Indian Institute of Science

Design of Photovoltaic Systems

Prof. L. Umanand
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

NPTEL Online Certification Course

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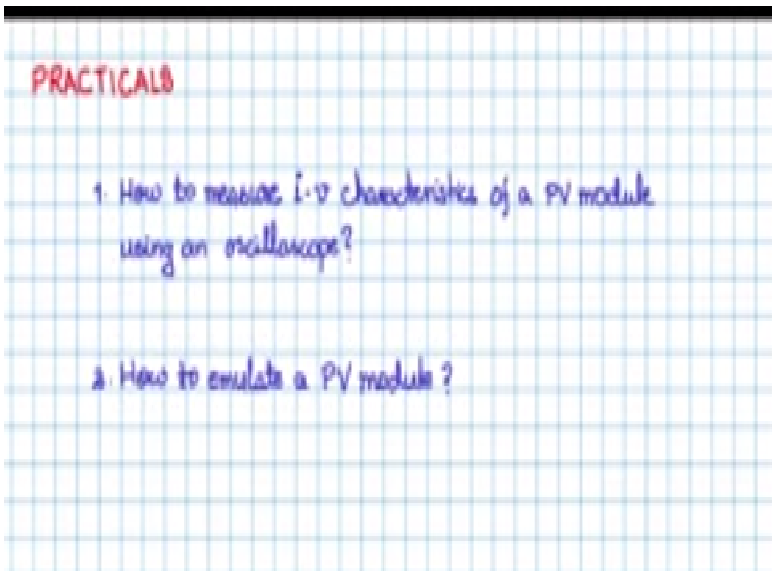

Let us look at some practical's, practical's are important for engineering and let us look at answers to two questions, one is how to measure IV characteristics of PV modules or PV panels using an oscilloscope, the next question that we need to answer and see how we can practically do that is how to emulate a PV module. Now why would you want to do that? See most of the experiments that with PV modules you may be doing during night time or during times when there is no Sun.

And even during the morning time and very Sun the insulation is varying so therefore the output of the PV module is highly uncertain, therefore especially for experimentation and what is the works research work related to PV modules you would like to have something which gives an output characteristic like the PV module but you can use it at any time of the day, which gets power from the utility grid. So therefore it becomes important to emulate PV module so we will look at few methods of emulating PV modules so that we can do our experiments.

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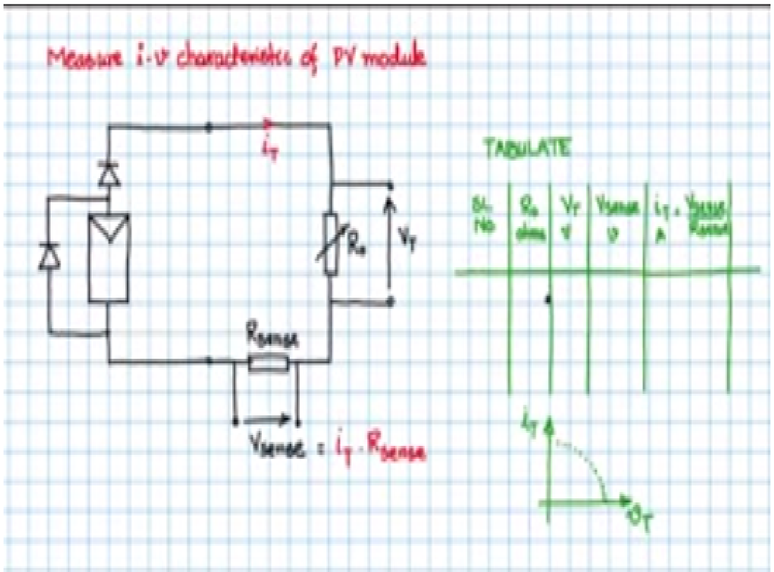

Let us now consider the first problem of how to measure our IV characteristic of a PV panel a PV module, now let us draw the circuit have this PV module let us put the production diodes the series these both the series protection the bypass diode and the parallel protection and you have the PV module with the protection, so terminated so these are this is the terminals of the PV module.

To this PV module let us connect an external load and in series of the load we will also connect a smaller resistance called R_{sense} to measure the current, now the voltage across this we will call it as VT across R0 and R0 is a variable resistance it could be a wire wound REO start. Now across the resistor for measuring current so let us say we causes as R_{sense} if you measure the voltage across start we will get V_{sense}.

