Interface Design for OSP / Satellite Device

Hernan Paz Penagos, Ph.D.[1], Johnny Alexander Lopez Arevalo, Eng.[1], Marco Andrés Ortiz Niño, Eng.[1]
[1] Colombian School of Engineering Julio Garavito, Colombia, hernan.paz@escuelaing.edu.co, Johnny.arevalo@escuelaing.edu.co, marco.ortiz@escuelaing.edu.co.

Abstract*– This paper presents the design and construction of communication interfaces EUSART (Enhanced Universal Synchronous Asynchronous Receiver Transmitter) using the OSP / Satellite device. The technological product that integrates hardware, software and communications interfaces, was the result of a research project developed by the Colombian School of Engineering JULIO GARAVITO jointly with the company OSP LTDA and funded by COLCIENCIAS. This OSP / Satellite device reused equipment GPRS or also called units Automatic Vehicle Location: AVL, specifically TT8750 + of Skypatrol and SYRUS of DCT, which are used for locating and tracking mobile assets with cellular coverage, and they add a channel satellite backup via modem STX-2 Globalstar®, to ensure continuity in communication at any geographic area in Colombia.

Keywords*— satellite device, OSP, tracking, communications, EUSART.

Digital Object Identifier (DOI): http://dx.doi.org/10.18687/LACCEI2015.1.1.176
ISBN: 13 978-0-9822896-8-6
ISSN: 2414-6668

Interface design for OSP / satellite device

Hernan Paz Penagos, Ph.D. Education[1], Johnny Alexander Lopez Arevalo: Electronic Engineer[2], Marco Andrés Ortiz Niño, Electronic Engineer[3]

[1] Colombian School of Engineering Julio Garavito, Colombia, hernan.paz@escuelaing.edu.co
[2] Colombian School of Engineering Julio Garavito, Colombia, Johnny.arevalo@escuelaing.edu.co
[3] Colombian School of Engineering Julio Garavito, Colombia, marco.ortiz@escuelaing.edu.co.

Abstract*– This paper presents the design and construction of communication interfaces EUSART (Enhanced Universal Synchronous Asynchronous Receiver Transmitter) using the OSP / Satellite device. The technological product that integrates hardware, software and communications interfaces, was the result of a research project developed by the Colombian School of Engineering JULIO GARAVITO jointly with the company OSP LTDA and funded by COLCIENCIAS. This OSP / Satellite device reused equipment GPRS or also called units Automatic Vehicle Location: AVL, specifically TT8750 + of Skypatrol and SYRUS of DCT, which are used for locating and tracking mobile assets with cellular coverage, and they add a channel satellite backup via modem STX-2 Globalstar®, to ensure continuity in communication at any geographic area in Colombia.

I. Introduction

In the telecommunications market various wireless communication systems for locating and monitoring mobile assets (vehicles, fleets, etc.) are evident: one hundred percent local or regional coverage via GPRS [1] (Mercury®, Sony / Ericsson®, Enfora®, DCT® and Skypatrol®) and one hundred percent of universal coverage by GPS [2], [3] (EIT®, Iridium®, Globalstar®, Inmarsat®, Orbcomm®). However, GPRS equipment can lose the continuity of communication due exit the cellular network and satellite solutions for this purpose are very expensive.

Likewise, there are in the market satellite modules that have the ability to enable backup channels: STX2, STX3 manufactured by Globalstar® [4] and 9603 manufactured by Iridium Company [5]; However, there are not technological developments that exploit the benefits of the above mentioned modems to communicate with existing GPRS equipment and give the possibility to the latter to maintain communication when these units are out of the cellular network.

In this context, the development of OSP / Satellite device, which has the ability to convey information simplex through the Globalstar® satellite network. This equipment/technology has simple interfaces and commands for communication with host devices such as computers, AVL units, development modules, microcontrollers, FPGA, among others. The OSP / Satellite device receives commands and data via serial interfaces using the above protocol, packages information and transmits it via satellite channel, including data parity check to ensure they are received correctly. With this technological development the high likelihood of transmission throughout the national territory is secured, as long as you have line of sight to the sky and weather conditions permit.

In the market there are several serial interfaces: RS-422, RS-485 and RS-232. Unfortunately, most PCs do not have available RS-422, RS-485 interfaces with the COM1 and COM2 ports. RS-422 is the standard for Macintosh computers with serial port. RS-485 is an enhanced version RS-422 and used for balanced transmissions distances up to 1200m.

National Instruments also offers serial interfaces: NI 8430/8431/8432/8433 NI that run on most PC platforms with a variety of options and reliable isolation ports; however, they are expensive. These interfaces meet the EMC specification without limitation. This means that under strong induction current (lightning), the maximum distance is not 1200 m to 30 m 422/485 but according to specifications.

RS-232 serial interface was chosen because it is the simplest transmission mode and is included in most PCs as COM1 and COM2. Was used at very short distances, consequently it was not vulnerable to the negative effect of the additive noise of the line.

This paper presents the design and construction of serial communication interfaces EUSART to OSP / Satellite device, allowing the passage from input to processing module, and from this module to STX2, to transmission in simplex mode through cellular or satellite network Globalstar®

II. THEORETICAL FRAMEWORK

As shown in the figure below, the OSP / satellite device has the following circuit blocks, which are interconnected by device interfaces. EUSART internal interfaces are physical connections that facilitate the flow of serial information through the satellite circuit blocks.

Fig. 1 Flow serial-satellite data over internal interfaces of OSP / Satellite device

13th LACCEI Annual International Conference: "Engineering Education Facing the Grand Challenges, What Are We Doing?"
July 29-31, 2015, Santo Domingo, Dominican Republic **ISBN:** 13 978-0-9822896-8-6 **ISSN:** 2414-6668
DOI: http://dx.doi.org/10.18687/LACCEI2015.1.1.176

The data from the external electronic device are variable measurement and / or geolocation as latitude, longitude, direction, altitude, speed, temperature, humidity and virtually any measurable variable. These must be in ASCII (American Standard Code for Information Interchange) format and cannot exceed 300 bytes to avoid buffer overflows in the microcontroller.

