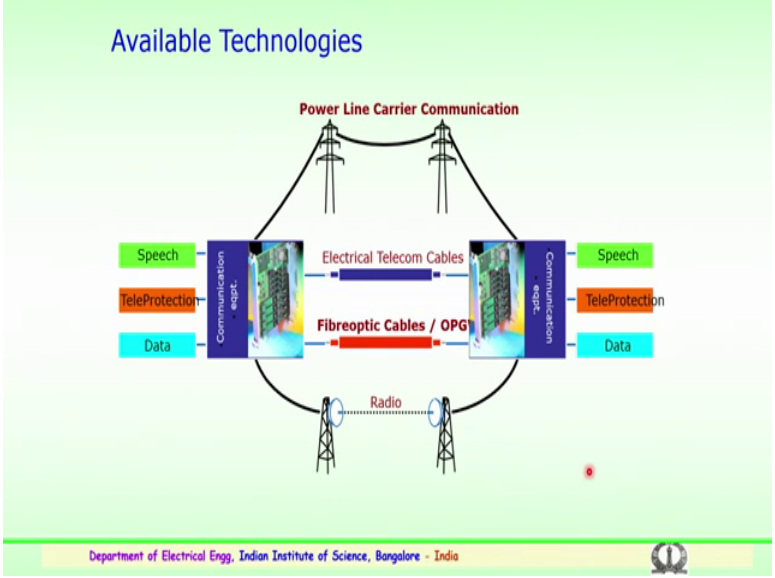
Advances in UHV Transmission and Distribution

Prof. B Subba Reddy
Department of High voltage Engg (Electrical Engineering)
Indian Institute of Science, Bangalore

Lecture - 30
Measurements of High Voltages

(Refer Slide Time: 00:18)



So, what are the present available technologies? So, where are this technologies being adopted very important. So, when you look into the transmission system, this power line carrier communication an example could be used for communication for various aspects. So, either power line carrier communications or electrical telecom cables which are a general telecom cables which are being used for communication directly or it could be fiber optic cables or the overhead ground wires, optical ground wires - OPGW. So, these are some of the technologies which are being adopted by the transmission or distribution utilities for proper communication of the data.

So, these technologies and finally being the radio, radio signals. So, these are the technologies which are being used for to communicate with the communication equipment; further the communication of this equipment could also be expanded for the speech or it could be for the tele protection or it could be for the data transfer. So, several of this benefits are being got with the technologies for the communication in the power networks.

(Refer Slide Time: 02:00)

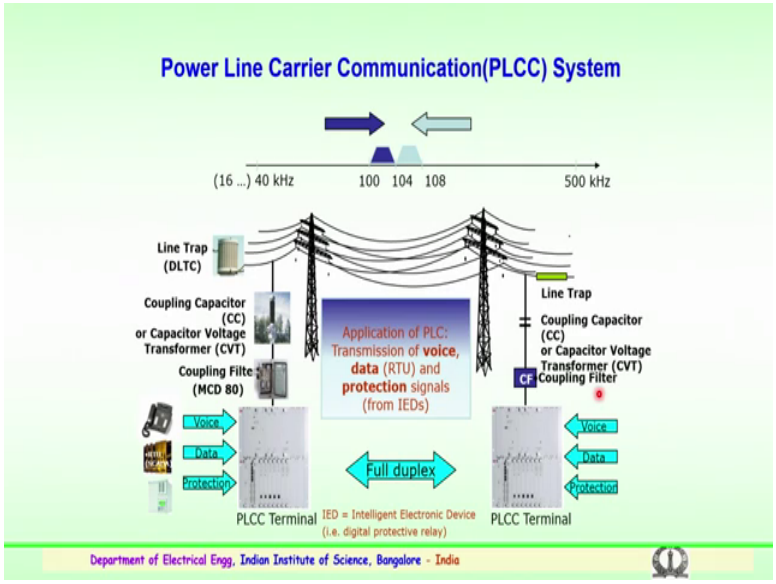
So, further the available technologies in the communication media, what type of technology is being adopted and what services could be provided with the available technology and the communication media are highlighted here. So, communication media could be as mentioned earlier it could be power line carrier, it could be distribution line carrier communication, it could be using the simple coaxial cables, it could be using the copper a conductors. It could be the radio relay link particularly working at microwave frequency. The optical fibers cables, which are being used in the communication and very high frequency ultrahigh frequency radio signals, which are used for the communication. And finally, the satellite communication.

So, several of this communication media are being used for the transmission and monitoring of the data. The technologies which are available are either wire type of technology or wireless communication. Again wireless communication several of this technologies are being adopted PDH, SDH, DWDM so on. Then mobile telephony or local area networks that could be Ethernet or could be a token ring type of arrangement or gigabit type of Ethernet LAN connectivity.

Then further you have XDSL, ADSL, HDSL, VDSL type of technologies which are being adopted for the communication. And using the communication and technology various technologies, so services various services could be provided like the voice, then fax, it could be the modem which will be helpful for the communicating to the further a

email, video surveillance, video conferencing, tele networking, telemetry, data communication then SCADA that is supervisory control and data acquisition then tele protection, and finally the management. So, several of this services are being used with the help of the proper communication and technology media. So, all these are very important for the SCADA or the smart grade which is coming up and very helpful for the electrical utilities to see that proper data management or monitoring of the system is very important.

