High Voltage DC Transmission

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Module No. # 04

Lecture No. # 01

HVDC System Faults and Protections

Welcome to this new module that is, a module number 4 and which is basically; the HVDC system faults and protection and today. I will discussed the lecture one and in this we will see the various faults; in HVDC system including. AC as well as the DC side and then; we will see; what are the repercussions what will be the problems during these fault conditions; and then at the end. I will discuss about the protection scheme for the HVDC link.

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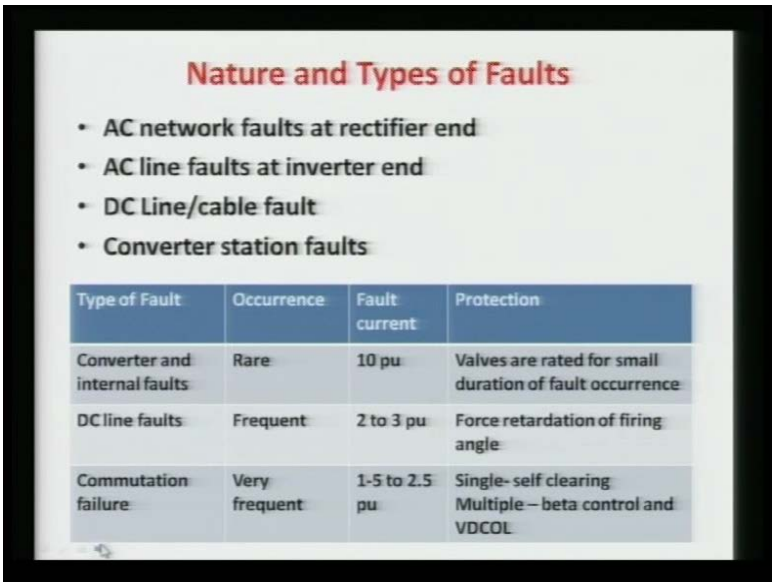

We know HVDC system basically; we are having if, you are talking about two terminal HVDC link. So, we are having one rectifier; we are having one inverter and the both side is a AC system is there so, the fault can be the rectifier and AC system; and also it can a (( )) the fault may be there and another there is a possibility that fault in the converter itself in the station itself.

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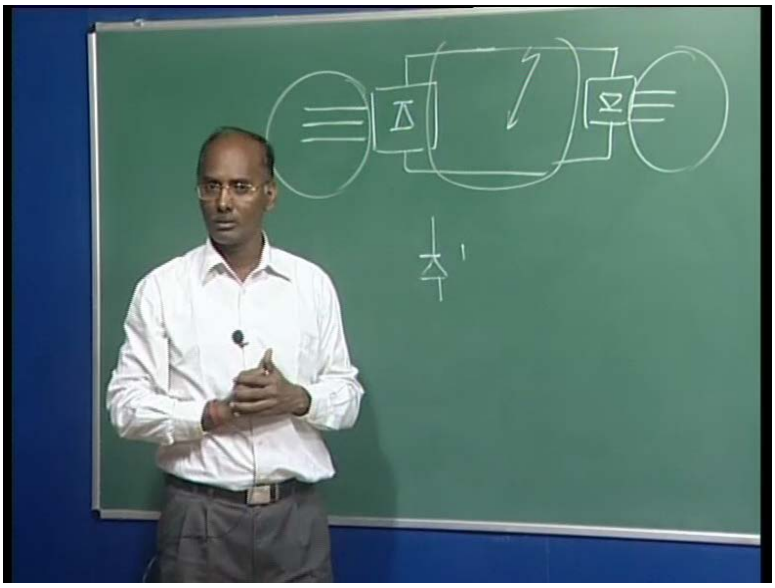

So, general here in HVDC transmission system; if, we are taking the two terminal systems here, is a three phase system and here, we are having the DC supply here the line and this is your inverter and you are having here; three phase supply system. So, fault may be this side fault may be this side fault may be in this DC line or cable whatever; it is and then it may be the possibility, that there is a some problem; here, in the converter or inverter station itself.

So, if the fault occurs this side no doubt it is a AC system and the protection of AC system is very strong. We are having the protective relays; we are having circuit breakers and then it will take care of that fault but no doubt any protects protection system in AC system. It requires several cycles to figure out the your reliable sense; the fault then it will give the signal to your circuit breaker and then circuit breaker will operate; it may require 2 to 5 cycle during that period this; your converter station will experience a very excessive either; the voltage high or voltage low depending on your fault.

You know very well that is, a fault in the AC system can be a symmetrical fault means that is, a nothing but is a three phase fault or it can be a symmetrical fault. It may be line to line fault; it may line to ground fault. It is it two lines to ground fault and on so for and depending upon that fault the voltages in the phases are wiring. If it is a dead three phase fault means the voltage will be 0 and then at that time here ,the DC voltage will be 0 and

your current situation would be the different you are the converter control will be acting accordingly; during the fault if, suppose it is happening here.

No, doubt this A C protection system will take care of the fault. If, it is happening this side but during that fault duration. This your link controller will act because the control action is very fast compared to the protection system here; and your system will be adversely; effected.

Now, here, the voltage may rise also depending upon the a symmetrical fault. If the fault in one line is there is the neutral is not connected properly. The voltage of other field may be go above that is, a voltage over voltage may experience; by this converter may be under voltage side may be there and of course, sometimes voltage may be 0. So, I am not going to discuss in detail because we are not concern about the A C protection system our concern here, is HVDC faults and the protection.

So, here we are talking inside the system the DC in this converter including. This rectifier and u d c system. So, that is why here, I have a classified there is a four type four sub group. I can say this is a first one this is your rectifier side; fault this is your inverter side AC fault and then the fault corresponding. To this DC system and third is in the converter station itself. So, it can be categorized in the four faults here.

Major concern here; in the converter station because if, there is some problem here in the valves firing misfiring whatever; the happening here, that is, a directly related to that it will inject the harmonics in the D C side as well as; it will introduce various harmonics in the A C side as well.

So, we have to see; what is the various mal operation of this converter station. Let us, see your rectifier including your inverter as well if the fault across this side in the DC line you can see here, I have a made of table you can see this converter and internal faults are very rare no doubt. I am talking about the faults inside; what will be the fault we will discussed in this later itself in this lecture itself. But the current here; can go very high because the current is directly controlled by the voltage of this as well as the this if this voltage has gone down very less current may exceed or vice versa

So, you can see here the converter and internal faults are rare no doubt because we are having so many safety factors for example, I told you here for making one as; normally, I

said here this is your valve one this valve basically; is a consist of several thyristors several g t o s. They are in series as well as the parallel combination; to make it sustain the proper voltage and the proper current and also; we gives some safety margin here; if required is 4 valve 4 thyristors. We go for 5 or 6 thirstier you have the one is punctured still we can operate this whole valve successfully.

So, here of course, the fault is very rare but it is very severe because your current can go up to ten per unit and of it is going very high. What happen some of the thyristors will be carrying this per unit current and that is that may damage it but what we do a normally these are having some for small duration. Because your control action will take care because there is some problem here current will increase your controller here they will work very fast and they will try to reduce for that momentary periods. This thyristors can sustain even though far higher voltage that is why protection is there.

