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SONIC-ANEMO-DLG

User manual, specifications and performances

Rev 2.3

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CONTENT

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SONIC-ANEMO-DLG is an ultrasonic wind sensor with the capacity to store wind measurement every 1 second (approximatively depending on the temperature, see part "*2.D Refresh time*" of this document) and a storage of 800 wind measurement sampling that can be sent by request.

1. Serial connection and power supply specifications

Wires connections of SONIC-ANEMO-DLG are described in the table 1 and represented on the figure1:
(For SONIC-ANEMO-DLG "wires version" only, USB version is not concerned)

Wire connections	
Blue	Ground (0V)
Orange	3.2V (+/- 0.1V) DC regulated
Green	Rx from senor side (TTL 3.2V)
Yellow	Tx from senor side (TTL 3.2V)

Table 1: SONIC-ANEMO-DLG wires connections description (For wires version only).

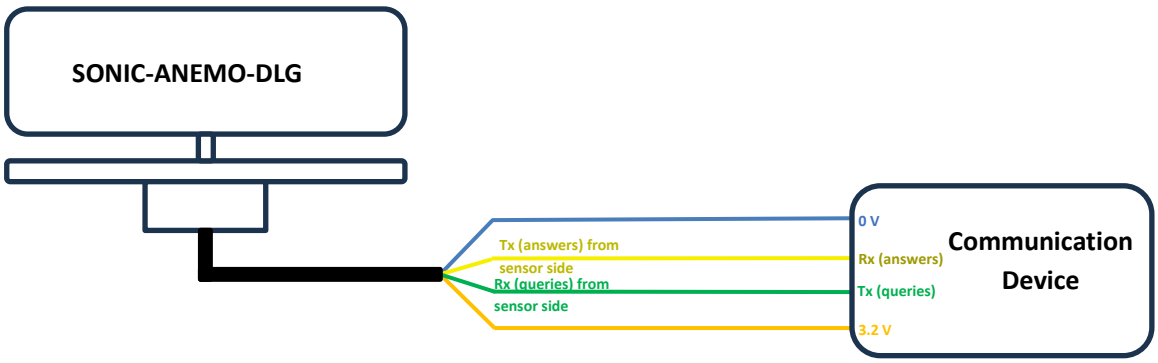

Figure 1: SONIC-ANEMO-DLG wires connections representation (For wires version only).

Serial connection configuration (RS232):

- Speed: Baud rate 38400 bd/s
- Data: 8 bits
- Stop bit: 1
- Parity: none
- NOT inverted: high state bit is 3.2 V, low state bit is 0 V
- Polarized: idle state is at 3.2 V

Wires length is 25cm (from the exit of the wires).

2. Queries

The following presents the queries that can be sent to the SONIC-ANEMO-DLG. Some details are given on specific queries especially the frames decoding of the "send data" answer. A table summarizing the queries is presented in the part "2.*B.7 Queries List*" of this document.

A. Operating Modes

1. DLG mode

By default, the sensor is set in DLG mode, besides the SONIC-ANEMO-DLG sensor send a "DLG_MODE_ACTIVE" frame at power on.

In DLG mode wind data are stored until:

- The "send data" query is sent (which send then erase the stored data)
- The sensor is powered off
- The "Reset" query is sent (that erase the stored data)
- The microcontroller memory is full (800 samples), in this case the first data sample is lost and the new data sample is written (circular buffer).

2. LCJ mode

The sensor can be configured in LCJ mode by sending the corresponding query (*0xFF 0x4C*). In LCJ mode data samples are not stored but directly sent at 1 Hz frame rate in LCJ format ("CV7XXXXXXX" with X data bytes).
LCJ mode is mainly used for sensors calibration at LCJ Capteurs, but it can also be useful to detect some issues on the sensor (access to information about the sensor that are not sent in DLG mode).

If you have any doubt about data validity of the sensor, you can send to a LCJ Capteurs responsible at least 2 minutes of logs of LCJ mode frames which would allow us to detect a potential sensor malfunction.

B. DLG Mode

1. General specifications

The wind speed resolution is 0.1m/s and the valid range is 0 to 40m/s.

The wind angle resolution is 1.0° and the valid range is 0 to 359°.

2. "Send Data" Frames decoding

Frame example: « DLG-aa aa bb cc dd ….. bb cc dd ee ff * gg ».

To facilitate the understanding of this part each byte is written with 2 characters and separated by a space.

- DLG-: preamble in ascii (in hexadecimal: 0x53 0x4C 0x42 0x2D)
- aa aa : samples number processed (2 bytes: Unsigned Integer 16 bits)
- bb : first byte of the first wind data(Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- cc : second byte of the first wind data(Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- dd : third byte of the first wind data (Unsigned Integer 8 bits that must be decoded see part 2.B.4)

  n-1 samples

- bb : first byte of the last wind data (Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- cc : second byte of the last wind data (Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- dd : third byte of the last wind data (Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- ee : last measured voltage (Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- ff : last measured temperature (Unsigned Integer 8 bits that must be decoded see part 2.B.4)
- * : to separate the checksum from the remaining data in ascii (in hexadecimal 0x2A)
- gg : checksum (1 byte hexadecimal see part 2.B.8)

Note about Temperature Calculation:

To calculate the temperature, use the following formula:

$$Temperature = ff - 40\ (°C) \qquad (Formula\ 1)$$

With ff the last measured temperature computed as decimal

The unit of temperature is **degree Celsius**.

The measured temperature is an indicative value of the wind temperature (which is not a temperature under shelter).

Note about Voltage Calculation:

The source of voltage is from the power supply. To calculate the voltage, use the following formula:

$$Voltage = ee \times 0.125 + 1.5\ (V) \qquad (Formula\ 2)$$

With ee the last measurement voltage computed as decimal

The unit of voltage is **Volt.**

The measured voltage is an indicative value of the supply voltage.

Example:

in a given frame, $ee = 0x0E\ (= 14\ in\ decimal)$ for the voltage and $ff = 0x38 (= 56\ in\ decimal)$ for the temperature.

Thus, we have:

$$Voltage = 14 * 0.125 + 1.5 = 3.25\ \boldsymbol{V}$$

and

$$Temperature = 56 - 40 = 16°\boldsymbol{C}$$

3. Unit of measurements

	Wind Angle	Wind Speed	Temperature	Voltage
Unit	degree	10^{-1} meter. second^{-1}	degree Celsius	Volt

Table 2: Units of the data sent by SONIC-ANEMO-DLG sensor

4. Wind Data decoding

As described in the part 2.B.2, wind data received (as answer of the "send data" query) are coded on 3 bytes. The following describes how to decode those 3 bytes.