(Refer Slide Time: 04:56)

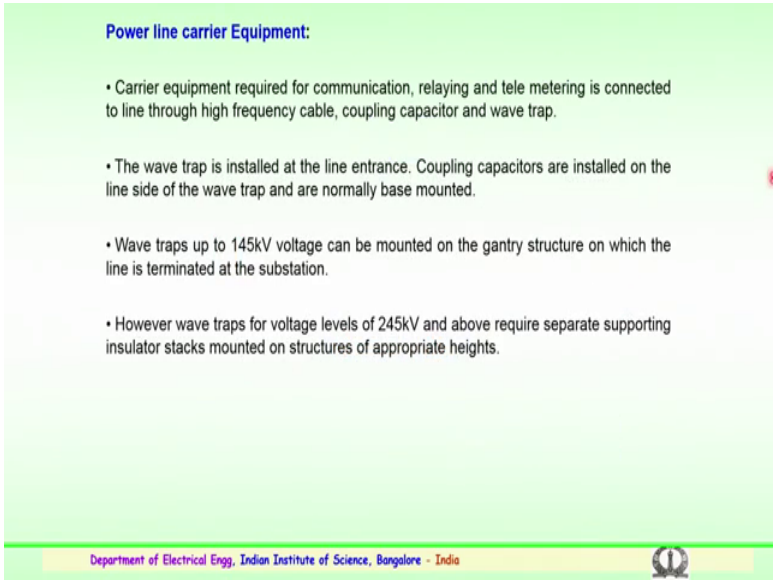


So, power line carrier communication system a very important, which is being done with the help of the power transmission lines. Here this could be anywhere from 40 kilohertz to 100 or up to sometimes 500 kilohertz a depending upon the equipments which have been used. A simple example here you can say the transmission system, you have line trap or a wave trap which is an equipment used for the communication system. So, this line trap or a wave trap is being installed in the substations of EHV or a ultrahigh voltage substation and this will help in communication of the data transfer.

So, basically these again consist of a coupling capacitor, the CVTs and coupling filters which are connected to these. Further, the data is being used in the power line carrier control terminal and this could again the using the RTO that is remote terminal units or remote telemeter units in the SCADA system, where the information like the voice, the data or the protection for this equipment, it could be done. So, employing several

intelligent electronic devices that is IDs and digital protective relays, this power line carrier communication is very useful in the power networks at very high voltage and ultrahigh voltage ranges and for the communication aspects. So, the application of power line communication is mainly as mentioned. It could be for transmission of voice data; this data could be transferred through the remote telemetry units. And the protection signals from the intelligent electronic devices, which have been used for the SCADA or the smart grade applications.

(Refer Slide Time: 07:14)



So, power line carrier equipment is one of the important component for the data acquisition, for the helping the communication aspect in the using the power lines. So, here the carrier equipment required for communication or for the relaying and telemetry is basically connected to the line that is a through a high frequency cable, a coupling capacitor and a wave trap as shown here. This is connected through the coupling capacitor coupling filter and a line through the line or wave trap which is shown here.

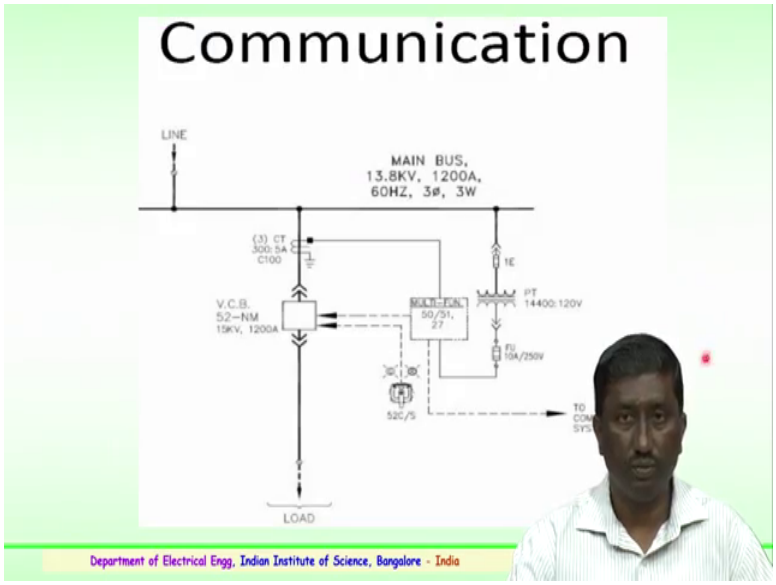
So, this wave trap or line trap is installed at the line entrance in the substation. And the coupling capacitors are installed in the line side of the wave trap and are normally a base mounted as shown here. So, this wave traps or line traps up to 145 KV voltage could be mounted on the gantry structure on which line is terminated at the substation. Or there should be especial arrangement above the higher voltages more than 220 KV or 400 KV where this wave traps could be planed or wave traps could be where does mounted that is

very, very important. So, however, these line traps or wave traps for voltage levels above 220 or 245 KV, this require a separate insulating stacks the clearances from the ground on the mounting of structures and looking into the clearances or maintaining the appropriate heights depending upon the voltage level of the operation of this line traps or wave traps is to be properly mounted.

(Refer Slide Time: 09:25)

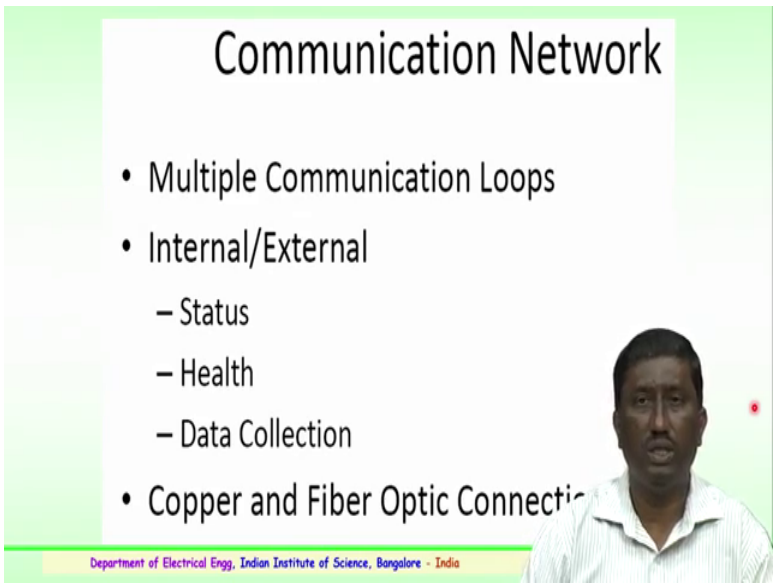
So, this is the one of the example, you can see here. These are the various wave traps or a line traps. This is the closer view of the line traps how it is being mounted you can see here in the substation at the entry level this power line carrier it will be helpful for the power line carrier communication. Again it consists of several components including the serge arrester in side were in case of lightening strike the arrester will help to see that this line trapper or wave trap does not get damaged. So, this is typical arrangement in any substation for a line or a wave trap power line carrier communication.

