PART I

Series R Recommendations

TELEGRAPH TRANSMISSION

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SECTION 1

TELEGRAPH DISTORTION

Recommendation R.2

ELEMENT ERROR RATE

(Geneva, 1964)

The CCITT,

considering

(a) that in practice, the error rate on transitions is not used and, with the development of data transmission, it is the notion of element error rate that has come into use,

(b) that in general, the expression *element error rate* is used with the meaning of *error rate on unit elements* . Although this equivalence of meaning is acceptable for isochronous signal trains, this is not so for start-stop signal trains. In fact, there may be elements in start-stop signal trains whose duration is different from that of the unit elements (for example, the stop element of a start-stop signal in accordance with International Telegraph Alphabet No. 2),

unanimously declares the view

(1) that the following definitions be adopted:

element error rate : the ratio of the number of incorrectly received elements to the number of emitted elements.

unit element error rate for isochronous modulation : the ratio of the number of incorrectly received elements to the number of emitted elements.

(2) that, for start-stop signal trains, the notion of character error rate be used;

(3) that, when error rates are measured to assess the quality of a communication, the original message acting as a reference for the calculation of the error rate shall be considered as being free of error;

(4) that measurement of the element error rate assumes that it has been possible to record the elements received in such a way that they can be recognized as being correctly or incorrectly recorded. As the result of an error rate measurement thus depends on the recording system at the end of the connection, this system must be specified when the results of the element error rate are given. Whenever possible the element error rate should be measured at the output of the regenerating device which normally precedes the translation device; the signals should be translated for checking purposes.

Recommendation R.4

METHODS FOR THE SEPARATE MEASUREMENTS OF THE DEGREES

OF VARIOUS TYPES OF TELEGRAPH DISTORTION

(New Delhi, 1960; amended at Geneva, 1980)

For separate measurements of the degrees of characteristic distortion, bias distortion and fortuitous distortion affecting a telegraph modulation or restitution, the following is recommended where circuits and voice-frequency telegraph (VFT) channels are used to carry information employing International Telegraph Alphabet No. 2, without regeneration;

1 Measure the degree of overall distortion (at the actual mean modulation rate) on text, for instance the **QKS** text specified in Recommendation R.51 **|** fIbis . Let Δ be the measurement obtained.

2 Measure the degree of distortion on reversals at the modulation rate used in the measurement of § (1) above. Let Δ_1 be the measurement obtained. Δ_1 is the sum of the bias and fortuitous distortions.

3 By using a compensator fitted to the distortion-measuring equipment, for example a compensating winding on the distortion meter relay, reduce the degree of distortion reading obtained to its minimum value. Let this figure be δ. For practical purposes δ is the fortuitous distortion. $\Delta_1 - \delta$ is, for practical purposes, the bias distortion.

4 Keep the distortion meter adjusted as for the measurement of δ. Measure the degree of distortion at the actual mean modulation rate on text (**QKS** text, for instance). Let Δ' be the reading. $\Delta' - \delta$ is, for practical purposes, the characteristic distortion.

Note 1 — This method gives approximate results; it is possible that the equation $\Delta_1 + \Delta' - \delta = \Delta$ may not be exactly satisfied.

Note 2 — The method can be applied by using either an isochronous distortion-measuring set or a start-stop distortion-measuring set.

Note 3 — The fact that the separate measurement of degrees of different types of distortion is said to be possible and that a method is recommended for such a measurement does not mean that separate measurements of the degrees of different types of distortion are to be recommended when international routine maintenance measurements are carried out.

Recommendation R.5

OBSERVATION CONDITIONS RECOMMENDED FOR ROUTINE DISTORTION

MEASUREMENTS ON INTERNATIONAL TELEGRAPH CIRCUITS

(New Delhi, 1960; amended at Geneva, 1964, Mar del Plata, 1968, and Geneva, 1980)

The CCITT,

considering

(a) Recommendations R.51, R.51 | fIbis , R.54 and R.55;

(b) that, for the measurement of the degree of distortion of signals on an international telegraph circuit, it is necessary to specify the best condition of observation in order to be sure that the measurement obtained gives a good indication of what the performance of the circuit will be during periods of normal traffic;

(c) that the observation conditions should be such that their duration or their complexity does not unduly increase the load on the maintenance services;

(d) that certain Administrations, to determine these conditions, have carried out statistical measurements of the degree of individual start-stop distortion using distortion analyzers, the results of which seem to be in agreement;

unanimously declares the view

(1) that the tests should be carried out at nominal modulation rates of 50, 75, 100 and 200 bauds, depending on the type of circuits concerned;

(2) that the text transmitted during measurements should be that of Recommendation R.51 | fIbis ;

(3) that the degree of transmitter distortion of text signals should not exceed 1%;

(4) that, during normal maintenance tests, the duration of the observation should correspond to the examination of at least 800 significant instants, whatever the type of distortion meter used, isochronous or start-stop. At a modulation rate of 50 bauds this results in an observation period of about 30 seconds. At other modulation rates, the observation should last about 20 seconds;

Note — The period of observation required to assess properly the performance of tandem code-independent time-division multiplexers may be much longer than for voice-frequency telegraph equipment.

(5) that, when making start-stop measurements using test equipment that does not register the peak early and peak late reading simultaneously, the observation period should be divided into two more or less equal parts: one part during which the significant instants in advance of their theoretical position could be observed and the other part during which the significant instants coming later than their theoretical position could be observed.

Recommendation R.9

HOW THE LAWS GOVERNING DISTRIBUTION OF DISTORTION SHOULD BE ARRIVED AT

(Geneva, 1964)

The CCITT,

considering

(a) that for the sake of comparative studies of degrees of distortion, it would be well if the procedures for measurement of distortion, and the layout of results, could be standardized. The distortion in question is:

— start-stop individual;

— isochronous individual;

— degree of start-stop distortion,

(b) that the degree of isochronous distortion is of no great practical interest, since it is the individual isochronous distortion that, when isochronous distortion is present, supplies all the useful information. Hence it is not proposed to include the degree of isochronous distortion in this Recommendation.

unanimously declares the following view :

1 Start-stop individual distortion

1.1 As regards start-stop individual distortion, the distribution curves will be plotted by means of a statistical distortion analyzer. The width of the measurement steps should make it possible to take measurements with steps of 1%, 2%, 4%, 8%. A measurement will cover about 20 | 00 transitions (measurement duration of about 15 minutes at 50 bauds: three transitions on the average per start-stop alphabetic signal).

1.2 The results will be shown on the graphs on the linear scale with distributional representation, or on the normal probability scale with cumulative representation, the ordinates being the probabilities or probability density and the abscissae the degree of distortion.

1.3 For individual distortion, the curves will give negative (early) and positive (late) distortion.

1.4 For more detailed studies, the number of transitions to be examined may be higher than 20 | 00, the number depending on the chosen probability that the nominal figure will be exceeded.

2 Isochronous individual distortion

2.1 There is the difficulty of synchronism between the transmitter and the distortion analyzer, when the measurements are made at two different points; moreover, the average propagation time of the signals is to be taken into consideration when loop measurements are made.

2.2 The methods of measuring and presenting the results will be the same as for the preceeding case, but the transmitter and the analyzer will have to be synchronized as accurately as possible, taking into account the distortion values to be measured.

3 Start-stop distortion

3.1 This is a matter of the (maximum) degree noted during a measurement. It is then necessary to decide on the length of the sample to be measured; the text to be measured will be composed at random. The measurement at 50 bauds will last 30 seconds, distributed as specified in § 5 of Recommendation R.5.

3.2 Distribution curves of these degrees of start-stop distortion will be drawn as a function of the number of samples.

Recommendation R.11

CALCULATION OF THE DEGREE OF DISTORTION OF A TELEGRAPH CIRCUIT

IN TERMS OF THE DEGREES OF DISTORTION OF THE COMPONENT LINKS

(New Delhi, 1960; amended at Geneva, 1964, 1980 and at Melbourne, 1988)

1 In general the isochronous standardized test distortion δ (Definitions 33.07 and 33.12, Recommendation R.140 of a telegraph circuit consisting of a number *n* of links in tandem lies between the arithmetic sum and the square root of the sum of the squares of the degrees of distortion of the individual links,

$$\sum_{i=1}^{n} \delta_i > \delta > \sqrt{\sum_{i=1}^{n} \delta_i^2}$$

n being the number of links in tandem. The few exceptions to this rule that have been observed related to extremely long circuits (for example, four links, each of approximately 3500 km looped at voice-frequency at the distant end to give the equivalent of four links (each 7000 km go and return) and a total length of approximately 28 000 km on cable and open-wire carrier telephone-type channels).

