Indian Institute of Science

Design of Photovoltaic Systems

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Let us look at a solar photovoltaic system a full plate solar photovoltaic system contains many parts the photovoltaic modules power converters and power converters for energy storage the storage mechanisms and the loads themselves all important aspects in any solar photovoltaic systems we need to understand study each of them clearly so that we will be able to design and implement each of the subsystems we shall look at the entire generic solar photovoltaic system first try to get an idea visualize. How it looks and then goon if into each of the subsystem try to understand them and then we shall design them to.

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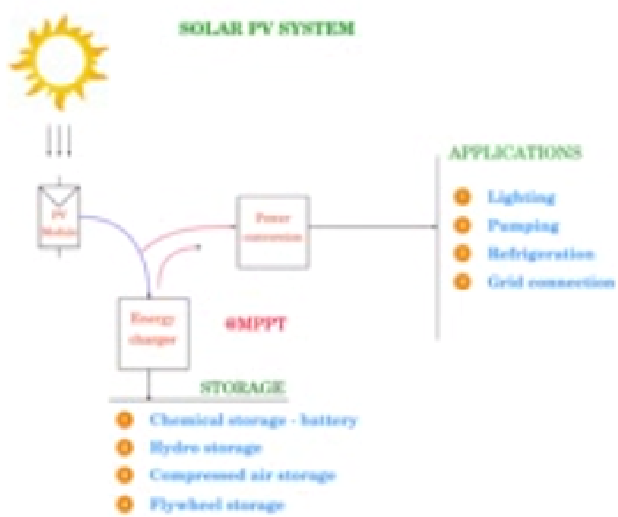

One of the important players of the solar PV system is the solar energy the Sun which is a very important component in the sense that it is the giver of the energy the source of the energy and this energy is incident on a collector which is the photovoltaic module, so the photovoltaic module collects the solar energy and then mix available in the form of an electrical energy across the terminals of the PV module, so it is a collector and the converter which converts solar energy into vertical form.

The electrical energy one of the things that can be done to it is store it so we pass it through a power electronic block it is an energy charger block it contains our electronic components like the BJT is most IGBT is an other control circuits and then that is used for passing the energy into a storage device there are many different types of storage devices one can choose from chemical storage like the battery where electrical energy is converted to chemical and then retrieved using electrochemical means

You could store it store it as a hydro storage the electrical energy is converted it lifts water to a height and stores potential energy of the lifted water is called the Pumped hydro you can retrieve the energy with the help of water turbine you can also store the electrical energy as compressed air so it can drive a compressor and compose the air to different levels of pressures and you can retrieve it with the help of an air turbine or you can store it as mechanical kinetic energy in the form of a rotating flywheel and retrieve it by means of an electric generator.

The solar energy gets converted to electric energy at the PV module and this electric energy is stored in one of the various storage mechanisms through the energy charger alternately the energy can also be routed directly to some load the energy can also be routed from the storage mechanism into the load to a bi-directional energy charger, so these both these part led to a power electronic device which does the job of conversion power conversion to an appropriate form which is compatible to the applications.

The power conversion can be a converter which means it gives you a DC output or it could be a power inverter which gives an AC output to drive applications that are either DC or AC respectively the inverter output should how AC loads the converter outputs will have DC loads and sample setup load would be something like lighting for LED lighting source and lighting it could be pumping to pump water up to height and store as potential energy the pumps would be a DC pumps or AC pumps you could have refrigeration the regular compressor based refrigeration which is an AC load.

You could also have DC refrigeration by means of using 28 junctions which are very compatible to the PV type of source you can have grid connection this is a very upcoming type of application where the photovoltaic power after getting converted into AC through grid connected inverter gets pumped into the grid any load that is connected to the utility grid can also be served so this is one of the application which is emerging as one of a popular applications for PV systems in the smart grid scenario.

Now what you should note is that MPPT maximum power point tracker is a very important term that you will be seeing more and more in the lessons to come of the discussions to come all the power conversion power converters and energy converters must incorporate maximum power point tracker what it basically means is that the PV module has a power V characteristic which has a peak at one operating point only and it is recommended that the PV module operates at that peak power operating point.

So that you can get the maximum out of the PV cells, so it is the job of the power conversion unit the power converters or the energy charger units to see that appropriately a load is presented to the PV module such that this will operate at maximum power point so this maximum power point tracking algorithm should be inbuilt and should become inherent part of these power converters. So these are some of the sample some of the important components that you will see in the solar PV systems.