DC line fault which is the frequent; why because if it is a transmission line it is on the towers and it is expose to atmosphere. So, always there is a some dust on the insulator there may be some fogging or there is a some weights are there there may be flash over if the even though small voltage rises and there are so it is a very common and may be self clearing as well and the current you can see it is going to be 2 to 3 times more if the fault something here occurs here but what happen if the fault across in the DC line.

Because one of the here converter is controlling current once current is going higher this converter will work in a such a fashion. It will try to reduce the current but once it has since the current has gone very high then; we have to operate one converter here, that the it can be the maintain the voltage 0 or we can just go for opening of this line if the fault here let us, opposite it is happening here, now there is a two type of fault here in the DC line itself there is a possibility that fault between the two poles itself.

That is just similar to line to line fault in AC system. Which is very rare because it is very spacious it is very rare no doubt line to line fault unless until; really you are having some wire between the two you connecting it by some means but from one to the ground it is very common.

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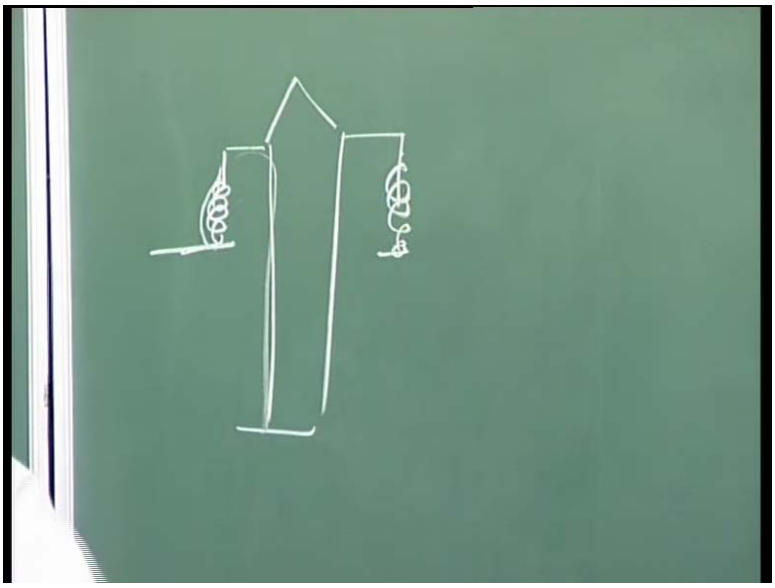

Because you know what is happening? It is your tower and it is just you're here, this is a insulator and your conductor is passing here, you know there is a some problem. So, there is spark over and this is a grounded. So, this is a pole to ground fault is very common because there will be some flash over here; due to the some dust some impurity some high voltage here and then it will be grounded. So, it is a pole to ground another here as this is insulator another pole is here; so the connection between these two is very rare no doubt this may be possibility, here ground here ground both are short circuited but it is very rare.

So, one current is going to increase then controller will act; it will try to reduce the voltage or it will try to do in a such a fashion. That we can just maintain the current and then; we can reduce so, that we can inspect for the faulty line and we can just clear the fault in this so it is again as a said it is a force retardation of the firing. What we do it is angle change here; simply so, that we can maintain the current and finally, we can make it 0. So, that the fault can be cleared and we can inspected.

Another; fault is a commutation failure, which is you can say very frequent specially; and this commutation failure always, occurs in inverter. We will discussed more detail about the commutation failure, because commutation has word is a current that is a incoming valve is unable to accommodate take care of complete current means from valve.

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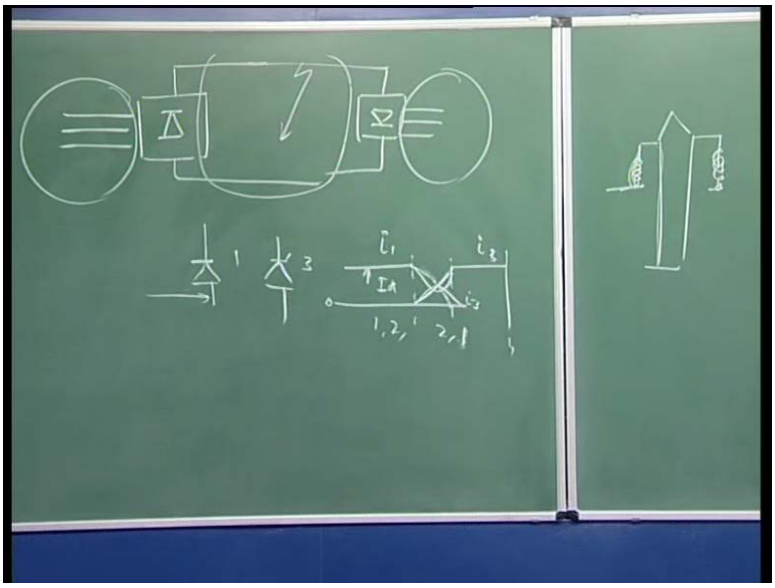

Let us, suppose the commutation is occurring between 1 and 3 here , so the current which was earlier taking I d current here; it must be taking by the valve 3 but due to some problem normally; the voltage which is here is going to increase here the voltage is going to decrease because certain; very small duration where the voltage will be positive across this and it is the reversing. If, it is not taken completely; here there is a failure mean it will not take the current completely; and again the current will shift from here means here for let us, suppose this is a current i 1. This is you are I can say Id it is flowing here.

Now, this is ideally; this I three this is your going to be this like this here, this is the during the commutation period the current of i 1 should decreases to 0 and i 3 should take complete I d but what happens here normally; this current is coming here, and again this is going here; and this i 3 here becomes here means, it started taking current but finally due to the change of voltage here is going to be in that negative side possibility. That it is again going back in the 0 step means current is not taken completely and the current is shifting from to here, to here again and then it is i 1 is taking current.

So, what happens now; you can see the sequence is failed normally, what we say here your 1 and 2 are conducting then here, 2 and 3 should be there but one is not coming again 1 and 2 is conducting. So, we will see what is the consequence of this in later

stage. So, this is called commutation failure; because current is not commutate from valve 1 to another valve in that upper link.

If, the commutation failure is the single means in one cycle if it is happening once then it is self clearing. Because we will see no doubt 1 and 3 is connecting. Here, later on now the turn of 4 will come and will find this it is automatically; clear but there is a possibility in between here; there is another failure between. Let us, suppose here; the 4 is fired of there is a fifth and three come 1 and 3 is not successful then it is called double commutation failure. In the same cycle commutation failure in one cycle it is occurring once it is a single commutation. If, there is a commutation failure is one cycle twice it is not in the same valve it will be here, one three failure there may be your 2 4 failure.

And on forth in one cycle if, it is more than one it is called multiple commutation failure. That is very severe and in that case the controller should take care and the voltage will go down in that case and finally, we have to apply the video call controller and shift on then we have to clear again; back this is basically; the converter station fault here, which I am discussing in this portion only.

Now, my concern here in this lecture; that, we have to consider basically; about the this problem here, either rectifier end are inverter end and then what are the various possibilities of the failure in this converter station.

