RECOMMENDATION ITU-R F.339-6*

BANDWIDTHS, SIGNAL-TO-NOISE RATIOS AND FADING ALLOWANCES IN COMPLETE SYSTEMS

(1951-1953-1956-1963-1966-1970-1974-1978-1982-1986)

The ITU Radiocommunication Assembly,

considering

(a) that it is desirable to classify the important points with which future studies will have to deal;

(b) that there is a need for numerical values which take into account fading and fluctuations in field intensity;

(c) that, however, the information contained in Annex I to Recommendation ITU-R P.313 gives some results from which provisional data on fading allowances can be derived,

recommends

1. that meanwhile, the values given in Table I should be adopted as provisional values for the signal-to-noise ratio required for the class of emission concerned;

2. that meanwhile, the values given in the last two columns of Table I, in conjunction with the estimate of the intensity fluctuation factor given in Note 4 to this Table, may be used as an aid to estimate monthly-median values of hourly-median field intensities necessary for the various types and grades of service;

3. that Table I be extended to include additional systems as the pertinent information becomes available;

Note 1 – Use of the provisional recommended values only permits an estimate to be obtained, which may have to be adjusted for radio circuits of different lengths depending on the grade of service required.

* Radiocommunication Study Group 9 made editorial amendments to this Recommendation in 2000 in accordance with Resolution ITU-R 44.

TABLE I – *Required signal-to-noise ratios*

Class of emission	Pre-detection bandwidth of receiver (Hz)	Post-detection bandwidth of receiver (Hz)	Grade of service	Audio signal-to-noise ratio (1) (dB)	RF signal-to-noise density ratio (2)(3) (dB)		
					Stable condition	Fading condition (4) non-diversity	Fading condition (5) dual diversity
A1 A Telegraphy 8 bauds	3000	1500	Aural reception (6)	−4	31	38	
A1 B Telegraphy 50 bauds, printer	250	250	Commercial grade (7)	16	40		58
A1 B Telegraphy 120 bauds, undulator	600	600		10	38		49
A2 A Telegraphy 8 bauds	3000	1500	Aural reception (6) (19)	−4	35	38	
A2 B Telegraphy 24 bauds	3000	1500	Commercial grade (7) (19)	11	50	56	
F1 B Telegraphy 50 bauds, printer $2D$ = 200 Hz to 400 Hz	1500	100	$P_C = 0.01$ $P_C = 0.001$ $P_C = 0.0001$ (8)		45 51 56 (9)	53 63 74 (9)	45 52 59 (9)
F1 B Telegraphy 100 bauds, printer $2D$ = 170 Hz, ARQ	300	300	(10)		43	52	
F1 B Telegraphy 200 bauds, printer $2D$ = ..., ARQ			(10)				
F1B Telegraphy MFSK 33-tone ITA2 10 character/s	400	400	$P_C = 0.01$ $P_C = 0.001$ $P_C = 0.0001$ (8)		23 24 26	37 45 52 (25)	29 34 39
F1B Telegraphy MFSK 12-tone ITA5 10 character/s	300	300	$P_C = 0.01$ $P_C = 0.001$ $P_C = 0.0001$ (8)		26 27 29	42 49 56 (25)	32 36 42
F1B Telegraphy MFSK 6-tone ITA2 10 character/s	180	180	$P_C = 0.01$ $P_C = 0.001$ $P_C = 0.0001$ (8)		25 26 28	41 48 55 (25)	31 35 41
F7B Telegraphy							
R3C Phototelegraphy 60 rpm	3000	3000			50	59	
R3C Phototelegraphy 60 rpm	1100	3000	Marginally commercial (22) Good commercial (22)	15 20	50 55	58 65	
A3E Telephony double sideband	6000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	50 59 67(14)	51 64 75(14) (20)	48 60 70(14) (15) (20)
H3E Telephony single-sideband full carrier	3000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	53 62 70(14) (23)	54 67 78(14) (20)	51 63 73(14) (15) (20)
R3E Telephony single-sideband reduced carrier	3000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	48 57 65(14) (24)	49 62 73(14) (20)	46 58 68(14) (15) (20)
J3E Telephony single-sideband suppressed carrier	3000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 5 33 (18)	47 56 64(14)	48 61 72(14) (20)	45 57 67(14) (15) (20)
B8E Telephony independent-sideband 2 channels	6000	3000 per channel	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	49 58 66(14)	50 63 74(14) (20)	47 59 69(14) (15) (20)
B8E Telephony independent-sideband 4 channels	12000	3000 per channel	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	50 59 67(14)	51 64 75(14) (20)	48 60 70(14) (15) (20)
J7B Multichannel V.F. telegraphy 16 channels 75 bauds each	3000	110 per channel	$P_C = 0.01$ $P_C = 0.001$ $P_C = 0.0001$ (8)		59 65 69 (21)	67 77 87 (21)	59 66 72 (21)
J7B Multichannel V.F. telegraphy 15 channels 100 bauds each with ARQ	3000	110 per channel	(10)				
R7B Multichannel V.F. telegraphy reduced carrier							
B7W Composite 16 channels 75 bauds each 1 telephony channel (16)	6000	110 per telegraphy channel 3000 for the telephony channel	$P_C = 0.01$ $P_C = 0.001$ $P_C = 0.0001$ (8)		60 66 70 (17)	68 78 88 (17)	60 67 73 (17)

