Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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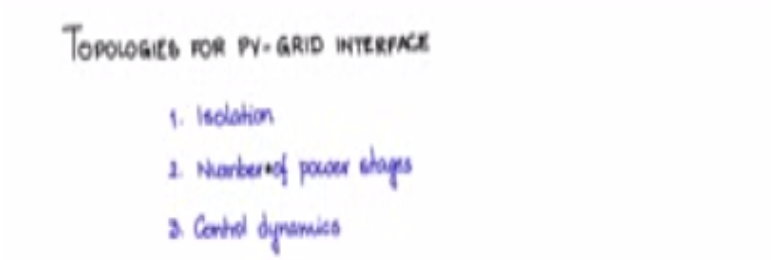

Let us now discuss some topologies for pv grid interface, there are many topology is available in the literature they probably maybe classified in the flowing way one of the main classifiers would be isolation there are many topology is based on isolation where one place is the isolation and whether isolation is needed or not, so you will find low frequency transformers being use for isolation high frequency transformers being use for isolation.

You will also find circuits without transformer isolation they are called transformer less pv grid interface each have their pros and cons we will discuss them. There is also classification based on the number of power stages we will see you may have one power stage one dc dc converter to do take care of maximum power point tracking for the pv modules source modules there is another dc dc converter which can be used for current control or voltage control of the output, there can be another converter for doing the unfolding.

So if you see that there are some topologies which uses two or three converter stages some topologies which will use just one power converter stage, so it has an impact on the efficiency of the whole system so you will see in the literature topology is based on the number of power stages two, you will also see converters based on control dynamics so you will see scalar control where the control is done inter cycle with inter cycle dynamics that it may take more than 150 hertz cycle for the dynamics to cycle.

If you use the deuce axes theory then you will obtain intro cycle dynamics that is the dynamics will settle within a cycle, so these are control blocks which are popular and which are in use and which are also use and which are also discuss some of these things while designing a real even looking at the pv grid interface circuits. So one by one let me introduce the different types of pv grid interface circuits and let us spend some time discussing that.

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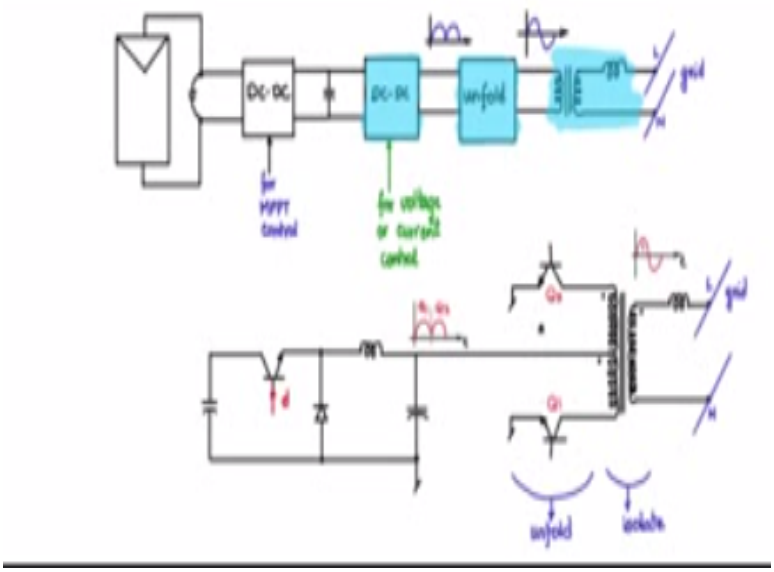

Let me take up the following topology where we have the pv module connected to a dc dc converter and the dc dc converter output as a capacitance dc dc converter has a control input like this and this control input is used for mppt control. Now this portion we have familiar with you have the buffer capacitor cd dc dc converter and then output capacitor, what we want to do here I will discuss.

Up to this portion e know and this dc dc convertor can be any dc dc convertor either non isolated or isolated which will appropriately do the matching of the load line to the pv terminals in such

way that maximum power is drawn from the pv. The output of this dc dc converter is given to input of another dc dc converter, so the job of this other dc dc converter is to control the output voltage on the downstream side the job of this dc dc converter was suppose to control the input impedance for maximum power point tracking.

So each of this dc dc converters is doing different functions, so outer of this dc dc converter is suppose to give an output which is unidirectional it is still dc, but it is a varying dc and the variation is such that it is in the shape of rectified sin wave, so you can control the duty cycle of this dc dc converter in a wave which will give you an output which is giving you rectified sin wave.

The output of that dc dc converter will go through a unfolding circuit I will call this one as an unfolding circuit, at what it does is alternately it will unfold this full rectified sinusoid, so that you will get a sinusoidal wave shape that it is output, so job to the unfolding circuit will be such that it will provide the positive first positive will still remain positive the second rectified sin will become inverter, so that together it becomes a sin wave.

Now this sin wave will be passed through an isolation transformer isolation low frequency because this is that now 50 hertz so you will use a low frequency transformer isolator and then output of that it going through an inductor and that will get connected to line and neutral of the gird. Absorb that this dc dc converter is also having a control input but this control input is used for modulating the output voltage of this can be used for voltage control or current control.

We are quite familiar with this portion of the circuit we know how to inter face the pv module with the dc dc convertor for mppt control, let me discuss about this portion of the circuit. Now let me put down a typical circuit for this portion starting from this capacitance onwards let me redraw the circuit here, so I have the capacitance let me follow it with the simple buck converter like this, so this is a buck converter.

So I have a power semi conductor switch here I have used a BJT you may use a mass fit or you may use an IDBT have the diode and you have an inductor and the capacitance, now you should remember that this portion what I have used this topology of a pup converter you may use any other dc dc converter topology, this is just only a represent you topology for explanation have used a puck converter.

