Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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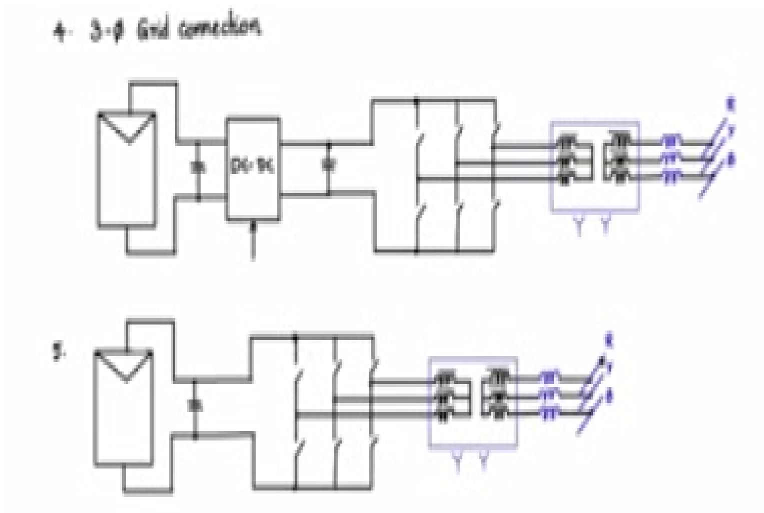

The PV module can also be connected to a 3 phase grid let us have a look at the topology for 3 phase grid connection we have a PV module the output of which is connected to a DC- DC converter this we are very familiar with now the DC- DC converter is a having a control input here which will modulate the input impedance and the output of the DC- DC converter is connected to a link capacitor that is a bus capacitance and from there you pick of for a 3 phase inverter.

Now the 3 phase inverter is also a bridge it consist of 3 half bridges like this 3 bridge arms one for each phase and these switches have shown symbolically they may be mass firesides or IGPT's with appropriate gate drives they are control switches so you connect them to the DC bus in this fashion and from the center of each arm you pull out the wire and connect it to each of the phases of a transformer a 3 phase transformer so this is a 3 phase transformer with one end of each winding wall connected together and that would be the neutral point for the transformer.

So the primary and the secondary they are all coupled so this whole together forms a star connected transformer this is connected in start with one end of the winding connected to the common the secondary also one end of the windings are connected to the common the other ends are coming out so this is the primary and this is the secondary from the secondary you pass it through 3 inductors separate and connect it to the r,y, b phases of a 3 phase grid.

So in this fashion you can have the PV module interface to the 3 phase grid only difference is that you need to have a 3 phase invertors a 3 phase transformer and 3 inductors we can further improve on this topology if you are using a inverter and if you are using especially a current controlled inverter then we can eliminate this DC- DC convert which is doing the job of maximum power point tracking to we can integrate the maximum we point tacking into the inverter control.

So let me draw that topology let me duplicate that and then we will remove this so this position let us say we remove and then mark this and then push that forward make the connections appropriate and then we have the topology where this DC- DC converter is not there now how do we do the maximum power point tracking if this inverter is doing current control there is the inductor current which is actually being pumped into the grid is being controlled.

Then the maximum power point algorithm can be used the terminal currents of the PV panel and the terminal voltage of the PV can be measured and the power that is obtained can be pass through the maximum power point tracking algorithm and then output of that can set the reference current reference for the inverter this will be sensed back fed back and the controller will see to it that the voltages will be appropriately modulated in such a way that the desired current flows through here.

And maximum power will be drawn from the PV panel so in this way we have now here a topology where there is only one power stage which is coming between the PV module and the grid you can also apply this for a single phase case where you have a single phase inverter a single phase transformer and a single inductor interfacing the PV panel to the grid.

