

**International Journal of Innovative Research in Science,
Engineering and Technology**

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

IoT Based Regenerative Braking System for Energy Harvesting

Kavitha B

Lecturer, Department of Electronics and Communication Engineering, IRT Polytechnic College, Chennai, India

ABSTRACT: When brake is applied in vehicles and in trains, a significant amount of kinetic energy that is available because of the movement of the vehicle is wasted in the form of both the power used for applying the brake and also the power lost as heat in the brake. This power is a significant amount of power and if it could be saved then it can be used for additional applications also. This can be achieved using regenerative braking. In regenerative braking instead of the conventional frictional braking system, a different mechanical system is used, wherein when the brake is applied instead of a conventional frictional braking system, a generator is mechanically connected to the wheel. The generator acts as a huge load and stops the vehicle. But in the time duration between the brake being applied and the vehicle coming to a total halt, the generator is running using the rotation of the wheel.

KEYWORDS: Braking System, Energy, Regenerative,

I. INTRODUCTION

Brakes are employed to stop or retard the motion of any moving body. Thus, in automobiles the brakes are having the most important function to perform. In conventional braking system the motion is retarded or stopped by absorbing kinetic energy by friction, by making the contact of the moving body with frictional rubber pad (called brake liner) which causes the absorption of kinetic energy, and this is wasted in form of heat in surroundings. Each time we brake, the momentum of vehicle is absorbed that it has gained by it and to re-accelerate the vehicle we have to start from the scratch to redevelop that momentum by using the more power from an engine. Thus, it will ultimately result in huge waste of energy.

As the basic law of Physics says „energy can neither be created nor be destroyed it can only be converted from one form to another“. It will be good if we could store this energy somehow which is otherwise getting wasted out and reuse it next time we started to accelerate. That's the basic concept of regenerative ("regent") brakes, which provide braking for the system when needed by converting the available energy to some usable form. These are widely used in electric trains and the latest electric cars. Regenerative brake is an energy recovery mechanism which slows a vehicle by converting its kinetic energy into another form, which can be either used immediately or stored until needed.

Thus, the generated electricity during the braking is fed back into the supply system (in case of electric trains), whereas in battery electric and hybrid electric vehicles, the energy is stored in a battery or bank of capacitors for later use. Energy may also be stored by compressing air or in a rotating flywheel. An Energy Regeneration Brake was developed in 1967 for the AMC Amitron. This was a completely battery powered urban concept car whose batteries were recharged by regenerative braking, thus increasing the range of the automobile. Many modern hybrid and electric vehicles use this technique to extend the range of the battery pack. Examples include the Toyota Prius, Honda Insight, the Vectrix electric maxi-scooter, and the Chevrolet Volt.

The rotation of the generation in the duration between the braking and the vehicle coming to a halt produces significant power. This power can be stored in any power storage device like a battery or a capacitor bank. Additionally

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

this power can be used for powering other electrical devices within a vehicle or a train. As it stands, when a person wants electricity they are forced to purchase it from someone else.

The average person does not have access to coal mining equipment or coal-fired power plants to make their own electricity. However, the average person does have the opportunity to obtain energy from other means. This setup when used for personal vehicles can benefit common man and usage in public transports like trains will help government to reduce the burden of relying on fossil fuels

It's something of an uncomfortable fact that civilized society is almost completely reliant upon fossil fuels for nearly every aspect of its existence. While fossil fuels have been integral in the development of most industrial nations, there are a few realities of using them that society needs to come to terms with. There are many arguments in favour of society's need for renewable energy. As it stands, when a person wants electricity they are forced to purchase it from someone else. The average person does not have access to coal mining equipment or coal-fired power plants to make their own electricity. However, the average person does have the opportunity to obtain energy from other means.

The paper is organized as follows, the literature survey on various ideas given from different scientists and researchers are studied and the best ideologies from various researches are employed to design this new system are given in section 2. In section 3 the proposed system is designed according to the concept and a detailed description of the block diagram and the components required in constructing this device are explained. Section 4 deals with the expected outcome.

