Modelling and Design of an Electric Vehicle Fed with Dual Drive Motors using Hybrid Energy Storage System

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Abstract-- Generally, battery running vehicles are there in public but those are limited to small ranges and life of battery also less. So in order to overcome those limitations, we aimed at hybrid energy storage systems which are combination of battery and Super capacitor. Dual drives using in this model are switched reluctance motor and Induction motor separately for front and rear wheels respectively. So that whenever one of the motor fails, the other motor should run the vehicle. To maintain supply at the motor input, two bi-directional converters exists for the motoring and braking operations. This whole model executed in MATLAB/SIMULINK model. Battery and super capacitor gives supply agreeing to the power demand. The controllers used for the SRM and IM are hysteresis current controller and FOC controller respectively.

Keywords—FOC-Field oriented control, IM-Induction motor, SRM-Switched reluctance motor.

I. INTRODUCTION

Now-a-days, the popularity of electric-vehicles has been increasing day by day as the fuel is exhausting. And also internal combustion engines cause pollution. Despite the popularity of electric vehicles, however, they were expensive and their driving ranges were limited. But the research is going on to increase the driving ranges based upon the battery and super-capacitor operation. The motors which are using designed for the electric vehicles are BLDC, PMSM, IM and SRM. In this thesis, electric vehicles fed with dual drive separately for front and rear wheels which improves the vehicle operation. Among them SRM is used for front wheels and IM motor is used for rear wheels. Battery and Super-capacitor used as sources for the vehicle. This arrangement enhances the life and efficiency of the battery so that cost also reduces as Super capacitor gives energy during peak current drives like acceleration and up gradient roads. During braking, Super capacitor first recharge then battery recharges using bi-directional converter.

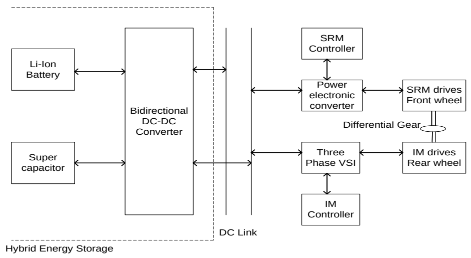

Figure 1: Block diagram

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To get efficient and smooth control speed, an independent dual drive used separately for front and rear wheels as shown in fig.1. Switched-reluctance motor energies the front wheels of the vehicle. Induction motor drives the rear wheels for the automobile. These two motors controlled by separate controllers as shown in figure. Battery and Super capacitor voltages are controlled by bi-directional converter. And the converter connected to constant dc link which keeps the voltage constant.

II. HYBRID ENERGY STORAGE SYSTEM

Battery and super capacitor are using as the sources of electric vehicle. Battery has high energy density compare to the super capacitor whereas super capacitor has the higher power density. Hence the usage of battery and super capacitor gives the advantages of both together to run the vehicle for longer distances with long life as comparing to the usage of only battery. The main drawback of less running range of ev's can be overcome with the hybrid energy sources. The super capacitor supplies the energy during high loads which means peak currents can be delivered by super capacitor. During acceleration and initial starting of an ev needs high torque with low speed for lesser duration, super capacitor will be in the ON state. So that, the life of a battery enhances along with higher efficiencies and minimum temperature rise.

III. BI-DIRECTIONAL CONVERTER

A super capacitor bank control system for an Electric Vehicle has been simulated. The purpose of this device is to allow higher accelerations and decelerations of the vehicle with minimal loss of energy, and minimal degradation of the main battery pack. The system uses an IGBT Buck-Boost converter, which is connected to the super capacitor bank at the Boost side, and to the main battery at the Buck side. The converter also has an IGBT controlled power resistor, which allows to drop energy when in some extreme situations cannot be accepted neither for the super capacitors nor for the battery pack.

