—Sequence of unmodulated pulses ..... P
—A sequence of pulses:
—Modulated in amplitude ..... K
—Modulated in width/duration L
—Modulated in position/phase .. M
—In which the carrier is angle-modulated during the period of the pulse ..... Q
—Which is a combination of the foregoing or is produced by other means V
(6) Cases not covered above, in which an emission consists of the main carrier modulated, either simultaneously or in a pre-established sequence, in a combination of two or more of the following modes: amplitude, angle, pulse ... W
(7) Cases not otherwise covered ... X

[1] Emissions where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation) should be designated under (2) or (3).

(d) Second Symbol—nature of signal(s) modulating the main carrier:

(1) No modulating signal 0
(2) A single channel containing quantized or digital information without the use of a modulating sub-carrier, excluding time-division muliplex 1
(3) A single channel containing quantized or digital information with the use of a modulating sub-carrier, excluding time-division multiplex 2
(4) A single channel containing analogue information 3
(5) Two or more channels containing quantized or digital information 7
(6) Two or more channels containing analogue information 8
(7) Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analogue information 9
(8) Cases not otherwise covered ... X

(e) Third Symbol—type of information to be transmitted: [2]

(1) No information transmitted ... N
(2) Telegraphy—for aural reception ..... A
(3) Telegraphy—for automatic reception ..... B
(4) Facsimile C
(5) Data transmission, telemetry, telecommand ..... D
(6) Telephony (including sound broadcasting) ..... E
(7) Television (video) ..... F
(8) Combination of the above ..... W
(9) Cases not otherwise covered ... X

(f) Type *B* emission: As an exception to the above principles, damped waves are symbolized in the Commission's rules and regulations as type *B* emission. The use of type B emissions is forbidden.

(g) Whenever the full designation of an emission is necessary, the symbol for that emission, as given above, shall be preceded by the necessary bandwidth of the emission as indicated in § 2.202(b)(1).

[49 FR 48697, Dec. 14, 1984, as amended at 75 FR 63030, Oct. 13, 2010]

§ 2.202 Bandwidths.

(a) *Occupied bandwidth.* The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission. In some cases, for example multichannel frequency-division systems, the percentage of 0.5 percent may lead to certain difficulties in the practical application of the definitions of occupied and necessary bandwidth; in such cases a different percentage may prove useful.

(b) *Necessary bandwidth.* For a given class of emission, the minimum value of the occupied bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions. Emissions useful for the good functioning of the receiving equipment as, for example, the emission corresponding to the carrier of reduced carrier systems, shall be included in the necessary bandwidth.

(1) The necessary bandwidth shall be expressed by three numerals and one letter. The letter occupies the position of the decimal point and represents the

[2] In this context the word ''information'' does not include information of a constant, unvarying nature such as is provided by standard frequency emissions, continuous wave and pulse radars, etc.

unit of bandwidth. The first character shall be neither zero nor K, M or G.

(2) Necessary bandwidths:

between 0.001 and 999 Hz shall be expressed in Hz (letter H);
between 1.00 and 999 kHz shall be expressed in kHz (letter K);
between 1.00 and 999 MHz shall be expressed in MHz (letter M);
between 1.00 and 999 GHz shall be expressed in GHz (letter G).

(3) Examples:

0.002 Hz—H002
0.1 Hz—H100
25.3 Hz—25H3
400 Hz—400H
2.4 kHz—2K40
6 kHz—6K00
12.5 kHz—12K5
180.4 kHz—180K
180.5 kHz—181K
180.7 kHz—181K
1.25 MHz—1M25
2 MHz—2M00
10 MHz—10M0
202 MHz—202M
5.65 GHz—5G65

(c) The necessary bandwidth may be determined by one of the following methods:

(1) Use of the formulas included in the table, in paragraph (g) of this section, which also gives examples of necessary bandwidths and designation of corresponding emissions;

(2) For frequency modulated radio systems which have a substantially linear relationship between the value of input voltage to the modulator and the resulting frequency deviation of the carrier and which carry either single sideband suppressed carrier frequency division multiplex speech channels or television, computation in accordance with provisions of paragraph (f) of this section and formulas and methods indicated in the table, in paragraph (g) of this section;

(3) Computation in accordance with Recommendations of the International Radio Consultative Committee (C.C.I.R.);

(4) Measurement in cases not covered by paragraph (c) (1), (2), or (3) of this section.

