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Designation of Emissions, Class of Station and Nature of Service

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Preface

Telecommunications Regulation Circulars (TRC) are issued as required to provide information to those engaged in telecommunications in Canada. In keeping with new developments, the content of these circulars is subject to change at any time.

It is therefore suggested that interested persons consult the nearest district office of Industry Canada for additional details. While every reasonable effort has been made to ensure accuracy, no warranty is expressed or implied. As well, these circulars have no status in law.

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1. Introduction

The purpose of this document is to outline designation of emissions, class of station and nature of service information used by Industry Canada for radio equipment certification purposes and for the issuance of licences to permit the operation of radio stations in Canada. Radio stations and their emissions are classified into various categories as detailed in this document. When applying for a licence to operate a radio station in accordance with the procedures established by Industry Canada, an applicant shall, to the extent possible, use the methods and symbols contained in this document.

2. Definitions

The following definitions of operational terminology may assist in the designation of radio emissions.

Necessary bandwidth: The width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions for a given class of emission.

***Telegraphy*:** A form of telecommunication in which the transmitted information is intended to be recorded on arrival as a graphic document;[1] the transmitted information may sometimes be presented in an alternative form or may be stored for subsequent use.

***Telecommand*:** The use of telecommunication for the transmission of signals to initiate, modify or terminate functions of equipment at a distance.

***Telemetry*:** The use of telecommunication for automatically indicating or recording measurements at a distance from the measuring instrument.

***Telephony*:** A form of telecommunication primarily intended for the exchange of information in the form of speech.

3. Related Documents

The following International Telecommunication Union (ITU) spectrum management document should be consulted:

Recommendation ITU-R SM.1138*: Determination of necessary bandwidths including examples for their calculation and associated examples for the designation of emission.*

[1] A graphic document records information in a permanent form and is capable of being filed and consulted; it may take the form of written or printed matter or the form of a fixed image.

4. Class of Station and Nature of Service Designators

4.1 Class of Station Designators

AL Aeronautical radionavigation land station
AM Aeronautical radionavigation mobile station
AT Amateur station

BC Broadcasting station, sound
BT Broadcasting station, television

E1 Space research (active sensor) space station
E2 Space research (passive sensor) space station
E3 Space station in the Earth exploration-satellite service (active)
E4 Space station in the Earth exploration-satellite (passive)
EA Space station in the amateur-satellite service
EB Space station in the broadcasting-satellite service (sound broadcasting)
EC Space station in the fixed-satellite service
ED Space telecommand space station
EE Space station in the standard frequency-satellite service
EF Space station in the radiodetermination-satellite service
EG Space station in the maritime mobile-satellite service
EH Space research space station
EI Space station in the mobile-satellite service
EJ Space station in the aeronautical mobile-satellite service
EK Space tracking space station
EM Space station in the meteorological-satellite service
EN Space station in the radionavigation-satellite service
EO Space station in the aeronautical radionavigation-satellite service
EQ Space station in the maritime radionavigation-satellite service
ER Space telemetering space station
ES Station in the inter-satellite service
ET Space station in the space operation service
EU Space station in the land mobile-satellite service
EV Space station in the broadcasting-satellite service (television)
EW Space station in the earth exploration-satellite service
EY Space station in the time signal-satellite service

FA Aeronautical station
FB Base station
FC Coast station
FD Aeronautical station in the aeronautical mobile (R) service
FG Aeronautical station in the aeronautical mobile (OR) service
FL Land station
FP Port station
FX Fixed station

