Power System Protection and Switchgear
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Lecture 20
Carrier Aided Schemes for Transmission Lines-II

Okay. So, let us continue our discussion on the Carrier Aided distance relaying scheme. So, we have discussed that we can utilize different types of communication medium for transmission of signal from one end to another end.

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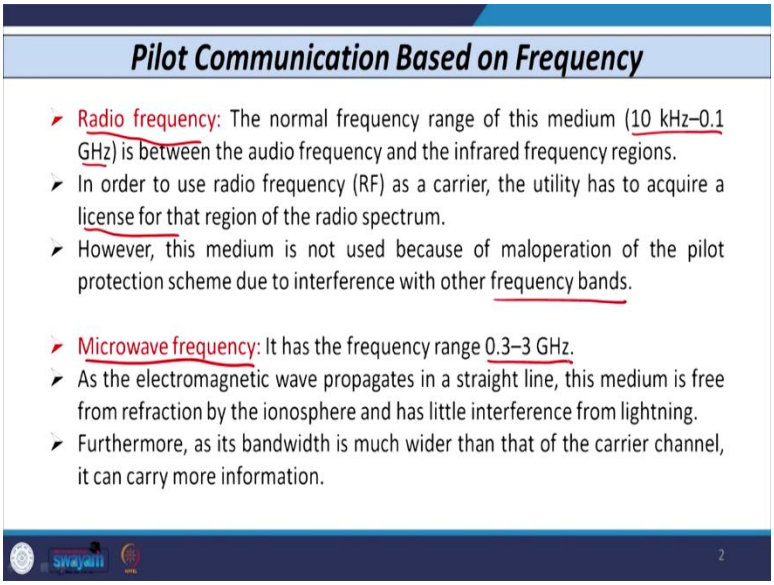

We have discussed based on we can transmit depending upon what type of signal we use either analog digital or we can also transmit based on what is the frequency we can use. So, let us continue with our radiofrequency that is the frequency based pilot. So, when we use the Radiofrequency, the normal frequency range of this radio frequency if I use radio frequency signal for carrier, then its range is from 10 kilohertz to 0.1 gigahertz.

So, when we use such type of scheme, the utility has to acquire the separate permission, separate band for such type of frequency band is required for transmission of signal from one end to another end. So, utility has to acquire the license, if I use radio frequency as the medium for transmission of signal or data.

However, this type of medium is not used because of mal operation of the pilot relay, due to interference of such type of frequency band with some other frequency bands. So, that's why this is not used. So, the next way is, we can use the microwave frequency and its frequency band. If I use microwave, then it is 0.3 to 3 gigahertz. As the electromagnetic wave propagates in straight line, so this where do I use microwave frequency as the medium, such type of medium is free from refractions.

So, it has a limited or little interference from the lightning search. Further, its bandwidth is much wider. So, compared to the carrier channel, so, it can carry more information. That means you can transmit more data from one side to the other side. That is the another advantage.

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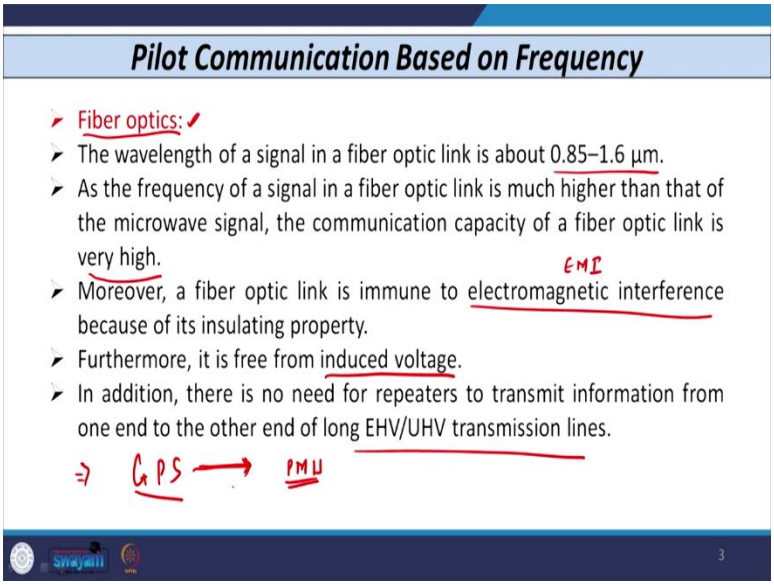

So, next type that is based on the fiber optic communication. So, the wavelength of this type of fiber optic link that is from 0.85 to 1.6 micrometer. So as the frequency of a signal is fiber optic link is much higher compared to the microwave and radio and audio earlier type of communication.

So, the communication capacity of fiber optic link is very high. So, that is very important advantage compared to other types. Moreover, the fiber optic link is immune to any electromagnetic interference. So, there is no interference of EMI, if I use the fiber optic signal. Furthermore, it is free from the induced voltage. So, the problem of induced voltage on the

parallel conductor, that is also rectified if I use the fiber optic type, the communication medium. In addition, there is no need of the repeaters to transmit the information from one end to another end, if I use long EHV transmission line.