Wind angle is coded on 9 bits.
Wind speed is coded on 12 bits.
A third byte adds excess bits for wind speed and angle, and alarm bits.
The data is sent chronologically. The first data is the oldest and the last data is the most recent.

Below is the description of fields of the three bytes:

- **bb**: is a byte with 4 different information

MSB$^{(1)}$	→						**LSB**$^{(2)}$
7	6	5	4	3	2	1	0
Measurement Alarm	Over Range Alarm	1 bit (MSB) wind angle	0	4 bits (MSB) wind speed			

Table 3: Answer of "send data" query first byte description.

There are 2 different alarm bits, 1 wind angle bit and 4 wind speed bits.
Concerning alarms:

- The "over range alarm" appears when the wind speed is over 40m/s.

- The "measurement alarm" appears when the signal of a transducer is too low (this may be caused by a drop of water on the reflector).

- **cc**: is the wind angle byte

MSB →							**LSB**
7	6	5	4	3	2	1	0
8 bits from wing angle (LSB)							

Table 4 Answer of "send data" query second byte description.

There are 8 bits for wind angle in "cc" byte + 1 bit in "bb" byte

- **dd**: is the wind speed byte

MSB →							**LSB**
7	6	5	4	3	2	1	0
8 bits from wing speed (LSB)							

Table 5: Answer of "send data" query third byte description.

There are 8 bits for wind speed in "dd" byte + 4 bits in "bb" byte

Note:

$MSB^{(1)} = Most\ Significant\ Bit$

$LSB^{(2)} = Least\ Significant\ Bit$

5. Software version

To know the software version (ASCII sentence), use the "software version request" (0xFF 0x56).

6. Wrong request

The sensor may not recognize a query. If so, the message "WRONG_REQUEST" is sent by the sensor.

7. Queries list

Below is a summary of the commands to interact with the SONIC-ANEMO-DLG sensor. There is CR-LF (equivalent to "\t" and "\n" or 0x0D and 0x0A in hexadecimal) at the end of each frame received.

Hex Request	Action	Answers format	Utility
0xFF 0x4D	DLG mode	"DLG_MODE_ACTIVE"	DLG mode operating
0xFF 0x53	Send data	"DLG -……."	Allows to send data
0xFF 0x56	Software version	"VX.Y"	Allows to know the software version with "X" the major version number and "Y" the minor one
0xFF 0x4C	LCJ mode	"CV7……."	LCJ mode operating (for tests). Note that power off or reset the sensor will exit the LCJ mode
0xFF 0x51	Stored samples	"xxxxSAMPLES"	The number in hexadecimal of stored samples with "xx xx"
0xFF 0x42	Bootload mode active	"BOOTLOAD"	The sensor starts on its Bootloader application, that allows the user to update the firmware. **Do not send this query if you do not have the LCJ Bootloader Host Application or you risk to make the sensor unusable.**
0xFF 0x52	Reset	"RESET"	The CPU resets. All data stored will be lost
Others	Nothing	"WRONG_REQUEST"	The sensor doesn't recognize the request

Table 6 : Summary of queries that can be sent to the SONIC-ANEMO-DLG and their corresponding answers

8. Checksum

a) General

The checksum is calculated by the "exclusive or" method (XOR) from the first byte of sample number to the tension byte. Dash and asterisk excluded.

b) Example

Frame example: « DLG -aa aa bb cc dd ….. bb cc dd ee ff * gg »
The checksum value will be a XOR of "aa aa bb cc dd ….. bb cc dd ee ff"

We have seen above the construction of the frame, below is an example of real frame in hexadecimal.

For instance:

44 4C 47 2D 00 07 00 B3 02 00 B3 02 00 87 01 00 B3 02 00 87 01 00 B3 02 00 B3 03 0B 3A 2A 86 0D 0A

With:

53 4C 42 2D = preamble (“DLG-“ in ASCII)

00 07 = sample number

00 B3 02 00 B3 02 00 87 01 00 B3 02 00 87 01 00 B3 02 00 B3 03 = wind data

Wind data	Alarm 1	Alarm 2	Angle	Speed
00 B3 02	0	0	179°	0.2 m/s
00 B3 02	0	0	179°	0.2 m/s
00 87 01	0	0	135°	0.1 m/s
00 B3 02	0	0	179°	0.2 m/s
00 87 01	0	0	135°	0.1 m/s
00 B3 02	0	0	179°	0.2 m/s
00 B3 03	0	0	179°	0.3 m/s

Table 7 : frame data decoding example

0B = voltage

Hexadecimal	**Decimal**	**Calcul**	**Voltage**
0x0B	11	(11 x 0.125V) +1.5V	2.875V

Table 8 : Conversion of voltage data example

3A = temperature

Hexadecimal	**Decimal**	**Calcul**	**Temperature**
0x3A	58	58-40	+18°C

Table 9 : Conversion of temperature data example

2A = separator (“*” in ASCII)

27 = checksum

0D 0A = end of frame character (CR – LF)

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C. Queries and corresponding answers on scope

1. Acquisition information

The scope used to make the following figures is a “Picoscope 2000 Series” from pico Technology.
The DC power supply used to supply the sensor under test is a “Voltcraft PS-1302 D” set to 3.3 V.
Note that in the following figures the response time of the sensor is around 3 ms (typical value), but this value can be significantly increased in the case that the microcontroller is processing wind data at the same time.