(d) The value so determined should be used when the full designation of an emission is required. However, the necessary bandwidth so determined is not the only characteristic of an emission to be considered in evaluating the interference that may be caused by that emission.

(e) In the formulation of the table in paragraph (g) of this section, the following terms are employed:

B_n = Necessary bandwidth in hertz
B = Modulation rate in bauds
N = Maximum possible number of black plus white elements to be transmitted per second, in facsimile
M = Maximum modulation frequency in hertz
C = Sub-carrier frequency in hertz
D = Peak frequency deviation, *i.e.*, half the difference between the maximum and minimum values of the instantaneous frequency. The instantaneous frequency in hertz is the time rate of change in phase in radians divided by 2
t = Pulse duration in seconds at half-amplitude
t_r = Pulse rise time in seconds between 10% and 90% of maximum amplitude
K = An overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion.
N_c = Number of baseband telephone channels in radio systems employing multichannel multiplexing
P = Continuity pilot sub-carrier frequency (Hz) (continuous signal utilized to verify performance of frequency-division multiplex systems).

(f) Determination of values of *D* and B_n for systems specified in paragraph (c)(2) of this section:

(1) Determination of *D* in systems for multichannel telephony:

(i) The rms value of the per-channel deviation for the system shall be specified. (In the case of systems employing preemphasis or phase modulation, this value of per-channel deviation shall be specified at the characteristic baseband frequency.)

(ii) The value of D is then calculated by multiplying the rms value of the per-channel deviation by the appropriate factors, as follows:

Number of message circuits	Multiplying factors	Limits of X (P_{avg} (dBmO))
More than 3, but less than 12	4.47 × [a factor specified by the equipment manufacturer or station licensee, subject to Commission approval].	
At least 12, but less than 60	$\frac{3.76 \text{ antilog } (X+2 \log_{10} N_c)}{20}$	X: −2 to +2.6.
At least 60, but less than 240	$\frac{3.76 \text{ antilog } (X+4 \log_{10} N_c)}{}$	X: −5.6 to −1.0.

Number of message circuits	Multiplying factors	Limits of X (P_{avg} (dBmO))
240 or more	$\frac{20}{3.76 \text{ antilog } (X+10 \log_{10} N_c)}{20}$	X: −19.6 to −15.0.

Where X represents the average power in a message circuit in dBmO; N_c is the number of circuits in the multiplexed message load; 3.76 corresponds to a peak load factor of 11.5 dB.

(2) The necessary bandwidth (B_n) normally is considered to be numerically equal to:

(i) $2M+2DK$, for systems having no continuity pilot subcarrier or having a continuity pilot subcarrier whose frequency is not the highest modulating the main carrier;

(ii) $2P+2DK$, for systems having a continuity pilot subcarrier whose frequency exceeds that of any other signal modulating the main carrier, unless the conditions set forth in paragraph (f)(3) of this section are met.

(3) As an exception to paragraph (f)(2)(ii) of this section, the necessary bandwidth (B_n) for such systems is numerically equal to $2P$ or $2M+2DK$, whichever is greater, provided the following conditions are met:

(i) The modulation index of the main carrier due to the continuity pilot subcarrier does not exceed 0.25, and

(ii) In a radio system of multichannel telephony, the rms frequency deviation of the main carrier due to the continuity pilot subcarrier does not exceed 70 percent of the rms value of the per-channel deviation, or, in a radio system for television, the rms deviation of the main carrier due to the pilot does not exceed 3.55 percent of the peak deviation of the main carrier.

