Review of technology used in grid connected solar power PV system

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Abstract- Solar power is a clean renewable resource with zero emission. Solar energy could be made financially viable with some government incentives and proper selection of technology used in System. most of developed countries are switching over to solar energy as one of the prime renewable energy sources. The important power electronics apparatus in grid- connected PV systems are Inverters and their most important function is to alter DC power into AC power. A study has been carried on different technologies and topologies for grid connected PV systems and their classifications on the basis of power stages. In PV system different technological concepts are used to connect the PV system to grid. Each technology has its disadvantages and/or advantage compare to other, in respect of maximum power tracking and efficiency inverter technologies. The challenges of grid-connected system are maintaining voltage, frequency, power factor, and phase with utility. The major challenge is to connect them into a standard utility and insert synchronized power in to the grid.

KEY WORDS; renewable, grid connected PV systems, fossil fuel, insert, synchronized, irradiances

1. INTRODUCTION

The total electrical power utilization in the globe is fourteen Tera-watts (TW) and irradiances this utilization is projected to be more than two times higher by 2050 [8]. All types of energy will to be increased quickly in the next few years to meet up the demand. The traditional energy resources are not reasonable and justified, due to its greenhouse gas emissions and pollution.

power demand is rising day by day due to enlarge in population and fossil fuel supply viz. petroleum, Coal, and natural gas will be exhausted in a few years. The rate of electrical energy utilization is increasing and fuel supply is depleting consequential in energy scarcity and inflation. This is known as power crisis. Consequently, renewable or alternative sources of energy needs to be developed to convene potential requirement of electrical energy. Now the point is what renewable and non-renewable energy are.

Non-Renewable Energy:

The energy Sources that cannot be created in a short period of time is called Non-renewable source of energy. Though, we are receiving maximum power from non-renewable energy sources, which includes for grid connected PV systems for grid connected PV systems – coal, natural gas, oil. They are limited on earth to running down at a rate that is faster than they are being formed. Fossil fuels are formed in the earth in a million of years. Use of fossil fuels for power generation causes enormous pollution. Therefore, there is imperative need to pick up the pace for the development of renewable power.

Renewable Energy:

These are the energy sources that we may use over and over again. Renewable energy sources include solar energy, which we get from the sun energy and the solar energy is transferred into electrical energy by means of solar cell and. Wind, biomass from plants, ocean energy from water geothermal energy from inside the earth, and hydropower are examples of renewable energy sources. A grid attached solar power PV system model is shown in fig 1

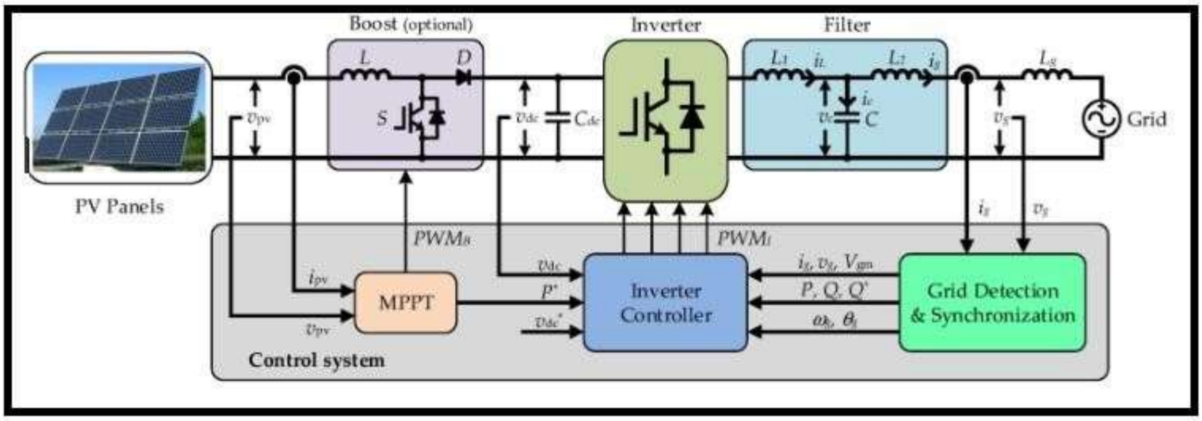

Fig 1. Grid Connected solar power PV system model.

