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SERIES G: INTERNATIONAL ANALOGUE CARRIER SYSTEMS

Transmission media – Characteristics

Measurement of the load of telephone circuits under field conditions

ITU-T G-series Recommendations – Supplement 5

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NOTES

1 Supplement 5 to the G-series Recommendations was approved in Málaga-Torremolinos (1984) and published in Fascicle III.2 of the *Red Book*. This file is an extract from the *Red Book.* While the presentation and layout of the text might be slightly different from the *Red Book* version, the contents of the file are identical to the *Red Book* version and copyright conditions remain unchanged (see below).

2 In this Supplement, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Supplement No. 5

MEASUREMENT OF THE LOAD OF TELEPHONE CIRCUITS UNDER FIELD CONDITIONS

(Mar del Plata, 1968; further amended)
(referred to in Recommendations G.223 and H.51 [1])

In the Study Periods 1968-1972 and 1973-1976 several Administrations carried out speech power measurements under field conditions. These measurements were carried out in accordance with rules and definitions as given in § 1. The results of the measurements are contained in § 2.

1 Rules and definitions for the measurement of the loading of telephone channels and transmission systems

1.1 *Rules and definitions for the measurement of speech power from the public switched telephone network in field conditions*

1.1.1 *List of definitions* (see also Figure 1)

Z_s (mW0) is the speech power, while talker is active

y_s (dBm0) is the level of speech power, while active $= 10 \log_{10} Z_s$

Z_c (mW0) is the speech power on a channel averaged over a conversation (a distinction may be made between auxiliary and main conversations)

y_c (dBm0) is the level of speech power on a channel averaged over a conversation $= 10 \log_{10} Z_c$

σ_{y_c} (dB) is the standard deviation of y_c

$\bar{y}_c$ (dBm0) is the mean of the levels of speech power y_c

y_p (dBm0) is the level of the long-term mean speech power averaged over a population of talkers participating in customer conversations,

$y_p = \bar{y}_c + 0.115\, \sigma_{y_c}^2$ (assuming y_c is Gaussian)

$\bar{\tau}_c$ is the long-term mean of the activity factor within a conversation

$$\tau_c = \frac{ab + cd + ef + gh}{XY} \text{ in } c) \text{ of Figure 1}$$

$\bar{\tau}_o$ is the long-term mean of the "channel busy" customer occupancy factor

$$\tau_o = \frac{XY}{WZ}$$

$\bar{\tau}_B$ is the long-term mean of the "channel engaged" factor defined as the fraction of "busy hour" during which "channel busy" conditions occur

$$\tau_B = \frac{\Sigma WZ}{\text{observation period}}$$

$\bar{\tau}_u$ $= \overline{\tau_o \times \tau_B}$; on the assumption that τ_o and τ_B are statistically independent, it follows that

$$\overline{\tau_o \times \tau_B} = \bar{\tau}_o \times \bar{\tau}_B$$

This is the long-term mean of the proportion of time of the "busy-hour" in which conversation occurs.

$\overline{Z}_{sig}$ (mW0) is the signalling power averaged over the signalling time intervals (WT + YZ)

$\overline{Z}_t$ (mW0) is the power of supervisory tones averaged over time interval UV

$\overline{Z}_{st}$ $= \overline{Z}_{sig} + \overline{Z}_t$

y_{st} $= 10 \log_{10} \overline{Z}_{st}$

$\overline{\tau}_{st}$ is the long-term mean of the occupancy factor for signalling and tones within a "channel busy" period

