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SOLAR PV-BATTERY BASED HYBRID WATER PUMPING SYSTEM USING BLDC MOTOR DRIVE

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Abstract— A brushless DC (BLDC)motor driven water pump powered by a solar photovoltaic(SPV) array and a battery storage. The SPV battery based hybrid generation is used as a power source in order to achieve a continuous full volume water delivery regardless of the c1imate condition. The SPV array is used as a primary source while the battery as a backup. Therefore the battery is discharged only under bad c1imate condition or at night when the PV array is insufficient to feed the water pump. Additionally, it is charged by the SPV array when the water delivery is not required. Thus no external supply is used for the battery charging. A bidirectional charging control enables to switch the mode of operation of the battery automatically through a buck boost DC-DC converter. The BLDC motor is consistently operated at its rated speed and load. No current sensing is required for the speed control and the power devices of voltage source inverter (VSI) are switched at fundamental frequency. The various performance analysis of the proposed water pumping are carried out in MATLAB/ SIMULINK platform.

I. INTRODUCTION

A brushless DC (BLDC) motor drive for solar photovoltaic (SPV) fed water pumping has gained a broad attention owing to its simplicity, high efficiency, easy to drive features no maintenance requirement and compactness. An SPV generation being intermittent in nature leads to an unreliable and interrupted water pumping. The course of bad c1imate condition the motor pump is underutilized as the SPV power is insufficient to run it at its full capacity. An unavailability of sunlight (at night) leads to shutdown of an entire water pumping system. Similarly the PV installation and other resources remain unutilized in case the water pumping is not required. These serious issues call for an extern al power backup if a full water delivery is desired continuously. As the remote and isolated areas are underprivileged from power grid supply usually a diesel generator is used as backup. As the today's challenge is to reduce threats to energy security and to create pollution free environment; a diesel generator will no longer exist. The only remaining and feasible solution is to use a battery storage as a power backup. This practice leading to a battery supported SPV hybrid power source offers a continuous and reliable water pumping.

Few attempts of battery supported SPV fed water pumping using an induction motor have been found in the literature. No such system with a BLDC motor drive is reported till date. As this motor is superseding the induction motor for many applications including water pumping; this paper proposes a SPV-battery hybrid power source based BLDC motor driven pumping system.

A power low control for charging/ discharging a battery storage is obtained through the bi directional buck-boost converter. The control governs whether the battery is required to be charged discharged as per the availability of amount of SPV power and water requirement. In fact; the battery is discharged when a water pumping is required at night or when a full volume of water output is required throughout the day. On the other hand; the battery is charged when an SPV power is available but the water pumping is no more required. The battery is made nonfunctional when a full amount of power required by the water pump is available from SPV array. The proposed system uses an SPV array as a charging source for the battery is an external power source is not required. it enables a full utilization of both PV installation and motor-pump system.

The bidirectional power tlow is accomplished by a common capacitor placed at the DC bus of voltage source inverter (VSI). The speed of BLDC motor-pump is maintained at its rated value by regulating the DC bus voltage of VSI. This practice enables a water pumping with full capacity. The speed control obviates the phase current sensors; resulting in an economical drive. The maximum power point tracking (MPPT) of PV array is achieved by an incremental conductance (InC) technique using a DC-DC boost converter. The magnitude of stator current of BLDC motor at starting is controlled by operating the VSI in PWM (Pulse Width Modulation) mode for a pre-defined duration. However; once the motor is started the VSI is operated with the pulses of

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fundamental frequency resulting in a minimized switching loss and an enhanced conversion efficiency. The SPV- battery based hybrid pumping system with a brushless DC motor drive is simulated in MATLAB/ SIMULINK platform and its functionalities are evaluated through the simulation results to demonstrate the claims.

Solar energy is remarkably exclusive form of renewable energy sources which has procurement increasing attention in modernistic year. The power generation from solar source is always clean; free from pollution furthermore a bend in nature due to that solar source is mostly used any place, where it gives maximum benefits from source. In recent year, the price of solar PV panel is going downwards which increase attention to use solar PV application in modernistic year. Renewable energy sources based application used in industries and hometown application. Among all other application based solar PV system, water pumping is most effective, crucial and cost effective application for power generation by Solar PV array. For water pumping system generally induction motor, dc motor are used in rural as well as grid connected area for induction motor. For pumping load, simple, low cost and efficient motor is generally used.

