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Solar PV Based Five-Level Inverter Fed BLDC Motor Drive Applications*

1st AKHIL KRISHNAN M
PG Student Department of Electrical and Electronics Engineering
Rajagiri School of Engineering and Technology Kakkanad ,Ernakulum, India

2nd UNNIKRISHNAN L
Assistant Professor, Department of Electrical and Electronics Engineering
Rajagiri School of Engineering and Technology Kakkanad ,Ernakulum ,India

ABSTRACT –
This paper proposes a solar photovoltaic (PV) based on high-quality inverter powered by a used brushless DC (BLDC) engine. Demand for electricity around the world is constantly growing and conventional power sources are declining, moreover, their price is rising. For all these reasons, the need for another source of energy is needed and solar energy seems to be another promising alternative due to its existence and pollution associated with nature. A multi-level inverter is used to drive the BLDC engine. Power inverter is provided by solar PV and high power point tracking (MPPT) system. The unpredictable state of PV production times is solved using a single-phase AC grid as a given external power supply. The range of PV cannot meet the energy requirement required for the required power to be obtained with a modified boost factor (PFC) converter. The proposed multi-level converter has a sub-transformer type and this system is used to meet power quality standards. MATLAB / Simulink-based simulation and performance analysis are performed to visualize system performance.

KEYWORDS: *Solar photovoltaic; Brushless DC motor boost converter; power quality; Maximum power point tracker*

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I. INTRODUCTION

The demands for energy grow, that times need for energy-saving criteria is increasing rapidly. The brushless dc motor (BLDC) motor is used in an important role. As an energy-efficient engine, in this motor peak value of torque / inertia ratio, and high range-power factor. Apart from this, unlike an induction motor, the speed of a BLDC motor is not limited to the power frequency. This leads to a reduction in size and an increase in motor capacity. In a standard Brush Less DC motor (BLDC) drive, the motor is usually powered by a Pulse Width Modulation (PWM) voltage which affect step voltage waveform (dv/dt) to the terminal across motor. This may protect the motor insulation damages. In addition, motor vehicle injuries are reported due to high power conversion rates (dv / dt) that generate high voltage normal mode voltage at motor windings. In variable-speed medium-voltage drives, this is the phase of a major problem where electricity levels remain too far above the ground. The expected problem can be solved by using a variable voltage with low dv / dt i.e., using a high-voltage inverter. Many inverters have always attracted the importance of many industries and are considered to be another impressive way to reduce switching pressures. The high-frequency output waveform is a key feature of these converters. multilevel inverters can work more efficiently on low frequency converters compared to conventional PWM inverters. In recently different multilevel structures have appeared, for example, a cascade bridge (CHB), a central boundary, and a flying capacitor. CHB multilevel inverter is topology of all the rage and has found prevalent applications in industry, The H-bridge components are generally allied in cascade on relevant grid side to achieve medium-voltage operation and low harmonic distortion. The system shows a solar-powered five-level transformerless inverter having efficiency higher than conventional type inverter. A photovoltaic solar panel is used to absorb sun radiation in light energy

M200402 AKHILKRISHNAN M,IDAC,RSET

form as a source of energy to generate electricity. The generated DC power. The power is stored in the battery. The output of the battery is given to the five-level cascade transformerless inverter with reduced output harmonic content for the PV system.

Providing ac output.it can be used at home, an industrial application. It is used to track high scores to automatically detect the position of the system. Information performance of the inverter in eight different phases is performed and the output is trampled by a square wave found in this analysis. The advantages of the systems are to create an output waveform with smooth steps and harmonic distortions. reducing domestic electricity bills, mineral fuel consumption is reduced, and the efficiency of solar panels increases the amount of solar energy output available. Improving battery technology increases battery density. The total weight of the system is reduced by a small inverter configuration transformer. The main limitation of a small transformer configuration is the high switching frequency. Changing the frequency of electrical power equipment increases switching losses also increases, initial costs such as solar system will be higher. Imitation results confirm that BDS produces higher power and has a higher power output compared to conventional converters. In the current context of increasing energy demand and growing environmental concerns, alternatives to renewable and non-renewable fossil fuels should be investigated. One such method is solar energy.

Solar energy is a type of energy generated by the sun directly and collected elsewhere, usually on Earth. The process creates heat and electromagnetic radiation. The heat stays in the sun and helps maintain a thermonuclear reaction. Electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) emits the atmosphere on all sides. Due to the nature of solar energy, two components are required for an effective solar power generator. These two components are the collector and the final unit. The collector simply collects the rays that fall on him and converts part of them into other energy sources (either electricity and heat or heat). The final unit is required due to the constant nature of the solar energy; from time to time a very small amount of radiation will be received. At night or during heavy cloud cover, for example, the amount of energy produced by the collector will be very small. The storage unit can capture more energy produced during higher production, and release it when production decreases. Supportive power supplies are often added, too, in cases where the amount of energy required is greater than both the output and the storage container. There are two types of power generation sources. One is normal and the other is unusual. Today to produce most of the electricity, conventional sources such as coal, gas, nuclear power plants are used. Other natural resources have polluted the environment to generate electricity. And nuclear power is not widely praised for its harmful effects of radiation. After ten years ordinary resources will not be enough to meet human needs. Therefore, some electrical energy must be produced by non-standard energy sources such as the sun, wind. With the continuous reduction in the cost of PV power generation and the continuous intensity of the power crisis, PV power generation technology is gaining more use.

