Electrical Overview

Year: 2021 Semester: Spring Team: 16 Project: Smart Conveyor Belt System

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Assignment Evaluation:

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| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Electrical Overview** | 5 | x3 |  |  |
| **Electrical Considerations** | 5 | x3 |  |  |
| **Interface Considerations** | 5 | x3 |  |  |
| **System Block Diagram** | 5 | x3 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** | 5 | x2 |  |  |
| **Formatting and Citations** | 5 | x1 |  |  |
| **Figures and Graphs** | 5 | x2 |  |  |
| **Technical Writing Style** | 5 | x3 |  |  |
| **Total Score** | 100 | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

*Well done! Please see my comments.*

1.0 Electrical Overview

For our Smart conveyor belt system, we will be utilizing a 32-bit microcontroller (MCU) that is responsible for all of the sorting logic, sensor communications, and logical outputs. The inputs to the MCU would be the data coming from the sensors and the enable button, while the outputs would be the signals sent to the ESC, Servos, and a simple status LED.

The enable button tells the MCU to start or stop the conveyor belt, which the MCU does by sending a PWM signal to the ESC, which in turn controls a brushed DC motor.

The MCU will be communicating with a barcode scanner and a laser distance sensor over UART. The barcode scanner will tell the MCU the value read from the barcode on a package, which allows the MCU to figure what servo needs to be activated to properly sort the parcel. The laser distance sensor is responsible for measuring the distance between itself and the package, which the MCU can then use to calculate where it is on the belt in relation to the servos. Once the MCU knows the location and destination of the package, it sends a PWM signal to the servo whose job it is to sort the parcel.

2.0 Electrical Considerations

2.1 Operating Frequency:

Because of the speed of operation of our system, we need our MCU to operate as fast as it possibly can, so the operating frequency is determined by the max frequency of the MCU, which is 48 MHz. Since we will be sourcing power from the wall, power efficiency is not a concern.

2.2 Maximum-Load Power Budget:

The whole system will receive its input power from the wall through a singular DC power supply, meaning the servos, sensors, Brushed motor, and MCU all have to be powered from a single source that branches to all of the subsystems at different voltages, so to determine the power specification of the supply, we should go through the power requirements of each subsystem first.

To start, the component with the highest voltage is the Brushed DC motor [1], which we will run at a maximum of 12V. With this in mind, we will choose to make our power supply output voltage match the 12V voltage of the motor. Even though this motor could technically draw much more current, maximum current we expect the motor to draw 6A under max load, so our power supply must be able to output more than 72 watts.

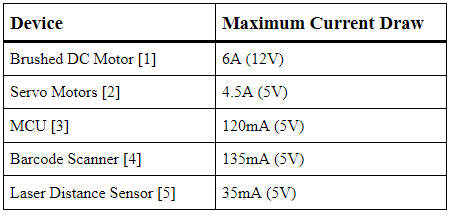
The components with the second highest power/voltage demand are the servo motors [2], with each one requiring a voltage of 5V and a maximum (stall) current of 1.5A. In order to power 3 servos at max current draw, we would need an additional 22.5 watts from our power supply, totaling 94.5 watts from the power supply so far.

Conveniently, all the other major components require 5V and have relatively low power consumption. The MCU [3] draws a maximum of 120mA, and both the barcode scanner [3] and the laser distance sensor [4] combined draws 170mA, totalling another 1.5 watts of power draw, which brings the total to slightly over 96 watts.

Something more to consider is the power consumed in the conversion from 12V to 5V, which is necessary due to the single power supply. Even though they operate at 5V, we will need to separate the servo motor’s voltage line from the mcu’s and sensor’s voltage line to keep the low power electronics safe from noise generated through current spikes from the servos. With a >90% efficiency for two parallel buck regulators [6] to convert a 12V input to two 5V 5A outputs, that will add about 4 watts to our power consumption, totaling 100 watts.

Touching back on the Brushed DC motor, we will likely be using an ESC [7] to drive the motor. It is difficult to say how much current/power is consumed by the ESC as they do not explicitly state that information in any document. Based on their load-test data [8], it was determined that the most power that could possibly be consumed for our application is about 15 watts. Considering our application uses 1/10th of the current used in the load test, 15 watts should be a generous overshoot. With that, the running total comes to 115 watts.

Finally, in order to ensure the safety of the power supply, it would be wise to add a 20% tolerance margin to the power rating for both the health of our power supply and to ensure that any low-power supporting circuitry (i.e., level shifters, isolating components, LEDs, etc.) will receive more than enough power under any conditions. With that said, the minimum viable rating needed for our power supply is 138W at 12V 11.5A.



2.3 Tolerances

Overall, tolerances are not a concern. Our brushed motor will operate at 12V but can handle up to 36V. The servo motors will operate at 5V but can go up to 6V. The buck converter can take inputs between 8V and 28V while still outputting 5V, so our system can handle an input fluctuation at the source between 8V and 28V without any ill effects.

3.0 Interface Considerations

We will be using one interface type, UART, in order to communicate with our barcode scanner [4] and our laser distance sensor [5]. This can be handled by two MCU pins per sensor: Tx and Rx. Our MCU can handle a maximum of 2 USART channels, meaning it can support both sensors without any additional circuitry.

The default baud rate of both sensors is 9600bps with 8 data bits and 1 stop bit, but the rate of the scanner can be manually set to as low as 1200bps and as high as 115200bps. The default baud rate should suffice, but we may exercise the ability to increase the baud rate of the barcode scanner in the future if we find it bottlenecking the operating speed of the whole system.

4.0 Sources Cited:

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Appendix 1: System Block Diagram

