Unit 4

Section One: Reading Comprehens

The Distribution System

Although there is no 'typical' electric power system, a diagram including the several components that are usually to be found in the makeup of such a system is shown in Figure 4-1; particular attention should be paid to those

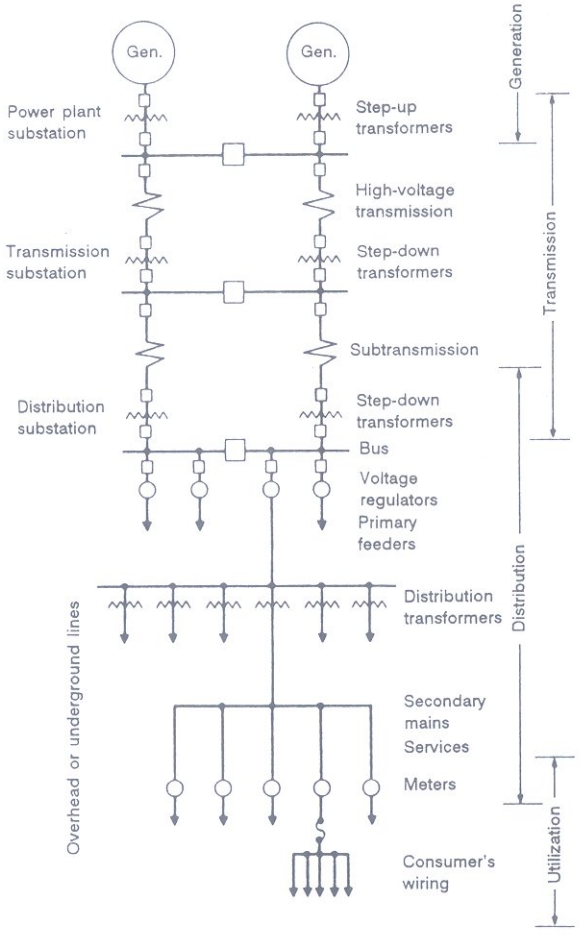

Figure 4-1. Typical Electric System Showing Operational Divisions. Note overlap of divisions.

elements which will make up the component under discussion, the distribution system.

While the energy flow is obviously from the power generating plant to the consumer, it may be more informative for our purposes to reverse the direction of observation and consider events from the consumer back to the generating source.

Energy is consumed by users at a nominal utilization voltage that may range generally from 110 to 125 V, and from 220 to 250 V, the nominal figures are 277 and 480 V, It flows through a metering device that determines the billing for the consumer, but which may also serve to obtain data useful later for planning, design, and operating purposes. The metering equipment usually includes a means of disconnecting the consumer from the incoming supply should this become necessary for any reason.

The energy flows through conductors to the meter from the secondary mains (if any); these conductors are referred to as the consumer's *service,* or sometimes also as the *service drop.*

Several services are connected to the secondary mains; the secondary mains now serve as a path to the several services from the distribution transformers which supply them.

At the transformer, the voltage of the energy being delivered is reduced to the utilization voltage values from higher primary line voltages that may range from 2200 V to as high as 46,000 V.

The transformer is protected from overloads and faults by fuses or so-called weak links on the high-voltage side; the latter also usually include circuit-breaking devices on the low-voltage side. These operate to disconnect the transformer in the event of overloads or faults. The circuit breakers (where they exist) on the secondary, or low-voltage, side operate only if the condition is caused by faults or overloads in the secondary mains, services, or consumers' premises; the primary fuse or weak link, in addition, operates in the event of a failure within the transformer itself.

If the transformer is situated on an overhead system, it is also protected from lightning or line voltage surges by a surge arrester, which drains the voltage surge to ground before it can do damage to the transformer.

The transformer is connected to the primary circuit, which may be a lateral or spur consisting of one phase of the usual three-phase primary main. This is done usually through a line or sectionalizing fuse, whose function is to disconnect the lateral from the main in the event of fault or overload in the lateral. The lateral conductors carry the sum of the energy components

flowing through each of the transformers, which represent not only the energy used by the consumers connected thereto, but also the energy lost in the lines and transformers to that point.

