Research Article

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A Simulation Analysis in Diesel Locomotive with Super Capacitors for Energy Saving Through Regenerative Braking

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Abstract

The intention of this research is to make AN electricity storage machine for regenerative braking, with use of dc to dc convertor, and testing rig to perform checking out for dc power with dc motor with the great electrical condenser financial institution in opposition to locomotive (WDM2) regenerative braking profiles. A bank of become created beside a biface DC to DC convertor allowing practical checking out of 2 of the four plausible financial institution configurations. An average of 55% and 63% end to end efficiency was found for the two configurations respectively when tested fewer than two modes of regenerative braking profiles. It were observed that electrical condenser banks with a higher maximum voltage i.e. additional cells asynchronous had been additional within your budget as there had been lower input and output currents and most of losses had been restrained to the convertor.

We observe energy-storage instrumentation it is linked to DC6 chopper of locomotive (WDM2) of railway. We have a tendency to take reference version of locomotive WDM2 for the look at of paper. For the duration of the powering amount, the acceleration of the educate will become large owing to the boosting operation of the instrumentation. The instrumentation charges a place of regenerated strength once it boosts the voltage during braking quantity, and discharges the hold on strength as soon as it accustomed operate distinctive electric instrumentation. At the time of regenerative braking we have a propensity to save the energy it's facilitate to save lots of the strength. For the duration of this research, we have a propensity to selected Ultra-capacitor for the energy memory tool of the instrumentation.

Keyword: Ultra-capacitor, WDM2, DC to DC convertor, Energy Storage

Introduction

These requirements have been satisfied by the introduction of new vehicles, that draw higher power peaks and greater energy consumption than traditional ones. However, the fast developing of transportation systems has not been always followed by corresponding modification of the power supply and overhead lines. The present loads running on railway lines are therefore responsible of a consistent growing of power losses and amounts of the electrical energy supplied by the electrical Substations (eSS). Moreover, greater currents drawn by trains during acceleration simply greater voltage drops on the overhead line that further affect negatively their safe starting[1].

In an eV, the energy resources are limited. However it is essential that the power requests from all loads be met. Conversely, with the limitation in energy systems, it is impractical and cost prohibitive to size a single energy storage unit to offer continuous power capacity many times higher than the average power demand, just to meet momentary peaks in power needs. For this reason, employing multiple onboard energy systems that are specialized for the various segments within a vehicular power demand bandwidth becomes a viable solution. The combination of energy storage devices with high-density specifications such as batteries with energy storage devices having high power density specifications such as ultra-capacitors provides such a solution. The task of a power and energy management system then is to suitably coordinate the dynamics of the energy storage systems. This is to be done without compromising the vehicle target performance. energy storage systems[2].

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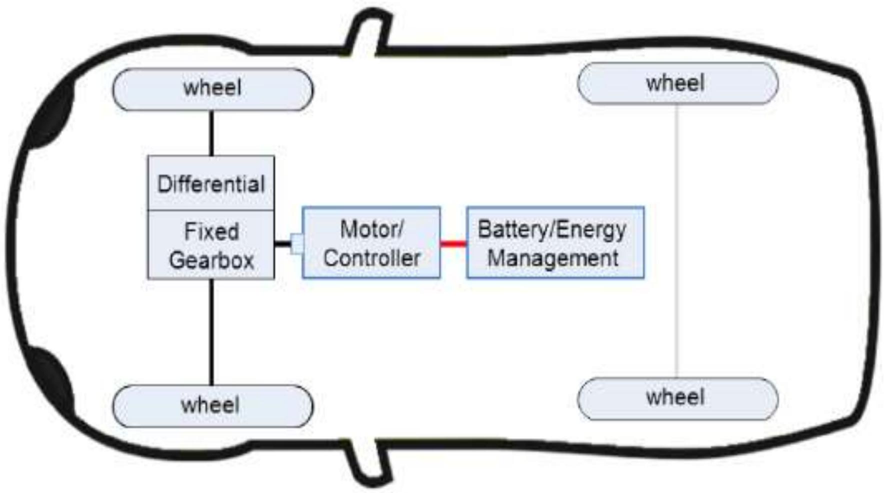

Figure 1: Electric Vehicle Drive Train Representation

Problem Scope

In the scope of this project, the specification of a power andenergy management for a dual energy system consisting of batteries as the primary 'energy' source and ultra capacitors as the primary 'power' sourcee is as follows.

