AUTOMOTIVE ENGINEERING-II

MEEN 689 - Project:IV

An Attempt towards Better Battery Efficiency in EVs

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1 Abstract

Electric vehicles are the order of the decade and will be for next decades to come. With the advent of Electric vehicles in the automobile sector,they have been a strong competitor for traditional IC engine, with a noble motive of reducing carbon footprint.However when it comes to challenges faced by EVs there comes two main hindrances that are currently being heavily researched, viz. Range and Battery charging. Every OEM is looking into manufacturing EVs with higher range, less battery charging time and better battery efficiency. In this project an attempt has been made to discuss an unique model for better battery efficiency and also inductive charging of EVs using Dymola.

2 Introduction

In this model two battery packs, two motors and a simple control algorithm is used to show a better battery efficiency compared to only one battery pack. The batteries supplement each other and take turns in driving the vehicle, when the voltage of second battery has been reduced below certain threshold, the other battery comes into picture and drives the vehicle. During this time the batteries are being charged by motor-generator unit. Switches are used to switch on and off different parts of the circuit. The switches are controlled by a controller unit which takes feedback from battery voltage to determine right operation of switches.The results are presented in comparison with a model containing only one battery. The battery model is connected to a gear reduction and finally connected to a vehicle model representing losses in a vehicle coming from drag and other frictional losses.

In the second part of this project, discussion on simple inductive charging of battery is presented. Inductive charging could be an alternative to plug in charging. In inductive charging the vehicle is charged through electromagnetic coupling without any actual electrical connection.With the increase in the awareness of Evs, this charging method could be beneficial when comes to charging vehicles.