Basically for pumping section, induction motor is generally preferred it is easily available in market furthermore gives good performances for any load condition but when induction motor is preferred for solar PV based application, it suffers from overheating phenomenon of motor , if voltage of motor is going to low, due to that it require a complicated control. Under low voltage condition, efficient, reliable and cost effective motor has to be used. So, The BLDC motor is used for such application.

The brushless DC motor is ideal choice for application that requires high reliability, high efficiency and power to volume ratio. Generally, a BLDC motor is well thought-out to be a high concert motor that is proficient of providing enormous amounts of torque more than a vast speed range. For Solar PV based application, BLDC motor is undoubtedly compete with any other motor for pumping application as it gives superior performance of motor along with soft starting. BLDC motor is advancement of most of the DC motor and they have almost same torque and speed usual curve uniqueness .The key variation between two is the use of brushes. BLDC motor for pumping system technique along with solar PV source, both combination increases its utilization and reliability. Maximum benefits from solar PV, is obtained by using maximum power point tracking (MPPT) algorithm. For MPPT tracking, generally P &O, incremental conductance algorithm is used. Among that incremental conductance gives best performance under rapidly changing atmospheric condition, however it DC converters. This paper elaborate idea for proper use of Solar PV based application and soft starting of BLDC motor. For maximum benefits from solar PV array, boost converter is Used and switch of boost converter is operated through incremental conductance MPPT algorithm. The following proposed system gives benefits of solar PV based application driven by BLDC motor for water pump.

There are various ways to control speed of BLDC motor like hysteresis control and other control scheme are used. But following configuration is simple, low cost, noise free and having least component of the system; make configuration is suitable for water pumping system.

The leakage current arises because of variations in AC common-mode voltage on stray capacitor between PV panels and ground; this stray capacitance can have a typical value of 60–110 nF/kW for modules with crystalline silicon cells (monocrystalline, polycrystalline); and 100-160 nF for modules with thin-film cells. The variations of the stray capacitor voltage causes the leakage current. The leakage current should be strictly limited, since it can lead to safety issues, increased the total harmonic distortion (THD) of the injected currents, and also electromagnetic interference (EMI) problems; all of which, may violate the grid standards. According to the VDE 0126-01-01 standard, the RMS value of the leakage current has to be limited below 300 mA.

In case of the traditional full-bridge (FB) inverter (also named as B6- type inverter), the leakage current is more than the regulated limit. There are two approaches to eliminate or reduce the leakage current issue: one is to block the leakage current and the other is to reduce the common-mode voltage variations.The first approach is achieved by employing additional switches, which can effectively separate the PV side from the grid side whenever a zero-switching state is produced. The second approach is to keep the common-mode voltage constant over the time or reduce its variations.

In order to separate the PV panels from the grid, several topologies have been proposed including the Highly Efficient and Reliable Inverter Concept (HERIC)], and H7. HERIC topology is a single-phase inverter, which employs two extra switches on the AC side of the inverter to decouple the PV array from the grid during the intervals that a zero state is generated. H5 and H7 topologies are single-phase and three-phase inverters in which, the PV array is disconnected from the grid through an extra switch on the DC side of the inverter. In , a Z-Source inverter (ZSI) with an additional fast-recovery diode (ZSI-D) is proposed that its modulation intends to maintain a constant common-mode voltage. If the array voltage is too low and boost ratio of much more than 2 is required, ZSI would not be an effective solution.

In a new space-vector modulation was proposed to reduce leakage current for 3-level three-phase T-type inverters. T-type inverters are three level inverters that require 4-quadrant switches. Reduced common-mode voltage pulse width modulation (RCMV-PWM) methods are also proposed to reduce the leakage current through omission of the zero switching states, which decreases the common-mode voltage variations. In RCMV-PWM methods, the output line-to-line voltage is bipolar; the drawbacks are high dv/dt, large current ripples across filter inductors, and high switching losses that reduce the system efficiency. In, a four-leg inverter with a new modulation method has been presented to reduce the leakage current by adding two switches paralleled with three-phase legs. Besides, a fourth leg of the inverter is connected to the midpoint of the LCL filter. In the four-leg inverters, the output line to line voltage is bipolar. In a modified full-bridge single-phase inverter named FB-DCB (full bridge inverter with DC bypass) has been presented to reduce the leakage current by adding two switches and two diodes to the full bridge inverter.

OBJECTIVES

- To introduce a new reliable hybrid DG system based on PV and wind driven PMSG as sources.
- To increase the boost ratio of the converter by means of SEPI.
- Reducing the switching and conduction losses.
- To decrease the number of power converters.
- To achieve maximum power extraction from both the sources.

