Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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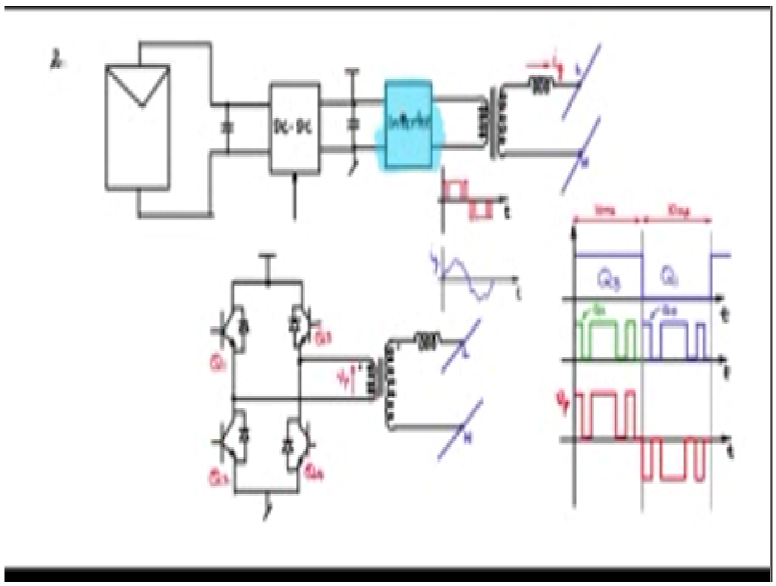

Let me now discuss another topology here what I will do is I will remove the DC-DC converter plus unfolding stage and replace it with a single power stage which is called the inverter stage it is a DC to AC converter. Let us have a look at that topology, we have the photovoltaic module as usual connected to a DC-DC converter and the DC-DC converter output is connected to a capacitor there is a buffer capacitance, and that acts as an input to the inverter.

So the inverter will take the DC input from here with the output of this DC-DC converter and the output of the inverter will get connected to an isolation stage which is a transformer isolation followed by an inductor which gets linked to the grid line and neutral of a single-phase system. So if you look at the inverter output the inverter output will be switched as switched AC, if I draw the waveform versus time you will see pulse width modulated switched waveform in this fashion.

So you see the pulse width modulated waveform is switching at high frequency, but the fundamental is 50 Hertz. So which one filtered by this inductor will give you a filtered current. So if I plot the current, the current will be filtered because the inductor and it will have this kind of almost both and 50 Hertz waveform, but it will have some switching harmonics. Now let me see what goes into this inverter how this inverter look like.

Take a single phase inverter, let me draw the single phase inverter which is a full bit circuit, I am using BJTs now, but remember that you can replace the BJTs with MOSFETs or IGBTs as depending upon the power and switching frequencies. So this point I will connect it to the negative of the DC-DC convertor and the positive of the bridge I will connect it to the positive of the DC-DC convertor.

This forms the VDC bus or the VDC link voltage applied to the input of the inverter, there are of course diodes which you need to put reverse conducting diodes they are needed here to provide freewheeling paths, I will explain that. So now let us say that you have this inverter and from the centre point I will bring it out to a transformer and the transformer secondary connected to an inductor which is connected to the grid in this fashion line and in order.

Let me now name the switches Q1, Q2, Q3, Q4, let us see how you would like to give the dry pulses for Q1, Q2, Q3, Q4. So that we get a voltage waveform across the primary in the secondary of the isolating transformer in this fashion, and the current along this wave shape line. So therefore, I would like to draw few access, time axis. So I will take 3 time axis, this one is for Q1 and Q3 gate base drive, this is for Q2 and Q4 base drive. And the last one third one is to see the voltage waveform across the primary of the transformer.

So let me divide the graph into two portions ten millisecond portions, so this is one fundamental this whole thing is one fundamental 20 millisecond period are divided into two half periods ten millisecond, ten millisecond, and let us see how the switching waveforms look like. S for Q1 and Q3 I will use the top okay. So during this period where I am showing the cursor, let us switch on Q3 and during the period when this waveform is low, I will switch on Q1 what it basically means is that I will invert it and then give it to the Q1.

