LIGHTNING AND SURGE PROTECTION

1. GENERAL

1.01 This section discusses and provides standards for lightning and surge protection of ac-powered equipment and apparatus. These standards are provided for use in the design of new buildings or building additions that are intended to house telephone equipment that meets the requirements of Section 800-610-164, "New Equipment-Building System (NEBS), General Equipment Requirements."

1.02 This section supersedes Section 8.4 of Specification X-74300, "NEBS Building Engineering Standards (BES)." Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 Experience has shown that ac-powered apparatus, especially solid-state types, are vulnerable to misoperation and damage from the effects of lightning and switching surges and other overvoltage disturbances that couple into the ac system. Damage to the equipment can be accompanied by electrical fires and a loss of commercial power.

1.04 Since elimination of these overvoltages is not possible, protection devices must be installed at strategic points in the ac plant to absorb the surge energy so that the generated voltages and currents do not exceed damage levels in the equipment.

2. COUPLING OF SURGES

2.01 Lightning energy can couple into the ac system in several ways: by a direct stroke on the overhead service line (Fig. 1); by capacitive and inductive coupling from the primary side to the secondary side of the commercial power transformer (Fig. 2 and 3); and by lightning ground current flow, due to nearby discharges directly to ground through the common ground impedance paths in the grounding network (Fig. 4).

2.02 Harmful switching surges are sometimes caused by power utility company switching (switching of power factor correcting capacitors, for example) and/or by load switching within the telephone building (switching of ac and dc power conversion equipment and elevator loads).

2.03 Other overvoltage disturbances can be generated by the resonating circuits associated with commutating devices (regulating silicon-controlled rectifiers) and by various fault conditions (arcing faults).

3. CHARACTERIZATION OF THE OVERVOLTAGE SURGE (WITH NO SECONDARY PROTECTION)

3.01 Attempts to characterize these surges, from a voltage-waveshape standpoint, with oscilloscope-camera arrangements and peak level detectors have been successful. In all cases, the surge appears as a damped oscillation randomly superimposed upon the 60-Hz power wave. Line-to-neutral measurements on residential and industrial power circuits (without secondary protection) show frequencies as high as 300 kHz with a peak voltage value as high as 5600 volts. Measurements on the 60-Hz power supply to telephone plants have shown frequencies between 5 and 20 kHz with peak voltage values over 1500 volts. (This voltage was selected as the highest recording level, because voltages above this value are well within the zone of high probability of damage to equipment.)

