ethertronics®

AN AVX® GROUP COMPANY

Application Note 003b

Closed loop Impedance Matching
Test Result for ETH-LORA-M-AX-01 (V1.2)

Table of Contents

Application Note 003b

Closed loop Impedance Matching
Test Result for ETH-LORA-M-AX-01 (V1.2)

ethertronics
AN AVX GROUP COMPANY

OVERVIEW

The Ethertronics LoRa module ETH-LORA-M-AX-01 (V1.2) embeds two antenna RF technologies to maximize antenna performances:

- Closed loop Impedance Matching (IM) to maximize the power transferred to the antenna when the antenna is detuned by its environment.
- Active Steering Technologies to maximize link connectivity. With that feature, the radiation pattern of the active steering antenna is driven by Ethertronics Modal Cognitive Diversity (MCD) algorithm in order to enhance RF budget link and increase reliability and range.

The purpose of this document is to show the result of the Close loop Impedance Matching (IM) technology embedded in the module EtherLoRa ETH-LORA-M-AX-01 (V1.2).

This document is divided in the following parts:

- General description
- IM Result
- Conclusion

REQUIREMENT

To perform the test of the IM algorithm the items below are needed.

Hardware Tools:

1. EtherLoRa module ETH-LORA-M-AX-01 (V1.2).
2. USB-UART Cable (FTDI USB-UART TTL Cable)
3. Computer with Windows OS
4. LoRa Gateway
5. Vector Network Analyzer (VNA)

Software Tools:

1. Driver for USB-UART cable
2. Ethertronics EtherLoRa Control Tool

SCOPE

This document focuses on the Impedance Matching technology (and its algorithm). This algorithm is running independently of the other RF technology (Active steering and its MCD algorithm)) and therefore can be used either with any passive antenna or with an active steering antenna. In this document, copper wire antennas are used.

GENERAL DESCRIPTION

IMPEDANCE

The impedance matching algorithm is developed by Ethertronics to maximize the power transfer to the antenna. Even a well matched antenna can be detuned due to constant change in its environment especially in urban areas. Once the antenna impedance is no longer optimized for the current condition, the RF performance will degrade and this could result in data lost or worst connection lost between the module and the gateway. This algorithm helps to compensate these scenarios by automatically readjusting the matching of the antenna.

BLOCK DIAGRAM OF THE MODULE USED WITH A PASSIVE ANTENNA

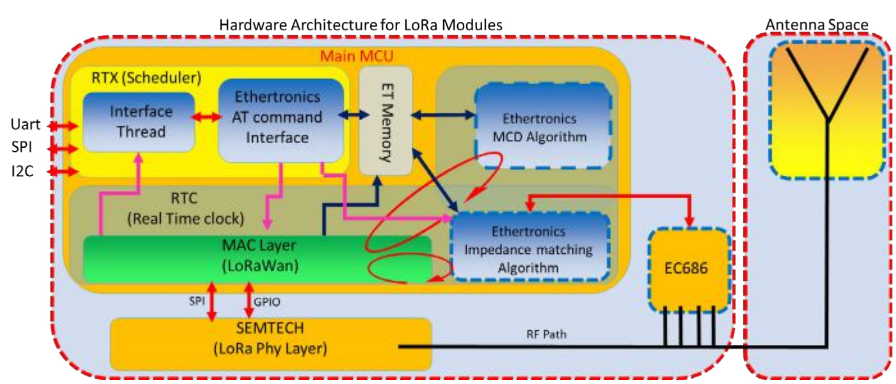


Figure 1

PASSIVE EVALUATION BOARD

To facilitate the final product's developers, Ethertronics has built complete passive/active evaluation boards (EVBs) for ETH-LORA-M-AX-01 (V1.2). In order to test the functionalities of the IM algorithm, a passive evaluation board is used. This evaluation board comes with test connectors to communicate with ETH-LORA-M-AX-01 using AT commands via UART interface. This board is modified to solder the SMA cable. This is done to easily connect the copper wire antenna to the EVB.

