Power System Protection and Switchgear
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Lecture - 22
Carrier Aided Schemes for Transmission Lines-IV

Okay. So, now let us discuss the carrier added transfer tripping scheme.

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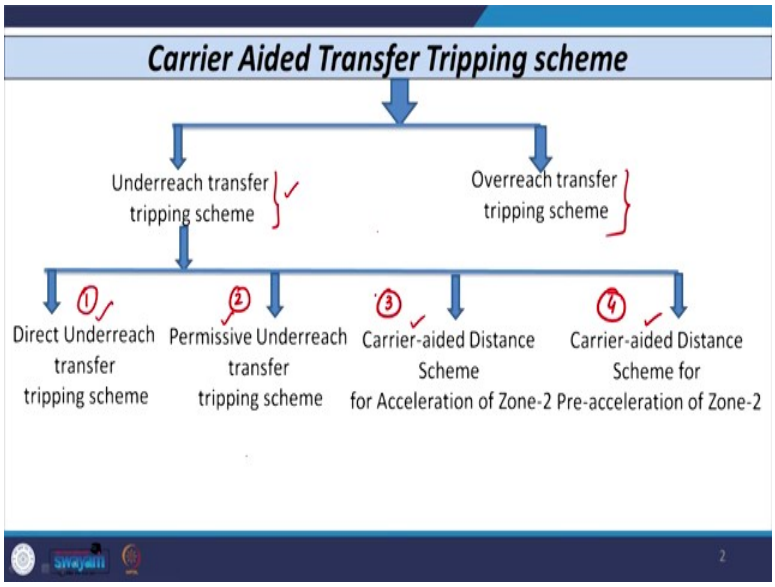

So carrier transport tripping scheme that is classified as one is known as the underreach transfer tripping scheme and the other is known as overreach transfer tripping scheme.

The overreach transfer tripping scheme that is further subdivided into direct underreach transfer tripping scheme permissive underreach transfer tripping scheme carrier aideddistance scheme for acceleration of Zone-2 and carrier aided distance scheme for pre-acceleration of Zone-2. So, these are the main different schemes available under the carrier aided transfer tripping scheme.

Again, as I told you earlier that the carrier tripping scheme or carrier added transfer tripping scheme works on the principle that, whenever the signal, carrier signal, that is received from the other remote and substation and if that carrier signal is used for the tripping of the relay then that is known as carrier tripping scheme.

And under that, that is classified as under reach and overreach and in under reach, there are four different schemes available. So, let us start with the, our discussion with the under reach transfer tripping scheme.

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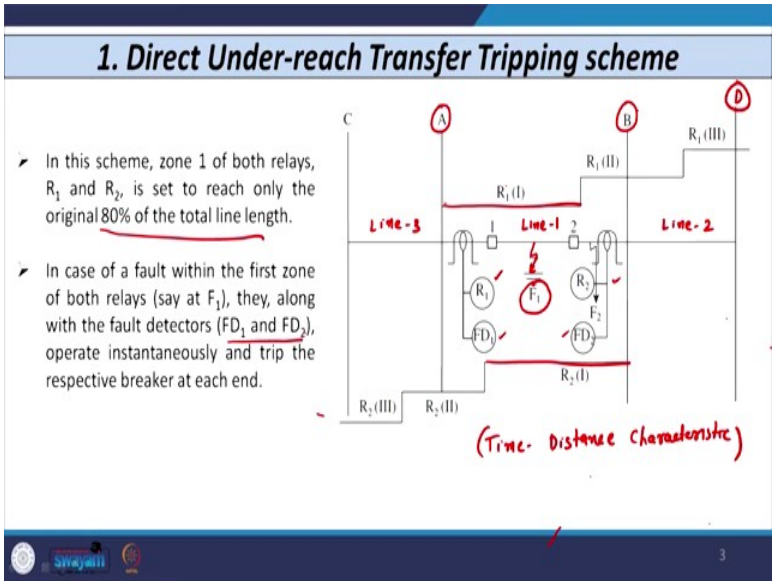

Now, if I consider the underreach transfer tripping scheme, let us discuss the first scheme that is the direct underreach transfer ripping scheme. So, let us discuss the first one, that is the underreach transfer trip scheme. This is the time distance characteristic of the underreach direct underreach transfer tripping scheme.

So, in this scheme, the again there are two relays that is the R1 and R2, that is used to protect the line connected between bus A and B. So we have a line, which we need to protect that is line 1. Here, we have the, another two adjoining lines, line 2 and line 3, these are these two lines are connected between the bus A and C and between the bus B and D.

So, Now, the you can see that the zones of this two distance relays R1 and R2, that is set as the normal zone of the distance relay that is the first zone of this R1 and R2 that will cover 80% of the line length, so that is why we have shown here this, that is the 80% and this also we have shown that is the 80%, R1 (I) and R2 (I). Similarly, the other two zones are there for R1 and R2.

Now in case of fault within the first zone of the both the relays. Let us say at F1, if fault occurs at F1, then this fault that is R1 relay detects this faulty in its first zone, R2 relay detects these faults in its first zone, as we have already discussed, that if fault occurs within the 60% of the line region then this fault that is detected in the first job by the two distance relays located at each side of the bus.

So, in this case if fault occurs at F1, then R1 and R2 both these relay detect this fault in its first showed. Now along with this two distance relays, we have the two another device known

as FD 1 and FD 2, it is fault detectors one and fault detectors two. So this faultdetectors one and two, these two are nothing but the basically the instantaneous overcurrent relays.

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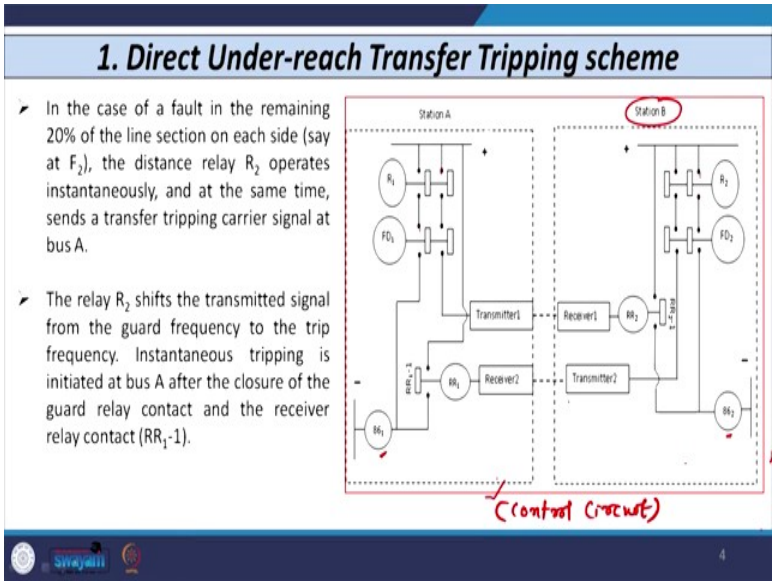

So, what will happen that if fault occurs at F1, this is the control circuit of the direct underreach transfer tripping scheme. So, if fault occurs at F1, which is the first zone of both the relays R1 and R2, then what will happen relay R1 operates sothese two contacts that closes here, similarly, fault detector one at bus 1 also operates because current exceeds the predetermined limit, so these two contacts also closes.