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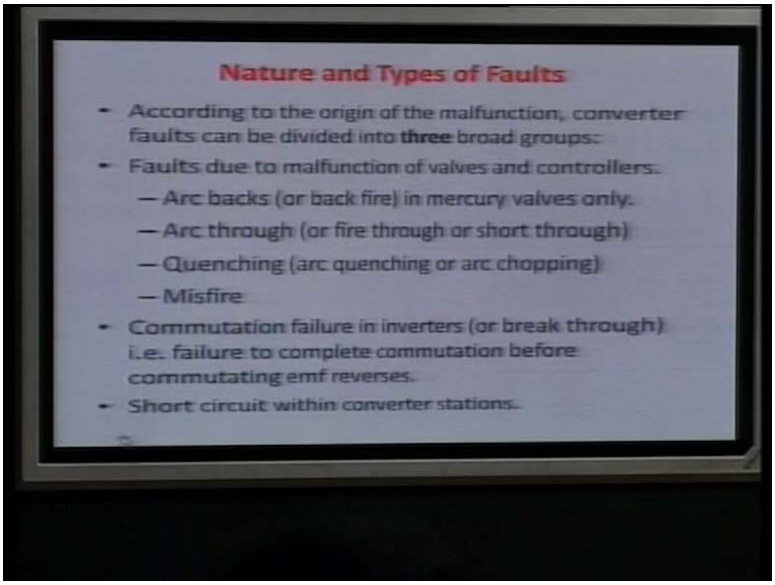

So, according to the origin of mal function or mal operation the converter fault can be divided into three categories. One is your here the fault due to the mal function of valve and controller here, then we are having the commutation failure. Which is a was completely for the inverter end and then, we are having the short circuit within the converter station itself. Because there is a possibility here, there is a positive polarity and there is a short circuit. So, inside the station not we are talking here the DC line short circuit I discuss all 4 separately. I discussed about this fault I discuss about this fault I discuss about this line fault and them I am discussing only in this dedicated to in this converter station.

Here, in this itself we are having the three categories one is basically; due to this mal function of valves mal function means we are giving pulse but it is not conducting even the positive voltage is there or it is conducting again; it is off due to some reason so this is basically mal function, we will discuss in detail all this thing.

Then another is the commutation failure which is only according in the inverter end and it is very common very frequent and here it is also known as the back throw that is a failure to the complete commutation. Before the commutation e m f reverses then another is the short circuit within the converter station itself here; we are not talking short circuit here short circuit there may be there is a shortage of various firing schemes or valves and on so forth.

In this here, the mal function or mal operation of the valves here, it is a categorize in 4 1 is called arc back. Sometimes this called the back fire and this is basically; it is a it was only occurring in the mercury arc valves and it is the modern thyristors and g t o s's it is not the common at that time you can say it is conduction in basically; the when the voltage across this valve even though it is a negative.

Normally, what happens in the thyristor, if, the voltage across the valve is negative if you are giving the gate pulse. It will not convert it will not conduct any case but it was the possibility that due to the negative. Some gate pulse is there even though in the negative polarity the mercury arc will were ever to conducted. So, it was only at that time it was the old stages then arc through here, that is a fire through or short through it is basically; occurring when it is the voltage across this is the positive.

When the voltage across the valve is positive due to the rate change of the searches of the voltage across this or due to change of current in this passing through the valves. There is a possibility; because the d b by d t is may be the concern may be d I by d t will be the concern will be the concern in that case here, the arc through is happening. I will go detail each by each another is quenching or arc quenching or arc shopping. What happens it is the conducting but due to certain problem. It is suddenly off means thyristor is conducting the valve is conducting but it suddenly off due to the (()) that is, called shopping arc quenching. It was also very common specially; here the mercury arc valve because arc concept is coming from there

Another is the misfire and misfire as it is name itself. It is the missed means it is the sequence voltage across this is positive you are giving the gate pulse but still it is not conducting so it should conduct but it is not conducting and it is known as a misfire. Now you can see; the possibility of all these 4 is very much can be recognized here; by looking the valve voltages.

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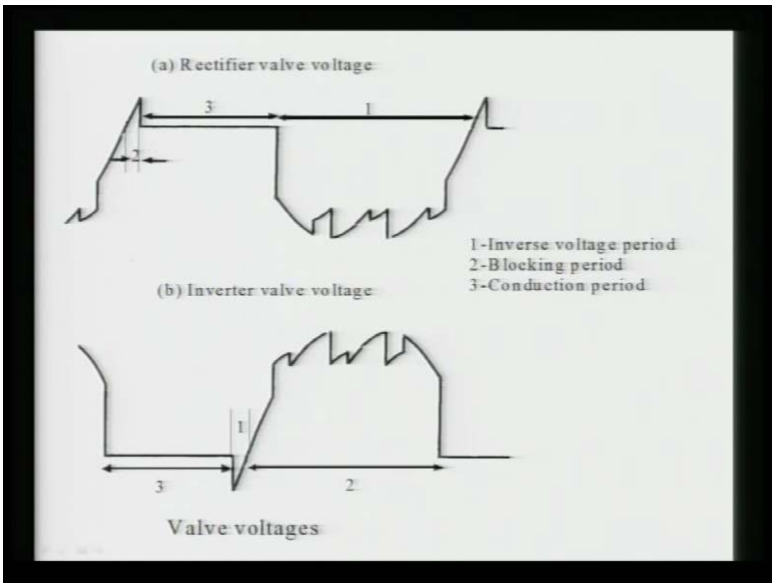

You can say this is the valve voltage across rectifier operation. Because the most of the time in the rectifier operation the voltage across, the valve are either 0 or it is a highly negative and the very small portion you can see very small portion it is a positive.

It is the reverse here, that is why here the one the third is called the conduction period. When the voltage across valve is 0 when in inverse voltage period it is called one period

here, which is the longer period in the rectifier, however; it is very small period here the negative voltage in the inverter and your blocking period is basically; two blocking period here, the voltage is the positive and we are trying to block here, you can say it is the most of the time based on that you can see when it is going to occur in inverter is most probability is there because if it is a arc back you can see in the negative period. If, it is happing here it is the most of the time it is possibility here because this is the longer period.

So, we will discuss one by one these entire arcs back and back firing etcetera.

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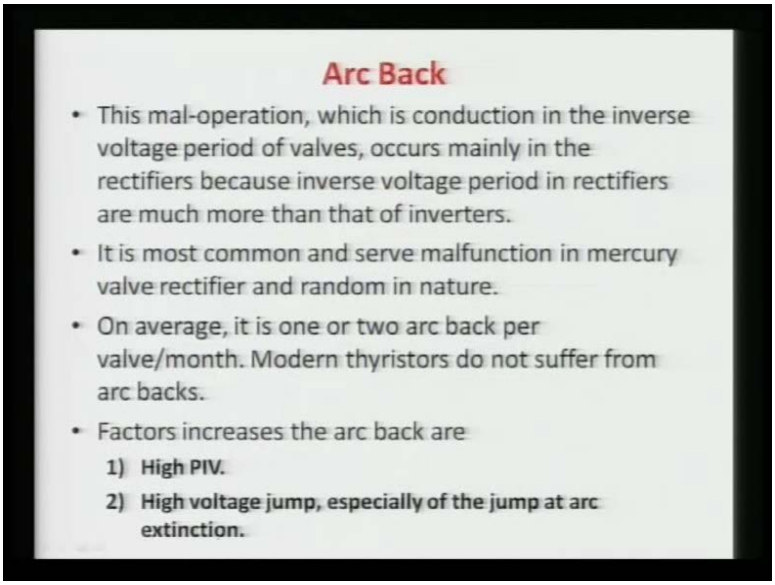

So, let us, see the arc back this Mal operation which is conduction in the inverse voltage period of the valve inverse voltage mean, the voltage negative and across mainly in the rectifier because this inverse voltage period inverse period. In the rectifier is much larger than the inverter operation, as we saw so this arc back occurs in the rectifier station and as, I said it was very best it was happening when it was the mercury arc valves because in the thyristors; if the voltages is negative even though your gate pulse is there the chance of getting. It is conduction is very rare almost nil because this is the property of a thyristor means it will only conduct if the voltage across this is a positive and the gate pulse is all able.