A multi-level inverter input is a solar PV system with one side connected to a single-phase grid. During the day the solar energy used by the engine works during the night the lack of sunlight leads to the closure of the motorcycle system. this problem affects industry production.to overcome these problems, external power is given to the system through the utility grid. This newly developed technology integrates a unit that produces PV into a grid for use. The main focus is to achieve working conditions that are completely uninterrupted and robust, whether day or night.

This function aims to recognize a reliable high-quality inverter based on solar PV fed BLDC motor

drive using the PV-utility grid interface. Indirect power flow controls are developed to enable the transfer of power from the grid to the BLDC vehicle pump in the event of a variety of PV power sufficient to drive the BLDC engine. No power is drawn on the utility grid if a full ray is available as the PV series alone is sufficient to provide the power required by the motor drive. The boost factor converter (PFC) configured in conjunction with the PV-utility grid interface performs the required function. The proposed system also meets the quality standards required by the grid for use as a standard by IEEE-519. The Incremental conductance (InC) method is used for maximum power point tracking (MPPT) of the same PV components using a boost converter. Current sensor-less control is adopted in BLDC motor speed control. The voltage source inverter of the multilevel inverter (MLVSI) is operated by the electronic fluctuations of the BLDC motor, resulting in reduced switching losses and efficient conversion efficiency. The grid-connected solar PV system is designed and modified on the MATLAB / Simulink platform, and its performance is tested with simulation results to reflect claims.

II. SYSTEM ADJUSTMENT

The suggested system power is provided by a multi-level converter (MLI) by a grid-connected to the PV for brushless DC motor applications.

The plan is added in Fig.1. 693.7 PV array with enough power to use BLDC engine. Power transfer to BLDC motor with boost converter and voltage source 3 phase multilevel inverter. The DC-DC boost converter and five level inverters have respectively MPPT PV array and switching of the engine. Three hall effect sensors are used to generate switching signals. A 4 pole 5.1 engine in BLDC with a maximum speed of 1500 rpm at 170V is used in this process. The grid connection used a single-phase AC provided with a bridge converter and power factor correction (PFC) boost converter on a standard DC multi-level inverter bus (MLI). The power transmission is limited using the PFC converter using an indirect power flow controller. Improved controls enable power transfer from the service grid to the DC bus if the generated power by the PV is less amount to meet the power requirement, otherwise, there is no power transmission from the application.

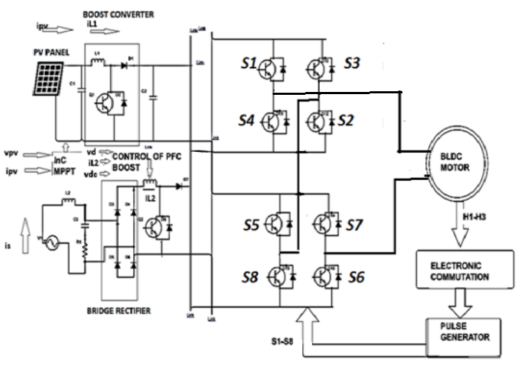


Fig.1 Overall Proposed Diagram

III. PROPOSED MULTI-LEVEL INVERTER

This paper, the topology of the five-stage multilevel inverter for the brushless dc motor drive is suggested. A multi-level inverter of the cascade bridge is used. The input voltage of the new topology is Vdc / 2, where both switches are connected to the same leg behavior at the same time. A detailed fifth-level analysis performed using the heart rate variables has changed the dynamics of many network companies. The number of bridge H required to determine the value of the inverter level produces different electrical levels with a minimal negative voltage and zero level. A circuit with eight switches, four switches on each five-level inverter bridge. In this proposal for the proposed topics, the total electricity level is twice that of the DC source. The switching condition is given at the bottom of Table 1.

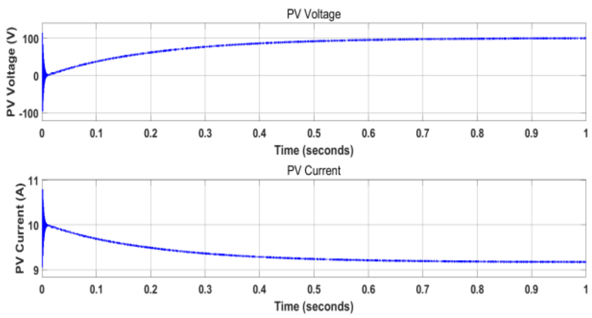
The table given below represents the switching of various conditions in a five-level inverter to produce different levels. Four switches are required to produce each level at the output voltage. Inverter load connected to BLDC motor drive. A voltage waveform with five output levels has two positive voltage levels, two negative voltage levels, and a zero-voltage level.

