XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

REPORTS OF THE CCIR, 1990

(ALSO DECISIONS)

ANNEX TO VOLUME III

FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

REPORTS OF THE CCIR, 1990

(ALSO DECISIONS)

ANNEX TO VOLUME III

FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

92-61-04181-7

Geneva, 1990

INDEX OF TEXTS WHICH HAVE BEEN DELETED AT THE END OF THE STUDY PERIOD 1986-1990

(In order to facilitate the retrieval of a given text, the page number of Volume III of the XVIth Plenary Assembly, Dubrovnik 1986, is indicated.)

ANNEX TO VOLUME III

ANNEX TO VOLUME III

FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

(Study Group 3)

TABLE OF CONTENTS

NUMERICAL INDEX OF TEXTS

ANNEX TO VOLUME III

Note - Decisions which already appear in numerical order in the table of contents, are not reproduced in this index.

SECTION 3A: COMPLETE RADIO SYSTEMS

3A a: Technical characteristics

REPORT 989

MEASUREMENT OF PROTECTION RATIOS FOR J3E EMISSION

(Question 1/3, Study Programme 1A/3)

(1986)

1. Introduction

Protection ratio is defined in No. 164 of the Radio Regulations as follows:

"*Protection Ratio* (R.F.): The minimum value of the wanted-to-unwanted signal ratio, usually expressed in decibels, at the receiver input, determined under specified conditions such that a specified reception quality of the wanted signal is achieved at the receiver output."

In the study of protection ratios for speech communications, there are two basic difficulties. One is to determine what type of signal power ratio should be applied, and the other is to determine exactly what type of evaluation should be associated with the degradation of service due to interference.

The measurement programme described in this Report was based on Recommendation 339, in which audio signal-to-noise (S/N) ratios of 33 dB, 15 dB and 6 dB give the service grades of good commercial, marginally commercial and just usable respectively. The objective was to obtain audio signal-to-interference (S/I) ratios for various interfering signals that give the same opinion scores as those corresponding to the specified S/N ratios.

2. Measurement

2.1 *Measurement principle*

MOS (mean opinion score) value versus S/N ratio curves and MOS value versus S/I ratio curves were obtained by opinion tests. From these curves, the S/I ratios ($X1$, $X2$, $X3$) corresponding to each of the above service grades were obtained for the same MOS values (P_1, P_2, P_3) as those which correspond to each S/N value of 33 dB, 15 dB and 6 dB (see Recommendation 339). The method is shown in Fig. 1.

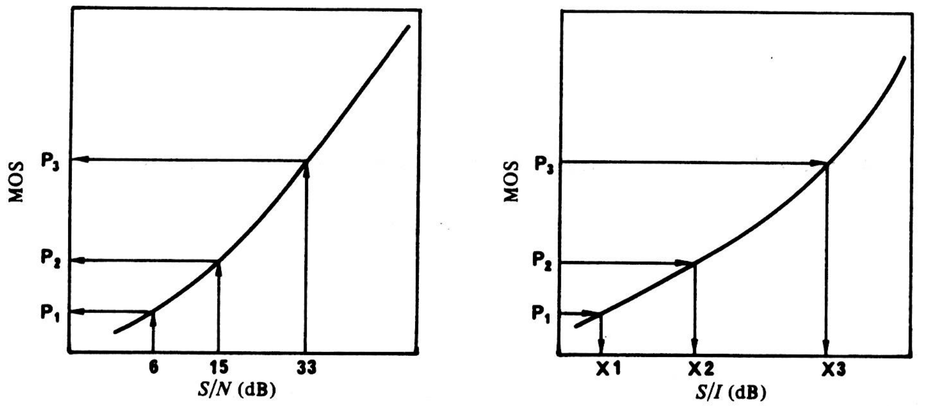

FIGURE 1 – *Conversion from S/N to S/I through MOS*

2.2 *Interfering signals*

The A1B, F1B, F3C, F7B, J7B and J3E emissions shown in Table I were added to the wanted J3E emissions (male and female Japanese speech signals) as interfering signals. The centre frequency of the interfering signal was set at 1400 Hz except for the J7B emission which occupied the band between 0.3 to 3.0 kHz.

