REPORT ITU-R SM.2048

Use of the *x* dB bandwidth criterion for determination of spectral properties of a transmitter in the out-of-band domain

(2004)

1 Description of the approach

1.1 A method, used by some administrations, is described for specifying and measuring the following spectral properties of transmitters in the out-of-band (OoB) domain (§ 1.2 of Recommendation ITU-R SM.1541 refers): the bandwidth of a transmitter emission beyond which OoB emission begins, and OoB emissions as such.

1.2 The transmitter spectral properties indicated in § 1.1 are specified and measured on the basis of a single criterion: the *x* dB bandwidth (§ 1.14 of Recommendation ITU-R SM.328 refers).

1.3 The bandwidth of a transmitter emission is specified and measured on the basis of –30 dB occupied bandwidth, B_c.

1.4 OoB emissions are specified and measured using values of bandwidths of their spectra obtained at the –40 dB (B_{-40}), –50 dB (B_{-50}) and –60 dB (B_{-60}) levels, and additionally at –35 dB (B_{-35}) level for certain classes of emissions, and they are compared with relevant value for the –30 dB occupied bandwidth, B_c, and through it with the necessary bandwidth, B_n.

1.5 For certain classes of radar emissions only OoB bandwidths starting from B_{-40} are given as the only available at the moment. On the other hand, for some classes of radar emissions bandwidths of in-band spectra at level –20 dB (B_{-20}) are additionally presented for better characterization of spectral properties of emissions in border area between in-band and OoB spectra. In other separate cases other *x* dB levels are also used for the same purpose.

1.6 Data of Tables 1-3 can be also used for purposes of radio monitoring by procedures given in Recommendation ITU-R SM.443.

2 Terms and definitions

Terms and definitions used herein are those given in the Radio Regulations (RR) and in Recommendation ITU-R SM.328.

3 Emission classes

Classes of emissions are provided in RR Appendix 1.

4 Requirements concerning –30 dB occupied bandwidth and OoB emissions

4.1 The basis for specifying –30 dB bandwidth and OoB emissions is the necessary bandwidth, B_n; it is determined using the formulas in Table 1 based on values given in Recommendations ITU-R SM.328, ITU-R SM.853 and ITU-R SM.1138. In calculating the necessary bandwidth, the modulation parameters provided in these requirements for the class of emission and transmitter type in question must be used. Symbols and abbreviations for types of modulation in this Report are

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explained in Annex 5. The figures, units and remarks in Table 1 are based on the experience of the administrations mentioned in § 1.

4.2 The requirements concerning bandwidths of emissions are determined using the formulas in Table 1 and correspond to the values of –30 dB bandwidth, B_c, specified and measured with respect to the defined 0 dB (reference) level.

4.3 The requirements concerning OoB emissions are given in the form of bandwidths of their spectra at fixed x dB levels, where x values are –35, –40, –50 and –60 dB (and corresponding bandwidths are B_{-35}, B_{-40}, B_{-50} and B_{-60}) with respect to the defined 0 dB (reference) level. Section 5.27 explains how the reference level is determined. The formulas in Table 1 are used to specify bandwidth values at those x dB levels. By joining points having as their ordinate the dB levels and as their abscissa the logarithm of the frequency separation from the carrier, a limiting mask for emissions in the OoB domain can be obtained.

4.4 It can be also required that measured values of the –30 dB bandwidth and of bandwidths of OoB spectra, as defined in § 4.3, should not exceed the specified values of those parameters by more than 10%; this figure includes the measurement uncertainty associated with the method described in § 5.

4.5 The requirements concerning OoB emissions of HF transmitters on board aircraft operating in the classes of emissions H2BBN, H3EJN, J3EJN, J7BCF and JXX--(1) are listed in Table 2.

4.6 The requirements concerning OoB emissions of transmitters of the maritime mobile service operating in the classes of emissions H2BBN, H3EJN, J3EJN and R3EJN are given in Table 3.

(1) Hyphens are used to indicate unused additional parameters in the designation of the class of emissions (see Annex 5).

