Speed control of DC motor by enhancing the efficiency using supercapacitor

[1]Roopali K. Edke, [2]R.H.Adware, [3]Dr. D.R.Tutakne

[1]Student, [2]Assistant Professor, [3]Professor
G.H. RAIONI COLLEGE OF ENGINEERING, NAGPUR

***Abstract*—A modular approach is practiced to study overall behavior of DC motor. Its performance is observed in detail with different load conditions. The proper energy management between motor and load by using battery and supercapacitor is the main objective of work to be achieved. supercapacitor is used in the topology for injecting energy at dc link together with the boost converter is incorporated. The hardware model shows the proposed work with all parameters needed into the system.**

***Keywords*: DC motor, battery, super capacitor, DC-DC converter.**

INTRODUCTION:

DC motor is considered as electric drive which is an electromechanical device just for converting electrical energy into mechanical energy. As DC motor has tremendous application in diverse area such as transportation, industrial, agriculture domestic, etc. DC motors are very commonly used as variable-speed drives and in applications where severe torque variation occurs. when motor rotates, it usually connected to the load which has a rotational or translational motion. The speed of the motor may be different from that of the load. Thus to analyze the relation among the motor and load an experiment is done. The speed of DC motor can be controlled by using storage devices such as Batteries, super capacitor, etc. The battery has the capability of high energy density whereas super capacitor has high power density capability. Therefore proper distribution of energy is done between the super capacitor

and the battery. When peak overloading occurs into the system at that time high or peak power demand with high current is necessary. Therefore this required power is delivered by the super capacitor during peak period. Otherwise super capacitor remains charged with full voltage if transient period does not occurs. The low voltage is an indication for the motor instantaneous situation to take the control between battery and super capacitor. Super capacitor carries excellent features over batteries like fast charging -discharging, gives best power performance, long lifetime, and high reliability. Thus super capacitor can protect batteries against fast charging/discharging, thereby improves battery lifetime by reducing thermal burden on it which is because of high peak power load.

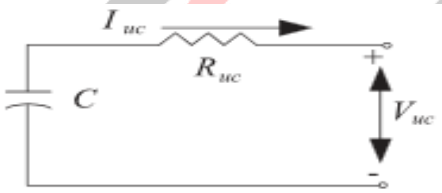

Fig.1: Equivalent model of Super capacitor:

Basically supercapacitor has advantages in applications where large amount of power is needed for relatively short time. Super capacitor fills the gap between low power-high energy rechargeable batteries and high power-low energy electrolytic capacitors. The energy stored in super capacitor is given by formula,

$$E_{max} = 1/2 * C_{total} * V^2_{loaded}$$

Only some part of energy is available to the applications because of the time constant over internal resistance and the voltage drop.

Method of controlling DC motor speed:

1) Flux control
2) Rheostatic control
3) Applied voltage control

Factors affecting speed of DC motor:

The speed equation of DC motor is given by-

$$N = (V - IaRa) / \phi$$

The resistances in armature winding and series field winding are considered to be small or negligible.
Therefore the voltage drops IaRa or Ia(Ra+Rs) are also negligible. Thus the expression for speed now becomes is as,

$$N = V/\phi$$

Since, V>>>IaRa

Therefore from these expression we can obtain the factors affecting the speed of a DC motor as follows:

1. The speed is inversely proportional to flux ϕ
2. Speed is directly proportional to armature voltage.
3. Speed is directly proportional to applied voltage V.

So, by varying one of these parameters, it is possible to change the speed of a DC motor.

PROPOSED MODEL:

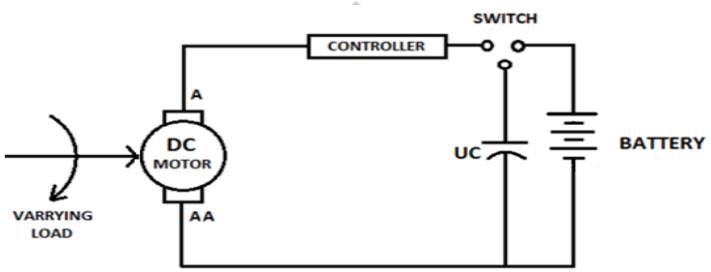

Fig.2: proposed model

Model shows the overall idea of system to be implemented where DC motor is subjected to for testing under various load conditions, for which variable load to the motor shaft is provided. Controller will take action for switching between battery and supercapacitor. Supercapacitor will act as the fast charging and discharging device as it has ability to act fast whereas in normal mode of operation, battery will supply the load.

:

Control of DC-DC Converter:

To achieve speed control of DC motor converter is used.

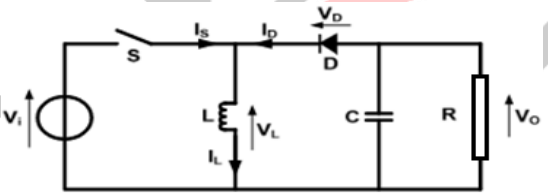

Fig.3: DC-DC converter

DC-DC converter acts an dc equivalent of ac transformers. Supercapacitors gets charged during buck mode while in boost mode it delivers its energy to the load. By varying the duty cycle of the transistor switch, dc voltage can be step up or step down. In this converter inductor is the main element which shows the key role as it has the tendency to resist changes in current. Inductor will absorb energy when being charged, it acts as load when being discharged, it acts as an energy source. DC-DC converters are thus used to regulate the energy flow among batteries and supercapacitors.