II. LITERATURE SURVEY

González-Gil [1] proposed a holistic approach to reduce the overall energy consumption of urban rail. Firstly, a general description of this transport mode is given, which includes an assessment of its typical energy breakdown. Secondly, a comprehensive appraisal of the main practices, strategies and technologies currently available to minimize its energy use is provided. These comprise: regenerative braking, energy-efficient driving, traction losses reduction, comfort functions optimization, energy metering, smart power management and renewable energy micro-generation. A logical methodology is described to optimally define and implement energy saving schemes in urban rail systems.

Álvaro J. López-López [2] carried out a deep, rigorous and comprehensive study on the factors which affect energy issues in a DC-electrified mass transit railway system. This study clarifies what the actual potential is for energy saving in each situation. Then, a methodology to assess several energy-saving techniques to improve energy efficiency in DC-electrified mass transit systems is presented, constituting the main contribution of this paper. This methodology has been conceived to help operators in assessing the effect of railway-infrastructure emerging technologies in transit systems, so making it possible to shape planning, capacity, etc. It is stepped out in three basic movements. First of all, a traffic-density scan analysis is conducted in order to clarify the effect of the headway on system behaviour. Secondly, several traffic-density scenarios are simulated for a set of infrastructure-expanded cases. Finally, annual energy saving is evaluated by applying a realistic operation timetable. This methodology has been applied to a case study in Madrid Metro (Spain) to illustrate the steps of its application and the effect of several energy-saving techniques on this specific system. Results confirm that regenerative braking generally leads to an important increase of system energy efficiency – especially at high traffic-density scenarios. It has also been proved that infrastructure improvements can also contribute to energy savings and their contributions are more significant at low traffic densities. Annual energy results have been obtained, which may lead to investment decisions by carrying out an appropriate economic assessment based on cost analysis.

Feng Wang, [6] A regenerative braking system, which could restore kinetic energy and potential energy to a battery or any other forms of power during braking, is a special system for electric and hybrid electric vehicles. However, the large current produced by the generator during braking would affect battery performance and shorten battery life. A hybrid-power system is an excellent energy storage system, in which an ultra-capacitor bank and a battery pack are connected together through a DC/DC power converter. And the ultra-capacitor in this system can store instantaneous large currents quickly, which is able to protect the battery from large currents. The application advantages of the hybrid-power system are analyzed in this paper, as well as a series control strategy for regenerative braking based on it. In order to verify the feasibility of the strategy, a braking force distribution model, which contains

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

one S-Function, between mechanical and regenerative braking is built in MATLAB/Simulink by taking into account the ultra-capacitor voltage, the motor regenerative braking ability and other factors. Simulation results suggest that the ultra-capacitor is able to restore the regenerative energy very quickly, which will improve starting and acceleration performance, extend driving range, and increase fuel economy.

Boris Axelrod [12] proposed a few simple switching structures, formed by either two capacitors and two- three diodes (C-switching), or two inductors and two-three diodes (L-switching) are proposed. These structures can be of two types. These blocks are inserted in classical converters: buck, boost, buck-boost, Cuk, Zeta, Sepic. The “step-down” C-or L-switching structures can be combined with the buck, buck-boost, Cuk, Zeta, Sepic converters in order to get a step-down function. When the active switch of the converter is on, the inductors in the L-switching blocks are charged in series or the capacitors in the C-switching blocks are discharged in parallel. When the active switch is off, the inductors in the L-switching blocks are discharged in parallel or the capacitors in the C- switching blocks are charged in series. The “step-up” C-or L-switching structures are combined with the boost, buck-boost, Cuk, Zeta, Sepic converters, to get a step-up function. The steady-state analysis of the new hybrid converters allows for determining their DC line-to-output voltage ratio. The gain formula shows that the hybrid converters are able to reduce/increase the line voltage more times than the original, classical converters. The proposed hybrid converters contain the same number of elements as the quadratic converters. Their performances (DC gain, voltage and current stresses on the active switch and diodes, currents through the inductors) are compared to those of the available quadratic converters. The superiority of the new, hybrid converters is mainly based on less energy in the magnetic field, leading to saving in the size and cost of the inductors, and less current stresses in the switching elements, leading to smaller conduction losses. Experimental results confirm the theoretical analysis.