- The technique of power arbitration between batteries and ultra-capacitors
- The power blending infrastructure for the battery- ultra capacitor system
- The energy management of theenergy storage systems
- The assessment of regenerative energy receptivity

The presentation and correlation of theoretical andempirical findings

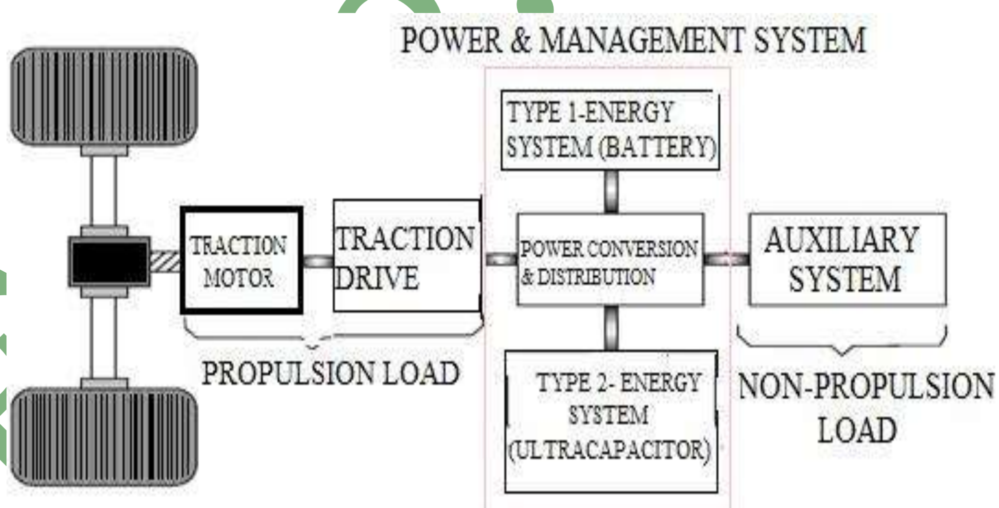

Figure 2: EV Drive Train and Power System Architecture

Literature survey

September/October 1968 C e Robinson [3] has suggested the accelerated trend toward the use of solid-state controlled power conversion equipment, as a replacement for the conventional Ward-Leonard motor generator set in direct current adjustable speed industrial drive systems, has focused attention on a number of undesirable side effects which detract from their outstanding advantages. These effects are due to the high ripple content in the rectified voltage output of the conversion units, which 'causes increased heat generation in the dc drive motor and adversely affects its ability to commutate armature currents without sparking at the brushes. These effects are

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described and analyzed for several basic configurations of converter power circuits. The Use of a laminated steel frame motor construction instead of the conventional solid steel frame ring to minimize these effects.

Danila,E., Lucache, D. D., & Livint, G. (2012)[4] A fixed frequency pulse width modulated chopper scheme is utilized to obtain a variable dc voltage from a constant dc voltage source. The steady-state performance of a separately excited chopper-fed dc motor is analyzed by four different methods based upon the following assumptions: 1) negligible commutation interval; 2) negligible ripple in the armature current; 3) constant current during commutation; and 4) direct solution of the governing differential equations. The effect of increased armature circuit resistance due to pulsating armature voltage on the characteristics obtained is discussed. The results by method 4) are found to show good agreement with experimental values.