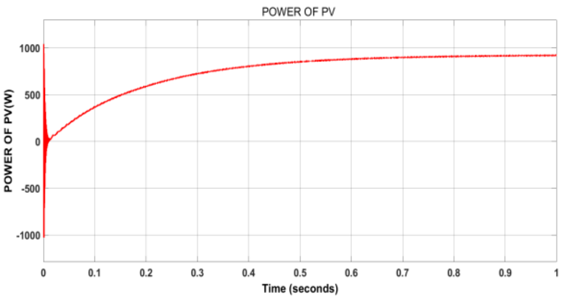
SWITCHES TURN ON	VOLTAGE LEVEL
S1,S2,S6,S8	$V_{dc}/2$
S1,S2,S5,S6	V_{dc}
S2,S4,S6,S8	0
S3,S4,S6,S8	$-V_{dc/2}$
S3,S4,S7,S8	$-V_{dc}$

TABLE 1 DIFFERENT SWITCHING STAGE

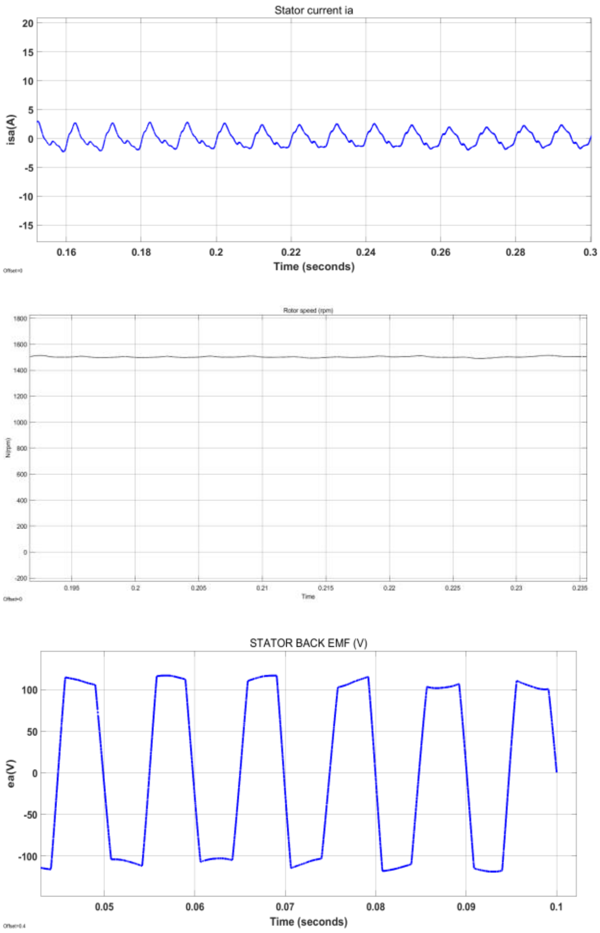
IV. BLDC MOTOR CONTROLLED SPEED

The proposed BLDC motor system is stagnant, attributable to the lack of back emf (electromotive force) and high value of current gravity in the stator winding of the motor which may damage the compression and power of the transformer device. A closed-loop controller for BLDC motor to run the speed installed exactly by the BLDC motor speed control system according to the user-defined speed. The BLDC motor is cheaper, more compact, controls the speed of the car more accurately and efficiently compared to other systems. The BLDC motor is compared to an induction motor with low power, low torque/ inertia ratio, and low power feature.





(a)



(b)

Fig. 2 Stable-state behaviors of (a) PV array and (b) BLDC motor drive.

V. SUGGESTED UNIDIRECTIONAL POWER FLOW CONTROL

In this cycle, the power flows only in one direction i.e., from the resource grid to the standard DC bus. The control meets the quality requirements of the grid required in terms of harmonic deviation (THD) and power factor (PF). BLDC. The error is transmitted by a PI (proportional-integral) controller that acts as an electrical controller. the output of the voltage regulator is repeated with the adjusted input voltage, Vd for the current reference inductor, iL2 *. This is done to adjust the current flowing in the inductor, iL2 as Vd wavelength, and to be set in phase with the input voltage, in comparison. As a result, the input power of the input arises from the opposite phase to ensure the strength of the bond. function factor (UPF). Currently audible, iL2 is compared to iL2 * and the error is transmitted to the current hysteresis controller to produce a hacking signal for the PFC development converter. The PFC boost converter is designed and controlled for use in continuous operation mode (CCM). While controlling the electric power of the DC bus, the controller determines whether the power from the application is required to be transferred or not. PV scheme MPPT p and o algorithm are used to generate maximum power.