2 For such purposes as the planning of networks, the degree of distortion of a telegraph circuit consisting of n channels or links in tandem in the telex service (where a great number of channels will be interconnected at random) is given fairly approximately by:

$$\delta_{\text{inherent}} = \sum_{1}^{n} \delta_c + \sqrt{\sum_{1}^{n} (\delta_{\text{bias}})^2 + \sum_{1}^{n} (\delta_{\text{irreg.}})^2}.$$

Similarly, for the combination of a transmitter and a telegraph circuit consisting of n channels or links in tandem in the telex service, the degree of distortion is given fairly approximately by:

$$\delta_{\text{text}} = \sum_{1}^{n} \delta_c + \sqrt{\delta_t^2 + \delta_v^2 + \sum_{1}^{n} (\delta_{\text{bias}})^2 + \sum_{1}^{n} (\delta_{\text{irreg.}})^2},$$

where

$\delta_{inherent}$ = the probable degree of inherent start-stop distortion on standardized text,

δ_{text} = the probable degree of gross start-stop distortion in service,

δ_c = the degree of characteristic start-stop distortion of a single channel or link,

δ_t = the degree of synchronous start-stop distortion of the transmitter,

δ_v = the degree of start-stop distortion due solely to the difference between the mean transmitter speed and the standardized speed. (The difference to be considered is equal to six times the mean difference for one element.)

δ_{bias} = the degree of asymmetrical (bias) distortion of one channel measured using 1:1 or 2:2 signals (either 1:1 or 2:2 signals should be used according to which is normally employed for adjusting the channels),

$\delta_{irreg.}$ = the degree of fortuitous distortion of one channel measured using 1:1 or 2:2 signals.

3 The values of distortion (except for δ_c) inserted in the foregoing formulae must have the same probability of being exceeded (*p*). The degree of characteristic distortion δ_c of a channel is fairly constant for each type of voice-frequency channel and can be determined in laboratory tests. Nevertheless, the maximum degree of characteristic distortion is reached for only about 20% of the signals of International Telegraph Alphabet No. 2. Empirical values for δ_c can be obtained with reasonable accuracy by using methods recommended by Recommendation R.4.

4 The probability of exceeding the degrees of distortion $\delta_{inherent}$ and δ_{text} calculated with the aid of the above formulae is 0.2 *p* .

Note — The laws governing the addition of distortion in tandem connected code-independent time-division multiplex systems, and in particular the duration of measurement to be assumed, are the subject of study.

Pending further study and mores specific advice, arithmetic addition of distortion can be safely assumed for simplicity in all cases. Although pessimistic this will not lead to unnecessarily restrictive planning decisions in those cases where there is a regenerative link in the chain, e.g., Recommendation R.101 TDM or a regenerative SPC exchange. However, where another law is known to apply then the appropriate law of addition can be used.

e.g.:

mcvft — see text of Recommendation above

code-independent tdm — see note above for non-synchronized tandemed systems

— for synchronized tandemed systems the distortion due to the multiplexing process will be that of a single system

code-dependent tdm — regenerative

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SECTION 2

VOICE-FREQUENCY TELEGRAPHY

Recommendation R.20

TELEGRAPH MODEM FOR SUBSCRIBER LINES

*(Geneva, 1980; amended at Malaga-Torremolinos, 1984 and at |
Melbourne, 1988)*

The CCITT,

considering

(a) that the use of high-level telegraph transmission with single or double current may cause disturbing impulse noise in adjacent cable pairs that may be eliminated by applying low-level transmission with telegraph modems;

(b) that telegraph modems would substantially reduce the power consumption in the central office;

(c) that where connection to a subscriber has to be achieved over a non-metallic pair (e.g., a voice-channel frequency-division multiplex or pulse code modulation system) a telegraph modem has to be utilized;

(d) that the frequencies given below are already standardized in Recommendation V.21 [1];

(e) that suitable inexpensive telegraph modems can be used for full duplex transmission on 2-wire circuits at modulation rates up to 300 bauds;

unanimously declares the view

that where low-level telegraph transmission is used, the following method of transmission should be recommended for all modulation rates up to 300 bauds.

1 Channel allocation

The method of transmission is based on Recommendation V.21 [1] with the following frequency designations:

Central office to subscriber (channel 1) F_A = 1180 Hz,

F_Z = 980 Hz;

Subscriber to central office (channel 2) F_A = 1850 Hz,

F_Z = 1650 Hz.

The characteristic frequencies as measured at the telegraph modem line output should not differ by more than ± | Hz from the nominal figures.

The modem shall continue to operate with a ± | Hz change in receive frequency.

It should be noted that there is equipment in use that applies alternative frequencies to those shown in this Recommendation.

2 Interface

Where the modem is a separate, self-contained unit, the following interchange circuits shall be used:

Common return (e.g. circuit 102 in Recommendation V.24 [2])

Transmitted data (e.g. circuit 103 in Recommendation V.24 [2])

Received data (e.g. circuit 104 in Recommendation V.24 [2])

Carrier detect (e.g. circuit 109 in Recommendation V.24 [2])

3 Electrical characteristics

The electrical characteristics (for stand alone telegraph modems) of the interchange circuits, should be in accordance with CCITT Recommendation V.28 [3].

4 Performance

4.1 The modem under test shall be connected to another modem (according to this Recommendation or to Recommendation V.21) via an attenuator having a return loss of 4 dB and an insertion loss of 30 dB. The relative group-delay characteristics of the transmit filters are subject to further study.

4.2 Uniform spectrum Gaussian noise (band limited to 10 kHz) shall be added to give a normalized signal-to-noise ratio of 32 dB. This is defined as:

$$\frac{\text{signal energy per bit}}{\text{noise power per herts}} = \frac{\text{signal power}}{\text{noise power}} \times \frac{\text{noise bandwidth}}{\text{signal bit rate}} = 32\ \text{dB}$$

4.3 Test signals to Recommendation R.51 *bis* (QKS) shall be sent at a —13 dBm transmit level in both directions simultaneously. (To ensure incoherence, the rate of the test signals for the direction not under test shall be slightly lower.) The test period shall be 15 seconds.

The performance shall be in accordance with Table 1/R.20.

H.T. [T1.20]

TABLE 1/R.20

This is considered optional, particularly at the subscriber’s location.

Transit rate (bit/s)	{		
	140 or 2600 ohm line	600 ohm line	No frequency error
50	5	7	3
75	6	8	4
100	7	10	5
110	7	10	5
134.5	8	12	6
150	9	13	6
200	11	16	8
300	15	22	11

Table 1/R.20 [T1.20], p.

4.4 In certain configurations, it is not possible to check the modem distortion, e.g. telegraph terminals, multiplex and switching equipment with integral telegraph modems on which the d.c. signal output of the telegraph modem is inaccessible for any reason. The performance will normally be in the form of a test for distortion margin before errors are output from the equipment.

Note — The modem needs only be tested at the maximum modulation rate of the equipment into which it is to be incorporated.

4.5 The design of the telegraph modem shall be such that the transmission performance is guaranteed without adjustment on installation or subsequently.

5 Line signal levels and terminating impedance

The line interface of the modem shall be balanced and shall present an impedance of 600 ohms with a return loss (reference 600 ohms resistive) of not less than 14 dB (reflection coefficient no greater than 20%) over the range 300-3400 Hz.

5.1 *Output signal level*

5.1.1 When terminated in 600 ohms the output level should be set to —13 dBm.

Note — In certain applications, in particular if carrier circuits for voice channel frequency division multiplex or pulse code modulation systems are used (where the input level should be limited to —13 dBmO) it may be necessary to have a setting range of output level which could give up to 0 dBm.

5.1.2 The difference in output levels between the Binary 1 (condition Z) and Binary 0 (condition A) signals shall not be greater than 1 dB for either of the channels.

5.2 *Receive signal level*

5.2.1 When the received signal level is —43 dBm or greater, the equipment should correctly interpret the line condition as either F_A or F_Z.

5.2.2 When the received signal level remains below a threshold between —45 dBm and —48 dBm, the equipment shall ignore incoming information within 300 ms of the signal level dropping below the threshold. During this delay the receiving equipment may interpret (correctly or incorrectly) characters received after the drop in received signal level below the threshold. Thereafter, the equipment should not interpret characters received until the received signal level has restored to at least 2 dB above the threshold. If the signal level drops below the threshold for less than 10 ms, the equipment should take no action.

5.2.3 Once the received signal level has fallen below the threshold value, the equipment shall ignore any subsequent increases in the signal level which are either less than 2 dB above the threshold or of more than 2 dB above the threshold but less than 10 ms in duration.

Note 1 — The requirements of § 5.2.3 need not apply during the first 20 ms from the fall in received signal level below the threshold.

Note 2 — The signal level detector shall respond to the total power contained within the nominal spectrum of the received line signal.

6 Maintenance facilities

Maintenance facilities, e.g. test loops, are a national matter.

7 Protection against high voltages

The equipment shall withstand residual lightning surges, high voltage line faults, and high level telegraph keying. The protection required is considered a national matter, though in some cases Recommendation K.21 could be applied [4].

Figure 1/R.20, p.

8 Line wetting

8.1 Line wetting, where required by the type of line plant used, will normally be sourced by the in-station equipment and looped by the subscriber’s equipment.

8.2 The current has a maximum value of 15 mA with the line short-cirucited. The wetting current shall be a minimum of 5 mA on 4000-ohm lines. The open circuit voltage shall be under 80 V.

Note — In some countries, other values may apply.

Where a modem may be required to work in the presence of line wetting, then the modem performance (see § 4) and the modem line impedance (see § 5) requirements must apply with line wetting current flowing.

The noise applied to the line from the wetting power supply shall be under —80 dBm (600 ohms) over a range 300 to 3400 Hz (flat).