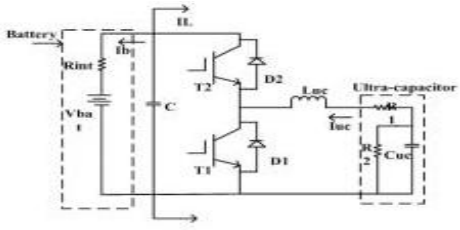

Figure 2: bi-directional dc/dc converter

The operation of Bi-directional converter is based upon the vehicle parameters such as speed and torque. During Boost operation (acceleration), T1 is switched on and off at a controlled duty cycle, to transfer the required amount of energy from the capacitor to the battery pack. When T1 is ON, energy is taken from the capacitor, and stored in the inductor L. When T1 is switched OFF, the energy stored in L is transferred into C, through D2, and then into the battery pack. The inductor Ls has the duty to soft the current pulses going to the battery pack. During Buck operation, the converter introduces energy from the battery to the super capacitor. That operation is accomplished with a controlled PWM (Pulse Width Modulation) operation on T2. When T2 is switched ON, the energy goes from the battery pack to the super capacitor, and L stores part of this energy. When T2 is switched OFF, the remaining energy stored in L is transferred inside the super capacitor.

IV. INDUCTION MOTOR

The three-phase induction motor may be a preferable sort of machine in all over fields and applications. It is commonly used in industrial drives for the reason that it is very sensible and vigorous, economical and reliable. Here, induction motor is used for the rear wheels, because of its speed-torque characteristics.

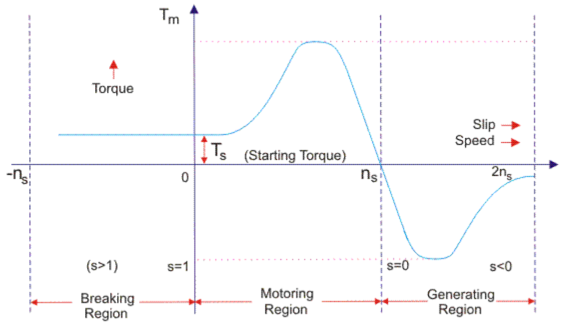

Figure 3: torque-speed characteristics

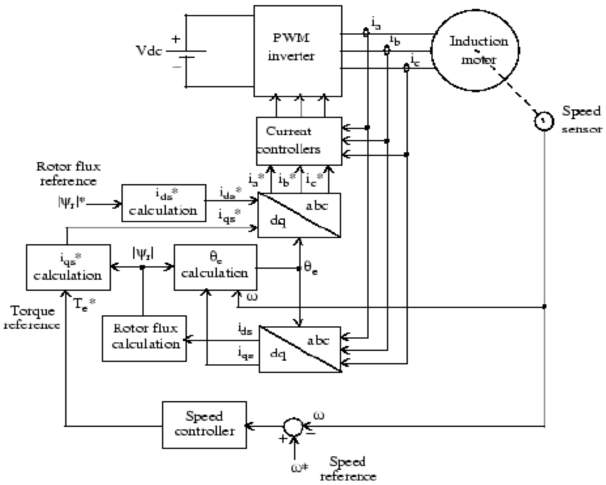

Figure 4: Control block of FOC

V. SWITCHED RELUCTANCE MOTOR

SRM is used for the front wheels as it has high initial torque characteristics as shown in below fig. at initial run and acceleration the front wheels needs high torque as comparing to the rear wheels. Generally, the PMSM motor will be used for the electric vehicles but whereas in this paper the SRM motor is used why because the SRM is economical and less losses as comparing to the PMSM and all other motors. The working principle of SRM- Torque is generated when the flux flowing over the salient rotor poles pulls them toward the stator poles to reduce the reluctance of magnetic path.

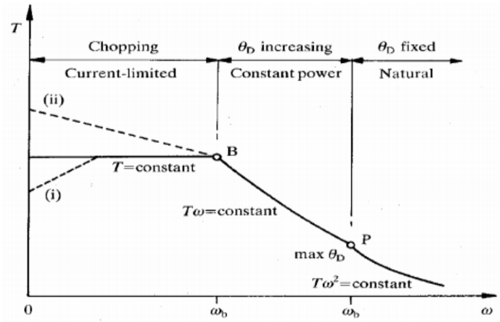

Figure 5: speed-torque characteristics

For the four quadrant operation of SRM, calculation of rotor position is essential which is done by position sensor. According to the turn on and turn off angles of the stator the motor runs in both motoring and generating mode. The speed of SRM is controlled by taking closed loop feedback and hysteresis current controller. The control block diagram of SRM is shown in below fig.