(Refer Slide Time: 10:12)



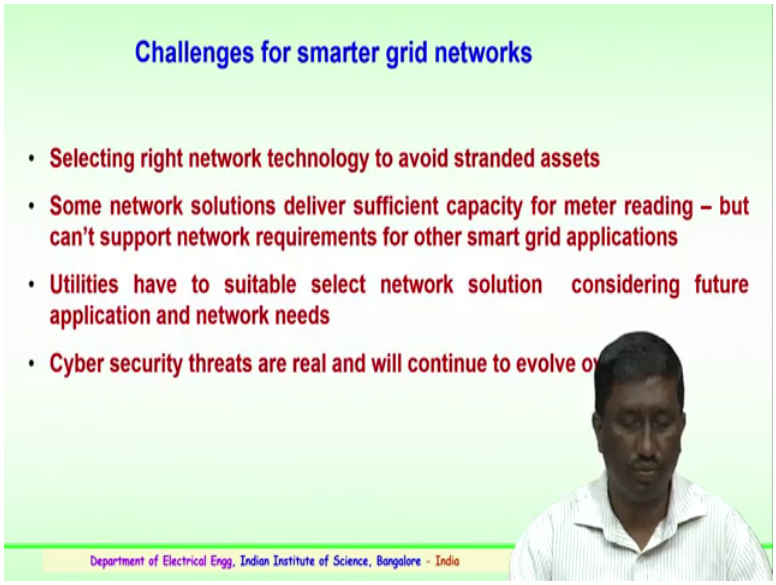
So, as mentioned earlier, this was a single line diagram of the communication aspect a line which may be typically 13 to 14 KV would be carrying 12100 amps at a frequency mentioned here a three phase line. So, all the arrangements like the current transformers, potential transformers, circuit breakers so on are basically connected for the metering aspects. And from the suitable arrangement of a line or wave traps, this could be communicated to the communication system where it will be helpful for the data and monitoring of the information.

(Refer Slide Time: 10:58)



So, communication networks could contain multiple communication loops. It could be internal or external networks. And the status of the internal or external, it is important is the health and how the data collection for the communication. The usage could be the fiber optic connections or through conductor of copper conductors. So, several means of communication are being employed in the substations.

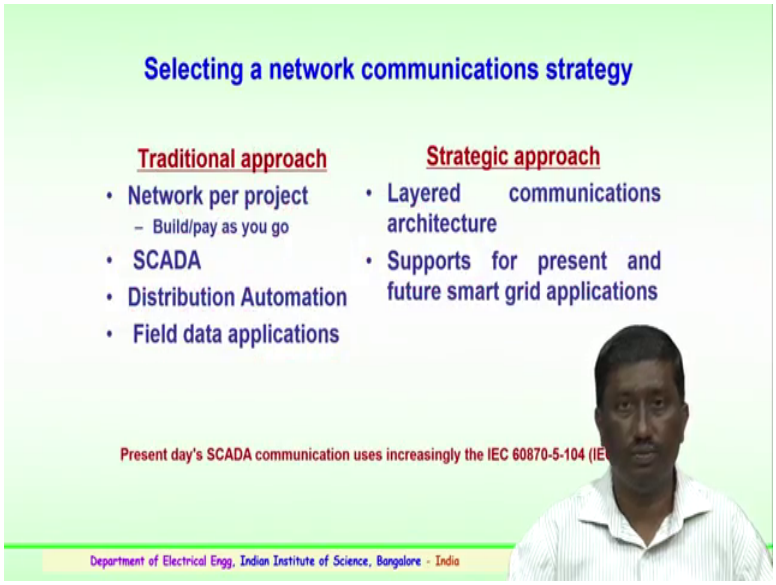
(Refer Slide Time: 11:34)



So, this information is very helpful as now we look for the greater challenges a particularly for the smarter grid networks as the voltage level goes higher the network electrical network is so complicated. We should have smarter grid networks, which will be helpful for selecting the right network technology, particularly to avoid the standard asset management. And the network solutions some which have been chosen should be able to deliver the sufficient capacity for the monitoring, but cannot support the network requirements for other smart grid applications.

So, the choosing of this networks which could be only for the present requirement have to be properly planned, so that when the network is expanded these devices should be also tried to be used. So, the utilities have to suitably select the network solution considering the future application and also the network requirements. And there is also important aspects like the cyber security threats which are real and will continue to evolve over the time. So, proper planning for these threads and the information connected with these is also challenge in the network grid networks.

(Refer Slide Time: 13:33)



