REMOTE OPERATED PROBE FOR DEEP-WATER CAVE EXPLORATION

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ABSTRACT

Remote operated probes can serve for under-water scientific research. For speleology purposes, low-cost remote operated deep-water probe was designed and built. Probe MCU and PC interface software were programmed. Finally, probe is tested in high-pressure chamber and in field under real environmental conditions.

1. INTRODUCTION

Remote operated vehicles (ROV) are commonly used for under-water scientific research. They are made in varied modifications. Many of them are designed only for a depth of 250m or even less. On top of that, their purchase costs are extremely high (some of them start at a price 25 000 EUR). A vast majority of small research organizations cannot afford such expenses and sometimes they would actually make do with a simplified remote operated probe. Therefore, I have decided to design and build a price-affordable deep-water probe capable of diving in a depth over 200m or even more, the probe that can sustain an extremely harsh environment. The proposed probe carries an on-board two-axis remote controlled CMOS camera and uses the latest technology including MEMS sensor systems and a high-speed data transmission via optical cable. Total expenses should not exceed 2500 EUR.

2. ELECTRICAL DESIGN

The entire system consists of several major electrical parts that include a microcontroller unit (MCU), an inertial measurement unit (IMU), additional sensors, servos, a power supply unit with two DC/DC modules, a high-power LED module, a CMOS camera and a terminal server, an Ethernet switch and converters for a communication. A block diagram is shown in the figure 1.

2.1. MICROCONTROLLER UNIT

MCU is the heart of the probe. MCU processes every sensor data, takes control of external periphery devices like DC/DC modules, the high-power LED module and the communication with the remote PC. MCU also controls camera servo movements and their positions. Together with IMU, MCU can serve as an inertial navigation system and can also work as a probe stabilization system. This function is reserved for a future control system extension. Therefore, a LCD extension port, RTC, a memory and a back-up Li-Ion battery have been already integrated to the designed.

