CMR
INSTITUTE OF
TECHNOLOGY

Internal Assesment Test – I-Solution

Sub:	POWER SYSTEM OPERATION AND CONTROL							Code:	15EE81
Date:	06/ 03/ 2019	Duration:	90 mins	Max Marks:	50	Sem:	8th	Branch:	EEE

1. Explain energy control centre operaion.

ENERGY CONTROL CENTER:

A focal point where generators, lines, sub-stations, transformers, switchgear operation is monitored and controlled; is called as Energy Control Center.

DIGITAL COMPUTER CONFIGURATION.

[DUAL COMPUTER CONFIGURATION].

*. For remote data acquisition, control, energy management and system security a redundant set of dual digital computers are used.

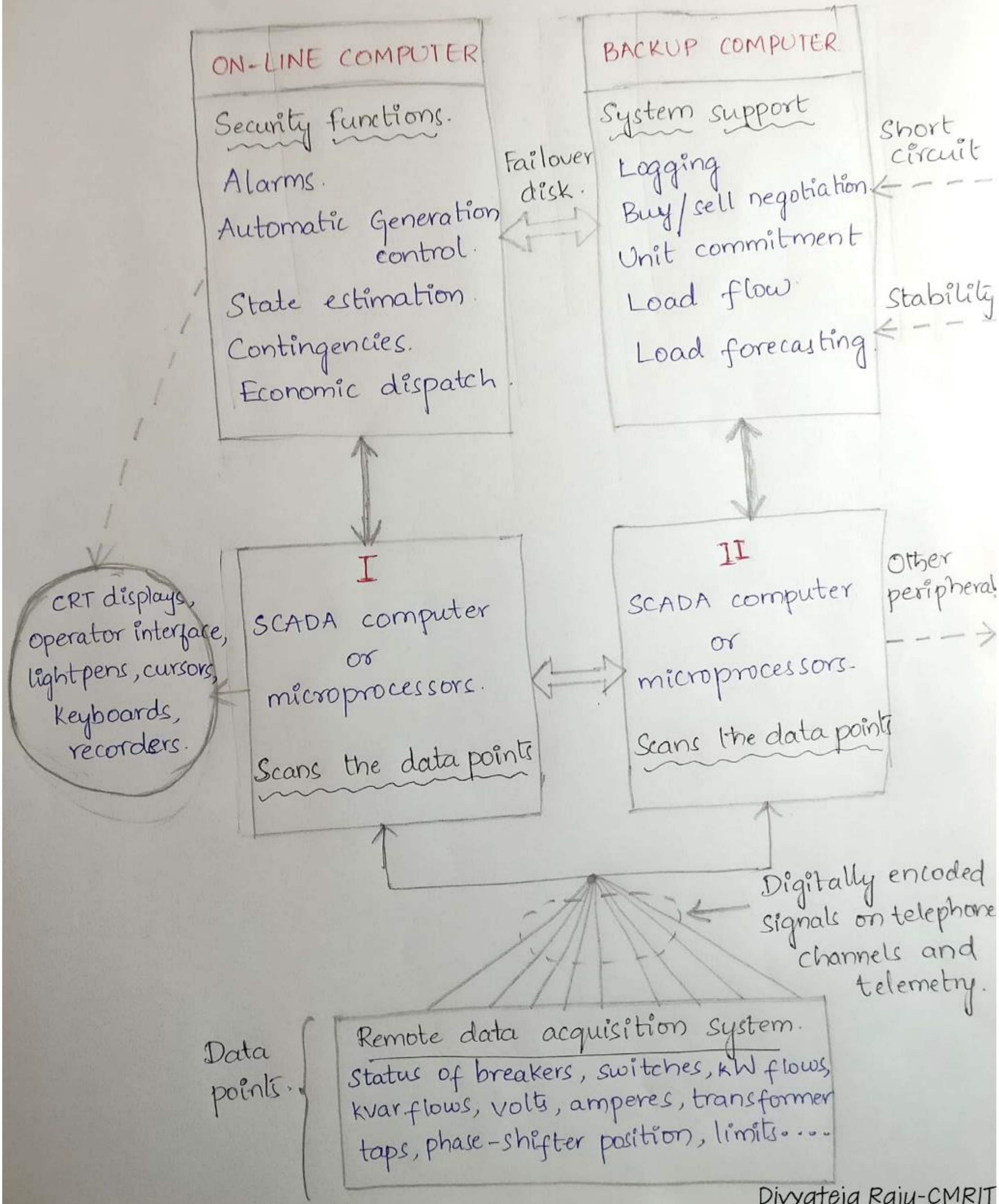
*. Both the computers have their own memory and Input/Output devices.