Same way on the other bus, station B also the R2 relay detects the same fault at F1 in first zone, so these two closes. Again, the fault detector two also detects the fault, so these two also closes and hance the direct tripping that is initiated and retrieve auxiliary relay that is 86(1) and 86(2) coil of auxiliary relay that is energized at both the bus,enhance the direct tripping is initiative, this stripping is known as instantaneous tripping.

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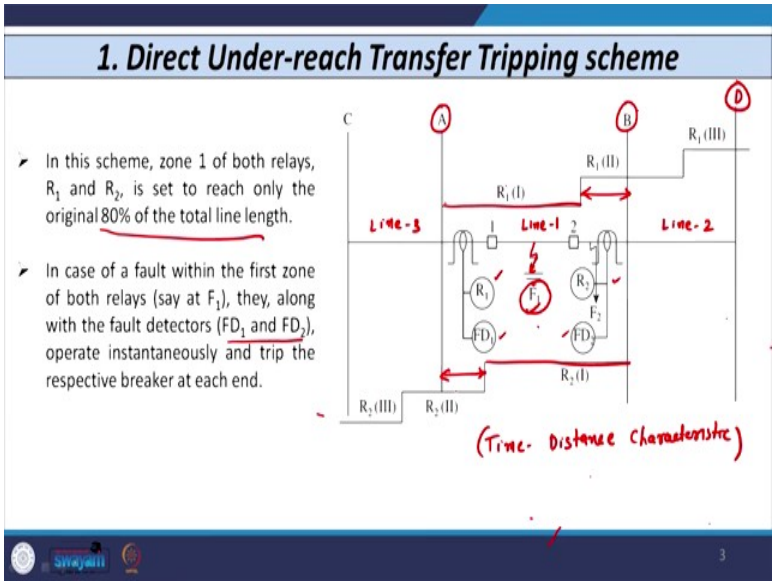

Now, in case of remaining 20% of the line section that means if fault occurs in this section or fault occurs in this section then let us see, how we can achieve the instantaneous tripping, which is not possible if we use the conventional distance relay scheme.

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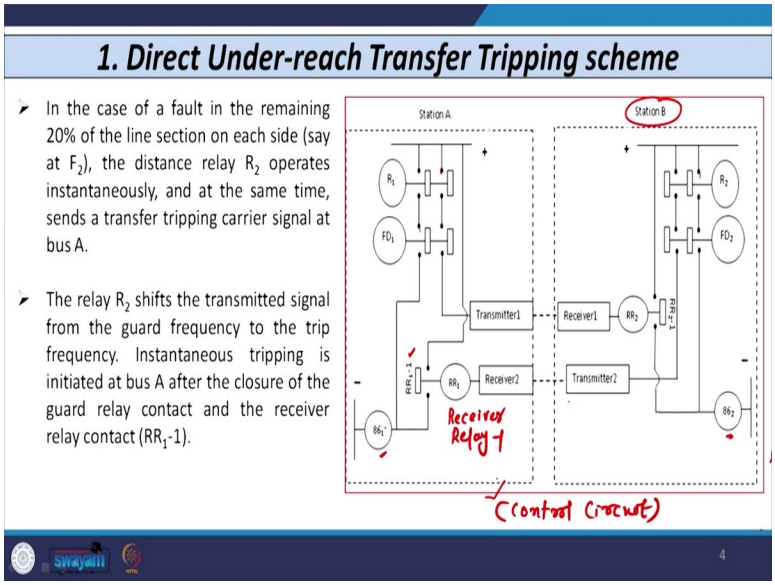

So, if fault occurs on either side of the 20%, let us say, the fault occurs at F2 somewhere here then in this case, as the fault is at F2, so, relay R2 detects that fault in its first zone and it operates instantaneously. So, as R2 operates the fault detector unit at bus B that also operates so this closes and direct tripping command is initiated and the coil of 86(2) that is energized.

At the same time the relay R2 also gives the signal from here you can see the signal is giventhrough the transmitter, this transmitter it transmit the signal at the substation A, at

substation A receiver two receive the signal from the substation B and along with that we have connected our RR1, which is known as the receiver relay one.

So, receiver relay receives and its coil is energized and the contact of this receiver relay RR1-1 that is this contact that becomes closed and hence from here you can see the direct tripping, as this contact closes the coil of 86(1) at substation A is energized and further tripping is initiated, which finally, opens the circuit breaker at substation A.

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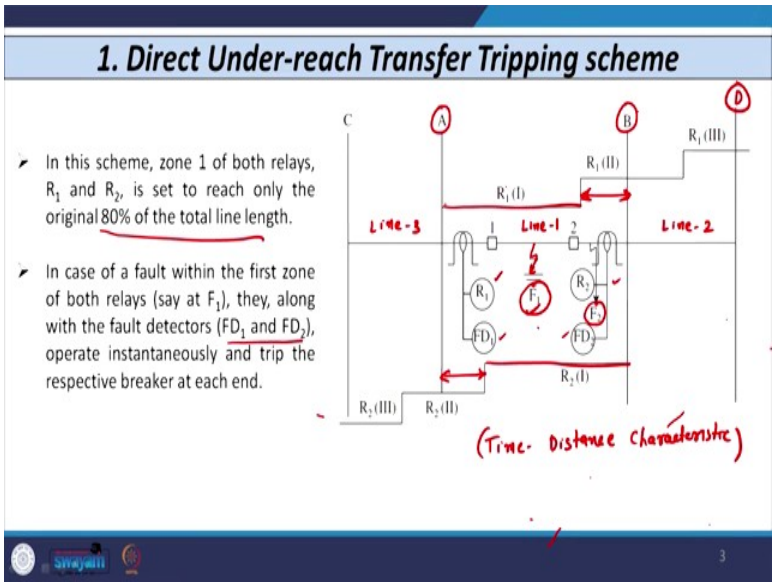

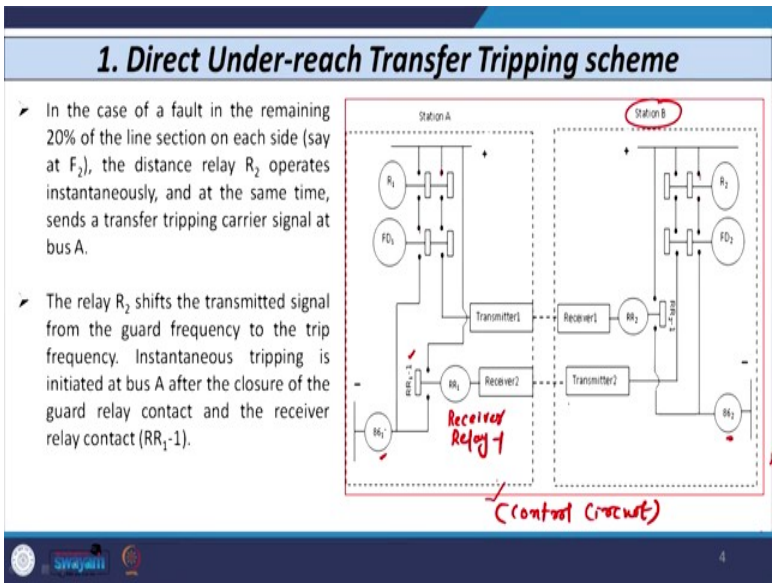

So, you can see that if fault occurs in remaining this 20% that is we have seen at F2 then the relay R2 energize, which R2 senses the fault and that will give signal to the breaker situated at substation B at the same time it also gives the transfer tripping signal at other substation at

substation A and the contact of this receiver relay that closes enhance the further tripping of the breaker at substation A that is given.