So, here that is why it is telling it was happening in the mercury arc valve but in the modern thyristor and I you can say g t o s. It is not so common but this was also just I

want to mention because it was happening only, in the mercury arc valves and specially; in the rectifier operation. It is most common and severe mal function in the mercury valve rectifier and the random is nature because you do not know when it will be conducting in the negative side or not so, it is a random in nature.

So, on average it is 1 or 2 arc back per valve per month specially; mercury arc valve in the early age your HVDC links they were using the mercury arc valves in that it was even though 1 or 2 per month. It was happening and the modern thyristor that is why here, do not suffer from the arc back the factor increases the arc back again; I can say it is here, the high peak inverse voltage if, the voltage across the valve is very high then this may be we do not know, It can a conduct due to the high voltage the high voltage jumps because you can say specially; of the jump at the arc extension here, if we will see the jumps here if the arc extension at this point. If we will see here this very high jump is there because it was conducting here and then it is arc extension means is off here there is a very huge voltage here arising and there is a possibility at this time voltage is going to very high negative and then it may it may conduct in this period.

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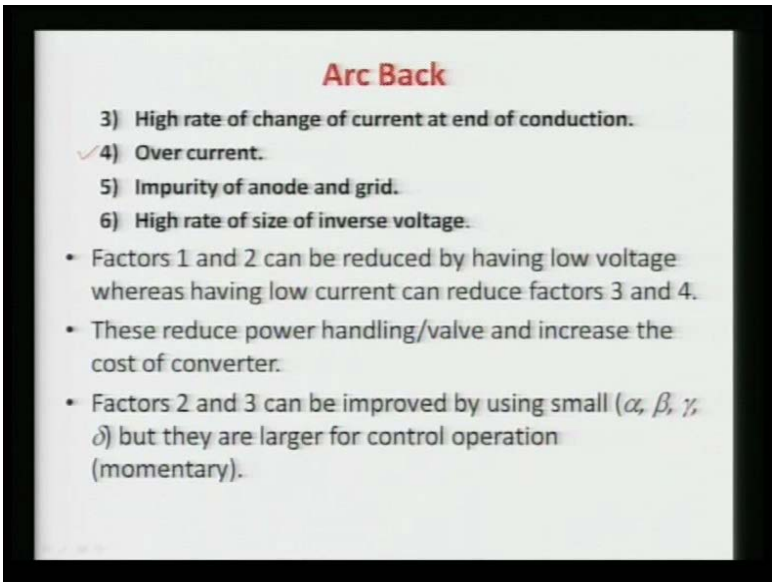

So, specially jump at the arc extension and another is high rate change of current at the end of the conduction when the conduction is ending then, again the current may switcher from again although conduct here, due to the u period it is there is a rate of rise but if this period is very small then this will be suddenly; it is going so it depending on u

if u is larger than possibilities is reduced slightly, but if u is here less this rate of rise is very high and there may be due to this again this arc back may happen another is your over current again. If current value is very high even through u is same and this is high value then again the rate is increasing and the possibility was there.

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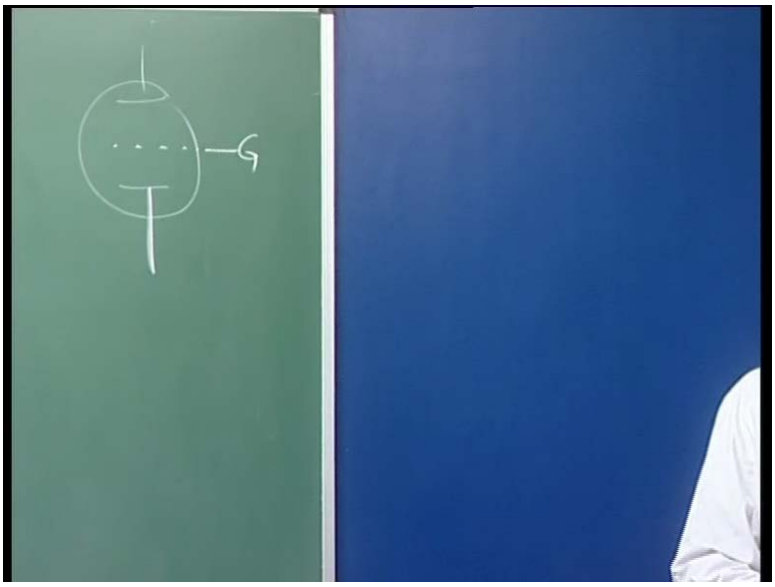

Another; it was due to the impurity of anode and grid you know the mercury arc valves here this is your cathode this is your anode and there was here, a grid if you remember the mercury arc valve in this here if there is some impurity here then that may cause the conduction because this works on the ionization of the gas which is inside this valve and another the high rate of not size high rate of rise, in the inverse voltage. Because you can see there is a some other conditions here, every time you can say here there is a change here there is change everywhere; there is a rate of change is a db by d t is very high specially whenever there is a change in the conduction sequence even though other valve is going to conduct this period. Here you can say there is a u period here sudden rise here sudden change and that may also cause the conduction in this period.

Now, to avoid this the factor 1 and 2 these factors means the high peak inverse voltage and high jump here can be reduced by having the low voltage means if, your voltage is reduced what will happen the voltage across valves will be also reduce but that is not a better option because if, you are reducing the voltage then for same power current should increase and then it is not desirable.

So, that is, why we are as having low current can reduce the factor 3 to 4th because here 3 and 4 here you can see this will be again the change and this will also reduce the power handling capability and then that will increase the converter cost the factor 2 and 3 can be improved by using small alpha beta gamma and the delta but again; the control operation is momentarily; sometimes we can do but not always.

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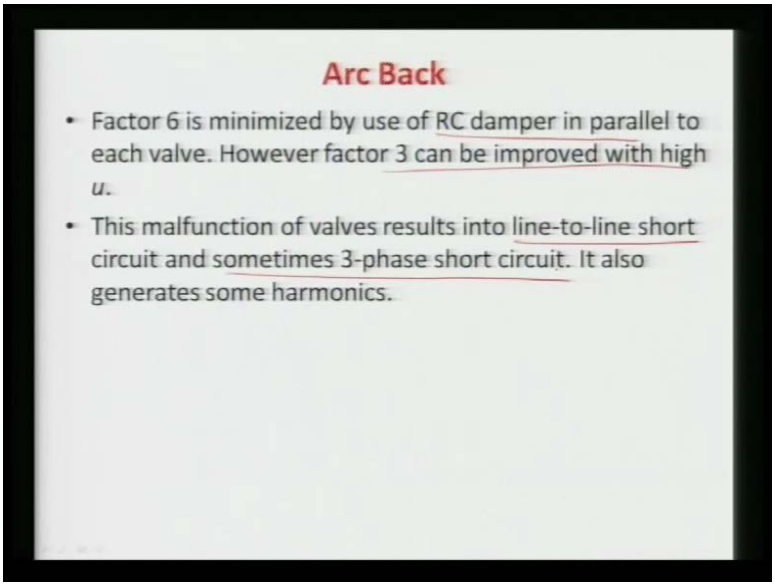