*. Online computer monitors and controls the power system

*. The Backup computer executes off-line programs such as load forecasting and unit commitment.

* The On-line computer periodically updates a disk memory shared between the two computers.

*. Upon a failover or switch in status command, the stored information of the common disk is inserted in the memory of the on-coming computer.



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*. The digital computers are usually employed in fixed cycles. With priority interrupts the computer periodically performs a list of operations.

*. The most critical functions have the fastest scan cycle such as

- Switchgear position
- Substation loads
- Transformer tap positions
- Tie-line flows etc.

Here the scan cycle is 2 seconds.

*. The turbine generators are frequently adjusted to the new power levels every 4 seconds.

*. The other system operations such as

- Recording of load
- Forecasting of load
- Determination of which generators to start up or stop

All these are non-critical operations hence the computer executes these programs on on hourly basis.

*. Most low-priority programs may be executed on demand by the operator for study purposes or to intialize power system.

*. An operator may also alter the digital computer code in the execution if a parameter changes in the system.

2. Discuss communication channels for SCADA in Power Systems.

12.2 Components of SCADA System

The general configuration is shown in Fig. 12.1[2]. Basically, SCADA systems collect information from the site (field) of the equipment, transfer it to a central computer facility and display the information to the operator to facilitate the control of the entire system from the central control center. In a SCADA system, the geographically dispersed sites contain either a remote terminal unit (RTU), which is a computer, or a programmable logic controller (PLC), which controls local actuators and monitor the sensors. The communication equipment allows transfer of information or data from the RTU/PLC to the central control center which houses a master terminal unit (MTU).The communication could be via telephone, radio, cable or satellite. The software of the SCADA system is programmed to tell the system what to monitor, what are the operating ranges, when to initiate alarms, controls, etc. Further, the system may consist of intelligent electronic devices (IEDs) that are smart sensors, at times combining a sensor, low level intelligent control, a communication system and program memory in one device. The IEDs can communicate directly with the MTU. Other components are the human–machine interface(HMI), also called the man–machine interface (MMI)that allows the operator to monitor the state of a process under control, modify

