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Ultra-Capacitor Storage in Regenerative Braking

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ABSTRACT
The modern world today has a wide variety of energy sources to integrate them, maximize, the efficiency of transmission and increase the accessibility of electricity. Since the late 1800s, only steam and EV disappeared with the introduction of the steam engine, ICE, and electric vehicles. However, electricity became viable for car drives as technology improved. Electric vehicles have recently become popular with improved technology in the field of batteries and electronics. At certain points, the energy consumption of these electric vehicle's peaks. For example, when the vehicle stops at a stop, the increased starting torque requires a higher motor power supply. This study identifies and analyses the use for the energy demand of regenerative braking and ultra-capacitors.

Keywords
Ultra- Capacitor, Voltage, Simulink, Braking, Boost Converter.

1. INTRODUCTION
Regenerative braking (RB) is an interesting option for charging electric cars (Electric vehicles), which offers numerous technical and economic opportunities [1]. When the vehicle is driven, a percentage of power can be recovered by combining emission-flow EV and regenerative braking. The energy produced by RB is nevertheless used to charge the EV battery. Given that an EV does not rely entirely on RB for braking, for obvious reasons of safety it also uses mechanical brakes. In this situation, the recovered energy is minimal and does not improve efficiency significantly. Over the years, several papers have been published on EV charging using different methods, including several review works. This work presents an increased power buffer for the electric transmission when a short power explosion is needed. The power demand for engines at the beginning is high, as the engines must overcome the static friction faced by tires and the vehicle must achieve momentum. To that end, at the beginning, the battery energy requirement is high and this should be reduced, typically by limiting starter speed or start up speed, until the engine has a threshold speed at which advanced control methods like field control for AC engines can take over.

The design suggested in this project uses a hybrid drive/engine generator that is connected to the drive motor axle. The DC motor provides a high input torque while starting to the shaft of the wheels when the vehicle must start from a quiet position[2] The battery can be used to draw the energy from the event, but the ultra-capacitors that are charged with the same DC motors acting as generators during regenerative braking are used in the design proposed. The energy recovered can be stored in the battery or in the ultra-capacitor on demand. Different relays in the system do this. The advantage of the ultra-capacitor is that the DC engine can be supplied with higher power rises, resulting in a high initial torque. The system is simulated in MATLAB and the system is evaluated by the simulation in terms of its technical and economic feasibility.

2. RELATED WORK
In Scotland it was Robert Anderson who made the first crude electric carriage that built the first electric car (ECV) between 1832 and 1839. The exact year is unknown. It wasn't built until 1895 after A.L. RYKER constructed an electric tricycle and William Morrison built a six-passenger car that the USA cared for. The electric car has a low sound of the engine and is therefore considered better than the internal combustion car. So, for two reasons, do what followed in the development of both cars with regard to the superiority of the internal burning car. First: excellence in long-distance cutting and second: low weight of fuel like petrol or diesel for heavier battery weights to decrease a reasonable distance. It was time for the electric car to get a drive running on petrol until this day[3]. Electric vehicles reappeared in the 1960s and 1970s because internal combustion vehicles created an environment which was not healthy to the Americans.

Regenerative braking is an energy regeneration mechanism which slows down a moving vehicle or object and transforms its fine energy into a form which can either be used or stored immediately. The electric traction engine uses the drive of the vehicle to recover the energy that would otherwise be lost as heat from the brake discs. This goes against conventional braking systems where the excess cinematic energy is transformed into unwanted and heat wasted through brake friction or with dynamic braking systems, where energy is recovered through electrical motors and then dissipated in resistors immediately. Regeneration can significantly extend the life of the braking system in addition to the overall efficiency of the vehicle since mechanical parts are not rapidly worn out.

Ultra-capacitors are recently used in regenerative braking systems to filter ripples and incoherent flow in electric drive systems, for example trains or other similar systems, used in heavy transport.

3. DESIGN AND METHODOLOGY
Simulation and design are based on Simulink and divided into two parts. The primary simulation includes regenerative energy system simulation, and the second simulation explains the generic train in electrical power trains.

The renewable energy system includes a boost transformer to increase the voltage generated by the renewable braking system that is stored in a super condenser rated at 20 farads during the simulation. At the other end of the ultra-capacitor, the battery supplies energy to the drive train The UC is isolated from the battery and boosts converter output with two relays at the positive side. The system allows the recovered energy to be either stored in the battery or used to deliver the starting momentum for the vehicle, or to provide a high toque of input in the case of sudden demand from the user.

