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Chapter 1 Significance and Basics of Power Systems 1.1 Introduction Modern world heavily depends upon electric grids for critical service capabilities such as healthcare, transportation, household heating and cooling and industrial manufacturing etc. Grid integrity more often effected by many reasons such as energy delivery systems age, natural disasters and man-made mistakes. Furthermore, urban infrastructure energy delivery networks are highly reliant on the electric grid and consequently, the vulnerability of infrastructure networks to electric grid outages is becoming a major national concern, Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. Essentially an electrical grid is an interconnected network for delivering electricity from producers to consumers. It consists of generating stations that produce electrical power, high voltage transmission lines that carry power from distant sources to demand centres and distribution lines that connect individual customers or businesses. Transmission lines are a vital part of the electrical distribution system, as they provide the path to transfer power between generation and load. Transmission lines operate at voltage levels ranging from 100kV to 1000kV. These transmission lines are interconnected for reliable operation of the electric grid. In recent years many new technologies such as advanced sensors, intelligent automation, communication networks have been integrated into the electric grid to enhance its performance and efficiency. In recent years, power quality has become the main concern in power systems engineering with major power systems faults occurs on distribution lines. The faults that occur on the transmission lines have a more significant and widespread impact on the consumers. The performance of a power system is affected by faults on the transmission lines, which results in interruption of the power flow. As the power system configuration becomes more complex quick detection of faults and accurate estimation of fault location is critical. The rapid repair, restoration of the power supply is essential for minimizing the local and regional economic impacts, reducing overall power outages and improving customer satisfaction. When a fault occurs in the transmission line, it initiates a transition condition. Transients produce overcurrents in the power system, which can damages power system equipment's depending upon severity. Transmission protection systems are designed to identify the faults and isolate only the faulted section of the network with compromising the network security of the system with significant accuracy. With the advent of new measurement devices like phasor measurement units (PMU), digital fault recorders (DFR) are often used to provide detailed information about the health of the grid. These operating technologies (OT) in power systems led to a massive amount of data from the monitoring of transmission lines. Using machine learning algorithms with that data opens potential to implement smart and robust fault diagnosis methods. 1.2 Basics of Power systems Fig.1 Building Blocks of Electric Power System Electric power systems are real-time energy delivery systems. Real-time means power is generated, transported and supplied the moment the switch is turned on. Electric power systems are not capable of storing the generated energy like water systems and gas systems. The generator produces energy as demand calls for it. Fig.1 shows the basic block diagram of the electric power system. The power system consists of three major part generation, transmission and distribution. In the generating stations, electrical energy is produced and then transformed in the power stations to high voltage electrical energy that is more suitable for long-distance transportation. The generating stations transform other sources of energy into electrical energy. For example, thermal, hydraulic, chemical, solar, wind, geothermal, nuclear and other sources of energy are used in the production of electrical energy. High voltage (HV) power lines in the transmission portion of the electric power system will transport the electrical energy from generating stations to long distances to the consumer locations. Finally, the substations at the remote locations are transforming this HV electrical energy to lower high voltage power lines called "feeders" that are most suitable for distribution of electrical energy. This electrical energy is again transformed to even lower voltage services for residential, commercial and industrial consumption. The power generation and distribution have four stages: 1) Generation: Power plants will produce electrical energy that is ultimately delivered to the consumers through transmission lines, substations and distribution lines. Electrical energy must be generated at the same rate as it is consumed. A sophisticated control system is required to ensure that the power generation closely matches with the consumption. 2) Transmission:

Transmission lines are necessary to carry high-voltage electricity over long distances and connect generators to consumers. Transmission line voltages are typically at above 110kV, with some transmission lines are even operating at 765kV. Power generators, however, produce electricity at lower voltages. The generated voltage is stepped-up to transmission voltages with the help of step-up transformers. 3) Distribution: Distribution systems are responsible for delivering electrical energy from distribution substation. Most of the distribution systems in India operates at 11kV. These networks carry power to consumers like a business and residential entities. 4) Load: This stage accounts for electrical energy used by various loads on the power system. Electricity is consumed and measured several ways depending on whether the load is residential, commercial, or industrial and whether the load is resistive, inductive, and capacitive. 1.3 Power Transmission Networks High voltage transmission lines transmit power long distances much more efficiently due to two reasons. First, high voltage transmission lines offer less resistive loses over distribution lines. Secondly, raising the voltage to lower the current one to use lower conductor size, or have more conductor capacity available for growth. Transmission lines systems relay the power from production sites to the users. Failure of these structures can lead to power cuts and therefore disrupt the day to day life of people as well as the industries dependent on electricity.

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