$$\tau_{st} = \frac{WT + UV + YZ}{WZ}$$

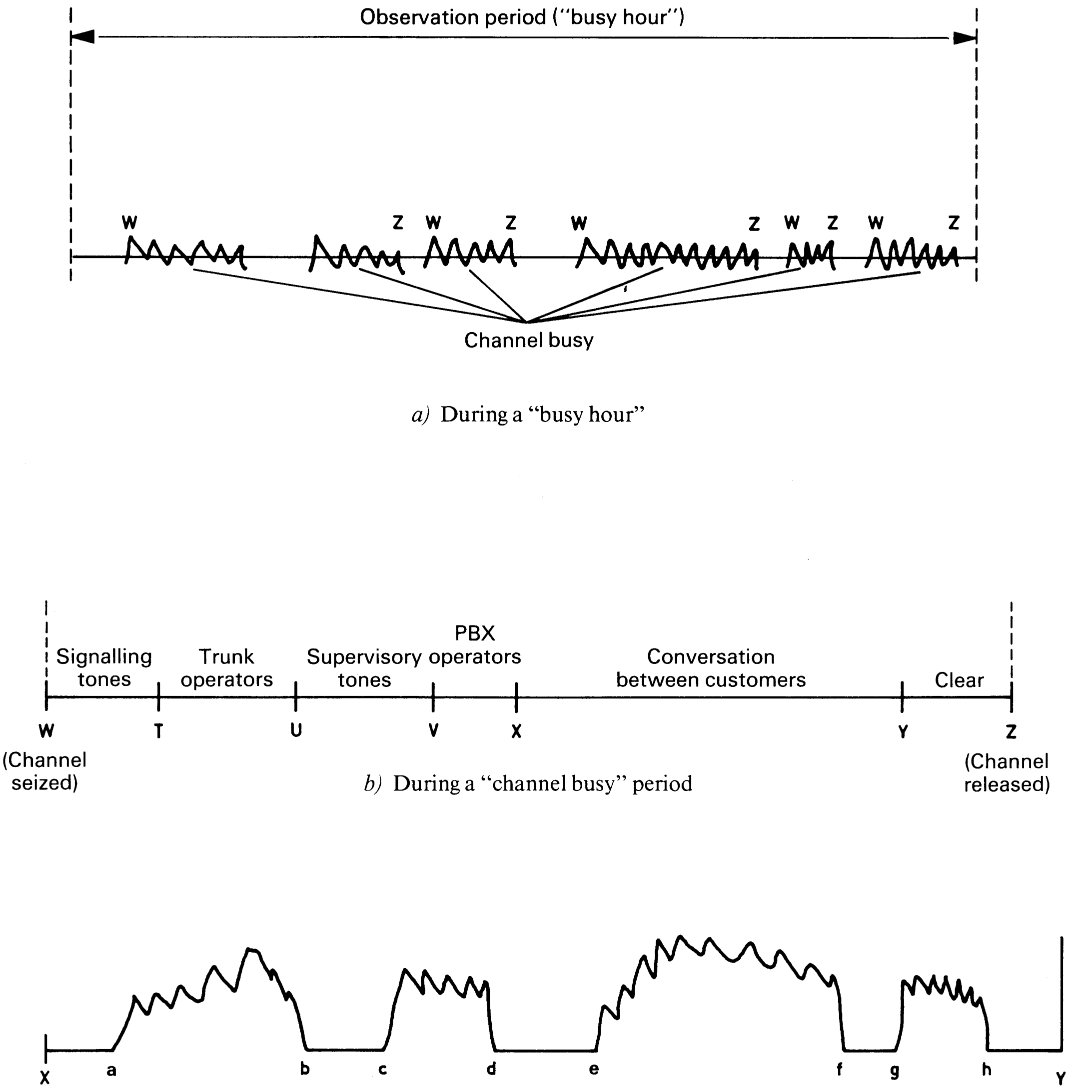
The following relationships apply:
level of mean power due to customer conversation averaged over the "busy hour"

$y_m = y_p + 10 \log_{10} \overline{\tau}_u$

$y_c = y_s + 10 \log_{10} \tau_c$

$y_p = \overline{y}_c + 0.115 \, \sigma_{yc}^2$ (assuming a Gaussian distribution)

All the mean values $\overline{\tau}$ of the various activity and occupancy factors τ_{ij} are mean values averaged over calls and channels.



a) During a "busy hour"

b) During a "channel busy" period

c) During a conversation

FIGURE 1

Load of a telephony channel

1.1.2 *Measurements made on one channel*

1.1.2.1 *Mean power level* during conversations of the subscribers, y_c dBm0. The results are presented in the form of $\bar{y}_c$ and σ_{yc} from which y_p may be derived.

