DC Power Transmission Systems
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Lecture - 58
Type of MTDC systems

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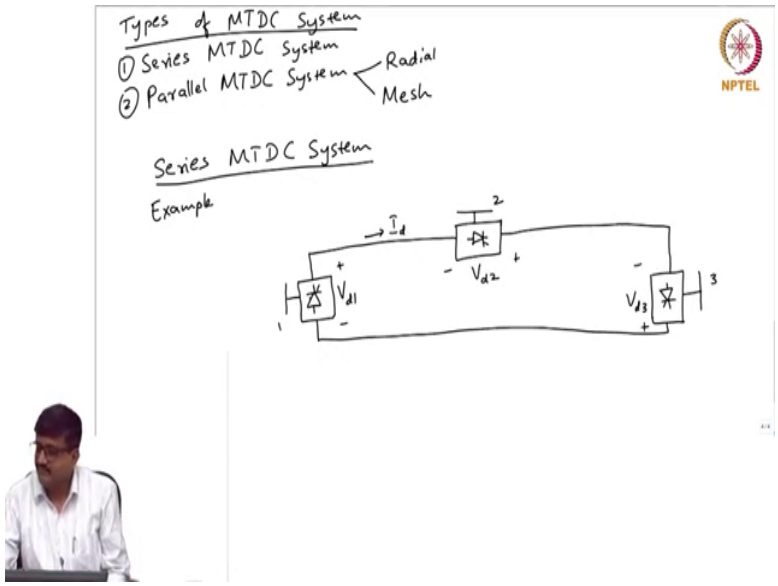

There is some classification possible for the MTDC system. So, let us see whether we can categorize the MTDC systems into a few types; types of MTDC system. There are two broad categories: one is series MTDC system, and parallel MTDC system. And in parallel again there are two types: one is radial MTDC system other one is mesh MTDC system.

Now, as we have been discussing so far, I will not try to start with a precise definition of what is series, what is parallel. We will try to give an example ok. So, example will convey better instead of trying to formulate a definition. So, if I want to know what is series MTDC system I

will start with an example. See, all the figures that were drawn in this class so far are just examples. So, let me take an example. So, I show the AC bus using a short straight line segment that is the usual symbol used even in the single line diagram.

And the schematic diagram of a converter is just a box rectangle or a I mean it is just a square with a thyristor shown ok. I will show it this way. So, I have shown three buses: bus 1, bus 2, bus 3. Bus 1, bus 2, bus 3 are far away, your distance between 1 and 2 is a say a few hundred kilometers between 2 and 3 it is a few hundred kilometers between 1 and 3 it is a few hundred kilometres and at each bus we have a converter.

So, on the DC side there are two wires; I will show the wire one wire like this one wire like this, one wire like this. So, if you look at any converter there are two wires shown these are the wires of the DC side ok. Now, what I am trying to say is this is an example of a series MTDC system. So that means the current is same in all the DC current is same in all the three converters. So, if I want one of them to operate as a rectifier and at least one should be operate as rectifier at least one should operate as inverter. Now so how do we decide the operation as I mean suppose we decide some converter to operate as rectifier. So, how do we get that rectify operation?

Student: Sir, (Refer Time: 03:58) alpha.

That is obvious so alpha ok. So, if I mean we know that alpha I mean close to 0 is rectifier operation alpha close to 180 degrees is inverter operation. So, depending on the choice of alpha we can ensure the, I mean we can ensure that we get the required operation. So, if I try to operate a few thing as rectifier and few thing as inverter; one of the converter is at least a rectifier one of the convert is at least a inverter.

Then the polarity of the voltage across the DC site terminals is dependent on whether it is rectifier operation or inverter operation ok. See the polarity suppose I take the polarity of this with respect to this, a polarity of this with respect to this, polarity of this with respect to this. Suppose, I call this V d 1, V d 2, V d 3 and the current is say I d ok. Now, at least one of

these V d 1, V d 2, V d 3 should be positive and at least one of these V d 1, V d 2, V d 3 should be?

Student: Negative.

Negative. If it is positive it is rectifier it is negative means it is inverter.

