Automated Bypass Electric Controlled Vehicle Regulation System

[1] S. Sindhuja, [2] M. Milcah, [3] S. Rathika, [4] S. Sowmiya, [5] S. Safrin Roja
[1]Assistant Professor,
[2,3,4,5] UG Students,
TRP Engineering College, Tiruchirappalli, India.

***Abstract*— An alluring solution to substitute the traditional petrol bikes is the Electrical vehicle (EV). Numerous brands of e-bikes are emerging day by day. An S-HEV is a car operated by two power source which is a combination of internal combustion engine (ICE) and electric motor (EM). It has various driving mode such as ICE driving alone, EM driving alone, ICE and EM driving together, EM regenerative braking and so on. We presented the results of our idea in three wheeled motor vehicle by revamping the existing design of an S-HEV and also tried to give a disclosure to the observed drawbacks in general e-bike. The revamped idea is that batteries are used only when the speed is between 20km/hr to 40km/hr i.e. streets and the area where people are busy. The major drawback of the general e-bike is the long charging time, which is of 6-8 hours and the short lifespan of battery is around 2 years. Our idea has overcome this drawback which eventually increases the lifespan of a battery and also reduces the fuel consumption.**

Index Terms - Alluring, E-Bike, Electrical Vehicle (EV), S-HEV.

I. INTRODUCTION

Automated bypass electric controlled vehicle regulation system mainly reduces the fuel consumption which in turn it reduces the emission of pollutant in the atmosphere. This vehicle is initially operated by electric motor (EM) up to the speed of 20kmph to 40kmph.Once it exceeds 40kmph, it automatically switched to internal combustion engine (ICE). Nowadays petroleum availability & its usage and the atmospheric pollution created by the vehicles has become a major threat to the world. Taking these complications into a report, we revamped the existing design of an electric bike which will give a better performance of using the hybrid system of electric motor (EM) and internal combustion engine (ICE). By fusing these two technologies in a three wheeled motor vehicle gives an outstanding performance regarding fuel-saving, economy, powerful, eco-friendly and cost. The greenhouse effect is the trapping of the sun's warmth in a planet's lower atmosphere, due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface. One of the major greenhouse gas which has the greater effect on earth is the carbon dioxide. The top 20 countries of higher carbon dioxide emission data has been released by the International Energy Agency (IEA), which estimates carbon dioxide emissions from the combustion of coal, natural gas, oil and other fuels, including industrial waste and non-renewable municipal waste by the year of 2015. In that list India stands in third place which says that the total carbon dioxide emission from fuel combustion is 2066.01million metric tons. This can be prevented by introducing this three wheeled motor vehicle. Also, in general electric vehicle (EV), the long charging time, which is of 6-8 hours and the short lifespan of battery is around 2 years. This drawback has also been taken into account by using the electric motor (EM) only within the speed of 40kmph which eventually increases the battery's life [1].

The EV is an alternative to reduce the fuel engine consumption due to the extra electrical power addition in the system that allows changing the engine operation point for a better efficiency region. The gear shifting strategy is a way to modify the engine operation point and it can be combined with the power management strategy to reach a better operational condition. The aim of this study was to analyze the influence of the gear shifting strategy in the configuration [2].

In central London the majority of the bus fleet has been replaced by diesel-electric hybrid buses. In this study, we will investigate the degree of energy efficiency via practical on-road bus performance recordings, forming a foundation for future improvements to diesel and fuel cell hybrid bus design. Research at UCL has investigated the design and performance of the ENVIRO 400H model bus on various different routes in London, obtaining a wide range of data for real world performance. This data includes information on routes, usage, energy consumption and passenger count profiling [3].

