Digital Protection of Power System
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Lecture 2
Introduction to Digital Relays-II

Hello friends. So, in the previous lecture, we have discussed regarding the classification of relays.

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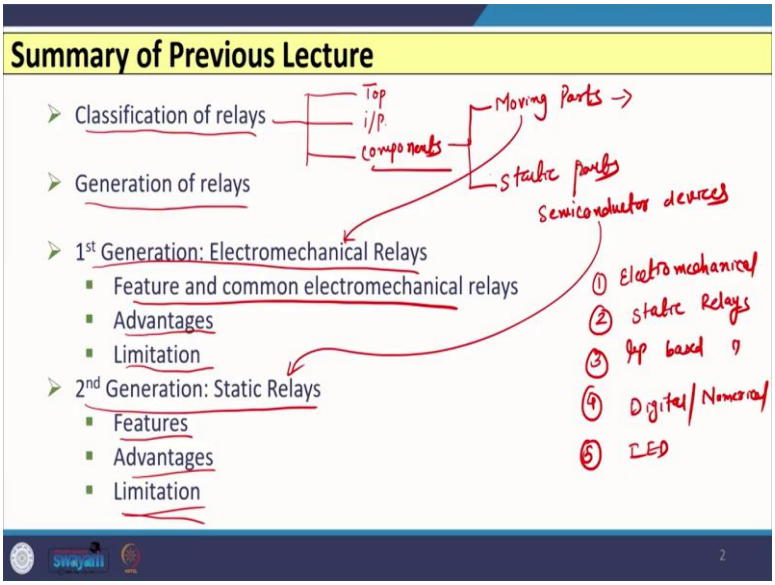

So, in that we have discussed that relays can be classified in terms of the time of operation, that is done by the relay. So, we may have instantaneous over current relay, we may have definite time relay, or we may have inverse overcurrent relay, or we may have IDMT overcurrent relays.

The second classification which we have discussed, that is based on the number of inputs required by the relay. So, relay may require single input and that is let us say current, that is in the form of CT secondary, or relay may require the double inputs, two inputs, maybe from the CT secondary, and PT secondary, or CVT secondary. So, both voltage and current are required by the relay as an input, and based on that relay will take the decision.

The third we have discussed based on the components used by the relay. So, components used by the relay, let us say relay may use some moving parts. So, if relay contains moving parts, then this type of relays are known as electromechanical relays, and this we have discussed. So, these relays are known as electromechanical relays. Relay may contain let us say, the static parts, or maybe semiconductor components, or devices. So, it contains

semiconductor devices. So, this type of relays are known as the static relays. So, this we have discussed.

Then in the generation of relays, we have discussed five different generation of relays, starting from the electromechanical relays. Then we have discussed the static relays. Then, we have discussed the third generation of relays, that is known as microprocessor based relay, and fourth generation of relay which we have discussed is the digital or numerical relays, and fifth generation of relays, we have discussed, that is intelligent electronic devices or IEDs. So, this we have discussed in the generation of relays.

After that, we have discussed the first generation of relays, that is electromechanical relays. And in that we have discussed features and different electromechanical relays available in the market. We have also discussed the advantages of this relay, that they are very rugged and they are still used by the utilities, because they are not affected by the switching surges and lightning surges, which are going to initiate or generate transients and spikes. However, this relay has certain limitations also, that also we have discussed.

And the important limitations are they contain moving parts. So, the maintenance requirement is very high. The burden imposed by this relay on the CT and PT that is on instrument transformers are also high. So, after that, we have discussed the second generation of relays, that is static relays, and we have discussed features, advantages, and limitations of static relays. So, in that we have discussed that, the static relays are better compared to the electromechanical relays. Because they do not contain any moving parts, and this relay has different other features also.

However, this relay has certain limitations, and those limitations are because of the semiconductor devices used, because their overload capacity is lower compared to the other devices. And, they may operate because of mechanical vibrations, or maybe because of temperature variations. And they are very prone to the protection, or they do not provide proper performance when transients or spikes are available. So, that we have discussed.

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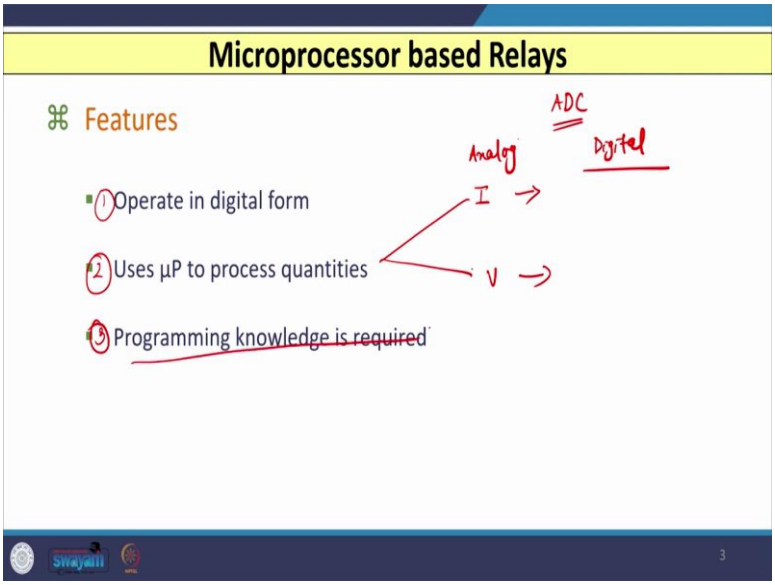

