Power System Protection and Switchgear
Professor Bhaveshkumar Bhalja
Department of Electrical Engineerig
Indian Institute of Technology, Roorkee
Lecture – 25
Auto-reclosing and Synchronizing-III

Okay. So, in this class, let us continue our discussion on auto reclosing and synchronizing. So, we have considered the several factors that on which the performance of auto reclosers depend.

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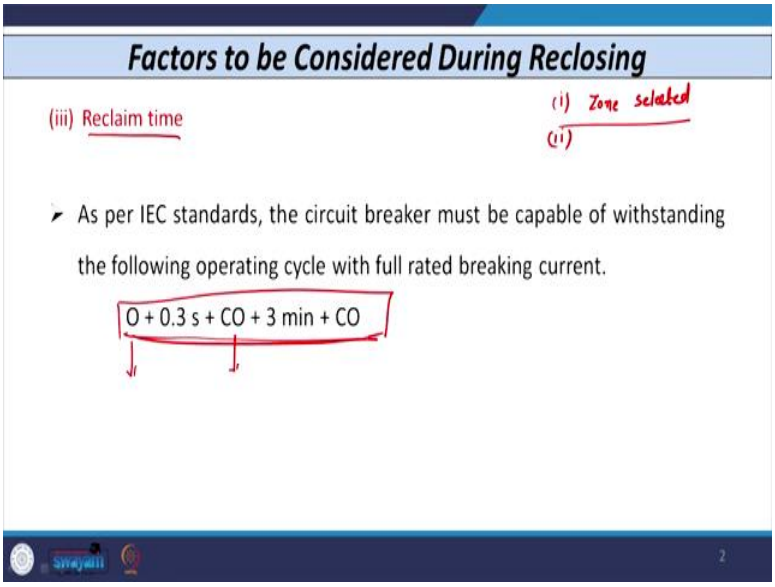

So, we have discussed first we started with the first factor that is the zone selection. So, we have discussed that if we use the auto reclosers along with distance relay, then we have to use the auto recloser only for the first zone that is instantaneous in nature. We cannot use or we should not use the auto recloser for the delayed zones that is zone two and zone three.

The second, we have discussed that is the deionization time or the, of the breaker as well as the auto reclosers, so that also we have discussed. And the third, we have discussed that is the reclaim time. So, reclaim time is also very important. And as I told you that it is the time between the two successive auto reclosing attempt.

And if we consider the IEEE standard, then the circuit breaker that must be capable of withstanding the certain operating cycle with the full load of rated breaking current and this cycle that is given by this equation. So, this is where O is the opening and CO is the closing followed by opening. Now, what is the meaning of this equation? So, to understand this, let us consider just one example.

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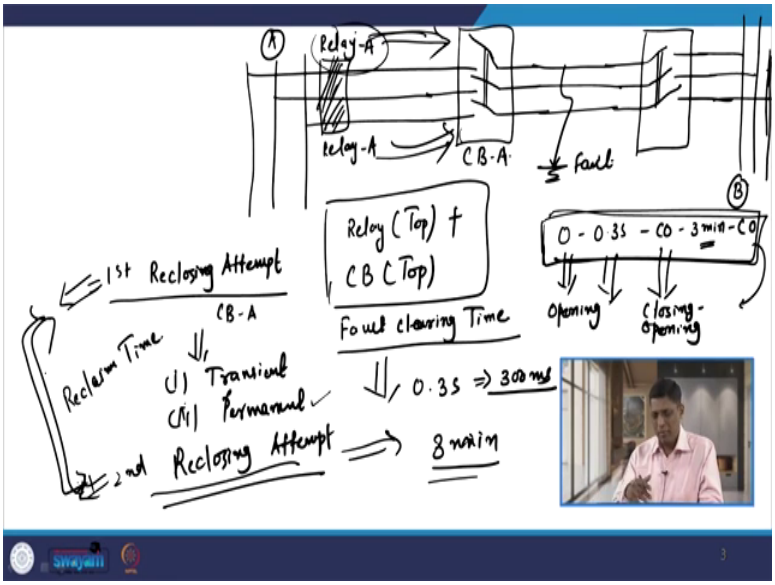

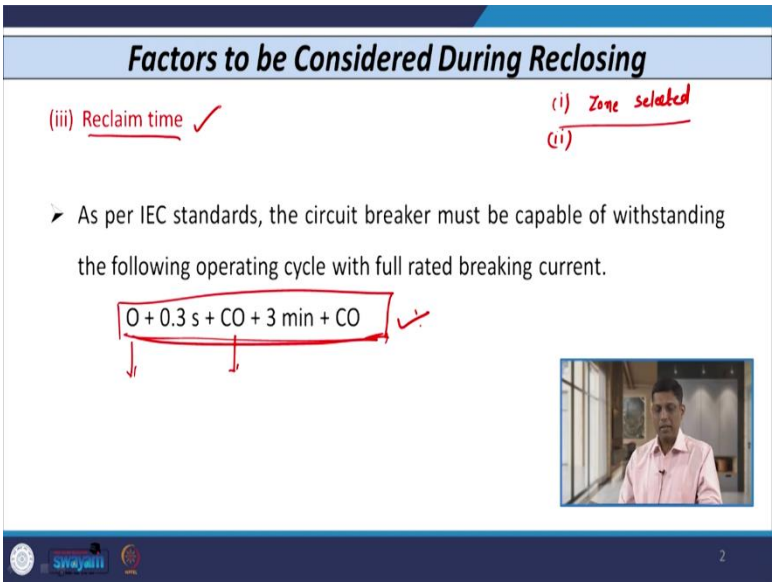

So, let us assume that we have three phase circuit and we have the breakers that is here at this end, and then we have the line and again we have the breakers at this end, and then we have this is connected with the bus. So, we have the three lines. Now, this is the your breaker equipped with auto reclosing facility and this is also the breaker equipped with auto reclosing facility. This is your substation A and this is your substation B. Now, what is the meaning of this sequence.

One is the you can see the sequence it is opening then point 0.3 second delay, then you have the CO then 3-minute delay, and then you have the again CO. So, let us understand what is the meaning of this equation. Now, whenever a fault occurs on this line here for a fault on this line the immediate effect is that the relay located at this point, this relay that will census

this fault and it gives signal to the breaker this is your circuit breaker at substation A, and this is really at substation A.

So, as soon as relay detects this fault, it gives signal to the circuit breaker and this circuit breaker after certain time means immediately after this the trip coil circuit breaker is energized and its contact become separate, as soon as it contacts separate, so there is an arc across the contact of circuit breakers and then because of the quenching medium dielectric strength of the quenching medium they are that will be quenched.

