

RECOMMENDATION ITU-R F.240-7^{* **}**Signal-to-interference protection ratios for various classes of emission
in the fixed service below about 30 MHz**

(Question ITU-R 143/9)

(1953-1956-1959-1970-1974-1978-1986-1990-1992-2006)

Scope

This Recommendation describes minimum signal-to-interference protection ratios and frequency separations for various classes of emission in the fixed service below about 30 MHz.

The ITU Radiocommunication Assembly,

considering

a) that knowledge of the signal-to-interference protection ratios for various classes of emission is needed,

recommends

1 that the values of signal-to-interference protection ratios shown in Table 1 for stable conditions, below which harmful interference occurs, should be considered appropriate for the emissions indicated;

2 that studies should be continued to provide values of signal-to-interference protection ratios for stable conditions where they are not shown in Table 1 and also to review the values that are shown;

3 that the studies in connection with Recommendation ITU-R F.339 should be continued for the purpose of determining whether the provisional values given for the fading allowances may be accepted or should be modified;

4 that meanwhile, the values given may be regarded as provisional total fading allowances (combined fading safety factors intensity fluctuation factors) and may be used as a guide, in conjunction with the values for signal-to-interference protection ratios (for stable conditions), appropriate to the various classes of emission;

* This Recommendation should be brought to the attention of the Radio Regulations Board and Radiocommunication Study Group 1.

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

TABLE 1
Minimum required protection ratios and frequency separations*

WANTED SIGNAL	CLASS OF EMISSION OF INTERFERING SIGNAL																							
Class of emission	Telegraphy												Telegraphy								Telegraphy			
	A1A Manual				A1B 50 Bd ⁽¹⁾				A1B 100 Bd				A2A Manual				A2B 24 Bd				F1B 50 Bd 2D = 200 Hz ⁽¹⁾			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	dB				kHz				dB				kHz				dB				kHz			
A1A telegraphy aural reception	13				13				13												13			
A1B telegraphy 50 Bd printer B = 500 Hz	13				11	0.36	0.44	1.41	(2)	(2)	(2)										13			
A1B telegraphy 100 and 120 Bd recorder B = 500 Hz	13				13				13												13			
A2A telegraphy aural reception																								
A2B telegraphy, 24 Bd																								
F1B telegraphy (3) 50 Bd, printer 2D = 280 Hz; B = 500 Hz					1.0	0.2	0.28	0.6	3												7			
F1B telegraphy 50 Bd, printer 2D = 400 Hz; B = 500 Hz					1.0				(2)	(2)	(2)										7			
F7B telegraphy 200 Bd, printer ARQ 2D = 400 Hz B = 500 Hz	4				4				4															
F7B telegraphy 200 Bd, printer ARQ 2D = 400 Hz; B = 500 Hz	4				4				(4)	(4)	(4)													
F7B (2), 50 Bd printer 2D = 1 200 Hz B = 1 200 Hz	Channel 1																				8			
	Channel 2																				18			
R3C phototelegraphy	16				16				16												16			
F3C phototelegraphy 60 rpm, B = 1 000 Hz	15				15				15	1.00	1.20										15			
A3E telephony DSB	just usable	13			13				13				1				1				21			
	marginally commercial	29			29				29				17				17				33			
	good commercial	56			56				56				44				44				60			
H3E telephony SSB full carrier ⁽⁵⁾	just usable	7			7				7				-5				-5				15			
	marginally commercial	23			23				23				11				11				27			
	good commercial	50			50				50				38				38				54			
R3E telephony SSB reduced carrier ⁽⁵⁾	just usable	2			2				2				-10				-10				10			
	marginally commercial	18			18				18				6				6				22			
	good commercial	45			45				45				33				33				49			
J3E telephony SSB suppressed carrier ⁽⁵⁾	just usable	1			1				1				-11				-11				9			
	marginally commercial	17			17				17				5				5				21			
	good commercial	44			44				44				32				32				48			
R8E telephony Two ISB reduced or suppressed carrier ⁽⁵⁾	just usable	7			7				7				-5				-5				15			
	marginally commercial	23			23				23				11				11				27			
	good commercial	50			50				50				38				38				54			
J7B multichannel V.F. telegraphy 250-3 000 Hz	17.5				17.5				17.5												20.5			
J7B multichannel V.F. telegraphy 300-3 400 Hz ⁽⁶⁾	17.5				17.5	1.7	1.7	8.0	17.5	1.7	1.8	9.1									20.5	1.9	1.9	2.0
R7B multichannel V.F. telegraphy reduced carrier	18.5				18.5				18.5												21.5			
J2D data transmission SSB suppressed carrier PSK/QAM ⁽¹³⁾	9				9				9				9				9				9			