The information from the external electronic device is sent to the MAX232 via serial link and in this to the EUSART 2 serial interface of the microcontroller PIC18LF26K22 [6] so that they are processed. Then the micro re-transmitted through the serial interface EUSART 1 to satellite modem STX2 from the manufacturer Globalstar® who is in charge of satellite transmission [7], [8].

The OSP / Satellite device has three modes of operation: two basic and one advanced. Both basic operation modes have the same purpose: the satellite data transmission received from external equipment when they do not have cellular coverage or other means of wireless transmission. To enable any of the three modes of operation will be three processing routines in the micro-controller. It uses EUSART communication interfaces that are compatible with existing devices and the satellite modem.

The basic operating modes allow the reception of serial data from the following external equipment AVL: SYRUS®, Skypatrol: TT8750® and Enfora: GSM1308®. Advanced operation mode allows communication with units, regardless of its purpose reference; and through an RS232 serial interface, data transmitted in accordance with the ASCII [9] standard.

III. METHODOLOGY AND DESIGN

Modeling microcontroller and communication interfaces.

For the microcontroller to fulfill its role of processing data in the OSP / Satellite device firmware is necessary to configure using the modules shown in the following figure:

Fig. 2 Microcontroller modules

The <u>storage module</u> has a nonvolatile memory EEPROM (Electrically Erasable Programmable Read-only) for storing data bytes up to 1024 in three forms (two fixed and one variable) that represent each mode of the OSP / Satellite device.

The data stored in memory are:

- Fixed data stored one (for mode one):
  - 0x5B 0x7E 0x02 0x5D (in Hexadecimal)
  - [~ .] (ASCII)
- Fixed data stored two (for mode two):
  - 0x5B 0x7E 0x02 0x5D (in Hexadecimal)
  - [~ .] (ASCII)
- Programmable data stored (for mode three):

Fig. 3 Data storage

Hexadecimal Storage Range: x000 → x3FF.

The <u>communication module two or EUSART</u> 2 allows reception and transmission of serial data and is configured with the following parameters:

Rango de almacenamiento en Hexadecimal: x000 x3FF.

TABLE I
FEATURES OF EUSART 2 INTERFACE

Variable 1	Number of bits 1
Variable 2	Number of bits 2
Variable n*	Number of bits n**

This module is responsible for receiving data in the receive buffer and then deliver it to the processing module or storage module according to the information contained in it.

Fig. 4 Diagram of decision according to data received

In order to make the data in the buffer pass to processing module it must satisfy the ASCII standard and not exceed the maximum buffer size (300 bytes). When the OSP / Satellite device is in basic operation mode, the frame to be received in the buffer corresponds to TAIP protocol (Trimble ASCII Interface protocol) and its structure is shown below [10]:

Fig. 5 TAIP frame. Interface A.

TABLE II
DESCRIPTION OF TAIP FRAME. INTERFACE A.

Extended values	[EV-TAGS] Extended values when more information is required to know
<	End frame delimiter
>	Start frame delimiter (ASCII 62 o 0x3E)
R	Frame qualifier
EV	Two-character identifier
#EV	Event number: 0 a 99
Weeks	Number of weeks from 0:00 AM january 6, 1980
D	Day 0 being Sunday
Hour	Time report generated in seconds from 0:00 to the current date
Latitude	EEEFFFFF. Latitude WGS-84. EEE represents the value in degrees and FFFFF decimals
Longitude	GGGGHHHHH. Length WGS-84. GGGG represents the value in degrees and decimal part HHHHH.
Speed	Speed in mph

Heading	Heading in degrees
Extended values	[EV-TAGS] Extended values when more information is required to know
<	End of frame delimiter

For the advanced mode, the frame to be received is valid for protocols that use the ASCII standard and do not exceed the buffer size (300 bytes).

The processing module converts the ASCII data received by the communication module 2 in decimal values without affecting its integrity, grouped to form one or more messages, each of 72 bits that are transmitted by the communication module one.

The processing is performed according to the operating mode previously stored in the EEPROM memory and is performed by the microcontroller following the logic shown in the following figure:

Fig. 6 Microcontroller' logic followed for processing information

The communication module one or EUSART 1 enables the transmission and reception of serial data and is configured with the following parameters:

TABLE III
CONFIGURATION OF EUSART 1 INTERFACE.

Type	Serial UART
Bit rate	9600 bps
Type of channel	Full duplex
	Asynchronous
Parity	Not
Stop bits	1 bit
Bits of data	8 bits

This module sends a data packet that already has passed through the processing module and which as noted above has a size of nine bytes. Interpreting the information contained in the packet is done according to the data held in the storage module, as well: for fixed data stored in one mode, the transmitted frame is:

Fig. 7 Satellite frame 1. Interface B

** Result of orientation should be multiplied by 10 to get the original value. The margin of error for this result is 5 degrees.*

*** Speed in mph.*

For fixed data stored mode two, the transmitted frame is:

Fig. 8 Satellite frame 2. Interface B

** Result of orientation should be multiplied by twelve to get the original value. The margin of error for this result is six degrees.*

*** Speed in m / s*

**** The time format will be presented one to twelve bits, for the case of the previous figure ten bits are used, of which the four least significant bits are used for time and for the remaining six minutes.*

For variable data, the frame is subject to the values programmed in the storage module as well:

TABLE IV
PRELIMINARY DESCRIPTION PLOT TO OPTION THREE MENU.

Variable 1	Number of bits 1
Variable 2	Number of bits 2
Variable n*	Number of bits n**

** Up to 72 for a nine bytes message*

*** The amount of bits for each variable is subject to validation to meet all nine variables occupy bytes sent by message.*

Modem STX2

The STX2 modem has a patch antenna type [11], [12] a digital input (which enables or disables) and a bidirectional serial interface. This interface has supported configuration parameters with the communication protocol established in the EUSART 1 interface (TABLE III). See Figure 1.

In the following two figures the state of the serial interface STX2 shown when available / unavailable to receive data from the micro controller.

