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FORMAT OF REPORT

Requirement Level - Number

Status:

Complete or Incomplete

Requirement Description:

Level 1 or 2 requirement description.

Verification:

Description for means to test the requirement.

Method of Validation:

Description for means to prove the requirement meets Mission Profile.

Justification:

Description for why this requirement is needed.

Result:

The team was able or unable to complete this requirement.

Issue:

Description of the general concept that was detected.

Example:

1. An example of the conceptual issue.

Lesson:

1. Description of a solution.

Requirement Level 1 - 1

Status:

Incomplete

Requirement:

The µBiPed robot shall be fully assembled and ready to test by December 16, 2015 (Day of Final for 400 D).

Verification:

The date of completion is specified by the course instructor and can be found from the following link: http://web.csulb.edu/~hill/ee400d/Lectures/Week%2014%20Housekeeping/a_Meeting%2014%20Agenda%20F'15.pdf

Method of validation:

The goal is to complete the program and project requirements by the date assigned by the course instructor.

Justification:

This requirement is a high level statement that focuses on overall completion of the program and project. If the team cannot complete this project, the results must show signs of completion. It is important for the team to consider the last phase (testing the product); errors that occur during this phase can affect the result of this requirement.

Result:

The group was unable to fully complete all program and project requirements by December 16, 2015.

Issue:

The team was unable to complete the project due to timing contingencies during two phases of the project:

Examples:

1. The structure was not printed during its time allotted according to the project schedule
2. The PCB assembly and testing was not completed during time allotted according to the project schedule.

Lessons:

1. The project manager must be aggressive in pursuit of completing action items.
2. The tasks provided to each engineer must be clearly defined and separated.
    a. Each task should be in line with Level 1 and 2 requirements.
    b. Each subsystem engineer must be able to work independently.

Requirement Level 1 - 2

Status:

Completed.

Requirement:

According to 2014-2015 ARXTERRA µBiped's parts list, the project shall cost no more than $400.00.

Verification:

All receipts of purchased materials for the creation of the µBiPed robot will be added up.

Method of validation:

The purchases that add to total cost must have been accounted for in the budget and used.

Justification:

The budget is set to ensure that the project is affordable for student purchase or for the school to fund. Although the project objective is a feasibility demonstration, the intent is to create a toy product. If the cost of completion is too high, the company will not be able to make any revenue from this merchandize.

Result:

The team was able to complete this requirement.

Issue:

Considering this year's model is a prototype with high deviations from previous BiPed robots, the cost of production resulted in high contingencies.

Example:

1. The designed foot does not support pose needed to advance in forward direction.

Lessons:

1. Produce series of cheap prototypes as quickly as possible.

Requirement Level 1 - 3

Status:

Completed.

Requirement:

As the prefix “Bi” in BiPed implies, the μBiPed shall only traverse on 2 legs.

Verification:

The structure must be designed and produced resulting with 2 lower limbs for the purpose of walking.

Method of validation:

The μBiPed robot will be observed during project demonstration to show human-like walking motion.

Justification:

The purpose of creating a bipedal robot promotes the study of structure in relation to motion. The definition of bipedalism can be found at https://en.wikipedia.org/wiki/Bipedalism#Bipedal_robots.

Result:

The team was able to complete this requirement.

Issue:

The issue of creating a bipedal robot is balance. Implementation of balance is balanced between structural and system control support. The issue came in creating an aesthetically pleasing design that must also be ductile and practical.

Example:

1. The printed head and tail came out to be too heavy.

Lessons:

2. Product series of cheap prototypes as quickly as possible.

Requirement Level 1 - 4

Status:

Completed.

Requirement:

To be considered a miniaturized Biped robot, the μBiPed shall range between 0.6 (120mm) ± 10% of Rofi's dimensions according to the ratio of an MG92B μservo to Rofi's servo.

Verification:

The μBiPed must be measured to have dimensions that meet the requirement of being near 120 mm.

Method of validation:

The μBiPed robot will be placed next to ROFI to be measured for height and width.

Justification:

Ensures that the project is meeting the definition of customer definition of producing a micro-sized project.

Result:

The team was able to complete this requirement.

Issue:

The limbs were unable to support balance independent of the proposed shoes (a solution discussed during Creativity experiment that was rejected by the President and VP during PDR review).

