Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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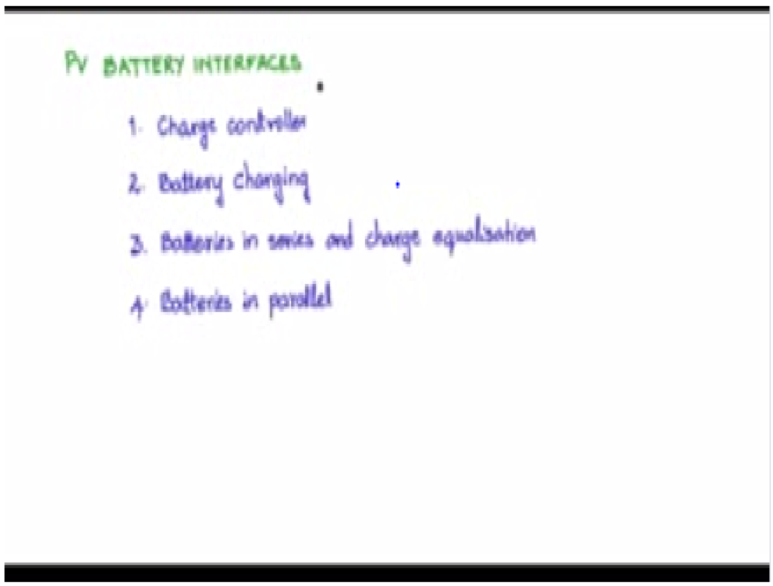

Pv battery interface this is the very important topic especially point of view of pv application because pv and battery are very good friends batteries are integrate part most of photo hold type driven application therefore interfaces between pv battery pv lode and any other components within the pv application becomes very important.

So among the interfaces one of the most important and commonly encounter one is the charge controller where the charge that is put into the battery or removed from the battery is controlled by electronic switching mechanisms so we will look into the circuits related to charge controller and then battery charging this the very important circuitry we need to look at how do you charge the battery from pv or output of the DC-DC converters which are interfaced pv and similar circuits.

Thirdly we need to look at problems associated with battery being connected in series so when you have batters connected in series there is a problem with charge sharing all the batters and series do not share equally the charge while being charge and while being discharged and therefore charge equalization is an important topic that need to be addressed with regard to battery being connected in series.

The fourth topic is batteries in parallel if so how do we connect them and if there are non identical batteries how do you go out connecting them in parallel what are the electronic that come in between so these are the issues that we will be discussing in pv battery interfaces topic.

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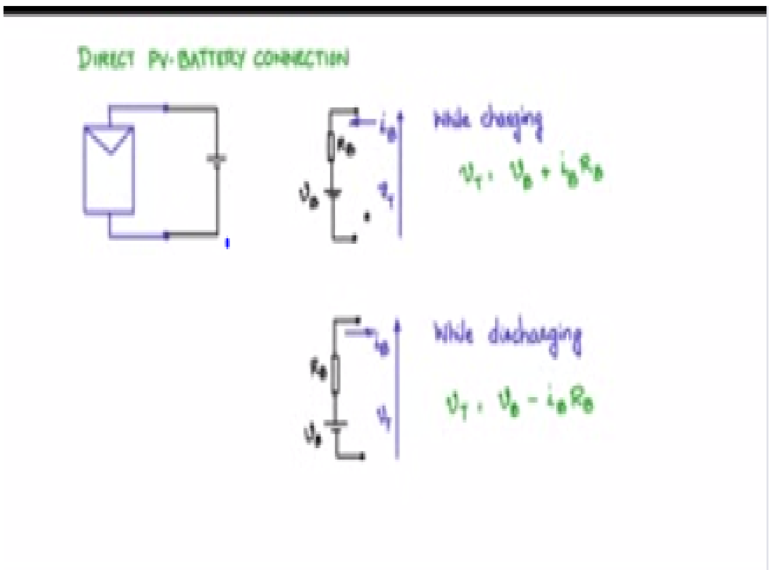

Let us see if we can connect a pv and battery directly so the direct connection of the pv and battery is it possible or it is not possible let us take up the pv source and the terminal of pv source I will connect battery like this is this possible is this valid will the pv source charge up the battery now consider a battery with the simple module like this battery is consisting of an ideal dc source v be in series there is an resistant RB the RB is not an external resistant that we are putting it is the internal resisentence of the battery strongly dependent.