Fig. 9 Communication DTE / STX-2, when the module is ready to receive data.
Source: Gen 2 satellite transmitter product data sheet. Page 12.

Fig. 10 Communication DTE / STX-2, when the module is not ready to receive data.
Source: Gen 2 satellite transmitter product data sheet. Page 12.

Communication with the modem is based on transmit a command and wait for a response [13]. The commands used in the transmission having a size of one byte, and are part of the transmitted data packet. When a packet is received in the STX2, a packet with 0X00 commands, internal message 9 bytes is removed and relocated to a new package that is re-transmitted to the satellite using an RF carrier (see Figure 11).

Fig. 11 RF carrier which modulates the message to F = 1.6 GHz

If the user message is more than nine bytes, is divided into several packages. The frame structure begins with a preamble, continues with the unit identifier, the number of messages to be transmitted, the number of packets per message nine bytes of user information (9 bytes) and ends with a 24-bit CRC [14].

Fig. 12 Data frame of the air interface.
Source: Gen 2 satellite transmitter product data sheet. Page 7.

Once the packet is created, it is sent repeatedly. The number of transmission attempts and the time interval for these attempts are configurable parameters [15]. The time interval is randomly selected as the minimum and maximum range set. To send multiple packets over air interface should follow a sequence for all attempts. For example, for transmission of three packets the sequence shown in the figure below is followed.

Fig. 13 Sequence followed by three packets that are sent over the air interface.
Source: Gen 2 satellite transmitter product data sheet. Page 8.

IV. RESULTS

Shown below the configuration of the communication interfaces, data are transmitted, received and stored in the internal memory of the device. The data received in the microcontroller PIC18(L)F2X/4XK22 [6] are stored in a buffer of size 300 bytes, and shows that according to the operating mode extracting relevant data and subsequent processing to assemble packets of nine bytes that are transmitted to the satellite module.

The following figure shows the records that show the configuration set of serial interfaces using a debug done on the microcontroller. There are shown in bits transmission rates, parity bits, message length, and stop bits.

Fig. 14 SFR registers and interrupt reception.

The following figure shows the connection with the OSP / Satellite device.

Fig. 15 Connection tab in the configuration software.

The following figure shows the OSP / Satellite device recognizes three modes in which you can configure; likewise, each of the three operating modes is displayed in the EEPROM.

Fig. 16 Satisfactory for each configuration modes shipments.

In the following figure, shows received frames for the two basic operating modes; this happens when the OSP / Satellite device is in operation.

Fig. 17 Frames transmitted and received in USART and land for two basic operation mode.

V. CONCLUSIONS

No flow control data to the serial interface is used due to two factors: The size of the buffer (300 bytes) and 64MHz frequency used by the microcontroller [16]. Therefore, the expected frame from the external device receiving the microcontroller cannot exceed 300 bytes.

The data stored in the buffer are in ASCII format, so it is necessary to know the narrative that delivers the external equipment to prevent buffer overflows leading to loss data communication.

The data processing is subject primarily buffer size in bytes that enables satellite transmission module, for this is necessary data conversion to decimal ASCII.

REFERENCES

[1] R. J. Bates, "GPRS". Kindle edición, Mc Graw-Hill. New York, 350p.

[2] Z. Zhao, W. Zhou, and N. Wang, N. "Shipping Monitoring System Based on GPS and GPRS Technology", in 2009 WASE International Conference on Information Engineering ICIE, vol. 1, Washington, DC, USA, 2009, pp.346-349.

[3] Orbcomm system review. (2001, Aug.). [Online]. Available: http://www.m2mconnectivity.com.au/sites/default/files/more-information/System_Overview_Rev_G.pdf

[4] Axxon - Globalstar. (2005, May). Satellite Transmitter Product Data Sheet. [Online]. Available: http://common.globalstar.com/doc/axonn/stx2-datsasheet.pdf

[5] Iridium Communications - Revised 4.0. Iridium 9602 SBD Transceiver Developer's Guide (2014 Jan.). [Online]. Available: http://www.g-layer.com.au/wp-content/uploads/IRDM_9602DeveloperGuideV4_DEVGUIDE_Sep2012.pdf

[6] Microchip Technology Incorporated (2012, June). PIC18 (L) F2X / 4XK22 Data Sheet 28/40/44-Pin, Low-Power and High-Performance Microcontrollers with XLP Technology. [Online]. Available: www.tme.eu/es/Document/.../pic18lf2x_4xk22.pdf

[7] A. Goldsmith. "Wireless communications". Fourth edition, Cambridge university press. Stanford University. Santa Barbara, California. 2005. 386p.

[8] S. E. Alberto. "Fundamentals of mobile communication systems". First edition, McGraw-Hill / Inter of Spain, SAU, 2004, 674p.

[9] M. Wael, A. A. El-Medany, R. Al-Hakim, S. Al-Irhayim and M. Nousif. "Implementation of GPRS-Based Positioning System Using PIC Microcontroller" 2nd International Conference on Computational Intelligence, Communication Systems and Networks CICSYN, 2010, pp. 365-368.

[10] W. On-Medany, A. Al-Omary, R. Al-Hakim, S. Al-Irhayim and M. Nusaif, M. "A Cost Effective Real-Time Tracking System Prototype Using Integrated GPS / GPRS Module", sixth International Conference on Wireless and Mobile Communications: ICWMC, 2010, pp.521-525.

[11] C.A. Balanis. "Antenna theory: analysis and design", fourth edition, John Wiley & Sons, Inc. New Jersey, 2005. 1047 pp.

[12] H. Paz. "Digital communications systems", first edition, Editorial: Colombian School of Engineering. Bogotá-Colombia. 2009. 399 p.

[13] B. Jun, W. Lu and L. Yue. "Traffic Data Collection System for Floating Car Based on GPS / GPRS / MM", second WRI Global Congress on Intelligent Systems: GCIS, vol. 3, 2010, pp.66-69.

[14] M. J. Donahoo and K. L. Calvert. "TCP / IP Sockets", in C. Morgan Kaufman Publishers. USA. 2001

[15] M. Scarpino. "Designing Circuit Boards with Eagle", Kindle edition, Prentice Hall, United Kingdom. 2014. 298p.