3 Modeling

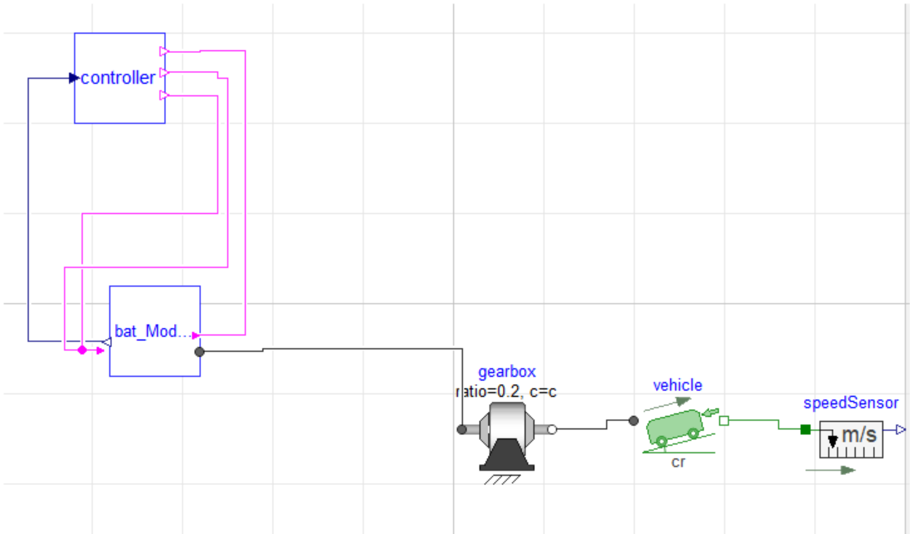

Figure 1: Block diagram for dual battery model

3.1 Dual Battery model

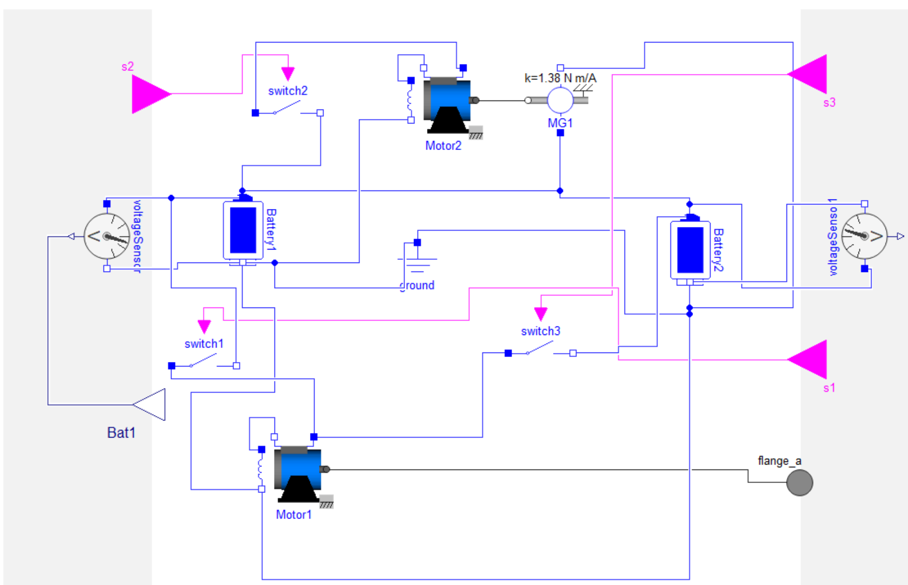

Figure 2: Model showing circuit connection of Dual battery model

The dual battery model shown in Fig.2 consists of two batteries, two motors, three switches and one motor-generator unit. Among two motors one motor is connected to the final drive and the other is connected to the Motor generator unit. The motor connected to final drive draws current from battery 1 and the motor connected to motor-generator unit is also connected to battery 1. here the motor generator unit is represented by a electromagnetic-force(emf) producer. There are three switches which are controlled by a simple control algorithm, that determines which switches are to be on and which switches are turned off. The parameters for all the elements used in the model are given in appendix-A.Switch S1 connects first battery to driving motor. Switch S2 is connected between the motor driving motor-generator unit and battery 1 and switch S3 is connected between battery 2 and final drive motor.

3.2 Control Algorithm

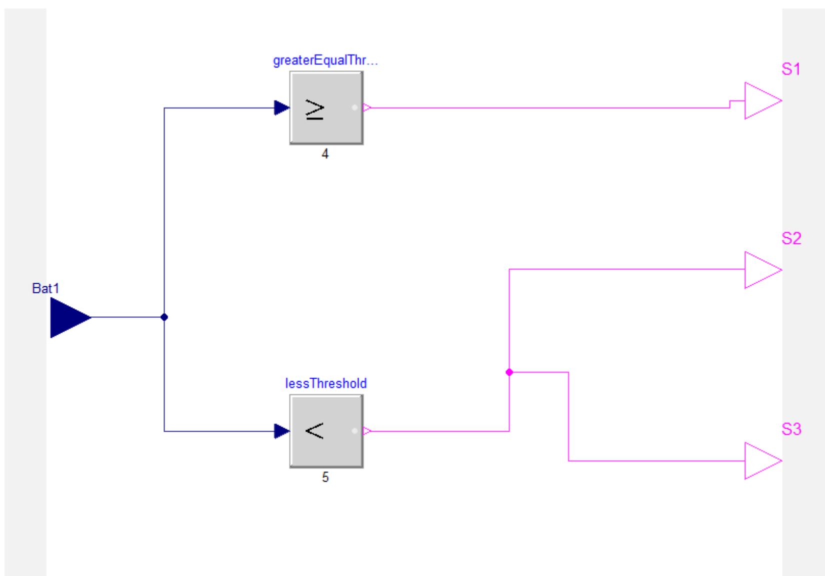

Figure 3: Simple control algorithm for choosing the switch operations

The control algorithm is a simple algorithm that determines which switches are to to be turned on and which switches are to be turned off based on the feedback voltage from Battery 1. When the feedback voltage is less than threshold value of 4V, switch S1 is turned off and switch S2 and S3 are turned on. When the feedback voltage is greater than threshold value 5V the switch S1 is turned on and switch S2 and S3 are turned off. However when the feedback voltage is between 4 and 5 V , all three switches are turned on.The flow chart for the switch operations are shown in Fig. 4.