Now, let us see the third generation of relays that is known as microprocessor based relays. So, important features of microprocessor based relays are, the first feature is they operate in digital form. So, no direct analog form they operate. The second feature is the microprocessor is utilized to process the acquired quantities. So, if we have let us say acquire quantity is current, or if we have acquired quantity is voltage, then we have to convert this analog input in the form of voltage and current into digital form.

So, this relay only accept digital inputs. So, we need some devices which is capable to convert the analog values into digital values. So, we need analog to digital converters. And, the third feature of microprocessor based relays, that is the programming knowledge is required because you need to write some code, or algorithm which is going to process. And if that particular condition is satisfied, then this relay operates, or it initiates a command, trip command and further it gives signal to the circuit breaker.

Now, let us see what are the advantages of microprocessor based relays compared to the previous generation of relays, that is electromechanical, and static relays.

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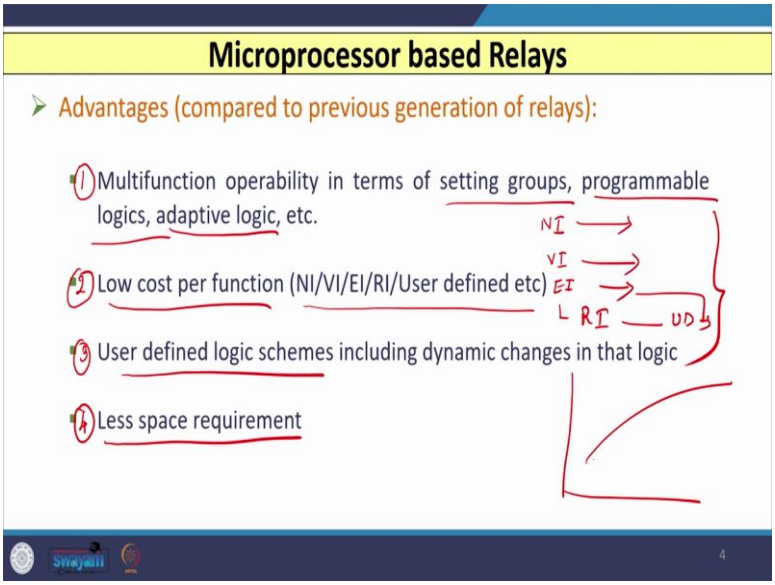

So, the first advantage of microprocessor based relays is the multifunction operability it has in terms of setting groups. So, this relay has basically two setting groups, one setting group that is used for working purpose, the other setting group that is normally as a backup, it has a programmable logic. So, you can develop your own code, or program if you want to design some different characteristic that you can design. It also supports adaptive logic.

So, suppose you want that, if current exceeds some value, let us say some threshold, then really operates, but that threshold is variable in nature. So, that type of adaptability if we want, then such type of relay supports that adaptive logic. The second advantage of microprocessor based relay is the low cost per function. So, we know that if I have electromechanical relay, and if I want normal inverse characteristic of overcurrent electromechanical relay, then I have to go for one relay, we have to purchase one relay, which has a normal inverse characteristic.

Then, now, if the requirement is such that, after some time we need let us say very inverse characteristic, instead of normal inverse characteristic, or we need extremely inverse characteristic, instead of normal inverse characteristic, or we need let us say some rarely inverse, or some user defined characteristic, then in that case, we have if we have electromechanical relay, then we have to purchase each time for each characteristic new relay from the market or from the manufacturer.

However, if we have microprocessor based relay, then this relay will provides all this characteristic along with this normal inverse, very inverse, extremely inverse, rarely inverse, maybe some IEEE inverse, supported inverse characteristic, those are also provided by such

type of relay. So, cost per function, or per characteristic is lower for microprocessor based relays compared to the electromechanical relays.

Now, the third advantage of microprocessor based relay is that, you can have user defined schemes including dynamic changes in that logic. So, if you want your own logic, your own characteristic. Let us say suppose, I want a characteristic, let us say like this, for a particular relay, then you can design, or define such type of characteristic in microprocessor based relay, even you want some dynamic changes or settings that also you can do.

The next advantage of microprocessor based relay is that it requires less space, or lower space compared to the previous two generation of relays. So, if you use, or if you install such type of relay in the utility where you have limited space, because you have to accommodate number of relay in one panel, there, I think microprocessor based relay is better choice compared to the previous two generation of relays.

