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PORFIDO on the NEMO phase 2 and KM3 phase 1 towers

O. Ciaffoni, M. Cordelli, R. Habel, A. Martini, L. Trasatti

INFN, Laboratori Nazionali di Frascati, P.O. Box 13, I-00044 Frascati

Abstract

PORFIDO (Physical Oceanography by RFID Outreach) is an underwater measurement system designed to gather oceanographic data from the Optical Modules of a neutrino telescope with a minimum of disturbance to the main installation. PORFIDO is composed of a sensor glued to the outside of an Optical Module, in contact with seawater, and of a Reader placed inside the sphere, facing the sensor. Data are transmitted to the reader through the glass by RFID and to shore in real time for periods of years. The sensor gathers power from the radio frequency, thus eliminating the need for batteries or connectors through the glass.
We have deployed four PORFIDO probes measuring temperatures with the NEMO Phase 2 tower in march 2013. After more than one year all probes are operative and are transmitting temperature data from 3500 m depth. In the fall of 2014 we will deploy with the first KM3 Phase 1 towers an improved version of PORFIDO with a resolution of 0.5E-3 °C.

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1 - INTRODUCTION

Underwater Neutrino telescopes offer the oceanographic community a unique opportunity to obtain seawater sensor data in real time, continuously and for long periods of time. Every installation carries some oceanographic instrument. Their number is limited by cost and by the necessity of penetrators or connectors. We have designed a system, PORFIDO[1),2)], that uses the well established technique of RFID to gather data through the glass spheres of the Optical Modules and to supply power to the sensors with the RF itself, without interfering with the PMT assembly.

PORFIDO is made up of two elements: the sensor (Tag), which is glued to the outside of the Optical Module (OM), and gathers data from the sea water. The Reader, which sits on the inside of the OM, reads the measured data through the glass using RFID, and communicates with the NEMO electronics via an RS-232 link to send the data to shore [1,2)].

2 - RFID

Radio Frequency Identification (RFID) is a technology developed for access control, and is spreading widely in this and other fields.

In the standard setup, a Reader emits an RF beam, and the responding unit (Tag) answers with its own identity code, deriving power from the RF itself and thus eliminating the need for batteries. Recent developments have focused on adding to the Tag the possibility to take measurements in the environment and transmit them to the Reader together with its ID code. The EPC C1GEN2 [3)] protocol, developed by EPCglobal, includes the possibility of sensors in RFID tags.

We have used as an RFID Tag the WISP, developed at the Intel Research center in Seattle[4).] It is passive (no batteries), has a thermometer and an accelerometer on board, and is designed with an open architecture to include new sensors. Software for the integration is available from the designers.

The RFID Reader to be installed inside the optical modules has to be small, does not need a lot of RF power and must be cheap. Several firms offer such instruments, and we have chosen the ThingMagic[5)] M5e-compact reader for its small footprint and good performance with the WISP.

We are using this technique to add temperature and salinity monitors to the OMs of neutrino telescopes, transmitting data and power through the glass of the spheres without the need for connectors, which are expensive and not highly reliable. The result is the possibility to gather oceanographic information from several sensors distributed throughout the telescope, mapping large amounts of sea bottom at a very low price.