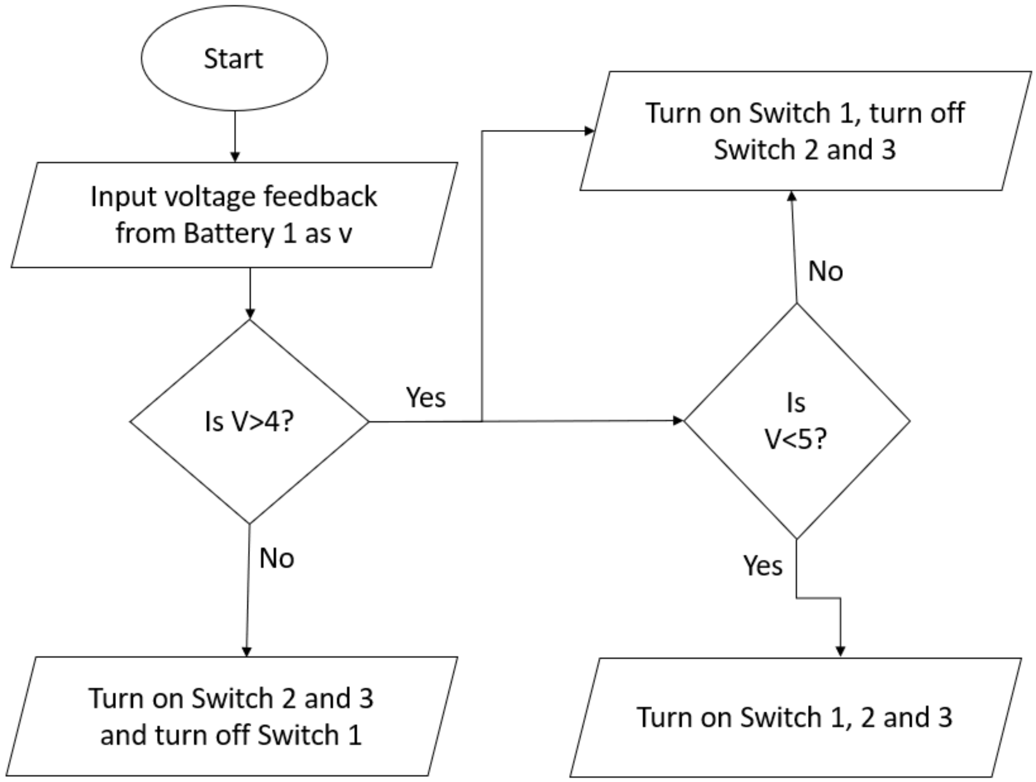

Figure 4: Switch operation Flow chart: Flow chart explaining the parameter to get into different stages of switching.

3.2.1 Working principle

The working principle of the model is as follows: At vehicle starting, the vehicle runs on motor 1(final drive motor) by drawing power from battery 1 only. When the battery 1 voltage drops below 4v, the final drive motor runs on battery 2. In the mean time battery 1 runs motor 2 which in-turn runs motor-generator that charges battery 1 as well as battery 2. When the battery 1 reaches again above 5v the connection from battery 2 is cutoff. There is a intermediate voltage range that is from 4v to 5v, two batteries together drive the power-train and charge simultaneously.

3.3 Final drive

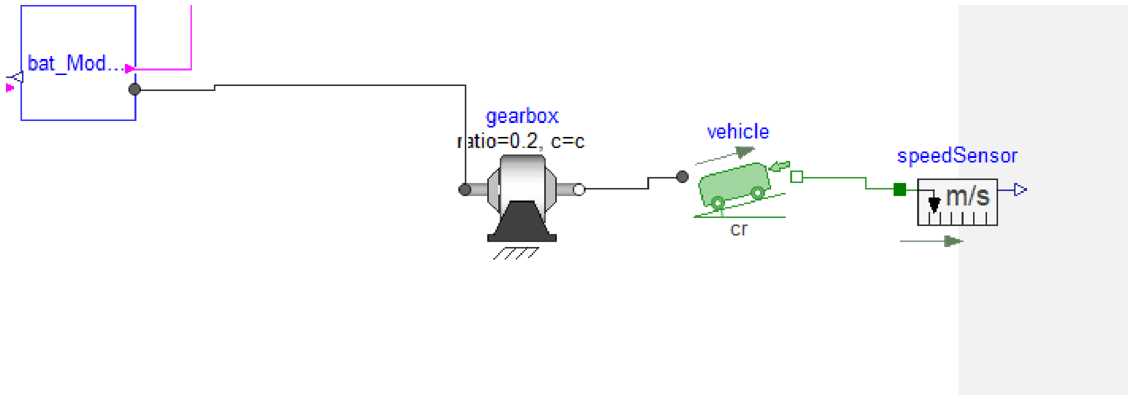

Figure 5: Connection at the final drive part of the model, in which gear reduction and losses are considered