RESULTS AND DISCUSSION

A simulation analysis based on the proposed MATLAB / Simulink of the proposed system is performed to demonstrate its behavior under a variety of possible operating conditions. The 24V, 1500 rpm engine is powered by a PV array and helped by a single 100 V Three phase, 50 Hz utility grid. The various functions performed in this way are for the PV system only, the performance of the power grid only, the interaction of the grid and the performance of the PV and finally switch from one mode to another, to assess the behavior of the dynamic, original and stable state of the system.

A. Sustainable Condition and Commencement

This test shows the initial soft operation of the engine, and the stable operation of the solar cell and grid utility. The following sections explained this operation of the system.

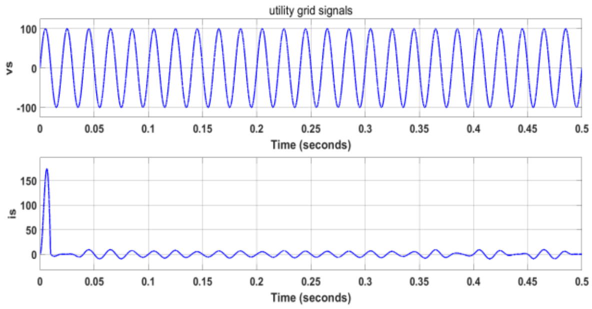
1) Only When solar PV cell Supports BLDC Motor Drives

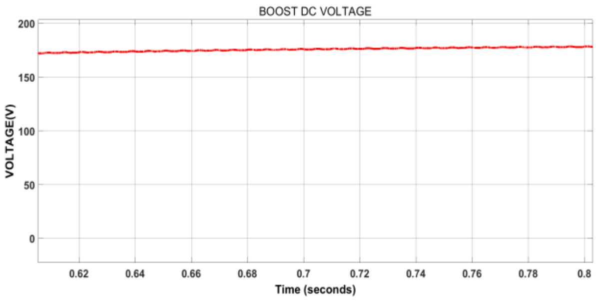
Under normal test conditions, the PV array can feed enough power to fully utilize the engine. As graphically explained in Fig.2, a full irradiance of 1000 W / m2 is available and 6.39 Kwp power is generated by the PV array. Because, the engine is worked at a moderate speed and torque as explained in Fig.2, b. No grid support is required in this case. Various BLDC motor indicators refer to the back-EMF (ea) stator current (isa) speed (N) electric torque (Te) and loading torque (TL)

The first simple operation is shown in Fig.2, c. The stator current increase at a controlled rate which confirms the soft start of the engine. A small ripple is visible in stator current due to pulse variability of MLVSI switching devices initially.

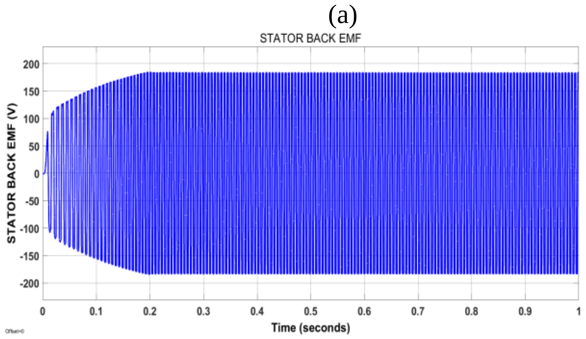
2) When the Service Grid Only Fed BLDC Motor Drives:

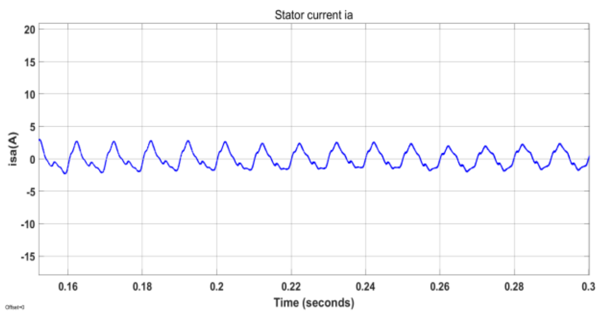
When pumping system is required at night, the motor draws only full power to the grid. Fig.3, (a). indicates that the maximum sinusoidal supply current, is 6.81 * 10-09 A drawn on UPF while controlling DC bus power, vdc at 230 V. The engine reaches its full speed and torque as shown in Fig.3 (b). In addition, THD and harmonic spectrum are shown in Fig.3, (c). THD is observed in less than 5% which meets the IEEE-519 level.