2. Version query

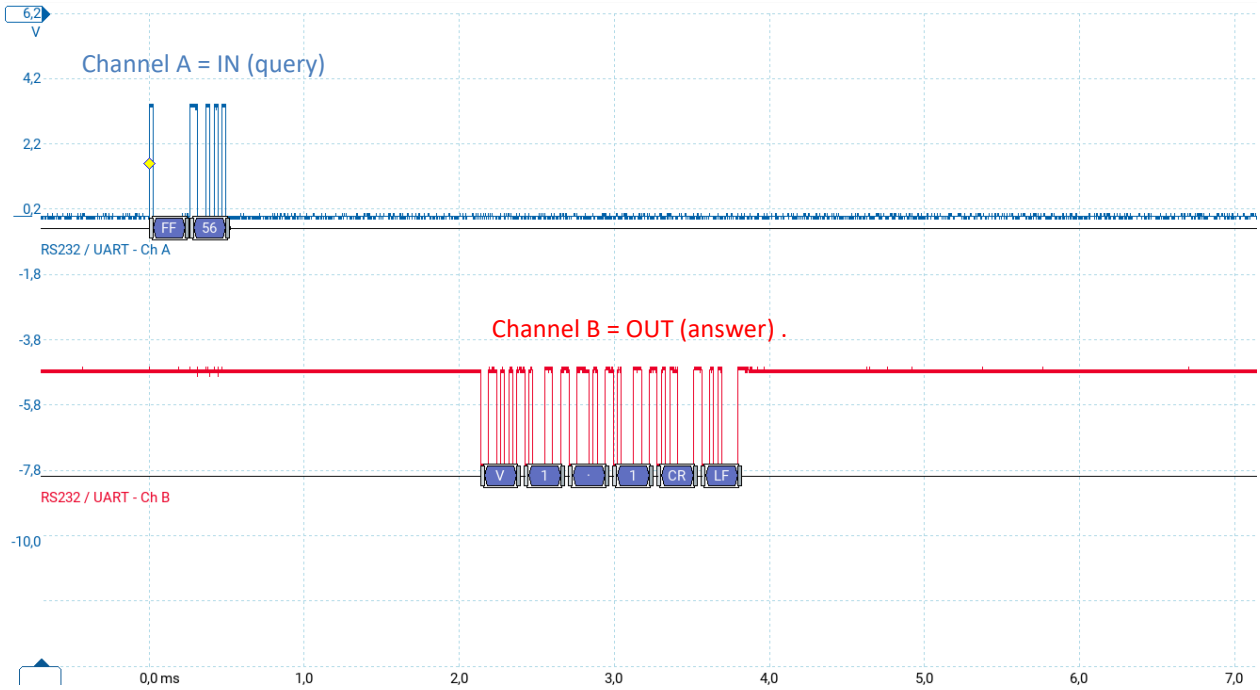

Figure 2 : « Version » query (0xFF 0x56) and its answer.

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3. DLG Mode query

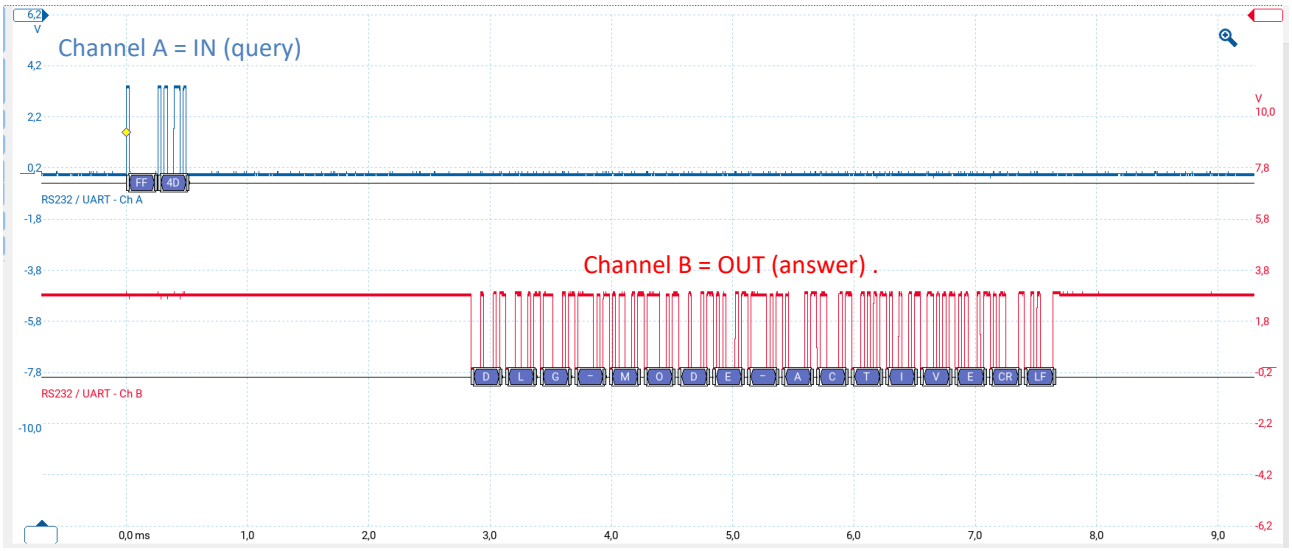

Figure 3« DLG MODE » query (0xFF 0x4D) and its answer.

4. Stored sample number query

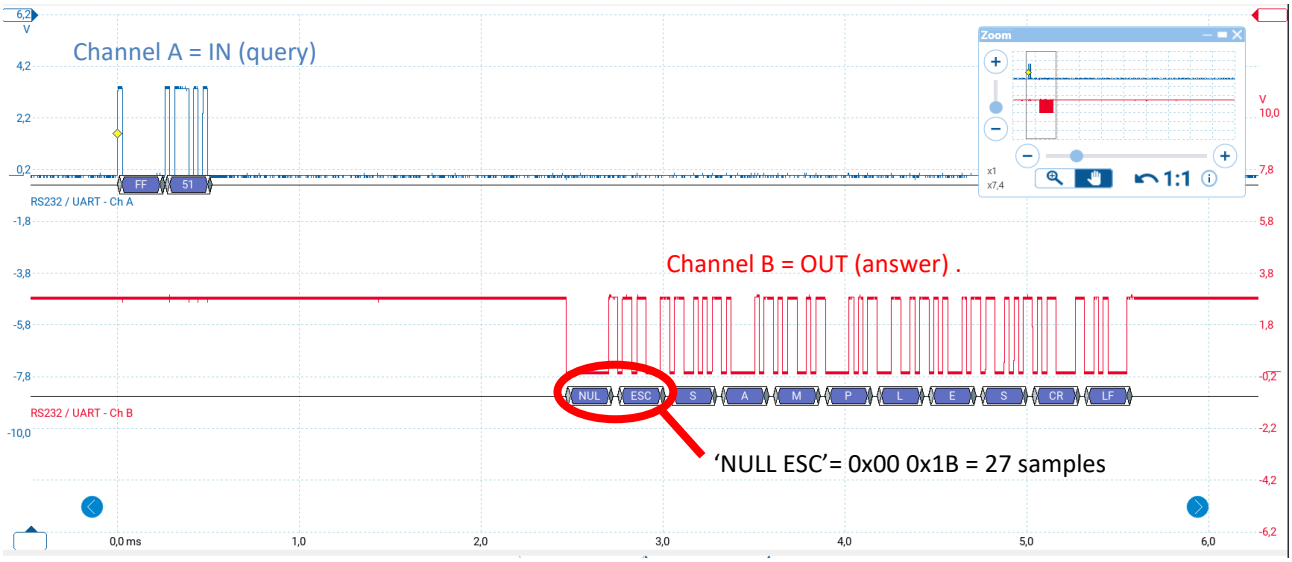

Figure 4 : « Stored samples number» query (0xFF 0x51) and its answer.