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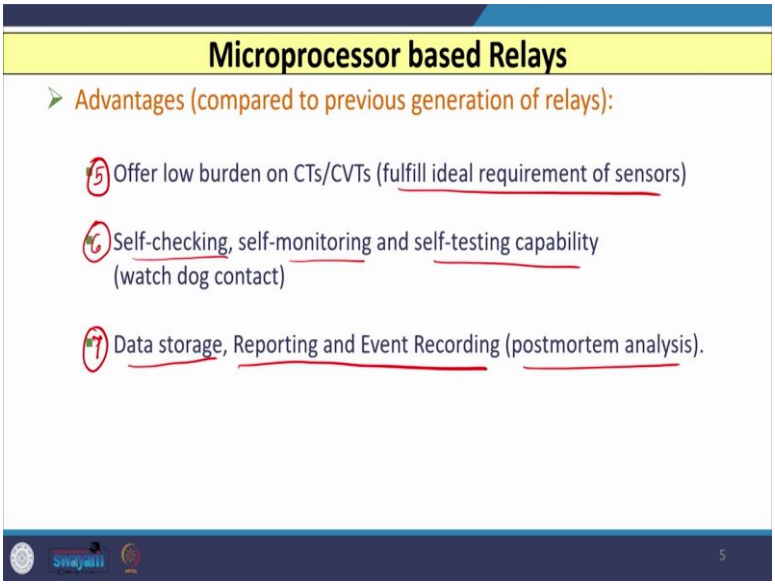

Then, we do have, the another advantage that is offered by this relay, that is the low burden imposed on the CTs, and CVTs. So, when we use microprocessor based relay, it imposes low burden on the CT, and PTs, or CVTs because of the lower VI requirement of the circuitry of this relay. And, this is going to fulfill the ideal requirement of any sensor, without utilizing the power of the acquired signal. It imposes low burden on the instrument transformers.

The sixth advantage of this relay is, this relay has a feature, special feature that is known as self-checking, self-monitoring, and self-testing capability. So, if something goes wrong inside the relay, then this relay is capable to check itself, and that is known as self-checking feature.

So, when we have discussed electromechanical relay, we have seen that, let us say for every 15 days, or once in a month, we need to carry out a maintenance, or periodic maintenance of electromechanical relays. So that, we assure that whenever a fault occurs in future, then relays capable to take care of that fault, means relay is going to operate.

However, if I use microprocessor based relays, then it has a self-checking feature. So, no separate maintenance is required, when we use this type of relay. The next advantage of microprocessor based relay is that, it has a data storage facility. So, you can store the data like pre-fault current, pre-fault voltages, or maybe you can store the data of transients, or you can store the data of harmonics, maybe if you need for any post mortem analysis, whenever something goes wrong, or when any abnormal condition takes place, then this such type of data will be very useful for the analysis purpose.

So, this relay has feature of data storage. Reporting, and event recordings are also there. So, if I wish to know, or visualise such data in waveform or graphical form, then this type of facility is also available with microprocessor based relays.

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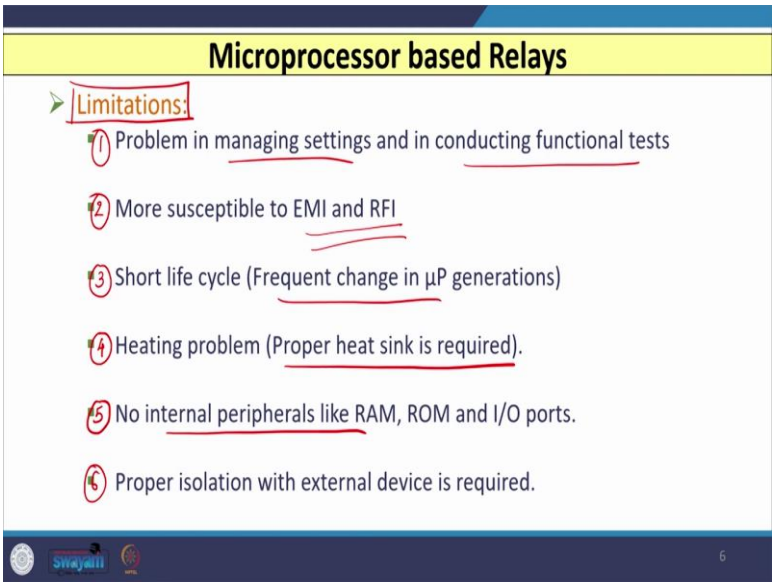

After this, let us see what are the limitations of the microprocessor based relays. So, the first limitation of this relay is, the problem in managing the settings and conducting the functional test. We know that this relay has large number of settings. So, managing the settings is itself a big issue. Of course, for that, for managing the settings certain setting management softwares are provided by the manufacturer. However, still the person who is involved in the setting, or who is involved in the functioning test of the relays, he is very expert and he knows all the things related to the settings of the relays.

