Fundamentals of Power Electronics
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Lecture - 77
Full bridge converter

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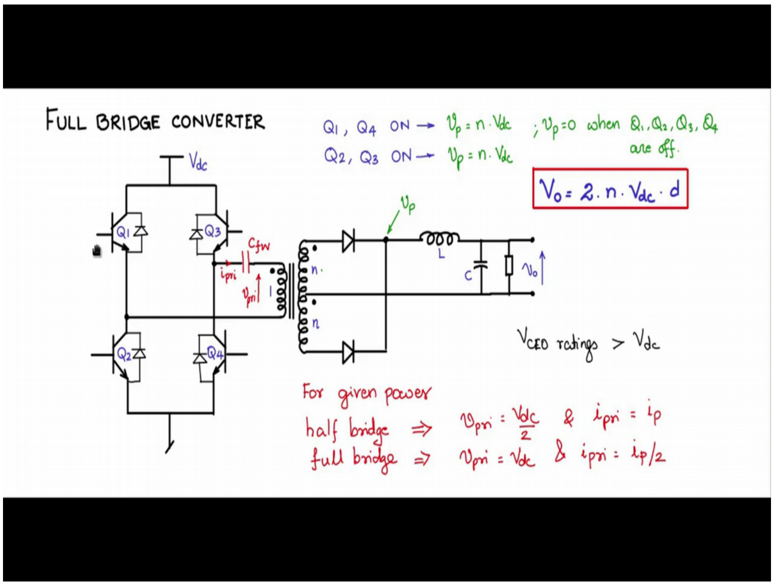

One of the most popular converters at high power is a full bridge converter, the topologies like this; you have 4 switches. In fact, it is comprised of 2 half bridges; see you have one arm switch 1 switch 2 top you have one top switch, one bottom switch. You have another arm, one top switch another bottom switch connected like this, and both are both arms are connected to V dc in this fashion.

Now, if you take the centre points of these two bridge arms, we connect the transformer across them. So, I am completing the circuit with body diode for the sake of completeness. They help in during freewheeling operations; so, you have Q1, Q2, Q3 and Q4.

So, across the centre points we will connect the primary of the transformer, the secondary of the transformer like in the case of the half bridge. You have the 2 diodes and through with respect to the centre tap we have the inductor, capacitor and the load which is operating as a buck derived converter. It is a buck a operating in the buck mode, but with O ring effect as in the case of push pull and also as in the case of the half bridge converter, operation is exactly similar.

Now, this V naught say C L, I will put the dot polarities like this. Now, let us this V dc; let us consider the case, you are now operating the switches in pairs, Q1 and Q4 will be turned ON simultaneously. Q2 and Q3 will be turned ON simultaneously; however, when Q1 is ON Q2 Q3 will be OFF, when Q2 Q3 are ON Q1 Q4 are OFF.

So, Q1 Q4, when they are ON; Q1 is ON means that the non dot end is connected to V dc, the dot end is connected to ground through Q4. So, what appears across the primary plus minus in the is in this fashion. So, the non dot end is minus, dot end is plus, this is the pole voltage v p, so, let us look at that. So, when you measure across a primary you get V dc measured in this fashion.

And the non dot end being positive, the bottom diode here is active and then it will supply power to the inductance v p will be n times V dc . If you take a turns ratio 1 is to n. So, V p will be n times V dc we will write it down, and during the time when Q2 and Q3 or ON; these 2 are ON simultaneously. You will see that Q3 is ON means dot end is positive and non-dot end is negative Q2 connected to ground.

So, secondary side also you will see the dot end positive non-dot end as negative. So, the primary voltage is V dc it will translate into n times V dc and v p will be n times V dc during the time. And during the time when v p is 0 when is it, when all the 4 switches Q1, Q2, Q3, Q4 are OFF.

So, when all these 4 switches are OFF, the inductor current is freewheeling and like as before in the case of the push pull converter and in the case of the half bridge converter; the secondary side is centre tap. The inductor current divides splits here exactly by half in to the top winding and into the bottom winding it goes into the dot end in the bottom winding, it goes in to the non dot end in the top winding.

The mmfs so, generated are opposing and cancel each other in the core and the flux does not change. So, d phi by d t is 0. And therefore, the induced voltage across all the windings are 0 and vp will be 0 and so, also the voltage across the primary.

So therefore, when you take V naught, V naught is with respect to v p; this is n times V dc v p is having double the duty cycle as that of the switches. So, n times V dc into 2 d and re-writing 2 into n into V dc into d. Now, this is the input output relationship for the full bridge converter. Now, let us say V CEO rating for the switch, like in the half bridge is maximum V dc. So, when Q1 and Q2 are ON, Q2 Q3 are OFF and you will see that Q2 is connected to V dc, Q3 is connected to ground through Q4 and therefore, Q3 has to be stand V dc Q2 has to with stand V dc .

Now, when Q2 and Q3 are ON Q1 is connected to ground Q1 has to with stand V dc, Q4 is connected corrector is connected to V dc and Q4 has to withstand V dc. Therefore, all 4 switches need to withstand V dc and they have to be rated for greater than V dc. In the half bridge convertor also the each of the switches were supposed to be rated for V dc, only in the push pull converter the switches need to be rated for 2 times V dc.

Now, in the case of the full bridge converter also we see that there is a requirement for solving the flux walking problem. Wherever, this kind of a situation occurs where you are having switches and practical or non-ideal switches and you are having a winding connected in this fashion, there is a chance of an average voltage occurring across the v primary.

Because when Q1 and Q4 are ON the voltage across a primary will be V dc minus v ce sat of Q1 v ce sat of Q4. And when Q2 and Q3 are ON it is V dc minus v ce sat of Q2 v c sat of Q3. All the v ce sat Q1, Q2, Q3, Q4 will not match and therefore, there can be a primary average voltage. And, this will get integrated and a there will be a flux which will have a proportionally with respect to time, when the flux will be increasing with time and ultimately saturate this core. Now therefore, you need to provide flux working and just like in the case of the half bridge and push pull case you can provide flux walking by adjusting the duty ratios of Q1 Q4 and Q2 Q3 set.

Alternately, like in the case of the half bridge, you have the primary winding which is a single winding not centre tap. Therefore, you can place a capacitance flux walking capacitance which will prevent an average flux occurring in the winding, and it the C fw or the flux working capacitor will absorb the average voltages. So, in this way flux walking can be avoided in the full bridge also, but note that full rated current has to flow through the capacitance here.

Now, let me mark i primary and v primary here and what is the difference between half bridge and full bridge. For a given power, given output power; let us say in case of the half bridge. The primary voltage is V dc by 2 recall and let us say the primary current is some value i p. For the full bridge case, for the same power if you take v primary voltage is V dc that is fixed by the topology. And the primary current for the same power has to be half as that of the half bridge should be i p by 2.

So, that the product V dc by 2 into i p and V dc in to i p by 2 are the same to realise the same power. Therefore, in the case of the full bridge converter to realise the same output power, you need to rate the switches half of that of the comparable half bridge converter, and this is the advantage of full bridge converter. However, you need 4 switches and 4 gate drives for the full bridge converter as against 2 switches and 2 gate drives for the half bridge converter.