# Group 29

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**Section 1: Design Evaluation**

* *You should concisely explain the overall design of your software and hardware.*
* *You must present your workflow, an overview of the hardware design, and an overview of the software functionality. (Done)*
* *You must briefly talk about your design choices before arriving at your final design. (Done)*
* *Visualizing hardware and software with graphics (i.e. flowcharts, class diagrams) must be shown.*
* *Make sure to mention how you arrived at tuning your Bang-Bang controller and P-type controller constants (i.e. bandcenter, bandwidth, P-type constant).*

Workflow

When we first start thinking about this lab, we started by brainstorming ideas on what we needed for this lab.  We started doing research on different possible hardware design for our vehicle. Then, we continued by looking at the theory for the software design. We began by the bang-bang follower then move on with the proportional type follower.

Hardware part

When we started thinking about the hardware part, we decided that the best option was to try several designs before settling for one. Our first design had four wheels: the front wheels were the one driven by the motor and two little wheels in the rear center of our engine. This design wasn’t optimal because, the robot had problems in term of mobility. The second design we tried was slender. We put the EV3 on an elevated platform which help to bring the wheels on the inside. However, the design was not stable and often collapsed. Our final design has three wheels: the two fronts wheels being the motored one and the gyroscope as the back wheel for better mobility.

\*\*\*add pictures\*\*\*\*

Controller Tuning

* **Bandcenter:** Through trial-and-error we discovered that because of our robot’s wide design, we had to increase the bandcenter so that it did not clip the corners of a block during a U-turn.
* **Bandwidth:** Due to our increased bandcenter, and wider frame, we had to increase the bandwidth to allow the robot more space to move before adjusting. This, combined with our quick adjustments (discussed in Band-Bang Controller below), allowed the robot to not constantly make tiny jittery adjustments, but instead make large quick moves when going straight or making U-turns, as well as while passing gaps.
* **Bang-Bang Controller:** We began with small changes in the delta speedand tested how effectively and quickly the robot traversed the test course. We tested different ‘motorHigh’ values as well just to quicken the pace of the robot during U-turns but decided the pre-defined value of ‘200’ was perfect. As the robot traversed the course successfully we increased the delta speed to make its adjustments quicker and allow it to stay tight against the wall. The final value we landed on was ‘190’ as opposed to ‘200’ which would have stopped the motor completely (The only reason we didn’t use ‘200’ is because ‘190’ gave us better test results)
* **P-Type Controller:** We used the error (distance - bandcenter) to gauge the change in speed of the outer wheel. Using many different types of linear equations to test what works best, we soon realized the large jumps in the error (when the ultra-sonic sensor looked through a gap) caused the speed to exponentially increase, thus we added upper and lower bounds to limit the speed at which the outer wheel could spin.

**Section 2: Test Data**

This section describes what data must be collected to evaluate your design requirements. Collect the data using the methodology described below and present it in your report.

**Testing the P-type controller constant**

1. Choose 2 values above and below your P-type controller constant used in the demo.

2. Run the **robot** using the **P-type controller**.

3. Note its performance, i.e. band center and oscillation behavior, for the 2 cases.

**(Current constant: 10)**

|  |  |  |  |
| --- | --- | --- | --- |
| Test Type | Controller Constant | Band Center | Oscillation Behavior |
| Higher constant | 20 | 35 | Oscillates more frequently as changes are more drastic (outer wheel accelerates faster as compared to the previous controller constant) |
| Lower constant | 5 | 35 | Oscillates less frequently as changes are slower (outer wheel accelerates slower) |
|  |  |  |  |

**Table of data 1: P-type controller constant**

**Bang-Bang controller test** (*3 independent trials*)

1. Place the **robot** at the starting corner of a **wall**.

2. Ensure the **wall** contains convex corners, concave corners, and gaps.

3. Run the **robot** using the **Bang-Bang controller**.

4. Check if it completes a lap without touching the **wall**.

5. Note its performance, i.e. band center and oscillation behavior for each trial.

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Successful Lap | Band center | Oscillation behaviour |
| 1 | Yes | 35 | Mild |
| 2 | No | 15 | Mild |
| 3 | Yes | 55 |  |

**Table of Data 2: Qualitative Data for Bang Bang Controller**

**P-type controller test** (*3 independent trials*)

1. Place the **robot** at the starting corner of a **wall**.

2. Ensure the **wall** contains convex corners, concave corners, and gaps.

3. Run the **robot** using the **P-type controller**.

4. Check if it completes a lap without touching the **wall**.

5. Note its performance, i.e. band center and oscillation behavior for each trial.

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Successful Lap | Band center | Oscillation behaviour |
| 1 | Yes | 35 | Mild |
| 2 | Yes | 15 | Less |
| 3 | Yes | 55 | More |

**Table of Data 3: Qualitative Data for P-type Controller**

**Section 3: Test Analysis**

Compare the performance of both controllers. Make sure to refer to your test data.

**What happens when your P-type constant is different from the one used in the demo?**

**How much does your robot oscillate around the band center?**

**Did it ever exceed the bandwidth? If so, by how much?**

**Describe how this occurs qualitatively for each controller.**

**Section 4: Observations and Conclusions**

**Based on your analysis, which controller would you use and why?**

Upon analysis of the two systems, it can be concluded that the P-Type controller better controls the system than the Bang-Bang controller. With the Bang-Bang Controller, the system can reach its desired output quicker, however, its quick rise time comes with the cost of overshoot and an oscillating steady-state condition. The increased control of the motor position in the Proportional controller comes with the cost of the system being over-damped for gains of 0.001 and less. With the flywheel attached, the moment of inertia of the motor system is increased which is why both control systems lose a degree of stability with the flywheel attached.**?????**

**Does the ultrasonic sensor produce false positives (detection of non-existent objects) and/or false negatives (failure to detect objects)? How frequent were they? Were they filtered?**

**Section 5: Further Improvements**

**What software improvements could you make to address the ultrasonic sensor errors? Give 3 examples.**

**What hardware improvements could you make to improve the controller performance? Give 3 examples.**

**What other controller types could be used in place of the Bang-Bang or P-type?**

### *Integral control:*

*A control signal produced by the integral controller is altered at a rate proportional to the error (i.e.) the control signal maximizes quickly if the error is big, and the control signal maximizes slowly if the error is small. This can be represented as:*

*m(t) = Ki ∫ e(t) dt*

*Here, the Ki denotes the integrator gain.*

*The transfer function will be:*

*M(s) / E(s) = Ki / s*

*Here, the 1/s is used for integration.*

*Source: http://www.roboticsbible.com/different-levels-of-robot-controller.html*