Example:

1. The foot needed more weight and thus a prototype of a shoe has been implemented.

Lessons:

3. Product series of cheap prototypes as quickly as possible.

Requirement Level 1 - 5

Status:

Incomplete

Requirement:

In accordance with the obstacle course, the μBiPed shall walk up an incline that starts initially at 8° and then decreases to a 6° slope in relation to level ground.

Verification:

The μBiPed will be placed on a path with an incline and decline to verify the structure stays balanced.

Method of validation:

We will test the μBiPed robot's ability to walk up the incline portion of the specified course (VEC 501).

Justification:

The purpose of this requirement is to demonstrate that the μBiPed is able to stabilize itself on uneven surfaces.

Result:

The team was able unable to complete this requirement.

Issue:

During the brainstorming phase of the class, we understood that this year's model will have high contingencies due to a complex design innovation in the structure. The proposed idea was rejected by the President and VP.

Example:

1. To account for the unprecedented error, we proposed the idea of adding shoes to aid structural integrity.

Lessons:

1. Although this year's model was unable to include shoes as a requirement, future generations can use this information to include this into their planning.

Requirement Level 1 - 6

Status:

Incomplete

Requirement:

In accordance with the obstacle course, the μBiPed shall walk on surfaces of varying friction coefficients.

Verifications:

The μBiPed prototypes will be placed on varying surfaces to observe motion and structural integrity.

1. Carpet: 1.0 static
   Verification: http://www.sciencedirect.com/science/article/pii/S187770581000367X
2. Linoleum: 0.5 static

Verification: http://www.sciencedirect.com/science/article/pii/S187770581000367X

3. Rubber: 1.0 static
   Verification: http://www.sciencedirect.com/science/article/pii/S187770581000367X

Method of validation:

The μBiPed will walk across the different portions of the specified course (VEC 501).

Justification:

The purpose of this requirement is to demonstrate that the μBiPed is able to stabilize itself on uneven surfaces.

Result:

The team was unable to complete this requirement.

Issue:

Same issue as Requirement Level 1 - 6

Requirement Level 1 - 7

Status:

Completed.

Requirement:

In accordance with customer specifications, the μBiPed shall communicate wirelessly on Bluetooth to an Android phone app.

Verification:

The μBiPed will be tested for remote control functions via Arxterra App from the Android phone (Moto G).

Method of validation:

The μBiPed will be tested for walking during the Project Demonstration by the Arxterra App from the Android phone (Moto G).

Justification:

The project has been specified by the customer to have wireless communication. Furthermore, considering that the intent of the design is to create a toy, having remote control capabilities is a must.

Result:

The team was able to complete this requirement.

Issue:

The designed PCB was did not account for the complete usage of all the ICs.

Example:

1. The Bluetooth IC needed 4 more pins on the PCB.

Lesson:

1. Design the PCB not just for efficiency, but also for ergonomics in regards to troubleshooting.

Requirement Level 1 - 8

Status:

Completed.

Requirement:

In accordance with customer specifications, the μBiPed shall have a payload that outputs a toy-like behavior. The current proposal for a payload is to use a cheap sensor that can react to certain changes in the environment.

Verification:

The sensor will have an object ahead of it to detect. The data must be acknowledged by the Arduino for processing. The values will then be read in Arduino IDE to verify that the numbers correlate to distance away from the object.

Method of validation:

The μBiPed shall be able to detect obstacles and stop in the direction of the obstacle regardless of remote commands.

Justification:

The project has been specified by the customer to have a payload. Furthermore, considering that the intent of the design is to create a toy, having multiple product functions gives it the flare needed to incentivize purchase.

Result:

The team was able to complete this requirement.

Issue:

Past designs have used the sensor to act as eyes. This year's model did not allow for this aesthetic design.

Example:

1. Because the head is designed to counter-balance the weight distribution of the walking motion, its movements (swing from left to right).

Lesson:

2. Use the proper sensor or consider sensor placement during planning Level 2 requirements.

Requirement Level 2 - 1

Status:

Completed.

Requirement:

To create a toy built for the attention span of a child between the ages of 7-12 years old, the μBiPed shall last 7-15 minutes on a single battery charge.

Verification:

The battery will be tested with a load equivalent to the finalized design of the μBiPed.

Method of validation:

The μBiPed will be tested to last 7-12 minutes during the Project Demonstration.

