Power, Controls and Backplane for RoboSub

Requirements Specification

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Ocean’s Seven

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1. Introduction
   1. Purpose
   2. Scope
   3. Definitions
      1. IMU-Inertial Measurement Unit
      2. DVL-Doppler Velocity Logger
      3. ESC-Electronic Speed Controller
      4. AUV-Autonomous Underwater Vehicle
      5. CPU-Central computer
   4. References
   5. Overview
2. Overall Description
   1. Product Perspective

The product is divided into three components: the backplane, the power system, and the motor/motion controller. The backplane unifies power distribution paths and communication buses throughout the AUV, providing simplified integration and upgrading of major components in the AUV. The power system will consist of multiple buck and/or boost circuits to facilitate efficient conversion of the single voltage level DC input from the LiPos to multiple DC voltage and current capacity requirements of the electrical components of the AUV. The Motor/Motion Controller is responsible for taking in information from multiple sensors then manipulating the motor array to maintain relative orientation and for taking a desired direction and velocity as input then maneuvering appropriately to achieve the desired outcome.

* + 1. System Interfaces

A waterproof connection is required to transfer main power from the LiPos to the backplane.The AUV backplane must interface with waterproof connectors in order to facilitate communication and power transfer from within the main hull to external enclosures. In addition it must interface with the other components in the product.

The AUV controller must interface with the IMU’s, DVL, ESC’s, CPU, and the backplane in order to sense and change the AUV’s orientation and velocity.

* + 1. User Interfaces

An external emergency kill switch must be available on the outside of the main hull which eliminates power to all moving parts on the AUV.

The controller will generate messages that are sent to the CPU stating the vehicle's current orientation and velocity.

* + 1. Software Interfaces

The AUV controller must interface with the CPU’s mission control software which gives desired orientation and velocity information to the controller.

* 1. Product Functions
     1. Essential Functions
        + User shut down actuator power in hardware (kill-switch) from outside the main hull
        + Power Supply monitors power usage. Unit powers down if abnormal power usage occurs
        + Power Supply distributes stable power to electronic components
        + Controls system keeps unit underwater during operation
        + Controls system allows unit to move in all 6 degrees of freedom so that it can change velocity and orientation as needed.
        + Controls system outputs logs of current orientation
        + Controls system outputs logs of current velocity
        + Controls system outputs logs of estimated position
        + Controls system samples orientation data from IMU’s
        + Controls system samples velocity and position data from DVL
        + Controls system accepts velocity change commands from CPU
        + Controls system accepts orientation change commands from CPU
        + Controls system outputs PWM signals to ESC’s in order to control motors
        + Backplane facilitates power transfer to electronic components
        + Backplane facilitates communication of electronic components via a bus
     2. Desired Functions
        + User shut down actuator power in software
        + User hot-swaps power switch between batteries and benchtop power supply
        + CPU supplies predefined mission functions which the controls system schedules
     3. Extension Functions
        + Power Supply manages power efficiently for extended run time
        + User powers on/off main CPU in hardware from outside the main hull
  2. User Characteristics

|  |  |
| --- | --- |
| Users | Robosub Team |
| Required Knowledge | The user will have explicit knowledge of the system and be able to recreate and debug problems from the documentation |
| Responsibilities | -The user will control software that drives the control system  -The user will be responsible for ensure connection outside of the backplane  -The user will physically install the product into the AUV  -The user will be responsible for charging batteries |
| Success Criteria | The user defines success as having power delivered from the power supply to the electronic components via the backplane, communication with key components via the backplane, and a well controlled AUV |
| Disability Accommodation | Installation will not have disability accommodations. Once installed the system should operate autonomously. |
| Language Challenges | Documentation will require knowledge of English. After installation the system should operate independently. |

* 1. Design Constraints
     1. Backplane Constraints
        + Backplane must fit within main hull dimension
          - W <= x.x”
          - L <= x.x”
        + Backplane must interface with waterproof connectors
     2. Control System Constraints
        + Control system must interact with a predefined CPU software system provided by the customer
        + Control system must interact with ESC’s provided by the customer
        + Control system must interact with sensors provided by the customer, or interact with sensors easily acquirable by the customer
     3. Power Constraints
        + Customer requires power over ethernet for certain components
  2. Assumptions and Dependencies
     1. Main hull provided by the customer must be built before full interfacing can be completed
     2. Controls system is dependent on sensors being available and in working condition
     3. Controls system is dependent on cpu input provided by customer
     4. Waterproof connectors provided by customer must be properly spliced and arranged in the main hull
     5. Controls system is dependent on motor placement which is to be determined based off the main hull design.
     6. Power requirements are dependent on electronic components provided by customer and subject to change
     7. Testing is dependent on access to a large body of water. Typically this will be the CU Rec Center pool which must be open and available.

1. Specific Requirements
   1. Marketing Requirements
2. Accurately maneuver the AUV through the mission
3. Maintain stable orientations and trajectories
4. Externally actuated mechanical kill switch removing power from moving components
5. Maintain power to all AUV electronics during normal operations.
6. Facilitate communication between electronic components
7. Whole system operation time greater than or equal to 25 minutes
8. Fit within the watertight enclosures on the main chassis without obstructing airflow
9. Include appropriate safety mechanisms (hardware,software) to avoid operating conditions that are unsafe to the system or bystanders

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| --- | --- | --- |
| Marketing Requirements | Engineering Requirements | Justification |
| 7 | The system must be no wider than x.x (<6) in., no longer than x.x in. and no taller than x.x in. | The watertight enclosures will be 6” diameter acrylic tubes and all components must fit within. |
| 3,4 | Power traces for all moving components must be isolated from all digital electronics | Activating the kill switch should only disable moving components and not digital. |
| 1 | The system must be able to adjust the vehicle's orientation and velocity to within x.x° and x.x m/s | The AUV will be travelling over distances up to 100 yards and must arrive at an objective within an observational distance.  The AUV must be able to move through designated areas as small as 4’x8’ |
| 4,6 | The system must deliver more than x.xA and y.yV for a minimum of 25 minutes, without replacing batteries | The competition constraints give no more than 25 minutes for running the course. |
| 5 | The system must have a communication bus using xxx standard to facilitate data transfer between electronic components | Multiple components in the AUV will require sending and receiving data. Implementing a single communication standard reduces the number of data buses required on the backplane. |
| 3,8 | The motor power traces must be switchable by means kill switch. | In order to prevent injury all motors must be disabled in the event the kill switch is activated. This must work even when power to the vehicle is lost. |
| 8 | The power system should shut down in the continuous current draw exceeds x.xA or the LiPo batteries falls below x.xV | LiPo batteries are very dangerous when operated outside of their normal ranges. |

1. Use Cases

4.1 Powering On

4.2 Normal Operation

4.3 Emergency Shutdown