II. REVIEW OF LITERATURE SURVEY

1) "Design and implementation of an intelligent energy savingsystem based on standby power reduction for a future zero-energy home environment"

Energy saving has attracted great attention as a global issue because of recent environmental problems. As a part of energy saving efforts, governments are operating policies that encourage the distribution of energy saving systems. Also, individual households are voluntarily installing energy saving systems to reduce electric power consumption. However, due to fixed system architecture, the existing systems have a disadvantage, lacking in scalability and usability. In addition, the existing systems bring up immense inconvenience as it returns to standby mode after automatic standby power cut-off. Therefore, we propose an intelligent energy saving system to solve these problems. The proposed system controls the power based on the hierarchical relationship among home appliances, along with the relationship between user activity and home appliances for standby power reduction. We designed and implemented the proposed system, deployed it in the test bed, and measured the total power consumption to verify the system performance. The proposed system reduces total power consumption up to 10.5%.

2) "MPPT with Single DC-DC Converter and Inverter for Grid Connected Hybrid Wind-Drive PMSG-PV System"

A new topology of a hybrid distributed generator based on photovoltaic and wind-driven permanent magnet synchronous generator is proposed. In this generator, the sources are connected together to the grid with the help of only a single boost converter followed by an inverter. Thus, compared to earlier schemes, the proposed scheme has fewer power converters. A model of the proposed scheme in the d-q-axis reference frame is developed. Two low-cost controllers are also proposed for the new hybrid scheme to separately trigger the dc-dc converter and the inverter for tracking the maximum power from both sources.

The integrated operations of both proposed controllers for different conditions are demonstrated through simulation and experimentation. The steady-state performance of the system and the transient response of the controllers are also presented to demonstrate the successful operation of the new hybrid system. Comparisons of experimental and simulation results are given to validate the simulation model.

3) "Flexible Microgrid Power Quality Enhancement Using Adaptive Hybrid Voltage and Current Controller"

To accomplish superior harmonic compensation performance using distributed generation (DG) unit power electronics interfaces, an adaptive hybrid voltage and current controlled method (HCM) is proposed in this paper. It shows that the proposed adaptive HCM can reduce the numbers of low-pass/bandpass filters in the DG unit digital controller. Moreover, phase-locked loops are not necessary as the microgrid frequency deviation can be automatically identified by the power control loop. Consequently, the proposed control method provides opportunities to reduce DG control complexity, without affecting the harmonic compensation performance. Comprehensive simulated and experimental results from a single-phase microgrid are provided to verify the feasibility of the proposed adaptive HCM approach.

4) "Permanent Magnet Synchronous Generator-Based Standalone Wind Energy Supply System"

A novel algorithm, based on dc link voltage, is proposed for effective energy management of a stand-alone permanent magnet synchronous generator (PMSG)-based variable speed wind energy conversion system consisting of battery, fuel cell, and dump load (i.e., electrolyzer). Moreover, by maintaining the dc link voltage at its reference value, the output ac voltage of the inverter can be kept constant irrespective of variations in the wind speed and load. A n effective control technique for the inverter, based on the pulse width modulation (PWM) scheme, has been developed to make the line voltages at the point of common coupling (PCC) balanced when the load is unbalanced. Similarly, a proper control of battery current through dc–dc converter has been carried out to reduce the electrical torque pulsation of the PMSG under an unbalanced load scenario. Based on extensive simulation results using MATLAB/SIMULINK, it has been established that the performance of the controllers both in transient as well as in steady state is quite satisfactory and it can also maintain maximum power point tracking.

5) "Voltage Control of an Autonomous Hybrid Generation Scheme Based on PV Array and Wind – Driven Induction Generators"

Hybrid distributed generators are increasingly found to supply reliable power in isolated locations. In this article, a DC-DC step-up converter for maintaining a constant load voltage in a hybrid PV array excited wind-driven induction generator is proposed. A closed loop PI controller is designed to automatically vary the duty-cycle of the DC-DC converter. A dynamic d-q axes model of the entire scheme is presented. Constant voltage regimes for varying irradiation and wind speed are obtained using the developed model. Further, close agreement between the experimental and simulated waveforms is established to demonstrate the veracity of the simulation.

III. PROPOSED SYSTEM:

• BLDC motor is used for pumping system , BLDC motor is operated by voltage source inverter of DC-link.

• The proposed system gives energy from solar PV based boost converter for pumping load. Solar PV array generates energy gives to the boost converter.