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5. LCJ Mode query

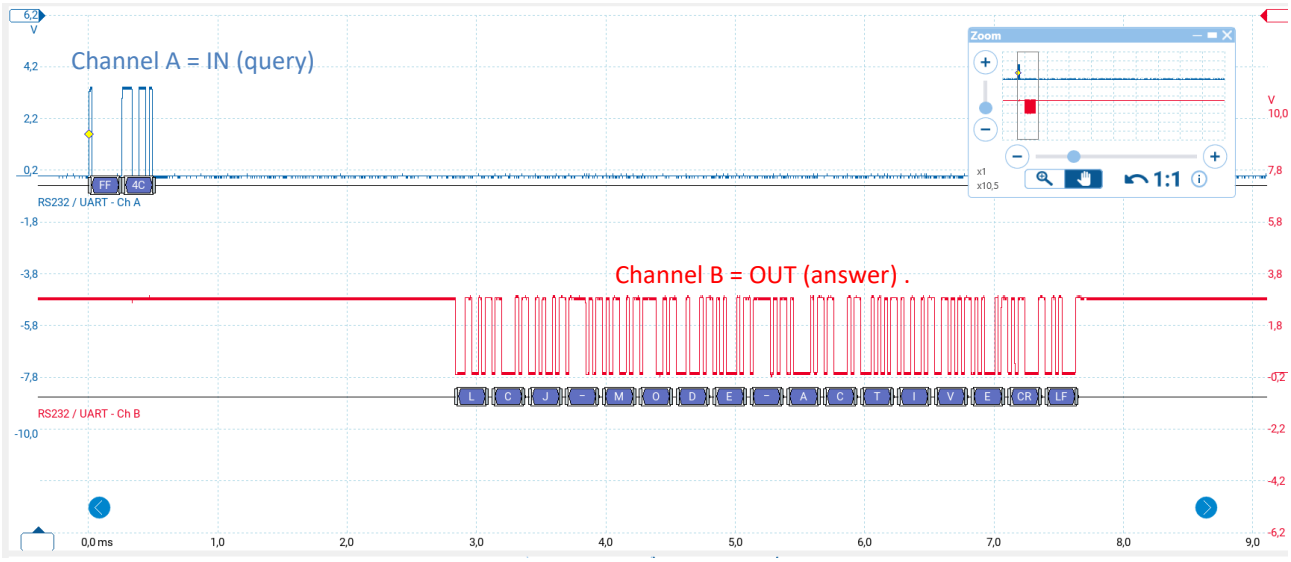

Figure 5 : « LCJ MODE» query (0xFF 0x4C) and its answer.

6. Frame received while LCJ Mode is running

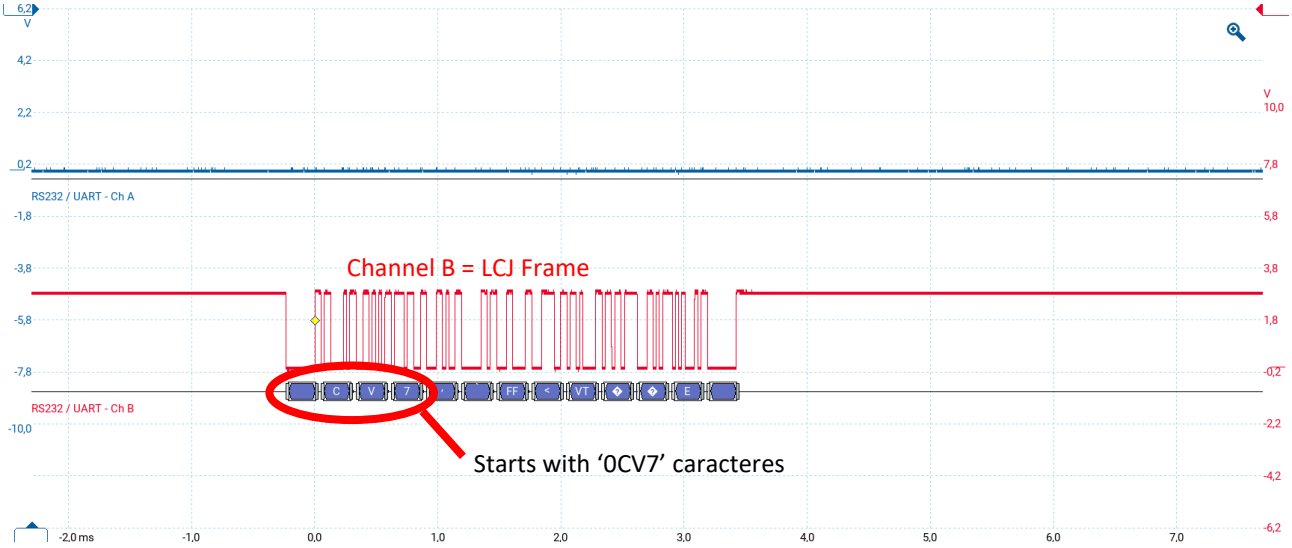

Figure 6 : Frame received in LCJ mode

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7. RESET query

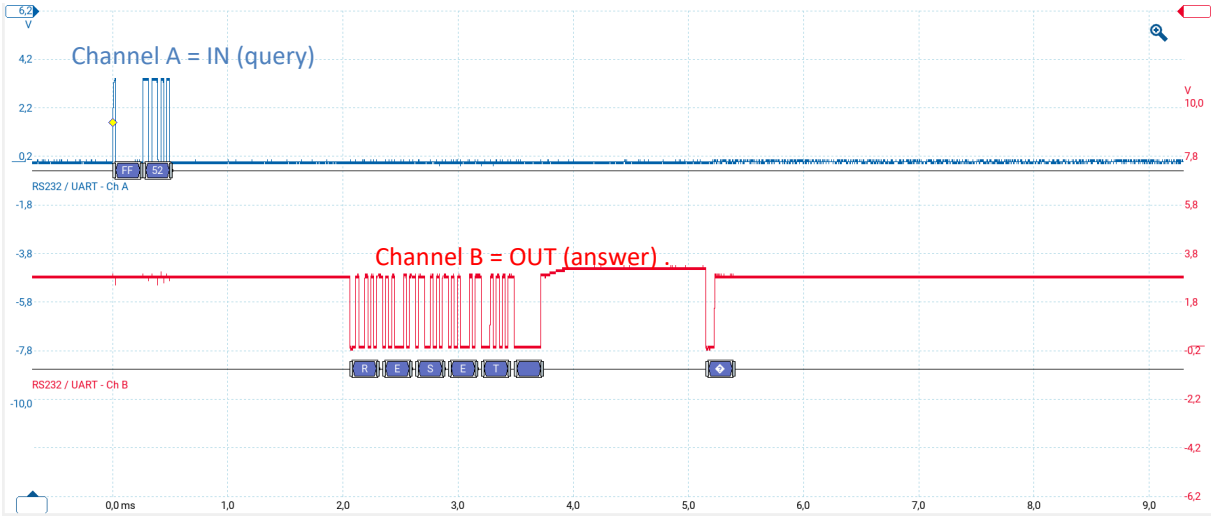

Figure 7: « RESET» query (0xFF 0x52) and its answer.

