Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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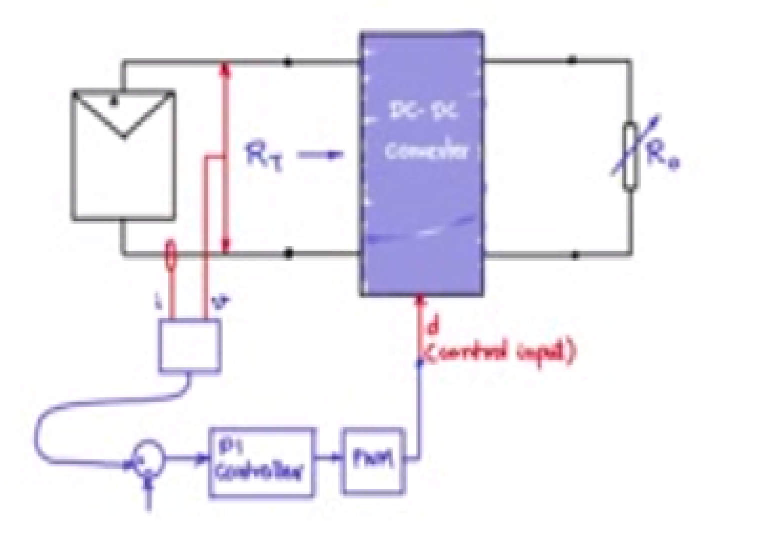

Let us gain some insight into the maximum power point tracking by simulating the DC- DC convertor acting as an interface between the PV module and the load or not but first we must know how to use the PV source in spice we have to develop the model for the PV source in spice.

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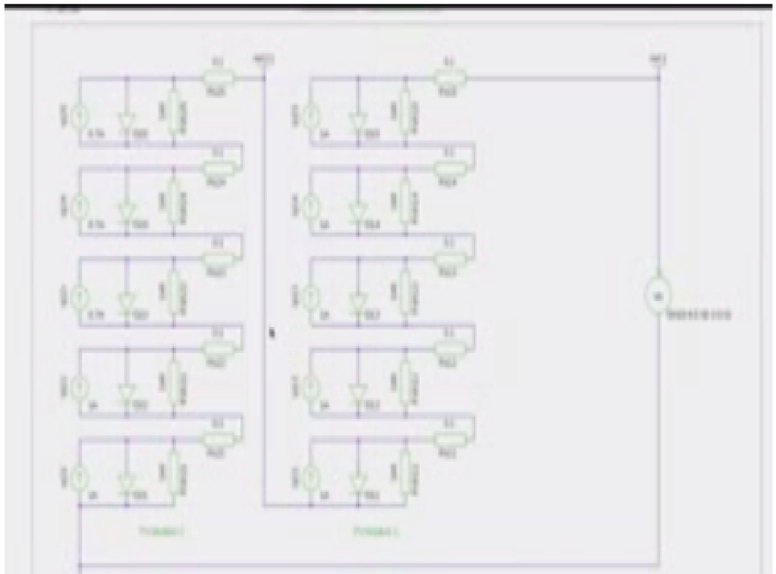

Earlier we had seen the model of the PV cell you see that each of the model of the PV cell and the PV cell modules are connected in series to achieve a higher value of VOC likewise you m ay also connect PV cell modules in parallel to achieve higher values of short circuit currents, however for the purpose of simulation we would like to have some flexibility in deciding the values of ISC and VOC values.

And try to build the model in this fashion lot of this PV cells putting in cascade can be very compress let me say you want to have a 40 volt open circuit module and you need to have 40 such cells in series not 40, 50 set cells in series so that 0.7 or 0.8 it is cut in voltage you will see that you will get 40 volts. But having in cascade 50 units of each 50 units of this models set connected in series will be really cumbersome and the number of components will be really large and the simulation can be slow so we need to have a kind of a generalize model of the PV cell.

