Power System Dynamic
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Lecture - 06
The Equal Area Criterion for Stability (Contd…)

Friends, we shall continue our discussion on equal area criteria of stability.

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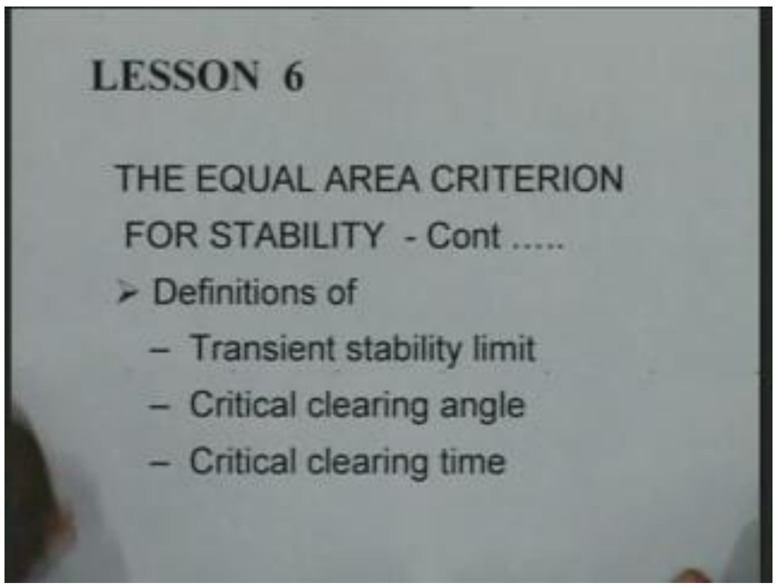

Today, we will cover I will address the following problems. The basic definitions of a transient stability limit, the meaning of critical clearing angle and critical clearing time then we shall study the effect of fault clearing time on transient stability limit, next we shall study the effect of type of fault on stability when we talk about the type of fault on stability we, I shall introduce the concept of fault shunts then we will study the effect of grounding on stability.

Now, before I address these issues I would like to mention that this subject has been very well addressed in power system stability written by Edward Wilson Kimbark there are 3 volumes, volume 1, volume 2 and third volume is now known as synchronous machines. These basic concepts are very well addressed in volume 1.

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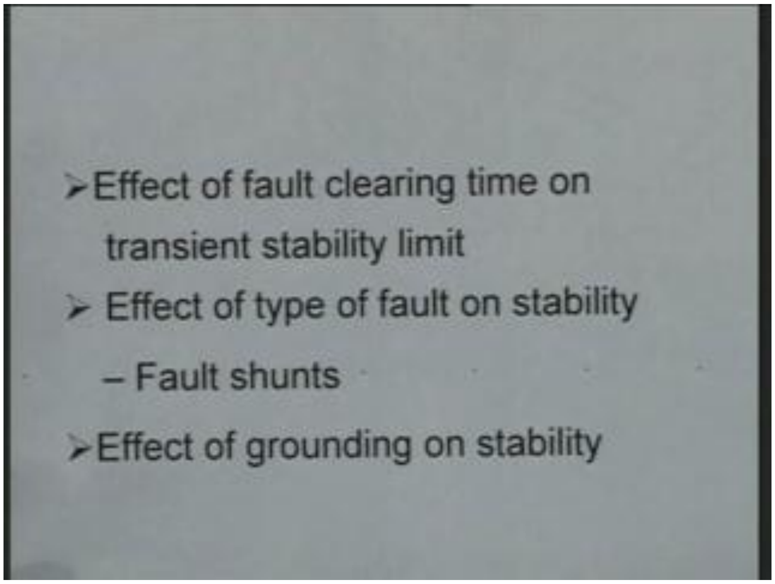

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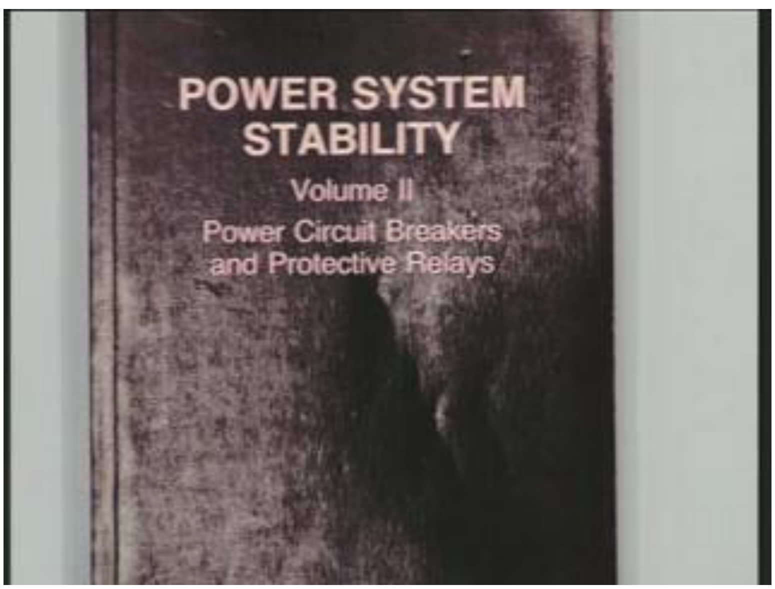

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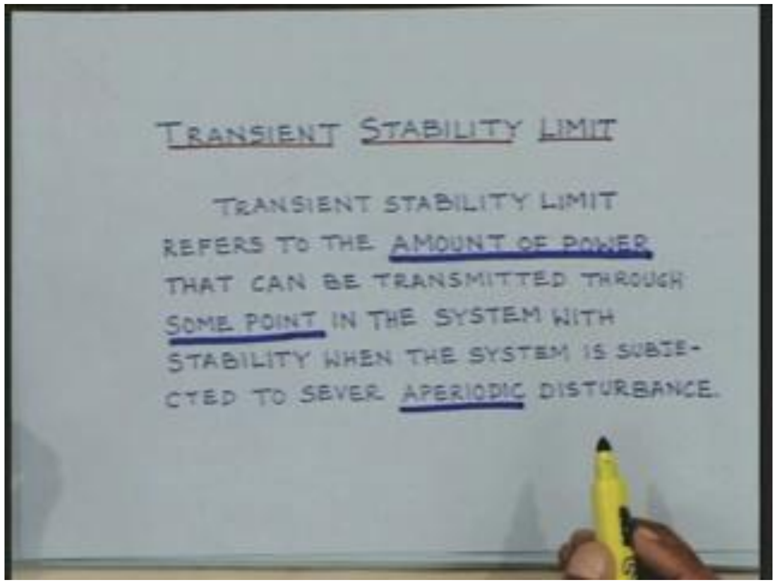

Now, let us define what the transient stability limit. We have defined earlier the transient stability, now today we will emphasize on this word transient stability limit. The transient stability limit refers to the amount of power that can be transmitted through some point in the system with stability when the system is subjected to severe aperiodic disturbance that here the stability limit is referred in terms of the amount of power that is what is the power in mega watts that can be transmitted and this is referred to some point in the system.

Now the emphasis here is on some point in the system. Now if you take a machine infinite bus system then there is only one transmission line and therefore whatsoever power that can be transmitted on that line with stability becomes the transient stability limit. However when I consider a multi machine system okay, in that system this limit refers to a point in the power system that is there may be number of transmission lines and you may refer that in this particular transmission line how much power can be transmitted for a given operating condition with given type of severe disturbance, given type of severe disturbance here.

Now here we emphasize the word aperiodic the disturbance is disturbance comes not in periodical manner but it comes in aperiodic manner it comes and goes it is not actually that after every 5 second the disturbance keeps on coming. Okay, this is what is the meaning of transient stability limit therefore, any power system when we operate, we have to operate below transient stability limit.

Okay so that it will withstand the the particular type of disturbance for which the system is designed. Now next term is the critical clearing angle. This critical clearing angle is specifically referred to a machine infinite bus system because in the multi-machine system, you will have number of angles right and therefore the definition to a multi-machine system is not that easily available.

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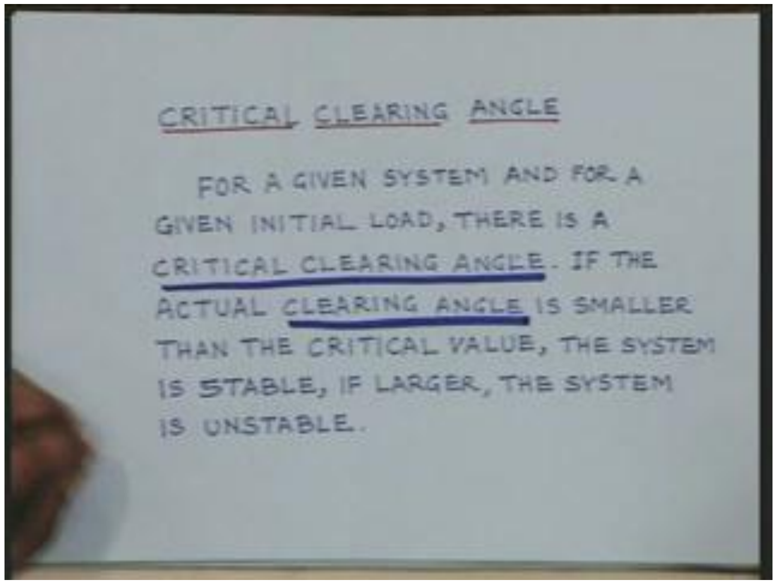

Now for a given system and for a given initial load, there is a critical clearing angle, if the actual clearing angle is smaller than the critical value a system is stable and if larger the system is unstable. I will explain this point in detail okay in our further discussion that here the meaning is that there is some critical clearing angle and actual clearing angle, if it is less than this value system is stable in case the actual clearing angle is more than the critical clearing angle system will become unstable.