On the battery chemistry. This is not a constant value it varies also whit the state of charge how ever let us consider this module and see how the IV characters of the battery looks like, so while charging when the battery is being charged the direction of the current through the terminal of the battery is like this it goes through the goes into the positive terminal and comes out negative terminal and the voltage is measured across the terminal like this here and we call it as VT.

So the terminal voltage VT is given by V battery + current is coming in this passion this is positive this is negative so +IB RB so this is we model equation for this battery model so let us also consider what happens when the battery discharges so consider the same model VB and RB and while discharging so while discharging the current leaves the positive terminal and we still measure the terminal voltage VT and the equation now is the current is flowing in this direction so this is positive and this is negative so V terminal is – this drop – IB RB. So this is model for the battery while discharging so how do the IV characters of these two look like.

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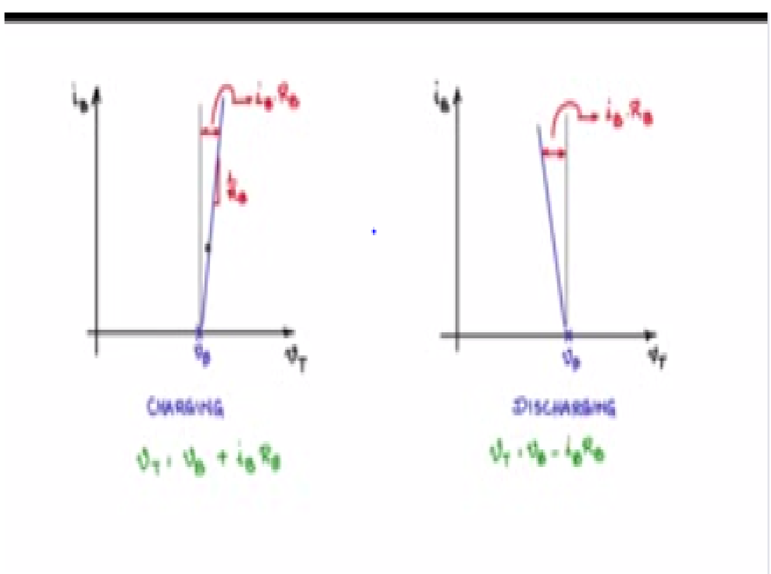

Let me draw the character axis X axis is VT terminal voltage the Y axis IB battery current I will also have one more axis one for charging one for discharging here also VT IB now let us say this is for charging and this is for discharging and the model for charging is VT = VB+IB the model for discharging is VT=VB-IBRB now let us draw the character.

Now when IB is 0 when there is no battery current this drop will not come in picture it is only VB so we will mark VB on the X axis here so that VB now under an ideal condition when RB =0 when there is no internal resistance these term does not appear so it will only be VB straight up whatever may be the battery current VB will just be constant fixed up so that would have been the character however because of this term $IB^{\times}RB$ which get added up as the current increases there is an increase depending upon the value of RB.

So let us say we have a slope line like this and this drop is not actually this additional voltage potential is due to IB RB so that is IB RB and this slop is nothing but 1/RB so in ideal saturation RB is 0 so the slope become vertical merges with the great line. So now in the discharging case also the point when IB is 0 same VB and if RB add in 0 it would been straight upward vertical line now VT is VB-IBRB as current increases discharging the drop from VB value increases so you will see slope like this and this drop noting but IB X RB as you are seeing here and this slope is won by 1/RB.

Now this two are IV character of the battery now let us conceal the case of charging because when pv is connected to the battery pv cannot sink only the batter can sink it can sink also so the pv is charging the battery so these is the characteristic that we need to look at and take this battery characteristic super impose the IV characteristic of pv panel and then discuss and then let us see whether it is possible directly interface battery to the pv panel.