9 Permitted out-of-band energy

9.1 The out-of-band energy is a national matter; however the following information is provided to assist equipment manufacturers:

9.2 The transmitted signal level (with an output level at —13 dBm) at any one frequency shall not exceed the following limits (with the forward and reverse channel keyed at 300 bit/s with a QKS code):

200 Hz to 3200 Hz	—13 dBm	
100 Hz to 200 Hz and 3200 Hz to 3400 Hz	—23 dBm	
Below 100 Hz	—33 dBm	
Above 3400 Hz	—33 dBm	and decreasing by 12 dB/octave to —67 dBm

References

[1] CCITT Recommendation *300 bits per second duplex modem standardized for use in the general switched telephone network* , Rec. V.21.

[2] CCITT Recommendation *List of definitions for interchange circuits between data terminal equipment and data circuit terminating equipment* , Rec. V.24.

[3] CCITT Recommendation *Electrical characteristics for unbalances double-current interchange circuits* , Rec. V.28.

[4] CCITT Recommendation *Resistibility of subscribers' terminals to over-voltages and over-currents* , Rec. K.21.

Recommendation R.30

TRANSMISSION CHARACTERISTIC FOR INTERNATIONAL VFT LINKS

(Mar del Plata, 1968; amended at Geneva, 1976)

1 Standardized carrier systems with 4-kHz and 3-kHz spacing permit homogeneous voice-frequency telegraph (VFT) systems providing the capacities of telegraph channels given in Table 1/R.30.

H.T. [T1.30]
TABLE 1/R.30

Bearer bandwidth	50-baud 120-Hz spacing	100-baud 240-Hz spacing	200-baud 360-Hz spacing	200-baud 480-Hz spacing
4 kHz	24	12	8 (not normally used)	6
3 kHz	22	11	7	5

TABLE 1/R.30 [T1.30], p.

2 Audio-frequency circuits with heavy or semi-heavy loading permit 12-channel 50-baud systems; circuits with lighter loading permit 18 channels at 50 bauds.

3 Four-wire links are to be preferred for voice-frequency telegraphy.

4 The composition of a 4-wire link for voice-frequency telegraphy differs from that of a telephone circuit in that there are no terminating sets, signalling equipment and echo suppressors.

5 With 2-wire links, a duplex arrangement would not be feasible since the links could not be balanced with the necessary precision to avoid mutual interaction. If the low frequencies are used for transmission in one direction and high frequencies for the other direction, a 2-wire link can be used for voice-frequency telegraphy.

6 The conditions of use of international VFT links are described in detail in Recommendation H.22 [1].

7 PCM (pulse code modulation) channels complying with Recommendation G.712 [2] are also suitable as bearers for FMVFT (frequency-modulated voice-frequency telegraph) links. However, the increase in telegraph distortion in relation to the transmission level and the number of tandem-connected PCM channels is the subject of further study.

References

[1] CCITT Recommendation *Transmission requirements of international voice-frequency telegraph links (at 50, 100 and 200 bauds)* , Rec. H.22.

[2] CCITT Recommendation *Performance characteristics of PCM channels at audio frequencies* , Rec. G.712.

Recommendation R.31

STANDARDIZATION OF AMVFT SYSTEMS FOR | A MODULATION RATE OF 50 BAUDS

(Mar del Plata, 1968, incorporating former Recommendations R.31, R.32 and R.34;

amended at Malaga-Torremolinos, 1984)

The CCITT,

unanimously declares the following view :

1 It is advisable to adopt, for amplitude-modulated voice-frequency telegraph (AMVFT) systems and for a modulation rate not exceeding 50 bauds, the series of frequencies formed by odd multiples of 60 Hz, the lowest frequency being 420 Hz as shown in Table 1/R.31.

H.T. [T1.31]
TABLE 1/R.31

Channel position	Frequency Hz	Channel position	Frequency Hz
1	420	13	1860
2	540	14	1980
3	660	15	2100
4	780	16	2220
5	900	17	2340
6	1020	18	2460
7	1140	19	2580
8	1260	20	2700
9	1380	21	2820
10	1500	22	2940
11	1620	23	3060
12	1740	24	3180

TABLE 1/R.31 [T1.31], p.

2 This numbering is valid whatever use is made of the channel (e.g. traffic channel, pilot channel, etc.) or the method employed to obtain the line frequencies, e.g. by group modulation. For the numbering of channels that has been adopted in the international service see Recommendation R.70 **|** fIbis .

3 In the case of systems on telephone-type circuits with a spacing of 3-kHz operating in accordance with the standardized frequency series, channel positions 23 and 24 cannot be used.

4 The frequencies applied to the telephone-type circuit that is used as the voice-frequency telegraph bearer circuit should not deviate by more than 6 Hz from the nominal value when the telegraph channels supplied are operating over a telephone-type circuit composed exclusively of audio-frequency sections, and not more than 3 Hz in other cases.

5 The power levels of carrier waves transmitted on the line and measured successively in as short a period as possible should not differ from one another by more than 1.74 dB when they are operating on a constant impedance.

6 The power of each of the carrier waves transmitted on the line should not vary in operation by more than ± | .87 dB when it operates on a constant impedance.

7 The amplitude of the signals transmitted by a channel modulator during a transition from condition A to condition Z should remain within the tolerances of Figure 1/R.31 in which the values t_0 and y_2 and y_1 are fixed as follows:

t_0 = 11 ms,

y_1 = 95%,

y_2 = 110%.

FIGURE 1/R.31, p.

8 Receivers with rapid-action level correction should not be so sensitive to secondary pulses following the signal pulse provided that the amplitude of the signal emitted does not exceed the reference level by more than 10% and that the reference level does not exceed the normal level by 10.4 dB. (This provision applies only to new systems.)

9 If 1:1 reversals at frequency f_p corresponding to the modulation rate are sent over a channel with mid-frequency F_0, the voltage at frequency $F_0 \pm 3 f_p$ must not exceed 3% of the nominal voltage at frequency F_0 and the voltage at the frequencies $F_0 \pm 5 f_p$ must not exceed 0.4% of the nominal voltage at frequency F_0.

Note — These tolerances will be required only for future systems. Administrations should try as far as possible to use systems satisfying these tolerances on international relations.

10 The unbalance of the emitted signal should not be greater than ± | % (methods of measuring this unbalance are described in [1] and [2]). This tolerance takes account of the limit in § 11 below for new systems.

11 For new systems, the static relay should introduce a difference of not less than 45 dB between the two signalling conditions. (For existing systems the limit is 30 dB.)

12 In the event of failure of the control current in the sending static relay, the attenuation of the residual signal relative to this nominal level should be at least 27 dB. This attenuation of the signal need not occur immediately on the failure of the control current.

13 Systems should be able to tolerate slow level variations of at least ± | dB. Administrations should equip systems that are unable to tolerate such variations with a common amplifier to enable them to tolerate variations of at least ± | dB.

14 The permissible limit for the power of the telegraph signal on each telegraph channel when a continuous tone is being transmitted is given in Table 2/R.31.

H.T. [T2.31]
TABLE 2/R.31
Normal limits (nominal values) for the power per telegraph channel in AMVFT systems

{	{	
	microwatts	decibels
12 or less	35	—14.5
18	15	—18.3
24	9	—20.45

Note — These limits are such that the maximum instantaneous voltage will exceed that of a sinusoidal voltage with a power of 5 milliwatts at a point of zero relative level. This is the maximum permissible for voice-frequency circuits.

TABLE 2/R.31 [T2.31], p.

15 Audio-frequency is transmitted to line when stop polarity (condition Z) is sent.

16 When a signal, whose frequency is equal to the nominal frequency of the channel and whose level is 18.3 dB below the normal signal level of the channel, is applied to the detector of a 24-channel AMVFT system, the receiving relay should not respond.

17 It must be possible to subject any channel to a test without withdrawing from service a channel other than the return channel of the circuit planned.

18 In graded harmonic frequency telegraphy, it is desirable that the same frequencies be used separately for circuits established on different successive sections of a 4-wire circuit.

19 In graded harmonic frequency telegraphy, the attenuation of the filters that pass a group of frequencies must, in the suppressed frequency band, be higher by at least 35 dB than that shown in the transmission band.

20 In graded harmonic frequency telegraphy, in order to facilitate local tests, the frequencies used for communications set up between two international offices in one direction should also be used in the opposite direction, if possible.

References

[1] *Measuring method to determine the asymmetry of an amplitude-modulated telegraph signal* , Blue Book, Vol. VII, Supplement No. 11, ITU, Geneva, 1964.

[2] *The measurement of the distortion produced in the sending terminal equipment of an A.M.-V.F. telegraph system* , Blue Book, Vol. VII, Supplement No. 12, ITU, Geneva, 1964.

Recommendation R.35

STANDARDIZATION OF FMVFT SYSTEMS | fR FOR A MODULATION RATE OF 50 BAUDS

(former CCIT Recommendation B.48, Geneva, 1956; amended at New Delhi, 1960,

Geneva, 1964, Mar del Plata, 1968, Geneva, 1972, 1976, 1980,

Malaga-Torremolinos, 1984 and at Melbourne, 1988)

Note — In this Recommendation, frequency-modulated voice-frequency telegraph (FMVFT) equipment with and without crystal control are distinguished. In order to improve the quality of transmission and to minimize maintenance costs, the application of equipment with crystal control is recommended.