The factor 6 here; that is here the factor 6 here, that is, the rate of rise of inverse voltage that can be minimized by using your RC damper circuits in parallel to the each valve however the factor three can be improved with the high u as. I said if you are having more u that rate of rise will be reduce and that can be done here but it you are reducing u again increasing u means, your voltage will be reduced so that is, another problem. So, this mal function of valve results into the line to lines short circuit and sometimes it is a 3 phase short circuit and it introduce lot of harmonics into the system no doubt why it is happing because it was in the blocking mode and then it is conducting. So, what happens if may give the short circuit because let us, suppose your 6 and 1 is conducting and suddenly 3 is there conducting. So, 3 and 6 and same lame so there is a d c short circuit line to line fault

So, whenever; there is a this type of fault there are possibility that you are going to land up with the line to line short circuit in this A C side and also the D C voltage will be 0 and it will generate the harmonic, so whenever you are going to have mal function of

here; either rectifier side or inverter side no doubt they will introduce harmonics into the system other than the converter. Because your voltage is not symmetric and you are getting some harmonics generated also due to this possibility will be there will be some dead short circuit and we will see for other as well.

So, for this case I am not going to analyze much more because we can see for taking any case and then we can draw the output voltage and we can see; how it is a line to line fault there are sometime three circuit fault is happening. Since, it was happening only in the old HVDC stations not in the modern I am not going to discuss much more about this.

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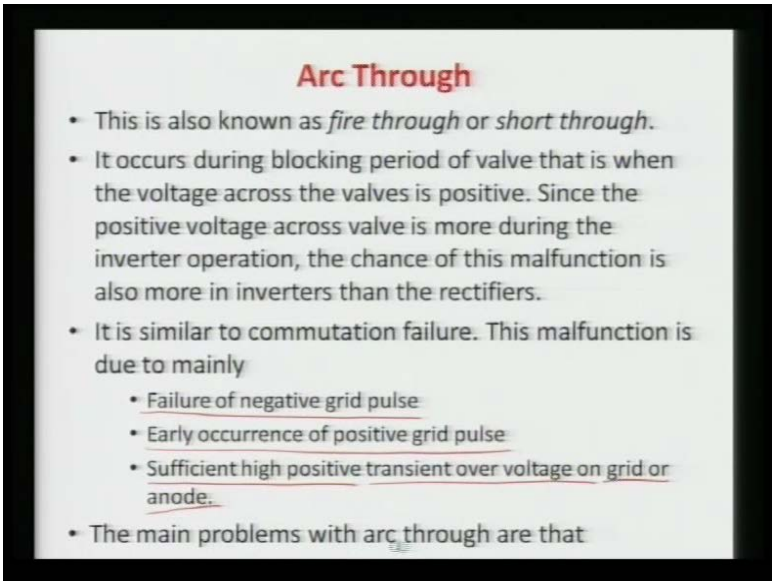

So, let us, take second mal operation this is also known as the fire through sometimes also known as a short through, it occurs during the blocking period of valve that is when voltage across this is positive. We saw the voltage positive in the rectifier operation is very small duration .So, the chance of this arc through is a minimum in rectifier operation but it is very common in the inverter operation because the period of this positive voltage across valve is very high in the inverter operation and that is, why it is it is very common in the inverter operation and it is impact is almost similar to the commutation failure.

Now we will see the when we will talk about the commutation failure here like this the impact will be the similar but the case is not similar here, you can say it was taking the current but it is not and it is coming back here we will see how it is going to happen. I

will just give you that is why here is written it is similar to the commutation failure and this mal function is due to mainly the failure of negative grid pulse.

What we do normally; if the voltage is very positive across the valve we normally; give the negative gate pulse always we maintain across the valve that it should not conduct why because you know there is a lot of jumps and dents the voltage changes across the valve again; you can see the valve voltage. So, due to this there is a possibility that it can it can conduct because the voltage is positive any is furious signal is arrival it will conduct so, the normally what we do here we provided the negative grid pulse when valve are not in the conducting phase.

Another is early; occurrence of the positive grid pulse let us, suppose you are giving every 60 cycle but due to some reason your pulse generator circuit is given pulse earlier do this it will conduct because the voltage is positive because we want always the sequence means after every 60 degree. We want the pulses should be given two in sequence orders 1 2 3 4 up to 6 and again; one so, there is a possibility that your this function generator that is a pulse generator circuit is giving earlier do this due to the control action again because your controller it will be changing. If, due to some problem it is giving this then this operation may happen.

Another is here, the sufficient high positive transient over voltage on the grid or the anode here, though the there is a suppose there is a voltage rise suppose high transient is occurring then this, may also happen that is arc through can happen.

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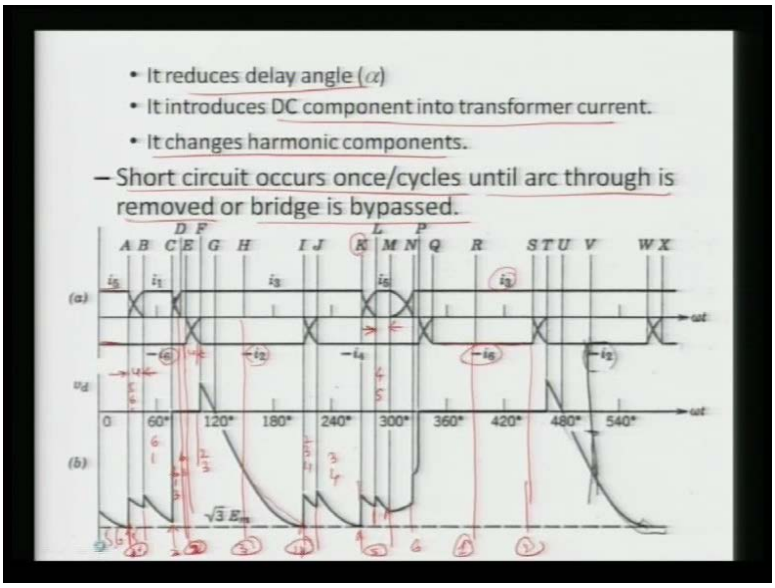

So, the main problems with this arc throw here, that it reduce it the delay angle. We will see how is a delay angle is reduce it introduce the DC component in the transformer side means the A C side because so many DC component will be generated and it will be going there and it also changes the harmonic components because earlier it was getting we are getting this characteristic harmonics but due to this we are getting some other harmonics in the A C side as well as the DC side. So, these are the three problem in this sometimes here, the short circuit occurs once a cycle until arc through is removed or bridge is bypass we will see here.

See in this diagram here you can see at this point 5 and 1 here, you can see this 1 is fired here, the 5 and 6 were conducting up to this period. Now, one was given a pulse here then 5 6 and 1 is conducting are conducting basically; here why you can see the current here 5 and 6 here this is 6 this is a 5 means your valve 5 and 6 were conducting right because the current i 5 is the positive and i 6 is minus it determines negative current here, this Id is there then we give the pulse here, to 1 and then during this period it is your u period where 5 6 and 1 are conducting.