• The switch of the boost converter is operated by MPPT algorithm such that maximum benefits from solar PV array is optimized and also gives smooth performance of BLDC motor for pumping application.

• The hall sensors are used in order to sense rotor position of motor. Hall sensors are electronically commuted circuit used for inverter switching.

A. METHODOLOGY

- ➢The generated voltages are filtered and boosted by **Single Ended Primary Inductor converter.**
- ➢The fuzzy logic control based **MPPT algorithm** is used to extract the **maximum power from the hybrid energy system.**
- ➢By using PI controller the inverter output voltage is made equal to the grid voltage.

B. ADVANTAGES

- ➢Low switch voltage operation.
- ➢High static gain at low line voltage.
- ➢Reduced hardware requirements.
- ➢Reduced filter size and eliminates the need of Separate input Filters.
- ➢Soft commutation with simple regenerative snubber circuit
- ➢Supports individual and simultaneous operation.

C. APPLICATIONS

- ➢ Speed control of AC motor.
- ➢ Renewable energy applications
- ➢ Speed control of Servo motor
- ➢ FACTS applications.

IV. BLOCK DIAGRAM

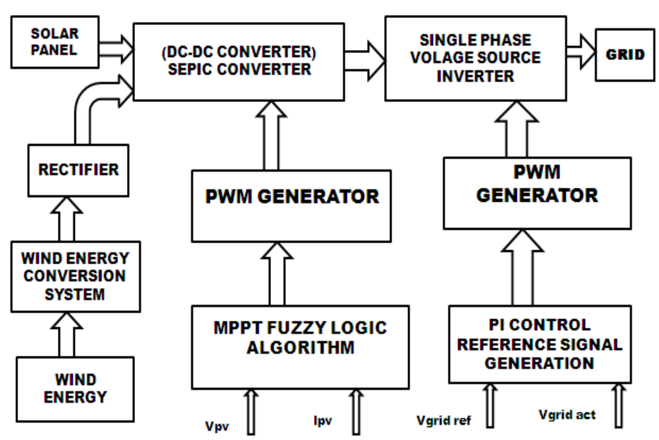


Figure.1 Block diagram

A. Brushless DC Motor

Brushless DC motors (BLDC) have been a much focused area for numerous motor manufacturers as these motors are increasingly the preferred choice in many applications, especially in the field of motor control technology. BLDC motors are superior to brushed DC motors in many ways, such as ability to operate at high speeds, high efficiency, and better heat dissipation.

They are an indispensable part of modern drive technology, most commonly employed for actuating drives, machine tools, electric propulsion, robotics, computer peripherals and also for electrical power generation. With the development of sensorless technology besides digital control, these motors become so effective in terms of total system cost, size and reliability.

B. Brushless DC motor Definition

A brushless DC motor (known as BLDC) is a permanent magnet synchronous electric motor which is driven by direct current (DC) electricity and it accomplishes electronically controlled commutation system (commutation is the process of producing rotational torque in the motor by changing phase currents through it at appropriate times) instead of a mechanically commutation system. BLDC motors are also referred as trapezoidal permanent magnet motors.

Unlike conventional brushed type DC motor, wherein the brushes make the mechanical contact with commutator on the rotor so as to form an electric path between a DC electric source and rotor armature windings, BLDC motor employs electrical commutation with permanent magnet rotor and a stator with a sequence of coils. In this motor, permanent magnet (or field poles) rotates and current carrying conductors are fixed.

The armature coils are switched electronically by transistors or silicon controlled rectifiers at the correct rotor position in such a way that armature field is in space quadrature with the rotor field poles. Hence the force acting on the rotor causes it to rotate. **Hall sensors** or rotary encoders are most commonly used to sense the position of the rotor and are positioned around the stator. The rotor position feedback from the sensor helps to determine when to switch the armature current.

This electronic commutation arrangement eliminates the commutator arrangement and brushes in a DC motor and hence more reliable and less noisy operation is achieved. Due to the absence of brushes BLDC motors are capable to run at high speeds. The efficiency of BLDC motors is typically 85 to 90 percent, whereas as brushed type DC motors are 75 to 80 percent efficient. There are wide varieties of BLDC motors available ranging from small power range to fractional horsepower, integral horsepower and large power ranges.

C. Construction of BLDC Motor

BLDC motors can be constructed in different physical configurations. Depending on the stator windings, these can be configured as single-phase, two-phase, or three-phase motors. However, three-phase BLDC motors with permanent magnet rotor are most commonly used.