So, this, because of all these advantages compared to earlier type of the signalling medium, the fibre optic communication that is also widely used nowadays. Now, along with this, one more type of medium is also there. That is known as the satellite based or GPS based communication. So, nowadays utility is also utilizing. The satellite based communication because we have the device available like phasor measurement unit, which works on the signal received from the GPS. So, such type of communication medium is also utilizing by utility nowadays.

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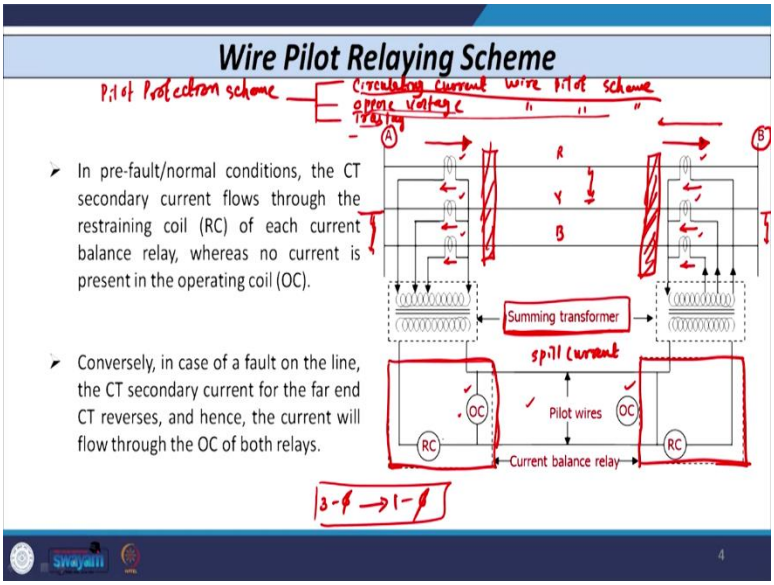

Now, with this discussion, let us start our first discussion scheme, that is based on pilot protection scheme. So, as I told you, the pilot protection scheme that is classified in three types. One is known as the circulating current wire pilot relaying scheme. The second one is the opposed voltage wire pilot relaying scheme and the third is the Translay type of scheme. So, out of this, let us discuss the first one only, that is circulating current wire pilot relaying scheme.

So, here, the diagram schematic diagram of this type circulating current wire pilot relaying scheme that is shown. There are two buses, that is bus A and bus B. And between that, three one single circuit transmission line is connected. So, let us say it has three conductors, that is R, Y and B.

Now, at substation A, we have the three-line CTs. In each phase, R phase, Y phase and B phase. And this is given signal, secondary signals of the CTs are given to the device, known as the summing transformer. Same way, on the at the substation B also, we have the three line CTs, on each you need one phase R, Y, B. And the secondary signal of three-line CTs that is given to again the device that is known as the summing transformer.

The summing transformer is a device whose function is to convert any three phase signal into the single phase quantity, why, what is the reason, because, see, wherever we have to transmit the signal from substation A to substation B, we need to lay-down the physical pilot wires, physical wires are required.

So, if we have to lay down three wires, then that is very costly. So, that is why in actual field, they have to convert the three phase quantity into single phase quantity. And there are many ways how to convert three phase quantity into single phase quantity. One of the way is to use the summing transformer.

So, here I have shown the device that is known as summing transfer. And then, after the summing transformer, you have the relay located that is shown here. So, this is the your relay located at substation A. And here, you have the relay, that is located at substation B. So, the relay is a current base relay. Basically, it has two coils, differential relay. So, it has one is the operating coil and it has the restraining coil that is RC. And then, you have the physical pilot wire. So, this all are the physical pilot wires, that is connected on each side of the substation, on A substation as well as B.

Now, if suppose, during normal condition or when there is no fault, the current shown here, that is as I have marked in the figure. So, this is the current, one primary side of CT. I let us take the example. This is when there is no fault or pre-fault condition. So, as this current is like this, the

current on secondary side that is like opposite. So, it is like this. So that is why I have shown the signal.

And here also, the direction of current that is like this. And that is why I have shown the current direction. Now, whenever no and there is no fault or during the pre-fault condition or maybe in case of external fault condition, if you have any line or conductor here, any fault occurs here, then also, this current entering and current leaving, both are in the same case.

So, that means whatever the current available on this relaying side, most of the current that will flows through the restraining coil of the relay here also and very ideally 0 current that flows through the operating coil of the relay practically a very small value of current that flows through the operating coil of relay, which is known as the spill current.

So, during normal condition or pre-fault or in case of external fault like this or maybe somewhere here also, the no current that flows through the or very small very magnitude of current that flows through the operating coil of relay. So, the relay does not operate. In case of internal fault, let us say somewhere here.

The direction of this CT current changes, because now it is going to feed the fault like this. So, obviously these three directions also changes. And hence, the current flows through the operating coil of the relay and this relay operates and give signal to the respective breaker. And whatever breaker that is available here, at substation A and whatever breaker that is available at substation B, these two breakers that become open simultaneously. And hence the such type of fault that is detected.

Now, if I use some other type of scheme like opposed voltage or translay type, the schematic diagram remain same, there is no difference. The only difference is somewhere here, that means, you have to connect this such a way that the voltage available across the coil of the relay that is in opposition normal condition the relay does not, of course, the relay available in this opposed voltage scheme that is also voltage based relay, not the current based relay. And in normal condition, the opposite voltage is available so relay does not operate. It remains stable and in case of internal fault it operates, same way for translay scheme. So, anyway we are not going to

discuss. But let us see what are the major disadvantages of this wire pilot relaying scheme that includes maybe circulating current, opposed voltage or translay type scheme.

