CIVIL AVIATION AUTHORITY OF FIJI

GUIDANCE MATERIAL

Aerodrome Electrical Systems – Types of Electrical Circuit

SD – AES (TEC)

Published by:

Civil Aviation Authority of Fiji
Private Mail Bag, NAP 0354
Nadi International Airport
Fiji

www.caaf.org.fj

PREFACE

This Guidance Material provides CAAF's technical guidance for examining aerodrome electrical circuitry, with particular reference to conventional incandescent lamp light fixtures. As aerodrome lighting systems increasingly transition to LED-based designs, aspects of this guidance may be reviewed and updated to reflect evolving technology and standards.

The document also outlines key system design and installation considerations for constant current series circuits used in aeronautical ground lighting, to support consistent performance, reliability, and safe maintenance practices.

Chief Executive
Civil Aviation Authority of Fiji

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS

No.	Date Applicable	Date Entered	Entered by
1	06/01/26	06/01/26	AI-ES

CORRIGENDA

No.	Date of Issue	Date Entered	Entered by

TABLE OF CONTENTS

PUBLICATIONS

(referred to in this GM)

International Civil Aviation Organization (ICAO)

Aerodrome Design Manual (Doc 9157), Part 5 — *Electrical Systems*

IEC 61822, Electrical installations for aeronautical ground lighting at aerodromes

Directive 2011/65/EU, *Directive on the restriction of the use of certain hazardous*

AC	Alternating current
AGL	Above ground level
AGL	Aerodrome ground lighting
CCR	Constant current regulator
DMM	Digital multimeter
DSP	Digital signal processor
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EPR	Ethylene-propylene rubber panel
MDT	Mean downtime
MR	Multifaceted reflector
MTBF	Mean time between failures
PAPI	Precision approach path indicator
PUR	Polyurethane
PVC	Polyvinyl chloride
RMS	Root-mean-square
VA	Volt-ampere
VOM	Volt-ohm-milliammeter/Volt-ohm-meter
XLP	Cross-linked polyethylene

INTRODUCTION

This document defines minimum requirements for electrical circuitry used in AGL systems throughout their lifecycle, from design to decommissioning.

AGL systems are critical to safe aircraft operations and must ensure reliability, uniform light intensity, and resilience against component failure.

1.1 ELECTRICAL CHARACTERISTICS

Most aerodrome lighting uses AC power at 50/60 Hz.

- Series circuits are used at large aerodromes (runways, taxiways, approach lights).
- Parallel circuits are common at smaller aerodromes or for apron, obstacle and area lighting. Also for sequence-flashing lights for approach lighting systems, although these may, if necessary, be powered from a series circuit using conversion adaptors.

1.2 SERIES CIRCUITS

1.2.1 A series circuit connects all elements in one loop with the same current through each component, maintained by a constant current regulator (CCR).

1.2.2 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. 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 is necessary to provide an aerodrome ground lighting (AGL) transformer, as part of the circuit design, to maintain continuity of the circuit with lamp failure. Where a single transformer is used to supply several light units, as shown in Figure 1-1, a bypass device is incorporated to ensure continuity on the secondary side.

Advantages of series lighting circuits

1.2.3 Some of the advantages of series circuits for aerodrome lighting are:

a) Uniform light intensity across all lamps (all lamps operating at the same current).

b) Single-conductor cable simplifies installation. (one conductor size and insulation voltage rating used throughout the circuit).

c) Wide range of intensity control possible.