This wave shape, this base drive will go for Q3 inverted base drive will go for Q1. So Q3 and Q1 are switched every 10 milliseconds, switched on every 10milliseconds, which means they have a switching period of 50 Hertz. Now for the bottom MOSFETs, now let us stick Q2, now Q3 is on, so I will drive the diagonally opposite MOSEFT Q2 to run seven Q2 is given a pulse like this during the time and Q2 is on, that during the pulse time this point is connected to minus of the DC-DC converter.

So Q3 is already on which means this point is already connected to the plus of the DC-DC convertor, so across the transformer you will see the full DC bus voltage. So if I say this is VP then you would see VP the full voltage. Now let us say Q2 has gone off Q3 was on Q2 has gone high and low, what will happen to the voltage across VP, there was a when Q3 and Q 2 were on there was a current flow like this.

And when Q2 switched off current flow continues because the reflected inductances and leakage inductances it will flow through this path. I am showing through the cursor from here Q3 through the primary winding flows to the other node, Q2 is off therefore it will go up through the body diode and then keeps coming back because Q3 is on. So this potential and this potential are same now and therefore V B is zero.

So even if Q2 is on we will have VP is 0 during that time when the Q2 is off also. So let me complete the Q2 wave shape, so this is the base driver will give for Q2, so when our Q2 is low also you will see VB going to zero because of freewheeling action and these two potentials being same. So I will draw that in that fashion. And now the next 10 millisecond Q1 has come into the picture Q3 is off, Q1 has come into the picture.

And you have to switch Q4, so Q4 will be switched on in this fashion pulse width modulated high frequency and because Q4 is switched on this dot end point is connected to the negative, the non dot end is connected to the DC bus. Therefore, we see a negative voltage when Q4 is being switched, so during the time and Q4 is on you will see a negative voltage coming across VP because dot end is connected to the negative non dot and is connected to the positive.

And when q4 is switched off you will see that there is a path for it to freewheel in this fashion up again like this. So you will see that both are at same potential VP is zero, so like that it continues and you will get a pulse width modulated waveform like this. So you will get this positive and negative pulse width modulated switched waveform like this, and the currents this waveform is available here, minus the grid voltage waveform which is VM sinωt will be available across the inductor which will integrate it and integrate the current and current will be in this form kind of the smoothened waveform with switching harmonics.

So therefore, this is another topology where we have removed the DC-DC converter and the unfolding stage two stages power stages have been clubbed into one single inverter stage thereby improving the efficiency.

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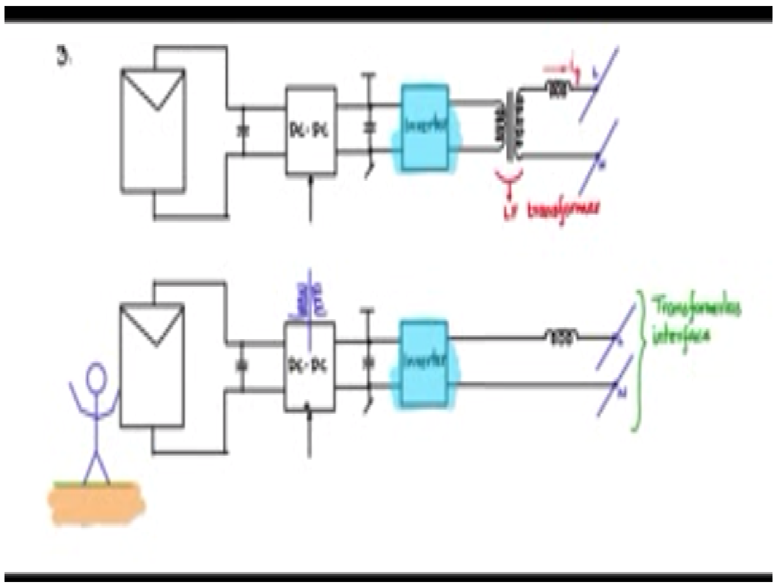

Consider this topology where we have used an inverter and an isolating transformer this transformer is a low frequency transformer, it is an LF transformer because the currents flowing there is 50 Hertz and the flux within the core is 50 Hertz and therefore, you have to design this transformer fault handling flux at 50Hertz. So it will be a low frequency transformer. Now this will be big bulky expensive and very heavy.