[16] S. Haykin. "Communications systems". Fourth edition. John Wiley & Sons, Inc. USA. 984p.

LIST OF FIGURES

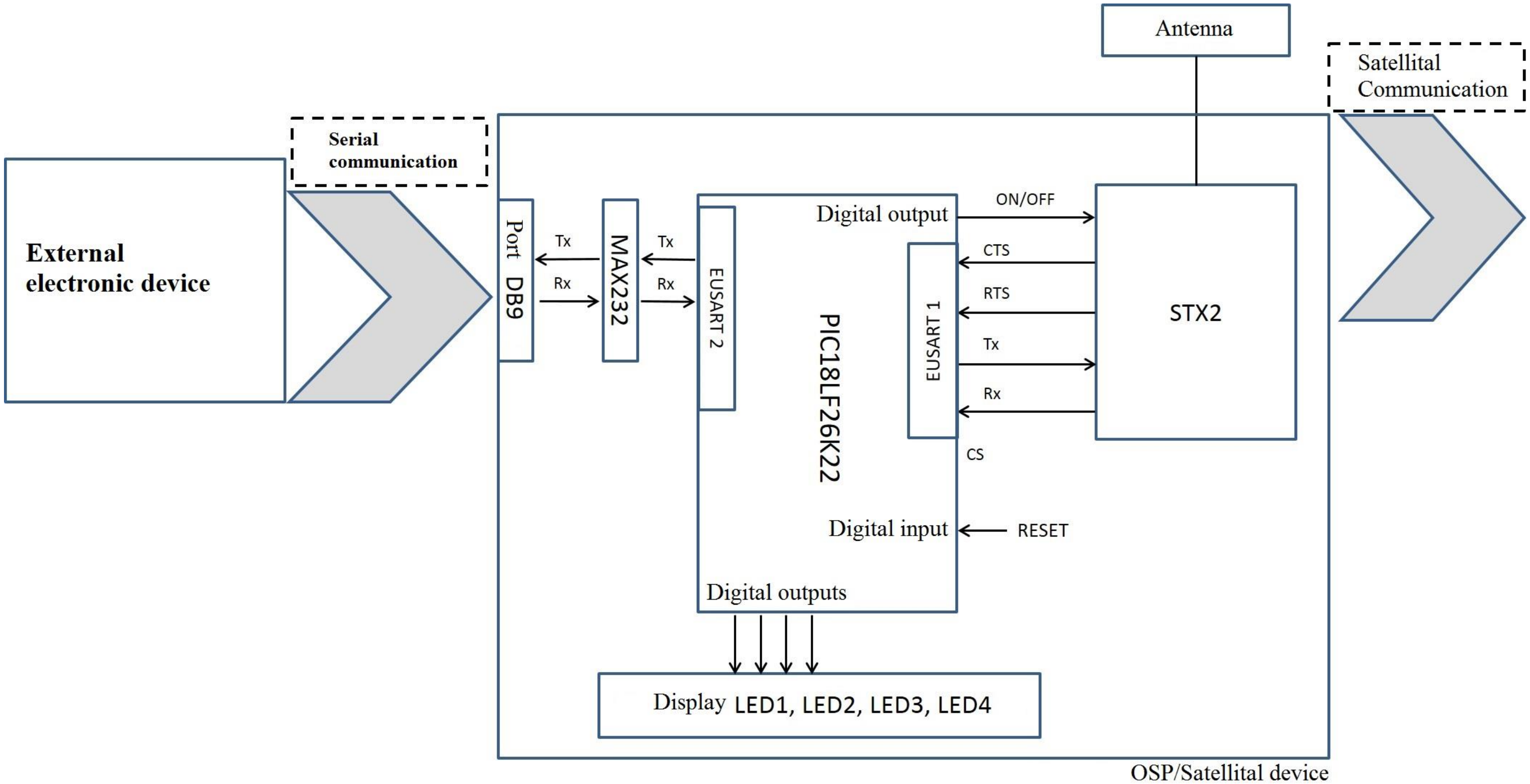

Fig. 17 Flow serial-satellite data over internal interfaces of OSP / Satellite device

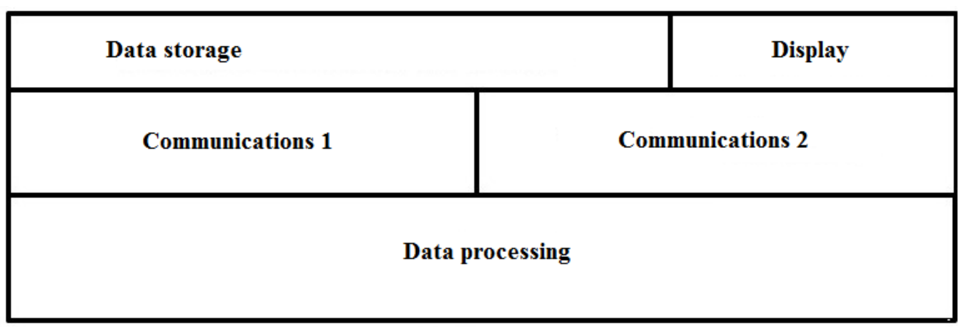

Fig. 18 Microcontroller modules

Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
000	0	0	4	0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
010	5B ([)	7E(~)	Opc. Menú	Cant. Var	Cant. Envios	23 (#)	Cant. Car 1	Pos ini 1	Cant. Car 2	Pos ini 2	Cant. Car 3	Pos ini 3	Cant. Car 4	Pos ini 4	Cant. Car 5	Pos ini 5
020	Cant. Car 6	Pos ini 6	Cant. Car 7	Pos ini 7	Cant. Car 8	Pos ini 8	Cant. Car 9	Pos ini 9	Cant. Car 10	Pos ini 10	Cant. Car 11	Pos ini 11	Cant. Car 12	Pos ini 12	Cant. Car 13	Pos ini 13
030	Cant. Car 14	Pos ini 14	Cant. Car 15	Pos ini 15	Cant. Car 16	Pos ini 16	Cant. Car 17	Pos ini 17	Cant. Car 18	Pos ini 18	Cant. Car 19	Pos ini 19	Cant. Car 20	Pos ini 20	Cant. Car 21	Pos ini 21
XX0	Cant. Car n	Pos ini n	5D (])													