It could be a play back converter it could be isolated converter it could be a buck boost converter so on and so, it could be a z source converter. Now the output of this should have a wave shape like this, full wave rectified sin rectified, so upper appropriately I will have a duty cycle here which is varying sight that it will produced an output wave shape in that passion.

Now the output of this I will give you to a push pull converter which is connected in this passion, now I have this transformer winding and this is a push pull circuit so recognize this push pull circuit there is a switch here there is a switch here, I have not a diode here purposely because this reverse body diode is used if the current through direction reverse this but we are talking of pumping in current always in faced with the grid.

So it is only the active portion of the power which is flowing through all ways therefore I have not any reverse diode, but you may put a revere diode if it is BJT or it is a mass fit in IGBT the reverse diode is already inbuilt within the body of the switch. So now this voltage output coming from the dc dc converter is now connected to the center point of the push pull transformer, the secondary of the push pull transformer is pass through an inductor and output of the at connected to the grid line and neutral as shown here.

So now this duty cycle here I will modulate this duty cycle in a sin passion such that at this point the output I will get a voltage in this passion you see this v0 for a buck converter v0 = d v in now if d is made sinusoidal in nature there is only rectified sinusoidal in nature you will get an output v0 which is v in sin of ω t, and therefore you will be able to get this kind of a wave shape. Now this kind of wave shape is given to the center of the push pull.

Now let us say this of sinusoidal or having 10ms width so 2 sinusoids 2 half rectified sin waves will make 20ms which is 50 hertz, now we will unfold this so what I will do? This is q1 I will switch on q 1 so which means during q1 this is the operative sinusoid half sinusoid and the dots absorb the dots here, and I will I am suppose to get this so when this is switched on this dot is positive this dot is positive, so the positive comes in here.

Now when q2 is switched on q1 is off so this is the q2 portion, so when q2 is switched on non not end is positive non not end is positive which means non dot end is negative this is the portion it gets inverter like this, so alternately you keep switching q1 and q2, so these are switched in the

50 hertz passion for 10ms this is on next on next 10ms this is on so these are switched on low frequency.

And this unfolding happens and then this 50 hertz signal is now interface to the grid through the inductor, so this is one way of interfacing. This portion is call the unfolding circuit that I mentioned here and this is the unfolding circuit and this portion is the isolation the push pull transformer is use for isolating, so this, this and this portion is what is actually indicate that is in this whole circuit this is one such topology. The unfolding stage here I am indicated using push pull stage q1 and q2 along with the push pull transformer.

With the unfolding stage can be replaced with the bridge circuit which is much more popular because the bridge stage is decoupled from the isolating stage here the push pull stage is tightly couple with the isolating stage, so let us have a look at that.

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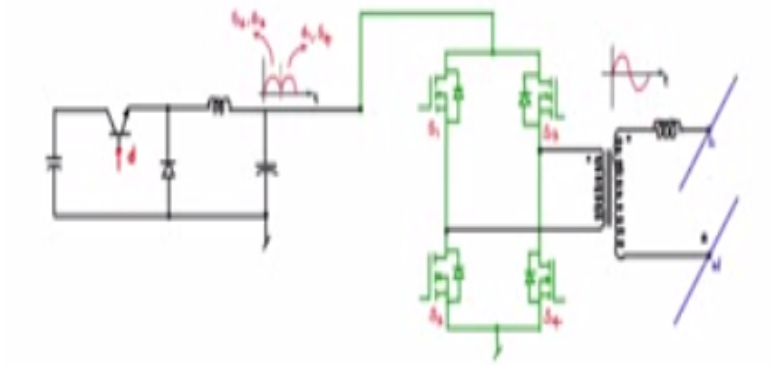

What I will do? I will remove this portion of the circuit and re draw that, let me reduce this and here I will use a full bridge stage which is switched at low frequency this time instead of using a BJT I will draw a mass fit as the power switch see the mass fit this is the n channel mass fit with the internal body diode you see why I normally use a BJT for switches representing the power semi conductor switches it is much easier to draw a BJT then draw the power mass fit.

But when I use in the lab and the experiments most of the time it is always power mass fits and power IGBDS where you rarely I use BJDs okay, so we have this full bridge made of power mass fits, this is connected to ground this point and this center point of this one is connected to this point which is actually getting the full wave rectified sin power signals. So I will connect it like that and then the center of the bridge I will connect the transformer like this and output of a transformer secondary the transformer go through the inductor and then to the line and neutral of the grid.

So let me complete this internal body diodes of the mass fits, so you have the body diodes the mass fits complete dot polarities, so this would be the complete circuit let me now name the switches I will call the switch as s1 this s2 this s3 and s4, now let us set during this period let switch s3 and s2 be connected s2 and s3 be on s1 and s4 are of during this 10ms period yeah, so during that time this dot end of the transformer is connected to the positive of this dc dc converter.

The non dot end is connected to the negative the dc dc converter, so the dot end positive this dot end is positive and therefore you will see this portion appearing here, then for the next 10ms I will switch on s1 and s4 switch off s3 and s2, s1 and s4 are switched off s3 and s2 are switched off, so when s1 and s4 are on you will see that the non dot end is connected to the positive the dc dc converter the dot end is connected to the negative of the dc dc converter.

Therefore the dot end is negative, so you will see an inversion here you will see full sin wave appearing across the primary of the secondary of the transformer, the primary and secondary terms ration is decided depending upon whatever this voltage of the dc dc converter and whatever the voltage would be of the grid and in India this grid voltage is 230 volt wornness or 235 sin ω, so you can adjust this ratio to match the grid voltage.