5.0 TYPES OF ELECTRICAL CIRCUITS

Note: The following discusses circuitry as applicable to conventional incandescent lamped light fixtures. This may change with the application of light fixtures using LED (light emitting diode) design (refer chapter 14).

IEC 61820 provides system design and installation requirements for constant current series circuits for aeronautical ground lighting.

5.1 Electrical characteristics

5.1.1 Electrical power for aerodrome lighting aids is almost entirely alternating current (AC) at 50 or 60 hertz. Both series and parallel circuits are used for lighting installations. At large aerodromes having lengthy runways and large number of taxiway, the lighting design is primarily based on series circuitry. At smaller aerodromes with short runways, the installation may be based upon parallel circuitry. Parallel circuitry is also used for sequence-flashing lights of approach lighting systems although these may if necessary be powered from a series circuit using conversion adaptors. Facilities such as apron floodlighting and obstacle lighting are primarily parallel circuit.

5.2 Series circuits

5.2.1 The circuit elements of series circuits are connected in a string with the same current flowing in each element. The circuit is one continuous loop starting and ending at the output terminals of the constant current regulator.

In the case of a parallel circuit and fixed input voltage, the current in the circuit would vary with the connected load. The constant current regulators of a series circuit, however, maintain a constant current independent of the load on the circuit. Thus the same current will flow in a long circuit as in a shorter circuit and will remain the same even if some of the lamps fail. This constant current means that a short-circuit across the output of a constant-current regulator is a no-load condition and an open-circuit is an overload. In a simple direct-connected series circuit, a lamp failure causes an open-circuit; hence, it necessary to provide an AGL transformer, as part of the circuit design. The AGL maintains continuity of the circuit with lamp failure. Where a single transformer is used to supply several light units as shown in Figure 5-1, a by-pass device is incorporated to ensure continuity on the secondary side.

5.2.2 Advantages of series lighting circuits. Some of the advantages of series circuits for aerodrome lighting are:

(a) All lamps are operating at the same current and thus at the same intensity;
(b) A single-conductor cable of one conductor size and insulation voltage rating can be used throughout the circuit;
(c) Intensity control of the lights can be obtained over a wide range;
(d) The circuit may have a single ground fault at any point along the circuit without affecting the operation of the lights; and
(e) Ground faults are easy to locate.
(f) The lamps used for series circuits are high-current low-voltage. For example, a runway edge light may contain a 6.6 ampere, 12 volt lamp. The low voltage enables the use of a compact filament which facilitates optical control through means of lensing.

![Series Lighting Circuit Diagram](image)

**Figure 5-1: Series Lighting Circuit**

5.2.3 Disadvantages of series lighting circuits. The major disadvantages of series circuits when used for lighting are:

(a) installation costs are high - the constant-current regulator and the isolating transformers add appreciably to this cost;
(b) an open-circuit fault anywhere in the primary side of the circuit makes the entire circuit inoperative and possibly may damage cable insulation or the constant-current regulator; and
(c) location of faults, especially open-circuit faults, may be difficult.

5.3 PARALLEL (MULTIPLE) CIRCUITRY

5.3.1 The use of parallel (multiple) circuits for aviation ground lighting is not recommended for large aerodromes and/or complicated lighting systems for the following reasons:

(a) parallel circuits usually entail a much more expensive cabling installation than does a high-voltage series circuit;
(b) accurate intensity balance between all lights in the pattern cannot be obtained easily; and
(c) the mass burn out of lamps in a circuit is much more likely due to the inability of average voltage regulators to control very rapid fluctuations in incoming supply volts.

5.3.2 In view of these considerations, parallel circuits should preferably be used when there are only a few fittings existing in the circuit and accurate intensity balance is not critical; for example, a short taxiway. Smaller aerodromes with short runways and taxiways can employ parallel voltage for the lighting.
5.3.3 Effects of faults. If the light fixtures are connected across the lighting circuit, a burned-out lamp or an open-circuit fault in a fixture does not seriously affect this lighting circuit, but a short-circuit fault will be an overload condition and, depending on which protective device (fused or circuit breaker) operates, may make the circuit of lights inoperative. To protect the lighting circuit, often each lamp is connected to the line voltage side of the circuit by a fuse.

5.3.4 Voltage characteristics. Most parallel-type light fixtures are designed for low applied voltages (less than 300 volts), and the circuit voltage is that required by the lamps or step-down transformers are used. The lights may be supplied from a single circuit connected between the line and neutral or by alternating between neutral and line voltage on each side of the neutral. Examples of these circuits are 120 volts line-to-neutral and 240/120 volts (240 volts line-to-line and 120 volts line-to-neutral) circuits. Other voltages are often used. Usually the cable insulation of parallel lighting circuits is rated at 600 volts, which limits the voltage for parallel lighting circuits to not more than 500 volts.

5.3.5 The circuit elements of parallel (multiple) circuits are connected in parallel across the conductors to which the input voltage is applied. In theory the same voltage is applied to each light; however, the current through the conductors causes a decrease in voltage (line drop) which for longer circuits may reduce appreciably the voltage to, and consequently the intensity of, the lights at the far end of the circuit. In distribution circuits where the voltage may be high and the current low, the voltage drop in the lines is less important, and parallel circuits are often used for such circuits. If intensity control of the lights is required, tapped transformers of induction-voltage regulators may be used, but these increase the cost of the installation and reduce the efficiency of the circuit.