TABLE 1 (continued)

WANTED SIGNAL	CLASS OF EMISSION OF INTERFERING SIGNAL																											
Class of emission	Telegraphy														Telegraphy													
	F1B 50 Bd 2D = 400 Hz ⁽¹⁾				F1B 100 Bd 2D = 400 Hz				F1B 100 Bd 2D = 500 Hz				F1B 200 Bd 2D = 500 Hz				F7B 100 Bd 2D = 400 Hz				F7B 100 Bd 2D = 1500 Hz				F7B 200 Bd 2D = 600 Hz			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	dB		kHz		dB		kHz		dB		kHz		dB		kHz		dB		kHz		dB		kHz		dB		kHz	
A1A telegraphy aural reception	13				13				13				13				3				3				3			
A1B telegraphy 50 Bd printer B = 500 Hz	13				13				13				13				(2) 3	(2) 0.40	(2) 0.55		3				3			
A1B telegraphy 100 and 120 Bd recorder B = 500 Hz	13				13				13				13				3				3				3			
A2A telegraphy aural reception																												
A2B telegraphy. 24 Bd																												
F1B telegraphy ⁽³⁾ 50 Bd, printer 2D = 280 Hz: B = 500 Hz	7				7				7				7				2				2				2			
F1B telegraphy 50 Bd, printer 2D = 400 Hz: B = 500 Hz	7				7				7				7				(2) 2	(2) 0.45	(2) 0.60		2				2			
F7B telegraphy 100 Bd, printer ARQ 2D = 400 Hz B = 500 Hz																	4				4				4			
F7B telegraphy 200 Bd, printer ARQ 2D = 400 Hz: B = 500 Hz																	(4) 4	(4) 0.50	(4) 0.70		4				4			
F7B ⁽³⁾ , 50 Bd, printer 2D = 1 200 Hz B = 1 200 Hz	Channel 1	8	0.85	0.95	1.51	8			8				8				8				8				8			
	Channel 2	18	0.98	1.1	2.06	18			18				18				18				18				18			
R3C phototelegraphy	16				16				16				16				16				16				16			
F3C phototelegraphy 60 rpm, B = 1 000 Hz	15				15				15				15				15	1.10	1.20		15				15			
A3E telephony DSB	just usable	21			21				21				21				17				17				17			
	marginally commercial	33			33				33				33				35				35				35			
	good commercial	60			60				60				60				66				66				66			
H3E telephony SSB full carrier ⁽⁵⁾	just usable	15			15				15				15				11				11				11			
	marginally commercial	27			27				27				27				29				29				29			
	good commercial	54			54				54				54				60				60				60			
R3E telephony SSB reduced carrier ⁽⁵⁾	just usable	10			10				10				10				6				6				6			
	marginally commercial	22			22				22				22				24				24				24			
	good commercial	49			49				49				49				55				55				55			
J3E telephony SSB suppressed carrier ⁽⁵⁾	just usable	9			9				9				9				5				5				5			
	marginally commercial	21			21				21				21				23				23				23			
	good commercial	48			48				48				48				54				54				54			
R8E telephony Two ISB reduced or suppressed carrier ⁽⁵⁾	just usable	15			15				15				15				11				11				11			
	marginally commercial	27			27				27				27				29				29				29			
	good commercial	54			54				54				54				60				60				60			
J7B multichannel V.F. telegraphy 250-3 000 Hz	20.5				20.5				20.5				20.5				20.5				20.5				20.5			
J7B multichannel V.F. telegraphy 300-3 400 Hz ⁽⁶⁾	20.5	1.9	1.9	2.1	20.5	1.9	1.9	2.8	20.5	2.0	2.0	2.9	20.5	1.9	2.0	3.1	20.5				20.5	2.4	2.5	3.5	20.5			
R7B multichannel V.F. telegraphy reduced carrier	21.5				21.5				21.5				21.5				21.5				21.5				21.5			
J2D data transmission SSB suppressed carrier PSK/QAM ⁽¹³⁾	9				9				9				9				9				9				9			

