Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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In practice to the PV cells of the solar sense are never identical even cells from the same batch of manufacture will not have identical id character tics for that you will see that when the PV cells are mounted on the root of some expose to the solar radiation that may be neighboring buildings the shadow of which may be falling on portion of the PV cells on PV modules there may be trees nearby who share will be falling on portions of the PV modules therefore some of the PV cells will be under shake and there will be some of the PV cells which will be under bright sunlight therefore the short-circuit current of the PV cells.

And the bright sunlight will be much higher than that of the PV cells which are in the shape therefore you will see that having non identical solar cells is a practical situation now if these cells having non identical IV character tics are connected in series what will happen? What will be the resulting IV character tics of the combination will there be mechanical effects can we

estimate the resulting IV character tics how is the power versus voltage current these are some issues that we would like to look at and study in this module.

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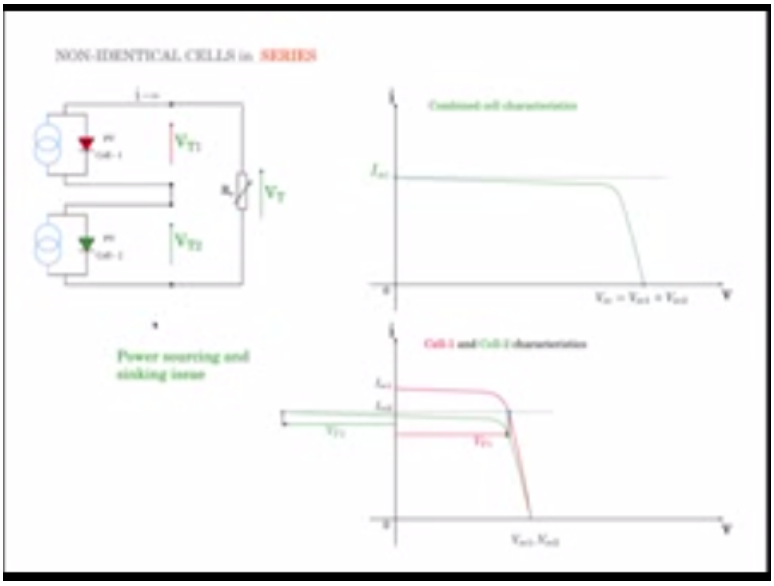

Here we see the subtitle of two PV cells non identical PV cells and that are connected in series like and these two points are the output terminals of the combined series connected cells the load is connected across the output terminals are not they are interested and the voltage VT across the terminals and the current through the terminals VT1 is the voltage across the terminals of the first cell VT2 is the voltage across the terminal of the second cell now we are interested in seeing how to get the IV character tics of this entire combination.

So let us have alongside the V versus I graph still unpopulated just under x and y axis let us have also another I and V axis and this is for having the IV character cell 1 and cell 2 and how they play a role in the development of the IV character tics of that combined cell now let us have the IV character tics this IV character tics shown in red is that of the PV cell one which is also shown in red here and the voltage being measured there is shown by red arrow the second IV charatertics shown in green represents that of the PV cell 2 is also shown in green.

So I have indicated the IV characters of PV cell 2 slightly lower than that of PV cell 1 indicating with the short circuit current of the PV cell 2 is smaller meaning that this cell is shaded I have considered the open circuit voltage VOC 1 and VOC 2 as same for both the cells as shown here the short circuit current ISC1 and ISC2 are shown here and the green one that of the cell 2 is bit

lower indicating that cell 2 is partially shaded now let me consider a situation where R_0 is infinite which means this is open circuited these terminal the combined terminal of this module is open circuited which means it means the load line is along the x axis in both the cases it will be along the x axis because the open circuited no current flowing through either of the cells each of the cells are open circuited.

So what is the operating point you will see for each of the individual cell the operating point is here because the load line is the X axis so the terminal voltages VT1 and VT2 are like this how does it look like here so if you see VT terminal voltage of the combined system is this plus this so one operating point you will get is this which is VOC1+VOC2 with the X axis as the float line. Now let us change the value of R_0 from open circuit we will put in some finite value of R_0 and if we do that let us say there is some current flows this is the current line.