The three-phase main may consist of several three-phase branches connected together, sometimes through other line or sectionalizing fuses, but sometimes also through switches. Each of the branches may have several single-phase laterals connected to it through line or sectionalizing fuses.

Where single-phase or three-phase overhead lines run for any considerable distance without distribution transformer installations connected to them, surge arresters may be installed on the lines for protection.

Some three-phase laterals may sometimes also be connected to the three-phase main through *circuit reclosers.* The recloser acts to disconnect the lateral from the main should a fault occur on the lateral, much as a line or sectionalizing fuse. However, it acts to reconnect the lateral to the main, reenergizing it one or more times after a time delay in a predetermined sequence before remaining open permanently. This is done so that a fault which may be only of a temporary nature, such as a tree limb falling on the line, will not cause a prolonged interruption of service to the consumers connected to the lateral.

The three-phase mains emanate from a *distribution substation,* supplied from a *bus* in that station. The three-phase mains, usually referred to as a *circuit* or *feeder,* are connected to the bus through a protective circuit breaker and sometimes a voltage regulator. The voltage regulator is usually a modified form of a transformer and serves to maintain outgoing voltage within a predetermined band or range on the circuit or feeder as its load varies. It is sometimes placed electrically in the substation circuit so that it regulates the voltage of the entire bus rather than a single outgoing circuit or feeder, and sometimes along the route of a feeder for partial feeder regulation. The circuit breaker in the feeder acts to disconnect that feeder from the bus in the event of overload or fault on the outgoing or distribution feeder.

The substation bus usually supplies several distribution feeders and carries the sum of the energy supplied to each of the distribution feeders connected to it. In turn, the bus is supplied through one or more transformers and associated circuit breaker protection. These substation transformers step down the voltage of their supply circuit, usually called the *subtransmission* system, which operates at voltages usually from 23,000 to 138,000 V.

The subtransmission systems may supply several distribution substations and may act as *tie feeders* between two or more substations that are either of

the *bulk power* or *transmission* type or of the distribution type. They may also be tapped to supply some distribution load, usually through a circuit breaker,

for a single consumer, generally an industrial plant or a commercial consumer having a substantially large load.

The transmission or bulk power substation serves much the same purposes as a distribution substation, except that, as the name implies, it handles much greater amounts of energy: the sum of the energy individually supplied to the subtransmission lines and associated distribution substations and losses. Voltages at the transmission substations are reduced to outgoing subtransmission line voltages from transmission voltages that may range from 69,000 to upwards of 750,000 V.

The transmission lines usually emanate from another substation associated with a power generating plant. This last substation operates in much the same manner as other substations, but serves to step up to transmission line voltage values the voltages produced by the generators. Because of material and insulation limitations, generator voltages may range from a few thousand volts for older and smaller units to some 20,000 volts for more recent, larger ones. Both buses and transformers in these substations are protected by circuit breakers, surge arresters, and other protective devices.

In all the systems described, conductors should be large enough that the energy loss in them will not be excessive, nor the loss in voltage so great that normal nominal voltage ranges at the consumers' services cannot be maintained.

In some instances, voltage regulators and capacitors are installed at strategic points on overhead primary circuits as a means of compensating for voltage drops or losses, and incidentally help in holding down energy losses in the conductors.

In many of the distribution system arrangements, some of the several elements between the generating plant and the consumer may not be necessary. In a relatively small area, such as a small town, that is served by a power plant situated in or very near the service area, the distribution feeder

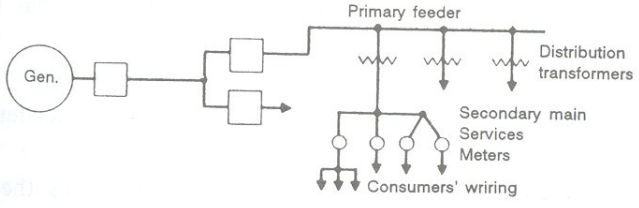

Figure 4-2. 'Abbreviated' Electric System.

may emanate directly from the power plant *bus*, and all other elements may be eliminated, as indicated in Figure 4-2. This is perhaps one extreme; in many other instances only some of the other elements may not be necessary; e.g., a similar small area somewhat distant from the generating plant may find it necessary to install a distribution substation supplied by a transmission line of appropriate voltage only.

