

RECOMMENDATION ITU-R SM.1138-2

Determination of necessary bandwidths including examples for their calculation and associated examples for the designation of emissions

(1995-2007-2008)

Scope

This Recommendation serves as a basis for the determination of necessary bandwidths of emissions under amplitude, frequency and pulse modulation by various types of signals. Sample calculations and designation of emissions are also provided.

The ITU Radiocommunication Assembly,

considering

- a) that the assignment of frequencies requires the determination of the necessary bandwidth of emissions;
- b) that necessary bandwidth is a key data element of all automated spectrum-management systems,

recommends

- 1 that the formulae given in Annex 1 shall be used to calculate the necessary bandwidth when required by the Radio Regulations (RR).

Annex 1**Determination of necessary bandwidths, including examples for their calculation and associated examples for the designation of emissions**

- 1 The necessary bandwidth is not the only characteristic of an emission to be considered in evaluating the interference that may be caused by that emission.
- 2 In the formulation of the table, the following terms have been employed:
 - B_n : necessary bandwidth (Hz)
 - B : modulation rate (Bd)
 - N : maximum possible number of black plus white elements to be transmitted per second, in facsimile
 - M : maximum modulation frequency (Hz)
 - C : sub-carrier frequency (Hz)
 - D : peak deviation, i.e. half the difference between the maximum and minimum values of the instantaneous frequency. The instantaneous frequency (Hz) is the time rate of change in phase (rad) divided by 2π
 - t : pulse duration (s) at half-amplitude

t_r : pulse rise time (s) between 10% and 90% amplitude

K : an overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion. In the case of orthogonal frequency division multiplexed multi-carrier signal, K is the number of active sub-carriers as defined by equation (52) in Recommendation ITU-R SM.328

N_c : number of baseband channels in radio systems employing multichannel multiplexing

f_p : continuity pilot sub-carrier frequency (Hz) (continuous signal utilized to verify performance of frequency-division multiplex systems)

N_s : frequency separation between two sub-carriers (kHz).

Description of emission	Necessary bandwidth		Designation of emission
	Formula	Sample calculation	
I. NO MODULATING SIGNAL			
Continuous wave emission	–	–	NONE
II. AMPLITUDE MODULATION			
1. Signal with quantized or digital information			
Continuous wave telegraphy, Morse code	$B_n = BK$ $K = 5$ for fading circuits $K = 3$ for non-fading circuits	25 words per minute $B = 20, K = 5$ Bandwidth: 100 Hz	100HA1AAN
Telegraphy by on-off keying of a tone modulated carrier, Morse code	$B_n = BK + 2M$ $K = 5$ for fading circuits $K = 3$ for non-fading circuits	25 words per minute $B = 20, M = 1\ 000, K = 5$ Bandwidth: 2 100 Hz = 2.1 kHz	2K10A2AAN
Selective calling signal using sequential single frequency code, single-sideband full carrier	$B_n = M$	Maximum code frequency is: 2 110 Hz $M = 2\ 110$ Bandwidth: 2 110 Hz = 2.11 kHz	2K11H2BFN
Direct-printing telegraphy using a frequency shifted modulating sub-carrier, with error-correction, single-sideband, suppressed carrier (single channel)	$B_n = 2M + 2DK$ $M = \frac{B}{2}$	$B = 50$ $D = 35$ Hz (70 Hz shift) $K = 1.2$ Bandwidth: 134 Hz	134HJ2BCN
Telegraphy, multichannel with voice frequency, error-correction, some channels are time-division multiplexed, single-sideband, reduced carrier	$B_n =$ highest central frequency + $M + DK$ $M = \frac{B}{2}$	15 channels; highest central frequency is: 2 805 Hz $B = 100$ $D = 42.5$ Hz (85 Hz shift) $K = 0.7$ Bandwidth: 2 885 Hz = 2.885 kHz	2K89R7BCW
2. Telephony (commercial quality)			
Telephony, double-sideband (single channel)	$B_n = 2M$	$M = 3\ 000$ Bandwidth: 6 000 Hz = 6 kHz	6K00A3EJN
Telephony, single-sideband, full carrier (single channel)	$B_n = M$	$M = 3\ 000$ Bandwidth: 3 000 Hz = 3 kHz	3K00H3EJN
Telephony, single-sideband, suppressed carrier (single channel)	$B_n = M$ – lowest modulation frequency	$M = 3\ 000$ lowest modulation frequency = 300 Hz Bandwidth: 2 700 Hz = 2.7 kHz	2K70J3EJN

Description of emission	Necessary bandwidth		Designation of emission
	Formula	Sample calculation	
2. Telephony (commercial quality) (cont.)			
Telephony with separate frequency modulated signal to control the level of demodulated speech signal, single-sideband, reduced carrier (Lincompex) (single channel)	$B_n = M$	Maximum control frequency = 2 990 Hz $M = 2\,990$ Bandwidth: 2 990 Hz = 2.99 kHz	2K99R3ELN
Telephony with privacy, single-sideband, suppressed carrier (two or more channels)	$B_n = N_c M$ – lowest modulation frequency in the lowest channel	$N_c = 2$ $M = 3\,000$ lowest modulation frequency = 250 Hz Bandwidth: 5 750 Hz = 5.75 kHz	5K75J8EKF
Telephony, independent sideband (two or more channels)	B_n = sum of M for each sideband	2 channels $M = 3\,000$ Bandwidth: 6 000 Hz = 6 kHz	6K00B8EJN
3. Sound broadcasting			
Sound broadcasting, double-sideband	$B_n = 2M$ M may vary between 4 000 and 10 000 depending on the quality desired	Speech and music $M = 4\,000$ Bandwidth: 8 000 Hz = 8 kHz	8K00A3EGN
Sound broadcasting, single-sideband, reduced carrier (single channel)	$B_n = M$ M may vary between 4 000 and 10 000 depending on the quality desired	Speech and music $M = 4\,000$ Bandwidth: 4 000 Hz = 4 kHz	4K00R3EGN
Sound broadcasting, single-sideband, suppressed carrier	$B_n = M$ – lowest modulation frequency	Speech and music $M = 4\,500$ lowest modulation frequency = 50 Hz Bandwidth: 4 450 Hz = 4.45 kHz	4K45J3EGN
4. Television			
Television, vision and sound	Refer to relevant ITU-R documents for the bandwidths of the commonly used television systems	Number of lines: 625 Nominal video bandwidth = 5 MHz Sound carrier relative to video carrier: 5.5 MHz Total vision Bandwidth: 6.25 MHz FM sound bandwidth including guardbands: 750 kHz RF channel Bandwidth: 7 MHz	6M25C3F -- 750KF3EGN
5. Facsimile			
Analogue facsimile by sub-carrier frequency modulation of a single-sideband emission with reduced carrier, monochrome	$B_n = C + \frac{N}{2} + DK$ $K = 1.1$ (typically)	$N = 1\,100$ corresponding to an index of cooperation of 352 and a cyclus rotation speed of 60 rpm. Index of cooperation is the product of the drum diameter and number of lines per unit length. $C = 1\,900$ $D = 400$ Hz Bandwidth: 2 890 Hz = 2.89 kHz	2K89R3CMN
Analogue facsimile; frequency modulation of an audio frequency sub-carrier which modulates the main carrier, single-sideband suppressed carrier	$B_n = 2M + 2DK$ $M = \frac{N}{2}$ $K = 1.1$ (typically)	$N = 1\,100$ $D = 400$ Hz Bandwidth: 1 980 Hz = 1.98 kHz	1K98J3C --