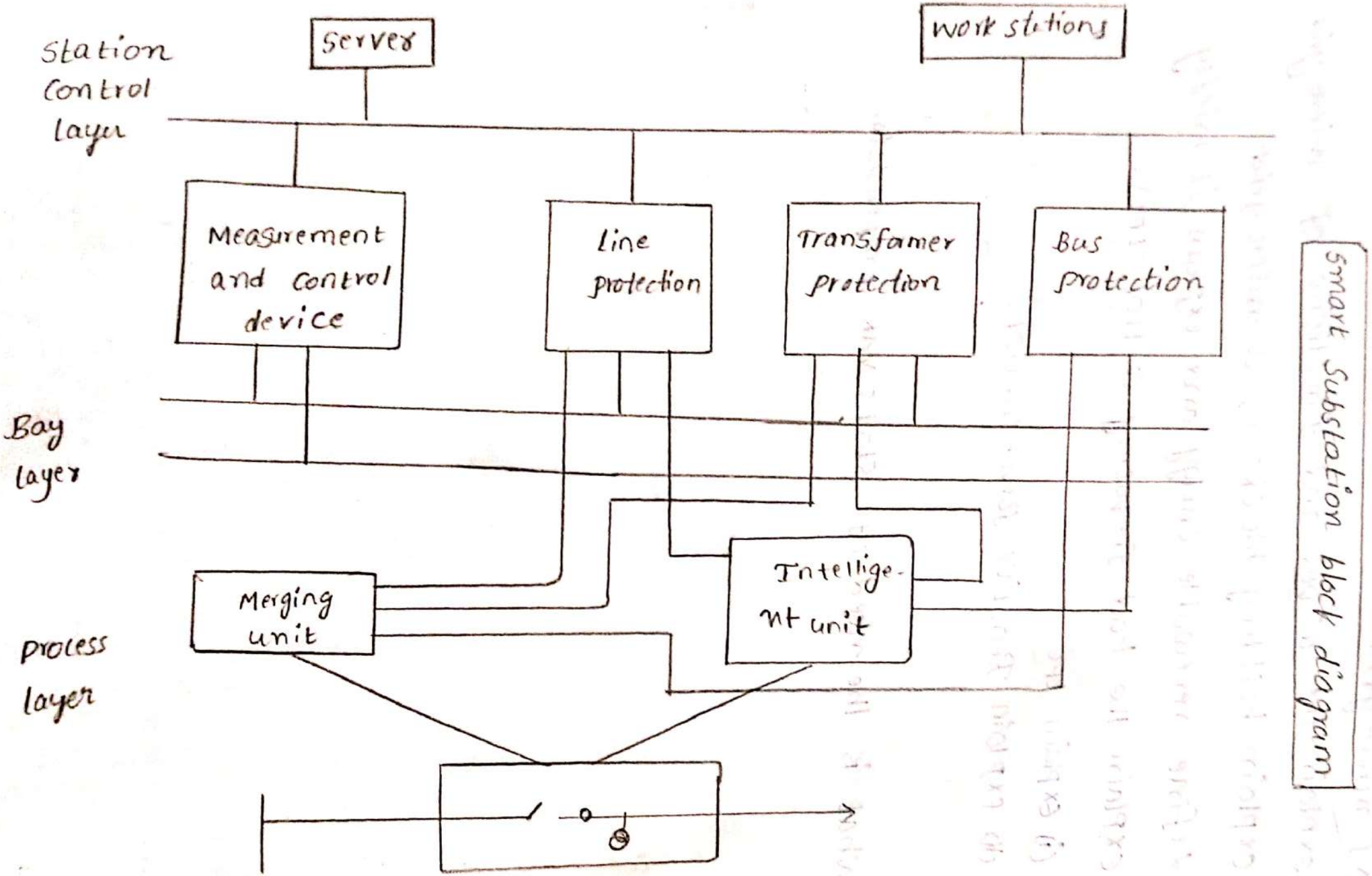


Smart Substation block diagram

According to high speed network communication, smart substation realize information and sharing information, inter operation, measurement and monitoring, controlling and protection, information management and intelligent connection. monitoring through standardize digital information, they can provide switch gear to change the configuration of the network, it helps the isolate the lines and to clear the fault before power can be restored safely.

Smart substation types:-

1) step up substation
2) step down substation
3) distribution smart substation
4) underground distribution substation.

/* [UNIT-II

Renewable energy generation, Integration Impact] */

Introduction:

The secondary system of smart substation adopt the structure of 3-layers and 2 network which is composed of station controlled layer, bay layer, process layer.

⇒ They are many problems in the secondary system such as complex structure any many intermediate links, reduced reliability & speed of protection, wide influence range of single equipment

failure, which are not conductive to the safe and stable operation of smart sub-station;

Smart Sub-station System Architecture:-

According to the smart substation system is divided into 3 parts such as:

1) Bay layer
2) process layer
3) substation layer; distributed open nlw syst.

process layer:-

⇒ The process layer is directly connected to the sensor signals, status signals, interfaces & activators are the primary device.

⇒ The device can be installed onsite with the primary device and the working status & equipment of the primary device (or) reliazed by merging unit & smart terminal.

⇒ The digitalization of the attribute. The process layer device is connected to the Bay layer device through the process layer Bus.

Bay layer:-

→ The Bay layer device mainly implements the

monitoring and protection & implements the related human computer interaction functions of controlling the block & the interval level information.

⇒ The Bay layer device can realize the mutual dialogue mechanism between the device through the Bay layer bus and the bay layer can concentrate the group screen are put in underground.

Station control layer:-

substation level equipment includes substation local operation backend system, external data.

⇒ Interaction interface (control center data forwarding protection information management system data interface, equipment management system and General functions.

⇒ The universal function service module realize the substation level interval control service through information transmitted by the bay layer devices such as voltage, reactive power control can also receive commands from the control center to realize regional system.