Justification:

The intent of the project is create a bipedal toy. This requirement is connected to a Level 1 requirement that can neither be verified nor validated without a third party.

Result:

The team was able to complete this requirement.

Issue:

None

Requirement Level 2 - 2

Status:

Completed.

Requirement:

To maintain balance (while retaining core features of bipedal motion), installment of a head and tail will be incorporated to the structure to aid in centering the structural balance.

Verification:

The assembly of the head and tail on the overall structure will be tested for balance with and without code for walking.

Method of validation:

The μBiPed shall demonstrate the head and tail's ability to help balance the body while walking the course.

Justification:

Because the design limits the degrees of freedom at the hip joint, the head and tail are used to offset the needed degrees of freedom for balance.

Result:

The team was able to complete this requirement.

Issue:

The issue came with weight distribution from the addition of a head and tail to the structure.

Example:

1. The printed head was too heavy for the tail to balance.

Lesson:

4. Produce series of cheap prototypes as quickly as possible.

Requirement Level 2 - 3

Status:

Completed.

Requirement:

To reduce the dimensions of the Biped, the μBiPed shall use a two-servo to one-leg system to eliminate bulkiness.

Verification:

The produced design should be a structure that can hold two servos that attach to a single leg.

Method of validation:

The μBiPed shall demonstrate its mobility (walking motion) during the Project Demonstration.

Justification:

The previous semesters utilized 6 servos per leg to increase the articulation and degrees of freedom, but this in turn increased the bulk, weight, and the height. A structural approach will be used to control the legs to imitate a velociraptor model.

Result:

The team was able to complete this requirement.

Issue:

The servos only existing at the hips limited the mobility.

Example:

1. The ankle needed more structural and/or control support.

Lesson:

1. The ankle can be supported by addition of a shoe or a servo at this joint.

Requirement Level 2 - 4

Status:

Incomplete

Requirement:

For the μBiPed to detect and adapt to inclines, a gyroscope shall be used to preserve chassis balance.

Verification:

The gyroscope will be integrated onto the structure and physically moved for the data to be collected in the microcontroller. Arduino IDE will then show if the data is linear to the displacement.

Method of validation:

During the Project Demonstration, the μBiPed shall be able to adapt to inclines without discontinuing its walking motion.

Justification:

The μBiPed shall move up an incline and down a decline. To adapt to such scenarios, the μBiPed must be able to keep the body balanced by adapting to its relative center of gravity.

Result:

The team was unable to complete this requirement.

Issue:

The data from the gyroscope did not meet the requirement to adapt to inclines.

Example:

1. The gyroscope focuses more on Earth's gravity rather than the object.

Lesson:

2. An accelerometer can detect the object's orientation (dynamic acceleration). Studying this can help adjust the center of balance in respect to the object's orientation rather than Earth's gravity.

Requirement Level 2 - 5

Status:

Completed

Requirement:

The μBiPed's extra feature is to avoid walls at a specified distance (25 cm). The payload used is an ultrasonic sensor (HC-SR04) and meets Level 1 – 8 requirement of having a toy-like behavior.

Verification:

The HC-SR04 will be integrated to the PCB. Once energized, the data in the microcontroller will be measured to check if it is linear to the analog data (measure the distance away from the wall).

Method of validation:

During the Project Demonstration, have the μBiPed intentionally walk towards a wall and observe if it will autonomously stop when facing the wall.

Justification:

For safety and control purposes, if the μBiPed walk towards an object, i.e. a wall, it must stop to avoid danger.

Result:

The team was able to complete this requirement.

Issue:

None

Requirement Level 2 - 6

Status:

Complete

Requirement:

To facilitate all the algorithmic functions of a walking Biped, the Arduino MICRO (with an ATmega 32u4 Microcontroller) will be used.

Verification:

Method of validation:

An Arduino micro will be purchased and used for creating the walking code.

Justification:

With the reduced amount of servos, the amount of PWM pins required are also reduced. Furthermore, the MICRO is smaller in dimensions. Therefore the Arduino MICRO is the better choice (than an Arduino UNO) for the μBiPed.

Result:

The team was able to complete this requirement.

Issue:

There were more inputs from the system than there was space provided by the Arduino MICRO.

Example:

1. The addition of PWM data from the head and tail could not fit on the MICRO.

Lesson:

2. An addition of a Servo Driver was embedded to the design of the PCB.

Requirement Level 2 - 7

Status:

Complete

Requirement:

In regards to Bluetooth communication with the Arxterra app, an HC-06 wireless adapter will be used.