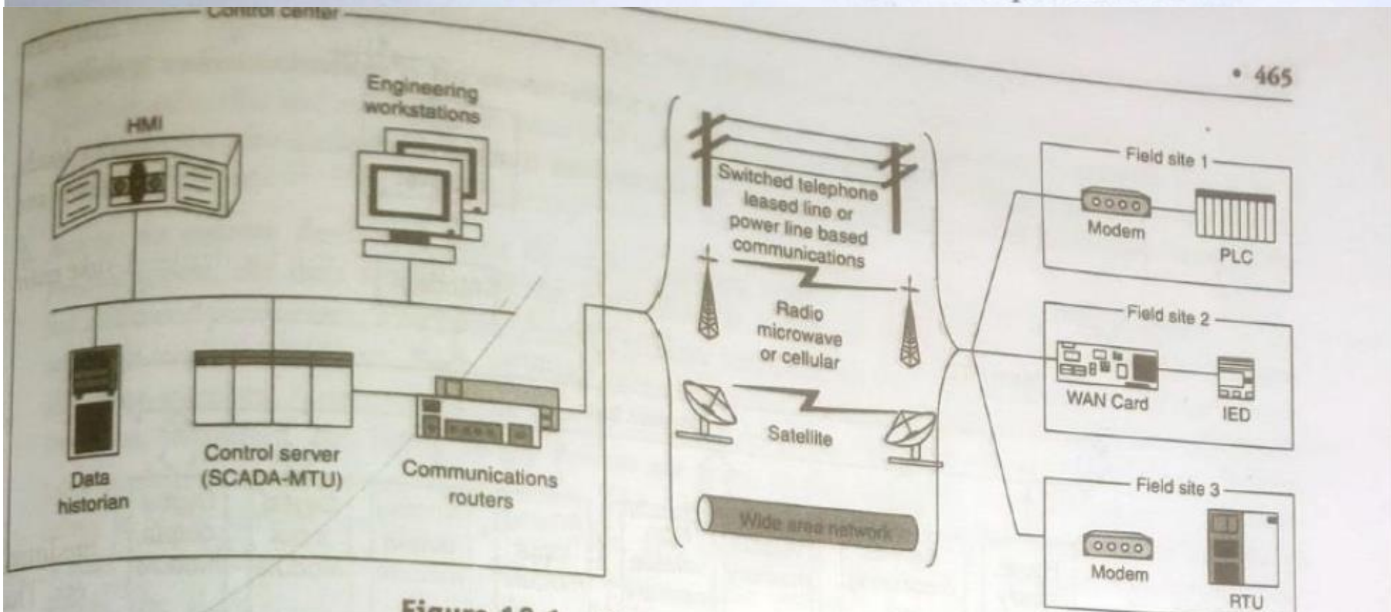


Figure 12.1 General SCADA configuration.

control settings if necessary, and permits the operator to override any automatic control previously set, should an emergency arise. The HMI is also responsible for displays, reports, historical information, status information, etc.

The major components of a SCADA system are thus classified as:

1. Field instrumentation,
2. Remote stations,
3. Communication network,
4. Central monitoring station and
5. Software.

12.2.1 Field Instrumentation

This refers to all the sensors and actuators that are interfaced directly to the equipment. They generate the analog and digital signals that are monitored by the remote station. The generated signals are conditioned to be compatible with the RTU/PLC at the remote station. The analog outputs of sensors have standard industry values like 0–5 V, 0–10 V, 0–20 mA, etc. Digital outputs of sensors are used to define the status of the equipment like On-OFF, Full-Empty, Open-Closed, etc.

12.2.2 Remote Station

Field instrumentation connected to the plant/substation/equipment which is being monitored and controlled is interfaced to the remote station to allow manipulation at a remote site. The remote station may be an RTU or a PLC. The RTU is a computer with good interfacing for communication and flexible programmability. The PLC is used mostly in industries. It has very good programmability. Modern PLCs also have extensive communication features and radio units for use with SCADA systems. A typical RTU unit is shown in Fig. 12.2.

