5i’

Recommendation T.6

FACSIMILE CODING SCHEMES AND CODING CONTROL FUNCTIONS FOR GROUP 4 FACSIMILE APPARATUS

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

1.1 *Scope*

1.1.1 Recommendation T.6 defines the facsimile coding schemes and their control functions to be used in the Group 4 facsimile.

1.1.2 This Recommendation should be read in conjunction with the following Recommendations:

T.503 A document application profile for the interchange of Group 4 facsimile documents

T.521 Communication application profile for document bulk transfer based on the session service (according to the rules defined in T.62 | fIbis)

T.563 Terminal characteristics for Group 4 facsimile apparatus

T.73 Document interchange protocol for the Telematic services

T.62 Control procedures for Teletex and Group 4 facsimile services

T.62 | fIbis Control procedures for Teletex and Group 4 facsimile services based on Recommendations X.215/X.225

T.70 Network-independent basic transport service for Telematic services

F.161 International Group 4 facsimile service

In addition, in the case of Group 4 Class II/III (Teletex or mixed mode of operation), the following Recommendations should also be read:

T.60 Terminal equipment for use in the Teletex service

T.61 Character repertoire and coded character sets for the international Teletex service

T.72 Terminal capabilities for mixed mode of operation

1.2 *Fundamental principles*

1.2.1 *Facsimile coding schemes and coding control functions*

Facsimile coding schemes consist of the basic facsimile coding scheme and optional facsimile coding schemes. They are defined in § 2 and §§ 3 and 4, respectively.

Facsimile coding schemes are specified assuming that transmission errors are corrected by control procedures at a lower level.

The basic facsimile coding scheme is the two-dimensional coding scheme which is in principle the same as the two-dimensional coding scheme of Group 3 facsimile specified in Recommendation T.4.

Optional facsimile coding schemes are specified not only for black and white images but also for grey scale images and colour images.

Facsimile coding control functions are used in facsimile user information in order to change facsimile parameters or to invoke the end of facsimile block. They are defined in § 2.4.

2 Facsimile coding schemes and coding control functions for black and white images

2.1 *General*

This section specifies the facsimile coding schemes, and associated control functions for black and white images.

Facsimile coding schemes consist of the basic facsimile coding scheme and optional coding schemes.

The use of the optional facsimile coding schemes is subject to mutual agreement between terminals and shall be initiated by the appropriate procedural steps.

2.2 *Basic facsimile coding scheme*

2.2.1 *Principle of the coding scheme*

The coding scheme uses a two-dimensional line-by-line coding method in which the position of each changing picture element on the current coding line is coded with respect to the position of a corresponding reference element situated on either the coding line or the reference line which is immediately above the coding line. After the coding line has been coded, it becomes the reference line for the next coding line. The reference line for the first coding line in a page is an imaginary white line.

2.2.2 *Definition of changing picture elements* | (see Figure 1/T.6)

A changing element is definied as an element whose ‘‘colour’’ (i.e. black or white) is different from that of the previous element along the same scan line.

Figure 1/T.6, (M), p.

2.2.3 *Coding modes*

One of the three coding modes are chosen according to the coding procedure described in § 2.2.4 to code the position of each changing element along the coding line. Examples of the three coding modes are given in Figure 2/T.6, 3/T.6 and 4/T.6.

2.2.3.1 *Pass mode*

This mode is identified when the position of b_2 lies to the left of a_1. (See Figure 2/T.6.)

However, the state where b_2 occurs just above a_1, as shown in Figure 3/T.6 is not considered as a pass mode.

Figure 2/T.6, (M), p.

Figure 3/T.6, (M), p.

2.2.3.2 *Vertical mode*

When this mode is identified, the position of a_1 is coded relative to the position of b_1. The relative distance a_1b_1 can take on one of seven values V(0), $V_R(1)$, $V_R(2)$, $V_R(3)$, $V_L(1)$, $V_L(2)$ and $V_L(3)$, each of which is represented by a separate code word respectively of b_1, and the number in brackets indicates the value of the distance a_1b_1 (see Figure 4/T.6).

Figure 4/T.6, (M), p.

2.2.3.3 *Horizontal mode*

When this mode is identified, both the run-lengths a_0a_1 and a_1a_2 are coded using the code words H + M(a_0a_1) + M(a_1a_2). H is the flag code word 001 taken from the two-dimensional code table (Table 1/T.6). M(a_0a_1) and M(a_1a_2) are code words which represent the length and ‘‘colour’’ of the runs a_0a_1 and a_1a_2 respectively and are taken from the appropriate white or black run-length code tables (Tables 2/T.6 and 3/T.6).

H.T. [T1.6]

TABLE 1/T.6

Code table

Mode	Elements to be coded	Notation	Code word	
Pass	b 1, b 2	P	0001	
Horizontal 001 + M(a 0a 1) + M(a 1a 2) (see Note) }	a 0a 1, a 1a 2	H	{	
Vertical	a 1 just under b 1 a 1 to the right of b 1	a 1b 1 = 0 a 1b 1 = 1 V L(1)	V(0) V R(1) 010	1 011 a 1b 1 = 2
Extension		0000001xxx		

Note — Code M( ) of the horizontal mode represents the code words in Tables 2/T.6 and 3/T.6.

Tableau 1/T.6 [T1.6], p.

H.T. [T2.6]

TABLE 2/T.6

Terminating codes

White run length	Code word	Black run length	Code word
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100
41	00101010	41	000001101101
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100

61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

Tableau 2/T.6 [T2.6], p.