I d is positive; I d is positive, V d 1, V d 2, V d 3 can be positive or negative. If a positive V d 1 or V d 2 or V d 3 means, the respective convertor is operating as rectifier. Similarly, negative voltage means inverter operation. So, is this clear?

Student: V d 3.

Oh, sorry. So, this is plus sign this is plus this is minus ok. So, this is just an example; this is just an example. Now, let us. So, I mean it is may not be; I mean straight away obvious why we call this series; maybe after looking at an example of a paralleled MTDC system then it may become clear why we call the series ok. Of course, one way is we see that the voltages are the D C voltages, I mean if I add the DC voltages where I can apply Kirchhoff's voltage law.

And say that V d 1 plus V d 2 plus V d 3 are adding to 0 ok. So, these three voltages are in series; these three voltages are in series. So, the D C side terminals are connected in series. So, that is one possible way of defining series MTDC system in the case of parallel MTDC system; I mean the DC voltage terminals are connected in parallel ok.

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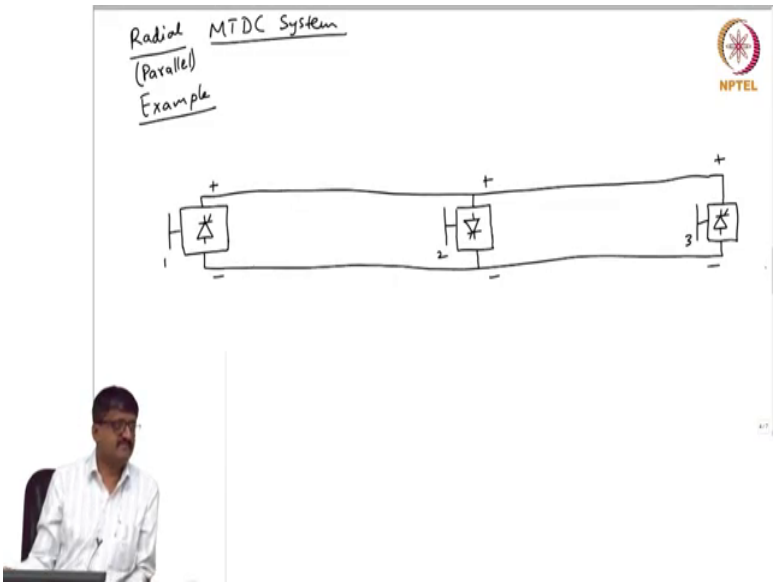

So, again I will take an example first I will take the example of a radial system; radial MTDC system.

So, radial means it is parallel MTDC system. So, again instead of giving a research definition, I will first give an example which conveys better. So, again I will show three buses and at each bus there is a converter. So, on the DC side there are two wires; I connect a the positive terminals of all the converters similarly, I connect the negative terminals of all the converters.

So, looking at the way I have shown the schematic diagram of the converter 1 can see that the converter at bus 2 is shown in a different way compared to the converters at busses 1 and 3. That means, if 1 and 2 a 1 and 3 are operating as rectifier then the converter bus two is operating as inverter ok. Say, the schematic I have shown is like that.

Now, this is an example of an MTDC system again please note the distance between 1 and 2 is a few say a few hundred kilometers distance between 2 and 3 is a few hundred kilometres. And similarly between 1 and 3 is also a few hundred kilometers. So, they are far away. Now, this is a parallel system. So, it may be obvious why it is called parallel because the DC sides a DC side terminals are connected in parallel, but it may not be obvious why it is called radial?

Why it is called radial?

So to understand the difference between the two types of parallel MTDC systems; one is radial another is mesh. I will give you an example of mesh, then we will come back to differentiating parallel I mean radial MTDC system and mesh system MTDC system.