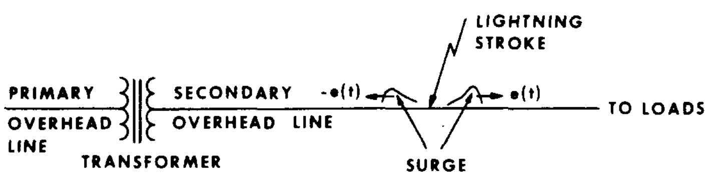

Fig. 1—Direct Stroke Effects

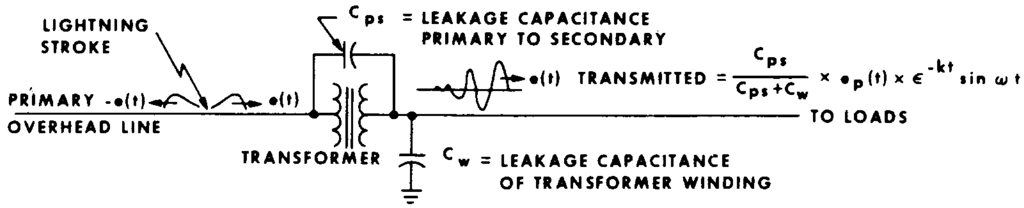

Fig. 2—Capacitive Coupling Effects

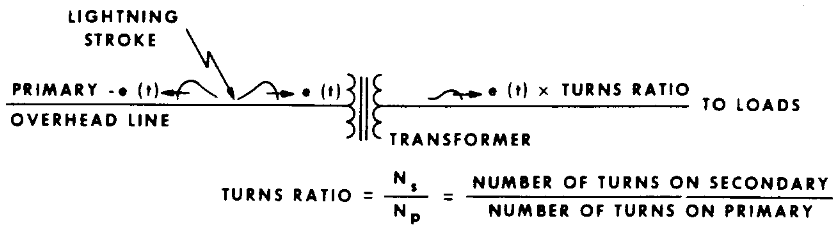

Fig. 3—Inductive Coupling Effects

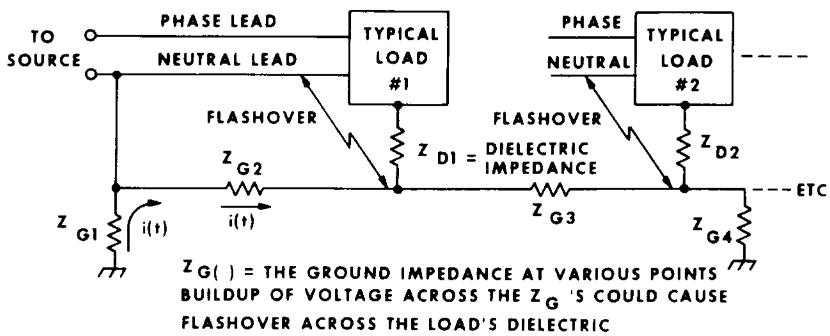

Fig. 4—Ground Impedance Effects

3.02 In lightning-prone areas, 3 percent of the voltage surges can be expected to exceed a 1000-volt peak. This is the voltage level at which the probability of damage to equipment begins to increase rapidly, becoming almost a certainty at the 2000-volt level.

4. RECOGNITION OF PROTECTION NEED

4.01 The need for lightning protection depends on the frequency and severity of thunderstorms. (Data on the annual number of thunderstorm days is given in Section 876-100-100.) However, "natural" protection from nearby structures, such as taller buildings that shield lower structures and power distribution lines (large cities), often precludes the need for protection even though the area is exposed to severe thunderstorm activity. Nevertheless, when there is doubt regarding the need, protection on the ac power line should be installed.

PROTECTION INSTALLATION ARRANGEMENTS

4.02 Detailed protection arrangements for specific types of telephone plants are covered on the SD and ED drawings listed in Part 7.

5. GROUNDING REQUIREMENTS

5.01 Efficient surge protection operation attempts to limit the voltage stress across the dielectric materials that provide the insulation between "live" parts and ground. This operation is directly related to the impedance value of the ground return paths within a building. (This is not to be confused with the protection requirements for the circuit components themselves, which involve limiting the voltage stress from line-to-neutral and line-to-line.) The simplified circuit in Fig. 4 shows a typical ground current, i(t), from a nearby lightning discharge flowing through a ground impedance, Z_{G2}. This may cause a voltage of sufficient magnitude across the dielectric Z_{D1} to cause a flashover across the dielectric material of the load. For this reason, the need to ground the neutral conductor of the ac system and to reduce the ground impedance at the site to an acceptable value is of primary importance. Information on the aspects of grounding is covered in the Sections listed in Part 7.

6. PRIMARY, SECONDARY, AND TERTIARY PROTECTION

6.01 A convenient terminology has been developed to define the location where the lightning and surge protection is connected within the ac power system. Protection on the high-voltage (above 600 volts) side of the system is called primary protection; protection on the immediate secondary side of the high-voltage, step-down transformer is called secondary protection; protection at or close to the utilization loads is called tertiary (or branch) protection. Figure 5 shows these locations on a simplified one-line diagram.

6.02 All three levels of protection are sometimes required because each performs a distinct function. The primary protection device is the "first line of defense" because of its high energy-absorbing capability. However, the voltage clamping level is generally high and exceeds that acceptable to the system. The role of the secondary protection device, therefore, is to reduce overvoltage levels, further absorbing the surge energy. Lastly, the tertiary protection device is used to limit the voltage and surge energy levels at the input to the loads to values below the flashover level of dielectric and circuit component paths. This prevents damage to the overall circuit. Tertiary protection is not capable of absorbing large amounts of surge energy and has a limited duty cycle. It is thus susceptible to damage if closely spaced discharges appear on the system.

6.03 Coordination of these protection levels is best accomplished when the devices are located in the system so that several ohms of surge impedance (either from a transformer or a length of conductor) are provided between the connection points. This helps attenuate the magnitude and change the waveshape of the surge permitting the protection devices to turn on and discharge the energy more efficiently.

