Embedded Systems Integration

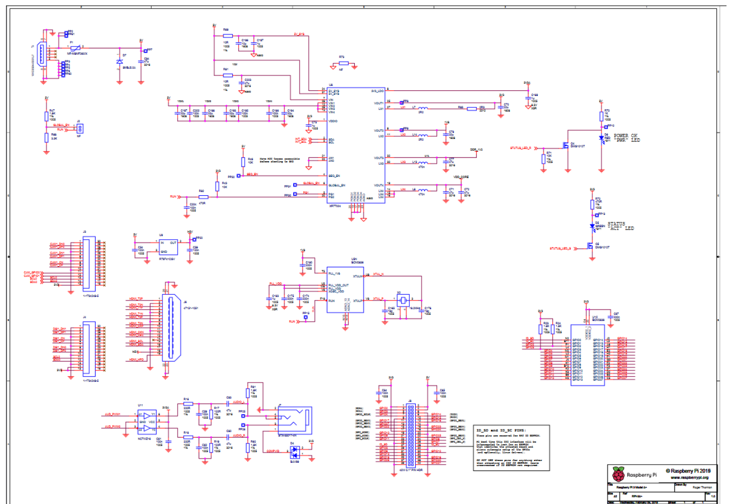
Overview:

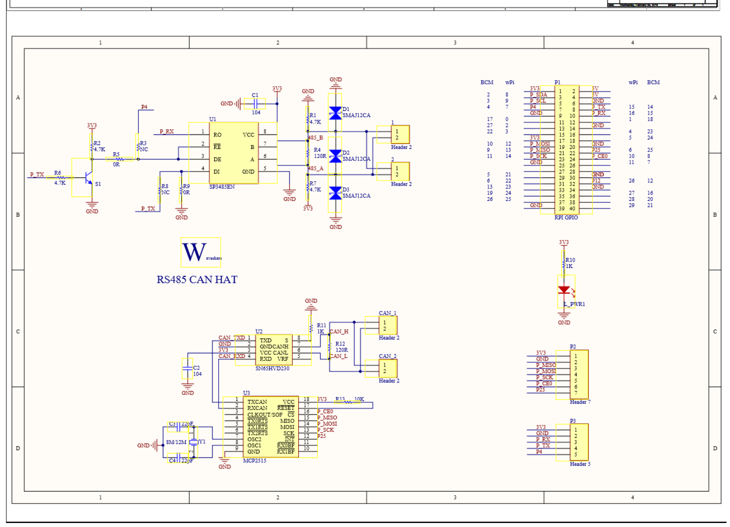
In order to create a platform on which to build the computer vision targeting system, it is necessary to integrate the VEX v5 Brain with an external device that would collect and process video.

Step: 1	Date: 12/05/2022	Engineer: Jeremy Eastham
Witness: Mariana Sanchez	Date Reviewed: 01/15/2023	

Objectives:

- Discuss and document design challenges
- Design appropriate solutions to these challenges
- Select appropriate hardware

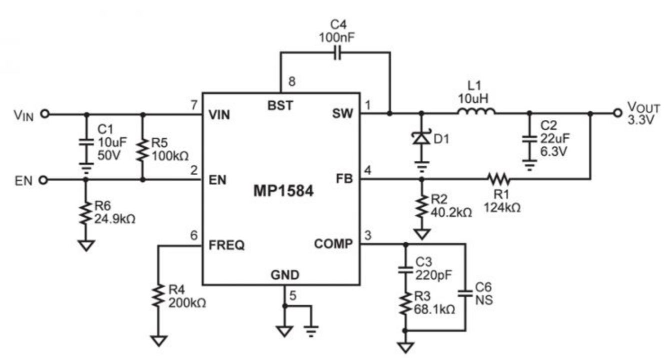




Remarks:

The Raspberry Pi Model 3 A+ was selected for its low power consumption, adequate processing power, ease of use, low-level access to hardware, and availability.

The first challenge the team encountered was interfacing with the VEX v5 Brain. There are three ways to interface with the Brain: through the Micro USB port, through one of the Brain's Smart Ports, or through a 3-wire Analog Sensor Port. The Analog Sensor Ports do not support bidirectional communication, which is a necessity in order for the Raspberry Pi to utilize odometry data. The team decided to interface with the Brain through a Smart Port due to its reliability, availability, and bandwidth. The Smart Ports are also connected directly to the VEX Brain's main power, making external power such as a battery pack unnecessary.



Next, the team needed to design the connection between the Pi and the Brain. On the software side, the Smart Port for the Pi can be accessed from the Brain as a generic serial port. This is an RS485 connection. In order to simplify this connection, the team decided to equip the Raspberry Pi with an RS485 CAN HAT. It would have been possible to implement the RS485 protocol at the software level, but the CAN HAT allows the Pi to interface with the Brain as a serial device, just like the Brain does. The CAN HAT also provides an easier mechanism for connecting the Smart Cord wires to the Pi.

The voltage that the Smart Port provides is too much for the Raspberry Pi, which does not have a built-in voltage regulator for its power pin. The team decided to wire an MP1584 Step-Down Voltage Converter in between the Brain and the Pi. This particular voltage converter was chosen because it holds constant voltage, regardless of input voltage. It is also easily adjustable with a potentiometer.