MODIFIED PASSIVE EVB WITH SOLDERED SMA CONNECTOR (TOP VIEW)

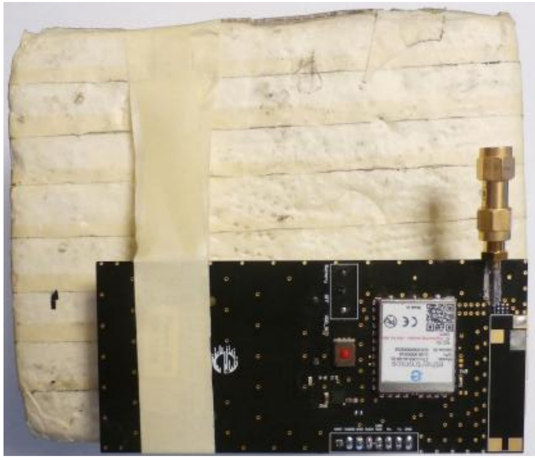


Figure 2

PASSIVE EVB (BOTTOM VIEW)

Figure 3

EVB PASSIVE COMPONENTS

Component	Position	Function	Description
ETH-LORA-M-AX-01	Top	LoRa Module	Module to communicate with the gateway using LoRa communication
SMA connector	Top	To connect the copper wire passive antenna	Connection to the antenna
Push Button	Top	Reset button	Reset the ETH-LORA-M-AX-01
Test connectors	Bottom	UART/Power Supply	To communicate using AT Commands and to supply the voltage to the module
Toggle switch	Bottom	Power Supply selection	To select the power supply whether from Battery or Test connector
Battery holder	Bottom	Place for 3 AA batteries	To supply the voltage to the module

Table 1

SETUP CONDITION

The measurement has been done for LoRa EU-868 band. Several cases where the detuning is created by cutting the three wire antennas to different length

GLOBAL SETUP DIAGRAM

RETURN LOSS MEASUREMENT SETUP

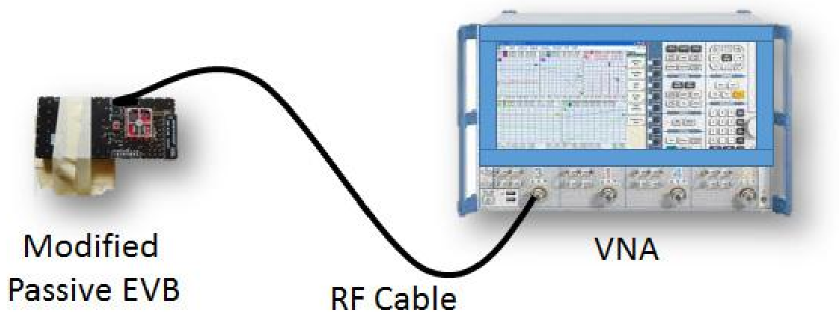


Figure 4

For the return loss measurement the passive EVB is modified to connect the RF cable on the PCB.

RSSI MEASUREMENT SETUP

Figure 5

The control software is installed on the PC host. User can use this software to communicate with the module ETH-LORA-M-AX-01 using AT commands. The procedures are as follow:

1. Setup the IM algorithm parameters if necessary
2. Initiate the join procedure using OTAA with gateway
3. Start the IM algorithm
4. Start the listener to collect information necessary and the state of the algorithm
5. Send the message to the gateway every 20 seconds
6. For every response of the gateway, the information is logged for the post processing.

PASSIVE EVB (DUT) SETUP

The passive EVB is then loaded with different length wire antennas configuration to study the effectiveness of the IM algorithm.

