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Electro-optical cable and power feeding system for the NEMO Phase-2 Project

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Abstract

The "NEMO Phase-2" project consist of a new facility placed on the sea floor at 3500 m depth, 40 nautical miles SE of the south coast of Sicily. Technical aspects of the facility under realisation are presented with particular attention to the electro-optical cable, the on shore and deep sea power transmission system, the control system and the connection system.

Keyword: electro-optical submarine cables; underwater power feeding systems

1. Introduction

The NEMO Phase-2 project represents a further step in the R&D activities of the NEMO collaboration towards the km^3 realisation. The experience gained with the Phase-1 project [1] and the progress in underwater telecommunications and related technologies have made the realization of this new facility possible. In this paper, we will outline the present technical status of the project with particular attention to:

- the backbone cable;
- the on shore and deep sea power transmission system;
- the control system.

The site location of the facility is the one that the seven year long characterization activities [2] of the NEMO collaboration have indicated as optimal for the installation of the km3 detector, namely a 3500 m deep abyssal plateau located at approximately 60 NM south east of Capo Passero (36° 20' N; 16° 05' E). It is believed that a further step in the site characterization must be the continuous monitoring of the deep sea waters. The Phase-2 project will allow

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this and, moreover, it will allow to install prototypes of the km^3 detector components at 3500 m.

This new facility may also be very attractive for the installation of interdisciplinary submarine observatories.

2. The NEMO Phase-2 project

The infrastructure presently under construction is composed by:

- a shore station in Portopalo di Capo Passero, to host the power feeding and data acquisition systems;
- a 100 km long backbone cable, connecting the 3500 m deep sea site with the shore;
- the shore power system;
- the submarine power system;
- the monitoring and control systems.

3. The backbone cable

Due to the longer cable length with respect to the Phase-1 project [2], a different solution for the electro-optical cable was chosen. In this case the backbone cable will be a DC cable, manufactured by Alcatel, that will carry a single electrical conductor, that can be operated at 10 kV DC allowing a power transport not less 50 kW, and 20 single mode ITU-T G652 optical fibres for data transmission. The cable total length is about 100 km.

The layout of the configuration is shown in fig. 1. Two passive Branching Units, which may be installed along the cable at 100 m and 1000 m depth, are also shown.

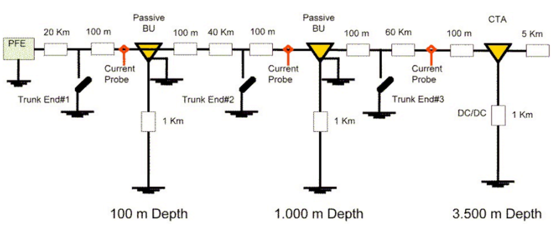

Fig. 1. The Backbone Cable configuration.

4. Power feeding equipment

The shore Power Feeding Equipment (PFE) is composed by a DC converter and a controller. The PFE provides 50 kW at 10 kVDC with sea current return.

A Supervisory Unit, based on a Dark Fiber Monitoring Equipment (DFME), provides the interface between the management system and the submerged plant. This unit, in conjunction with a line supervisory gain cell, provides full supervisory functionality for the submerged Branching Unit, allowing BU switch commands to be sent from the station. The supervisory messages sent from the DFME are transmitted by an over-modulation of the optical line output signal with a subcarrier tone (typically 150 kHz). This subcarrier is modulated by the supervisory command data stream.

5. Submerged plant

An Active BU, a DC/DC Converter and a Junction Box compose the submerged plant that is schematically shown in fig. 2.

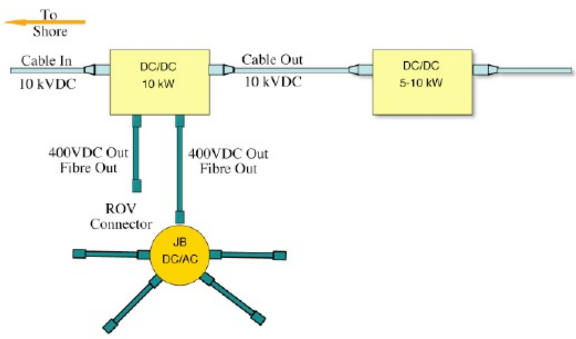

Fig. 2. Scheme of the underwater infrastructure.