TABLE I – *Type of interfering signal*

Class of emission	Frequency shift (Hz)	Modulation rate (Bd)
A1B	–	100
F1B	400	200
F3C	800	(60 rpm)
F7B	600	100
J7B	85 per channel	100 per channel
J3E	–	–

2.3 *Measurement method*

2.3.1 *Test speech samples and sending order*

As shown in Table II, 29 test speech samples containing 14 different *S/N* ratios and 15 different *S/I* ratios, were presented randomly to the listeners for their evaluation. The time duration for one test speech sample was 5 s and a period of 10 s silence was provided between successive 5 s samples. This silent period was used by the listeners to log the speech quality on a questionnaire.

TABLE II – *An example of the random sending order of the test speech samples*

Sample No.	Power ratio (dB)		Sending order
1	*S/N*	0 (1)	14
2		4	4
3		6	25
4		8	27
5		12	23
6		15 (1)	9
7		20	29
8		24	22
9		28 (1)	13
10		33	24
11		36	16
12		40 (1)	1
13		44	8
14		48 (1)	11
15	*S/I*	−8	19
16		−4 (1)	10
17		0	26
18		4 (1)	5
19		8 (1)	17
20		12 (1)	7
21		16	12
22		20	15
23		24	20
24		28	3
25		32	21
26		36 (1)	28
27		40	18
28		44 (1)	6
29		48	2

Note. – The samples and sending order indicated above were used for the preliminary test in the case of F1B interfering signal.

(1) These power ratios were selected for detailed tests.

2.3.2 *Mean opinion score (MOS)*

Speech quality was evaluated by a five-point listening effort scale (see Supplement No. 2, § 3, CCITT Yellow Book, Volume V) as follows:

4 complete relaxation possible (no effort required);

3 attention necessary (no appreciable effort required);

2 moderate effort required;

1 considerable effort required;

0 no meaning understood, with any feasible effort.

MOS was calculated as the mean value of the scores of 12 Japanese (5 male and 7 female) listeners.

2.3.3 *Listening conditions*

Standard conditions as indicated in CCITT Recommendation P.74 and in Supplement No. 2 and set out below, were used for the listening tests:

- telephone set: No. 601 (side tone added),
- room noise: +36 dB (A),
- sound pressure level: 75-80 dB.

2.3.4 *Setting of S/N ratio and S/I ratio*

A schematic diagram of the configuration used for the tests is shown in Fig. 2. The magnetic tapes used for the measurements were prepared as follows:

- speech signals and interfering signals were separately recorded in advance on analogue magnetic recording tapes. These signals were played back, digitized by A/D converter (12 bits) and recorded on magnetic tape (MT-A) in the form of digital data. The sampling frequency of the A/D conversion was 8 kHz;
- in the computer (CPU), the mean power of the wanted speech signal, interfering signal and noise, as well as the coefficient, α, which gives the required S/I or S/N ratio, were calculated from the following equation:

$$S/I \text{ (or } S/N) = 10 \log \frac{\frac{1}{n} \sum_{i=1}^{n} (d_i)^2}{\frac{1}{m} \sum_{k=1}^{m} (\alpha d_k)^2}$$

where:

d_i : sampled data of amplitude of wanted signal;

d_k : sampled data of amplitude of interfering signal;

α : coefficient for setting S/N or S/I ratio;

- the predetermined S/I or S/N ratio of test speech sample (S_i) was obtained by multiplying each sample of the amplitude of the interfering signal (d_k) by α and adding the result to the value of the sample of the amplitude of the wanted signal (d_i). This sum (S_i) was then converted to the analogue signal by the D/A converter ($S_i = \alpha d_k + d_i$).

The measured mean power to peak envelope power ratios of the signals are shown in Table III.

