

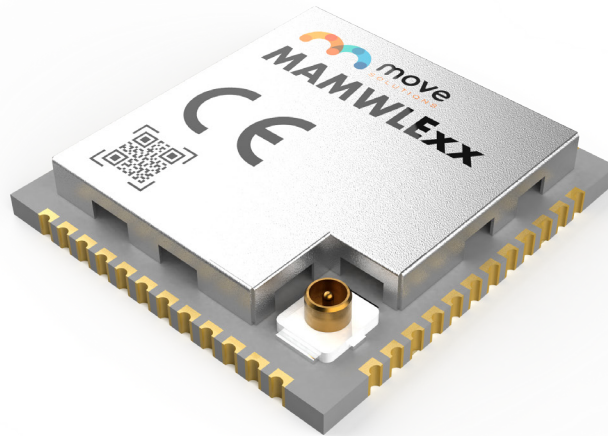


# MAMWLExx

Low Power Radio Module with M4/M0+ Core.

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## Features:

**Radio:** LoRa/(G)FSK/(G)MSK/BSPK Modulation, LoRaWAN Compliant, 868 Mhz to 960 Mhz frequency range, coaxial connector UfL inside.

**Code Correction Algorithm:** New code correction algorithm for LoRa point to point communication to increase link budget and robust communication.

**Cores:** 32 bits ARM M4 core with DSP instructions plus 32 bits ARM M0+ in same package.

**Memories:** 128Kbyte Flash, 48Kbyte RAM.

**Security:** Hardware encryption module for AES, CRC calculator and more

**Clock:** TCXO 32Mhz for high power transmission (up to +22dBm) and 32Khz oscillator.

**Peripheral:** Rich GPIO, 12 ADC at 12 bit with oversampling up to 16 bit with high samples rate, DAC, multiples I2C,SPI,UART,LPUART, timers and more.

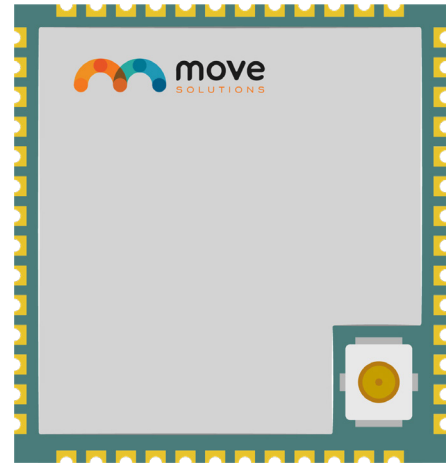
## Applications:

- Smart meters,
- Supply chain,
- Building automation,
- Agricultural automation,
- Drone Control,
- GPS RTK,
- Smart cities,
- Retail Store sensors,
- Assets Tracking,
- Street Lights,
- Parking Sensors,
- Environmental Sensors,
- Healthcare Sensors,
- Remote control applications.



## General Description:

MAMWLExx is a new low power radio module with a high performance processing unit for the most complex task and high demand applications. The module come with a great size of RAM and FLASH Memory which can be used for important computing calculations and to embed the biggest software applications. Since the module is based on the STM SoC it can be used all the environment produced by ST itself to program the module as the STM32CubeIde.



The MAMWLExx module is designed to be easily integrated to any PCB offering a U.FI coaxial connector on the top of the package without the need for any developer to design a RF circuit for the antenna. If you wish to create your own antenna design, there is the chance to have the antenna directly on a 50 Ohm pin of the module.

The module use an high performance ARM Cortex M4 32 Bits RISC core operating at 48 Mhz implementing a set of DSP instruction that are really helpful when speed and resources are the keys. The same package contains also an ARM Cortex M0+ which is used to control the radio system. The module have different type of low power operation states, perfect for different application especially the ones that needs power saving.

MAMWLExx implements multiples radio modulations: LoRa, (G)FSK, (G)MSK and BPSK with different options (Bandwidth, SF, Powers, CR) to meets different needs of communication. The system also implement a new code correction packet algorithm for LoRa point to point transmission, which enable to communicate data with higher robustness to interferences correcting symbols that can be distorted by noise on the channel. This system is made by creating a new layer on the modulation scheme using code correction algorithm on the top of the layers already implemented by LoRa communication. To guarantee the higher stability the module include on board a TCXO enabling power delivery to antenna up to +22dBm and high frequency stability.