(g) Table of necessary bandwidths:

Description of emission	Necessary bandwidth		Designation of emission
	Formula	Sample calculation	
I. NO MODULATING SIGNAL			
Continuous wave emission.			N0N (zero)
II. AMPLITUDE MODULATION			
1. Signal With Quantized or Digital Information			
Continuous wave telegraphy.	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	100HA1A
Telegraphy by on-off keying of a tone modulated carrier.	B_n=BK+2M, K=5 for fading circuits, K=3 for non-fading circuits	25 words per minute; B=20, M=1000, K=5, Bandwidth: 2100 Hz=2.1 kHz	2K10A2A
Selective calling signal, single-sideband full carrier.	B_n=M	Maximum code frequency is: 2110 Hz, M=2110, Bandwidth: 2110 Hz=2.11 kHz	2K11H2B
Direct-printing telegraphy using a frequency shifted modulating sub-carrier single-sideband suppressed carrier.	B_n=2M+2DK, M=B÷2	B=50, D=35 Hz (70 Hz shift), K=1.2, Bandwidth: 134 Hz	134HJ2B
Telegraphy, single sideband reduced carrier.	B_n=central frequency+M+DK, M=B÷2	15 channels; highest central frequency is: 2805 Hz, B=100, D=42.5 Hz (85 Hz shift), K=0.7 Bandwidth: 2.885 Hz=2.885 kHz	2K89R7B
2. Telephony (Commercial Quality)			
Telephony double-sideband.	B_n=2M	M=3000, Bandwidth=6000 Hz=6 kHz	6K00A3E
Telephony, single-sideband, full carrier.	B_n=2M	M=3000, Bandwidth: 3000 Hz=3 kHz	3K00H3E
Telephony, single-sideband suppressed carrier.	B_n=M − lowest modulation frequency	M=3000, lowest modulation frequency is 3000 Hz, 2700 Hz Bandwidth: 2700Hz=2.7 kHz	2K70J3E

Description of emission	Necessary bandwidth		Designation of emission
	Formula	Sample calculation	
Telephony with separate frequency modulated signal to control the level of demodulated speech signal, single-sideband, reduced carrier.	B_n=M	Maximum control frequency is 2990 Hz, M=2990, Bandwidth: 2990 Hz=2.99 kHz	2K99R3E
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=3000 lowest modulation frequency is 250 Hz, Bandwidth: 5750 Hz=5.75 kHz	5K75J8E
Telephony, independent sideband (two or more channels).	B_n=sum of M for each sideband	2 channels, M=3000, Bandwidth: 6000 Hz=6 kHz	6K00B8E
3. Sound Broadcasting			
Sound broadcasting, double-sideband.	B_n=2M, M may vary between 4000 and 10000 depending on the quality desired	Speech and music, M=4000, Bandwidth: 8000 Hz= 8 kHz	8K00A3E
Sound broadcasting, single-sideband reduced carrier (single channel).	B_n=M, M may vary between 4000 and 10000 depending on the quality desired	Speech and music, M=4000, Bandwidth: 4000 Hz= 4 kHz	4K00R3E
Sound broadcasting, single-sideband, suppressed carrier.	B_n=M − lowest modulation frequency	Speech and music, M=4500, lowest modulation frequency=50 Hz, Bandwidth: 4450 Hz=4.45 kHz	4K45J3E
4. Television			
Television, vision and sound.	Refer to CCIR documents for the bandwidths of the commonly used television systems	Number of lines=525; Nominal video bandwidth: 4.2 MHz, Sound carrier relative to video carrier=4.5 MHz	5M75C3F
		Total vision bandwidth: 5.75 MHz; FM aural bandwidth including guardbands: 250,000 Hz	250KF3E
		Total bandwidth: 6 MHz	6M25C3F
5. Facsimile			
Analogue facsimile by sub-carrier frequency modulation of a single-sideband emission with reduced carrier.	B_n=C − N÷2+DK, K=1.1 (typically)	N=1100, corresponding to an index of cooperation of 352 and a cycler rotation speed of 60 rpm. Index of cooperation is the product of the drum diameter and number of lines per unit length C=1900, D=400 Hz, Bandwidth=2.890 Hz=2.89 kHz	2K89R3C
Analogue facsimile; frequency modulation of an audio frequency sub-carrier which modulates the main carrier, single-sideband suppressed carrier.	B_n=2M+2DK, M=N/$_2$, K=1.1 (typically)	N=1100, D=400 Hz, Bandwidth: 1980 Hz=1.98 kHz	1K98J3C
6. Composite Emissions			
Double-sideband, television relay.	B_n=2C+2M+2D	Video limited to 5 MHz, audio on 6.5 MHz frequency modulated subcarrier deviation=50 kHz: C=6.5×10^6 D=50×10^3 Hz, M=15,000, Bandwidth: 13.13×10^6 Hz=13.13 MHz	13M2A8W
Double-sideband radio relay system.	B_n=2M	10 voice channels occupying baseband between 1 kHz and 164 kHz; M=164,000 bandwith=328,000 Hz=328 kHz	328KA8E