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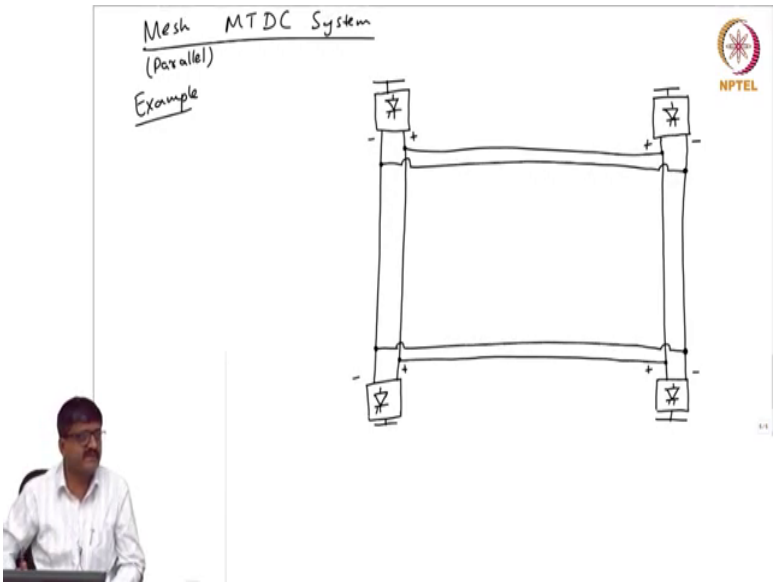

Suppose, I take the mesh MTDC system. So, again these also an MTDC system which comes under the category of parallel MTDC. So, let us try to look at an example. Suppose, I have four busses of the AC system and at each bus I have a converter. So, here I have an example of what is called as a mesh MTDC system four AC buses four converters at least one of them operating as rectifier at least one of them operating as invertor.

Now, I mean it should be obvious why it is called parallel. We are connecting in all the DC side terminals in parallel if you take all the four converters the DC side terminals are connected in parallel, but why it is called mesh what is the difference between mesh by looking at the example of this mesh and the example of this radial. Why; what is the difference? Do you see any difference?

There is a loop which is formed. See, the point here is even if there is loss of one transmission lines there is a connection between any converter and any other converter. Suppose, one of the there are four transmission lines here one transmission line is lost; that means, we disconnect still there is a connection established which can be established between any two converters. So, that is possible only if you have a mesh connection. Now, this is similar to the AC transmission system or AC transmission systems are mesh connections unlike most of the distribution systems which are?

Student: Radial.

Radial. See when it is ray if you have a radial connection if you lose one feeder or one transmission line then you will form islands; you will form islands. But, in a mesh system if you lose one transmission line then the system is still interconnected ok. So, that is what is the difference between radial and mesh. Now, mesh will have of course now, I mean it appears as if we have some redundant connections, but that is for the sake of?

Student: (Refer Time: 13:35).

Sake of what?

See we.

Student: Reliability.

Reliability, but looking at these examples and explanations.

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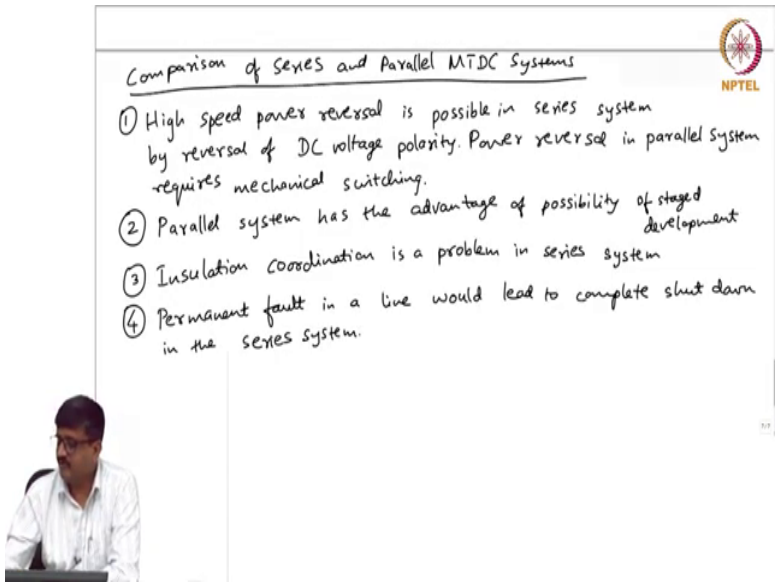

We will say whether we can do a comparison of series and parallel systems; series and parallel MTDC systems. Now, do you see any says comparison means maybe one of them has an advantage other has a disadvantage do you see any such possibility?

