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Aerospace — Requirements for digital equipment for measurements of aircraft electrical power characteristics

Constructions aérospatiales — Exigences relatives aux équipements numériques de mesure des caractéristiques de puissance électrique à bord des aéronefs

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12384 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 1, *Aerospace electrical requirements*.

ISO 12384 is closely allied with ISO 1540 and references from one to the other are freely used, particularly from ISO 12384 to ISO 1540. The proper use of this International Standard through referencing the applicable specific digital measurement methods should simplify the preparation of specifications and help to expedite the purchase and acceptance of the digital measuring equipment.

Introduction

Various types of digital measuring equipment for electrical power characteristics are applied to the aircraft electrical system. There is no International Standard for digital measuring equipment for electrical power characteristics in the aerospace industry. The purpose of this International Standard is to explain, establish and standardize specific methods for digital measurements of the aircraft electrical system. The intended use of this International Standard is to define how to measure parameters of electrical characteristics in aircraft electrical power systems. The specific measurement methods are included here, while the terminology and general methods of digital measurement and signal processing are also presented. The requirements of digital measuring equipment are verified by testing of the aircraft electrical system.

Aerospace — Requirements for digital equipment for measurements of aircraft electrical power characteristics

1 Scope

This International Standard specifies the requirements for digital measuring methods and digital measuring equipment for aircraft electrical power characteristics, including accuracy, algorithms and digital measuring equipment. The measuring equipment should be applied mainly for the use of laboratory or rig tests.

This International Standard can be applied to digital measuring equipment which is involved in the measurement of power electrical characteristics of the power supply system, power distributing systems and the utilization of equipment in aircrafts.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1540, *Aerospace — Characteristics of aircraft electrical systems*

ISO 7137, *Aircraft — Environmental conditions and test procedures for airborne equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1540 and the following apply.

3.1
sampling frequency
reciprocal of sampling interval time

3.2
sampling time
total of sampling interval time

4 Symbols

Symbols used by this International Standard are listed in Table 1.

Table 1 — Symbols and definitions

Symbol	Unit	Definition
F_P		power factor
F_C		crest factor
f	Hz	steady state frequency
f_m	Hz	frequency modulation
I	A	steady state a.c. current
i_j	A	instantaneous value of a.c. current
j		sampling serial, j = 1,2,3, ... n
F_d	%	a.c. voltage distortion factor
n		total number of sampling points during the steady state time
N		cycle numbers during T_W
T		sampling period
T_w	s	time of a period not to exceed one second
T_θ	s	difference in time between the fundamental components of any two normalized phase voltages taken at consecutive zero crossings traced in the negative to positive direction
t_θ	s	difference in time between the fundamental components of any two phase voltages taken at consecutive zero crossings traced in the negative to positive direction
U	V	steady state phase voltage
U_A, U_B, U_C	V	phase A, B and C steady state voltage
U_d	V	distortion of a.c. voltage
U_Adc	V	d.c. component of a.c. voltage
U_j	V	rms value corresponding to the j^th cycle
U_P	V	peak value of a.c. voltage for each cycle
U_rm	V	voltage ripple
U_m	V	voltage modulation
U_n		n^th harmonic rms value of current or voltage
U_dc	V	steady state d.c. voltage
U_f	V	rms value of fundamental component of a.c. voltage
U_ε	V	voltage imbalance
U_D	V	rms value of a.c. distortion voltage
D_TH	%	total harmonic distortion
u_j	V	instantaneous value of a.c. voltage
$u_{\mathrm{D}j}$	V	instantaneous value of a.c. distortion voltage
u_dmax	V	maximum value of cyclic variation in relation to the mean level of d.c. voltage during steady state operation
u_dmin	V	minimum value of cyclic variation in relation to the mean level of d.c. voltage during steady state operation
u_dcj	V	instantaneous value of d.c. voltage
U_Ddc	V	distortion of the d.c. voltage
F_ddc	%	d.c. voltage distortion factor
Δt	s	sampling interval time
θ	°	phase voltage displacement

5 Measurement requirements for the aircraft electric power characteristics

5.1 General rules, measurement states and the admissible errors of the measurement results

5.1.1 General

The electric power characteristics measurement shall be implemented in accordance with the definitions of ISO 1540 and the requirements of this International Standard.

5.1.2 Measurement states

5.1.2.1 Steady state

The measurement of steady state parameters shall be processed only when negligible changes in electrical parameters appear. For example, no load state, rated load state, etc.

5.1.2.2 Transient state

The measurement of transient state parameters shall be processed in the transient state. Momentary variations of a characteristic from its steady state limits, and back to its steady state limits may occur as a result of a system disturbance. For example, apply the load immediately, switch from one load to another load, power bus or power source switching, building up and shut down power source, etc. The whole transient procedure should be tested.