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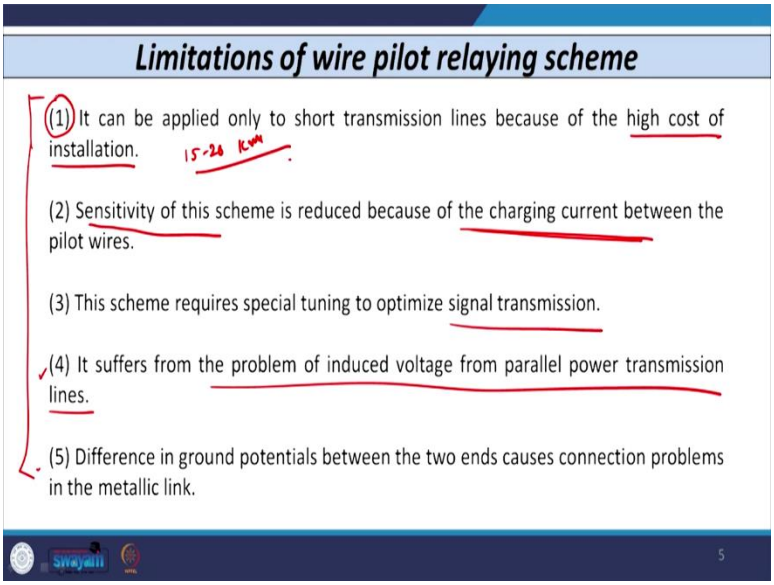

So, the major disadvantages of this wire pilot relaying scheme. The very first disadvantage that is, it can be applied only for short transmission line. We cannot use for long transmission line, because we have to physically lay down the wires. So, its cost is very high, that is why it is used only up to let us say 15 to 20 kilometer short lines or particularly cables.

The second disadvantage or limitation of the wire pilot relaying scheme is its sensitivity. So, sensitivity of this scheme that is reduced because of the charging current, because as I told you, this type of scheme is used when we have a cable, when we need to lay down the cable and when there is a any island is there and then we have to lay down the cable, underground cable then we use.

Now, in case of that, the charging current is very high compared to the overhead conductor. So, the sensitivity of this type of scheme that has to be reduced. The third point, a limitation of this wire pilot relaying scheme is it requires a special tuning circuit to optimize the signal transmission. The fourth important disadvantage is this type of wire pilot relaying scheme that suffers with the problem of induced voltage on the parallel transmission line.

So, we have to rectify this type of problem by some means, so some compensation is required. And, the another disadvantage is the difference in the ground potential at the two ends, that may cause the connection problems if I use some metallic link or some other structure. So, with all the five disadvantages, the wire pilot relaying scheme that is not used in actual practice.

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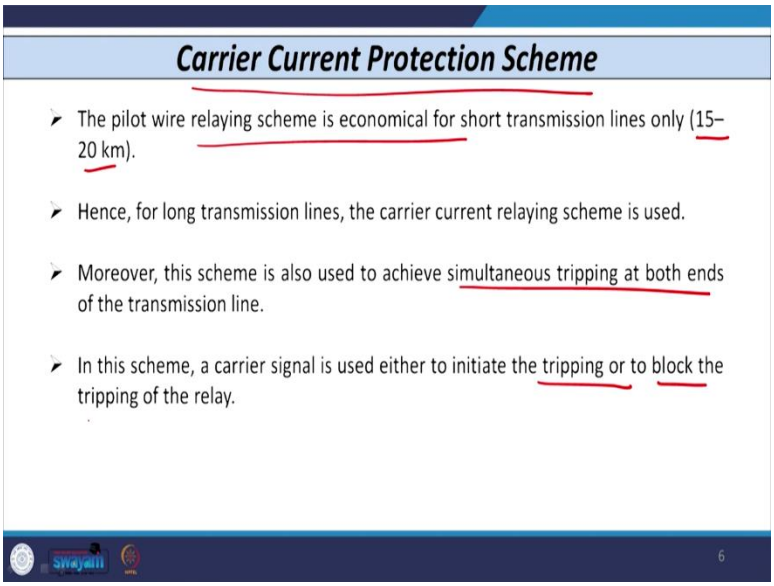

So, instead of that, nowadays, utilities that is using the scheme known as the carrier current based protection scheme. So, let us discuss now, what is the carrier current based protection scheme. So, as I told you, this type of scheme is used in place of the wire pilot relaying scheme, because we can use only up to 50 to 20 kilometer. If I use carrier current based scheme, then again, we can have the simultaneous opening of breakers at both the ends, that is also possible.

Now, carrier current protection scheme that can be divided or classified by two ways. One is known as if I use the carrier signal to initiate the tripping on the line or circuit or device, then that is known as the carrier current tripping type of scheme. And whatever signal that is carrier signal I received, if I use that signal to block the operation of relay, then that is known as carrier blocking scheme.