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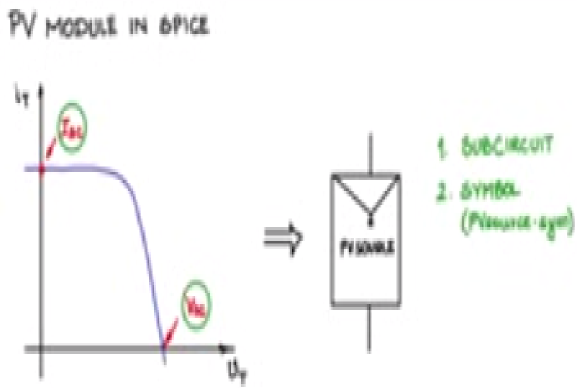

A PV module in spice or in NG spice should have an IV characteristic like this further one should be able to define this point the short circuit point ISC and also the VOC point, now these two parameters we should be able to define for the PV module model which is in spice, then only we will be able to perform the simulation of interfacing power convertors with PV module and further check whether maximum power point tracking is occurring for various different types of modules PV arrays are different IV characteristics having different short circuit and different VOC points, remember that the short circuit point ISC this point this ISC is directly a measure of the insulation.

And therefore definition of this point is spice what you mean that you are able to also control the value according to insulation, so it is important that we have some measure of control in deciding what ISC should be for the PV panel and also VOC therefore we need to have in the spice NG spice source called PV source which is having a symbol like this and a characteristic the IV characteristic like this which the PV source should be able to emulate.

And such a source having this IV characteristic we will call it as PV source. We need to do two things one is to write a sub circuit and the sub circuit model should represent the PV source having this kind of an IV characteristic, so we can use the current source diode model for writing the sub set model infact we can leave out the R hunt and R series and have I idealized the diode and current source model itself that should be sufficient and second we have to make the symbol, so that you can call it in the schematic editor and let us say that we write the symbol in a file called DV source. Sym so these two aspects we need to do then we will have the model of PV source and then we can use this model the PV source as the component within the spice and along with all other components for example the components in the DC converter and stimulate the entire system now let us first generate the PV source model.

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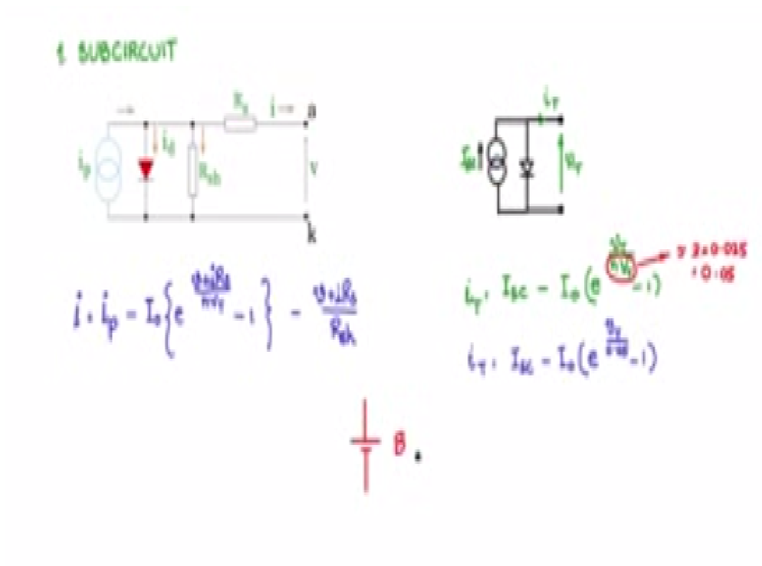

So recall that we had discussed this model of the PV cell consists of the current source that diode the dark and dark series RS and R_{ab} or non idealities we can distance with them and then to make model simple we will try to use only what is the essential most essential the current source and the diode, and let us build a model along base line with the modified simplified circuit, so let us have a current source and let us have a diode and the current source will have a constant value and we have the terminal.

With the terminal voltage V_T and we have iT the terminal current here and this what we need to determine the current source value we will send it as a constant and we will set it proportional to insulation which is ISC value, now for this let us write down the model iT which is what want equal to ISC – the diode current value will be iT and what is the diode current value it is as given here, so I_0 the saturation current into exponential V_T the terminal voltage / n, NV_T this V_T is the voltage equivalent.

Of temperature - 1 so this value N is 2 for silicon and V_T is 0.026 or 4.2500C so I will take it as a value equal length equal to approximately 2 x 0.025 =0.05 for easy calculation and rewrite our

IT model as I see – $I0^{e\ VT / 0.05 - 1}$ so this will be the model of the simplified PV cell or PV module, here you see that IC is a value ISC the short circuit current is a value that we can set so that is settable and we can adjust that for module to module what about the VOC,VOC how we will adjust for the V_{OC2}. But first this module how will you implement it in the sub circuit, so within the sub circuit we will use what is called as a de source which is size provides and non linear source call the de source.