Advantages:-

→ They can provide power for switching gear to change the configuration of the network.

→ It helps to isolate lines and clear the fault.

Disadvantages:

violations of privacy standed from the presence of continuous data uses.

2nd unit

Renewable energy generation Integration impact

→ solar and wind energy in-to a power system where other generators are available to provide balancing power, requlations and precise load following capabilities.

⇒ The greater the no. of intermittent renewable energy generation is operating in a given area.

⇒ Typical transmission and distribution system related problems include the following:

(i) power quality, voltage fluctuations, temporary over voltages, thicker and harmonics.

(ii) Photovoltaic and wind capacity factor in the range of 15% to 30%.

(iii) No dispatch capability of pv, solar and wind from form without storage

(iv) Lack of coordination control of existing reactive power support.

(v) Ultrafast ramping requirements.

⇒ High penetration of intermittant resources effect their n/w in following ways.

(i) Power flow and reactive power
(ii) Shat circuit
(iii) Transient stability
(iv) Electromagnetic Transient
(v) protection and Islanding
(vi) power levelling and energy balancing
(vii) Power Quality
(viii) Other Distribution energy resource facilities

i) Power flow and reactive power:

Interconnected transmission and distribution lines not be overloaded.

⇒ Reactive power should be generated throughout the network not only at the interconnection point and should be compensated locally thrugh the feeder

ii) Short Circuit:

Impact of additional generation sources to the short circuit current rating of existing electrical equipment on the network should be determined.

(iii) Transient Stability:

dynamic behaviour of the system Sudden

load changes and disturbance cloud can affect stability and power Quality.

⇒ voltage regulation, angular stability during this system disturbance and production changes are very important.

(iv) EM transient:-

ensure these past operational switching transient have a detailed representation of the connected equipment, capacitor banks their control and protection convertors.

(v) Protection and Islanding...

Investigate reverse powa flow may have a large impact on existing protection scheme.

⇒ Large levels of photovoltaic production will reverse powerflow during sometimes and as well as protection circuit need to be able to protect the distribution feeders under this condition.

(vi) power levelling and energy balancing:-

Due to the fluctuating and uncontrollable nature of windpower as well as the generation from photovoltaic power and load, photovoltaic

power generation has to be balance with other very fast Controllable generation resources.

vii) Power Quality:

Fluctuation in the photovoltaic and wind power production and strength of the transition and distribution network at the interconnection point had consequence to the power quality.

Smart substation :

Protection, monitoring and Controlling device

⇒ Intelligent electronic Devic (IED) are micro-processor based device with the capability to exchange the data & control signals with another device (IED, electronic meter, SCADA, controller etc.) over a communication link.

⇒ Intelligent Electronic Device (IED) perform protection monitoring, controlling & data Aquisition functions in generating stations, substations and along with feeders and are critical to the operation of the electrical n/w.

⇒ IED are widely used in substations for different purpose. In some cases, they are separately used to achieve indastividual functions such as differential protection, distance protection, over current protection & monitoring.

⇒ They are also multi functional IED that can perform several protection, monitoring, controlling & user interfacing functions on one hardware platform

⇒ IED's are key component of substation, Integration & automachine technology. sub-station integration involve integration protection, controlling & data Acquisition functions into a minimal no. of platforms to reduce capital & operating cost, reduce panel & control room space and eliminate redundant equipment & database.

⇒ The main advantage of multi functional IEDs are: they are fully IEC 61850 compatible & compact in size & that they combine various functions in one design & increase in efficiency and improvement in robustness & providing extensible Solutions based on Communication technology

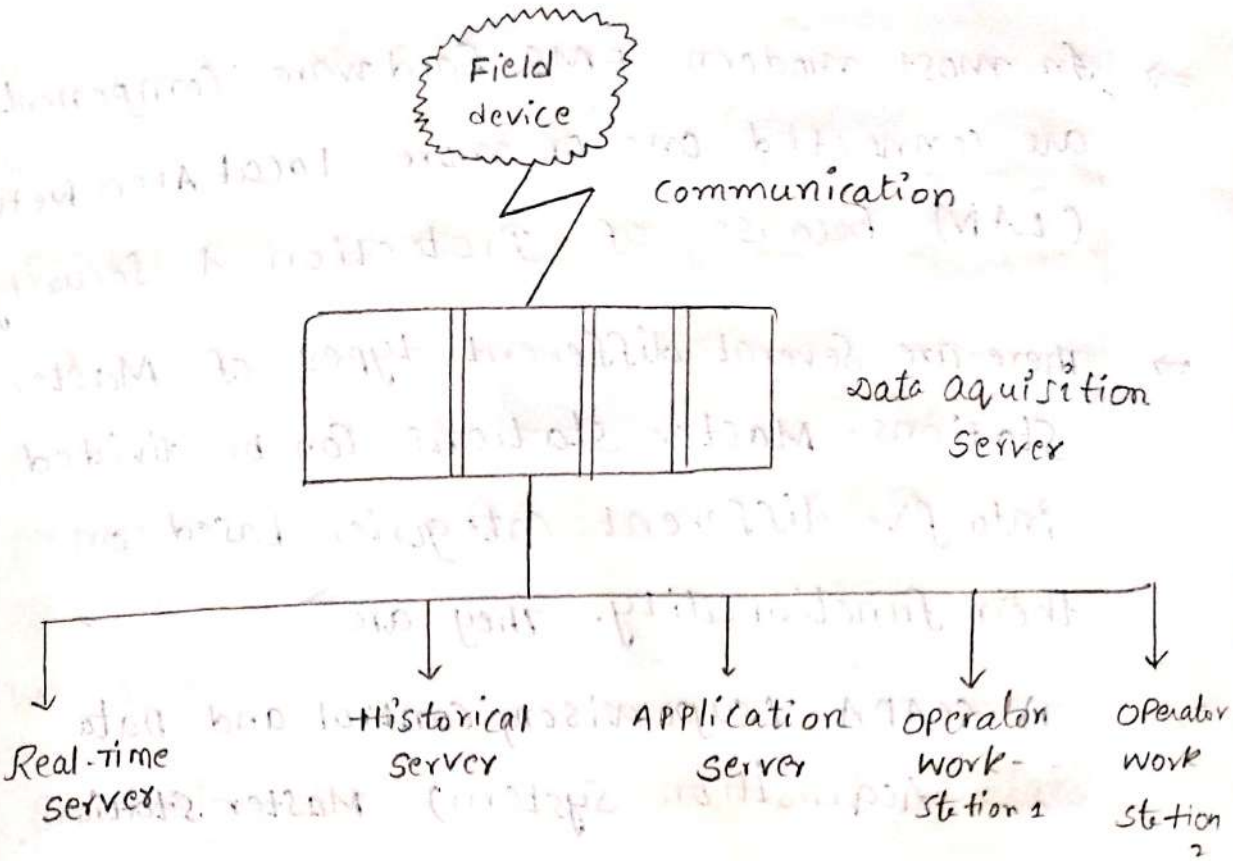
⇒ The IED technology can help utilize improve reliability, increase in efficiency, life extension & improved planning.