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TABLE 1

Calculation of –30 dB bandwidth and bandwidths of OoB spectra

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
1. Amplitude modulation				
1.A Signal with quantized or digital information				
Telegraphy, continuous wave **A1AAN, A1BBN**	Transmitters in the mobile service Transmitters in the land and maritime mobile service > 100 W	$B_n = K_{fade}\,B$ K_{fade} = 5 for links with fading K_{fade} = 3 for links without fading	$B_{c-30} = B_n$ $B_{-40} = 1.3B_c$ $B_{-50} = 1.6B_c$ $B_{-60} = 2B_c$	The coefficient K_{fade} is determined in the technical instructions for various types of transmitter, depending on transmitter function and the frequency band used
	Transmitters in the land and maritime mobile service ≤ 100 W	$B_n = 5B$	$B_{c-30} = 7B$ $B_c = 1.4B_n$ $B_{-40} = 1.86B_c$	
	Aircraft transmitters in the aeronautical mobile service	$B_n = 5B$	$B_{c-30} = 7B$ $B_c = 1.4B_n$ $B_{-40} = 1.86B_c$ $B_{-50} = 3.3B_c$ $B_{-60} = 5.8B_c$	Requirements apply for manipulation speeds below 20 baud; for speeds above 20 baud limits are introduced in consultation with the customer
Binary amplitude-shifted carrier **A1D**		$B_n = 5B$	$B_{c-30} = 1.4\,B_n = 7B$ $B_{-40} = 1.4B_c$ $B_{-50} = 2.5B_c$ $B_{-60} = 4.5B_c$	$B_{-25} = B_n$
	Radio link	$B_n = K_{fade}\,B$ K_{fade} = 3 for links without fading K_{fade} = 5 for links with fading	$B_{c-30} = 1.05B_n$ $B_{-40} = 1.3B_c$ $B_{-50} = 1.6B_c$ $B_{-60} = 2B_c$	
Voice-frequency telegraphy **A2AAN, A2BBN**		$B_n = 2F_U + 5B$	$B_{c-30} = 2F_U + 6.8B$ $B_{-40} = 2F_U + 13B$	

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
Multichannel telegraphy **A7B, A7D**		$B_n = 2B_{ch}$	$B_{c-30} = B_n$ $B_{-40} = 1.3B_c$ $B_{-50} = 1.6B_c$ $B_{-60} = 2B_c$	
Voice-frequency telegraphy, single sideband, full carrier **H2BBN** **H2BFN**		$B_n = 2F_U + 5B$	$B_{c-30} = B_n$ $B_{-40} = 1.25B_c$ $B_{-50} = 1.55B_c$ $B_{-60} = 2B_c$	Does not apply to transmitters of the aeronautical and maritime mobile service, the requirements for which are given in Tables 2 and 3 respectively
	Selective calling signal using sequential single-frequency code	$B_n = F_U$	$B_{c-30} = B_n$ $B_{-40} = 1.25B_c$ $B_{-50} = 1.55B_c$ $B_{-60} = 2B_c$	
Single-sideband telegraphy, suppressed carrier **J2A--**(1)		$B_n = 5B$	$B_{c-30} = B_n$ $B_{-40} = 1.3B_c$ $B_{-60} = 2B_c$	
Narrow-band voice-frequency telegraphy **J2B, J2D**	Maritime mobile service NBPM	$B_n = 1.1B$	$B_{c-30} = 2.5B$ $B_{-40} = 2B_c$ $B_{-50} = 2.8B_c$ $B_{-60} = 3.6B_c$	
Voice-frequency telegraphy, single sideband, suppressed carrier **J2BBN**	Secondary multiplexing of channel formed by single-sideband transmitter with suppressed carrier and voice packets on 1 kHz or 1.6 kHz subcarrier	$B_n = 5B$	$B_{c-30} = B_n$ $B_{-40} = 1.3B_c$ $B_{-50} = 1.6B_c$ $B_{-60} = 2B_c$	
		$B_n = 5B$	$B_{c-30} = 1.36B_n = 6.8B$ $B_{-40} = 1.9B_c$	Applies to transmitters in the land mobile service ≤ 100 W