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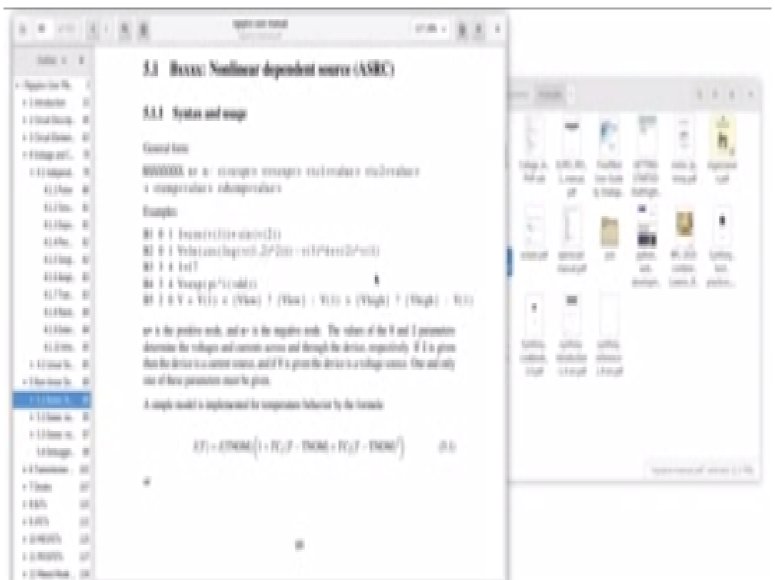

Go to the in this spice user manual and refer to the syntax on de source then non linear dependence source PD is between a plus node wand the minus node you can either a expression for current or expression for voltage like this D1 0 to 1 is the node ϕ is the current expression and goes like this you can also give a conditional statement within here, so let us try to use the de source module into our PV source module.

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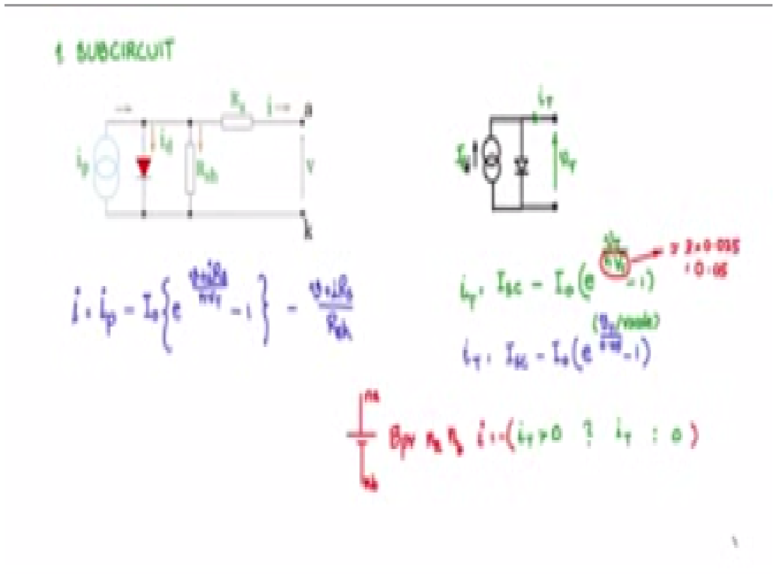

So we will use the de source between na to nb and let me call it as Bpv it is nodes na and nb and let us have current output I normally the current output is positive considered positive for a source when it is entering the positive node and negative and leaving the positive node and other case it is to leave the positive node therefore I will indicated as a minus of something some expression which will come in here, what is the expression that will coming here it will i_T this expression for i_T that we have written.

We can introduce one more point at this stage of the modeling we do not want negative current to sink into the PV cell when i_T goes negative that is reveres direction we just want to not allow that so set i_T to 0 during those times, so which means only when i_T is greater than 0 then allow i_T as calculated by this equation or l make i_T this current i=0, so this is the conditional inline conditional statement that ngπ's allows and we can use this equation in our sub circuit model.