In this way if fault occurs in this remaining 20% then we can achieve the instantaneous operation. Same way if fault occurs somewhere here, let us say F3, right, then R1 operates instantaneously it gives command here and it gives directly it energize this coil at the same time it gives command to the transmitter that is received at substation B by receiver one and hence a receiver relay coil is energized and itscontact closes, and hence further, tripping is initiated by energizing the coil of86(2). So this is how, the under direct underreachtransfer tripping scheme works.

You can see that they really R2 shift the transmitter signal from the guard frequency to the trip frequency and hence instantaneous tripping is initiated at bus A, after the closer of the relay contact and the receiver relay RR1. Now, the question comes why this scheme is known as direct underreach transfer trip scheme.

The scheme that is called as direct underreach transfer tripping scheme because if fault occurs in this remaining 20% either this or either in this region, let us say, in this region F2 then what will happen if fault occurs at F2, relay R2 gives a signal through this transmitter, so whenever the tripping signal or carrier signal is received from substation B at substation A, the receiver relay contact directly closes and hence no other series contact is available in series with this RR1(1) or on the other side in series with the RR2(1).

So as soon as the tripping signal is available from the other substation on each side by closing of this receiver relay contact on each side the direct tripping is initiated and that is why the name given direct underreach transfer tripping scheme.

The name underreach is given because the first job of the relay R1 one and R2 that is going to cover 80% of the entire line length, not the full hundred percent that is why the underreach name is given. In case of overreach, it covers the entire line section or beyond that, that is the main difference in under underreach and overreach. So, because of this reason, this scheme is known as direct underreach transfer trip scheme.

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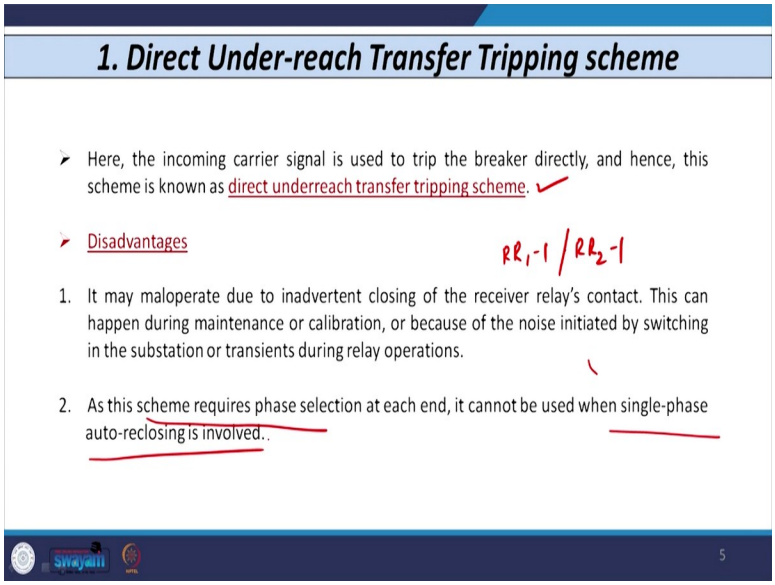

Here this scheme has certain disadvantages, let us see. Now, when we use direct underreach transfer trip scheme this scheme may mal operate due to the inadvertent closing of the receiver relay contact that is the RR1-1 or RR2-1 right on each side, and this contact closes inadvertently due to the maybe when maintenance is going on or when calibration is carried out or maybe because of the noise initiated due to switching surge is in the substation or any transient or abnormal condition. So, because of this reason, the contact of the receiver relay on each side that may close wrongly and hence, in this case mal operation of the relay that may possible.

The other disadvantage is that this scheme requires the face selection logic at each bus, bus A and bus B, so this type of scheme cannot be used when single phase auto reclosing that is involved. So when we want to use the single pole tripping facility that means we want to close only that phase in which fault occurs assuming that the other two phases are healthy then same similar type of scheme we cannot implement if we use direct underreachtransfer trip scheme.

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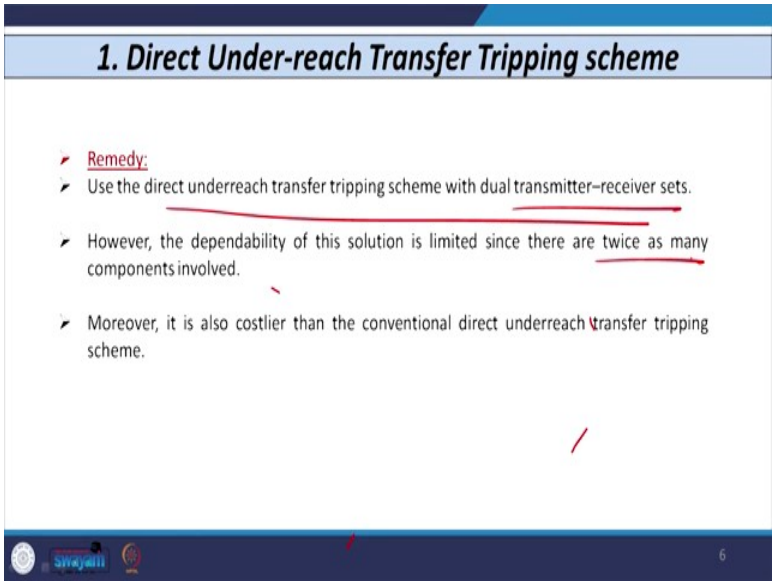

So, what is the remedy? So remedy, one of the easiest remedy is we use the dual transmitter and receiver set under the direct underreach transfer trip scheme, but again, as we use dual transmit set of receiver and transmitter so the cost of this scheme increases compared to the conventional direct underreach transfer tripping scheme, so, and hence this type of scheme that is not used.

