNE APP server allows embedded firmware updates for all deployed IOT devices in the field via WiFi interface. The TUNE APP server will be uploaded with new firmware files so that all deployed IOT devices firmware update is taken care. This TUNE APP server validates the devices credentials and informs device FOTA Downloader to initiate the Over-The-Air download of new device firmware.
4. The Bootloader downloads the new Firmware file from this FOTA server (TUNE APP server).

During the initial 3 to 5 seconds of power-on boot time, the Bootloader code checks all 3 firmware:

a) Host MCU firmware version and b) WiFi module firmware with FOTA server for any new updated version firmware available in the server. If it is available, it downloads the firmware and updates the same.

The module comes with device authentication mechanism part of Bootloader using PKCE (Proof Key for Code Exchange) based Device authentication. The PKCE is used to provide one more security layer to the authorization code flow of OAuth. The Bootloader initiates the Device Authorization Flow by requesting a set of verification codes from the authorization server by issuing an TCP/IP socket requests to the authorization server. The server can approve or deny the requests to authorise the device. After successful authentication of device, the server issues valid access token to the device. The access-token has a limited lifetime mentioned in minutes. When it expires the Bootloader can fetch a new refresh-token. This access-token can be read by user's main embedded application.

At the end of Bootloader execution, the Bootloader launches the user's main embedded application.

Module User Configuration during Boot time

SNO	Parameters	Description
1	Network configuration	WiFi b/g/n 2.4G Works in Station mode. Gets connected with Access Point (AP) and gets the IP address (IPv4) from AP.
2	Data protocol	TCP Sockets for FOTA Data downloading and Device registration.
3	WiFi Initialization	The initialization of WiFi is done as per device requirements. 1. WiFi b/g/n 2. IP: IPv4 only 3. AP: <APN Name>, <Password>. These fields will be configured via AT Commands through debug console by the users. 4. Authentication: CHAP only 5. Protocol: TCP Socket 6. FOTA Server setting: <Server URL>, <Port>. These fields will be configured via AT Commands through debug console by the users. 7. PKCE setting: <PKCE Secret>. This field will be configured via AT Commands through debug console by the users.
4	Device Registration	The device gets registered with Server using Device ID and PKCE Secret. The WiFi MAC ID is used as Device ID. The server authenticates the devices and generates the access token and refresh token for the device.

AT Commands supported during Boot time

The user inputs for device configuration are done via AT Commands through debug console. The user can press escape character during the boot time to initiate AT commands from debug console. The format of AT command is "AT%<cmd>=<args>" where <cmd> is the command name and <args> is the list of arguments. There are four types of AT Commands.

SNO	Types	Description
1	Read command AT%<cmd>?	This command returns currently set value of the parameters.
2	Write command AT%<cmd>=<arg1,arg2,..>	This command sets user defined parameter values.
3	Test command AT%<cmd>=?	This command returns list of supported parameters and its possible values as help info to users.
4	Execution command AT%<cmd>	This command is non-argument command and reads value of parameters.

5.1.1 SW Version Command

SW Version command	
AT%SWVER Execution command	Response: **%SWVER-FIRMNAME: <Device-SW>** **%SWVER-NUM: <V10>** **%SWVER-DATE: <dd-mon-yyyy>** **OK**

5.1.2 Setting WiFi Network Configuration

Set WiFi Network Configuration	
AT%WIFINW=<APN Name>,<Password> Write command	Response: **OK**
AT%WIFINW? Read command	Response: **%WIFINW-AP-NAME: <Access point name>** **%WIFINW-AP-PWD: <****Password>** **OK**

5.1.3 Setting FOTA Server Configuration

Setting FOTA Server Configuration	
AT%FOTASER=<Server URL>,<Port>	Response: **OK**

Write command	
AT%WIFISER? Read command	Response: **%FOTASER-URL: <FOTA server URL>** **%FOTASER-PORT: <Port number>** **OK**