MODIFIED PASSIVE EVB WITH COPPER WIRE ANTENNA

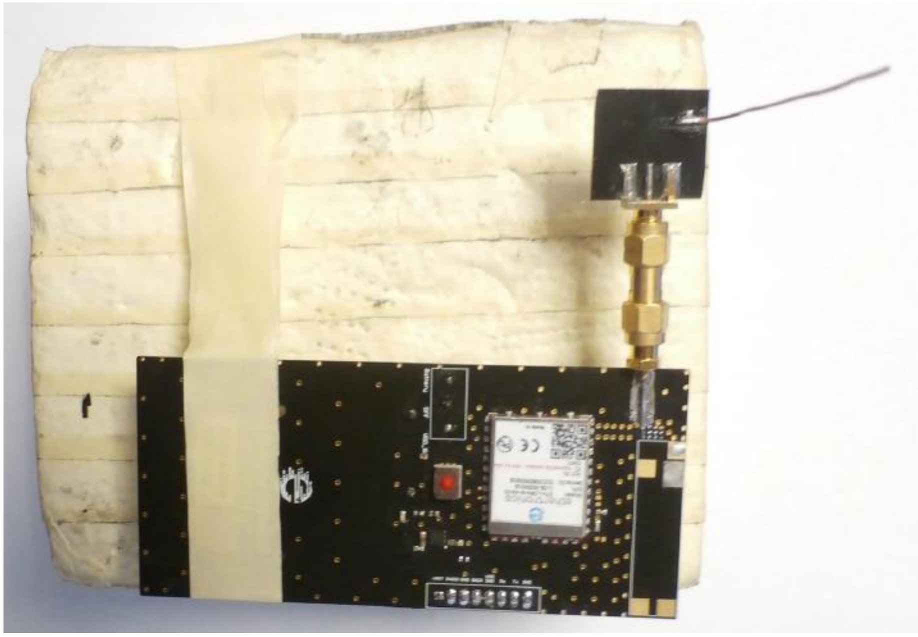


Figure 6

RESULT

RETURN LOSS MEASUREMENT

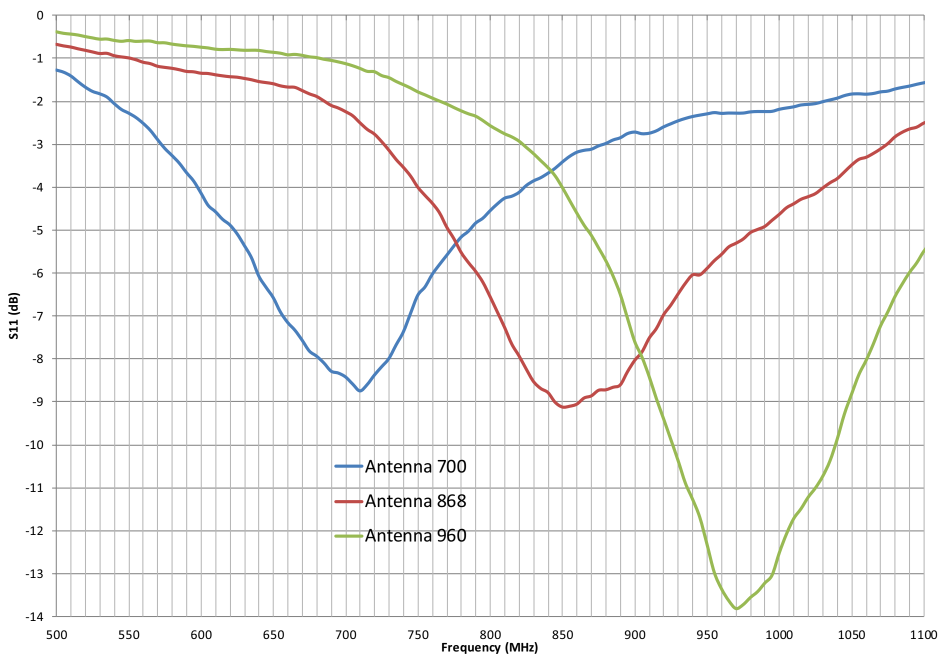


Figure 7

The antenna 868 is well tuned for the LoRa EU868 frequency. The antenna 700 is tuned to the lower frequency and the antenna 960 is tuned to the higher frequency.