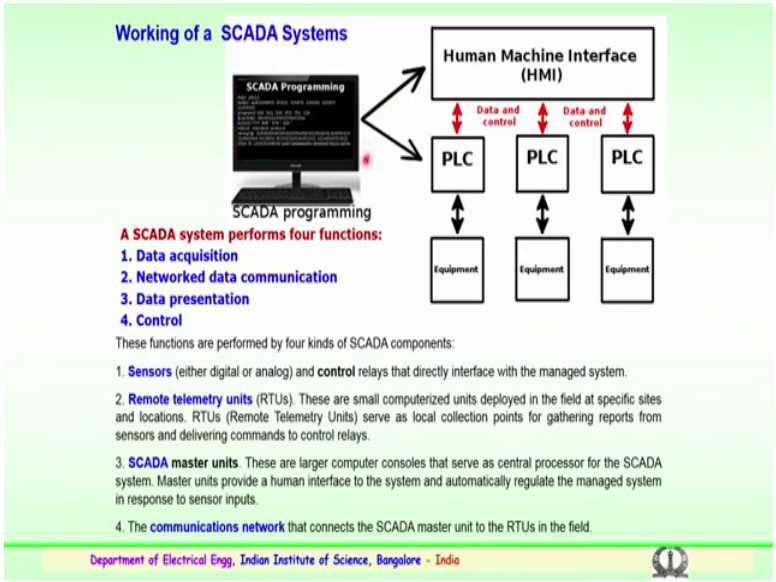
So, how do we select network communication strategy is a important aspect. Before a selecting the communication strategy, two important as approaches are available. First being the traditional approach, the second being the strategic approach. So, the traditional approach here again depends on the network per project, it could be a build pay as you go that is as you increase the network capability or the traditional approach could be going in for the SCADA that is a supervisory control and data accusation systems. Then going in for distribution automation is one traditional approach and going in for field data application. So, gathering the data in the field this could be the traditional approaches.

The strategic could be a layered type of communication or different architecture, which supports the information or network communication and also support for present and future a smart grid application. So, here the planning is a different in comparison to a traditional approach where not only for the present the future applications are also being considered in the strategic approach. A point to be noted is the present day, the supervise control and data acquisition which is being monitored the communication which uses increasingly is as per the standards IEC 80870 or IEC 104 is protocols which are being used for on the present is SCADA communication by the electrical utilities.

(Refer Slide Time: 15:37)

So, this shows arrangement for the SCADA monitoring SCADA is supervisory control and data acquisition where you can monitory the entire data from various data which have been obtain taking proper measures in case of the emergency and also try to monitor analyze the data very important. The SCADA system could be used for several of the applications and the incase of electrical or utilities, this has been a bone for the utility engineers where the data monitoring control has being done with the help of the data acquisition which is being gaining very, very important in the country.

(Refer Slide Time: 16:39)



So, how is the SCADA functions or any working of a SCADA system is typically this is basically human machine interface. So, it has data under control arrangements which the data and controls are through the programming logic controllers help of a programming logic controllers. And these data and control information is got from various equipments which are in the field. So, the sensors which have been placed near the equipments, these data from the sensors is communicated to the PLC further the data and the control system where the entire through the SCADA that is supervisory control and data acquisition, you can see monitor, you can try to see the analysis perform the analysis and take a right decision.

So, the SCADA system performs mainly a four important functions. The first is the data acquisition from the equipments. Then the network data communication how the equipment data through the sensors is communicated to the programming logic controllers further to the SCADA machine or a SCADA server. Then the data presentation the data, which is obtained is being presented, monitor and analyzed; and fourth is the control very important. So, based on the data, which is available suitably analyzed and wherever necessary the proper control management is being done. So, important four functions of a SCADA system; these above function that is the four functions are performed by the four kinds of SCADA components.

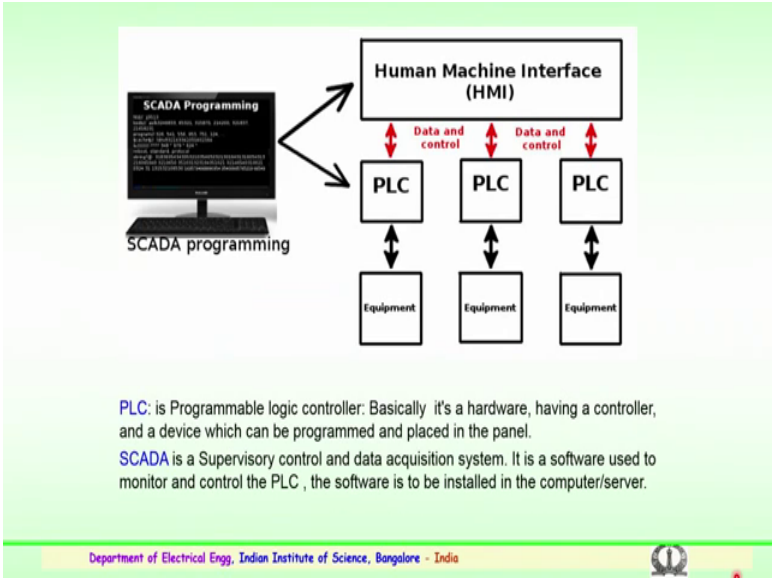
So, what are the four components, as mentioned earlier it could be the sensors, the first is the sensors, these sensor could be a digital or analog, and the control the help of control relays that directly interface with the managed system. So, the second is the remote telemetry units which have mentioning RTUS. So, these RTUS are a small computerized units basically deployed in the field at a specific locations. And the RTUS are remote telemetry units serve as a local collection points, so data collection points. So, if you have place the RTU, the local collection near the equipment this entire data is being sent or the data is being gathered from the sensors through the sensors and through the delivery command it sends through the PLCs data control and it is being sent to the a SCADA terminal. So, this is how it performs very important and delivers commands to the control through the relays.

So, third is a SCADA master unit. Here basically these are larger terminals the computer terminals or a consoles what is known these serve as so central processing units for the SCADA system. So, the master unit usually provides a human machine interface to the

system, and automatically tries to regulate the managed system in response to the sensor inputs the data which is being obtained. This tries to take decision making system where will be helpful for the diagnosing in case of falls and so on.