1 The nominal modulation rate should be standardized at 50 bauds.

2 For the nominal mean frequencies, the series formed by the odd multiples of 60 Hz should be adopted, the lowest frequency being 420 Hz in accordance with Recommendation R.31, § 1, the mean frequency F_0 being defined as half the sum of the two characteristic frequencies corresponding to the permanent start polarity F_A and stop polarity F_Z. For the numbering of channels that has been adopted in the international service, see Recommendation R.70 | fIbis .

3 The mean frequencies at the sending end should not deviate from their nominal value by more than:

a) for equipment without crystal control 2 Hz;

The tightening of this tolerance is for further study.

b) for equipment with crystal control 0.5 Hz.

4 The unbalance due to the modulation process $\delta = 2 \frac{F_0 - F_l}{F_A - F_Z}$ should not exceed 2%,

where

F_A and F_Z are the two characteristic frequencies measured over a period of 10 s;

F_0 is the mean static frequency measured $= \frac{F_A + F_Z}{2}$;

F_l is the mean dynamic frequency measured with 1:1 rectangular signals during 10 s.

Measurement should be made applying to the input of the transmitter 1:1 rectangular signals with the build-up and hangover time below 1 µs and with the unbalance below 0.1%. In the event that in service the transmitter is controlled by an electro-mechanical relay (with a certain transit time), the measurement should also be made with that type of relay inserted between the 1:1 signal generator and the input to the transmitter. Both forms of measurements need not necessarily be included in the maintenance procedure but should be included in laboratory type tests.

Note — To determine the unbalance due to the modulation process by the method indicated above, it is necessary to measure the frequencies F_A, F_Z and F_l and to calculate the mean frequency F_0 and the unbalance

$$\delta = 2 \frac{F_0 - F_l}{F_A - F_Z}$$

A more rapid method for checking whether or not the unbalance is less than the limit fixed is to measure:

— the mean dynamic frequency F_l with 1:1 signals during 10 seconds;

— the mean dynamic frequency F_m with 2:2 signals during 10 seconds;

$$\delta = 2 \frac{F_0 - F_l}{F}$$

A —
F |

Z $$1e = 4
$$1 | fIF |

0
—
F

m |
$$1uF |

A — F |

Z $$1e

or to subtract:

| fIF
l — F
m | =
$$Bo1
} over {
$$Be (F |

A —
F |

Z) δ =
$$Bo1
} over {
$$Be (F

A —
F
Z) | (*d 0.4 Hz.

The absolute value of the difference between the two frequencies measured, F_l and F_m, must be less than 0.4 Hz.

5 The difference between the two characteristic frequencies (corresponding to the start and the stop conditions) should be 60 Hz.

6 The maximum tolerance on this difference should be ± | Hz.

7 The total average power transmitted to the telephone-type circuit is normally dependent on the transmission characteristics of the circuit as follows:

a) For circuits with characteristics not exceeding the limits given in Annex A, the total average power transmitted by all channels of a system should preferably be limited to 50 µW at a point of zero relative level. This sets, for the average power of a telegraph channel (at a point of zero relative level), the limits given in Table 1/R.35.

b) For other circuits, the total average power transmitted by all channels of a system is limited to 135 µW at a point of zero relative level. This sets, for the average power of a telegraph channel (at a point of zero relative level), the limits given in Table 2/R.35.

H.T. [T1.35]

TABLE 1/R.35

Normal limits (nominal values) for the power per telegraph channel in FMVFT systems for bearer circuits with charactistics not exceeding the limits given in Annex A

{	{ in microwatts	{
12 or less	4.0	—24.0
18	2.7	—25.7
24	2.0	—27.0

TABLE 1/R.35 [T1.35], p.

H.T. [T2.35]

TABLE 2/R.35

Normal limits (nominal values) for the power per telegraph channel

in FMVFT systems for others bearer circuits

{	**{ in microwatts**	**{**
12 or less	**10.8**	**—19.7**
18	**7.2**	**—21.4**
24	**5.4**	**—22.7**

Note — The figures in Tables 1/R.35 and 2/R.35 assume the provision of a pilot channel on the telegraph bearer at a level of —27 dBm0 and —22,7 dBm0 respectively.

Table 2/R.35 [T2.35], p.

8 In service, the levels of the signals corresponding to continuous condition Z and continuous condition A should not differ by more than 1.7 dB in the same channel. Both of these levels must lie between ± | .7 dB with reference to the level given in Table 1/R.35 or Table 2/R.35 as applicable.

9 The frequency for the transmitted condition corresponding to the condition A is the higher of the two characteristic frequencies and that corresponding to the condition Z is the lower.

10 In the absence of a channel-modulator control telegraph current, a frequency should be transmitted within ± | Hz of the frequency normally transmitted for the start polarity. This frequency need not be sent immediately after interruption of the control current.

11 The frequency spectrum of the emitted signal, when transmitting 1:1 reversals (Definition 31.401, Recommendation R.140) at the modulation rate of $2\,f_p$ (f_p = frequency of modulation), should be in accordance with the limits specified in Figure 1/R.35, which shows the levels of the spectra of different components with respect to the amplitude of the non-modulated carrier as ordinates and the frequencies as abscissae.

12 The receiving equipment should operate satisfactorily when the receiving level falls to 17.4 dB below the nominal level. The receiving equipment should have been restored to condition A when the receiving level has fallen to 23.5 dB below the nominal level. The nominal level is the level resulting from the choice of power per channel (see Tables 1/R.35 or 2/R.35 as applicable) depending upon the number of channels (12, 18 or 24) on the circuit. The alarm-control level is left to the choice of each Administration.

13 On delivery by the manufacturer of 50-baud FMVFT equipment, the following values must not be exceeded for the degree of distortion on a telegraph channel. These values correspond to closed circuit measurements, made with the audio-frequency line terminals of the sending and receiving equipments connected together through an artificial line. Before the series of measurements taken in accordance with Recommendation R.51, the levels are adjusted to their normal values, the mean frequencies are checked to see whether they are within:

1) for equipment without crystal control ± | Hz;

2) for equipment with crystal control ± | .5 Hz ,

of their nominal value (see § 3 above) and the difference between the two characteristic frequencies is within the permitted tolerance of less than 3 Hz (see § 6 above). Bias distortion is eliminated by adjustment in the channel receivers. The other channels of the system are modulated with unrelated signals when the effect of inter-channel interference is to be included in the measurement. These ‘‘unrelated signals’’ can conveniently be 1:1 signals from different generators at approximately 50 bauds but not synchronous to each other or to the signal on the channel under test.

a) The transmission levels being normal, the artificial line introducing no frequency drift, but the measured channel being subject to fortuitous distortion due to interchannel interference: 5% for the degree of inherent isochronous distortion.

b) The level being maintained constant, but at a value different from the normal level, for all constant levels between 8.7 dB above the normal reception level and 17.4 dB below the normal reception level, the other conditions being the original measurement condition: 7% for the degree of inherent isochronous distortion.

c) In the presence of interference by a single sine-wave frequency equal first to one and then to the other characteristic frequency, with a level of 20 dB below the signal level, the other conditions for the start of measurements being maintained: 12% for the degree of inherent isochronous distortion (i.e. total distortion including the increase due to the interfering frequency, not distortion due to the interfering frequency alone).

d) By introducing a frequency drift (Δf Hz) of the signals during transmission through the artificial line, Δf being not more than 5 Hz and the initial condition of the test otherwise being preserved:

— for equipment without crystal control ?04

— for equipment with crystal control but without ?05 (5 + 2.5 Δf Hz) %

compensation for frequency drift ⌡

— for equipment with crystal control and compensation

for frequency drift | 7%

for the degree of inherent isochronous distortion.

By introducing a frequency drift (Δf Hz) of the signals during transmission through the artificial line, Δf being not more than 10 Hz, and the initial conditions of the test otherwise being preserved:

— for equipment with crystal control and compensation

for frequency drift | 13%

for the degree of inherent isochronous distortion. The measurements shall be made after the transient effects of changing frequency have ceased.

e) Equipment with crystal control, with any climatic conditions specified for the tested equipment, the initial condition of the test otherwise being preserved: 8% for the degree of inherent isochronous distortion. The bias distortion caused by changes of climatic conditions should not be eliminated.

FIGURE 1/R.35, p.

14 Frequency drifts on modern telephone-type circuits are generally less than 2 Hz. Hence it is not necessary to recommend frequency drift control. For circuits on which a maximum frequency drift of not greater than ± | Hz cannot be guaranted, and on which the distortion resulting from the frequency drift is not acceptable, compensation seems necessary. Two methods can be used:

a) compensation for each channel up to about 15 Hz;

b) compensation for all the channels by using a pilot. In this case, the receiving end must be able to request and obtain a pilot frequency. Administrations should agree among themselves on the advisability of sending the pilot and the choice of frequency. The frequencies 3300 Hz or, preferably, 300 Hz are recommended for this pilot, with a tolerance of:

1) for equipment without crystal control ± | Hz

2) for equipment with crystal control ± | .2 Hz.

The mean power emitted at the relative zero point on this frequency should not exceed —27.0 dBm0 or —22.7 dBm0 as appropriate (see Table 2/R.35).

15 The number of significant modulation conditions is fixed at two; this number may be increased, if necessary, by agreement between the Administrations concerned.

