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Research Article

A Report on Application of Power Electronics on Renewable Energy System

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Abstract: Power electronics is having blended use in renewable energy in wind and photovoltaic system. Power electronics is now developing in the area of efficiency and reduction of installation cost. Wind turbine now uses inverter with improved efficiency and regulation.

Keywords: Photovoltaic System, Inverter, Renewable Energy

INTRODUCTION

The cost of renewable energy is reducing day by day and its demand is gradually increasing. Most of the power electronics application is in solar and wind energy. Most of the system used in such application produces DC current. For this inverters are required to convert this into AC. There are two types of

photovoltaic system: Stand alone and Grid connected. Stand alone connection is used in remote location and grid connected system inject power to utility grid.

POWER ELECTRONIC IN PHOTOVOLTAIC SYSTEM

The PV module is made of several solar cells which converts the energy of sunlight into electricity (quantum mechanics process) and produces different levels of DC voltage. The commonly used semiconductor material for solar cell is Monocrystalline Si cells, Polycrystalline Si cells and Amorphous Si cell. All PV modules have typical voltage and current characteristic curve [5].

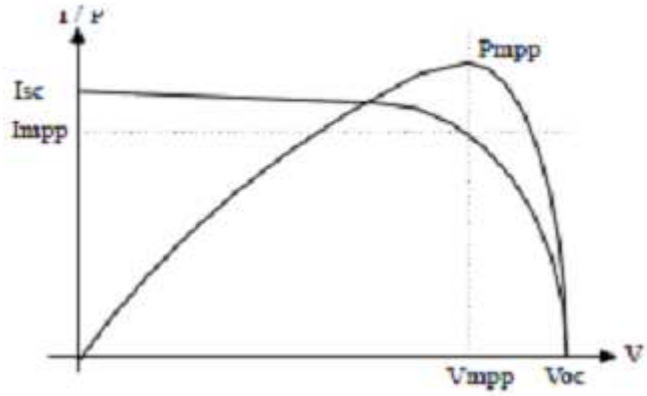

Fig1.1: PV module curve

Off Grid PV system are used in stand alone connection and uses battery to store energy to cover demand. Where more than one string is used over current protection is required A switch mode DC-Dc converter[1, 2] is used to give stable voltage and current characteristic and match the Dc output to the load. It uses either step down converter or step up converter or combination of these two. To maximize the performance of string in most charge regulator, Maximum Power Point Tracker (MPPT) controller is used. It applies Algorithm to track the array voltage which results in Maximum Power. Its efficiency is between 92-97% and its Actual gain depends upon Temperature, Battery charging stare [4, 5]

The input of this Dc to Dc converter is the output of Solar panel string. It converts Dc to high frequency (20-80 KHz) Ac and then back to DC

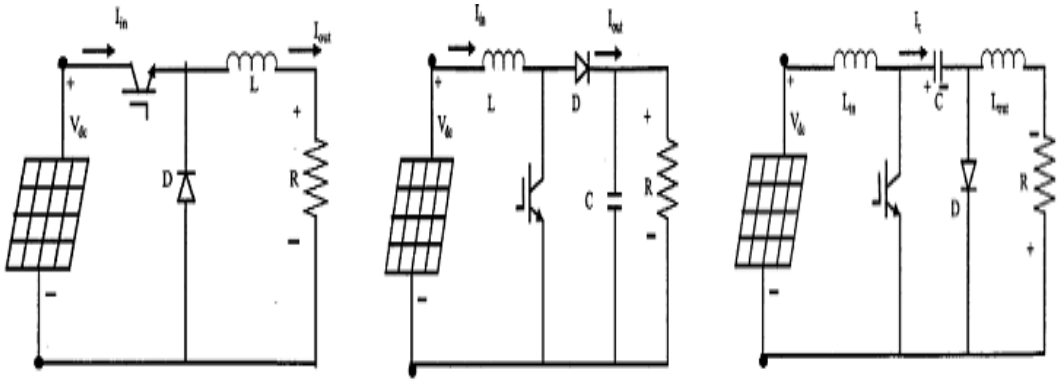

Fig.1.2: dc/dc converter techniques

Stand alone PV system uses self commutated inverter producing Ac current without synchronization they produce Ac current same as that of the grid to supply off grid load. MOSFETs and IGBTs based inverter are used in which MOSFET based is used only up to 3KW. Single or three phase inverters are used and