Solar power is the most excellent renewable source of energy in our country owing to its secure closeness to the equator. India is situated in the equatorial sun strap of the earth, so getting plentiful sunlight throughout the year. The standard solar emission incident over India is in the range 4-7 K WH/□^{2}/ day. The expected solar radiations over India's land are approximately 5,000 trillion kWh/ year.Though, solar radiation, not at all, remains constant and keeps on changeable during the day. The environmental parameters such as temperatures, solar irradiances change the value of voltage. When solar power is delivered to grid at constant voltage irrespective of the variation in solar parameters. Solar energy is dominating energy as it is easily available in India. latest data shows that the annual energy getting from the sun on the earth is larger than traditional energy resources, and all non-renewable sources on the world containing, coal, natural gas, oil and nuclear power [12]

In PV system, efficiency and price are two dissimilar factors for the augmentation of PV panels in power generation applications. The cost of solar modules decreases from about US $ 100 per peak watt in 1974 to less than US $ 4 per peak watt in 2008. Decreased prices was a factor of fast expansion of PV markets in the year 1990. Further decline was observed in the price of PV modules due to the mass production, In year 2013, the cost per watt of PV modules was about 0.74 USD [9]. As the cost of PV panels is the foremost contributor in the price of the complete system, The declining price of PV panels will direct manufacturers to center on the pollution -free, cheap, maintenance-free, and financially viable solution. Efficiency of Solar cell is approximately from 7 % to 40% [6]. The PV cell with Higher efficiency is not all the time economically viable since of crucial production cost. Efficiencies of commercially solar cells are from 14% to 20 %. In latest years, solar power demand has been increased due to the factors mentioned below.

1) Rising efficiency of PV cells,
2) Industrialized expertise enlargement of PV cell,
3) Improvement of control technology, and Economies level.

PV panels is used either on grid-line or off-grid line. PV panels supply local loads in off-grid line. In on-grid connected applications, the PV system delivers power to local loads as well as to utility grid. Here, the PV system is entitled **–grid-connected PV system**. in recent times, grid associated PV system mechanism is rising enormously in countless countries. The grid-connected system are about 76% of total PV systems installed in the world [9]. In the prospect, the penetration pace will be higher because of the reasonable reward of the renewable energy systems. A general schematic diagram of grid-connected PV system with control system is illustrated in fig..2.

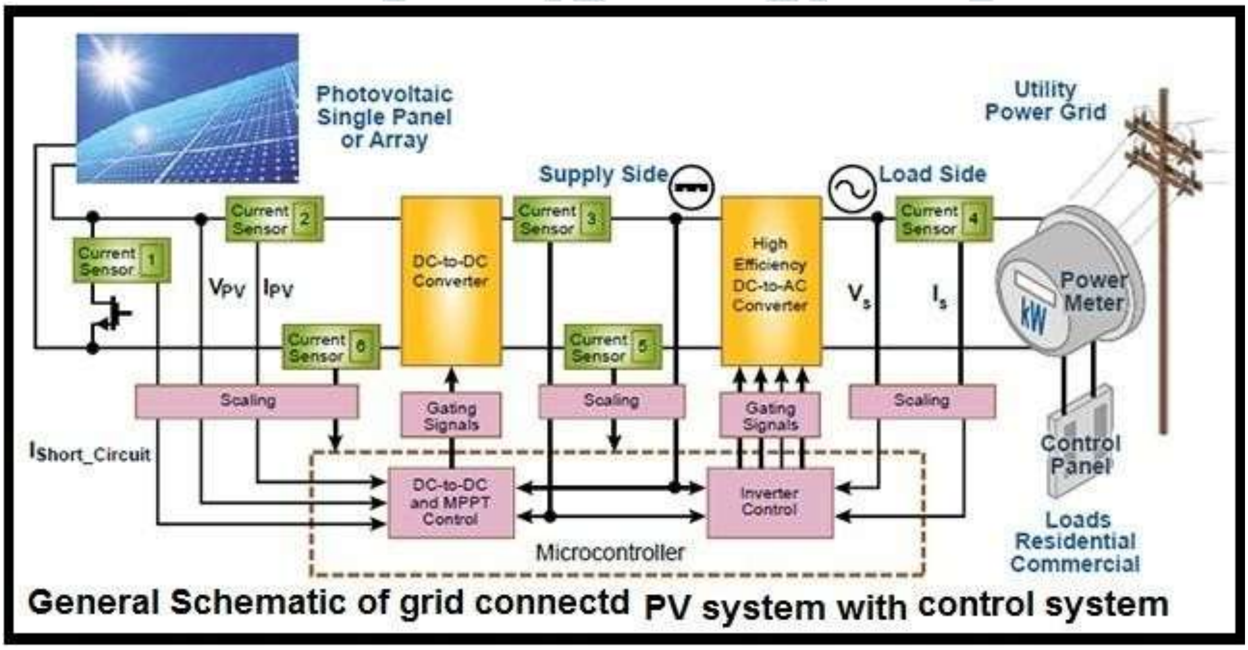

Fig.2. General plan of grid- attached PV system with control system.

