Design and Implementation of Fpga Based Real Time Multiple High Frequency Charger for Electric Vehicle Charging System

R.Ramya, Dr.T.Pasupathi , Dr.T.Shanthi
PG Student, Assistant Professor

Department of Electronics and Communication Engineering,

Kings College of Engineering, Punalkulam, Thanjavur

Ramyar08091999@gmail.com, pasu.tamil@gmail.com

***Abstract*- Electric Vehicle Charging Station (EVCS) for fast DC charging of multiple Electric Vehicles (EVs) simultaneously is studied in our concept. An real time FPGA based multiple high frequency EV charger is proposed in this project. The proposed system has an central rectifier and a charging controller. The charging controller has an DC-DC converter and PWM generator. FPGA is used to generate high frequency PWM signal for the charging controller. The central rectifier maintains DC bus voltage and each EV charger controls the battery charging power. A typical EV station can have five EV charger and one central rectifier. In this system multiple electric vehicle can be charged. Faults of various fault impedances have been introduced at various fault locations of EVCS and corresponding effects on EVs are analyzed. Short comparison has been carried out distinguishing the advantages and disadvantages of DC bus over AC counterpart. An appropriate protection strategy has been suggested and put to use in order to alleviate the faults, mainly to ensure safe charging of EVs connected. All the simulations are performed in MATLAB ® results show feasibility of proposed model using FPGA. A scope for further improving the proposed model has been discussed for research purpose**

Keywords- Electric vehicle charging station (EVCS), charging control circuit, Field programmable gate array (FPGA), Battery electric vehicle (BEV).

1.INTRODUCTION

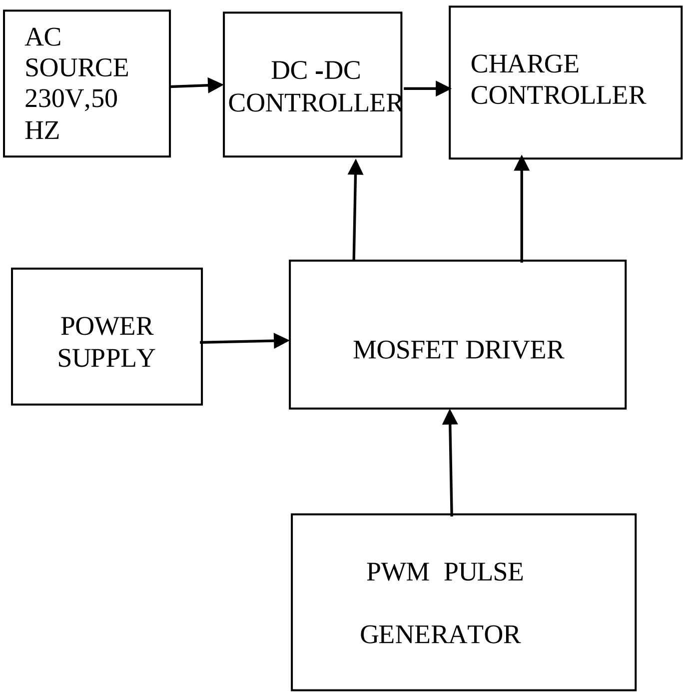
Electric Vehicle is a vehicle that uses one or more electric Motor for propulsion. It can be powered by a collector system with electricity from extra vehicular sources or it can be powered autonomously by a battery. Electrified Vehicles refers to a range of technologies that use electricity to vehicle. HEV: Hybrid Electric Vehicles obtain all net propulsion energy from petroleum but use an electrical system to improve fuel efficiency. Battery electric vehicles also called BEVs and more frequently Called EVs are fully electric vehicles with rechargeable batteries and no gasoline engine Electric vehicles produce zero tailpipe emissions, reducing air pollution. The production of electric vehicles produces fewer greenhouse gas emissions than traditional gasoline Vehicles. Electric vehicles can be powered using renewable energy sources like solar and wind power. The development of electric vehicles (EVs) depends on several factors: The EV's acquisition price, autonomy, the charging process and the charging infrastructure. This project is focused on the last factor: design of an EV fast charging. In order to improve the profitability of the fast - charging stations and to decrease the high energy demanded from the grid ,the station and to include renewable generation (photovoltaic)and a storage system .This one use a detailed model of charging process that considers that arrival time and state of charge of electric vehicles.