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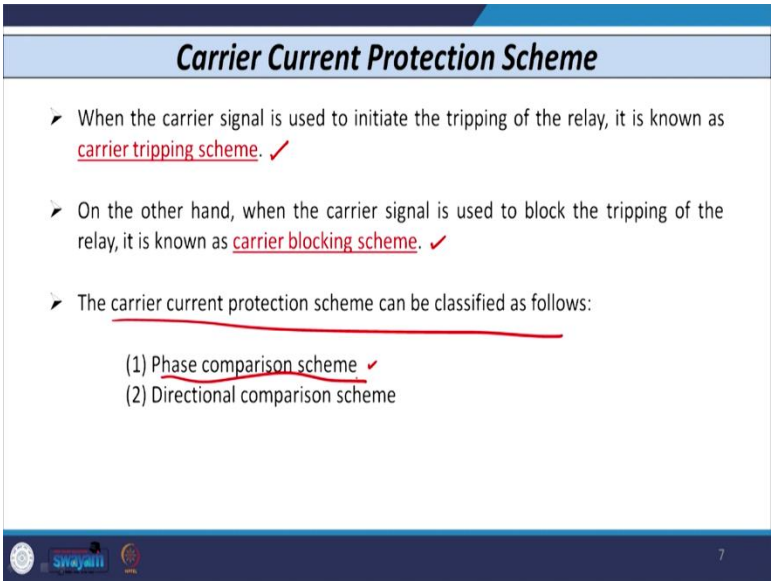

So, when the as I told you, when the carrier signal is used to initiate or start the tripping of the relay, then that is known as carrier tripping scheme or sometimes carrier intertripping scheme. And on the other hand, if I use the carrier signal to block the operation of relay, then that type of scheme that is known as the carrier blocking scheme.

So, what that means, when I use carrier current protection scheme, it can be used as a carrier tripping scheme or it can be used as a carrier blocking scheme. When I use carrier tripping scheme, that means, for all types of internal fault whenever I received the carrier signal, the tripping is initiated, whereas, for all types of external fault or normal condition, whenever carrier signal is available, no initiation or tripping is given or when and the other end when I use carrier scheme as a carrier blocking scheme, then for all types of external faults whenever such type of fault exist or in case of normal condition, the carrier blocking scheme or blocking signal is given on each substation or each side of the line. And hence the signal is blocked and that is why it is known as carrier blocking scheme.

The carrier current protection scheme can be sometimes also classified as phase comparison scheme and directional comparison scheme. So, let us discuss first with the phase comparison scheme, similar way, the directional comparison scheme also works.

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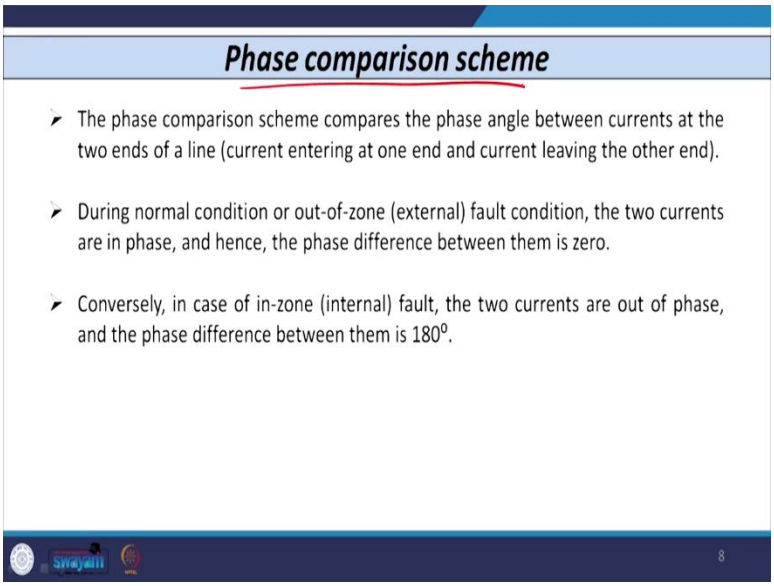

Now, let us start with phase comparison scheme. So, phase comparison scheme compares the angle between voltage and current. So, current entering and current leaving the line, the angle between these two, that is compared. So, during normal conditions or and in case of external fault, the two currents are in phase. So, the phase difference between them is 0, whereas, in case of interval fault as the opposite and remote and current reverses, so the two currents are out of phase and the phase difference is 180 degrees. And hence, the tripping is given. So, this phase comparison scheme works on this principle.

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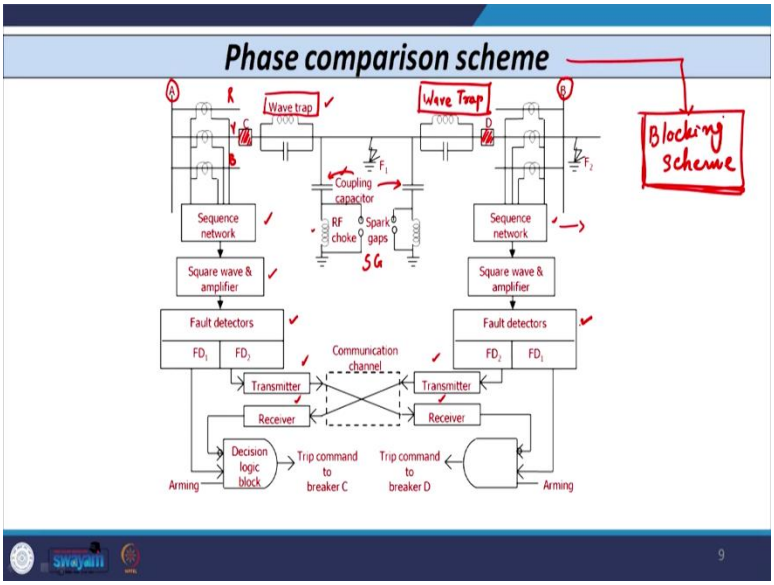