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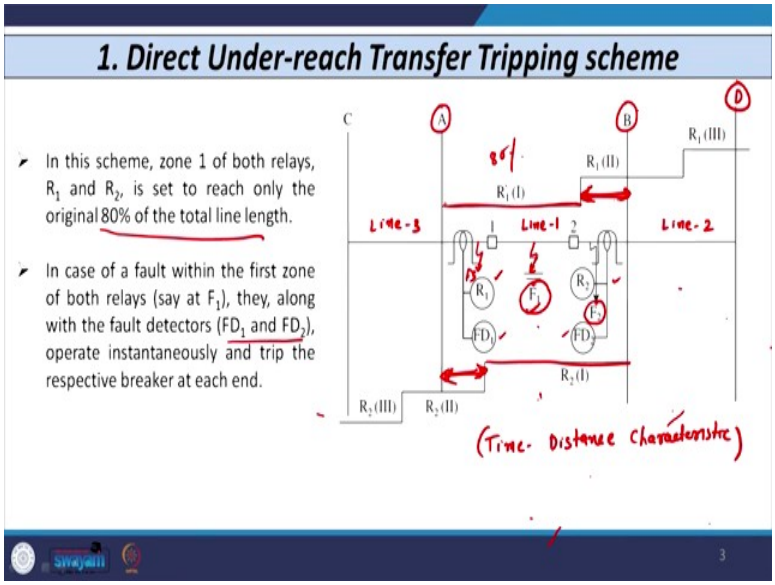

So, with this background, let us discuss the next type of scheme that is known as the second one, permissive underreach transfer tripping scheme. So, let us see what is the permissive underreach transfer tripping scheme. Now, I have shown here only the control circuit I have not shown the time distance characteristic because the time distance characteristic of

permissiveness under reach retransfer trip scheme that remains same as the direct under reach transfer trip scheme.

So, as we have discussed the first zoneof relay R1 covers 80% first zoneof really R2 that covers 80%, so this will remain same in case of the permissive underreach transfer tripping scheme.

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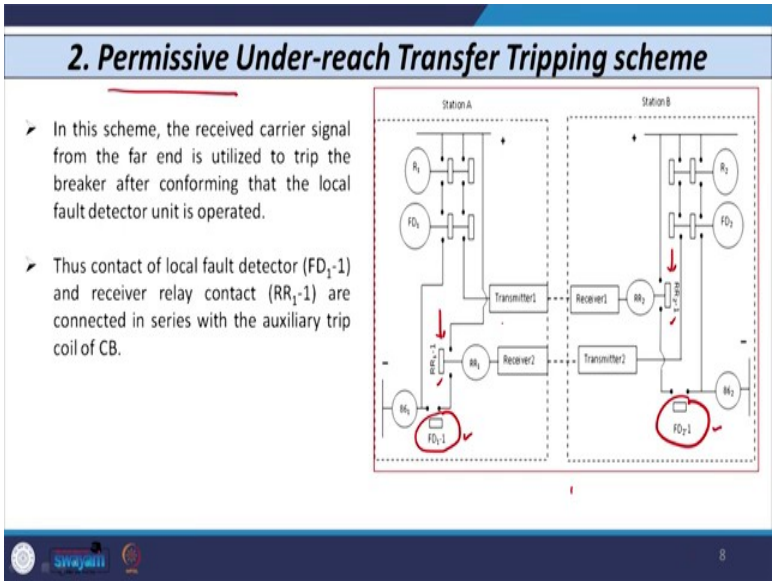

The control circuit also remains more or less same, the only difference is that this is the control circuit of the direct underreach transfer tripping scheme.

Right. So, you can see that when we use, as we have discussed this underreach transfer tripping scheme then whatever signal is received from here the receive, coil of receiver relay one, that is directly energized or relay two that is directly energized and it is contact immediately closes. And as soon as this contact closes either RR1-1 or RR2-1 direct tripping is initiated and this may mal operate because of noise available due to switching surges in the system.

So, to avoid that, what we will do, we will use the permissive under reach transfer tripping scheme. So, in the control circuit of permissive under reach transfer tripping scheme the only difference is, we have included this contact or this contact in series with the contact of receiver relay one and the receiver relay one on the substation B. So, that is the only difference.

So, in this scheme whenever the carrier signal is received from the far end or the remote end then that signal is utilized to trip the breaker, after confirming that, the local fault detector unit has operated. So, whenever as soon as we received the signal from the far end, whenever we received the tripping signal tripping carrier signal from the far end instead of directly going for tripping it will wait forpermission fault detector unit whether it has operated or not, when such type of permission is required such type of coordination is required the scheme that is why it is known as permissive underreach transfer tripping scheme.

So, in this scheme what will happen the contact of this fault detector unit one at substation A and the contact of the fault detector unit at substation Athat is connected in series with the contact of the receiver relay one and receiver relay two contact. So, in this case as these two are connected in series the chances are mal operation of this contact receiver relay contact or closing of the receiver relay contact on each side because of the noise present in the signal that can be avoided because we are confirming this will close only and only means stripping is initiated only and only when local fall detector unit operates.

So, now what how this scheme works, in case of the internal fault somewhere here F1, what will happen both this unitthe R1 senses this fault, fault detector one senses the fault. So, FD-1 contact that becomes close and the tripping is directly initiated here same way on this side also R2, and fault detector unit two both will operate and hence the ripping is given.

If fault occurs in the remaining 20% of the line section that means, somewhere here or somewhere here, let us consider as a case study the fault F2, then what will happen you can see that in this case R2 will detect this fault in the first zone, so relay R2 operates,fault detector two that will also operate the ripping is hence initiated from here and the coil of 86(2) two auxiliary relay that is energized with further use stripping to the circuit breaker.

The relay R2 at the same time also transmit the signal through this transmitter to that is received at substation A by receiver two enhance the coil of receiver relay one is energized and its contact closes.

Now, as you can see here we have again, connector default detector unit contact of FD-1here, so soon as this contact closes direct tripping is not initiated, it will wait for this closer of this contact and this contact will definitely close because you can see that whenever fault occurs somewhere here in F2, fault detector unit visit basically instantaneous over current relay that actually operates instantaneously because the current exceeds the predetermined value. So, in

this way, the mal operation in case of underreach transfer tripping scheme that can be avoided compared to the direct underreach transfer tripping scheme.

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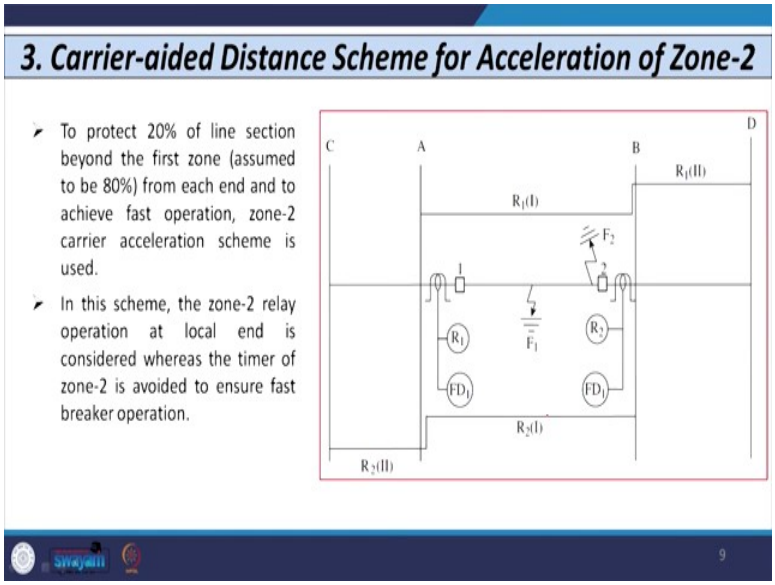