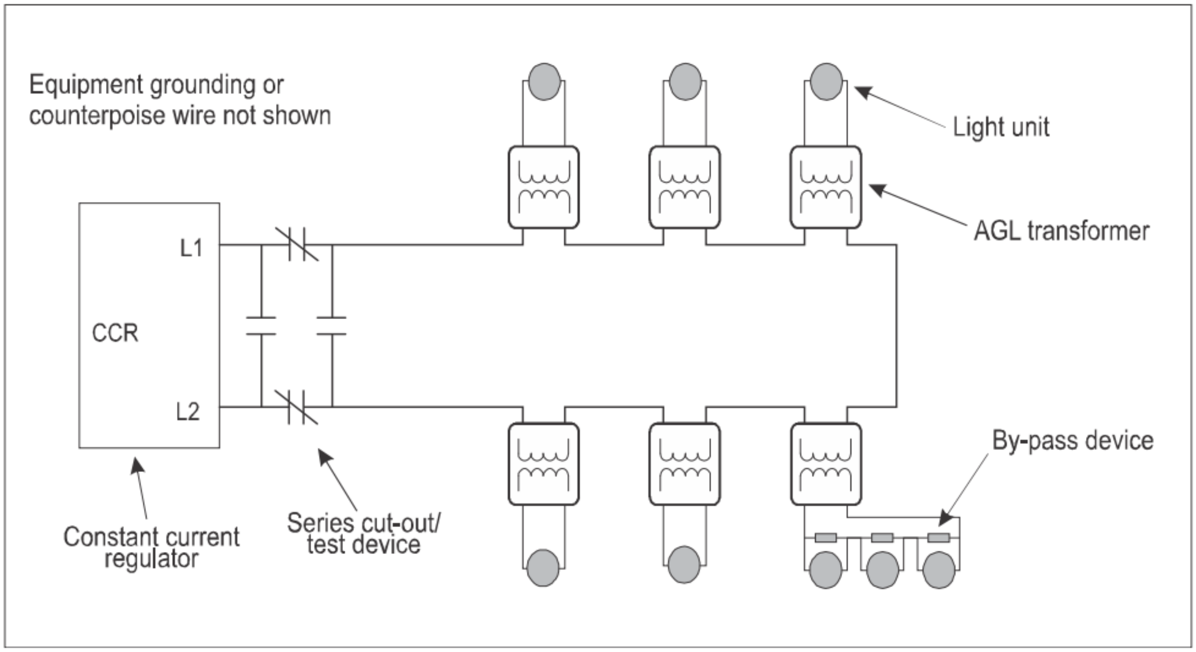

Figure 1-1. Series lighting circuit

d) Operates with a single ground fault without loss of circuit. (a single ground fault at any point along the circuit will not affect the operation of the lights).

e) Compact lamp filaments allow precise optical control. (lamps used are high-current and low-voltage. 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 acts as a point source and facilitates optical control through means of lensing).

f) series circuits can more easily be applied to interleaving.

Disadvantages of series lighting circuits

1.2.4 The major disadvantages of series circuits when used for lighting are:

a) Higher installation cost (CCR and AGL transformers required and add to the cost).

b) A single open-circuit fault disables the entire system and possibly damage cable insulation or the constant current regulator.

c) Location of faults, especially open circuit faults, can be difficult to locate.

1.3 PARALLEL (MULTIPLE) CIRCUITS

1.3.1 A parallel circuit connects light fittings across the supply voltage. It is simpler but less suited to large, complex lighting systems.

1.3.2 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 cable installation than a high-voltage series circuit.

b) an 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 of the voltage on the supply side.

1.3.3 The parallel circuit can be of advantage at small airports where maintenance is contracted from the local community, in which electricians may not have the special training needed for series circuit installations.

1.3.4 Given these considerations, parallel circuits should preferably be used when there are only a few fittings 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.

Effects of faults

1.3.5 For parallel circuits, the light fixtures are connected across the lighting conductors; a burned-out lamp that produces an open circuit fault does not seriously affect the overall lighting system, but a short circuit fault will be an overload condition and depending on which protective device (fused or circuit-breaker) operates, it would make the system of lights inoperative. This is the opposite of the effect on a series circuit, for which a short is not an overload condition.

