Functional Decompositions

And

Roles, Responsibilities, and Components

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# Change Log

1. Change under outputs section of the description of the FD0: replacement of “Current Velocity/Orientation” and addition of “Status Information” with “Status Information”
   1. This change was implemented because the CPU will now handle peripherals such as current velocity and orientation
2. Change under Sub Modules section of the description of the FD0: addition of Merge Circuit
   1. This change was implemented due to the removal of the merge circuit from backplane to its own PCB.
3. Change to FD1: addition of merge circuit and status info to CPU from power conversion board, removal of sensor data and desired orientation/velocity as inputs to the backplane
   1. This change was made due to a change in our final design
4. Change under Inputs section of the description of the Backplane for the FD1: removal of external power, desired velocity/orientation, and sensor data
   1. This change was made due to a change in our final design
5. Change under Outputs section of the description of the Backplane for the FD1: removal of external power, desired velocity/orientation, and sensor data
   1. This change was made due to a change in our final design
6. Change under Sub modules section of the description of the Backplane for the FD1: removal of all sub modules
   1. This change was made due to a change in our final design
7. Addition of Merge Circuit section to the description of the FD1
   1. This change was made due to a change in our final design
8. Change under the Outputs section to the description of the Power Conversion Board for the FD1: removal of the 3.3V requirement and addition of current requirements
   1. This change was made due to a change in the final design from Robosub
9. Change under the Sub Modules section to the description of the Power Conversion Board for the FD1: addition of the teensy and a current sensing circuit
   1. This change was made in order to ensure that our board is making the correct conversions
10. Change under Outputs section to the description of the Controls Board for the FD1: removal of current velocity/orientation, and addition of LED motor status indicators
    1. This change was implemented because peripherals will now be handled by the CPU and for testing and debugging purposes
11. Change under Sub Modules section to the description of the Controls Board for the FD1: removal of ethernet and addition of FT232, 3.3V linear regulator, board to board slot connector, and reset button
    1. These changes were made as a result of better product description
12. Addition of a Merge Circuit FD2 and description
    1. This change was added as a result of a change in our final design
13. Removal of Ethernet Socket and IMU data, and addition of LED status indicators to Controls Systems Board FD2
    1. These changes are to remove overhead from our MCU and simplify the design
14. Removal of 14.8V to 3.3V conversion and addition of a 48V conversion on the Power Conversion FD2
    1. These changes are due to changes made by Robosub
15. Removal of backplane FD2
    1. This change is due to the change in functionality of the backplane

# 

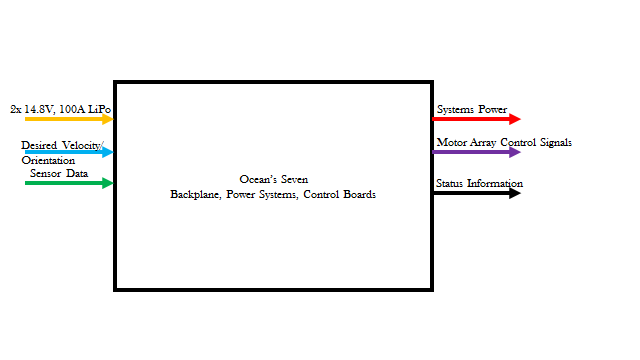
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# Functional Decompositions

## Level 0: Systems Overview



|  |  |
| --- | --- |
| Module | Backplane, Powers and Controls systems |
| Inputs | * 2x 14.8V 100A LiPo: External Power provided by two lithium ion polymer batteries. * Desired velocity/orientation: Orientation and velocity information provided by the CPU based current location and desired location * Sensor Data: IMU and DVL data to determine relative position, acceleration and velocity vectors. |
| Outputs | * Systems Power: 3.3V, 5V, 12V, 14.8V, 19V, 48V requirements to maintain power to all systems on the AUV * Motor Array Control Signals: PWM or I2C signals provided to the ESCs to regulate individual motor torques. * Status Information: Current draw on voltage rails, PWM pulse widths, Kill Switch status |
| Functionality | The backplane, power systems and controls boards are responsible for providing required power to all components in the AUV, vehicle stability and maneuvering, and standardizing connection of additional unspecified components |
| Sub Modules | * Merge Circuit * Backplane * Power Board * Controls Board |