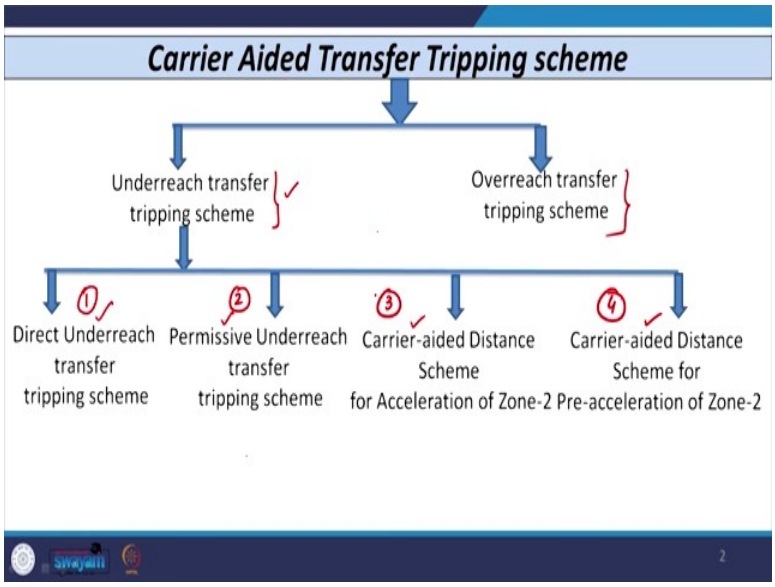

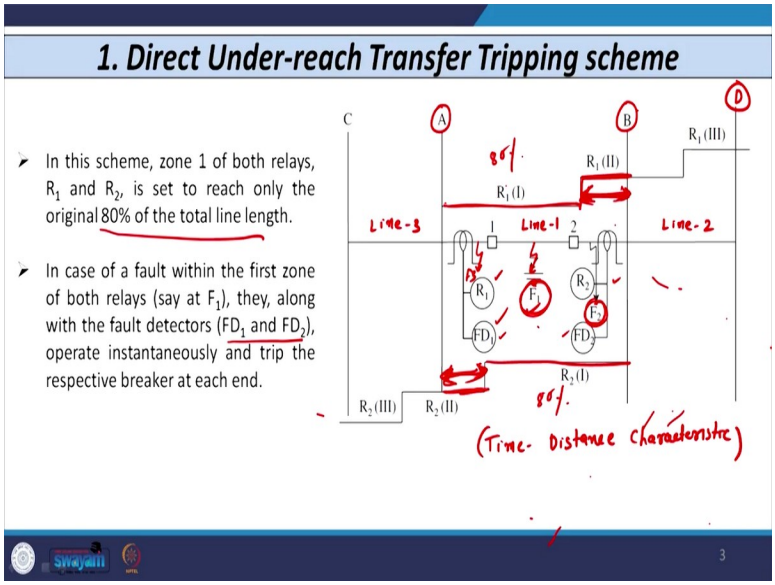

Now, let us discuss this third point, third section, which we have discussed earlier, that is the third one that is the carrier aided distance scheme for acceleration of zone two. So, let us discuss how the scheme works.

So, in this case the carrier aided distance scheme, you can see the name given carrier aided distance scheme for acceleration of zonetwo. Now see this is very important. Acceleration of zone two that means, that you can see our conventional zonetwo of distance relay it looks like this, right, it starts from here. So, 80% of the line section that covers under the first zone of distance relay remaining 20% right, that is covered in thesecond zone.

Now, acceleration of zone two that means, we are going to accelerate this zonetwo, that means we are converting this zonetwo in zoneone so that whatever fault that falls under this region 20% and under this region that will be taken care by zone one of the distance relay itself and it operates instantaneously.

So, this zone two and zone two that will be converted into zoneone by increasing the reach of the distance relay, right first zone reach of the distance relay on each side such that the remaining fault that falls under this region 20% and 20% that will be taken care in the first zone. Let us see how it can be done.

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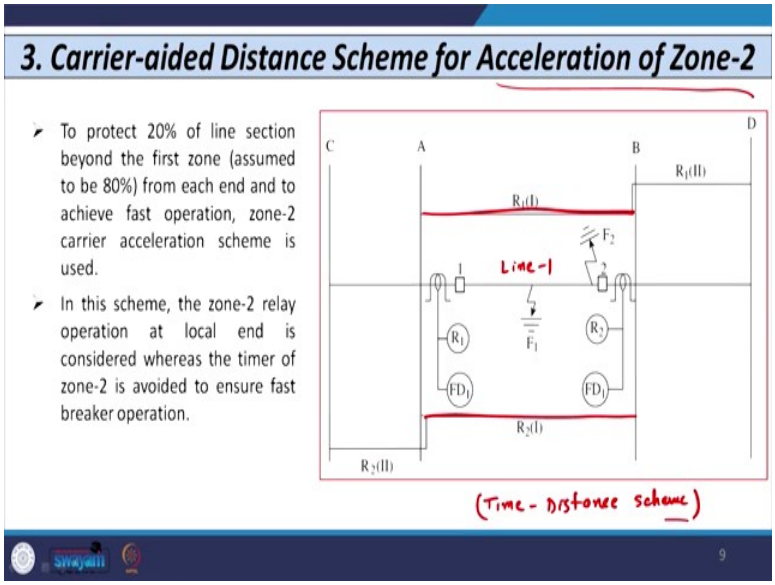

So, this is the time distance characteristic of the carrier-aided distance scheme for acceleration of zonetwo right, this is time distance scheme or characteristic. Now, you can see that I have shown here the same similar diagram time distance diagram the only difference is the first zone, I have extendedalmost up to the 95% or 100% of the line to be protected, so this is the line which we need to protect.

Similarly, the first zone of relay R2,that I have extended up to 100% of the line one. So,here, to protect the 20% of the section beyond the first zone right 20% on this side and 20% on this side on each side, zone two of the distance relay that is R1 and R2 that will be converted into zone one we can say the acceleration of zone two that is carried out.

Now, in this scheme the zone two relay operation at local end, that is considered whereas the timer of zone two that is avoided to ensure the fast breaker operation.

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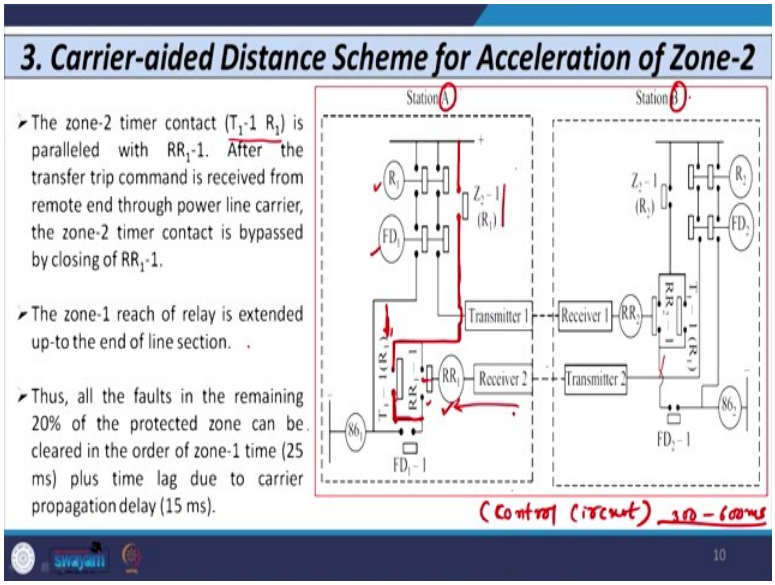

So, let us discuss how the control circuit of the carrier-aided distance scheme for acceleration of zone two works. So, now you can see that here at substation A and substation B, you can see that the control circuit is more or less similar to the permissive underreachtransfer tripping scheme right. So, here you can see the relay R1, FD-1 is there its contacts are there the only circuit which that is included that is this path. This path, right, along with the another contact Z2-1, R1 that is this contact again, you have the path like thisand here, we have included a parallel to this receiver relay contact.

