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Aircraft — Solid-state remote power controllers — General requirements

Aéronefs — Contacteurs-disjoncteurs statiques commandés à distance — Prescriptions générales

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8816 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Sub-Committee SC 1, *Aerospace electrical requirements*.

Aircraft — Solid-state remote power controllers — General requirements

1 Scope

This International Standard specifies the general design and performance requirements of solid-state (remote) power controllers for use in aircraft electrical power systems. The solid-state (remote) power controller consists of solid-state switching device(s) and associated solid-state circuitry for protection, actioning of control signals, and providing status information.

NOTE 1 Phrases, clauses and/or sentences in parentheses are intended to refer strictly to remote power controllers.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2678:1985, *Environmental tests for aircraft equipment — Insulation resistance and high voltage tests for electrical equipment.*

ISO 3389:1975, *Aircraft — Radio frequency flexible coaxial cables — Dimensions and electrical characteristics.*

ISO 7137:1992, *Aircraft — Environmental conditions and test procedures for airborne equipment (Endorsement of EUROCAE/ED-14C and RTCA/DO-160C).*

IEC 50(446):1983, *International electrotechnical vocabulary, Chapter 446: Electrical relays.*

3 Definitions

For the purposes of this International Standard, the following definitions apply. See also IEC 50(446).

3.1 (remote) power controller: Device providing a power switch which presents a low impedance to the flow of current from its supply to its load terminal when in the ON state and a high impedance in the OFF state.

NOTES

2 The state of the power switch normally conforms to that represented by the last command signal applied to the controller.

3 The controller reverts to the OFF state on detection of an electrical overload or other specified condition. A resetting operation is required to terminate the trip state. Trip-free action prevents the ON state being held in the presence of an overload trip condition.

4 (The state of the power switch is represented by an indication signal supplied by the controller.)

5 A (remote) power controller may be fully solid-state or hybrid.

3.1.1 solid-state (remote) power controller: A (remote) power controller design utilizing solid-state technology exclusively.

3.1.2 hybrid remote power controller: A remote power controller design utilizing a combination of solid-state and electromechanical technology.

3.2 temperature cycling: The imposition of extreme high and low temperatures in a repetitive cyclical manner to determine the effect of alternate exposures to these extremes.

3.3 load conditioning: The imposition of step function voltage inputs to (remote) power controllers to energize and de-energize the devices at a given duty cycle at maximum rated current.

3.4 burn-in: The exercise of (remote) power controllers by applying a step voltage input to energize the devices for a specified length of time at maximum rated current.

3.5 lot: All (remote) power controllers covered by a single specification sheet, produced and sealed under essentially the same conditions, and offered for inspection at one time within a period not exceeding one month.

3.6 AUX input: An input other than bias, control or status which is specified for operation of the (remote) power controller, i.e. ENABLE, SET, RESET, voltage supply, or other.

3.7 resistive load: A load consisting of resistors which have a ratio of inductance to resistance that does not exceed 10^{-4} H/Ω.

3.8 stabilization time: The minimum time required for the power controller to attain thermal stability under specified environmental and electrical load conditions.

3.9 power dissipation: The total electrical power losses under specified conditions of electrical load and ambient temperature.

3.10 temperature derating: A reduction of the rated steady-state current of the power controller at higher operating temperatures, based on the thermal properties of the power controller.

3.11 turn-on time

(1) d.c. devices and non-zero crossing turn-on a.c. devices: The time interval between initiation of turn-on signal and the time when the output signal has come to within 10 % of its steady-state value. See figure 1.

(2) a.c. devices with zero-crossing turn-on: The time interval between initiation of turn-on signal and the time when the output switch is ON at zero crossing.

3.12 turn-off time

(1) d.c. devices and non-zero crossing turn-off a.c. devices: The time interval between initiation of turn-off signal and the time when the output signal has come to within 10 % of its steady-state value. See figure 1.

(2) a.c. devices with zero-crossing turn-off: The time interval between initiation of turn-off signal and the time when the output switch is OFF at zero crossing.

3.13 prospective current: The maximum current that will flow in a circuit in which the power controller operates when the power controller is replaced by a short-circuit link of zero impedance.