Likewise the same current line is indicated here also indicating that there is some current flowing through the external load the same current flowing through each of the two cells now I know how much amount of R_0 I have applied and therefore the $1/R_0$ line is known the current line is known the point of intersection is one operating point maximum now this current line here with respect to the two individuals cells you will see that the operating points are as shown here points of intersection the respective I'd cup so this distance is the voltage across the cell 2 VT2 and this distance with respect to the other operating curve is VT1 which is the voltage terminal voltage across the cell 1 this voltage plus this voltage will be the voltage at this operating point here as shown which is this VT1+VT2 now let us increase the load further decrease R_0.

So you will see that the load line the slope as increased this is the increased I_0 the load current and this is the point of intersection is the new operating point on the combined cell id cup so I get one more point here for the increased load current with respect to the individual IV character tics of the cell1 and cell2 you see here all the new operating points and this is voltage across cell2 this is voltage across cell 1 addition of this will be the voltage of the operating point of the combined cell now I will further increase the load which means I will further decrease or not.

So what happens this is moving up further like this and this is the operating point with respect to the load current line as shown here the horizontal line so this would give you the operating one more operating point as you travel as you sweep the load line from here onwards so with respect to this load current you see the operating points on the two IV character tics on PV cell is as

shown like this and you see the voltage across PV cell 2 is much reduced compared to that of PV cell 1.

And summation of this is what you see here VT1+VT2 let us see at another critical point when this when increase the load big further I can reach at this point that is the 0 voltage point of the cell 2 where you have the operating point exactly in such a way that it is exactly at the vertical axis for cell2, cell1 is at an appriate point here now what happens to the combined character tic you see that the load line like this and this is the operating point this will match exactly with this because the voltage contributed by the cell 2 is 0.

So you see here VT2is 0 and VT1 is voltage that is occurring here and that should exactly be VT1 and which means that the cell character tics one must pass through that point so there o is a point on the cell charatertics 1 which passes through further on if I try to increase try to increase the load or decrease the current i0 there is not much significant rise in the current because you see that the cell character tics 2 starts going on to this quadrant it is not in the generating quadrant this is the only quadrant the first quadrant is the only quadrant which is generating quadrant of the source quadrant this is as sink quadrant for cell 2 so the voltage here becomes negative there is a negative voltage appearing across this and this is a positive voltage with respect to the cell.

So cell 1 is acting as a source cell 2 is acting as sink summation of this 1VT1-VT2 is actually what is this point and proceeding further by if decrease this still further to a short circuit let us say 0 and make it 0n you will see that the operating point here shift here for this current you will see that this voltage will exactly match this voltage such that these two will cancel and the voltage under the term now is 0 so VT2 which is negative VT1 which is positive these two will exactly balance each other out so that you get an operating point here which is 0 now let us look into some problems in series connecting the non identical cells.

One of the main problems is that some of the cells will act as source and also sink and we saw that PV cell 2 under some conditions operating condition was sourcing and under some other operating condition was sinking power which means desperation and as a consequence that cell can become hot during that condition and detail

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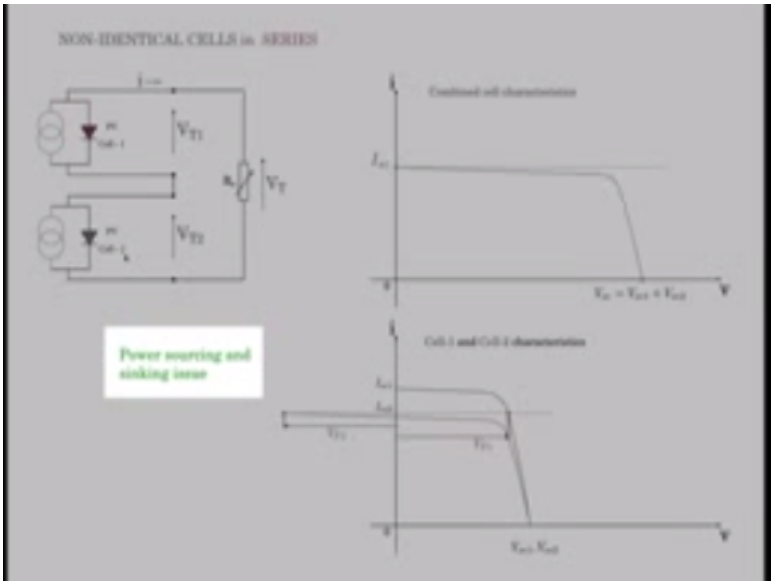