We have added another contact in parallel with our RR1-1 and similarly on this side RR2-1. So, here we have included one contact, right, and this contact is known as even R1. Now, what is this Z2-1, R1 and T1-1, R1?

So, this Z2-1, R1 is the zone two contact of relay R1. So, we know that there are three zones of relay R1, so first zone contact is Z1-1, second zone contact is Z2-1, thirdzone is Z3-1. Similarly, we have this zone 2, 1 that is second zone contact, it has the timer also T1-1, R-1 that means the timer one first contact of timer T1 for relay R1. So, this part we have included on each side that is the replica on substation B also.

Now, what will happen in this case that the zone two timer contact that is T1-1, R1 you can see here that is we have connected in parallel with the contact of the receiver relay that is RR1-1. So, after the -- once we have received the transfer trip command from this side for the remaining fault on 20% of the line.

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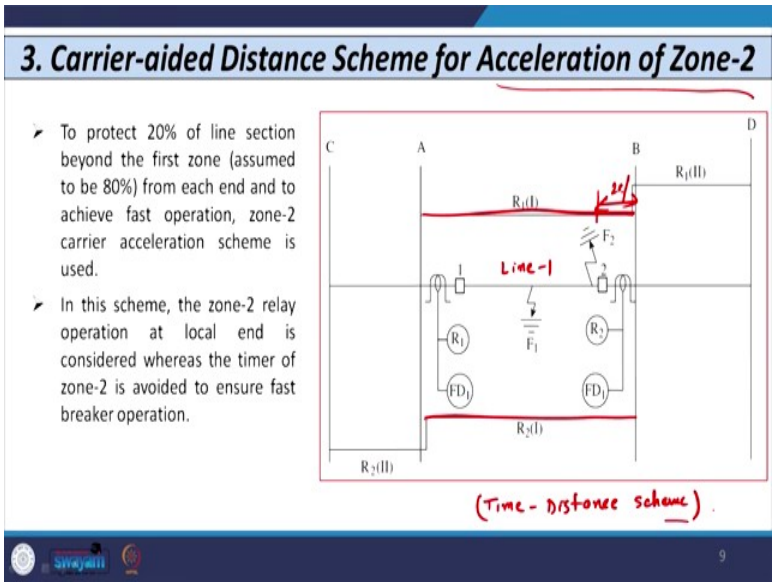

So if fault occurs somewhere here in this region right 20% or in this region, that is 20%say F2, right, and same as we have considered in earlier two cases that is direct underreach and permissive underreach.

So, in this case what will happen you can see that as soon as the command is received for fault at F2 or F3, what will happen you can see that the immediately as soon as this command is received zonetwo contact, which is available right which is connected here in parallel with this that is bypassed.

So, what we are doing is that as soon as the command is received from the remote side maybe from bus A to bus B or bus A to bus B then the zone two timer contact that is bypassed by closing of RR1-1 contact So, RR1 contact that is somewhere here. So, as soon as the command is received this coil is energized coil of RR1 relays is energized so when whenever the coil of receiver relay one is energized this contact closes. So, whenever this contact closes here, this circuit that will flow like this. So, this contact ultimately we are bypassing.

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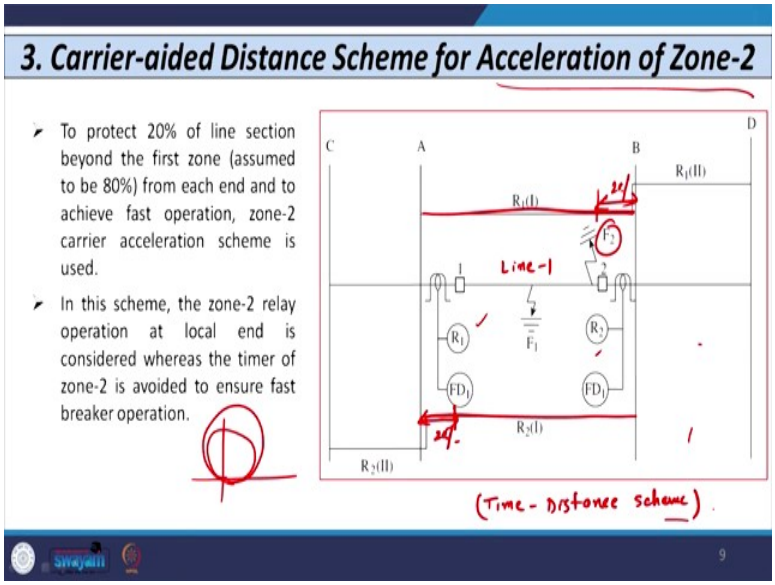

Now, what actually happen? See, whenever fault occurs in this remaining 20% of the line let us say at F2, relay R2 sees this fault in its first zone, but really R1 sees this fault in its second zone, but as you can see the second zone the circle of the second zone if we consider move relay that encompasses the first zone right so the circle of the move relay of first zone is like this second zone is like this, it encompasses the first zone.

So, what will happen, this contact that will be closed immediately, but no tripping is given because this is a timer contact and this timer contact will operate once the timeof the operation of second zone that will be completed and that is from 300 millisecond to 600 millisecond that is the timing of the second zone of distance relay.

Instead of waiting for that, we have connected this timer contact in parallel with receiver relay one contact. So, as soon as we received the signal there is no way for this timer that means this time of timer is not completed even though this contact will closes and hence the tripping is given directly from this for remaining fault in 20% side on each side of the line section. So, this is how the carrier-aided distance scheme for acceleration of zone two works.