8. Send data query

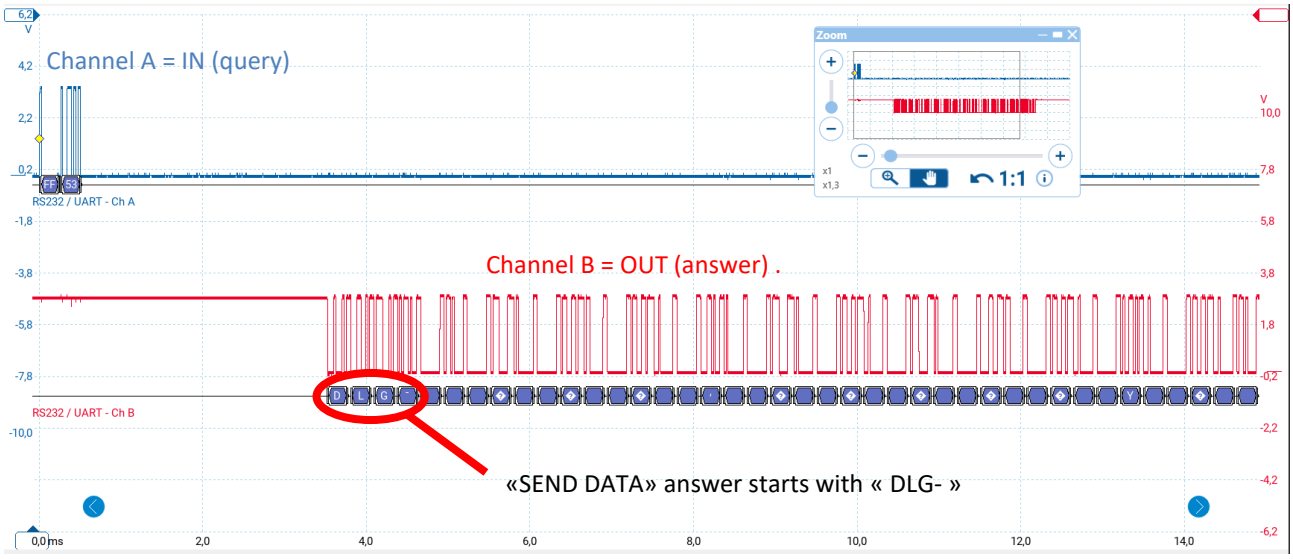

Figure 8 : « SEND DATA» query (0xFF 0x53) and its answer.

9. Wrong Request answer

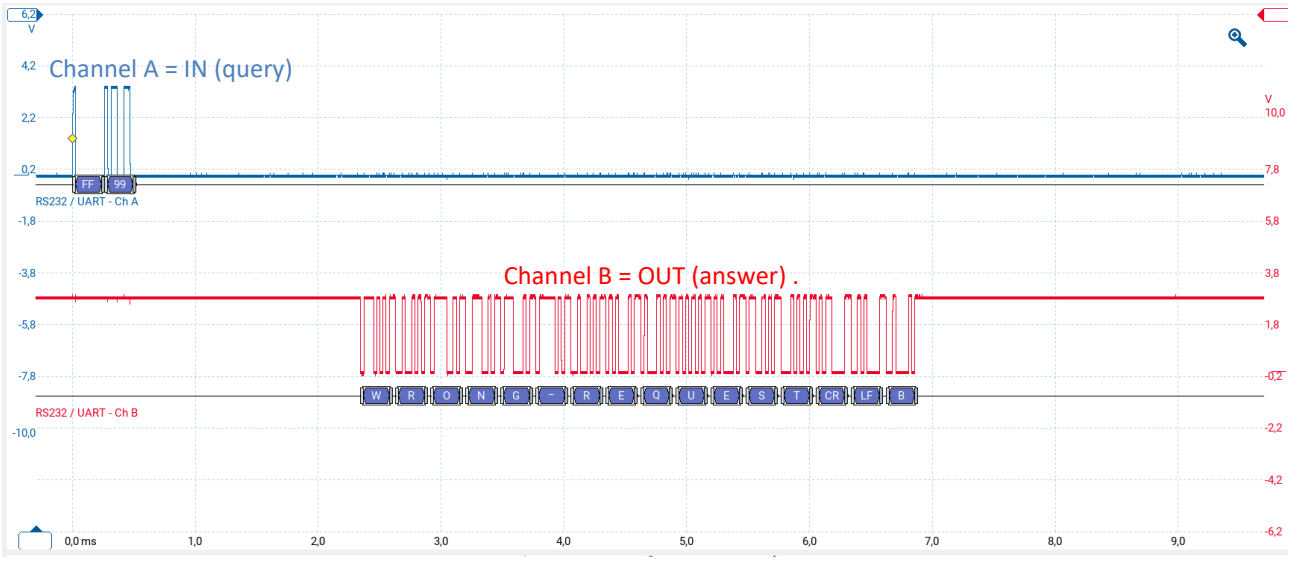

Figure 9 : «WRONG_REQUEST » answer received when an unknown query is sent.