Fig. 19 Data storage

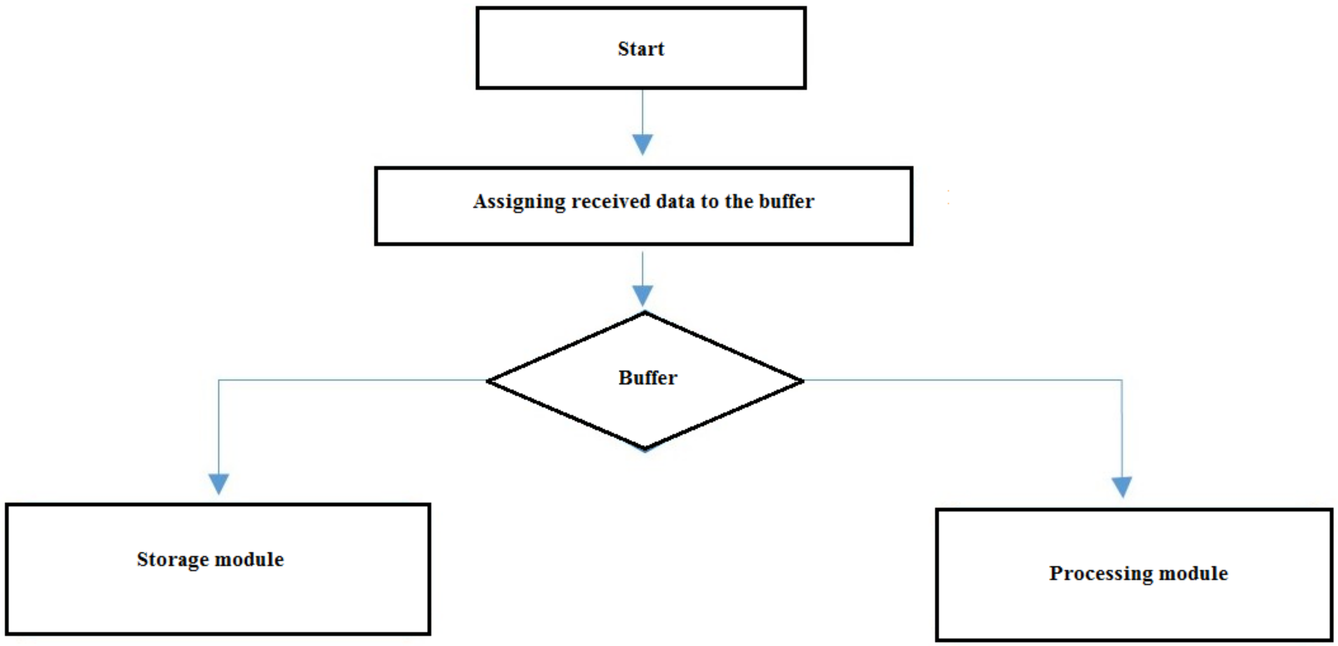

Fig. 20 Diagram of decision according to data received

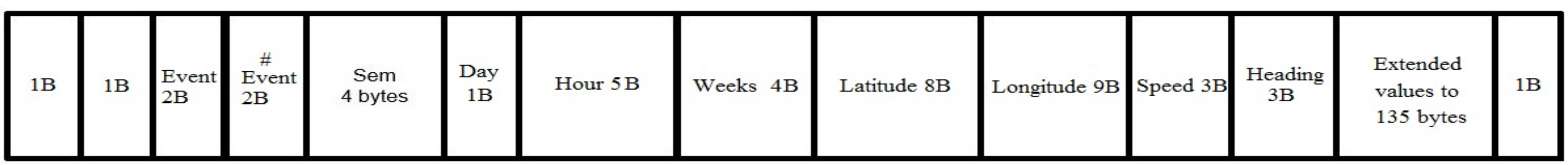

Fig. 21 TAIP frame. Interface A.