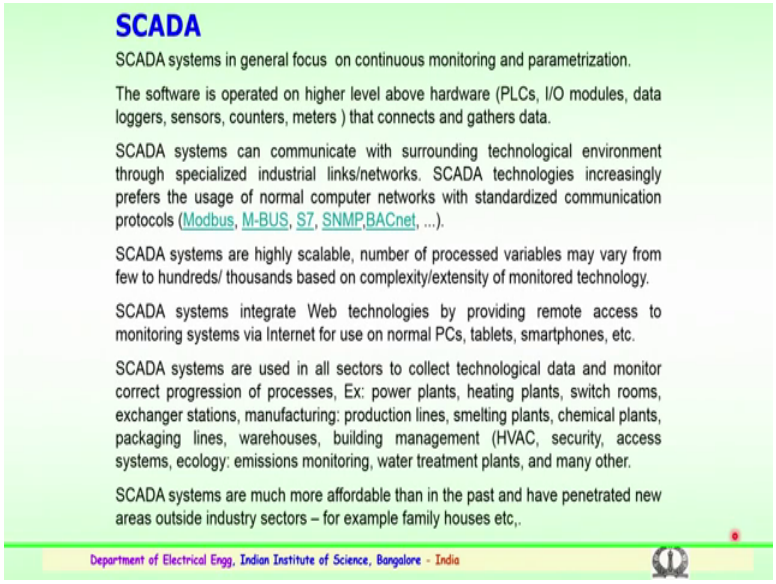
The final point is the communication network, which connects the SCADA master unit to the remote telemetry units, which are installed in the field. So, this entire system shows or explains the basic or the importance of working of supervisory control and data acquisition system which is being used in several utilities for monitoring the data trying to get the information of the various components various equipment data.

(Refer Slide Time: 21:07)



So, continuing the program PLC or the programmable logic controller is being used basically this PLC or program logic controller is a hardware which has a controller, device which can be programmed and it is embedded in the panel. Then the SCADA as mentioned is the supervisory control and entire data acquisition system, it is basically a software which is used to monitor and control the power line or programmable logic controller. This software has to be installed either in the computer or in the main server of the monitoring section. So, this is important points to be consider.

(Refer Slide Time: 22:00)

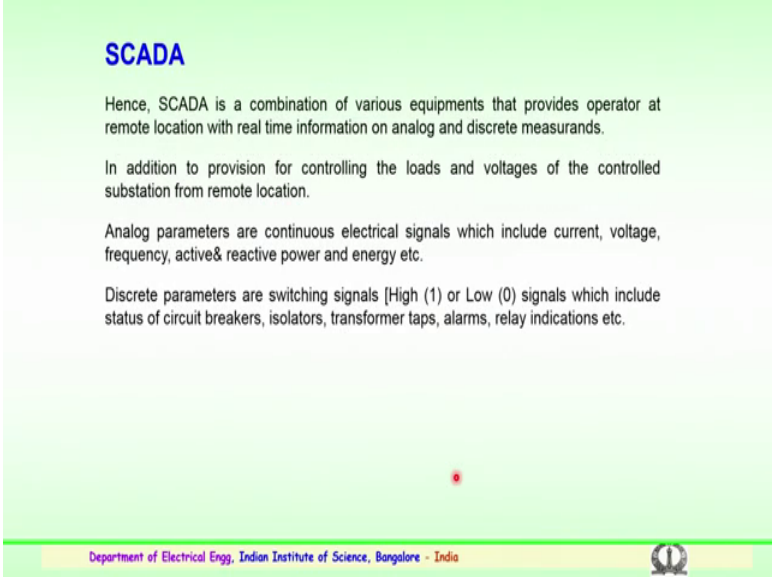


So, in general, this SCADA systems focus on continuous monitoring and parameterization. The software which is used is basically for operation or higher level above hardware that is programmable logic controllers could be input output modules, the data loggers, the sensors counters or in a metering devices. These connects and the data is gathered or collected. This SCADA system can communicate with surrounding technology environment through a specialized industrial networks. And SCADA technology could be used for increasingly the usage of normal computer network particularly with the standard communication protocols, which are available or the technology available during the present or the insulation of this SCADA arrangement. So, it could be a modbus, it could be a M-BUS, seven or several other technologies again these technologies are adopted or adapted depending upon the newer technologies which a come into the existence.

So, the SCADA systems are highly scalable very important with number of processed variables and could vary from few hundred or thousands based on the complexity the extensity of the monitored technology the SCADA systems integrate also with the web technologies by providing remote access to monitoring systems via internet for use of normal PCs, tablets, smartphones etcetera. So, present day this usage are integrating with web technologies is being used for electrical billing or the payment for the electrical billing and so on and so forth. So, there is a important aspect with the technology being upgraded and technology being used.

So, the SCADA systems can also be used for all sectors it to collect technological data and monitor the correct progression of the processes, it could be an industrial processes like example the power plants the entire SCADA system could monitor the data and see the performance of various equipments. It could helpful in heating plants, switching rooms or the manufacturing a production lines, could be smelting plants, chemical packaging lines, warehouses, it could be used for the proper building management particularly for the security, the access system could be used for the ecology emission monitoring water treatments plants many, many other advantages. So, this SCADA systems are much more affordable than in the past and have penetrated into new areas outside the industry sectors, it could also being very recently being employed for the monitoring of the family houses etcetera, etcetera so very important.

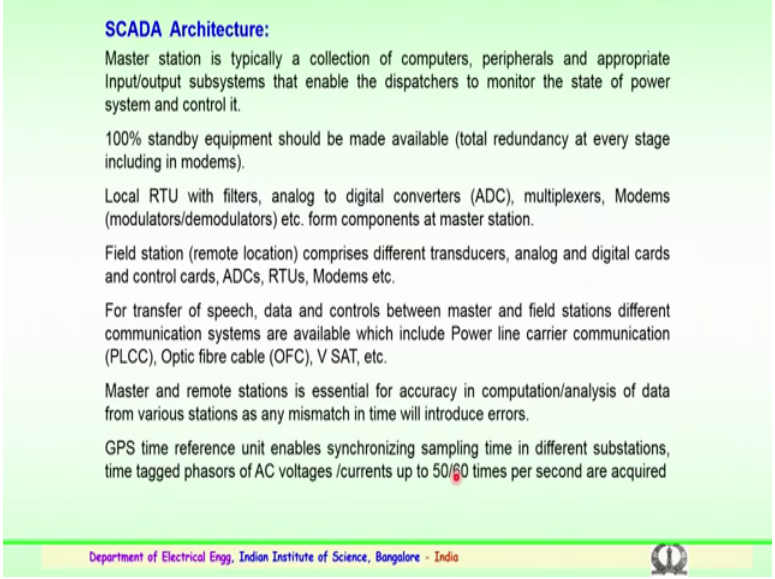
(Refer Slide Time: 25:44)