The relay motors can use the boom converter or simply return to the battery DC bus via a bypass route on the DC motor/generator (DCMG) side[4]. The DCMG relays control whether the DCMG functions as an engine or generator. The DCMG is a separate DC engine powered by a battery during the simulation. Nevertheless, the vehicle battery is provided with energy, or the DC motor is a permanent magnet type, in true applications instead of a single battery.

There are 4 relays which control the flow of the energy in the regenerative braking mechanism, which are listed and explained further below.

3.1. Regenerative setup

The Simulink regenerative braking simulation is shown below in Figure 1 and consists of battery, ultra-capacitors, relays, converters, DC motors, simulation control.

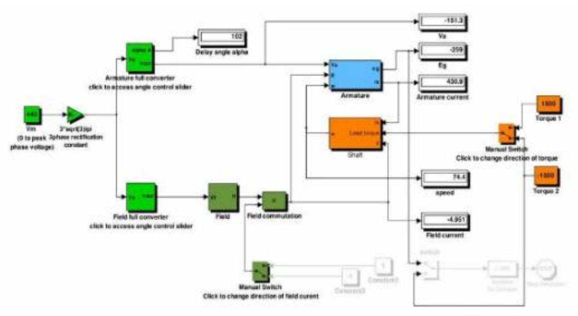

Figure 1: Simulink diagram for regenerative braking

The battery is a battery containing lithium-ion components which are shown in the following image. Because of its energy density of around 100-265 W/kg, the lithium-ion battery is the most common battery of modern electric battery cars[5].

Battery parameters monitored are charging status (SOC), the ratio of the battery voltage to the nominal voltage, usually as a percentage calculated and gives you an idea of when the battery is capable of supplying energy, it's 50 percent here. $(V_{current} / V_{nom})$*100 In addition to SOC, the battery tension and current is monitored.

For the simulation purpose, the battery is rated 15.5Ah and 240V, as the lower numbers can be computed more quickly. The Ah capability is 44,5 kWh and Ah capacity is 394 V = 0,12944KAh = 112,944 Ah for a typical electric vehicle battery rated to 44.5 and 394 V. Electrical batteries are even higher than 100kWh, but that segment forms a very small part of the current market in electric vehicles.

Ultra-capacitor lies directly to the battery right and has a common negative battery reference and an isolated positive battery terminal. The voltage and current parameters monitored for the UC are.

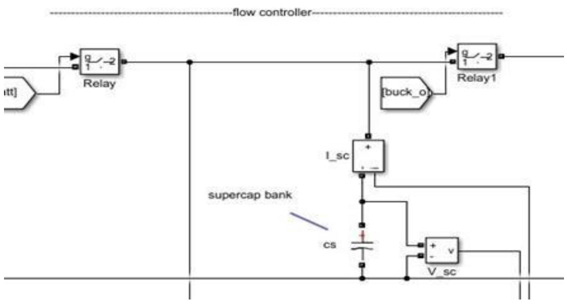

Figure 2: Enlarged UC System

The super-capacitor bank in the diagram should be mentioned. Note. This is because a typical UC is rated for low voltage, and therefore, several of them must be connected to the desired voltage and capacity rating in series and parallel. Note also the relays labelled as relays and relay-1 that help control the flow of energy If the energy is to be recovered and stored at the UC, then relay1 will be switched on during the regenerative braking period and relay will be switched off during that time, and the energy condenser will then be used in order to supply high torque entrances to wheels using the same DCMG[6] in motoring mode. The relay-1 can be used in a UC mode for the restoration and regenerative braking time. Enlarged UC system is shown in Figure 2

This is achieved with a demonstrative 60 per cent duty cycle to reduce the simulation time using the boost converter to increase the voltage and store it in the UC. The input from the boost converter is to the right and the output on the left side; the input side condenser is 1000e-6F or 1mF. This is the filtering and relays and DCMG decoupling condenser on the input side. The UC lies after Relay1 on the output side. The boost transducer is rated at 120uH and the switch is a discreet MOSFET with a constant duty of sixty percent. This is implemented in a closed-loop in an advanced and complex system.

