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Methods of measurement of equipment used in terrestrial radio-relay systems - Part 2: Measurements for sub-systems - Section 5: Frequency demodulators

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METHODS OF MEASUREMENT FOR EQUIPMENT USED IN TERRESTRIAL RADIO-RELAY SYSTEMS
PART 2: MEASUREMENTS FOR SUB-SYSTEMS
SECTION FIVE - FREQUENCY DEMODULATORS

Méthodes de mesure applicables au matériel utilisé dans les faisceaux hertziens terrestres
Deuxième partie: Mesures sur les sous-ensembles
Section cinq - Démodulateurs de fréquence

Meßverfahren für Geräte in terrestrischen Richtfunksystemen
Teil 2: Messungen an Untersystemen
Hauptabschnitt fünf: Frequenzdemodulatoren

BODY OF THE HD

The Harmonization Document consists of:

- IEC 487-2-5 (1984) ed 1; IEC/SC 12E, not appended

This Harmonization Document was approved by CENELEC on 1986-09-10.

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.

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 1987-03-15

to publish their new harmonized national standard
by or before 1987-09-15

to withdraw all conflicting national standards
by or before 1987-09-15.

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Méthodes de mesure applicables au matériel utilisé dans les faisceaux hertziens terrestres

Deuxième partie:
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Methods of measurement for equipment used in terrestrial radio-relay systems

Part 2:
Measurements for sub-systems
Section Five – Frequency demodulators

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHODS OF MEASUREMENT FOR EQUIPMENT USED IN TERRESTRIAL RADIO-RELAY SYSTEMS

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Section Five — Frequency demodulators

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
12E(CO)87	12E(CO)104

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

METHODS OF MEASUREMENT FOR EQUIPMENT USED IN TERRESTRIAL RADIO-RELAY SYSTEMS

Part 2: Measurements for sub-systems

SECTION FIVE — FREQUENCY DEMODULATORS

1. Scope

Methods are given in this section for the measurement of the electrical characteristics of frequency demodulators. Threshold aspects are not included as these are not normally required for line-of-sight radio-relay systems. Furthermore, where possible, only measurements involving the basic demodulator are considered, excluding the equipment comprising the de-emphasis network and the networks associated with sound sub-carrier signals, pilot signals and auxiliary signals.

Methods of measurement for frequency modulators are given in Section Four. Measurements between the baseband terminals of modulator/demodulator assemblies are covered by various sections of Part 3 of this publication.

2. Definition

For the purpose of this standard a frequency demodulator is a sub-system which, by analogue means, demodulates an intermediate frequency (i.f.) carrier which has been frequency modulated by a baseband signal. This may be a multi-channel telephony or television signal with associated sound sub-carrier signals, pilot signals and auxiliary signals.

Such baseband signals are normally analogue but digital signals are not excluded. However, the methods of measurement described in this section are intended for assessing the performance of the demodulator when analogue signals are transmitted.

A demodulator sub-system usually comprises the following three main sections:

— an i.f. section;
— an i.f. to baseband section (discriminator);
— a baseband section.

3. General

A block diagram for a typical demodulator as used in terrestrial radio-relay systems is shown in Figure 1, page 26.

The characteristics to be measured can be divided into three principal categories:

- Non-transfer characteristics.
- I.F. to baseband characteristics.
- Certain baseband-to-baseband transmission characteristics in conjunction with a measurement modulator.

The first category of measurements applies to i.f. input measurements (Clause 4) and baseband output measurements (Clause 5).

The second category of measurements forms the essential part of this section because of the nature of the device under test—transfer from i.f. to baseband. In order to assess the influence of the i.f. input level, some specified tests should be made at nominal, minimum and maximum specified i.f. input levels.

Note. — Measurement of the influence of amplitude modulation is not included in the present standard since the input level is assumed to be entirely within the operating range of the limiter, the amplitude/phase conversion of the latter being assumed to be negligible.

The third category of measurements includes those to be carried out on the complete modulator/demodulator (modem) assembly except that the actual or system modulator is replaced by a measurement modulator.

It is very desirable to know the separate contribution of a demodulator to the total permitted tolerances of performance characteristics because, in an operational situation, demodulators of one design or manufacturer may have to work with modulators of another. Compensation effects between modulator and demodulator are therefore undesirable and each demodulator should fulfil the prescribed specification in association with a measurement modulator. This procedure requires that the measurement modulator has a better performance than that specified for the demodulator under test.

4. I.F. input return-loss

See Part 1, Section Three of this publication: Measurements in the Intermediate-frequency Range.

Measurements at harmonics of the intermediate frequency may also be required.

5. Baseband output-impedance and return-loss

See Part 1, Section Four of this publication: Measurements in the Baseband.