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of:		Remarks
		Necessary bandwidth B_n (Hz)	–30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	
Voice-frequency telegraphy, single sideband, suppressed carrier **J2BBN**	2-position code without error correction, transmitters in the land mobile service ≤ 100 W	$B_n = 5B$	$B_{c-30} = 1.36B_n = 6.8B$ $B_{-40} = 1.25B_c$	
Voice-frequency telegraphy, single sideband, suppressed carrier **J2BCN**	2-position code with error correction, transmitters in the land mobile service	$B_n = 5B$	$B_{c-30} = B_n$ $B_{-40} = 1.3B_c$ $B_{-50} = 1.6B_c$ $B_{-60} = 2B_c$	
		$B_n = 5B$	$B_c = 1.36B_n = 6.8B$ $B_{-40} = 1.9B_c$	Applies to transmitters in the land mobile service ≤ 100 W
Multichannel voice-frequency telegraphy, single sideband, reduced carrier **R7BCF, R7BCN, R7DCN**		$B_n = F_U$, where F_U is the upper frequency of the SSB channel	$B_c = 1.2B_n = 1.2F_U$ $B_{-40} = 1.75B_c$ $B_{-50} = 3.33B_c$ $B_{-60} = 5.75B_c$	
Multichannel voice-frequency telegraphy, single sideband, suppressed carrier **J7BCF**		$B_n = F_{uc} - F_{lc}$, where: F_{uc}: upper frequency of the SSB channel F_{lc}: lower frequency SSB channel	$B_c = 1.2B_n = 1.2(F_{uc} - F_{lc})$ $B_{-40} = 1.75B_c$ $B_{-50} = 3.33B_c$ $B_{-60} = 5.75B_c$	
Narrow-band voice-frequency telegraphy **J7B**	Maritime mobile service NBPM	$B_n = 1.1B$	$B_c = 2.3B_n = 2.5B$ $B_{-40} = 2B_c$ $B_{-50} = 2.8B_c$ $B_{-60} = 3.6B_c$	
Multichannel telegraphy **J7B**	Excludes transmitters in the maritime mobile service	$B_n = F_{uc} - F_{lc}$	$B_c = 1.4B_n$ $B_{-40} = 1.6B_c$ $B_{-50} = 2.2B_c$ $B_{-60} = 2.9B_c$	

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
1.B Telephony (not sound broadcasting)				
Telephony, double-sideband, single-channel **A3EJN**	Transmitters in the mobile service without frequency response correction	$B_n = 2F_U$	$B_c = 1.9B_n = 3.8F_U$ $B_{-40} = 1.74B_c$ $B_{-50} = 3.16B_c$ $B_{-60} = 5.53B_c$	
	Transmitters in the mobile service with frequency response correction and transmitters in the mobile service	$B_n = 2F_U$	$B_c = 2.5B_n = 5F_U$ $B_{-40} = 1.8B_c$ $B_{-50} = 3.12B_c$ $B_{-60} = 5.52B_c$	
	Aircraft transmitters in the aeronautical mobile service	$B_n = 2F_U$	$B_c = 2.5B_n = 5F_U$ $B_{-40} = 1.8B_c$ $B_{-50} = 3.2B_c$ $B_{-60} = 5.6B_c$	
Telephony, single sideband, full carrier **H3EJN** Reduced carrier **R3EJN**	Transmitters in the mobile service	$B_n = F_U$	$B_c = 1.15B_n = 1.15F_U$ $B_{-35} = 1.09B_c$ $B_{-40} = 1.39B_c$ $B_{-50} = 2.52B_c$ $B_{-60} = 4.7B_c$	
	Transmitters in the land mobile service > 100 W	$B_n = F_U$	$B_c = 1.2B_n = 1.2F_U$ $B_{-40} = 1.75B_c$ $B_{-50} = 3.33B_c$ $B_{-60} = 5.75B_c$	
Telephony, single sideband, full carrier **J3EJN** Reduced carrier **R3EJN**	Transmitters in the land mobile service ≤ 100 W	$B_n = F_U$	$B_c = 1.8B_n = 1.8F_U$ $B_{-40} = 1.9B_c$ $B_{-50} = 3.33B_c$ $B_{-60} = 6.11B_c$	