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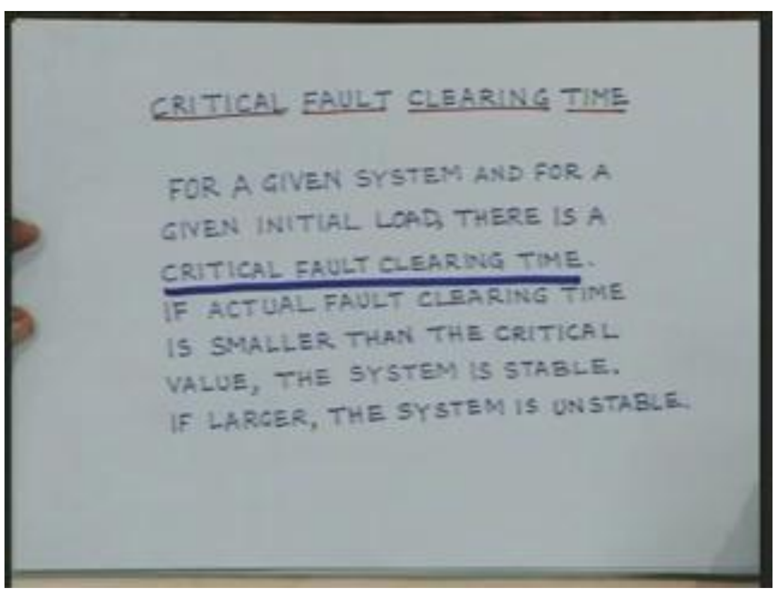

Similarly, we define another term critical fault clearing time again for a given system and for given initial loading there is a critical fault clearing time, if actual fault clearing time is smaller than the critical value the system is stable, if larger then the system is unstable. Now this definition is applicable to machine infinite bus system or a multi-machine system because whenever a system is operating okay and if fault occurs on a particular element of the system then this fault is cleared by removing the faulted element by operating the circuit breaker at the two ends and therefore there is certain time required to clear this fault.

In case this actual fault clearing time is less than the critical clearing time system is stable otherwise, it is unstable further if suppose the critical clearing time for a system comes out to be say .2 second and actual fault clearing time is say .1 second then the difference .1 second is called the stability margin. Okay therefore, we have been discussing in these days in terms of what is the stability margin and stability margin can be quantified in terms of difference in the critical clearing time for the system and actual fault clearing time because actual fault clearing time depends upon the operating time of the protection system and circuit breaker fault interruption time.

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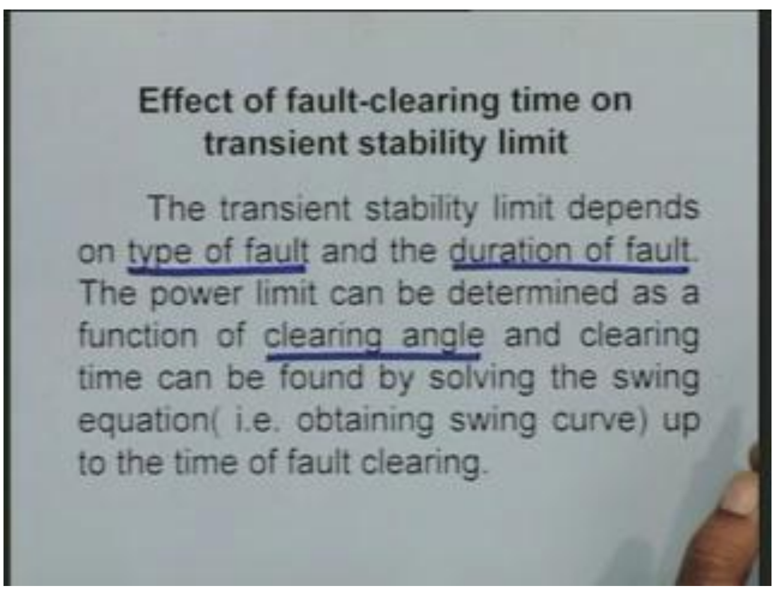

Now let us understand what is the effect of fault clearing time on transient stability limit, now here when I say it is a transient stability limit it means it is a certain amount of power that can be transmitted without loss of stability. The transient stability limit depends on type of fault and the duration of fault, a very we shall state these aspects type of fault and duration of fault. The power limit can be determined as a function of clearing angle suppose it is a machine infinite bus system we can find out the transient stability limit or power limit as a function of clearing angle and clearing time can be found by solving the swing equation up to the time of fault clearing that if I want to know know the transient stability limit as a function of fault clearing time.

The approach we will discuss here but for a machine infinite bus system the simple approach is that you first apply the equal area criteria, find out for a given power what is the critical clearing angle and then once we know the angle, we solve the swing equation up to the up to the fault clearing angle and corresponding to that we read the value of time and that becomes our critical clearing time and therefore when I say here, when I discussed earlier that when you apply this graphical method that is equal area criteria of stability.

We do not completely diverse the need for solving swing equation but partially we do it wholly or partially this is what we are the they are partially means partly you have to solve it and suppose a swing curve is required to be solved for say 2 seconds for normal stability steady analysis but in this particular case the time for which it is to be solved is very small suppose the for critical fault clearing time comes out to be it is a .2 second okay, then I solve it from 0 to .2 second not from 0 to 2 second and therefore this saves my time or computation time.

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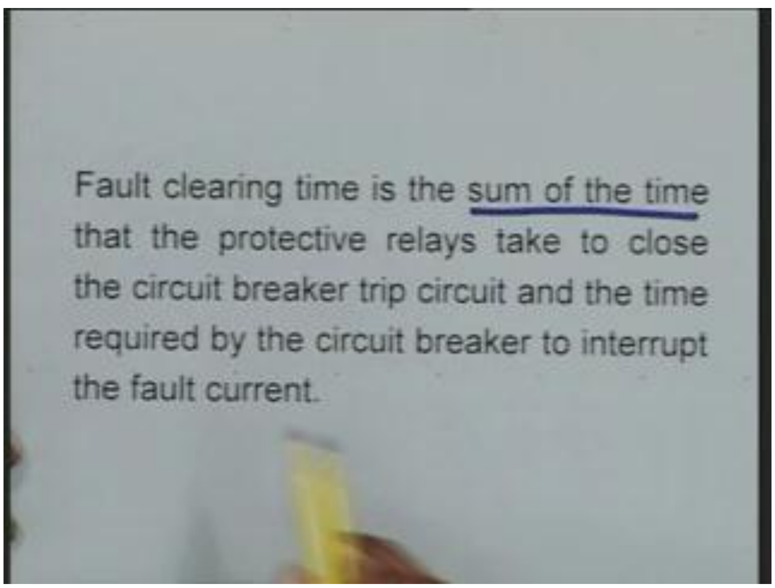

As I have stated that fault clearing time is sum of the time that the protective relays take to close the circuit breaker trip circuit and the time required for the circuit breaker to interrupt the fault current.

The general conclusion that decrease in fault clearing time improves stability and increases transient stability limit is just as valid for a multi machine system as for a 2 machine system. This point I stated earlier also again we reiterate that general conclusion is the decrease in fault clearing time improves stability and it improves the transient stability limit okay.

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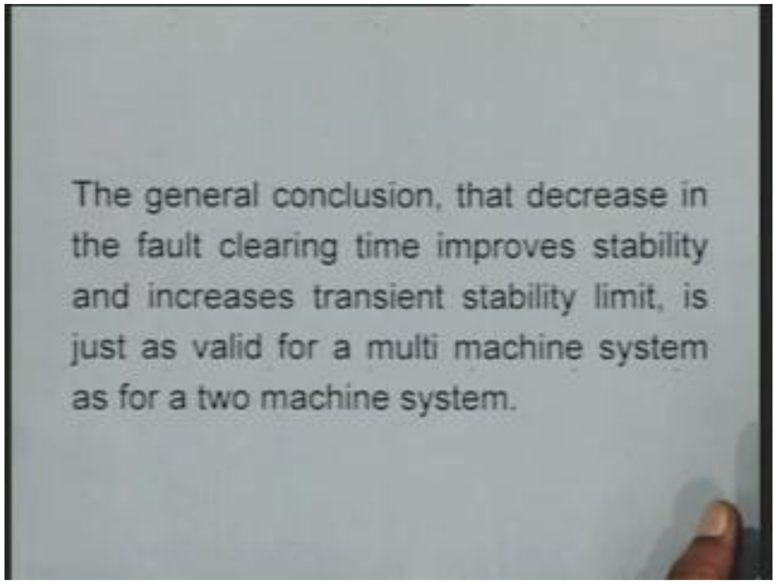

Now this conclusion is valid for machine infinite bus system 2 machine system and even for a multi machine system and that is why the efforts have been made all through to reduce the fault clearing time this has been possible by applying fast acting protective relays and fast acting circuit breakers.

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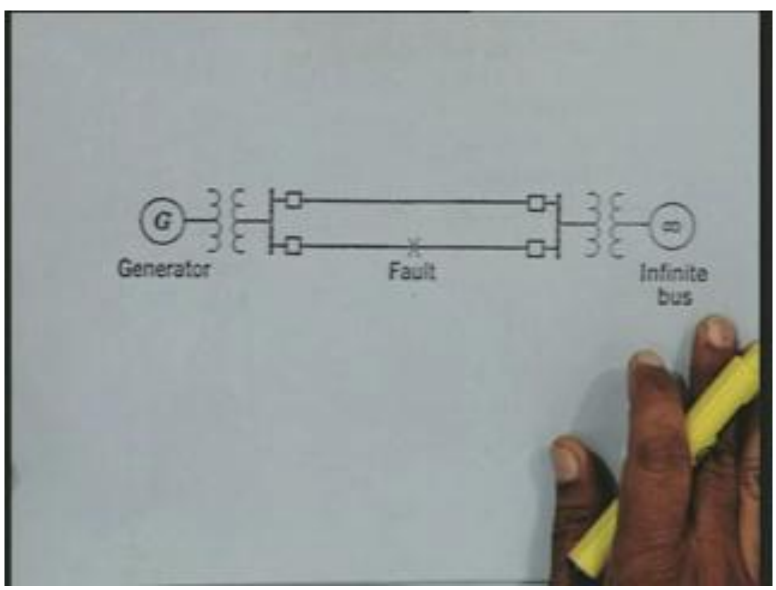

Now to illustrate this that how do we calculate the transient stability limit and obtain a curve relating the transient stability limit and the fault clearing time, we will consider these 2 machine system and a generator infinite bus and consider that the fault occurred at the middle of the line. Now for this system we can find out the 3 power angle curves, pre fault, during the fault and post fault, once we know this power angle curves we can apply the equal area criteria and determine the certain points on the transient stability limit versus the fault clearing time.