Controlling devices are:

(1) Sensors
(2) SCADA
(3) Master Stations
(4) RTU

10 M

Master station



⇒ Master station is a computer system responsible for communicating with the field equipment and include HMI (Human Machine Interface) in the control room or else where.

⇒ A large electric utility master station (or) EMS (energy management system) typically has the following:

1) One or more data aquisition Server:
2) Real time server, that contain real time database.
3) Application Server, that runs with various 'EMS' applications
4) Historical Server, that contains histori-

cal database

5) operator workstations with HMI

⇒ In most modern EMS, hardware components, are connected one or more Local Area Network (LAN) because of Protection & Security.

⇒ There are several different types of Master Stations. Master stations can be divided into five different categories based on their functionality. They are:

1) SCADA (supervisory control and Data Acquisition System) Master station.

2) SCADA Masterstation include AGC (Automatic Generation control)

3) EMS (Energy Management System)

4) Distribution Management system (DMS)

5) Distribution Automation system (DAS)

SCADA Master station primary functions

1) Remote Control
2) User interface
3) Data Acquisition
4) Huge area responsibility
5) Historical data analysis

SCADA Master station include AGC primary functions

(1) Automatic Generation Control (AGC)
(2) Economic dispatch
(3) Interchange transaction schedule.

Energy Management System Master station primary functions

(1) Network Configuration.
(2) State estimation
(3) optimal power flow
(4) 3-ϕ balanced operator power flow.

Distribution management System Master station Primary functions

(1) Interface to Automatid Mapping.
(2) Interface to customer information Service (CIS)
(3) Interface to outage management
(4) 3-ϕ unbalanced operated power flow

Distributed Automation service Master station primary functions

1) Fault identification
2) Voltage Reduction
3) Load Control
4) Power factor Control
5) Two-way Communication Distibution network

⇒ All types of master stations are interfaced with the field device.

Sensor:-

A sensor is a device, it receives the signal (Physical signal, biological signal, chemical signals) converted into electrical signal.

physical signal ⟶ electrical signal

⇒ The main functionality of sensor is to collect data from power equipment at the substation yard such as transformers, circuit Breakers, feeder, power transmission lines, isolators. With the introduction of digital and optical technologies in combination with Communication.

⇒ Original copper wire, analog operators can now be replaced by optical operators with fibre based sensor used for monitoring, controlling, management, metering etc..

⇒ The most prominent advantage of such sensors are:

(i) high accuracy
(ii) No Saturation

(iii) High efficiency
(iv) High bandwidth
(v) Friendly environment.
(vi) higher performance
(vii) Wide dynamic range.
(viii) Low maintenance

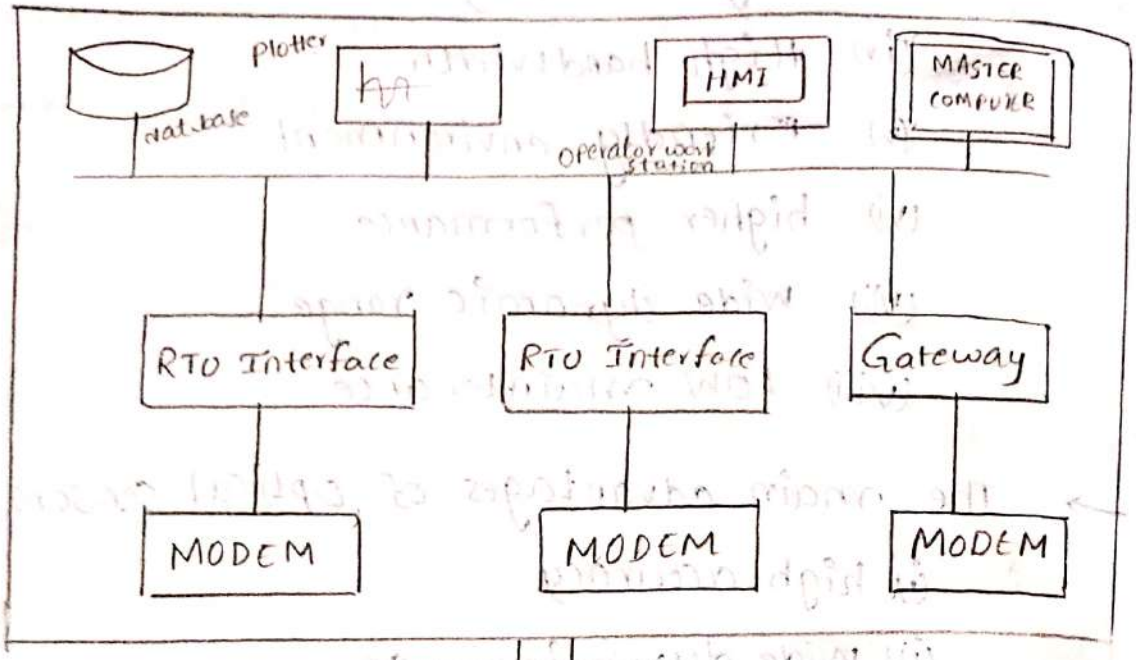
→ The main advantages of optical sensors are:
(i) high accuracy
(ii) wide dynamic range
(iii) wide frequency, bandwidth