The construction of this motor has many similarities of three phase induction motor as well as conventional DC motor. This motor has stator and rotor parts as like all other motors. Construction of BLDC Motor

Stator of a BLDC motor made up of stacked steel laminations to carry the windings. These windings are placed in slots which are axially cut along the inner periphery of the stator. These windings can be arranged in either star or delta. However, most BLDC motors have three phase star connected stator.

Each winding is constructed with numerous interconnected coils, where one or more coils are placed in each slot. In order to form an even number of poles, each of these windings is distributed over the stator periphery.

The stator must be chosen with the correct rating of the voltage depending on the power supply capability. For robotics, automotive and small actuating applications, 48 V or less voltage BLDC motors are preferred. For industrial applications and automation systems, 100 V or higher rating motors are used.

D. Rotor

BLDC motor incorporates a permanent magnet in the rotor. The number of poles in the rotor can vary from 2 to 8 pole pairs with alternate south and north poles depending on the application requirement. In order to achieve maximum torque in the motor, the flux density of the material should be high. A proper magnetic material for the rotor is needed to produce required magnetic field density.

Ferrite magnets are inexpensive, however they have a low flux density for a given volume. Rare earth alloy magnets are commonly used for new designs. Some of these alloys are Samarium Cobalt (SmCo), Neodymium (Nd), and Ferrite and Boron (NdFeB). The rotor can be constructed with different core configurations such as the circular core with permanent magnet on the periphery, circular core with rectangular magnets, etc.

E. Hall Sensors

Hall sensor provides the information to synchronize stator armature excitation with rotor position. Since the commutation of BLDC motor is controlled electronically, the stator windings should be energized in sequence in order to rotate the motor. Before energizing a particular stator winding, acknowledgment of rotor position is necessary. So the Hall Effect sensor embedded in stator senses the rotor position.

Most BLDC motors incorporate three Hall sensors which are embedded into the stator. Each sensor generates Low and High signals whenever the rotor poles pass near to it. The exact commutation sequence to the stator winding can be determined based on the combination of these three sensor's response.

F. Working Principle and Operation of BLDC Motor

BLDC motor works on the principle similar to that of a conventional DC motor, i.e., the Lorentz force law which states that whenever a current carrying conductor placed in a magnetic field it experiences a force. As a consequence of reaction force, the magnet will experience an equal and opposite force. In case BLDC motor, the current carrying conductor is stationary while the permanent magnet moves.

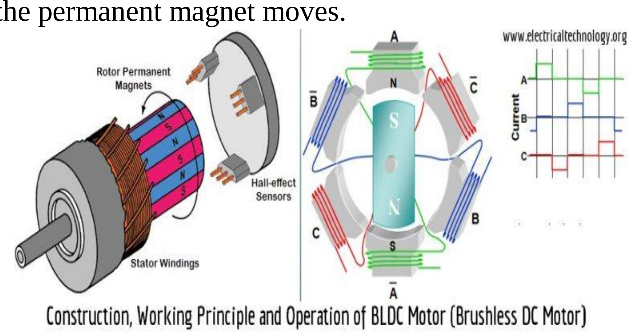


Figure 2 :Working principle of BLDC MOTOR

When the stator coils are electrically switched by a supply source, it becomes electromagnet and starts producing the uniform field in the air gap. Though the source of supply is DC, switching makes to generate an AC voltage waveform with trapezoidal shape. Due to the force of interaction between electromagnet stator and permanent magnet rotor, the rotor continues to rotate.

Consider the figure below in which motor stator is excited based on different switching states. With the switching of windings as High and Low signals, corresponding winding energized as North and South poles. The permanent magnet rotor with North and South poles align with stator poles causing motor to rotate.

Observe that motor produces torque because of the development of attraction forces (when North-South or South-North alignment) and repulsion forces (when North-North or South-South alignment). By this way motor moves in a clockwise direction.