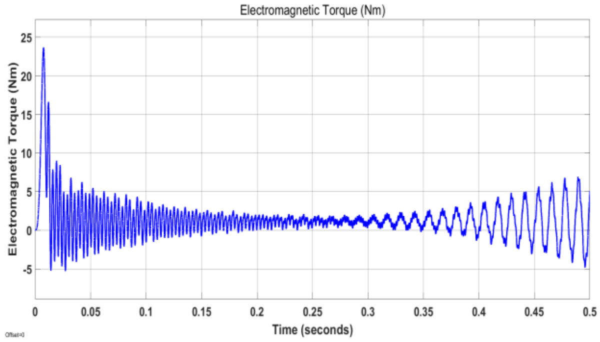


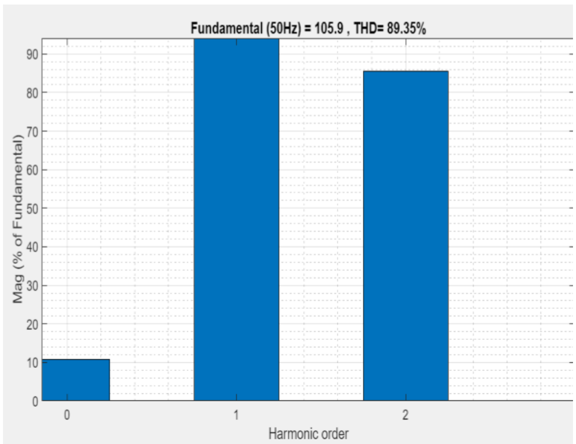


(a)









(c)

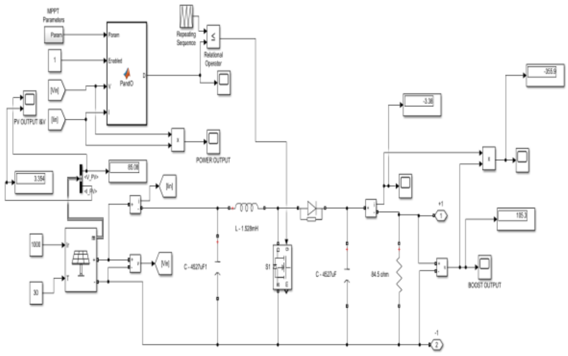
Fig. 3 Sustainable conditions for (a) grid use and (b) BLDC motor, and (c) THD and harmonic spectrum for supply current.

A. Powerful Performance
Flexibility is caused by sudden weather fluctuations such as solar irradiance or grid supply uncertainty. System behavior under these conditions is described in more detail in the following sections.
1) Conversion from Grid connected to the motor to PV Array Feeding motor: This analysis assumes that the engine is initially used by the operating grid as no PV power is available within 0.3 seconds. It is also assumed that total irradiance is achieved at 0.3 sec. This major change is set to ensure that the system is subject to maximum flexibility. As the boundary power point is traced (MPPT) as shown in Fig.4 (b), the current taken from the grid removes the value as shown in Fig.5, (b) The current grid decreases slightly due to time. took the MPPT route to track the MPPT PV list.
2) Conversion from PV Array Feeding motor to Both PV Array and Grid Feeding motor: To demonstrate this efficiency, it is assumed that full irradiance is achieved within 0.3 seconds as shown in Fig.4 (b). Therefore, no grid support is required and no grid is currently selected as shown in Fig.5, (a). Full engine performance is also shown in Fig.2 (c). A sudden decrease in sun irradiance is taken at 0.3 s. The

irradiance level drops to 1000 W / m2 and that is why insufficient power is produced by the PV series. The remaining power now needs to be taken from the utility grid. As required, the maximum sinusoidal supply current of 27.03 A is taken from the UPF while controlling the DC bus power at 100 V as shown in Fig. The engine works without interruption when it is full. THD and harmonic spectrum are shown in Fig.3, (c). THD is seen in less than 5% indicating energy levels in this regard.

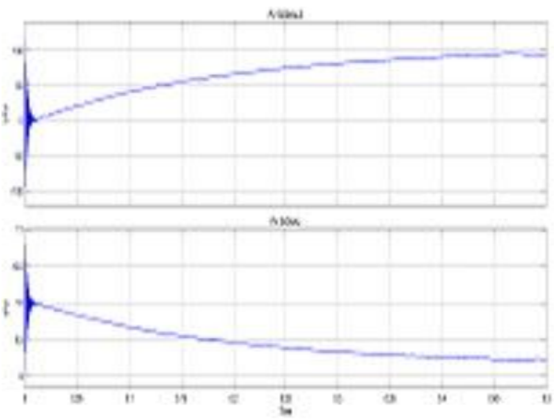
SIMULATION DIAGRAM AND WAVEFORM

1) SOLAR PV MPPT SYSTEM



(a)

This cycle reflects the layout of solar PV and the MPPT system used in this topology. The P and O algorithm was used for the system. The INC algorithm can be summarized as in topology. a simulation model for use of INC with solar PV boost dc to dc converter is shown in the simulation diagram. As the INC algorithm uses the power-voltage curve of the same PV member is equal to zero in MPPT. PV characteristics and simulation effects of the PV model due to the radiation differences in the I-V and P-V elements at constant temperature and the impact of the temperature variation in the I-V and P-V elements at the constant cost (1000W / m2).