ANNEX A
(to Recommendation R.35)

Limits required by a bearer circuit for FMVFT application if the

total power transmitted by all channels is set at 50 microwatts

A.1 *Loss/frequency distortion*

The variation with frequency of the overall loss of the link with respect to the loss at 800 Hz should not exceed the limits shown in Figure A-1/R.35.

FIGURE A-1/R.35, p.

A.2 *Random noise*

The mean psophometric noise power referred to a point of zero relative level should not exceed 32 | 00 pW0p (—45 dBm0p), using a psophometer in accordance with Recommendation P.53 [1].

A.3 *Impulsive noise*

The number of counts of impulsive noise that exceeds —28 dBm0 should not exceed 18 in 15 minutes when measured with an impulsive noise counter in accordance with Recommendation O.71 [2].

A.4 *Error rates*

The telegraph character error rate that may be caused by interruptions and noise in the bearer circuit should not exceed the limits stated in Recommendations R.54 and F.10 [3].

References

[1] CCITT Recommendation *Psophometers (apparatus for the objective measurement of circuit noise)* , Rec. P.53.

[2] CCITT Recommendation *Specification for an impulsive noise measuring instrument for telephone-type circuits* , Rec. O.71.

[3] CCITT Recommendation *Character error rate objective for telegraph communication using 5-unit start-stop equipment* , Rec. F.10.

Recommendation R.35 | fR *bis*

50-BAUD WIDEBAND VFT SYSTEMS

(Geneva, 1964)

The CCITT,

considering

(a) that Voice-frequency telegraph (VFT) systems standardized by the CCITT for 50-baud channels are described in Recommendations R.31 (for amplitude modulation) and R.35 (for frequency modulation). Systems that comply with these Recommendations are those normally recommended by the CCITT. However, it may sometimes be advisable to use a VFT system for a speed of 50 bauds in which the channels have wider spacing than in systems complying with Recommendations R.31 and R.35,

(b) that the use of channels with a spacing of more than 120 Hz for a modulation rate of 50 bauds offers certain advantages in the following cases:

i) on links with not much traffic (which it is not intended to increase to more than 12 channels for a long time to come);

ii) on links where channels are required to have less distortion than on channels established in accordance with Recommendations R.31 and R.35;

iii) as far as maintenance is concerned, wideband equipment requires less attention,

(c) that in particular, if telephone-type circuits carrying VFT systems are unstable, the use of wideband channels together with frequency modulation is recommended,

(d) Moreover that, if systems are standardized so that only one modulation method is used, the cost of equipment should be lower.

unanimously declares the view

that when Administrations agree to set up a 50-baud VFT system with spacing of more than 120 Hz, the VFT equipment should have the following characteristics:

1) VFT systems for wideband 50-baud channels should be homogeneous systems using frequency modulation only;

2) equipment in conformity with Recommendation R.37 is recommended for this purpose.

REPORT ON VOICE-FREQUENCY TELEGRAPH

CHANNELS FOR USE ABOVE 50 BAUDS

(Common introductory report on Recommendations R.36, R.37, R.38 | and R.38 |)

(Geneva, 1964; amended at Mar del Plata, 1968, and Geneva, 1980)

1 The CCITT has examined the characteristics of telegraph circuits for use above 50 bauds. It has been noted that modulation rates of 75, 100, 150, 200 and 300 bauds are envisaged. The CCITT considers that the number of different types of VFT channels to be provided should not fully correspond to such a detailed list, for two basic reasons:

a) With the exception of 300 bauds, a particular rate circuit can be provided over a higher rate channel. In some cases a lower rate channel might also be considered, this being the situation where a 300-baud circuit may sometimes be supported on a nominally 200-baud channel.

b) The lease charges envisaged are generally such that a marginal tariff difference may exist between circuits operated at the next higher rate.

2 The CCITT has therefore established VFT standards for nominal 100- and 200-baud channels in addition to the earlier standards for channels for operation at nominally 50 bauds.

Note — The performance of a circuit operated at a modulation rate of 75 bauds via one VFT channel conforming to Recommendation R.35 should be quite satisfactory. Similarly, the performance of a circuit operated at a modulation rate of 300 bauds via one VFT channel conforming to Recommendation R.38 | may be satisfactory. However when a circuit consists of two or more channels in tandem, the use of a regenerative repeater may be required. To judge this,

it is advisable to conduct distortion measurements on the end-to-end circuit concerned and also on the individual VFT channels employed. In general, it is recommended that circuits operated at a particular modulation rate should not be routed over nominally lower rate VFT channels, whenever this can be avoided.

3 Very different possibilities for using these channels may be envisaged:

— start-stop transmission or synchronous transmission;

— tandem operation of several channels;

— use of point-to-point circuits, circuits with broadcast or switched circuits;

— integration into the world network;

— data transmission.

4 Signal regeneration devices do not normally form an integral part of a VFT channel, as their presence reduces the flexibility to assign a channel for a different use.

5 With regard to channels for 200 bauds, it has been agreed that the spacing for such channels should normally be 480 Hz because of the

advantages of 480 Hz spacing compared with 360-Hz spacing with regard to distortion and the cost of equipment. But when the advantage of having a greater number of telegraph channels on the same bearer circuit is considered essential by the Administration (e.g. on long submarine cables employing narrow band 3-kHz telephone channeling equipment), the use of 360-Hz spacing between 200-baud telegraph channels may be justified.

6 For the above reasons, Recommendations R.36, R.37, R.38 | and R.38 | have been adopted.

7 Recommendation R.36 applies to heterogeneous systems and Recommendations R.37, R.38 | and R.38 | apply to homogeneous systems.

8 For the homogeneous systems referred to by Recommendations R.37, R.38 | and R.38 | , only frequency modulation is recommended.

H.T. [T3.35]
Comparative table of values for the degree of tolerable distorsion
on telegraph channels with various modulation rates

Reception condition	{		
	Recommendation	R.35 (50 bauds 120 Hz)	R.35 | is (50 bauds 240 H
{ For the normal reception level }	5		5
{ In the case of slow level variation of +8,7 dB to —17,4 dB with respect to the normal reception level }	7		7
{ In the presence of interference by a single sinewave frequency equal to either of two characteristic frequencies with a level of 20 dB below the signal level of the test channel }	12		12
{ With introduction of a frequency drift (Δf Hz) of the signals: } { a) for a drift | Hz: Equipment without crystal control Equipment with crystal control but without compension for frequency drift } ($6 + 1.2 \Delta f$) Equipment with crystal control and compensation for frequency drift } 7 { b) for a drift | 0 Hz: Equipment with crystal control and compensation for frequency drift }	($5 + 2.5 \Delta f$) 13	7	($5 + 1.3 \Delta f$) 10

TABLE R.36 to 38 (R) [T3.35], p.

Recommendation R.36

COEXISTENCE OF 50-BAUD/120-Hz CHANNELS, 100-BAUD/240-Hz CHANNELS, 200-BAUD/360-Hz OR 480-Hz CHANNELS

ON THE SAME VOICE-FREQUENCY TELEGRAPH SYSTEM

(New Delhi, 1960; amended at Geneva, 1964 and 1980)

1 Common views

1.1 Channels with higher modulation rates (100 or 200 bauds) must be capable of being inserted in systems of amplitude-modulated 50-baud/120-Hz channels conforming to Recommendations concerning them respectively as well as in systems of frequency-modulated 50-baud/120-Hz channels (conforming to Recommendation R.35). However, it is preferable that these high-speed channels should, as far as possible, be placed in a frequency- modulated system (conforming to Recommendation R.35). However, 200-baud/360-Hz channels can be set up only on systems established on bearer circuits having a spacing of 3 kHz.

1.2 If there are 50-baud channels on a mixed system, the distortion limits for the 50-baud channels on homogeneous 50-baud channel systems will have to be respected; hence, 100-baud and 200-baud channel equipment will have to be designed to this end. If this is not possible, the power levels on the 100-baud and 200-baud channels will have to be reduced.

1.3 The 100- and 200-baud channels should have performances comparable to those that could be obtained in a homogeneous system, as specified in Recommendations R.37, R.38 | , R.38 | , provided that the condition indicated under § 1.2 above is respected. They should, in particular, satisfy § 13a) of Recommendations R.37, R.38 | , or R.38 | respectively.

1.4 The mean power transmitted to line at a point of zero relative level is normally dependent on the transmission characteristics of the bearer circuit as follows:

a) 50 µW total for FMVFT aggregates carried on circuits complying with the limits specified in Annex A to Recommendation R.35;

b) 135 µW total for other circuits and for AMVFT.

The mean normal power for each channel should not exceed the values specified in Table 1/R.36, for cases a) and b) above.

H.T. [T1.36]
TABLE 1/R.36
VFT channel power levels

VFT channel power level (µW) Bearer case a)	Relevant Recommendation Bearer case b)		Bandwidth (Hz)	Type of modulation
— 9.6 fR↑a↑)	R.31	50	120	AM
2.0 fR↑a↑) 5.6 fR↑a↑)	R.35	50	120	FM
4.0 ua)	10.8 ua)	R.37	100	240
—	19.2 ua)	R.38B	200	360
8.0 ua)	21.6 ua)	R.38A	200	480
FM				

a) Provided that the condition mentioned under § 1.2 is respected.

