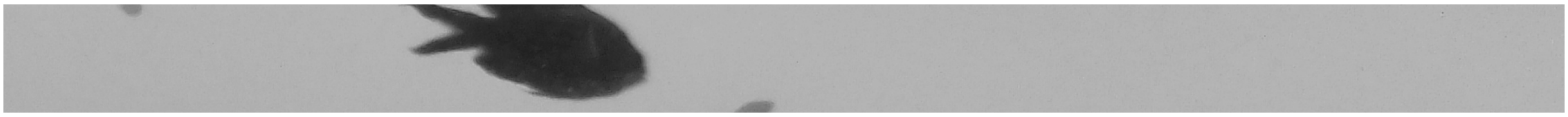

ID3- DEVELOPMENT AND CALIBRATION OF A COST-EFFECTIVE TEMPERATURE SENSOR

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***Abstract** – Oceanographic sensors are accurate and reliable but very expensive. We have developed and calibrated a cheap temperature sensor with a good cost/accuracy ratio.*

***Keywords** –Marine technology, Low cost temperature sensor, Calibration, Oceanographic sensors.*

1. INTRODUCTION

Ocean temperature has been recorded for years with reversing thermometers, thermistors or some kind of instrument including a thermometer like a CTDs or thermosalinometers. Oceanographic instrumentation is commonly designed in different housings to allow deployment from 250 m to 10000 m. Some of them achieve an accuracy of ± 0.001 oC and a resolution of 0.0001 oC. After more than 6 years working on the metocean network of the RAIA Observatory (www.marnaraia.org), , we have realized that in some applications there is no need to get such a high accuracy or resolution. Besides, it is most important to be able to obtain data at different depths without risk thousands of euros- . Oceanographic thermometers that can be connected to a datalogger and send collected registers by any digital technology usually cost hundreds or thousands euros depending on quality of housing materials, accuracy, resolution, etc. Maintenance, spare parts and cables are usually expensive too. In this context, RAIA-TEC project has aimed to increase oceanographic instruments' reliability and availability. As part of this project, we have tested two digital thermometers, commonly used in industry, in an effort to reduce costs in oceanographic data collection. The DS18B20 sensor has a 1-wire interface and the TMP275 sensor uses I2C to send data. The obtained results are being used in the framework of SMARNET project, which tries to use cheap metocean sensors in fishing boats as a way to reinforce data collection from opportunity ships We decided to connect those devices to an Arduino because the datalogger in our stations is not compatible with them.

II. ELECTRONIC DESIGN.

The initial requirements were that the prototype must be as cheap as possible, must have Rs232 interface, low power consumption and be watertight. Size was not important but the smaller the better. Should be able to submerge at 20 m depth. An Arduino Nano was chosen because there are libraries that work with both DS18B20 and TMP275, its small size, price and our previous experienced in that platform. The Arduino Nano works as an interface adaptor, receiving data in I2C and 1-wire protocols and sending data in Rs232 9600 baud format. Our first electronic design was a compact shield to be connected to the Arduino NANO. See next figure.

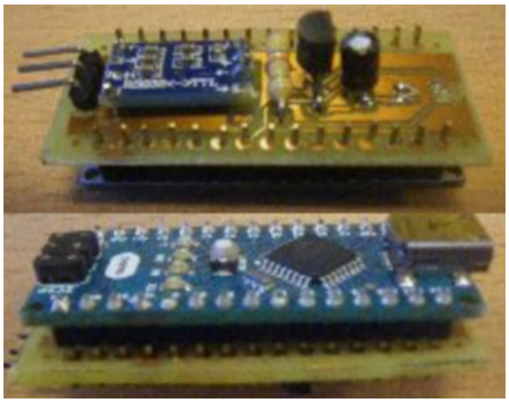

Fig 1 Arduino and sensors.

In previous images we can see the Arduino and the custom shield board including a DS18B20 and a TMP275 plus a small board that converts serial interface from TTL levels to Rs232 levels. That board is needed in order to allow our datalogger work with the prototype but could be discarded in other projects.

III. WATERTIGHT HOUSING.

We tried two different materials to protect the devices from water and pressure. We look for insulation kits and selected a 3M ScotchCast kit that provides an epoxy-like black mixture. After the mixture is done, it reaches a solid state in just 10 minutes. We used another product called Magic- Joint from Ray-Tech. This kit provides two liquids to be mixtured and after some minutes stays as a transparent gel that allows us to reopen the device

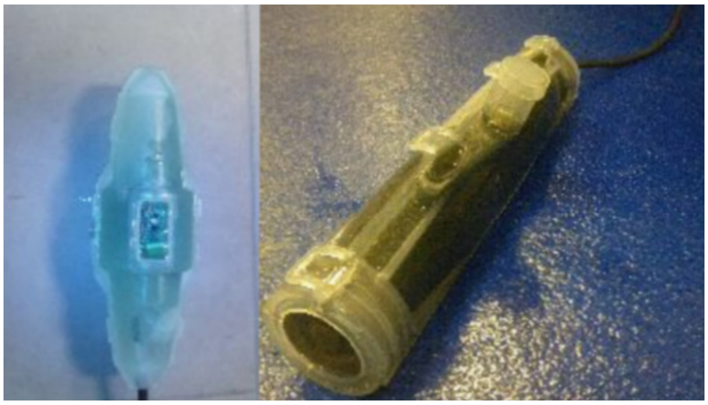

Fig 2 Magic-Joint kit and 3M ScotchCast kit assemblies.