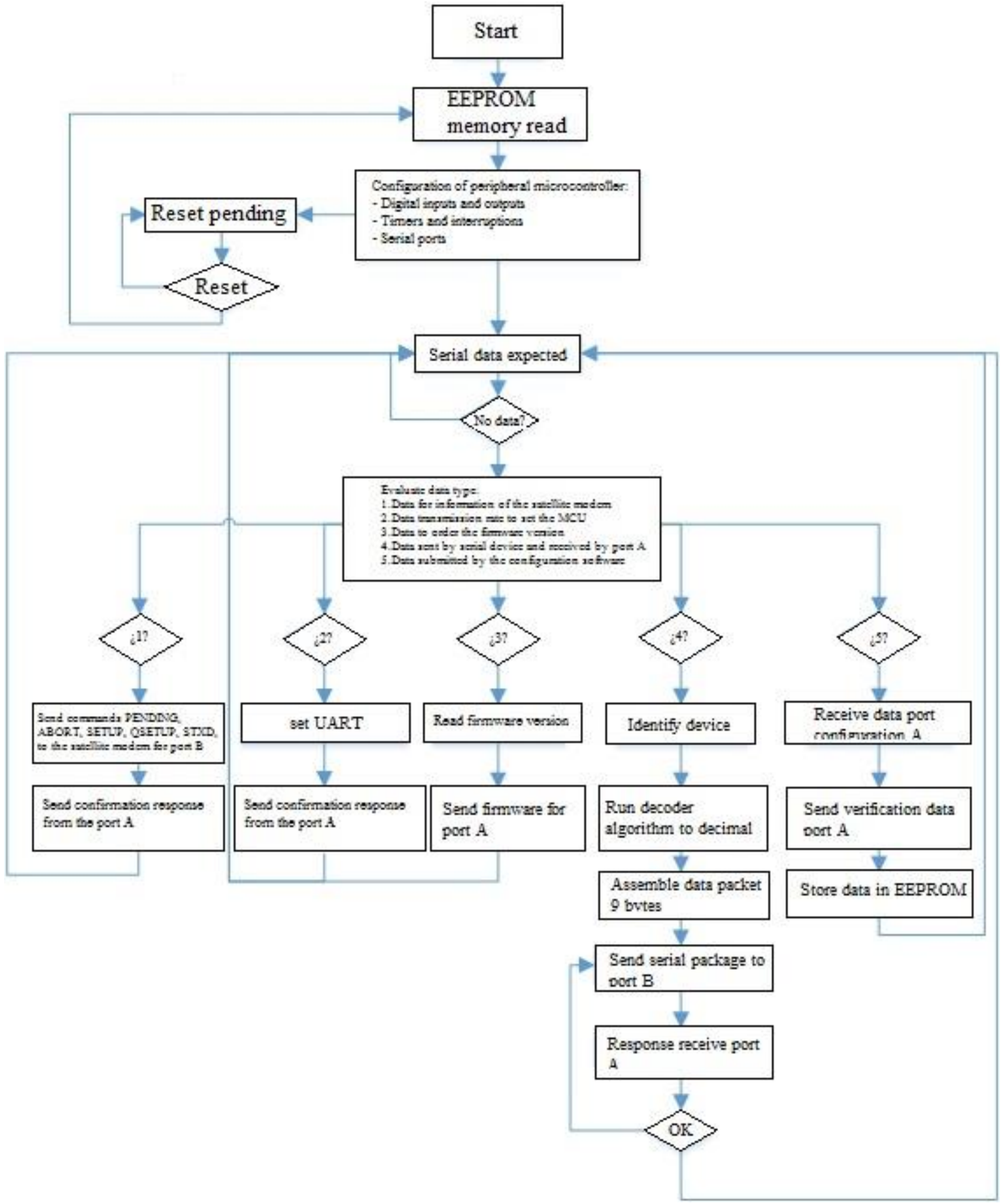

Fig. 22 Microcontroller' logic followed for processing information

Code 7 bits	Latitude 25 bits	Longitude 26 bits	Orientation* 6 bits	Speed** 8 bits	Extended to 135 bytes

Fig. 23 Satellite frame 1. Interface B

Code 7 bits	Latitude 22 bits	Longitude 22 bits	Orientation* 5 bits	Speed** 6 bits	Hour*** 10 bits	Extended to 135 bytes

Fig. 24 Satellite frame 2. Interface B

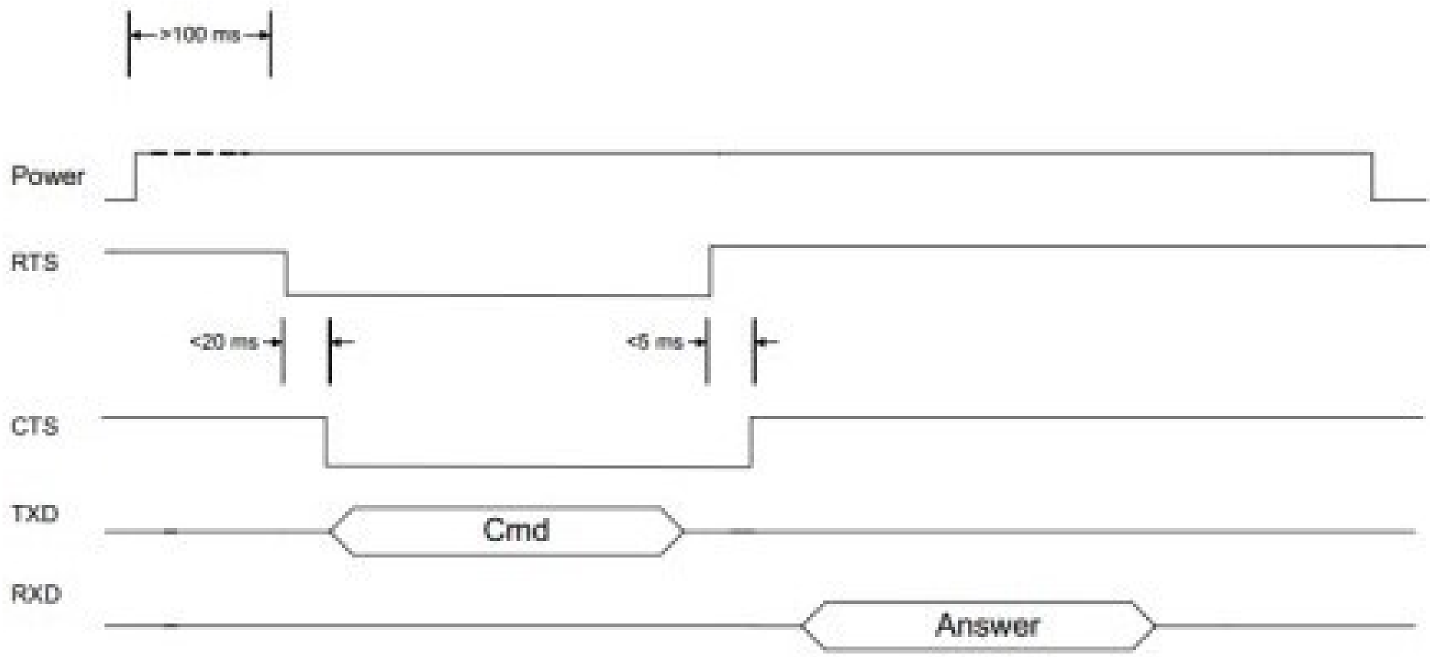

Fig. 25 Communication DTE / STX-2, when the module is ready to receive data.