## Level 1: Module Overview

|  |  |
| --- | --- |
| Module | Backplane |
| Inputs | * Systems Power: 5V, 12V, 14.8V, 19V, 48V requirements |
| Outputs | * Systems Power: 5V, 12V, 14.8V, 19V, 48V requirements |
| Functionality | The backplane is responsible for routing all requirements throughout the AUV. |
| Sub modules | None |

|  |  |
| --- | --- |
| Module | Merge Board |
| Inputs | 2x 14.8V, 100A Lithium Ion Polymer Battery |
| Outputs | * 8x 14.8V 30A rails to motors * 1x 14.8V 40A rail to backplane * Status information to CPU |
| Functionality | Safely place two 14.8V lithium Ion batteries in parallel, providing a maximum of 200A current draw across the entire system. Monitor current draw by each motor and and the AUV electronics systems, and status of the motor kill switch. Send the information to the CPU |
| Sub Modules | Teensy, Merge circuit, 5V Linear Regulator, Current sensing circuits |

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| --- | --- |
| Module | Power Conversion Board |
| Inputs | * 2x 14.8V 100A LiPo: External Power provided by two lithium ion polymer batteries. |
| Outputs | * 5V, 1A * 12V, XA * 19V, 4A * 48V, 1A * 48V, 0.5A |
| Functionality | Conversion of 14.8V to voltage and current specifications required by RoboSub, 5V, 12V, 19V, 48V |
| Sub Modules | * Teensy * Current sensing circuits * DC-DC Switching Converters 14.8V to: 5V, 12V * DC-DC Boost Converters 14.8V to: 19V, 48V * Physical or optical isolation for 19V line |

|  |  |
| --- | --- |
| Module | Controls Board |
| Inputs | * 5V, 1A rail * Desired velocity/orientation * Position and orientation information |
| Outputs | * 8x PWM signal to AUV motors * Pulse width values for motors * 8x LED Motor Status Indicators |
| Functionality | Maintain AUV Pitch, Roll, Yaw, Depth, and Speed, based on reference inputs from the CPU |
| Sub Modules | STM32F767VIT, USB Socket, FT232, JTAG Socket, 3.3V linear Regulator, board to board slot connector, reset button |

## Level 2 Functionalities

### Merge Circuit

FD Level2 Merge Circuit.png

|  |  |
| --- | --- |
| Module | Positive High Voltage Diode Controller |
| Inputs | 2x 14.8V, 100A Lithium Ion Polymer Batteries |
| outputs | 8x 14.8V, 30A trace  1x 14.8V, 20A trace  1x 14.8V, 10A trace |
| Functionality | Safely place in parallel and provide current isolation for two LiPO batteries |
| Submodules | None |

|  |  |
| --- | --- |
| Module | Mechanical Kill Switch |
| Inputs | 8x 14.8V, 30A trace |
| outputs | 8x 14.8V, 30A trace  Kill switch status |
| Functionality | Provide software and mechanical means of disabling motors in the event malfunctions |
| Submodules | Mechanical switch, 8x NMOS transistors, 2to1 logical AND gate |

|  |  |
| --- | --- |
| Module | 5V Switching Regulator |
| Inputs | 14.8V |
| outputs | 5V |
| Functionality | Provide a system independent 5V rail for the kill switch and MCU on the merge circuit |
| Submodules | none |

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| --- | --- |
| Module | 10x Current Sensing Circuits |
| Inputs | 14.8V 10-30A trace |
| outputs | Current draw as a voltage (0-5V) |
| Functionality | Translate current drawn through each power trace on the merge circuit into a voltage readable by an ADC on the Teensy |
| Submodules | none |

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| --- | --- |
| Module | Microcontroller, Teensy |
| Inputs | 5V, 0-5V voltages from current sensing circuits, USB inputs from CPU |
| outputs | Killswitch status, Software killswitch Enable, current draw information, LED status indicators |
| Functionality | Monitor current draw through 10 voltage rails. Monitor battery voltage level. Provide software enabled killswitch operation. Provide visual debugging information via LEDs. Provide status information to CPU via USB |
| Submodules | Software |

|  |  |
| --- | --- |
| Module | LED Status Indicators |
| Inputs | Logic level voltages from the Teensy |
| outputs | Photons, Current draw through rail is above nominal value |
| Functionality | Provide visual feedback of power trace statuses |
| Submodules | none |