So that is one of the major disadvantage of this transformer, so there are apology in the literature which do away with this transformer something in this fashion I have duplicated this, I will remove this transformer and then I will just put an inductor, and then connect it to the grid in this fashion line in neutral. Now this topology does not have any transformer right from the PV module to the grid.

But still it will work it will pump power into the grid, and this is called a transformer less interface. One problem with such an interface is though it will work one has to be a bit more careful with respect to safety. Now let us say that I have a ground here, and a person is cleaning the PV modules and he's in contact with the PV modules, and the edges of the PV modules have aluminum beadings.

And if there is an electrostatic discharge and it could discharge through him into the ground which is the physical ground which is at absolute zero potential, even if there is a neutral and the earth at a different potential there are chances of shocks for the person who is cleaning the PV modules. Therefore, it is recommended not to go in for a transformer less interface, but to put the organic isolation, magnetic isolation somewhere in the path in between even if it is not a low frequency at least a high frequency transformer so that the person cleaning the PV module is protected.

So therefore, in some of the topologies you will see that the transformer has been shifted to the high frequency portion that is in the DC-DC converter one can use a high frequency transformer here isolation here, and still how isolation along with a much more compact component count compared to this kind of a very heavy big and expensive LF transformer. Let us briefly look at how this DC-DC converter with isolation looks like.

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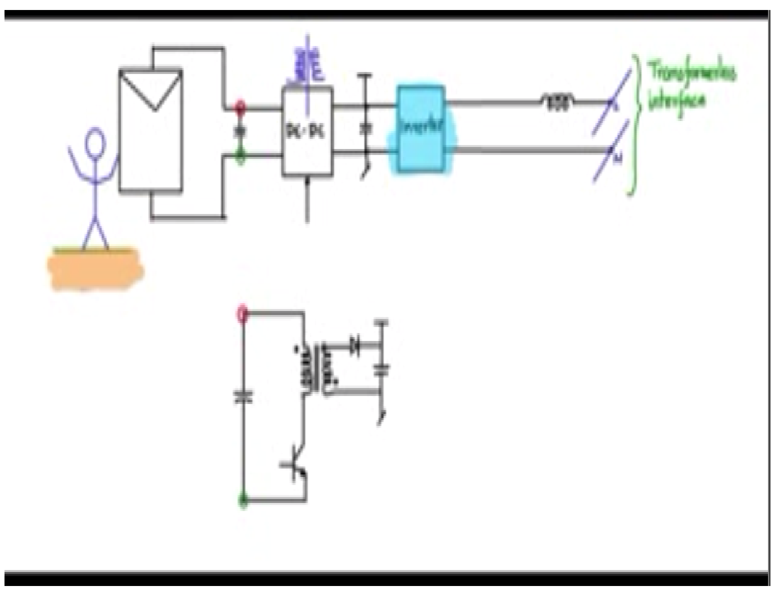

Consider this topology let us look at this DC-DC converter portion where we would like to introduce this high-frequency isolation. Now I will use a fly back converter topology which is the isolated version of the buck boost topology, because the buck boost topology can handle the entire first quadrant of the static curve of the PV module fly back can also do that similarly.

But there is no hard and fast rule which converter you will have to use here you could definitely use a forward converter half bridge, full bridge converter push pull converter one of them one of the isolated topologies. Now this capacitance is same as this capacitance let me indicate this point is same as this point and this point is same as this point. So this is actually a fly back inductor which gives you the isolation this switch is switched on and off at high frequency this is a high frequency magnetic.

The secondary of this fly back transformer is connected through a diode to a capacitance, so that you get a DC voltage across this capacitance. Now be careful with the dot polarity in a fly back capacitor these two are opposite poles when the transistor switch is on, it will charge up this magnetic, this dot is positive, it will charge up this magnetic which is acting like an inductor . Ad when this is switched off whatever magnetically stored charge is there it will get released in this fashion.

And this was on this was positive, when this switches off this becomes negative the non.n becomes positive. So non dot.n will make the diode on and tart of this capacitance. So that is how the fly back converter works. Now observe these two points this point is same as this point I will put that, this point is same as this point as the rest of the inverter and the inductor are connected here.

So in this way you have shifted the isolation to the high frequency point thereby, making the whole system more compact, because the high frequency transformers are very compact.