1.1.2.2 The point of measurement is chosen so that only unidirectional signals are incorporated in the results. The relative level of this point is indicated as well as its situation in the connection in some cases.

1.1.2.3 The *circuit occupancy factors* τ_o, τ_B and their product τ_u are given in the form of their long-term mean value.

1.1.2.4 The level of the signalling and supervisory tone power y_{st} are in the form of mean level in dBm0 and the standard deviation.

1.1.2.5 The *signalling occupancy* τ_{st} is indicated as long-term mean value.

1.2 *Rules and definitions for the measurement of the power of a multiplex system, averaged over a given time*

1.2.1 This measurement expresses, in dBm0, the level of the mean power of all signals in a particular multiplex system, averaged over a time interval determined by the measuring equipment.

The measurement is usually conducted during a number of busy periods and gives directly, after division by N (number of channels in the system), the mean power per telephone channel. If channels are used to carry signals other than telephony, suitable corrections have to be applied. The mean power per channel obtained in this way can be compared with the conventional load.

1.2.2 *List of definitions*

y_l (dBm0) level of the multiplex signal power averaged over a specified time interval (e.g. 1 minute)

σ_{y_l} (dB) standard deviation of y_l

$\bar{y}_l$ (dBm0) mean level (mean of y_l)

y_N (dBm0) level of the mean power

($y_N = \bar{y}_l + 0.115\ \sigma_{y_l}^2$ assuming a Gaussian distribution)

P (mW0) mean power, whereby

$y_N = 10 \log_{10} P$.

1.2.3 *Measurements made on assemblies of channels*

1.2.3.1 The *mean power* on assemblies of channels (basic groups, supergroups, etc., and multichannel systems) is measured. Information about the constitution of the groups (numbers of channels used for telephony, telegraph bearers, programme circuits, data, etc.) is also provided.

1.2.3.2 Statistical information on the multiplex signal, averaged over several busy hours (probability distribution of the instantaneous signal level in dBm0) is of interest, particularly for estimating the probability of overload. (Distribution curves are contained in this Supplement.)

2 Results of speech power measurements under field conditions

The results of the measurements of the power on one channel are contained in Table 1.

The results of measurements on groups of channels and systems are shown in Table 2.

Figures 2 and 3 indicate distribution curves for the instantaneous signal levels on basic groups and supergroups. Measurement results obtained during Study Period 1973-1976 as shown in Figures 4 to 8 are also given.

TABLE 1

Measurements on one channel

Administration	$\bar{y}_c$ dBm0	σ_{yc} dB	y_p dBm0	Auxiliary conversations included	Auxiliary conversations excluded	Echo included	Echo excluded	Measuring point	Start/stop of measuring	Special remarks
Switzerland COM Sp. C-No. 77	—17.2	5.2	—14.1	X		X		+10 dBr audio frequency output channel translating equipment – secondary switching centre	Called subscriber answers → subscriber announcing end of conversation	National circuits
Australia Temp. Doc. No. 1 (March 1972)			—16.1	X		X		0 dBr	Called subscriber answer	National circuits
			—16.25	X		X		—2 dBr	Called subscriber answer	International cable circuits
			—16.7	X		X		—2 dBr	Called subscriber answer	International satellite circuits
United Kingdom Post Office COM Sp. C -No. 83 + -No. 87	—21.6	5.7	—17.9	X		X		—3.5 dBr nominal sending	Called subscriber answers → called subscriber clears	National circuits
Federal Republic of Germany Sup. 5 Vol. III			—17.8	X		X		—17.4 dBr input channel equipment	Called subscriber answer	International connections
Italy Temp. Doc. No. 11 March 1972)	—20.8	4.7	—18.3	X		X		—3.5 dBr	Called subscriber answer	National connections
Hungary COM Sp. C-No. 84	—15.8 —15.4 —17.4	4.6	—13.5 —13.1 —15.1		X	X		—13 dBr	Called subscriber answer	Overall operator switched automatically switched
Netherlands COM Sp. C-No. 12 (1973-1976)			—21.8 —22.3	X X		X X		—3.5 dBr input channel equipment	Channel busy	National circuits

TABLE 1 *(end)*

Measurements on one channel

(Activity and occupancy factors)

