DC Power Transmission Systems
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Lecture – 59
Non-characteristic harmonics

Today we will look at a topic which is relevant to harmonics and filters. We have seen that there are some harmonics that are always present. Even if I consider the simplest model on the AC and DC sides. So, the simplest models of the converter, I mean the simplest model of the AC side of the converter is just a three-phase balanced voltage source and the simplest model on the DC side is a constant current source.

So, we know that there are harmonics in the AC side current and the DC side voltage. So, the sum of these harmonics, in fact, infinite number of harmonics to be precise, half the number of harmonics are eliminated if I use what is known as a 12 pulse converter, but still there are harmonics.

So, these harmonics are known as characteristic harmonics. Now, these harmonics are present in spite of having a ideal conditions. So, say by ideal conditions what I mean is the AC voltages or are actually balanced, and the three-phase network is symmetric. That means, the impedance that comes on the AC side, the series resistance or series inductance are identical in all the three phases.

And we also assume that the pulses are exactly given at the required instance and with all these ideal conditions or assumptions, we get some harmonics. These are known as characteristic harmonics. Now in practice, there can be unbalance in the voltages, there can be a difference in the resistance of the transformers of the which are I mean which are feeding the 2 bridges in the 12 pulse LCC.

If you take a 12 pulse LCC, there are 2 transformers: one Y-Y connected transformer, one Y-delta connected transformer. So, these two transformers have a resistance and a leakage inductance. So, there can be a difference in the resistance and leakage inductance of these 2 transformers. So, that will result in something which will not cancel out to the harmonic. Say if you take 12 pulse LCC, some harmonics get eliminated. Now, that is based on some assumptions.

So, one can actually prove. Though, we proved it in the case of ideal transformer, even if I add an impedance which includes the resistance and leakage reactance, as long as the leakage and reactance and the resistance are same for both the transformers, I can still eliminate. But, if they are different, then there will not be complete cancellation.

So, there are some harmonics which are supposed to be canceled and do not get cancelled. So, they are called non-characteristic harmonics.

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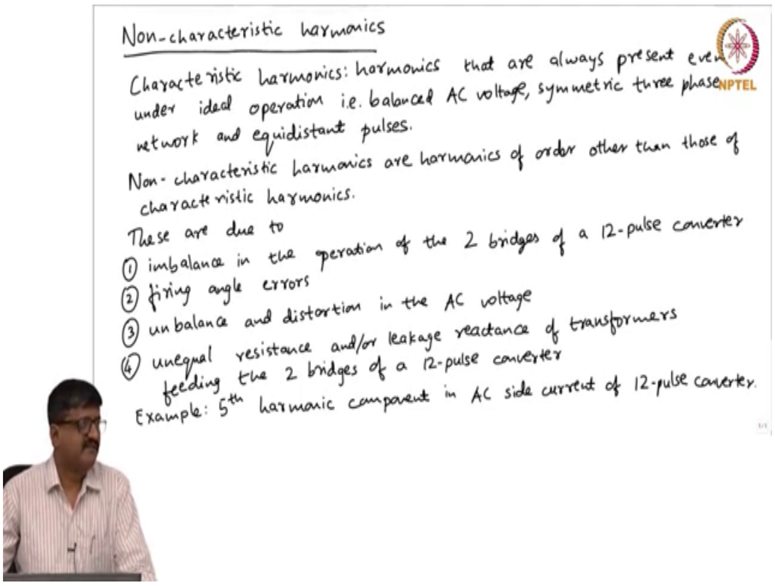

And some harmonics are actually present due to other conditions which i just mentioned. Unbalanced AC voltages and the network itself the three-phase network itself is say, not symmetric we can actually categorize the harmonics into 2 types, one is characteristic harmonics, the other one is non-characteristic harmonics.

So first of all, let us define what is known as characteristic harmonics. So, characteristic harmonics or the harmonics that are always present harmonics that are always present, even under ideal conditions even under ideal conditions or ideal operation. So, what we mean by ideal operation is, balanced AC voltages in the three phases. And the three-phase network itself is symmetric.

So, symmetric three-phase network and the pulses are given at the right instance. That means, if I take a 6 pulse converter, if I give a gate pulse at some instant, exactly after 60 degrees, I have to give one more gate pulse to the next thyristor. Similarly after 60 degrees I have to give the next gates. So, the distance between any 2 consecutive gate pulses should be same.

So, we say equidistant pulses equidistant pulses ok. So, this is the definition of characteristic harmonics. So, non-characteristic harmonics or harmonics other than characteristic harmonics. So, by definition non-characteristics harmonics or harmonics of order other than those of characteristic harmonics.