Verification:

The HC-06 will be connected to the microcontroller. Once energized, a user will use the Arxterra Application from an Android Phone to give control commands. The connection can be verified by observing the Command Handler.

Method of validation:

The connection will be validated during the Project Demonstration when the user must send control commands to the μBiPed. If the μBiPed articulate motion, the connection is valid.

Justification:

To be controlled by an Android app, the machine must have a wireless adapter to enable wireless communication.

Result:

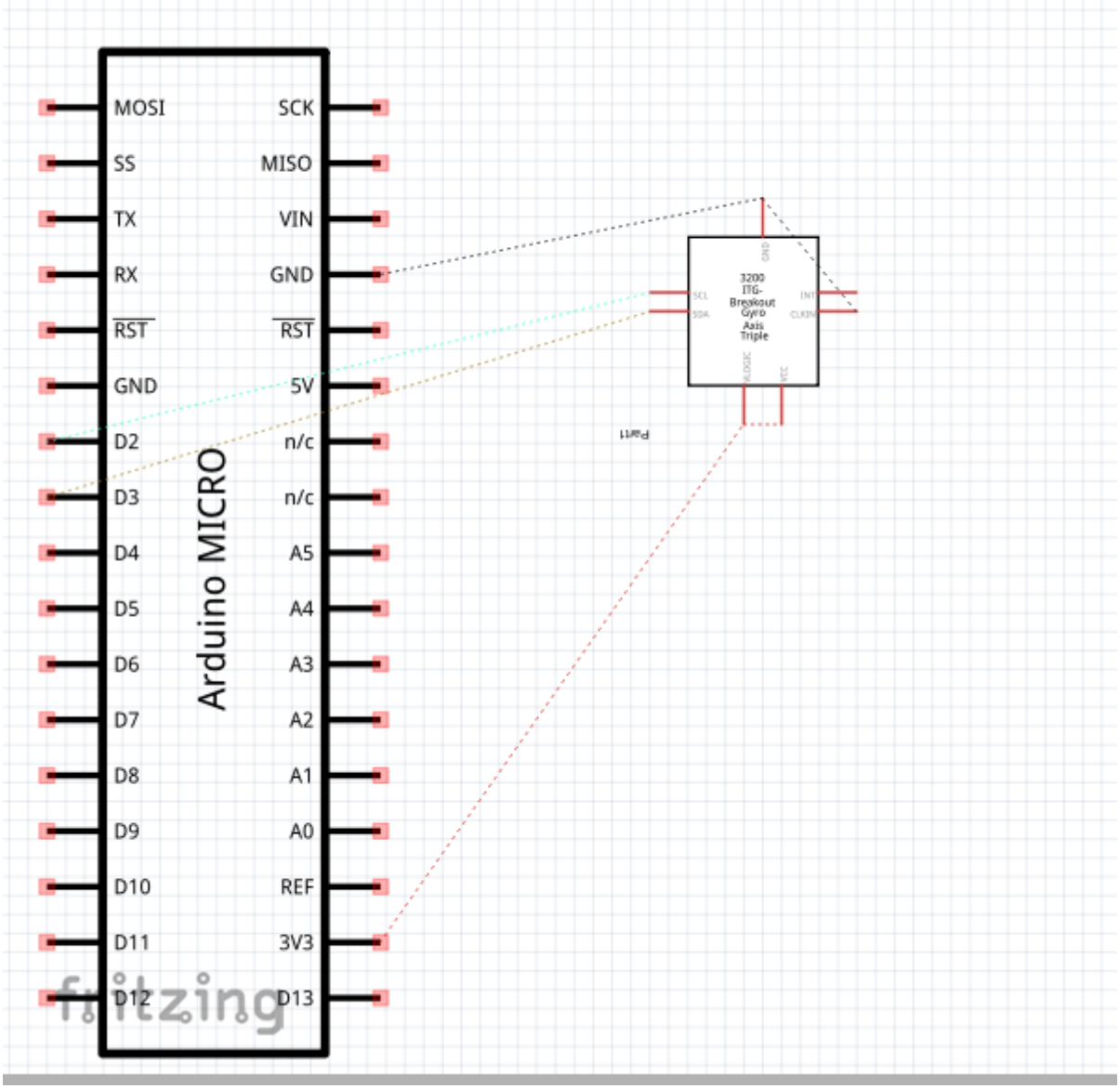
The team was able to complete this requirement.