Ehsani, M., Rahman, K. M., & Toliyat, H. A. (1997).[5] has discussed a comprehensive analysis which predicts the performance of a thruster-chopper controlled dc series motor during regenerative braking operation. The analysis takes into account all the possible modes of operation during this type of braking, the nonlinearity of the magnetization characteristics including the variation of the field inductance, and the effect of the commutating capacitor in the chopper circuit on the braking performance. It is shown from the computed results that above a critical speed, the value of the commutating capacitor sets a maximum value of mark/space ratio of the chopper regulator beyond which the regenerative braking operation fails. Typical test results on a practical system are shown to agree with the computed results.

Methodology and Implementation

I. Ultra-capacitor

An ultra-capacitor cell construction consists of two electrodes, a separator, and an electrolyte illustrated in Figure 3. The electrodes consist of two parts, a metallic current collector and a high surface area active material. A membrane called the 'separator' separate the two electrodes. The separator permits the mobility of charged ions but prohibits electronic conduction[6].

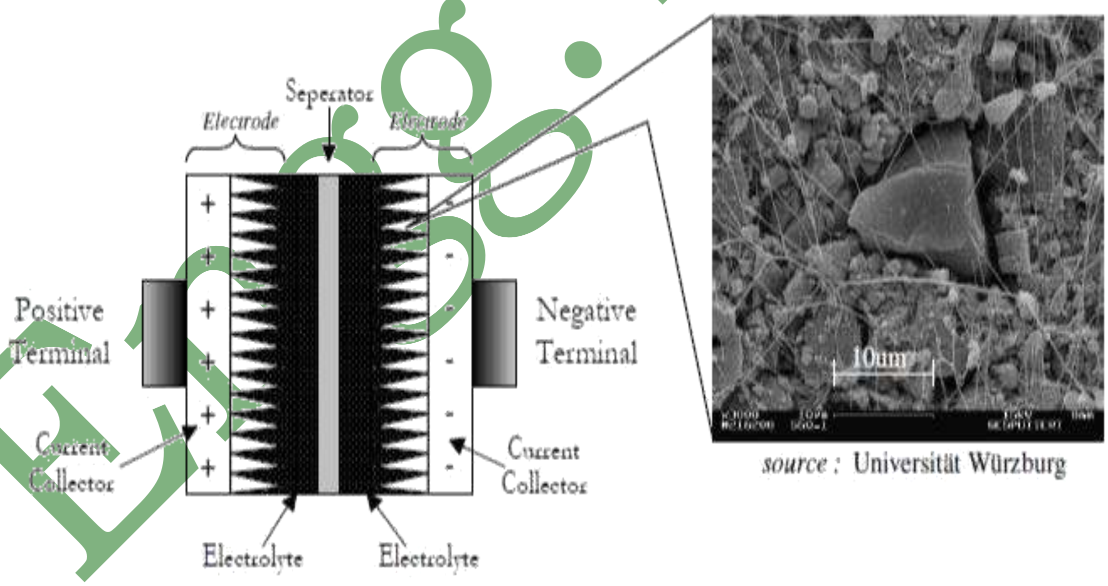

Figure 3: Basic cell construction of an ultra-capacitor

II. Ultra-capacitor Modeling

The EPR represents the current leakage and influences the long-term energy storage. In multiple series connections of ultra-capacitors, the EPR influences the cell voltage distribution due to the resistor divider effect. Using empirical methods, Sypker and N elms [7] showed that the EPR is related to the voltage decay ratio by,

$$EPR = \frac{-V}{\ln\left(\frac{V_2}{V_1}\right)C}$$

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Where
V1 is the initial voltage,
V2 is the final voltage and C is taken as the rated capacitance.