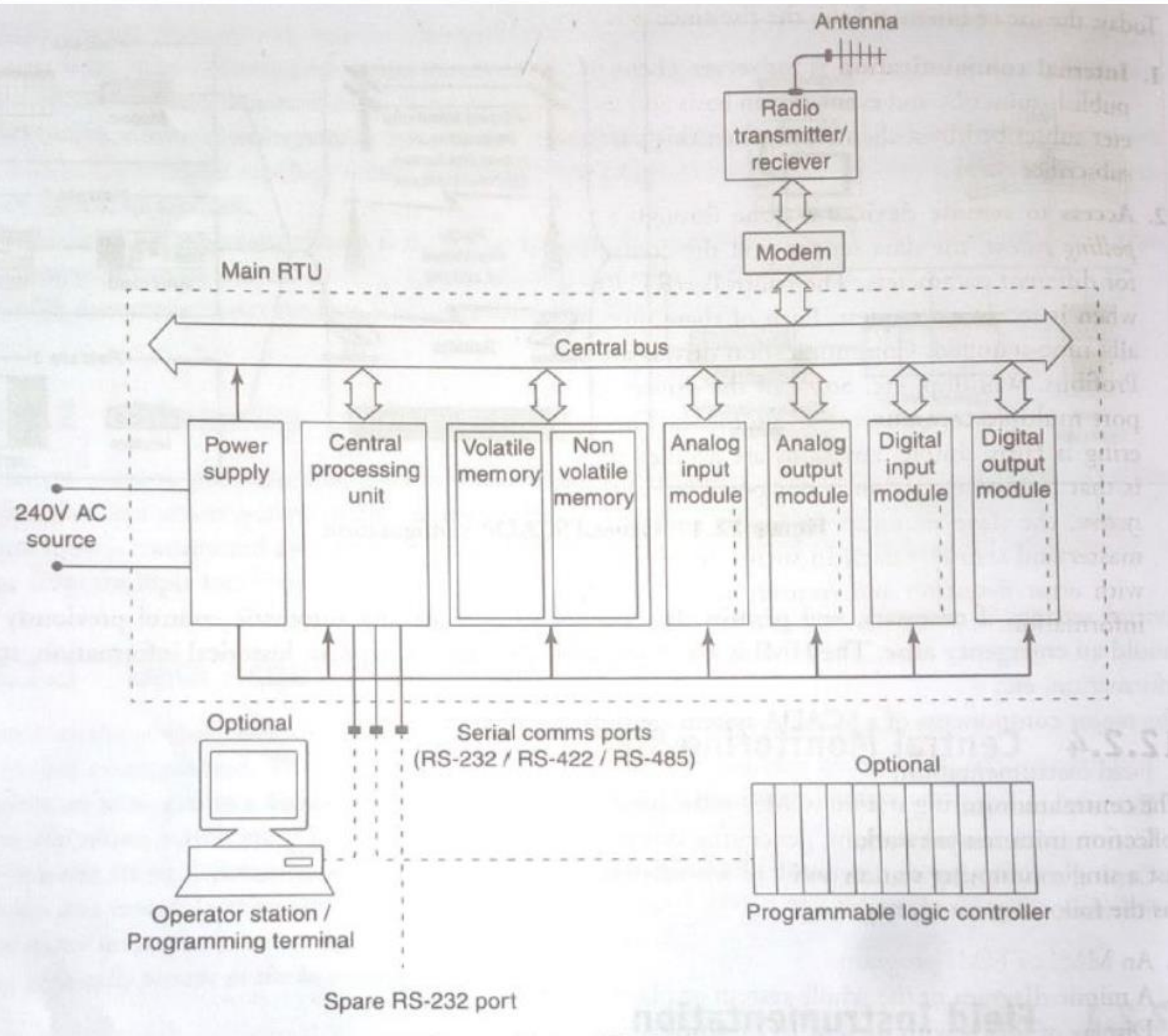


Figure 12.2 RTU unit.

12.2.3 Communication Network

This refers to the communication equipment needed to transfer data to and from different sites. Commonly used communication media are RS-232/RS-442/RS-485, dial-up telephone lines or dedicated landline, microwave, satellite, X.25 packet protocols and radio via trunked/VHF/UHF. Cables are normally used in factories and are not practical for systems spread over wide geographical areas due to the high cost of cables. The use of radio lines is common. Dial-up telephone lines are used for connecting remote stations economically. This is shown in Fig. 12.3.

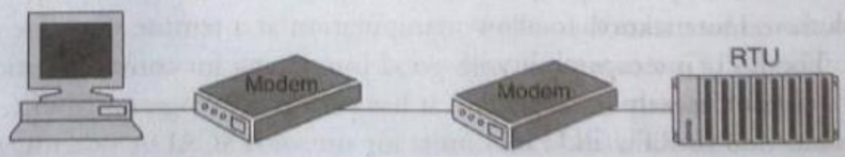


Figure 12.3 Use of telephone lines for communication.