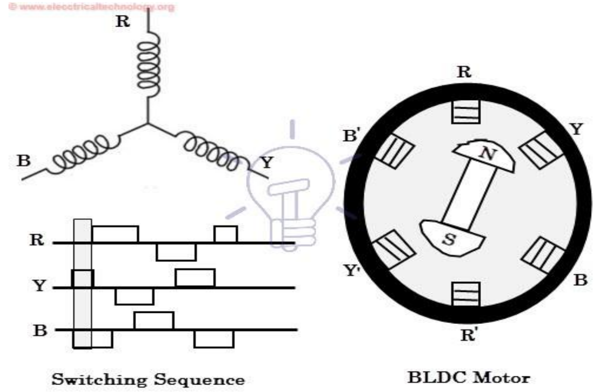


Figure 3: WORKING BLDC MOTOR

Here, one might get a question that how we know which stator coil should be energized and when to do. This is because; the motor continuous rotation depends on the switching sequence around the coils. As discussed above that Hall sensors give shaft position feedback to the electronic controller unit. Based on this signal from sensor, the controller decides particular coils to energize. Hall-effect sensors generate Low and High level signals whenever rotor poles pass near to it. These signals determine the position of the shaft.

G. Brushless DC Motor Drive

As described above that the electronic controller circuit energizes appropriate motor winding by turning transistor or other solid state switches to rotate the motor continuously. The figure below shows the **simple BLDC motor drive circuit** which consists of MOSFET bridge (also called as inverter bridge), electronic controller, hall effect sensor and BLDC motor.

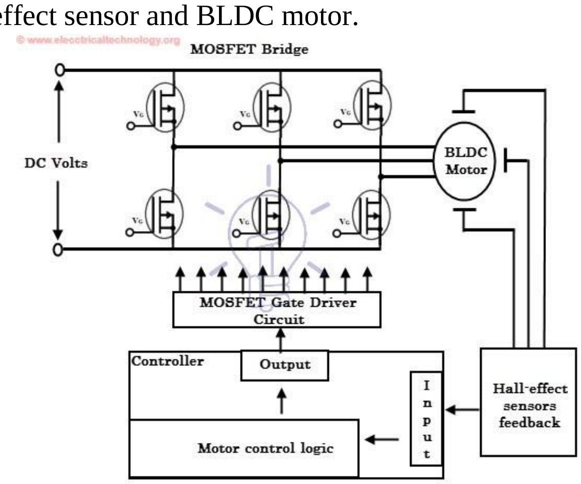


Figure 4 Driver circuit

Here, Hall-effect sensors are used for position and speed feedback. The electronic controller can be a microcontroller unit or microprocessor or DSP processor or FPGA unit or any other controller. This controller receives these signals, processes them and sends the control signals to the MOSFET driver circuit.

H. Advantages of BLDC Motor

BLDC motor has several advantages over conventional DC motors and some of these are It has no mechanical commutator and associated problems

- High efficiency due to the use of permanent magnet rotor
- High speed of operation even in loaded and unloaded conditions due to the absence of brushes that limits the speed
- Smaller motor geometry and lighter in weight than both brushed type DC and induction AC motors
- Long life as no inspection and maintenance is required for commutator system
- Higher dynamic response due to low inertia and carrying windings in the stator
- Less electromagnetic interference
- Quite operation (or low noise) due to absence of brushes

I. MOSFET with Working MOSFET as a Switch

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semiconductor device which is widely used for switching and amplifying electronic signals in the electronic devices. The MOSFET is a core of integrated circuit and it can be designed and fabricated in a single chip because of these very small sizes. The MOSFET is a four terminal device with source(S), gate (G), drain (D) and body (B) terminals. The body of the MOSFET is frequently connected to the source terminal so making it a three terminal device like field effect transistor. The MOSFET is very far the most common transistor and can be used in both analog and digital circuits.

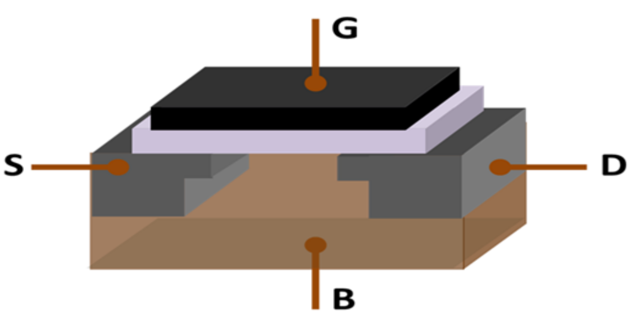
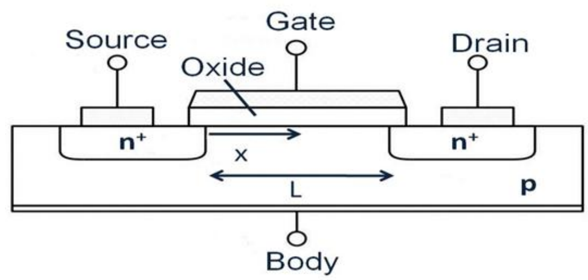