5.1.4 Setting PKCE Configuration

Setting PKCE Configuration	
AT%PKCE=<PKCE Secret> Write command	Response: **OK**
AT%PKCE? Read command	Response: **%PKCE-SECRET: <PKCE Secret>** **OK**

5.1.5 Device Info Command

Device Info command	
AT%DEVINFO Execution command	Response: **%DEVINFO-DEVNAME: <IP Address>** **%DEVINFO-MACID: <WIFI MAC ID>** **%DEVINFO-IPADDR: <IP Address>** **OK**

5.2 User Application Functional Specifications

At the end of Bootloader execution, the Bootloader launches the user's main embedded application. This user application runs as main application which controls the sensors, interfaces, memory, and data transfer of the IOT device. The WiFi module configuration, sensor configuration, sensor data transfer via TCP Sockets/HTTP/MQTT APIs are maintained by the user embedded application.

The embedded device's memory map is defined as per below table so that memory map has 3 sections: 1) Bootloader section, 2) Main user application firmware and 3) Backup user application firmware sections.

Features	**Description**
Memory map of program flash of embedded device	1. **BOOTLOADER_MEMORY** Contains ISR_VECTOR, FIRMWARE, USER_CONFIG, ACCESS_TOKEN memory segments. 2. **MAIN_FIRMWARE_MEMORY** Contains ISR_VECTOR and Main running app's MAIN_FIRMWARE, MAIN_FIRMWARE_SWVER info memory segments. 3. **BACKUP_FIRMWARE_MEMORY** Contains ISR_VECTOR and Main running app's BACKUP_FIRMWARE, BACKUP_FIRMWARE_SWVER info memory

	segments

After successful authentication of device, the server issues valid access token to the device and stored in ACCESS_TOKEN memory section. This access-token can be read by User Main Application through App Development Lib APIs from this ACCESS_TOKEN memory section. Also main application firmware name, version number and release date in MAIN_FIRMWARE_SWVER info memory segment.

Features	**Description**

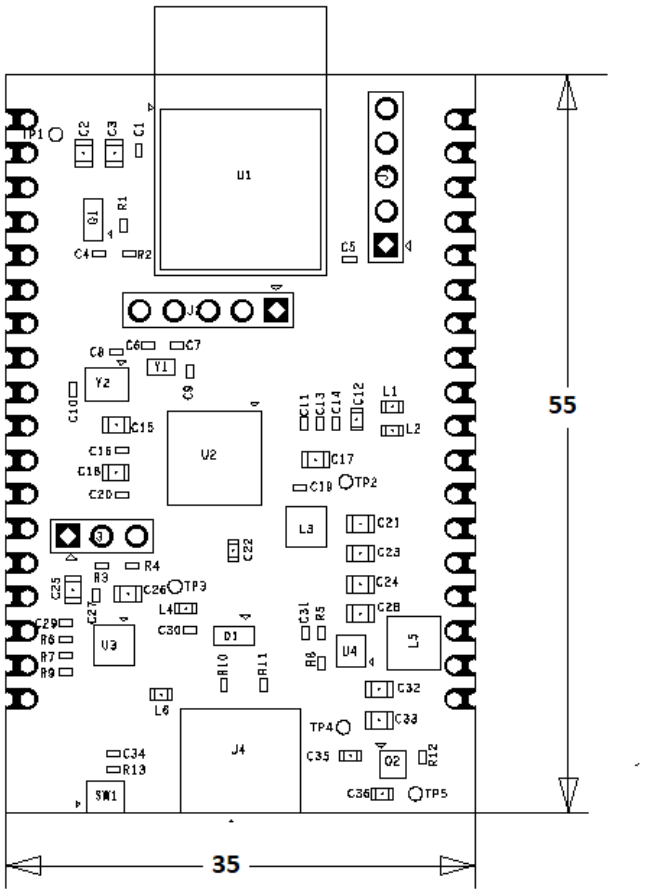
ACCESS_TOKEN memory segment: Access Token memory section	{
	ACCESS_TOKEN: <Access token>
	}

MAIN_FIRMWARE_SWVER memory segment: Main Firmware Info memory section (User application firmware info)	{
	FIRM_NAME: <Device-SW>
	SWVER: <V10>
	DATE: <dd-mon-yyyy>
	}

6 Module Layout and Dimensions

This module layout and dimensions are shown below.

