Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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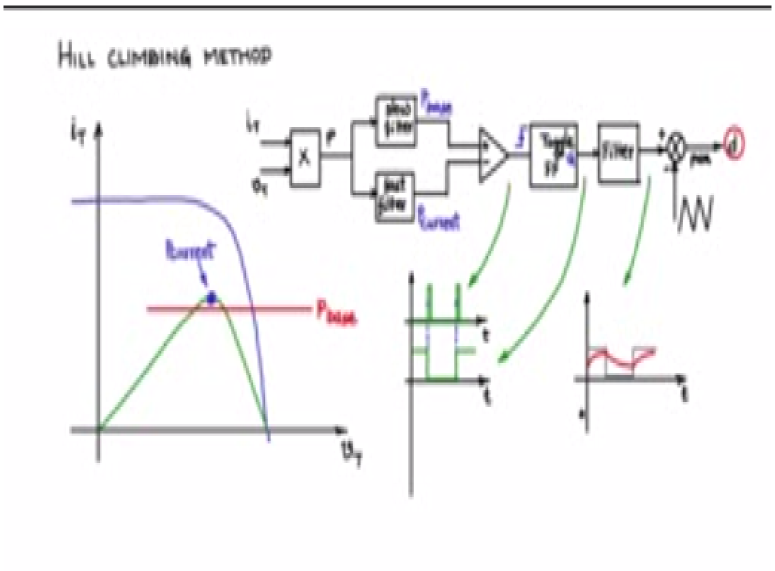

We shall now discuss the hill climbing method for maximum power point tracking. It is a very robust and popular method, it does not use the reference cell, it does not use sampling, it does not use any resistive switches there is no d/dt, no derivative terms only I and V terminal current and terminal voltage are measured, and based on the calculation of the power the hill climbing algorithm is used for tracking the maximum power point.

Let us now see how we go about achieving MPPT all through this method. Let me first draw the VT versus IT characteristic. So you have the IV curve and you have the PV curve. So observe the PV curve this is the important curve that you need to note here, this is in the shape of hill and then the operating point the operating power point will climb this hill either from this direction or this direction and try to reach the top and stay in the top.

How that happens we will be trying to see. Let us consider that you are measuring IT and VT and you are calculating the power as the product of IT and VT. So you have the power, now let me draw a base line and I will call this as P base or power base the base power. Now this is a limiting plane or limiting line, and let us see how it operates I will also have another component here dot.

And I will name it as P current, what it basically means that this is the current operating point, current operating power point the most immediate one and P base is a kind of an average the previous powers. So this is a slow moving base, and this is a fast moving point. Now for the movement consider the base is fixed, and let only this point move. Now why should the point move we will change the duty cycle.

We saw that as an example in the case of a buck boost converter the load line along the horizontal x-axis d=0, the load line along the vertical Y-axis d=1. So if I swing D from 0 to 1 you will see the operating point moves and the operating power point also moves like that. So let us say D is increasing, the operating point will be moving to the left. So let us say it moves to the left like this the moment it encounters the P ways line there is toggle effect.

The duty cycle now starts moving in a direction such that operating point moves to the right. So the duty cycle will reverse, so the operating point will start like this and the operating power point will start moving to the right. So it will move like this and again the moment it encounters the base line P base there is a toggling effect D will reverse. So D will now reverse such that the operating point moves to the left.

So then it starts moving like this, so in this way again when it encounters this P base there is a toggling effect on the duty cycle, duty cycle will shift the direction of change and it starts moving again. Now let us say that the P base is also moving slowly not as fast as P current, but slowly moving up trying to catch up with P current. So let us say the P current is moving up and P base is slowly also moving try to catch up with it.

And let us say this is one snapshot P bases at this point, P current here and the P current is moving fast, and let us say it is moving and reaches the other end. The moment it reaches the P base line there will always be the toggling of the duty cycle. Now the duty cycle moves in the other direction, so let us say it moves in the reverse direction, P base is still trying to catch up with P current, and the duty cycle is continuous to move till it reaches P base line were it again toggles reverses direction.

And this happens and then P base line also moves up trying to catch up with P current slowly and in this way you will see that there is this P current fast operating point trying to get control within an arrow region around the peak of the power hill and hovering near and around the peak power point, and thereby achieving maximum power point tracking. So the P base will try to catch up with P current and try to narrow down the swing of the P current and try to maintain as close to the maximum power point as possible.

So this is the logic that we will use in trying to build a block schematic for the hill climbing method. Let us now draw the multiplier, the two inputs of the multiplier are IT, the terminal current of the PV panel, and VT the terminal voltage of the PV panel, the resulting product is the power P. Now this power P I will pass it through two blocks, one block is called a slow filter which means this filter has a very large time constant.

Let us say a very large as a time constant I will pass the power through another filter and I will call it as a fast filter, the reason I call it as fast filter is that, this filter has a low time constant small value of RC, so that this is dynamically much faster than this. So therefore, I will call the slower one as P base which corresponds to this P base line, and I will call the faster one as P current which corresponds to the moving operating point dot.

Now these two I will pass it through a comparator, and I will give the + and – as shown here P base to the + and P current to the -. And then the output of the comparator let me give it to the toggle flip flop, in the toggle flip flop and let us say I am going to do edge triggered toggle flip flop the output Q is a filter, and the output filter is compared with a triangle carrier. And the output of this is nothing but the PWM which goes to the duty cycle input of the DC-DC converter to which the PV panel has been interfaced with.

So now let us look at this wave form here in the output of the comparator. Now the output of the comparator we are comparing P base and P current, P current is most of the time higher than P base, so which means P current given to the minus the output will be low. Now let us say this op-amp is having a VCC and 0 as the power supply. So you will see most of the time that it will be 0 except when P current goes below P base, when it goes below P base then this comparator output becomes high.

And then it will immediately become low because there is a shift in the duty cycle and P current again moves up why there is a shift, we will see it shortly. Now let us say it behaves in this fashion. So when this P current goes and hits the other side P base again it will go below, and then there is high at the output of the comparator and after sometime again goes slow and there is a reverse of the duty cycle and P current moves in the reverse direction.

So this is the type of wave form that you will expect at this point here. Now how to the toggle flip flop we are saying edge triggered. So let us say the rising edge will be used as a trigger, now let me extent this and then plot this also. So let us have the rising edge we will, let us say the output Q is at high, and when there is a rising edge it will toggle low, and again and there is a rising edge when this operating point is in the other side of the P base it will toggle and so on keeps toggling like that.

So this is the wave form at this point, and what about the output of the filter? So this wave form gets filtered, so let me draw that. You will see that this wave form I am going to repeat that here, and this is the filtered version of this. So you will see that the output of the filter rising up to 1 then rising down to 0, and then again rising up to 1 and so on. So if you look at this portion it is a rising up means now that is given to a triangle and then to the duty cycle.

So as it is rising up the duty cycle is increasing, so duty cycle is increasing means that the operating point is moving to the left, so it is moving to the left here and at this point this has gone down and there is a toggle and there is a change in the state when this goes down which means now the filter output is going down implying the duty cycle is decreasing. Movement duty cycle is decreasing this moving to the right.

So as it starts moving to the right again goes and hits at that point again you will see that there is a toggle, and this filter output increases duty cycle is increasing toggles again. So it moves to the left so it keeps on happening and this operating point keeps moving back and forth like this same time this P base here is also moving up triangle catch up with P current slowly. And thereby locks this P current within the narrow and narrow region till it reaches the top in this way maximum power point tracking is achieved.