III. PROPOSED METHODOLOGY

The methodology of this project design can be divided into two sections; hardware and software implementations. The hardware implementation consists of the power generation using a dynamo, the SEPIC Converter which boosts the power accompanied with a PIC Controller and a driver board while the software implementation consists of monitoring the load using IoT.

The following actions are carried out by the system

- i. When brake is applied, power is obtained from the wheel using dynamo.
- ii. The power obtained is being boosted by the SEPIC Converter with the help of a driver board and the PIC controller.
- iii. The boosted power thus obtained is used to run the load which may be a fan or a lamp.
- iv. The control of the load comes in the area of software with the help of IoT.
- v. The control is done by IoT using PIC Controller.

SEPIC Converter is the vital part of the supporting hardware. SEPIC converter is the one which boost up the power that is being obtained from the dynamo.

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment. A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python. The output of the load is shown as simulation using MATLAB which comes under software implementation.

Hardware required for implementation of the proposed system are Dynamo, Battery, SEPIC Converter, Driver Board, PIC Controller, Power supply unit, Load, IoT. The block diagram of the proposed design is given in figure 1.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

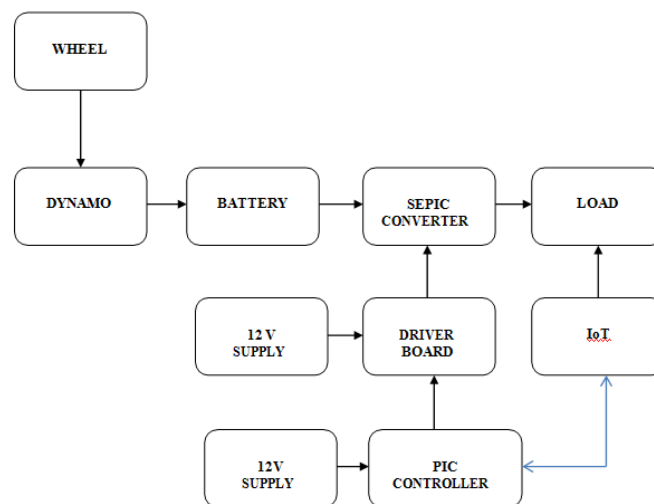


Fig. 1 – Block Diagram

The wheel is rotated position the dynamo is fixed at the position. The dynamo is generating the power. The generated power is storing to the super capacitor. The lamp is act as a load. Then it is given to the modified SEPIC converter. From that voltage is get boosted. The whole setup is controlled by PIC controller with the help of driver circuit with the 12 voltage supply. Filter circuits which are usually capacitors acting as a surge arrester always follow the rectifier unit. This capacitor is also called as a decoupling capacitor or a bypassing capacitor, is used not only to “short” the ripple with frequency of 120Hz to ground but also to leave the frequency of the DC to appear at the output. C1R1 is for bypassing ripples. C2R2 is used as a low pass filter, i.e. it passes only low frequency signals and bypasses high frequency signals. The load resistor should be 1% to 2.5% of the load.

The voltage regulators play an important role in any power supply unit. The primary purpose of a regulator is to aid the rectifier and filter circuit in providing a constant DC voltage to the device. Dynamos and Generators convert mechanical rotation into electric power. Dynamo - a device that makes direct current electric power using electromagnetism. It is also known as a generator, however the term generator normally refers to an "alternator" which creates AC power.

In the most basic sense a generator/dynamo is one magnet rotating while inside the influence of another magnet's magnetic field. You cannot see a magnetic field, but it is often illustrated using lines of flux. In the illustration above lines of magnetic flux would follow the lines created by the iron filings. The generator/dynamo is made up of stationary magnets (stator) which create a powerful magnetic field, and a rotating magnet (rotor) which distorts and cuts through the magnetic lines of flux of the stator. When the rotor cuts through lines of magnetic flux it makes electricity.

The magnets are usually not made of natural magnetite or a permanent magnet (unless it is a small generator), but they are copper or aluminum wire coiled around an iron core. Each coil must be energized with some power to make it into a magnet. This coil around iron is called a solenoid. Solenoids are used instead of natural magnetite because the solenoid is MUCH more powerful. A small solenoid can create a very strong magnetic field.