In the case of areas of high load density and rather severe service reliability requirements, the distribution system becomes more complex and more expensive. The several secondary mains to which the consumers' services are connected may all be connected into a mesh or network. The transformers supplying these secondary mains or network are supplied from several different primary feeders, so that if one or more of these feeders is out of service for any reason, the secondary network is supplied from the remaining ones and service to the consumers is not interrupted. To prevent a feeding-back from the energized secondary network through the transformers connected to feeders out of service (thereby energizing the primary and creating unsafe conditions),automatically operated circuit breakers, called *network protectors,* are connected between the secondary network and the secondary of the transformers; these open when the direction of energy flow is reversed.

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answer

..... 1. The text describes the distribution elements used between the power generating plant and the consumer.

..... 2. The metering device is mainly used to offer data useful for design and operating purposes.

..... 3. The three-phase main may consist of several three-phase branches which in turn may consist of several single-phase laterals.

..... 4. Any power system must have secondary mains in order to supply the consumer with energy through the services.

..... 5. Primary feeders are connected to the substation bus via voltage regulators or protective circuit breakers.

..... 6. The voltage regulator is the same as the transformer.

..... 7. Subtransmission systems may be used as tie feeders between different types of substations.

..... 8. The closer the power plant to the area it serves the fewer the elements between the generating plant and the consumer.

9. Distribution transformers may directly supply the consumer with

energy.

10. The elemental arrangement in a complex distribution system is so that service interruption is improbable.

B. Choose a, b, c, or d which best completes each item.

1. It is true that ..... .

a. circuit breakers disconnect the high-voltage side of the transformer in the event of overloads

b. fuses and circuit breakers are identical devices

c. fuses are weak links always installed on the secondary side of the transformer

d. circuit breakers protect the high-voltage side of the transformer in the event of overloads

2. The distribution transformer ..... .

a. is connected to the primary circuit through a line or sectionalizing fuse

b. is connected to the primary main through a line or sectionalizing fuse

c. helps to disconnect the lateral from the main in the event of fault or overload

d. helps to disconnect the consumers from the services in the event of fault or overload

3. A circuit recloser is used to ..... .

a. connect a three-phase lateral to the three-phase main

b. disconnect the lateral from the main if a fault occurs on the lateral

c. reconnect the lateral to the main after a predetermined time delay

d. all of the above

4. It is true that ..... .

a. the substation bus supplies substation transformers

b. substation transformers supply the substation bus

c. the substation bus is supplied by the distribution feeders

d. substation transformers are the same as subtransmission systems

5. The bulk power substation handles the energy supplied to ..... .

a. the subtransmission lines and associated substations

b. the substation bus and the primary feeders

c. the distribution transformers and the meters

d. the secondary mains and associated services

6. According to the text, ...

a. material and insulation limitations do not allow the generators to work at their full capacities

b. material and insulation limitations have resulted in the use or various protective devices to protect the generators

c. the voltages produced by the generators are stepped up in the substation associated with the power plant

d. the voltages produced by the generators are reduced to usable voltages in the substation associated with the power plant

7. The last paragraph mainly describes ..... .

a. consumers' service interruption b. consumers' service reliability

c. a complex distribution network d. a complex distribution system

C. Answer the following questions orally.

1. What is called the service?
2. What is the function of a surge arrester?
3. What does a lateral refer to?
4. What is the function of a voltage regulator?
5. What part does the substation bus play in the distribution system?
6. Where do the transmission lines originate from?
7. What is the function of a capacitor installed on an overhead primary circuit?
8. When does the distribution system become more complex?
9. What is a network?
10. How do network protectors help a distribution system?

Part IL Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The ..... deliver electric energy from the secondary distribution or street main, or other distribution feeder, or from the transformer, to the wiring system of the premises served.

a. meters b. buses

c. services d. feeders

2. The function of ..... is to interrupt circuit faults.

a. a line b. a service

c. a main d. a transformer

3. A ..... serves as a common connection for two or more circuits.

a. fuse b. switch

c. lateral d. bus