Even when the testing on such type of relays are carried out. In that case you have to let say deactivate certain settings. So that proper testing is to be carried out. After testing, when it is available in normal condition. Then whatever settings you have deactivated, you have to reactivate those settings. If you let us say forgot by mistake, then again those settings are not available for the user. The second limitation of microprocessor based relays is that, they are more susceptible against electromagnetic interference and radio frequency interference.

So its performance of this relays are affected, and the earlier electromechanical relays, they are more immune against such type of interferences. The third limitation of microprocessor based relay is that, this relay has a very short life cycle, because let us say we are using some operating system for our computers. So, we know that whenever one operating system is available, or we are using, and whenever next operating system is available for the users. Then, there is a significant change from one operating system to another operating system, or from one generation to another generation.

So similarly, in microprocessor based relays also, whenever there is a frequent change in the generation of microprocessors, then they whatever user that is using such type of relay, it is well acquainted by such type of change in the generations, and maybe this type of operations, they may last maybe for six months or one year. So, the engineer working in the utility, he has to create an expertise in such type of generation changes.

The fourth type of limitation of microprocessor based relay is that, it has a heating problem and for that, to avoid the short circuit, in that case, we need a proper heat sink, when we use such type of relay. The another disadvantage of this relay is that, this relay does not have any peripherals like RAM, ROM, or any input-output ports. And the last, but not the least, that is the this relay needs proper isolation with external devices that is must when you use such type of relay.

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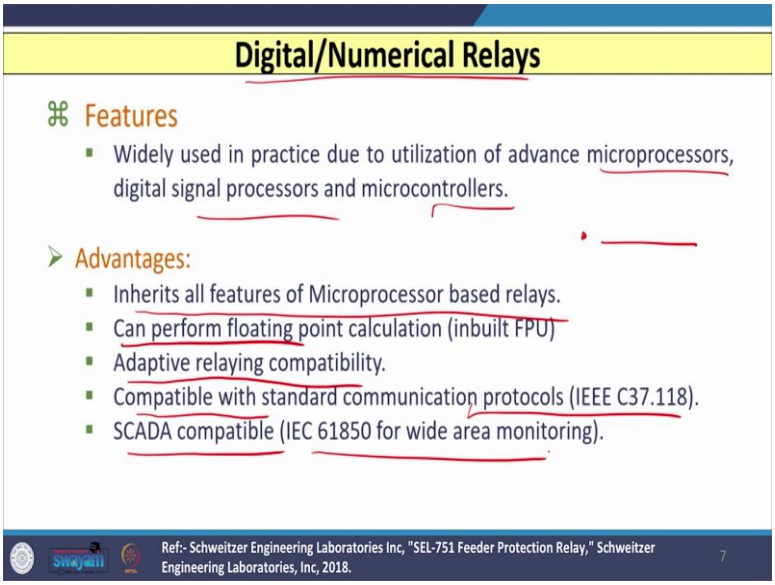

Now, with this limitations of microprocessor based relays, let us move to the fourth generation of relay, that is digital or numerical relays. So, this relays are widely used by the utilities because of the advancement in the microprocessors, and digital signal processors, and controllers. So, important advantages of this relays is that it inherits all the features of microprocessor based relays. So whatever advantages we have discussed for microprocessor based relays, those advantages are also applicable for digital or numerical relays.

This relay can perform floating point calculations. So, after decimal point, if we need the calculation, then separate calculations, or separate processors are there. So, this relay can perform such type of calculations. This relay has adaptive capability, let us say when there is a change in external system conditions, and because of change in external system conditions, if some parameter changes and because of that, if threshold changes, and if we want adaptive threshold, then such type of feature is possible when we use digital or numerical relays.

This relays are compatible with the latest communication protocols that is IEEE C 37.118. And, they are also SCADA compatible even this relays is compatible with IEC 61850 substation and automation protocols. And these protocols are widely used in wide area monitoring control, measurement and protection purpose.

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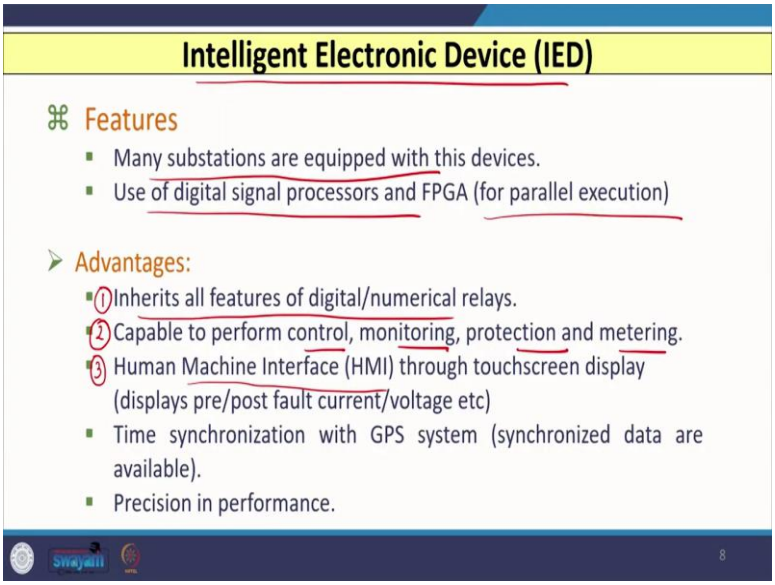