3.2. Relays and DCMG

The relay and DCMG control and engine side of the renewable as shown in figure 3

Installation. The relays check whether or not the boost converter is connected to the motor (it should be connected only during regenerative braking). You can also switch the DCMG motor on or off from the remaining configuration. The DCMG engine itself is simply a DC engine designed to offer maximum performance in both engine and generation modes[7]. This is one of the benefits of a separate engine and a drive engine.

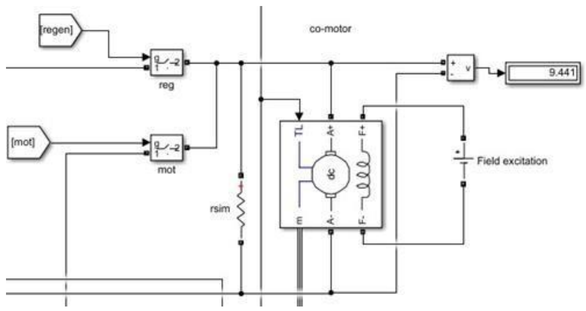

Figure 3: Relays and DCMG

relay " reg " and "mot" here controls whether the DCMG functions with UC relays as a motor or generator. The DCMG regenerative voltage is switched on by the boost converter and the battery side relay is disabled when the reg relay is energized and the mot relay is switched off. When it begins to accelerate, the mot relay turns on, then the reg relay switches off, also the relay-1 after UC switches off and the battery relay is already in its absence, and a torque demand is considered insufficient in the case of the main drive motor. After torque demand decreases, the battery relay is reactivated and the energy flows to DCMG with less demand torques. The battery relay is re-activated along with other relays after the process, and the control is transmitted to the main engine drive. Figure 4 shows the timing of relays

The control of the relays is generated by a signal manufacturer block, which is in reality generated using a[7] Vehicle ECU or an electronic control unit sensor for braking, acceleration, and time systems. Note that during regenerative braking and main relays, the motor relay is turned off and the boost converter is installed. Figure 5 shows signal Builder Block

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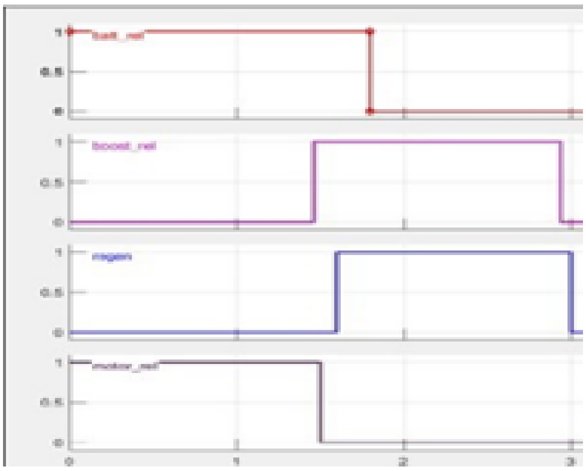

Figure 4: Timing of Relays

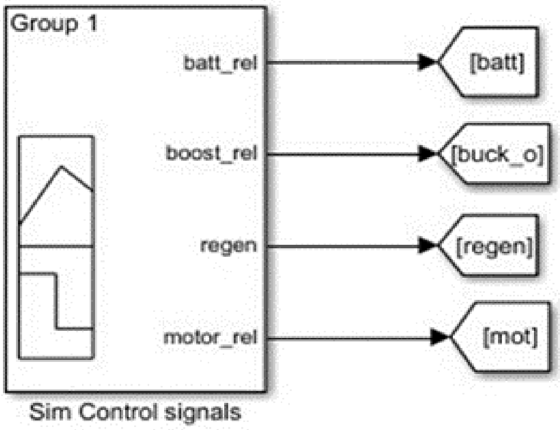

Figure 5: Signal Builder Block

The "mode" signal is created by differentiating the speed curve and, afterward, by using a "relay block," the Information whether the vehicle brakes or speeds or whether the car is accelerating, is obtained by means of switches used as electromechanical relays in the principal electrical system (the Schmitt hysteresis trigger). The controller uses this signal to generate signals that are constructed by the signal builder block Speed characteristics can be seen in Figure 6.