TABLE 1 (continued)

WANTED SIGNAL	CLASS OF EMISSION OF INTERFERING SIGNAL																			
Class of emission	Telegraphy								Telegraphy								Telephony			
	F7B 200 Bd 2D = 3 000 Hz				A1B 200 Bd 2D = 1 200 Hz				R3C				F3C				A3E DSB (7)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz		
A1A telegraphy aural reception	3				3												5			
A1B telegraphy 50 Bd, printer B = 500 Hz	3				3												5			
A1B telegraphy 100 and 120 Bd recorder B = 500 Hz	3				3												5			
A2A telegraphy aural reception																	5			
A2B telegraphy, 24 Bd																	5			
F1B telegraphy (3) 50 Bd, printer 2D = 280 Hz: B = 500 Hz	2				2												-3			
F1B telegraphy 50 Bd, printer 2D = 400 Hz: B = 500 Hz	2				2												-3			
F7B telegraphy 100 Bd, printer ARQ 2D = 400 Hz B = 500 Hz	4				4															
F7B telegraphy 200 Bd, printer ARQ 2D = 400 Hz: B = 500 Hz	4				4															
F7B (3), 50 Bd, printer	Channel 1	8			8	1.24	1.33	2.32												
2D = 1 200 Hz B = 1 200 Hz	Channel 2	18			18	1.33	1.51	3.08												
R3C phototelegraphy	16				16															
F3C phototelegraphy 60 rpm, B = 1 000 Hz	15				15															
A3E telephony DSB	just usable	17			17				19				20				6			
	marginally commercial	35			35				34				35				18			
	good commercial	66			66				64				65				39			
H3E telephony SSB full carrier(5)	just usable	11			11				13				14				0			
	marginally commercial	29			29				28				29				12			
	good commercial	60			60				58				59				33			
R3E telephony SSB reduced carrier(5)	just usable	6			6				8				9				-5			
	marginally commercial	24			24				23				24				7			
	good commercial	55			55				53				54				28			
J3E telephony SSB suppressed carrier(5)	just usable	5			5				7				8				-6			
	marginally commercial	23			23				22				23				6			
	good commercial	54			54				52				53				27			
R8E telephony Two ISB reduced or suppressed carrier(5)	just usable	11			11				13				14				0			
	marginally commercial	29			29				28				29				12			
	good commercial	60			60				58				59				33			
J7B multichannel V.F. telegraphy 250-3 000 Hz	20.5				20.5															
J7B multichannel V.F. telegraphy 300-3 400 Hz (6)	20.5	3.2	3.3	5.1	20.5															
R7B multichannel V.F. telegraphy reduced carrier	21.5				21.5															
J2D data transmission SSB suppressed carrier PSK/QAM(13)	9				9				9				9				9			

TABLE 1 (continued)