Now, then commutation is over now here we are having 6 and 1 are conducting. Now at this point let us, suppose 3 we will see the voltage across 3 will be positive and let us, suppose there is a arc this fault has occurred here, at 3 at this point. Now, you can see the

d c voltage become 0 because 6 and 3 in the same limbs are conducting means to see this again you remember this diagram.

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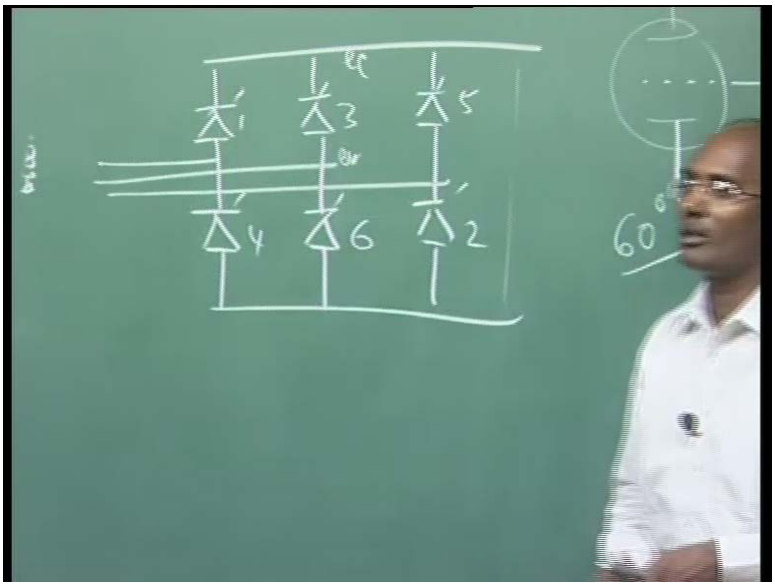

So, let us, draw it here this is 1 4 this your 6 3 here, it is your 5 here is it your 2 and this is your converter this is phase A phase B and phase C means (( )) what happens your 6 and one are conducting and here this your this arc through has occurred at this point.

Now, what happens as I said here the 6 and 1 were conducting this is the case I am taking about inverter case why you can see that D C output voltage is negative as I said it is a very much common in the inverter. Because it is a longer period it is your positive voltage is occurring across the valve. So, it was positive here and due to this arc through here this let us, m suppose it is conducting and then there is a 6 and 3 in the same limb it is here conducting so the output voltage here v d becomes 0.

Now, what happens your 6 and 1 were conducting now 3 is also conducting no doubt the d c voltage is going to be 0 but the voltage across this is rising is increasing. So, there is a commutation between one and three will be successful and then the current which was I d which was flowing here, now going to be here, you can see there is a commutation between 1 and 3 is successful for the very shorter duration. Because the voltage across this is rising very fast the three and here it is a one is decreasing so there is a successful commutation here 1 and 3.

So, after that at point here, you can see this d point onwards your 6 and 1 here is a is conducting as 6 and 3 means in here, I can write in this graph itself, you can see here at this point here three is there so, it is a 1 6 1 and 3 are conducting then commutation is over means during this period here your 6 and 3 are conducting.

Now, what happens at this point now this is a turn of 4 no it is turn of 2. It is a turn of 2 now the 2 is getting the gate pulse as in the sequence order. So, here it was one now it is we are giving the 2 and the 2 will be conducting and the current from here to here will be the commutation will be the take place then, now what happens your 2 and 3 are conducting commutation here is a successful. Now, the D C short circuit which was 0 now is over and the voltage will be you can see here, it is the going to appear at this point you can see once commutation is over because here all are conducting means your 2 3 and 6 are during this period is conducting that is why D C voltage is 0 and then once commutation is there you can say D C voltage will follow this.

Now, this voltage here is coming you can say the positive voltage is appearing across this valve during that instantaneous but average will be negative because mostly; it is negative at here, so I can say at this point here the commutation you can say this u period when the commutation between 6 here and the valve 2 is successful and here once commutation of 6 is over. Now, at this period your valve 2 and 3 are conducting now valve 2 and 3 are conducting it will conduct now this is the turn at the certain point here that three is to be fired and 3 is already conducting. So, it will be continue it because 2 was fired here, now is a your 3 is getting pulse it is conducting and it will continue that is why you can say this is a voltage is coming up to here now at this point now we are giving pulse to the 4.

It will be successful again because 2 and 4 here, there will be successful as usual practice we are assuming so between this period here, your 3 2 3 and 4 are conducting then and this time here we are having 3 and 4 during this period up to here now here we are giving the pulse 5.

At this point k we are giving the pulse to the 5 because we are having in order 1 2 3 4 then it is your 5. Now, we are just giving the pulse here 5 and the commutation will be the successful and now during this period your 4 and 5 are conducting. So, here during this period here you can see during this period your valve 4 and 5 are conducting but at

this point when this 4 and 5 are conducting the voltage across 3 again becoming positive we can check it here, once your 4 and 5 are conducting here 4 and 5 are conducting the voltage across this you will find it is your e c here it is your e b c will be positive because it can be also understood most of the time the voltage across this is a positive.

So, once it is a positive here e b c here what happens if there is a some problem in this valve itself means again; there is a possibility it will be going for arc back arc through this fault can be again repeated and then what happens you can say there is again the commutation between 5 and 3 may take place means there was so problem here, it is not cured means if this is always in the positive cycle let us, suppose it is conducting due to the some furious signal or due to the some problem here in the manufacturing of this thyristor itself then there is a possibility again; it will conduct if it is not conducting then whole process is cleared you can see continuously, it is again here 4 5 then 5 6 then your 6 6 1 1 2 and on it will be continuously; and it is a clear but the possibly once it is has occurred here there is the possibility the same phenomena may occur here because here again the voltage across this is going be positive.

You want to say something no you can see again the commutation between 5 and three is taking place and then it is here the three is taking place here and now it is your 4 and now here it is a turn of your 6 valve because it is unless until. You are blocking this 6 or you can bypass the bridge means do something otherwise; what will happen you are giving a gate pulse here, 6 because it is in the continuous sequence and then again there is a dead short circuit because on 3 on 6 now after that here, at this r point you are going to give the gate pulse to one but it will not conduct because the voltage across this it will be negative.

Here, we are giving we can see at this now, after here this is your 6 here we are giving one pulse again here gate pulse. One but at this point if we will check in draw the voltage across this because your this is the conducting your this is a case where is a 3 and 6 are conducting across this voltage will be not positive even though you are getting giving the gate pulse if 3 will continuous. So, what happens your three and 6 are you know see it is a conducting then here again; we are going to have your 2 is coming and then it will conduct and there is a 6 and 2 we be successful again; we are getting the voltage like this.

So, here in this you can say the short circuit across once per cycle no doubt here, the short circuit across until Arc through is removed. If you are not removing then, it will be continuously going. So, I mean to say here the short circuit across once per cycling if it is removed here means there is no here this is arc through means again there is not a repetitive in the three valve then ;it is removed and we are having the proper conduction it is self clearing but if still it is there then, we are having this the again more short circuit here for longer period and that is very dangerous for the valves because that may damage your the valve etc. So, this is basically; arc through concept in your mal operation of the converter it is clear.