A method for minimizing the cost of vehicle battery charging given variable electricity costs while also accounting for estimated costs of battery degradation using a simplified lithium-ion battery lifetime model. The simple battery lifetime model, also developed and presented here, estimates both energy capacity fade and power fade and includes effects due to temperature, state of charge profile, and daily depth of discharge. This model has been validated by comparison with a detailed model developed at National Renewable Energy Laboratory, which in turn has been validated through comparison with experimental data. The simple model runs quickly, allowing for iterative numerical minimization of charge cost, implemented on the charger controller. Resulting electric vehicle (EV) charge profiles show a compromise among four trends: 1) charging during low-electricity cost intervals; 2) charging slowly; 3) charging toward the end of the available charge time; and 4) suppression of vehicle-to-grid power exportation. Simulations based on experimental Prius plug-in hybrid EV usage data predict that batteries charged

using optimized charging last significantly longer than those charged using typical charging methods, potentially allowing smaller batteries to meet vehicle lifetime requirements. These trends are shown to hold across a wide range of battery sizes and hence are applicable to both EVs and plug-in hybrid EVs. [4]

A complex transmission between motor and wheel is not needed, as electric motors are efficient over a wide speed range. If the motors are attached to the vehicle body, flexible couplings are required. The vehicle designs have separate electric motors for each wheel. Motor integration into the wheels has the disadvantage that the mass increases, decreasing ride performance. Advantages of individual wheel motors include simplified traction control (no conventional mechanical transmission elements such as gearbox, transmission shafts, differential), all wheels drive, and allowing lower floors, which is useful for buses. Some 8x8 all-wheel drive military vehicles use individual wheel motors. [5]

The lifecycle of a battery represents the number of charging and discharging cycles possible before it loses its ability to hold a useful charge (typically when the available capacity drops under 80% of the initial capacity) (Mierlo et al. 2004). The lifecycle of a battery depends on the depth of discharge (DOD). Improvement of the lifecycle is important to extent the calendar life of a battery. Batteries for electric vehicles should last as long as the lifetime of the vehicle. Otherwise replacement of the car battery is necessary within the lifetime of the car. This will increase the price of driving a S-HEV.The amount of electricity drawn from the grid is calculated by multiplying the NEDC fuel economy with the efficiency of charging the battery. The fuel costs of the S-HEV are the electricity drawn from the grid multiplied by the electricity price. The vehicles in this research are being charged at a home charger. Prices for charging the S-HEV at a charging station elsewhere are not known yet. Also the first S-HEVs sold to private owners will be charged at home chargers as there is no good infrastructure for electric cars yet. Therefore the cost of charging a S-HEV at a charging station is not taken into account. The efficiency of a battery is given by the energy losses that occur when charged and discharged. The amount of energy that is available to power the wheels represents the efficiency of the battery. The successful deployment of EVs over the next decade is linked to the introduction of international standards and codes, a universal infrastructure, and associated peripherals and user-friendly software on public and private property.

II. PRESENT SCENARIO

The S-HEV has two working modes, Fuel mode i.e. Internal Combustion engine mode *fig.1* and Electric mode *fig.2*. The charging of battery is done in two ways. One is done by solar panel and another is by AC supply.

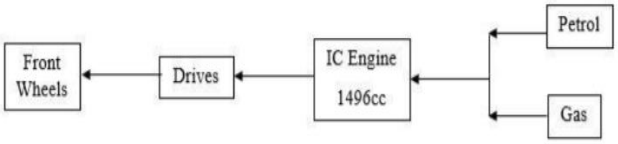

Fig 1: Fuel mode

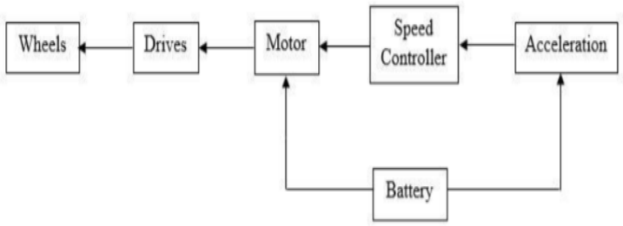

Fig 2: Electric mode

During day time while running or in rest position, the solar panel on the top of the car charges the battery. During night time, AC supply can be provided to charge the battery. In fuel mode, the IC engine is connected to the front wheel. The fuel may be a petrol or diesel or LPG. In electric mode, the BLDC motor is connected to the rear wheel. The controller controls the motor. It controls the speed as well as the direction. Whether to move in forward direction or in reverse direction. The Global Positioning System (GPS) detects the current location and send the signals to the controller. If the car enters city limit, the controller switches from fuel mode to electric mode and if the car reaches the highway, the controller switched from electric mode to fuel mode. The GPS values of the city limit and highway will be fed to the controller. For example if the vehicles crosses the limit and enters the city, the fuel mode will be converted to electric mode. Ultrasonic sensor is been used in the vehicle. The sensor is kept in front of the car. It measures the distance between the car and the obstacles. If the distance is less than 20 meter and the speed is above 30kmph, the car automatically slows down. If the distance is less than 10 meter and the speed is above 30kmph, the car automatically goes to rest position where the break is automatically applied. These conditions will be fed to the controller. This sensor decreases the possibilities of accident. Mainly accidents occur because of collision of two vehicles or with foreign bodies.