Administration	$\bar{\tau}_o$	$\bar{\tau}_B$	$\bar{\tau}_u$	y_{st}	$\bar{\tau}_{st}$	Level of total long-term mean power on channel, dBm0	Remarks
Switzerland COM Sp. C-No. 77	0.89	0.68	0.61	—12.1	0.10	—15.6 (22.8 + 4.4 μW)	$\bar{\tau}_B$ refers to measured channels
Australia	—	—	—	—	—	—	
United Kingdom Post Office	0.83	0.93	0.76	— 5.4	0.14	—12.7 (12.4 + 41.0 μW)	$\bar{\tau}_o$ and $\bar{\tau}_B$ measured y_{st}: level of mean-signalling and supervisory-tones power, including switching spikes
Federal Republic of Germany	—	—	—	—	—	—	
Italy	—	—	—	—	—	—	
Hungary COM Sp. C-No. 84	0.69	0.61	0.42	—16.1 (average)	0.17		Minor conversation $\bar{y}$ = —17.7 dBm0 τ (automatic) = 0.05; τ (operator) = 0.2
Netherlands COM Sp. C-No. 12 (1973-1976)	0.85 0.82	0.7 0.7				—19.2 —20.3	— Incoming — Outgoing $\bar{\tau}_B$: from traffic statistics

TABLE 2

Measurements on groups of channels

Administration	Class of assembly of channels (group, supergroup, system)	Integration time	Frequency of evaluated samples	Number of telephone channels in operation	Number of non telephone channels in operation	Total mean power for all channels	Level of mean power per assembly of channels (See Note 1)	σy for samples	Total mean power for non telephone channels	Mean power per channel	Mean power per telephone channel
				A	B	mW0	dBm0	dB	mW0	µW0 (dBm0)	µW0 (dBm0)
Switzerland	Groups (30)	1 minute	60/hour	360 (12 per G)	—	6.850	—6.4*	2.9	—		19.0 (—17.2)
	Supergroups (19)	1 minute	60/hour	1128 (60 Ch. per SG on 15 SG; 52-59 Ch. per SG on 4 SG)	—	21.900	+0.6*	1.6	—		19.3 (—17.1)
Federal Republic of Germany	Supergroups	5 minutes	~ 2/hour	405	5	6.880		0.8	~ 0.675	16.8 (—17.7)	15.3 (—18.1)
	Systems (960- and 1260-Ch)	5 minutes	~ 2/hour	1094	13	19.700		0.4	~ 1.755	17.8 (—17.5)	16.4 (—17.8)
Italy	Supergroups (4) (—18 dBm0 signalling)	1 minute	20/hour	240	—	4.3	+0.2**	1.0	—	17.4 (—17.6)	17.4 (—17.6)
	Supergroups (10) (—6 dBm0 signalling)	1 minute	20/hour	591	8	16.8	+2.3**	1.8	3.15	28.0 (—15.5)	23.1 (—16.4)
	16-supergroup assemblies (5) (—18 dBm0 signalling)	1 minute	20/hour	3968	162	78	+12.6**	0.8	8.1	18.9 (—17.2)	17.6 (—17.5)
	16-supergroup assemblies (5) (—6 dBm0 signalling)	1 minute	20/hour	2153	75	75.9	+15.3**	1.0	22.3	34.1 (—14.7)	25.0 (—16.0)