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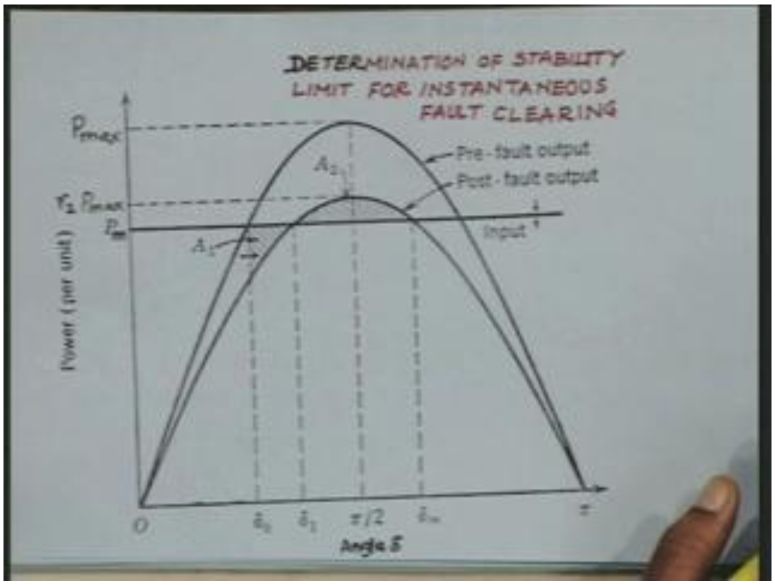

Now we will consider the 2 extreme cases, first case we will consider that the fault is instantaneously clear. Suppose fault occurs in the system and the time which it takes to clear the fault is instantaneous it does not have any time practically it does not happen okay. Now this can also be considered similar to that one transmission line is stripped, okay by operating the circuit breakers.

Now in that case if you want to find out what is the transient stability limit then the approach would be you make use of these two power angle characteristic, pre fault output characteristic and the post fault output where during fault we do not require it because the system has not operated with fault on the system.

Now in this case what we will do is, this mechanical input line, the mechanical input line P_m is moved up and down, P_m is moved up and down till these two areas are equal that is a_1 and a_2 is the area bounded by mechanical input line, the post fault power angle curve that is from delta naught to delta 1 and a_2 is again the area bounded by the post fault power angle curve and the mechanical input line but they have opposite signs.

Now when these two areas are equal that will give us the stability limit that is this P_m becomes the stability limit you have, what a what is to be done is that you have to move this mechanical input line up and down you have to do 1 or 2 you know iterations and the movement these two areas becomes equal that becomes the stability limit because here the fault has been cleared instantaneously.

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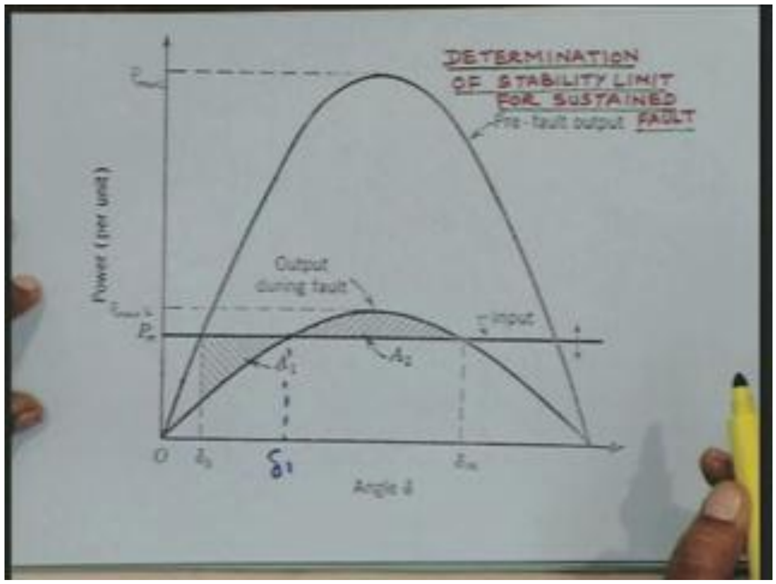

Now we will take another extreme case, where the the sustained fault on the system, that is fault is not cleared in this situation we require the two power angle curves, one is the pre fault another is the during the fault power angle curve. Now these 2 curves are plotted here again the approach will be that you move the mechanical input line up and down till these 2 areas a_1a_2 are equal that is when you do this computations you assume some value of P_m.

You know the value of delta naught initial operating angle, you can find out what is the value of this angle delta 1 that will depend upon the intersection of mechanical input and fault on power angle curve. Okay similarly, you can find out delta m which is equal to phi minus delta 1, okay now you find out this area by process of integration and you equate this with the area a_2, in case these 2 areas are equal then this P_m becomes the transient stability limit with sustained fault. Now the third situation will be that the fault is clear infinite time.

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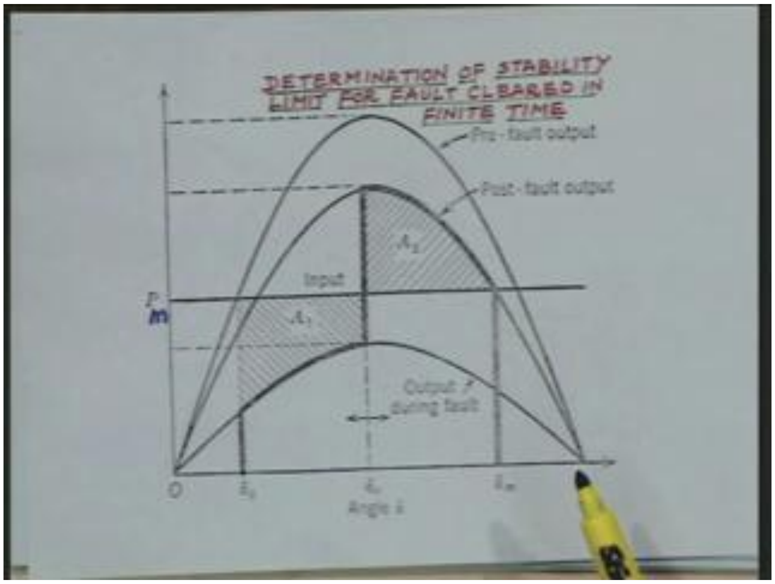

Now under this situation we require all the 3 power angle curves, okay. Now one way is that you move this mechanical input line P_m up and down and see that these 2 areas are equal and but this there actually we required the information and what is the fault clearing angle there were 2 parameters involved, one is the fault clearing angle another is the mechanical input line. The easiest process will be we assume some value of P_m and instead of moving this mechanical input line up and down you adjust this clearing angle, you will you move this line either on left or on right it means you assume some value of fault clearing angle and see whether these 2 areas are equal.

In case you find actually that for a assumed value of angle a_1 is greater than a_2 move this line on left so that a_1 decreases and a_2 increases right and you do this exercise still these 2 areas are equal it means what we have done now here is for given input P_m we have obtained the critical clearing angle and then we integrate the swing equation from this point delta naught up to this critical clearing angle and find out the corresponding value of critical clearing time.

Now this is the way you can find out a number of points assume some value, suppose the value of P_m is small you will find that delta c will be very large and a stage may come when delta c will coincide with delta m right that is the case for sustained fault that is when you are moving here right and if this fault you find actually that P_m is such that system is stable when delta c equal to delta m that is the condition for sustained fault then when you, if you are moving if the P_m is moved up and when you are you have to move this line the moment you find actually the delta critical clearing angle delta c same as delta naught that become the instantaneous occurring time and therefore by this approach we can plot the curve relating the transient stability limit versus the fault clearing time in seconds.

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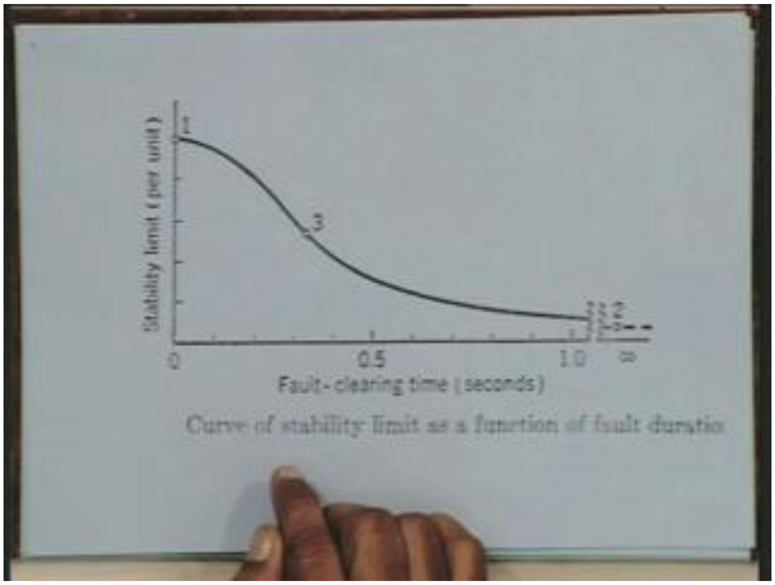

For example, this graph shows for a typical system on this x axis by plotting the fault clearing time in seconds, y axis we are plotting the stability limit in per unit and the stability limit of the system when the fault is cleared instantaneously is denoted as 1 per unit and for all other fault clearing time it is going to be less than this okay.

Now here actually this .2 shows the sustained condition because there is a break here in the graph right because when the fault is sustained the stability limit is going to very small, sustained fault condition there is a fault is there and system is not losing stability it means that is the situation which occurs only when the fault, I am sorry a a the power output is small right. Further as we have seen that the post fault, I am sorry the post fault power angle characteristic depends upon the element which has been removed and the remaining system.

Similarly, the during the fault power angle curve is concerned it depends upon the location of fault on the transmission line. Suppose you consider the 2 machine system and for the whole analysis what we have done is we have assumed the fault in the middle of the line suppose I shift the fault location from the middle toward the sending end of the line or you shift this from middle to the receiving end of the line in that case you will find that the stability limit will be different the curve relating the stability limit versus the fault clearing time will be different.