Now, let us see one specific type of phase comparison scheme. And here this type of scheme, we have used this scheme as a blocking scheme. So, face comparison scheme here you can use as a tripping scheme also. But here whatever diagram I have shown, that is a phase comparison type of scheme. And we have used the carrier signal to block the operation of the relay, that is why I told you it is a blocking type of scheme.

Now, in this scheme, you can see again there are two buses A and B. And between these two buses, the line is connected, three conductors, again R, Y, B. So, I have shown only one conductor, why, the similar type of circuit that exists for R and B also. Now, you can see here, on the Y Phase, I have shown the two breakers that is breaker C at substation A and breaker D at substation B. I have also shown the one device that is known as the wave trap. So, wave trap that is also available here the other end. So, this is also your wave trap at substation B. So, what is the function of this wave trap?

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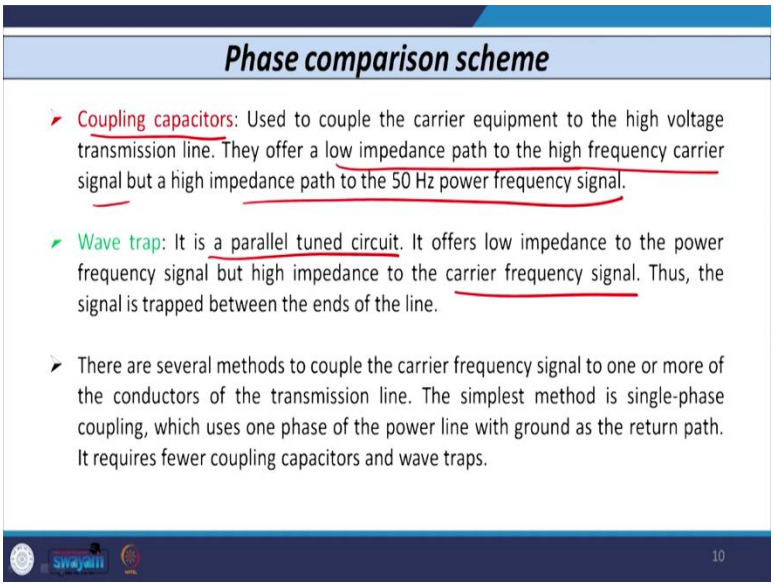

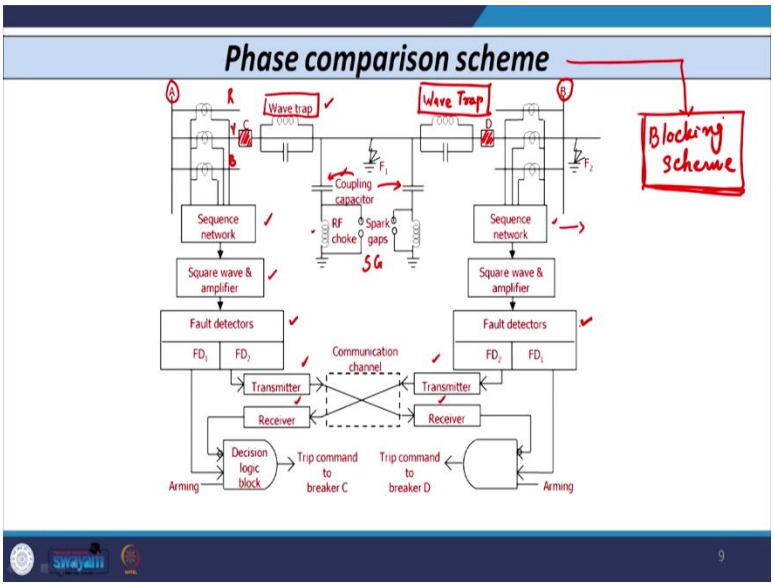

So, the main function of the wave trap it is a basically a parallel circuit and it provides low impedance for the fundamental frequency component and high impedance to the high frequency carrier signals. So, whatever your fundamental frequency component signal is there, all that signals that is available or given to the relay or available with the relay or CT.

That is the main function of the wave trap. So, wave trap that is also available here. The second device that is known as the coupling capacitor that exists here as well as here at both the sides.

So, the main function of the coupling capacitor that is say its working principle is exactly opposite to the wave trap. As I told you, wave trap provides a low impedance path to the fundamental or power frequency and a high impedance path for carrier frequency, whereas coupling capacitor, it provides the low impedance path to the high frequency carrier signal. So, all the carrier signals that is available, that is available through the coupling capacitor and it offers the high impedance path to the fundamental 50 hertz frequency signal.

So, that is the main function of the coupling capacitor and it provides low impedance path to the high frequency signal. Now, so we have the coupling capacitor. Now, along with the coupling capacitor, we do have the RF choke, that is radio frequency choke. So, this, along with this RF choke, we have another device known as the spark gap.