TABLE 2 *(end)*

Administration	Class of assembly of channels (group, supergroup, system)	Integration time	Frequency of evaluated samples	Number of telephone channels in operation	Number of non telephone channels in operation	Total mean power for all channels	Level of mean power per assembly of channels (See Note 1)	σy for samples	Total mean power for non telephone channels	Mean power per channel	Mean power per telephone channel
				A	B	mW0	dBm0	dB	mW0	µW0 (dBm0)	µW0 (dBm0)
K.D.D., Japan	Supergroup	1 minute	60/hour	60	0	1.34	+1.27*	1.23	—	22.33 (—16.5)	22.33 (—16.5)
	Supergroup	1 minute	60/hour	43	14	2.19	+3.40*	0.58	0.842	38.48 (—14.2)	31.35 (—15.0)
Hungary (See Note 2)	Groups (4)	1 minute	~ 60/hour	37	9	1.97	—3.1			42.83 (—13.7)	
	Supergroups (2)	1 minute	~ 60/hour	104	9	3.25	+2.1			28.76 (—15.4)	
United Kingdom	Groups (4) —Forward signalling	5 seconds	720/hour	48	—	0.48	—9.2*	3.3	—	10 (—20.0)	10 (—20.0)
	Groups (6) —Backward signalling	5 seconds	720/hour	72	—	1.07	—7.5*	2.8	—	15 (—18.3)	15 (—18.3)
	Groups (4) —Forward signalling	40 milliseconds	3600/hour	48	—	0.52	—9.0*	5.5	—	11 (—19.6)	11 (—19.6)
	Groups (6) —Backward signalling	40 milliseconds	3600/hour	72	—	2.6	—5.9*	5.7	—	22 (—16.6)	22 (—16.6)
	Supergroups (9)	5 seconds	720/hour	540	—	5.7	—2.0*	1.1	—	11 (—19.8)	11 (—19.8)
Poland See Note 2)	Groups (10)	1 minute	30/hour	99	13	5.11	—2.9*	3.06	1.03	45.6 (—13.4)	41.2 (—13.9)
	Supergroups (3)	1 minute	30/hour	158	17	8.14	+4.3*	1.2	1.76	46.5 (—13.3)	40.3 (—13.9)

Notes relating to Table 2:

Note 1 – If the assembly measured is only partially filled (i.e. A + B < N, where N is the capacity of the assembly) the level of mean power per assembly of channels can be defined in two ways:

a) Level of mean power (measured) per assembly

$$= 10 \log_{10} \frac{\text{Total mean power for all channels}}{\text{Number of assemblies measured}}$$

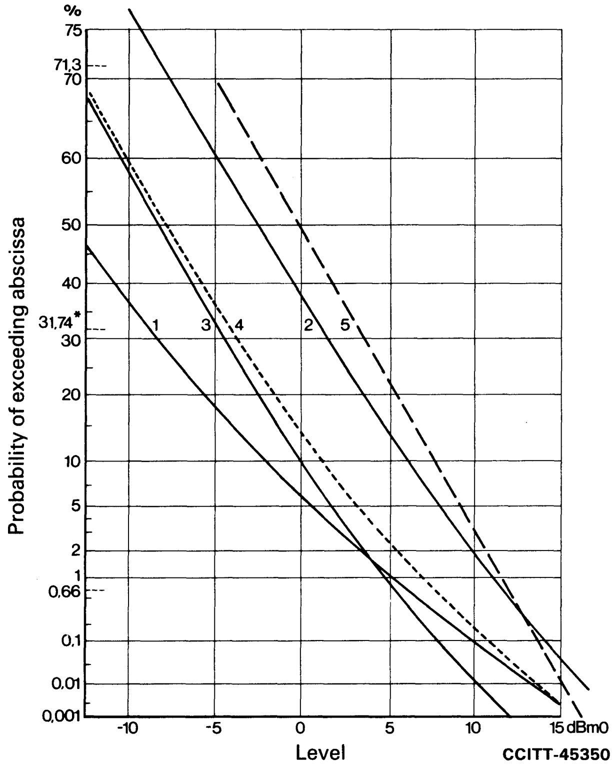
The results of this calculation are indicated by an asterisk in Table 2.

b) Level of mean power (possible) per assembly

$$= 10 \log_{10} \frac{\text{Total mean power for all channels}}{\text{Number of assemblies measured}} \cdot \frac{N}{n}$$

where N = capacity of the assemblies, and n = total number of channels in operation (A + B in Table 2). The results of this calculation are indicated by a double asterisk in Table 2.

Note 2 – Calculated from information supplied by the Administration.