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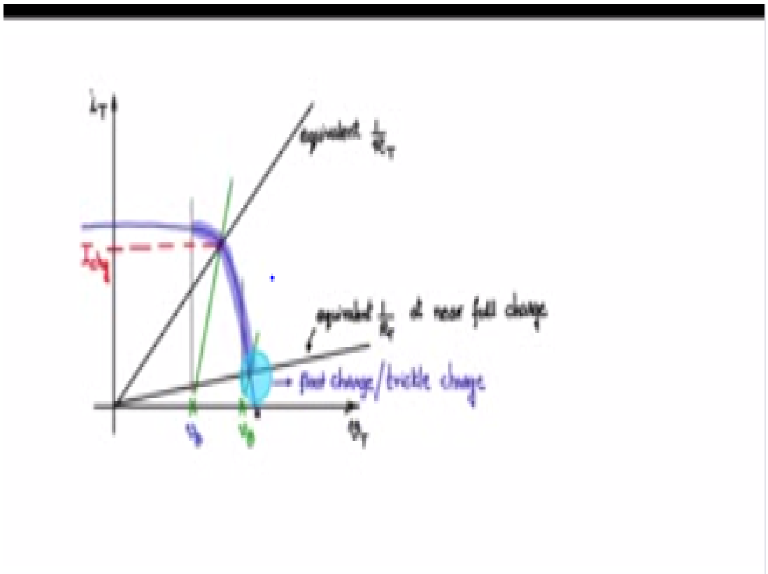

Let us now super impose the IV characteristic panel and the IV character battery and try to understand how direct connection pv panel to battery operator, so here I have X axis VT on the Y axis I will have the terminal current passing through the pv terminals of pv panel and I will draw the IV character in the pv panel now on to this let us super impose the charging battery characteristic because the battery is getting charged by the pv panel.

So let us say that I have VB here when there is no current this is the open circuit battery voltage and let me have this reference line with an ideal line with an ideal battery and the line as we saw the battery is charging there is an extra potation that appears across the terminal of the battery because of the internal resistance RB.

Now this would be the operating point for the battery and the battery is getting charged you see there is an positive current that is flowing into the battery of this value and charging up the battery so if we take as snap short of this instant there is a load line which is passing through this operating point. So this would be the equalent load line that is presented to the terminal of the pv panel.

So we can call it as an equalent 1/RT line now let us say current is flowing through it the battery is charging so as the battery is charging you will see that the battery voltage from the discharge to the charge condition is different the charge condition of the battery will be slightly higher so it will start moving to the right so as it starts moving to the right the operating point also start moving to the right so let us say at some point here when it is closed to full charge we will have VB around here.

Let me mark here the battery potation under close to full charge condition VB and let me draw vertical and let me also draw the load line of the battery when the current is flowing through that one you should also know that as the battery is getting charge the internal resentence RB also changes generally the internal resentence RB is lesser at full charge than under discharge therefore as the operating point moves closer to the full charge condition this slop will be vertical because RD is lesser.

Okay this point here intersection point would be the new operating point of the charged battery so now let us say if you draw a line now these would be equalent 1/RT line when the battery is closed to full charge so you see that for charging the operating point moves in this region if the battery is further it will charge it will come near the curser the load line battery will come and intersect here.

So you can see that there is a region where the battery charging operating points move so it may goes till further down near the open circuit value so as it comes here this region the current starts decreasing so you see that as the battery is discharge condition the operating point is such that the charging current of the battery is high as the battery starts moving towards full charge the charging current id decreasing.

So this is very comparable the pv module and battery when they connect together they are automatically comparable because of the nature of charging current decreasing as the battery starts getting fully charged because when it reaches full charge the battery has to just need trickle charge. So this region here is the trickle charge region or the float charging region or it is basically means is that when it is completely charged let us say near the open circuit value there is no current flowing through it the movement.

It discharges slightly due to any reason either load or even during non connected periods the battery can discharge through an automospere and the loss of the charge as to be made up so therefore we keep providing at trickle current called a tipple charge or float charge once the battery voltage slightly decrees there will be a slight current to bring up the to make up the loss of charge.

So this region automatically behaves as a float charge as a trickle charge region you see that you don't need any extra electronic at all to connect pv and the battery if the battery voltages VB under discharge condition and as under fully charge condition or matched properly with the pv panel VOC and the charging current or matched properly amp power rating of battery then the pv panel and the battery can be directly connected and there is no need of any other further electronic or potation electronic.

It is automatic when the battery is discharged more current flows through it to charge it up and the battery is fully charged very less current optical charge current only flows through it and there by maintains the battery potation.