RSSI MEASUREMENT

ANTENNA 700

WITHOUT IM ALGORITHM

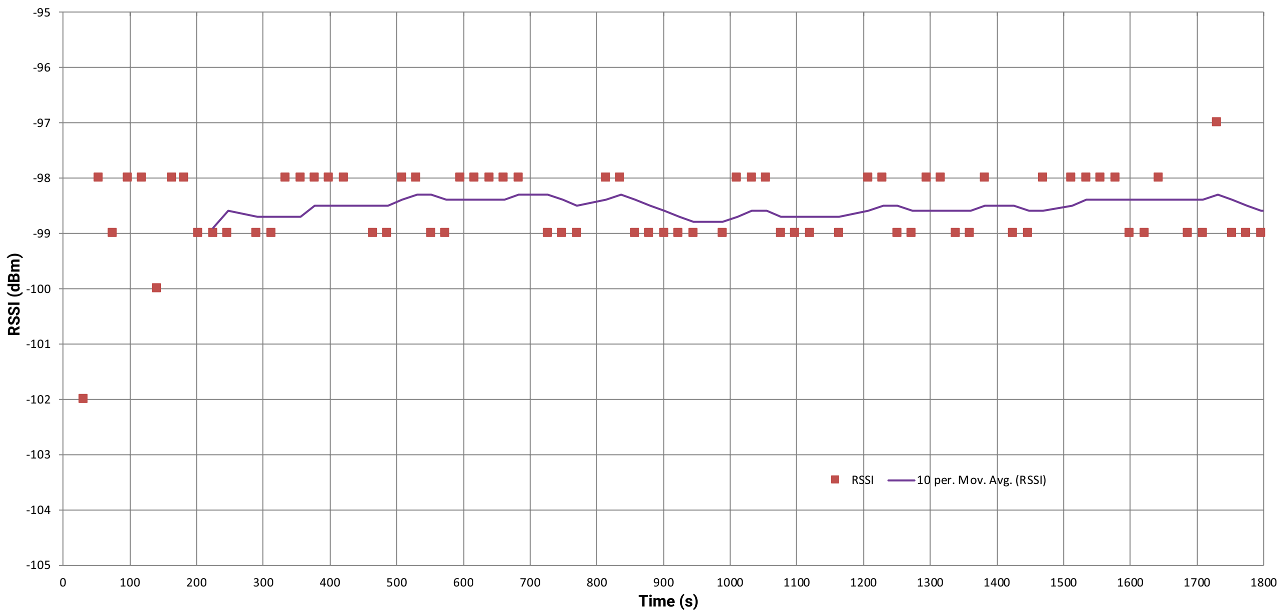


Figure 8

Without the IM algorithm, the RSSI value achieved with this antenna is ~-98.5 dBm.

WITH IM ALGORITHM

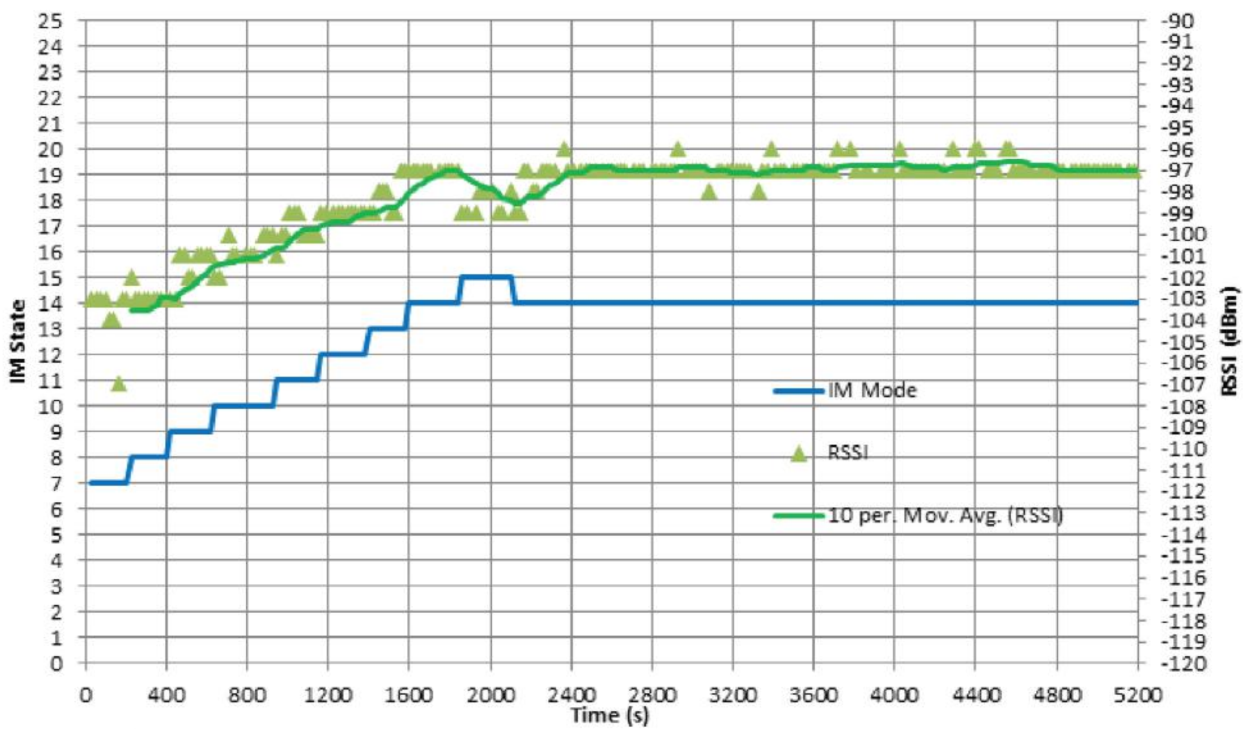


Figure 9

The IM algorithm converges to state 14 in the measurement with this antenna. The best RSSI value can be achieved in this state (~-97 dBm).