3.14 rupture current: The maximum current the power circuit is capable of interrupting at maximum system voltage without damage.

3.15 short-circuit current: The maximum current that the power circuit will pass without damage for a specified maximum time under the most adverse combination of electrical and environmental conditions.

3.16 current limiting: A method of limiting the peak let-through current under overcurrent conditions.

3.17 trip: The automatic reversion to the OFF state of the power controller output caused by an overcurrent condition.

3.18 trip free: When a controller has tripped due to an overcurrent condition, a trip-free feature will prevent subsequent re-closing unless preceded by a reset signal.

3.19 trip time: The time interval between the application of an overcurrent condition and the 10 % value of rated output current.

NOTE 6 In general, the higher is the overcurrent condition the shorter is the trip time.

3.20 fault-clearing delay time: The time interval between the occurrence of a fault, i.e. a short circuit or overload condition, and the fault-detection circuit initiating turn-off.

3.21 fault-clearing time: Summation of the fault-clearing delay time and the turn-off time.

3.22 reset time: The minimum time interval the control signal must be in the OFF state before re-application of the ON state command, or application of a dedicated reset signal that will cause reset after trip.

3.23 peak let-through current: Peak value of the current at maximum system voltage that a controller will conduct for a specified time interval without damage.

3.24 switch status: An indication showing the actual state of the power switch (ON or OFF).

3.25 current-flow status: An indication that current flowing through the power switch of the (remote) power controller has reached a minimum level.

3.26 status turn-off time: The time interval between initiation of a trigger signal (turn-off signal or other as specified) and the time when the status signal has changed to 10 % of its steady-state value. See figure 1.

3.27 status turn-on time: The time interval between initiation of a trigger signal (turn-on signal or other as specified) and the time when the status signal has changed to 10 % of its steady-state value. See figure 1.

3.28 zero voltage turn-on/zero current turn-off (a.c. devices only)**:** A characteristic that requires the power controller to turn ON and turn OFF only at the half-cycle zero-crossing point, regardless of when the control signal is applied or removed.

3.29 d.c. offset voltage (a.c. devices only)**:** The difference in the measured d.c. content of the a.c. supply at the load terminal of the (remote) power controllers between the measurement with a short circuit applied to the devices from line terminal to load terminal and the measurement with the short circuit removed.

3.30 minimum current (a.c. devices only)**:** The lowest load current with resistive load for which a conducting device is rated such that the EMI limits and d.c. offset voltage limits are within specifications.

4 General requirements

4.1 Materials

Materials shall be used which will enable the controllers to meet the performance requirements of this International Standard.

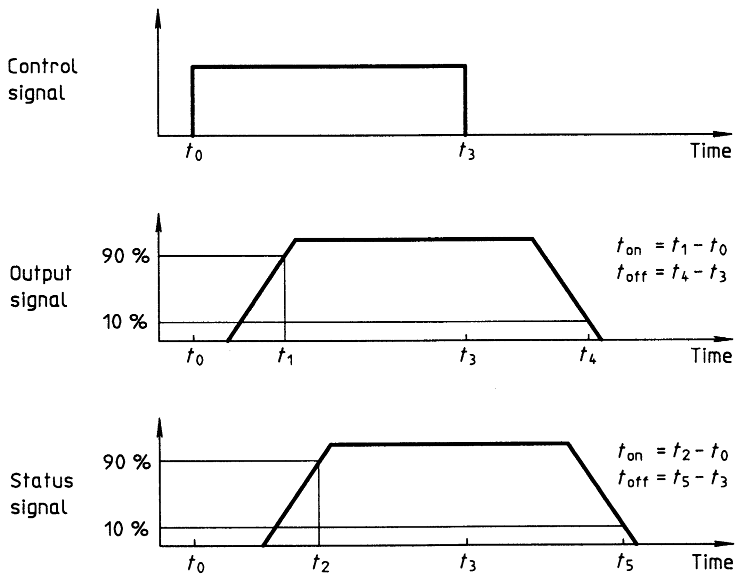
Materials used shall not support combustion, give off noxious gases in harmful quantities, give off gases in quantities sufficient to cause explosion of sealed enclosures, cause functional contamination of any part of the controller, or form unintended current-carrying tracks when subjected to any of the tests specified herein.