So, once arc is fully quenched, that is the, that comes under the relay time. So, I can say the time of operation of relay plus you can say the circuit breaker time of operation and this we called as the fault clearing time, fault clearing time this we have already discussed, when we consider the overcurrent and distance relays.

So, once the breaker contact of the breaker becomes open then there is a we have to give a 0.3 second time delay as mentioned here, so that is 300 millisecond time delay. After 300 milliseconds, the operation first reclosing attempt that has to be performed by breaker A. So, first reclosing attempt that is performed by this recloser that is circuit breaker A and its contact that becomes closed.

So, again its coil is energized it gives signal and then the contact closes. So, once this is done now there are two chances what is the fault that can be transient in nature and the other possibility that is the fault that is permanent in nature. So, if the fault is transient in nature that will automatically die out so, the breaker remain in close condition.

If the fault that is in permanent if it is a permanent time, then obviously what happened that the again this protective relay at A comes in picture so relay that will again A census default it again gives to the signal to the circuit breaker and hence the contact of the circuit trip coil is energized contact become separate and then arc is quenched.

So, again, whenever this contact becomes open, so this is nothing but your closing followed by opening. So, this is nothing but your opening and this CO is nothing but closing followed by opening. Again, if you go for next secondary reclosing attempt, second reclosing attempt assuming that default is permanent in nature or fault still persist, then again you need to do 3-minute time delay. So, there is a 3-minute time delay.

Again, you need to close the contact of the breaker and again if fault still persist if it is a permanent then again the relay at this point A detects the fault it gives signal to the breaker and contact of the breaker that becomes open and then it remains in lockout condition because this is already completed, this sequence is already completed. If you need to go for third reclosing attempt then again, you need to continue from this side. So, this is just the overview of what is the meaning of this equation.

And this equation if you consider here, the time between the first reclosing attempt right and the secondary closing attempt this time that is known as reclaim time. This time is known as reclaim time and there should be sufficient time. Otherwise, if this time between two reclosing attempt that is very small, then there are chances of the some other recuperation may occur and because of that some of the fault that can be, that may not be cleared or relay may mal operate in this situation. So, this is all about the operating sequence with reference to the reclaimed time.

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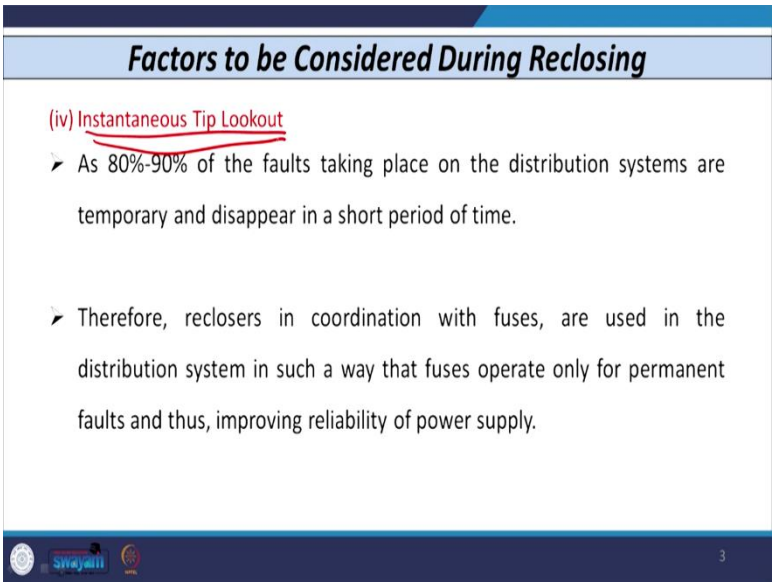

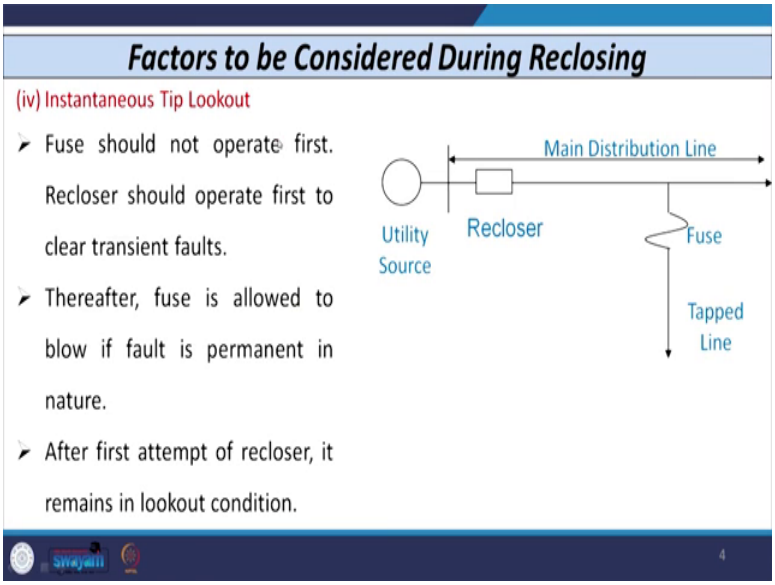

Let us consider the fourth factor which needs to be considered when we decide the application of auto reclosing in actual field and the fourth factor that is very important that is known as the instantaneous trip lockout. Now, instantaneous trip lockout that is very important when we consider the distribution system.

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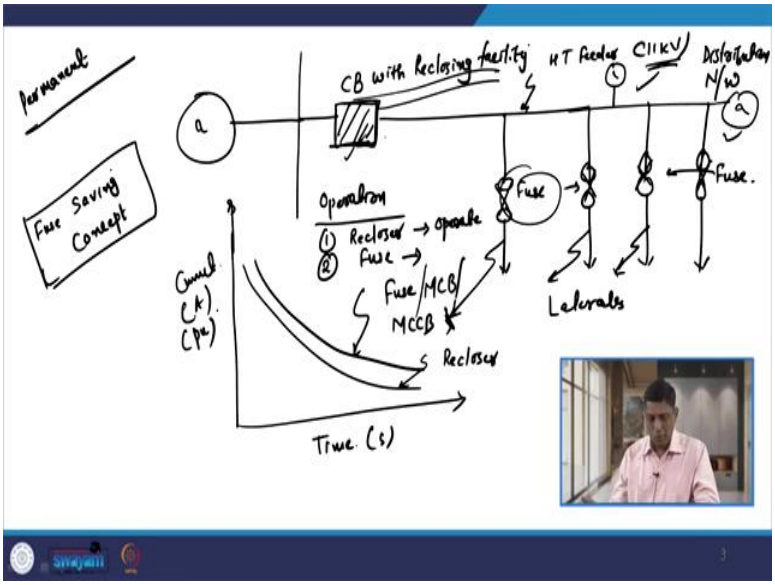

So, if I consider the distribution system, for example, let us say we have source and then bus and then we have a breaker, so this is your circuit breaker with auto reclosing facility with reclosing facility, and then you have this is your HT feeder that is 11 kV feeder let us assume and then you have the several laterals that is going on from this and this laterals that is protected by the device known as the fuse. So, this is all are the laterals, which is protected by the fuse. So, these all are laterals and this all are the fuse from here.