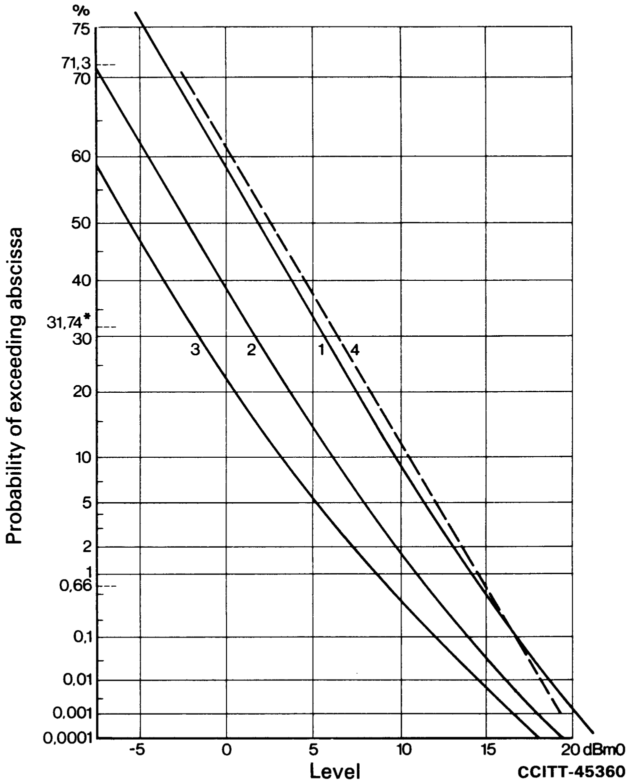


* Point of r.m.s. value for Gaussian signal

1 Group carrying telephony only
2 Group with nine telephone channels and one sound-programme channel
3 Group with 10 telephone channels and two channels carrying telegraphy
4 Curve representing the long-term mean signal, averaged over the 21 groups considered
5 Curve of conventional load (Gaussian)

FIGURE 2

Amplitude distribution curves of signals on basic groups (Swiss Administration)

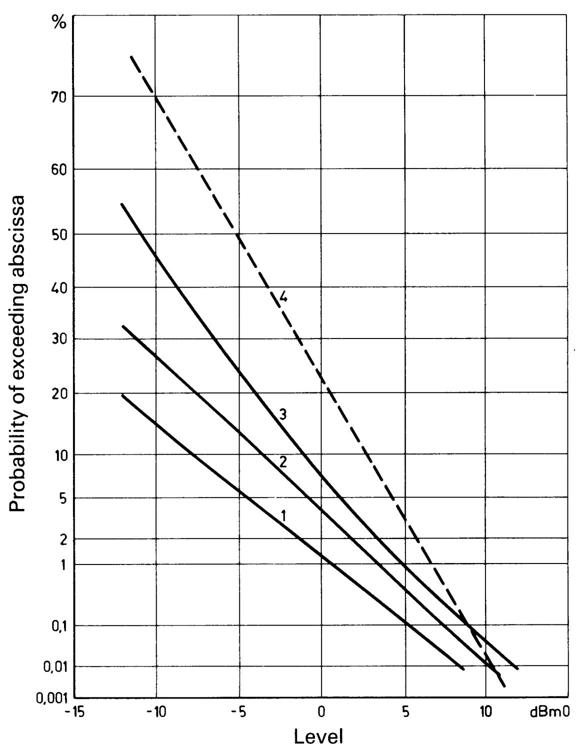


* Point of r.m.s. value for Gaussian signal

1 Supergroup with 54 telephone channels and two sound-programme channels
2, 3 } To indicate the range in which most of the measured curves are situated
4 Curve of conventional load (Gaussian)

FIGURE 3

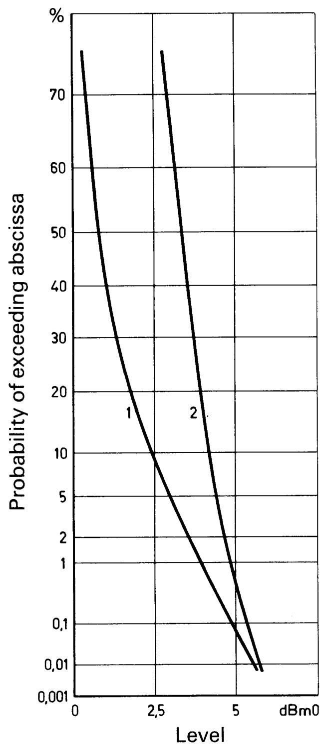
Amplitude distribution curves of signals on supergroups (Swiss Administration)