6. Deviation sensitivity

6.1 *Definition and general considerations*

The deviation sensitivity S_d of a demodulator, for a sinusoidal signal of a given frequency, is expressed as the ratio of the peak value of the baseband output voltage V_b to the frequency deviation Δf:

$$S_d = \frac{V_b}{\Delta f} \quad \text{(V/MHz)} \qquad (6\text{-}1)$$

V_b and Δf are both expressed in peak values or both in r.m.s. values.

The deviation sensitivity of the demodulator is usually a function of the baseband frequency due to the effect of the de-emphasis network. In some cases, however, it is possible to gain access to the baseband output point V'_b (see Figure 1, page 26) before the de-emphasis network: in such cases the measured deviation sensitivity of the demodulator is independent of the baseband frequency used.

6.2 *Methods of measurement*

Two methods for obtaining the deviation sensitivity by means of a test signal of accurately known deviation may be used, namely, the Bessel zero and the two-signal methods as discussed below.

In the first method, the measurement is made with a well-defined modulation index of 2.404 83 at relatively low modulation frequencies, e.g. less than about 2 MHz, whilst in the second method a low modulation index (e.g. not exceeding about 0.2) at relatively high modulation frequencies (e.g. above 2 MHz) is used. This latter method is therefore especially applicable to measurements at the pilot and sound sub-carrier frequencies.

6.2.1 *The Bessel zero method*

A suitable arrangement for measuring the deviation sensitivity of the demodulator and for calibrating the deviation of the measurement modulator is shown in Figure 2, page 26. The method of measurement is known as the Bessel zero method and calibration of the deviation sensitivity of the measurement modulator is based upon the fact that, in the case of sinusoidal modulation, the carrier frequency spectral line first disappears for a modulation index m_f; given by:

$$m_f = \frac{\Delta f}{f} = 2.404\,83 \qquad (6\text{-}2)$$

where:

Δf is the peak frequency deviation
f is the modulating frequency

The "zero", or point of first disappearance of the i.f. carrier, is observed on the spectrum analyzer, but a perfect zero may not be obtained due to residual harmonic distortion of the baseband signal generator. However, a decrease in carrier level of 30 dB or more is regarded as adequate.

Since there are many values of the modulation index at which a carrier-zero may be obtained, the best way of ensuring that the first zero is used is by increasing the modulating voltage smoothly from zero to the point where the carrier disappears for the first time.

The measurement procedure is as follows:

i) The baseband generator is set to the required frequency at which the deviation sensitivity is to be measured.

ii) The output level of the generator is set to zero and then smoothly increased until the i.f. carrier on the spectrum analyzer first disappears.

iii) The r.m.s. voltage V_b at the baseband output of the demodulator is measured.

iv) The demodulator deviation sensitivity S_d at modulation frequency f is then calculated from the following equation:

$$S_d = \frac{\sqrt{2}\, V_b}{2.404\,83\, f} \quad \text{(V/MHz)} \tag{6-3}$$

Note. — As a modulation index of 2.404 83 corresponds to an occupied i.f. bandwidth which increases linearly with modulation frequency, the use of this method is restricted to modulation frequencies not exceeding one-third of the highest baseband frequency.

6.2.2 *The two-signal method*

A suitable arrangement for measuring demodulator deviation sensitivity by the two-signal method is shown in Figure 3, page 27. The method is used to calibrate the demodulator deviation sensitivity at low modulation indices, up to about 0.2, and uses high modulating frequencies between 2 MHz and 10 MHz; it is therefore especially applicable at the pilot and sound sub-carrier frequencies.

An accurate frequency deviation at a specified frequency is generated by means of two i.f. crystal oscillators having equal output levels but different frequencies. The first at the nominal carrier frequency (e.g. 70 MHz) and the second at a frequency differing from the carrier frequency by a known value f_x.

As shown in Figure 3, the output signal from crystal oscillator No. 2, suitably attenuated as specified below, is added to the signal from crystal oscillator No. 1. The level of the composite signal is then adjusted by attenuator No. 2 to the appropriate input level of the demodulator under test. Due to the limiting action in the demodulator, a practically pure angle-modulation signal is generated. In order to reduce the unwanted amplitude modulation, an extra limiter has to be inserted before the demodulator under test. This limiter should have a low a.m./p.m. conversion in order to reduce the measurement error to an acceptable level.

The r.m.s. frequency deviation is given by:

$$\Delta f = \frac{f_x}{a' \sqrt{2}} \tag{6-4}$$

where a' is the voltage attenuation of attenuator No. 1.

From this equation, the required voltage attenuation a' can be calculated. For example, to produce a frequency deviation of 140 kHz r.m.s. at a frequency f_x of 8500 kHz the required attenuation is $20 \log_{10} a'$, where a' is given by:

$$a' = \frac{8500}{140 \sqrt{2}} \tag{6-5}$$

which corresponds to 32.7 dB.