3.3. Drive setup

The regenerating braking system is an overlay on the main drive system that can be directly or through a torque converter or a high ratio gearbox integrated in the principal engine drive shaft. In some cases, this assembly is called a "e-axle" in order to improve the handling of vehicles such as the ABS (anti-control braking systems) or anti-skid systems for the purpose of torque-vectoring or distributing torque among parallel wheels on the same shaft. The following simple imitation of a basic electric vehicle (EV)[8] drive was conducted in MATLAB using a FOC bundle to show how the system works with a closed-loop speed control, typically using an advanced form of modified field-oriented control (FOC). Implementation in Simulink can Be seen in figure 7

It consists of an AC source and speed reference and the FOC block, together with measuring blocks (because the MATLAB FOC bloc has a rectifier)

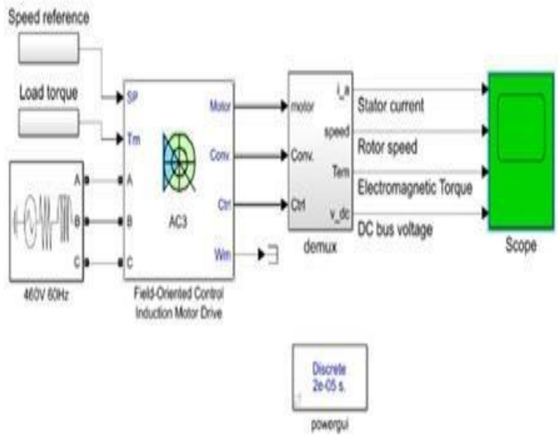

Figure 6: Implementation in Simulink

3.4. Combined Motor Drive

In the common mechanical energy transfer system, either through a common shaft or a gearbox, the regenerative system with the DCMG and the main engine drive with the main motor are integrated closely.

3.5. Boost Converter

A simple, non-isolated topology is the boost converter used in the design in this case. The Boost Converter is a DC-DC control system which transforms input voltage to a higher level based on controlled commuting of the switching device, usually a MOSFET. The design is carried out by shortening the inductor, to the source with the button. A simple, non-isolated topology is the boost converter used in the design in this case[9]. The Boost Converter is a DC-DC control system which transforms input voltage to a higher level based on controlled commuting of the switching device, usually a MOSFET. The design is carried out by shortening the inductor to the source with the button. The switch switches off, which are seen in series with the inductor across the Diode. This results in a high-voltage spike, as the Lenz's law explains on the junction. This voltage peak is commensurate with the switching period and, because the voltage is in series, it is added to the source voltage. The increased voltage is then buffered by a condenser on the output side to minimise the onslaught. This side output condenser is UC here. The relationship between the tariff ratio or the switch ratio. The $v_{out} = v_{in} / (1\text{-}k)$, where k is duty ratio, is indicated during period and input voltage and output voltage. It is maintained at 0.6 and steps to 0.8 in this simulation.

3.6. Ultra-Capacitor

UC is a kind of polarized condenser with a very high load storage capacity, which usually exceeds 10F. But they can only operate at lower voltages, so that higher ratings can be achieved by being connected in parallel[10]. The advantage is that they can store higher energy than ordinary condensers and can react very quickly to changing current compared to batteries. This makes them ideal for dealing with short energy bursts. In the design of electrolytic condensers, they are usually similar and thus polarized[11].

4. RESULT

The responses show the current via the inductive and output condenser and switch. It includes the same component voltages.

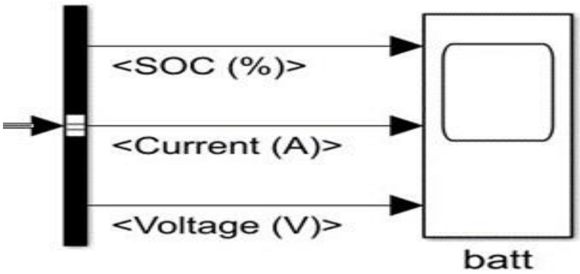

Figure 7: Measuring scope for the battery and regenerative braking simulation

At the relay point and in the production of the power product, the battery parameters can be monitored separately. DCMG speed which would be the same as the shaft speed is the output reported in the simulation and is thus similar to that of the shaft speed. The torque of the engines reflects the charge and effect of the system's regenerative recovery. The battery and SOC output (starting at 50 percent). The voltage decreases steadily until the braking process is regenerative. After this is over, the voltage starts to decrease again when the vehicle is moved. The measuring scope is shown in Figure 8. Measuring scope in the model can be seen in Figure 9