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
Two or more telephony channels with frequency multiplexing **A8EJN**	Radio links in the fixed service	$B_n = 2F_U$ F_U: upper frequency of the group band	$B_c = 5F_U = 2.5B_n$ $B_{-40} = 1.8B_c$ $B_{-50} = 3.2B_c$ $B_{-60} = 5.6B_c$	
Two or more telephony channels combining different types of transmission **A8W**	Television relay	$B_n = 2F_{sc} + 2F_U + 2D$	$B_c = 2.5B_n$ $B_{-40} = 1.8B_c$ $B_{-50} = 3.2B_c$ $B_{-60} = 5.6B_c$	
Telephony, single sideband, suppressed carrier **J3EJN**	Transmitters in the mobile service	$B_n = F_{uc} - F_{lc}$	$B_c = 1.15B_n = 1.15(F_{uc} - F_{lc})$ $B_{-35} = 1.09B_c$ $B_{-40} = 1.39B_c$ $B_{-50} = 2.52B_c$ $B_{-60} = = 4.7B_c$	
	Transmitters in the land and maritime mobile service > 100 W	$B_n = F_{uc} - F_{lc}$	$B_c = 1.2B_n = 1.2(F_{uc} - F_{lc})$ $B_{-40} = 1.91B_c$ $B_{-50} = 3.33B_c$ $B_{-60} = 5.75B_c$	
	Transmitters in the land and maritime mobile service ≤ 100 W	$B_n = F_{uc} - F_{lc}$	$B_c = 1.8B_n = 1.8(F_{uc} - F_{lc})$ $B_{-40} = 1.9B_c$ $B_{-50} = 3.3B_c$ $B_{-60} = 6.1B_c$	
Telephony, transmission in independent sidebands, reduced or suppressed carrier **B8EJN**	Telephony in two independent bands	$B_n = 2F_U$	$B_c = 1.05B_n = 2.1F_U$ $B_{-40} = 1.43B_c$ $B_{-50} = 2.57B_c$ $B_{-60} = 4.67B_c$	
	Telephony in four independent bands	$B_n = 4F_U$	$B_c = 1.05B_n = 4.2F_U$ $B_{-40} = 1.43B_c$ $B_{-50} = 2.57B_c$ $B_{-60} = 4.67B_c$	

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of:		Remarks
		Necessary bandwidth B_n (Hz)	–30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	
Telephony, transmission in independent bands **B9WWF**		$B_n = Np\ F_U$, where Np is the number of independent bands	$B_c = 1.8B_n$ $B_{-40} = 1.2B_c$ $B_{-50} = 2.2B_c$ $B_{-60} = 3.7B_c$	
Two or more channels, single sideband **J8EKF**	Telephony with privacy	$B_n = Np(F_{uc} - F_{lc})$, where Np is the number of independent frequency bands	$B_c = 1.2B_n$ $B_{-40} = 1.83B_c$ $B_{-50} = 3.33B_c$ $B_{-60} = 5.83B_c$	
1.C Sound broadcasting				
Sound broadcasting, double-sideband **A3EGN**		$B_n = 2F_{uc}$	$B_c = 1.2B_n = 2.4\ F_{uc}$ $B_{-40} = 1.13B_c$ $B_{-50} = 2.42B_c$ $B_{-60} = 2.75B_c$	
Sound broadcasting, single sideband, reduced carrier **R3EGN**		$B_n = F_{uc}$	$B_c = 1.15B_n = 1.15\ F_{uc}$ $B_{-40} = 1.22B_c$ $B_{-50} = 2.09B_c$ $B_{-60} = 3.83B_c$	
Sound broadcasting, single sideband, suppressed carrier **J3EGN**		$B_n = F_{uc} - F_{lc}$	$B_c = 1.15B_n$ $B_{-40} = 1.22B_c$ $B_{-50} = 2.09B_c$ $B_{-60} = 3.83B_c$	
Sound broadcasting, transmission in independent sidebands, reduced or suppressed carrier **B8EGN**		$B_n = 2F_{uc}$	$B_c = 1.05B_n = 2.1F_{uc}$ $B_{-40} = 1.43B_c$ $B_{-50} = 2.57B_c$ $B_{-60} = 4.29B_c$	