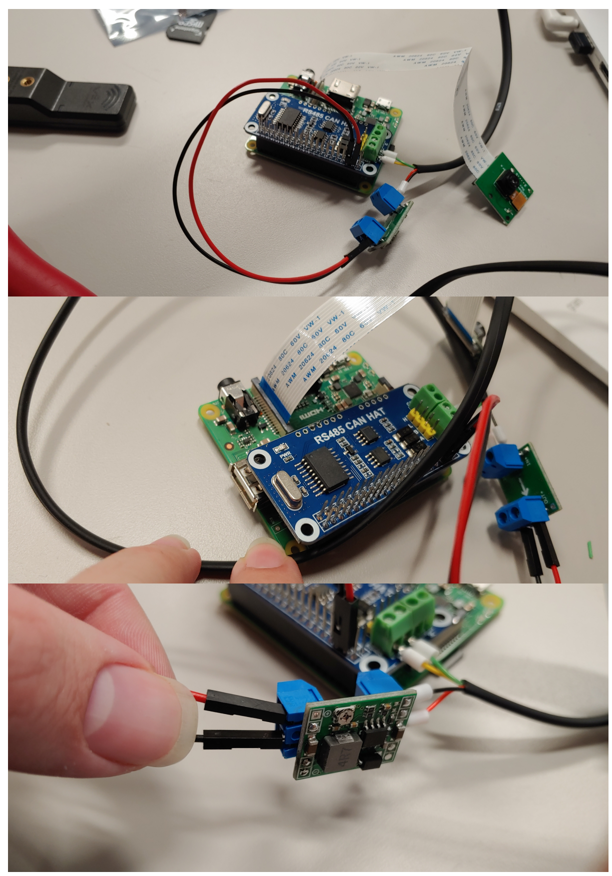
Accomplishments:

- Designed the Raspberry Pi assembly architecture
- Purchased and prepared hardware for building

Step: 2	Date: 12/14/2022	Engineer: Jeremy Eastham
Witness: Mariana Sanchez	Date Reviewed: 01/15/2023	

Objective:

- Build and test the Raspberry Pi assembly



Remarks:

Building this assembly was time-consuming. However, since both power and data are provided to the Raspberry Pi via a Smart Cord, the entire assembly can be easily moved between different robots for testing.

There were a couple of issues with this design. First, since the Raspberry Pi gets power from the Brain when the Brain goes to “sleep”, it kills the power to the Pi. This does not seem to be an issue, but the software implementation will need to account for sudden power loss. This can also be mitigated by running any program on the robot so that it does not go to sleep.

In order to enable serial communication over UART (the interface that the RS485 CAN HAT uses), it was necessary to disable terminal access to the Raspberry Pi over USB. Terminal access is still possible over Wi-Fi, but all wireless communication on the robot will have to be disabled for the competition. The team decided to solve this by loading programs onto the robot that give the Raspberry Pi certain commands, like enabling and disabling wireless communication. These sorts of commands can also be used for pre-flight checks.

Connecting over Wi-Fi was not reliable. A real-time video stream was not possible during testing, which could hinder our ability to debug issues with vision code.

Despite these issues, establishing the connection between the Brain and the Pi was successful and did not suffer from any data loss during testing.

Accomplishments:

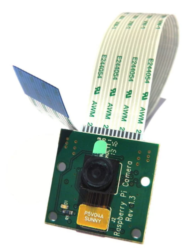
- Built the Raspberry Pi assembly
- Discovered potential issues with our design and discussed potential solutions

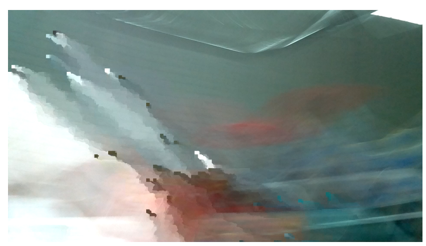
Step: 3	Date: 02/06/2023	Engineer: Jeremy Eastham
Witness: Mariana Sanchez	Date Reviewed: 02/21/2023	

Objective:

- Test cameras to attach to the Raspberry Pi

Remarks:





The first camera candidate was the Raspberry Pi Camera Module v1.3. It has a variety of resolution and refresh rate options, but it has a very narrow field of view. On our testbed halfway across the field, the camera view was not wide enough to see the ground. This is important because the vision algorithm may use other field elements to locate the goal. This camera also suffers from dramatic motion blur and slight desaturation, making this camera unusable for vision.

The next camera was the Microsoft Lifecam HD 3000 Webcam. This camera was noticeably better than the Camera Module. It features a wider field of view, less blur, automatic exposure adjustment, and a mount for attaching the camera to the robot. However, colors were still desaturated. This might be correctable with software, but it would be best to correct it with hardware. Distortion on the edges of the camera view could also be an issue, but more testing will need to be done when the vision algorithm is complete.

The final camera is the Logitech C270. This was the best camera out of the three that the team had access to for testing. It has the best color and also has automatic exposure adjustment and a mount.

Accomplishments:

- Discussed pros and cons of three different cameras