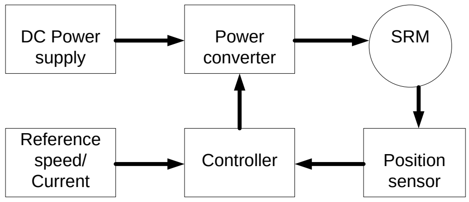

Figure 6: control block

VI. SIMULATION MODEL

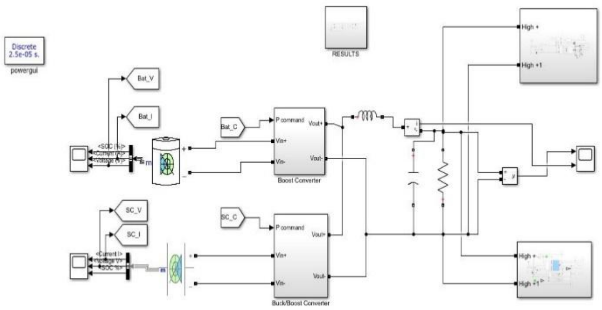

Figure 7: dual motors fed with HESS

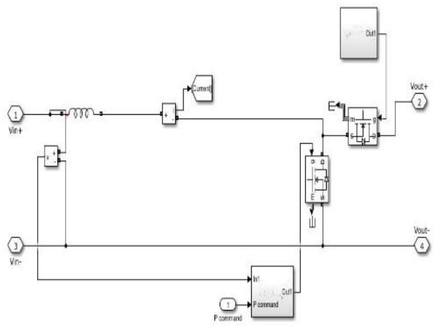

Figure 8: bi-directional converter

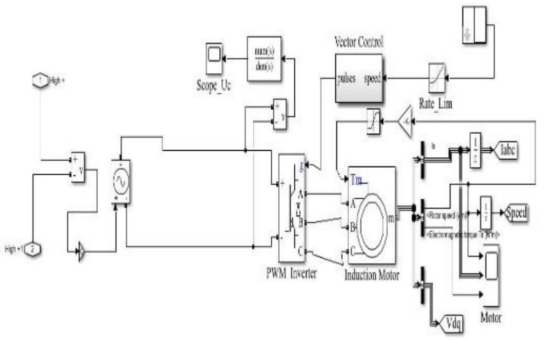

Figure 9: Induction motor subsystem

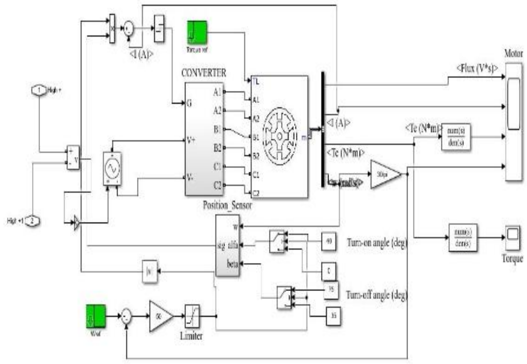

Figure 10: SRM subsystem

VII. RESULTS AND ANALYSIS

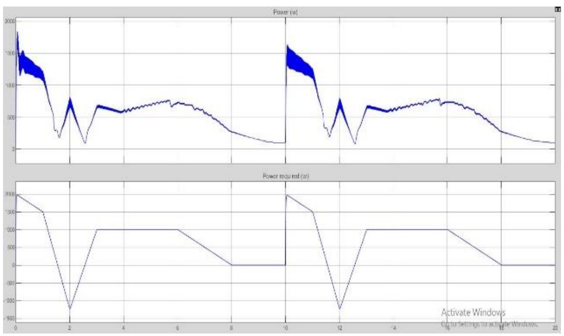

Figure 11: power delivered by battery & SC, power demand

The power demand has given as 2000W, 1500W, -1200W,1000W,1000W,0W, 2000W…. for the time values of 0,1,2,4,6,8, 10, sec. this is periodically repeated after every 10sec. the power delivered by both sources is approximately equal to the power demand as seen from the above fig.

