Component Analysis

Year: 2022 Semester: Spring Team: 08 Project: Gimbal Vehicle

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Assignment Evaluation:

| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| --- | --- | --- | --- | --- |
| **Assignment-Specific Items** | | | | |
| **Analysis of Component 1** |  | x2 |  |  |
| **Analysis of Component 2** |  | x2 |  |  |
| **Analysis of Component 3** |  | x2 |  |  |
| **Bill of Materials** |  | x6 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

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

General Comments:

*Relevant overall comments about the paper will be included here*

IMPORTANT NOTE: The Bill of Materials is a separate document and should be downloaded and filled out for another assignment. The Bill of Materials is to be submitted separately, per the course calendar (possibly on a different week), and will graded collectively with this assignment.

1.0 Component Analysis:

The first component we are analyzing is IMU which gathers the data needed for the auto adjustment of the gimbal. The second component we are analyzing is the servo motor which controls the movement of the gimbal. The third component is wireless module which transmit and receive data. The last module is BLDC motors which drive the wheel of our vehicle.

1.1 Analysis of Component 1: IMU (MPU6050)

In our product “Filming Vehicle”, there is a gimbal on top of the vehicle to keep the camera balanced. Therefore, a steadier video can be achieved. In order to control the movement of the gimbal, we need the data of the angle (Yaw, Roll, Pitch) of the vehicle. The more precise the angle data we can get, the more precise the gimbal can adjust itself to keep the camera balance. In order to get the angle data of the vehicle, we need an IMU (Inertial Measurement Unit) which includes a gyrometer and an accelerometer. We compared three different IMUs before making our decision on choosing MPU6050. The other two we compared it with are FSM305 and MTI-1-0I. The main feature we are concerned with is the precision of its measurement of the angular velocity and velocity. Secondly, we care about its price due to our limited budget. At last, we are looking for a product that has sufficient documentation available. First of all, the IMU MTI-1-0I came into our sight while searching online. It has a built-in magnetometer alongside the accelerometer and gyroscope. It is very useful for us because it can give the precise yaw angle of the unit without the need to do any calculations. However, it lacks official documentation which kept us away from choosing it as our IMU. There is only one page of the datasheet we are able to find online. Then, we noticed another IMU called FSM305. It has seventeen pages of datasheets which is decent. It also has a gyroscope range of 2000 deg/s and a resolution of 0.2 deg/s which is desirable for the purpose of our project. Nevertheless, it has an operating temperature of 0~50 degree celsius. Since our product will be operated outside regardless of the season, we ruled out FSM305. Finally, we found the MPU6050. It has more than thirty pages of datasheet which clearly listed all the registers of it and all its specifications and usage. It can operate in the range from -40~85 degree celsius which satisfies our requirement. Moreover, it has a price of only 8.72$ per unit which is significantly less than the ones of the other two. All the reasons above led to choosing MPU6050 as our IMU.

| **Feature** | **MPU6050[1]** | **FSM305[2]** | **MTI-1-0I[3]** |
| --- | --- | --- | --- |
| **Connectivity** | I²C | I²C, SPI, UART | I²C, SPI, UART |
| Operating Temperature | -40°C ~ 85°C | 0°C ~ 50°C | -40°C ~ 85°C |
| Sensors Included | Gyroscope, Accelerometer | Gyroscope, Accelerometer | Gyroscope, Accelerometer, magnetometer |
| Gyroscope Range | 2000 deg/s | 2000 deg/s | 2000 deg/s |
| Price | 8.72$ | 176$ | 149$ |

1.1 Analysis of Component 2: Servo Motor (MG996R)

The movement of the gimbal is achieved by two servo motors. There are several aspects we are mainly concerned with: amount of torque, power consumption, cost, and resolution of angular movement. We compared three servo motors in our component selection process. They are DS3218MG, MG996R, and SG90. Since the servo motors are expected to operate a large portion of the time. Therefore, we would like a servo motor with less power consumption given the nature of our product (a remote vehicle). One of the options has quickly been abandoned by us. LS-0009AF has a stall current of 900 mA-1A given its relatively small torque of 1.3 kgf·m. The other disadvantage of LS-0009AF is its high price. Between SG90 and MG996R, we selected MG996R because of its larger torque. Since our product allows the users to choose their own cameras to install on the gimbal and we expected some users would choose heavier cameras for a better video quality. Thus, we went with the higher torque one to prevent any difficulties of operation due to the weight of the cameras.

