SUPERVISORY CONTROL AND DATA ACQUISITION(SCADA)

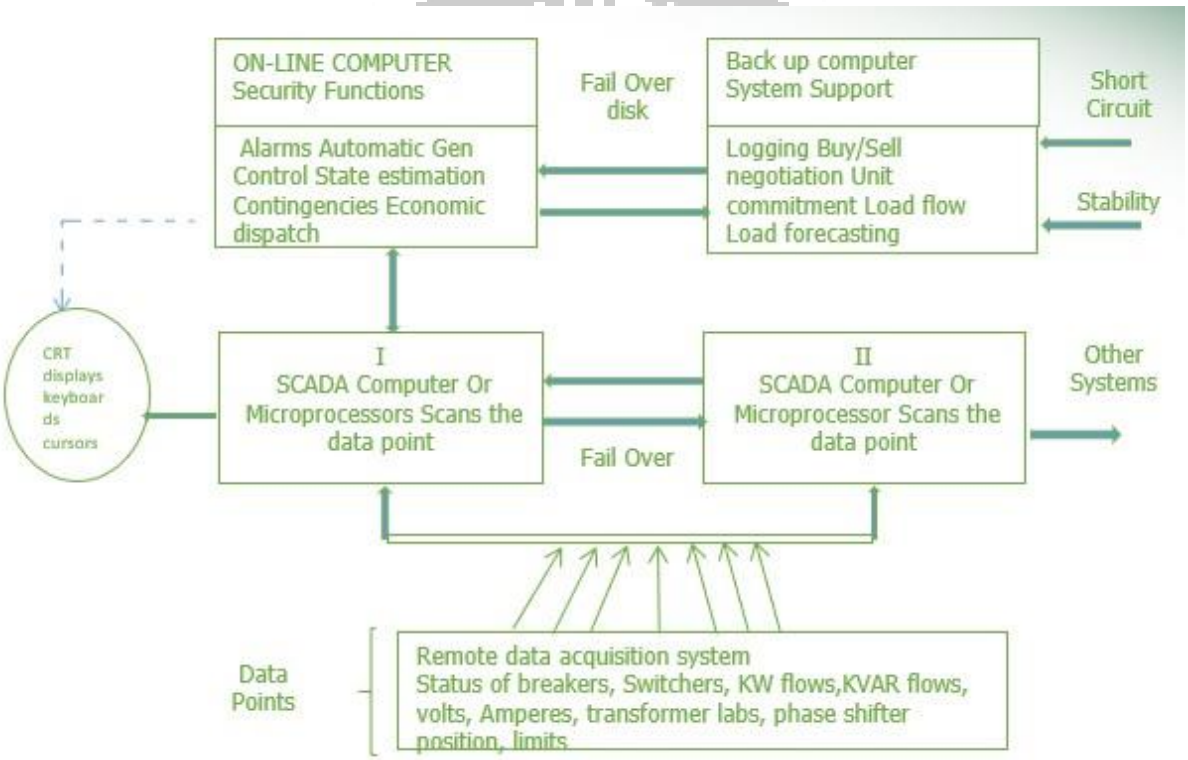
- There are two parts to the term SCADA Supervisory control indicates that the operator, residing in the energy control center (ECC), has the ability to control remote equipment.
- Data acquisition indicates that information is gathered characterizing the state of the remote equipment and sent to the ECC for monitoring purposes.
- The monitoring equipment is normally located in the substations and is consolidated in what is known as the remote terminal unit (RTU).
- Generally, the RTUs are equipped with microprocessors having memory and logic capability. Older RTUs are equipped with modems to provide the communication link back to the ECC, whereas newer RTUs generally have intranet or internet capability.
- Relays located within the RTU, on command from the ECC, open or close selected control circuits to perform a supervisory action.
- Such actions may include, for example, opening or closing of a circuit breaker or switch, modifying a transformer tap setting, raising or lowering generator MW output or terminal voltage, switching in or out a shunt capacitor or inductor, and the starting or stopping of a synchronous condenser.
- Information gathered by the RTU and communicated to the ECC includes both analog information and status indicators.
- Analog information includes, for example, frequency, voltages, currents, and real and reactive power flows.
- Status indicators include alarm signals (over-temperature, low relay battery voltage, illegal entry) and whether switches and circuit breakers are open or closed.
- Such information is provided to the ECC through a periodic scan of all RTUs. A 2 second scan cycle is typical.