SPWM method. The output of inverter is connected to load through transformer .The output voltage is higher if Full wave bridge inverter is used in case of half wave bridge inverter. [4, 5]

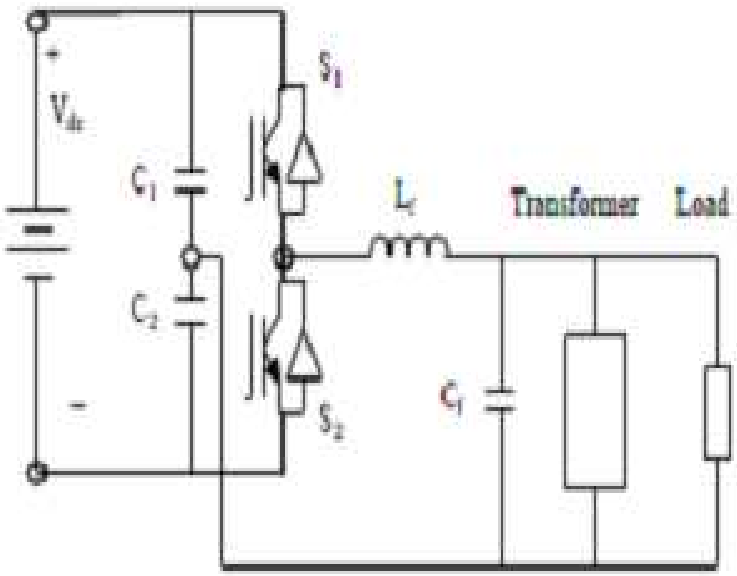

Fig.1.3: Single Phase half wave bridge Inverter

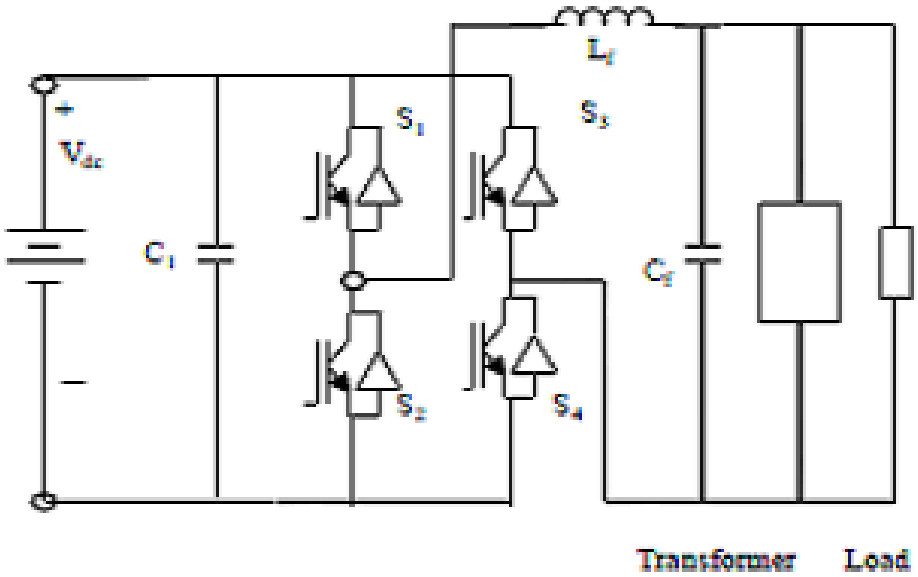

Fig. 1.4: Single phase full wave bridge Inverter

In grid connected application energy is provided directly to grid It reduces the cost of the system and maintenance. The inverter used in this case has different connection and produces sine wave output, follow the frequency and voltage of grid and obtain maximum power from module and MPPT controller. The most common modulation used is PWM modulation. And operates range from 2-20KHz.Grid connected inverters are VSI or CSI. [1]