So, hence for the power communication or the power line power transmission and power distribution, SCADA is being also employed which is very being very useful. So, the SCADA is a combination of various equipments which provides an operator at the remote location with real time information particularly the data which is available on analog or discrete measurements. In addition to this, the provision for controlling the loads that is voltages of the control substation from the remote a location is possible. And the analog parameters which are giving the continuous electrical signals this could be current voltage frequency or could be active or reactive power and energy which is a very helpful data. And also the discrete parameters like the switching signals which

could include status of circuit breakers or the isolators or the transformer taps which presently it is being connected and necessary alarms and relay indications etcetera could be obtained with information. And suitable action could be taken in the substation by the utility engineers or the distribution engineers in the transmission or distribution utility.

(Refer Slide Time: 27:26)

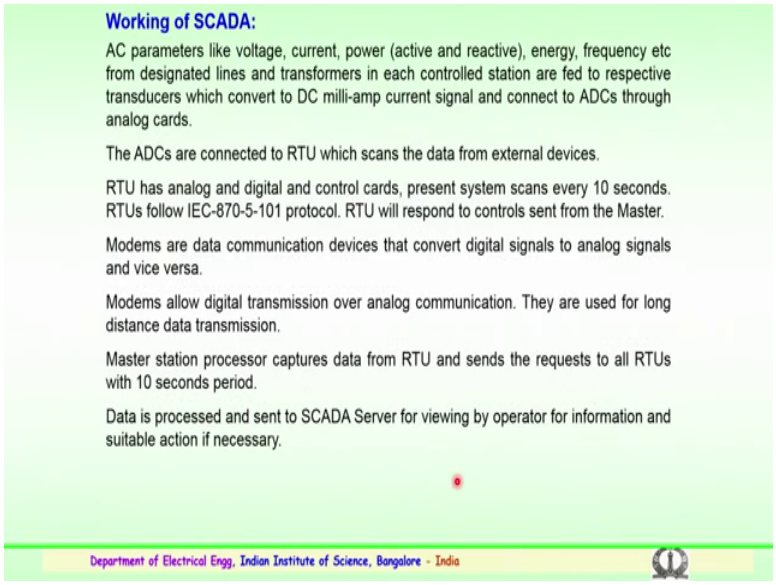


The SCADA architecture very important, this basically consists of master station. And typically a collection of computers, peripherals with appropriate input and output systems that enables the dispatchers to closely monitor the state of power system and helps in controlling the power networks. It is 100 percent stand by equipment, it should be made available with total redundancy at average stage including its modern which are been used for the communication.

The local remote telemetry units with filters that may be analog to digital converters, multiplexers, modems etcetera form components as a master substation for the architecture in the SCADA. The field station or the remote location where the sensors are being employed comprises different transducers could be analog and digital cards and a control cards, it could be analog to digital converters or remote terminal limiter unit or modems etcetera. So, in case of transfer of speech, data and controls between the master and field station, different communications systems are presently available which could include a power line carrier communication, optical fiber communication, the satellite communication etcetera.

So, the master and remote stations in essential for accuracy in computation analysis of data and various station has any mismatch in the time will introduce errors. So, there is also a global position system time reference which enables the synchronizing the sample time and difference substations when the time tag phases of AC voltage are currents up to 50 to 60 times per second are also acquired.

(Refer Slide Time: 29:36)

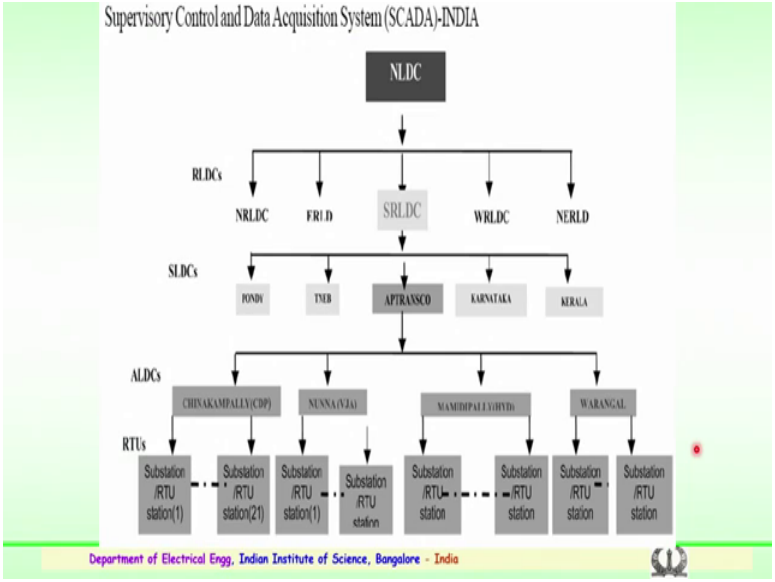


So, working as mentioned previously several parameters could be like the voltage, current, power again the power could be active or a reactive power, the energy, the frequency etcetera from the designated lines and transformers in each controlled station are communicated to respective transducers, which convert to the signals current signals and connect to analog to digital converter through the analog cards these analog to digital converters are connected to the remote telemetry units which scans the data from the external devices. And the analog and digital control cards the present system scans every 10 seconds data. So, this follows the protocol IEC standard protocol 870-5-101 protocol which will respond to the controls sent from the master substation. So, various modems and data communication devices are used to convert the digital signal to analog and vice versa.

The modems which are being used allow the digital transmission over analog communication and these are used for long distant data transmission. The master station processor which captures data from the remote term telemetry unit and sends the requests

to all the RTUS within period of 10 seconds. This data is processed and is being communicated to the SCADA server for viewing by the operator for taking proper action or necessary action with the information, which is available. So, this is the typical working of the SCADA.