WANTED SIGNAL		CLASS OF EMISSION OF INTERFERING SIGNAL															
Class of emission		Telephony								Telegraphy							
		J3E suppressed carrier				B8E reduced or suppressed carrier				J2B				H2A/H2B			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		dB	kHz			dB	kHz			dB	kHz			dB	kHz		
A1A telegraphy aural reception		11				5				13				7			
A1B telegraphy 50 Bd, printer $B = 500$ Hz		11				5				13				7			
A1B telegraphy 100 and 120 Bd recorder $B = 500$ Hz		11				5				13				7			
A2A telegraphy aural reception		17				11											
A2B telegraphy, 24 Bd		17				11											
F1B telegraphy ⁽³⁾ 50 Bd, printer $2D = 280$ Hz: $B = 500$ Hz		9				3				3				-3			
F1B telegraphy 50 Bd, printer $2D = 400$ Hz: $B = 500$ Hz		9				3				3				-3			
F7B telegraphy 100 Bd, printer ARQ $2D = 400$ Hz $B = 500$ Hz										4				-2			
F7B telegraphy 200 Bd, printer ARQ $2D = 400$ Hz: $B = 500$ Hz										4				-2			
F7B ⁽³⁾ , 50 Bd, printer $2D = 1\ 200$ Hz $B = 1\ 200$ Hz	Channel 1																
	Channel 2																
R3C phototelegraphy										16				10			
F3C phototelegraphy 60 rpm, $B = 1\ 000$ Hz										15				9			
A3E telephony DSB	just usable	18				12				13				7			
	marginally commercial	30				24				29				23			
	good commercial	51				45				56				50			
H3E telephony SSB full carrier ⁽⁵⁾	just usable	12				6				7				1			
	marginally commercial	24				18				23				17			
	good commercial	45				39				50				44			
R3E telephony SSB reduced carrier ⁽⁵⁾	just usable	7				1				2				-4			
	marginally commercial	19				13				18				12			
	good commercial	40				34				45				39			
J3E telephony SSB suppressed carrier ⁽⁵⁾	just usable	6				0				1				-5			
	marginally commercial	18				12				7				11			
	good commercial	39				33				44				38			
R8E telephony Two ISB reduced or suppressed carrier ⁽⁵⁾	just usable	12				6				7				1			
	marginally commercial	24				18				23				17			
	good commercial	45				39				50				44			
J7B multichannel V.F. telegraphy 250-3 000 Hz										17.5				11.5			
J7B multichannel V.F. telegraphy 300-3 400 Hz ⁽⁶⁾										17.5				11.5			
R7B multichannel V.F. telegraphy reduced carrier										18.5				12.5			
J2D data transmission SSB suppressed carrier PSK/QAM ⁽¹³⁾		9				9				9				9			

TABLE 1 (end)

WANTED SIGNAL		CLASS OF EMISSION OF INTERFERING SIGNAL																Provisional total fading allowances ⁽⁸⁾ for the protection of a fading signal against an interfering signal subject to fading and day-to-day intensity fluctuations. (See ⁽⁹⁾) (dB to be added to values in columns numbered 1)		
Class of emission		Multichannel V.F. telegraphy												Data transmission						
		J7B suppressed carrier 250-3 000 Hz				J7B suppressed carrier 300-3 400 Hz				R7B reduced carrier				J2D PSK/QAM						
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
																			Non-diversity	Diversity
A1A telegraphy aural reception															11					
A1B telegraphy 50 Bd, printer <i>B</i> = 500 Hz															11					27 ⁽¹⁰⁾
A1B telegraphy 100 and 120 Bd recorder <i>B</i> = 500 Hz															11					
A2A telegraphy aural reception															17					
A2B telegraphy, 24 Bd															17					
F1B telegraphy ⁽³⁾ 50 Bd, printer 2 <i>D</i> = 280 Hz: <i>B</i> = 500 Hz															9					
F1B telegraphy 50 Bd, printer 2 <i>D</i> = 400 Hz: <i>B</i> = 500 Hz															9					27 ⁽¹⁰⁾
F7B telegraphy 100 Bd, printer ARQ 2 <i>D</i> = 400 Hz <i>B</i> = 500 Hz																				
F7B telegraphy 200 Bd, printer ARQ 2 <i>D</i> = 400 Hz: <i>B</i> = 500 Hz																				12 ⁽¹¹⁾
F7B ⁽³⁾ , 50 Bd, printer 2 <i>D</i> = 1 200 Hz <i>B</i> = 1 200 Hz	Channel 1																			
	Channel 2																			
R3C phototelegraphy																			20	
F3C phototelegraphy 60 rpm, <i>B</i> = 1 000 Hz																			20	
A3E telephony DSB	just usable	20				20				19				18						
	marginally commercial	34				34				33				30						
	good commercial	56				56				55				51					17 ⁽¹²⁾	
H3E telephony SSB full carrier ⁽⁵⁾	just usable	14				14				13				12						
	marginally commercial	28				28				27				24						
	good commercial	50				50				49				45						
R3E telephony SSB reduced carrier ⁽⁵⁾	just usable	9				9				8				7						
	marginally commercial	23				23				22				19						
	good commercial	45				45				44				40					17 ⁽¹²⁾	
J3E telephony SSB suppressed carrier ⁽⁵⁾	just usable	8				8				7				6						
	marginally commercial	22				22				21				18						
	good commercial	44				44				43				39					17 ⁽¹²⁾	
R8E telephony Two ISB reduced or suppressed carrier ⁽⁵⁾	just usable	14				14				13				12						
	marginally commercial	28				28				27				24						
	good commercial	50				50				49				45						
J7B multichannel V.F. telegraphy 250-3 000 Hz																				
J7B multichannel V.F. telegraphy 300-3 400 Hz ⁽⁶⁾																				
R7B multichannel V.F. telegraphy reduced carrier																				
J2D data transmission single sideband suppressed carrier PSK/QAM ⁽¹³⁾		9				9				9				9						