1 Groups carrying telephony (forward signalling)
2 Groups carrying telephony (return-path)
3 Supergroups
4 Curve representing Gaussian distribution

FIGURE 4

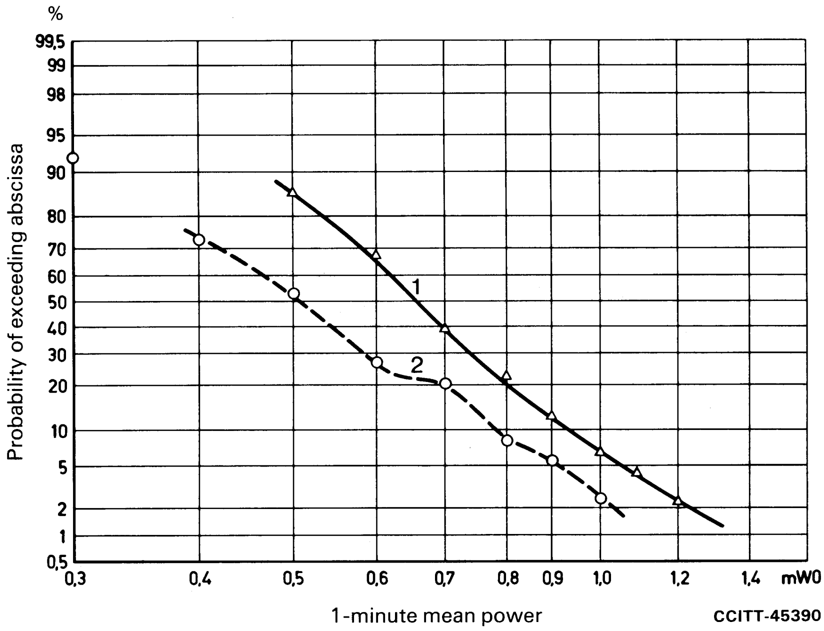
Amplitude distribution curves of signals (UKPO)



1 Supergroup with 60 telephony channels
2 Supergroup with 43 telephony channels and 14 non-telephony channels

FIGURE 5

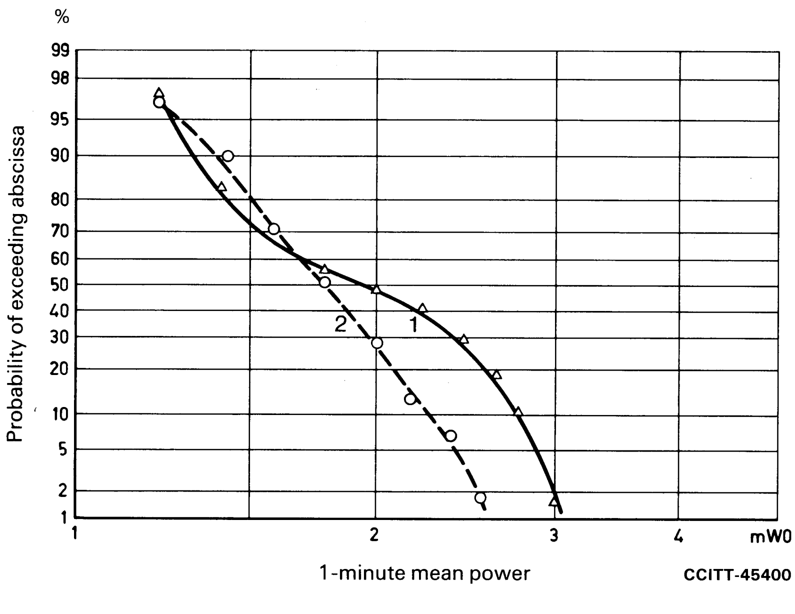
Amplitude distribution curves of the one-minute mean-power on supergroups (KDD)



1 Measuring series extended over 10 working days (seven days for one group A, and one day for each of three groups B, C and D)
2 Replication of the measurements on group A during five working days