10. Bootload query

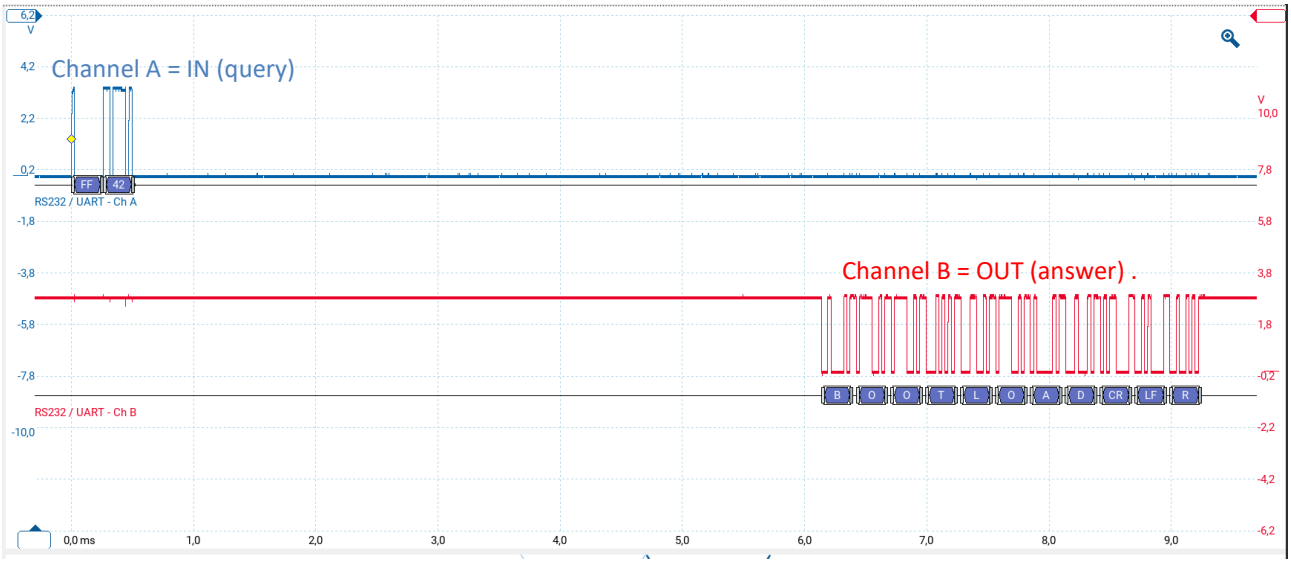

Figure 10 :« BOOTLOAD» query (0xFF 0x42) and its answer.

D. Refresh time

Typical values shown below were found on a R&D model.
According to the temperature, wind sampling takes more or less time. The sampling period is set to 1 second.

Temperature	Sampling time
-15 °C	~820 ms
+ 20 °C	~1040 ms
+ 50°C	~1150 ms

Table 10 : SONIC-ANEMO-DLG Sampling time at various ambient temperature

E. Energy consumption

1. Acquisition information

The device used to measure the consumption of the sensor is a "X-NUCLEO-LPM01A" board, USB connected to a computer with the software "STM32CubeMonitor-Power". This device allows a good accuracy of the measurement (µA) and a proper real time display of the data.

2. Consumption specification

LCJ chose the constraint that SONIC-ANEMO-DLG sensor must consume less than 420 µA (average) for 1s sampling.

3. Consumption results

Following figures presents the power consumption measurement over a 10 second window. However, measurement duration is 15 minutes, which allows to have an average of the consumption over this duration.
Consumption measurement have been made for five different configurations:

- Without "send data" query (figure 11).
- With "send data" query every 10 second (figure 12).
- With "send data" query every 20 second (figure 13).
- With "send data" query every 30 second (figure 14).
- With "send data" query sent after waiting 10 minutes (figure 15).

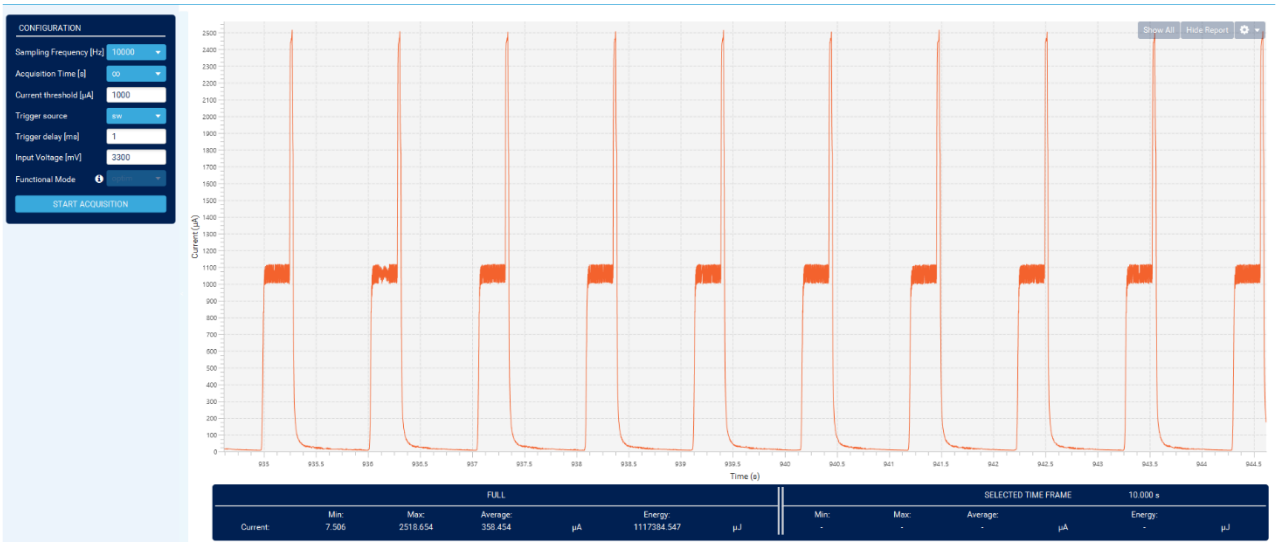

Figure 11 : Real time consumption without sending any query. Average consumption is 358 µA

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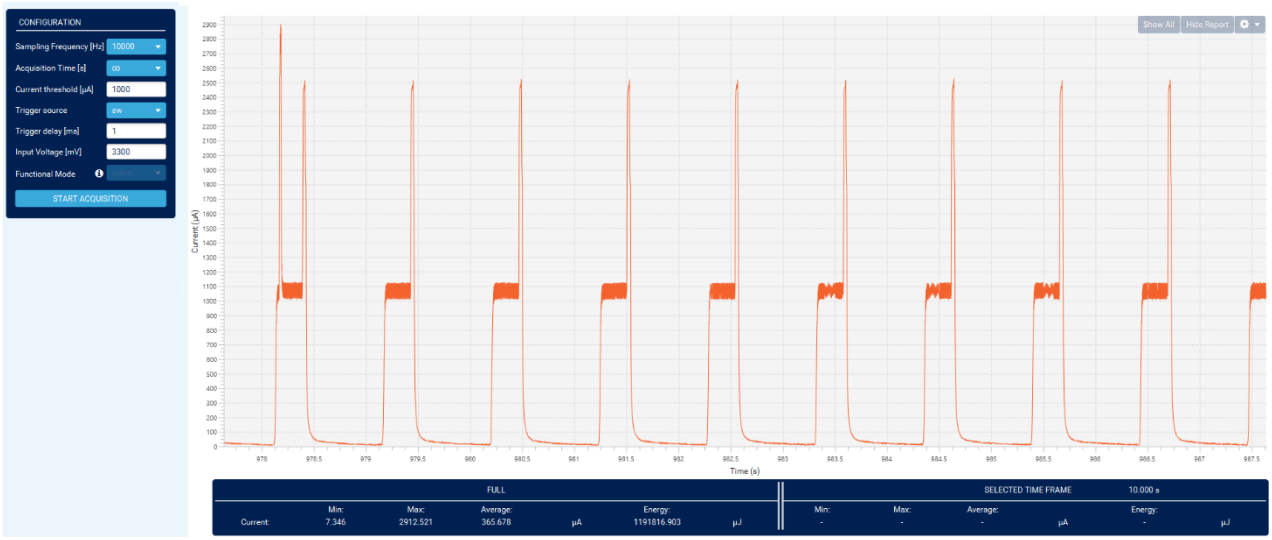