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of:		Remarks
		Necessary bandwidth B_n (Hz)	–30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	
Single-sideband broadcasting **H3EGN, J3EGN**		$B_n = F_{uc} - F_{lc}$	$B_c = 1.15\ B_n$ $B_{-40} = 1.22\ B_c$ $B_{-50} = 2.1\ B_c$ $B_{-60} = 3.83\ B_c$	
1.D Facsimile				
Facsimile with carrier modulation, frequency-modulated subcarrier, double-sideband **A3C--**[(1)]		$B_n = 2F_{sc} + 3F_U$, where F_{sc} is the subcarrier frequency	$B_c = B_n$ $B_{-35} = B_n + 2F_U$	
Facsimile with carrier modulation, frequency-modulated subcarrier, single sideband, reduced carrier **R3C, R3CMN**		$B_n = F_{sc} + 1.5F_U$	$B_c = B_n + F_U = F_{sc} + 2.5F_U$ $B_{-40} = B_c + F_U$ $B_{-50} = B_c + 2F_U$ $B_{-60} = B_c + 3F_U$	
1.E Composite emissions				
Composite emissions in two independent bands, suppressed or reduced carrier **B9WWX**	One sideband for SSB telephony, the other for multichannel voice-frequency telegraphy	$B_n = 2F_U$ or $B_n = 2B_{ch}$, where B_{ch} is the overall channel speed	$B_c = 1.1B_n\ B_c = 2.2B_{ch}$ $B_{-40} = 1.8B_c$ $B_{-50} = 3.36B_c$ $B_{-60} = 5.8B_c$	B_n if upper frequency F_U of SSB channel greater than voice-frequency telegraphy speed; otherwise, B_{ch} is used in place of B_n

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
2. Frequency modulation				
2.A Telegraphy				
Frequency-shift telegraphy, single-channel **F1B, F1D**		$B_n = 2.4B\sqrt{m'}$ for $0.5 \le m_p < 1.5$ $B_n = 1.2B + 2.4D$ for $1.5 \le m_p < 5.5$ $B_n = 1.9B + 2.1D$ for $5.5 \le m_p \le 20$	$B_c = 2.3B_n/(m_p + 12)^{1/6}$ $B_{-40} = B_c[2.86 - (m_p + 12)^{1/6}]$ $B_{-50} = B_c[4 - (m_p + 8)^{1/4}]$ $B_{-60} = B_c[4.8 - (m_p + 5)^{1/3}]$	$m_p = 2D/B$
Narrow-band direct-printing telegraphy with error correction **F1BCN**		$B_n = 2B + 2.4D$ $D = 85$ Hz		
Frequency manipulation of subcarriers **F2B**		$B_n = (N_f - 1)\Delta F + B_{nF1B}$ N_f: number of subcarriers ΔF: subcarrier separation (Hz) B_{nF1B}: necessary bandwidth calculated for *F*1*B*	$B_c = B_n$ $B_{-40} = 1.3\ B_c$ $B_{-50} = 1.6B_n$ $B_{-60} = 3B_n$	
Multichannel frequency shift telegraphy **F7B, F7D**		$B_n = 2.4B\sqrt{m'}$ for $0.5 \le m_p < 1.5$ $B_n = 1.2B + 2.4D$ for $1.5 \le m_p < 5.5$ $B_n = 1.9B + 2.1D$ for $5.5 \le m_p \le 20$	$B_c = 2.3B_n/(m_p + 12)^{1/6}$ $B_{-40} = B_c[2.86 - (m_p + 12)^{1/6}]$ $B_{-50} = B_c[4 - (m_p + 8)^{1/4}]$ $B_{-60} = B_c[4.8 - (m_p + 5)^{1/3}]$	$m_p = 2D/B$ where B is the maximum transmission speed in the channels

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
Four-frequency duplex telegraphy **F7BDX**	Transmitters in the fixed and mobile service	a) $B_n = B + 2.2D$ for synchronized channels	$B_c = B_n$ $B_{-40} = (4m_p + 13)B$ $B_{-50} = (4.6m_p + 26)B$ $B_{-60} = (5.1m_p + 47)B$	$m_p = 2D/3B$
	Aircraft transmitters in the aeronautical mobile service	b) $B_n = 4B + 2.2D$ for non-synchronized channels where B is the maximum transmission speed in the channels	$B_c = B_n$ $B_{-40} = 13m_p^{2/3}B$ $B_{-50} = 18\ m_p^{2/3}B$ $B_{-60} = 37\ m_p^{2/3}B$	$m_p = 2D/3B$, for $(1.3 < m_p < 5)$
2.B Telephony				
Commercial telephony **F3EJN**		$B_n = 2F_U + 2D$	$B_c = B_n = 2F_U + 2D$ $B_{-40} = (7.8m_p + 3)F_U$ for $0.25 \le m_p \le 1.3$ $B_{-40} = (7.8m_p + 4)F_U$ for $m_p > 1.3$ $B_{-50} = (8.4m_p + 4.4)F_U$ for $0.25 \le m_p \le 1.3$ $B_{-50} = (8.4m_p + 6)F_U$ for $m_p > 1.3$ $B_{-60} = (9m_p + 6)F_U$ for $0.25 \le m_p \le 1.3$ $B_{-60} = (8.8m_p + 8)F_U$ for $m_p > 1.3$	$m_p = D/3F_U$
2.C Sound and television broadcasting				
Sound broadcasting (monaural) **F3EGN**	$D = 50$ kHz, $D = 75$ kHz	$B_n = 2F_U + 2D$ for $1 \le m_p \le 1.7$	$B_c = (6.7m_p + 2)F_U$ $B_{-40} = (7.8m_p + 3)F_U$ $B_{-50} = (8.4m_p + 4.4)F_U$ $B_{-60} = (9m_p + 6)F_U$ for $1 \le m_p \le 1.7$	$m_p = D/3F_U$