So, now if I consider a fault somewhere here on the lateral then this breaker that is equipped with reclosing facility, so if I just draw the characteristic of the breaker, the time current characteristic of the breaker this is the time in seconds and this is the current, maybe ampere or you can say in per unit also then now what we will do whenever fault occurs or any of this laterals we do not know whether the fault is permanent or transient.

So, what we will do we, will allow the recloser to operate first. So, the operation is like this that the recloser will operate first. So, recloser first operate. So, the characteristic of recloser that should be let us say like this, so, this is the characteristic of recloser. If a fault is transient in nature then when you reclose it means, this breaker, this fault that is detected by this recloser so breaker becomes open then we reclose it.

So, firstly reclosing attempt, and if fault is transience in nature, then it will automatically die out and the system becomes healthy, it comes in normal condition so no need to do anything, but if fault that is in permanent in nature, then again, what we will do, we after first reclosing is attempt when the reclosing is carried out fault still persists, so then the breaker again becomes open and we assume that we allow the fuse to operate.

So, fuse characteristic that is somewhere here. So, this is the characteristic of fuse you can say some other device also like MCB or MCCB. So, what we assume is that whenever fault occurs on the laterals any of the laterals then fuse must operate only for the permanent fault. It should not operate for any transient fault.

So, if we wish this then what we need to do is we need to just the second operation is fuse, that is one thing, but that is only for permanent fault. So, the proper coordination between fuse and this recloser that is required still we have this is just and this concept that is known as the fuse saving concept.

Now, this is very simple problem and this this this type of problem exists when we consider the distribution network. So, this type of problem exists normally in distribution network. But as we know that nowadays the renewable energy sources are government that is encouraging this type of sources and we are allowing various solar and wind other types of sources to connect here. So, any of this DG or solar type of generation if exist some on other side also right this is small scale generation, then again the coordination that is entirely different right that is not the scope, but this is just a very good research point of view it is a very good area to work.

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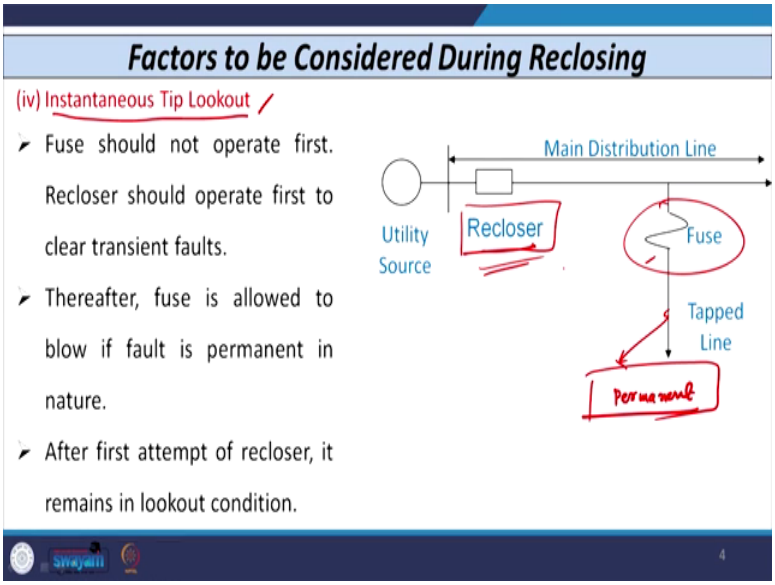

So, that means whenever fault occurs somewhere here then fuse should operate only for permanent fault it should not operate for any transient fault. In case of transient fault, recloser should operate first so that there is no need because we know that 80 to 90 percent faults are a single-line to ground fault, so for all these 90 percent or transient faults, no need to again rewire the fuse and fuse saving concept that can be applicable at the distribution network. So, this is all about this thing.

So, in this case what will happen? In this case you can say that the name that is given is instantaneous trip lockout. So, if fault is permanent in nature, let us assume that this fault is permanent in nature, so even though fault is transient or permanent we do not know so recloser should first operate first reclosing attempt is carried out the fault is permanent, so again the breaker contacts become open then fuse operates and hence, we need to rewire of this fuse in this as the fault is permanent in nature.

So, after firstly reclosing attempt recloser should not operate or no further sequence of events that is to be carried out for recloser. So, after first reclosing attempt, this recloser should go in lockout condition. So, that is why it is known as the instantaneous trip lockout feature and this factor is very important when we consider the distribution network where we need to coordinate the recloser with the other load and devices like the fuse MCB or MCCB.

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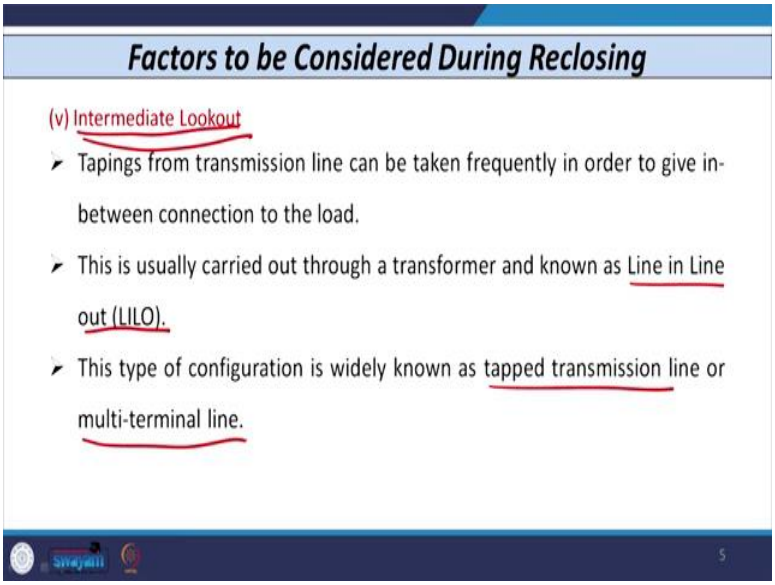

Now, the fifth factor which is very important that is known as intermediate lockouts. Now, what is intermediate lockout? Now, we know that the tappings from transmission line or maybe distribution line also that can be taken very frequently and this is required because we need to provide the connection to the load in between.

