PROGRESS ON THE REALIZATION OF A LOR® BASED COMMUNICATION SYSTEM FOR ATMOSPHERIC MONITORING PROBES

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Abstract

The work presents the progress on the realization of the communication system realized for atmospheric monitoring probes. The realization of a link based on the Long Range (LoRa®) technology to connect and exchange data between the probes and the base station located on the ground is the potential adopted solution. After a brief description of the whole project, the realization of the first prototypal transmission system using Adafruit® Feather 32u4 LoRa Radio RFM95 embedded modules is described. First propagation measurements and results are presented.

Index Terms – LoRa, atmospheric probes, propagation measurements, electromagnetic measurements, LoRa measurements, Internet of Things, IoT.

I. INTRODUCTION

As part of the Horizon 2020 Innovative Training Network Cloud-MicroPhysics-Turbulence-Telemetry project (ITN-COMPLETE), a new kind of ultralight radio probe with an embedded processor, capable of floating in stratocumuli clouds is being developed. The probes must have a fluid-dynamic behavior to allow them to “float” inside warm clouds after been released. They must be equipped with a set of sensors and low power consumption techniques must be implemented in order to allow them to float as longer as possible making ensuring in this way a deeper study of warm clouds [1]. The probes are based on a preliminary feasibility study presented by Bertoldo in 2016 [2]. They acquire information about the surrounding atmosphere characteristics and send them to a receiver located on the ground with a dedicated communication link.

In this work the communication system is briefly presented and some preliminary results about its realization are reported.

II. LORA™ BASED COMMUNICATION SYSTEM

LoRa® technology uses a proprietary Chirp Spread Spectrum (CSS) technique to encode information, achieving low power properties and long communication distances. This modulation scheme allows to improve the receiver sensitivity by the type of modulation itself and accomplishing high tolerance to misalignments in frequency between the transmitter and the receiver. The chirp pulses used in LoRa® modulation allow frequency offsets, equivalent to have timing offsets, between the receiver and the transmitter, increasing in this way the robustness against channel degradation mechanisms such as Doppler Effect, fading and multipath. The reached distances greatly depend on the environment and obstacles, however LoRa® provides better link budget than other similar communication standards. These are the main reasons why the LoRa® technology can be chosen as a communication system for the atmospheric monitoring probes.

The first realization of the communication system is based on the module Adafruit® Feather 32u4 LoRa Radio RFM95. It is an embedded module, which contains a LoRa® transceiver RFM95 and an ATmega32u4 microcontroller. The chip has 32 kB of flash memory and 2 kB of RAM memory. The radio module can be powered using 3.3 volts either by using a micro USB or an external battery. Among its main features, there are the small size (51 mm x 23 mm x 8 mm) and the lightweight (5 g), which are fundamental for the radio probes. Moreover, the operative frequency range is 868-915 MHz, including the band around 868 MHz allowed by the European laws, and the transmitted power ranges between 5 dBm to 20 dBm, thus theoretically allowing to reach distances of a tenth of kilometers. This fact is again a basic point for the choice of this chip.

FIG. 1 – Adafruit® Feather 32u4 LoRa Radio RFM9 on the left and LoRa Radio RFM9 transceiver module on the right.

Both, the transmitter placed on the final working prototypes of the radio probes, and the receiver located on the ground, will be equipped with the RFM95 transceiver module. The module will be controlled with an Arduino© microcontroller, since the microcontroller of the Adafruit® Feather 32u4 LoRa Radio RFM9 can be programmed with the same libraries of Arduino©, which is the basic chip of the final realization of the system according to the design specifications.

III. MEASUREMENTS

The first preliminary measurements were made using a single transmitter and a receiver located in different positions. Both of them are properly programmed. The transmitter is capable to work with a power supply that can be either a USB cable connected to a PC or a battery. It transmits a set of packets (N_{PACKET}=200) with a predefined transmitted power (P_{TX}=5 dBm), at the frequency of 865 MHz with a spreading factor in order to have a channel bandwidth of 125 kHz. The receiver is connected to a PC in order to count the number of correctly received packets, make measurements about RSSI, SNR and log other information. At the same time, next to the receiver, a spectrum analyzer is equipped with the same antenna of the receiver in order to measure also the received power values as far as possible, since the noise floor of the instrument is significantly higher with respect to the sensitivity of the Adafruit® Feather 32u4 LoRa Radio RFM9.

The spectrum analyzer parameters are reported in the Table I. We believe that they can be used as a reference to define a procedure for electromagnetic measurements on LoRa® technologies.

Table I – Spectrum analyzer parameters for LoRa© measurements

Center frequency (CF)	865 MHz
Resolution bandwidth (RBW)	10 kHz
Video bandwidth (VBW)	30 kHz
Sweep time	5 ms
Span	500 kHz
Measurement mode	Max hold

Preliminary results of the measurements are reported in the following Table II and Table III, where comparisons between the measured path losses and the free space path losses are reported as well.

For all the measurements, the SNR ranged from +8 at shorter distances to -6 at the longest. The negative values of SNR “indicate the ability to receive signal powers below the receiver noise floor” as reported on the official application note on LoRa™ Technology released by Semtech© [3], and it happens when the range of the communication link is increased.

The RSSI of the packets decreased with distance; however, the majority of the packets were received. For most of the cases, the percentage of packet losses was 0%, while in few cases <1%. Only in the last test, where the separation distance was larger than 800 meters, the percentage of losses reached 4%. At that distance, the Spectrum Analyzer did not measure the received power since the value is below its noise floor. The receiver module correctly received the packets.

Table II – Preliminary results for indoor measurements

POSITION #	DISTANCE [m]	SNR (dB)	RSSI [dBm]	LOST PACKETS (%)	Received power (Spectrum) [dBm]	Measured losses [dB]	Free space path loss [dB]	Difference [dB]
1	15	8	-55	1	-35,03	40,03	54,71	14,68
2	29,4	8	-71	0	-54,74	59,74	60,55	0,81
3	41,6	8	-75	0	-54,4	59,4	63,57	4,17
4	57,2	7	-93	1	-75,37	80,37	66,33	-14,04
5	13,3	8	-69	0	-52,63	57,63	53,66	-3,97
6	32,2	8	-85	0	-68,99	73,99	61,34	-12,65
7	27,7	7	-93	0	-77,82	82,82	60,03	-22,79

Table III – Preliminary results for outdoor measurements

POSITION #	DISTANCE [m]	SNR (dB)	RSSI [dBm]	LOST PACKETS (%)	Received power (Spectrum) [dBm]	Measured losses [dB]	Free space path loss [dB]	Difference [dB]
1	122	8	-82	0	-69,25	74,25	72,91	-1,34
2	170	7	-87	1	-71,13	76,13	75,79	-0,34
3	376	1	-90	1	-78	83	82,69	-0,31
4	616	-1	-132	1	-85	90	86,98	-3,02
5	839	-6	-140	4	Below noise floor of SA, impossible compute losses with received power measurements		89,66	

IV. CONCLUSIONS AND OUTLOOKS

A possible realization of the communication system based on the LoRa® technology is described and some preliminary measurements presented. Particularly detailed measurements will be made in harsh environmental conditions (e. g. rain, fog, drizzle…) in order to simulate a set of possible environmental conditions that can be found inside a warm cloud. A set of prototypes of radio probes will be realized to make further measurements with the final star topology network.

The work presents also a possible configuration for the Spectrum Analyzer to make measurements with LoRa™ technology.

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