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
Television transmission with FM **F3FM, F3FN, F3FW**		$B_n = 2F_U + 2D$	$B_c = 1.2B_n = 2.4F_U + 2.4D$ $B_{-60} = 1.67B_c$	
Sound broadcasting (stereo channel) **F8EHN**	$D = 50$ kHz, $D = 75$ kHz	$B_n = 2.4F_U + 2.4D$ for $0.3 \le m_p \le 1.7$	$B_c = (8m_p + 2.4)F_U$ $B_{-40} = (9.36m_p + 3.6)F_U$ $B_{-50} = (10m_p + 5.28)F_U$ $B_{-60} = (10.8m_p + 7.2)F_U$ for $0.3 \le m_p \le 1.7$	$m_p = D/3F_U$
Sound broadcasting, FM **F8E, F9E, F9W**		$2F_U + 2D$	$B_c = 2F_U + 2.3D$ $B_{-60} = 6F_U + 3D$	
Sound broadcasting with subsidiary channel **F8EHF**	$D = 75$ kHz	$B_n = 2F_U + 2D$ for $0.3 \le m_p \le 0.5$		$m_p = D/3F_U$
2.D Facsimile				
Facsimile, with frequency modulation of carrier by image pulse signal **F1CMN** **F3CMN** (monochrome signal) **F3C,** **F1CNN, F3CNN** (colour signal)	Transmission of black-and-white facsimile (text) images	$B_n = 2F_U + 2.2D$, $F_U = Z/2$	$B_c = 1.2B_n = 2.4F_U + 2.64D$ $B_{-40} = 1.33B_c$ $B_{-50} = 1.75B_c$ $B_{-60} = 2.25B_c$	
	Transmission of half-tone and colour images	$B_n = 2F_U + 2.2D$, $F_U = Z/2$	$B_c = 1.2B_n = 2.4F_U + 2.64D$ $B_{-40} = 0.83B_c \cdot 10^{5.1/(11.8+3.2m_p)}$ $B_{-50} = 0.83B_c \cdot 10^{8.1/(11.8+3.2m_p)}$ $B_{-60} = 0.83B_c \cdot 10^{11.1/(11.8+3.2m_p)}$	$m_p = D/F_U$

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of: Necessary bandwidth B_n (Hz)	Calculation of: –30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	Remarks
2.E Composite emissions				
Frequency modulation by two or more frequencies **F8B, F9B** **F8BBT, F8BBN,** **F9BBT, F9BBN**		$B_n = 2B + 2D$, with $D = 0.25B$, where B is the maximum transmission speed in the channels	$B_c = 2.5B_n$ $B_{-60} = 2.8B_c$	
FM oscillation modulated with signal from FDM transmission system **F8EJF**	Line-of-sight and tropospheric relays	$B_n = 2F_U + 2D$, where D is determined from Table 1A	$B_c = 0.3B_n$ for $60 \leq N600$ $B_c = 0.7B_n$ for $N \geq 720$	For systems with a pilot signal, use F_{ps} instead of F_U
FM oscillation modulated with television signal and sound subcarriers **F8WWN**	Line-of-sight relay systems	$B_n = 2F_U + 2D_{MAX.TV}$, where: $D_{MAX.TV}$: peak frequency deviation created by the video signal (Hz) F_U: frequency of upper sound subcarrier	$B_c = 0.7B_n$	For systems with a pilot signal, use F_{ps} instead of F_U
Frequency MSK (unfiltered) **F9E, F9D** **F9EBT, F9EBN** **F9DBT, F9DBN**		$B_n = 1.18B$, for $D \approx B/4$	$B_c = 1.18B_n = 1.4B$ $B_{-40} = 1.3B_c$ $B_{-50} = 1.56B_c$ $B_{-60} = 1.74B_c$	

