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| Battery State of Charge Estimation with Youla Parameter Control Design |
| MAE 273A SISO Optimal Robust Control Final Project |
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| Abstract |
| *Abstract goes here.* |

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# Introduction & Literature Review

## Project Introduction:

The goal of this project is to implement the method of Youla Parameterization, as an effective means of estimating the State of Charge or SOC, of a Lithium Ion battery.

## Literature Review:

Introduce your project and briefly review the sources you used for this paper. This is expected to be 1-2 papers at most. Cite references in the text using IEEE style [1].

# Body

## Battery Technology & Modeling:

Like most engineering systems, the physical description of a batteries operation is define by Partial Differential Equations. Tthe predominate issue with controlling or estimating states defined by complex models such as PDEs is the inability to compute solutions without extensive computational resources and time. In the domain of real-time engineering systems, these models do not meet the cost/performance trade off required to make them a viable solution. Instead, it is desired to develop a finite dimensional model capable of matching the dominate dynamics of the system, and whose implementation cost is within reason. In the realm of system modeling, this typically suggests a lumped parameter model. The benefits of a such a model is the ability to capture large dynamics while maintaining computationally inexpensive.

To bypass this problem, it is desired to use simplified low order dynamic models that are numerically tractable for the intended application. This leads to the use of “Equivalent Circuit Models” (ECMs). The benefit of ECMs is their inherent ease of derivation and application which becomes apparent in commercial uses where computing overhead is extremely limited, for cost considerations.

### Equivalent Circuit Model

## Estimation Techniques:

### Controlled Output Observer

A “Controlled Output Observer” or COO, is a method which effectively reframes an observation problem ( such as a Luenberger Observer) into an output tracking problem. This is achieved by implementing a linear estimated version of the desired plants dynamics, and designing a controller which takes, as its input, the measured output of the actual plant, and attempts to track

### Kalman Filter

## Simulation and Testing:

## Results

## Youla Estimation versus Kalman Filtering:

You can title this section as you see fit, and structure it appropriately with subsections and so on.

## Figures

Figures should be centered on the page. Every figure should be numbered, have a caption, and be cited in the text. For example, see Figure 1. If you have many figures, you may find it useful to use Word’s Cross-Reference feature to keep track of figure, table, and equation numbering.

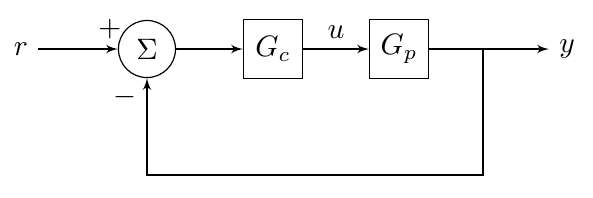


Figure - A simple block diagram as an example of how to structure a figure.

## Tables

Tables of data should be treated like figures: centered, captioned, and cited in the text. For example, see Table 1.

Table - This is a caption.

|  |  |  |
| --- | --- | --- |
| Column 1 Title | Column 2 Title | Column 3 Title |
| 1 | 5 | 9 |
| 2 | 6 | 10 |
| 3 | 7 | 11 |
| 4 | 8 | 12 |

## Equations

Equations should be on their own line and centered. Be sure to define all terms used in the equation. For example,

where is force, is mass, and is acceleration.

# Conclusions and Future Work

Briefly summarize your project and its findings. Discuss any open questions or potential avenues for further research.

# References

Use IEEE format for your references. It is useful but not necessary to use Word’s built in features for references and bibliographies.

|  |  |
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| [1] | IEEE Periodicals, "IEEE Reference Guide," IEEE, Piscataway, NJ, 2018. |

# Supplemental Material

Include all Matlab code (Matlab has a “publish” feature that will help format your code nicely for Word). If you have Simulink models, include pictures of the models and code for any user-defined functions. If applicable, include additional figures and any other important work that you did not include in the body.

## Matlab Code

### File 1

(code here)

### File 2

(code here)

## Simulink Models

### Model 1

(image here)

(code for user-defined functions here)

## Additional Figures

## Anything Else