⇒ These new sensors allow monitoring and control to be implemented with two important applications:
(i) Single layer or Single Sensor may be served by different types of IED (Intelligent electronic Device).
(ii) Single Sensor may Serve large no. of IED

⇒ Those Sensors also need accurate time Synchronization of input.

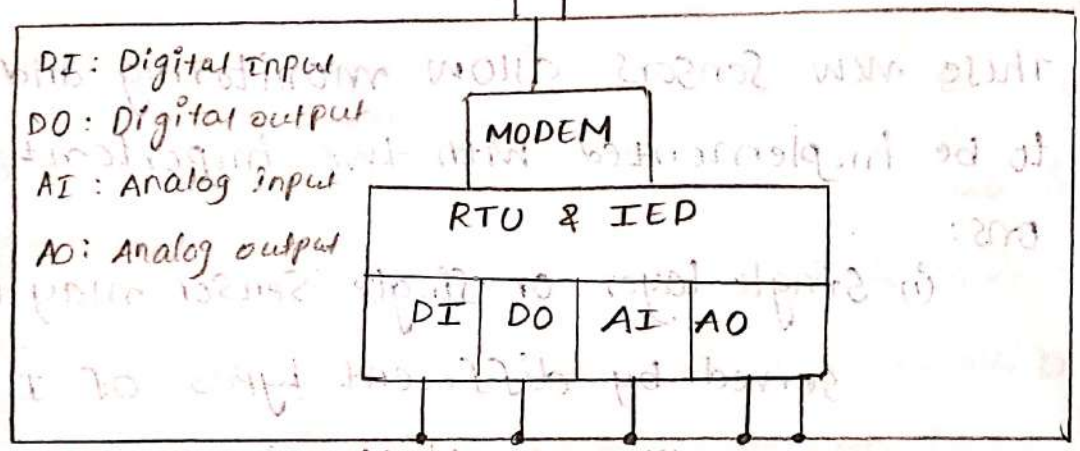
** 10 M SCADA

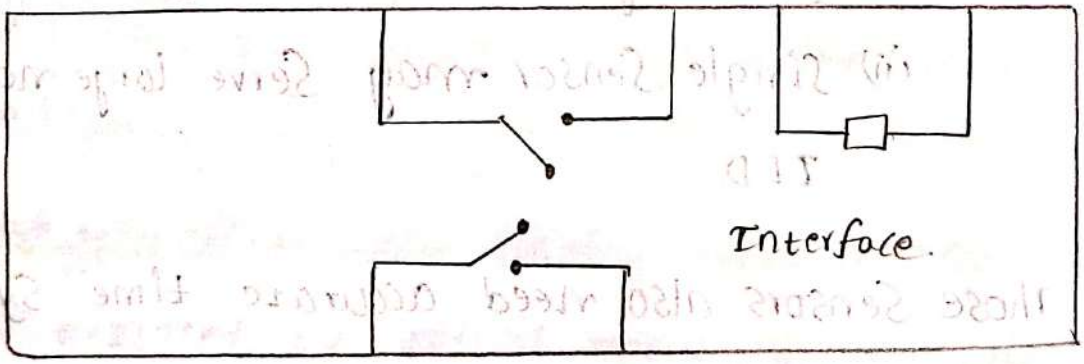
(Supervisory Control AND Data Aquisition System)

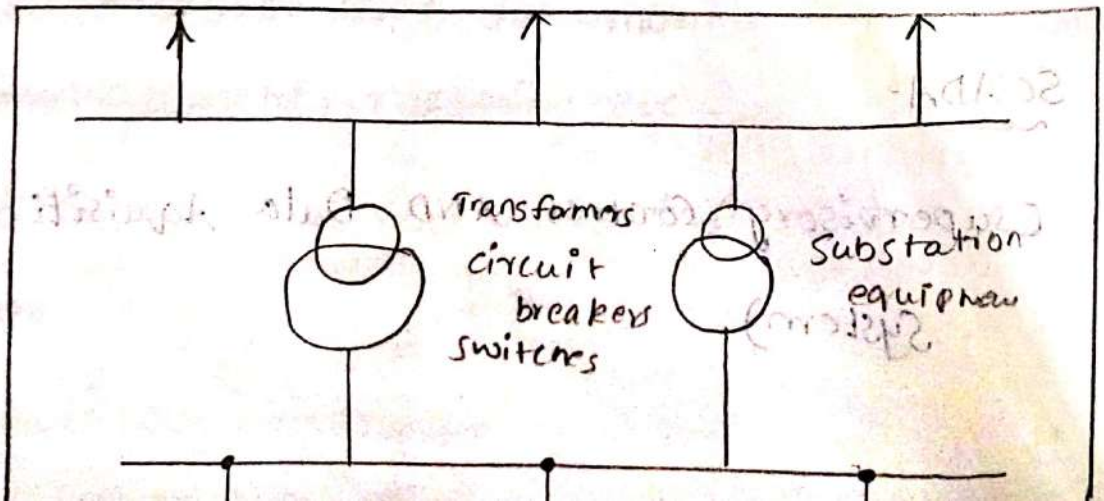


Communication medium

DI : Digital Input
DO : Digital output
AI : Analog input
AO : Analog output







Now a days, a computer controls is one of the most effective solution for improving reliability, optimum operation, intelligent control and protection of power system network. Having advanced data collection capabilities, SCADA system play a significant role in a power system.