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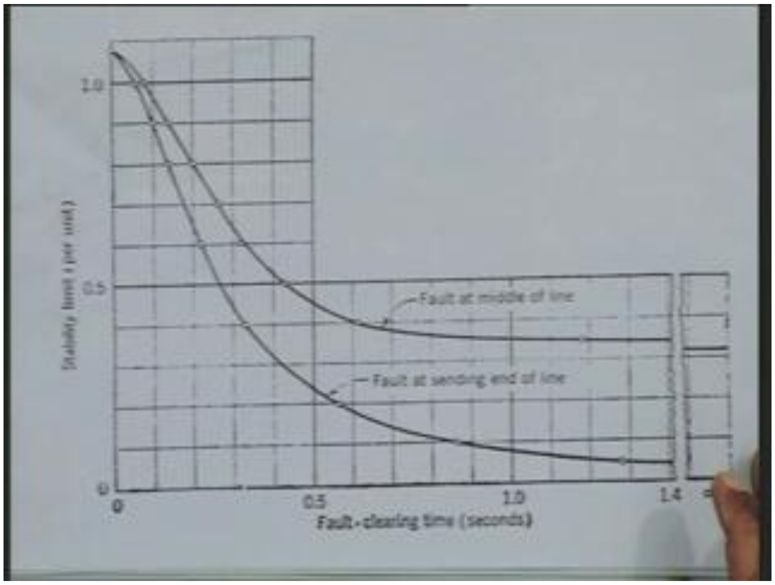

Now these 2 curves show the fault at sending end of the line and this show the fault at middle of the line now you can easily see that where the fault occurs at the sending end of the line okay what will happen to be power angle curve the during the fault condition during the fault condition no power will be can be transmitted on this when you consider the machine infinite bus system let us say the system right, if suppose the fault occurs right at the sending end of the line then this fault is as good as a fault on this bus.

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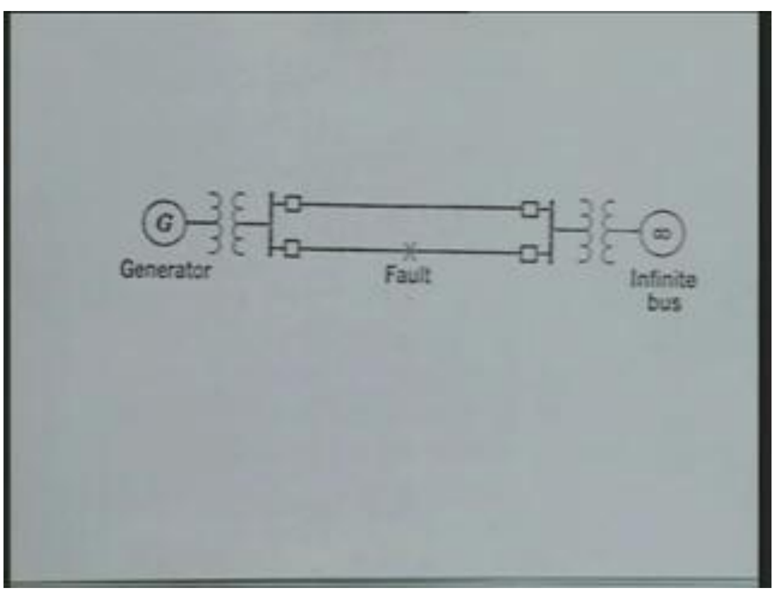

Okay and therefore the voltage at this bus becomes 0 or it collapses because I am considering here a balanced 3-phase fault and therefore no power can be transmitted from generator to the infinite bus right, therefore you will find actually the r_2 r_2 which is multiplying r_2 P_{max} sin delta r_2 will become 0. This is a very special case and you will find that the transient stability limit will be less as compared to where the fault occurs in any other point on the transmission line that is why these 2 curves have been plotted to illustrate the effect of location of fault on the transmission line.

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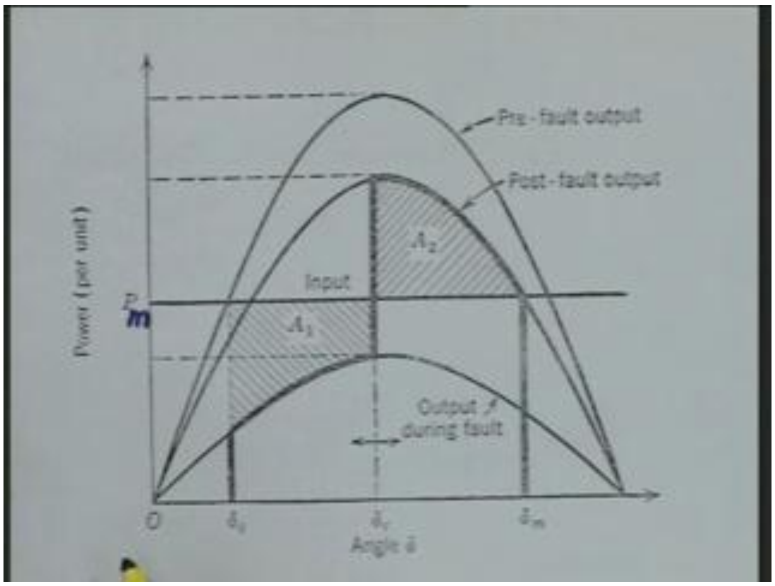

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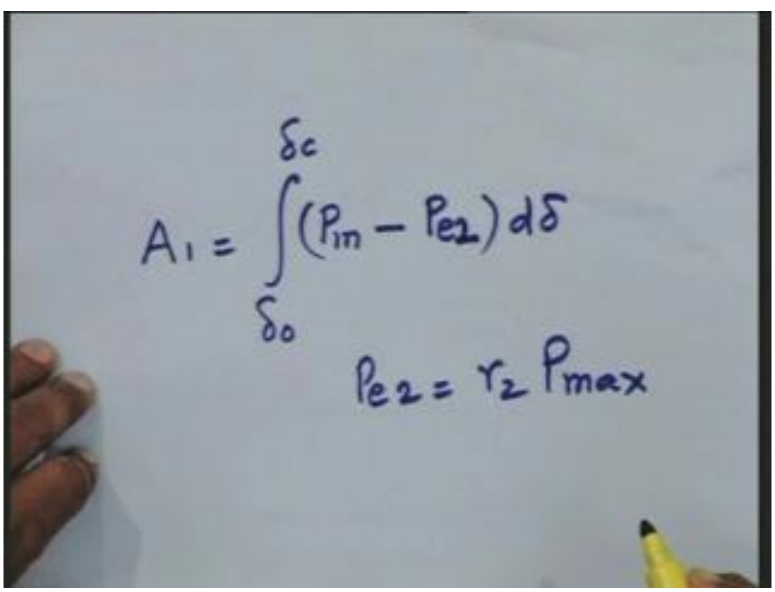

Now by applying the equal area criteria of stability, we can find out for a given value of mechanical input and for given fault location we can compute the value of the angle fault clearing angle delta at which the system just stable that is we can compute the critical clearing angle for computing the critical clearing angle what is to be done is that you find out this area a_1 that is you integrate, you integrate that is a_1 can be written as integral of delta naught to delta c P_m mechanical input minus P_{e1} not P_1 P_{e2} d delta where P_{e2} is equal to r_2 times Pmax sin delta okay.

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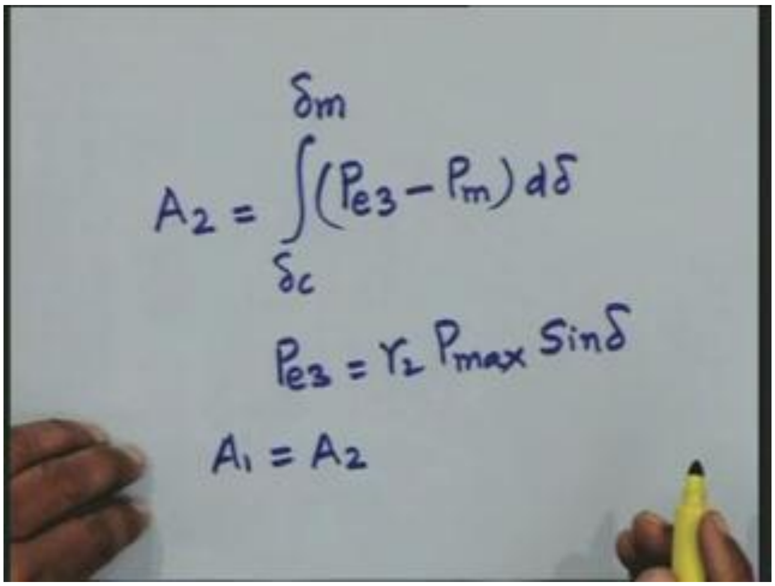

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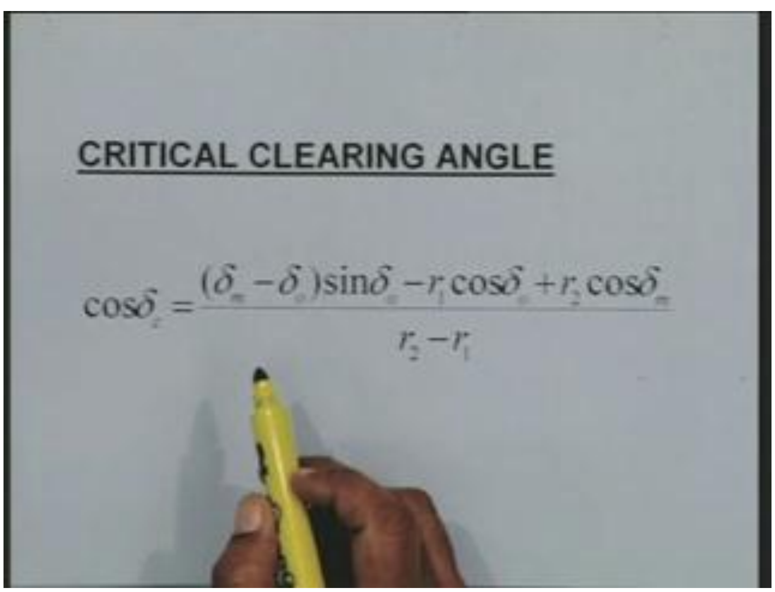

Then the area a_2 can be computed integral delta c to delta M, here we will be writing this as P_{e3} minus P_m d delta where P_{e3} is equal to r_2 P_{max} sin. Okay, if you equate these 2 areas that is you equate a_1 with a_2 and you can find the expression for critical clearing angle or the equation for computing critical clearing angle. This equation has been obtained and it is a cos delta c equal to delta m minus delta o, sin delta o minus r_1 cos delta o plus r_2 cos delta m divided by r_2 minus r_1 this, this expression can be derived without any difficulty by equating those 2 expressions.