So, this is usually carried out with the help up transformer and this type of whole activity that is known as Line in Line out activity and this is frequently performed by the utility particularly at distribution or sub transmission network. So, this type of configuration is that is widely known as tapped transmission line sometimes also known as multi-terminal line.

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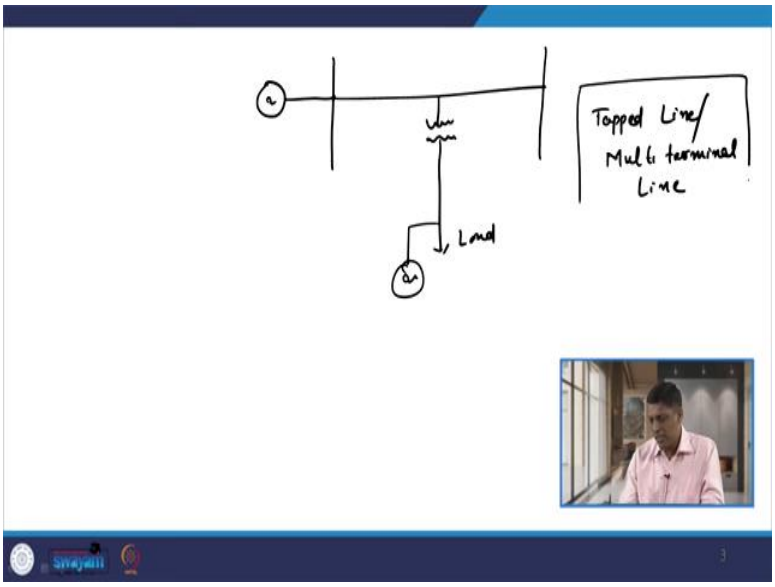

So, if I just consider here what is the structure of this. So we have a source here, then we have a bus and then we have a line somewhere here. So, from here what you do is with the help of transformer, you can take the tappings from it and give it to the load. Sometimes, it may be possible that the some of the source may exist, as I told you, it may be renewable sources. So, this type of structure that is known as the tapped line or multi-terminal line, multi-terminal line. And whenever such type of configuration exist in distribution or sub transmission level.

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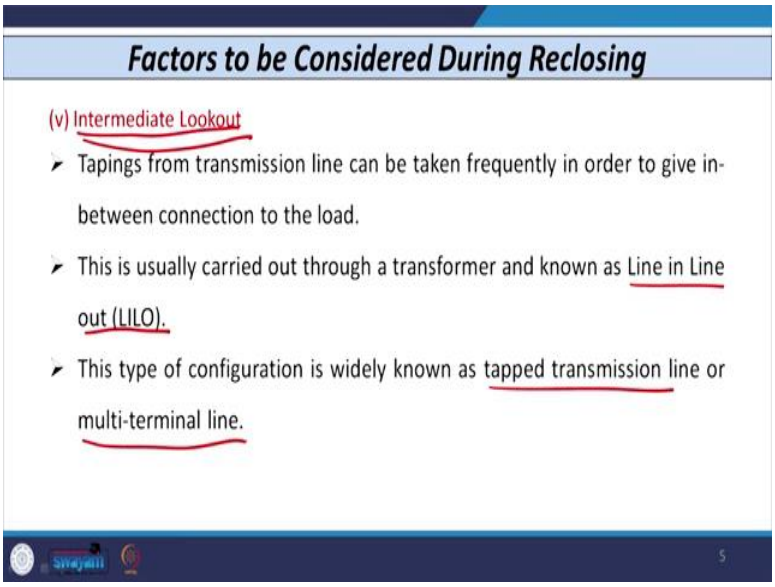

And we need to apply auto reclosers on such type of configuration of line then we need to take care of certain factors. So, that factor is known as intermediate lockout.

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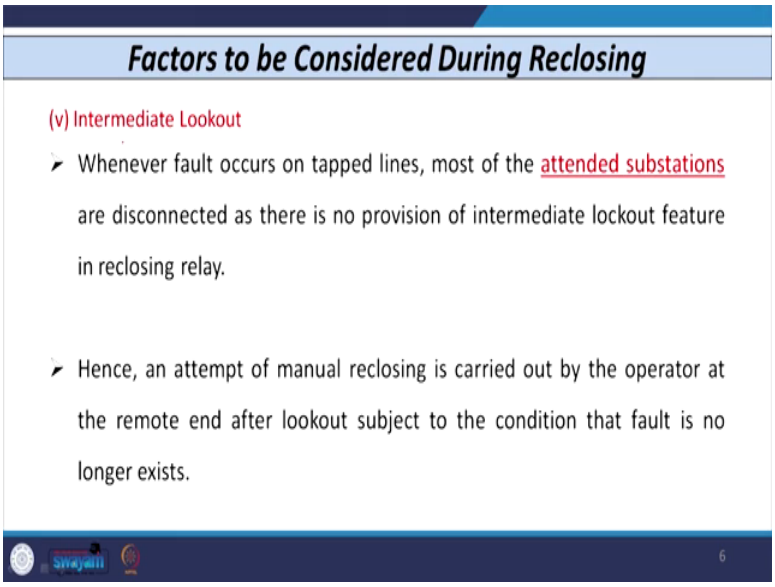

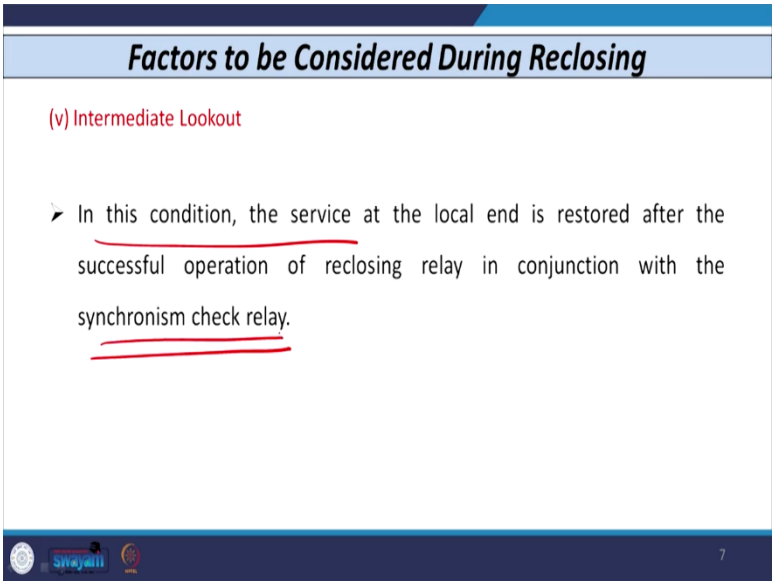

Now, whenever fault occurs on such type of tapped line or multi-terminal lines, there are two possibilities. Maybe one, we have the attended substations the other possibility is we have the unattended substations. As I told you attended substations are those substations where operator exists and non-attended substations are those substations where the operator that is not there and we are operating all the devices automatically or maybe from the remote substation.