⇒ SCADA system is one of the sollution available for data aquisition, monitor and control system, covering a large geographical area

⇒ SCADA systems are mainly used for the implementation of monitoring and control of an equipment like power plants, oil plants and gas plants, telecommunication etc...

⇒ In smart substation SCADA performs the opeation like load balancing control, circulating over current control, load control, transformer fault protection etc...

⇒ SCADA system continuously monitors the status of various equipments in substation and accordingly send control signal to the remote control equipments and also it collects the data of the substation.

⇒ From the above figure, the "SCADA" based substation control system so various inputs / outputs (AI, AO, DI, DO) modules connected to

the substation equipment

⇒ The SCADA collecting the data from power equipments like feeders, transformers, circuit breakers, Power transmission lines, isolators, switches, capacitors etc--

⇒ SCADA having some components

(1) Remote Terminal Unit (RTU).

(2) Master Station (MS)

(3) Communication.

⇒ The Remote Terminal Unit collect input and o/p data & transfer to Remote master station via n/w interface modules.

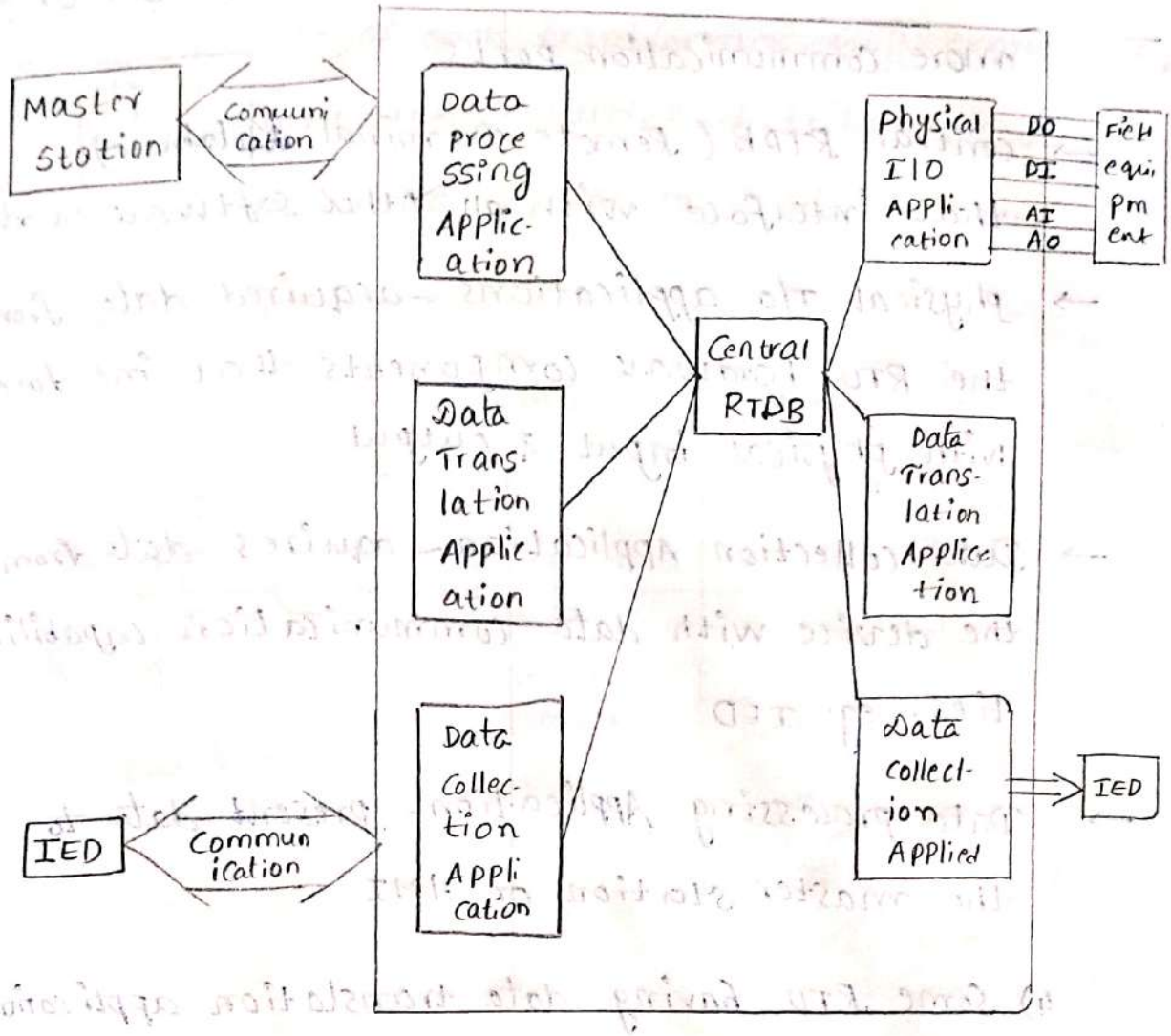
⇒ The central control or master station receives the information, display on HMI (Human Machine Interface), the central controller also responsible for generating trend analysis and reporting.

⇒ Finally, the SCADA system improves the reliability of the network and minimize the down time with high speed transfer of measurement & control commands.

write some advantages of master station

Sensor communication

Remote Terminal Unit (RTU)



1) RTU is a microprocessor based device that interface with a SCADA system by transmitting telemetry data to the master station and changing the state of connected device based on control message received from the master station, Command generated by RTU itself.

2) The RTU provides data to the master station and enables master station to issue control to the field equipment.

3) The RTU have physical hardware inputs to interface with field equipment and one or more communication ports.