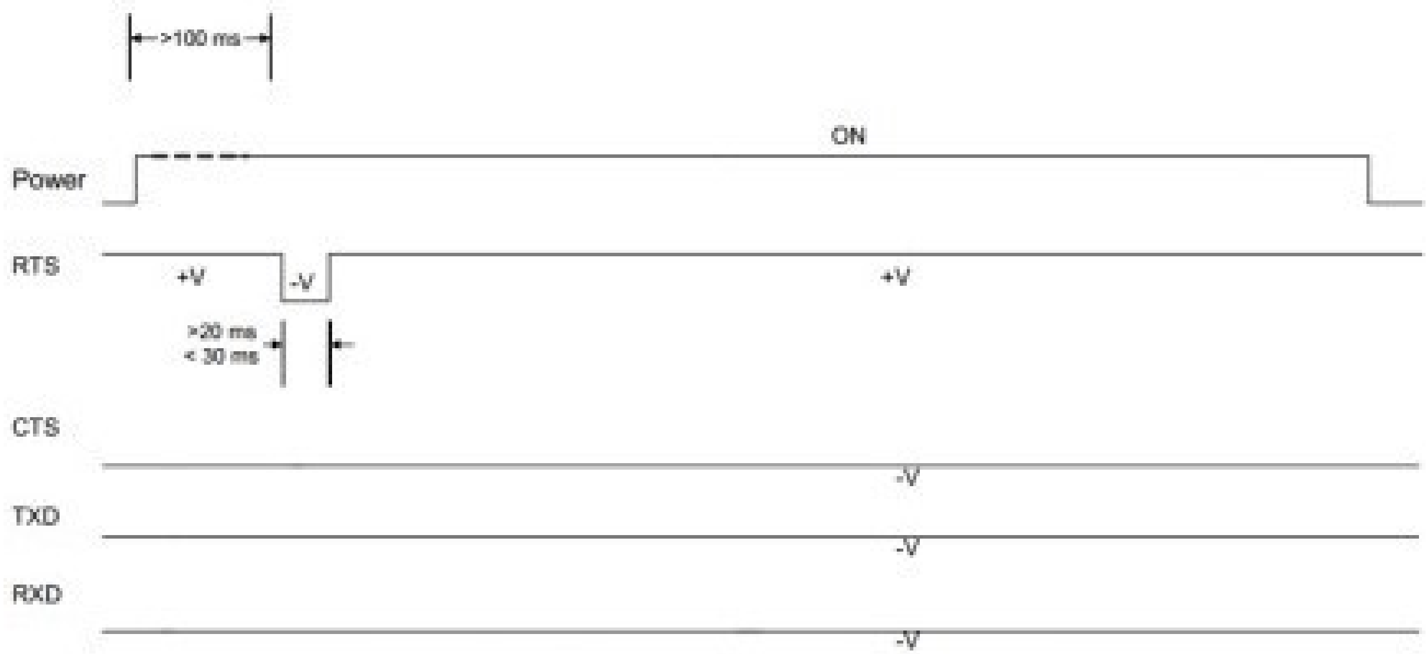

Fig. 26 Communication DTE / STX-2, when the module is not ready to receive data

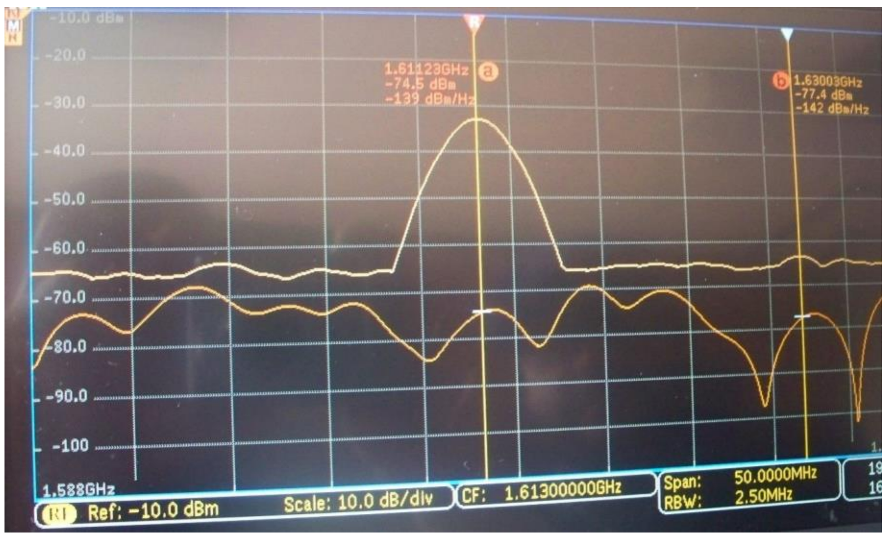

Fig. 27 RF carrier which modulates the message to F = 1.6 GHz

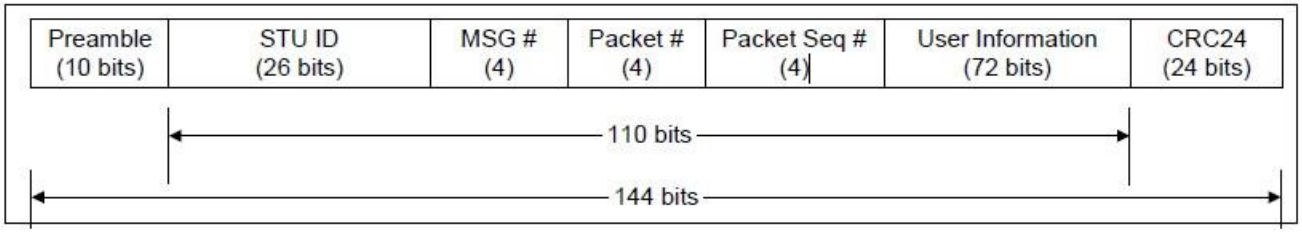

Fig. 28 Data frame of the air interface.

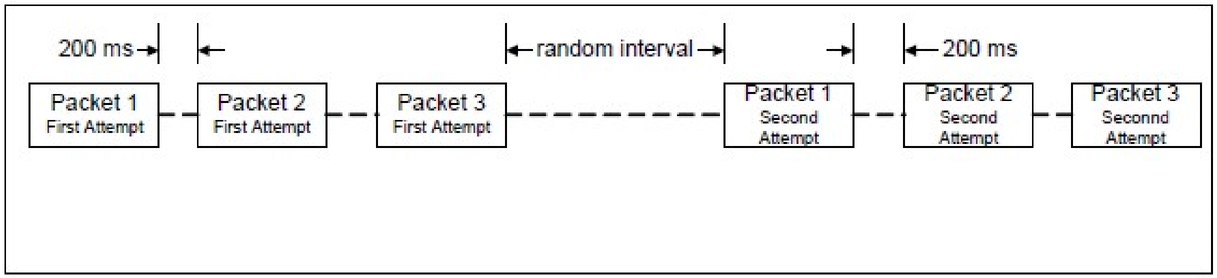

Fig. 29 Sequence followed by three packets that are sent over the air interface.