SCADA

It consists of a master station and RTU linked by communication channel. Thehardware components can be classified into

1. Process computer and associated hardware at the energy control center

2. RTU and the associated hardware at the remote stations.
3. Communication equipment that links the RTUs and process computers at themaster station
4. Fig. Digital computer control and monitoring for power system



System Hardware Configuration:

The supervisory control and data acquisition system allows a few operators to monitor the generation and HV transmission system. Consistent with principles of high reliability and fail safe features, electric utilities have almost universally applied a redundant set of dual digital computers for the functions of remote data acquisition control, energy management and system security. Both computers have their own core memory and drive an extensive number of input- output devices such as printers, teletypes, magnetic tape drive, and disks and so on.

Usually one computer, the on-line units, is monitoring and controlling the power system. The backup computer may be executing off-line batch programs such as load forecasting to hydro-thermal allocation. The on-line computer periodically updates a disk memory shared between the two computers.

Upon a fail over or switch-in status command, the stored information of the common disk is inserted in the memory of the on-line computer.

The information used by the on-line computer has a maximum age of update cycle. The figure gives a detailed block diagram of a typical digital computer control and monitoring for power systems.

- All of the peripheral equipment is interfaced with the computer through input-output microprocessors that have been programmed to communicate, as well as preprocess the analog information, check for limits, convert to another system of units and so onThe microprocessors can transfer data in and out of computer memory witprocessing unit. As a result of these precautions, for all critical hardware functions, there is often a guaranteed 99.8 % or more availability. Software also allows for multilevel hardware failures and initialization of application programs, iffailures occur. Critical operations and functions are maintained during either preventive or corrective maintenance.

- Besides hardware, new digital code to control the system may be compiled and tested in the backup computer, then switched to on-line status. The digital computers are usually employed in a fixed cycle operating mode, with priority interrupts wherein the computer periodically performs a list of operations. The most critical functions have the fastest scan cycle. Typically, the following categories are scanned every two seconds.
  - All status points such as switchgear position, substation loads and voltages, transformer tap positions and capacitor banks.
  - Tie-line flows and interchanges schedules.
  - Generators loads, voltage, operating limits ad boiler capacity.

- Telemetry verification to detect failures and errors in the remote bilateral communication links between the digital computer and the remote equipment

- The turbine generators are often commanded to new power levels every four seconds, sharing the load adjustment based on each unit's response capability in MW/min. The absolute power output of each unit's response capability is typicallyadjusted every five min by the computer executing an economic dispatch program to determine the base power setting.

- Most low priority programs may be executed on demand by the operator for studypurposes or to initialize the power system. An operator may also alter the

digital computer code in the execution if system. The computer software compiler and data handlers are designed to be versatile and readily accepts operator inputsa parameter changes in the system.

Types of SCADA systems and areas of applications:

- **Type 1**: Small distribution systems, small hydro stations, HVDC links.
- **Type 2**: Medium sized power system (plant control center), power station HVDC link distribution systems.
- **Type 3**: Regional control center, distribution system in large urban areas several hydro power stations with cascade control.
- **Type 4**: National and Regional control center distributed systems in large urban areas, several hydro power station with cascade control.

Components of SCADA

- SENSORS - Analog and digital sensors are used to interface the systems
- RELAYS– Relays are used to sense the abnormal conditions and protect the system.
- REMOTE TERMINAL UNITS – RTU's are microprocessors controlled electronics devices which are used to collect various data's and transmit to SCADA system.
- MASTER UNIT- Master unit act as a central processor computer.
- COMMUNICATION LINKS- It is used to link RTU's and SCADA system. Satellite communication, microwave communication, fiber optic communication maybe used for communication purpose.