![Figure 5-2: Parallel Circuit](image)

5.3.6 Advantages of parallel lighting circuits. Some of the advantages of parallel circuits for aerodrome lighting are:

(a) lower cost of the installation, especially if voltage regulation and intensity control are not required;
(b) more efficient utilization of electrical power;
(c) easy to add to or reduce an existing circuit;
(d) the circuits are more familiar to most people;
(e) cable faults, especially open-circuit faults, may be easier to locate;
(f) an open-circuit may not disable the entire circuit; and

5.3.7 Disadvantages of parallel lighting circuits. Some of the major disadvantages of parallel circuits for aerodrome lighting are:

(a) The intensity of the lights decreases with line drop along the circuit. This may be misinterpreted if it is noticeable in a pattern of lights;
(b) Two conductors are required along the complete circuit, and larger conductors may be needed to reduce the line voltage drop;
(c) Lamp filaments are usually longer which may require larger optics and larger light fixtures;
(d) Intensity control, especially at the lower intensities, is more difficult to furnish accurately, or the equipment cost adds appreciably to the installation cost;
(e) A single ground fault on the high-voltage feeder will disable the circuits; and
(f) Ground faults are difficult to locate.

5.4 Comparison of series and parallel lighting circuits

5.4.1 Acceptable lighting can be provided by either series or parallel circuits. Series circuits are usually used for aerodrome lighting systems because of the more uniform intensity of the lights and better intensity control. Such systems include most runway and taxiway lights and most steady-burning lights of approach lighting systems. Parallel circuits are used for most area illumination, individual or small numbers of visual aids, and power distribution. Aerodrome lighting systems usually using parallel circuits are apron floodlighting, other apron lights, sequence-flashing lights, special purpose visual aids such as beacons and wind direction indicators, some obstacle lights and electrical distribution circuits.

5.6 Series Circuitry for Aerodrome Lighting

5.6.1 Factors to be considered

5.6.1.1 If a series circuit is to be used, certain options on the equipment to be used should be evaluated. Often when one choice is made it reduces the options of other equipment. First, the complete circuit should be analysed for critical performance, reliability, economy of installations and operations, ease of maintenance, and how the several types of equipment are interrelated. Some optional factors are the following items.

5.6.1.2 Choice of current. Equipment development has limited the available options of current to be used in a particular series circuit. Most aerodrome lighting series circuits are either 6.6 or 20 amperes at rated full intensity, although other currents have been used. The line power loss for a fixed cable conductor and length for 6.6 amperes circuits is about one-ninth that for 20 amperes circuits. Either value of current can be carried in 5000 volt insulation cable by conductors of 4 mm diameter without excessive temperature rise.
The load on the regulator of series circuits, should be at least 80% of its rated capacity. A current of 6.6 amperes circuits is commonly used for long circuits with smaller electrical loads, and 20 ampere circuits have been used for larger loads and shorter cable lengths. For the range of regulator ratings, 6.6 amperes is used for ratings of 30kw or less and 20 amperes for ratings of more than 30kw. This transition point is based upon the full load operating voltage which should not be in excess of 5000volts. A 30kw regulator has a voltage of 4545 volts with 6.6 amperes current.

The above said, there is a tendency towards use of only 6.6 amperes for the series circuits. The primary reason being that the loading of lighting facilities is decreased by reduction of lamp ratings and primarily because of the application of interleaving. For example, the major portion of an approach lighting system may represent a load of 70kw in which case a single constant current could be used. However, with the addition of circuits and interleaving, the load on each circuit may be less than 20kw resulting in the use of 6.6 amperes. Similar use of lower rated constant current regulators occurs for large facilities such runway centreline and touchdown zone lighting.

5.7 Grounding.

5.7.1 All the equipment in the control/distribution centre should be bonded to earth. A ground wire (counterpoise) should also be run from the distribution centres with the series circuit cables. Refer Chapter 12 for Underground Electrical Systems.

3.3.1.5 Step-down transformers. The use of higher voltages for transmission of power reduces the line voltage drop and then step-down distribution transformers reduce the voltage to that more suitable for local distribution. Similarly, the power to aerodrome lighting circuits may be at a higher voltage on the feeder circuits and reduced by a step-down transformer at the beginning of the lighting circuit to match the desired circuit voltage. Of course, these feeder cables must be adequately insulated for the feeder voltage. Sometimes it is desirable to use long low-voltage cables for feeders, such as when these cables are already installed and available. Assuming these feeders have 600 volt insulation, the line drop can be reduced by using a higher voltage within the insulation limit of the cable on the feeders and reducing the voltage with step-down transformers at the input to the circuit or to the individual light fixtures. An example is to use 480 volts on the feeders and step-down to 120 volts at the lighting circuit. Use of lamps in the voltage range of 6 to 30 volts in aerodrome light fixtures is usually more effective than the use of 120 or of 240 volt lamps. Thus, when step-down transformers are to be used for individual lights, or for a small group of lights in a barrette, consideration should be given to choosing lights which use low-voltage lamps. Unless individually fused, step-down transformers used as indicated above should be of the high-reactance type so that a short-circuit in that part of the lighting system fed by one transformer will not cause failure of the entire system.

Series Plug Cutout

For series circuitry a device termed a Series Plug Cutout can be installed at or inside the constant current regulator (CCR) to facilitate maintenance and trouble shooting activity. With the handle of the cutout inserted, the CCR is connected to the series loop circuit. When the handle is
removed the CCR output is isolated from the airfield series loop for maintenance personnel safety. Figure 5-3 shows a typical installation inside a CCR. An alternate design has a second cover which can be inserted so as to provide contact points to take insulation resistance measurements.

Figure 5-3 Series cutout device

Figure 5-4. Series cutout device