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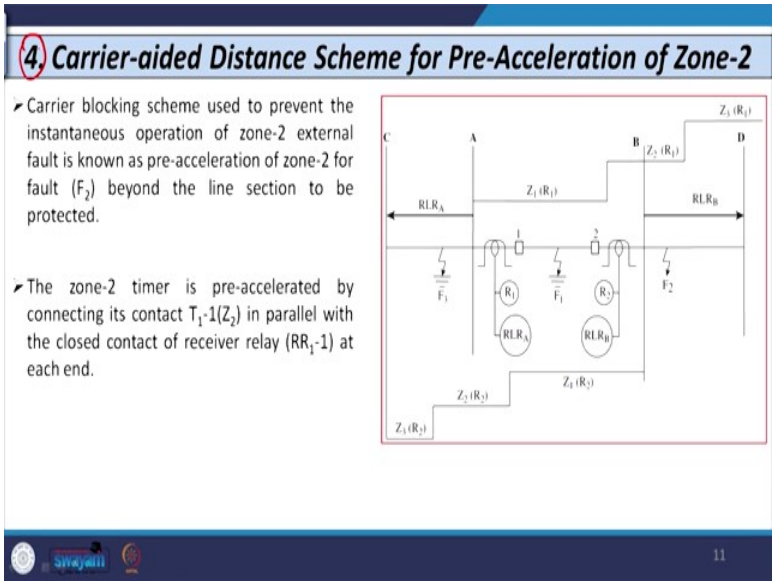

Now, let us see the fourth scheme which is known as the carrier-aided distance scheme for pre-acceleration of zone two. Now, what is the difference? Now in case of carrier blocking scheme, we know that we have already discussed the carrier blocking scheme that is used to prevent the instantaneous operation of zone two means any fault occurs on F2 remaining 20% on this side or this side.

So, the zone two timer is pre-accelerated by connecting its contact in parallel with the contact of the receiver relay. So, if I just look at the earlier case third one acceleration of zone two and this case pre-acceleration of zone two there is a one difference. Here, we have a separate reverse looking relay that is there at each bus.

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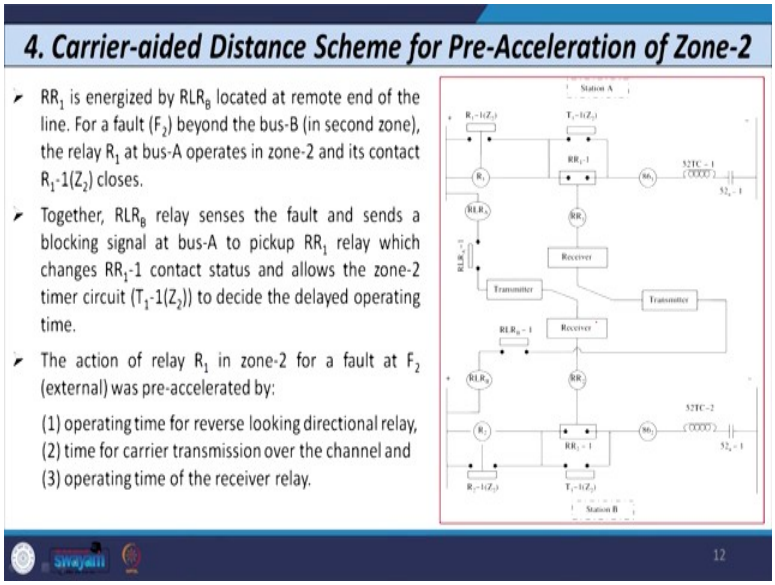

So, if I just look at the control circuit of this, then the RR1 that is energized. So, you can see that the RR1 coil that is available here, so this coil of the receiver relay one that is energized, which is located based on the signal received from the remote end that is from substation B, right, and so really R1 at bus A operates in zone two and it is contact R1-1, Z1 that closes. So R1-1, Z1 that closes so the contact of this relay R1 this contact that closes.

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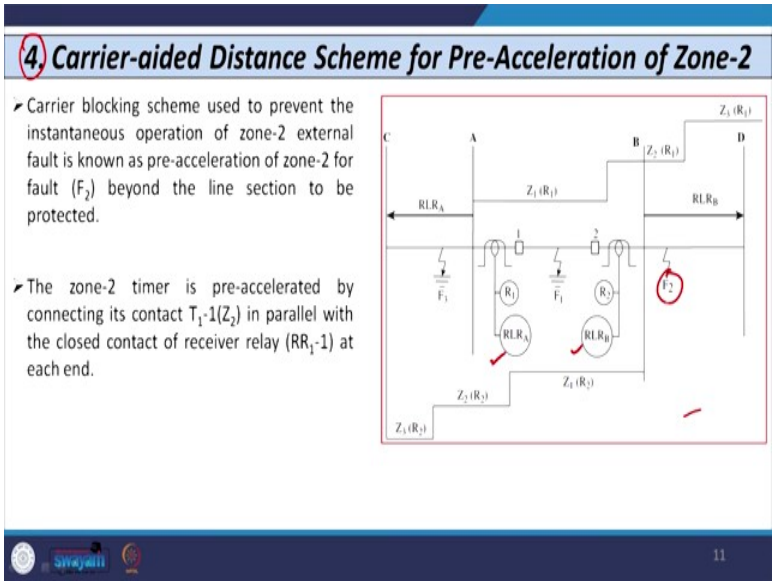

Now together with this reverse looking relay at B, you can see that here we have the if default occur at F2, this reverse looking really will look in this direction so this is going to sense the this type of fault at F2. So, reverse looking really senses the fault and sends a blocking signal to the bus A which will further pick up the receiver relay and changes the contact of its receiver relay that is our RR1-1 status and hence that is going to allow the zonetwo timer contact that is the T1-1, Z2 this contact that is decided and that will be operated in this case.

There is the only difference in previous case that is we have the reverse looking relay available in pre-acceleration of zone two, which is going to send a blocking signal, whereas, in in the case of earlier that is a carrier-aided distance scheme for acceleration of zonetwo no reverse looking relays is there.

Now, you can see that the accent of this relay R1 or you can say are two in zone two for a fault at F2 that can be accelerated means zone two that can be converted into zone one by different ways, so we have to consider the operating time of the conventional relay or reverse looking relay, we have to consider the operating time of receiver relay and we have to

consider the carrier transmission what is the delay in the transmission of the signal from one bus to another bus that also we need to consider.

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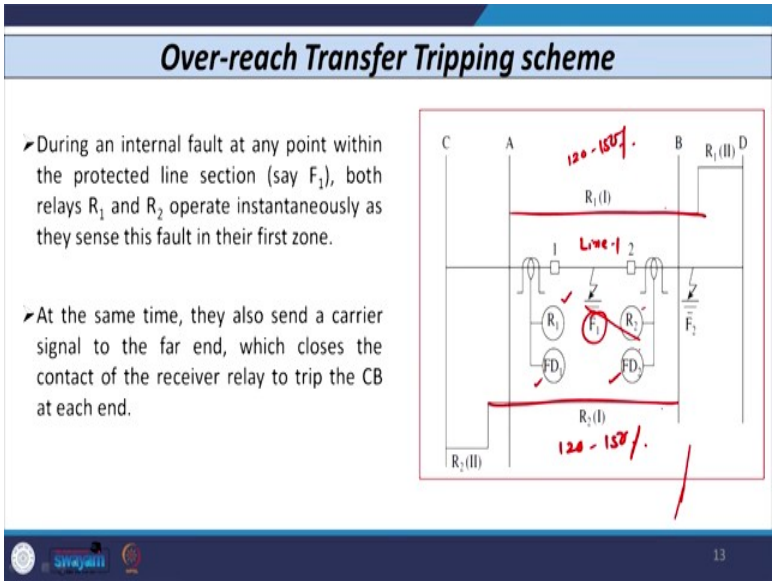