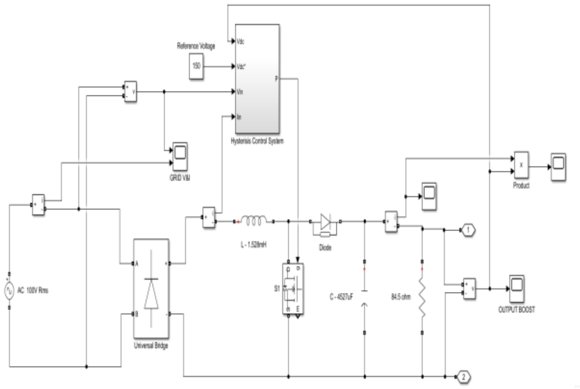


(b)

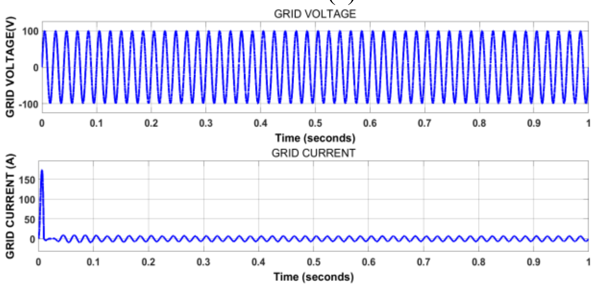
Fig. 4, (a), Simulation of PV,(b)PV Simulation waves

2) UTILITY POWER GRID SYSTEM

The grid is used to give power to the system through the PFC boost DC-DC converter used.



(a)

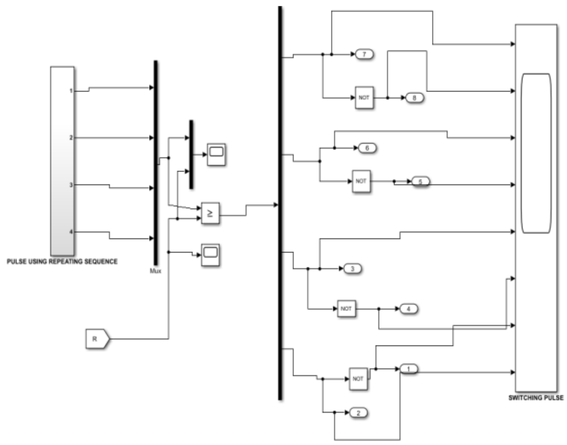


(b)

Fig. 5, (a) Simulation of the utility grid, (b) simulation wave of grid

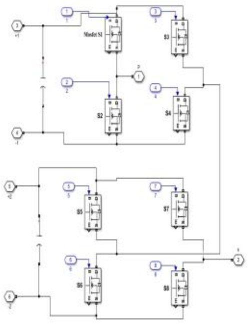
3) MULTILEVEL INVERTER

The simulation was carried out in MATLAB /SIMULINK.In this circuit 8, MOSFET is used.



(a)

Controlling a three-phase multilevel inverter with an output voltage of three levels; two carriers are produced and compared at a time with a set of three sinusoidal reference waves. One network company wave above zero references and one network company wave below reference. These carriers are similar in quantity, size and categories; but they are just different from dc offset to take the band together.



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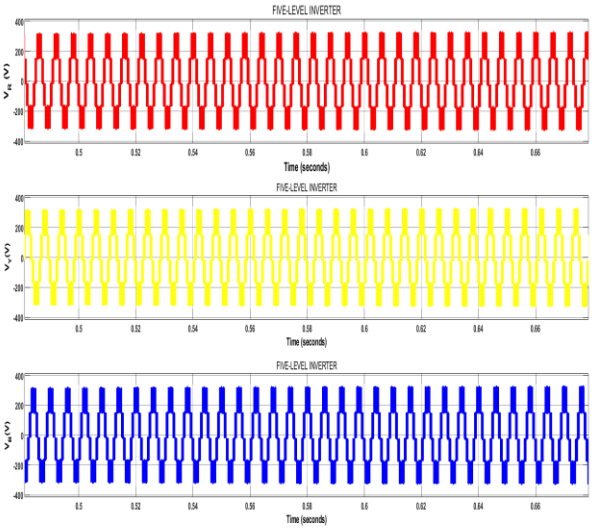


(C)

Fig. 6, (a) Simulation of Multilevel Inverter, (b)simulation of PWM (c) simulation wave of Multilevel Inverter,