III. Ultra-capacitor Power And Energy

The minimum number of ultra-capacitors needed is determined by the energy profile that the super capacitive bank has to assume. However, due to the voltage decay property of ultra-capacitors, not all the stored energy can be utilized. Therefore the sizing is based on the usable energy that the ultra-capacitor bank can transfer.
the fundamental electrical equations defining an ultra-capacitor are

$$i = C\frac{dv}{dt}$$

$$E = \frac{1}{2}Cv^2$$

Therefore for a given energy specification, the number of ultra-capacitors required can be found by

$$n = \frac{2E_{Tu}}{CV^2_{max}\left(1-\left(\frac{vdr}{100}\right)^2\right)}$$

Using , the following was computed for various vdr values to obtain the corresponding number of 2600 F ultra-capacitor required for a usable energy level of 50 kJ. The graph in Figure 4. shows the plot of ultra-capacitor c ell numbers versus the voltage discharge ratio, vdr. The graph and table shows that a large number of ultra-capacitors in parallel is required to maintain a high voltage discharge ratio. Although the storable energy increases with the number of ultra-capacitors in parallel, the usable energy is constrained by the allowable voltage deviation during discharge.

Table 1: Voltage deviation during discharge

Vdr(%)	**n (rounded up)**	**Actual energy storage (kj)**
50	9	73.125
60	10	81.250
70	13	105.625
80	18	146.250
90	33	268.125

The determination of required number of ultra-capacitors from the above derivation was obtained based on energy requirements only. From simulations, it is seen that for a voltage discharge ratio of 90%, the number of ultra-capacitors required is 33 units. Although the actual stored energy of the 33, 2600F ultra-capacitors is 286.12 kJ, the usable energy at (vdr=90%) is only 50 kJ(13.9Wh)

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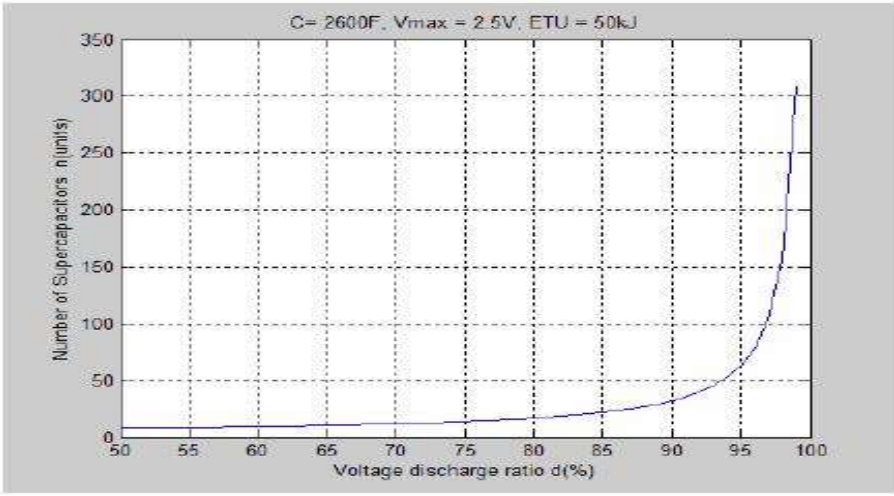

Figure 4: Ultra-capacitor Cell Number Dimensioning for Usable Energy

Result

The voltage e is now available for charging the battery or any other storage like super capacitor. In the proposed model super capacitor are being used as storage. A PI based charger the super capacitor bank up to 400 V. At the time 2.75 to 3.4 seconds we observed charging voltage which can show.