The challenges of grid-connected system are maintaining voltage, frequency, power factor, and phase with utility. The major challenge is to connect them into a standard utility and insert synchronized power in to the grid. As the panel output is D.C, the interface is a DC- AC converter that converts DC output to AC that coming from the PV panels into a synchronized sine waveform [7].

Another challenge is mainly linked to the characteristics of PV panels. The PV module has a nonlinear characteristics and output power depends on temperature, irradiations, and environmental weather conditions. The grid-connected PV system will carry out two important purposes [4]:

- Extract highest energy output commencing PV arrays and
- Insert a nearly harmonic liberated sinusoidal current into the grid

2. Grid-Connected PV System Topologies:

The important power electronics apparatus in grid- connected PV systems are Inverters and their most important function is to alter DC power into AC power. Additionally, inverter linking PV panel(s) with the utility ensures that the PV panel is operating at the highest power point (MPPT) [11]. The PV grid-connected system will implement dissimilar topologies on the basis of PV panels output power, output voltage and applications.

Inverters Technology:

Different technologies and topologies are presented for grid connected PV systems and they are classified on the basis of power stages. In PV system, different technological concepts are used to connect the PV system to grid. Each technology has its disadvantages and/or advantage compare to other, in respect of maximum power tracking and efficiency.

Classification based on Inverter Structures:

Grid-connected inverters can be classified on the basis of their internal topology. They are classified as:

- Current Source Inverter (constant current source), or
- Voltage Source Inverter (constant voltage source).

The typical voltage source inverter or current source inverter depends on selections to supply single step DC-AC conversion. **Fig.3 (a)** shows the typical voltage source inverter topology. The VSI get power from a DC-link capacitor which is attached in parallel through PV arrays. **Fig. 3 (b)** shows the topology of a typical current source inverter [2]. A large DC-link inductor feed to inverter.

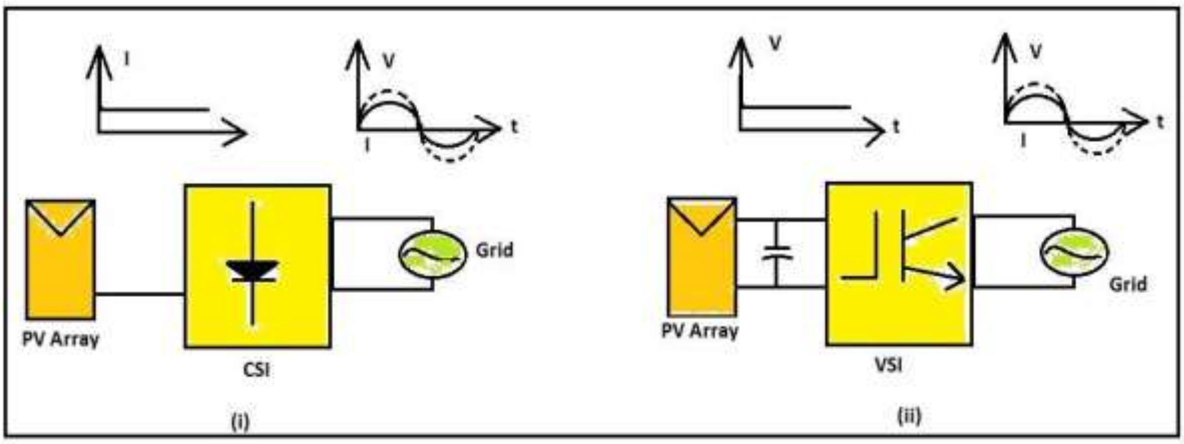

Fig..3. Topologies of grid-connected PV system (i) CSI, and (ii)VS

Classification of Inverter based on Configurations:

There are some classifications of inverter configurations on the basis of power stages. All configurations are separated into three classes [1,5,6,9] (a) Single-stage inverters,
(b) Dual-stage inverters, and (c) multi-stage inverters.