Notes to Table 1:

DSB: Double sideband

ISB: Independent sideband

SSB: Single sideband

* Under “class of emission”, B represents the receiver bandwidth and $2D$ represents the total frequency shift.

- (¹) Bandwidth of interfering signals limited to 500 Hz.
- (²) For a probability of character error $P_C = 0.0001$.
- (³) For a probability of character error $P_C = 0.001$.
- (⁴) For a traffic efficiency of 90%.
- (⁵) For telephony the values of protection ratios for stable conditions have been derived from information contained in Annexes 1 and 2. The figures for A3E telephony are valid only for reception with an SSB receiver.
- (⁶) Values derived from information contained in Annex 3.
- (⁷) Average degree of modulation 70%; sideband components extended to ± 3 kHz.
- (⁸) Combined allowances for fading safety factor and intensity fluctuation factor.
- (⁹) The probability distribution of the ratio of two signals fading independently has been applied. The combined intensity fluctuation allowance for two signals has been taken as 7 dB, which represents a compromise between the 0 dB allowance, appropriate to perfectly correlated intensity fluctuations of the two signals, and the 14 dB allowance appropriate to uncorrelated intensity fluctuations of the two signals.
- (¹⁰) For protection 99.99% of the time.
- (¹¹) Based on 90% traffic efficiency.
- (¹²) Based on 90% protection.
- (¹³) The protection ratio for the J2D wanted signal is the values for user data rate of 3.2 kbit/s in the wanted signal. For the other user data rate, add the correction factor (dB) shown below:

User data rate (kbit/s)	3.2 or less	4.8	6.4	8.0	9.6	12.8
Correction factor (dB)	0	4	7	10	12	18

- 5** that Annex 1 should be referred to for measurement of protection ratios for J3E emission;
- 6** that Annex 2 should be referred to for conversion factors for deriving the protection ratios;
- 7** that Annex 3 should be referred to for measurement of protection ratios and minimum necessary frequency separation for class of emission J7B.

8 that the Notes shown below should be considered as part of this Recommendation.

NOTE 1 – Use of the 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 and on the specific propagation conditions on these radio circuits. In calculating the fading safety factor for rapid or 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.

NOTE 2 – Table 1 provides, in column 1 for each interfering signal, the value of the protection ratio as the ratio of wanted-to-unwanted signals whose powers are expressed in terms of peak envelope power (P_X) in general when the occupied band of the interfering emission either falls entirely within the passband of the receiver, or covers it completely.

When one of the signals is expressed in terms of mean power (P_Y) or carrier power (P_Z) the corresponding value of the protection ratio can be obtained by appropriately using the conversion factors given in Recommendation ITU-R SM.326.

For the wanted signal of the J2D emission, the value of the protection ratio is given as the power ratio of wanted-to-unwanted signals whose powers are expressed in terms of mean power.

NOTE 3 – Columns 2, 3 and 4 of Table 1 indicate the frequency separation necessary between the assigned frequency of a wanted signal and that of an interfering signal when the level of the latter is respectively 0, 6 and 30 dB higher than the wanted signal (as defined in No. 1.148 of the Radio Regulations, the assigned frequency is the centre of the assigned frequency band).

NOTE 4 – Signal processing techniques such as Lincompex, Syncompex, etc., and the use of noise reducers and notch filters may reduce the susceptibility of radiotelephone signals to interference.

Annex 1

Measurement of protection ratios for J3E emission

1 Introduction

Protection ratio is defined in No. 1.170 of the Radio Regulations as follows:

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

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

The measurement programme described in this annex was based on Recommendation ITU-R F.339, in which audio signal-to-noise (S/N) ratios of 33 dB, 15 dB and 6 dB give the service grades of