III. PROPOSED METHODOLOGY

An alluring solution to substitute the traditional petrol bikes is the Electrical vehicle (EV). Numerous brands of e-bikes are emerging day by day. The major drawback of this e-bike is the long charging time, which is of 6-8 hours and the short lifespan of battery is around 2 years. Taking these drawbacks into a report, we revamped the existing design of an electric bike which will give a better performance of using the hybrid system of battery and fuel. We have tried to give a discourse to the observed drawbacks in general e-bike and we presented the results of our idea. Here batteries are used only when the speed is between 20km/hr to 40km/hr i.e., streets and the area where people are busy, which will eventually increase the lifespan of a battery.

Schematic Representation

Automated bypass electric controlled vehicle regulation system operates by two modes-electric mode and internal combustion engine mode. The battery is charged by AC supply. During night time, the charging of the battery can be done.

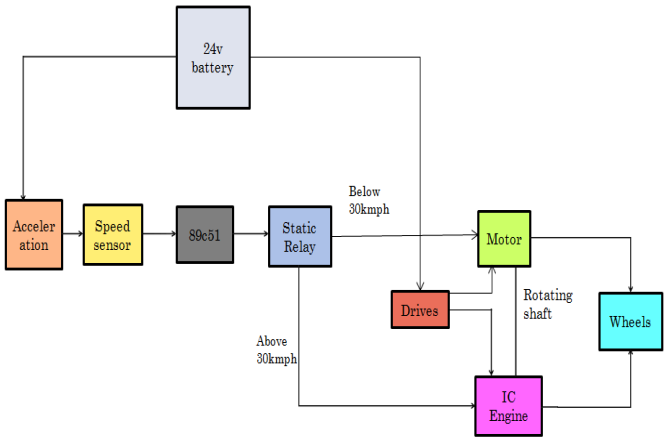

Fig 3: Proposed scheme

The vehicle is initially operated by electric motor (EM) which has been connected to the wheels. The three wheeled motor vehicle at first works under this condition within the speed limits of 20-40 km/hr i.e. in streets and places where people are busy. Once it exceeds 40km/hr, it automatically switched to internal combustion engine mode (ICE) through static relay. The speed is sensed by speed sensor and the relay commands the electric motor (EM) and the internal combustion engine (ICE) through the controller. The controller decides how much power to be delivered. When the car is in off state , then it means that controller sends zero power and when the driver accelerates , the controller provides full power. The wheels are powered by the EV motor by battery initially up to 40km/hr. There are a few possible electric motors that are suitable for a EV. A distinction can be made between a DC motor and an AC motor. The electric motor can either be placed in the wheels of the EV.

Speed Sensor

A speed sensor is a simply switch that recognises when the pedals are being turned. A magnetic disc is mounted on the crank axle and when one of the magnets pass by the sensor a pulse is sent to the controller and the motor is activated. The amount of power delivered to the motor is controlled by either the setting on the handle bar controls or by the throttle if fitted.

Lithium-ion Battery

Lithium-ion batteries have the potential to become the dominant battery technology in S-HEVs. They rapidly developed the last years for the use in small consumer electronics like cell phones and notebooks. Most S-HEVs that are coming to the market the next years will be equipped with lithium-ion battery packs. Lithium-ion batteries are very suitable as high performance EV batteries because of the main characteristics of lithium metal. Of all the different metals lithium has the highest standard potential and electrochemical equivalent.

Fig.4. Batteries

The above *fig.4* exhibits the batteries used in three wheeled motor vehicle which plays a major role. This acts as an input for many devices such as for sensors, driver circuits, indicator lights, LCDs and so on.