2.3.5 *Determination of sending order of speech samples*

As an example, the random sending order of 29 test speech samples is shown in Table II. The digital signals in each sample were converted to analogue signals by the D/A converter, and recorded on magnetic tape B (MT-B) through a 3 kHz band pass filter.

The processes described above were carried out automatically by the computer.

3. Measurement results

3.1 *MOS versus S/N ratio*

As shown in Table II, for every group of 29 speech samples, the MOS was measured for both S/I and S/N ratios. The MOS versus S/N data were then used to derive the S/I ratios corresponding to the service grades of just usable, marginally commercial and good commercial quality.

By averaging all of the 480 MOS values for each of the 14 S/N ratios tested, a mean value, having a small error, was obtained. The 95% confidence interval calculated for each of the mean S/N values varied between 0.072 and 0.039.

The mean values thus obtained for 14 cases of S/N are plotted in Figs. 3 to 8 with black circles.

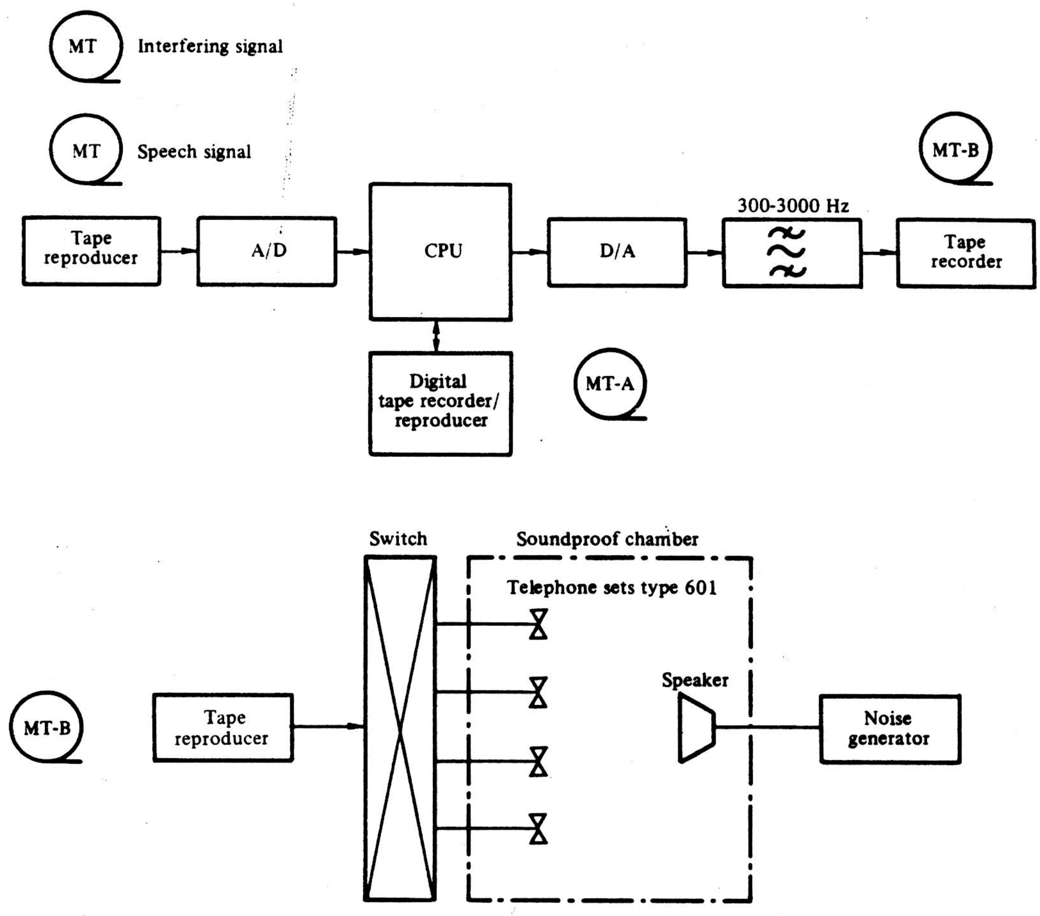

FIGURE 2 – *Configuration of the test*

MT: magnetic tape

TABLE III – *Measured mean power to peak envelope power ratios*

Class of emission	Mean power (¹) to peak envelope power (dB)	Mean power (²) to peak envelope power (dB)
J3E	−15	−17.5
A1B	0	−3.2
F1B	0	0
J7B	−11	–

(1) This mean power was averaged during the time when the signal level was above a threshold which was negligibly small.