Voltage characteristics

1.3.6 Most parallel-type light fixtures are designed for low voltage (less than 300 volts), and step-down transformers may be used where the feeder cables are at a higher voltage to minimize voltage drop from the vault to the load center. The lights may be supplied from a single circuit connected between neutral and line voltage or by alternating between neutral and line voltage in a 3- or 4-wire distribution system. Intensity control of the lighting is typically achieved by means of tapped transformers.

Advantages of parallel lighting circuits

1.3.7 Some of the advantages of parallel circuits (see Figure 1-2) for aerodrome lighting are:

a) Lower installation cost where voltage regulation and intensity control is not critical.

b) More efficient utilization of electrical power.

c) Easier to extend or modify existing circuits.

d) Faults, especially open circuit faults, often easier to isolate.

e) Open-circuit in one fitting does not disable the whole system..

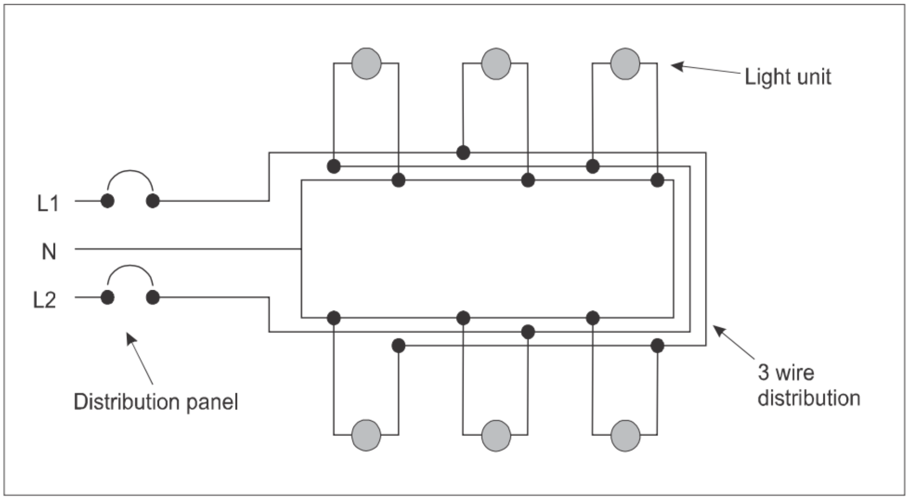

Figure 1-2. Parallel circuit

Disadvantages of parallel lighting circuits

1.3.8 Some of the major disadvantages of parallel circuits for aerodrome lighting are:

a) Light intensity decreases with voltage drop along the circuit. This may be misinterpreted if it is noticeable in a pattern of lights.
b) Requires two conductors and larger cable sizes to reduce the line voltage drop.
c) Lamp filaments are usually longer, which may require larger optics and larger light fixtures.
d) Intensity control is limited and less precise. (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 can disable the circuits; and
f) Ground faults may be difficult to locate.

1.4 COMPARISON OF SERIES AND PARALLEL CIRCUITS

Parameter	Series Circuit	Parallel Circuit
Uniformity	Excellent	Variable
Intensity Control	Accurate, wide range	Limited
Fault Impact	Open circuit affects all	Open circuit localized
Installation Cost	Higher	Lower
Typical Use	Runway, taxiway, approach lights	Apron, beacons, wind indicators

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 use 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.

1.5 SERIES CIRCUITRY FOR AERODROME LIGHTING

Factors to be considered

1.5.1 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 for other equipment. First, the complete circuit should be analyzed 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.

Choice of current

1.5.2 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-ampere circuits is about one-ninth that for 20-ampere circuits. The value of current can be carried in 5 000-volt insulation cable by conductors of 4 mm diameter without excessive temperature rise.

1.5.3 The load on the regulator of series circuits should be at least 80 percent of its rated capacity. A current of 6.6 amperes 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 30 kW or less, and 20 amperes for ratings of more than 30 kW. This transition point is based upon the full load operating voltage, which should not be in excess of 5 000 volts. A 30-kW regulator has a voltage of 4 545 volts with 6.6 ampere current.