More advanced lithium batteries used for military applications are lithium sulphur dioxide (LiSO2) or lithium thionyl chloride (Li-SOCl2). The specific energy of lithium-ion batteries today ranges from 50 Wh/kg (THUNDERSKY) to 200 Wh/kg (SAFT) for the more advanced batteries. Power density can be as high as 2000 W/kg (electrovaya 2009).

Lithium-ion batteries usually use a liquid non-aqueous organic electrolyte but also solid electrolytes are used for dry lithium-ion batteries. The most common electrolytes solutes are lithium salts such as LiClO4, LiBr, LiCF3SO3, and LiAlCl (Linden and Reddy 2002)

Charger

Charging a battery is not a matter of just plugging in a EV on your home 230 V electricity network or on a charger elsewhere. A battery charger needs an advanced control system to regulate the current and voltage going in. Without this the lifetime can be drastically reduced (Larminie and Lowry 2003).

A battery for an electric vehicle is in fact a number of cells connected in series. When charging and discharging it can happen that the battery cells carry different charges over time. This is due to the circumstances, like the temperature or production abnormalities, that can differ in the battery cells. If the battery cells are not fully charged once in a while, it happens that one battery cell goes totally flat. This can result in a drastically drop in battery voltage and eventually battery failure. To prevent battery failure and a reduced lifetime the battery cells have to be fully charged regularly. The battery cells therefore have to be designed to withstand overcharging.

Table.1 specifications

Components	Specifications
Battery	24v
Sensor	Speed sensor
Microcontroller	89c51
LCD	18 pin
E-Bike Motor	80-100 rpm
IC engine	2 stroke, 100 rpm

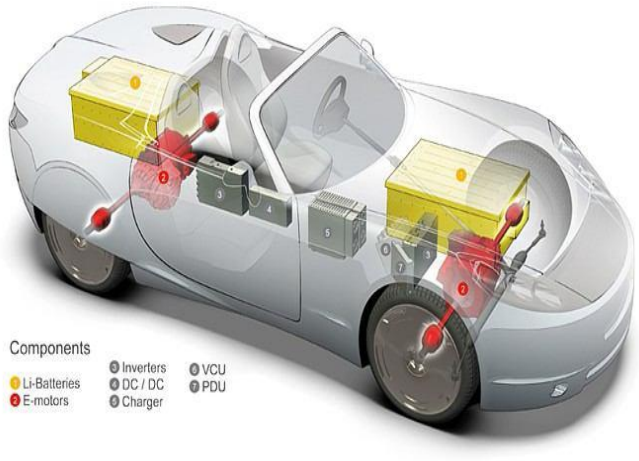

Fig 5: Components of HEV

IV. HARDWARE IMPLEMENTATION

S-HEV provides large potential to save energy and reduce emission. This can be achieved through a selected platform by optimizing the fuel consumption with the help of battery. The *fig.6* shows the rear wheel of ICE through which EV motor is connected.

Fig.6. rear wheel of ICE

Fig.7. rear wheel of EV

The *fig.7* shows the rear wheel of EV motor. The EV motor do not need any lubricants since it has metal and plastic parts. It also includes sophisticated electronics that regulate energy flow from the batteries and control its conversion to driving power.

Fig.8. three wheeled motor vehicle

V. FUTURE SCOPE

In future, this idea can be implemented in two wheelers because the production of two wheeler is being increased day by day. Since the batteries are used during the start, the fuel consumption is readily decreased. The most important hazard to the environment is pollution. The pollutant emitted can be reduced by replacing with the batteries which accounts this to eco-friendly. The noise pollutions are low compared to general vehicle (only ICE), especially low emission of pollutants.

VI. CONCLUSION

Among the number of technologies, hybrid vehicles are the one which discloses most of the disadvantages of the vehicle with only ICE mode. This paper presents an outline of hybrid electric vehicle with certain modifications like batteries are used initially up to 40km/hr. Beyond this speed ICE mode comes into action. Hence the fuel consumption can be reduced in near future with the implementation of this concept in both two wheelers and four wheelers and also the life time of batteries can be extended in Electric Vehicles. The emission levels in cities can be brought under control with this technology.