So, we know that most of the attended substations are disconnected, if use multi terminal tapped line, as there is no provision of intermediate lockout feature in this case, because whenever we have attended substations it is not possible to use this and we have to shift the breaker from auto to manual mode and whatever operator is there in the attended substation, he has to carry out the further operation or further sequence.

So, an attempt of manual reclosing is carried out, as I told you in the attended substations at the remote end after the lockout subject to the condition that fault no longer exists in such type of configuration. So, in this condition, the service at the local end that can be easily restored after successful operation of reclosing relay in conjunction with the synchro check relay. What is synchro check relay? That I will explain within 5, 10 minutes.

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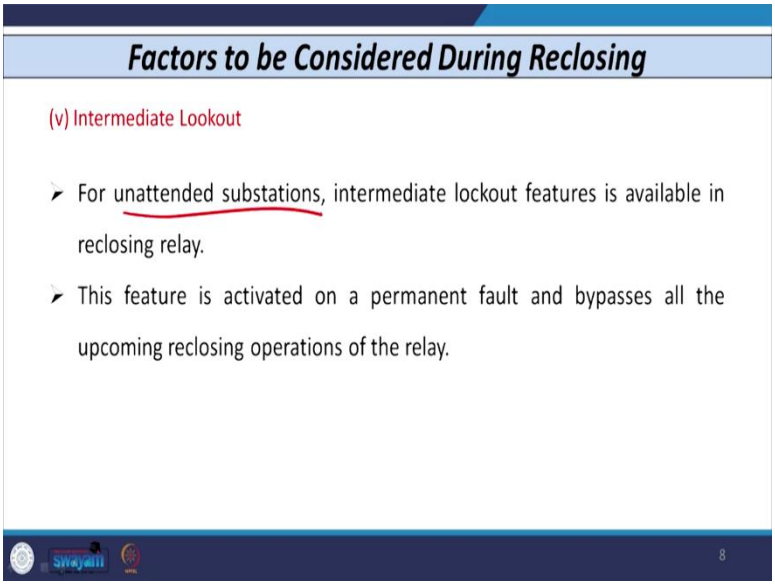

So, on the other hand if I consider the unattended substations and where we have such type of transmission or distribution configuration exist like tapped or multi-terminal lines then intermediate lockout feature that is easily available in the reclosing relay, so this feature is activated in case of permanent fault only.

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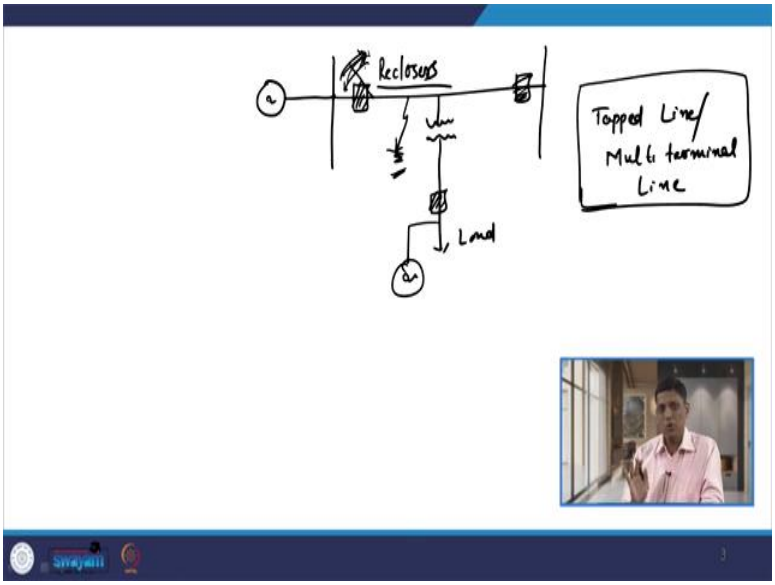

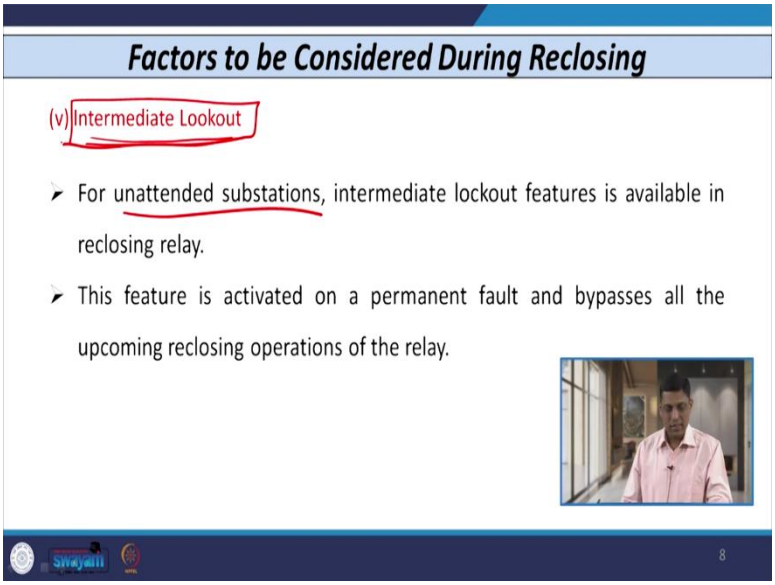

So, that means, what will happen if suppose we have a breaker here, breaker here and we do have a breaker here also if we have a source over here. Now, wherever permanent fault occurs on any of this subsection of this tapped line or multi-terminal line, this breaker that remain in open condition that breaker becomes open.