Unless otherwise specified, the selection of material shall be such as to provide a shelf-life of ideally 20 years without affecting the operation of the controller.

4.2 Construction

Power controllers shall be of design, construction, minimum mass and physical dimensions compatible with requirements. Controllers shall be designed so as to ensure proper operation when mounted in any attitude.

The construction of the controllers shall preclude mechanical damage, flaking of the finish, loosening of terminals, or deterioration of marking when subjected to the test methods of this International Standard.



NOTES

1 Output signal can be output current or output voltage.

2 All logic is considered to be positive.

Figure 1 — Timing diagram

4.3 Terminals

There are three acceptable types of terminal as follows.

4.3.1 Stud terminals (threaded)

These terminals shall accept connections using aircraft-approved crimped-type lugs. A flat washer having a diameter at least equal to that of the base of the terminal, and a standard nut with suitable locking washer shall be used on each terminal. Suitable insulation barriers shall be placed between the terminals in order to prevent an accidental short circuit. The height and extent of these barriers shall be sufficient to prevent the short-circuiting of any adjacent terminals through the presence over these partitions of a flat conducting part.

No rotation or other loosening of a terminal, or any fixed portion of a terminal, shall be caused by material flow or shrinkage, or any mechanical force (specified in tables 1 and 2) involved in connection or disconnection, throughout the life of the controller.

The equivalent metric threads given in table 2 may be used.

Each terminal shall have a terminal seat that shall provide the normal current-conduction path. The diameter of the seat shall not be less than the area necessary to assure that the current density does not exceed 1,55 A/mm^2. The seat does not include the cross-sectional area of the stud.

Stud terminals shall be capable of accommodating two crimped-type lugs, with hardware as specified. A minimum of one and a half threads shall remain above the nut, with all parts tightened in place.

4.3.2 Plug-in terminals

Plug-in terminals, where applicable, shall conform to the dimensions and requirements necessary for proper mating with the associated sockets.

Units shall have the electrical and environmental tests performed with the associated socket or connector assembled to the unit.

4.3.3 Solder terminals

Solder terminals used for 2 A rating or less shall be designed to allow the securing of two 0,6 mm^2 wires with 19 strands. Terminals used for more than 2 A rating shall be designed to allow the securing of three wires, the size of which shall comply with the requirements of the detail specification.

Solder terminals for printed circuit board mounting shall comply with the requirements of the detailed specification.

The finish of the terminals shall provide a good electrical contact and meet the performance requirements specified in this International Standard. All terminals used for external soldered connections shall meet the requirements of the solderability test specified in the detail specification.

Table 1 — Strength of threaded terminals (static value of pull and torque)

Thread designation 1)	Force		Installation torque		Design torque	
	N	lbf	N·m	lbf·in	N·m	lbf·in
No. 4-40 UNC	22,2	5	0,3	2,4	0,5	4,4
No. 6-32 UNC	133,4	30	0,5	4,5	1,1	10
No. 8-32 UNC	155,7	35	1	9	2,3	20
No. 10-32 UNF	177,9	40	1,7	14,5	3,7	32
No. 10-24 UNC	177,9	40	1,8	16	4	35
1/4-28 UNF	222,4	50	3,9	34	8,6	75
5/16-24 UNF	311,4	70	5,2	45	11,5	100
3/8-24 UNF	444,8	100	7,8	68	17,3	150
7/16-20 UNF	444,8	100	7,8	68	17,3	150
1/2-20 UNF	444,8	100	7,8	68	17,3	150

1) See ISO 263:1973, *ISO inch screw threads — General plan and selection for screws, bolts and nuts — Diameter range 0.06 to 6 in.*

Table 2 — Strength of threaded terminals — Metric units (static value of pull and torque)

Thread designation	Force		Installation torque		Design torque	
	N	lbf	N·m	lbf·in	N·m	lbf·in
M2,5	22,2	5	0,3	2,4	0,5	4,4
M3	133,4	30	0,5	4,5	1,1	10
M4	155,7	35	1	9	2,3	20
M5	177,9	40	1,8	16	4	35
M8	311,4	70	5,2	45	11,5	100
M10	444,8	100	7,8	68	17,3	150
M12 × 1,25	444,8	100	7,8	68	17,3	150
M14 × 1,25	444,8	100	7,8	68	17,3	150

NOTE — There is no direct metric equivalent to the thread size 1/4-28 UNF. M7 would correspond but is not used.