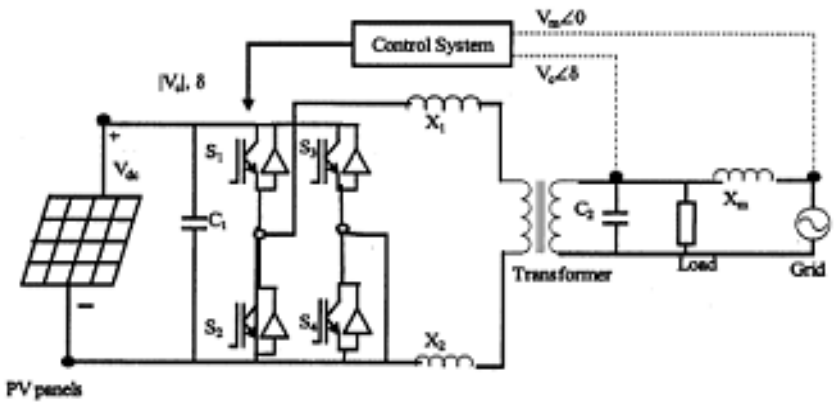

Fig.1.5: VSI Inverter

The PV modules are divided into strings each generating sufficiently high voltage for avoiding amplification. String are connected in parallel through diodes initially line commutated inverter using thyristors were used but has poor harmonics performance. So one or two string of crystalline module are connected to each inverter which has own MPP tracker controller [1][2] and power losses are reduced. By this inverter efficiency is increased to 90-92%. Transformer imposes limitation of grid current by inverter. Transformer used is bulky, costly and produce losses so not used commonly. The factors which effect the design optimization are maximum input voltage of inverter and its bandwidth.

IGBTs and MOSFETs with high pulsing frequency provide improved Power Quality with regulation of grid. .The frequency leads to the usage of high frequency transformer with lower weight. This is thus easier in installation and has low transportation cost.

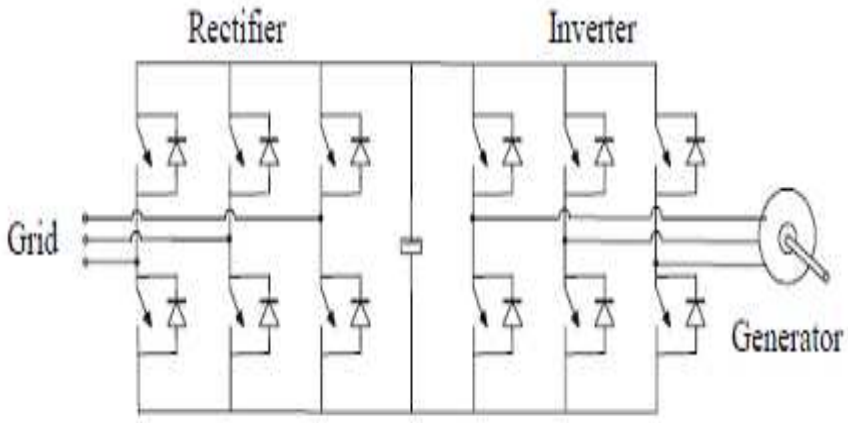

Fig.1.6: Back to back PWM VSI Inverter

Now string inverters are available at the range of 2-30 KWp. The three phase string inverters are also in use now days. The multi-string is development in string inverter which is combination of string connected to separate DC/DC converter and then to common DC/AC converter. Each string is controlled individually so it has better performance and efficiency