→ central RTDB (Remote Terminal Database) that interface with all other software modules

→ physical I/o applications - acquired data from the RTU hardware components that interface with physical input & output

→ Data collection Application - aquires data from the device with data communication capabilities. eg: IED

→ Data processing Application - present data to the master station or HMI

4) Some RTU having data translation application that manipulate data before they are presented to the master station.

Voltage | VAR control equipment inside the substation

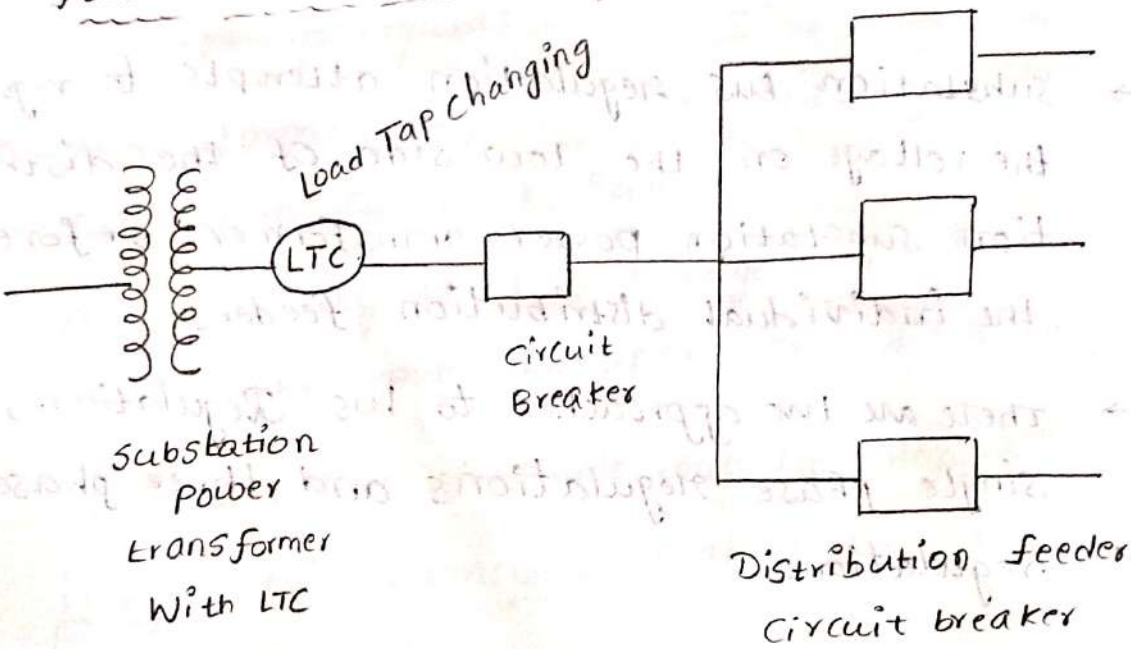
→ The majority of electricity delivery losses occur at distribution voltages. Distribution substations are typically fed from two (or) more transmission lines.

→ There are typically one (or) more transformers

in the distribution substation that step the voltage down to b/w 4 and 25 kV.

→ The low side of each transformer will connect to a bus that feeds multiple distribution feeders to distribute the power to end customer

Power transformer



→ A power Transformer has fixed winding ratio connections and as discussed earlier, may also have variable tap to actively change the turns ratio of the Transformer while energized.

→ The fixed taps allows for an adjustment of the voltage on the low side and there are typically settings for 0%, ±2.5%, and ±5%.

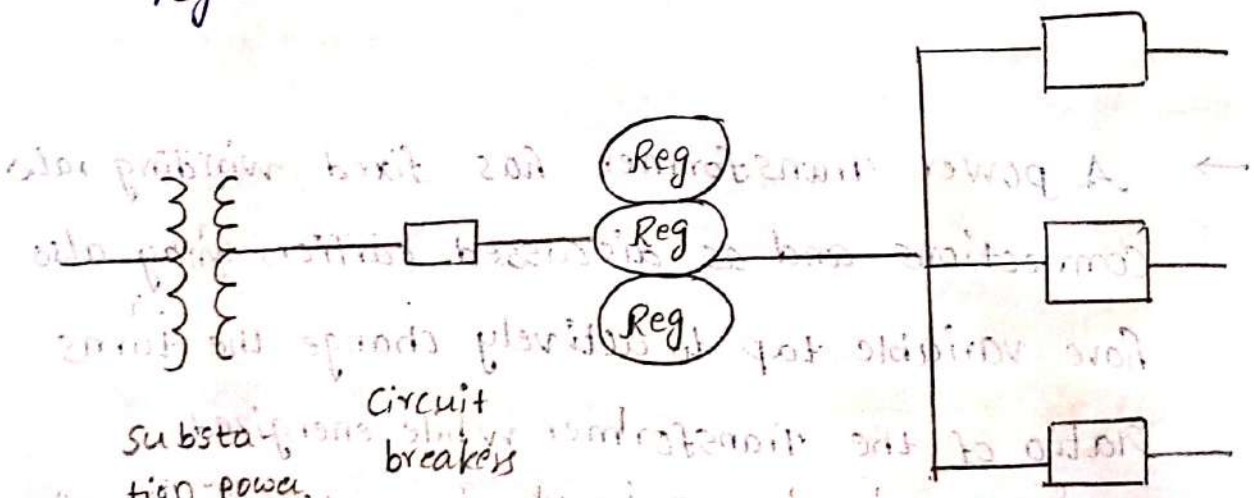
→ The fixed Tap setting can only be changed when the transformer is out of service.

→ The LTC [LOAD TAP CHANGES] is a single-phase sense, three phase and operate device it monitors one phase of voltage and current to make decisions but then acts on all the three phases.

Substation Bus Regulation:

→ Substation bus regulation attempts to regulate the voltage on the low side of the distribution substation power transformer before the individual distribution feeders.