ANTENNA 868

RSSI WITHOUT IM ALGORITHM

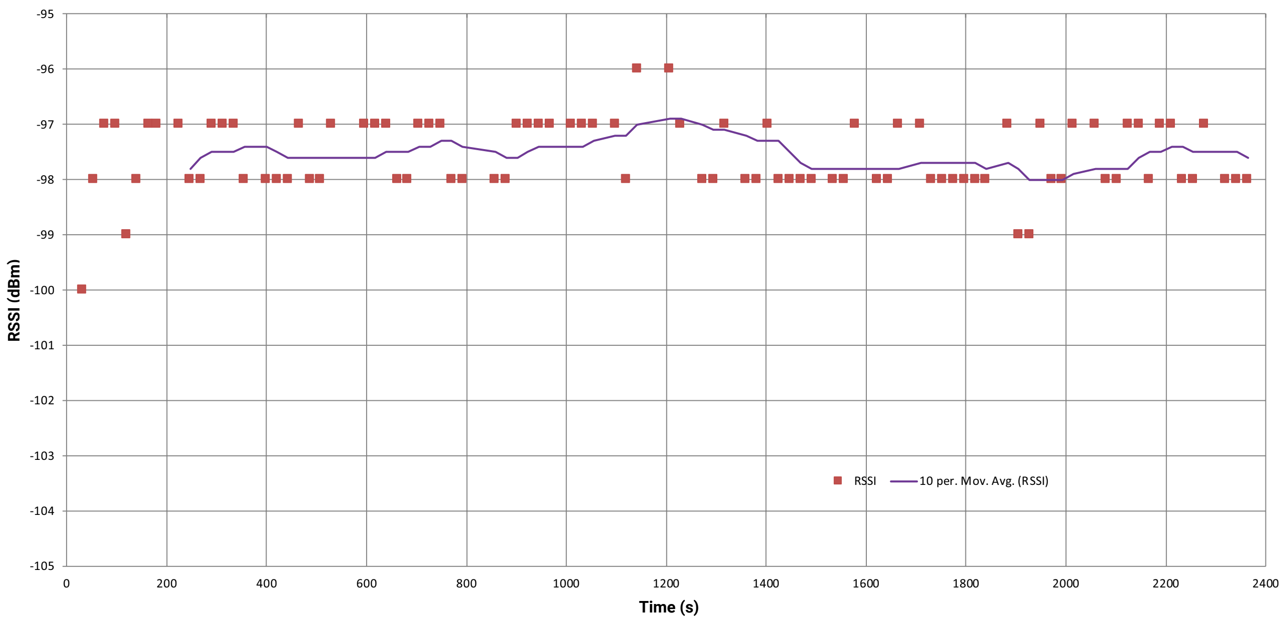


Figure 10

Without the IM algorithm, the RSSI value achieved with this antenna is ~-98.5 dBm.