POWER ELECTRONICS FOR WIND TURBINE

There are two types of wind turbine: horizontal axis and vertical axis with range from 50W to 7MW.There are three types of wind power system: (i) Stand alone (ii) Hybrid and (iii) Grid type system. Stand alone type is mostly used and uses batteries to store produced energy and inverter to convert AC current. It requires charge regulator which will feed power from wind generator to battery bank in controlled way. It uses permanent magnet generator and charging control is done by controlled rectifiers. The charged regulator must be programmed to limit current in batteries to reduce current when batteries are charged to maintain trickle charge[2][5] The hybrid system includes other renewable sources like PV system Grid connected Wind turbine is connected through power electronics device. There are different types of inverter used such as PWM-VSI converter and matrix converter. The back to back PWM-VSI is bidirectional power converter having two PWM inverters. To obtain full control of grid current DC link voltage is boosted to level higher than amplitude of grid line voltage. The power flow of grid side converter is controlled to keep DC link voltage constant while control of generator is according to magnetization demand and reference speed.

The matrix inverters can effectively convert three phase power output to WT to electrical grid characteristic for proper connection they have array of controlled bidirectional switch to convert AC power from one frequency to another. They produce variable output voltage. They do not posses DC link circuit and do not use large energy storage element. MOSFET for low power and IGBTs for high power enable the implementation of bidirectional switches make inverter easy for power handling.

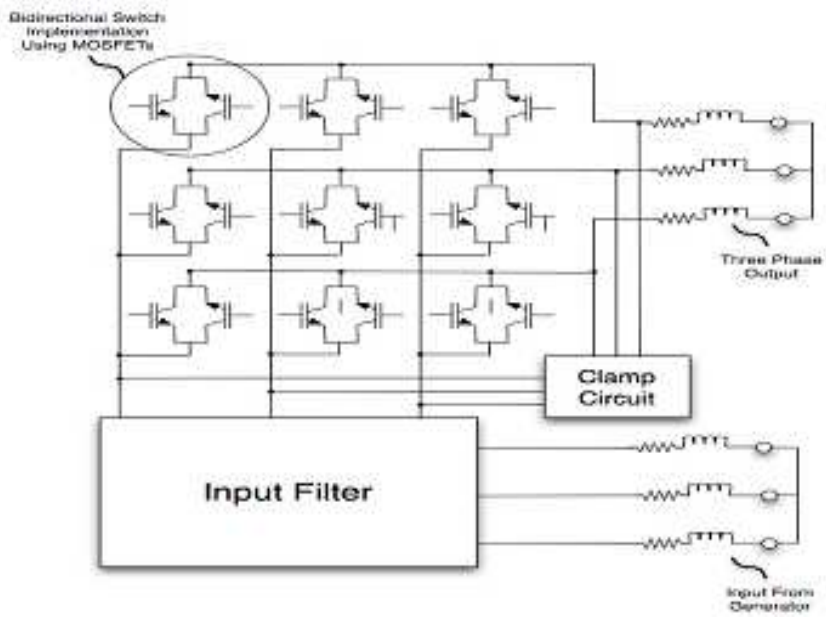

Fig.1.7: Matrix converter

Input filter minimizes high frequency component in input current and reduces disturbance of input power. Input filter is designed with combination of L and C with parallel damping resistor and clamp circuit provides overvoltage protection and uses fast recovery diodes.There is duty cycle factor which adjust to regulate ratio of output to input voltage to maximum value. The output is then passed through filter to reduce harmonics. The driving circuit of IGBT is same as of MOSFET and linkage capacitor between

IGBT terminals are low. In PWM type rectifier when switching frequency increases power loss becomes high during deactivation of switching element and commutation diode. This case limits the usage of IGBT with 50 KHz as switching element. In high frequency resonant inverters the frequency can be up to 250 KHz.