Now, when you apply this formula, you have ensure that these angles are the delta m delta naught they are they are yes substituted in radians sometimes people committed mistake they put directly in degrees and therefore the result will be observed.

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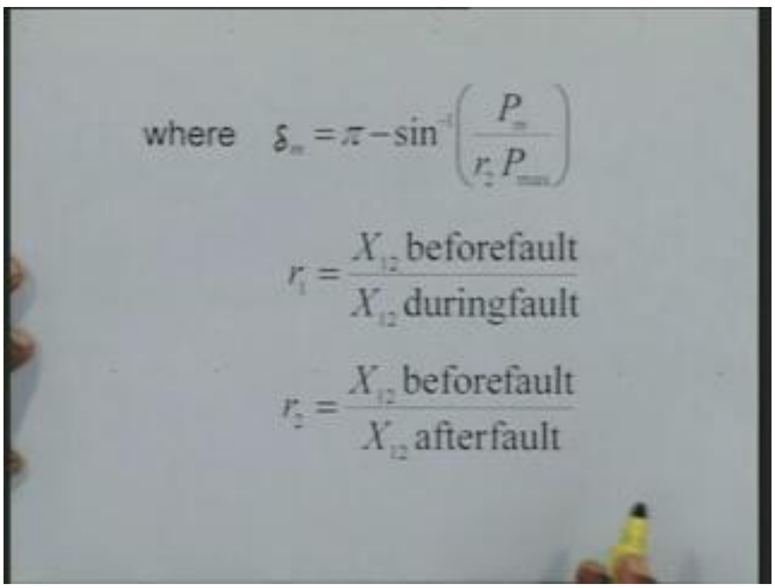

Now this angle delta m has to be calculated by using this formula delta m is equal to phi minus sin inverse P_m divided by r_2P_{max} because delta m is delta m is obtained where the where the post fault power angle characteristic intersects with mechanical input line like it intersect at 2 points one is the angle which is given by this this equation and another will be phi minus this, therefore delta m is equal to phi minus this therefore another sometime people commit mistake in computing the value of delta m correctly and where this r_1 is the x_{12} before fault and x_{12} during fault r_2 is x_{12} before fault x_{12} after fault, that is x_{12} is the reactance connecting the nodes that is internal voltage of the generator to the infinite bus voltage and this formula is applicable to a 2 machine system only we do not have such formula for a multi machine system.

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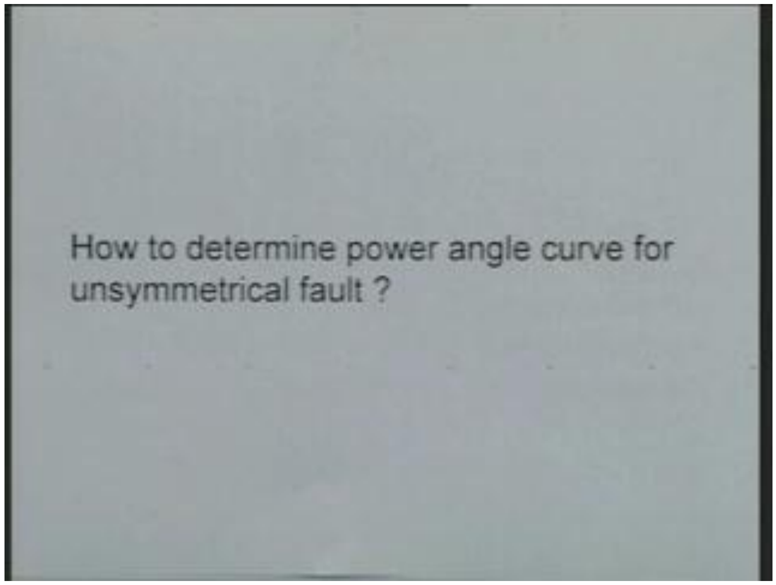

Now next point we have to address is how to determine power angle curve for unsymmetrical fault, till now till now we have assumed a balanced 3-phase fault for our analysis and we also assume that this 3-phase fault is a metallic short circuit there is no fault impedance involved, under this situation the, the faulted point is directly connected to the reference bus in the equivalent network and we analyze it but the moment you have unbalanced fault then things cannot be as simple as in a 3-phase system because as you know actually that unbalanced faults can be analyzed by by using the method of symmetrical components.

Okay and when we apply the method of symmetrical components we will come across positive sequence network negative sequence network zero sequence network and we can compute depending upon the type of fault the positive sequence currents, negative sequence currents, zero sequence currents.

We also know that how to draw for a given system the positive sequence network, negative sequence network and zero sequence networks before I tell you how to account for the unsymmetrical fault for determining power angle curve during fault condition. We have to understand some basic concepts one basic concept is which I will introduce and explain in subsequent discussion.

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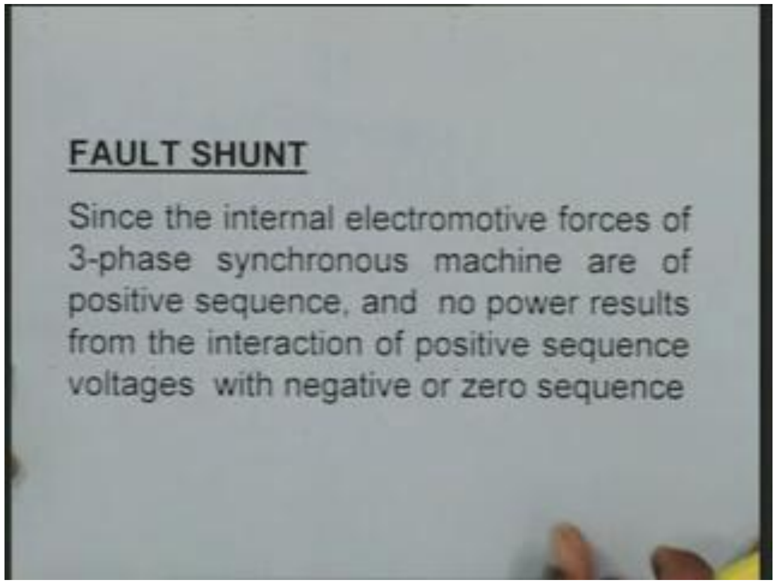

The concept of fault shunt now here to ah before we understand this fault shunt, let us understand a since the internal electromotive forces of 3-phase synchronous machine are of positive sequence that is so for the three phase synchronous generators are concerned we always generate positive sequence voltages. We do not generate negative sequence or zero sequence voltages, no power results from interaction of positive sequence voltages with negative or zero sequence currents. Although, the stator may be carrying negative sequence current, zero sequence current but when this negative sequence current interacts with the positive sequence voltages no power is generated no average power is generated.

Similarly, no average power is generated when positive sequence voltages interact with 0 sequence current, okay and therefore to compute the power angle characteristic which basically relates with the power transfer from machine to the infinite bus okay. We are we have to, we have to compute primarily the positive sequence currents okay and to compute the positive sequence currents as we know actually that during fault condition the positive sequence, negative sequence zero sequence networks are connected in a particular fashion if suppose there is a line to ground fault these three networks will be connected in series if it is a line to line fault then these two networks will be connected in parallel looking into the looking into the faulted terminals.

We have to look where do we connect in parallel where the fault occurs in two faulted points similarly, we have it is a double line to ground fault then the three networks will be connected in parallel.

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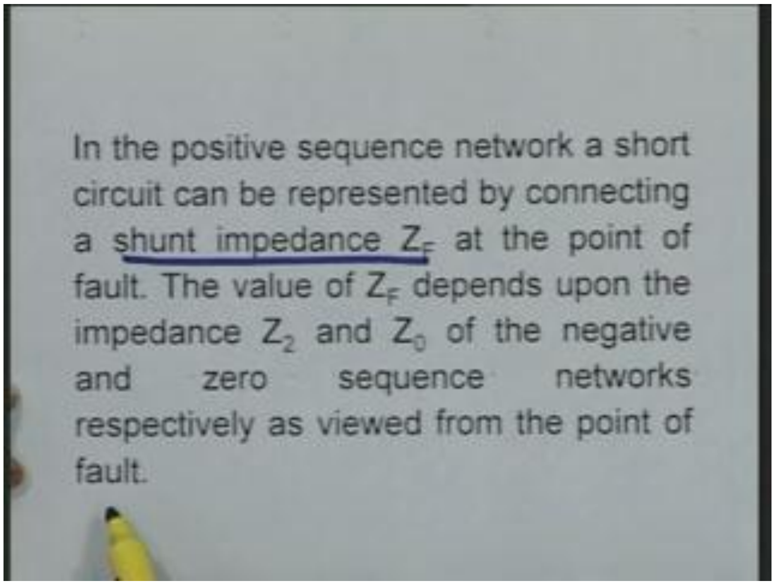

The simplest approach to account for the unbalanced or unsymmetrical fault is by connecting shunt impedance Z_F at the point of fault that is in the positive sequence network we return the positive sequence network as it is earlier between the fault point and the reference we were connecting zero impedance that is directly connected.