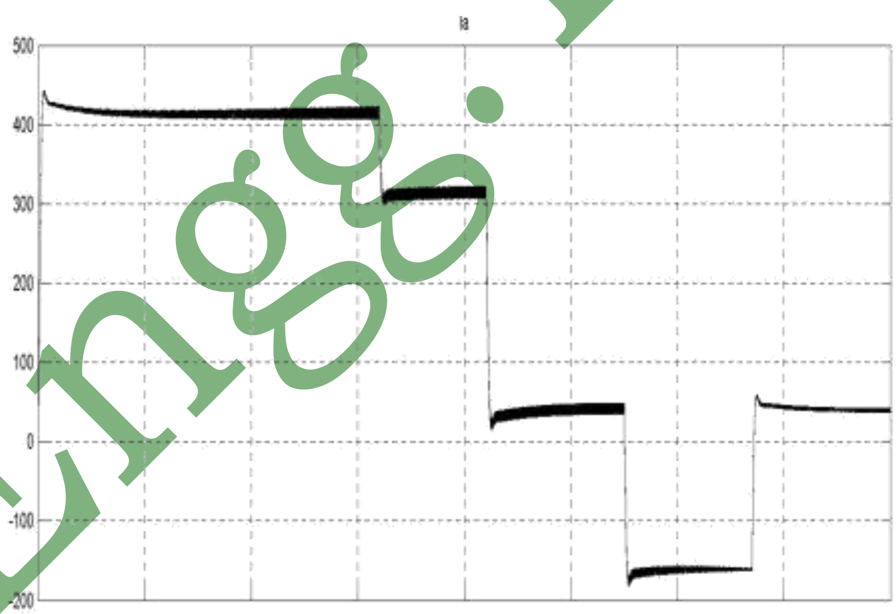

Figure 5: Charging Voltage for Ultra Capacitor

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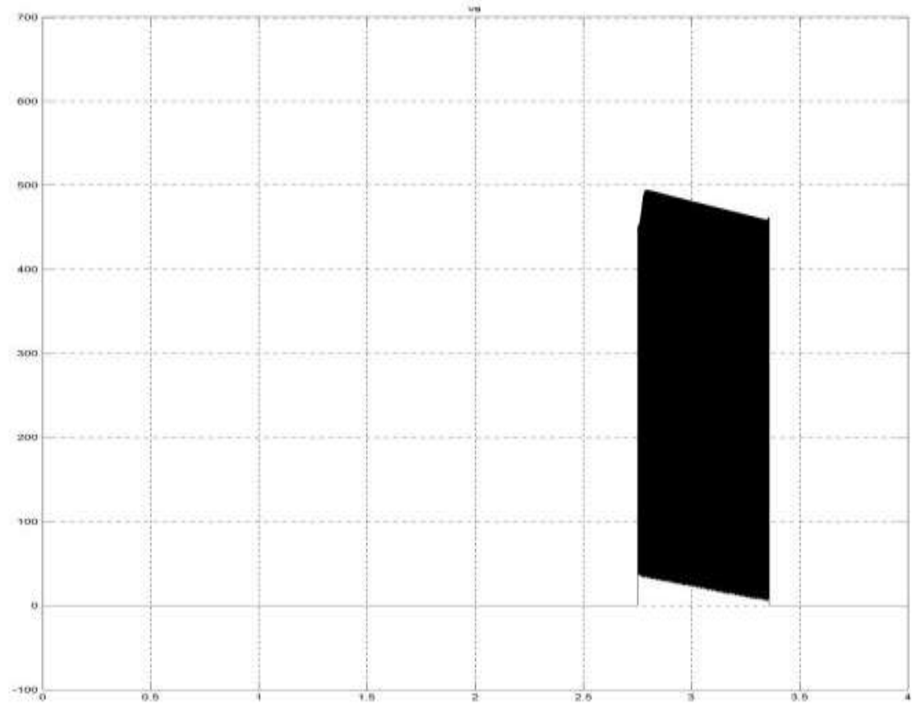