A genetic algorithm (GA) optimizes the installation and operation of the EV fast –charging station. It finds the optimal solution that maximizes the profit measured by its net present value. It leads to a reliable range prediction, Eco-routing and Eco-driving as well as novel functionalities like smart fast charging and assured charging. The key objectives are: Ensure a leap forward in user's confidence, functionalities and energy efficient of future. Electric cars are quieter, emit no exhaust, and have fewer over all pollutants than combustion engine (ICE) vehicles. Electric cars have minimal expenditures since they have fewer parts to maintain and they are also ecofriendly because they consume no carbon fuels (petrol or diesel).

2.BACK GROUNDAND RELATED WORK

This paper presents a EV off-board chargers that consist of ac dc and dc-dc power stages from the power network to the EV battery. Although EV chargers are categorized into two types, namely, on-board and off-board chargers, it is essential to utilize off-board chargers for dc fast and ultra-fast charging so that volume and weight of EV can be reduced significantly. Here, we discuss the state-of-the-art topologies and control methods of both ac-dc and dc-dc power stages for off-board chargers, focusing on technical details, ongoing progress, and challenges. In addition, most of the recent multiport EV chargers integrating PV, energy storage, EV, and grid are presented. Moreover, comparative analysis has been carried out for the topologies and the control schemes of ac-dc rectifiers, dc-dc converters, and multiport converters in terms of architecture, power and voltage levels, efficiency, control variables, advantages, and disadvantages which can be used as guideline for future research direction in EV charging solutions. Wide – scale adoption and projected growth of electric vehicles (EVs) necessitate research and development of power electronic converters to achieve high power, low-cost ,and reliable charging solutions for the battery

3. BLOCK DIAGRAM



The source for EVCS is AC supply from the grid. A centralized conversion from AC to DC is done with the help of an inverter which is interfaced with LC filters and transformer. Appropriate DC bus capacitances are placed on the DC side in order to stabilize the DC bus voltage during sudden and high load demands. The main part of EVCS is the DC bus where all the EVs are connected for charging

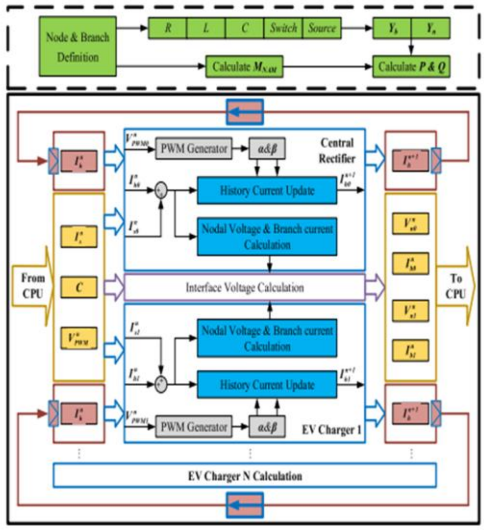


Fig 2 : EV charging station

The green part shows the initialization electrical circuit, in which each subsystem performs its own initialization and the coefficient matrices and variables are loaded to the corresponding simulation steps.

The node voltage Vn and brand current Ib are sent to the CPU and the control signals are transferred to α and β to control the circuit. The purple part shows the interface calculation between the subsystems. The whole EV station circuit is modeled in one single FPGA board for maximum resource utilization. This method avoids the amount of data to be exchanged between boards and reduces simulation. The subsystem are decoupled at the capacitor, and thus each EV charger composes a subsystem and the central rectifier is also defined as a subsystem. With this de-coupling method, the scalability of the electric vehicle charging station simulation is improved, and the number of simulated EV chargers can be adjusted at any time according to actual needs.