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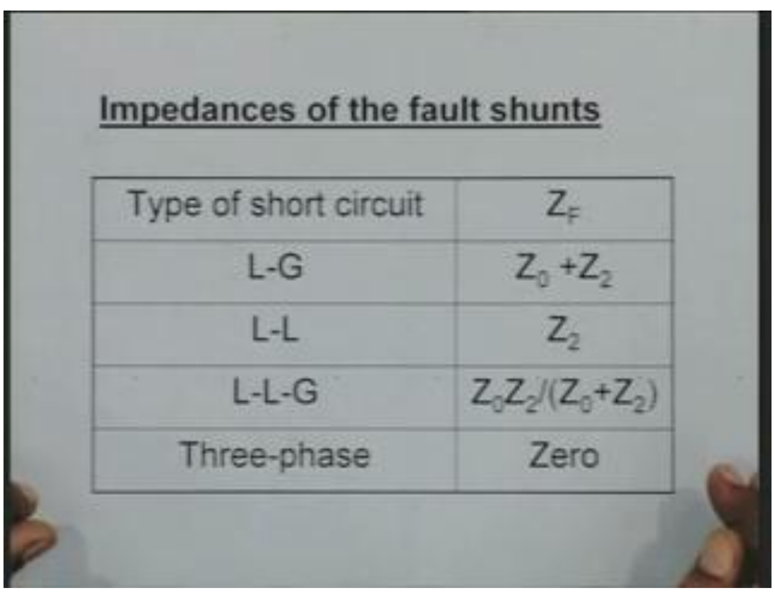

Type of short circuit	Z_F
L-G	$Z_0 + Z_2$
L-L	Z_2
L-L-G	$Z_0 Z_2 / (Z_0 + Z_2)$
Three-phase	Zero

However, when unbalanced or unsymmetrical fault is there we have to connect an impedance of value ZF that is called fault shunt ZF. The value of ZF depends upon the impedance Z2 and Zo of the negative and zero sequence networks viewed from the point of fault that is ZF is function of positive sequence I am sorry, negative sequence and zero sequence impedances. Here, I will without a derivation right now I am just giving the result the this table shows the type of short circuit and the fault shunt Z_F is the impedance of the fault shunt, if it is a line to ground fault the value of Z_F is Z_0 plus Z_2, if it is a line to line fault the fault shunt impedance is Z_2, if it is a double line to ground fault if the fault shunt is the parallel combination of Z_0 and Z_2 and if it is 3 phase fault Z_F is 0 okay.

Now this table is very important and I will show you a list through illustration, how do we get this in time, now a typical statistics of the occurrence of type of faults or frequency of occurrence type of fault.

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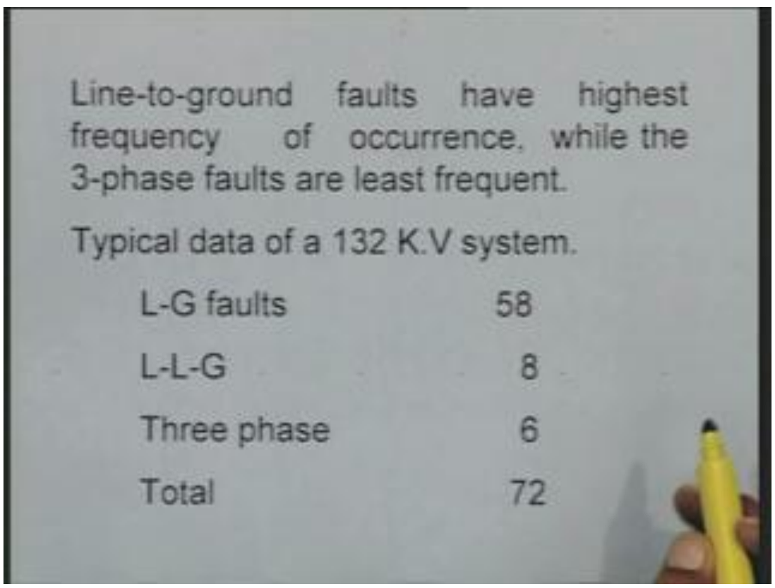

A typical 132 K. V system the data were obtained and out of the total 72 faults which occurred on the system, 58 were lined to ground faults double line to ground faults were 8 and 3-phase faults were 6 in fact line to line faults generally gets converted into line to line to ground fault. You can see very easily here that the frequency of occurrence of 3- phase fault is lowest and the the frequency of occurrence of line to ground fault is the highest and therefore, in case you design your system or operating condition of the system is design, considering 3- phase fault it means we are very very pessimistic in our approach, it may be assumed actually that faults are would be very severe and we are taking a very safe margin.

However, if you apply only considering line to ground fault definitely you are optimistic where you feel that these faults may not occur because if you design considering line to ground fault and if 3- phase fault occurs, system is going to lose stability similarly double line to ground fault occurs it is going to loose stability in case you do not have any margin right and therefore the practices I will tell you what are the practices which are as followed ah for designing the system because we have to make a balance.

We have, we should not be very optimistic we should not be very pessimistic in our approach before I tell you about the effect of grounding, let us just see how do we account and compute the value of fault shunt impedance Z_F okay. I have told you actually that fault shunt impedance Z_F is different for different fault and the the table had been shown to show you the expressions.

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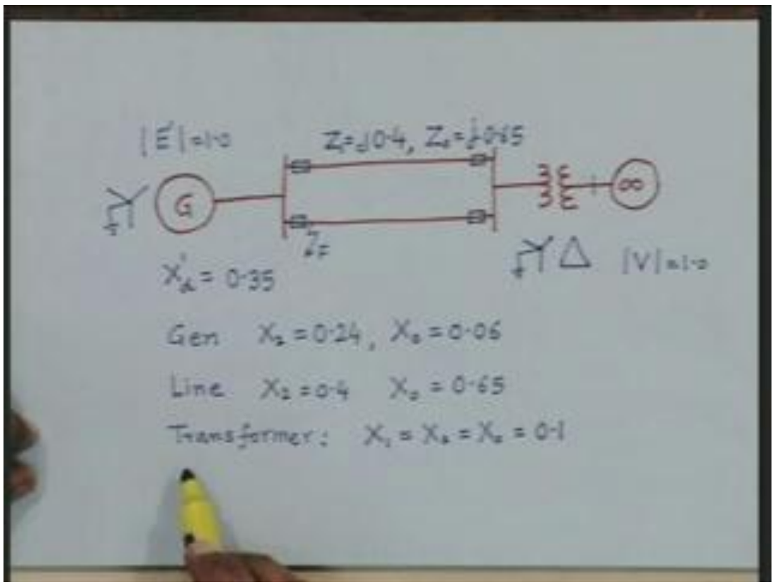

Okay let us take this the simple machine infinite bus problem where you have generator neutral of the generate is grounded double circuit transmission line. In this case I have taken only one transformer there is no transformer shown here but if that is there is a transformer here that can also be considered this delta star connected transformer start point grounded infinite bus system.

Now when you solve the problem considering unsymmetrical fault we need information about positive negative and zero sequence reactance's of the system components for generator X_d prime is 0.35, the negative sequence reactance of the generator is less than X_d prime is 0.24, X naught is the lowest that is zero sequence reactance is always low 0.06, for the transmission line is concerned its positive and negative sequence reactance's are equal that is Z_1 is 0.4 and j times 0.4 the and the negative sequence reactance is also 0.4 the zero sequence reactance of the transmission line is always more than the positive or negative sequence reactance, in this case it is 0.65 the typical values it may be even more it may be sometimes 2 to 2.5 times even 2 to 3 three times it all depends upon this system. For a transformer we can assume this X_1 X_2 X_0 equal to .1 that is they are equal, with this the data's which we have assumed let us first obtain the positive sequence, negative sequence and zero sequence networks.

The positive sequence network is simple is same as what you do actually for analyzing for balance 3-phase fault condition, this is the internal voltage E prime the direct axis transient reactance I am putting the reactance value only 0.35 transmission line reactance 0.4, 0.4 and the transformer reactance here 0.1 and the infinite bus voltage okay this is the voltage V. I am showing this as a voltage V, now V we shall consider that the fault occurs at the sending end of one of the transmission lines right at this point.

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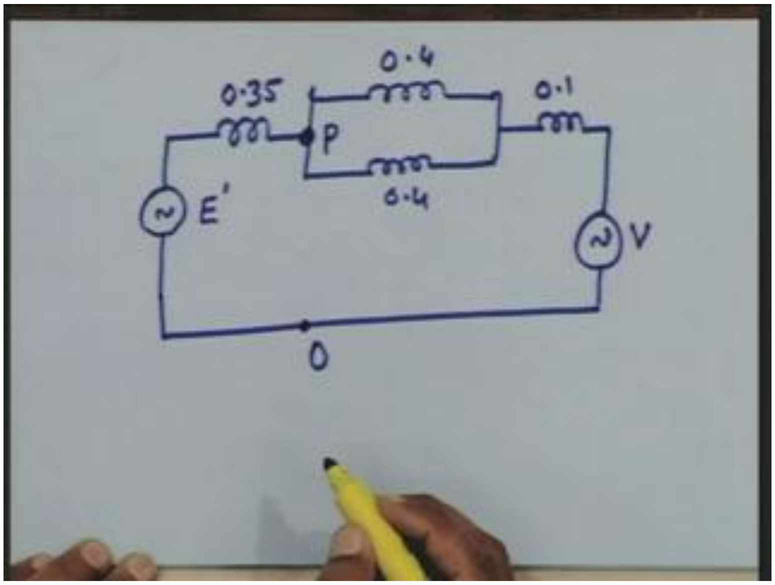

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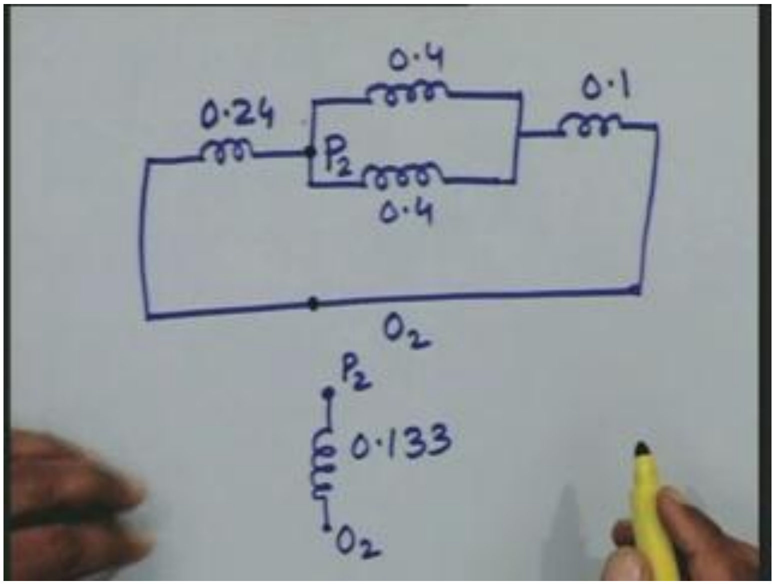

This is the sending end of the line and therefore I will added this is as good as the fault occurring at the bus therefore let us call this point as the point P on the series and this is our reference. Now so far the negative sequence network is concerned it is it will have the same structure except that the sources will not be present there are no sources because we do not generate the negative sequence voltages and therefore the negative sequence network can be drawn.