12.2.4 Central Monitoring Station

The central monitoring station (CMS) is the master unit of a SCADA system. It is in charge of information collection from remote stations, generating control actions for any event and generating reports. It could be just a single computer or a network of workstations to allow sharing of information. The CMS in general has the following components:

1. An MMI or HMI program
2. A mimic diagram of the whole system or plant displayed on screen for the operator
3. Display of RTUs with present I/O reading
4. Window for alarms
5. Trending display

These have been discussed in subsequent sections.

12.2.5 Software for SCADA

Software for SCADA is based on real-time database (RTDB). SCADA software is of two types: *proprietary* and *open*. Proprietary software is developed by companies to communicate with their own hardware. Vendors sell the system as a turnkey solution. This makes the customer heavily dependent on the vendor. Open software systems have gained popularity because of interoperability capabilities and the ability to mix different equipment manufactured by different vendors on the same system. Some of the key features of SCADA software are user interface, graphics displays, alarms, trends, RTU/PLC interface, scalability, redundancy, networking and distributed processing.

3a. Mention objectives of Power System Operation and Control.

* POWER QUALITY:

Maintain continuity of supply at desired frequency and voltage level.

* RELIABILITY:

Minimize loss of load probability (LLOP), failure rate of components and systems.

* SECURITY:

Robustness of system to remain in normal state even if some contingency takes place.

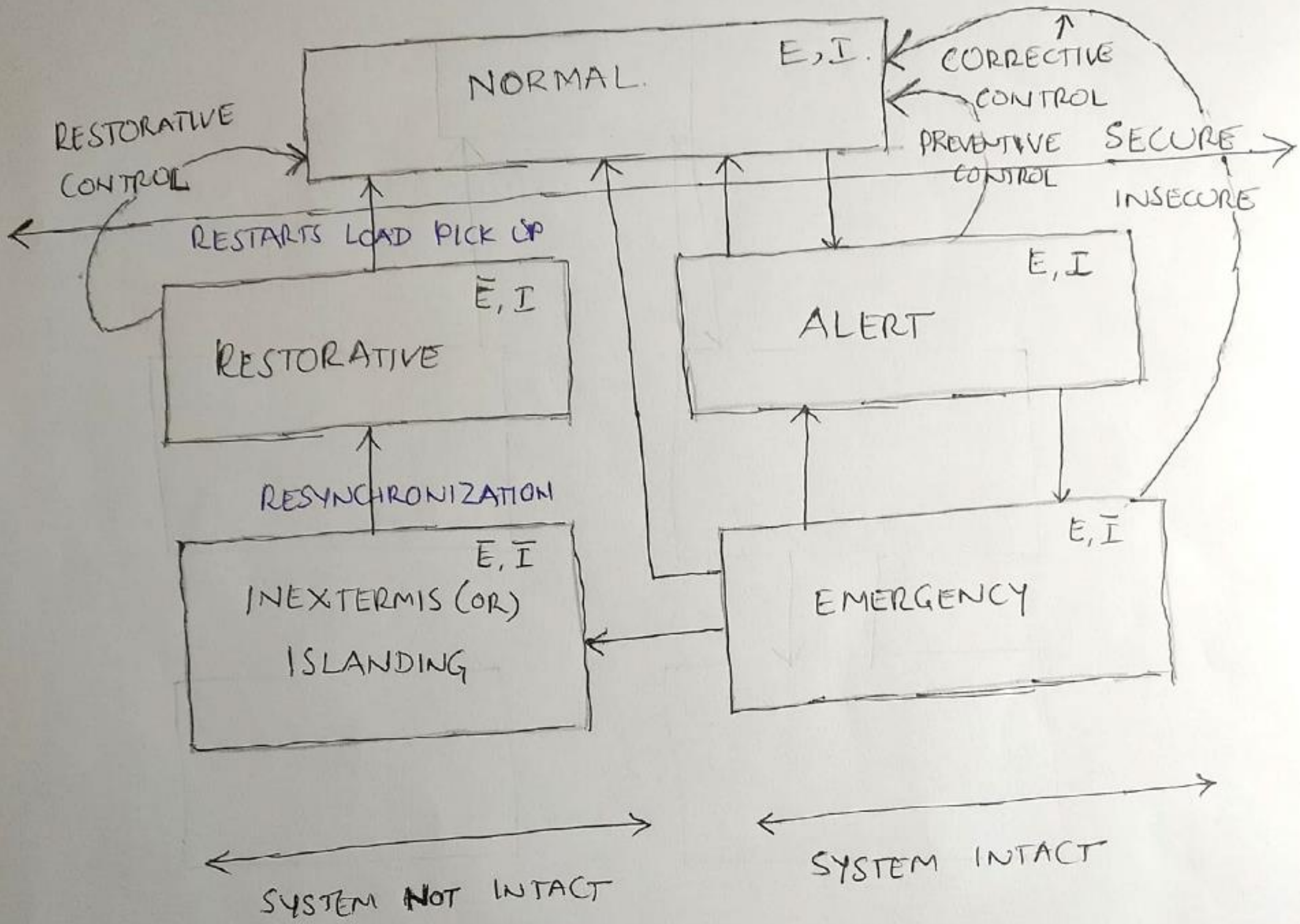
* STABILITY:

Ability of a system to maintain synchronism.

* ECONOMY:

Minimize capital cost, operating (running) cost and maintenance cost.

3b. Explain different operating states of Power System.



* NORMAL:

All constraints equality, inequality (E, I) are satisfied, with enough power generation reserve is available. Incase of any generator outage, the reserve from other generators can supply the load without any interruption.

* ALERT:

All constraints equality, inequality (E, I) are satisfied, but reserve power generation is zero. As a result, in the event of a loss of generator, the remaining generators can't supply the load, load shedding has to happen. The power system can be brought back to normal state through preventive control action.

*. EMERGENCY :

In this state, the equality constraint is satisfied, while the inequality constraint is violated. Corrective control is used to bring the system back to normal operating state directly or through ALERT state.

* In-extermis or islanding :

In this state, the power system enters into an islanded mode of operation, where both equality and inequality states are violated. Once the system comes to this state it cannot go back to the emergency state. In this state, the large power system is separated into small areas or islands, where the loads are supplied from generators. All the tie lines connecting the areas are open and they work in an indepedent mode of operation. System reliability is more important in this stage than economic operation.

*. RESTORATIVE MODE :

In this mode, the power systems has to be restored through several steps by switching generators and transmission lines. This is a difficult task and requires strategies for bringing on the generator and synchronizing it to the grid. Improper sequence will cause tripping.

4a. State Unit Commitment Problem.

*. STATEMENT OF UNIT COMMITMENT PROBLEM (UCP):

The UCP in electrical power production is a large family of mathematical optimization problems where the production of set of generators is coordinated to match the energy demand at minimum cost or maximize revenues from energy production.

4b. Explain constraints in unit commitment.

1. SPINNING RESERVE:

*. Spinning Reserve is the term used to describe the total amount of generation available from all units synchronized (i.e. Spinning) on the system minus the present load and losses being supplied.

$$\text{Spinning Reserve} = P_g - P_{Load} - P_{Loss}.$$

*. Spinning reserve must be carried so that the loss of one or more units does not cause a drop in system frequency

* Spinning reserve must be

→ The capacity of largest generation + Fraction of peak load (OR)

→ Sufficient to make up for a generation-unit failure (OR)

→ Sufficient to meet the losses of the entire system

* Reserves must be allocated among

a) Fast-responding units – Quick start diesel, gas-turbine unit hydro units, pumped storage hydro units

b) Slow responding units – Thermal power plants.

*. The Unit Commitment Problem may involve various classes of "scheduled reserves" or 'off-line reserves'.