For the EV station, all the calculations of the circuit and control subsystems start simultaneously. The control signal calculation on the CPU usually takes more time than the circuit update on the FPGA depending on the actual execution times of the CPU and FPGA. As a result, the FPGA must wait for the CPU until the next time step is reached. In order to improve real-time simulation performance the control signal calculation in the CPU has a 100 µs time step and the circuit simulation is calculated in the FPGA with a 250ns time step.

4. PWM GENERATOR

PWM - Pulse width modulation

PWM is a modulation techniques that generates Variable width pulse amplitude of analog input signal. the output switching transistor is one or more time for a high amplitude signal and time for low amplitude signal .PWM is a modulation techniques that generates variable width pulse amplitude analog input signal. The output switching transistor is one or more time for a high amplitude signal and of the time for low amplitude signal. PWM is commonly used to control to generates analog signals from digital devices such as microcontroller. PWM is commonly used to generate analog signals from digital devices such as microcontroller. PWM is used to control motor to power LEDs. PWM allows for controlling the average amount of power deliver to the load. The system input is an N-bit data word corresponding to the desired PWM

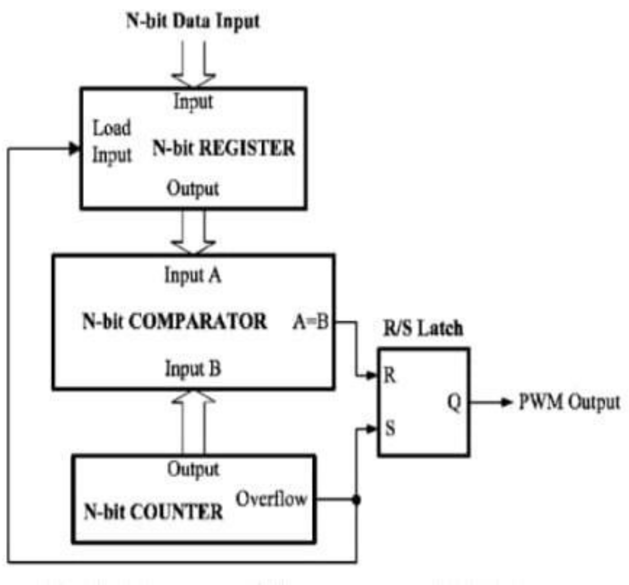


Fig 3 : PWM Architecture

The system input is an N-bit data word corresponding to the desired PWM duty cycle value it can be easily interfaced to a port. The N- bit register output containing the N -bit data input is compared with the output value of an N-bit free running synchronous counter. When these two values become equal the comparator output is used to reset the R/S Latch output which produce the PWM wave.

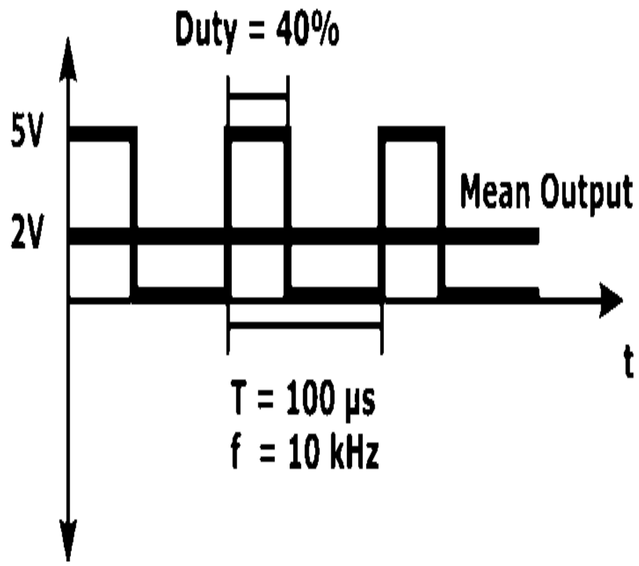


Fig 4 : Duty cycle of PWM generator

The duty cycle of a PWM signal is the relative amount of time the signal will be on expressed as percentage. If the duty cycle is 100% the signal. Duty cycle is the ratio of time a load or circuit is ON compared to the time the load or circuit is off. A duty cycle refers to how frequently an air compressor can be run over a certain period of time. For ex: if an air compressor has a 100% duty cycle that means it can run continuously without the needing to rest and cool down. Most standard compressors have a duty cycle between 50-100%