When we give reclosing attempt still fault is permanent in nature, so again, it becomes open. And then, if we are sure that this fault is permanent type of fault there are some algorithms available, which can tell you whether a fault is transient or permanent. So, if we are sure that this type of fault or this fault is a permanent in nature, then after first three closing attempts, and suppose these reclosers that is capable to carry out three closing attempts, then if we are sure that the fault is permanent in nature then after first reclosing attempt, this recloser should go in the lockout condition that is the meaning of this intermediate lockout.

So**,** even though the recloser is capable to carry out 3 reclosing operations, but we found out that okay, if default is in permanent type, so after the first reclosing attempt it will directly go into the lockout situation. So, another next two or one reclosing attempts that cannot be attempted. So, this is nothing but the intermediate lockout feature. That is very important as far as the auto reclosers are concerned.

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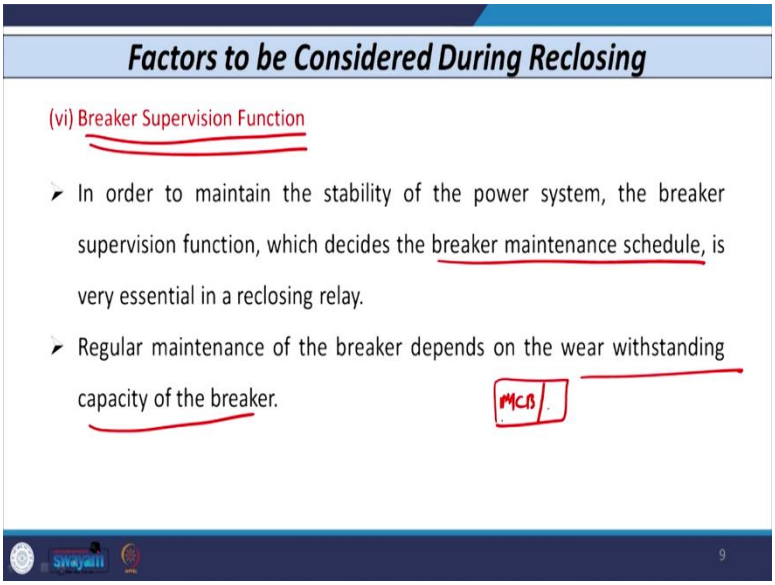

The next factor that is known as the Breaker Supervision Function. So, we know that in order to maintain the stability of power system, the circuit breaker supervision function that is very important, and that decides the breaker maintenance schedule. So, if we wish to decide the maintenance schedule of the circuit breaker then that is this type of feature breaker supervision function that is very important, and the regular maintenance of the bridge circuit breaker that depends on the wear withstanding capability of the breaker.

So, whenever we purchase the circuit breaker each and every manufacturer has to specify how many number of mechanical operations this breaker that is capable to carry out successfully. Even though if you purchase let us say the MCB also from the market, then for that MCB also the number of operating mechanisms, mechanical operations that can be successfully carried out by this MCB that is also mentioned by the manufacturer. Same thing is applicable for the circuit breaker.

When we use digital relays the separate function is provided which issues the alarm or maybe warning when there is a need of the breaker maintenance. So, digital relay associated with circuit breaker, so digital relay will issue a command based on the because whenever you install such thing you have to in the relay itself the breaker supervision function is available. So, you have to feed or provide how many mechanical operations this breaker can easily carry out.

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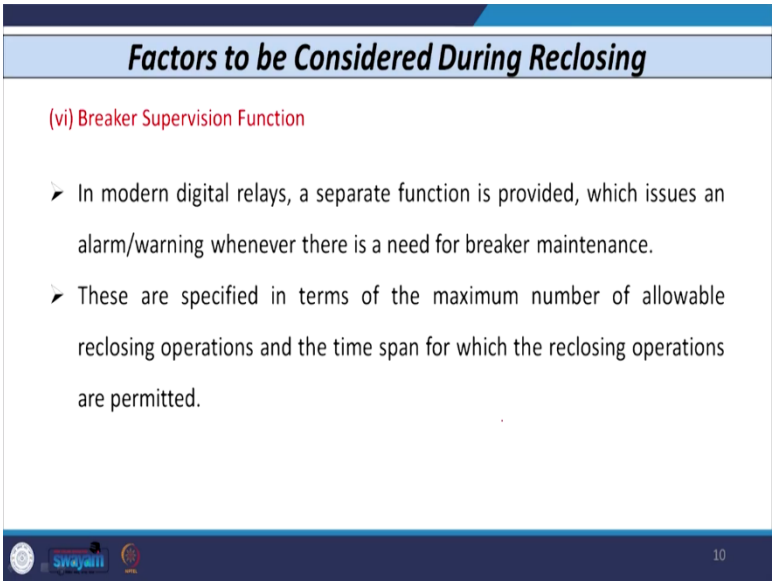

So, once a relay has this number, then it can automatically issue the alarm or warning that okay now there is a need of the breaker maintenance and the operator has to take care of such warning or alarm. So, this are specified in terms of maximum number of allowable reclosing operations, and the time spam for which the reclosing operations are permitted.

So, the relay has to issue a command that okay, this much reclosing operations are permitted or allowed and what is the time between each reclosing operation that has to be specified or given by the digital relay associated with the circuit breaker.

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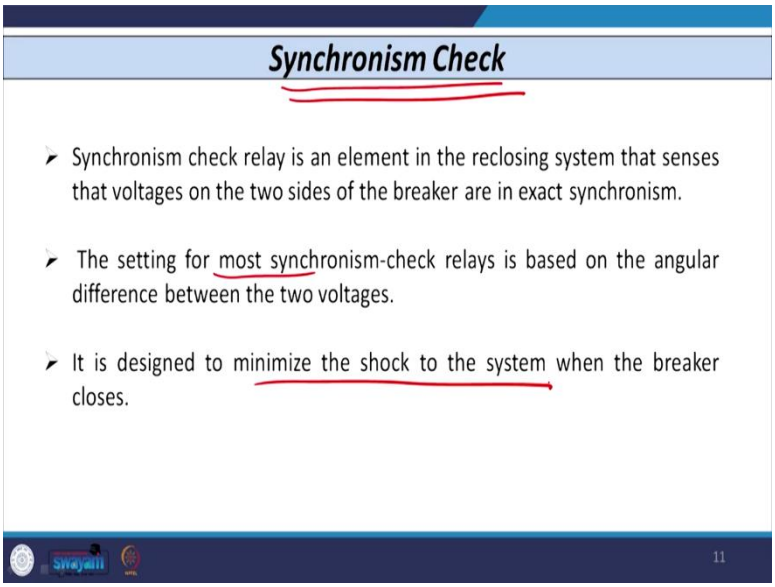

Now, with this background, let us consider the next part that is known as Synchronism Check. Now, what is synchro check? So, synchronism check it is a relay or an element in the reclosing system. So, when we use the recloser we have to use the synchro check relay or synchro check element.