(2) This mean power was averaged during the whole time, including the time when no signal was present.

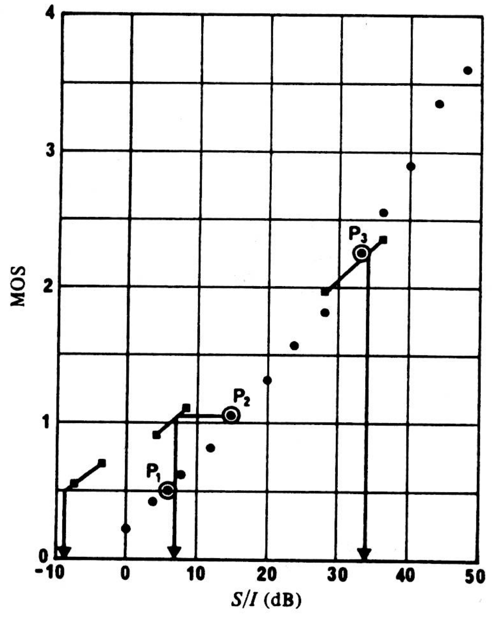

FIGURE 3 – *MOS for speech signal with A1B interference*

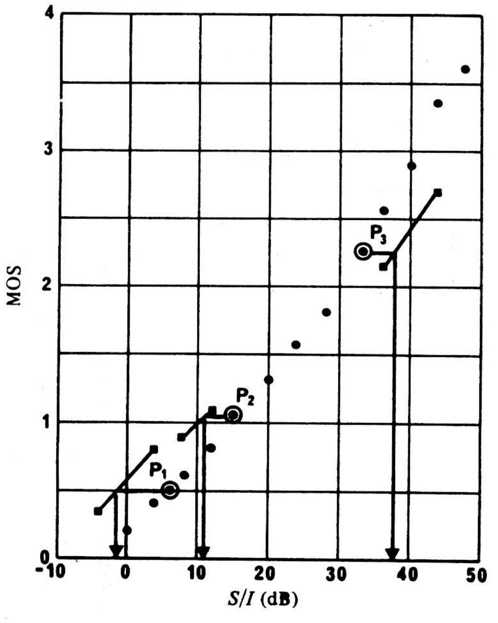

FIGURE 4 – *MOS for speech signal with F1B interference*

Note 1. – The • in Figs. 3 to 8 indicates MOS value to *S/N* ratios (dB).

Note 2. – P_1, P_2 and P_3 represent just usable, marginally commercial and good commercial grades of service respectively.