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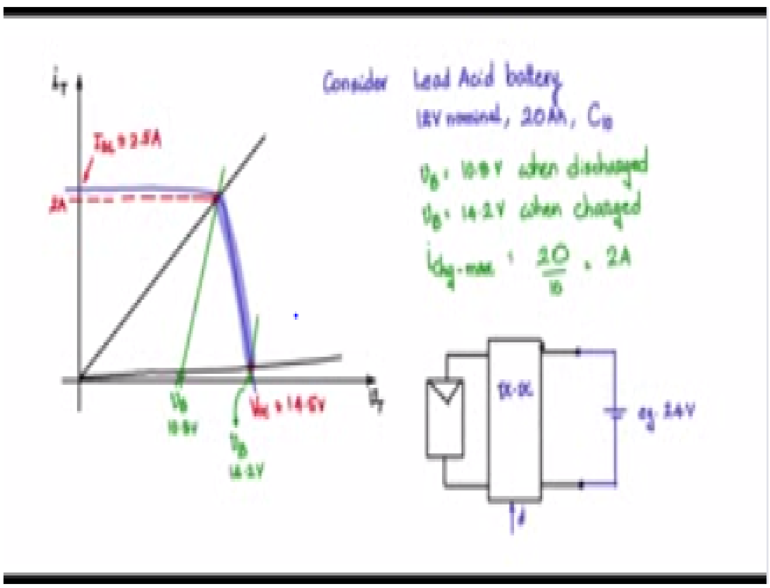

So let us now consider an example where we connect a battery to a pv panel so this is the characteristics of a pv panel VT IT and this is the IV characteristics of pv panel, now let us see how we can match the battery characteristics such that without any electronic can automatically charge a discharge battery now consider lead acid battery the most popular lead acid battery we have 12 volte it is 20amp battery and it is C/10 that is capacity by 10 will be the current accrue will be discharging from the battery and also for charging the battery.

Now the battery voltage when the battery is discharged for an lead acid battery it is around 10.8 volts when it is in discharge condition and the battery voltage is fully charged is around 14.2 volts when fully charged so these are the voltage limits for the battery and it will be within this two fully discharged fully charged and what is the current that you have to charge it with you have to use this two values so let us say I charge maximum will be 20/c10c rates which is 2amp.

So when it is in discharge condition here its start at 2amps charging let us say around here 2amps and then starts charging as the battery charging the current is decreasing gradually it decreases to article charge. So let us now decide the extreme operating points so when the battery is under discharge condition we would like the operating point to be close to the ISC line so let us say a large value of current to charge it and as it charges the operating point to the right and then it should come lower down under the full charge condition when it is close to 14 point to volts.

So this we will set it to 2amps max charge current so whenever the battery in discharge condition it will draw 2amps from VV pane lm the short circuit current you see lightly higher so let us say short circuit current is around 2.5amps. Now the VOC you see this operating point should correspondent 14, 2 volts so VOC is slightly to the right and we will say that VOC is set at 14.5 volts.

So now if you draw a load line of the battery using its RV value this VB here is 10.8 v as the current increases you will see the intersection point will be there and here also if you put the load line this point where intersect the x axis will be VB 14.2 v when it is fully charged so you will see that the charging between this two extreme load lines for the battery so you can design the panel such that it matches the batter of your choice or you can select the batter which match the pv panel and if you have done it properly where comparatiable one then you can directly connect the pv panel and the battery without any electronics.

In case of some reason you are not able to match the battery and pv panels for an example pv panel given to you is 2,5amps 14.5v of having that characteristics and the battery that is given to you is 24v so apparently it will fall out of range and you cannot use this pv panel and the battery to be connected directly under that condition we know how to solve that problem because we know that we have to operate within this load line we can use the converter DC-DC something like this pv module we are connecting a DC-DC converter and to the out you connect the battery.

So this DC-DC converter will do the job of matching the output load line load to the input side load by means of duty circle so example if you have 25v battery and this pv panel is having 14.5voc and you are not able to connect directly then by means of duty cycle control we should be able to connect any voltage and any current rating to appropriate or available pv module by means of interfacing between DC-DC converter and duty cycle converter later on discussion detail how we charge the battery by means of DC-DC converter especially we will focus on current control DC-DC converter later.