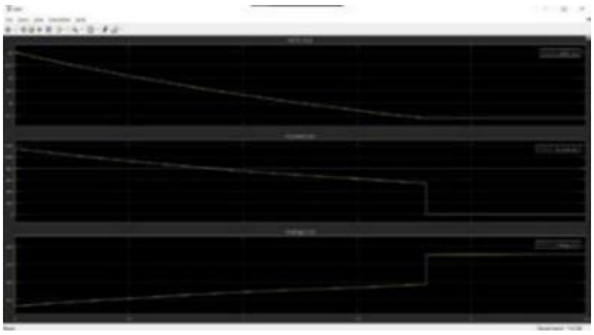

Figure 8: Measuring scope for the battery and regenerative simulation in model

Note that the voltage is not falling sharply as shown in Figure 10 as inrush scenarios are expected. The reason is the UC Please note that the Battery SOC does not increase, as regenerative energy is stored in UC and reprocessed from there without battery demand.

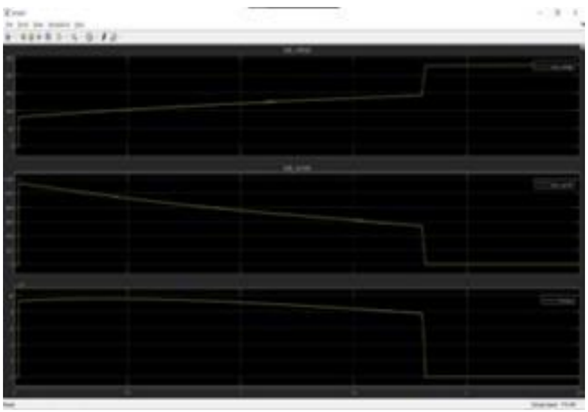

Figure 9: Battery voltage, current and the power product

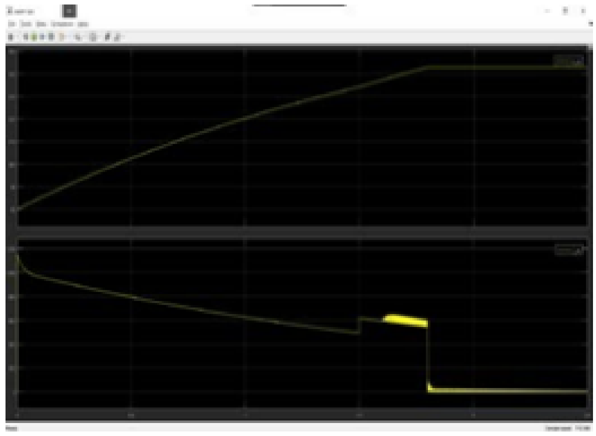

Figure 10: Current through the super capacitor and voltage across it

The first is voltage and the second is current as shown in Figure 11. The voltage in the capacitor increases as the battery charges slowly during engine operation, resulting in an exponential reduction of the current.
Then the current starts rising again in a small bump with a little bit of jitter due to the boost converter regenerative mode is enabled. This power is very small and thus advantageous in such a design, which only needs so much for short bursts of energy in the system. The car speed curve for the primary simulation is shown below, starting accelerating first, then decreasing acceleration, and then starting braking. The regenerative braking system is completely handling this braking. In this case. In the real world, the main mechanical brakes take over when the brake pedal is pressed hard enough because a safe stop is a priority to recover energy from vehicle inertia. Note that the speed of the DCMG is similar to the input profile. The changes, however, are diminished

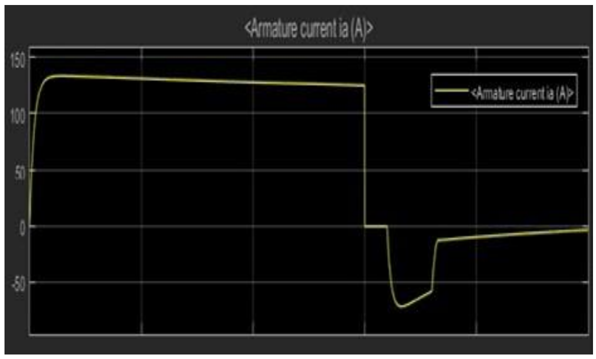

Figure 11: Armature current or regenerated energy current

During motor mode, before handing controls to main motors, it is constant as the vehicle is accelerated by DCMG. The current goes negative or the DCMG acts as the generator during regenerative braking. As a result, the curve is also similar for DCMG electromagnetic torque. The armature current can be seen in figure 12.