Issue:

None

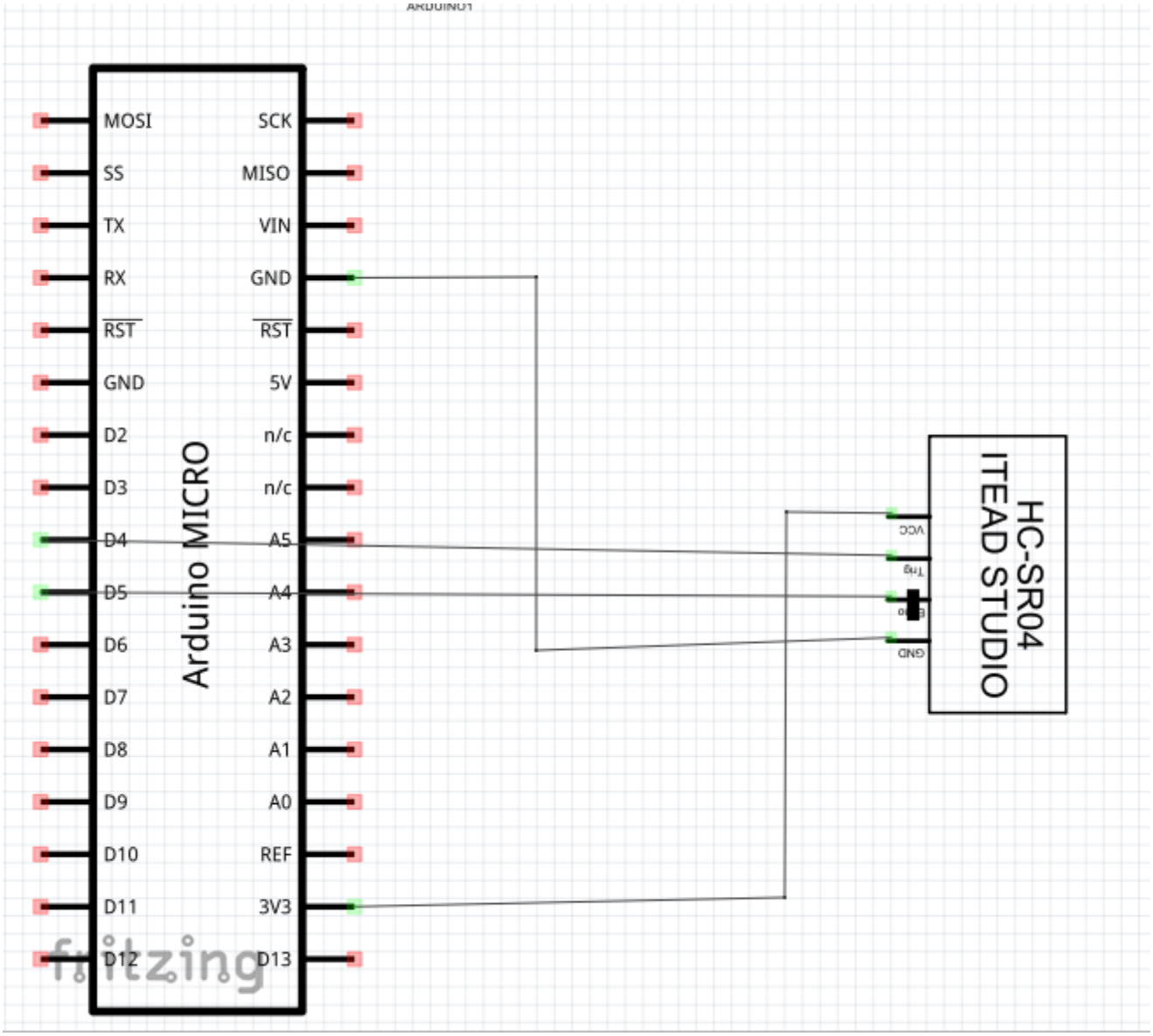
APPENDIX A

REQUIREMENT LEVEL 2 – 4



APPENDIX B

REQUIREMENT LEVEL 2 – 5



APPENDIX C

REQUIREMENT LEVEL 2 – 7