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Methods of measurement for radio equipment used in satellite earth stations - Part 1: Measurements common to sub-systems and combinations of sub-systems - Section 2: Measurements in the r.f. range

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METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN SATELLITE EARTH STATIONS
PART 1: MEASUREMENTS COMMON TO SUB-SYSTEMS AND COMBINATIONS OF SUB-SYSTEMS.
SECTION TWO - MEASUREMENTS IN THE R.F. RANGE

Méthodes de mesure pour les équipements radioéléctriques utilisés dans les stations terriennes de télécommunication par satellites
Première partie: Mesures communes aux sous-ensembles et à leurs combinaisons.
Section deux - Mesures aux fréquences radioéléctriques

Meßverfahren für Funkgeräte in Satelliten-Erdfunkstellen
Teil 1: Messungen an Untersystemen und Kombinationen von Untersystemen
Hauptabschnitt zwei: Messungen im Radiofrequenzbereich

BODY OF THE HD

The Harmonization Document consists of:

- IEC 510-1-2 (1984) ed 1; IEC/SC 12E, not appended

This Harmonization Document was approved by CENELEC on 1986-02-27.

The English and French versions of this Harmonization Document are provided by the text of the IEC publication and the German version is the official translation of the IEC text. The German translation is available.

According to the CENELEC Internal Regulations the CENELEC member National Committees are bound:

to announce the existence of this Harmonization Document at national level by or before 1986-07-01

to publish their new harmonized national standard by or before 1987-07-01

to withdraw all conflicting national standards by or before 1987-07-01.

Harmonized national standards are listed on the HD information sheet, which is available from the CENELEC National Committees or from the CENELEC Central Secretariat.

The CENELEC National Committees are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

NORME INTERNATIONALE

INTERNATIONAL STANDARD

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Méthodes de mesure pour les équipements radioélectriques utilisés dans les stations terriennes de télécommunication par satellites

Première partie: Mesures communes aux sous-ensembles et à leurs combinaisons

Section deux – Mesures aux fréquences radioélectriques

Methods of measurements for radio equipment used in satellite earth stations

Part 1: Measurements common to sub-systems and combinations of sub-systems

Section Two – Measurements in the r.f. range

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN SATELLITE EARTH STATIONS

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Section Two: Measurements in the r.f. range

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 12E: Microwave Systems, of IEC Technical Committee No. 12: Radiocommunications.

The text of this standard is based upon the following documents:

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
12E(CO)18 12E(CO)88	12E(CO)32 12E(CO)95	12E(CO)39	12E(CO)65

Further information can be found in the relevant Reports on Voting indicated in the table above.

METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN SATELLITE EARTH STATIONS

Part 1: Measurements common to sub-systems and combinations of sub-systems

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SECTION TWO — MEASUREMENTS IN THE R.F. RANGE

1. Scope

This section deals with measurements normally made at radio frequencies (r.f.), for transmitting and receiving equipment used in earth stations for communication through orbiting satellites. It applies both to sub-systems and to combinations of sub-systems.

2. Introduction

It is not possible to describe fully the precautions necessary to obtain quantitative results of acceptable accuracy for all possible cases which may be covered by the types of measurements given below but attention is drawn to the following cases of general interest.

The possible presence of spurious signals, including harmonics, at the ports where the test signals are applied should not be overlooked. These spurious signals could disturb the operation of the test equipment or the system or sub-system under test. Consideration should be given to the removal of undesired signals at the test ports because although their amplitudes may be insufficient to affect the test arrangement, their presence may modify the r.f. characteristics to be measured, for example by the generation of heat.

Changes to the mechanical mounting of sub-assemblies including ferrite isolators and circulators, or changes to the location of r.f. screens, should not be made unless it is certain that the ensuing overall performance will adequately represent the performance of the system or sub-system which is being simulated.

In the following methods of measurement, no reference will be made to the requirements for protecting the test arrangement against possible r.f. interference. When sweep-frequency measurements are made, the pass-band of the test receiver (the selective amplifier, amplitude detector and oscilloscope) should be of the order of 50 to 100 times the repetition rate of the frequency sweep, depending upon the waveform of the sweep signal.

It is the responsibility of those conducting the tests to arrange the test equipment as necessary in order to keep measurement errors within permissible limits.