MAMWLExx come with a rich pin out to meet different need of applications. The pin out is designed to use different peripherals at the same time using different protocols as I2C, SPI, LPUART, USART. The module has 12 multiplexed pins for a 12 bit (up to 16 bits) SAR ADC with DMA controllers, 12 bits DAC, 2 ultra low power comparator, multiple timers and independent watchdog. MAMWLExx has up to 32 I/O, most of them 5V-tolerant.

The module implements a hardware encryption/decryption accelerator for different type of standard as AES (both 128 - 256 bits) and PKA for RSA, Diffie-Hellmann or ECC (Elliptic Curve Cryptography) over GF(p) (Galois fields).

## Electrical Characteristics

### Absolute Characteristics

Parameter	Minimum	Typical	Maximum	
Temperature	-40		+85	°C
Supply Voltage (VDD)	-0,3		3,9	V
Supply Voltage (VREF+)	-0,3		3,9	V

### Operating Characteristics

Parameter	Minimum	Typical	Maximum	
Temperature	-40		+85	°C
Supply Voltage (VDD)	1,8	3,3	3,6	V
Supply Voltage (VREF+)	1,8	-	-	V
Frequency Band	868		915	Mhz
TCXO		32		Mhz
XTAL		32,768		Khz
Power consumption (shutdown mode)	40	50	166	nA
Power consumption (standby mode)		198		nA
Power consumption (Sleep mode*)	29		37	uA
Power consumption (Run mode*)	63		101	uA

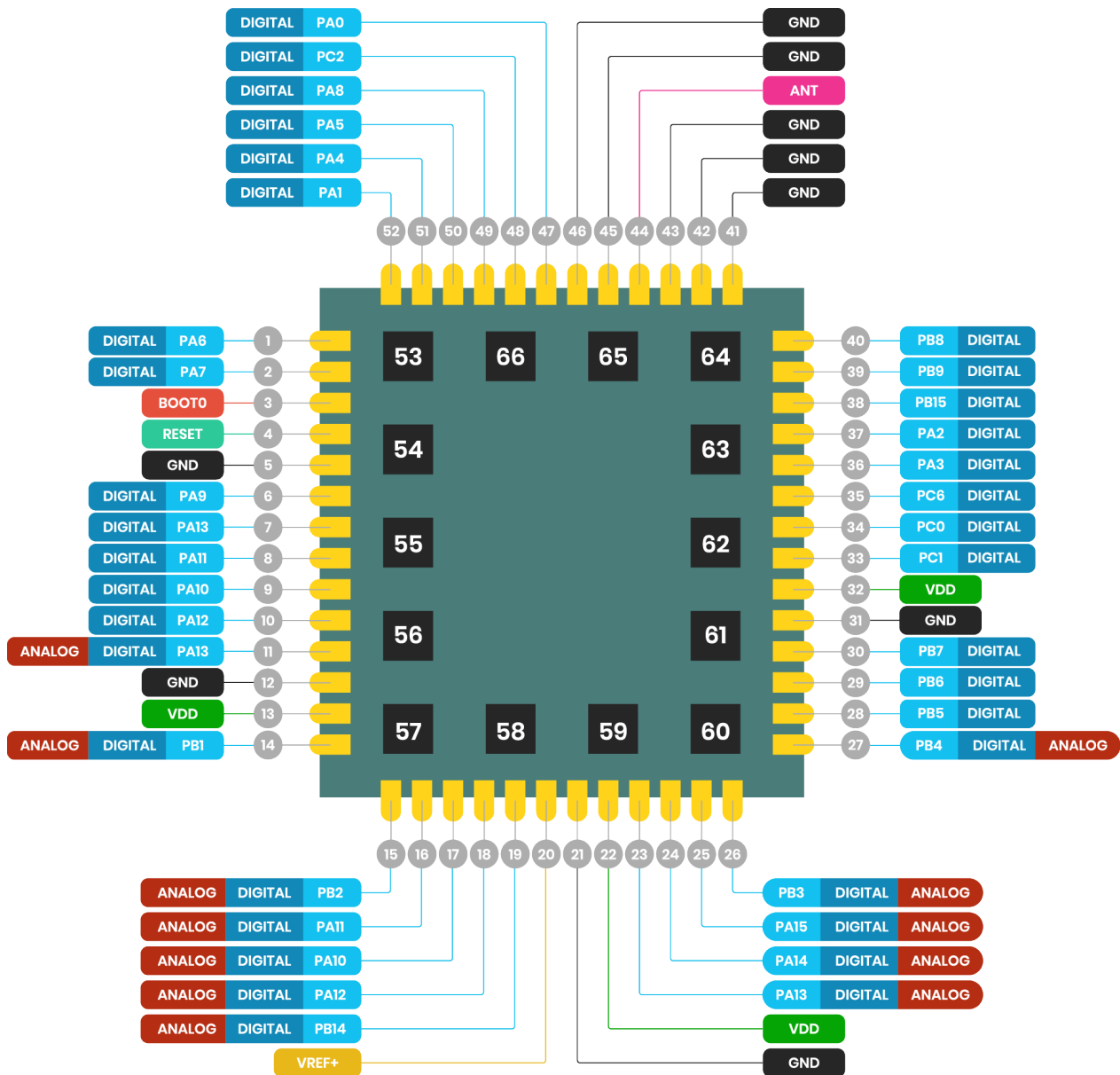
\*at 48 Mhz.