5.1. Active Branching Unit

Branching Units are used as optical and electrical junctions in submerged electro-optical systems, fulfilling requirements for multiple landing points on multi-node sub-sea observatories. They provide twoway digital data single and multi-channel transmission with other submerged equipments operating at approximately 1550 nm wavelength.

Also the BU is designed to power a series of nodes from the backbone cable. The nodes may be disconnected or connected according to the system requirements. In the event of a backbone fault, power may be maintained to the "upstream nodes" by disconnecting at the prior BU, until repair is complete. Circuits internal to the BU allow any legs A, B, C or D to be powered in series between their respective Terminal Stations. The leg A is connected to the shore. The leg B is used for future extensions. The leg C is used to deploy power and fibers to the science node. The Sea Earth via the D connection is used for reconfiguration, safety and reconfiguration monitoring.

The BU can be permanently latched in one of the four states (A-B, A-C, B-C or A-B-C), as shown in fig. 3. It will maintain its power configuration as long as no optical command is received from the shore to change the state.

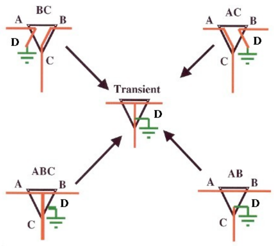

Fig. 3. BU State Diagram.

The Active BU is controlled, by the DFME, from the Shore.

5.2. The DC/DC converter

The DC/DC Converter is based on a design developed by JPL NASA for the NEPTUNE Project, which is being deployed on the MARS project [4-6]. It is constructed from a number of low power sub-converters blocks arranged in a series-parallel configuration, see fig. 4, to share the load and provide redundancy.

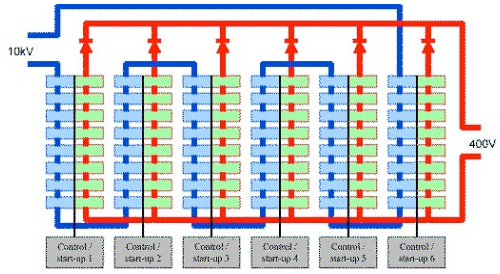

Fig. 4. DC/DC Converter layout.

The converter has an input of up to 10 kV DC and output of 400 VDC/25 A. The estimated efficiency is > 90% at full load. The converter configuration will be 48 Power Converter Building Blocks (PCBB) arranged as matrix of 6 parallel legs with 8 in series in each leg. This arrangement allows for faults within some PCBB's without a failure of the full converter. The entire power converter is housed in a pressure vessel, Fluorinert filled to facilitate cooling and reduce voltage clearances (see fig. 5). It depicts PCBB's mounted on several Printed Circuit Boards and a bellows unit to control pressure.

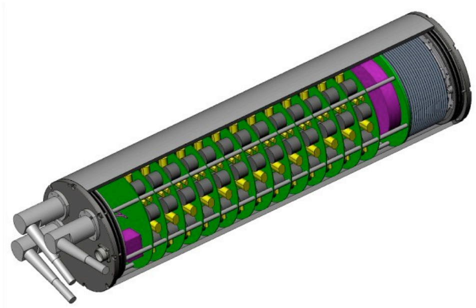

Fig. 5. DC/DC Converter Layout

The final arrangement of the converter is still under development.

The PCBB is a pulse width modulated switching forward converter with an input of 200 V and an output of 50 V at around 200 W. Each block has 4 MOSFETs, two working as a primary switch and two on the secondary side as a synchronous rectifier. A block diagram of the circuit is shown in fig. 6. The various transformer are capable of withstanding continuous 10kV operation when operated in a dielectric fluid.

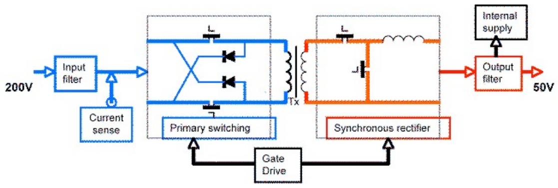

Fig. 6. PCBB block diagram

6. Conclusions

An underwater infrastructure is under realization on the deep sea site selected by the NEMO collaboration as a candidate for the installation of the km^3 neutrino telescope.

The infrastructure includes a 100 km long electro-optical cable, a shore station in Portopalo di Capo Passero and the power feeding and control equipments.

The construction of the backbone cable and power systems has started. The plant will be installed by the end of 2007.

The possibility to install along the backbone cable two other electro-optical branch outputs has also been considered in the project. This branches are foreseen to provide access to multidisciplinary research activities.

Acknowledgments

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