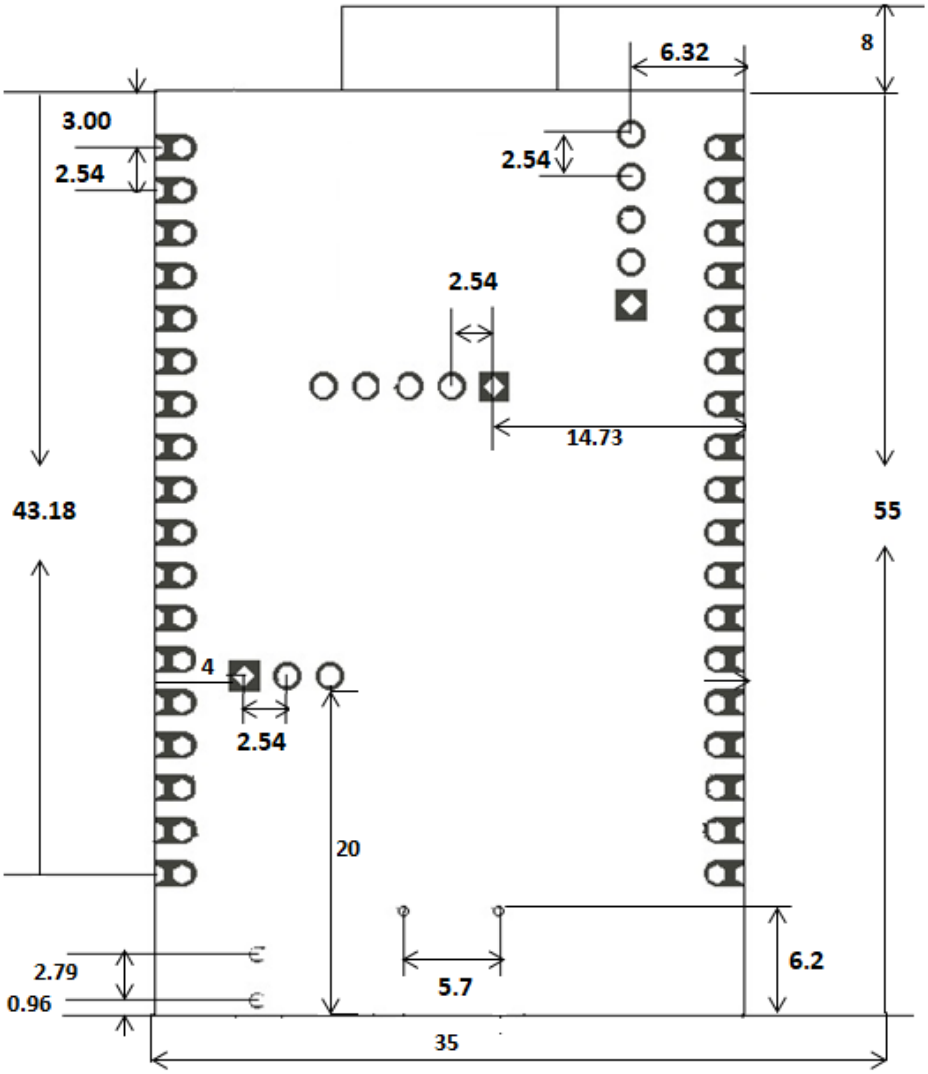
Module Dimensions (in mm)



