Energy control centres

When the power system increases in size-the number of substations, transformers, switchgear and so on-their operation and interaction become more complex. So it becomes essential to monitor this information simultaneously for the total system which is called as energy control centre.

A fundamental design feature of energy centre is that, it increases system reliability and economic feasibility. In other words, Energy Management (EM) is performed at control centre called system control centre.

Fig. shows the schematic diagram showing the information flow between various functions to be performed in an operations control centre computer system. The system gets information about the power system from remote terminal units (RTU) that encode measurement transducer outputs and operand/closed status information into digital signals that are transmitted to the operations centre over communication circuits.

The control centre can transmit control information such as raise/lower commandsto the speed changer and in turn to the generators and open/close commands to circuit breakers (CBs). The information coming into the control centre is breaker/switch status indications and analog measurements.

The analog measurements of generator outputs must be used directly by the Automatic Generation Control (AGC) program, whereas, all other data will be processed by the state estimator before being used by the other programs. Real time operations are in two aspects.

Three level control

- Turbine-governor to adjust generation to balance changing load-instantaneous control.
- ACG (called Load Frequency Control (LFC)) maintains frequency and net powerinterchange –action repeated at 2-6 sec. interval.
- Economic Dispatch Control (EDC) distributes the load among the units suchthat fuel cost is minimum-executed at 5-10 minutes intervals.

Primary voltage control

- Excitation controls regulate generator bus voltage.
- Transmission voltage control device includes SVC (Static VAR Controllers),shunt capacitors, transformer taps, etc

Automatic Generation Control

Automatic generation control (AGC) consists of two major and several minor functions that operate online in real time to adjust the generation against load at minimum cost. The major functions are load frequency control and economic dispatch, each of which is described below. The minor functions are reserve monitoring, which assures enough reserve on the system; interchange scheduling, which initiates and completes scheduled interchanges; and other similar monitoring and recording functions