When presenting the results of the measurements described in the following clauses, it is advisable to provide a diagram of the actual test arrangement employed—showing loads, isolators, low-pass filters and other details—and to list the type numbers of the various instruments used and the power ratings of attenuators. The accuracy of measurement and the sources of error should be stated together with any other information which is necessary to avoid ambiguity in the interpretation of the results.

3. Frequency

3.1 *Definitions and general considerations*

In satellite communications systems more than one carrier frequency is often present at the output of the equipment under test. The carrier frequency is that frequency in the r.f. signal spectrum which is modulated by the information signal.

In the absence of a baseband test-signal, the spectrum line corresponding to the carrier frequency may not be easily identifiable on a spectrum analyzer when, for example, it is modulated by the dispersal signal which has a high modulation index. In such cases the carrier frequency may be defined as the average number of positive or negative-going zero-crossings per second provided that the averaging interval is sufficiently long, for example 100 cycles of the lowest modulating frequency.

Two methods of measuring the frequency of an r.f. carrier are recommended. The first applies to an unmodulated r.f. carrier and the second applies to a carrier modulated by a sinusoidal baseband test-signal. Measurement of the frequency of an r.f. carrier in the presence of operational baseband signals, such as f.d.m.-telephony or television, will not be considered.

The frequency of the carrier can be measured either at the r.f. output port of the originating radio transmitter or after transmission through a number of sub-systems, where different values will be observed depending upon the errors in the local oscillator frequencies. The frequency of the local oscillators themselves can also be measured by the methods to be described.

3.2 *Methods of measurement*

3.2.1 *Unmodulated r.f. carrier*

The general arrangement for measuring the frequency of an unmodulated r.f. carrier is shown in Figure 1, page 40. The filter is required only if spurious signals are present: the amplifier and/or attenuator and frequency transposer are required only if the frequency meter does not cover the specified range of levels and/or frequencies.

Both the equipment under test and the test equipment itself should be allowed to attain thermal stability before making any measurements, and energy dispersal arrangements, if any, should be rendered inoperative.

The digital frequency meter indications are then read during an interval, for example of 1 s; the interval will depend upon the integrating time of the instrument used.

Alternatively, the recorder shown in Figure 1 may be used to record the indications of the digital frequency meter for a number of counts. One hundred counts are sufficient for practical purposes but in any given instance the number will depend upon whether noise is present or not and whether it modulates the signal or is superimposed upon it. Generally, the analysis of a statistical series averaged over several measuring intervals will provide evidence of the repeatability of the results.

Notes 1. — The above method may also be used when the r.f. carrier is modulated by a baseband signal, provided that the digital frequency meter does not introduce errors which depend upon the modulating signal frequency and the frequency deviation. The averaging interval of the digital frequency meter should exceed 100 cycles of the modulating frequency.

2. — In multi-carrier systems, each carrier should be measured individually with the other carriers either switched off or rejected by means of a suitable filter.

3.2.2 *Modulated r.f. carrier*

The method of measurement is illustrated in Figure 2, page 40 and can be employed to determine whether any significant change in carrier frequency occurs when modulation is applied. The modulation signal used for this test is chosen so that the spectral line corresponding to the carrier frequency can be identified with the required accuracy.

The signal to be measured (either modulated or unmodulated) is displayed on a spectrum analyzer which has appropriate resolution: only the central part of the spectrum need be displayed. The frequency of the reference oscillator is then adjusted until its signal appears on the display and coincides with the carrier frequency of the signal to be measured. The frequency of the reference oscillator will then be that of the carrier to be measured and its frequency may be read on the digital frequency meter.

Note. — The measurement may be made at intermediate frequency if more convenient.

3.2.3 *Presentation of results*

When the direct method of measurement (Sub-clause 3.2.1) is used, the readings of the digital frequency meter may be recorded manually or automatically as a function of time. The integrating time of the digital frequency meter should be stated.

The indirect method of measurement (Sub-clause 3.2.2) is not suitable for recording readings automatically, but a manual record may be made showing radio frequency as a function of time, modulation level, modulation frequency, or of any other appropriate variable.

3.2.4 *Details to be specified*

The following items should be included as required in the detailed equipment specification:

a) the carrier frequency or frequencies;

b) tolerances;

c) modulation test signal.

4. Impedance (or admittance) measurements

4.1 *Definition and general considerations*

The input and output impedance (admittance) of equipment used in satellite systems is usually expressed either in terms of return-loss relative to the nominal value of the impedance of the equipment under test or as the voltage standing-wave ratio (v.s.w.r.).