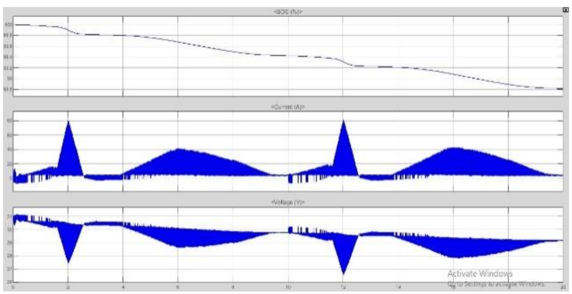

Figure 12: Battery SOC%, voltage, current

The battery discharges up to the 20% of state of charge. To reach that percentage battery takes some hours again it depends on the load current. During regenerative operation, the current suddenly raises at t = 2sec,12sec,22sec…. here power fed back to battery from motor drives.

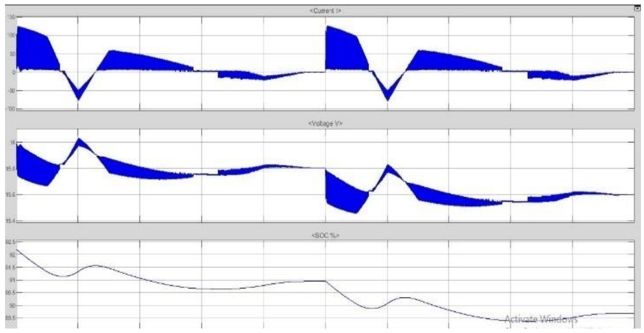

Figure 13: Super capacitor Current,Voltage,SOC%

The supercapacitor discharges at t = 0,1sec and charges again at t = 2sec as the drives runs in braking mode at this time. Supercapacitor operates for small durations only.

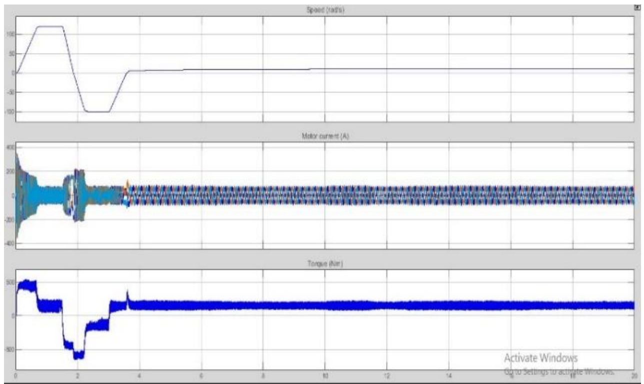

Figure 14: four quadrant operation of an IM a)speed, b)current, c)torque

At t = 0sec to t = 1.8sec, Induction motor operates in motoring mode. From t = 1.8sec to t = 1.9sec it operates in generating mode.

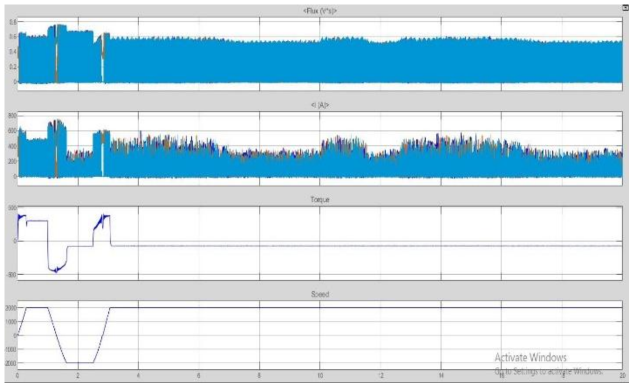

Figure 15: four quadrant operation of SRM a) flux, b) current, c) torque, d) speed

Same as induction motor, SRM operates in motoring mode from t = 0sec to t = 0.5sec and from t = 1sec to t = 1.5sec operates in generating mode.

VIII. CONCLUSION

In the whole project, the speed control of the Switched Reluctance Motor and Induction Motor during motoring operation and braking operation executed using MATLAB software. From the results, we can say that the SRM has high torque below rated speed and Induction motor can be used for high speed operations as the speed control is efficient by Field Oriented Control.

Both the motors driven from the Bidirectional converter which works as buck and boost converter as per the speed and torque characteristics. However, which maintains the constant supply at the dc link to maintain steady state characteristics of an electric vehicle. The battery supplies the energy at constant current loads at the same side super capacitor supplies during high peak currents so that the burden on the battery reduces and the life of battery enhances. Including that by usage of dual motors the vehicle never come across failure as any one of the motor can run that vehicle.

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