REFERENCES

[1] A. Senthilnathan, et al, "Smart Hybrid Electric Vehicle", 2017.
[2] E.Bongermino," Model And Energy Management System For A Parallel Hybrid Electric Unmanned Aerial Vehicle", 2017.
[3] Cedric lin," Fuel Economy Of A Current Hybrid London Bus And Fuel Cell Bus Application Evaluation", 2016.
[4] Mohammad Kebriaei," Hybrid Electric Vehicles", 2015.
[5] Anderson Hoke," Accounting For Lithium-Ion Battery Degradation In Electric Vehicle Charging Optimization", 2014.
[6] S. Bai and S. Lukic, "Unified Active Filter and Energy Storage System for an MW Electric Vehicle Charging Station," IEEE Trans. Power Electron., vol. 28, no. 12, pp. 5793–5803, Dec. 2013.
[7] L. Dickerman and J. Harrison, "A New Car, a New Grid," IEEE Power Energy Mag., vol. 8, no. 2, pp. 55–61, Mar./Apr. 2010.
[8] V. Silva and C. Kieny, "Impacts of EV on Power Systems and Minimal Control Solutions to Mitigate These," Essen, Germany: RWE Deutsch-land AG, May. 2011, http://www.g4v.eu/downloads.html.
[9] J. T. Salihi, "Energy Requirements for Electric Cars and Their Impact on Electric Power Generation and Distribution Systems," IEEE Trans. Ind. Appl., vol. IA-9, no. 5, pp. 516–532, Sept 1973.
[10] S. Sindhuja and K. Divya Parkavi, "SSVC & UPFC for Voltage Stability Enhancement of TNEB Sixty Nine Bus System", IJCTA 10(02), 285-291.
[11] GSKG and S. Sindhuja, "Voltage Stability enhancement of TNEB sixty nine bus system using STATCOM", International journal of Applied Engineering Research, 10(20), 16224-16227.
[12] S. Sindhuja, AS. Raj and A. Vishwanathan, "Enhancement of Voltage Stability in an Indian practical utility system under contingency condition using FACTS devices", Advances in Natural and Applied Sciences 8(21), 52-58.
[13] S. Sindhuja, "Enhancement of Voltage Stability in 62-Bus system using FACTS device", International JOURNAL of Advanced and Innovative Research 3 (CONFERENCE), 98-104.
[14] J. Gomez and M. Morcos, "Impact of EV battery chargers on the power quality of distribution systems," IEEE Trans. Power Del., vol. 18, no. 3, pp. 975–981, July 2003.
[15] K. Qian, C. Zhou, M. Allan, and Y. Yuan, "Modeling of Load Demand Due to EV Battery Charging in Distribution Systems," IEEE Trans. Power Syst., vol. 26, no. 2, pp. 802–810, May 2011.
[16] J. Sexauer, K. McBee, and K. Bloch, "Applications of probability model to analyze the effects of electric vehicle chargers on distribution transformers," IEEE Trans. Power Syst., vol. 28, no. 2, pp. 847–854, May 2013.
[17] P. Fan, B. Sainbayar, and S. Ren, "Operation analysis of fast charging stations with energy demand control of electric vehicles," Smart Grid, IEEE Transactions on, vol. PP, no. 99, pp. 1–1, 2015.
[18] S.Palaniyappan, Dr. P.Anbalagan, "A Nature Inspired Algorithm for Reduction of CO_2 Emission in Thermal power station", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), ISSN: 2278 - 8875, Vol.2, Issue 9, Page No: 4516-4522, September 2013.
[19] S.Palaniyappan, I.Ilayaranimangammal, "An Optimistic Solution technique for Economic Load Dispatch Problem using Immune Inspired Algorithm", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), ISSN: 2278 - 8875, Vol.2, Issue 12, Page No: 6191-6195, December 2013.
[20] I.Ilayaranimangammal, S.Palaniyappan, N.Vaishnavadevi, "Exposure and Expulsion the Soft Errors in Digital Systems using Redundancy Techniques" in *IEEE Explore Digital Library* through IEEE International conference on Green Computing, Communication and Electrical Engineering (ICGCCEE), 2014 ISBN No:978 – 1 – 4799 – 4982 - 3, Page No: 01-06, March 2014.