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### Power Conversion Board

Power CDR.png

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| --- | --- |
| Module | 14.8V-5V DC/DC Switching Converter |
| Inputs | 14.8V: Main system power |
| Outputs | 5V: To be used by microcontrollers and sensors. |
| Functionality | Provide stable 5V output |
| Submodules | Supporting Passive Components |

|  |  |
| --- | --- |
| Module | 14.8V-12V DC/DC Switching Converter |
| Inputs | 14.8V: Main system power |
| Outputs | 12V: To be used by actuators |
| Functionality | Provide stable 12V output |
| Submodules | Supporting Passive Components |

|  |  |
| --- | --- |
| Module | 14.8V-19V Boost Converter |
| Inputs | 14.8V: Main system power |
| Outputs | 19V: To be used by the CPU |
| Functionality | Provide Isolated stable 19V output |
| Submodules | Supporting Passive Components |

|  |  |
| --- | --- |
| Module | 14.8V-48V Boost Converter |
| Inputs | 14.8V: Main system power |
| Outputs | 48V: To be used by the DVL, power over ethernet line |
| Functionality | Provide stable 48V output |
| Submodules | Supporting Passive Components |

### Controls Systems Board

Controls FD2.png

|  |  |
| --- | --- |
| Module | FTD232 |
| Inputs | USB Data |
| Outputs | RS232 Data |
| Functionality | Convert USB data signal into RS232 |
| Submodules | None |

|  |  |
| --- | --- |
| Module | JTAG Programmer |
| Inputs | Software, Firmware, debugging signals, from Computer |
| outputs | Software, Firmware, debugging signals, to Microcontroller |
| Functionality | Allows programming and debugging of software and firmware on the STM32 microcontroller. |
| Submodules | None |

|  |  |
| --- | --- |
| Module | 3.3V linear regulator |
| Inputs | 5V |
| Outputs | 3.3V |
| Functionality | Step down 5V to 3.3V to power the STM Microcontroller |
| Submodules | None |

|  |  |
| --- | --- |
| Module | STM32F767VIT |
| Inputs | * 3.3V: Main voltage for MCU * JTAG Programmer: Software/Firmware * FTD232: Desired Velocity/Orientation, Sensor data from CPU |
| Outputs | * 8x PWM Signals to Motors * Pulse Width values to CPU, via USB |
| Functionality | Maintains situational awareness of the AUV and provides stable maneuvering by taking in desired position/velocity vectors from the CPU and running the values through control algorithms |
| Submodules | Software |

# **Roles Responsibilities and Components**

Use Cases:

1. System Power Up
2. Normal Operations
3. Kill Switch Activated

|  |  |  |  |
| --- | --- | --- | --- |
| Use Case Reference | Responsibilities | Roles | Hardware Component, Software Component, or Both |
| 1, 2 | Provide voltage and current at required levels to IMU’s and ESC PWM lines | Switching Conversion to 5V at 3A | 14.8V to 5V DC buck converter |
| 1,2 | Provide voltage and current at required levels to the actuators | Buck Conversion to 12V at 1A | 14.8V to 12V DC buck converter |
| 1,2 | Provide stable voltage and current to the main computer | Boost Conversion to 19V at 4A | 14.8V to 19V DC boost converter |
| 1,2 | Provide voltage and current to the power over ethernet (POE) downwards facing camera and DVL | Boost Conversion to 48V at 2A | 14.8V to 48V DC boost converter |
| 2 | Maintain, pitch, roll, and depth based on reference input from CPU | Pitch, Roll, Depth controller | Hardware: 4 Blue Robotics T100 Thrusters, MCU  Software: PID control algorithm |
| 2 | Maintain yaw based on reference input from CPU | Heading Controller | Hardware: 2 Blue Robotics T100 Thrusters, MCU  Software: PID control algorithm |
| 2 | Maintain vehicle speed based on reference input from CPU | Vehicle speed controller | Hardware: 2 Video Ray Thrusters, MCU  Software: PID Control Algorithm |
| 1 | Ensure the system powers up in an effective order | Power on Routine | Hardware: MCU  Software: Power up sequence with communication between MCU and main computer |
| 1,2 | Monitor voltages and currents to maintain safe operation | Voltage and Current monitor | Hardware: MCU, Voltage Sensor, Current Sensor  Software: Data log, and automatic shut down |
| 3 | Disable power traces to motors | Mechanical Kill Switch | Hardware: Reed Switch, Power Mosfet |
| 3 | Disable power traces to motors | Software enabled killswitch | Hardware: Teensy MCU  Software: Manipulate digital I/O pin |