Many operational characteristics of the classical SEPIC converter are changed with the proposed modification, as the elevation of the converter static gain. The capacitor CM is charged with the output voltage of the classical boost converter. The polarity of the CS capacitor voltage is inverted in the proposed converter and the expressions of the capacitors voltages and other operation characteristics are presented in the theoretical analysis. The continuous conduction mode (CCM) of the modified SEPIC converter presents two operation stages. All capacitors are considered as a voltage source and the semiconductors are considered ideals for the theoretical analysis.

A buck converter is a voltage step down current step up converter. The simplest way to reduce the voltage of a DC supply is to use a linear regulator (such as a 7805), but linear regulators waste energy as they operate by dissipating excess power as heat. Buck converters, on the other hand, can be remarkably efficient (95% or higher for integrated circuits), making them

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

useful for tasks such as converting the main voltage in a computer (12 V in a desktop, 12-24 V in a laptop) down to the 0.8-1.8 volts needed by the processor.

A boost converter is a DC-to-DC power converter with an output voltage greater than its input voltage. The buck–boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a fly back converter using a single inductor instead of a transformer. Two different topologies are called buck–boost converter. Both of them can produce a range of output voltages, ranging from much larger (in absolute magnitude) than the input voltage, down to almost zero.

A battery is a device that converts stored chemical energy to electrical energy. Batteries are commonly used as energy secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. A rectifier is used to convert alternating voltage to a pulsating direct voltage, followed by a filter, comprising one or more capacitors, resistors, and sometimes inductors, to filter out (smooth) most of the pulsation.

An AC power supply typically takes the voltage from a wall outlet (mains supply) and uses a transformer to step up or step down the voltage to the desired voltage. Some filtering may take place as well. In some cases, the source voltage is the same as the output voltage; this is called an isolation transformer. Driver amplifies the voltage from microcontroller which is 5 volts. Also it has an optocoupler for isolating purpose. The driver circuit forms the most important part of the hardware unit because it acts as the backbone of the inverter because it gives the triggering pulse to the switches in the proper sequence.

PIC 16F877A is used for producing switching pulses to multilevel inverter so as to use those vectors which do not generate any common mode voltage at the inverter poles. This eliminates common mode voltage. Also it is used to eliminate capacitor voltage unbalancing. The microcontroller are driven via the driver circuit so as to boost the voltage triggering signal to 9V. To avoid any damage to micro controller due to direct passing of 230V supply to it we provide an isolator in the form of optocoupler in the same driver circuit.