## RF Characteristics

Parameter	Minimum	Typical	Maximum	
Output RF level (Low PA)			+14	dBm
Output RF level (High PA)			+22	dBm
Power consumption (PA=+10dBm)*	15		20	mA
Power consumption (PA=+14dBm)*			26	mA
Power consumption (PA=+20dBm)*	87		106	mA
Power consumption (PA=+22dBm)*			120	mA
Sensitivity (868Mhz, BW=125Khz SF=12)		-135,4		dBm
Sensitivity (868Mhz, BW=125Khz SF=7)		-124,2		dBm
Sensitivity (868Mhz, BW=500Khz SF=12)		-129,6		dBm
Sensitivity (868Mhz, BW=500Khz SF=7)		-116,2		dBm
Sensitivity (915Mhz, BW=125Khz SF=12)		-135,6		dBm
Sensitivity (915Mhz, BW=125Khz SF=7)		-122,4		dBm
Sensitivity (915Mhz, BW=500Khz SF=12)		-127,9		dBm
Sensitivity (915Mhz, BW=500Khz SF=7)		-115,1		dBm

## Main System Peripherals and GPIO

The size of MAMWLExx is about of 16,5 mm X 15,5 mm LGA and comes with a 66 pin out to bring all the functionality and rich peripherals of the STM32WLExx. It has multiples interfaces availables:



Interface	Quantity
I2C	3
SPI	2
U(S)ART	2
LPUART	1

With a number of 36 I/O that includes:

Task	Quantity (Pin out)
Digital Pin	up to 36 pins
ADC	12 pins
VREF+	1 pin
Comparators	2 pins
DAC	1 pin

GPIO can have different operations states for output and input operation as:

- 1) Output States: Push-Pull or Open drain + pull-up/down
- 2) Input States: Floating, pull-up/down, analog

Most of pins are 5V tolerant.

The module has also different system peripheral to achieve great performances such as:

System Peripheral
2x DMA controllers
Timers and Low Power Timer
RTC with 32-bit sub-second-wakeup counter
Independent watchdog, Window watchdog
Hardware Encryption/Decryption accelerator



## DMA

The direct memory access (DMA) controller is a bus master and system peripheral. The DMA is used to perform programmable data transfers between memory-mapped peripherals and/or memories, upon the control of an off-loaded CPU. All DMA channels are independently configurable to give the best performance needs.

The DMA support:

- 1) ADC and DAC
- 2) I2C and SPI
- 3) LPUART and USART
- 4) Timers
- 5) AES

## RTC

The RTC provides an automatic wakeup to manage all low-power modes. The real-time clock (RTC) is an independent BCD timer/counter. The RTC provides a time-of-day clock/calendar with programmable alarm interrupts. As long as the supply voltage remains in the operating range, the RTC never stops, regardless of the device status (Run mode, low-power mode or under reset). The RTC is functional in VBAT mode.

The RTC supports the following features:

- 1) Calendar with subsecond, seconds, minutes, hours (12 or 24 format), week day, date, month, year, in BCD (binary-coded decimal) format.
- 2) Binary mode with 32-bit free-running counter.
- 3) Automatic correction for 28, 29 (leap year), 30, and 31 days of the month.
- 4) Two programmable alarms.
- 5) On-the-fly correction from 1 to 32767 RTC clock pulses. This can be used to synchronize it with a master clock.
- 6) Reference clock detection: a more precise second source clock (50 or 60 Hz) can be used to enhance the calendar precision.
- 7) Digital calibration circuit with 0.95 ppm resolution, to compensate for quartz crystal inaccuracy.
- 8) Timestamp feature which can be used to save the calendar content. This function can be triggered by an event on the timestamp pin, or by a tamper event, or by a switch to VBAT mode.
- 9) 17-bit auto-reload wakeup timer (WUT) for periodic events with programmable resolution and period.