TABLE 1/R.36 (R) [T1.36], p.

2 Combined use of channels with 240-Hz spacing and channels with 120-Hz spacing

For the numbering of channels that has been adopted in the international services see Recommendation R.70 | fIbis .
2.1 Channels with 240-Hz spacing should be installed in the following preferred order: 12 (if possible), 11, 10, 9, 8, 7, . | | The channel numbers are in accordance with Recommendation R.37 (100-baud channels with 240-Hz spacing).

3 Combined use of 200-baud channels with 360-Hz spacing and channels with 120-Hz or 240-Hz spacing

3.1 The characteristics of these channels with high modulation rates are defined in Recommendations R.37 on 100-baud channels with 240-Hz spacing and R.38 | on 200-baud channels with 360-Hz spacing.

3.2 The 200-baud/360-Hz channels should be installed in the following preferred order: 5, 4, 6, 3, 2, 1 instead of the corresponding 50-baud channels. The channel numbers are in accordance with Recommendation R.38 | .

3.3 In combined systems using channels with three different smodulation rates, the order indicated in § 3.2 above should be used in preference to that indicated in § 2.1 above.

4 Combined use of 200-baud channels with 480-Hz spacing and channels with 120-Hz or 240-Hz spacing

4.1 For a combination of channels with 240-Hz spacing and channels with 480-Hz spacing, the channels with 480-Hz spacing should be installed in the following preferential order: 4, 3, 5, 2, 6

4.2 For a combination of channels with 120-Hz spacing and channels with 480-Hz spacing, the order indicated in § 4.1 above is applicable.

Note — In cooperation with a system using 6-channel group modulation, the preferred order would be: 4, 3, 6 (if possible), 1

4.3 In combined systems using channels with three different modulation rates, the order indicated in § 4.1 above should be used in preference to that indicated in § 2.1 above.

Recommendation R.37

STANDARDIZATION OF FMVFT SYSTEMS FOR | A MODULATION RATE OF 100 BAUDS

(Geneva, 1964; amended at Mar del Plata, 1968, Geneva, | 1972, 1976, 1980,

Malaga-Torremolinos, 1984 and at Melbourne, 1988)

Note — In this Recommendation frequency-modulated voice-frequency telegraph (FMVFT) equipment with and without crystal control are distinguished. In order to improve the quality of transmission and to minimize maintenance costs, the application of equipment with crystal control is recommended.

1 The nominal modulation rate is standardized at 100 bauds.

2 The nominal mean frequencies are 480 + (*n* — 1) 240 Hz, *n* being the channel position number. The mean frequency is defined as half the sum of the characteristic frequencies corresponding to the start polarity and stop polarity. For the numbering of channels that has been adopted in the international service see Recommendation R.70 | fIbis .

3 The mean frequencies at the sending end should not deviate from their nominal value by more than:

a) for equipment without crystal control 3 Hz;

b) for equipment with crystal control 0.5 Hz

4 The difference between the two characteristic frequencies in the same channel is fixed at 120 Hz.

5 The maximum tolerance on this difference should be ± | Hz.

6 The unbalance due to the modulation process δ = 2 $$1 | fIF | $_0$ — F_l | $$1u*F* |

A — *F* |

Z $$1e, should not exceed 2%,

where

F |

A and F |

Z are the two characteristic frequencies measured over a period of 10 s;

F $|_0$ is the mean static frequency measured $$1oF |

A + F $|_Z$ $$1u2 $$1e;

F_l is the mean dynamic frequency measured with 1:1 rectangular signals during 10 s.

Measurement should be made applying to the input of the transmitter 1:1 rectangular signals with the build-up and hangover time below 1 μs and with the unbalance below 0.1%. In the event that in service the transmitter is controlled by an electro-mechanical relay (with a certain transit time), the measurement should also be made with that type of relay inserted between the 1:1 signal generator and the input to the transmitter. Both forms of measurement need not necessarily be included in the maintenance procedure but should be included in laboratory type tests.

Note — To determine the unbalance due to the modulation process by the method indicated above, it is necessary to measure the frequencies F_A, F_Z and F_l and to calculate the mean frequency F_0 and the unbalance

$$\delta = 2 \frac{\lvert F_0 - F_l \rvert}{\lvert F_A - F_Z \rvert}$$

A more rapid method for checking whether or not the unbalance is less than the limit fixed is to measure:

— the mean dynamic frequency F_l with 1:1 signals during 10 s;

— the mean dynamic frequency F_m with 2:2 signals during 10 s;

$$\delta = 2 \frac{\lvert F_0 - F_l \rvert}{\lvert F_A - F_Z \rvert} = 4 \frac{\lvert F_0 - F_m \rvert}{\lvert F_A - F_Z \rvert}$$

or to subtract:

$$\lvert F_l - F$$

m | =
$$Bo1
} over {
$$Be (F |

A —
F |

Z) | (*d =
$$Bo1
} over {
$$Be (F
A — F
Z) | (*d 0.9 Hz.

The absolute value of the difference between the two frequencies measured, F_l and F_m, must be less than 0.9 Hz.

7 The total average power transmitted to the telephone-type circuit is normally dependent on the transmission characteristics of the circuit as follows:

a) For circuits with characteristics not exceeding the limits (nominal values) given in Annex A to Recommendation R.35, the mean power per channel at a point of relative zero level should not be more than 4.0 µW (—24.0 dBm0). The pilot channel, where employed, should have a level of not more than 2.0 µW (—27.0 dBm0);

b) for other circuits, the mean power per channel at a point of relative zero level should not be more than 10.8 µW (—19.7 dBm0). The pilot channel, where employed, should have a level of not more than 5.4 µW (—22.7 dBm0).

8 In service, the levels of signals corresponding to continuous condition Z and continuous condition A should not differ by more than 1.7 dB in the same channel. Both of these levels must lie between ± | .7 dB with reference to the level in § 7 above.

9 The frequency for the transmitted condition corresponding to the condition A is the higher of the two characteristic frequencies and that corresponding to the condition Z is the lower.

10 In the absence of a channel-modulator control telegraph current, a frequency shall be transmitted that shall be within ± | 0 Hz of the frequency normally transmitted for the condition A. It is not necessary for this transmission to take place immediately after the control current has been cut.

11 The frequency spectrum of the emitted signal, when transmitting 1:1 reversals (Definition 31.401, Recommendation R.140) at the modulation rate of 2 f_p (f_p = frequency of modulation), should be in accordance with the limits specified in Figure 1/R.37, which shows the levels of the spectra of different components with respect to the amplitude of the non-modulated carrier as ordinates and the frequencies as abscissae.

12 The receiving equipment should operate satisfactorily when the receiving level falls to 17.4 dB below the nominal level. The receiving equipment should have been restored to condition A when the receiving level has fallen to 23.5 dB below the nominal level. The alarm-control level is left to the choice of each Administration.

13 On delivery by the manufacturer of 100-baud FMVFT equipment, the following values must not be exceeded for the degree of distortion on a telegraph channel. These values correspond to closed circuit measurements, made with the audio-frequency line terminals of the sending and receiving equipments connected together through an artificial line. Before the series of measurements taken in accordance with Recommendation R.51, the levels are adjusted to their normal values, the mean frequencies are checked to see whether they are within:

1) for equipment without crystal control ± | Hz;

2) for equipment with crystal control ± | .1 Hz ,

FIGURE 1/R.37, p.

of their nominal value (see § 3 above) and the difference between the two characteristic frequencies is within the permitted tolerance of less than 4 Hz (see § 5 above). Bias distortion is eliminated by adjustment in the channel receivers. The other channels of the system are modulated with unrelated signals when the effect of interchannel interference is to be included in the measurement. These ‘‘unrelated signals’’ can conveniently be 1:1 signals from different generators at approximately 100 bauds but not synchronous to each other or to the signal on the channel under test.

a) The transmission levels being normal, the artificial line introducing no frequency drift, but the measured channel being subject to fortuitous distortion due to interchannel interference: 5% for the degree of inherent isochronous distortion.

b) The level being maintained constant, but at a value different from the normal level, for all constant levels between 8.7 dB above the normal reception level and 17.4 dB below the normal reception level, the other conditions being the original measurement conditions: 7% for the degree of inherent isochronous distortion.

c) In the presence of interference by a single sine-wave frequency equal first to one and then to the other characteristic frequency, with a level of 20 dB below the signal level, the other conditions for the start of measurements being maintained: 12% for the degree of inherent isochronous distortion (i.e. total distortion including the increase due to the interfering frequency, not distortion due to the interfering frequency alone).

Recommendation R.38 |

STANDARDIZATION OF FMVFT SYSTEM FOR A MODULATION RATE OF

200 BAUDS WITH CHANNELS SPACED AT 480 Hz

(Geneva, 1964; amended at Mar del Plata, 1968, |
Geneva, 1972, 1976, 1980,

Malaga-Torremolinos, 1984 and at Melbourne, 1988)

Note 1 — This is the standardized system for operation at 200 bauds.

Note 2 — In this Recommendation frequency-modulated voice-frequency telegraph (FMVFT) equipment with and without crystal control are distinguished. In order to improve the quality of transmission and to minimize maintenance costs, the application of equipment with crystal control is recommended.

