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Robotic Platform for 1kg Loads (RP1)

## Project Team:
P09204

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1 Overview

1.1 Hardware Control Document

The Hardware Control Document (HCD) is a compilation of hardware designs and specifications. This is a comprehensive design document detailing any hardware specific information, which may not be specified in an interface document. Board schematics, PCB layouts, electrical properties and descriptions will all be discussed here. Wiring between hardware assemblies internal to the Robotic Platform 1kg (RP1) control unit will be discussed in full detail.

1.2 General Information

The Robotic Platform for 1kg Payloads (RP1) is a robotic assembly and physical platform built for the purpose of expediting construction of robotics of a much higher complexity. Quite frequently, rudimentary navigation and obstacle avoidance logic consumes a large portion of time when building any robotic device. This platform is intended for applications in which a robotic device needs navigation control, but the builder does not want to focus a lot of time or money into designing the components that manipulate motion.

The RP1 system consists of two core assemblies: the RP1 Control System and the RP1 Mechanical Motor Module and chassis. The control system will interface with a payload, which will have full control over the platform itself. This will allow the payload to control the navigation of the platform. The payload in this instance would be any robotic device using the RP1 platform as a basis of motion.

The platform does not rely solely on the payload to command navigation. The RP1 control system also comes equipped with a wireless communications device which will allow a user at any PC machine equipped with the Graphical User Interface (GUI) software and appropriate wireless communication hardware to control navigation of the robotic platform. In this scenario, the payload may rest idle and perform its own, separate tasks or it may poll the platform for encoder data, power data, or any peripheral sensor data for which the system may come equipped.

1.3 System High Level Design

The System High Level Design is the technical layout and design of the RP1 control system. The system is broken down into a number of subsystems that are designed, implemented, and tested individually and also during integration.

There are a total of seven subsystems, the Graphical User Interface, the Wireless Communications subsystem, the Power Distribution subsystem, the Processing subsystem, the Motor Module Controller subsystem, and lastly the Motor Module subsystem. A block diagram of these subsystems and their interconnections is displayed in Figure 1.

The Graphical User Interface (GUI) is a software application written in JAVA and is thusly cross platform compatible. Any operating system running the JAVA JRE (Java Runtime Environment) will be able to run
the GUI client software. The details of the GUI are described in the Interface Control Document (ICD). Please see section 5 below for the location of the ICD.

The Wireless Communications subsystem is a subsystem dedicated to maintaining wireless control over the robotic platform. The details of the communication properties and communication protocol of this subsystem are described in the ICD. Please see section 5 below for the location of the ICD.

The Processing subsystem is the computational heart of the robotic platform. This subsystem contains the processing core where all commands issued are computed through the communication channel into motor controls and sensor feedback to the user. The details of this subsystem are not relevant within the scope of the ICD. For more information please reference the Customer Needs, Design Specifications, and any design documentation that may pertain to the Processing subsystem.

The Motor Module Controller subsystem and subsequent Motor Module subsystem are the logic and device systems for actuating a motor. The Motor Module Controller subsystem contains logic to actuate a motor, but does not contain the motor or driver circuitry itself. The controller subsystem simply generates the timing and control signals, which are then fed into the Motor Module subsystem. There are a variety of Motor Module controllers for the various supported motors. DC and Stepper motors required extra controller and timing circuitry to operate, while Servos require only Pulse Width Modulation (PWM) input. DC and Stepper motors require PWM inputs as well. Moving PWM generation responsibility off chip onto a separate microcontroller, identified in the diagram as the PID Controller module will allow for increased system modularity and less load on the core processing system.

The Motor Module system is not part of the RP1 control system platform, but is mentioned here only for clarity of the design. The Motor Module will interface with the control system through the electrical interface defined in the ICD. Please see section 5 below for the location of the ICD. The Motor Module is expected to utilize the timing signals specified in this interface to control driver circuitry and the motor. The driver circuitry, whether this may be a motor H-Bridge or some other device, shall be contained within the Motor Module itself and not within the RP1 control system.
2 Hardware Subsystems Design

2.1 General Information
Listed in this section is a description of each subsystem schematic design and the expected signal properties for input and output. Also described are the behavior of the unit and typical and maximal operating conditions.