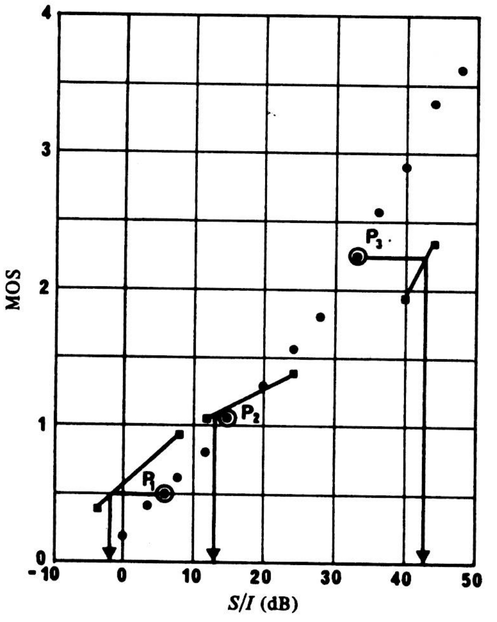

FIGURE 5 – *MOS for speech signal with F3C interference*

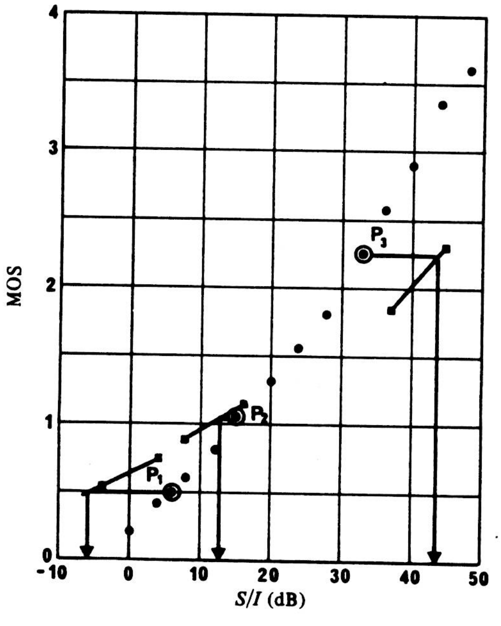

FIGURE 6 – *MOS for speech signal with F7B interference*

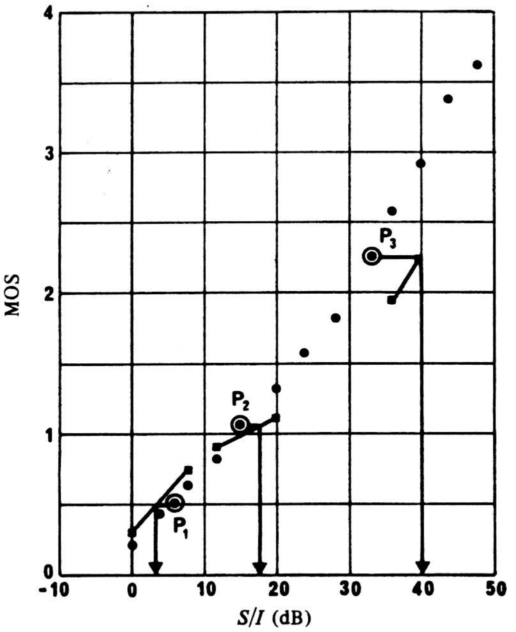

FIGURE 7 – *MOS for speech signal with J7B interference*

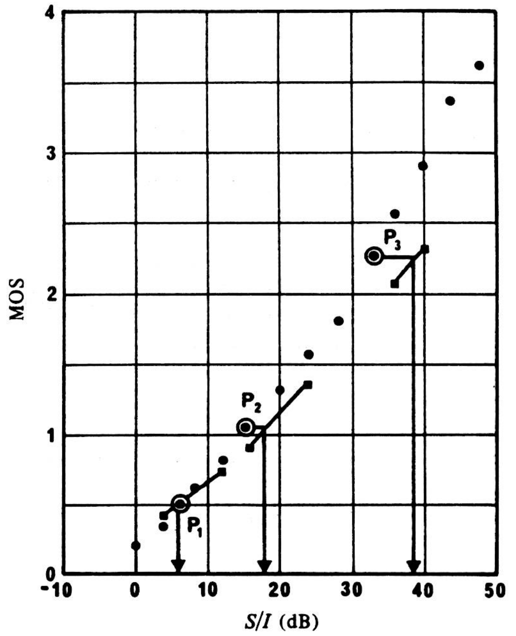

FIGURE 8 – *MOS for speech signal with J3E interference*

3.2 *MOS versus S/I ratio*

Similarly, for the MOS versus S/I data, the MOS levels corresponding to the values of the S/I ratio for each of the three grades of service quality, are obtained by interpolating or extrapolating between the two mean S/I values as shown in Figs. 3 to 8.