AREA CONTROL ERROR

To maintain a net interchange of power with its neighbors, an AGC uses real power flow measurements of all tie-lines emanating from the area and subtractsthe scheduled interchange to calculate an error value. The net power interchange, together with a gain, b , the frequency bias, as a multiplier on the frequency is called area control error.

The interchange power Ps, is generally scheduled for periods of the day and is changed as 'blocks' of MWhr are bought or sold to neighboring utilities. A positive ACE or positive net exchange of power represents a flow out of the area.

$$ACE = \sum_{K=1}^{n} P_K + P_S + 10b(f_{act} - f_0)$$

Where,

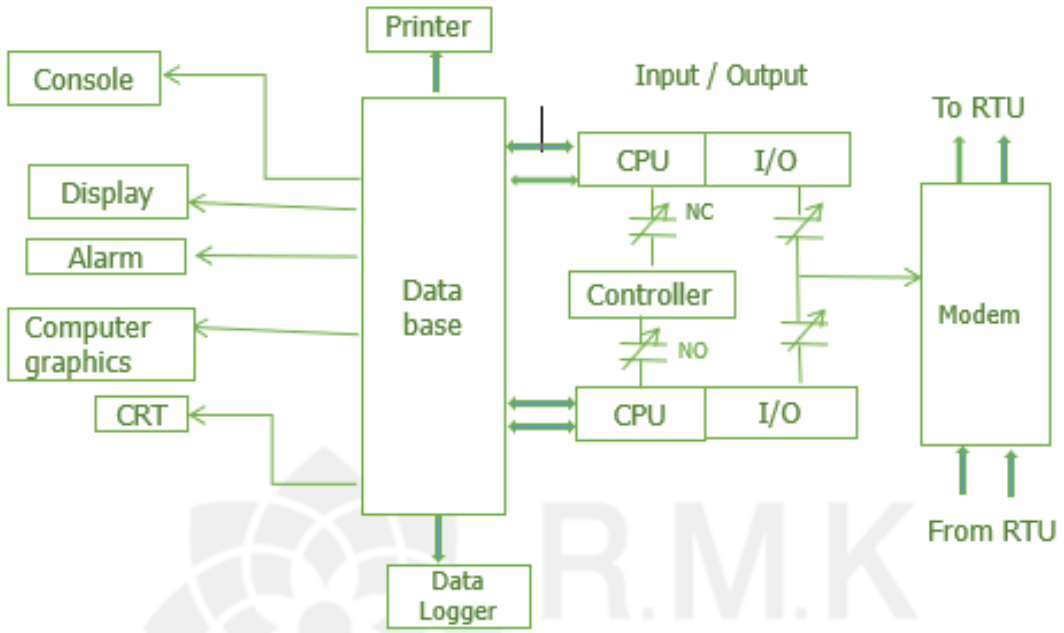
Pk – MW tie flow defined as positive out of the area

Ps – Scheduled MW interchange

f_0- Scheduled base frequency

MASTER STATION

Master unit is provided with a digital computer with associated interfacing devices and hardware to receive information from RTU, process data and display salient information to the operator.



