CHAPTER 14

MICROWAVE POWER SUPPLIES

The reliability of a microwave radio relay system depends to a large degree upon the reliability of the source of power at each station. Since the reliability of the power source can be made to approach 100 percent through the use of primary and standby power sources and automatic switching devices, the determination of primary and standby power requirements must be made on the basis of system reliability specifications and economic considerations. The most common sources of primary and standby power will be discussed here, and comparisons will be made between several types of generating mechanisms. Recommendations will also be made in an effort to reduce the number of options and thereby simplify the task of the system planner.

14.1 ANALYSIS OF PRIMARY POWER SOURCES

Two primary power sources will be considered: one is a large scale commercial (or possibly private or military) power plant and the other an independent on-the-site generating plant. Of course, one usually thinks of the commercial power source in terms of the nearest power transmission line. For the larger terminal stations in the United States, the choice of commercial power is almost taken for granted because power lines are likely to be available at such sites. For stations at remote sites, the choice of an independent power plant may also be taken for granted since power lines are not likely to be nearby. But for the majority of stations, a comparison must be made between the installation and occasional maintenance costs of service lines to existing power lines and the installation, regular maintenance, and depreciation costs of an independent power plant, before a decision can be made. The following paragraphs present the factors which should be considered in order to arrive at the most satisfactory conclusions.

14.2 COMMERCIAL POWER

The use of power from a large scale commercial power plant is highly desirable if commercial power lines are available and if the power characteristics are compatible with radio relay equipment requirements. Information concerning commercial power lines and power characteristics can be obtained from the report of the field survey. The frequency must be between 50 and 60 Hz, and the nominal voltage should be 115 volts or 230 volts. If the radio relay equipment is not adaptable to 230-volt operation, a 2:1 stepdown transformer can be employed to provide 115 volts. Likewise, single-phase requirements can be met by means of transformer arrangements. The line-voltage tolerance need not meet the system requirements of $\pm 5\%$, but it must meet the input range of available voltage regulators 95 to 130 volts. The power handling capacity of the lines must also be ascertained; this is particularly important for long lines in remote areas and for large stations with heavy power demands. Commercial power must also meet the standards of dependability that can be established by the system planner. Obviously, the outage time of primary power cannot exceed the maximum operating period of standby power equipment. This requirement should not be difficult to meet if weather conditions are not unusually severe. The measure of dependability will therefore be based on an estimate of the line maintenance problems that will be encountered in times of heavy snow or ice, high wind, or high water. The possible frequency of such occurrence will naturally enter into this estimate.

In addition, the initial cost of installing power lines from existing lines to the radio relay site and the cost of maintaining these lines must be calculated and/or estimated.

14.3 INDEPENDENT PRIMARY POWER (SIZING)

An alternative to the use of commercial power is the generation of primary power on the site. One of the most economical and convenient methods of doing this is by the use of an internal combustion engine and a generator. The diesel engine generator is preferred for primary power service.

A recommended independent power source uses two separate diesel engine generator sets, connected through a common panel so that the load can be transferred from one to the other every 48 hours, or whenever the failure of one of the units makes such a transfer necessary. The output voltage of these generators should be 115 volts AC, regulated within the limits of $\pm 5\%$ to eliminate the need for separate voltage regulators.

The size of the engine generators depends upon the power requirements of the station. The capacity of the fuel tank for these units depends upon the accessibility of the site and the size of the engine generators. It should not be necessary to refill the fuel tanks more than once a month. If inclement weather or undue hardship makes necessary a longer period of time between refuelings, a larger tank is recommended. The approximate rate of fuel consumption, in gallons per hour, of a diesel driven generator can be calculated by multiplying the output in kilowatts by 0.136; this calculation will be helpful in determining the size of tank needed.

14.4 STANDBY POWER (EMERGENCY POWER) SOURCES

Several secondary power sources for standby or emergency service are considered here. The most common standby setup is described first; this setup can be used only when a short outage time for switchover purposes is permissible. Two other equipment arrangements, which are applicable when no outage time is permitted, are then described.

14.5 COMMON STANDBY POWER SOURCE

When the system reliability requirements are not too stringent, a gasoline engine generator set is adequate for standby service. An automatic transfer panel is required for proper utilization of the standby engine generator. This panel normally connects the load to the primary power source. If the line voltage falls below the required minimum value for a period of 3 to 5 seconds, the engine is started. When the engine generator output exceeds the minimum voltage value, the load is transferred from the primary power terminals to the standby generator terminals. Normally, the load is supplied by the standby engine generator for approximately 15 minutes, then is switched back to the original condition if primary power is restored. The size of the engine generator required depends on the power requirements of the station.