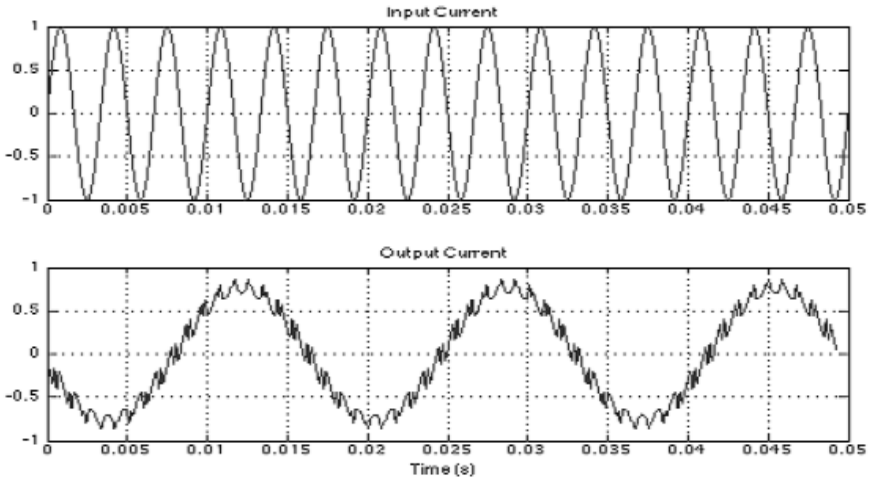

Fig.1.8: Matrix converter steady state simulation

Along with matrix converter, the other type used is: (i) Tandem converter (ii) multilevel converter and (iii) Resonant converter. The matrix converter can replace the transformer without the need of high voltage rating .With respect to harmonics reduction the best system to be used is multilevel converter both on the generator and grids side. The resonant converter system is used widely. An example of static converter is switching to grid of wind turbine equipped with induction generator [1] ,the direct connection of wind turbine to the can cause high current and torque pulsation. So a soft starter is used to regulate the applied stator voltage of IM. The commutating device has two anti parallel thyristor per phase[1] whose firing angle(α) depends upon power factor of the element which is connected .In case of resistive load 0< α<90 and for purely inductive load 90< α<180.

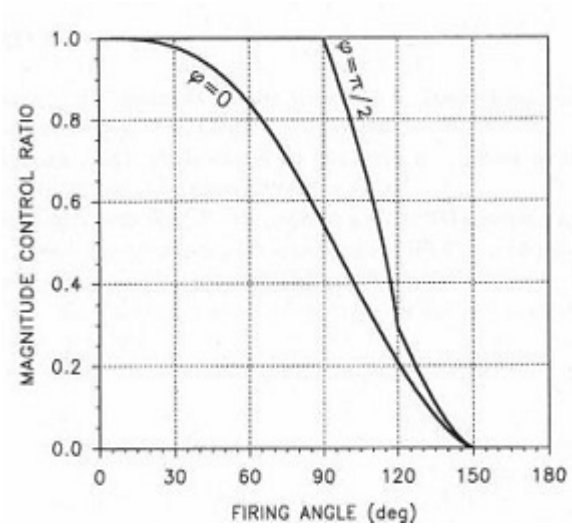

Fig.1.9: Controlled characteristic of controlled starter

The turbine accelerates under pitch control to synchronous speed through wind power alone and then switched to grid. [1]

AC controller is connected to grid at zero speed and fast acceleration to operating speed .When generator is connected to grid contractor is used to bypass the starter to reduce the losses.