→ There are two approaches to bus Regulation, single phase regulations and three phase regulations.



→ The advantage of doing this is that breakers maintainance of the three phase regulator can be performed without taking the transformer

out of service

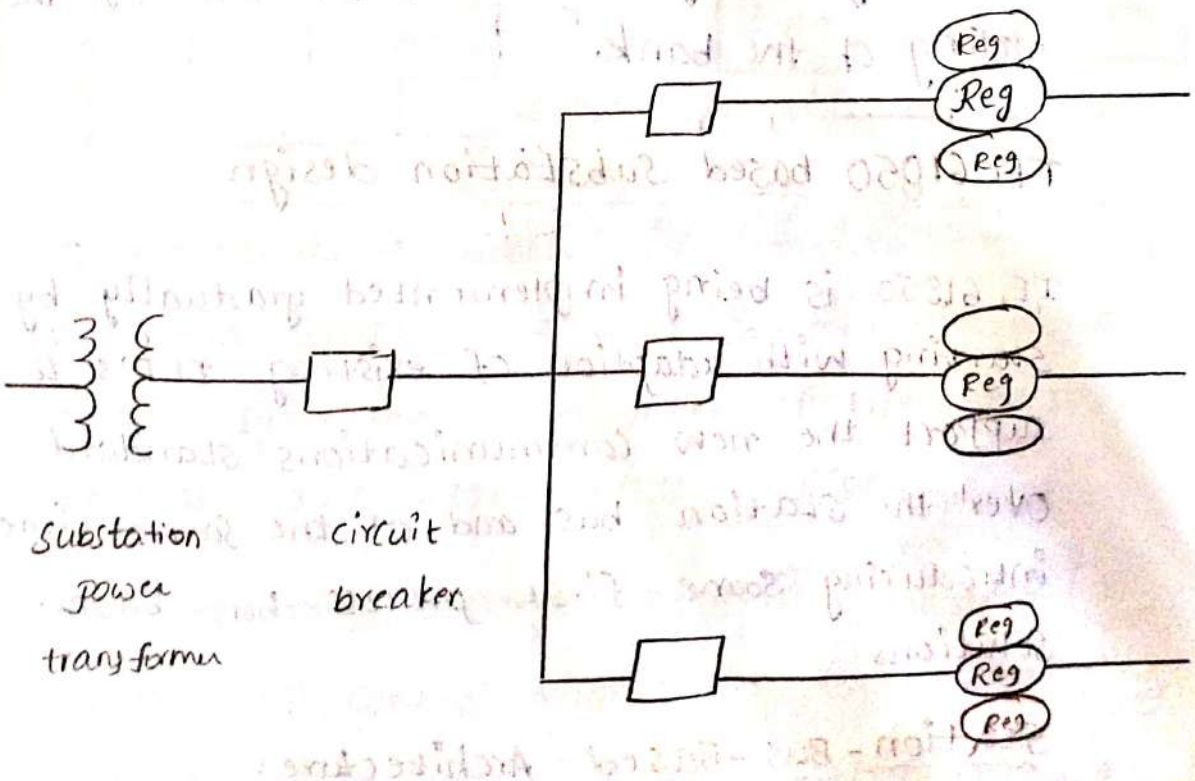
Single-phase voltage Regulators

→ With single-phase regulation, each distribution feeder is regulated separately prior to leaving the substation.

→ In this approach, the transformer and low side bus are left unregulated.

→ This approach requires the most spaces in the substation for installation.

→ The reliability of this voltage Regulations approach is higher than the approaches disiussed earlier since a failure of single control (or) Regulator only impact the customers on that phase of that distribution feeder.



Substation Capacitor Bank:-

→ placing capacitor banks at the substation bus level is sometimes done in order to regulate both the bus voltage and supply VARs to the distribution system and load.

→ Use of capacitor bank at the substation level has disadvantages. First the size is typically fairly large, so when the capacitor bank operate, they have a larger effect on the secondary voltage.

→ This can cause LTCs and regulators to operate in response.