In addition to the automatic transfer panel, a starting battery and battery charger must be provided. Protective controls usually include an over-cranking limiter, a low-oil-pressure cutout, and a high-temperature cutout. Radio interference suppressors are normally furnished. Crankcase immersion heaters are available for quicker cold weather starting. The capacity of the fuel tank depends upon the size of the engine generator and the reliability of the primary power source.

14.6 CONTINUOUS SERVICE POWER SOURCES

For system specifications that call for a high degree of reliability, where engine starting time and switching interruptions cannot be tolerated, a more extensive standby power source is required. At least two types of continuous service power systems are available. One type employs an AC motor, an AC generator, and a gasoline engine (figure 14-1). The motor is mechanically connected to the generator, and the engine is linked to the generator by means of a magnetic clutch. When primary power is available, the AC motor drives the generator, which furnishes power to the station load. In this condition, the magnetic clutch is de-energized; therefore, the engine is disconnected from the generator. If the primary power fails, the magnetic clutch is energized, and the engine is cranked by the rotational energy of the generator. The engine starts and becomes the prime mover of the generator, which continues to furnish power to the load throughout the operation. In addition, the AC motor is disconnected from the primary power line. When primary power is restored for a continuous period of at least 10 minutes, the magnetic clutch is de-energized, the AC motor is reconnected to the primary power line, and the engine is stopped.

Another type of continuous service power system employs an AC motor, an AC generator, a DC motor, and a group of storage batteries. The two motors and the generator are mechanically connected so that they rotate together. Normally, the AC motor, which is supplied by the primary power source, is the prime mover, and the AC generator furnishes power to the load. In this condition the DC motor acts as a DC generator which charges the batteries. If the primary power fails, the DC motor receives power from the batteries and becomes the prime power. The AC generator continues to furnish power to the load. The batteries must have sufficient capacity to supply power for the maximum anticipated outage time of the primary power source. For stations where it is impracticable to meet this requirement, a separate engine generator can be employed to supply power to the DC motor and batteries if the primary power failure is of long duration.

14.7 COMPARISON OF ENGINE GENERATORS

The selection of an engine generator for use as an independent power source (primary and/or standby) will depend on several factors. The selection is usually between