H.T. [T3.6]

TABLE 3/T.6

Make-up codes between 64 and 1728

White run length	Code word	Black run length	Code word
64	11011	64	0000001111
128	10010	128	000011001000
192	010111	192	000011001001
256	0110111	256	000001011011
320	00110110	320	000000110011
384	00110111	384	000000110100
448	01100100	448	000000110101
512	01100101	512	0000001101100
576	01101000	576	0000001101101
640	01100111	640	0000001001010
704	011001100	704	0000001001011
768	011001101	768	0000001001100
832	011010010	832	0000001001101
896	011010011	896	0000001110010
960	011010100	960	0000001110011
1024	011010101	1024	0000001110100
1088	011010110	1088	0000001110101
1152	011010111	1152	0000001110110
1216	011011000	1216	0000001110111
1280	011011001	1280	0000001010010
1344	011011010	1344	0000001010011
1408	011011011	1408	0000001010100
1472	010011000	1472	0000001010101
1536	010011001	1536	0000001011010
1600	010011010	1600	0000001011011
1664	011000	1664	0000001100100
1728	010011011	1728	0000001100101

Tableau 3/T.6 [T3.6], p.

2.2.4 *Coding procedure*

The coding procedure identifies the coding mode that is to be used to code each changing element along the coding line. When one of the three coding modes has been identified according to Step 1 or Step 2 mentioned below, an appropriate code word is selected from the code table given in Table 1/T.6. The coding procedure is as shown in the flow diagram of Figure 5/T.6.

Figure 5/T.6, (M), p.

Step 1

i) If a pass mode is identified, this is coded using the word 0001 (Table 1/T.6). After this processing, picture element a'_0 just under b_2 is regarded as the new starting picture element a_0 for the next coding (see Figure 2/T.6).

ii) If a pass mode is not detected, then proceed to Step 2.

Note — It does not affect compatibility to restrict the use of pass mode in the encoder to a single pass mode. Variations of the algorithm which do not affect compatibility should be the subject of further study.

Step 2

i) Determine the absolute value of the relative distance a_1b_1.

ii) If | | d1b_1 | 3, as shown in Table 1/T.6, a_1b_1 is coded by the vertical mode, after which position a_1 is regarded as the new starting picture element a_0 for the next coding.

iii) If | | d1b_1 | > 3, as shown in Table 1/T.6, following horizontal mode code 001, a_0a_1 and a_1a_2 are respectively coded by one-dimensional run length coding

Run lengths in the range of 0 to 63 pels are encoded with their appropriate terminating code word of Table 2/T.6. Note that there is a different list of code words for black and white run lengths. Run lengths in the range of 64 to 2623 pels are encoded first by the make-up code word representing the run length which is nearest, not longer, to that required. This is then followed by the terminating code word representing the difference between the required run length and the run length represented by the make-up code. Run lengths in the range of lengths longer than or equal to 2624 pels are coded first by the make-up code of 2560. If the remaining part of the run (after the first make-up code of 2560) is 2560 pels or greater, additional make-up code(s) of 2560 are issued until the remaining part of the run becomes less than 2560 pels. Then the remaining part of the run is encoded by terminating code or by make-up code plus Terminating code according to the range as mentioned above.

After this processing, position a_2 is regarded as the new starting picture element a_0 for the next coding.

Note — Coding examples are given in Recommendation T.4, § 4.2.5.

2.2.5 *Processing the first and last picture element in a line*

2.2.5.1 *Processing the first picture element*

The first starting picture element a_0 on each coding line is imaginarily set at a position just before the first picture element, and is regarded as a white picture element (see § 2.2.2).

The first run length on a line a_0a_1 is replaced by a_0a_1 — 1. Therefore, if the first actual run is black and is deemed to be coded by horizontal mode coding, then the first code word $M(a_0a_1)$ corresponds to an imaginary white run of zero length (see Figure 10/T.4).

2.2.5.2 *Processing the last picture element*

The coding of the coding line continues until the position of the imaginary changing element situated just after the last actual element has been coded. This may be coded as a_1 or $_2$. Also, if b_1 and/or b_2 are not detected at any time during the coding of the line, they are positioned on the imaginary changing element situated just after the last actual picture element on the reference line.

2.3 *Optional facsimile coding schemes for black and white images*

2.3.1 *Uncompressed mode*

Uncompressed mode is an optional coding scheme associated to the basic facsimile coding scheme and is used to transmit the image information without data compression techniques as shown in Table 4/T.6.

The extension code in § 2.2.4 with the xxx bits set to 111 is used as an entrance code from the basic coding scheme in § 2.2 to the uncompressed mode.

While using the uncompressed mode, the last picture elements of the end of the line and the first picture elements of the beginning of the following line are concatenated to one pattern.

H.T. [T4.6]

TABLE 4/T.6

Uncompressed mode code words

{
Entrance code to
uncompressed mode
}
Basic coding sheme: 0000001111
}
	{	

Uncompressed mode code *Image pattern* 1 01 001 0001 00001 00000 } *Code word* 1 01 001 0001 00001 000001 }	{ {	

{
Exit from
uncompressed
mode code
}
 	
0
00
000
0000
}
0000001T
00000001T
000000001T
0000000001T
00000000001T
T denotes a tag bit which tells the colour of the next run
(black = 1, white = 0).
}
	{
	{	

Tableau 4/T.6 [T4.6], p.

2.4 *Facsimile coding control functions*

2.4.1 *Control functions for basic facsimile coding scheme*

2.4.1.1 *End-of-facsimile block*

The end-of-facsimile block (EOFB) code is added to the end of every coded facsimile block. The format of EOFB is as follows:

Format: 000000000001000000000001

24 bits

2.4.1.2 *Pad bits*

Pad bits may be used after the end-of-facsimile block code if it is necessary to align on octet boundaries or to a fixed block size. The format used is as follows.