And what is V_{sense} equal to? Now if you have a current I T as shown like this V_{sense} is nothing but I T x R sense. So V_{sense} is proportional to IT knowing R_{sense} you can find out IT where the terminal current. Now for the circuit let us tabulate and the find out the IV characteristic this IV characteristic is not still directly viewable on the oscilloscope so you will not first tabulate and then plot that.

So let us do a tabulation what do we tabulate, serial number you include R0 in ohms this is something that you will be varying then the measurement of VT volts measurement of V_{sense} then

IT is computed based on the measurement of V_{sense} and R_{sense}, so using this tabulation we can plot VT versus IT so in fact you can now plot something like this VT versus I T, so you would probably get the characteristic based on the characteristic you can measure the fill factor measure the efficiency measure the power versus V curve and all these things.

But this is an experiment which will give you DC values and you cannot see directly on the oscilloscope because there is no sweep voltage as you expect when we did the simulation we put across the terminals sweep voltage source and that would definitely give you a direct plot of the oscilloscope we will see that experiment later but for this experiment it is something that you need to tabulate and then graphically plot it in a manual manner or through a package like octave where you can take the VT vectors and ID vectors and plot the same.

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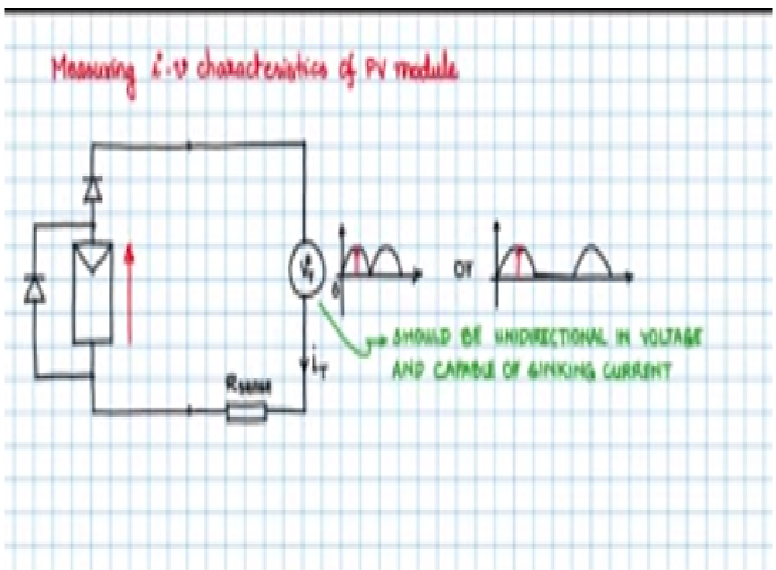

Let us now look at a method where we will be able to see the IV characteristic on an oscilloscope, so for that let us draw the circuit diagram this is the PV module with the protection diodes both series and parallel protection let us terminate the PV module now across the terminals let us draw now not a load but our voltage source just like we did in the simulation exercise and then incorporate a series resistance here called R_{sense}.

Such that this will give you a measure of the current IT flowing through the terminals, now what should be VT note that VT should have some special character so the wave shape should be something like this a full wave rectified wave shape or a half wave rectifier shape will also do as long as the voltage is unidirectional since your voltage is unidirectional the terminals are always positive, now the terminals are positive then the system is in the first quadrant and this fellow will be sourcing that is very important. If the holes the voltage goes negative if you are using a regular sine wave and then the voltage goes negative then during the time and this becomes positive you see that there will be a circuit current path which goes like this.

So it will be a large surge current for the circuit and something may blow so it is not recommended to have VT going negative, so or very importantly you need to ensure that it is unidirectional so therefore we qualify that the voltage must be an absolute value voltage and also it should be capable of sinking current this is a very important condition constraint because IT is going through the voltage source V T connect it across the terminal.

And the VT should be able to sink IT value of current otherwise the circuit will not operate if you just put an absolute level circuit using rectifiers then rectifier will not allow sinking capability therefore it is important that not only to the voltage be unidirectional it should also be capable of sinking current only then this circuit will work and then the IV characteristic can be plotted on the oscilloscope.

If you have such a voltage source you can give the VT value to the external trigger of the oscilloscope and capture the voltage across R_{sense} and give it to one of the channels of channel A or channel B of the oscilloscope then you could see the XY plot or the IV characteristic, what would be the amplitude of the VT signal you see that the VT signal is acting like a sweep and therefore the amplitude should be related to the amplitude of the module voltage.