The hardware at the master station includes the following

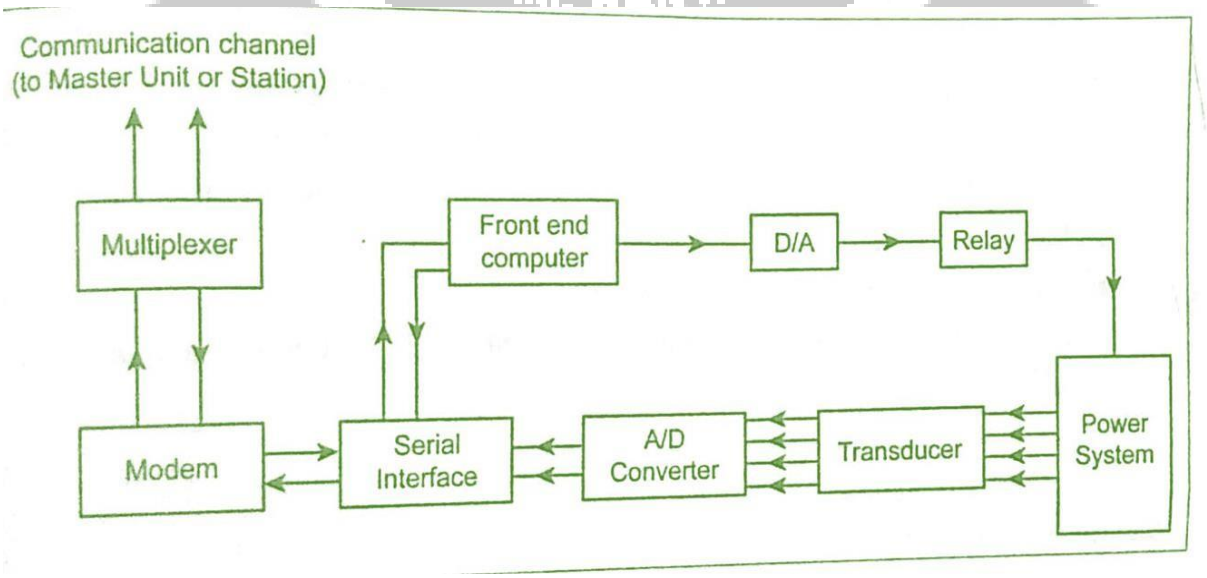
1. Process computer
2. CRT display
3. Printer
4. Data logger

5. Computer graphics
6. Control console
7. Keyboard
8. Alarm panel
9. Instrument panel
10. Modem
11. Multiplexer

REMOTE TERMINAL UNIT

The RTU'S are installed at selected power stations and substations. Thehardware components of RTU may include the following.

1. Transducers
2. A/D and D/A converters
3. Serial Interface
4. Modems
5. Multiplexers
6. Front end Computer
7. Control relays



REMOTE TERMINAL UNITS

The analog quantities like voltage , MW, MVAR and frequency measured at stations are converted into DC voltage or current signals, through transducers andfed to the A/D converters with convert the analog signals into digital from suitable for transmission. The digital signal is fed to the front end computer and modems through the serial interface . MODEM sends the information to the master unit through multiplexer. MODEM will also receive commands from master units tocontrol the station equipment's through the control relays. In addition to measure quantities, status of various devices is informed to master station.

The master station scans the RTU sequentially and gathers information on the system operating condition i.e Voltage, Current, line flows, generation, output, etc as well as equipment status. Computer, using real time data can check operatinglimits of various quantities and give an alarm to operator if overloading or any otherabnormal condition is detected, the system real time information is presented to the operator through CRT, computer graphic terminals, alarm panels, alarm printer so that the operator can supervise minute by minute, system operating condition and take control action to prevent system disturbances whenever emergency conditions and system status at specified interval is printed by data loggers.

FUNCTIONS OF SCADA SYSTEMS

1. Data acquisition
2. Information display.
3. Supervisory Control (CBs : ON/OFF, Generator: stop/start, RAISE/LOWER command)
4. Information storage and result display.
5. Sequence of events acquisition
6. Remote terminal unit processing.
7. General maintenance.
8. Runtime status verification.

9. Economic modeling.
10. Remote start/stop.
11. Load matching based on economics.
12. Load shedding.

CONTROL FUNCTIONS

- Control and monitoring of switching devices, tapped transformers, auxiliarydevices, etc.
- Bay-and a station-wide interlocking
- Dynamic Bus bar coloring according to their actual operational status.Automatic switching sequences
- Automatic functions such as load shedding, power restoration, and high speedbus bar transfer
- Time synchronization by radio and satellite clock signal

MONITORING FUNCTIONS:

- Measurement and displaying of current, voltage, frequency, active and reactivepower, energy, temperature, etc.
- Alarm functions. Storage and evaluation of time stamped events.Trends and archiving of measurements
- Collection and evaluation of maintenance data Disturbance recording and evaluation

PROTECTION FUNCTIONS:

- Substation protection functions includes the monitoring of events like start, tripindication and relay operating time and setting and reading of relay parameters.
- Protection of bus bars. Line feeders, transformers, generators.
- Protection monitoring (status, events, measurements, parameters, recorders)
- Adaptive protection by switch-over of the active parameter set.

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