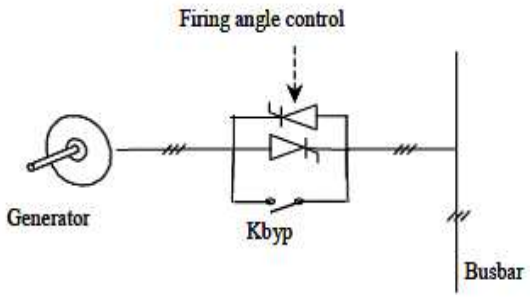

Fig.1.10: Soft Controller

USE OF MICRO INVERTER IN RENEWABLE SYSTEM

In commercial application, the component interfaces with photovoltaic panel, batteries that stores charge and the utility grid. [8] A solar inverter takes low voltage from DC output of the array from the PV system and converts into combination of DC battery voltage, AC line voltage and Distribution Grid voltage. In Solar energy harvesting system, multiple solar panels are connected parallel with single Inverter that converts Variable DC output voltage of multiple PV cell into sinusoidal voltage source. Using a micro inverter for individual solar panel using single inverter reduces the different controlling requirement and adjusts the conversion parameter using PWM technique. They manage the energy conversion and improve the system monitoring. The microcontroller is integrated on chip communication peripheral to simplify interfacing with other micro inverter in the solar array. The microcontroller detects the load current and changes the output voltage by turning off the output MOSFET .It has Analog and digital converter to sample out the voltage and current.

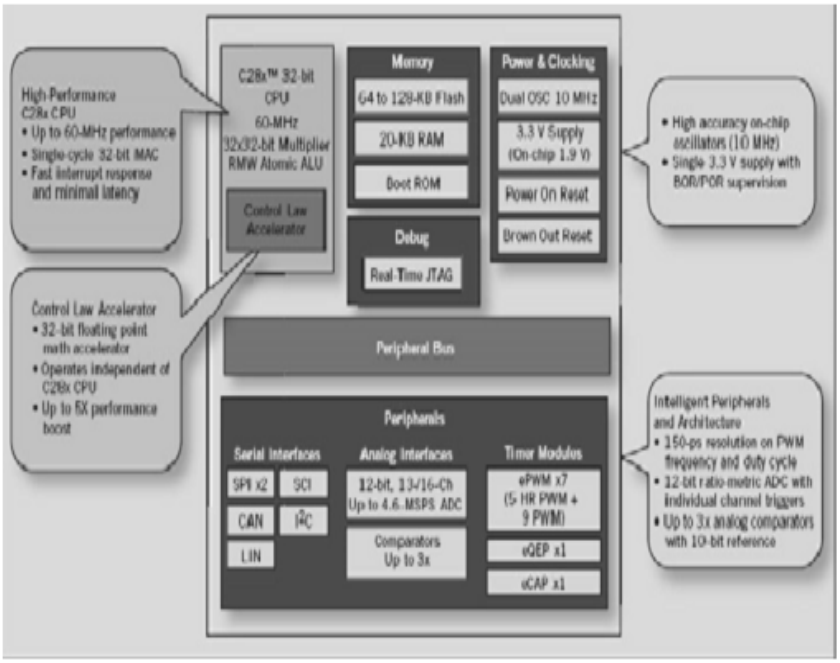

Fig.1.11: Micro Inverter based PV system

FEATURES OF MICROINVERTER BASED PV SYSTEM

It supports the different types of Protocol like PLCs (Power Line Communication). It also has high power PWM capability and posses the advantage of software programmability .It has Integrated Dual on-chip oscillator for clock comparison, multiple high resolutions PWM with interface and communication protocol. [7] In the direct method of energy conversion PVs generate DC output which is converted into AC by Inverter. PV based solar energy has limited distribution and capacity but some facilitate up to 60Mw in recent development. In solar thermal conversion the sun rays directed by mirror heat the thermal exchange agent to high temperature and exchange heat to run steam turbine which is driven by a synchronous Generator. They also store energy and plant has the capacities of several hundred MWs. The storage of energy is done through thermal phase transition.

CONCLUSION

In this paper the trend of power electronic usage in renewable energy PV system is discussed. In PV system inverter efficiency is continuously increasing and weight is been minimized to reduce transportation and installation cost The power and voltage range of string and inverter is increased so that efficient and cheaper PV installation can be realized using lesser number of inverter. Power Electronics for Wind Turbine system is more efficient control system with more effective converter used now. The extra cost of saving the energy is recovered which reduces consumption and generation that causes environmental pollution and thus reduces global warming. The significance of power electronics is clear in terms of Advancement in inverters; microcontroller and high temperature solid state fuel cell.

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