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TABLE 1 (*continued*)

Class of emission	Additional characteristics	Calculation of:		Remarks
		Necessary bandwidth B_n (Hz)	–30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)	
Frequency MSK with Gaussian filter **F9E, F9D**	With normalized Gaussian shaping filter bandwidth, $\varphi = \Delta F_G T$	If $\varphi = 1$ then $B_n = 1.14B$ If $\varphi = 0.7$ then $B_n = 1.1B$ If $\varphi = 0.5$ then $B_n = 1.07B$ If $\varphi = 0.3$ then $B_n = 0.93B$	If $\varphi = 1$ then $B_c = 1.34B$ $B_{-40} = 1.3B_c$, $B_{-60} = 1.74B_c$ If $\varphi = 0.7$ then $B_c = 1.21B$ $B_{-40} = 1.2B_c$, $B_{-60} = 1.51B_c$ If $\varphi = 0.5$ then $B_c = 1.16B$ $B_{-40} = 1.14B_c$, $B_{-60} = 1.4B_c$ If $\varphi = 0.3$ then $B_c = 0.95B$ $B_{-40} = 1.1B_c$, $B_{-60} = 1.3B_c$	If $T = 1/B$ and $D \cong B/4$
FM oscillation with FDM **F9WWF**	FDM-FM, Line-of-sight relay link	$2F_U + 2D_m$, where D_m is determined from Table 1A	$B_c = 0.3B_n$ for $60 \leq N_C \leq 600$ $B_c = 0.7B_n$ for $N_C \geq 720$	For systems with a pilot signal, use F_{ps} instead of F_U

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TABLE 1 (*continued*)

TABLE 1a

Calculation of peak frequency deviation of multichannel message, $D = 3.76\ \Delta fch \cdot 10^{0.05 P_{load}}$

Number of voice channels, N_c	**Effective frequency deviation created by the measured level of one voice channel, Δf_{ch} (MHz)**	**Mean power of multichannel message (P_{load}) (dBm)**	**Mean power of one voice channel $\lambda(P_{ch.mean})$ (dBm)**
$12 \le N_c < 60$	0.1	$2.6 + 2 \log N_c$	
$60 \le N_c \le 240$	0.2	$\approx 5.5 \log N_c - 1.5$	
$240 < N_c \le 1\,020$	0.2	$P_{ch.mean} + 10 \log N_c$	–13
$N_c > 1\,020$	0.14	$P_{ch.mean} + 10 \log N_c$	–13

Class of emission	**Additional characteristics**	**Calculation of:**		**Remarks**
		Necessary bandwidth B_n (Hz)	**–30 dB occupied bandwidth, B_c, and bandwidths of OoB spectra (Hz)**	
2. Frequency modulation (continued)				
2.F Phase modulation				
Single-channel telegraphy, phase-shift **G1B, G1D**	$K_{fade} = 3$ for links not subject to fading, $K_{fade} = 5$ for links subject to fading	$B_n = K_{fade}B$	$B_c = 1.4B_n = 1.4K_{fade}B$ $B_{-40} = 1.86B_c$ $B_{-50} = 3.29B_c$ $B_{-60} = 5.7B_c$	
Continuous phase manipulation telegraphy **G1BCN**		$B_n = 11B$	$B_c = B_n = 11B$ $B_{-40} = 1.7B_c$ $B_{-50} = 2.7B_c$ $B_{-60} = 5.5B_c$	
	Narrow-band relative phase-shift keying; recommended transmission speed 100 or 200 Bd NBPM	$B_n = 1.1B$	$B_c = 2.4B_n = 2.64B$ $B_{-40} = 1.5B_c$ $B_{-50} = 2.12B_c$ $B_{-60} = 2.75B_c$	MF and HF transmitters in the maritime mobile service

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