ZAAPP

Precisely Weeding Tree Nurseries Autonomously

Power Distribution System

Conceptual Design

Team F:

Zihan Wan

Amaar Quadri

Adrian Walker

Parth Shah

Philip Koch

16-681: MRSD Project 1

Master of Science in Robotic Systems Development

Robotics Institute

School of Computer Science

Carnegie Mellon University

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Carnegie Mellon University
Robotics Institute

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1 Power Source

The system we are developing will be a modular attachment to an existing system. The existing system is based on a modified Clearpath Robotics Husky A200. The modifications that are relevant to our system are as follows:

- Replacement Battery Installed
- Husky Power System Power Distribution bypassed to a bus bar

The replacement battery system installed consists of two 12 V LiFePO4 batteries in series, linked above. The pertinent information is as follows:

- Cell Type: LiFePO4 Pouch
- Nominal Voltage: 12.8 V
- Rated Capacity: 100 Ah
- Energy: 1280 Wh
- Internal Resistance: < 40 m Ω
- Max. Continuous Discharge Current: 100 A
- Charge Voltage: 14.4 V
- Internal BMS with over-voltage, under-voltage, and over-current protection
- Connection: M8 bolts

2 Powered Sub-systems

The system currently consists of the following power-line-connected subsystems:

- The system computer
- The Husky Base

The system computer is powered by a 400W version of this power supply. The details are as follows:

- 94% DC-DC Efficiency
- 12 - 48V input

The Husky base is stated to have a 1000W peak power draw.

Our modular system would add the following components:

- Laser sub-system
- Manipulation sub-system motors and drivers
- 3 x Realsense Cameras

The cameras will be supplied through their connection to the PC; therefore, their power requirements are already included in the ATX power supply.

For the initial full-power design, the laser sub-system will require 3A at 12V. The eye-safe laser sub-system will require at most 1A at 12V.

This system is expected to undergo several iterations and it is difficult to fully predict the power requirements.

The two motor drivers and motors are listed here:

- NEMA17 geared brushless DC motor
- DC linear actuator
- Brushless DC motor driver
- DC motor driver for the linear actuator

The brushless DC motor is rated for 24V at 3.5A, while the linear actuator is rated for 12V with the driver capable of supplying 4A.

The 24V motor driver can be powered directly from the battery system, while the 12V motor will either require regulation or a clever connection to one of the two batteries in series.

3 Design Requirements

3.1 Connections

Due to the nature of the system and the usefulness of various voltage levels, in addition to the connections necessitated by the systems described above we will be including additional connectors at each power level.

Specifically, the connections we require are:

- 1x power input connection rated at at least 10A (7A from above output values + some buffer)
- 2x 5V output power connectors at at least 1A (auxiliary power connection - 5V is very versatile and may prove useful later)
- 2x 12V output power connectors rated at 4A each (from the motor driver max current)
- 2x 24V output power connectors rated at 5A each (from 24V motor + headroom)

3.2 Input Power

The batteries being used already contain a built-in BMS capable of protecting against under-voltage, over-voltage, and over-current; however, this is more meant as a protection to the batteries themselves, not the system to which they are connected. Due to the ability of the batteries to supply very high currents, over-current (or short-circuit) protection should be included. This will ideally be in the form of a replaceable fuse with an appropriate current rating. Monitoring of the battery levels is already being handled by the base system and as such is not pertinent for this system. Additionally, we can piggyback our power connection to the base system's bus bar, which is already controlled by a manual switch.

3.3 Voltage Regulation

The system will require 3 separate voltage levels - 5V, 12V, and 24V. Ideally, efficient switching power supplies should be used for the 5V and 12V levels, while the 24V can be supplied directly. At least 90% efficient power supplies should be used.

It may be worth considering power supplies with the same form factor for the 12V and 5V levels - this will allow the 5V supply to be replaced by an additional 12V supply or vice versa, should it be required. This may also be useful for separating the noisy motor power lines from the more sensitive laser system, should the noise become a problem.

3.4 Power Control/Switching

None of the systems would require power switching at this level. The motors are both controlled by dedicated controllers, making MOSFETs and the like unnecessary. The laser sub-system will contain a power-switching device too. No control by the main system will be required at this level.

3.5 Output Connection Protection Circuitry

The dedicated motor drivers each contain a replaceable fuse and back EMF protection for the motors. The laser sub-system will use ICs that handle fault conditions too. It may still be useful to use appropriately sized replaceable fuses on these outputs.

3.6 Power Monitoring/Indication

While the system will not be required to monitor the voltage or current at this level, the visual aid of an LED to mark a system as powered and operational is always useful and requires minimal cost or effort; therefore, an LED to indicate each of the states of the power input and outputs will be added.