SYSTEM TOPOLOGY:

The DC motor performance can be control during its dynamic period. The above system topology explains the power circuit for dc motor. The speed control of motor is performed by varying load on its shaft. Suppose motor is pulling up the laod A through pulley. Now again if extra pulley load is added, there occurs a difference between load torque and electrical torque thus by decreasing the speed momentarily.

Thus it is observed that as the load increases on the motor shaft, the actual speed of the rotor tends to fall further behind the speed of the rotating magnetic field in the stator.

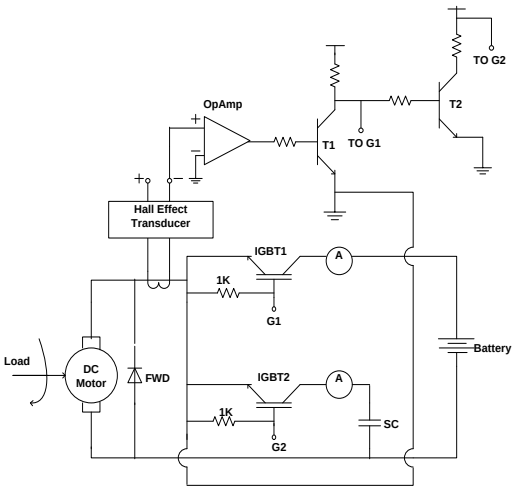

Fig.4: system topology

Hall effect sensor is kind of a transducer which varies its output voltage with respect to magnetic field of motor, thereby notifying the current and voltage parameters of motor. The Opamp which also called as comparators can compare the voltage level with another reference level of voltage. The output of Opamp will decide energy into the system is to be provided. The IGBTs and Transistors acts as a switching device.

PROPOSED HARDWARE MODEL:

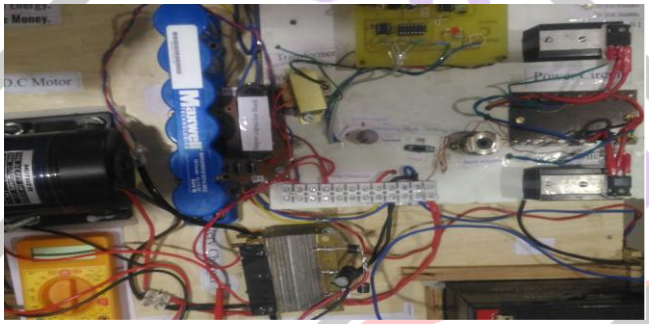

Fig.5: proposed hardware model

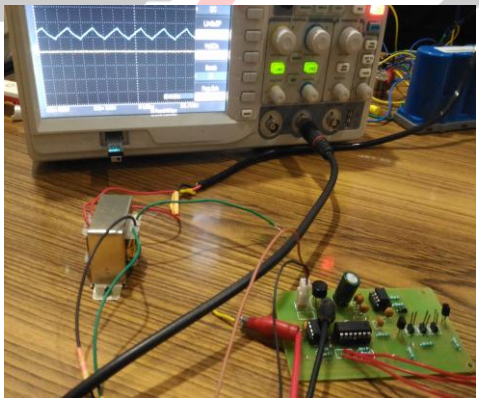

Fig.6: testing of control circuit

CONCLUSION

Thus the above technique is proved successfully to achieve the desired aspect of work for controlling the speed of DC motor by using storage device. Supercapacitor gives its best impact into system to maintain the system optimized.

REFERENCES

[1] P.F. Ribeiro, B.K. Johnson, M.L. Crow, A. Arsoy, Y. Liu,"Energy storage systems for advanced power applications," Proceedings of the IEEE, Vol. 89, Issue 12, Dec. 2001 pp. 1745 – 1755.

[2] Ortuzar, J. Moreno, and J. Dixon, "Ultracapacitor -based auxiliary energy system for an electric vehicle: Implementation and evaluation," IEEE Trans. on Industrial Electronics , vol. 54, no. 4, Aug. 2007

[3] S. M. Lukic, J. Cao, R. C. Bansal, F. Rodriguez, and A. Emadi, "Energy storage systems for automotive applications," IEEE Trans. on Industrial Electronics, vol. 55, Jun. 2008.

[4] Miquel Massot-Campos1, Daniel Montesinos-Miracle1,Joan Bergas-Jané1 and Alfred Rufer2, "Multilevel Modular DC/DC Converter for Regenerative Braking Using Supercapacitors", Journal of Energy and Power Engineering 6 (2012)

[5] Frede Blaabjerg, Fellow, IEEE , Zhe Chen , Senior Member, IEEE , and Soeren Baekhoej Kjaer , Member, IEEE, "Power Electronics as Efficient Interface in Dispersed Power Generation Systems", IEEE Transactions on power electronics, vol. 19, no. 5, September 2004.

[6] White Paper: Design Advantages of Solid State Batteries versus Super capacitors: Cymbet Corporation