So, spark gap is a device which is used for the over voltage protection of the radio frequency choke. So, whenever the voltage exceeds beyond a certain predetermined value, this spark gap triggers. And hence the RF choke that is protected.

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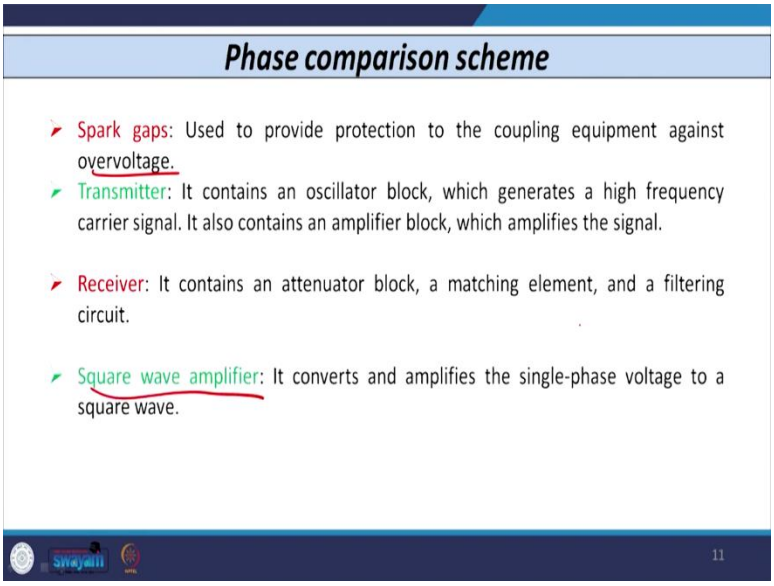

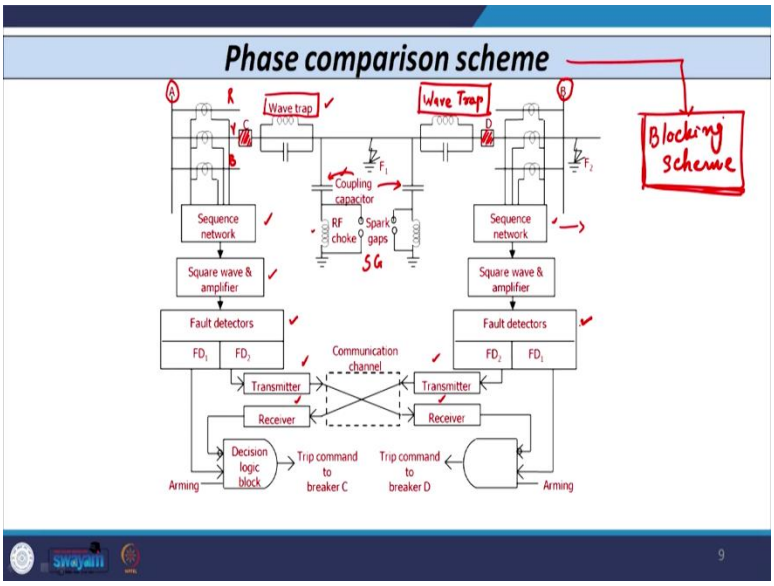

So, as I told you, the spark gap that is used for the protection against over voltage. Now, we do have some other device also. You can see here, we have a square wave and amplifier. And we have some sequence networks also. This sequence network, as I told you while in wire pilot relaying scheme, this is nothing but your summing transformer. So, basically it converts three phase circuit into single phase circuit.

You do have the transmitter and receiver on each side. So, you can see here, the transmitter and receiver, that is also available at each substation. So, the function of transmitter is it basically contains the oscillator block, which generates very high frequency carrier signal. So, high frequency carrier signal is generated in the transmitter. It also contains the amplifier block, which needs to amplify the signal for further transmission.

On the other hand, the receiver contains the attenuator lock, matching element and the filtering block. So, filtering lock is necessary because whenever any signal is received by the receiver from the other substation, that signal may contain noise. So, in order to remove that noise, some filter that is required. As I told you, square wave amplifier is also there, which converts and amplify the single phase voltage to the square wave voltage, square wave type, so that is also very important. Along with that, you can see here, there are, on each side, you have the fault detectors. So, two fault detectors are used FD1 and FD2 on each side.

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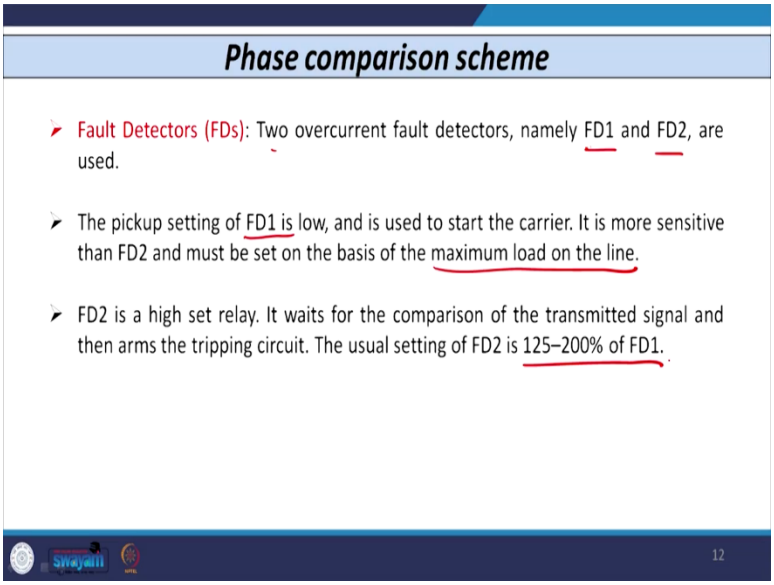