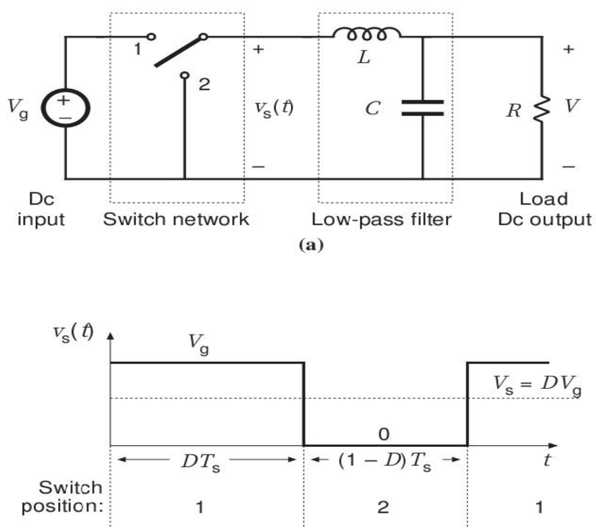


Fig 5 : DC – DC Converter

5. METHODOLOGY

This paper presents a novel approach to design a charger for battery electric vehicles (BEV) by utilizing an enhanced DC – DC Converter. DC-DC Converter specifically tailored to operate during individual values of supply voltage there by improving power quality at the output. This design lies in its ability to enhance charger efficiency compared to other converter while ensuring a consistent charging current of the battery. Set to operate in discontinuous conduction mode (DCM) with multiple high frequency charging which brings about cost and size reduction. DC-DC converter is a type of power electronics converter .it can be used in variety of applications including power supplies for personal computers,office equipment, space craft power systems ,and telecommunications equipment as well as dc motor drives.These converters are known for their simplicity, high efficiency, and ability to handle the wide input/output voltage ranges. Integrating a DC-DC converter into an electric vehicle (EV) charging station can have various applications, depending on the design and requirements. In voltage regulation a DC-DC converter can be used to regulate the voltage output of the In voltage regulation a DC-DC converter can be used to regulate the voltage output of the charging station ensuring compatibility with different electric vehicle models and battery systems. In some charging station design a DC-DC converter may be employed to interface with the grid. This can include power factor connection and ensuring that the charging station operates efficiently within the grid specifications. These converters are known for their high efficiency. Incorporating them into the charging station design can contribute to minimizing energy losses during the charging process. If the charging station is designed to incorporate renewable energy sources (such as solar or wind) can help manage the variable input voltages efficiently. In charging station types level 1 charging used a standard household outlet (120 volts). It is slow but is often used at home. In level 2 charging requires a 240- volt circuit and provides faster charging commonly found in public charging stations and residential installations. DC fast charging provides rapid Charging using DC current .Mostly used for public charging, enabling quicker refueling. Fast charging stations can become a convenient as well as alternative besides charging significant quantities with renewable energy .