Now, the last or recent generation of relay available that is known as the intelligent electronic devices. So, this relay has the feature like they have widely used by the utilities in the substation, whatever digital signal processors advancement, and whatever field programmable gate array, those things are used inside this intelligent electronic devices. Important advantages of this relays is that, the first advantage is, it inherits all the features of digital or numerical relays, which are available in previous generation of relays.

The important point for this relay is, this relay is capable to perform all the four functions together and those functions are control, monitoring, protection, and metering. The third advantage of this IED based relay, it has human machine interface facility through touchscreen display. So, let us say, if I have this is the IED based relay available or digital relays you can say, and when you see you have several buttons available, and several IEDs are also available.

So, you can visualise this thing using the human machine interface. Though this is not IED, this is a digital relay. But still you can see that this looks like same as IED. Even when you use digital relay, or IED on the side view side the diagram is provided, using which you can identify that which are the terminals of the relay. So, these all are the relay terminals, where you can connect CT, or any other contacts are there. Even this has several input output contacts, several communication ports are also there. So, this type of facilities are available in this type of relays.

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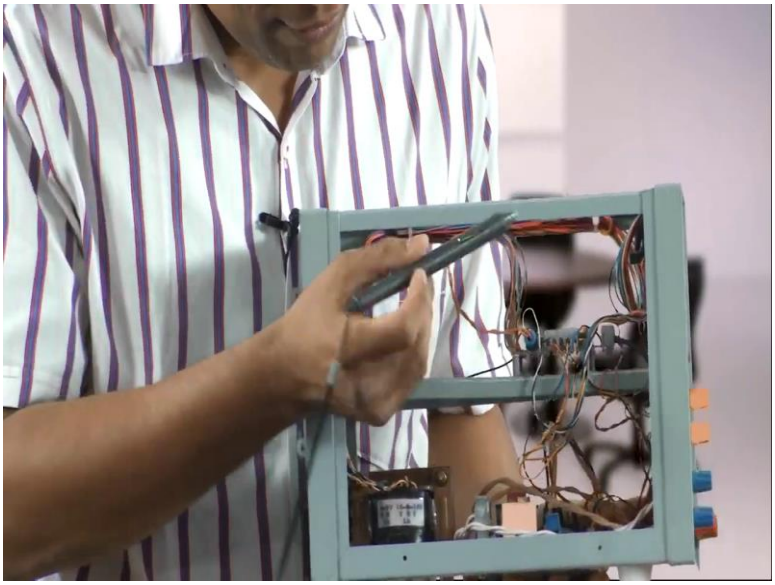

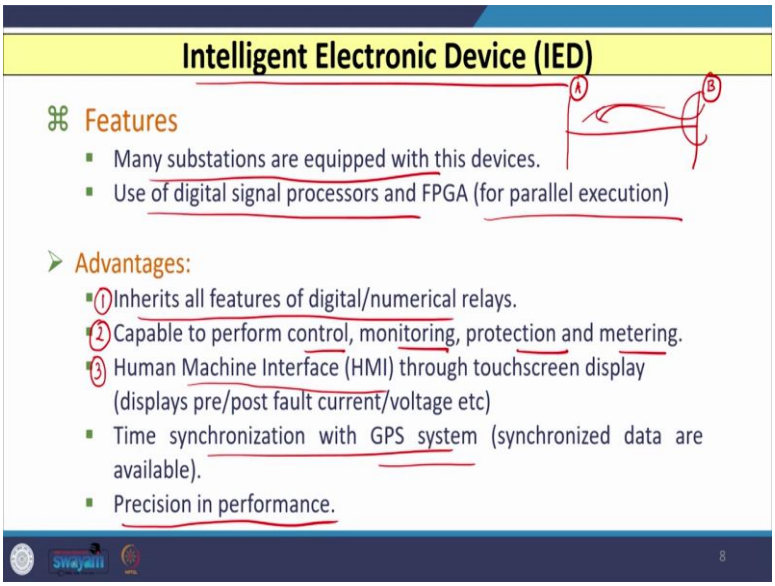

Whereas, if I consider the microprocessor based relays, then this relay looks like this. So, if you see, this is nothing but the microprocessor based relay, where you can see the processors that is available here, and below that some signal conditioning units are also available here. Now, if I consider the important advantage of this intelligent electronic devices, which are not available with microprocessor based relay, that advantage is, the time synchronisation with GPS.