Figure 12 : Real time consumption sending "send data" query every 10 second. Average consumption is 365 µA

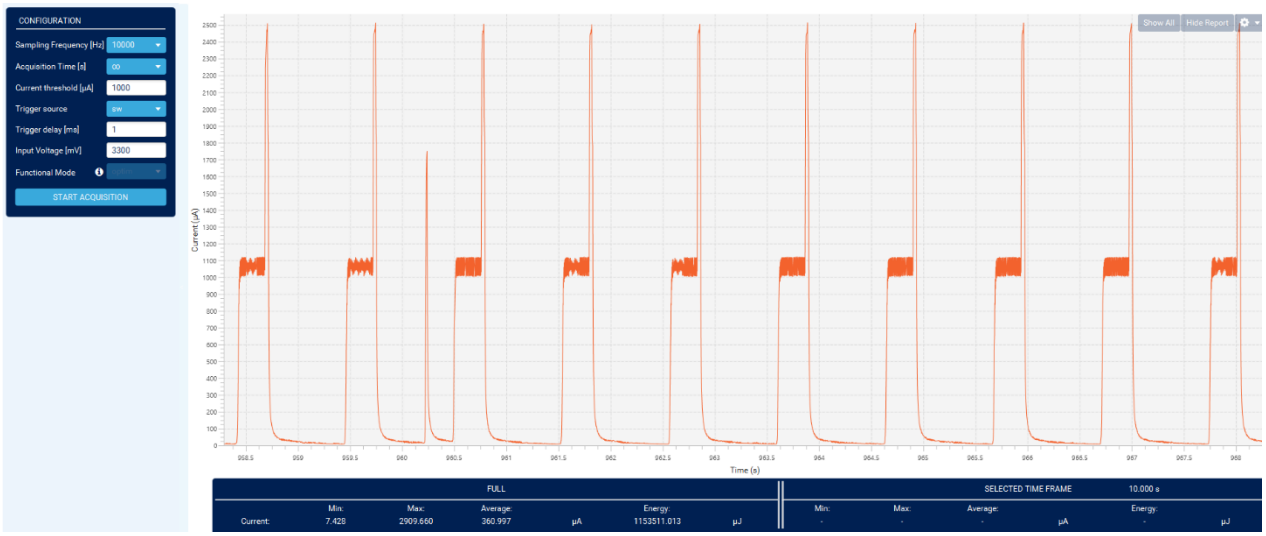

Figure 13 : Real time consumption sending "send data" query every 20 second. Average consumption is 360 µA

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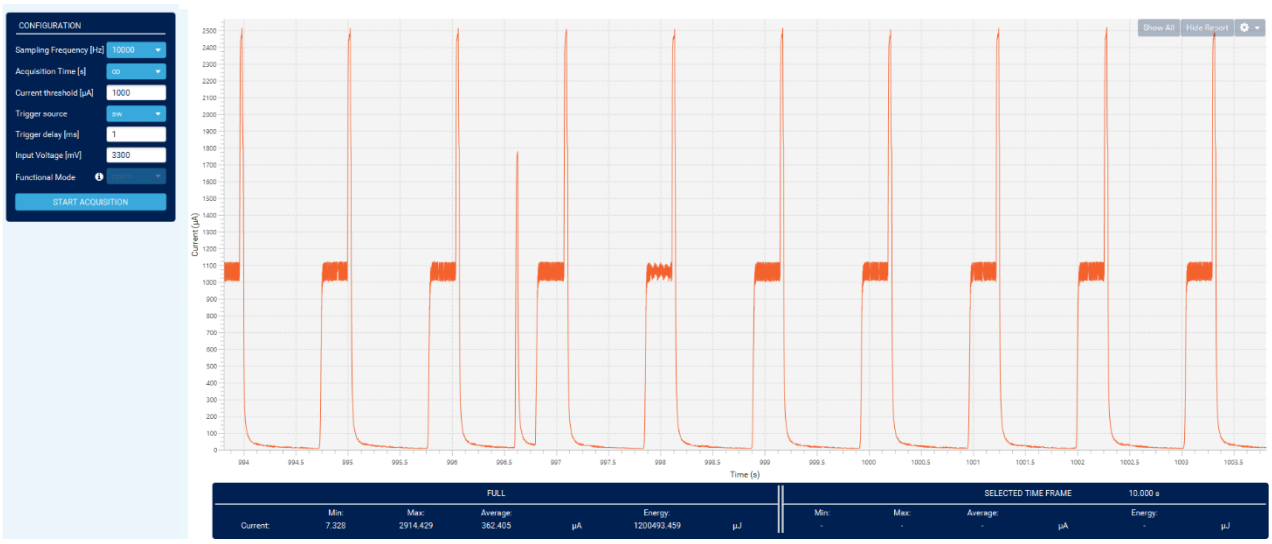

Figure 14 : Real time consumption sending “send data” query every 30 second. Average consumption is 362 µA

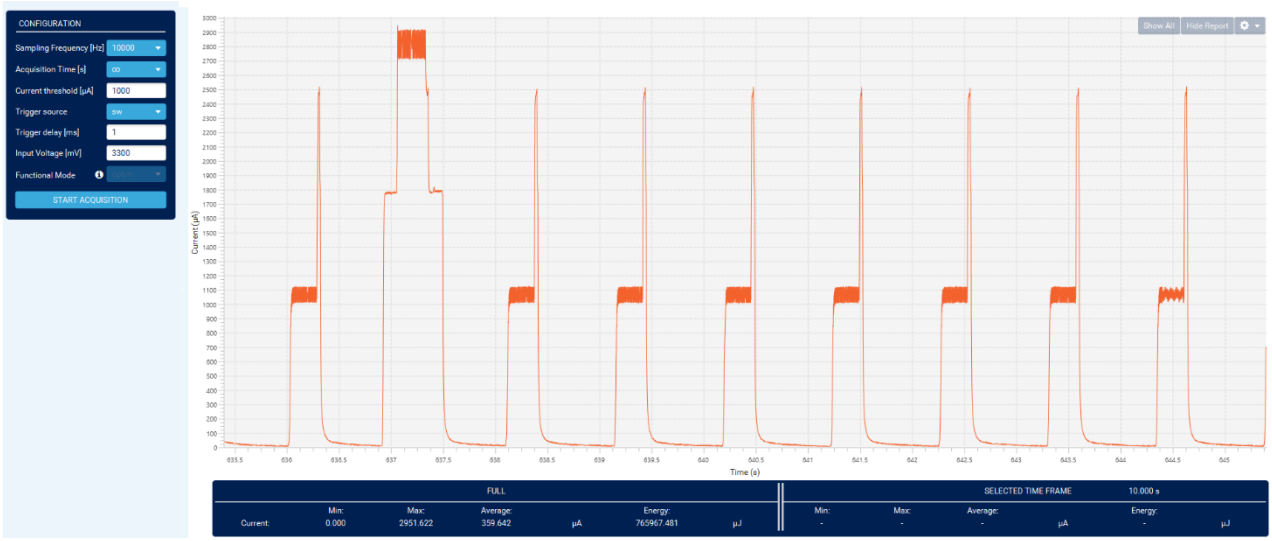

Figure 15 : Real time consumption sending “send data” after 10 minutes. Average consumption is 359 µA