5.1.3 Admissible errors of the measurement results

5.1.3.1 Steady state characteristics

When measuring voltages and currents within the range of waveform characteristics allowed in ISO 1540, the steady state measurement error shall meet the following requirements:

a) voltage:

1) steady state a.c. and d.c. voltage: in the range of measurement, the absolute error of readings shall be in the range of ±0,5 %;

2) D.C. component of the a.c. voltage: the absolute error of readings shall be in the range of ±10 %;

b) current:

1) steady state a.c. current: in the range of measurement, the absolute error of readings shall be in the range of ±1 %;

2) steady state d.c. current: in the range of measurement, the absolute error of readings shall be in the range of ±0,8 %;

c) frequency:

the a.c. system: in the range of measurement, the absolute error of readings shall be in the range of ±0,1 % of the nominal frequency;

d) phase difference:

in the condition that the voltage phase difference is in the range of 110°~130°, the absolute error of readings shall be in the range between ±0,2°;

e) amplitude of distortion spectrum:

the absolute error shall be in the range between ±5% of limited value.

5.1.3.2 Transient characteristics

Measurement error of the transient characteristics should meet the following requirements:

a) voltage:

1) a.c. voltage: in the range of measurement, the absolute error of readings shall be in the range of ±1,0 % of the specified maximum transient a.c. voltage;

2) d.c. voltage: in the range of measurement, the absolute error of readings shall be in the range of ±1,0 % of the specified maximum transient d.c. voltage;

3) d.c. content of the a.c. voltage: absolute error of readings shall be in the range of ±10 % of the specified maximum transient d.c content voltage;

b) current:

1) a.c. current: in the range of measurement, the absolute error of readings shall be in the range of ±2 % of the specified maximum transient a.c. current;

2) d.c. current: in the range of measurement, the absolute error of readings shall be in the range of ±2 % of the specified maximum transient d.c. current;

c) frequency:

in the range of measurement, the absolute error of readings shall be in the range of ±0,2 % of the specified maximum frequency.

5.2 Measurement of constant frequency (CF) a.c. power system characteristics

5.2.1 Steady state characteristics

5.2.1.1 Phase voltage

The measurement of the phase voltage should be processed according to the following:

a) sampling frequency on each phase voltage not less than 72 kHz;

b) the three phase voltages sampled at the same time;

c) sampling time over a period not to exceed one second.

Calculate the steady state phase voltage according to Equation (1):

$$U = \sqrt{\frac{1}{T_W} \sum_{j=1}^{n} u_j^2 \Delta t} \quad (1)$$

where

U is steady state phase voltage, V;

T_W is the time of a period not to exceed one second, s;

n is the number of samples;

j is sample serial, $j = 1,\ 2,\ 3 \ldots n$;

u_j is the instantaneous value of a.c. voltage, V;

Δt is the sampling interval time, s.

5.2.1.2 Phase voltage imbalance

The measurement of the voltage imbalance should be processed according to the following requirements:

a) calculate the steady state a.c. voltage U_A, U_B, U_C according to 5.2.1.1;

b) substitute the U_A, U_B, U_C into Equation (2) to calculate the phase voltage imbalance.

$$U_\varepsilon = \max\left[\left|U_A - U_B\right|, \left|U_B - U_C\right|, \left|U_C - U_A\right|\right] \tag{2}$$

where

U_ε is phase voltage imbalance, V.

5.2.1.3 Phase voltage modulation

Each phase voltage should be sampled at the frequency of more than 72 kHz. The sampling time should be at least one second. Calculate the positive peak voltage of each phase in every cycle, denoted as U_{PAj}, U_{PBj}, U_{PCj} (j = 1,2,3, ..., n) and find out the maximum value and minimum value from these series:

$$U_{PAj,max};\ U_{PAj,min};\ U_{PBj,max};\ U_{PBj,min};\ U_{PCj,max};\ U_{PCj,min}$$

Substitute them into Equation (3) to calculate the phase voltage modulation:

$$U_m = \max\left[U_{PAj,max} - U_{PAj,min}, U_{PBj,max} - U_{PBj,min}, U_{PCj,max} - U_{PCj,min}\right] \tag{3}$$

where

U_m is voltage modulation, V.

According to the positive peak voltage of every cycle in each phase, the cyclic or random variation of a.c. peak voltage can be obtained by computing the amplitude of the components at individual frequencies by the Fourier transformation, then plotting the frequency characteristics of voltage modulation.

5.2.1.4 Phase voltage displacement

Each phase voltage shall be sampled at the same time. The sampling time should be over a period not to exceed one second. The difference period among the three phases should not be more than one cycle of a fundamental component, finding the positive zero-crossing of the fundamental component wave of each phase and the period between the consecutive positive zero-crossing. Calculate the angle between the fundamental components of the two phase voltage according to Equation (4) which is the phase voltage displacement.