So, if we want synchronise data from various buses, say for example, I have a transmission line connected between two substations A and B, and I want data at substation A, from substation B, through some communication channels, let us say we have some low bandwidth communication channel available, and we want data from substation B. But this data can be

synchronised or it can be unsynchronised. If I have this relay, and GPS system then we can have this data that is synchronised.

So, synchronised data also available if we use this type of relay, and this relay has the operating time that is lower compared to the other previous generation of relays. So, fault clearing time can be reduced drastically if we use this type of relay.

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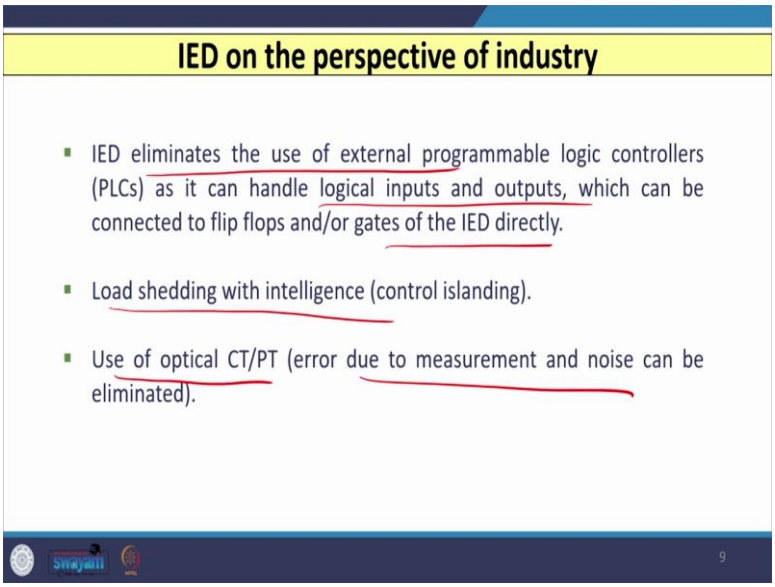

Now, let us consider how we can use IED as far as the industry perspective is concerned. So, IED eliminates the external utilisation of programmable logic controllers, as it can handle the logical inputs and outputs. So, this type of feature is not available in previous generation of relays. So, we can use IED, or industry people can use IED without utilising the external programmable logic controllers. When we have to use the load shedding with intelligence, let us say if I want to use control islanding scheme.

So, we know that island is a phenomena, when any small area is disconnected from the electrical network, and which is going to form an island, this is known as electrical island. Islanding can be controlled islanding, or it can be the force islanding. So, we will discuss this thing later on.

However, if we wish to perform control islanding, then such type of relay will definitely helpful compared to the previous type of relays. If I use the optical CTs, and PTs, then error such as which is going to occur because of the noise, or maybe because of the measurement, those can be definitely eliminated if I use IED along with optical, CTs and PTs.

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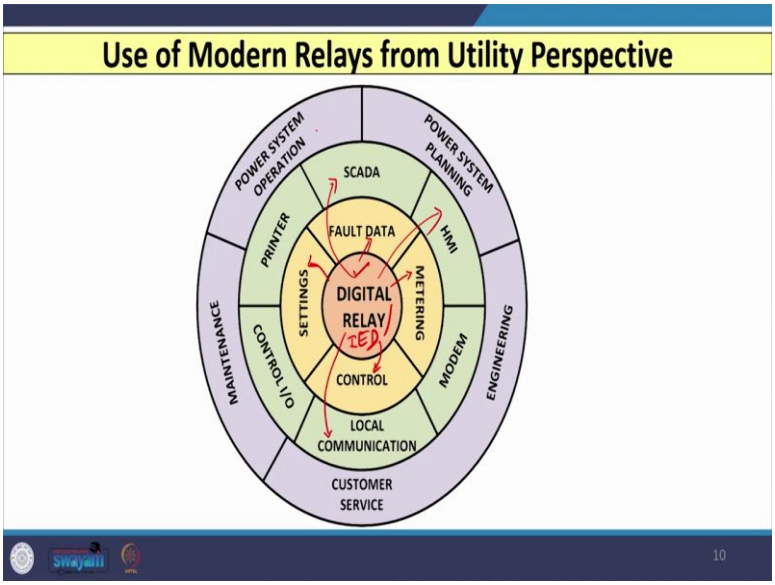

Now, if I use the modern relays, and if I see the digital relay, or numerical relay, or IEDs, anything so this can be applicable to IED also. So, if I use this then you can see from this diagram, that this relay has settings available here. So, a number of settings are available in electromechanical relay, you have some fixed seven plug settings, and maybe you have let us say ten time dial settings are available, or twenty time dial settings are available, but in digital relay or IEDs, these settings are even you can say fifty or hundred settings are also available

You can use fault data, whatever data you have recorded, maybe for postpartum analysis, you can also measure some important parameters. Even you can control also, if required, you can also use these relays with SCADA, because this relays are SCADA compatible, and this relay has communication facility also. So, they are supported with IEEE C 37.118 standards.