IV. RESULT ANALYSIS

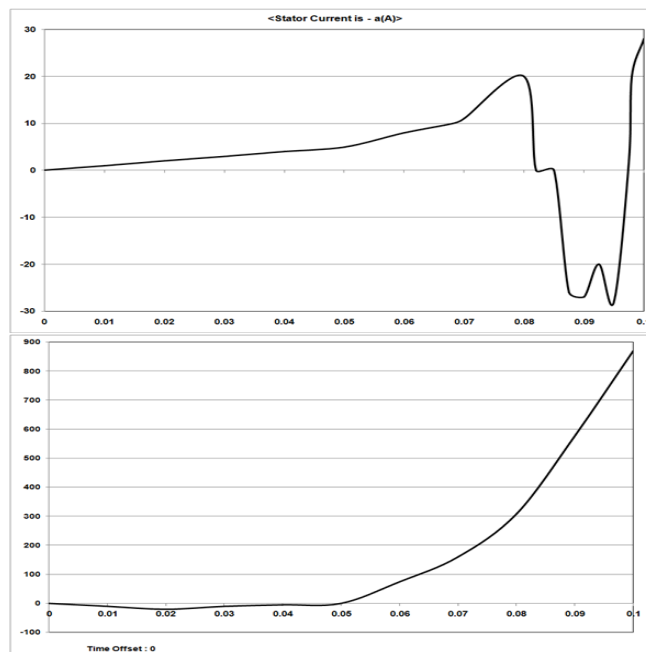


Fig – 2 Output Response of Regenerative Braking System

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

The effects of regenerative braking on air quality depend mainly on the way the electricity is produced. In general, the introduction of regenerative braking on electric trains and subway trains will have no direct effect on the local air quality. However, lowering the electricity demand will lower the emission of air pollutants, like NO_x, SO₂ and particulate matter in power generation, if power generation is based on fossil fuels. In real time applications modified SEPIC Converters are being used for better result but for demo purposes SEPIC converter is being used in this project. Using SEPIC converters above buck, boost and buck-boost converters will give increased power which can be extensively used for several applications. Applying IoT into the project gives as opportunity to operate the project as per the growing technology. Regenerative braking is a small, yet very important, step toward our eventual independence from fossil fuels. These kinds of brakes allow batteries to be used for longer periods of time without the need to be plugged into an external charger. These types of brakes also extend the driving range of fully electric vehicles. The Simulation result i.e Output Response of RGS is shown in Figure 2.

V. CONCLUSION

The effects of regenerative braking on air quality depend mainly on the way the electricity is produced. In general, the introduction of regenerative braking on electric trains and subway trains will have no direct effect on the local air quality. However, lowering the electricity demand will lower the emission of air pollutants, like NO_x, SO₂ and particulate matter in power generation, if power generation is based on fossil fuels. Complete eradication of energy needs isn't possible in this developing world. By using regenerative braking considerable amount of energy can be gained which can be utilised if performed in a proper way.

REFERENCES

1. A. González-Gil, R. Palacin, P. Batty, and J. Powell, "A systems approach to reduce urban rail energy consumption," *Energy Conversion and Management*, vol. 80, pp. 509–524, 2014.
2. A. J. López-López, R. R. Pecharromán, A. Fernández-Cardador, and A. P. Cucala, "Assessment of energy-saving techniques in direct-current electrified mass transit systems," *Transportation Research Part C: Emerging Technologies*, vol. 38, pp. 85–100, 2014.
3. C. W. Gellings, *The smart grid: enabling energy efficiency and demand response*. The Fairmont Press, Inc., 2009.
4. E. P. de la Fuente, S. K. Mazumder, and I. G. Franco, "Railway electrical smart grids: An introduction to next-generation railway power systems and their operation." *IEEE Electrification Magazine*, vol. 2, no. 3, pp. 49–55, 2014.
5. F. Ciccarelli, A. Del Pizzo, and D. Iannuzzi, "Improvement of energy efficiency in light railway vehicles based on power management control of wayside lithium-ion capacitor storage," *IEEE Transactions on Power Electronics*, vol. 29, no. 1, pp. 275–286, 2014.
6. F. Wang, X. Yin, H. Luo, Y. Huang, "A series regenerative braking control strategy based on hybrid-power", *Proc. Int. Conf. CDCIEM*, pp. 65-69, 2012.
7. M. Cheng, W. Hua, J. Zhang, W. Zhao, "Overview of stator-permanent magnet brushless machines", *IEEE Trans. Ind. Electron.*, vol. 58, no. 11, pp. 5087-5101, Nov. 2011.
8. O. Erdinc, N. G. Paterakis, T. D. Mendes, A. G. Bakirtzis, and J. P. Catalão, "Smart household operation considering bi-directional ev and ess utilization by real-time pricing-based dr," *IEEE Transactions on Smart Grid*, vol. 6, no. 3, pp. 1281–1291, 2015
9. P. J. Grbovic, P. Delarue, P. Le Moigne, P. Bartholomeus, "A bi-directional three-level dc-dc converter for the ultra-capacitor applications", *IEEE Trans. Ind. Electron.*, vol. 57, no. 10, pp. 3415-3430, Oct. 2010.
10. R. R. Pecharroman, A. Lopez-Lopez, A. P. Cucala, and A. Fernandez- Cardador, "Riding the rails to dc power efficiency: Energy efficiency in dc-electrified metropolitan railways." *IEEE Electrification Magazine*, vol. 2, no. 3, pp. 32–38, 2014.



ISSN (Online): 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

11. S. R. Cikanek and K. E. Bailey, "Electric vehicle braking systems," in Proc. 1997 International Electric Vehicle Symposium.
12. Boris Axelrod; Yefim Berkovich; Adrian Ioinovici , "Switched-Capacitor/Switched-Inductor Structures for Getting Transformer less Hybrid DC-DC PWM Converters", IEEE Transactions on Circuits and Systems I: Regular Papers , Volume: 55, Issue: 2, pp- 687 – 696, March 2008