| **Feature** | **MG996R[4]** | **LS-0009AF[5]** | **SG90[6]** |
| --- | --- | --- | --- |
| **Control** | PWM | PWM | PWM |
| Operating Temperature | 0°C ~ 55°C | -10°C ~ 50°C | 0°C ~ 55°C |
| Stall Torque | 9.4 kgf·cm (4.8 V ), 11 kgf·cm (6 V) | 1.3 kgf·cm (4.8 V ), 1.5 kgf·cm (6 V) | 1.8 kgf·cm |
| Operating Speed | 0.17 s/60º (4.8 V), 0.14 s/60º (6 V) | 0.12 s/60º (4.8 V), 0.1 s/60º (6 V) | 0.1 s/60 degree |
| Stall Current | 500-900 mA | 900mA-1A | 360 mA |
| Price | 5.4$/unit | 28$/unit | 2.3$/unit |

1.1 Analysis of Component 3: Wireless Module (NRF24L01)

NRF24L01 wireless modules are used for data transmission from our controller and data receiveing for the vehicle. Because the wireless module will be responsible for continuously transmitting data from the joysticks to the MCU mounted on the vehicle, transmission stability is the most important aspect that we concern. ESP8266 was the other wireless module candidate. It supports both Radio and Wi-Fi transmission and can be cinfugred to communicate by I2C, SPI and I2S protocoal. However, NRF24L01 has a better performance in long range data

transmission. ESP8266 is commonly used in IoT projects, which is not the field of project. Therefore, our final decision is to use NRF24L01 as the wireless transmission module

| **Feature** | **NRF24L01[7]** | **ESP8266[8]** |
| --- | --- | --- |
| Peripheral Intergace | Serial Peripheral Interface | SPI, I2C & I2S |
| Operating Voltage | 1.9-3.6 V | 2.5-3.6 V |
| Max Data Transfer rate | 2Mbps | 7Mbps |
| Communication Range | 800 m | 336 - 479 m |
| Price | $2/unit | $8/unit |

1.1 Analysis of Component 4: (BLDC Motor with hall sensor rotary encoder)

In our implementation, we used BLDC Motor with a hall sensor rotary encoder (LA37D-208).

We had fair enough voltage supply in our module. Therefore, we decide to use the type with stronger torque, speed, yet consump more power. One special thing needs to be mentioned is that not many motors at this size contain a hall sensor rotary encoder. So our choices are highly limited.

A brief introduction of hall sensor rotary encoder. Each wheel motor is inserted with 4 different sections of magnetics with an alternative magnetic source of N and S. A change of magnetics field will cause the electrons on the plate to alter its position from side to side. We measure the voltage difference of two sides of the plate, we have the information of which part of the magnet is closer to the plate now. This alternating behavior of magnetics will result in a square wave in voltage, since we have an equivalent number of N and S, this square wave would be a PWM wave with 50% duty cycle. We can obtain all of the information we need using this output duty cycle.

These two parts at the bellowing chart are popular choices we have found. Like I said, we have more than enough power supply. we believe it would be sensible to choose the one with high power output. So, we assign our vehicle with sufficient functionalities to accomplish the ability of omnidirectional move, and the ability to move on multiple terrains.

| **Feature** | LA37D-208 | LA37D-221 |
| --- | --- | --- |
| Connectivity | PWM | PWM |
| Rated voltage | 12V | 12V |
| Reduction ratio | 1:30 | 1:19 |
| No-load speed | 333rpm | 530rpm |
| Rated torque | 3.5 kg.cm | 2.2 kg.cm |
| Rated current | 2.3A | 2.5A |
| locked-rotor current | 5 kg.cm | 3.1 kg.cm |
| locked-rotor torque | 22 mm | 22 mm |

2.0 Sources Cited:

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