And this relay are also has a facility with human machine interface. So, you can have some display, and where you can help post-fault current, or maybe voltages or maybe some other parameter that you can visualise. And all these things can be used for power system operation, power system planning, and maybe for maintenance purpose.

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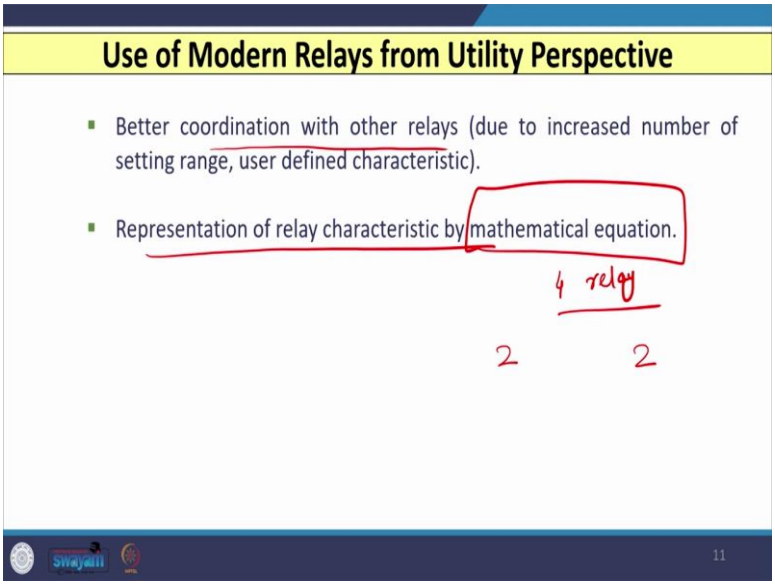

Now, if I use the modern digital relays, then the important advantage which we have, that is in terms of better coordination. And, this we have because we know that nowadays the penetration of renewable energy sources are increasing. And in that case, if I want to coordinate this relay with some other relay. Let us say we have four relays available. And out of these four relays, let us say two relays are electromechanical, and two relays are digital or IED.

So, if I wish to coordinate characteristic of IED with electromechanical relay, or IED with IED, or IED with let us say digital relay, then you will have better coordination, because you have different setting range is available in this relay, and you have even your own user defined characteristic. The second important point is the characteristic which is represented in this IED, or digital relay, these characteristics are represented by mathematical modelling. So, the issues which is faced by actual relay characteristic in electromechanical relays, those can be avoided.

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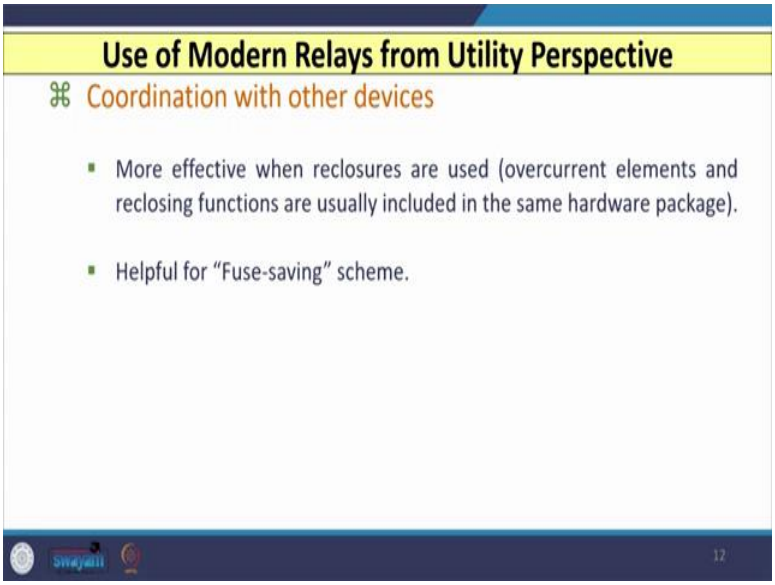

Further, we know that nowadays we are utilizing reclosers in the our conventional electrical system, and this is used just to improve the reliability of the system because if we reclose the system, we know that eighty to ninety percent faults are transient in nature, and they may die out after some time.

So, if were reclose, and if transient faults are there, then that can be die out, and our system is in normal condition or healthy condition. So, the situations where we use reclosers along with the overcurrent relays, then this can be easily utilised, or accommodated because nowadays in hardware package the overcurrent element as well as the reclosing elements both are included together.

So, this can be performed better compared to the previous generation of relays, and this is also useful particularly when you have fuse saving concept. So, we know in distribution system when we are utilizing fuse for the protection against short circuit, and if we want to avoid the operation of fuse, then we can use recloser. So, when we want to coordinate this recloser with the other upstream devices, then we can easily carry out the coordination if we use this thing.