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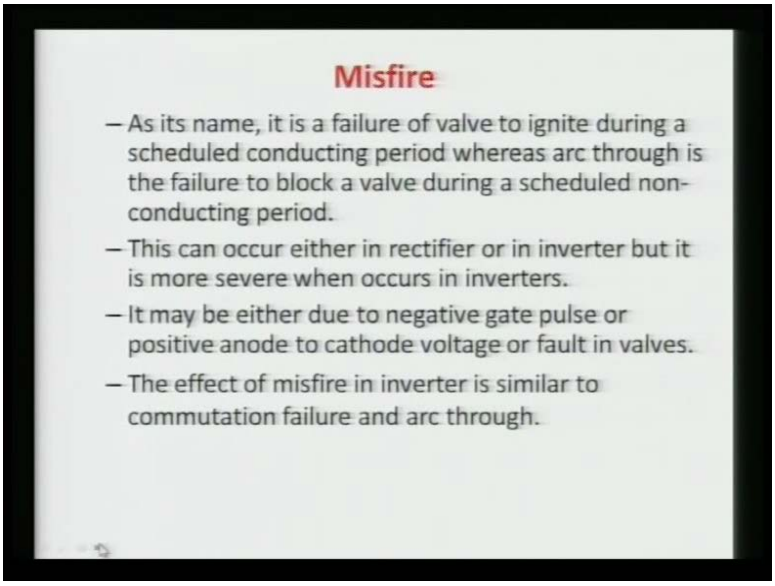

Now, let us, go for the Misfire in the Misfire as it is name it is a failure of a valve to ignite during a scheduled conduction earlier the, two were this random in the nature depending the on the fault condition faulty, of valve etc here you are giving gate pulse in the regular just your pattern is 1 6 1 2 3 4 5 again; 6.

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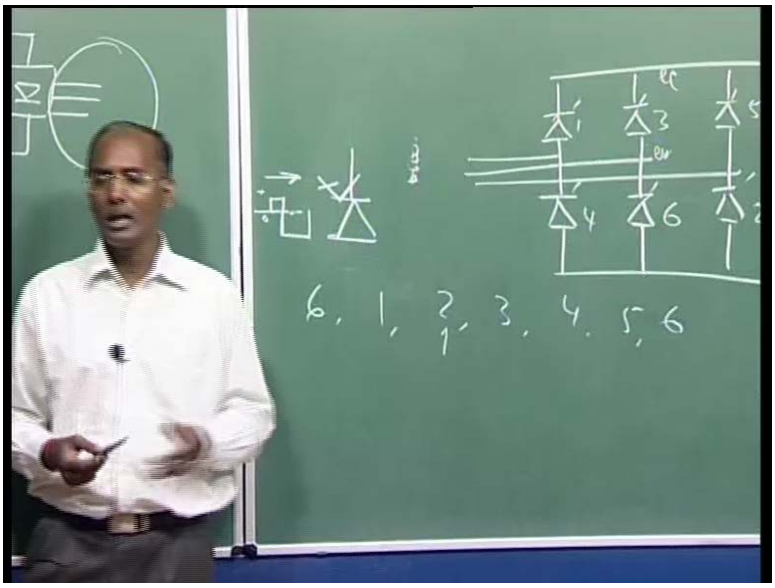

So, in regular sequence you are giving the pulses to these valves you gave the gate pulse gate pulse. But it is misfired it is not conducted there is and may be various because the voltage across this is a positive it should conduct but there is a some problem. It is not conducting and that is known as misfire.

So, this can occur either in rectifier it can occur in inverter but it is a most severe in the inverter because this is again; just like a simple it is just like your commutation failure.

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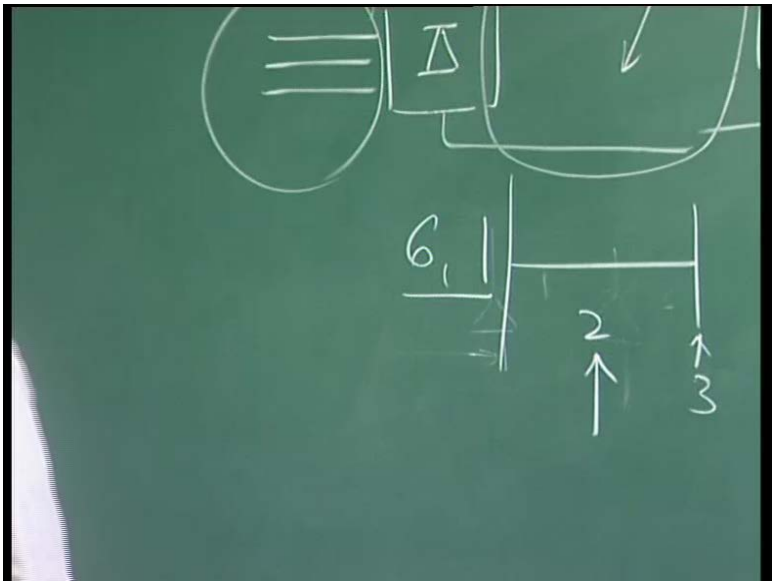

Because what happens suppose, your 6 and 1 are conducting then you give the pulse to 2 it did not conduct then what happen then it will continue then, the number of third will come and then the commutation between 6 and 3 will be there but dead short circuit is there.

So, it may be either due to the negative gate pulse are positive anode to cathode voltage or fault in the valve. So, it due to the certain problem it is misfired the effect of misfire in the inverter is similar to the commutation failure and is also similar to the arc through. I said arc through is also just like a commutation failure the consequence is same effect is same but the phenomena is different.

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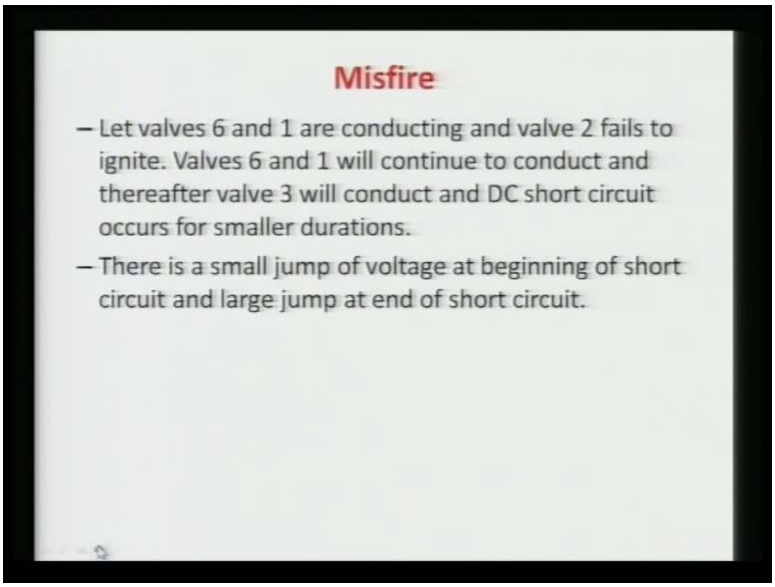

Now, let us, say condition that your valve 6 and 1 are conducting and valve 2 fails to ignite. So, what happens valve 6 and 1 will continue to conduct and there after valve 3 will conduct and there is a dead short circuit during that period that is a smaller duration there is a small jump in the voltage at the beginning of the short circuit and the large jump at the end of short circuit to verify this.