This element senses the voltage on the two sides of the breaker and whenever the minimum voltage that is available or exists across the contact of the circuit breaker phase wise, then we have to go for the reclosing attempt. So, that whatever the impact on the contact of the breaker that should be minimized.

Now, how to carry out the setting of synchro check element or relays? So, this setting that is based on the angular difference of the two voltages. So, sometimes you can take only the difference of magnitude sometimes you can take the difference of angular difference also or sometimes you can take the phasor difference also across the contact of circuit breaker, so you consider both magnitude and angle, so that is the different ways how you can check the voltage across the contact of circuit breakers.

So, it is designed to minimize the, basically the main function of synchro check element is to minimize the shock on the system, when the circuit breaker closes when the contact of circuit breaker closes. So, this is very important point. Now, the angular difference between the voltages.

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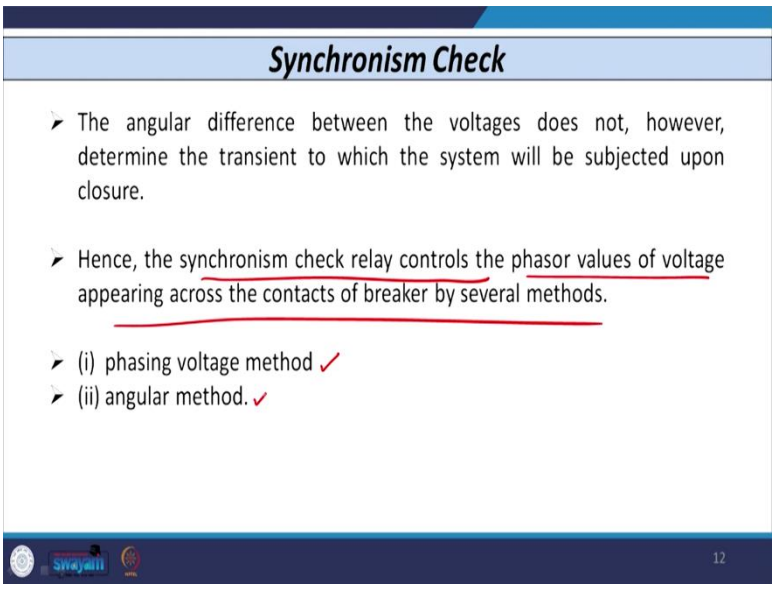

Sometimes you can say that the angular difference between the voltages you can measure. However, this is not going to determine any transient condition, so when we use the synchro

check relay we can see that the phasor values of voltage appearing across the contact of circuit breaker as I told you, that we can also utilize. So, basically there are two methods for applicable on synchro check element one is known as the phasing voltage method and another that is known as the angular method. So, let us discuss what is the phasing voltage method.

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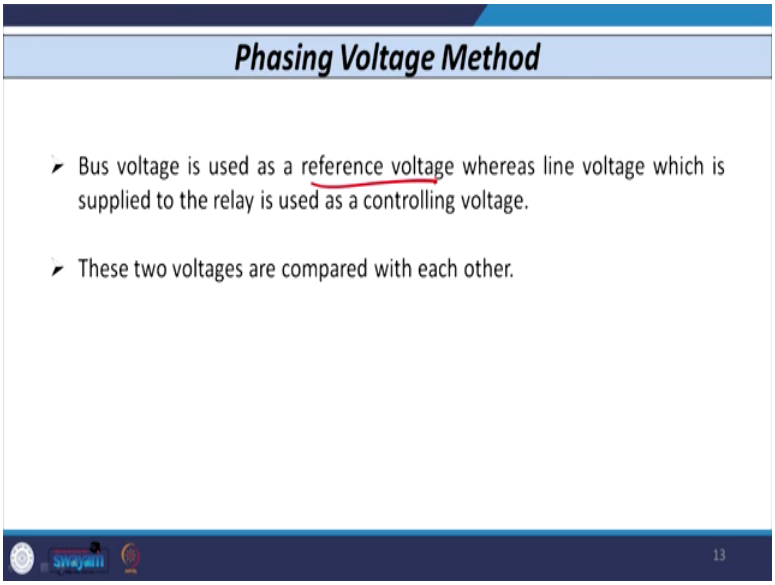

So, here the bus voltage is used as a reference and the line voltage that is supplied or given to the synchro check element or synchro check relay as a controlling voltage. So, these two voltages are compared with each other and when the difference that exceeds some predetermined value, then the output of the synchro check relay that is available.

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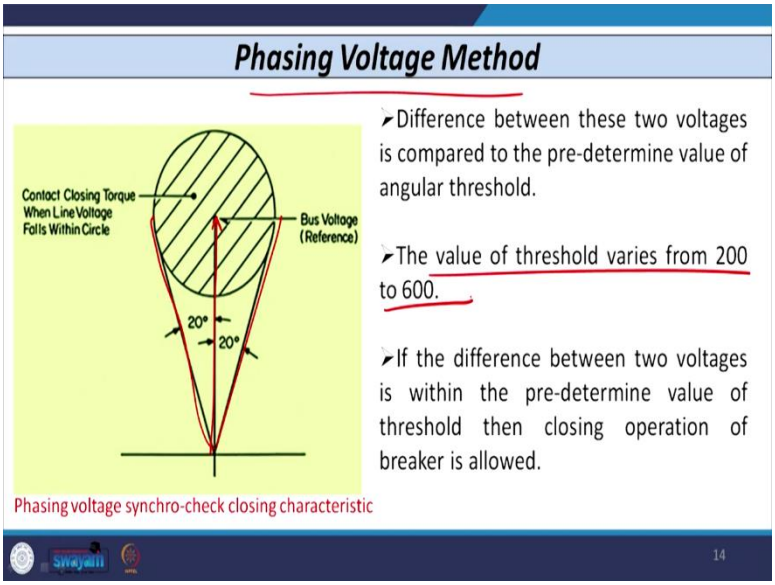

So, you can see that this is the just the phasor diagram of phasing a voltage synchro check element or based on the phasing voltage method. So, you can see that once you have the, this is your bus voltage which acts as a reference and you have the other voltage line voltage. So, this line voltage either on this side or this side that tend to be compared with the reference value and the pickup value or predetermine threshold that is varies from this to this value usually, it is not always sure that the pickup varies always or threshold value varies always within this range.