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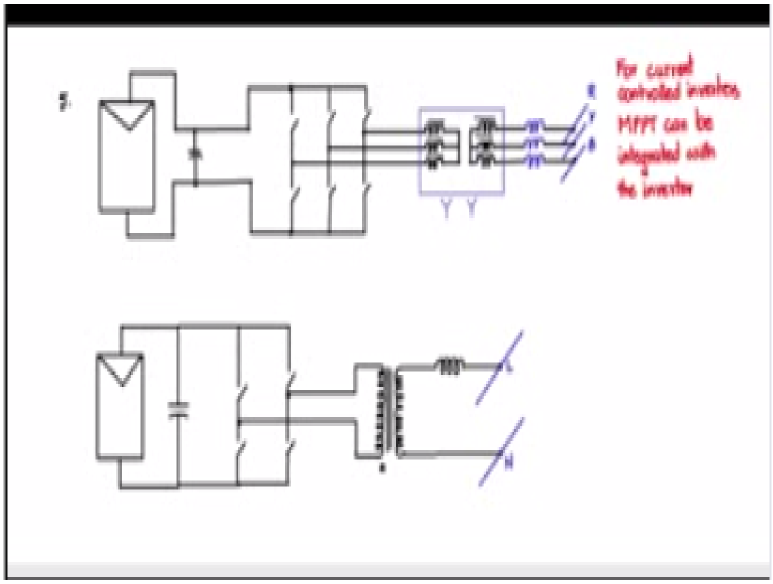

Let me make some space and then I have indicated f for current control inverter the MPPT can be integrated within inverter now let me draw the single phase topology also so in the case of single phase topology also the PV module can be connected to a single phase inverter which is containing just two bridge arms and the center the bridge arms are connected to a single phase transformer like this and the secondary of the transformer is connected to an inductor which interfaces to the grid line and neutral in this fashion.

So this is a single phase equivalent of this 3 phase circuit doing the same function and the MPPT is integrated in the into the inverted provide we have current controlled inverter for the 3 phase case here I have shown this 3 phase transforms symbolically as a start connected transformer but you can also have a start Δ connected inverter in case the line the grid is unbalanced and has harmonics the 0 sequence components of the currents can circulate in a Δ connected inverter so sometimes you will see that the transformer is start but start Δ.

We can further improve on this topology you see this inductor is carrying the low frequency that is 50 Hz component of the current full load current and therefore this will be pretty large huge expensive and it is a low for make of low frequency laminations just like this low frequency transformer now you have 2 big components one is this transformer and this inductor likewise and the 3 phase also this is a big transformer and you have a set of 3 inductors.

No one can include the inductor within this transformer in the form of leakage inductance if the leakage inductance of the transformer is large then the leakage inductance itself will do the job of the inductance inductor here in that case you do not need to have a special indicator however it is not easy to control the value of the leakage inductance so you make the transformer check for the leakage inductance is not sufficient for the difference amount you can put has smaller inductors.

So that is also a approach that one can take so let me draw the these two topology without the inductor and let me explain with the equivalent circuit the transformer how the leakage inductance can help now consider this position of the circuit only let me explain that one with equivalent circuit of the transformer.

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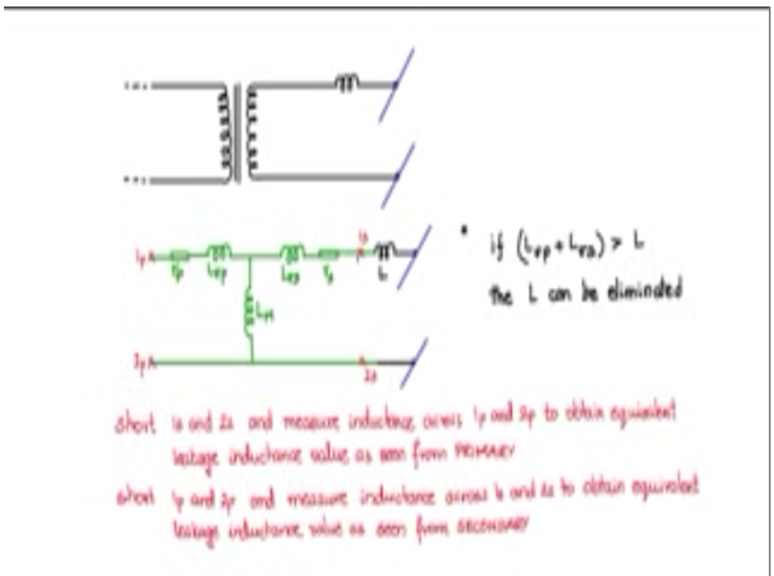