1.5.4 Based on the above, there is a tendency towards the use of only 6.6 amperes for the series circuits. The primary reason is the application of multiple circuits and interleaving. For example, the major portion of an approach lighting system may represent a load of 70 kW, in which case a single constant current regulator rated at 70 kW and 20.0 amperes might be used. However, with the addition of circuits for interleaving, the load on each circuit may be less than 20 kW, resulting in the use of regulators rated at 6.6 amperes. Similar use of lower-rated constant current regulators occurs for large facilities, such as for runway centerline and touchdown zone lighting, which are composed of two or more circuits.

1.6 GROUNDING

All AGL equipment must be effectively bonded to earth for personnel safety and electromagnetic compatibility, per ICAO Doc 9157 Part 5, Chapter 13.

1.7 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 which is 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. 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. The 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 240-volt lamps. Thus, when step-down transformers are to be used for individual lights or a small group of lights in a barrette, consideration should be given to choosing lights that 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.

1.8 SERIES CUT-OUT

A series cut-out device (Figure 1-3) within the CCR isolates the regulator from the loop circuit during maintenance, allowing safe troubleshooting and insulation checks without interrupting other operations. With the cover plate of the cut-out inserted (Figure 1-4), the CCR is connected to the series loop circuit. When the cover plate is removed, the CCR output is isolated from the airfield series loop for maintenance personnel's safety. Both the output of the CCR and the input to the loop circuit are shorted. A second cover plate can be inserted so as to provide contact points to take insulation resistance measurements.

Figure 1-3. Series cut-out device receptacle (source: Liberty Airport Systems)

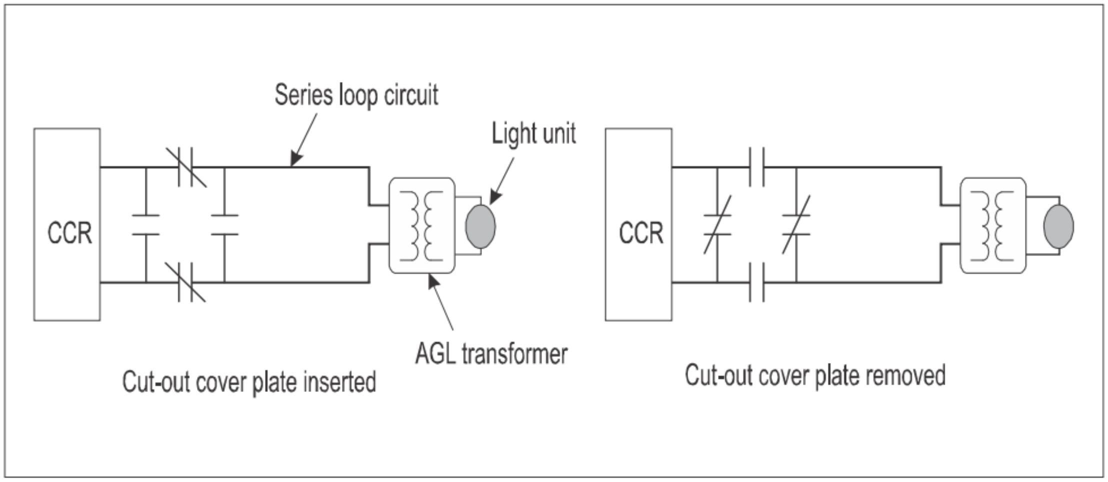

Figure 1-4. Series cut-out device (diagram)

1.9 INSPECTOR APPLICATION NOTE

Inspectors should verify that the chosen circuit type and current rating match the aerodrome's category, runway length, and lighting layout. Any deviation from ICAO or CAAF standards must be justified by an engineering assessment accepted by CAAF.