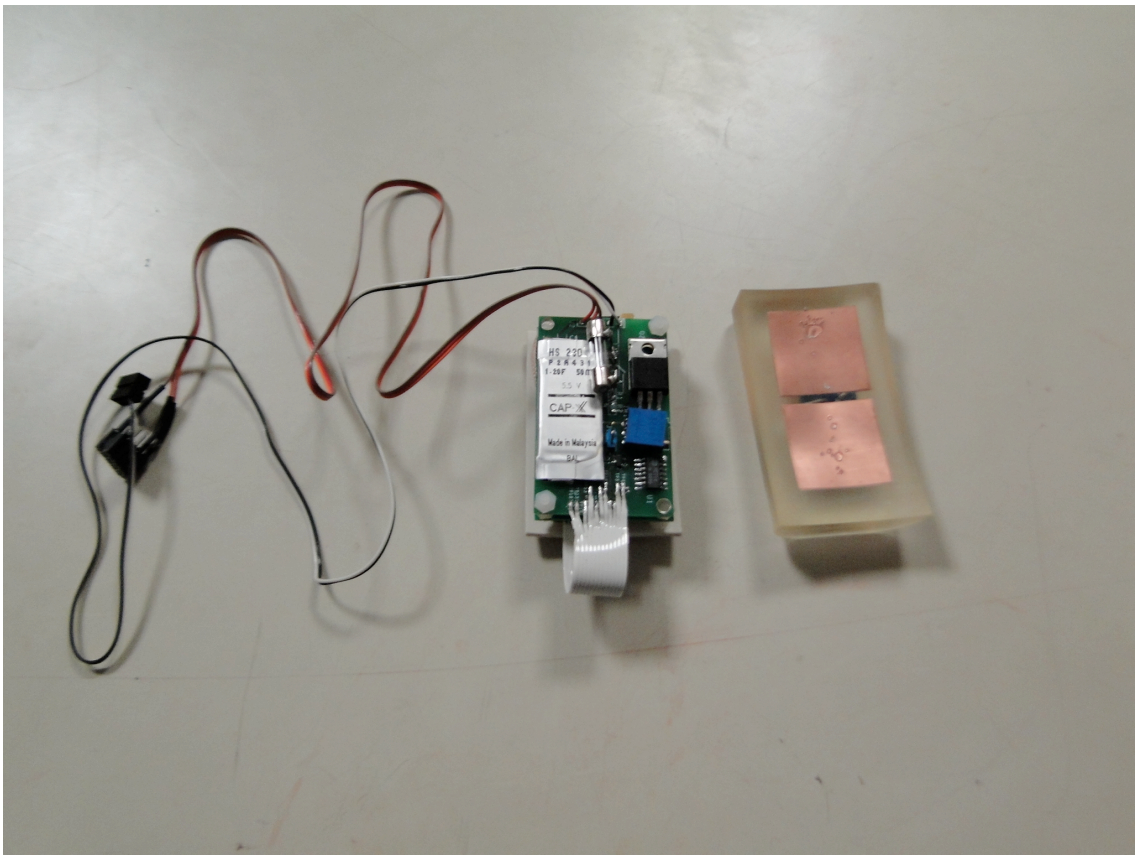

Fig. 1: The external and internal sections of PORFIDO

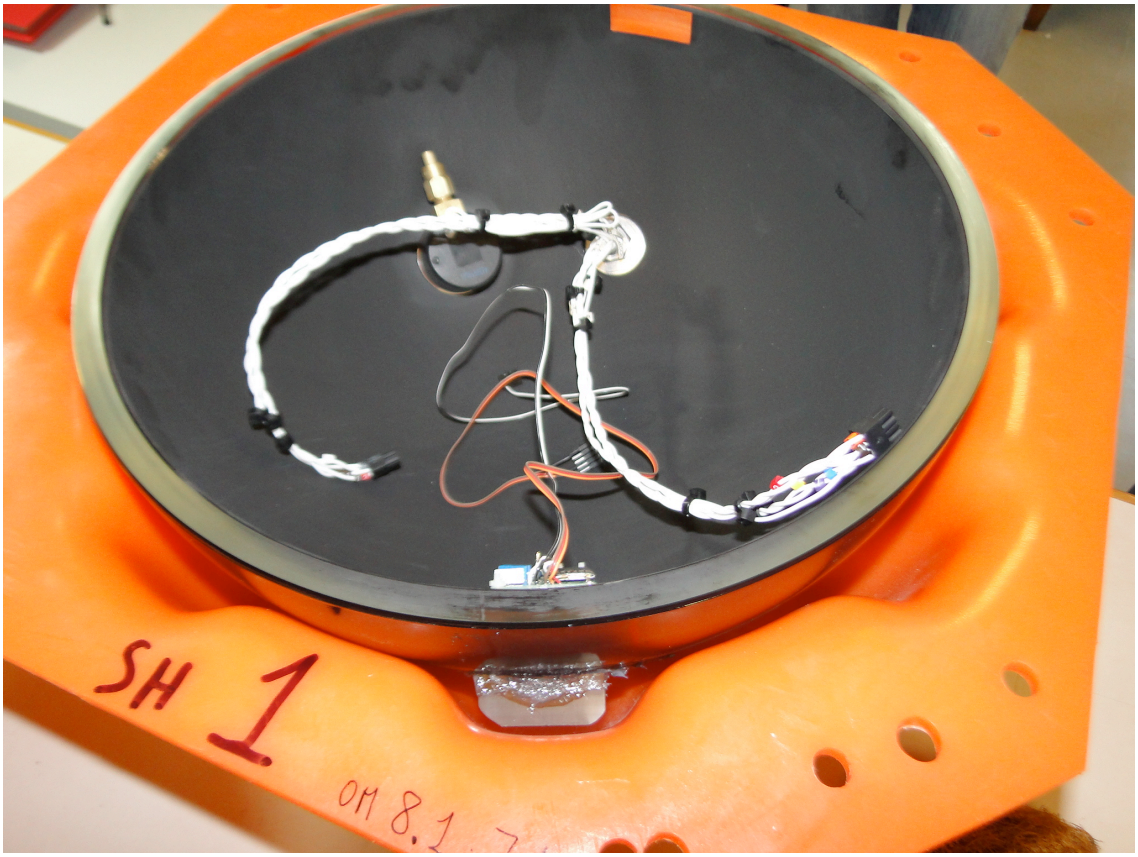

Fig. 2: PORFIDO mounted on an Optical Module of NEMO Phase 2. The loose cables are plugged into the FEM that is installed on the other half of the glass sphere.

3 – THE NEMO PHASE II TOWER

We have installed four PORFIDO probes on two different floors of the NEMO Phase II tower that was deployed in March 2013 at the Capo Passero site. In these probes the temperature is read from a sensor embedded in the wisp CPU, designed to monitor the temperature of the wisp itself, and with a sensitivity of only ± 1°C. The test was just intended to check the feasibility of the proposed technique.
The functionality of the probes has been tested in May 2013 and in May 2014 and after one year, all probes are still working correctly.

3.1 - POWER

We had strict restrictions on the power available for PORFIDO, only 50mA @ 5V. Since the Reader draws about 0.5 A @5V for 200 ms, we installed a 1 F capacitor to store the necessary power. The capacitor recharges slowly while the reader is inactive. Commands to the reader are sent transparently on a simulated serial connection in the optical fiber link of NEMO.

3.2 - RF INTERFERENCE

We tested the interference between the PORFIDO generated RF and the PMT - data acquisition system of NEMO Phase II. While some extra events were recorded at full RF power (0.2 W), we were able to reduce the power by a factor of 4 eliminating every interference with the system and with PORFIDO still working correctly. No RF shield was used.

4 - CONCLUSIONS

With the PHASE II installation PORFIDO has proven to be stable and reliable, although the temperature sensitivity was not sufficient for oceanographic studies.

In the meantime we have developed a board connected to the WISP containing two 24 bit ADC's. We now have temperature sensors with a sensitivity of one thousandth of a degree centigrade, and we are working on a salinity sensor to go with it.

Twelve new probes will be deployed in the next 2 – 3 years with the Km3 Phase I towers, again in the Capo Passero site.

We believe that the oceanographic community could greatly benefit by the use of this kind of instrument, that can efficiently parasite the Čerenkov neutrino telescopes which will be built in the future.

5 - ACKNOWLEDGEMENTS

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