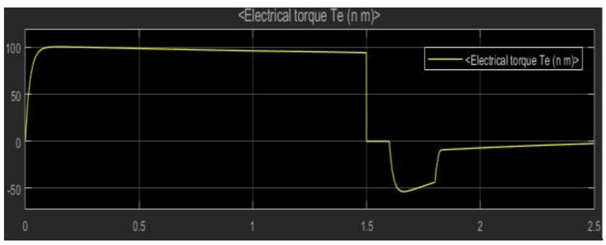

Figure 12: Motoring mode

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Figure 13 shows the motoring mode. The combined plot also includes the field current which even though here seems to be varying is actually very negligible. Figure 14 shows the current through the super capacitor and voltage across it.

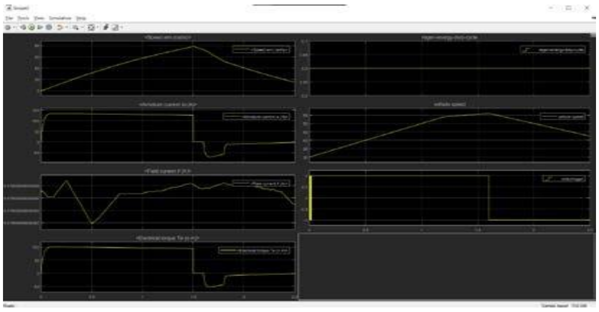

Figure 13: Current through the super capacitor and voltage across it

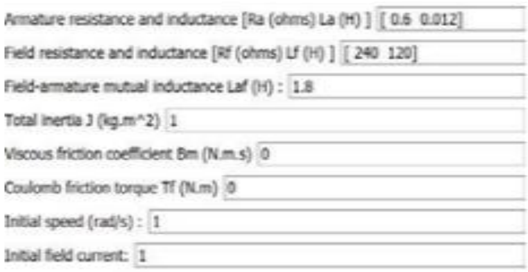

Figure 14: DCMG Parameters

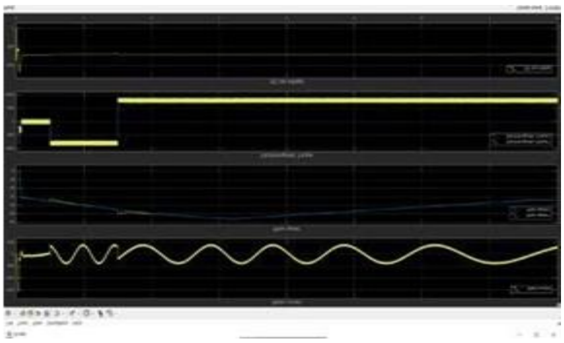

Figure 15: Drive mechanism simulation

DCMG parameters are kept as shown in Figure 15.

Figure 16 shows the drive mechanism simulation. The first plot is current and as can be seen changes frequency as per the FOC controller based on the speed input. The speed curve is the second plot and can be observed to first accelerate and then reduce speed.

The third plot is the electromagnetic torque of the AC motor. The last one is the DC bus voltage or the voltage on the main battery supply in case of a battery powered system. Following is the speed input in this case, which is for an 8 second simulation as opposed to 2.5 seconds for the main simulation;

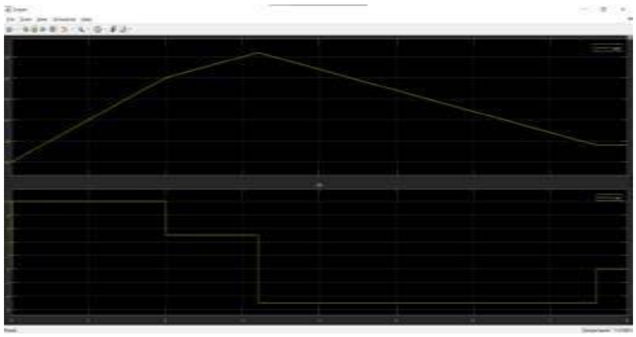

Figure 16: Speed input at 8 second simulation

The first curve is speed and the second is the derivative of the same, which gives the idea about acceleration level as well as the direction of rotation. The formulation is done using ramps. Speed t 8 seconds is shown in Figure 17. Formulation results can be seen in Figure 18.