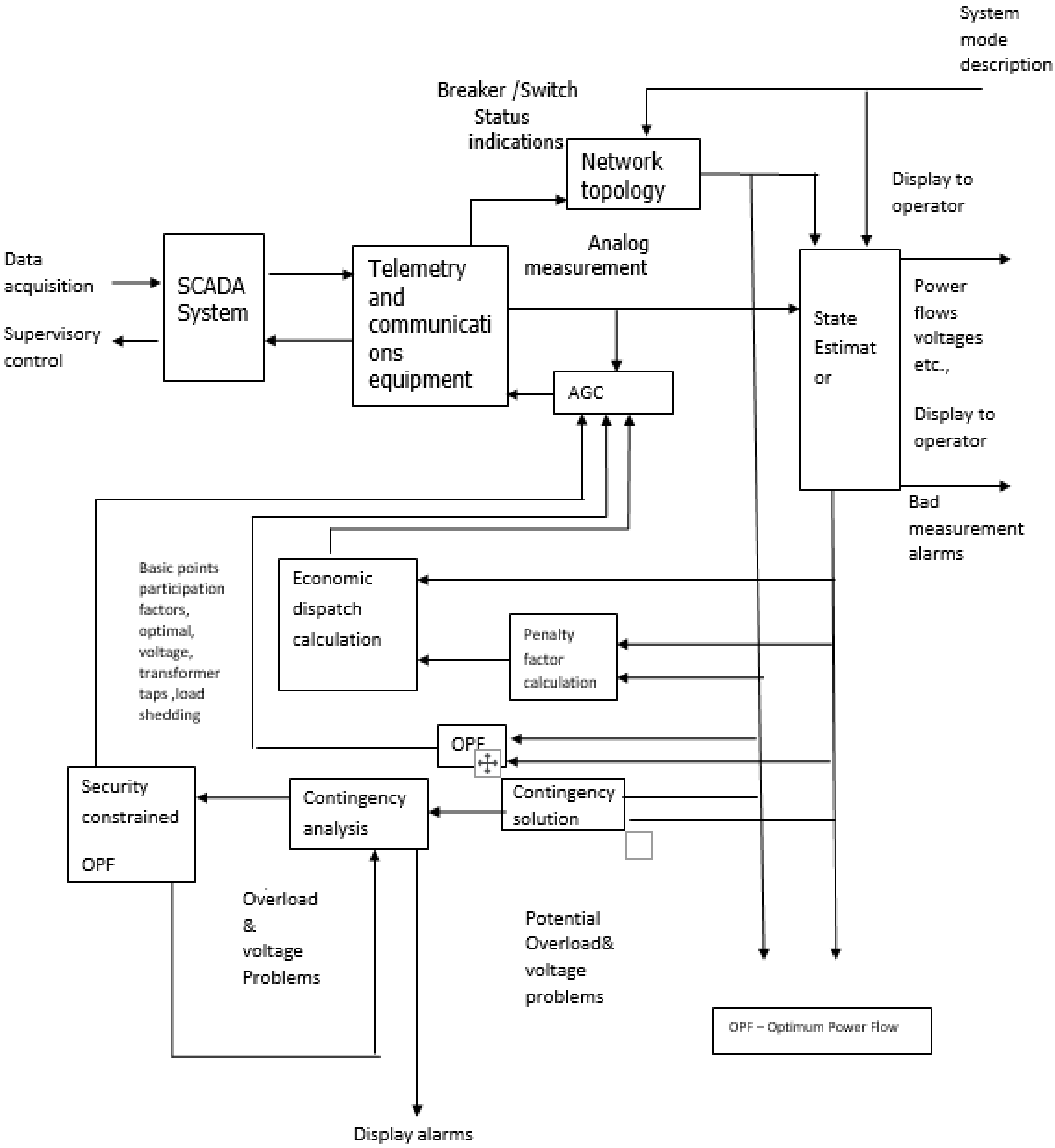

Fig. Energy control centres

ECC Functions

The practice of all communication links between equipment and the control centrecould be interrupted and still, electric service is being maintained. The generating in the system remains synchronized to the transmission network and maintains its existing power output level even without signals received from control centre.

Monitoring

An energy control centre fulfills the function of coordinating their response of the system elements in both normal operation and emergency conditions.

The burden of repetitious control in normal situations is delegated to the digital computer and selective monitoring is performed by human operators.

The digital computer is used to process the incoming stream of data to detect abnormalities and the human operator via lights, buzzers and CRT presentations. Many lower level or less serious cases of exceeding normal limits are routinely handled by digital computer. A more serious abnormality detected by the digital computer may cause suspension of normal control functions

In emergencies such as loss of a major generator or excess power demands by a neighboring utility on the tie lines, many alarms could be detected and the systemcould enter an emergency state.

Data Acquisition and Control

Data acquisition provides operators and computer control systems with status and measurement information needed to supervise overall operations. Security control analyses the consequences of faults to establish operating conditions.

A SCADA system consists of a master station and remote terminal unit (RTU). Master station communicates information to the RTU for observing and controllingplants.

RTUs are installed at generating station or transmission substation or distribution substation. RTUs transmitting status of the device and measurements to master station and receive control commands from the master station.

In a computer aided data acquisition scheme, the steady state reading can be acquired simultaneously from various instrument locations and can be saved for future analysis.

The transient may result in the form of voltage or current fluctuations. In a real power system, the transient may result in the failure of components and it is sometimes difficult to trace the origin of disturbance. Using a Data Acquisition system, the transients can be reduced and analyzed.

Phasor Measurement Units for Power Systems (PMU):

A phasor measurement unit (PMU) is a device used to estimate the magnitude and phase angle of an electrical phasor quantity (such as voltage or current) in the electricity grid using a common time source for synchronization. Time synchronization is usually provided by GPS or IEEE 1588 Precision Time Protocol, which allows synchronized real-time measurements of multiple remote points on the grid. PMUs are capable of capturing samples from a waveform in quick succession and reconstructing the phasor quantity, made up of an angle measurement and a magnitude measurement. The resulting measurement is known as a synchrophasor. These time synchronized measurements are important because if the grid's supply and demand are not perfectly matched, frequency imbalances can cause stress on the grid, which is a potential cause for power outages.