Figure 5. MOSFET SWITCH

The MOSFET works by electronically varying the width of a channel along which charge carriers flow (electrons or holes). The charge carriers enter the channel at source and exit via the drain. The width of the channel is controlled by the voltage on an electrode is called gate which is located between source and drain. It is insulated from the channel near an extremely thin layer of metal oxide. The MOS capacity present in the device is the main part



The MOSFET can function in two ways

❖Depletion Mode
❖Enhancement Mode

1) Depletion Mode:

When there is no voltage on the gate, the channel shows its maximum conductance. As the voltage on the gate is either positive or negative, the channel conductivity decreases.

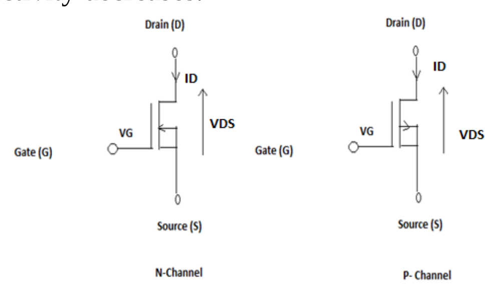


Figure 6. N Channel and P Channel

2) Enhancement mode:

When there is no voltage on the gate the device does not conduct. More is the voltage on the gate, the better the device can conduct.

J. Working Principle of MOSFET:

The aim of the MOSFET is to be able to control the voltage and current flow between the source and drain. It works almost as a switch. The working of MOSFET depends upon the MOS capacitor. The MOS capacitor is the main part of MOSFET. The semiconductor surface at the below oxide layer which is located between source and drain terminal. It can be inverted from p-type to n-type by applying a positive or negative gate voltages respectively. When we apply the positive gate voltage the holes present under the oxide layer with a repulsive force and holes are pushed downward with the substrate. The depletion region populated by the bound negative charges which are associated with the acceptor atoms. The electrons reach channel is formed. The positive voltage also attracts electrons from the n+ source and drain regions into the channel. Now, if a voltage is applied between the drain and source, the current flows freely between the source and drain and the gate voltage controls the electrons in the channel. Instead of positive voltage if we apply negative voltage , a hole channel will be formed under the oxide layer.

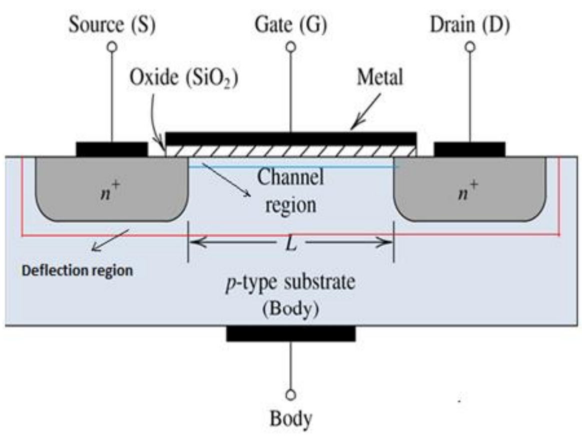


Figure 7 . MOSFET Block Diagram

K. P-Channel MOSFET:

The P- Channel MOSFET has a P- Channel region between source and drain. It is a four terminal device such as gate, drain, source, body. The drain and source are heavily doped p+ region and the body or substrate is n-type.

The flow of current is positively charged holes. When we apply the negative gate voltage, the electrons present under the oxide layer with are pushed downward into the substrate with a repulsive force. The depletion region populated by the bound positive charges which are associated with the donor atoms. The negative gate voltage also attracts holes from p+ source and drain region into the channel region.

L. N- Channel MOSFET:

The N-Channel MOSFET has a N- channel region between source and drain It is a four terminal device such as gate, drain , source , body. This type of MOSFET the drain and source are heavily doped n+ region and the substrate or body is P- type. The current flows due to the negatively charged electrons. When we apply the positive gate voltage the holes present under the oxide layer pushed downward into the substrate with a repulsive force.

The depletion region is populated by the bound negative charges which are associated with the acceptor atoms. The electrons reach channel is formed. The positive voltage also attracts electrons from the n+ source and drain regions into the channel. Now, if a voltage is applied between the drain and source the current flows freely between the source and drain and the gate voltage controls the electrons in the channel. Instead of positive voltage if we apply negative voltage a hole channel will be formed under the oxide layer.