Now as I said there are many reasons for non-characteristic harmonics. So, so, these are due to, so, I will distort some of the reasons imbalance in the operation of the 2 bridges. So, that I am referring to the bridges of a 12 pulse converter of a 12 pulse converter. Then, there can be firing angle errors. Now the AC voltage itself can be unbalanced or there can be distortion.

See, we assume sinusoidal waveform. So, there can be distortion. Distortion means deviation from sinusoidal, so, unbalance, undistortion in the AC voltages. Now, there can be an imbalance in operation of the 2 bridges, there can be an imbalance in the 2 transformers also as far as the resistance and leakage inductance is concerned.

So, unequal resistance and or leakage reactance of transformers feeding the 2 bridges of the 12 pulse converter of transformers feeding the 2 bridges of a 12 pulse converter say bridge is a 6 pulse converter feeding the 2 bridges of a 12 pulse converter.

Student: (Refer Time: 08:52).

Yes.

Student: One and the you are saying that non the non-characteristic harmonics are those which are of order than the characteristics.

Yes.

Student: Is it possible that we have the same order and its (Refer Time: 09:05).

Yeah, the same order also may have a change in the magnitude.

Student: Yes.

That is also there.

Student: That is also non-characteristics.

No, by definition this is a definition by definition, we call non-characteristics as those harmonics of order which are ideally not there, but they just come up because of these reasons.

Student: Yes and also it can be like if eleventh order was having some magnitude a.

Now, it will have a different yes.

Student: Different.

Yes it may have.

Student: That is also because of non-characteristics.

No, by definition.

Student: Ok.

See this is just a definition

Student: Ok.

The definition given in books is this.

Student: Ok, ok.

I mean by non-characteristic we mean in harmonic of order which was not there earlier which has now come.

Student: Ok

Ok, but that does not mean that the characteristic harmonics will remain same, they may change in magnitude.

Student: Ha ok.

They may change in magnitude due to these reasons

Student: Yes.

But its unlikely that they will go away, it is still there. But we know that at least that order is there. Even in ideal operation that order is there

Student: Order is there, ok.

So, what I am trying to say is if you do some measurement using some meter ok. So, there are meters available to measure harmonics you know, you may see that some harmonics which are not supposed to be there is coming. Suppose you take a meter and see fourth harmonic is there.

Student: Yes.

Now, you may be wondering why it is there? Ideally, it should not be there but, it can come due to some reasons. So, the reasons are these

Student: And the one more question was that we assume unequal resistance and leakage. So, since it is root 3 into the other one, its almost like double number of turns. So, lengths will start (Refer Time: 10:40).

See, I made one assumption you recall what? When I mean, I stated this assumption, I assumed that the resistance and leakage reactance

Student: (Refer Time: 10:50) are same.

Are same. If they are not same, there will be no cancellation, perfect cancellation. I made that assumption. Now, that assumption is strictly not true, but the point is they are small. This resistances and leakage reactances are small. So though there will be not complete elimination, there will be a drastic reduction in all those harmonics which are not supposed to be there ideally.

Suppose, I take fifth harmonic it will not get completely eliminated. So now, if you thinks are actually stated in order to understand what is happening. So, under ideal conditions something happens, but in practice we never get that. In practice we never achieve that, obviously. But see the point is this a fifth harmonic is not fifth harmonic component is 0, ok. Fifth harmonic component is 0.0001 percent of fundamental. Now, in practice both are same.

Student: Yes.

So, that is what we get in practice. So there is a difference. Mathematically, 0 and non-zero are different.

Student: Yes.

But in practice, what we mean by 0 is not 0, negligible. That is all. So these are the reasons which result in non-characteristic harmonics. So for example, ok. Let me give an example um. So, this is just one example there can be many other examples. Suppose I have fifth harmonic component in AC side current of 12 pulse converter.

So, I am giving an example of characteristic harmonic or non-characteristic harmonic?

Student: Characteristic, non-characteristic.

It is non-characteristic. See, fifth harmonic is characteristic for 6 pulse for 6 pulse.

Student: 12.

For 12 pulse it is non-characteristic.

Student: Non-characteristic.

It is not supposed to be there, ok. So, this is an example of non-characteristic harmonic, ok. So that means, what was supposed to be eliminated may not be eliminated if there is a large imbalance in the operation of the 2 bridges. Or resistance and leakage reactances are not very close, ok.

So, I mean instead of trying to give more examples, let us take one case in detail and see exactly the generation of a non-characteristic harmonics. So, there are many ways in which non-characteristic harmonic can get generated. So, I said one of the reasons is firing angle error. So, let me take that example.