WITH IM ALGORITHM

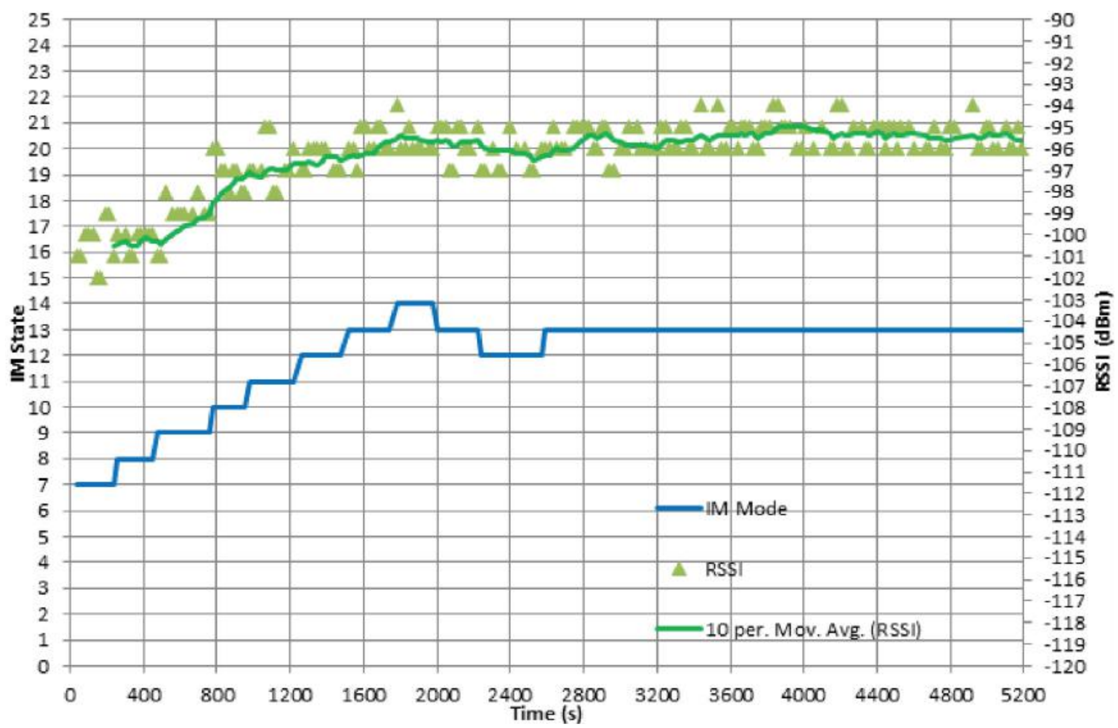


Figure 11

The IM algorithm converges to state 13 in the measurement with this antenna. The best RSSI value can be achieved in this state (~-95.5 dBm).

ANTENNA 960

RSSI WITHOUT IM ALGORITHM

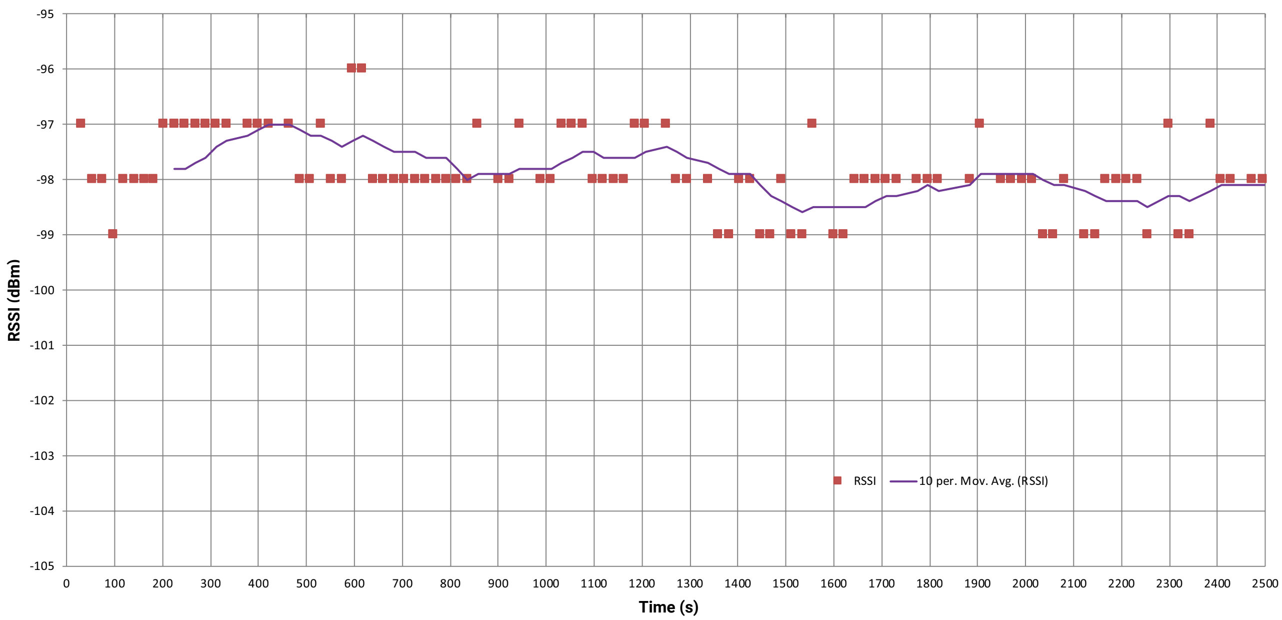


Figure 12

Without the IM algorithm, the RSSI value achieved with this antenna is ~-97.5 dBm.