The final drive consists of three parts, one is a gear ratio, another one is the losses present in the vehicle and third one is a speed sensor to detect the speed of the vehicle model. The vehicle model is an inbuilt model in Dymola. In the vehicle model the vehicle is initiated with a starting value of speed which goes to zero after some time due to losses. The time for going to zero is studied and compared for both dual battery and single battery model.

3.4 Single Battery Model

In the single battery model(shown in Fig. 6, only one battery is used to drive the final drive. the battery used has parameter values twice that of dual battery model. The comparison between result is presented in the result section. The parameters used in the battery model is presented in Appendix-A. The final drive elements are same as that of dual battery model. The parameters of the final drive elements are kept same as dual battery model to have a comparison.

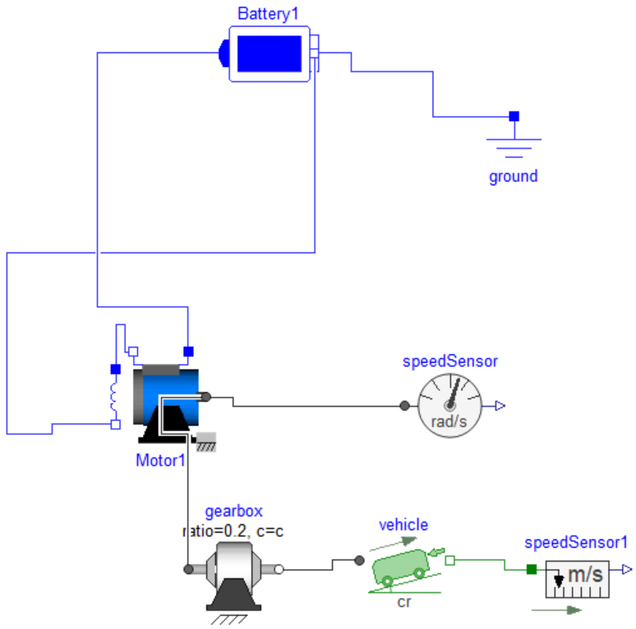

Figure 6: Single Battery Model :Model showing only one battery being used to drive the final drive motor .

3.5 Battery Charging model

Inductive charging can be used as an alternative to plug in charging in EVs. In this model(shown in Fig.7) stationary method of charging is presented. the inductive charging can be of two types, one is when a vehicle is driving on the road and there are coils underneath the road to charge the battery or there can be a specified charging station to charge the battery. In both cases the variation of magnetic flux creates a current in the circuit containing batteries.

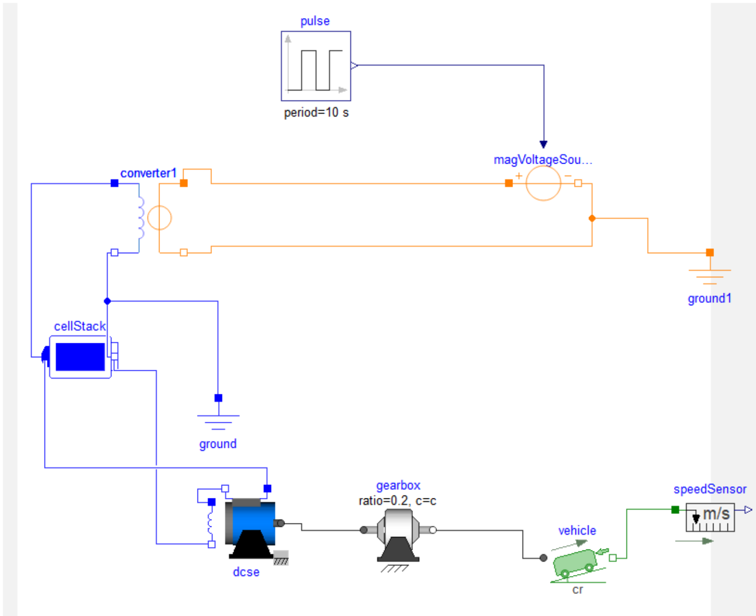

Figure 7: Model showing a simple circuitry connection of inductive charging for a battery

4 Results and Discussion

In this section, both battery models are compared to see the better efficient model. As a comparison is being made the parameter values are taken only for reference, they do not represent a real world parameter value. It is to be noted that as there is no actual drive cycle present the final drive comes to a zero after some time and battery voltages remain constant.