2. THERMAL UNIT CONSTRAINTS:

a. Minimum up time: Once the unit is running, it should not be turned off immediately.

b. Minimum down time: Once the unit is decommitted, there is a minimum time before it can be recommitted.

c. Crew Constraints : If a plant consists of two or more units, they cannot both be turned on at the same time since there are not enough crew members to attend both unit while starting up.

d. Pressure And Temperature Constraints: Since the temperature and pressure of the thermal unit must be moved slowly, a certain amount of energy must be expended to bring the unit on-line.

* This energy doesnot result in any MW generation from the unit and is brought into the unit commitment problem as a start-up cost.

*. Start-up cost when cooling $= C_c(1-e^{-t/\alpha}) \times F + C_f$

where C_c = cold-start cost (MBtu)

F = fuel cost

C_f = fixed cost (crew + maintenance expenses) (in R)

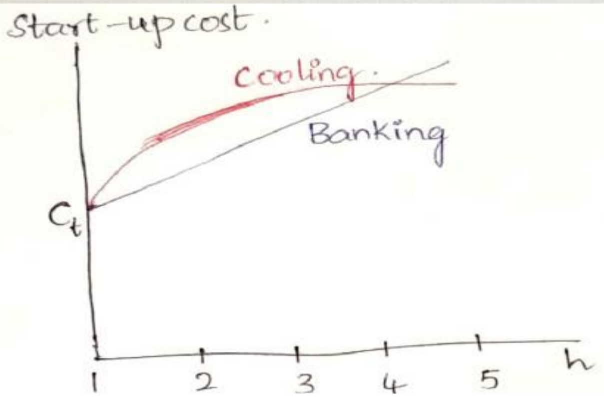
α = thermal time constant for the unit.

t = time (h) the unit was cooled.

* Start-up cost when banking $= C_t \times t \times F + C_f$.

where C_t = cost (MBtu/h) of maintaining unit at operating temperatures.

*. Upto a certain number of hours, the cost of banking will be less than the cost of cooling. as shown in Fig(a).



Fig(a).

1 2 3 4 5

e. Must Run: Some units are given a must-run status during certain times of the year for reason of voltage support on the transmission network or for such purposes as supply of steam for uses outside the steam plant itself.

f. Fuel Constraints: A system in which some units have limited fuel or else have constraints that require them to burn a specified amount of fuel in a given time.

.5. Explain the priority list method with a help of flowchart in unit commitment.

a. PRIORITY-LIST METHOD (PLM):

* The simplest unit commitment solution method consists of creating a priority list of units.
* The priority list could be obtained in a much simpler manner by noting the full-load average production cost of each unit, where the full-load average production cost is simply the net heat rate at full load multiplied by the fuel cost.

Full load average production cost = Net heat rate at full load × Fuel cost.

Assumptions:

1. No load cost is zero
2. Unit input-output characteristics are linear between zero output and full load.
3. Start up costs are a fixed amount.
4. Ignore minimum up time and minimum down time steps to be followed.

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ALGORITHM:

1. Determine the full load average production cost for each units.
2. Form priority order based on average production cost.
3. Commit number of units corresponding to the priority order.
4. Assume load is dropping or decreasing, determine whether dropping the next unit will supply generation and spinning reserve.
    a. If NOT, continue as it is
    b. If YES, goto the next step.
5. Determine the number of hours H, before the unit will be needed again.
6. Check H < minimum shut down time
    a. If NOT, goto the last step
    b. If YES, goto the next step.
7. Calculate two costs
    a. Sum of hourly production for the next H hours with the unit up
    b. Recalculate the same for the unit down + start up cost for either cooling or banking
    c. If Cost(b) < Cost(a), unit should be shut down, otherwise keep it on.
8. Repeat the procedure for next unit on the priority list.

PLM Merits:

1. No need to go for N combinations.
2. Considered only one constraint
3. Ignore the minimum up time and down time.
4. Complication reduced.

Demerits:

1. Start up cost are fixed amount
2. No load costs are not considered.