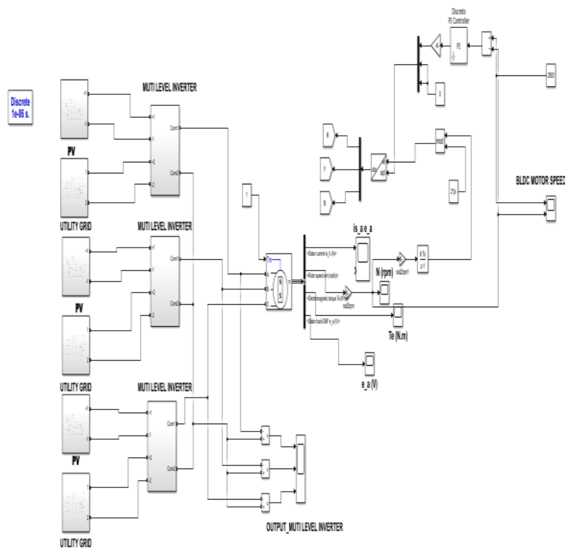


FIG.7.SIMULATION DIAGRAM OF THE PROPOSED TOPOLOGY

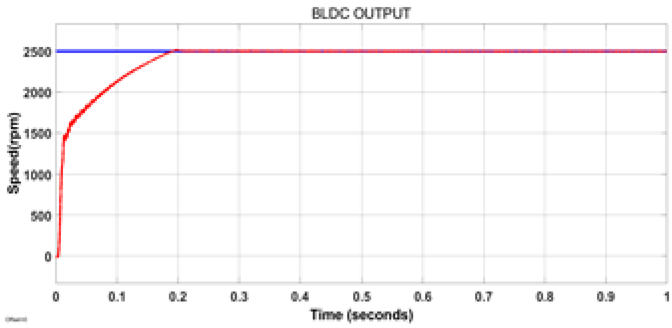


FIG.7.SIMULATION OF PROPOSED BLDC MOTOR DIFFERENT SPEED TOPOLOGY

VIII. HARDWARE DETAILS

This paper used a prototype system is implemented. The hardware is completed using a microcontroller DSPIC30F2010 and his driver circuit ICTLP350 AND 8 MOSFT switch used this paper using PV P&O algorithm for mppt system and solar 10W power 12V the BLDC motor 60W 24V 1000 microfarad capacitor and 1 millihenry inductor is used this small ferrite core transformer 12V 5A used.

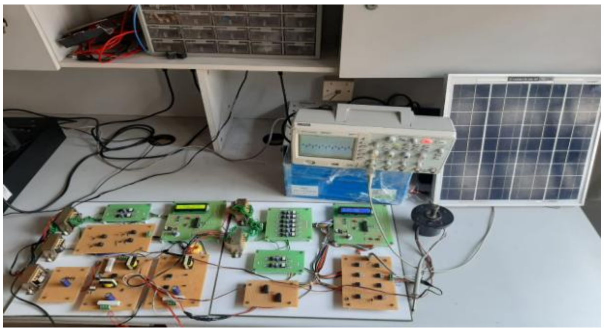
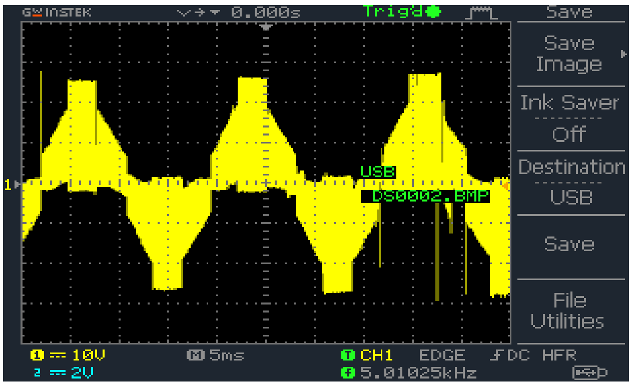


Fig 8 Hardware prototype



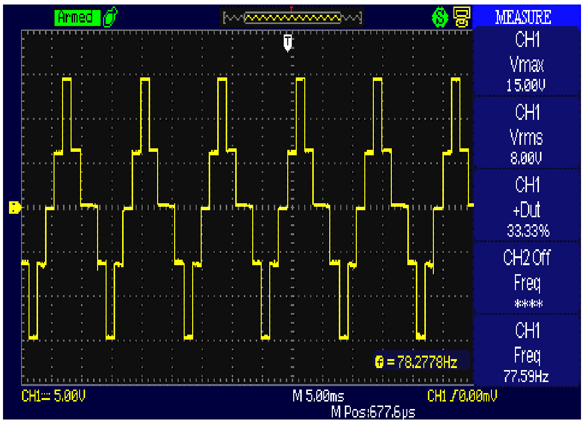


Fig 9 Hardware Result with different Load

IX. CONCLUSION

A SINGLE-PHASE grid connected to a solar PV system with a brushless DC motor drive has been proposed and demonstrated for its performance testing using the MATLAB / Simulink platform. Grid support to be used as a power backup is provided on a standard DC bus. Indirect power flow controls are built and characterized by a PFC development converter to enable conditional power transfers. Energy quality standards are met as standard IEEE-519. A simple BLDC car speed control method has been adopted that offers cost savings. Therefore, the proposed topology has the reliability and efficiency of the BLDC driving system.