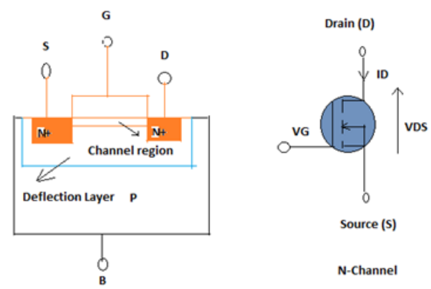


Figure 8. Enhanced mode

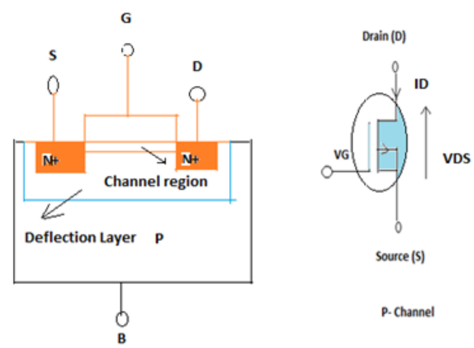


Figure 9 Depletion Mode

M. MOSFET SWITCH

In this circuit arrangement an enhanced mode and N-channel MOSFET is being used to switch a sample lamp ON and OFF. The positive gate voltage is applied to the base of the transistor and the lamp is ON (V_{GS} =+v) or at zero voltage level the device turns off (V_{GS}=0). If the resistive load of the lamp was to be replaced by an inductive load and connected to the relay or diode which is protect to the load. In the above circuit, it is a very simple circuit for switching a resistive load such as lamp or LED. But when using MOSFET to switch either inductive load or capacitive load protection is required to contain the MOSFET device. We are not giving the protection the MOSFET device is damage.

For the MOSFET to operate as an analog switching device, it needs to be switched between its cutoff region where V_{GS} =0 and saturation region where V_{GS} =+v.

V. SIMULATION RESULT

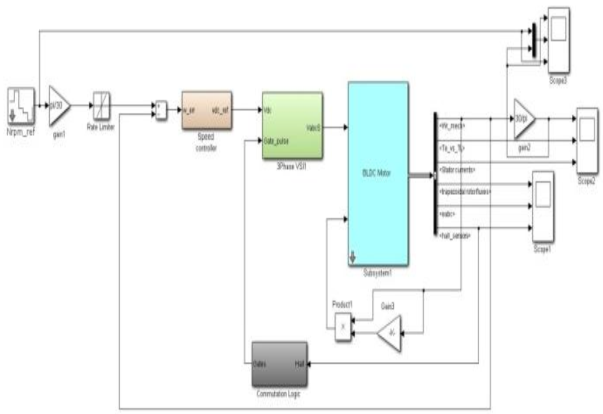


Figure 10: Wireless Hybrid Water Pumping System Using BLDC Motor Drive

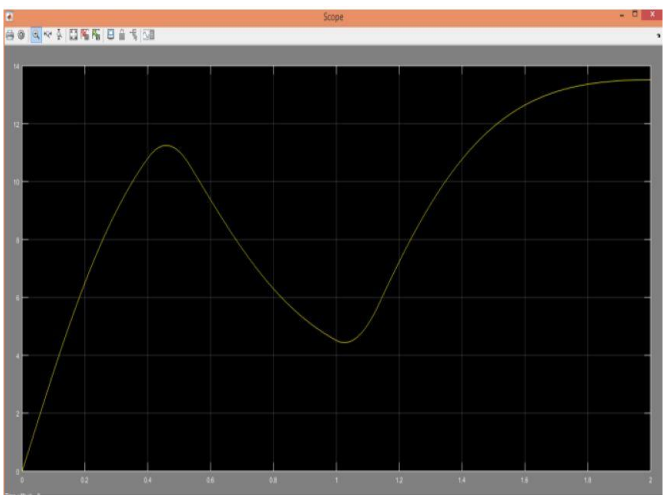


Figure 11: Output MATLAB Simulation For Using BLDC Motor Drive

VI. CONCLUSION

A BLDC motor driven water pumping fed by an SPV battery hybrid source has been proposed and its various performances have been analyzed under the dynamic conditions. The proposed water pumping has been demonstrated as a reliable system. Moreover; a full utilization of the SPV array and pumping system has been made possible. A power tlow control has been applied to enable a power transfer between the DC bus and battery storage through a bi directional buck-boost converter. A reduced sensor based BLDC motor drive has led to a low cost and compact pumping system. This grid independent system has been found more useful for remote and isolated regions.

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