So if the model voltage is some VX the amplitude of the VT signal should be of that order whatever may be the unidirectional signal that you will be giving? It should be noted that obtaining VT which is both unidirectional and capable of sinking is not easy so if you take if you derive it from the mains voltage which is sinusoidal to get a wave a wave shape like this you should either have a full bridge rectifier or a half bridge rectifier.

And if you use a rectifier you will not be able to sync current and therefore you will have to make an electronic regulated power source for that which is more difficult to do that an experiment in a short time, therefore what we will do is slightly change the circuit.

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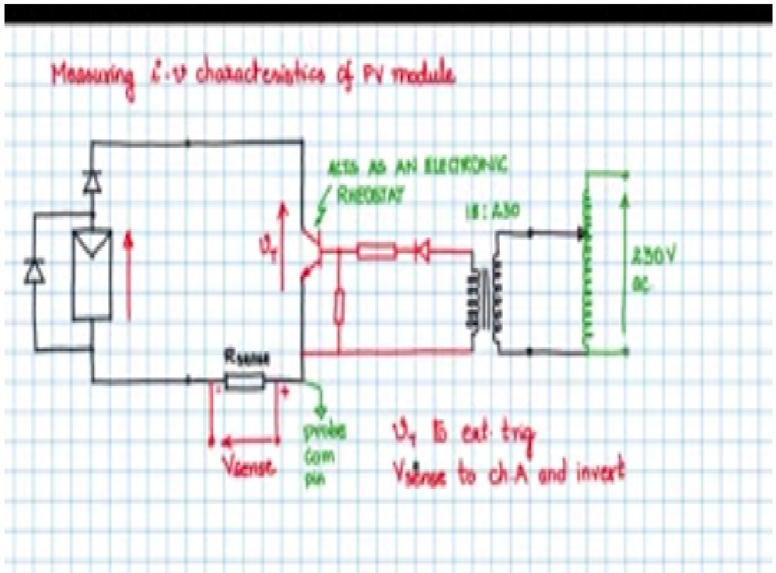

So that it is easily implementable in practice and you can quickly get the IV characteristic on the oscilloscope so instead of a source there we will put a transistor a BJT it could be a BJT or a MOSFET so let us drive it with base drive resistance and let us have a resistance across the base and emitter for removing the base charges when the devices supposed to switch off and then let us have a diode there so that it will pass only unidirectional voltage.

And as a consequence only unidirectional base drive and therefore the transfer will receive the base current in the proper direction the transistor of course will be capable of sinking IT will flow in this direction, now we have to get this voltage so let us get this voltage from a step-down transformer so let us draw this transformer so you have a step-down transformer and the output of this transformer let us connect it to an autotransformer which is here in the lab.

So this is an auto transformer and the autotransformer input is connected to the 230 supply of the 230 outlet the grid outlet, now 230 here is applied here so which means this potential swings from 0 to 230 and what we will have is a transformer here which is having a step-down ratio 230 to 18 so when this is at maximum value what you would get here is 18 volts and when this is at minimum value this will also be 0.

So you will get voltage here which is swinging from 0 to 18 volts and this will be a sine wave swings in both direction, putting a diode here gives your affair rectified waveform here so the base current is half wave rectified and that will try to drive the transformer transistor here the

BJT here into the linear region, so as the base drive increases due to the sine nature this goes deeper into the on state finally into saturation when the resistance as seen across the collector emitter terminal becomes 0 at saturation.

And at that point the voltage across this will be VC sag so the base current here will modulate the impedance as seen across the terminals of the PV panel, therefore we can say that this BJT here transistor acts like an electronic rheostat, so let us say the voltage across the BJT collector emitter terminals is called VT and the voltage across R_{sense} is V_{sense} VT we will give it to the external trigger of the oscilloscope and V_{sense} observe that V_{sense} is now measured in this way.

This is the positive potential one with respect to this but still V_{sense} is measured like this which means you will get a negative voltage there is a reason, V_{sense} you give it to channel A or channel B and invert because V_{sense} is negative measured in this fashion the reason is that you can use a dual channel oscilloscope and make this as the common probe point the common point of the probe can be connected here and the other two channel probes can be connected one can be connected here and other can be connected here.

Thereby you do not need to use differential probe oscilloscope, so that is the reason I have taken negative at this point for that one. Now we say that this is the probe common point probe common tip so you can probe the channel here + point here which will go in here other probes plus will go here and connect to the external trigger, so this if you give it to the oscilloscope the oscilloscope will plot the IV characteristics.