Description of emission	Necessary bandwidth		Designation of emission
	Formula	Sample calculation	
Double-sideband emission of VOR with voice (VOR=VHF omnidirectional radio range).	$B_n=2C_{max}+2M+2DK$, K=1 (typically)	The main carrier is modulated by: —a 30 Hz sub-carrier—a carrier resulting from a 9960 Hz tone frequency modulated by a 30 Hz tone—a telephone channel—a 1020 Hz keyed tone for continual Morse identification. C_{max}=9960, M=30, D=480 Hz, Bandwidth: 20,940 Hz=20.94 kHz	20K9A9W
Independent sidebands; several telegraph channels together with several telephone channels.	B_n=sum of M for each sideband	Normally composite systems are operated in accordance with standardized channel arrangements, (e.g. CCIR Rec. 348–2) 3 telephone channels and 15 telegraphy channels require the bandwidth 12,000 Hz=12 kHz	12K0B9W
III-A. FREQUENCY MODULATION			
1. Signal With Quantized or Digital Information			
Telegraphy without error-correction (single channel).	$B_n=2M+2DK$, M=B÷2, K=1.2 (typically)	B=100, D=85 Hz (170 Hz shift), Bandwidth: 304 Hz	304HF1B
Four-frequency duplex telegraphy.	B_n2M+2DK, B=Modulation rate in bands of the faster channel. If the channels are synchronized: M=B÷2, otherwise M=2B, K=1.1 (typically)	Spacing between adjacent frequencies=400 Hz; Synchronized channels; B=100, M=50, D=600 Hz, Bandwidth: 1420 Hz=1.42 kHz	1K42F7B
2. Telephony (Commercial Quality)			
Commercial telephony ...	$B_n=2M+2DK$, K=1 (typically, but under conditions a higher value may be necessary	For an average case of commercial telephony, M=3,000, Bandwidth: 16,000 Hz=16 kHz	16K0F3E
3. Sound Broadcasting			
Sound broadcasting	$B_n=2M+2DK$, K=1 (typically)	Monaural, D=75,000 Hz, M=15,000, Bandwidth: 18,000 Hz=180 kHz	180KF3E
4. Facsimile			
Facsimile by direct frequency modulation of the carrier; black and white.	$B_n=2M+2DK$, M=N÷2, K=1.1 (typically)	N=1100 elements/sec; D=400 Hz, Bandwidth: 1980 Hz=1.98 kHZ	1K98F1C
Analogue facsimile	$B_n=2M+2DK$, M=N÷2, K=1.1 (typically)	N=1100 elements/sec; D=400 Hz, Bandwidth: 1980 Hz=1.98 kHz	1K98F3C
5. Composite Emissions (See Table III-B)			
Radio-relay system, frequency division multiplex.	$B_n=2P+2DK$, K=1	Microwave radio relay system specifications: 60 telephone channels occupying baseband between 60 and 300 kHz; rms per-channel deviation 200 kHz; pilot at 331 kHz produces 200 kHz rms deviation of main carrier. Computation of B_n: D=($200\times10^3\times3.76\times1.19$), Hz=$0.895\times10^6$, P=$0.331\times10^6$ Hz; Bandwidth: 2.452×10^6 Hz	2M45F8E
Radio-relay system frequency division multiple.	$B_n=2M+2DK$, K=1	Microwave radio relay relay systems specifications: 1200 telephone channels occupying baseband between 60 and 5564 kHz; rms per channel deviation 200 kHz; continunity pilot at 6199 kHz produces 140 kHz rms deviation of main carrier. Computation of B_n: D=($20^0\times10^3\times3.76\times3.63$)=$2.73\times10^6$; M=$5.64\times10^6$ Hz; P=6.2×10^6 Hz; (2M+2DK<2P; Bandwidth 16.59×10^6 Hz	16M6F8E