So, fault detectors is basically nothing but your simple overcurrent relay. This is the IDMT or instantaneous type overcurrent relay. So, this name of these fault detectors are given as FD1 and FD2. The setting of FD1 is usually lower than the FD2. So, the setting of FD1 is carried out based on the full load current of the line and it is more sensitive than the other fault detectors that is FD2. The FD2 fault detector, second fall detector that is the FD2. Its setting is a 125 to 200 percent of the FD1. So, there is of course there is a timer connected with this fault detector two.

So, your fault detector one operates immediately as soon as the current exceeds the full load current of the feeder or line, whereas your fault detector to that setting is higher than that, so that will operate once the time of the timer that is completed. So, that is the main difference between these two.

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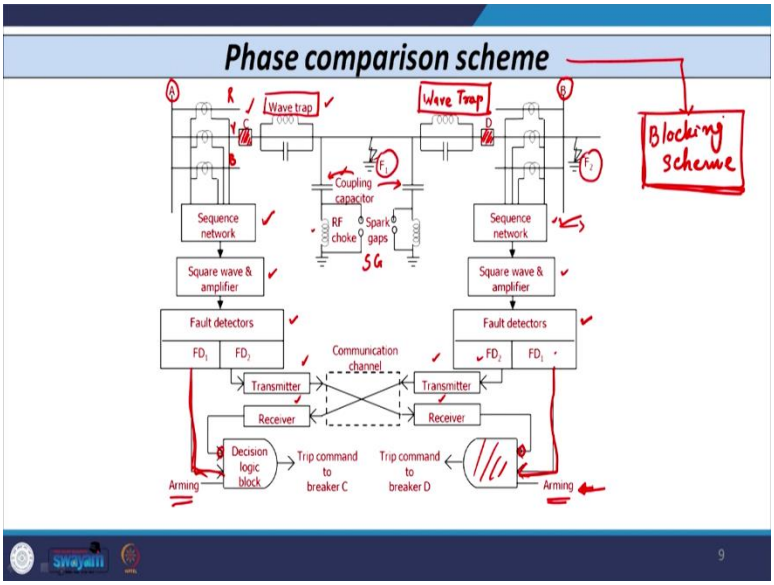

Now, you can see here, how this works. This CT on each substation that acquires the signal, that signal is given to the sequence network or summing summation transformer or summing transformer, which converts three phase signal into the single phase. Then, that signal is converted into square wave. Of course, this signal is a voltage signal. And that signal is further given to the fault detectors. So, there are again, there are two fault detectors and the input, one input from the fault detector one that is directly available to this block, that is known as decision logic block.

This decision logic block can be usefully flip-flop, or it can be a competitor. So, one signal is directly given from FD1 so, on this side also at substation A, one signal is directly given to decision logic block, one signal is given that is known as arming signal. So, that is sometimes necessary. And this arming signal, the name arming is given from as such type of signal is used by Department of State's Army of the Department of State for some purpose, that is why this name given and the third signal from this decision logic block that is available through receiver.

So, receiver you can see here at substation A, the signal is available from receiver. This receiver achieves signal from the transmitter of the substation located at B and this is given from FD2. Same way, on this side also, FD2 give signal to transmitter and then the receiver is at substation B receives the signal and it is given to the decision logic block. And once the output of decision

logic block exceeds or becomes one, then it gives command to the circuit breaker C as well as circuit breaker D.

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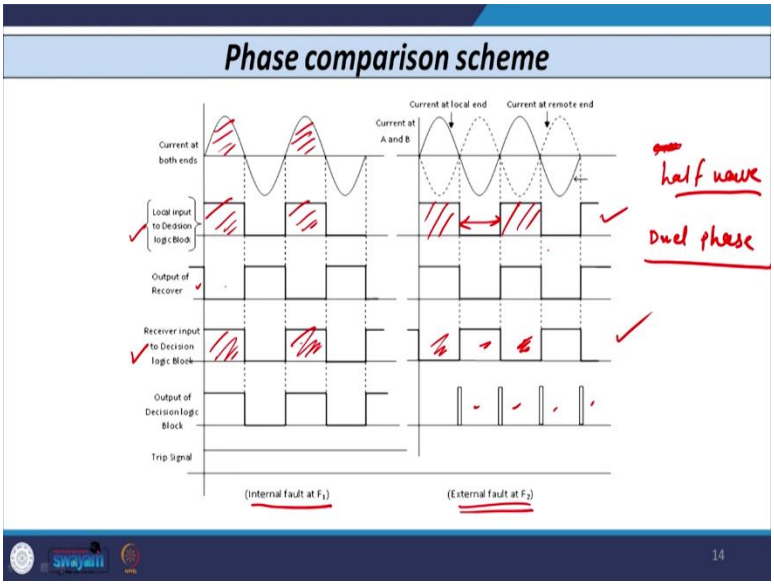