Format: Variable length string of 0s.

2.4.1.3 *Extension*

Extension code is used to indicate the change from the current mode to another mode, e.g., another coding scheme.

Format: 0000001xxx,

where xxx = 111 indicates uncompressed mode which is specified in § 2.3.1.

Further study is needed to define other unspecified xxx bit assignments and their use for any further extensions.

3 Optional grey scale facsimile coding schemes and their coding control functions

For further study.

4 Optional colour facsimile coding schemes and their coding control functions

For further study.

Recommendation T.10

DOCUMENT FACSIMILE TRANSMISSIONS ON LEASED | TELEPHONE-TYPE CIRCUITS

(Geneva, 1964; amended at Mar del Plata, 1968;

at Geneva, 1972, 1976 and 1980)

1 Type of circuits to be used

The telephone-type circuits used should have characteristics as recommended in Recommendation H.12.

Note — If the leased circuit is used alternately for telephone conversation and facsimile transmission and if the latter is unidirectional, it is not necessary to provide for disabling echo suppressors located on the long-distance leased circuit. However, when such a circuit is used for the simultaneous operation in both directions appropriate measures should be taken to disable echo suppressors before the actual facsimile transmission takes place.

2 Modulation

Equipment conforming to Recommendation T.2 or Recommendation T.3 may be used. In the case of Recommendation T.2 equipment, either amplitude or frequency modulation may be chosen.

3 Power

The maximum power output of the transmitting apparatus into the line shall not exceed 1 mW whatever the frequency.

For frequency-modulation equipment conforming to Recommendation T.2, the level at the transmitter output shall be so adjusted that the level of the facsimile and control signals on the trunk circuit does not exceed —13 dBm0 regardless of the type of operation (duplex or simplex).

For amplitude-modulation equipment conforming to Recommendation T.2, higher black levels may be used provided the mean power in any hour, in one direction of transmission, does not exceed 32 microwatts (—15 dBm0) at the zero relative level point of the trunk circuit.

For equipment conforming to Recommendation T.3, higher white levels may be used provided the mean power in any hour, in one direction of transmission, does not exceed 32 microwatts (—15 dBm0) at the zero relative level point of the trunk circuit.

4 Multipoint transmission

If facsimile transmissions take place simultaneously from a transmitting station to several receiving stations, arrangements shall be made at the junction points so that, on the circuits following the junction points, the same power levels are maintained as those prescribed for individual transmissions.

5 Phase distortion

Equipment conforming to Recommendation T.2 should not require any special treatment. However, equipment conforming to Recommendation T.3 may require phase distortion correction in some cases.

DOCUMENT FACSIMILE TRANSMISSIONS IN THE GENERAL SWITCHED TELEPHONE NETWORK

(Mar del Plata, 1968; amended at Geneva, 1972, 1976 and 1980)

1 Type of circuits to be used

Since circuits of the general telephone network and the station lines of telephone subscribers should be capable of being used for document facsimile transmissions on the general network, the circuits to be used are those of the general switched network which have 2-wire terminals at both ends of the facsimile station.

Note — For the actual document transmission, which is one-way, there is no need to cater for the disabling of echo suppressors Compandors do not seem detrimental to document facsimile transmission.

2 Overall loss

The conditions for overall transmission loss are the same as those for circuits of the general switched telephone network.

3 Modulation

Equipment conforming to Recommendation T.2 or Recommendation T.3 may be used. In the case of Recommendation T.2 equipment, frequency modulation shall be used.

4 Power

In order to avoid the risk that facsimile signals be disturbed, e.g. by dial pulses transmitted over adjacent channels or by noise, it is important that the sending level should be as high as possible, provided, however, that it shall not exceed —13 dBm0 on the trunk circuit for frequency-modulation equipment conforming to Recommendation T.2 or that the mean power in any hour, in one direction of transmission, shall not exceed 32 microwatts (—15 dBm0) at the zero relative level point of the trunk circuit for equipment conforming to Recommendation T.3.

The maximum power output of the transmitting apparatus into the line shall not exceed 1 mW whatever the frequency.

5 Amplitude and phase distortion

Equipment conforming to Recommendation T.2 should not require any special treatment. However, equipment conforming to Recommendation T.3 may require both amplitude and phase distortion correction on certain connections.

Blanc

Recommendation T.11

PHOTOTELEGRAPH TRANSMISSIONS ON TELEPHONE-TYPE |
CIRCUIT

(former CCIT Recommendation D.3; amended at New Delhi, 1960;

Geneva, 1964, 1972 and 1980)

Note — In the case of carrier circuits , this Recommendation applies only to systems established on the basis of 12-channel group links. Systems using 16-channel group links will be the subject of subsequent study.

The CCITT,

considering

(a) that both audio-frequency telephone circuits and carrier circuits can be used for phototelegraphy;

(b) that when normal audio-frequency circuits or carrier circuits are used, amplitude modulation offers some advantages over frequency modulation and is therefore to be preferred for phototelegraph transmissions on circuits set up from end to end on cable or line-of-sight radio-relay links

However, in the case of circuits subject to sudden level variations or to noise, frequency modulation may be preferable to amplitude modulation; Administrations could in this case come to an agreement to use frequency modulation for phototelegraph calls over such circuits; the provisions of Recommendation T.1 relative to the frequency-modulation characteristics should then be applied.

Note — Study Group XV/Joint Working Party LTG mention in Recommendation H.41 that when carrier circuits are used, frequency modulation offers advantages over amplitude modulation in that it does not overload carrier systems and avoids the influence of sudden level variations or noise. It is therefore to be preferred. However, this point should be studied further from the phototelegraph transmission point of view.

unanimously declares the view

that phototelegraph transmissions over telephone circuits require that the following conditions be observed, according to the way in which the circuits are used for phototelegraphy :

1 Circuits permanently used for phototelegraphy

It seems that these circuits are few. In any case, they should even more easily meet the characteristics given in § 2 below.