WITH IM ALGORITHM

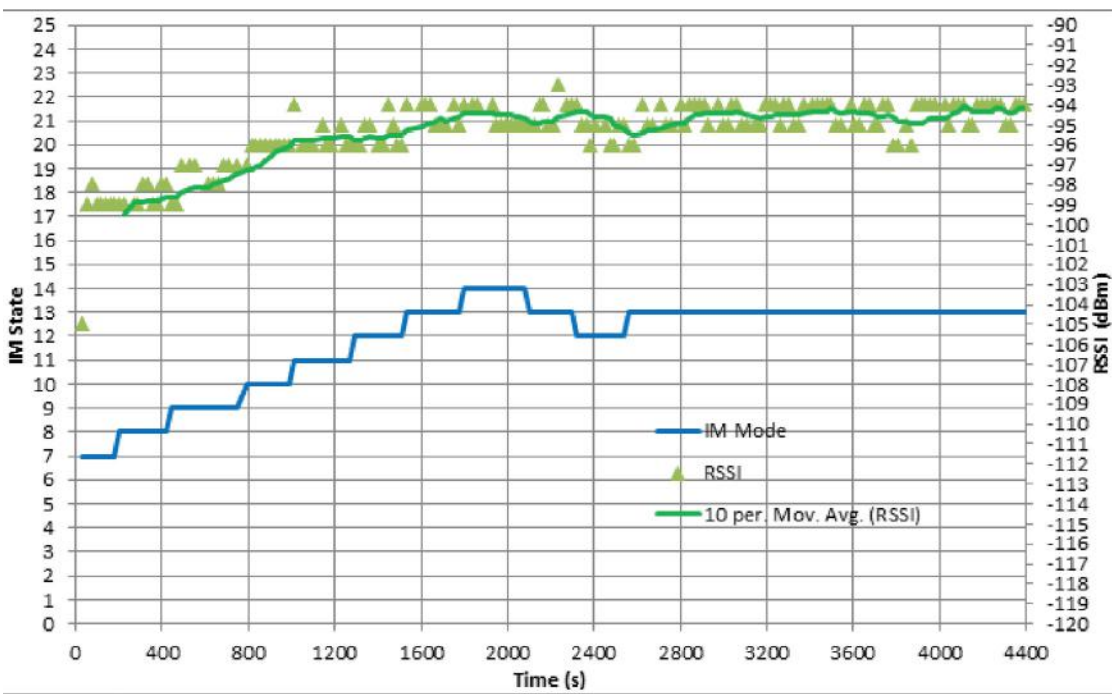


Figure 13

The IM algorithm converges to state 13 in the measurement with this antenna. The best RSSI value can be achieved in this state (~-95 dBm).

CONCLUSION

From the return loss measurement, the different length antennas have different return loss values at 868 MHz.

RETURN LOSS MEASUREMENT SUMMARY

Antenna	Return Loss Without IM at 868 MHz	Description
Antenna 700	-3.14 dB	Tuned too low in frequency
Antenna 868	-8.91 dB	Tuned for the LoRa frequency
Antenna 960	-4.89 dB	Tuned too high in frequency

Table 2

In term of RSSI measurement, the IM algorithm has selected the best state for the best RSSI value of each antenna.

RSSI MEASUREMENT SUMMARY

Antenna	RSSI without IM	RSSI with IM	Improvement
Antenna 700	~-98.5 dBm.	~-97 dBm	~1.5 dB
Antenna 868	~-97 dBm.	~-95.5 dBm	~1.5 dB
Antenna 960	~-97.5 dBm.	~-95 dBm	~2.5 dB

Table 3

Antenna 868 has the highest RSSI value when measured without the IM as it is well tuned for the LoRa EU868 frequency band.

The Improvement of the 1.5 dB for the 868 MHz antenna can therefore appear surprising, considering that the return loss is ~- 8.9 dB, but the Return Loss had been measured on a 50 Ohms VNA port, while the impedance at the input of the Semtech chipset is not exactly 50 Ohms when the Impedance matching is OFF.

The reason is that even when the tuner is OFF, the off state parasitic capacitors of the tuner, detune the antenna (so the Return loss would not be as good as -8.9dB). So, the RSSI is slightly lower with the tuner OFF, than what it would be without any tuner. This is however corrected and optimized as soon as the tuner is ON and rematch the antenna.

The RSSI values for all the antennas have been improved when measured with the IM algorithm.

The Impedance Matching Tuner and algorithm have rematched the impedance of each copper wire antennas and have maximized the RSSI Level.