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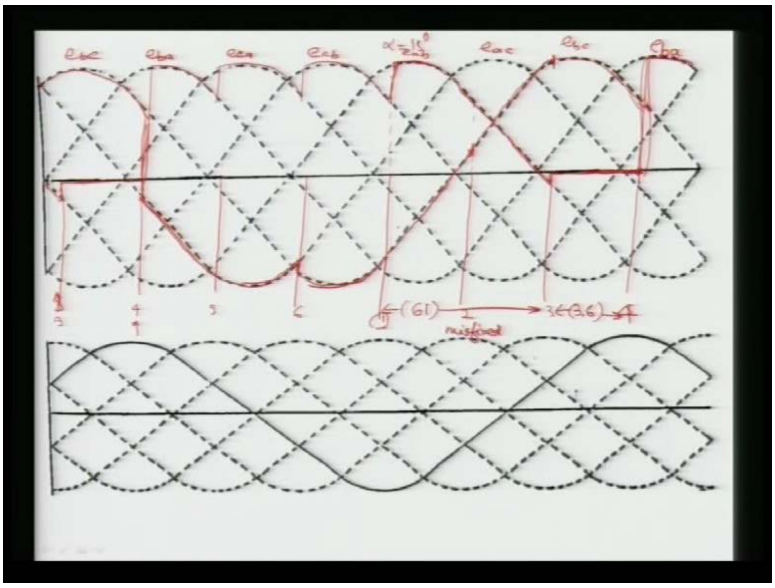

Let us, see and draw the voltage this is as our usual diagrams line to line voltage and here if I can say our e b a is your commutation voltage of valve 3 and now I am talking for the rectifier end similarly, we can talk about the inverter end misfire condition here, I am just discussing the rectifier because is very simple inverter you have to delay again; and then you have to measure from this side rather than this side alpha.

Let us, take a ideal condition means u is 0 one condition. We can have u also we can have u 0 also and there will be no difference in the generality. So, I can take let us suppose your alpha here alpha is your 15 degree and now your 6 1 are conducting means what will be your output voltage you know your firing pulse here, this is a 30 degree. This 15. So, here, your 3 will come here your 4 will come this is I am just writing the firing sequence here, your valve 5 will come here your 6 come here your 1 will come and then here your 2 will come and then again; we are repeating here 3 at this side and then continuously; we are monitoring so it is very easy to I miss something your 4 and on so forth.

So, now, we have to write the line voltage as usual practice. So, it is e b a here it is your e c b good here it is e a c here, it is your e b a and now this voltage will be your e c a this voltage is e b c this which is left out this voltage is e a b this voltage is e b c.

Now, you can see when 6 and one are conducting what will be the output voltage. We are giving the pulse here, in the rectifier mode your just see here this is a 6 and one are

conducting it is a and here, it is a b e a b is the output voltage and e a b output voltage here, it will be this much here it is starting at this moment no. This is your just one is given here is a 6 1 is conducting e here, now we are coming here, now it is given your 2 but it misfires means it is misfire means your e a b will continue. So, it is your misfire I can write here what happen it will be continually conducting till here.

Now, you are giving the pulse three what will happen there is a short circuit and finally, here there is a voltage will be 0. So, you can see now in the conduction pattern here during this period 6 and 1 are conducting till here the commutation between 3 and 6 will be over 1 and 3 will be over and your 3 and 6 will be continuing here 3 and 6 during this period you can say the output voltage here.

Now, when the 4 is coming now, we have to see what will the voltage now there is the commutation between 4 and 6 will be happening so your output voltage will be e b a means suddenly; it is going here and it will be continue conducted here, and then we will find the sequence continuously; so we can come back here, to make it our clear here it was here I can I can just make here, the complete cycle from this side it is coming here then it is going to be e b a here and now it is coming here and then here again this is here and finally, we are giving here.

So, you can see the d c this is a D C output voltage in case of misfire. When it is operating in the rectifier mode because alpha is less than 90 degree. You can say most of the time the voltage is positive in this you can say the most the problem is here, huge search the voltage at the end of conduction huge voltage is jumping and this may lead to the puncture of the valve. Some of the valves and that is sometimes not desirable.

So, here it is a rectifier similarly, you can draw the valve voltage of any of the valve an the same plane and it will find it will be just down the voltage here, so you can draw the valve voltage as well and your valve voltage. Let us, I want to draw here for again; valve 2 let suppose I want to draw the valve voltage 2 and the same excess so what happens we can start here somewhere; we can start let us, suppose your three is fired here at this case three is fired here, now what will the voltage when your I can we can start forth. I think better 3 and 4 are conducting yeah so then it will be 1 cycle basically; it is better to go for the complete whether; so 3 and 4 are conducting so, the valve voltage 2 I am drawing so, 4 here it is your ea and here is e c so e a c will be the voltage so during this period

here e a c where is e a c is this was here, and when the voltage is there here is e a c here you see this is e a c this is e a c is there here.

Now, when fifth is coming it will not change so, it will be continuing here, up to 6 because this conduction will not change the voltage across this because the voltage here this will be always A C and the voltage whatever; they are conducting the voltage will be appearing here so whenever there is a conduction change from here, then the voltage will change otherwise it will continue simple rule. Now it will be same.

Now, once it is a 6 is there now it is e b c and e b c is your e b c is here, you can say very well here and it will be continuing to here now, then it is one and it will continue to conduct because here it will be your this voltage this period. One is there so it will not change the voltage so this is going to be this and now, here once to we get the voltage but it is not conducting. So, what happened the voltage will be again because here it is conducting now from here onwards what will the voltage the question is this so it will continue and the finally, we have to reach up to this point once this voltage is this is a dead short circuit this e b will be coming and it will follow the e b c.

Here and it is e b c is there still here at this point because then again fourth is coming here and then we are getting this very that this is we are here and then at the 4. We have come back here this is your following e b c e b c was this was here up to, this point and then it will be coming here suddenly and this is the valve voltage.

So, basically, this is the voltage you can say not has that smooth due to this here, the different voltage appearing otherwise; there was some change here and it was basically; the conduction pattern here but it is not conducting see in whole cycle the valve 2 is not conducting. So, the voltage will be not 0 but you can most of the time here again the voltage is positive here because once it was conducting here 2 it will 0 here.

So, this is valve 2 similarly, if we will go for your inverter operation you will find that this is totally; means again; the reversing the voltage will be going the D C voltage will be the down side and the valve voltage in other side and we will see that due to this is a just like a commutation failure because if it is coming in your inverter side here, you are operating there is a possibility. That once two is misfired here three you are giving the gate pulse 4 it may not conduct because you have to see the voltage across this should be positive at that time because this is the condition, so this severity will be the different

than your rectifier rectifier it will be because you can say here this is positive it will be the conducting.

So, the inverter operation is basically; the typical operation always and we have to very sure that the voltage once we are giving the pulse and voltage across that valve is positive then only it will conduct so for each instant you have to check what is the voltage across that valve in the sequence order this is your basically; misfire.

In this lecture in this first lecture we just say arc back and the fire through and the misfire the 3 mal operation. We saw next turn we will and next lecture 2. We will see the commutation failure how this is happening the single commutation and then, we will also go for the two commutation in the same cycle then, we will discussed about the protection as well so, with this I can close this and in the next lecture, we will see the commutation failure up to inverter side.