The return-loss (L) of an impedance (Z) relative to its nominal value (Z_0) is given by:

$$L = 20 \log_{10} \left| \frac{Z+Z_0}{Z-Z_0} \right| \text{ (dB)} \quad (4.1)$$

or alternatively by:

$$L = 20 \log_{10} \left| \frac{1}{\rho} \right| \text{ (dB)} \quad (4.2)$$

where ρ is the voltage reflection coefficient of the impedance (Z) relative to Z_0, i.e.:

$$\rho = \frac{Z-Z_0}{Z+Z_0}$$

Return-loss (L) is related to voltage standing-wave ratio (v.s.w.r.) as follows:

$$L = 20 \log_{10} \left| \frac{\text{v.s.w.r.}+1}{\text{v.s.w.r.}-1} \right| \text{ (dB)} \quad (4.3)$$

4.2 *Methods of measurement*

The following methods of measurement are valid for measuring the return loss of linear devices.

Special methods, which are not given here, are required for the measurement of non-linear devices or for measurement in the presence of extraneous signals.

Measurements may be made by using either sweep-frequency or point-by-point methods.

The point-by-point method requires a large number of individual measurements and is time-consuming. Slotted-line or reflectometer techniques may be used with either method. When measuring with the best equipment techniques, v.s.w.r. may be measured to within about 0.01.

4.2.1 *Slotted-line point-by-point method*

A typical test arrangement for the slotted-line method is shown in Figure 3, page 41. The equipment under test should behave linearly at the signal level necessary to operate the v.s.w.r. indicator.

The signal generator is usually amplitude modulated and the moving probe contains either a tunable or a wideband diode detector. The v.s.w.r. indicator is usually a selective voltmeter tuned to the modulation frequency, for example 1 kHz to 200 kHz and measurements should be made over the entire r.f. band of interest.

4.2.2 *Slotted-line sweep-frequency method*

A typical test arrangement for the slotted-line sweep-frequency method is shown in Figure 4, page 41. The sweep-frequency generator is usually amplitude modulated and the moving probe contains a wideband diode detector. The audio frequency amplifier has a detector at its output and is tuned to the modulation frequency. The v.s.w.r. indicator may be an oscilloscope, preferably of the storage type, or an X–Y plotter. The test arrangement is calibrated by using loads having known values of mismatch. The horizontal sweep of the oscilloscope corresponds to the frequency sweep of the generator and the measurement is made by moving the detector at least one-half wavelength at the lowest r.f. The frequency sweep should include the entire r.f. band of interest.

At any given radio frequency (which corresponds to a given point on the abscissa), the ratio between the maximum and minimum amplitudes of the displayed envelope, as given by the calibration lines, is the v.s.w.r. at that frequency.

4.2.3 *Sweep-frequency reflectometer method*

A typical test arrangement for the sweep-frequency reflectometer method is shown in Figure 5, page 42. Samples of both the incident and the reflected power are obtained using a four-port directional network. From these samples of incident and reflected power, the modulus of the reflection coefficient is measured at each frequency.

To calibrate the test equipment, the equipment under test is replaced by a short circuit and the attenuator is set to simulate a known return loss, for example 26 dB attenuation corresponds to 26 dB return loss. This method of calibration is preferable to one which requires a knowledge of the law of the detector.

If the level of the incident wave is not constant, the calibration lines should be recorded under the conditions of adjustment used for the calibration.

Notes 1. — The extent to which the directivity of the directional network exceeds the return loss to be measured determines the accuracy attainable; for example, 40 dB directivity enables a 26 dB return loss to be measured with an accuracy of −1.6 dB to +1.9 dB.

2. — Reflectometers enabling both amplitude and phase measurements to be made may be used to provide a Smith's Chart presentation.

4.3 *Presentation of results*

The results of the measurements should be presented in the form of curves or photographs of the oscilloscope display complete with the calibration, or as a copy of the plot from the X–Y recorder.

When the results are not presented graphically, they should be given as in the following example:

"The return loss is greater than 26 dB over the frequency range 6.1 GHz to 6.2 GHz."

The maximum error in the results should be given in all cases.

4.4 *Details to be specified*

The following items should be included as required in the detailed equipment specification:

a) nominal impedances;

b) permitted minimum return loss;

c) frequency range.