Let me draw the transformer position the inductor and you have the terminals connected to the grid now this is the transformer let me draw the equivalent circuit of the transformer if you have a primary resistance primary side leakage inductance you have the mutual inductance of the magnetizing inductance the secondary side leakage inductance secondary resistance and then this transformer through the inductor the same inductor is connected to the grid.

Okay now let me name these parts this is RP this is Lσp this is Lm the mutual inductance this is a pretty large value of inductance that is the leakage inductance of the secondary resistance now when a current flows from the primary to the secondary slide you will see that it take this path flows through the inductor and the grid load and then back again so this leakage inductance L σp and Lσs come in the series part of the current flow and therefore they act has a series impedance.

Now this Lm is a very large inductance and therefore this impedance will be very large compared to the inductance of Lσ as an L σp if Lσ p+ L σs is greater than this inductance value L then this value L can be removed can be eliminated now how do we know the value of L σ can L σs now once you have the transformer you do this experiment of line you remove the transformer of the circuit shaft to the secondary.

Once you shaft the secondary this is shattered than what comes has the impedance seen from the peripheral terminals you will see that Lm in parallel Lσs I will make rs and rp negligible Lm in parallel Lσs is Lm is very large compared to Lσs therefore the parallel combinations will be almost equal to Lσs Lσp+ Lσs will appear and measured across so measure across the primary terminal.

After having shaft at secondary terminal of line then you will get the equivalent inductance equivalent inductance leakage inductance as seen from the primary if you want from secondary sideward do this shaft to the primary remove the transformer after the shaft the primary windings and then measure from the secondary terminals.

So what will what you will get is that the equivalent leakage inductance as seen from the secondary terminals on shafting the primary terminals making that is rp and rs are insignificant Lσp is parallel with the Lm the impedance of Lσp so low compare to the impedance of Lm that this can be neglected it is it will be Lσp and Lσs coming in series these two impedance and that is what you will see this secondary terminals.

So you can measure else the leakage inductance as seen from the primary terminals or to the secondary terminals as a appropriate depending upon where you would like to put this inductance or replace this inductance so therefore if I mark this 1p 2p 1s and 2s shaft 1s and 2s shaft this two that is all this express to be done this measurement experiment to be done offline.

When the circuit is not operative you have remove the transformer out to the circuit and separately your doing this experiment shaft 1s and 2s these two you shaft and measure the inductance as seen from here and the value of the inductance that you obtain is the equivalent leakage inductance as seen from the primary side.

Likewise if I shaft 1 p and 2 p and measure the inductance across these two terminals then you obtained the equivalent leakage inductance value as seen from this secondary side so in this way you can find out the equivalent leakage inductance use that value compare it with the value of the earlier input if it is of the same order if it is equal to greater than you can remove this L and just use the leakage inductance of the transformer.

If it is lesser then only put the difference amount and you will add up the smaller inductance the same thing can be done for the 3 phase transformer also you have to shaft let us say you want to see the equivalent inductance at the same from the secondary side shaft all the primary sides and then measure the inductance as seen from each of the secondary side a, b, c or why b phases of each of the secondary side.

You will get the equivalent inductance have seen from the secondary likewise it could also do from the primary by shafting the secondary side, secondary windings so in this way you can replace even this inductance and have very sleek small circuit which will give you good efficiency.