2.2 Power Distribution Subsystem

2.2.1 Description
Power distribution is a very important aspect of the design. The design utilizes two separate batteries to power two distinct power distribution boards as described below.
2.2.2 9V Power Distribution System

A 9V battery and distribution system is used to supply power to the microcontroller and other logic subsystems. The current is limited to less than 700mA by a fuse at the input. A status LED is used to indicate the operation of the system and a power sense output is used to supply a reading of the voltage input. The 9V input is fed through a 5V regulator and subsequently fed to four identical 5V outputs. Capacitors are utilized at both the input and output of the regulator to improve stability and prevent rapid changes in current. This current is again limited through the use of a fuse to under 500mA. All fuses are mounted with fuse clips to provide ease of access and replacement as necessary.

Figure 1 - 9v Power Distribution
2.2.3 12V Power Distribution System
While the 9V system supplies the microcontroller and logic systems, the 12V battery is used to deliver power to the motor systems. This 12V distribution system feeds 12V directly to the DC motors as well as regulating and supplying 6V to multiple Servo motors. The 6V regulators again use capacitors to ensure stability and limit current spikes. Fuses are used both at the 12V input and at the output of each regulator. A status LED is used to indicate operation of the entire system. Separate LEDs are used to indicate operation of each Servo distribution subsection. Four 12V outputs are present along with two 6V outputs used to power DC and Servo motors respectively.
Figure 3 - 12v Power Distribution
2.2.4 Unit Test Setup
Refer to Section 2 in the Test Case Document, which can be found under System Testing section on the EDGE website: http://edge.rit.edu/content/P09204/public/Home.

2.3 DC Motor Driver

2.3.1 Description
The DC motor driver is controlled via a programmable PWM signal (generated by the PID controller), and two discrete inputs. One discrete input is reserved for enabling or disabling the driver entirely while the other is used to drive the motor in forward or reverse directions. This circuit requires both 5v logic and 12v motor power. Voltage clamp diodes are used to prevent back EMF from effecting the logic signals and electrolytic capacitors are placed on the 12v power rails to ease the impact of large current draws when the motor is actuated from full stop.
2.3.2 Design Schematic

![Design Schematic]

Figure 3 – Schematic of DC motor driver

2.3.3 PCB Layout

![PCB Layout]
2.3.4 Unit Test Setup
Refer to Section 3 in the Test Case Document, which can be found under System Testing section on the EDGE website: http://edge.rit.edu/content/P09204/public/Home.

2.4 Proportional Integral Derivative (PID) Controller

2.4.1 Description
The PID controller is implemented on the Arduino Nano development board. The details for this COTS hardware assembly can be found at their website: http://www.arduino.cc/en/Main/ArduinoBoardNano. For convenience Figure 5 shows the Arduino Nano assembly.

2.4.2 Unit Test Setup
Refer to Section 6 in the Test Case Document, which can be found under System Testing section on the EDGE website: http://edge.rit.edu/content/P09204/public/Home.
2.5 Microcontroller

2.5.1 Description

The microcontroller is contained within the selected BDMicro MAVRICIIB development board. However, many subsystems and devices interface directly with the I/O ports on this board and such interactions are defined in this section. No PCB layout is provided due to the nature of this description; no custom PCB is necessary for this subsystem. Please reference the BDMicro website and design schematic for details on the assembly and interconnect (Section 5 below). Figure 6 shows the MAVRICIIB microcontroller development board described above.
2.6 Internal Cables

Figure 7 - Internal Encoder Cable
Figure 8 - Internal Programming Cable
Figure 9 - Internal Power-In Cable
Figure 10 - Internal Serial Cable
Figure 11 - Internal Logic Power Cable
Figure 12 - Internal DC Motor Driver Hookup Cable
Figure 13 - Internal Servo Cable
Figure 14 - Internal TWI Cable
2.7 External Cables

Figure 15 - External Power-In Cable
3 Hardware Wiring

Below is a color coded internal and external wiring diagram. For users who are concerned only with external wiring please disregard everything within the control box chassis. For information regarding the pins to which each connector mates with please refer to the appropriate cable schematic in Sections 2.6 and 2.7.

Figure 16 - External DC Motor Hookup Cable
3.1 Interconnect Wiring Diagram

Figure 17 - Interconnect Wiring Diagram

4 Acronyms

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<td>JRE</td>
<td>JAVA Runtime Environment</td>
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## 5 Document References

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