LIST OF ABBREVIATIONS

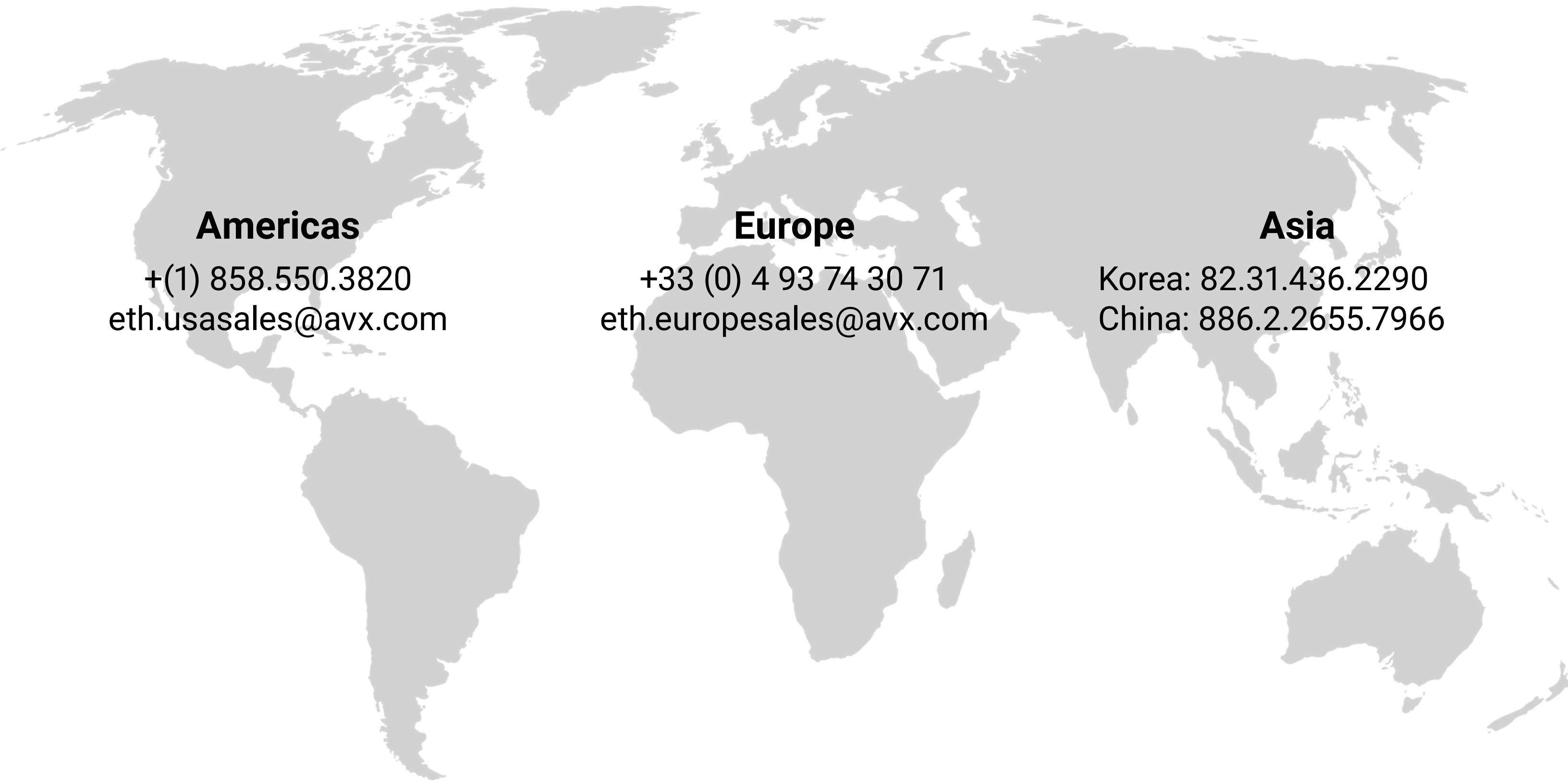
LoRa: Long range
IM: Impedance Matching
MCD: Modal Cognitive Diversity
USB: Universal Serial Bus
TTL: Transistor–transistor logic level
UART: Universal Asynchronous Receiver/Transmitter
OS: Operating System
VNA: Vector Network Analyzer
EU: European Union
RF: Radio Frequency
EVB: Evaluation Board
OTAA: Over The Air Activation
DUT: Device Under Test
RSSI: Received Signal Strength Indicator

LIST OF FIGURES

LIST OF TABLES

ethertronics®

AN AVX GROUP COMPANY



Americas
+(1) 858.550.3820
eth.usasales@avx.com

Europe
+33 (0) 4 93 74 30 71
eth.europesales@avx.com

Asia
Korea: 82.31.436.2290
China: 886.2.2655.7966

FOLLOW US:

VISIT US AT WWW.AVX.COM