Description of emission	Necessary bandwidth		Designation of emission
	Formula	Sample calculation	
Radio-relay system, frequency division multiplex.	B_n=2P	Microwave radio relay system specifications: Multiplex 600 telephone channels occupying baseband between 60 and 2540 kHz; continuity pilot at 8500 kHz produces 140 kHz rms deviation of main carrier. Computation of Bn : D=($200\times10^3\times3.76\times2.565$)=$1.93\times10^6$ Hz; M=2.54×10^6 Hz; 2DK≤2P Bandwidth: 17×10^6 Hz	17M0F8E
Unmodulated pulse emission.	B_n=2K÷t, K depends upon the ratio of pulse rise time. Its value usually falls between 1 and 10 and in many cases it does not need to exceed 6	Primary Radar Range resolution: 150 m, K=1.5 (triangular pulse where $t\simeq t_r$, only components down to 27 dB from the strongest are considered) Then t=2×range resolution÷velocity of light=$2\times150\div3\times10^8=1\times10^{-6}$ seconds, Bandwidth: 3×10^6 Hz=3 MHz	3M00P0N
6. Composite Emissions			
Radio-relay system	B_n=2K÷t, K=1.6	Pulse position modulated by 36 voice channel baseband; pulse width at half amplitude=0.4 us, Bandwidth: 8×10^6 Hz=8 MHz (Bandwidth independent of the number of voice channels)	8M00M7E
Radio-relay system	B_n = 2K/t K=1.6	Pulse position modulated by 36 voice channel baseband: pulse width at half amplitude 0.4 μS; B_n = 8×10^6 Hz = 8 MHz (Bandwidth independent of the number of voice channels)	8M00M7E
Composite transmission digital modulation using DSB-AM (Microwave radio relay system).	$B_n = 2RK/\log_2 S$	Digital modulation used to send 5 megabits per second by use of amplitude modulation of the main carrier with 4 signaling states R = 5×10^6 bits per second; K = 1; S = 4; B_n = 5 MHz	5M00K7
Binary Frequency Shift Keying.	(0.03 <2D/R <1.0); B_n = 3.86D + 0.27R (1.0 <2D/R <2) B_n = 2.4D + 1.0R	Digital modulation used to send 1 megabit per second by frequency shift keying with 2 signaling states and 0.75 MHz peak deviation of the carrier R = 1×10^6 bps; D = 0.75×10^6 Hz; B_n = 2.8 MHz	2M80F1D
Multilevel Frequency Shift Keying.	$B_n = (R/\log_2 S) + 2DK$	Digital modulation to send 10 megabits per second by use of frequency shift keying with four signaling states and 2 MHz peak deviation of the main carrier R = 10×10^6 bps; D = 2 MHz; K = 1; S = 4; B_n = 9 MHz	9M00F7D
Phase Shift Keying	$B_n = 2RK/\log_2 S$	Digital modulation used to send 10 megabits per second by use of phase shift keying with 4 signaling states R = 10×10^6 bps; K = 1; S = 4; B_n = 10 MHz	10M0G7D
Quadrature Amplitude Modulation (QAM).	$B_n = 2R/\log_2 S$	64 QAM used to send 135 Mbps has the same necessary bandwidth as 64–PSK used to send 135 Mbps; R = 135×10^6 bps; S = 64; B_n = 45 MHz	45M0W
Minimum Shift Keying ...	2-ary: B_n = R(1.18) 4-ary: B_n = R(2.34)	Digital modulation used to send 2 megabits per second using 2-ary minimum shift keying R = 2.36×10^6 bps; B_n = 2.36 MHz	2M36G1D

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