Next comes the point on how to adjust the voltage of the PV module can I increase the voltage of the PV module. Now let us say here in this point of the equation I divide a v scale value, now let us say for example when v scale was not there v_T terminal voltage was around 0.7 to 0.8. Now if I make v scale as a value 10 then for the same amount of diode current to flow this numerator here should be around 0.7 to 0.8 which means v_T should go to 7 or 8, 7 or 8/10 will be 0.7 to 0.8 therefore automatically because this is the current source, automatically to achieve the same current levels v_T will automatically scale to a higher voltage or 7 to 8 volt if we make a v scale 10.

If you make v scale for any other arbitrary integer value or non integer value greater than 0 v_T will accordingly scale such that this numerator will be around 0.7 to 0.8. So therefore we can get a voltage scaling also by adjusting this value, so v scale and ISC will be two parameter values that we will adjust.

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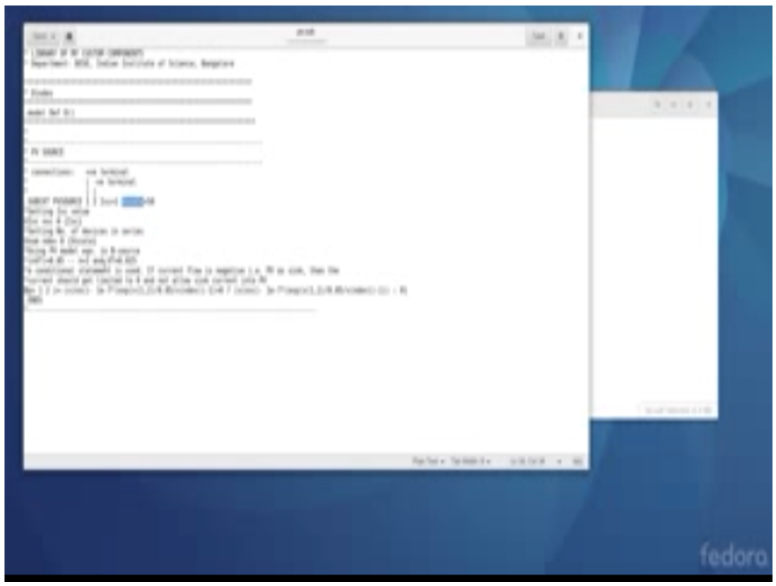

Now let us try to build the sub circuit and see how we incorporate that into the spic schematic I have created here a folder call PV module and within that folder I have three files one is PV.CIR file or familiar with what is a CIR file there is a schematic file and then PV.SUB file but I will first look at this PV.SUB file where we have placed the sub circuit. So if you recall we had a PV. SUB file sub circuit file earlier which had only the module of the diode.

Now I have included this part, the PV source so the sub circuit or the PV source is as follows it has two terminals the positive terminal and negative terminal I am passing two parameters default value of ISC at 1 voltage scaling factor set to 50. And the first part here setting the ISC value so I am opening a voltage source between NSC and 0 two nodes and then passing this ISC parameter here so I will have a node voltage value of ISC likewise I will have a node voltage value of v scale decoupled independent nodes and I will use that later in this model here. Now observe this is the DPV model between 1 and 2, between 1 and 2 of the terminals high and I am setting it has – now this is our IT equation VNSC is an old voltage here which represents ISC, ISC value-7 this is I^0 E^{v12} is $V_t/0.05$ for N V_T I also divided by Vn_{dv} the V scale value.

Now if these values if this I_t value is greater than 0 than take the value of I_t has calculated or L if It values is turning negative clip it to 0 so this is the model of the PV source that we will be using which ahs both I_{SC} and voltage scalable and just able and which is what we need now we have the model we need a symbol which will call this model.

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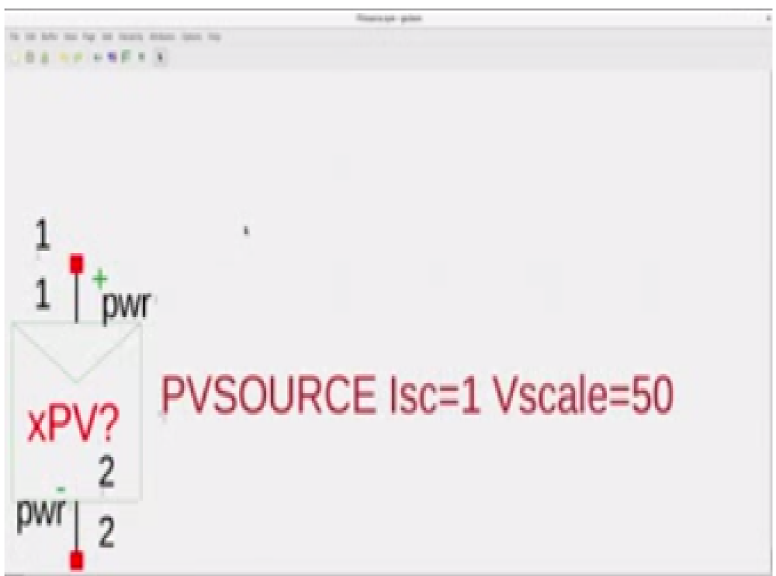