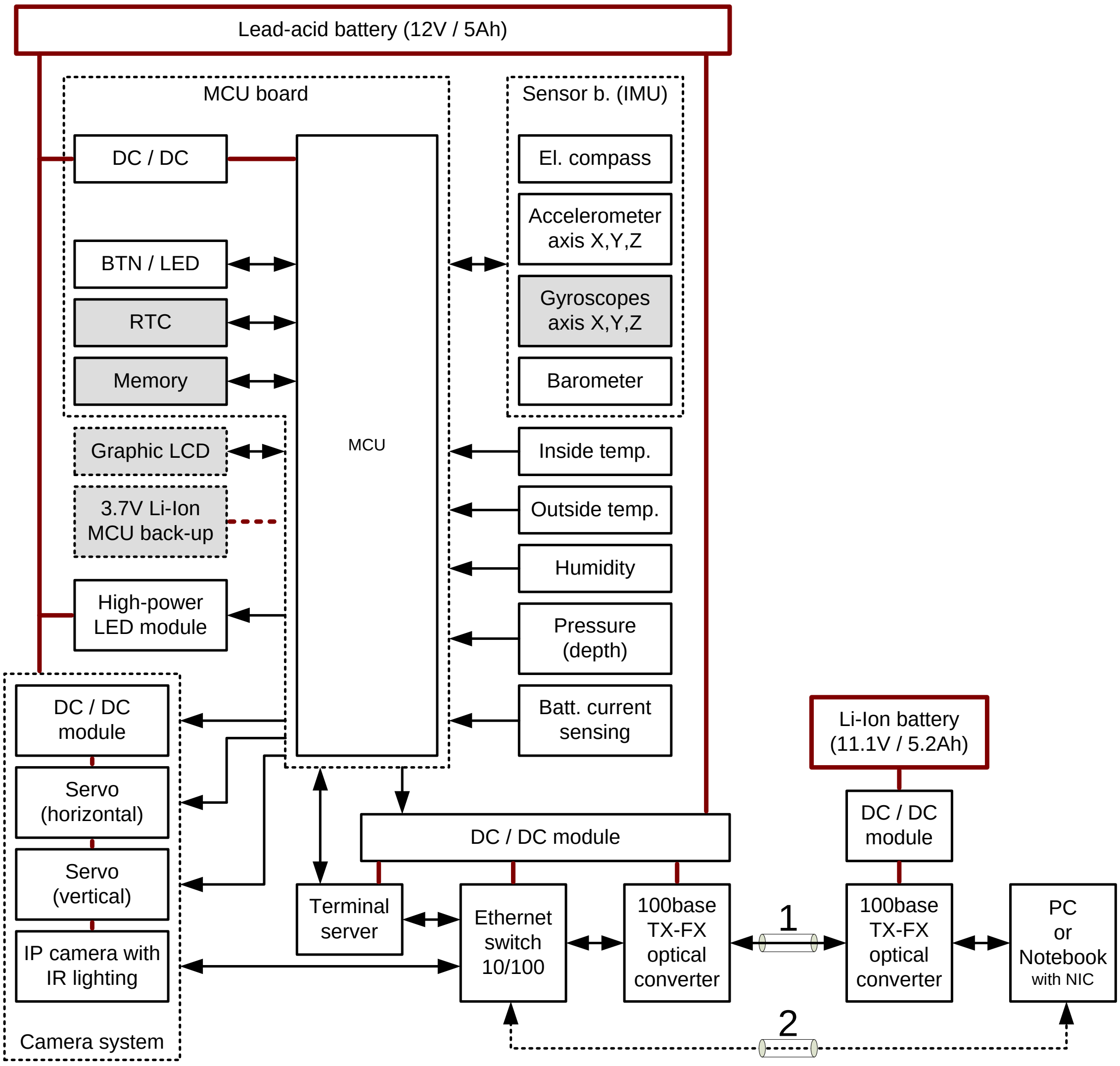

Figure 1: Block diagram

2.2. SENSORS

The probe is supplied with a full package of control and instrumentation sensors. For starters, there is an inside and an outside temperature measurement. A pressure sensor measures a real depth. IMU tracks position and can stabilize the probe. The probe is also equipped with the leak detection system. A very sensitive barometer and a humidity sensor can be monitored to ensure that there are no system leaks. The power-supply system is also under surveillance due to the voltage and the currency measurement. All of the sensors together with MCU provide the real-time measurement.

2.3. LIGHTING

The probe can be equipped with two external 5 watt high-power LED modules mounted on the probe chassis. Modules are easily replaceable in the field. Each light is individually controlled and the light intensity is adjustable from the surface PC.

2.4. VIEWING SYSTEM

A viewing system is what makes this probe so special in its class. In my current design, the probe is equipped with a low light CCD color video Gembird® LAN-controlled IP camera, which is the best solution for a monitoring, that comes with MJPEG recording, motion detection, flash-card and night-vision support. An internal web server can be accessed any time by the remote PC. CAM77IP is capable of a direct connection to a local and a broadband network. Using Internet explorer such as IE, user can perform a remote image surveillance and a management task, allowing an instant capture of the surveillance site. CAM77IP also combines the hardware-accelerated motion detection and the night-vision function.

The camera is mounted on two-axis servo mechanism which provides 360 degrees rotation and allows the camera to view up, down, left or right through a bottom transparent cover.

Using optical cable, the probe is capable to transfer data up to 100Mbit within 2km distance (100baseFX limit). Therefore the probe is ready to be fitted with a high-resolution camera if necessary. An inside Ethernet switch allows to connect more than one IP camera (up to three cameras).

3. MECHANICAL DESIGN

The probe shell is made of hard anodized aluminum and has a regular cylinder shape, 330mm in high and 140mm in diameter. A top cover is also made from hard anodized aluminum, thickness of 20mm. A bottom cover is a transparent plastic material that can sustain high pressures, also thickness of 20mm. Top and bottom covers are fixed with stainless hinges with locks. Every mechanical joint is sealed using the special technical glue. There are two O-rings at the top and bottom covers to provide a proper sealing. Optical or electrical cables are sealed with rubber bushings.

An internal self-supporting structure is made from non-corroding steel and carries most of the internal devices. Every other additional part (ether internal or external) is made of non-corroding steel. The entire probe is hooked to a carrying cable.

4. SOFTWARE

As for software, both MCU and PC interface had to be programmed. PC interface software provides all probe system function controlling including inertial navigation system and telemetry data displaying and storing.

5. CONCLUSION

Considering the manufacturing costs, we are getting the state-of-art probe that has many innovations like the optical high-density data transmission and the digital camera. Together with the external additional system, this probe is one of the best in its class.

REFERENCES

[1] Hyball ROV. *Sonavision Application notes for Hyball Remote Operated Vehicle.* [cit. 2009-02-11]. Available on WWW: http://www.sonavision.co.uk/hyball/hyball.html