Recommendation T.11 corresponds to Recommendation H.41.
In particular, with the same index of cooperation and speed, frequency-modulation necessitates a wider frequency range than that of amplitude-modulation to obtain a picture of the same quality.
See Recommendation T.15 for phototelegraph transmissions over combined radio and metallic circuits.

2 Circuits used normally (and preferentially) for phototelegraphy

2.1 *Types of circuit to be used*

Two-wire circuits have no practical value for phototelegraphy because of feedback phenomena.

For the same reason, 4-wire circuits should be extended to the phototelegraph stations on a 4-wire basis at the appropriate amplifier stations, the terminating units and echo-suppressors always being disconnected.

The configuration of a phototelegraph circuit is given in Figure 1/T.11.

Figure 1/T.11, (M), p.

2.2 *Overall loss*

The same conditions apply to the overall transmission loss of 4-wire circuits used for phototelegraphy as apply, in general, for telephony.

2.3 *Sent signal power*

The emission voltage for the phototelegraph signal corresponding to maximum amplitude should be so adjusted that the maximum power level of the signal at the zero relative level point is —13 dBm0 for frequency modulation phototelegraph transmissions and that the peak signal power level for amplitude-modulation photo telegraph transmissions in principle should be —3 dBm0. In the case of amplitude-modulation, the level of the signal corresponding to black is usually about 30 dB lower than that of the signal corresponding to white.

Note — The levels of —3 and —13 dBm0 specified above are provisional and need further study from the facsimile transmission point of view.

2.4 *Relative levels*

If phototelegraph transmissions take place simultaneously from a transmitting station to several receiving stations, arrangements shall be made at the junction point so that, on the circuits following the junction point, the same power levels are maintained as those prescribed for individual transmissions.

2.5 *Attenuation distortion*

The limits for attenuation distortion on international circuits used for phototelegraphy are given in Recommendation G.151 concerning telephone circuits. The attenuation distortion between two terminal national centres shall therefore not exceed the limits indicated in Recommendation G.132 and it will not normally be necessary to compensate the distortion of the lines linking the phototelegraph stations to the terminal national centres in order to obtain, for amplitude-modulated phototelegraph transmission , an attenuation distortion between phototelegraph stations of less than 8.7 dB in the wanted band.

2.6 *Variation of circuit overall loss with time* | See Notes 1 and 2)

2.6.1 The objective is that:

2.6.1.1 The difference between the mean value and the nominal value of the transmission loss value should not exceed 0.5 dB.

2.6.1.2 The standard deviation from the mean value should not exceed 1 dB.

However, in the case of circuits set up wholly or partly on older-type equipment, where the international line consists of two or more circuit sections, a standard deviation not exceeding 1.5 dB may be admitted.

2.6.2 The method for achieving the above objective values is left to the discretion of Administrations (better maintenance, fitting of automatic regulators, etc.).

2.6.3 The assumption is made that these limits for the variation of loss with time of a single circuit may be compared to limits for loss measurements made on a set of circuits at a given time. Experience indicates that such a comparison has a practical validity although it has not been fully demonstrated at this time. Administrations are encouraged to use this Recommendation as giving currently practical limits for sets of circuits. This does not preclude the application of these limits to single circuits, should this prove practical at any time.

Note 1 — See Recommendation M.160 and Reference [1].

Note 2 — The provisions specified in § 2.6 are provisional and need further study from the facsimile transmission point of view.

2.7 *Phase distortion* | see also Recommendation T.12)

Phase distortion limits the range of satisfactory phototelegraph transmissions. Differences between the group delays of a telephone circuit, in the interval of the phototelegraph transmission, should not exceed

Δt

[Unable to Convert Formula]

where:

f_p = maximum modulation frequency corresponding to the definition and scanning speed

2.8 *Interference*

Interfering currents, whatever their nature, should not exceed the CCITT recommended limits for telephone circuits.

3 Telephone circuits rarely used for phototelegraphy

3.1 *Transmission characteristics*

It seems that the majority of the characteristics specified by the CCITT for modern telephone circuits are sufficient to permit phototelegraph transmissions on a circuit chosen at random in a group of circuits normally used for telephone working. However, it is not certain that such a circuit would have a sufficiently low phase distortion for such use, particularly channels 1 and 12 of a 12-circuit group, use of which is not advised. The influence of phase distortion is more noticeable in frequency modulation.

With amplitude modulation there is a further risk that phototelegraph transmissions will be subject to faulty modulation because the special precautions applied to circuits regularly used for phototelegraphy (see § 2.6 above) cannot be applied to circuits taken at random.

3.2 *Precautions concerning signalling*

As long as automatic switching for phototelegraph circuits is not envisaged, the signal receiver can be disconnected so that no signalling disturbances can occur even when frequency modulation is used. However, if frequency modulation is used for phototelegraph transmission and if it is impracticable to disconnect the signal receiver, then it would be desirable, in the case of the single-frequency system, that a blocking signal be transmitted along with the picture signal to operate the guard circuit and render the receiver inoperative.

It is also apparent that the frequency of such a blocking signal should lie well outside the range of frequencies involved in the picture transmission.

The frequency and the level of the blocking signal must depend on the characteristics of the VF receiver (or receivers in the case of a tandem international connection), as designed by different Administrations to meet the specification to be prescribed for international signalling.

In the case of the two-frequency international signalling system, the CCITT has indicated its view that no interference will take place.