So let us now create a symbol before I start creating the PV modules symbols would like to show you on the browser if you put in the keywords like Geda symbol creation we keep you will have lot of search outputs Geda gap symbol creation of the project and other is a good point for you to read and get and making symbols another point of entry for you to learn more is this creating your own symbols.

This is also a good place for you to start so read up on this and see how the symbols are created now we will go to making our PV source symbols open the Geda schematic open supply Vat and for symbol creation you need to remove all this delete them and the extension dot Sch make it has dot Sym so you save as PV source.

And let us store it here so now we have PV source at sym now very important to note this here you see at the bottom grid 100, 100 you have to keep the grid at 100 and 100 but you can improve the resolution at the time of drawing but it time of saving always keep this as 100, 100 and make the resolution like its bigger.

You can always change this by going to auctions scale up grid spacing scale down grid spacing use that one to adjust the grid spacing here and use this add net add bus add attitude add text had component these are the things that you will be suing add pin okay so I can add pin okay and place it like that okay that is obtained.

Now when I double click on the pin you will see that you will see the properties coming in pin type unknown pin label pin number pin sequence you need to give the proper attributes here pin number and pin sequence these can be different but most of the time they are same built pin number sometimes can be different from pin sequence, pin sequence is the sequence that you will use an sub circuit so this is associated with the sub circuit sequence pin number here is associated more with the IC package details, so that is very important for you to provide. So I added one pin here another pin here, now with the double click you see that I have given pin number 1, pin sequence 1, you can give pin label it can be α numeric, I can say it is + pin type power. So these are the attributes that I am giving to this pin, you see the other pin number 2 with sequence 2 – label and again power pin. Now I have added this by going to add attribute.

So go to add attribute you can choose ref desk value, so for this particular label, so I have added this and given x PV? Can be if you are having many PV sources within schematic you may want to name it has 1,2,3,4 so add that? x because I am going to refer it to the sub circuit and therefore for sun circuit the first letter should be x. now we need to draw the symbol, so take the add line, let me make the drawing, like this such that it represents PV source like that. Say in between, so after having completed the drawing look at all the labels.

It is label +.- power everything shows up it is to noisy and this is the value, so in value I am calling PV source sub circuit passing IC value and V scale value, this is important. So what you can do is mask everything, let there just be a pin and this XPV and then it looks neat, so if you use EN everything disappears at there it is hidden. Save now do not just quit go to edit select all, this is a very important step, if you want to get your graphics right when you are doing the lay out.

So that when your drawing wiring the circuit diagram that should lock to the pins the wires, so select all and then go to symbol translate very important step. Every edit you do that simple translate to 0 okay that is it, now you save. After this process you can close it, every time you edit the symbol do the select all symbol translate. So I have saved it into the, in your local home directory you will have a caps folder when you install GEDA.

Inside the gap folder there is a symbols and inside the symbol you can have your own library of components, so I have created some components I will share them with you the resources, so within that I have created PV source, there are various other thing also, which I will share and you can look at them in the leisure. So the PV source this is what we created, so I will put it back.

So this is created and placed in this place but you have to tell JAD to look at this place where you tell to look at the place. So in your user home control h , you will unhide the dot files, so dot JAD configuration file go in, there is a gasp of C5 if it is not there create an empty file and inside that, if I double click.