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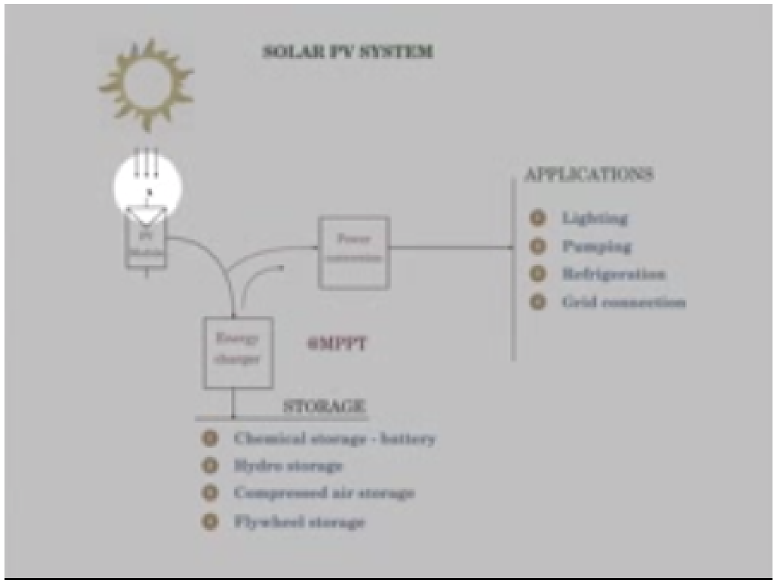

Now we have three important components here of course MPPT is part of these two which we need to study and also design so that we can implement these kind of components for any solar PV system, fist let us take up the sizing of the PV modules I think the PV module is very important because it occupies a lot of real estate and real estate does not come cheap and therefore you need to give a lot of thought into this unfortunately this has lot of dependency on the local geography the incident radiation coming from the Sun that most very conditioned water vapor content the latitude time of the day time of the year all these parameters affect the effective energy that is coming out of the PV module.

So it is very important to study this PV module in connection with the local geography and the local latitude.

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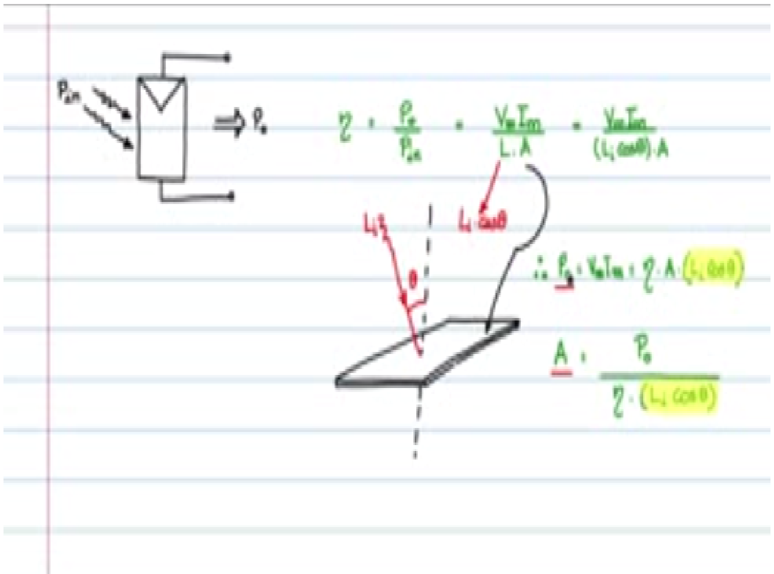

Consider a PV panel which has these outputs it is taking the input from the Sun and it has a input of P in this is the power and output power P0 and recall that efficiency is given by P0 / Pn this is equal to Vm Im which is the voltage and the current corresponding to the operating point on the IV characteristic of the PV panel divided by P in is nothing but the incident insulation into the area the insulation is having units of kilowatt per this is having unit of kilowatt per meter square this is a meter square so this would become the input power.

Now what is this A and the insulation L now if you consider a panel drawn like this then this area has seen here the on the flat plate solar PV panel that is the area A in meter square consider a normal passing through this area and let us say that the solar radiation is falling in this fashion at an angle θ as shown this angle θ like this, so what you should consider is actually the normal incidence so if this is called a Li then what you should consider for the PV panel calculation is the Li cos θ which would be the normal incidence.

So what is effectively converted as power is the incident insulation normally on the flat plate panel, so this will become Li cos θ so now replacing you will see that Li cos θ is the effective insulation that is given to the panel, therefore then we can say becomes VmIm by a Li cos θ into K therefore P0 = VmIM and this is equal to if I take these two components efficiency into Li cos θ into A.

So you see the P0 is dependent on the area of the collector and Li cos θ which is the incident insulation normal to the collector P0 is dependent on the application the application will tell how much load power is needed and this is the amount of electrical power output the panel as to give so P0 is a requirement efficiency is from the datasheet of the PV panel Li cos θ is the incident insulation in kilowatt per meter square and area is the size of the collector panel plate that has to be exposed to the solar energy in order to collect enough energy to provide this P0.

S0 we need actually to find out what is the value of A in order to size and select the PV power so if you rewrite this equation A = P0 by efficiency and we are Li cos θ so you see that area of the paddle is proportional to P 0 and also inversely proportional to the incident insulation so at a given places the insulation is high than area of the panel that you need to select and choose for that place can be lower and likewise more the load power higher should be the area of the pattern so we see that both the load power is dependent on the incident insulation.

And also the area of the panel that we need to choose is also dependent on the incident insulation however it is not easy to find out what this incident insulation is because it is dependent on very many factors it is dependent on the time of the day it is dependent on the time of the year it is dependent upon the local climatic conditions it is dependent on the water vapor content in the vertical column of the air above the collector it is dependent on seasons.

So like this it is dependent on so many factors and many of the factors are uncertain it is not easy to estimate the incident insulation but our objective now is to go towards finding as accurate a value of the incident insulation as possible so that we may be able to size the panel size the collector area for a given load our requirement.