7. REFERENCES

1. Section 802-001-180—Protective Grounding Systems for Power Plants—General Equipment Requirements—Power Systems

2. Section 802-001-190—Protective Grounding Systems—Equipment Ground Systems Material—General Equipment Requirements —Power Systems

3. Section 802-001-190—Protective Grounding Systems—Office Ground Electrodes—Power Systems

4. Section 802-001-192—Protective Grounding Systems—Equipment Ground System—Central Offices (CO GRD)

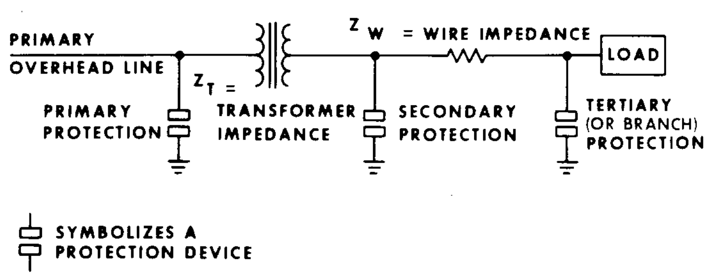

Fig. 5—Protection Levels

5. Section 802-001-194—Protective Grounding Systems—Equipment Ground System—Central Offices—General Interface Requirements for Manual Toll Relay Rack Ground System

6. Section 802-001-195—Protective Grounding Systems—Equipment Ground System—Central Offices—General Interface Requirements for Electronic Switching Systems—Power Systems

7. Section 802-001-197—Protective Grounding Systems—General Equipment Requirements for Microwave Radio and Auxiliary Stations

8. Section 802-001-198—Protective Grounding Systems—General Equipment Ground Requirements for AC Service Distribution Systems in Buildings Housing Communication Systems—Power Systems

9. Section 876-100-100—Electrical Protection Principles

10. Section 876-101-100—Electrical Protection Devices—Central Office Protection

11. Section 876-200-100—Electrical Protection—General Offices

12. Section 876-210-100—Protection Practices—Lightning Protection for Radio or Microwave Relay Stations

13. Section 876-700-100—Protection Practices—Characteristics and Measurement of Grounds

14. Section 876-701-100—Protection Practices—Earth Resistivity Measurement Use of Ground Megger

15. SD-81094-01—Power Systems—TD-2 Radio Grounding Circuit for Repeater Stations

16. SD-81095-01—Power Systems—400-Type Plants—Power Service Circuit Commercial and Engine Distribution—TD-2 Microwave Stations—425A Plant

17. SD-81140-01—Power Systems—400-Type Plants—Power Service Circuit Using a Single Bay for AC Distribution Engine Distribution Only—TD-2 Microwave Stations—425A Plant

18. SD-81704-01—Power Service and Distribution Circuit for TJ Radio Using Auto-Start Diesel-Alternator as Standby

19. SD-81731-01—Power Systems—TH Radio Power Service and Distribution for TH Microwave Stations—520A Plant

20. SD-81782-01—Power Systems—TH Radio Grounding Circuit for TH Microwave Stations

21. ED-2H085-01—Electronic Switching Systems—No. 2A AC Surge and Lightning Protection

22. SD-81968-01—Power Systems—AC Distribution and Service Circuits—Lightning Arresters for Telephone Offices Application Schematic

23. ED-82372-30—Power Systems—AC Distribution Lightning Arrestor for Telephone Offices

24. IEEE STD28-1972 (ANSI C62.1-1971)—IEEE Standard for Surge Arresters (Lightning Arresters) for Alternating-Current Power Circuits

25. IEEE Committee Report—Bibliography on Surge Voltages in AC Power Circuits Rated 600 Volts and Less

26. Fire Protection Association National Electric Code—Code for Protection Against Lightning (NEPA No. 78 File To)—Copyright 1957—Series Electrical National

8. AC PLANT ELECTRICAL PROTECTION STANDARDS

8.01 Install lightning and surge protection in the ac plant where the need is obvious and when there is possible doubt regarding its need.

8.02 Install protection devices at strategic points in the ac plant to absorb the surge energy as a protection for equipment damage.

8.03 Use three levels of protection as shown in Fig. 5.

8.04 Bell System documents have precedence over other referenced documents. Follow referenced sections, where applicable, and SD and ED drawings covering protection for specific types of telephone plants.

8.05 Follow SD-81968-01 and ED-82372-30 to provide protection for telephone offices served by overhead utility lines in lightning-prone areas and ***not*** covered by the dedicated drawings.