[21] S.Palaniyappan, I.Ilayaranimangammal, N.Vaishnavadevi, S.Anbuselvan, "The Pareto Optimal Solution for Multi Objective Electric Power Dispatch Problem", International Journal of Engineering and Innovative Technology (IJEIT), ISSN: 2277 - 3754, Vol.4, Issue 2, Page No: 58-63, August 2014.
[22] I.Ilayaranimangammal, S.Palaniyappan, S.Anbuselvan, "Generation of Self Acting code from Single dimension flow chart", International Journal of Modern Trends in Engineering and Research (IJMTER), ISSN: 2349 - 9745, Vol.2, Issue 3, March 2015.
[23] S.Palaniyappan, I.Ilayaranimangammal, "Discover and Remove the Local Bridging Errors using Fault Tolerance Technique", International Research Journal of Engineering and Technology (IRJET), ISSN: 2395 - 0056, Vol.2, Issue 5, Page No: 356-361, August 2015.
[24]Ali, A. Nazar. "Cascaded Multilevel Inverters for Reduce Harmonic Distortions in Solar PV Applications." Asian Journal of Research in Social Sciences and Humanities 6.Issue : 11 (2016): 703-715.
[25]Ali, A. Nazar. "A Single phase Five level Inverter for Grid Connected Photovoltaic System by employing PID Controller." African journal of Research 6.1 (2011): 306-315.
[26]ali, A.Nazar. "A SINGLE PHASE HIGH EFFICIENT RANSFORMERLESSINVERTER FOR PV GRID CONNECTED POWER SYSTEM USING ISPWM TECHNIQUE." International Journal of Applied Engineering Research 10.ISSN 0973-4562 (2015): 7489-7496.
[27]Ali, A. Nazar. "Performance Enhancement of Hybrid Wind/Photo Voltaic System Using Z Source Inverter with Cuk-sepic Fused Converter." Research Journal of Applied Sciences, Engineering and Technology 7.ISSN: 2040-7459; (2014): 3964-3970.
[28]Ali, A. Nazar. "Ride through Strategy for a Three-Level Dual Z-Source Inverter Using TRIAC." Scientific Research publication 7.ISSN Online: 2153-1293 (2016): 3911-3921.
[29]Ali, A. Nazar. "An ANFIS Based Advanced MPPT Control of a Wind-Solar Hybrid Power Generation System." International Review on Modelling and Simulations 7.ISSN 1974-9821 (2014): 638-643.
[30]Nazar Ali, A. "Performance Analysis of Switched Capacitor Multilevel DC/AC Inverter using Solar PV Cells." International Journal for Modern Trends in Science and Technology 3.05 (2017): 104-109.
[31]Ali, A.Nazar. "FPGA UTILISATION FOR HIGH LEVELPOWER CONSUMPTION DRIVES BASEDONTHREE PHASE SINUSOIDAL PWM -VVVF CONTROLLER." International Journal of Communications and Engineering 4.Issue: 02 (2012): 25-30.
[32]ali, A.Nazar. "A SINGLE PHASE HIGH EFFICIENT TRANSFORMERLESS INVERTER FOR PV GRID CONNECTED POWER SYSTEM USING ISPWM TECHNIQUE." International Journal of Applied Engineering Research 10.ISSN 0973-4562 (2015): 7489-7496.
[33]JAIGANESH, R. "Smart Grid System for Water Pumping and Domestic Application using Arduino Controller." International Journal of Engineering Research & Technology (IJERT) 5.13 (2017): 583-588.
[34]Pau1l, M. Mano Raja, R. Mahalakshmi, M. Karuppasamypandiyan, A. Bhuvanesh, and R. Jai Ganesh."Classification and Detection of Faults in Grid Connected Photovoltaic System."
[35]Ganesh, Rajendran Jai, et al. "Fault Identification and Islanding in DC Grid Connected PV System." Scientific Research Publishing 7.Circuits and Systems, 7, 2904-2915. (2016): 2904-2915.
[36]Jaiganesh, R., et al. "Smart Grid System for Water Pumping and Domestic Application Using Arduino Controller." International Journal for Modern Trends in Science and Technology 3.05 (2017): 385-390.
[37]Kalavalli,C., et al. "Single Phase Bidirectional PWM Converter for Microgrid System." International Journal of Engineering and Technology (IJET) ISSN : 0975-4024 Vol 5 No 3 Jun-Jul 2013.
[38] Lilly Renuka, R., et al. "Power Quality Enhancement Using VSI Based STATCOM for SEIG Feeding Non Linear Loads. " International Journal of Engineering and Applied Sciences (IJEAS) ISSN: 2394-3661, Volume-2, Issue-5, May 2015.