Footnotes to Table I

(1) Noise bandwidth equal to post-detection bandwidth of receiver. For an independent-sideband telephony noise bandwidth equal to the postdetection bandwidth of one channel

(2) The figures in this column represent the ratio of signal peak envelope power to the average noise power in a 1 Hz bandwidth except for double-sideband A3E emission where the figures represent the ratio of the carrier power to the average noise power in a 1 Hz bandwidth.

(3) The values of the radio-frequency signal-to-noise density ratio for telephony listed in this column, apply when conventional terminals are used. They can be reduced considerably (by amounts as yet undetermined) when terminals of the type using linked compressor expanders (Lincompex) are used. A speech-to-noise (r.m.s. voltage) ratio of 7 dB measured at audio-frequency in a 3 kHz band has been found to correspond to just marginally commercial quality at the output of the system, taking into account the compandor improvement.

(4) The values in these columns represent the median values of the fading signal power necessary to yield an equivalent grade of service, and do not include the intensity fluctuation factor (allowance for day-to-day fluctuation). In general, a value of 14 dB may be added as the intensity fluctuation factor to the values in these columns to arrive at provisional values for the total required signal-to-noise density ratios which may be used as a guide to estimate required monthly-median values of hourly-median field strength. This value of 14 dB has been obtained as follows:

The intensity fluctuation factor for the signal, against steady noise, is 10 dB, estimated to give protection for 90% of the days. The fluctuations in intensity of atmospheric noise are also taken to be 10 dB for 90% of the days. Assuming that there is no correlation between the fluctuations in intensity of the noise and those of the signal, a good estimate of the combined signal and noise intensity fluctuation factor is

$$\sqrt{10^2 + 10^2} = 14 \text{ dB}.$$

(5) In calculating the radio-frequency signal-to-noise density ratios for rapid short-period fading, a log-normal amplitude distribution of the received fading signal has been used (using 7 dB for the ratio of median level to level exceeded for 10% or 90% of the time) except for high-speed automatic telegraphy services, where the protection has been calculated on the assumption of a Rayleigh distribution. The following notes refer to protection against rapid or short-period fading.

(6) For protection 90% of the time.

(7) For A1B telegraphy, 50 baud printer: for protection 99.99% of the time. For A2B telegraphy, 24 bauds: for protection 98% of the time.

(8) The symbol P_C stands for the probability of character error.

(9) Atmospheric noise (V_d = 6 dB) is assumed.

(10) Based on 90% traffic efficiency.

(11) For 90% sentence intelligibility.

(12) When connected to the public service network: based on 80% protection.

(13) When connected to the public service network: based on 90% protection.

(14) Assuming 10 dB improvement due to the use of noise reducers.

(15) Diversity improvement based on a wide-spaced (several kilometres) diversity.

(16) Transmitter loading of 80% of the rated peak envelope power of the transmitter by the multi-channel telegraph signal is assumed.

(17) Required signal-to-noise density ratio based on performance of telegraphy channels.

(18) For telephony, the figures in this column represent the ratio of the audio-frequency signal, as measured on a standard VU-meter, to the r.m.s. noise, for a bandwidth of 3 kHz. (The corresponding peak signal power, i.e. when the transmitter is 100% tone-modulated, is assumed to be 6 dB higher.)

(19) Total sideband power, combined with keyed carrier, is assumed to give partial (two element) diversity effect. An allowance of 4 dB is made for 90% protection (8 bauds), and 6 dB for 98% protection (24 bauds).

(20) Used if Lincompex terminals will reduce these figures by an amount yet to be determined.

(21) For fewer channels these figures will be different. The relationship between the number of channels and the required signal-to-noise ratio has yet to be determined.

(22) Quality judged in accordance with article 23.1 of ITU publication “Use of the standardized test chart for facsimile transmissions”.

(23) For class of emission H3E the levels of sideband signals and pilot-carrier corresponding to 100% modulation are each −6 dB relative peak envelope power (p.e.p.). SSB receiver used for reception.

(24) For class of emission R3E the pilot-carrier level of −20 dB relative to p.e.p. is applied and the level of the sideband signal corresponding to I00% modulation is I dB lower than the p.e.p.

(25) Dependent on fading rate, typical values shown.