Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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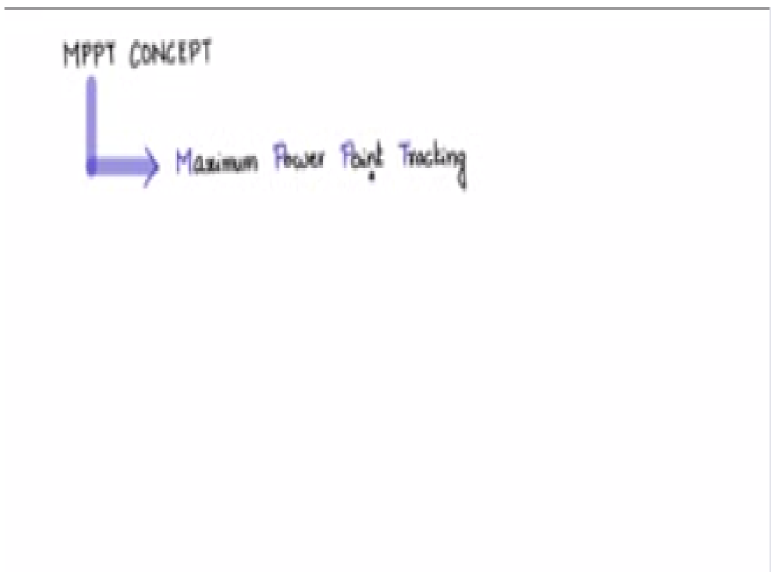

We shall now discuss MPPT, what is MPPT, what is the concept of MPPT so we shall do that just now. MPPT stands for Maximum Power Point tracking, so MPPT what does this mean, see in the case of the photovoltaic modules there is one single operating point at any given point in time where maximum power can be drawn, so we need to locate this point track this point and see that the operating point of MPPT module is always at that point are hovering near and around that point.

The process of doing this always trying to maintain the operating point of the PV panels at maximum power point is called the maximum power point tracking.

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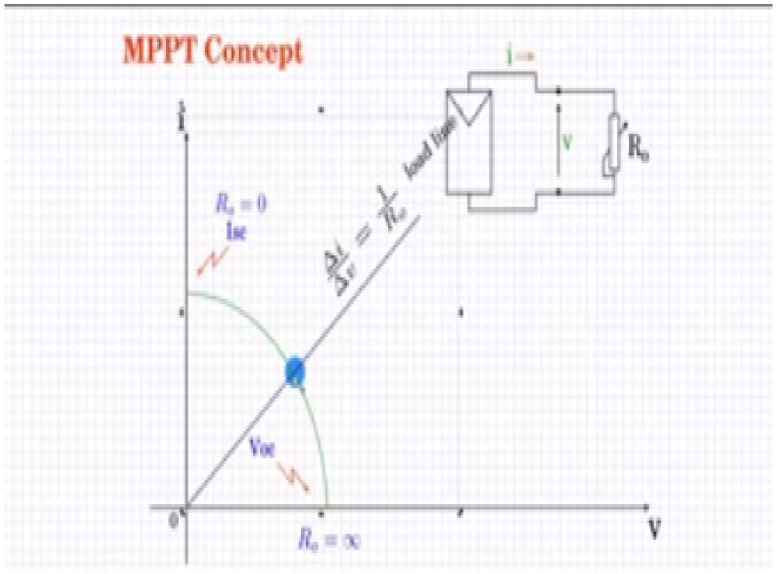

Consider this simple circuit we have the photovoltaic module connected to a simple load R0 simple resistive load R0, R0 is a variable resistance, now what happens when we sweep R0 from a shorts virtual actual short circuit 0 to open circuit we can see that in the IV characteristic of the PV panel that is we measure the V here and I here and then we plot the V on the x axis plot the I on the y axis this is approximate the IV curve of PV panel we see this line here this line on which I am drawing I am moving the mouse along now that is called the load line.

We have discussed this load line in week 2 you can refer back to that, now this load line is nothing but the ratio of Δ/ΔV which is 1/R0 so if I move this load line along such that it is along the x axis like this then 1/R0 the slope of that line is 0 therefore R0 has to be infinity so which means that this is open circuit across the terminals. Similarly if we rotate the load line such that the slope is infinite and aligned along the y axis then the operating point represents R0 as a short circuit R0 is equal to 0.So for any arbitrary operating point I will keep it like this and this operating point should represent the peak power that is being drawn.