6. SIMULATION RESULT

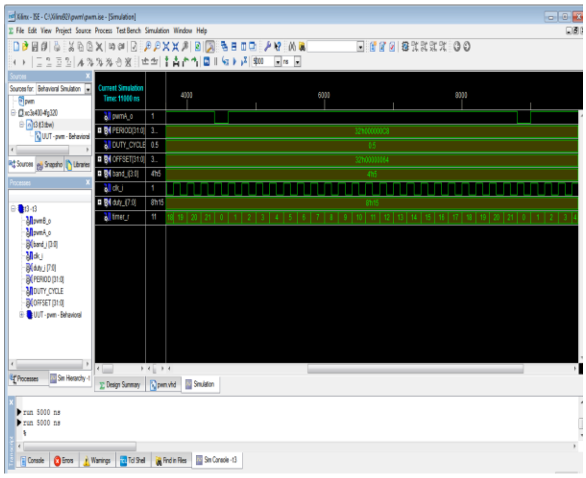


FIG 6: PWM generation using Xilinx ISE

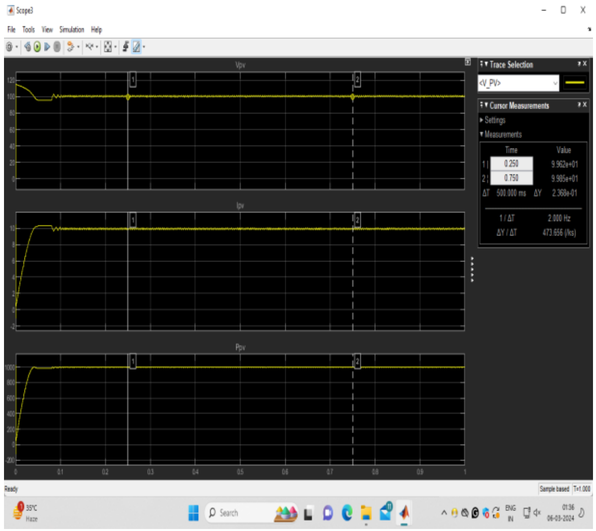
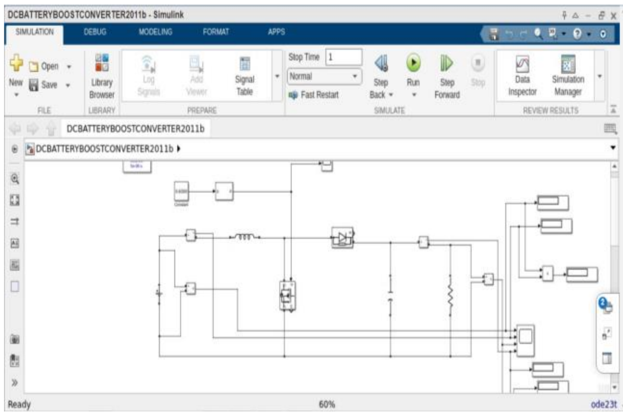


FIG 7: DC OUTPUT of AC-DC converter



8. CONCLUSION

Modeling of an Electric Vehicle Charging station is discussed in brief and is supported with required simulation results. General faults that occur commonly are introduced to the modeled EVCS and the effects are studied to implement a protection scheme that would alleviate all the possible faults occurring both on AC side as well as DC side. Modeling of protection strategy is also discussed as a whole. The responses of protection scheme to various faults introduced are studied. Lastly, few possible inclusions that would make the EVCS work efficiently are proposed for further research. In fast charging station infrastructure impact on distribution of the grid systems customized electric vehicle policy. developed methods are emerging to start moving the global community to feasible electric vehicle. Innovations would be used well as standard will also developed with ongoing charging research.

9.APPENDICES

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;
entity pwm_prog is
generic(
N : integer := 8); -- number of bit of PWM counter
port (
i_clk : in std_logic;
i_rstb : in std_logic;
i_sync_reset : in std_logic;
i_pwm_module : in std_logic_vector(N-1 downto 0);
-- PWM Freq = clock freq/ (i_pwm_module+1); max
value = 2^N-1
i_pwm_width : in std_logic_vector(N-1 downto 0); -
- PWM width = (others=>0)=> OFF; i_pwm_module
=> MAX ON
o_pwm : out std_logic);
end pwm_prog;
architecture rtl of pwm_prog is
signal r_max_count : unsigned(N-1 downto 0);
signal r_pwm_counter : unsigned(N-1 downto 0);
signal r_pwm_width : unsigned(N-1 downto 0);
signal w_tc_pwm_counter : std_logic;
begin
w_tc_pwm_counter <= '0'
when(r_pwm_counter<r_max_count) else '1'; -- use
to strobe new word
---------------------------------------------------------------
--
p_state_out : process(i_clk,i_rstb)
begin
if(i_rstb='0') then
r_max_count <= (others=>'0');
r_pwm_width <= (others=>'0');
r_pwm_counter <= (others=>'0');
o_pwm <= '0';
elsif(rising_edge(i_clk)) thenr_max_count <=
unsigned(i_pwm_module
end rtl;
if(i_sync_reset='1') then
r_pwm_width <= unsigned(i_pwm_width);
r_pwm_counter <= to_unsigned(0,N);
o_pwm <= '0';
else
if(r_pwm_counter=0) and
(r_pwm_width/=r_max_count) then
```