MAMWLExx provide to the RTC a 32,768 Khz high accuracy crystal inside the module to have the best performance.



## ADC and DAC

The MAMWLExx includes 12 external pins multiplexed to a high quality SAR ADC 12 bits resolutions. The resolution bits can be programmed from 6 to 12 bits.

ADC conversion time is about 2.5MSPS at 12 bits and can be incremented by lowering the resolution and the sampling time can be programmed to answer at different type of applications.

The ADC is supported by the DMA and it can operate a self-calibration. The converter can apply a oversampling with 16 bit data register and a ratio adjustable from 2 to 256x.

The DAC module is a 12 bit digital-to-analog-converter. It can be configured in 8 or 12 bit mode and used with the DMA and it can operate also as a Noise/Triangular-wave generator. VREF+ can be used to have a better resolution.

Digital inputs are converted to output voltages on a linear conversion between 0 and VREF+.

The analog output voltage on the DAC channel pin is determined by the following equation:

$$DAC_{output} = (VREF * DOR) / 4096 \text{ where } DOR \text{ is the data register for DAC}^*$$

*\*Read the STM32WLExx Datasheet*

## Watchdog

The MAMWLExx implements two different system to catch malfunction of the software:

- 1) Independent Watchdog
- 2) System Watchdog

### **Independent Watchdog:**

The devices feature an embedded watchdog peripheral that offers a combination of high safety level, timing accuracy and flexibility of use. The Independent watchdog peripheral detects and solves malfunctions due to software failure, and triggers system reset when the counter reaches a given timeout value.

The independent watchdog (IWDG) is clocked by its own dedicated low-speed clock (LSI) and thus stays active even if the main clock fails.

The IWDG is best suited for applications that require the watchdog to run as a totally independent process outside the main application, but have lower timing accuracy constraints

### **System Window Watchdog:**

The system window watchdog (WWDG) is used to detect the occurrence of a software fault, usually generated by external interference or by unforeseen logical conditions, which causes the application program to abandon its normal sequence. The watchdog circuit generates an MCU reset on expiry of a programmed time period, unless the program refreshes the contents of the down-counter before the T6 bit becomes cleared. An MCU reset is also generated if the 7-bit down-counter value (in the control register) is refreshed before the down-counter has reached the window register value. This implies that the counter must be refreshed in a limited window.

The WWDG clock is prescaled from the APB clock and has a configurable time-window that can be programmed to detect abnormally late or early application behavior.

The WWDG is best suited for applications which require the watchdog to react within an accurate timing window.



## Radio

The Sub-Ghz Radio is a low power radio with a high quality matching filter for operate in the band of 868 Mhz and 915 Mhz. It can operate different modulation techniques such as:

Modulation	Mode
LoRa	TX/RX
(G)FSK	TX/RX
(G)MSK	TX/RX
(D)BPSK	Only TX

The radio is compliant for LoRaWAN specification and for different radio regulations ETSI EN 300 220, EN 300 113, EN 301 166, FCC CFR 47 part 15, 24, 90, 101 and the ARIB STD-T30, T-67, T-108.

The Sub-Ghz Radio is equipped with two high performance power amplifier to transmit up to +22dBm and the power can be programmed with a step of 1 dB within 32 steps. A high quality TCXO 32 Mhz guarantee great stability during transmission.

The LoRa modulation can operate with different bandwidth:

0	1	2	3	4	5	6	7	8	9	Code
7,81	10,42	15,63	20,83	31,25	41,67	62,5	125	250	500	BW[KHZ]

And with different Spreading Factors (from 5 to 12).

It can be set multiple different mode of operations for LoRa Packet (Explicit/Implicit Header Mode) choosing also different coding rate:

0	1	2	3	4	CR Settings
4/4	4/5	4/6	4/7	4/8	Coding Rate

The radio is completely programmable to achieve the best performances needs for different kind of application.

The module can implement a C LoRa Point-to-Point library with a custom code designed by MOVE that increase the probability of long communications increasing data-rates and stronger robustness to error. The library implements multiple error-correcting code.

The MAMWLExx comes with two different option:

- 1) UfL connector
- 2) 50 Ohm Antenna pin

The UfL connector is already applied on the top of the module with a high performance Pi Filter, so there are no needs to design any RF circuit to implement the module. To give the best flexibility to the designer the MAMWLExx implement a 50 Ohm pin antenna to enhance a complete custom antenna design.

The module can implement Over-The-Air Firmware update.

## Size and Dimension