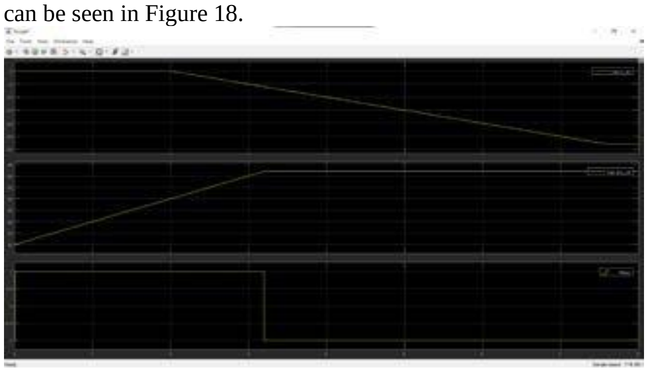

Figure 17: Formulation using ramps

5. CONCLUSION

The goal of this work was finally achieved. The simulation has been completed for a system with a super-condenser that recovers the energy of regenerative braking, model the control scheme, and investigate the behaviour of the DCMG and the UC under the relay switching. The system also reduced the battery inrush. The simulations proved that in real-world design this system is viable. This topic can be continued with a view to improving control in hardware systems and studying the same thing.

REFERENCES

[1]IEEE Transactions on Industrial Electronics, vol. 56, 2203-2212, June 2009, Ming-Ji Yang, H.-L. J.-Y.-K. "A Cost effective Method of Electric Brakes for Energy Regeneration of Electric vehicles."

[2] H. Wu, S. Cheng and S. Cui, IEEE Trans, vol. 40, no. I, pp. 509-513, January 2005 — "The brushless DC Motor Controller for Electric Vehicles."

[3]A. Rufer and P. Barrade, "A soft-commutated elevator energy storage system based on super capacitors," 36 IEEE Industry Application Conference vol.2, pp.1413-1418, 2001;

[4]"Ultra "Bidirectionally DC-DC Converter for Ultrasound Applications": P. J. Grbv, P. Delarue, P. Le Moigne and P. Bartholomeo, vol. 57, no. 10, pp. 415–3430, Oct. 2010 IEEE Trans. Ind.

[5] Binggang Cao, Z.B. "Electric Vehicle Control Research" IEEE, 92-97, 2005. Read more...

[6] Oscar, J. Oscar (2010). Industrial Technology (ICIT), International IEEE Conference, (p.20-26), 2010. The energy storage of electric vehicles

[7]N. L. Hinov, D. N. Vacheva and G. I. Vacheva, regenerative electric vehicle braking condensers, 2016 XXV International Scientific Electronics Conference (ET), 2016, pp. 1-4, p. 10.1109/ET.2016.7753484.

[8]Naseri, E. Farjah, and T. Ghanbari, BLDC-based Efficient Regenerative Braking System, in IEEEVehicular Technology Transactions Vol. 66, no. 5, pp. 3724-3730 of May 2017, doi: 10.1109/TVT.2016.2611655. [8] F. Naseri, E. Farjah and T. Ghanbari, "An Effective Regenerative Braking System."

[9]S. M. Lukic, S. G. Wirashanga, F. Rodriugez, C. Jian and A. Emadi, Proc. IAEE Veh. Power Propulsion Conf., pp. 1 - 6 2006: "Power Management for HEV Ultra-capacitor Hybrid Energy Storage Systems, Proc.

[10]Vivek Kumar Yadav and Navjot Bhardwaj, International Journal of Electricity and Electronics Engineering Research, Vol. 3, No. 4, pp. 35-42, Oct 2013, ISSN 2250-155X, "Hybrid Energy Storage Electrocarbon Braking," vol. 3, No. 4, pp. 35-42, oct.

[11]Jin-uk Jeong, Hyeoun-Dong Lee, Chul-soo Kim, Hang-Seok Choi and Bo-Hyung Cho, "Development of the Super Capacitor Energies Storage System," 2002 EVS19, pp. 1379-1389.