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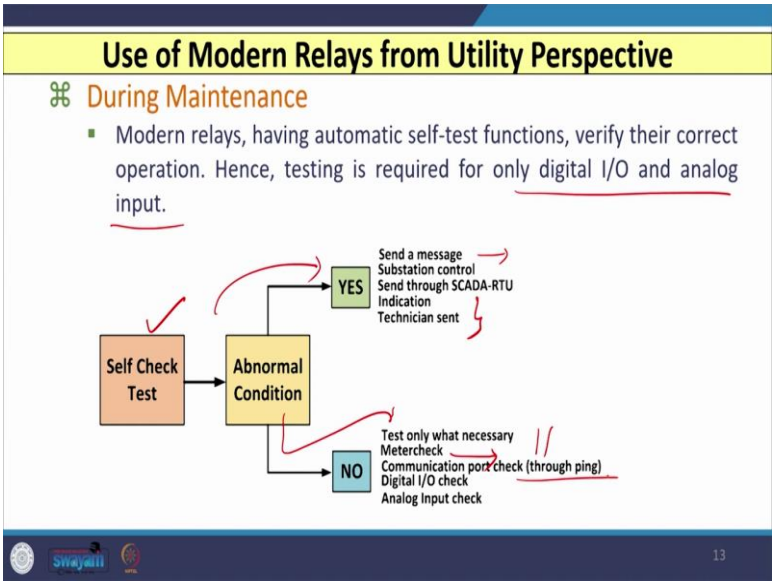

One important point is, that is it helps during maintenance. So, let us say we know that we have discussed also that this relay has self-checking, self-monitoring facility. So, with this self-checking, and self-monitoring facility, these relays are capable to verify their own operation, and when testing is carried out, we need to test only for the digital input output, and only analog input. For this three only we need the checking, or maintenance otherwise for other parts, the maintenance that is not required or that can be reduced.

So, if I have let us say relay is carried out its own checking. So, self-check test is performed by the relay, and if any abnormal condition is detected, then this relay will send a message in the substation control, maybe it can send messages through the SCADA remote unit, and accordingly whatever the operator is there he can perform, or he can send some person. If abnormal condition is not detected, then the only thing as I told you, you need to check is the meter check. And maybe you have to check the communication port, or maybe you have to check either digital input output, or analog input that is only required.

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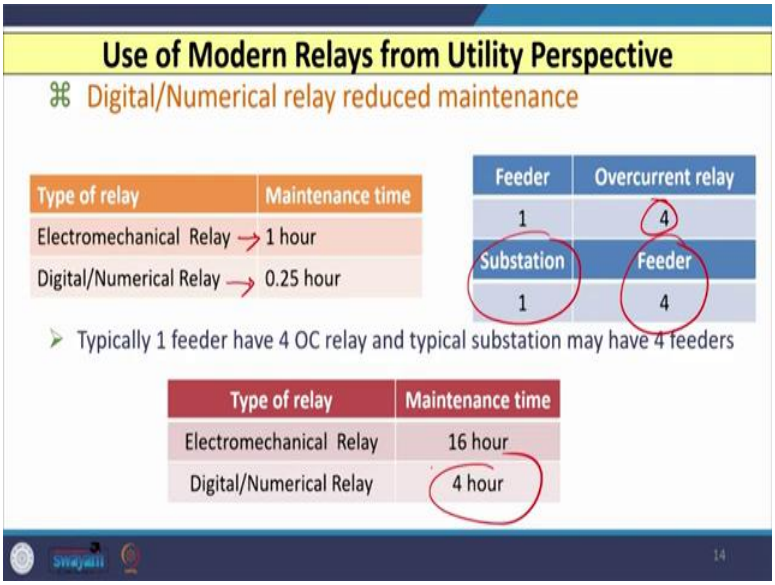

Further in the maintenance. Let us say, if I have a substation, which has four feeders, and each feeder, let us say that needs four overcurrent relays. So total sixteen relays are available in the substation, for four feeders. Now, if I wish to carry out the maintenance of this one substation containing four feeders and total sixteen relays, then if I use electromechanical relay, then it needs almost sixteen hours. So almost we can say one hour per relay that is required. Compared to that if I have digital or numerical relay or IEDs, then it requires only 0.25 hour per relay, and hence total four hours are only required.

This relay will also help in maintenance also, your maintenance time that can be reduced, compared to the electromechanical relays. So, in this lecture, we have discussed the advantages and disadvantages of microprocessor based relays. Then, we have discussed the advantages, and disadvantages of digital or numerical relays. And then, we have discussed, how the latest generation of relays that is IED looks like.

And, we have also discussed the two importance perspective, that if we use industry perspective, then how IED will be helpful, and if we use IED in the utility, or in the actual substation, then how the utility will get a benefit. So, this thing we have discussed. Thank you.