In Figs. 3 to 8, each value represents the mean of 240 MOS tests at each S/I ratio, and the values P_1, P_2 and P_3 represent just usable, marginally commercial and good commercial grades of service respectively.

For the S/I measurement, detailed tests were conducted only for a limited number of values of S/I (the six points plotted in Figs. 3 to 8 as black squares), which were expected to give MOS values very close to the S/N ratios corresponding to the three grades of service, in order to increase the test reliability and to save time.

The confidence interval calculated for all measured MOS versus S/I ratio values ranged from 0.06 to 0.117 for the J7B tests.

4. Considerations

4.1 *MOS*

It is interesting to note that the MOS versus S/I ratio curves and MOS versus S/N ratio curves cross at certain S/I and S/N ratios as shown in Figs. 3 to 8. This was not anticipated before the measurements were made. For example, in cases when an F1B or an A1B emission was the interfering signal, noise was more unpleasant than the interfering signal when the S/I ratio was small. On the other hand, the interfering signal was more annoying than white Gaussian noise when the S/I ratio was large, because the interfering signal was easily recognizable.

4.2 *Protection ratios*

Based upon the measurements above, required S/I ratios for J3E emissions against various interfering signals were obtained as shown in Table IV. For obtaining the RF protection ratios for J3E emissions, it is necessary to convert the values of Table IV by using the relationships between the power ratios of the various kinds of interfering emissions. The conversion factors for obtaining protection ratios of various types of emissions against various interfering signals are discussed in Report 990.

TABLE IV – *Required S/I ratios for J3E emissions against various interfering signals*

Type of interfering signal	Required S/I ratios (dB)		
Class of emission	Just usable	Marginally commercial	Good commercial
A1B	–9 (–17)	7 (–8)	34 (10)
F1B	–1 (–6)	11 (3)	38 (21)
F3C	–2 –	13 –	43 –
F7B	–5 –	13 –	44 –
J7B	4 –	18 –	40 –
J3E	6 –	18 –	39 –
White Gaussian noise	6 (5)	15 (14)	33 (32)

Note 1. – The values in parenthesis in each column are the protection ratios shown in Report 525 of Study Group 1.

Note 2. – The audio signal powers for the A1B and J3E cases were measured during the time when the signal was above a specified threshold level.

REPORT 990-1

CONVERSION FACTORS FOR DERIVING THE PROTECTION RATIOS

(Question 1/3, Study Programme 1A/3)

(1986-1990)

1. Introduction

The protection ratios for J3E, R3E, H3E, A3E and B8E emissions (radio telephony) are shown in Table I of Recommendation 240. These values are derived from the results of the measurements of J3E protection ratios given in Report 989.

This Report describes the conversion between the mean power measured data of Report 989 and the protection ratios of Recommendation 240. These protection ratios are expressed in terms of peak envelope power (PX).

Protection ratio values for non-telephony emissions such as A1A, A1B, A2A, A2B, F1B, F7B, R3C, F3C, J7B and R7B emissions can also be obtained by applying the concept of the conversion factors.

2. Calculation of protection ratios

2.1 *Calculation method*

Protection ratios for various radiotelephony signals can be obtained by using the required *S/I* ratios for J3E emission against various interfering signals appearing in Table IV of Report 989 and the conversion factors appearing in Table I of this Report for the case where interfering signals are radiotelephony. For the case where interfering signals are radiotelegraphy, the following conversion factors should be applied:

- in the case of F1B, F7B and F3C emissions, *PX* is equal to the mean power (*PY*);
- PX of a J7B emission is 6 dB higher than PY;
- PX of an R7B emission is 7 dB higher than PY;
- PX of A1B and J2B (negligible carrier) emissions is 3 dB higher than PY;
- PX of an H2A/H2B emission is 6 dB higher than PY and is identical to PX of a J2B emission;
- PX of an R3C emission is 1 dB higher than PY;
- PX of A1A and A1B (50 baud) emissions is the same as that of an A1B (100 baud) emission;