Reference

[1] *Statistical theory requirements* , Green Book, Vol. IV.2, Supplement No. 1.6, ITU, Geneva, 1973.

Recommendation T.12

RANGE OF PHOTOTELEGRAPH TRANSMISSIONS ON A TELEPHONE-TYPE CIRCUIT

(former CCIT Recommendation D.3; amended at New Delhi, 1960 and Geneva, 1964)

Note — In the case of carrier circuits , this Recommendation applies only to systems established on the basis of 12-channel group links. Systems using 16-channel group links will be the subject of subsequent study.

The CCITT,

considering

(a) that the differences between the delays of the various frequencies and the width of the transmission band actually usable on a circuit for telephony give rise, when phototelegraph signals are started or stopped, to transient phenomena which limit the phototelegraph transmission speed ;

(b) that the range of phototelegraph calls of satisfactory quality, for a given transmission speed, depends especially on the constitution of the circuit, i.e. on:

— the loading and length, in the case of audio-frequency circuits ;

— the number of 12-channel group links used in tandem in the case of carrier circuits,

and on the choice of the carrier frequency for amplitude-modulated photograph transmission, or on the mean frequency in the case of frequency modulation;

(c) that phototelegraph transmission of satisfactory quality requires that the limits of differences between the group delays in the transmitted frequency band, as shown in Figure 1/T.12, are not to be exceeded;

(d) that the CCITT has recommended the following for international telephone circuits:

the permissible differences for a worldwide chain of twelve circuits, each set up on a single group link between the minimum group delay throughout the frequency band transmitted and the group delay at the upper and lower limits of this band are those given in Table 1/T.12;

unanimously declares the view

that, as regards the effect of phase distortion on phototelegraph transmission quality, the carrier frequency (where amplitude modulation is used) or the mean frequency (when frequency modulation is used) must be chosen in such a way that it is as near as possible to the frequency which has the minimum group delay on the telephone circuit.

Figure 1/T.12, (M), p.

H.T. [T1.12]

TABLE 1/T.12

Lower limit of the frequency band } Upper limit of the frequency band }	{ {	
International chain	30 ms	15**.5** ms
{ Each of the national chain 4-wire extensions }	15 ms	7.5 ms
On the whole 4-wire chain	60 ms	30**.5** ms

Tableau 1/T.12 [T1.12], p.

1 Circuits permanently used for phototelegraphy

1.1 It will generally be possible, by agreement between Administrations, to choose a circuit satisfying stricter limits than those specified above from the point of view of phase distortion.

1.2 Moreover, it will be possible to compensate phase distortions by inserting phase equalizers and to effect phototelegraph transmissions occupying the whole nominal band of the circuit.

2 Circuits used normally (or preferentially) for phototelegraphy

2.1 The greater the differences between the delays in the transmission intervals, the narrower should be the bandwidth chosen (leading to a lower phototelegraph definition or transmission speed).

2.2 Hence, audio-frequency circuits should in any case be lightly loaded circuits.

2.3 Phase distortion is well within the limits indicated above, in the case of carrier circuits, if a single modern-type carrier system is considered (and considering especially the telephone channels in the middle of a 12-channel group of such a system).

2.4 Nevertheless, it would be unjustifiable from the financial point of view to make the aforementioned recommendation concerning phase distortion stricter simply with a view to the occasional use of only a few circuits for high-speed phototelegraph transmissions

2.5 The curves of Figure 2/T.12 give information on the relative performances of amplitude- and frequency-modulated phototelegraph transmissions on audio-frequency and carrier telephone circuits.

Figure 2/T.12, (M), p.

3 Telephone circuits rarely used for phototelegraphy

If phototelegraph connections are set up on circuits selected at random from modern-type groups of telephone circuits (for example, by automatic switching), a circuit may be taken which has too high a degree of phase distortion, particularly if it has been set up on channels 1 or 12 of a 12-channel group, use of which is deprecated. It is impossible, in this case, to draw up general information on the range of phototelegraph transmissions; however, it will be possible to meet the conditions for a transmission of adequate quality if the phototelegraph connection comprises only one 12-channel group link and if transmission is effected in normal conditions as outlined in Recommendation T.1.

Recommendation T.15

PHOTOTELEGRAPH TRANSMISSION OVER COMBINED RADIO AND METALLIC CIRCUITS

(former CCIT Recommendation D.4; amended at New Delhi, 1960;

at Geneva, 1964; Mar del Plata, 1968 and Geneva, 1976)

The CCITT,

considering

(a) that, to facilitate interworking, it is desirable to standardize the characteristics of systems employed for phototelegraph transmission over long-distance HF (decametric) circuits ;

(b) that it is desirable to standardize certain characteristics of the systems in such a way as to make them equally suitable for transmission over metallic circuits;

(c) that the transmission system using direct amplitude modulation is generally unsatisfactory over HF (decametric) radio circuits, because of the intolerable fading ratio usually encountered;

(d) that the system of sub-carrier frequency modulation has proved satisfactory, but requires standardization in respect of the centre frequency and shift frequencies, taking into account the values of the picture-modulation frequencies to be transmitted;

(e) that, when a direct frequency-modulation system is employed, the terminal equipment normally used for a sub-carrier modulation system should be usuable without serious modifications;

(f) that, taking into account the quality necessary for reproduction of the picture received, the effect of multipath echoes on long-distance HF (decametric) radio circuits normally limits the maximum admissible picture-modulation frequency to approximately 600 Hz,

unanimously declares the view

that phototelegraph transmissions over combined radio and metallic circuits should conform to the following provisions:

1 Characteristics of radio circuits

1.1 When a sub-carrier frequency-modulation system is used, the following characteristics should be observed:

centre frequency 1900 Hz
frequency corresponding to white 1500 Hz
frequency corresponding to black 2300 Hz

(the 1500-Hz frequency is also used for the phasing signal)

This Recommendation corresponds to CCIR Recommendation 344.
The transmission over communication-satellite systems will be the subject of later study.