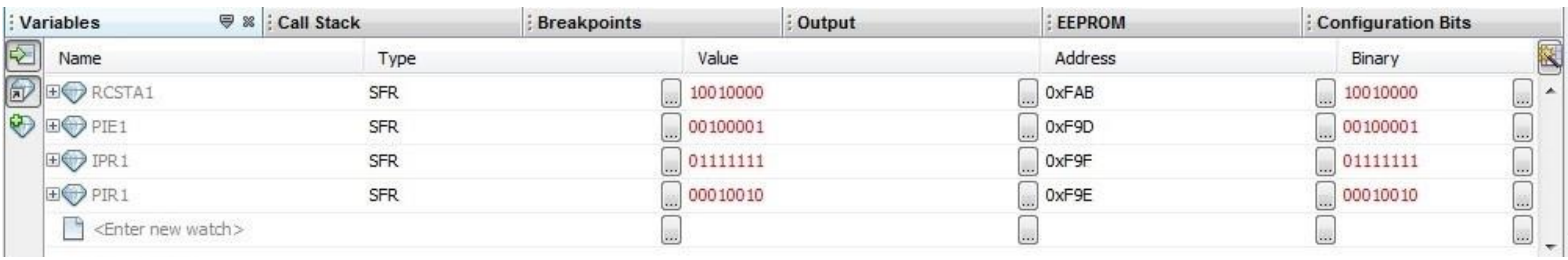

Fig. 30 SFR registers and interrupt reception.

Fig. 31 Connection tab in the configuration software.

Fig. 32 Satisfactory for each configuration modes shipments.

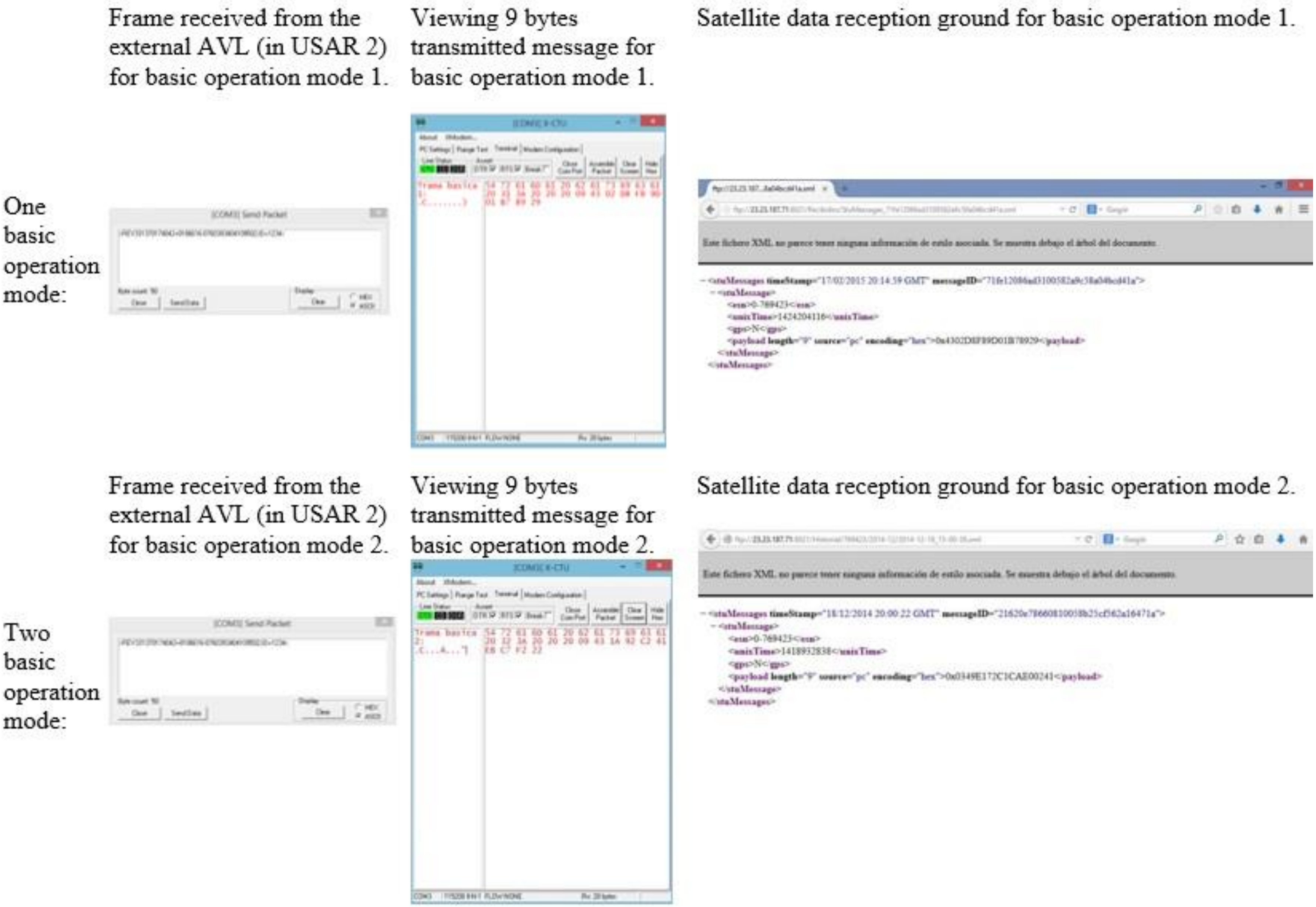

Fig. 17 Frames transmitted and received in USART and land for two basic operation mode