(Refer Slide Time: 31:36)

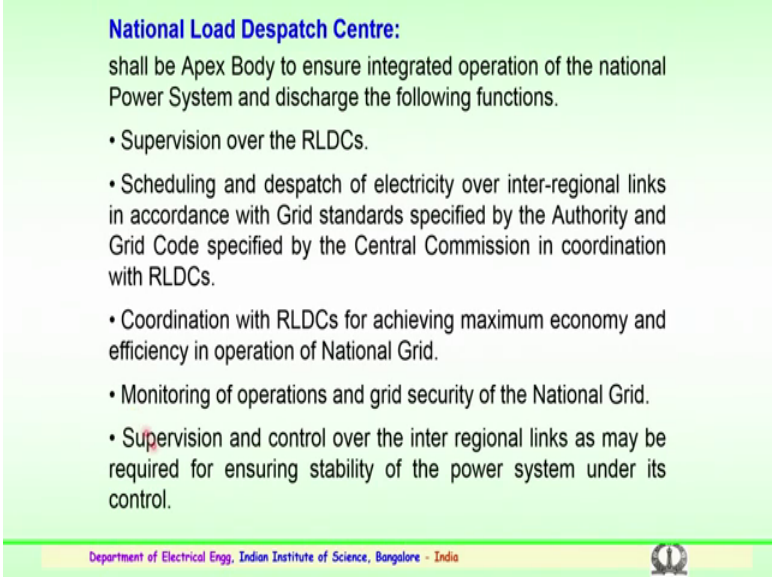


And now we come to the important aspects of the supervisory control and data acquisition in the country which is being followed in the various layers of communication. You can see the graph here, it shows the national load dispatch center, how this SCADA control arrangement is being employed in the country. This is the national load dispatch center. The national load dispatch center is being communicated via the regional load dispatch center – RLDCs. You have five regional loads dispatch centers here; northern load dispatch center, eastern load southern load, western load and north eastern load dispatch center. So, these five are further connected to the state load dispatch centers this state load dispatch center five examples are given here. From the state load dispatch centers further are connected to the area load dispatch centers. So, this is how the hierarchy of the supervisory control and data acquisition is being followed for the transmission system in the country.

So, area load dispatch centers, you have divided; and these area load dispatch centers are further getting the information from the remote telemetry units which are being placed in the substations at various locations in the respective areas. So, this is how the level of

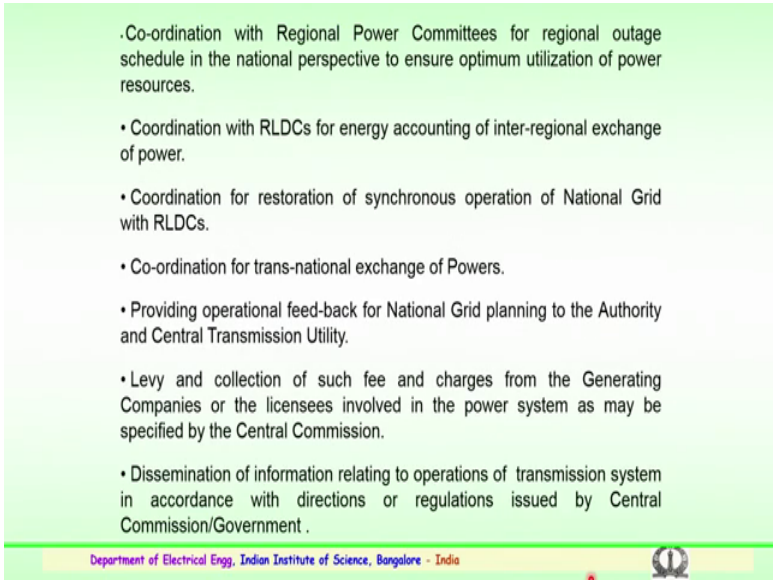
SCADA arrangement is being followed in the country transmission network. We will look into the important functions of the various a load dispatch centers, how the hierarchy is being followed for communication and proper management of this system.

(Refer Slide Time: 33:29)



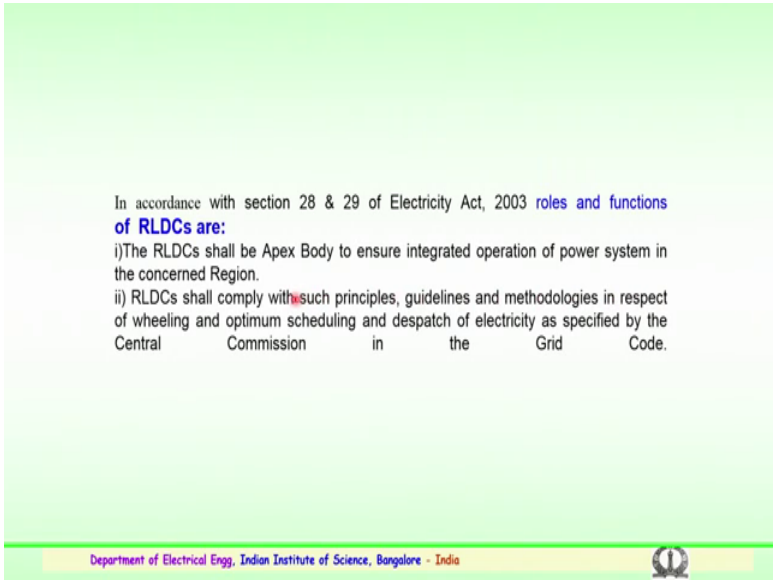
So, national load dispatch center this is a important apex body which ensures entire integrated operations of the entire country power system and discharges the main functions. It supervises over the all the regional load dispatch centers. Schedules and dispatches the electricity over inter regional links in accordance with the grid standards which are specified by the center electricity authority of the country or the electrical commission or the central electrical commission in coordination with the load regional load dispatch center. It has to coordinate with the regional load dispatch center for achieving maximum economy and also efficiency in power operation of the National Grid it helps in monitoring of the operations and grid security of the National Grid. It supervises and control over inter regional links as may be required for ensuring better stability of the power system under its control.