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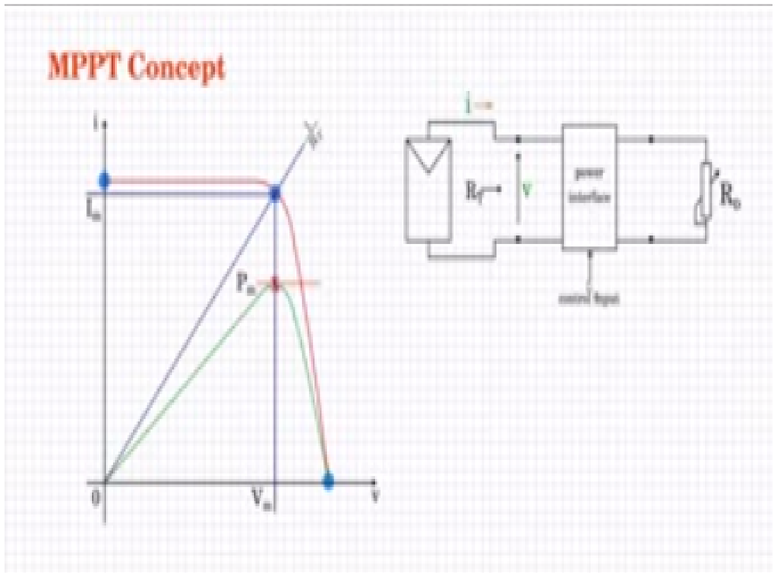

Now consider this modified figure R_T is the resistance seen across this terminal viewers on the PV module side so view from here the terminal resistance is called R_T and that is what I am using for load line so this is the load line having admittance $1/R_T$. Now this IV characteristic of this particular PV panel let us say is like this and the point of intersection of the load line $1/R_T$ line with the IV characteristic is the operating point.

Now on to this let us superpose the power curve power P versus V so this is the P versus V curve we have seen this earlier so I am just introducing this power curve into this figure. Now somewhere here is the peak power point so the tangent to that hill that would be the peak power point so we will call that one as Pm and let me mark the peak power here with an x mark if you draw that line straight through the peak power point and make it intersect to the IV characteristic.

So what is what is the y intercept that is called Im whatever is the x intercept that is called Vm so Vm is the voltage at peak power operating point Im is the current at peak power operating point Vm into Im will be Pm, so this will be the operating point this is how it will look like the operating point at peak power if the load line is shifted to the right from the operating point which represented the tea power point as shown here it means that the slope has decreased that is R_T has increased R_T has increased implies that R0 has increased it has gone more towards open circuit.

And with this operating point which is the point where the load line intersects with the IV curve you see the y-intercept is an arbitrary I x-intercept is an arbitrary V and the intersection with the

P curve or the power curve is here X as shown and it is much away from the peak power point, so this operating point does not draw the peak power from the PV panel it draws a power much less than the PV panel.

If we shift the load line to the left implying that R_T has decreased R_T decrease means R0 as decrease it is going towards short-circuit, so in such a case also you will see that the y-intercept is closer to the short-circuit current value the x intercept we sum arbitrary voltage V and it cuts the and the vertical line drops down and intersect the power curve vat this point X and you see that this operating point results in a power drawn which is much lesser than the peak power, so it is only at this operating point here you see that the power drawn on the PV panel is maximum let me say that the this operating point is tracking the maximum power point or its drawing maximum power from the PV panel.

So it is our job now to see that the load line is always at around this point such that maximum power is always drawn. Now the problem would arise what if R0 changes if R0 changes this load line has to change either to the right or to the left the load line slope will either increase or decrease if that happens then the corresponding maximum power point will be lower as we saw. There in that case how do we still maintain the operating point to be at this point as shown here such that the power drawn is maximum?

For that we need to introduce an interface here of our interface now job of that power interface is to see that R_T is always at this operating point whatever may be the value of R0 this block is called a power interface it can be a DC-DC converter it needs to have a control input the job of the power interface with the control input is as follows if R0 changes the control input should we treat such that the input impedance of the power interface which is same as R_T is maintained constant.

So input impedance should be regulated, so whatever may be the value of R0 the swing in R0 the control input should accordingly change in such a way that the input impedance of this power interface block is made constant in such a case R_T the terminal impedance as seen from the PV module will remain fixed or constant irrespective of the value of R0 in such a case as the PV module is seeing hearty and that is fixed and therefore this load line will be fixed and the load line will see to it that maximum power is being drawn from the PV panel.

So this is called maximum power point tracking and this concept of this maximum power point tracking is very crucial if you want to utilize the PV module tool it will just extend. How does one give the control input, now that is where we need to do some sensing and then we need to pass it through a controller and appropriately give the control input in such a way that R_T is regulated and kept constant in the face of varying or not we shall of course look at what are the different types of control mechanisms that we can apply to this control input.