Figure 6: Armature Current Curve for System

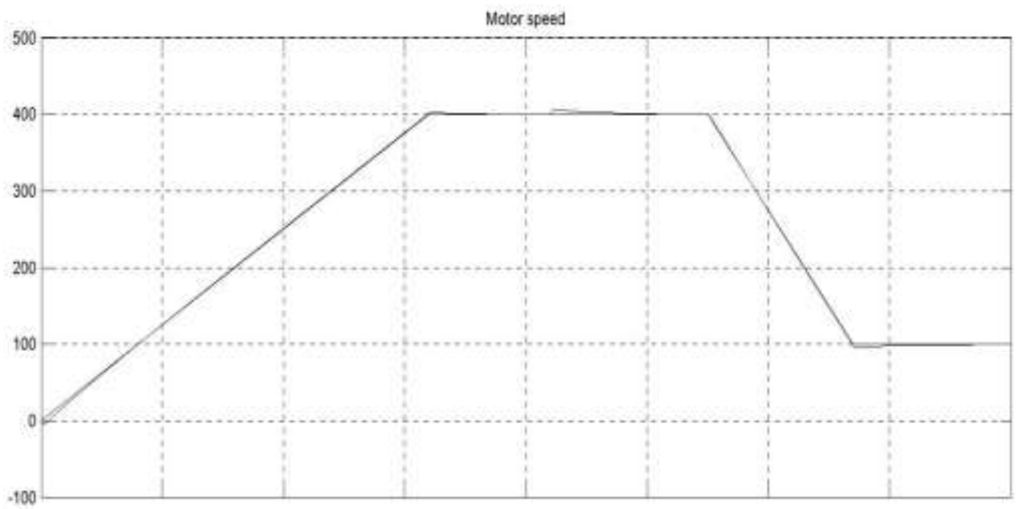

Figure 7: Motor Speed Curve for System

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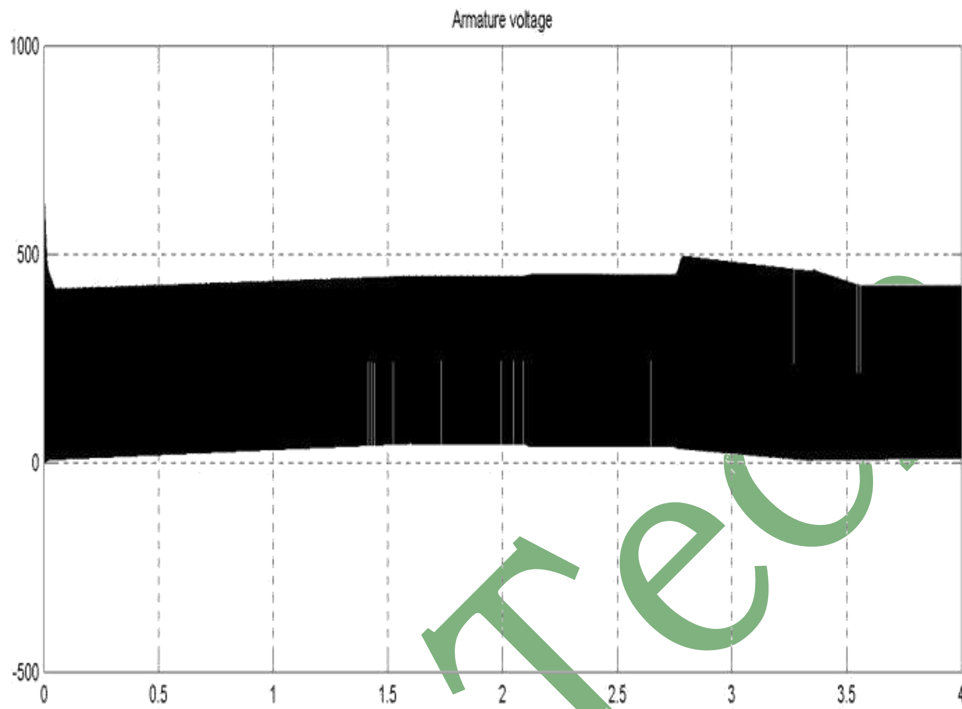