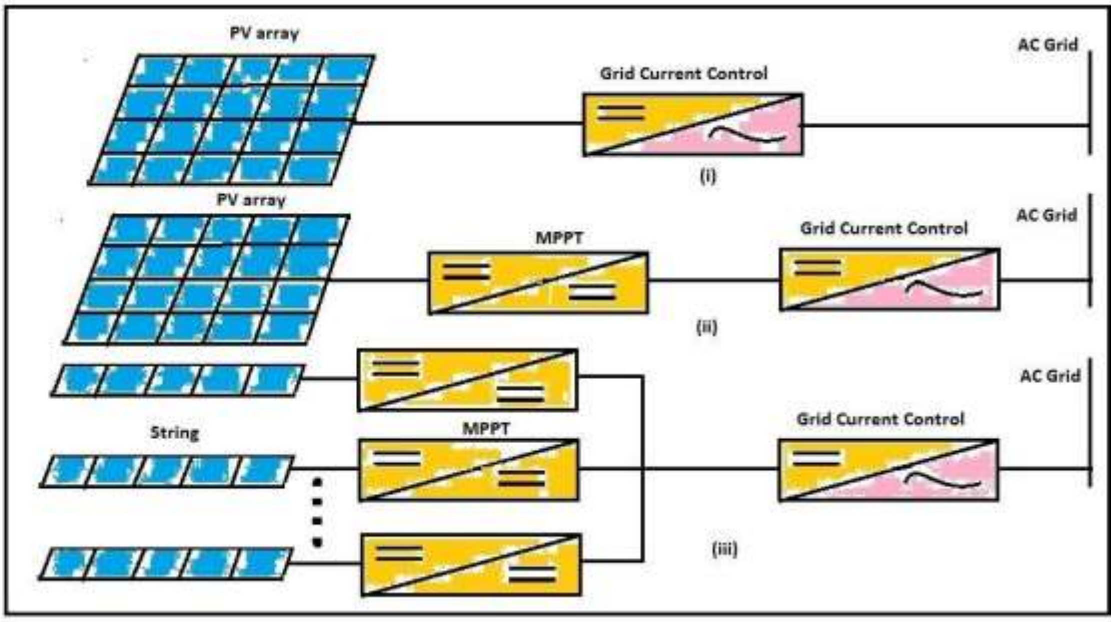

Fig 4 Configurations of Inverters (i) Single stage (ii) Double stage (iii) Multi stage

In single-stage inverters, control loops and maximum power point tracker are connected in one step as illustrated in **Fig.4 (a)**. In case of dual-stage inverters, the maximum power point tracker are connected by extra DC-DC converter in linking the PV panels and control loops and inverter, are useful to the inverter as presented in **Fig.4 (b).** In case of multi-stage inverters, a DC-DC converter will be concerned to every string with maximum power point racking control and one control inverter will care of the control loops as shown in Fig.4(c)) [2]

3. Acceptable Configurations for Inverters Technology:

In addition to these classifications for grid connected PV systems for profitable applications, four acceptable configurations are listed below [6].

(a) Central Inverter, (b) String Inverter

(c) Multiple string inverter, and (d) Module integrated inverter

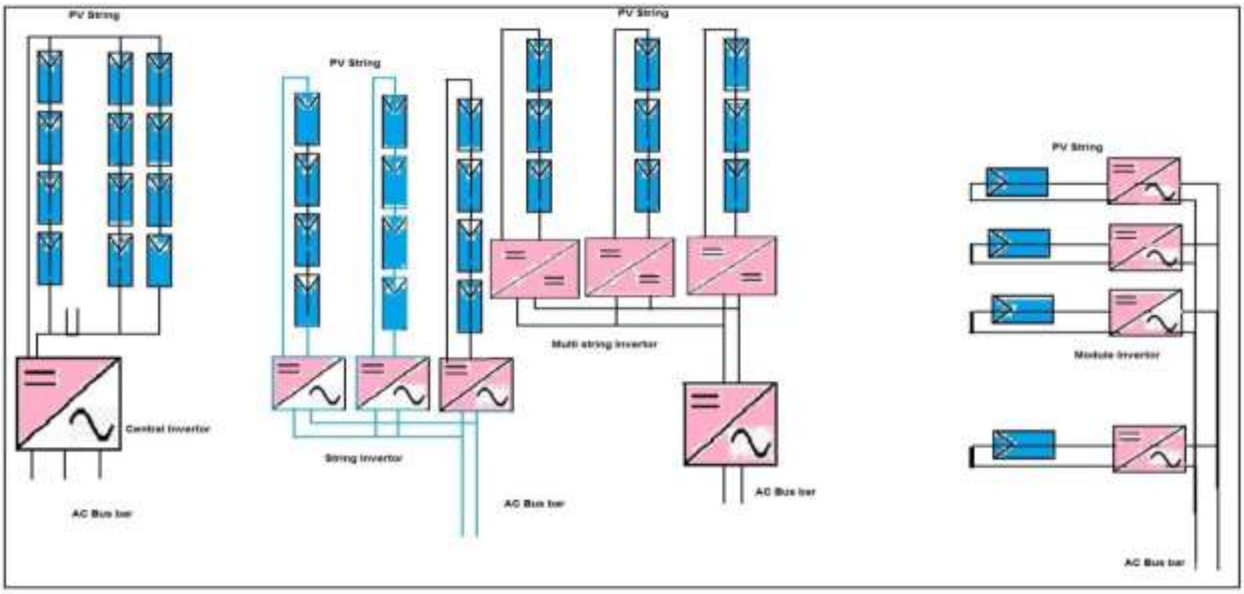

Fig 5. PV System configurations (i) Centralized Inverters(ii) String Inverters (iii)Multi-String Inverters (iv) Module inverters [10]