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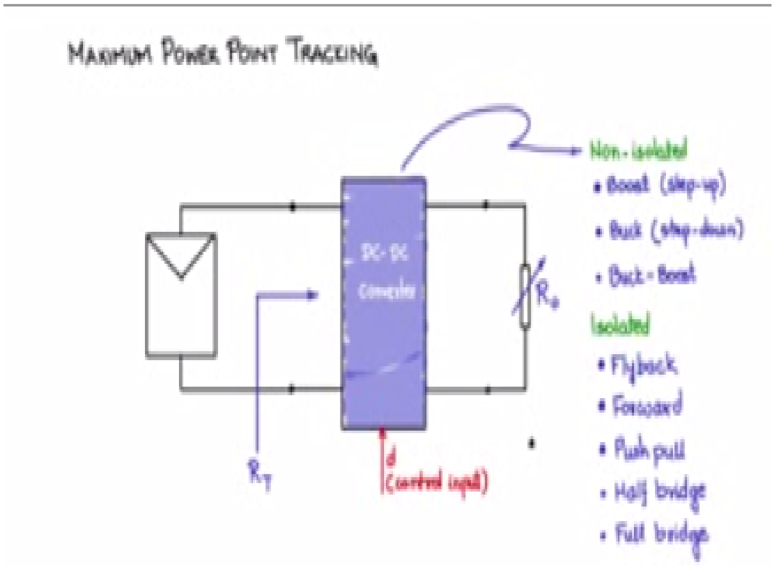

Consider the maximum power point tracking topology with a power interface the input impedance R_T which is also the terminal impedance of the photovoltaic module R0 is the load of the application load which is varying not under your control the power interface for a DC application where the output load requires a DC voltage we will use a DC-DC converter which has a control input and the control input for a DC-DC converter is duty cycle. D and that is the control input the DC-DC converter can be any of the topologies that you are familiar with you have the isolated as a non isolated topology in a non isolated we have the primary topology that the boost step-up.

Buck converter step-down converter the buck boost converter and the isolated topology you can use probably the fly back converter forward converter push poles, half bridge converter full bridge converter and so on so there all these converters and any other converters that you are your application demands you could use it as a power interface appropriately such that the duty cycle if it is controlled should be able to control the input impedance and therefore the terminal impedance as seen by the photovoltaic module.

If the application is an AC application that is the load demands an AC voltage then you need to use a DC to AC converter or an inverter and that also needs to have a control input which is also duty cycle and we will see that also how we go about doing maximum power point tracking for a load that demands AC voltage.

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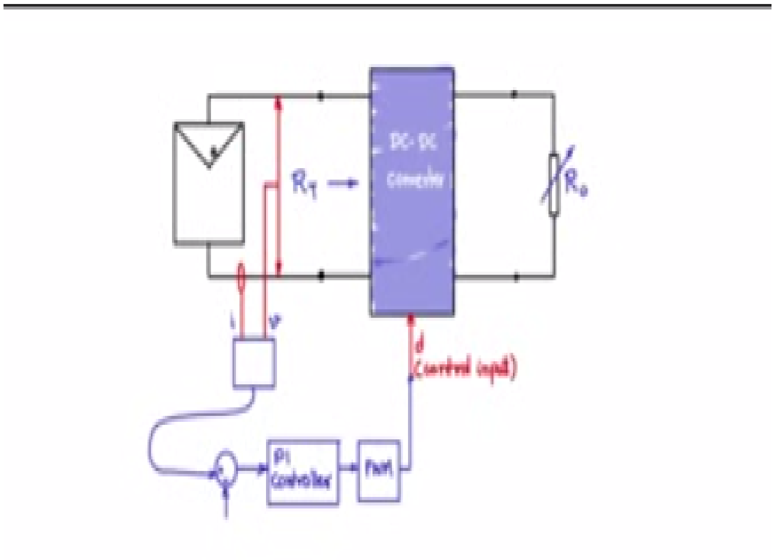

Let us see how we give this control input to the DC-DC converter in a generic way in such a way that R_T is regulated. So we need to measure two items one is the voltage across the photovoltaic module the other is the current that is flowing through the photovoltaic module so basically the source the PV source voltage and currents terminal voltage and current, now these two inputs are needed now these two is processed appropriately.

There are different algorithms to process that we will discuss that later and then out of it comes the reference, so a reference generator this block can be considered as a reference generator using the Inv a reference is generated and that reference is compared with another variable which is the actual variable which is also sensed measure such that R_T will be maintained constant.

So generally this will be a power variable again we will discuss there are different control topologies so what is the feedback variable and what is the reference variable is basically the concern in the most MPPT and how it is designed and developed will be discussed in discussions to follow. So right now consider that there will be a reference which will be generated appropriately and there will be a feedback variable.

These two will be compared and the error is passed to a PA controller a controller like this will see to it that the error here goes to 0 in which case the feedback will match the reference and under that condition MPPT would have been achieved, so this VI controller output will lead to a PWM block it will generate the PWM necessary for giving the duty cycle control to the DC-DC converter, so this would be the gentle topological block diagram block schematic of any maximum power point tracking system.

You will need the voltage and the current sensing you will need a controller something like this VI controller and PW which will be given to the duty cycle control input of the DC-DC converter. The DC-DC converter for any general DC-DC converter that fits your application which you would have pre chosen. Now what we shall do is look at this block the power interface block first let us consider DC applications so we will discuss about DC-DC converters for the primary DC-DC converters.

So that we get an idea of how we would go about doing MPPT, so let us investigate this block interpose actual an actual DC-DC converter circuit and see how this whole control mechanism operates to regulate R_T in such a way that the maximum power is drawn from the photovoltaic module.