1 The nominal modulation rate is fixed at 200 bauds.

2 The nominal mean frequencies are 600 + (n — 1) 480 Hz, n being the channel position number. The mean frequency is defined as half the sum of the characteristic frequencies corresponding to conditions A and Z. For the numbering of channels that has been adopted in the international service see Recommendation R.70 | fIbis .

3 The mean frequencies at the sending end should not deviate from their nominal value by more than:

a) for equipment without crystal control 4 Hz;

b) for equipment with crystal control 0.8 Hz

4 The difference between the two characteristic frequencies in the same channel is fixed at 240 Hz.

5 The maximum tolerance on this difference should be ± | Hz.

6 The unbalance due to the modulation process δ = 2 $$1 | fIF | $_0$ — F $_l$ | $$1uF |

A — F |

Z $$1e should not exceed 2%,

where

F_A and F_Z are the two characteristic frequencies measured over a period of 10 s;

F_0 is the mean static frequency measured $\left(\frac{F_A + F_Z}{2}\right)$;

F_l is the mean dynamic frequency measured with 1:1 rectangular signals during 10 signals.

Measurement should be made applying to the input of the transmitter 1:1 rectangular signals with the build-up and hangover time below 1 μs and with the unbalance below 0.1%. In the event that in service the transmitter is controlled by an electro-mechanical relay (with a certain transit time), the measurement should also be made with that type of relay inserted between the 1:1 signal generator and the input to the transmitter. Both forms of measurements need not necessarily be included in the maintenance procedure but should be included in laboratory type tests.

Note — To determine the unbalance due to the modulation process by the method indicated above, it is necessary to measure the frequencies *F* |

A , *F* |

Z and F_l and to calculate the mean frequency *F* | 0 and the unbalance

δ = 2
$$1 | fIF |
0
— *F*
l |
$$1u*F* |

A —
F |

Z $$1e

A more rapid method for checking whether or not the unbalance is less than the limit fixed is to measure:

— the mean dynamic frequency F_l with 1:1 signals during 10 s;

— the mean dynamic frequency F_m with 2:2 signals during 10 s;

δ = 2
$$1 | fIF |
0
— *F*
l |
$$1u*F* |

A —
F |

Z $$1e =
4
$$1 | fIF |
0
— *F*
m |
$$1u*F* |

A —
F |

Z $$1e

or to subtract:

| fIF
1 — *F*

m | =
$$Bo1
} over {
$$Be (F |

A —
F |

Z) | (*d =
$$Bo1
} over {
$$Be (F
A — F
Z) | (*d 1.8 Hz.

The absolute value of the difference between the two frequencies measured, F_l and F_m, must be less than 1.8 Hz.

7 The total average power transmitted to the telephone-type circuit is normally dependent on the transmission characteristics of the circuit as follows:

a) For circuits with characteristics not exceeding the limits given in Annex A to Recommendation R.35, the mean power per channel at a point of relative zero level should not be more than 8.0 µW (—21.0 dBm0). The pilot channel, where employed, should have a level of not more than 2.0 µW (—27.0 dBm0).

b) For other circuits, the mean power per channel at a point of relative zero level should not be more than 21.6 µW (—16.7 dBm0). The pilot channel, where employed, should have a level of not more than 5.4 µW (—22.7 dBm0).

8 In service, the levels of the signals corresponding to continuous condition Z and continuous condition A should not differ by more than 1.7 dB in the same channel. Both of these levels must lie between ± | .7 dB with reference to the level in § 7 above.

9 The condition A frequency is the higher of the two characteristic frequencies, and the condition Z frequency is the lower one (see Recommendation V.1 [1]).

10 In the absence of a channel-modulator control telegraph current, a frequency shall be transmitted that shall be within ± | 0 Hz of the frequency normally transmitted for the condition A. It is not necessary for this transmission to take place immediately after the control current has been cut.

11 The frequency spectrum of the emitted signal, when transmitting 1:1 reversals (Definition 31.401, Recommendation R.140) at the modulation rate of 2 f_p (f_p = frequency of modulation) should be in accordance with the limits specified in Figure 1/R.37, which shows the levels of the spectra of different components with respect to the amplitude of the non-modulated carrier as ordinates and the frequencies as abscissae.

12 The receiving equipment should operate satisfactorily when the receiving level falls to 17.4 dB below the nominal level. The receiving equipment should have been restored to condition A when the receiving level has fallen to 23.5 dB below the nominal level. The alarm-control level is left to the choice of each Administration.

13 On delivery by the manufacturer of 200-baud/480-Hz frequency-modulated voice-frequency telegraph (FMVFT) equipment, the following values must not be exceeded for the degree of distortion on a telegraph

channel. These values correspond to closed circuit measurements, made with the audio-frequency line terminals of the sending and receiving equipments connected together through an artificial line. Before the series of measurements taken in accordance with Recommendation R.51, the levels are adjusted to their normal values, the mean frequencies are checked to see whether they are within:

1) for equipment without crystal control ± | Hz;

2) for equipment with crystal control ± | .8 Hz,

of their nominal value (see § 3 above) and the difference between the two characteristic frequencies is within the permitted tolerance of less than 6 Hz (see § 5 above). Bias distortion is eliminated by adjustment in the channel receivers. The other channels of the system are modulated with unrelated signals when the effect of interchannel interference is to be included in the measurement. These ‘‘unrelated signals’’ can conveniently be 1:1 signals from different generators at approximately 200 bauds but not synchronous to each other or to the signal on the channel under test.

a) The transmission levels being normal, the artificial line introducing no frequency drift, but the measured channel being subject to fortuitous distortion due to interchannel interference: 5% for the degree of inherent isochronous distortion.

b) The level being maintained constant, but at a value different from the normal level, for all constant levels between 8.7 dB above the normal reception level and 17.4 dB below the normal reception level, the other conditions being the original measurement conditions: 7% for the degree of inherent isochronous distortion.

c) In the presence of interference by a single sine-wave frequency equal first to one and then to the other characteristic frequency, with a level of 20 dB below the signal level, the other conditions for the start of measurements being maintained: 10% for the degree of inherent isochronous distortion (i.e. total distortion including the increase due to the interfering frequency, not distortion due to the interfering frequency alone).

d) By introducing a frequency drift (Δf Hz) of the signals during transmission through the artificial line, Δf in Hz being not more than 10, and the initial conditions of the test otherwise being preserved: (5 + 0.7 Δf Hz)% for the degree of inherent isochronous distortion; the measurements shall be made after the transient effects of changing frequency have ceased.

e) Equipment with crystal control, with any climatic conditions specified for the tested equipment, the initial condition of the test otherwise being preserved: 8% for the degree of inherent isochronous distortion. The bias distortion caused by changes of climatic conditions should not be eliminated.

14 Frequency drifts on modern telephone-type circuits are generally less than 2 Hz. Hence it is not necessary to recommend frequency drift control. For circuits on which a maximum frequency drift of not greater than ± | Hz cannot be guaranteed, and on which the distortion resulting from the frequency drift is not acceptable, compensation seems necessary. Two methods can be used:

a) compensation for each channel up to about 15 Hz;

b) compensation for all the channels by using a pilot. In this case, the receiving end must be able to request and obtain a pilot frequency. Administrations should agree among themselves on the advisability of sending the pilot and the choice of frequency. The frequencies 3300 Hz or, preferably, 300 Hz are recommended for this pilot, with a tolerance of:

1) for equipment without crystal control ± | Hz

2) for equipment with crystal control ± | .2 Hz.

The mean power emitted at the relative zero point on this frequency should not exceed —27.0 dBm0 or —22.7 dBm0 as appropriate (see § 7 and Tables 1/R.35 and 2/R.35 in Recommendation R.35, which are also applicable to equipment to this Recommendation).

15 The number of significant conditions of the modulation is fixed at two; this number may be increased, if necessary, by agreement between the Administrations concerned.

Reference

[1] CCITT Recommendation *Equivalence between binary notation symbols and* the significant conditions of a two-condition code , Rec. V.1.

Recommendation R.38 |

STANDARDIZATION OF FMVFT SYSTEMS FOR A MODULATION RATE |
OF 200 BAUDS
WITH CHANNELS SPACED AT 360 Hz
USABLE ON LONG INTERCONTINENTAL BEARER CIRCUITS

GENERALLY USED WITH A 3-kHz SPACING

(Geneva, 1964; amended at Geneva, 1972, 1976, 1980 and Malaga-Torremolinos, 1984)

1 Frequency-modulated voice-frequency telegraph (FMVFT) systems, with a spacing of 360 Hz between the mean frequencies, can accommodate seven channels. In the case of telephone bearer channels with 4-kHz spacing, channel position 8 can be used.

2 The nominal modulation rate is fixed at 200 bauds.

3 The nominal mean frequencies are 540 + (*n* — 1) 360 Hz, *n* being the channel position number. The mean frequency is defined as half the sum of the characteristic frequencies corresponding to the conditions A and Z. For the numbering of channels that has been adopted in the international service see Recommendation R.70 | fIbis .