This is my reference bus, okay we call this o this point continues to be P now what we will do here is that this point we will call as P_2 that is the fault point in the negative sequence network and we will call this point as P_1 in the positive sequence network, the points are same P_1 and P_2 are same on the physical system. The values here are now because in a zero sequence, a negative sequence network, the generator reactance is 0.24 per unit, the transmission line is same 0.4, 0.4 transformer is also 0.1 okay.

Now we can find out the equivalent reactance of the negative sequence network looking into this points P_2 and o, this exercise when you do you will find actually that equivalent comes out to be a reactance whose value is 0.133 for this problem you can say this is P_2 and you can even call this as a o_2 the reference bus for the negative sequence network, therefore these 2 terminals are important for us. The next step is to draw zero sequence I mean to draw the zero sequence network for the system.

When we draw the zero sequence network, we have to consider the connection of transformers because transformers may be connected in different modes and we have to also consider the neutral impedance. In case you have put a impedance, in the neutral circuit in the equivalent circuit that impedance will appear as 3 times the actual value in this particular case, the neutral have been solidly grounded therefore they do not appear.

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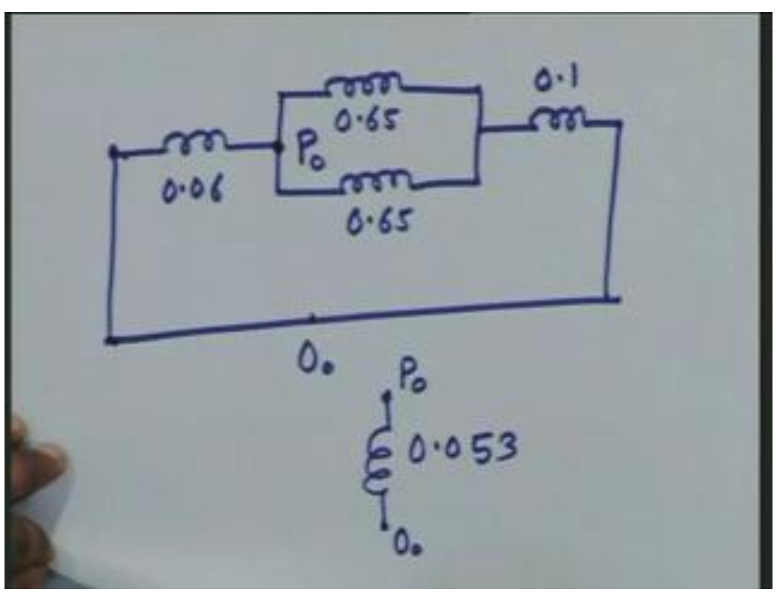

In this particular case if you draw this zero sequence network it will come out to be this value is 0.65, this is also 0.65, this is 0.1 this is 0.06, this is the zero sequence reactance of the generator. This is our reference bus incidentally in this connection, the generator neutrally is grounded therefore we can connect a neutral point to the reference. Okay if you had it not been grounded this would have been open the transformer is a start delta transformer with start point grounded and therefore again this point will be connected.

Now those who do not have the practice of drawing the zero sequence network, I will advice them to refresh their knowledge about drawing the positive negative in zero sequence networks particularly zero sequence networks, considering the different types of transformer connections now here this is the fault point I will call this as a P_{000} and the equivalent impedance looking into these two terminals has been computed it comes out to be equal to 0.053 these points are P_o and okay this so far we have obtained the positive negative in zero sequence networks and we have also obtained the equivalent value of the positive, negative sequence impedances for the network considering the fault location.

Now in order to consider the effect of different type of fault in the system right, these 3 networks have to be connected in a proper fashion. They for line to ground fault which we have considered these 3 networks can be connected in this fashion.

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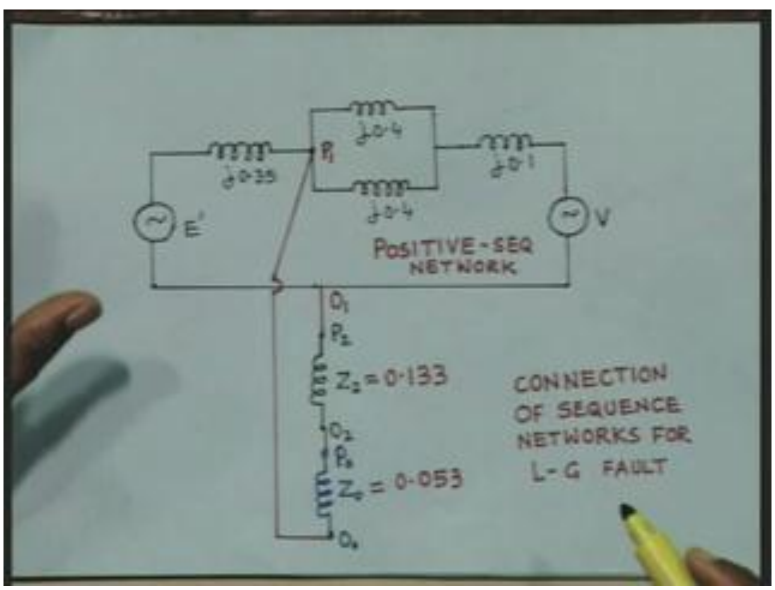

This diagram shows the positive sequence network and here we have not simplified this network, the fault occurs at the point P_1 in the negative sequence network is shown in the terminals P_2 and O_2, well while zero sequence impedance is on between the terminals P_o and O_o.

Now for simulating line to ground fault the 3 networks positive, negative and zero sequence networks are connected in series that how we can connect these 3 networks in series that is O_1 is connected to P_2, O_2 is connected to P_o and O_o is connected to P_1 this becomes a series connection. It can be very clearly seen here that the positive sequence network is modified and here we have now and the impedance connected between P_1 and O_1 for line to ground fault, the value of the impedance connected is Z_2 plus Z_0 and this becomes the fault shunt.

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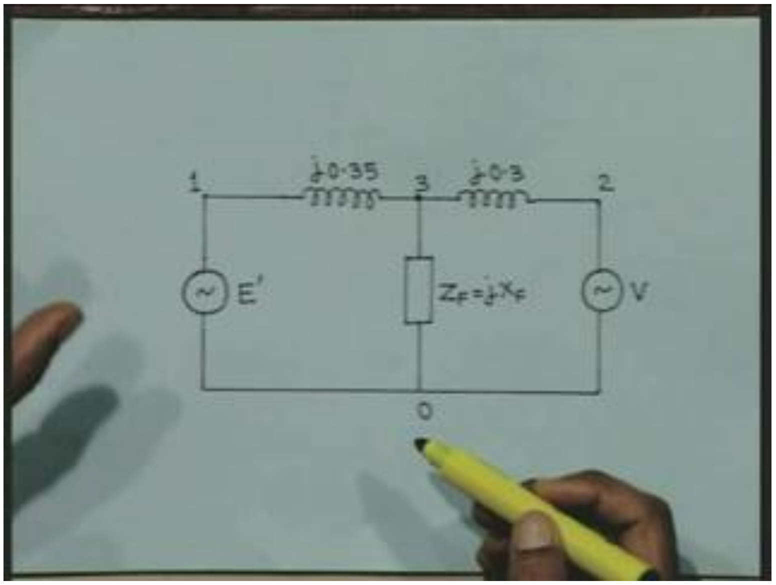

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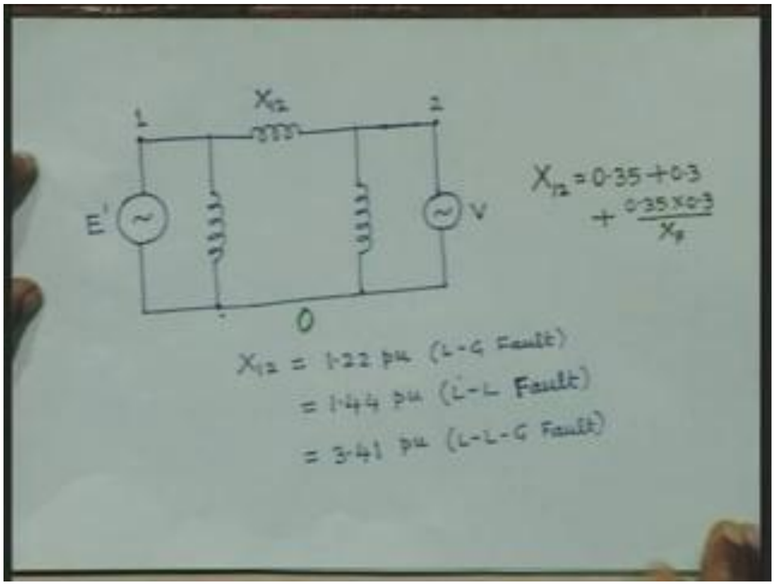

Now this network can be simplified, I will put in this simple form here between the node 1 and 3 the reactance is the transient direct axis transient reactance of the generator, this is the equivalent reactance of transmission line and the transformer and between this node 3 and O, reference node we have connected the fault shunt. If we have considered the lossless system then the fault shunt impedance becomes a pure reactance that is j times X_F. This network can be further transformed that is the start connected three impedances can be replaced by an equivalent delta connected impedances.

This figure shows the equivalent delta the nodes 1 and 2 are retained, the reference node is also retained as it is now the reactance connecting the node 1and 2 is X_{12} and the reactance which is directly coming across the E prime source E prime is shown here. Similarly, the reactance coming directly across the infinite bus voltage is also coming and is shown here now know that these 2 reactance's do not affect the power transfer capability or power transmission capability of the system therefore we concentrate only on the reactance connecting the nodes 1and 2. Now for line to ground fault X_{12} is equal to 0.35 plus 0.3 plus 0.35 into 0.3 divided by X_F where X_F will be the sum of the 2 impedances that is zero sequence and negative sequence impedance.