If the difference between these two voltages that is within the predetermined value of the threshold then the closing operation of breaker that is allowed otherwise the closing is not allowed and then again you need to continuously check for every sample by sample, and then whenever the difference that is within certain value then and then the closing of the circuit breaker that is allowed.

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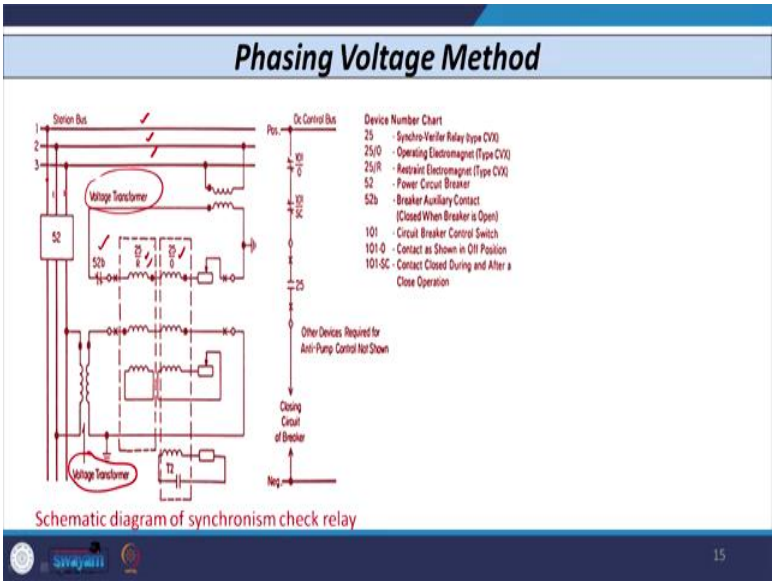

So, this is the control circuit of facing voltage method. You can see that there are three bus voltages, and then you have the three lines emanating from this. So, you have the voltage transformer element, and you have the voltage transformer element here also. And on the secondary side you can see that there are two things the 52b that is related to circuit breaker associated switch and you can see the 25 O and 25 R that is existing and this 25 O that is the operating element that is known as the synchro check element, operating coil and restraining coil of the synchro check relay or synchro check element. So, whenever it is within this predetermined threshold value, then the operation that is not carried out otherwise the operation is performed.

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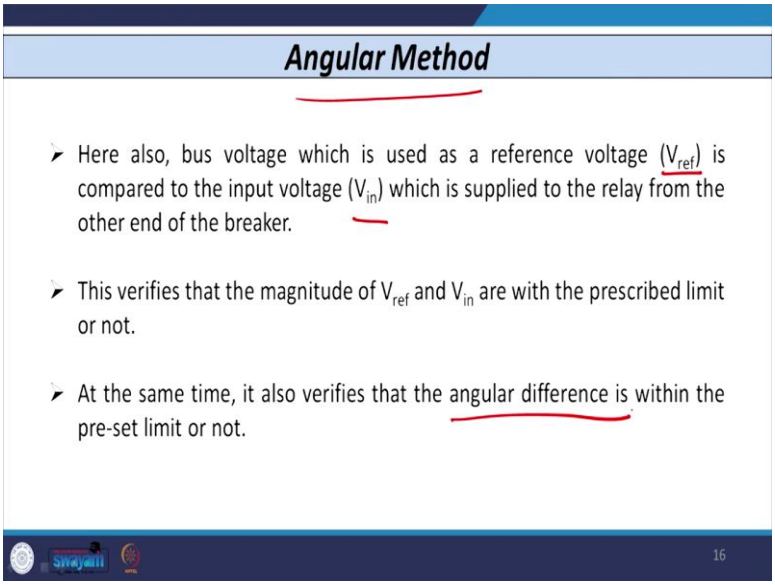

In the second method that is the synchro check method, the angular method is used. So, here the again the same thing is that the bus voltage is used as a reference that is V ref and the line voltage that is used as a V input voltage, and you need to compare these two. So, this verifies the magnitude of V reference and V in. And if this is within the prescribed limit or not that need to be checked.

So, you can see that here, along with the magnitude you are also going to verify the angular difference, whether it is within the some pre-set or predetermined value or not. So, that need to be checked.

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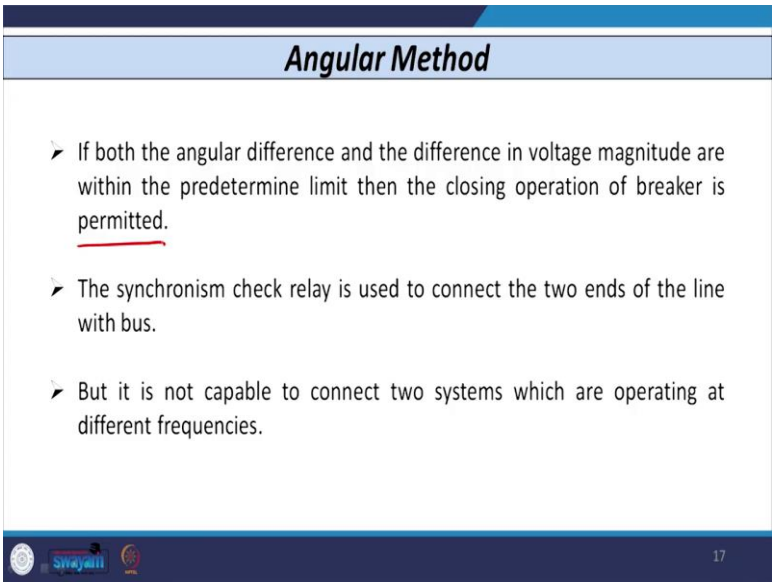

If both the angular difference and the difference in the voltage magnitude are within the predetermined limit, then the closing operation of the breaker that is permitted. If the difference is beyond the limit then the cruising operation that is not allowed. And sometimes nowadays, along with this synchro check relay or element, the interlocking is provided, so that will be done automatically in the unattended substation.

So, whenever the difference is above the limit then even though or if even though the operator press the button for closing of the breaker, then also is not allowed. So, this is all about the angular method. So, we started our discussion with the factors to be considered. When we apply the auto reclosers on the actual field that is very important. And then we have discussed the synchro check element, there are two methods phasing voltage method and the angular method. So, I stop here and we will continue in the next class we will discuss the next topic. Thank you.