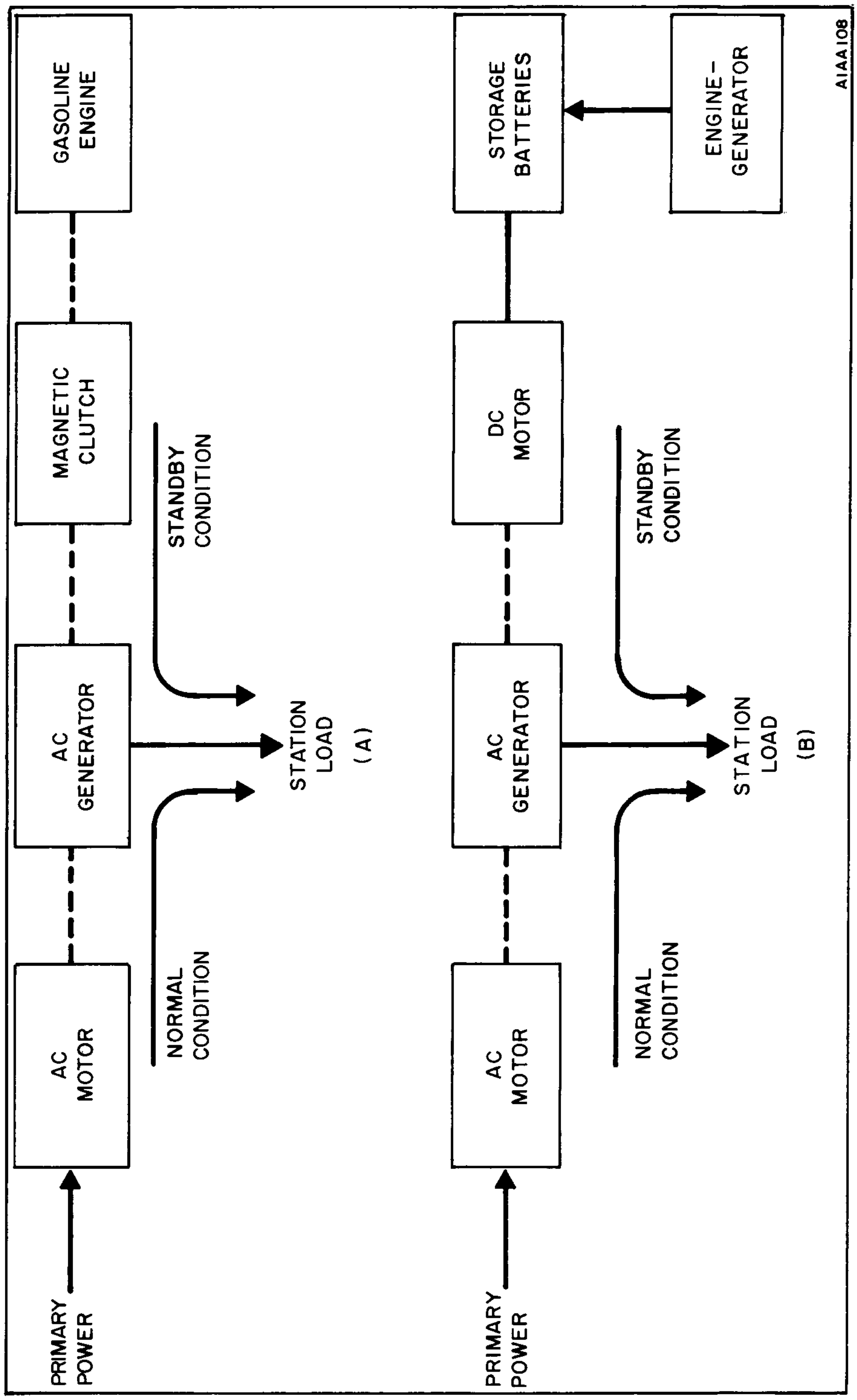

Figure 14-1. Continuous-Service Power Sources, Block Diagram

a diesel and a gasoline engine. Each has its own characteristics which determine its suitability for a particular application.

The diesel engine is suitable for either continuous or part-time service. The initial cost of a diesel engine is slightly higher than that of a comparable gasoline engine. For certain applications, however, this disadvantage is more than offset by other advantages. The diesel engine is extremely rugged, it uses less and lower cost fuel, it has a long life expectancy, and it offers maximum reliability. Several reasons for these advantages are: diesel fuel has a higher energy content than gasoline or liquid petroleum, the operating speed of the diesel engine is approximately half that of the gasoline engine, and the diesel engine does not require an electrical ignition system. The last two factors mentioned account for the lower maintenance and overhaul costs for the diesel engine. Engine starting time is comparable for diesel and gasoline engines.

Gasoline engines can be used for continuous duty, but are better suited for standby use. As previously mentioned, the gasoline engine is lower in initial cost, but has a shorter life expectancy. It has a higher operating speed, which wears the engine out more rapidly. It uses more and higher cost fuel, and it is not as reliable as a diesel engine. This is true because a gasoline engine uses the well known electrical ignition system which is subject to failure due to dampness, age, and carbon buildup.

Liquid petroleum engines are basically gasoline engines with a modified fuel intake system. The conversion cost to liquid petroleum is modest, but the conversion results in a 10 percent reduction in horsepower. This is true because there is less energy per gallon in liquid petroleum than in gasoline. Liquid petroleum is a highly volatile type of fuel consisting of butane and propane combined in varying percentages, depending on the operating temperatures and geographical locations. Engines using this fuel are generally not economically competitive with gasoline or diesel engines.

Fuel energy is measured in British thermal units; this system of measurement gives a comparison of the power possibilities of different fuels.

The factor of personnel safety is also an important consideration in the choice of fuel. Gasoline and liquid petroleum are very volatile, and constitute a safety hazard. The possibility of fires or explosions, therefore, is much greater with these fuels than with diesel fuel. Diesel fuel is not highly volatile, and is, therefore, quite safe.

The two graphs shown in figure 14-2 show the initial cost plus cumulative fuel costs, plotted against time of operation for diesel and gasoline engine generators.