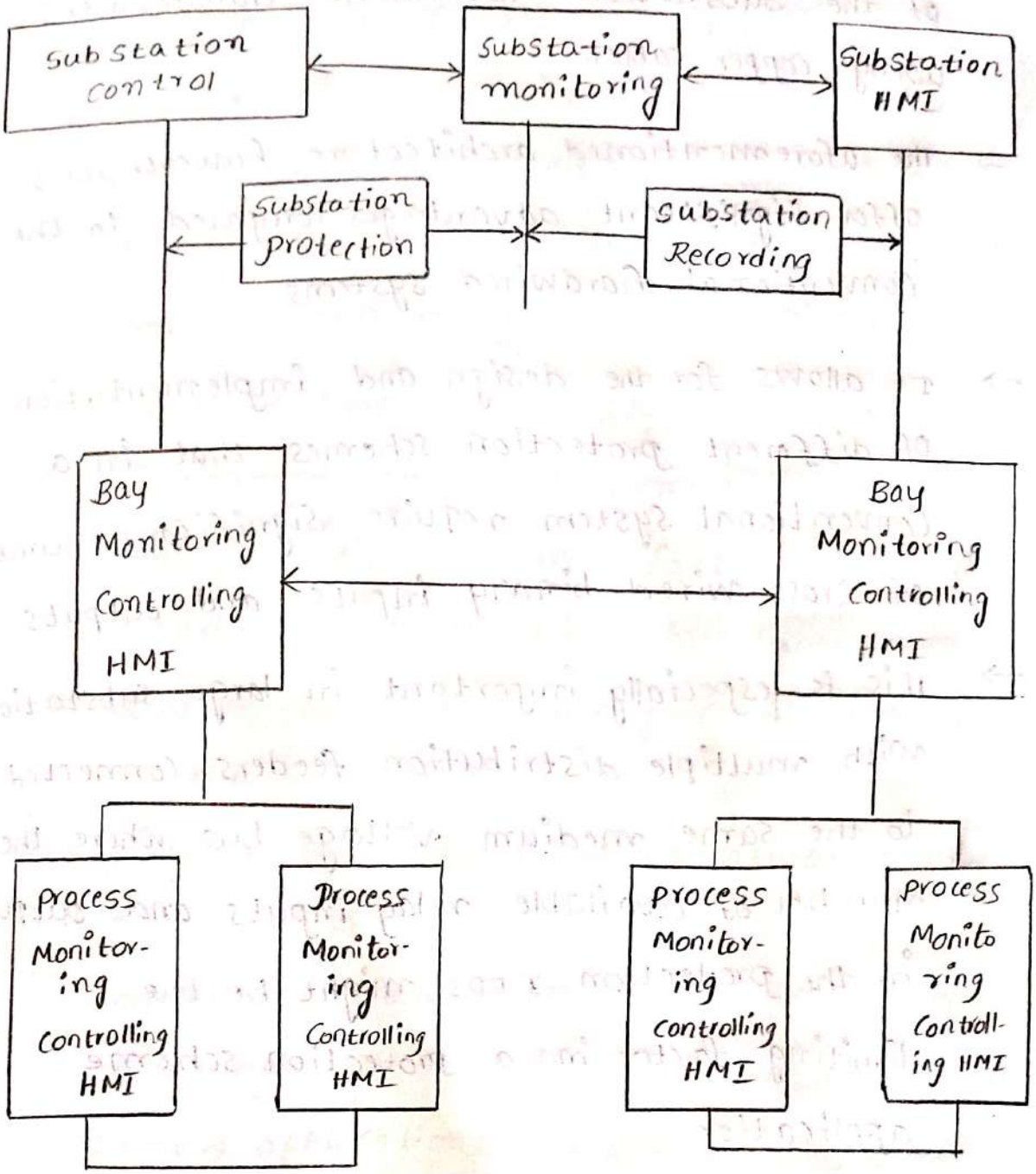
→ The effect that the capacitor has on the secondary voltage is combination of the rating of the bank.

IEC61850 based Substation design

IE 61850 is being implemented gradually by starting with adaption of existing IED's to support the new communications standard over the station bus and at the same time introducing some first process-bus-based solutions.

Station-Bus-Based Architecture :-

⇒ The functional hierarchy of station-bus-based architecture is as shown. as follows



⇒ It represents a partial implementation of IEC 61850 in combination with convential techniques and designs and brings some of the benefits that the IEC 61850 standard offers.

⇒ The current & voltage inputs of IEDS (Protection, control, monitoring or recording) at the bottom of the functional hierarchy are conventional and wired to the secondary side

of the substation instrument transformers using copper cables.

⇒ The aforementioned architecture however does offer significant advantages compared to the conventional hardwired systems.

→ It allows for the design and implementation of different protection schemes that in a conventional system require significant number of cross wired binary inputs and outputs.

→ This is especially important in large substations with multiple distribution feeders connected to the same medium voltage bus where the number of available relay inputs and outputs in the protection IEDs might be the limiting factor in a protection scheme application.

→ Some examples of such schemes are a distribution bus protection based on the over current blocking principle, breaker failure protection, trip accelaration schemes or a sympathetic trip protection.

→ IEC 61850 - based substation systems provide some significance advantages over conventional protection and control systems used to

perform the some functions in the substations

→ Reduced writing, installation, maintenance and commissioning costs.

⇒ optimization possibilities in the design of the high voltage system in a substation.

⇒ Improved inter operatability due to the use of standard high speed communicationss between devices of different manufacturers over a standard communications interface.

⇒ Easy adaption to changing configurations in the substation.

⇒ practical elimination of CT saturation and open circuits.

⇒ easier implementation of complex schemes & solutions as well as easier integration of new applications & IEDS by using GOOSE messages and SVs m that are multicasted on the communications network and that the applications & IEDs can simply subscribe to.

→ ⇒ It has been shown that the greatest benefits of using IEC 61850 may not be found in initial deployment but it will be IEC 61850's additional flexibity later

in the substation life cycle that shows the greatest benefits

→ of the three factors for which IEC 61850 is believed to show a clear benefits only the configuration benefits could be realized on the first installation by a utility.

→ The result is a significant improvement in configuration time as well as a reduction in the errors introduced by having to configure both the IED & Server as in a traditional approach.

→ An expected 75% reduction in labor costs when configuring a substation represents a significant savings.

→ For a more complex device that would normally take a day to configure the savings could be even higher perhaps approaching 90%.

SM

Substation role in a Smart grid:-

A substation containing electrical components transformers, circuit breakers, feeders, transmission lines etc.

→ These components are connected in a definite sequence such the circuit can be switched off during normal operation by manual command.

Substation:-

Substation is an integral part of power system (Generation, Transmission, Distribution, Utilization) and from link b/w Generating point to the utilization point.

→ Classification based on application:-

i) Step up substation - associated with generating station as the generating voltage is low.

ii) Primary grid substation - create a suitable load center along primary transmission lines.

iii) Secondary substation:- along secondary transmission lines.

iv) Distribution substation:- created a where the transmission line voltage is stepdown to supply voltage.

Main role:-

i) Protection of transmission system.

ii) Controlling the exchange of energy

iii) Ensure steady state and transient stability

iv) Load shedding and prevention of loss of synchronization, maintaining the system frequency within target limits

v) voltage control, reactive power reduce, compensation of reactive power, tap changing

vi) provide security of the power line capacity

vii) determine the energy transfer through transmission lines.

viii) Fault analysis and pinpointing the cause and subsequent improvement in the area of field.

ix) Data transmission via powerline carrier for the purpose of network monitoring, control and protection.