Let us consider the IV character tics of the combined cell and plot the power curve also in the same graph so this is the power curve of the combined cell with respect to the voltage let me now super impose the cell 1 charatertics this is the cell 1 charatertics as you will see and the important point is here the intersection of the cell 1 charatertics with the combined cell charatertics and at this point if I draw the vertical line we see that this is a crucial junction to the right of this line you will see that both the cells are sourcing and to left to the line only PV cell1 is sourcing PV cell2 is sinking so this is the dividing line.

And now at this line exactly if you look at the power curve of P2 this is the power curve PVcell2 see that at this point when the voltage VT2 is 0 the power that is delivered from PV cell 2 is 0 so it's now stops behaving as a source and if we go still further down towards the 0 axis its starts behaving like as a sink it's a dissipater in these region now if you consider this portion of the charter tics the combined charter tic which is shown lightly shaded reflects on to the second quadrant for the individual cell of the PV cell 2.

In this case and the second quadrant is not a associating quadrant it is a sinking quadrant only the first quadrant is a sourcing quadrant so if has cell is in the first quadrant the operating point is in the first quadrant then it is a source otherwise it is a sink that is what is happening to the PV cell 2 to the right of the line the PV cell 2 the operating points are in the first quadrant and therefore you will see that P2 is positive to the left of this line when VT becomes 0.

And negative the operating points for PV cell 2 is in the second Quadrant and therefore you see that it is acting in a you will see that PV cell1 is positive in both the regions of the IV current and therefore it is always a source now if you look at it is more or else constant this can be seen from the fact for variation in the current in this narrow region narrow space the variation in voltage of PV cell 1 is not much and the variation in the current flowing through both the cells is also not much and essentially the product of I into the cell voltage is essentially constant.

And that is why you see almost it is a constant and you see that here this power balances out the negative power and positive power gets balanced out and therefore the power of the combined cell is 0 at that point the important take away is that cell 2 act as a sink during our portion of the IV characters in the combined cell and that is detrimental to the PV cell 2 it detriates its character tics not only that it becomes the dissipater and it dissipates these extract power and thereby bring down the efficient of the entire system .So we should find ways to avoid this problem as fast as we can

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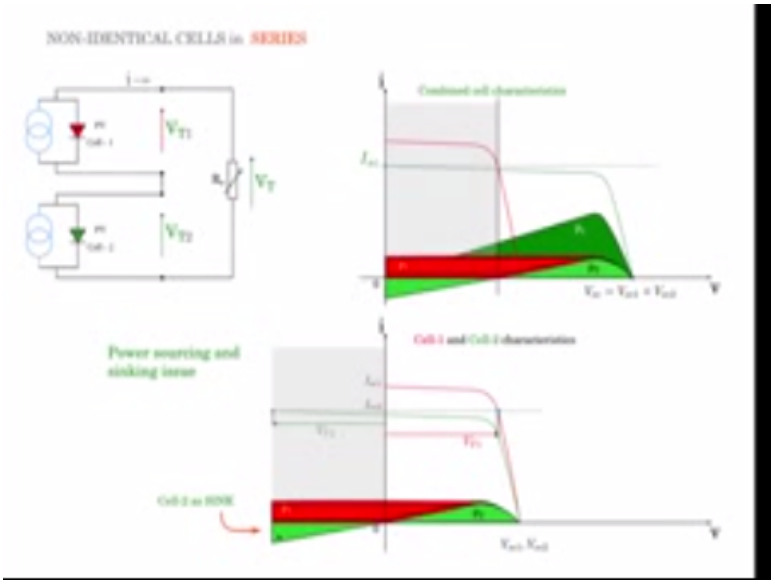

The important take way is that cell 2 acts as a sink during our portion of the Iv characterics the combined cell and that is terminal to the PV cell 2 it dissipater its charter tics not only that it becomes dissipates this extract power and there by brings down the efficiency of the entire system so we should find ways to avoid this problem as best as we can.