[39]Karthikeyan,B. JEBASALMA. "RESONANT PWM ZVZCS DC TO DC CONVERTERS FOR RENEWABLE ENERGY APPLICATIONS ."International Journal of Power Control and Computation(IJPCSC)Vol 6. No.2 – Jan-March 2014 Pp. 82-89©gopalax Journals, Singaporeavailable at :www.ijcns.comISSN: 0976-268X.

[40]Gowri,N, et al. "Power Factor Correction Based BridgelessSingle Switch SEPIC Converter Fed BLDC

[41]Motor."ADVANCES in NATURAL and APPLIED SCIENCES. ISSN: 1995-0772 AENSI PublicationEISSN: 1998-1090 http://www.aensiweb.com/ANAS2016 March 10(3): pages 190-197.

[42]Ramkumar,R., et al." A Novel Low Cost Three Arm Ac AutomaticVoltage Regulator" ADVANCES in NATURAL and APPLIED SCIENCESISSN: 1995-0772 AENSI PublicationEISSN: 1998-1090 http://www.aensiweb.com/ANAS2016 March 10(3): pages 142-151.

[43]Kodeeswaran, S., T. Ramkumar, and R. Jai Ganesh. "Precise temperature control using reverse seebeck effect." In Power and Embedded Drive Control (ICPEDC), 2017 International Conference on, pp. 398-404. IEEE, 2017.

[44]Subramanian, AT Sankara, P. Sabarish, and R. Jai Ganesh. "An Improved Voltage follower Canonical Switching Cell Converter with PFC for VSI Fed BLDC Motor." Journal of Science and Technology (JST) 2, no. 10 (2017): 01-11.

[45]Murugesan.S, R. Senthilkumar."DESIGN OF SINGLE PHASE SEVEN LEVEL PV INVERTER USING FPGA."International Journal of Emerging Technology in Computer Science & Electronics, 2016, Vol.20, No.2, pp.207-2012.

[46]S. Murugesan, C. Kalavalli, " FPGA Based Multilevel Inverter With Reduce Number of Switches For Photovoltaic System", International Journal of Scientific Research in Science, Engineering and Technology(IJSRSET), Print ISSN : 2395-1990, Online ISSN : 2394-4099, Volume 3 Issue 6, pp.628-634, September-October 2017.

[47]Vikram, A. Arun, R. Navaneeth, M. Naresh Kumar, and R. Vinoth. "Solar PV Array Fed BLDC Motor Using Zeta Converter For Water Pumping Applications." Journal of Science and Technology (JST) 2, no. 11 (2017): 09-20.

[48]Nagarajan, L. Star Delta Starter using Soft Switch for Low Power Three Phase Induction Motors. Australian Journal of Basic and Applied Sciences, 9(21), 175-178.

[49]Vinusha, S., & Nagarajan, L. (2015). CURRENT SOURCE INVERTER FED INDUCTION MOTOR DRIVE USING MULTICELL CONVERTER WITH ANFIS CONTROL.

[50]Nagarajan, L., & Nandhini, S. (2015). AN EFFICIENT SOLAR/WIND/BATTERY HYBRID SYSTEM WITH HIGH POWER CONVERTER USING PSO.

[51]Subramanian, AT Sankara, P. Sabarish, and R. Jai Ganesh. "An Improved Voltage follower Canonical Switching Cell Converter with PFC for VSI Fed BLDC Motor." Journal of Science and Technology (JST) 2.10 (2017): 01-11.

[52]Compensator, D. S. (2015). AN ADAPTIVE CONTROL AND IMPROVEMENT OF POWER QUALITY IN GRID CONNECTED SYSTEM USING POWER ELECTRONIC CONVERTERS.

[53]Sabarish, P., Sneha, R., Vijayalakshmi, G., & Nikethan, D. (2017). Performance Analysis of PV-Based Boost Converter using PI Controller with PSO Algorithm. Journal of Science and Technology (JST), 2(10), 17-24.