Systems for Radiological Surveillance & Monitoring

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Integrated Environmental Radiation Monitor with Autonomous Profiler for Underwater Radiation Monitoring

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Autonomous vertical profiler

ABSTRACT

Environmental Monitoring and Assessment Division (EMAD) is involved in the design and development of Geiger-Mueller (GM) Tube based standalone Environmental Radiation Monitors (ERMs) with online data communication. National Institute of Oceanography (NIO) has developed Autonomous Vertical Profiler (AVP) for controlled underwater movement for measuring below-surface parameters along with Radiofrequency (RF) based data communication. BARC and NIO have collaboratively designed an integrated Environmental Radiation Monitor with Autonomous Vertical Profiler (ERM-AVP) in order to develop a single system capable of underwater radiation monitoring.

KEYWORDS: *Environmental monitoring, Underwater radiation monitoring*

Introduction

Autonomous underwater gamma radiation monitoring is important for monitoring of liquid radioactive waste discharge points of nuclear facilities, radiological surveillance of coastal areas and detection of release of radiation or radiological substances from waterborne vehicles. This type of monitoring and/or surveillance can provide valuable input for national level emergency preparedness program of the Department of Atomic Energy (DAE). EMAD, BARC, under the Indian Environmental Radiation Monitoring Network (IERMON) project, has established a countrywide network of standalone solar powered ERMs, for monitoring of gamma dose rate in air, with Global System for Mobile communications (GSM) based real-time data communication [1, 2]. NIO has developed a battery-powered motor-driven in-situ robot profiler [3], called AVP, for controlled underwater movement and measurement of vertical structure of water column at high resolution along with RF based data communication. In this work, an integrated ERM-AVP system has been designed and developed jointly by BARC and NIO for underwater monitoring of gamma dose rate.

The ERM-AVP System

The ERM-AVP is a DC thruster driven robot profiler [3] that can be programmed by the user to descend through the water column down to a certain pre-set maximum depth while stopping for specified periods of time at different depths en route to sense and store the gamma radiation levels at those depths. After completing its downward mission, it ascends slowly to the surface of the water without propulsion, due to its in-built positive buoyancy.

On breaking the water surface, it transmits its coordinates recorded using Global Positioning System (GPS), the measured gamma dose rate data and the vehicle parameters via RF communication to a remote PC. The system has an installed echo sounder enabling bottom detection and a pressure sensor providing depth data, both of which can facilitate in stopping the thruster in case of an emergency in terms of seabed proximity or pressure overshoot.

Description of AVP

The AVP (Fig.1), developed by NIO [4], consists of three main sections:(i) the nose cone (bottom) (ii) the hull (middle) and (iii) the tail cone (top). The nose cone is free-flooding, i.e. it permits water to enter as the sensors housed in this section are water-tight and pressure-proofed. The nose cone is machined from an Acetal SA 550-grade cylinder. The hull is made from an open cylindrical aluminium alloy tube section and contains the electronics including the ERM PCBs and the batteries. The hull is sealed at both ends with removable aluminium alloy end-plates. The hull assembly has been pressure-tested in a pressure chamber up to 300 m. The tail cone is also free-flooding and is fixed on the rear end-plate of the hull. It serves the purpose of gripping the thruster body, of accommodating pressure-proof foam for extra buoyancy and also provides a means of locating the GPS and satellite antennas tubs through it. The system has been designed to have a large separation between the centre of buoyancy (C_b) and the centre of gravity (C_g), which helps to keep the AVP stable and vertical in orientation before a dive [4]. Technical specifications of the AVP are summarized in Table 1.

The electronic architecture of AVP is based on ARM based microcontrollers. A user-friendly Graphical User Interface (GUI) using LABVIEW enables mission programming, vehicle data monitoring, data acquisition and downloading, plotting etc. The GUI is loaded on a remote PC and interacts with the AVP through a radio modem connected to a serial port.

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Fig.1: Autonomous Vertical Profiler (front side view).

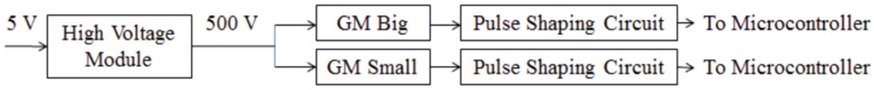

Fig.3: Block diagram of an ERM PCB.

Table 2: Technical Specifications of ERM.

Parameter	Value
Detected Radiation	Gamma
Detectors	Energy Compensated Geiger-Mueller Tubes
Energy Response	35 keV – 2MeV (in air)
Measurement Range (Combined)	50 nGy/h – 20 Gy/h (in air)
Operating Temperature	-20^{0}C – 60^{0}C(in air)
Relative Humidity	Up to 100%
Power Requirement	5 V, 50 mA for each of the two PCBs

Table 1: Technical Specifications of AVP.

Parameter	Value
Length	1.17 m
Diameter	0.18 m
Weight	13 - 16 kg; varies on installed sensors
Material	Hull: Aluminium alloy; End cones: Acetal
Propulsion	Single DC thruster
Electronics	ARM based
GUI	LABVIEW based
Speed	0.1-1.0 m/s
Depth	200 m (max)
Batteries	Lithium ion polymer (324 W-h)
Communication	RF (2.4 GHz)
Vehicle sensors	Pressure, Echo sounder, GPS
Scientific sensors	Depth, ERM

Description of ERM

The ERM, developed by BARC [1], measures gamma dose rate. It consists of two PCBs, each (Fig.2) containing one big (high sensitivity, low dose rate) and one small (low sensitivity, high dose rate) energy compensated GM tubes, accommodated inside the hull of the AVP.

The PCBs (Fig.3) accept 5 V input from the battery of AVP and produce 500 V bias voltages for the GM tubes. The shaped output pulses from the GM tubes are fed to the microcontroller of the AVP, which counts the pulses and stores the count rates when it is underwater. Upon reaching the water surface, the count rates are transmitted via RF to a remote PC where the calibration factors are applied to convert the measured count rates to the required dose rates. The ERM PCB consumes 50 mA (max) current. Two such PCBs are used for simultaneous measurement of gamma dose rate. Table 2 summarizes the technical specifications of the ERM.

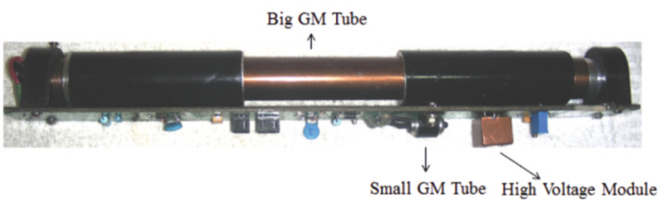

Fig.2: The ERM PCB (Top view).

Results and Discussion

Two units of the ERM-AVP were fabricated by M/s. Control Technologies, Bengaluru, an industrial partner of NIO, Goa, under license from BARC. These units were field-tested in Mumbai Harbour Bay (Arabian Sea). Both units satisfactorily operated in their underwater missions.

Conclusion

The indigenously developed state-of-the-art integrated ERM-AVP is a useful addition to the family of radiation monitoring systems for DAE's emergency response program when it comes to surveillance/security of coastal and/or port areas. These cost-effective indigenously developed systems can be effectively used in large numbers by DAE's Emergency Response Centres (ERCs).

Acknowledgements

ERM-AVP has been designed and developed under an MoU between BARC and NIO. The AVP is a proprietary item of NIO and the ERM is a proprietary item of BARC. The integrated system has been produced by Control Technologies, Bangalore (industrial partner of NIO), under a license from BARC.

References

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