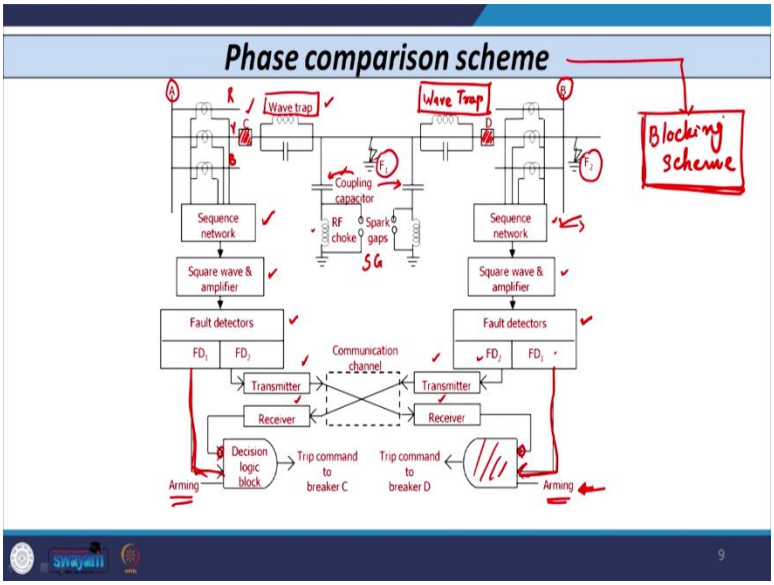

So, with this background, let us just understand how the signal works. So, here, I have shown the several wave shaped wave form. The one is for internal fault. So, in case of internal fault, the current, both current are, you can see that both are in phase. So, the local input to the decision logic block that is high. You can see for every positive half cycle, this signal that is high.

So, this signal is basically nothing but the signal directly given from this FD1, this signal. So, you can see here and again, output of receiver, you can see which is available or given here that is from the other substation that is exactly opposite to that of this signal.

And as you can see here, I have shown the NOT gate on each side. So, whatever output is given, input that is opposite to the output of the receivers. So, you can see from the waveform, this is the output. And exactly opposite to that, that is the receiver input to the decision block. Then, you can see this and this, as these two values are in phase, so that means the output of the decision logic block that is high for every positive half cycle so, the trip signal that is given. Exactly on the other hand, in case of external fault, say at F2, I have shown the two faults, one is here F2, external fault and one is here that is F1.

So, you can see here that in case of external fault, the two signals are out of phase at local end and at remote end. So, local input to decision logic block that remain same, no change. But the output of receiver that changes. So, because of not gate this value also changes right here. So, as this point, this value and this value are both out of phase, so that is why only blocking signal is given after every half cycle. And so, there is no tripping that is given to the circuit breaker.

So, you can see here that every half cycle, we are giving the signal, that is why this type of scheme is known as single phase comparison scheme. So, that is known as the just you can say the half wave phase comparison scheme or single phase comparison scheme, because we are giving signal to every half cycle. So obviously there is a delay of half cycle in this scheme.

So, if you want to rectify this, you can use the dual phase comparison scheme, where you can give the or you can transmit the signal for every positive and negative half cycle. So, that is very important point, that is just as I told you, dual phase and single phase comparison scheme.

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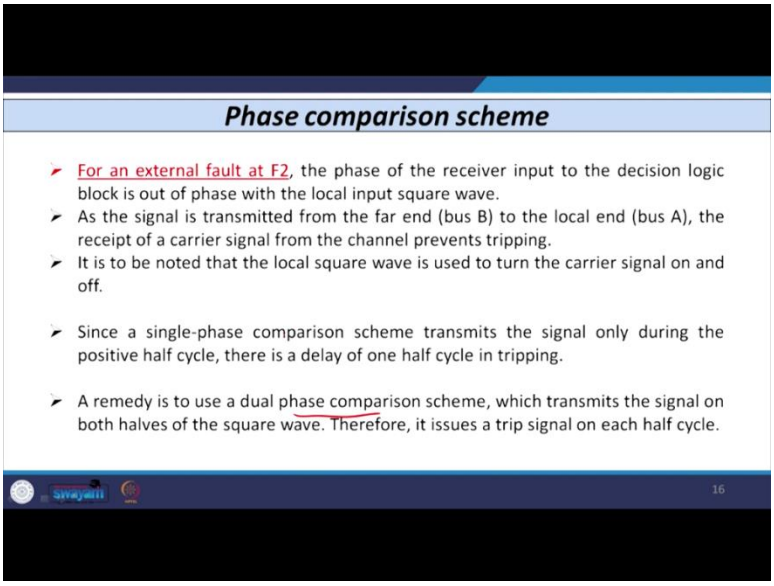

We started our discussion with the different types of pilot signal available. We started with radio frequency, then microwave and then fiber optic and satellite. And then, we have discussed the working of wire pilot relaying scheme and then after looking the limitations of the wire pilot relaying scheme, we started the discussion with the carrier current protection scheme. And in that, we have discussed the phase comparison scheme. The next is the directional comparison scheme that we will discuss in the next class. Thank you.