1.2 When a direct frequency-modulation system is employed, the following characteristics should be observed:

centre frequency (corresponding to assigned frequency) f_0 |
frequency corresponding to white f_0 — 400 Hz
frequency corresponding to black f_0 + 400 Hz

(the frequency f_0 — 400 Hz is also used for the phasing signal)

1.3 In both systems the stability of frequencies should be such that the variations are less than:

8 Hz during a period of 1 second,

16 Hz during a period of 15 minutes.

2 Characteristics of equipment and metallic circuits

The standards for phototelegraph apparatus and the specifications for transmission on metallic circuits are given in Recommendations T.1 and T.11.

On the metallic sections connected to both ends of the radio path, frequency modulation can be used whatever type of modulation is used over the radio circuits. However, amplitude modulation should preferably be used (see Recommendation T.11 on this subject).

3 Typical circuit

In principle, a worldwide hypothetical connection consisting of combined radio and wire channels may involve a maximum of two radio circuits with two metallic circuits at either end. Another metallic circuit may be required in the radio channel link if, in a country, the receiving and transmitting radio stations are at a distance from each other or if the two radio circuits terminate in neighbouring countries. The typical circuit for this connection is shown in Figure 1/T.15.

The frequency tolerances on each of the various sections of this connection should be no greater than those proposed by the CCITT (see Recommendations G.225 and T.1) as shown in Figure 1/T.15.

Figure 1/T.15, (M), p.

If it is assumed that these deviations are distributed at random and if we take the standard deviation, we shall obtain the values 15 and 28 Hz respectively, which are not harmful for satisfactory reception, since CCITT Recommendation T.1 admits a maximum deviation of 32 Hz.

4 Modulation conversion

When conversion from amplitude modulation to frequency modulation (or vice versa) is required, the conversion should be such that the deviation of the frequency-modulated carrier varies linearly with the amplitude of the amplitude-modulated carrier.

Each Administration will decide, when the question arises, on the location of modulation converters. They may be placed either at the terminal phototelegraph station or at the control station associated with the radio station, to facilitate speech on the circuit used for phototelegraphy, if the radio channel will carry speech.

Recommendation T.20

STANDARDIZED TEST CHART FOR FACSIMILE TRANSMISSIONS

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

The CCITT,

considering

that it will be a great advantage to use a standardized test chart to check the quality of facsimile transmissions and that such a chart would provide the receiving office with a reliable and rapid means of checking the quality of test transmissions according to uniform principles and of making comparisons between different transmission results in a precise way. The chart has been designed for measuring the quality of both picture and black-and-white transmissions and it enables the apparatus used and the communication channels to be judged by means of objective measurements, the results of which may be expressed in code.

unanimously declares the view

(1) that tests of facsimile transmission quality will be carried out in the international service with the aid of the ‘‘CCITT standardized test chart’’.

(2) that this test chart is made by the ITU under the supervision of the CCITT and should be offered for sale by the ITU. There are two editions:

— test charts sold before the IVth Plenary Assembly of the CCITT (October 1968) are of the first edition;

— test charts sold since the IVth Plenary Assembly of the CCITT are of the second edition.

These test charts are described in the annex to this Recommendation; the specimens printed in the annex cannot be used for measurements.

(3) that these two test charts are compatible and a test chart of either the first edition or the second can be used in the international service.

With the standardization of two test charts for document facsimile transmission (Test charts Nos. 2 and 3) in Recommendation T.21, this chart will be designated as ‘‘Test chart No. 1’’.

ANNEX A
(to Recommendation T.20)

Description of the
standardized test chart No. 1

A.1 The test chart No. 1 has the following dimensions:

— length: 250 mm,

— width: 110 mm.

The lateral margin is some 10 mm wide on either side. The margin at top and bottom is 20 mm wide, approximately. The chart is divided into sections marked on the transparent paper delivered with every chart.

A.2 Sections 1 and 2 contain two tone scales, each having 15 density steps, varying from black and white and vice versa. Nos. 1, 4, 8, 11, and 15 bear their numbers on them, the number 1 always betokens white and the number 15 black.

A.3 Section 3 is occupied by a group of black lines on a white background, in the form of hyperbolae. The thickness of the lines and the distances between them diminish regularly from left to right, from 1 mm to 1/6 mm.

If a vertical line be drawn through the hyperbolae, the lines therein will subtend distances on the vertical line equal to the inverse of the figures on the scale graduated from 1 to 6 at the bottom of Section 3.

A.4 Section 4 contains two groups of hyperbolae similar to those of Section 3 but limited to the scanning densities lying between 3 and 6. One group is made up of grey lines on a white ground, the other by grey lines on a black ground.

A.5 Section 5 contains three patterns.

a) *First edition*

The first pattern is made up of five black lines on a white background, the lines being 0.25 mm thick, arranged in one group of two lines and another of three lines. These lines are 0.25 mm apart, and the two groups are separated by 1.5 mm.

The second pattern is the same as the first, but the lines are white on a black background.

The third pattern consists of two similar groups of black lines on a white background, as follows: — line, thickness 1 mm |

— separation 0.25 mm
— line, thickness 0.25 mm
— separation 1 mm |
— line, thickness 0.25 mm
— separation 0.25 mm
— line, thickness 1 mm |

The two groups are separated by 1 mm.

b) *Second edition*

The first pattern is made up of eight black lines on a white background, separating into three groups:

— one group of two black lines being 0.25 mm thick and 0.25 mm apart;

— one group of three black lines being 0.25 mm thick and 0.25 mm apart;

— one group of three black lines being 0.1 mm thick and 0.25 mm apart.