4.4 Enclosures

The enclosure design is identified by a single digit, in accordance with table 3.

Table 3 — Enclosure design

Type	Enclosure
1	Open
2	Enclosed (ventilated, explosion-proof)
3	Sealed (other than hermetically)
4	Hermetically sealed

4.4.1 Open enclosures

Type 1 controllers shall be uniformly coated on all surfaces with the exception of the mounting and terminals.

4.4.2 Enclosed enclosures (ventilated explosion-proof)

Unsealed units shall be totally enclosed for mechanical and dust protection and shall be explosion-proof.

4.4.3 Sealed (other than hermetically) enclosures

Environmentally sealed enclosures shall be constructed by any means other than that defined under hermetically sealed enclosures to achieve the degree of seal specified. Environmentally sealed units shall be purged and filled with a suitable gas of such characteristics that the leakage rate may be determined by conventional means. The units shall be designed to ensure that the essential electrical performance is not jeopardized in the event of a failure of the environmental seal in service.

4.4.4 Hermetically sealed enclosures

Hermetically sealed enclosures shall be constructed as gas-tight enclosures which have been completely sealed by fusion of glass or ceramic to metal, or by welding, brazing or soldering of metal to metal. Hermetically sealed units shall be purged and filled with a suitable inert gas of such characteristics that the leakage rate may be determined by conventional means.

4.4.5 Grounding of enclosures

The enclosures for type 2, 3 and 4 controllers shall be electrically isolated and provide means for grounding where appropriate.

The mountings shall provide an effective electrical contact to ground when the unit is mounted as specified. Alternatively, the enclosures shall be provided with a grounding connection such as a terminal or lug.

The covers shall be rugged in design, constructed of high-impact materials and securely mounted to the unit. Metal covers shall be provided with a means of grounding.

4.4.6 Heat sinking

For the purposes of maximizing reliability and minimizing size, the amount of heat which is generated within the enclosure shall be kept as low as possible.

If a heat sink is necessary, the thermal resistance of the heat sink and an adequate method of mounting shall be stated for type 2, 3 and 4 controllers.

5 Design characteristics

Solid-state (remote) power controllers provide both control and protection functions (as well as status feedback information).

5.1 General design of solid-state (remote) power controllers

5.1.1 The controller shall incorporate a current-sensing means to measure output current flow and to detect specified overcurrents. The controller shall incorporate specified trip-time characteristics.

5.1.2 Up to a specified fault-current level, the device shall follow a defined trip characteristic. Above this level, the device shall current-limit or provide a near instantaneous trip.

5.1.3 After the controller has tripped on overcurrent, it shall exhibit a trip-free characteristic remaining in the OFF state (and providing trip status information) until reset.

5.1.4 Reset is accomplished by cycling the control input from ON to OFF and then back to ON, or employing a dedicated RESET (auxiliary) input.

5.1.5 In the event of repeated attempts to switch into a fault, the controller shall not be damaged.

In order to prevent damage to associated wiring, as well as the overheating of the controller, a duty cycle for switching into various overload conditions shall be specified.

5.1.6 The controller shall meet the specified stabilization times after power-up, after a momentary power outage and during a supply voltage drop due to a fault, until the controller opens, clearing the fault and allowing supply voltage recovery.

5.1.7 The specified turn-on and turn-off characteristics of the controller shall minimize the effects of current inrush and capacitive loading on turn-on and control inductive kick on turn-off.

5.1.8 Coordination of trip times for given controllers with multiple current rating may not be assured for those controllers exhibiting the instant-trip feature. The response time, of the order of several microseconds, is nearly constant and independent of the current rating of the controller.