4.1 Voltage difference and SOC

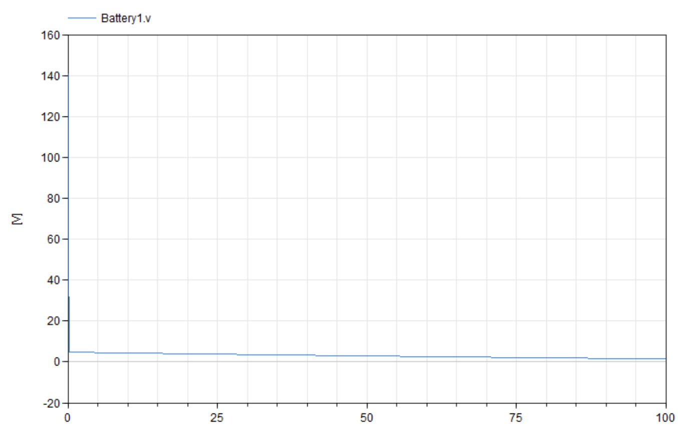

Figure 8: Voltage difference between two terminals of battery in single battery model

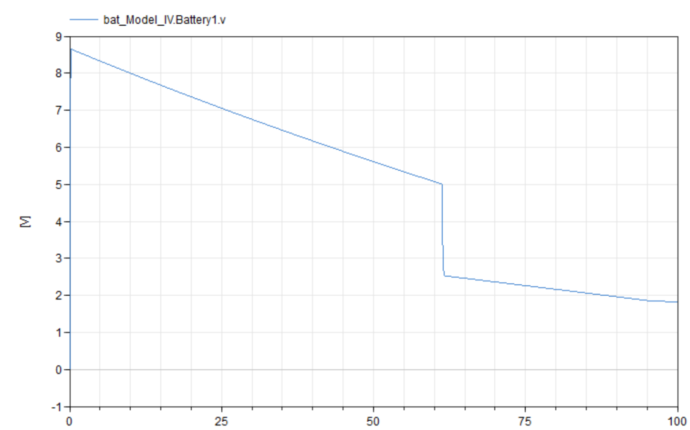

Figure 9: Voltage difference between two terminals of battery in dual battery model

As shown in Fig.8 and Fig.9, it can be seen that in the single battery model the voltage of battery abruptly drops from 140V to 2 volts and remains stationary in that region.In the dual battery model battery is slowly discharging and comes to 2V around 100 ms.Which signifies Dual battery model is better than single battery model.The SOC and voltage for battery 2 is same as that of Battery 1 in Dual battery model. The state of charge comparison is shown in Fig.10.

As there is no actual drive cycle present, the graphs are linear and become constant after certain time. Provided an actual drive cycle was present a more realistic picture would have been obtained. The simulation time for both the models are taken as 100ms.

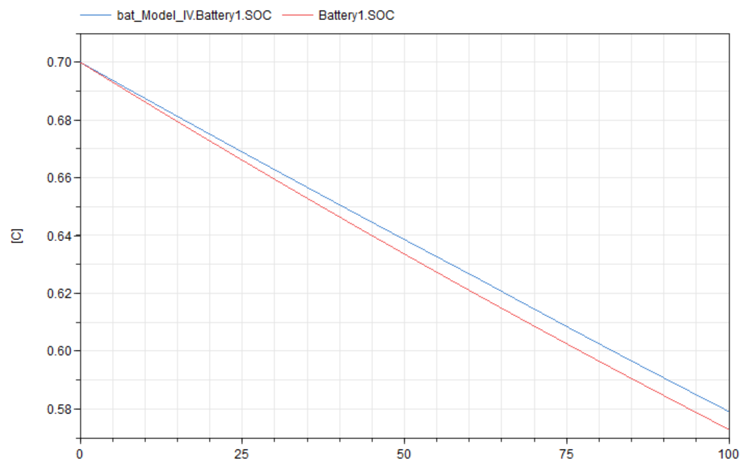

Figure 10: Showing SOC of two different models, the red line corresponds to single battery model and blue line corresponds to dual battery model