```
else
o_pwm <= '0';
end if;
if(w_tc_pwm_counter='1') then
r_pwm_width <= unsigned(i_pwm_width);
end if;
if(r_pwm_counter=r_max_count) then
r_pwm_counter <= to_unsigned(0,N);
else
r_pwm_counter <= r_pwm_counter + 1;
end if;
end if;
end if;
end process p_state_out;
```

10.REFERENCE

[1] Bhim Singh, Rajan Kumar,"Solar photovoltaic array fed water pump driven by brushless DC motor using Landsman converter,".IET Renewable Power Generation , Volume: 10, Issue: 4, 4 2016

[2] Ali F.Murtaza, Hadeed Ahmed Sher,Marcello Chiaberge, Diego Boero,Mirko De Giuseppe, Khaled E. Addoweesh,"Comparative Analysis of Maximum Power PointTrackingTechniques for PV applications,". 16th International Multi Topic Conference (INMIC), 2013

[3] Qiuxia Yang , Qi Wang ,"An Improving Control Method of CTV +P&O on Photovoltaic Power Generation Maximum Power Point Tracking," Fifth International Conference on Intelligent Human-Machine Systems and Cybernetics,IEEE,2013

[4] Deepak, Rupendra Kumar Pachauri, Yogesh K. Chauhan,"Modeling and simulation analysis of PV fed Cuk, Sepic, Zeta and Luo DC-DC converter," International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES),IEEE .2016

[5] World Energy Outlook 2019. Paris: IEA, 2019.

[6] R. Newell, D. Raimi, S. Villanueva, and B. Prest, Global Energy Outlook 2020: Energy Transition or Energy Addition? Washington: RFF, 2020.

[7] A. Gerlach, D. Stetter, J. Schmid J., and C. Breyer, "PV and wind power – Complementary technologies," 30th ISES Biennial Solar World Congress 2011

[8] Renewables 2020. Global Status Report. Paris: REN21, 2020.

[9] Renewable Energy Statistics 2020. Abu Dhabi: IRENA, 2020.

[10] Renewables 2019. Analysia and forecasts to 2024. Paris: IEA, 2019.

[11] High-Voltage Stations for Electric Vehicle Fast-Charging: Trends, Standards, Charging Modes and Comparison of Unity Power-Factor Rectifiers YanhuiXie, Senior Member, IEEE, Reza Ghaemi, Jing Sun, Fellow, IEEE,and James S. Freudenberg, Fellow, IEEE

[12] Effect of different drive modes on energy consumption of an electric auto rickshaw Pengju Sun, Luowei Zhou, Senior Member, IEEE, and Keyue Ma Smedley, Fellow, IEEE

[13] Hybrid-Switching Full-Bridge DC–DC Converter with Minimal Voltage Stress of Bridge Rectifier, Reduced Circulating Losses, and Filter Requirement for Electric Vehicle Battery Chargers Bin Gu, Student Member, IEEE, Jih-Sheng Lai, Fellow, IEEE, Nathan Kees, Student Member, IEEE, and Cong Zheng, Student Member, IEEE

[14]Bin Gu, Student Member, IEEE, Jih-Sheng Lai, Fellow, IEEE, Nathan Kees, Student Member, IEEE, and Cong Zheng, Student Member, IEEE Proposed work

[15] Iker aretxabaleta member IEEE high voltage stations for electric vehicles fast charging trends,standard ,charging modes and comparsion of unity power factor rectifiers