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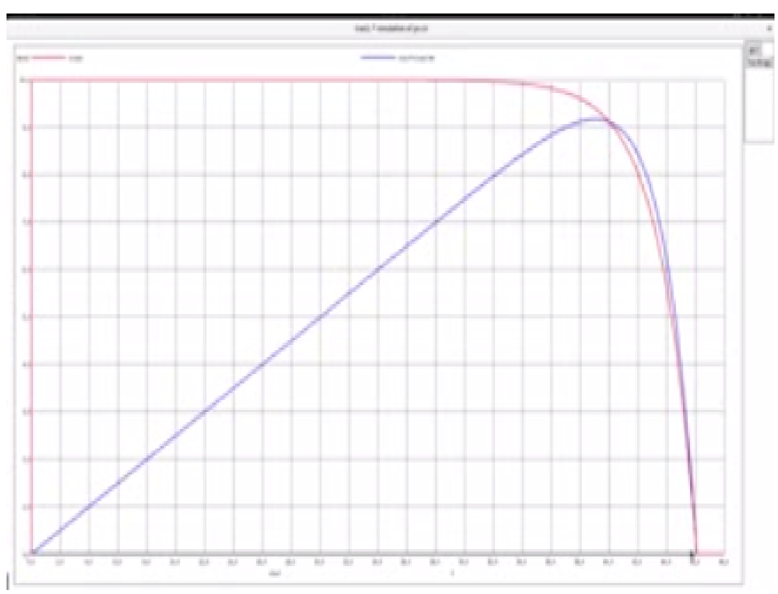

You have to write this component/ library/ search within the double quotes /home in your local home directory gas is the directory where you place this folders symbols folder within that it will search for all the folders and separate libraries and component libraries that you have created so this search part is need then it will recognize and it will put it up so let us now look weather it is going to look for our symbol that we have created and see if we can sublimate this next I open the VP . sch we create the semantic we go into the semantic and then here we shall place the components.

Let me go into the component library I have placed in a components let me look down and see if PV source is popping up you see PV force is popping that we just now created I will place it here I will take that close this I will also take a sign source place this here and then let me the connections let me edit the label let me edit the value parameters I will make i_{sc} short circuit current and voltage scalars 50.

I have here included PV that 5 fine which contains the sub circuit so you see that PV. sub is containing the sub circuit which is called by the PV. Semitic with in PV. Semitic we have the symbol and this symbol is calling the PV source sub circuit by which is residing here so all are connected well so that is it now we can simulate in this spice now I will open PV . c_{ir} so PV. c_{ir} performance these operations . ran between from 0 to 5ms 0.01 ms as the print out using initial conditions.

It includes PV. Net which we need to generate we will generate that then this is a set of .control statements I would like the plots to be on white background and black foreground so you can do that we have done this earlier run the command then plot what do you want to plot so you see that I will reduce this so that you can see what we are doing so plot ivsc the current through this out source verse VnV verse the terminal voltage then VnV the terminal voltage into the current through that is a power / 40 verse the voltage so we are actually seeing the IV and the PV current.

Why did I do divide b y 40 so that both can be clearly visible at the same screen you see that if I am setting this at IC 10 amps and approximately 40 v for the Voc you will see that it is around 400 vats so or less that 400 vats because it is 70% of VOC in to ISC and that divided by 40 will be around 10 so this is kind of a normalize so that we can see both on the same screen but mentally you multiply by this value whatever you see on the plot out to get eh actual power. So now let us plot this and then see I will close this and then open the terminal window so we will go to the folder now so first generate the net list g net list all these commands slash out PV. Net PV. SCH we have seen this command before when we did the spice experiments.

So let us do that and then ng spice PV. CIR so it will rum execute and it will plot this you see it is plotted this and as excepted short circuit current 10 and open circuit voltage around 46 and see does not go negative beyond that current become 0 because we have set at clipper limit for IT going negative. So that is advantages and this blue line is the power cut of course you can try for various combinations what we have now achieved is that we are able to have a PV source symbol where I can scale the value of ISC and VOC and the same symbol you can it for any PV application and it gives you a curve almost IV curve like an excepted photovoltaic cell characteristic.

As again the original model where we used the diode and current sources and kept on adding putting them in series and parallel and so huge number of component you will have to include and for every different specification you will, have to keep changing the set of PV cells in series and parallel and keep adjusting them which can lead to not only may stitch but a huge PV souse circuit and number of components which would slot on the simulation, this is very elegant you do not have to do anything whichever be the experiment that you want to simulate you just have to give the ICISC the short circuit current value or the insulation value.

And voltage scaling factor and you are done you have a PV source we will use this PV source to stimulate our MPPT tracking with DCDT converters, so before we put in the MPPT algorithms we need to first see if our PV source when inter phase with the DCDC convertor lax well.