The graphs are for a 10 kW generator operating at full load and at half load. The fuel prices used were 15 cents per gallon for diesel fuel, and 25 cents per gallon for

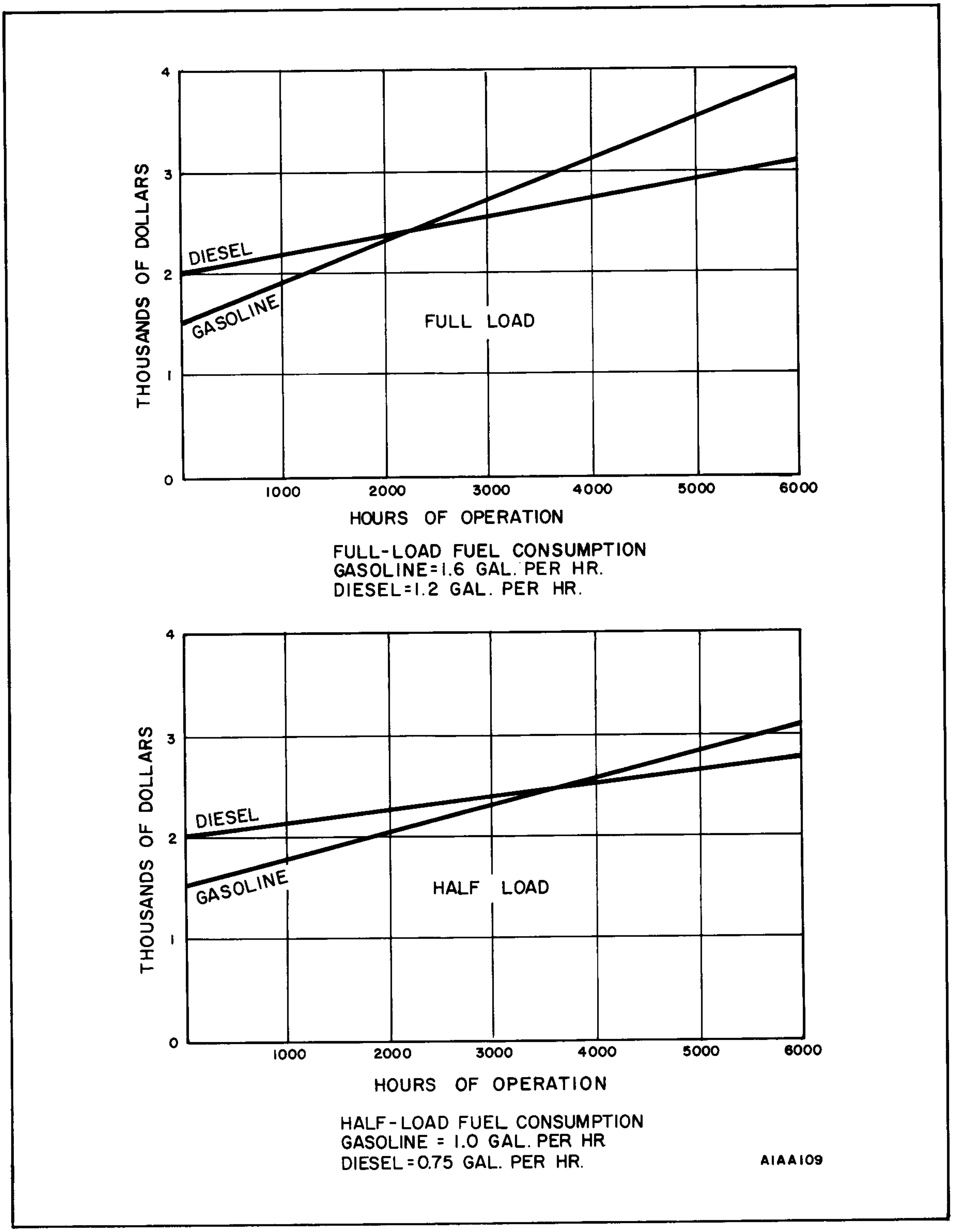

Figure 14-2. Comparison of Engine-Generators, Diesel and Gasoline

gasoline. The crossover point, which shows the number of hours of operation required to equalize the costs, can be computed as follows:

$$\left(\text{Gallons of gasoline used per hour} \times \text{Cost of gasoline}\right) - \left(\text{Gallons of diesel fuel used per hour} \times \text{Cost of diesel fuel}\right) = \text{Net savings per hour using diesel engine generator}$$

$$\frac{\text{Extra cost of diesel engine generator}}{\text{Net savings per hour using diesel engine generator}} = \text{Number of hours needed to equalize costs}$$