Let me go back to the example, suppose I have a series connection I want to change the operation of one of the converters from rectify to inverter or inverter to rectifier. What I do? I just change the.

Student: Alpha.

Alpha that is very easy in the case of series come to MT this parallel system. I want to change the operation of one of the converters from rectifier to inverter or inverter to rectifier what should I do?

Student: Alpha has (Refer Time: 14:59) the connection.

I have to change the connection also; I have to change the connection. That means, I need a mechanical switch there is a mechanical switch required whenever I have parallel MTDC system that is what that was not required in the case of series ok. So, there is one disadvantage of series sorry parallel systems that is high speed say I may actually do the reversal of power flow in the case of series instantaneously I mean in a fraction of a second.

Because changing alpha takes only one cycle. In one cycle alpha was such that the operation is as a rectifier. In the next cycle, I can make it an inverter ok. So, high speed power reversal is possible in series system; series MTDC system. By reversal of D C voltage; by reversal of d c voltage polarity. So, when it comes to a power reversal in parallel MTDC system; power reversal in parallel system requires mechanical switching.

Because, you cannot just change the polarity of the voltage in the case of a parallel system; you cannot just change the see always see when you look at the parallel MTDC system. Suppose, this is plus and this is minus this is plus and is minus plus is always connected to plus and minus is always connected to minus. So, you cannot just change the polarity of the voltage in the case of parallel.

So, that is what we have done even in the case of mesh. So, all the pluses are connected by interconnected all the minuses are interconnected ok. Then any other advantage or disadvantage of one of the systems over the other.

Student: (Refer Time: 17:24).

Yeah! When it comes to a parallel connection, what is our I mean our conventional AC system is parallel or DC mesh sorry parallel or series?

Student: AC

Ac system the AC system that we know.

Student: Parallel.

They are parallel; they are parallel. See the see in series system through all the equipment the same current flows, but that is not the way it work it works. In the parallel system all voltages are same, but not current in series system current is same voltages is different. So, if I want to change the power in the case of series voltage is changed because current is same in all the equipment in the case of parallel system voltage is same, but current is changed in order to change the power ok.

Now, one advantage of parallel system is that there is a possibility of a staged development which actually happens in practice. Parallel system, has the advantage of possibility of staged development. So, it; so it seems that I mean we prefer parallel whether it is DC or ac because of some advantages which will over weigh the disadvantageous. Say the only advantage of series is size speed power reversal in the cases of MTDC systems.

We will see that for all in all the other aspects of parallel is actually better. So, when it comes to insulation coordination; Insulation coordination. Now, Insulation coordination; you may have some idea of insulation coordination and you will be very knowledgeable if you have studied a high voltage course. Now, which has better insulation coordination series system or a parallel system?.

Student: Parallel system.

Parallel system say in series system the insulation at any point is dependent on the?

Student: Current.

Current that is flowing ok. So, though the current is constant the voltages are actually variables see the voltage which is as actually produced by the converter is a variable. So, insulation coordination becomes a problem in series system is a problem in series system ok. Then there is one more advantage of parallel system that is.

Because if a permanent fault occurs; permanent fault in a transmission line occurs in a series system it would lead to complete shutdown; would lead to complete shutdown in a serious system. Now, why is this happening? See, if you look at the case of this example of series. If there is a complete shutdown then you cannot operate the system because you need each of these components suppose you take the wire between converter 1 and 2 wire between 2 and 3 or 3 and 1.

All these wires are required for the entire operation of system even if one wire is actually not working, the series system does not work. On the other hand, if you take a parallel system suppose the connection between 2 and 3 is lost. I can still have the connection between 1 and 2 intact I mean I can still transfer power between 1 and 2 ok.

So, operation of the parallel system is still possible if I remove one of the lines, but that is not the case in the case of series. Because, the series I mean the connection would not get I mean the circuit would not be completed without even one wire. If one wire is lost I mean the connection is lost and the circuit would not be completed ok. So, that is one disadvantage of series. So, if you try to see the comparison I mean it seems the parallel system is better than the series system ok. I will stop here.