These groups are separated by 1.5 mm.

The second and third patterns are respectively the same as those of Section 5 of the first edition.

A.6 Section 6 contains a tapering black line on a white background, and a tapering white line on a black background. The maximum width of the tapering lines is 0.7 mm.

At the top of the section is a scale in millimetres, showing the width of the tapering lines.

A.7 Section 7 contains a strip of tone equivalent to that in Section 1, step 11, on a background of Section 1, step 5.

A.8 In the first edition, Section 8 accommodates a photograph of UNESCO House in Paris.

In the second edition, Section 8 accommodates a portrait of an Argentine boy.

A.9 Section 9 contains two concentric circles, the radii of which differ by 1 mm. A square, with its diagonals, is inscribed in the inner circle.

In the second edition the radii of the two circles are bigger than those of the first edition and the exterior circle is osculating with the limits of Section 9.

A.10 There are two Sections numbered 10 which contain adjustment lines.

In the first edition, these lines are numbered from 1 to 6 and these figures are placed in the central part of the left half of Section 10.

In the second edition, only the even adjustment lines are numbered and these figures are placed at the left of the prolongation of the line separating Sections 3 and 12, 7 and 12 respectively.

A.11 Section 11 contains a pattern of lines, with a spacing of 2.5 mm. It is divided into two equal parts by a vertical line. The column on the right contains white rectangles, while that on the left contains alternate white and black rectangles.

In the second edition Section 11 is so cut that the parts adjacent to Sections 10 are kept in white. These parts are used for extension of the adjustment lines of Sections 10.

To indicate the centre of the test charts of the second edition, a line in the right column of Section 11 which is the prolongation of the line separating the density steps 8 and 9 of Section 1 is 0.5 mm thick.

A.12 Section 12 contains letters, digits, and punctuation marks printed in various styles, and arranged so that they can be read sideways.

Section 12 is divided into three parts:

— the bottom part contains typographical signs (letters, figures, and a few punctuation marks), printed in various styles.

— the middle part contains signs in typewritten characters 2.3 mm high.

— the top part contains two words: ‘‘TEST’’ and ‘‘INTERNATIONAL’’ one above the other. ‘‘TEST’’ is black on a white background, while ‘‘INTERNATIONAL’’ is white on a black background.

A.13 Section 13 contains

— space for the name of the transmitting station;

— the cooperation indices most often used;

— the diameters in millimetres of the drums most often used;

— the r.m.p. of the drums;

— ‘‘Mod.: AM FM’’ to indicate either amplitude modulation or frequency modulation (the second edition only);

— the indication ‘‘CCITT’’ in the test charts of the first edition is replaced by ‘‘CCITT 2’’ for the test charts of the second edition.

Blanc

Figure MIRE No 1, p.15

Recommendation T.21

STANDARDIZED TEST CHARTS FOR DOCUMENT FACSIMILE | TRANSMISSIONS

(Geneva, 1980)

The CCITT,

considering

(a) that a standardized test chart to check the quality of document facsimile transmissions will have great advantages. Owing to the development of international document facsimile transmission services, a great variety of characters and symbols, including ideographic symbols, are involved and must be taken into consideration.

(b) that the many different reasons for conducting the test has led to the definition of two test charts:

— one, ‘‘ transmission test chart ´make-up of the page and the legibility of the text in the various languages used by the ITU;

— the other, ‘‘ characterization test chart ´evaluation of the technical quality parameters enabling the technicians to detect any faults;

unanimously adopts the view

(1) that tests of document facsimile transmission quality should be carried out in the international service using the CCITT standardized test charts;

(2) that these test charts should be produced by the ITU under the supervision of the CCITT and should be offered for sale by the ITU. There are two types of charts:

— ‘‘Test chart No. 2: Transmission test’’ intended for the general evaluation of legibility,

— ‘‘Test chart No. 3: Characterization test’’ intended to check the quality parameters of apparatus.

The charts are described in Annex A; the specimens printed in Annex A cannot be used for measurements;

(3) that the charts should be used with facsimile apparatus in accordance with Recommendations T.2, T.3 and T.4.

ANNEX A

(to Recommendation T.21)

Description of the standardized document facsimile test charts

1 Dimensions of the test charts

— length: 297 mm

— width: 210 mm

They are divided into sections marked:

— 2.1 - 2.16 on the Test chart No. 2 for transmission test,

— 3.1 - 3.23 on the Test chart No. 3 for characterization test.

These section markings are also used to designate the following paragraphs which describe the given section.

The characterization test chart is prepared by a process using a small frame in order to simplify production.

2 Test chart No. 2: Transmission test

This test chart contains elements permitting quantitative evaluations of distortion and character groups intended for evaluation of the readability of the facsimile document.

2.1 *4 groups of arrows and lines*

These groups permit evaluation of framing distortions of the facsimile document appearing as lost margins.

2.2 *Alternating black-white lines, thickness 0.5 mm*

The black lines on the facsimile document must be separated: this is the test of minimum acceptable definition.

2.3 *2 sets of 1 black band and 1 white band*

Limits of horizontal resolution for isolated black and white lines. The numbers placed between the two bands indicate thicknesses in microns.

2.4 *Diagonal line*

This line permits evaluation of sweep uniformity over the entire test-pattern surface.

2.5-2.6 *Black circles and concentric circles with two perpendicular diameters*

Flattening of circles along either diameter indicates differences between the transmitting and receiving devices, either in the selection of horizontal and vertical definitions or in the index of cooperation.