7 Mechanical Specifications

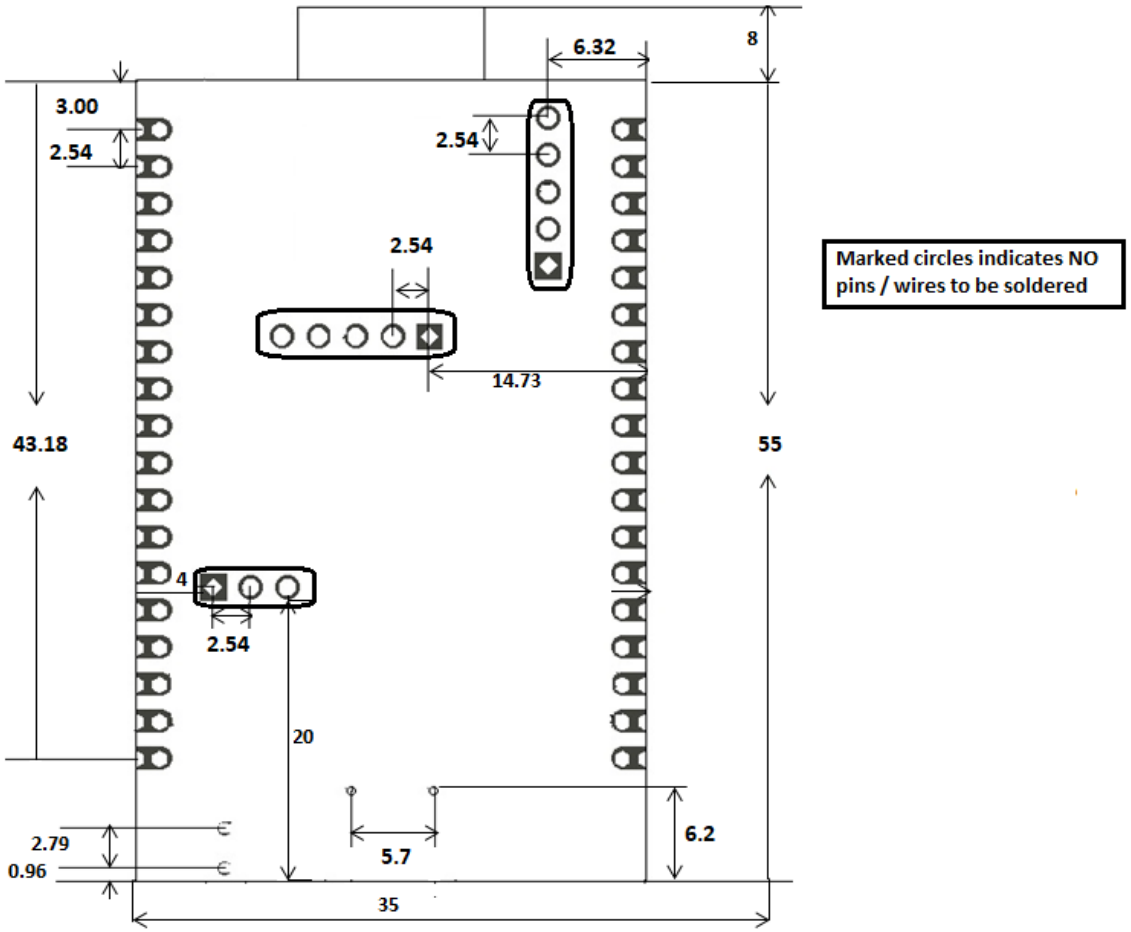
The XENO+ module is a single sided 55x35mm 1mm thick PCB with dual castellated/through-hole pins around the remaining edges. XENO+ module is designed to be usable as a surface mount module as well as being in Dual Inline Package (DIP) type format, with the 36 main user pins on a 2.54mm (0.1") pitch grid with 1mm holes.

Mechanical Specifications



(All dimensions are in mm)

Mechanical Specifications with no pins/vias to be present



(All dimensions are in mm)

Carrier Board PCB Footprint