4.2 Switch actuation

The switching actuation is presented in Fig.11. The switching takes place just one time in the 100s duration, it is because other is no drive cycle present, there is no variation in battery charging. Also battery charging is a function of EMF voltage to current conversion. Provided there were an actual speed cycle present and the variation could have been more prominent.

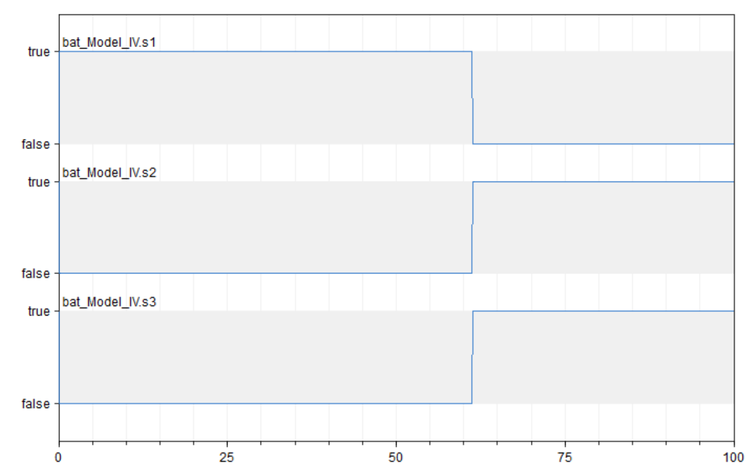

Figure 11: Showing actuation of control algorithm in 100 ms to control the switching action

4.3 Charging by induction

In the induction charging model the magnetic voltage source is provided with a pulsating square wave of magnitude 100.The same battery is used to showcase charging by induction,the SOC and voltage drop is shown n Fig.12 and Fig.13. The Pulse may represent the static inductive charging or charging when vehicle is moving on the road. The square pulse is taken just for simplicity, in actual the magnetic voltage variation can be a complex curve resulting in a more realistic battery parameters. It can also be seen that with a pulsating pulse also the SOC is decreasing as before.