APPENDICES

A. POWER PARAMETER SOLAR PV ARRAY PEAK 562.5W; SECOND OPENING VOTE = 60 V; MPPT VOLTAGE 75 V; ISIZULU SHORT NOW = 10A; CURRENT MPPT = 7.5 A.

B. DETAILS OF BLDC MOTOR NUMBER OF BRAINS = 6; ESTIMATED SPEED = 3000 RPM; STATOR RESISTANCE = 0.41 Ω ; STATOR INDUCTANCE = 1 MH; VOLTAGE CONSTANT = 78 VL-L / KRPM; PUMP CONSTANT EQUITY = 1.672E10-4.

C. GRADE COLLECTION FIELD FILTER R-C = 5Ω, 5MF; DC BUS CAPACITOR = 1000 MF

REFERENCES

[1]. Rajan Kumar, Bhim Singh, “, Grid Interfaced Solar PV Based Water Pumping Using Brushless DC Motor Drive” *IEEE Journal*, vol. 8, 2016.

[2]. N. Narasimha Rao, K. Balakrishna, N. Bharath Kumar, K. rachanjali, “Design &Performance of Cascade H-bridge Multi-Level Inverter Fed BLDC Application” International Journal of the grid and distributed computing, vol 13, 2020

[3]. Felipe Bovolini Grigoletto, “Five-Level Transformer-less Inverter for Single-Phase Solar Photovoltaic Applications,” –IEEE Journal vol. 8, issue. 4, 2019.- Base paper

[4]. Sunil Govindan Solanki, Uthaya Kumar Rostem Ganesa lingam, Manickam Ramasamy and Shahid Manzoor” Design & Development for OFF grid Solar Inverter” 2018 IEEE 4th International Symposium in Robotics and Manufacturing Automation (ROMA).

[5]. XINGWU WANG, YONGJUN LIN, BINGSHU WANG, WEI LIANG LIU AND KANG BAI “Output Voltage Control of BESS Inverter in Stand-Alone Micro-Grid Based on Expanded Inverse Model”-IEEE ACCESS vol.8, DEC 2019.

[6]. Rezkallah Miloud, Ambrish Chandra and Maarouf Saad Department of Electrical Engineering École de Technologies Supérieure, 1100 Notre-Dame Montréal, Quebec H3C1K3, Canada Marco Tremblay1, Sanjeev Singh2, Bhim Singh3, and Hussein Ibrahim4 1 Suez Water Treatment, Montreal Canada Québec, G4R 5B7, “Control of Standalone Microgrid for Mine Site “-IEEE Canadian Conference2018.

[7]. Ambarnath Banerji, Member, IEEE, Sujit K. Biswas, Sr. Member, IEEE & Bhim Singh, Fellow, ” Enhancing Quality of Power to Sensitive Loads with Microgrid” IEEE Trans. Industry Appl.2015.

[8]. A. Soleimanisardoo, H. Kazemi Karegar, Member, IEEE, and H. H. Zeineldin, Senior Member, IEEE” Differential Frequency Protection Scheme Based on Off-Nominal Frequency Injections for Inverter-Based Islanded Microgrids”, IEEE Trans. Industry Appl.2017.

[9]. Ratnakar Babu Bollipo, Suresh Mikkili, Praveen Kumar Bonthagorla” Hybrid, Optimization, Intelligent and Classical PV MPPT Techniques: Review” IEEE Journal vol.5,2020.

[10]. B. Dastagiri Reddy, M. P. Selvan, Member, IEEE, and S. Moorthi, Member, IEEE” Design, Operation and Control of S3 Inverter for Single-Phase Micro-Grid Applications” IEEE Trans. Industry Appl.2015.

[11]. Johannes Schiffer, Thomas Seel, Jörg Raisch, and Tevfik Sezi” Voltage Stability and Reactive Power Sharing in Inverter-Based Micrograds with Consensus-Based Distributed Voltage Control” IEEE Trans. Industry Appl.2015.

[12]. Sheng-yen, Li Wang, Te-Ming Lo Anton V. Prokhorov “Integration of Wind-Power and

Wave-Power Generation Systems Using a DC Micro

[13]. Grid" IEEE conference paper,2015.Yixin Zhu1, Qigao Fan1, Liansong Xiong2, Member, IEEE, Gaofeng Zhang1 and Xin Qian1" Coordination Control Strategy for Battery Ultracapacitor Hybrid Energy Storage System in Microgrids with Unbalanced and Nonlinear Loads " IEEE Trans. Industry Appl.2017.