Central inverters:

A large number of modules are connected to centralized inverters that is interfaced to grid as shown in **Fig.5 (a**). The PV modules has been divided in series connection and the series strings are linked in parallel. They produce suitably higher voltage level, and parallel links increase the level of output power. The arrangement is used for three phase PV system. The power rating of inverter lies between **10 - 1000 KWp.** In this architecture, the PV arrays are linked in parallel to a centralized inverter. This configuration has the advantages of high efficiency and low cost and is used for connecting modules to the inverter where the above factors are considered in applications and the losses by string diodes, mismatching between modules, and central maximum power point tracker [9] [4]

String Inverters:

The technology contains a string inverter and ac modules as shown in **Fig.4 (b).** The string inverter is a compact description of the central inverter. The voltage input is adequate high to evade further voltage amplification [3]. Comparing to centralized inverters, in this topology the panels are linked to separate inverters. If the input voltage to inverter is small, a DC-DC converter will be used to raise the level of voltage. The arrangement permits individual MPPT for every string; therefore, the reliability of the system is enhanced due to the reality that the system is not dependent on one inverter in comparison to central inverter topology [29]. The mismatch loss is also reduced, but not completely eliminated. This arrangement increases the general efficiency and decrease the price, due to opportunity for mass production [8] [4]. The voltage from the PV array varies from 150 to 450 V [4].

Multi-String inverters:

Multi-string inverter is a arrangement a of the string and module inverters [29]. The multi string inverter is **shown in Fig 4(c).** This inverter is the additional improvement of the string inverter, where some strings are connected with the D.C–D.C converter to a common D.C–A.C inverter. This is more beneficial, because every string will be controlled independently [7] [8].

The limit of power rating of the arrangement is less than 5 kW and the strings utilize an individual DC-DC converter and then connected to a central inverter. The topology allows the association of inverters with diverse power ratings and modules with different current/ voltage characteristics. MPPT is connected for every string, thus better power efficiency is to be obtained [11]. This gives a flexible design with high efficiency, and will become standard where central and string converters are used today [10].

Module Inverters:

Module Inverters is the current and prospect technology. The arrangement has a single solar panel linked to the grid through an inverter as shown in **fig 4 (d).** An improved efficiency is obtained compared to string inverters as MPPT algorithm is connected for every panel [9]. In this pattern the mismatch losses are removed, and allowing personage MPPT for every module. This inverter will provide the benefit of large-scale production. But the input voltage will become small, needs high voltage amplification. This will reduce on the whole efficiency of the system [12]. The inverter is to be intended to get elevated power transfer efficiency.

4. Conclusion

The inverter price tag per watt is as significant as efficiency of the inverter as these factors straightforwardly control final price of the generated power. Usually, central plants with single-stage inverter have privileged efficiency, lesser price, and better reliability. Though, this pattern wants greater DC voltage to give voltage/var control Also, by reducing converter phase decreases the whole price of grid-connected solar systems. The other aspect which affects the plan configuration of grid-linked solar systems is to utilize of a 1-Ø or a 3-Ø system. In high-power applications,3-Ø system is used. The 3-Ø system has the advantages as diminishing the stress on switches, decreasing ratings of reactive components size and rising the frequency of current which decreases the dimension of output filter. The cost of solar modules decreases from about US $ 100 per peak watt in 1974 to less than US $ 4 per peak watt in 2008. Decreased prices was a factor of fast expansion of PV markets in the year 1990. Further decline was observed in the price of PV modules due to the mass production, In year 2013, the cost per watt of PV modules was about 0.74 USD [9]. As the cost of PV panels is the foremost contributor in the price of the complete system Consequently, **3-Ø single- step grid- attached PV system** has been taken in this thesis work. The declining price of PV panels will direct manufacturers to center on the pollution -free, cheap, maintenance-free, and financially viable solution. Efficiency of Solar cell is approximately from 7 % to 40% [9]. The PV cell with Higher efficiency is not all the time economically viable since of crucial production cost.

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