The advantage of the transparent gel is that allows visual inspection and any failure of can be easily checked by eliminating the insulation. The 3M product can not be reopened but provides a capacity to deploy the device deeper than the Ray-Tech's. For tests, we made two prototypes, one insulated with epoxy and one with gel, each of them with a TMP275 and a DS18B20 inside.

III. CALIBRATION AND REBUILD.

In our calibration facilities we tested the two assembled prototypes and compared results against a Seabird SBE37- SIP CTD.

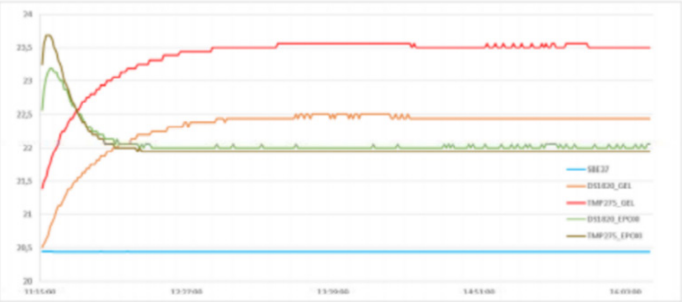

Fig 3 Data from test.

In previous capture, blue line represents data from SBE37 at 20.5oC, orange and red are DS18B20 and TMP275 insulated in gel and green and brown are DS18B20 and TMP275 insulated in epoxy. After some tests we realized two facts. Insulation materials produced different behaviours because of its different thermal conduction coefficients, and the second fact is that there was self-heating in the boards. Those two variables make the prototypes to have an offset and some delay to achieve the temperature set point. In view of these results, we verified that TMP275 and the DS18B20 digital thermometers behaviour and characteristics were very similar. We decided to rebuild the design. TMP275 sensor was discarded due to its similarity to DS18B20, chip format, price, interface, etc. DS18B20 sensor was set apart from Arduino and shield board so self-heating does not affect the thermometer. In this new assembly the electronic components are not insulated and a 20 m cable connects the DS18B20 to the Arduino.

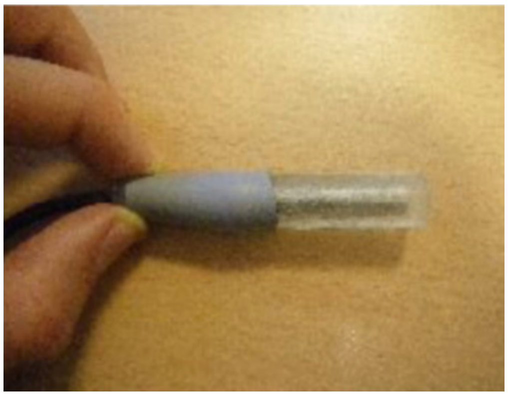

Fig 4 View of final design.

In this design we have used a DS18B20 waterproof model. This version is made of stainless steel but we decide to cover the device with a thin epoxy insulation. As we previously described, electronic boards are going to be connected to a datalogger which is inside a watertight case so there is no need, in this design, to insulate them. Anyway some kind of protection is advised depending on user application.

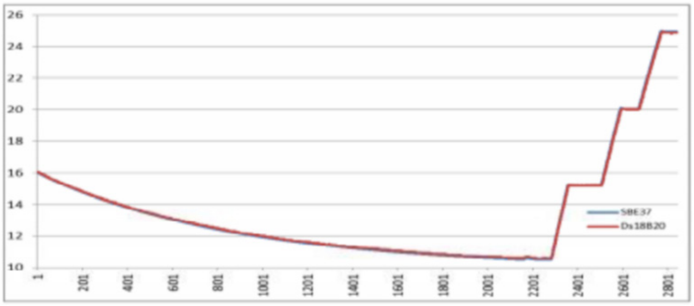

Fig 5 Final design test. Ds18B20 and SBE37 compared.

Manufacturer claims that sensor accuracy is ± 0.5 oC along the – 10 oC to + 85 oC range. We selected this thermometer because after reading the specifications we expected to get an error of ± 0.2 oC or less in 10 oC to 30 oC range. In these new tests the sensor works better than we have expected and the accuracy is less than ± 0.1 oC

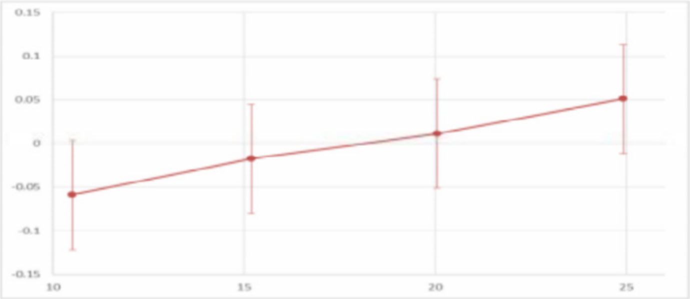

Fig 6 Residue vs temperature.

In previous graphic, residue (SBE37 measure – DS18B20 measure) is displayed in some set points. The sensor resolution of 0.0625 oC is displayed in each set point.

IV. CONCLUSIONS AND FURTHER WORK.

The designed device is a fully cost-effective way to monitoring temperature at different levels without putting in risk thousands of euros. Our tests have proved that DS18B20 sensor and our electronic interface provide a digital thermometer with a good ratio accuracy versus price, obtaining an accuracy of ± 0.1 oC or less. Future works will focus on evaluation of measure drift and uncertainty..

V. ACKNOWLEDGEMENTS

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