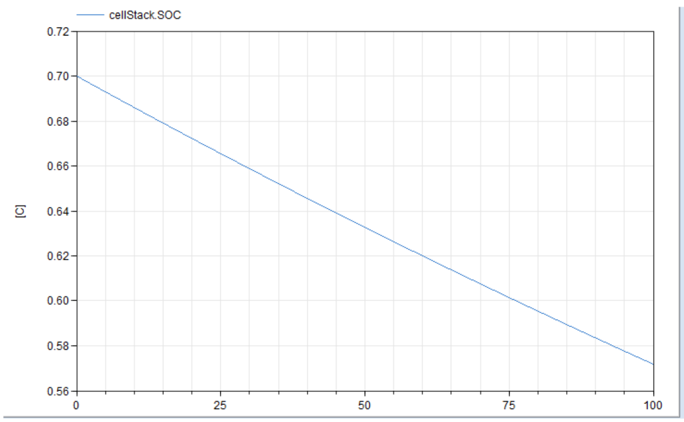

Figure 12: SOC of battery in inductive charging method

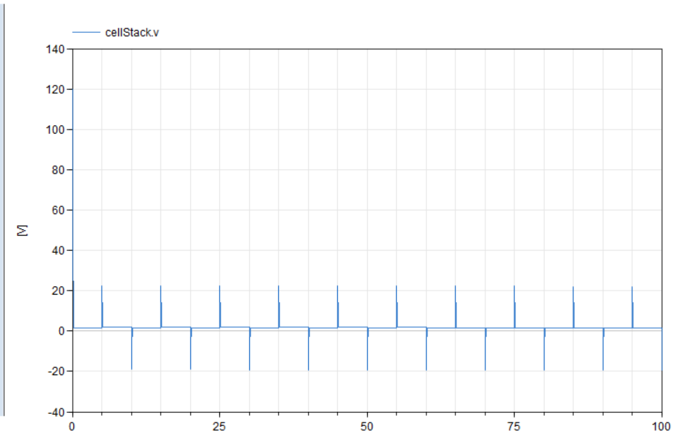

Figure 13: Voltage across the battery terminals

5 Conclusion

In this model comparison, an attempt was made to improve the battery efficiency in an EV. The dual battery model has a marginal advantage of having a better SOC and significant voltage across battery terminals. The model presented here is not in alignment with real world battery characteristics, provided a real world battery was simulated in the dual battery model, the result would have been better. Also as there is no drive cycle present the charge switching seems to be limited, which may be different in real world scenario.At last the charging by induction method was presented. For better efficiency both dual battery model and charging by induction method can be implemented in an EV.

References

[1] Green Car reports,*"Wireless-EV-Charging-gets-a-boost-single-standard-will-harmonize-systems-up-to-11-kw"*, *Link*

[2] Power Electronics,*"Wireless Charging technologies for EVs"*, *Link*

[3] Chargedevs,*"Dual battery System for EVs EVs"*, *Link*

A Model Parameters

A.1 Battery Used for Dual-Battery Model

The parameters used in battery model for dual battery model is presented below. The parameters are same for both the batteries used in the model.

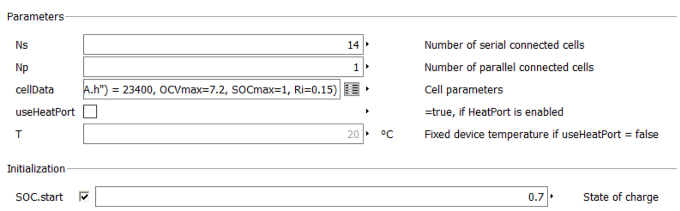

Figure 14: Showing Cell stack parameters

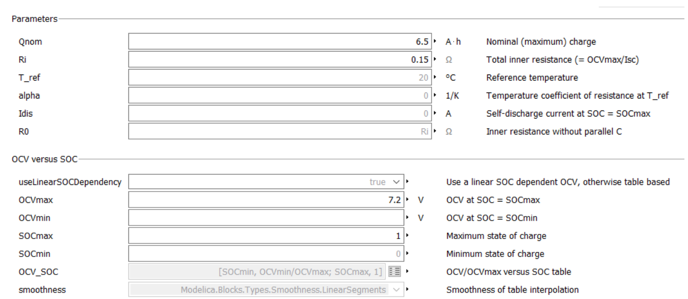

Figure 15: Showing each cell parameter

A.2 Battery Used for Single-Battery Model

The parameters used in battery model for Single battery model is presented below. The same parameters are used in battery charging by induction model.

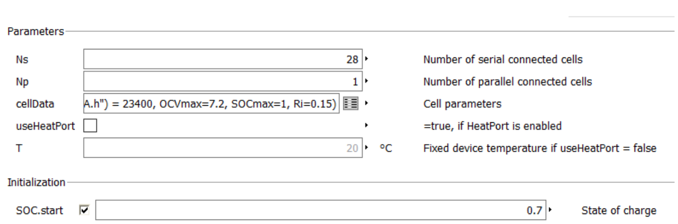

Figure 16: Showing Cell stack parameters

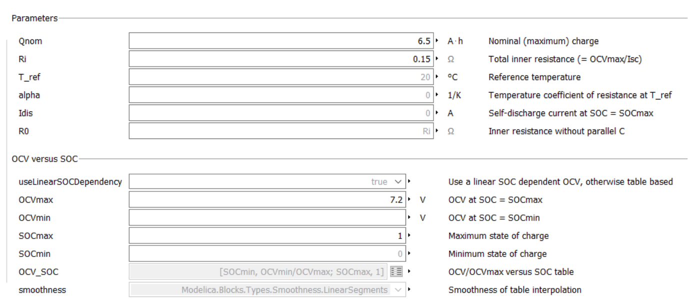

Figure 17: Showing each cell parameter

A.3 EMF

The EMF used in the dual battery model has below parameters:

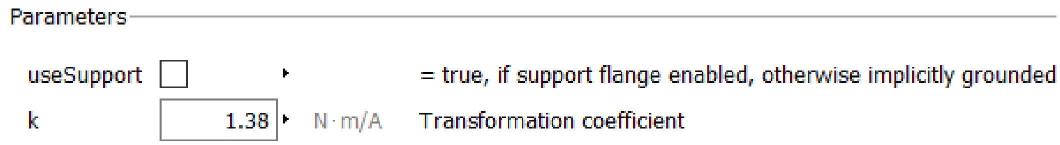

Figure 18: EMF conversion constant value used in dual battery model

A.4 Final Drive Parameters

The final drive parameters used throughout the whole model. The final drive consisted of a gear reduction and a vehicle model, whose parameters are as below:

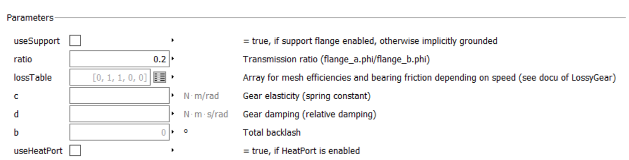

Figure 19: Parameter for Final reduction used throughout the model

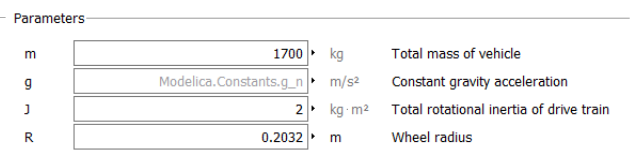

Figure 20: Parameters used for vehicle model throughout the project

A.5 Charging parameters

A.5.1 Pulse used

The pulse used for driving magnetic voltage source is presented below:

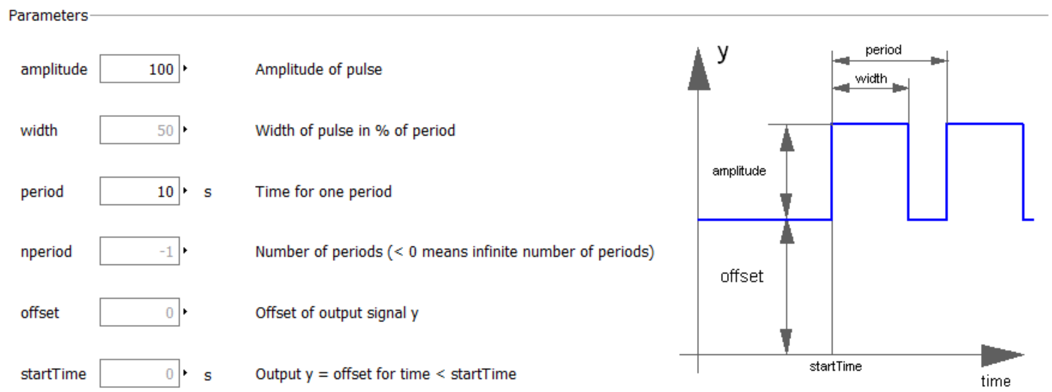

Figure 21: Square pulse used for input into magnetic voltage source

A.5.2 Electromagnetic converter

In the electromagnetic converter following parameters were used:

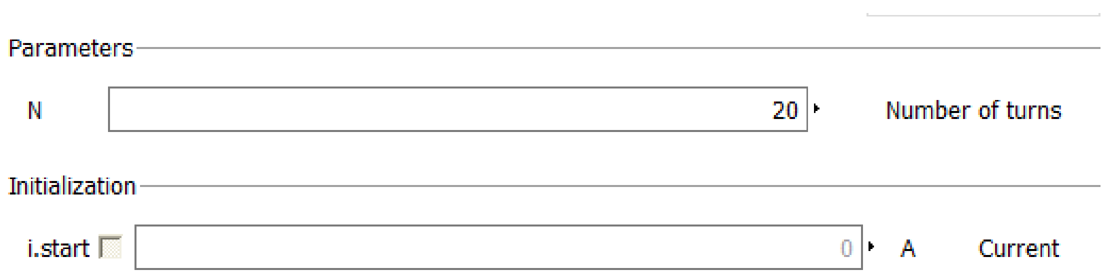

Figure 22: Parameters taken for number of turns in electromagnetic conversion model