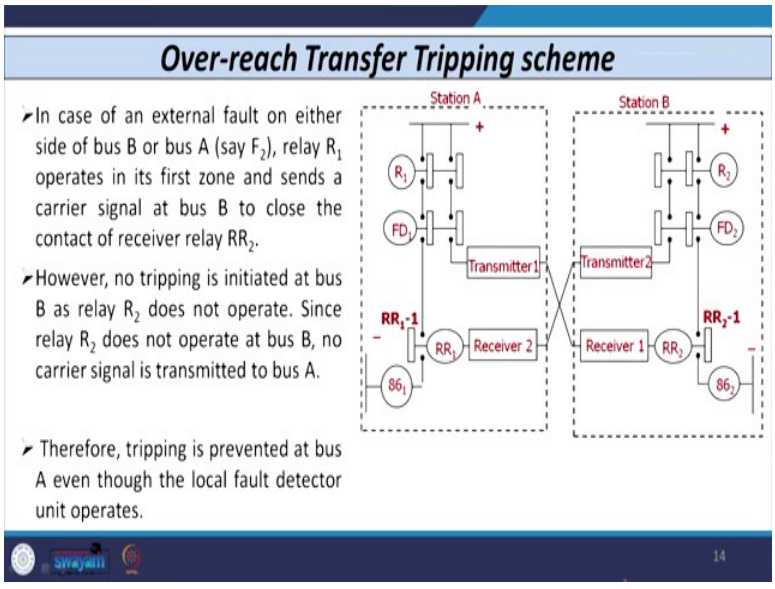

So, with this background, let us discuss the last scheme that is known as overreach transfer tripping scheme. So, as I told you in case of overreach, the first zone reach of relay R1, that will go beyond the line section, so here this is the line to be protected. Similar the first job of relay R2 that will go beyond the line section, the usual setting is 120% to 150% each side.

So this is the first zone setting of relay R1 and R2. So, whenever fault, any fault occurs at F1 both this relay R1 and R2 will sense this fault in its first zone and the fault detector units FD1 and FD2 that will also senses the fault and these two contact that will close enhance direct tripping that is initiated on each sideright.

Now, how the tripping is initiated in case of the internal fault? Whenever the fault occurs at F1 it will also give signal to this transmitter it receives and this contact becomes closed. Similarly, whenever fault occurs at F1, this also gives the signal it is received and this contact closes so the tripping is directly given to the auxiliary relay 86(1) and 86(2).

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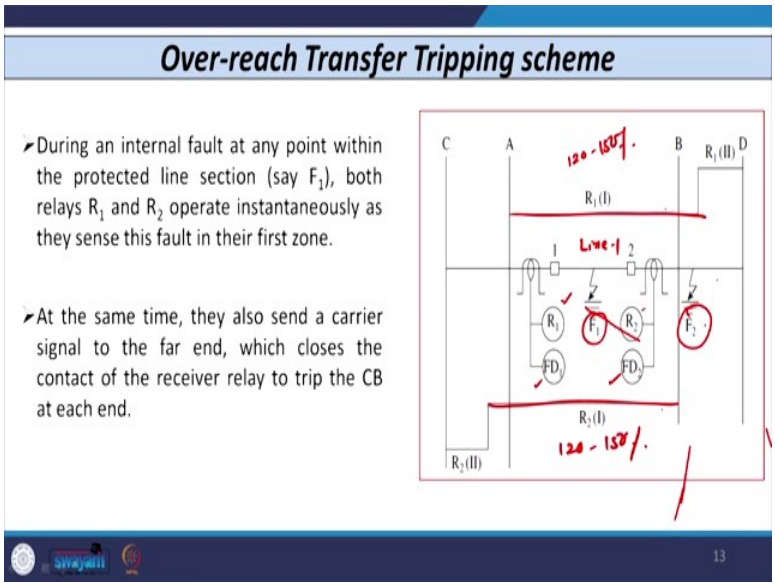

Now in case of external fault at F2 say here, somewhere beyond the zone between any adjoining line section, say line section two.So in this case if fault occurs at F2, then the relay R1 operates in its first zone because that will detect this fault in its first zone because you can see the reach of R1 that is 120%. So R1 that is going to detect this fault in its first zone.

It will also going to send a signal right to bus B to close the receiver relay. So this contact that will close, but you can see that really R2, that is not going to sense the fault so no further tripping is initiated at substation B, right. And as no R2 is not going to sense the fault, no signal is transmitted through transmitter two, so no signal isreceived at receiver two at substation A so this will also remain in open condition.

So, even though relay R1 operates as this is in open condition no tripping command that is given or initiated. Therefore, the tripping is prevented at bus A or similarly at bus B through the local fault detector unit contact. So, that is important point as far as overreach transfer tripping is concerned.

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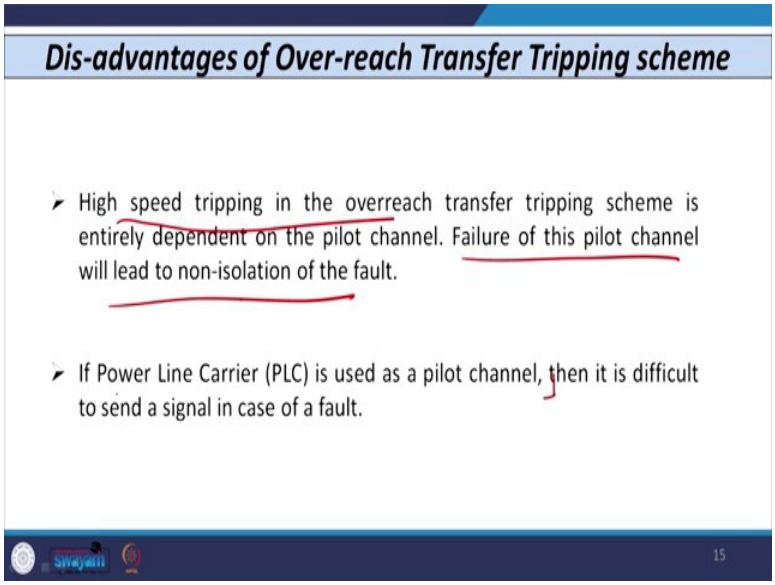

Overreach transfer tripping scheme is advantages compared to under reach transfer tripping scheme because using this you can achieve the high speed tripping of on both the side of the relays. The only disadvantage of this scheme is that if your communication channel fails, then there is a probability of mal operation in case of the default on beyond the zone of the each side of the line section that is F2 or F3. Otherwise there is no disadvantage of the overreach transfer tripping scheme.

So, one more disadvantage is that we know that in our country earlier we were using powerline carrier communication to transmit the signal. So, if we use that then -- and if we use overreach transfer tripping scheme then this type of scheme may face a difficulty, but nowadays we are not at all utilizing the power line carrier communication for transmission of the any signal from one side to the other side.

So, in this lecture, we have discussed the different types of underreach and overreach transfer tripping scheme. We started our discussion with direct underreach transfer tripping scheme then we have discussed the permissive underreach transfer tripping scheme and then we have discussed the carrier-aided distance scheme for acceleration of Zone-2 and pre-acceleration of Zone-2 and then finally, we have discussed the overreach transfer tripping scheme.

So, I stop here and we will continuethe next chapter in the next class. Thank you.