(Refer Slide Time: 34:33)



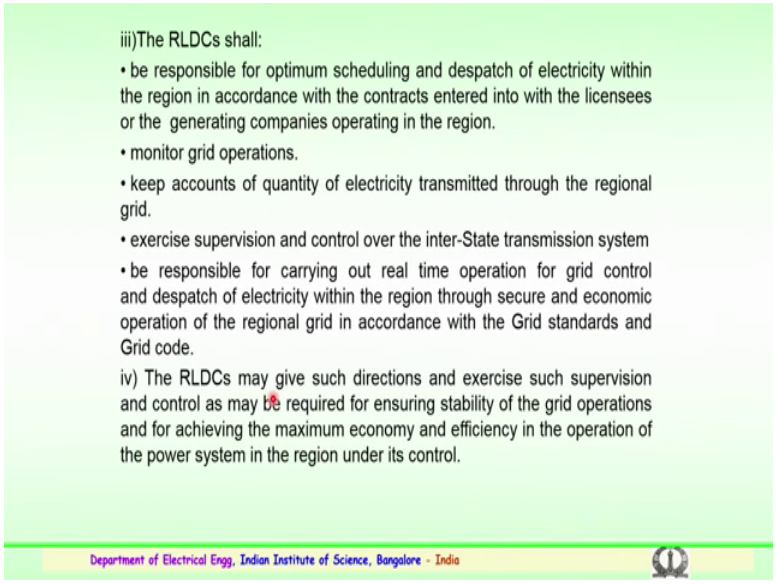
Proper coordination has to been made with the regional power committees for regional outage schedule in the national perceptive to ensure optimum utilization of power resources. So, the national load dispatch center coordinates with the regional load dispatch centers for energy accounting of inter-regional exchange of power. It coordinates for restoration of synchronous operation of National Grid with the regional load dispatch centers this coordinates for trans-national exchange of powers provides operational feedback for National Grid planning to the central electricity or a transmission utility. And collection and levy of fees or charges or Generating Companies based on the licenses involved in the power system may be specified by the central regulatory commission or Government of India.

(Refer Slide Time: 35:45)



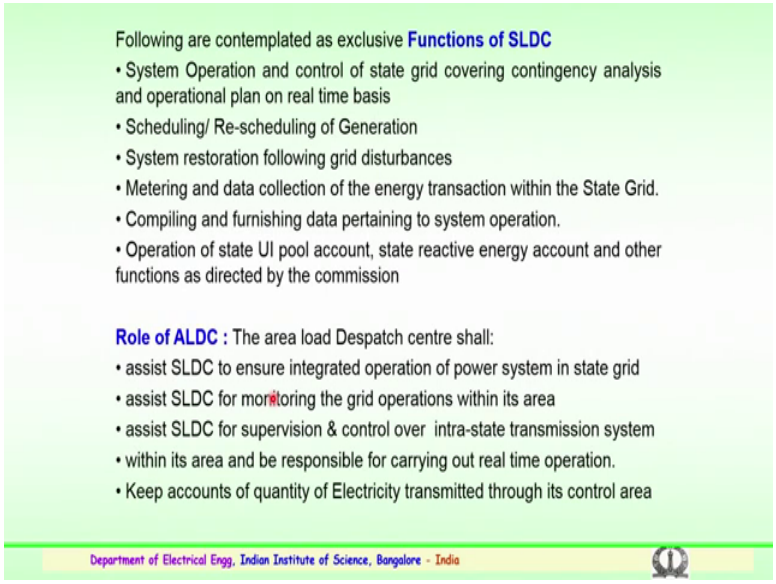
So, the dissemination of the information relating to operations of transmission system in accordance with the directions of regulations which are issued by the central commission or government are also being coordinated with help of national load dispatch centers. In accordance with the electricity act, 2003, section 28 and 29 the major roles and functions of the regional load dispatch centers are again the regional load dispatch center is an apex body which ensures integrated operation of power systems in concerned region I mentioned five regions. So, these regional load dispatch center shall comply with principles or guidelines and methodologies in respect of wheeling and optimum scheduling and dispatch of electricity which is specified by the central commission in the grid code by followed to be by the national load dispatch centers. And also the regional load dispatch centers shall be responsible for optimum scheduling and dispatch of electricity within the region.

(Refer Slide Time: 36:30)



Again this is in accordance with the contracts which is entered with the licensed or a generating companies operating in that particular region monitoring the grid operations and the regional load dispatch center should be able to keep the accounts of quantity of electricity transmitted through the regional grid. And exercise supervision and control over the interstate transmission system and also should be responsible for carrying out real time operation for grid control dispatch of electricity within the range through secure and economic operations. Further, the regional load dispatch center may give directions and exercise supervision and control as may be required for ensuring stability of the grid operations and for achieving the maximum economy and efficiency in operation of the power system in the region which it is under its control.

(Refer Slide Time: 37:40)



So, similarly the functions of the state load dispatch center are famed. Here again the state load dispatch center the system operation control of the grid covering the contingency analysis and operational plan on real time basis SLDCs have to properly schedule or reschedule of the generation they should be contemplating system restoration following grid disturbances. The metering and data collection of energy transaction with the State Grid and SLDC have to compile and furnishing detail data pertaining to the system operation. And the operation of the state pool account state reactive energy account and other functions which are directed by the commission.

And finally, the role of area load dispatch center is mainly to assist the state load dispatch centers to ensure integrated operation of power system in the state grid. They should also assist the state load dispatch center for better monitoring the grid operations within that area, they should assist the state load dispatch center for supervision proper control over interstate a transmission systems within its area which it will be responsible a for carrying out the real time operations. And has to keep account of electricity transmitted through its control area. So, these are various functions of the national load dispatch center regional load dispatch center state load and the role of the area load dispatch centers.

Thank you.