2.7 *Horizontal band*

Permits evaluation of vertical definition.

2.8 *Random characters*

The characters are in ‘‘Univers 8 points’’ and ‘‘English Times 8 points’’.

Certain characters are arranged in a vertical line. These groups must be reproduced legibly by all facsimile machines.

2.9 to 2.14 *Texts in English — French — Spanish — Chinese — Arabic — Russian*

They permit evaluation of the overall quality of the transmitter-receiver system by examination of the limits of readability for the small characters.

2.15 *Empty box*

Special typed or handwritten texts may be entered in this box, as required by users.

2.16 *4 scales with millimetre graduations*

These scales permit determination of distortions in length on horizontal and vertical lines by direct measurement with a graduated rule.

3 Test chart No. 3: Characterization test

This test chart permits a definition of the quantizeable limits in the performance of facsimile machines (half-tone, framing, definition, etc.).

This is a reference for the drafting of lists of characteristics for CCITT Recommendations or of technical specifications.

As such, this test chart is intended for facsimile-machine adjustment and maintenance operations.

3.1 *Band of alternating black and white lines, thickness 5 mm*

Permits measurement of scanning distortion and adjustment of the black and white levels.

3.2 *2 density level bands in complementary order*

These scales permit measurement of the scanners' analogue response curves and definition of the white/black decision threshold level in digital transmission devices.

The two bands, covering nearly the width of the page, are reversed for verification of the uniformity of the scanner's response over the entire length of the horizontal line.

The densities, varying between 0.2 and 1.5, are indicated in the margin of each of the bands.

3.3 *Black band covering the entire page width*

Permits adjustment of characteristic ''black'' signals through the entire sequence of the electronic devices.

3.4-3.5 *Isolated black and white lines, variable thickness, 2 complementary bands*

Using this group, it is possible to define the limits of resolution for isolated black and white lines.

Line thicknesses are indicated in microns.

3.6 *Band of alternating lines, 8 lines per mm (black and white line thickness 125 microns)*

Obliqueness: 2°

This band permits verification of the optical definition of integrated 1728-point scanners.

Obliqueness is required in order to obtain, during test pattern advance, a situation in which the points of the image are perfectly centred on the detector's photosensitive cells where the modulation depth is at a maximum.

3.7-3.8 *Strips of alternating lines, 6 lines per mm (black and white line thickness 166.6 microns)*

Zone 3.7 consists of lines with an obliqueness of 3°.

Zone 3.8 consists of vertical lines.

Zone 3.7 has the same purpose as zone 3.6, but less severe.

Zone 3.8 permits examination of limits of definition.

3.9 *Alternating lines, 4 lines per mm (black and white line thickness 250 microns)*

Permits verification of standardized facsimile-machine definition.

The black lines on the received copy must be separated.

3.10 *Alternating lines, 2 lines per mm (black and white line thickness 500 microns)*

This scale represents the minimum permittable definition for a facsimile machine. The black lines on the facsimile document must be clearly separated.

3.11 *Vertical and horizontal bundles (converging patterns)*

This group of 3 bundles of converging lines permits quantization of the limits of horizontal and vertical definitions.

The numbers shown along the bundles indicate the thickness of black and white lines in microns.

3.12 *Diagonal line*

This line is designed for evaluation of sweep uniformity over the entire test chart surface.

3.13 *Black lines, thickness 250 microns, spaced 750 microns*

3.14 *Black lines, thickness 250 microns, spaced 1000 microns*

The two scales of 3.13 and 3.14 simulate character downstrokes. They must be faithfully reproduced by facsimile.

3.15 *Black spindle and white spindle*

Permits quantization of the limits of horizontal resolution for isolated black and white lines. The numbers shown along the band indicate line thicknesses in microns.

3.16 *2 vertical lines, thickness 250 microns, spacing 1000 microns*

The purpose of this group of 2 lines is the evaluation of longitudinal jitter effect. The value of the jitter effect may be quantized by measurement of the minimum dimension reached at the spacing between the two lines.

3.17 *Decreasing-density character set*

This group of characters permits examination of the limits of reproducible density. Results obtained yield information on the effectiveness of adaptive thresholds. They also permit definition of unusable document types, due either to insufficient relative density of characters (e.g., hard pencils), or to inadequate character size, or to a combination of these two parameters.

3.18 *ISO characters* | cf NFZ 43006 - June 1965)

Correct identification of the ISO character is a guarantee of satisfactory imaging of comparable typographic characters. They therefore permit completely objective readability tests.

3.19 *Random characters*

Some of the characters are in ‘‘Univers 6 point’’ font. The characters are arranged in two groups:

— a first group along horizontal lines, positioned in the lower part of the test pattern;

— a second group along vertical lines, positioned in the centre of the test pattern.

These characters permit qualitative evaluation of readability.

3.20 *Group of Chinese, Russian and Arabic characters*

This group completes the group of 3.11 and 3.19 for evaluations of readability of Chinese, Russian and Arabic characters.

3.21 *4 scales, graduation in millimetres*

These scales permit determination of distortions in length of horizontal and vertical lines by direct measurement with a graduated rule.

3.22 *4 groups of arrows and lines*

These groups permit quantization of framing defects of the facsimile document.

The numbers indicate distances in millimetres measured from the edge of the test pattern.

3.23 *Frame A‘ A B B‘*

This frame permits measurement of parallelogram deformation of the image caused by time-base frequency differences.

A square placed on A B B‘, with one side aligned with AB, intercepts line A‘ B‘ at a point B".

Quantization may take the form of a value in millimetres for the distance B‘ B".

Figure MIRE No 2, p.

Figure MIRE No 3, p.