Now the value of X_F will be different for different type of fault. The value of X_{12} is computed for three different types of unsymmetrical faults for line to ground fault condition the X_{12} is 1.22 per unit, for line to line fault X_{12} comes out to be 1.44 per unit and for double line to ground fault it comes out to be 3.41 per unit.

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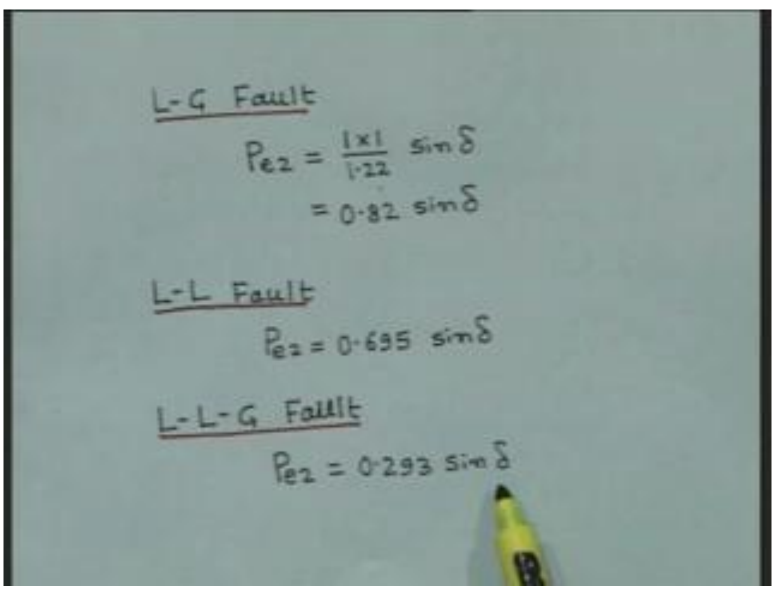

We can see here that the reactance connecting the nodes 1 and 2 which is primarily affects the power flow on the transmission line increases as we go from line to ground fault to double line to ground fault, if we determine the power angle characteristic during fault considering different type of faults for line to ground fault, for this particular system consider the power angle characteristic comes out to be P_2 equal to 0.82 sin delta, for line to line fault the power angle curve is P_2 equal to 0.695 sin delta and double line to ground fault P_2 is 0.293 sin delta that is if you examine these 3 power angle curves we find that the power angle curve with line to ground fault has the highest amplitude while the power angle curve corresponding to line to line to ground fault or double line to ground fault is having the smallest amplitude or and hence the, from the consideration of the transient stability limit or the power which can be transferred without loss of synchronism, the line to ground fault will provide more transient stability limit as compared to double line to ground fault.

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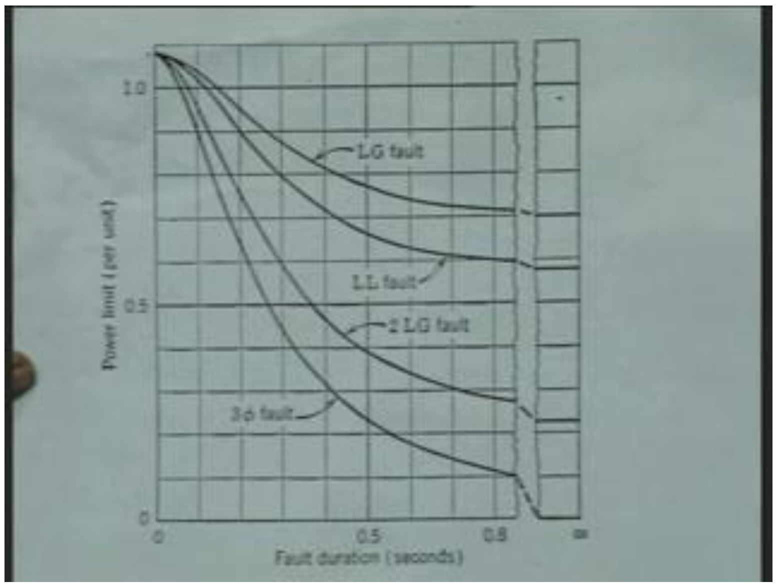

This figure shows the plot of transient stability limit or power limit as a function of fault duration in seconds. This curve shows the relationship between transient stability limit and fault duration for line to ground fault, the second curve is for line to line fault, third curve is for 2 line to ground fault and the last curve is plotted for a 3- phase fault.

Now we can easily see here that in case the fault is clear instantaneously that is when the fault duration is 0, then the transient stability limit is same in all the 4 cases and therefore we can conclude that the transient stability limit is not affected by the type of fault, if the fault is cleared instantaneously.

However, if the fault is cleared the time delay then it is very clear actually that the transient stability limit is lowest when 3- phase fault occurs and transient stability limit is highest for line to ground fault therefore, we can see that from the point of view of severity the line to ground fault is the least severe as compared to 3- phase fault or we can say that 3- phase fault is the severest fault from the stability consideration.

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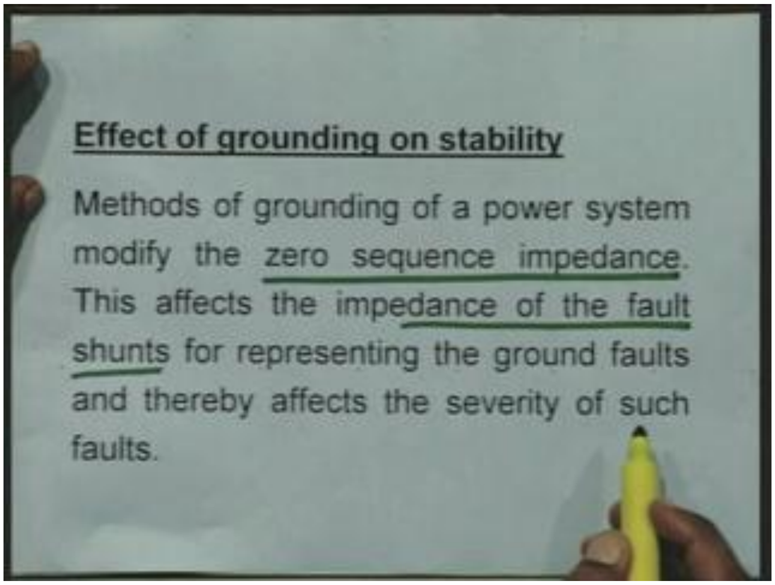

Now we study the effect of grounding on stability the methods of grounding of a power system modify the 0 sequence impedance this affects the impedance of the fault shunts for representing the ground faults and thereby affect the severity of such faults.

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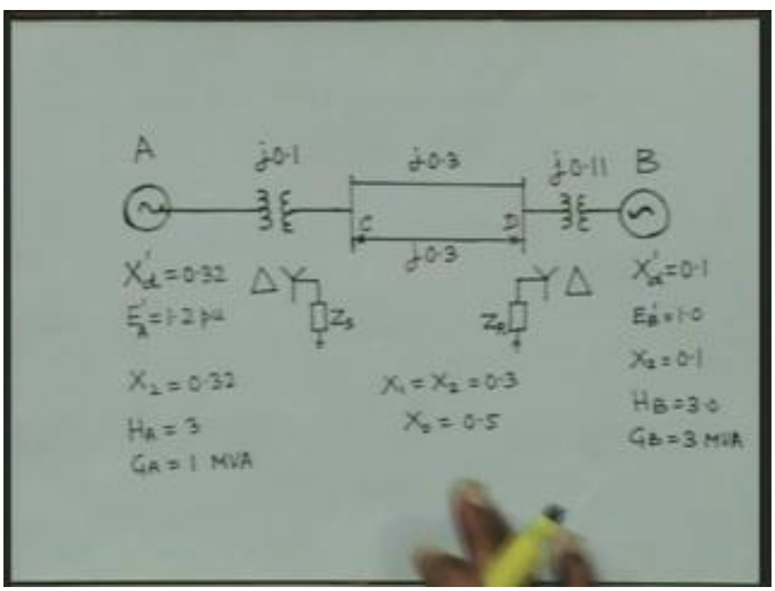

A typical to a system has been examined and transient stability limit is computed for different values of Z_S and Z_R for a 2 machine system.

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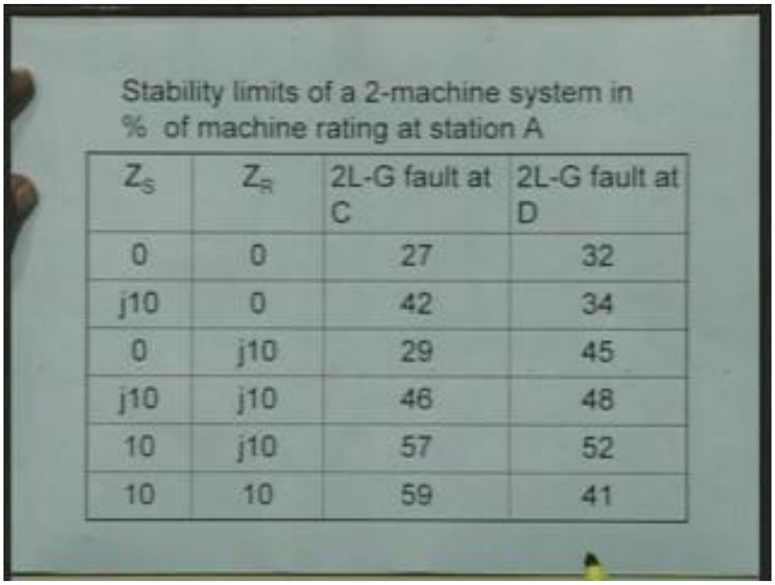

Stability limits of a 2-machine system in % of machine rating at station A

Z_S	Z_R	2L-G fault at C	2L-G fault at D
0	0	27	32
j10	0	42	34
0	j10	29	45
j10	j10	46	48
10	j10	57	52
10	10	59	41

Here the value of ZS and ZR are varied from resistive to the reactance value and this stable shows that as the as the value of the impedance connected in the neutral of the receiving end side and in the sending end side are varied from ohmic value to the reactance value, the stability limit varies thus we can say that is grounding affects the stability. Now I can say conclude my presentation that today we have examined the affect of fault duration type of fault location of fault and the grounding on the stability of the system, thank you.