FIGURE 6

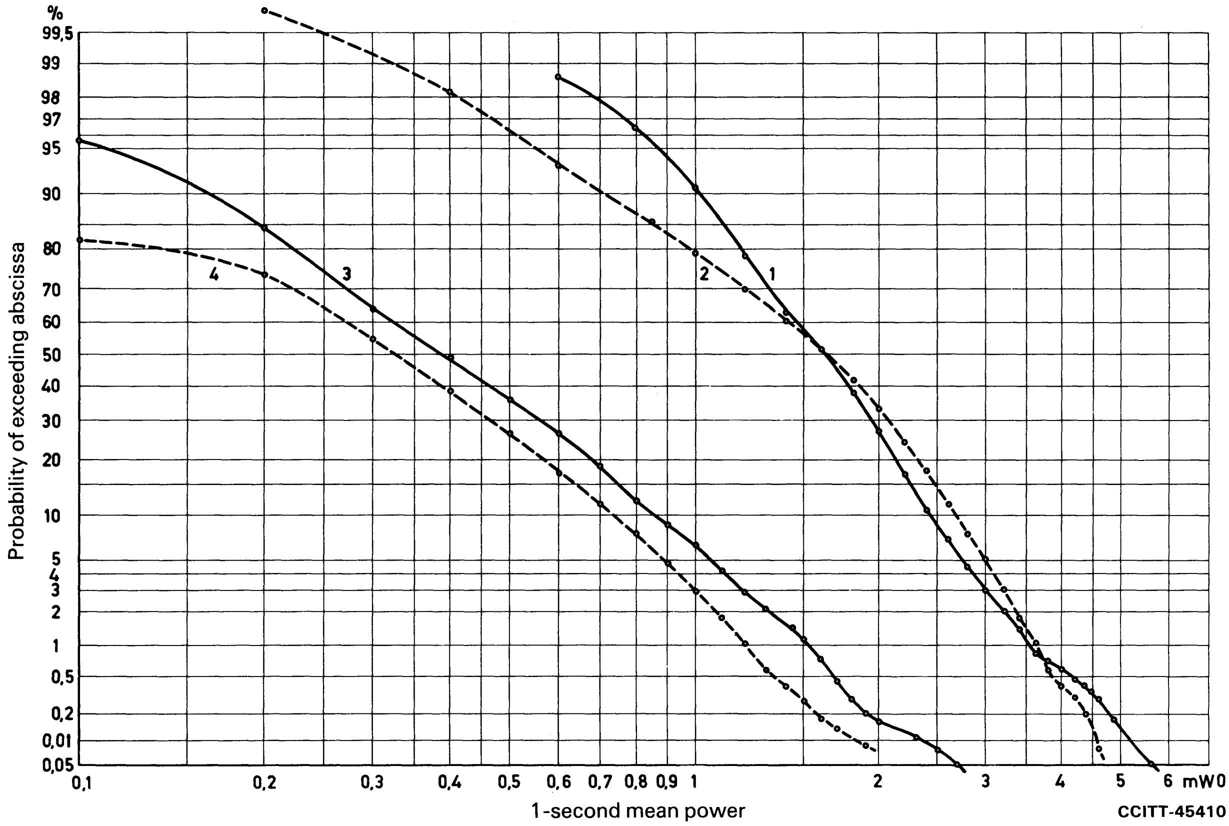
Distribution of one-minute mean-powers during busy hour on groups (Hungarian Administration)



1 Measuring series extended over seven working days (five days on a supergroup E, and two days on a supergroup F)
2 Replication of the measurements on supergroup F during five working days

FIGURE 7

Distribution of one-minute mean-powers during busy hour on supergroups (Hungarian Administration)



1 Measuring series extended over 2000 1-second measurements (supergroups E and F)
2 Measuring series extended over 3500 1-second measurements (supergroup F)
3 Measuring series extended over 4000 1-second measurements (groups A, B, C, and D)
4 Measuring series extended over 3500 1-second measurements (group A)

FIGURE 8

Distribution of the one-second mean-powers during the busy hour on groups and supergroups (Hungarian Administration)

Reference

[1] CCITT Recommendation *Power levels for data transmission over telephone lines*, Vol. III, Fascicle III.4, Rec. H.51.

Geneva, 2004