4 The mean frequencies at the sending end must not deviate by more than ± | Hz from their nominal value.

5 The difference between the two characteristic frequencies in the same channel is fixed at 180 Hz.

6 The maximum tolerance on this difference should be ± | Hz.

7 The unbalance due to the modulation process δ = 2 $$1 | fIF $|_0$ — F_l | $$1uF |

$_A$ — F |

$_Z$ $$1e should not exceed 2%,

where

F |

$_A$ and F |

Z are the two characteristic frequencies measured over a period of 10 s;

F_0 is the mean static frequency measured $\dfrac{F_A + F_Z}{2}$;

F_l is the mean dynamic frequency measured with 1:1 rectangular signals during 10 s.

Measurements should be made applying to the input of the transmitter 1:1 rectangular signals with the build-up and hangover time below 1 μs and with the unbalance below 0.1%. In the event that in service the transmitter is controlled by an electro-mechanical relay (with a certain transit time), the measurement should also be made with that type of relay inserted between the 1:1 signal generator and the input to the transmitter. Both forms of measurements need not necessarily be included in the maintenance procedure but should be included in laboratory type tests.

Note — To determine the unbalance due to the modulation process by the method indicated above, it is necessary to measure the frequencies F_A, F_Z and F_l and to calculate the mean frequency F_0 and the unbalance

$$\delta = 2 \frac{| F_0 - F_l |}{F_A - F_Z}.$$

A more rapid method for checking whether or not the unbalance is less than the limit fixed is to measure:

— the mean dynamic frequency F_l with 1:1 signals during 10 s;

— the mean dynamic frequency F_m with 2:2 signals during 10 s;

$$\delta = \frac{2\,|F_0 - F_l|}{F_A - F_Z} = \frac{4\,|F_0 - F_m|}{F_A - F_Z}$$

or to subtract:

$$|F_l - F_m| = \frac{1}{4}(F_A - F_Z)\,\delta = \frac{1}{4}(F_A - F_Z)\,\delta \leq 1.3 \text{ Hz.}$$

The absolute value of the difference between the two frequencies measured, F_l and F_m, must be less than 1.3 Hz.

8 The mean power per channel at relative zero level should not be more than 19.2 microwatts.

9 In service, the levels of the signals corresponding to continuous condition Z and continuous condition A should not differ by more than 1.7 dB in the same channel. Both of these levels must lie between ±1.7 dB with reference to the level in § 8 above.

10 The condition A frequency is the higher of the two characteristic frequencies, and the condition Z is the lower one (see Recommendation V.1 [1]).

11 In the absence of a channel-modulator control telegraph current, a frequency shall be transmitted that shall be within ± | 0 Hz of the frequency normally transmitted for the condition A. It is not necessary for this transmission to take place immediately after the control current has been cut.

12 The receiving equipment should operate satisfactorily when the receiving level falls to 17.4 dB below the nominal level. The receiving equipment should have been restored to condition A when the receiving level has fallen to 23.5 dB below the nominal level. The alarm-control level is left to the choice of each Administration.

13 On delivery by the manufacturer of 200-baud/360-Hz FMVFT equipment, the following values must not be exceeded for the degree of distortion on a telegraph channel. These values correspond to closed circuit measurements, made with the audio-frequency line terminals of the sending and receiving equipments connected together through an artificial line. Before the series of measurements taken in accordance with Recommendation R.51, the levels are adjusted to their normal values, the mean frequencies are checked to see whether they are within ± | Hz of their nominal value (see § 4 above) and the difference between the two characteristic frequencies is within the permitted tolerance of less than 4 Hz (see § 6 above). Bias distortion is eliminated by adjustment in the channel receivers. The other channels of the system are modulated with unrelated signals when the effect of interchannel interference is to be included in the measurement. These ‘‘unrelated signals’’ can conveniently be 1:1 signals from different generators at approximately 200 bauds but not synchronous to each other or to the signal on the channel under test.

a) The transmission levels being normal, the artificial line introducing no frequency drift, but the measured channel being subject to fortuitous distortion due to interchannel interference: 6% for the degree of inherent isochronous distortion.

b) The level being maintained constant, but at a value different from the normal level, for all constant levels between 8.7 dB above the normal reception level and 17.4 dB below the normal reception level, the other conditions being the original measurement conditions: 8% for the degree of inherent isochronous distortion.

c) In the presence of interference by a single sine-wave frequency equal first to one and then to the other characteristic frequency, with a level of 20 dB below the signal level, the other conditions for the start of measurements being maintained: 15% for the degree of inherent isochronous distortion (i.e. total distortion including the increase due to the interfering frequency, not distortion due to the interfering frequency alone).

d) By introducing a frequency drift (Δf Hz) of the signals during transmission through the artificial line, Δf being not more than 10; and the initial conditions of the test otherwise being preserved: ($6 + 1.2\ \Delta f$ Hz)% for the degree of inherent isochronous distortion; the measurements shall be made after the transient effects of changing frequency have ceased.

14 Frequency drifts on modern telephone-type circuits are generally less than 2 Hz. Hence, it is not necessary to recommend frequency drift control. For circuits on which a maximum frequency drift of not greater than ± | Hz cannot be guaranteed, and on which the distortion resulting from the frequency drift is not acceptable, compensation seems necessary. Two methods can be used:

— compensation for each channel up to about 15 Hz;

— compensation for all the channels by using a pilot. In this case, the receiving end must be able to request and obtain a pilot frequency. Administrations should agree among

themselves on the advisability of sending the pilot and the choice of frequency. The frequency 300 Hz is recommended, with a tolerance of ± | Hz. The mean power emitted at the relative zero point on this frequency should not exceed that recommended for a telegraph channel in the case of a 24-channel group, i.e. —22.5 dBm0.

15 The number of significant conditions of the modulation is fixed at two; this number may be increased, if necessary, by agreement between the Administrations concerned.

Reference

[1] CCITT Recommendation *Equivalence between binary notation symbols and the significant conditions of a two-condition code* , Vol. VIII, Fascicle VIII.1, Rec. V.1.

Recommendation R.39

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(former CCIT Recommendation B.49, Geneva, 1956; amended at Geneva, 1964,

Mar del Plata, 1968, Geneva, 1976 and Melbourne, 1988)

It is necessary to distinguish between the case in which the radio frequency used is below approximately 30 MHz, and the case in which the radio frequency used is greater than approximately 30 MHz.

1 Radio circuits the frequency of which is below approximately 30 MHz

1.1 In the case of radio circuits whose frequency is less than approximately 30 MHz, it appears that the use of amplitude-modulated voice-frequency telegraph systems, as defined by Recommendation R.31, cannot be recommended. In such a case, the nature of the telephone-type circuits available for telegraph operation may vary widely according to the radio system used, and several systems of telegraph transmission are available (e.g. two- or four-tone telegraph systems, frequency modulated systems, etc.).

1.2 However, frequency-shift systems are in use on many routes and the frequency-exchange method (Definition 32-32, Recommendation R.140) of operation is in use on long routes suffering from severe multipath distortion.

1.3 *Synchronous telegraphy operating at approximately 100 bauds*
| see CCIR Recommendation 436-2 [1])

Radiotelegraph channels that operate synchronously at a modulation rate of 96 bauds and employ automatic error correction are being increasingly used. The channel arrangement shown in Table 1/R.39 is preferred for voice-frequency multi-channel frequency-shift systems operating at a modulation rate of approximately 100 bauds over HF radio circuits. For

frequency-exchange systems (Definition 32.32, Recommendation R.140), the central frequencies of Table 1/R.39 should be used, and should be paired in the manner found to be best suited to the propagation conditions of the route. (A typical arrangement would take alternate pairs giving 340 Hz between tones.)

H.T. [T1.39]
TABLE 1/R.39
Central frequencies of voice-frequency frequency-shift telegraph channels with a channel separation of 170 Hz and a modulation index of about 0.8
(Frequency shift: ± | 2.5 Hz or ± | 0 Hz)

Channel position	Central frequency (Hz)	Channel position	Central frequency (Hz)
1	425	8	1615
2	595	9	1785
3	765	10	1955
4	935	11	2125
5	1105	12	2295
6	1275	13	2465
7	1445	14	2635
		15	2805

TABLE 1/R.39 [T1.39], p.

1.4 *Start-stop telegraphy at 50 bauds*

For several years, various Administrations have had in service, on certain selected circuits, equipment with a channel spacing of 120 Hz, the central frequencies and frequency deviations of which are in agreement with Recommendation R.35. The central frequencies of these systems are given in Table 2/R.39.

H.T. [T2.39]
TABLE 2/R.39
Central frequencies of voice-frequency frequency-shift telegraph channels with a channel separation of 120 Hz and a modulation index of about 1.4
(Frequency shift: ± | 5 Hz or ± | 0 Hz)

Channel position	Central frequency (Hz)	Channel position	Central frequency (Hz)
1	420	11	1620
2	540	12	1740
3	660	13	1860
4	780	14	1980
5	900	15	2100
6	1020	16	2220
7	1140	17	2340
8	1260	18	2460
9	1380	19	2580
10	1500	20	2700

TABLE 2/R.39 [T2.39], p.

2 Radio circuits whose frequency is greater than approximately 30 MHz

The use of voice-frequency telegraphy on line-of-sight radio-relay links and on trans-horizon radio-relay systems is under study.

Reference

[1] CCIR Recommendation *Arrangement of voice-frequency telegraph channels working at a modulation rate of about 100 bauds over HF radio circuits* , Vol. III, Rec. 436-2, ITU, Geneva, 1978.

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