5.2 Control signal

Each controller shall be designed to operate from one of the following types of input signal.

a) Nominal voltage 28 V d.c.

b) Grounded controller input to switch controller ON; in the ON state the impedance seen by the input control shall not exceed 600 Ω.

c) Logic level signal for interfacing to a control bus (TTL or CMOS).

d) Impedance control multiplexed with status and BITE.

e) 10 mA source at 1 V to 12 V (to switch controller ON). This allows compatibility with existing remote-control circuit breakers.

5.3 Status signals for remote power controllers

As a minimum, one status signal shall be provided. The preferred status signals are switch status and/or current-flow status.

5.4 Fail-safe considerations

When a fail-safe feature is incorporated, its characteristics shall be specified. When tested, the fail-safe element shall open the circuit at specified currents and times.

5.5 Safety of personnel

Since solid-state devices in the ON or OFF state may present deadly hazards, precautions shall be taken to ensure the safety of personnel.

6 Operating characteristics

6.1 General

All controllers shall function satisfactorily over the full specified range of applied electrical and mechanical steady-state and transient conditions.

6.2 Timing sequence

The timing sequence shall be as specified.

6.3 Dielectric strength

Tests shall be carried out in accordance with ISO 2678. Any restrictions arising from the semi-conductors shall be declared.

The test voltage shall be in accordance with ISO 2678.

6.4 Insulation resistance

Tests shall be carried out at 500 V d.c. A controller shall exhibit insulation resistance greater than 100 MΩ at all authorized temperature extremes at ground level and greater than 20 MΩ at all authorized temperature extremes at maximum altitude.

6.5 Control/power isolation

The controller shall exhibit an isolation resistance greater than 100 MΩ when tested with 500 V d.c. applied between mutually isolated groups of control/power terminals.

6.6 Electrical characteristics

6.6.1 Direct-current controllers

6.6.1.1 Voltage drop

The controllers shall exhibit ON-state impedance values such that the voltage drop across the controller is a minimum at rated load.

6.6.1.2 Leakage current

The controllers shall exhibit OFF-state impedance values such that the leakage current through the rated load is a minimum.

6.6.1.3 Ripple voltage

The ripple voltage introduced by the controller onto the d.c. supply input shall be a minimum at rated current.

6.6.2 Alternating-current controllers

6.6.2.1 Voltage drop

The controllers shall exhibit ON-state impedance values such that the voltage drop across the controller is a minimum at rated load.

6.6.2.2 Leakage current

The controllers shall exhibit OFF-state impedance values such that the leakage current through the rated load is a minimum.

6.6.2.3 D.c. offset voltage

The d.c. offset introduced by the controller (d.c. content at the output terminal minus the d.c. content at the a.c. input terminal — see 3.29) shall be a minimum at rated load. The maximum guidelines are ± 100 mV.

6.6.3 Quiescient power dissipation

The controller power dissipation in the OFF-state for a normally open device, or in the ON-state for a normally closed device, shall be a minimum.

6.6.4 Rupture capacity

The prospective currents are those which would be broken by an ideal controller of no internal impedance. They are defined in table 4 and shall be reached as follows:

— between 2 ms and 10 ms for 28 V d.c. systems, counted from fault application;

— between 2 ms and 5 ms for 115/200 V/400 Hz systems, counted from fault application.

Recovery voltages after interruption of fault current for 28 V d.c. systems and 115/200 V/400Hz systems are as defined in ISO 7137.

Table 4 — Prospective short-circuit currents

	Systems	
	d.c.	400 Hz a.c.
Voltage at controller power terminals in open circuit	28 V $^{+4}_{0}$ V	115 V $^{+10}_{0}$ V (effective value)
Connecting mode	—	star connection
Prospective currents	6 000 A (all ratings)	3 000 A *) (all ratings)

*) Assuming current-limiting in the electrical power system.

7 Environmental conditions and test procedures

These shall be in accordance with ISO 7137 and in accordance with the categories given in table 5.

8 Qualification

The object of qualification tests is to ensure that the design is capable of meeting the specifications of this International Standard. Production units shall be used for the tests.