F. Measurement noise

We put a prototype in our wind tunnel without wind to observe the electrical noise with a 1s sampling period. This test lasted around 15 minutes.
We can see below that the electrical noise affects the measurements. The average wind speed measurement is 0.24 m/s and the standard deviation is 0.08 m/s

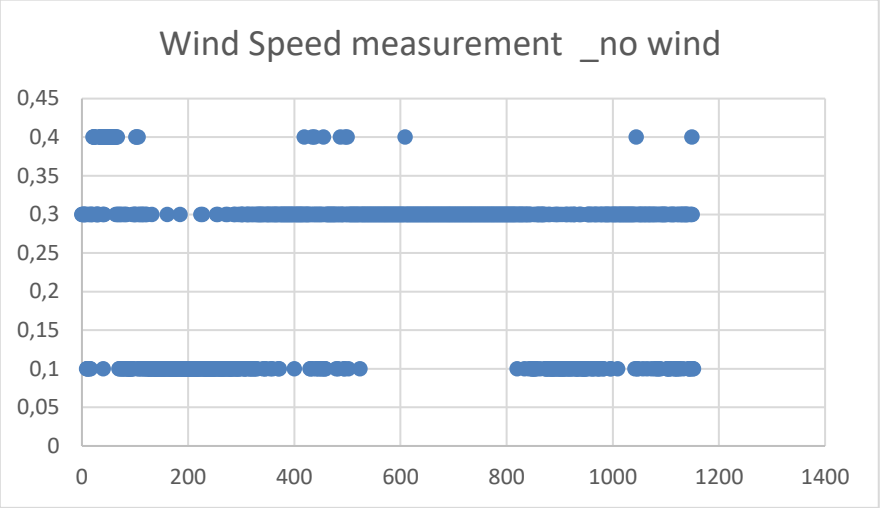

Figure 16 : Wind speed measurement without wind.

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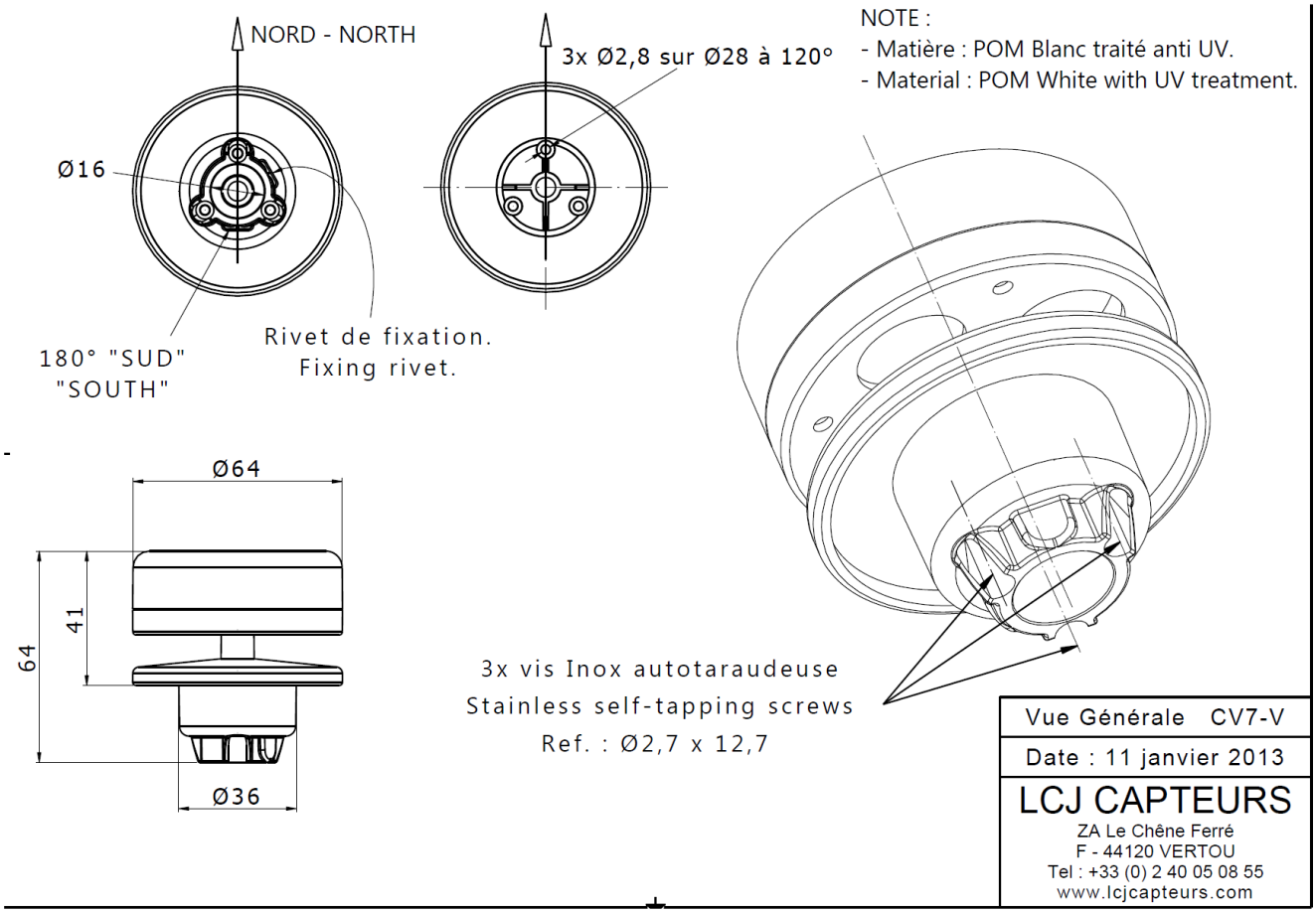
G. Dimensions



Shaded area:
keep clear of any obstacles