Figure 8: Armature Voltage Curve for System

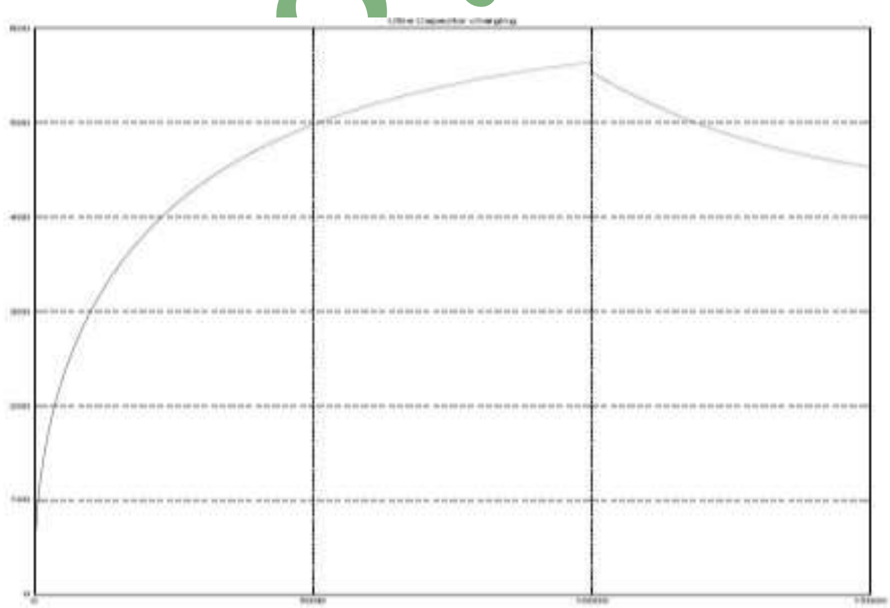

Figure 9:Ultra Capacitor Charging Characteristics

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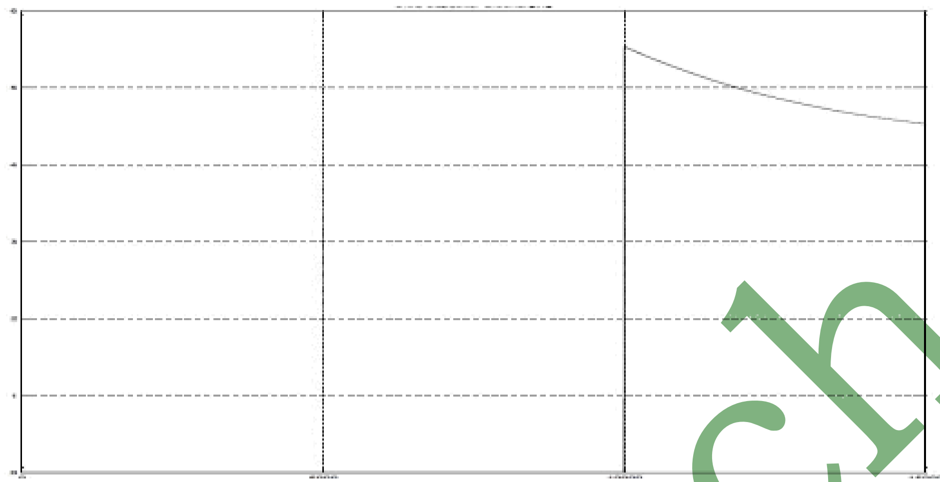

Figure 10: Ultra Capacitor Discharging Characteristics

Conclusion

A high working voltage will bring about some diminishment in the mass of the power electronics converter and the related interconnection and disengagement gadgets. In seclusion, this appears to be positive. How regularly, doing as such at that point requires an expansion in the quantity of series energy sources to accomplish the higher terminal voltage. Not exclusively does this move the mass towards the batteries and ultra-capacitors, the more drawn out arrangement string will likewise require extra arrangement charge adjusting hardware.

Since with useful situations, the correct vehicle control request profiles are not known ahead of time and are hard to precisely anticipate, and since a battery-ultra-capacitor framework can't be dimensioned to catch every conceivable circumstance, vitality administration turns into a trade-off between capacity framework benefit life and round trek effectiveness.

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