PMUs can also be used to measure the frequency in the power grid. A typical commercial PMU can report measurements with very high temporal resolution, up to 120 measurements per second. This helps engineers in analysing dynamic events in the grid which is not possible with traditional SCADA measurements that generate one measurement every 2 or 4 seconds. Therefore, PMUs equip utilities with enhanced monitoring and control capabilities and are considered to be one of the most important measuring devices in the future of power systems. A PMU can be a dedicated device, or the PMU function can be incorporated into a protective relay or other device.

Existing systems in power grid such as Energy Management System (EMS) and Supervisory Control and Data Acquisition system (SCADA) have the capability to provide only steady state view of power system with high data flow latency. In Supervisory Control and Data Acquisition system (SCADA) it was not possible to measure the phase angles of bus voltages of power system network in real time, dueto technical difficulties in synchronising measurements from distant locations.

Measurements were obtained at slower rates; it was not possible to get dynamic behaviour of power system as well as limited situational awareness was conveyed to the operator. Advent of Phasor Measurement Units (PMUs) alleviated this problem by synchronising voltage and current waveforms at widely dispersed locations with respect to global positioning system. PMU is superior to SCADA withrespect to speed, performance and reliability.

As per definition of IEEE, PMU is defined as device that produces synchronised phasor, frequency and rate of change of frequency estimates from voltage and/or current signals and time synchronising signal. PMUs provide real time synchronised measurements in power system with better than one microsecond synchronisation accuracy, which is obtained by Global Positioning System (GPS) signals. PMUs are situated in power system substations, and provide measurement of time stamped positive sequence voltages and currents of all monitored buses and feeders. Data from various substations are collected at suitable site, and by aligning time stamps of measurements a coherent picture of the state power system is created. PMUs are time synchronised, high speed measurement units that monitor current and voltage waveforms (sinusoids) in the grid, convert them into a phasor representation through high end computation and securely transmit the same to centralised server.

PMU technology is well suited to track grid dynamics in real time, the data obtained can be used for wide area monitoring, stability monitoring, dynamic system ratings and improvement in state estimation, protection and control. It enables utilities to proactively plan energy delivery and prevent failures.

PMU application

- Post disturbance analysis
- Stability monitoring
- Thermal overload monitoring
- Power system restoration
- State estimation
- Real time control
- Adaptive protection

System Hardware Configuration

The supervisory control and the data acquisition system allow a few operators to monitor the generation and HV transmission system. Consistent with principles of high reliability and fail safe failures, electric utilities have almost universally applieda redundant set of dual digital computers for the function of remote date 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, and magnetic tape drive, disks. 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 or 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. All of the peripheral equipment is interfaced with the computer through input- output microprocessors that have been programmed to communicate, as well as pre-process the analog information, check for limits, convert to another system of units and so on.

The microprocessors can transfer data in and out of computer memory without interrupting the central processing 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, if failures occur. Critical operation and functions aremaintained 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 computer periodically performs a list of operations. The most critical functions have the fastest scan cycle. Typically, the following categories are scanned every 2 seconds.

- All status points such as switchgear position, substation loads and voltages, transformer tap positions and capacitor banks.
- Tie-line flow and interchanges schedules.
- Generator loads, voltage, operating limits and boiler capacity.
- Telemetry verification to detect failures and error in the remote bilateralcommunication links between the digital computer and remote equipment.

The turbine-generators are often commanded to new power levels every 4 seconds, sharing the load adjustment based on each unit‘s response capabilityin MW/min. The absolute power output of each unit‘s response capability is typically adjusted every 5 min by the computer executing an economic dispatch program to determine the base power settings.