LR Radiolocation land station

MA	Aircraft station
ML	Land mobile station
MO	Mobile station
MR	Radiolocation mobile station
MS	Ship station
NL	Maritime radionavigation land station
NR	Radionavigation mobile station
OD	Oceanographic data station
OE	Oceanographic data interrogating station
PL	Combination of two or more classes of station (limited to collective entries made under the terms of the ITU's *Radio Regulations*, Article 20.5)
RA	Radio astronomy station
RM	Maritime radionavigation mobile station
RN	Radionavigation land station
SA	Meteorological aids mobile station
SM	Meteorological aids base station
SS	Standard frequency and time signal station
TA	Earth station in the amateur-satellite service
TB	Aeronautical earth station
TC	Earth station in the fixed-satellite service
TD	Space telecommand earth station
TE	Satellite EPIRB in the mobile-satellite service
TF	Fixed earth station in the radiodetermination-satellite service
TG	Ship earth station
TH	Earth station in the space research service
TI	Coast earth station
TJ	Aircraft earth station
TK	Space tracking earth station
TL	Mobile earth station in the radiodetermination-satellite service
TM	Earth station in the meteorological-satellite service
TN	Fixed earth station in the radionavigation-satellite service
TO	Mobile earth station in the aeronautical radionavigation-satellite service
TQ	Mobile earth station in the maritime radionavigation-satellite service
TR	Space telemetering earth station
TT	Earth station in the space operation service
TU	Land mobile earth station
TW	Earth station in the earth exploration-satellite service
TX	Fixed earth station in the maritime radionavigation-satellite service
TY	Base earth station
TZ	Fixed earth station in the aeronautical radionavigation-satellite service

UA	Mobile earth station
UB	Earth station in the broadcasting-satellite service (sound broadcasting)
UD	Space telecommand mobile earth station
UE	Earth station in the standard frequency-satellite service
UH	Mobile earth station in the space research service
UK	Space tracking mobile earth station
UM	Mobile earth station in the meteorological-satellite service
UN	Mobile earth station in the radionavigation-satellite service
UR	Space telemetering mobile earth station
UT	Mobile earth station in the space operation service
UV	Earth station in the broadcasting-satellite service (television)
UW	Mobile earth station in the earth-exploration-satellite service
UY	Earth station in the time signal-satellite service
VA	Land earth station

4.2 Nature of Service Designators

AS[2]	Stations using adaptive system
AX	Fixed station used for provision of services related to aircraft flight safety
CO	Station open to official correspondence exclusively
CP[3]	Station open to public correspondence
CR	Station open to limited correspondence
CV	Station open exclusively to correspondence of a private agency
FS	Land station established solely for the safety of life
HP[4]	Fixed station using high altitude platform
MX	Fixed station used for transmission of meteorological information
OT	Station open exclusively to operational traffic of the service concerned
PX	Fixed station used for press transmission
RC	Non-directional radiobeacon
RD	Directional radiobeacon
RG	Radio direction-finding station
RT	Revolving radiobeacon

[2] Adaptive System: A radiocommunication system which varies its radio characteristics according to channel quality. (ref. the ITU's *Radio Regulations* No. **1.109A**)

[3] Public correspondence: Any telecommunication which the offices and stations must, by reason of their being at the disposal of the public, accept for transmission (CS). (ref. the ITU's *Radio Regulations* No. **1.116**)

[4] High altitude platform station: A station located on an object at an altitude of 20-50 km and at a specified, nominal, fixed point relative to the Earth. (ref. the ITU's *Radio Regulations* No. **1.66A**)

ST[5] Fixed station using tropospheric scatter

5. Designation of Emissions

Emissions are designated according to their necessary bandwidth and their classification.

The first four characters of the designation of an emission describe the necessary bandwidth. These four characters are followed by three to five additional characters which describe the classification.

Examples of emissions designators are provided in Section 9.

6. Designation of Necessary Bandwidth

The necessary bandwidth, as determined in accordance with the formulas and examples given in this TRC, are expressed by three numerals and one letter. The letter occupies the position of the decimal point and represents the unit of bandwidth. The first character shall not be zero or K, M, or G.

Necessary bandwidths shall be designated as shown below:

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); and
between 1.00 and 999 GHz shall be expressed in GHz (letter G).

Examples of designated necessary bandwidths would be:

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

7. Classification of Emissions

A minimum of three symbols are used to describe the basic characteristics of radio waves:

1. The first symbol—Type of modulation of the main carrier
2. The second symbol—Nature of the signal(s) modulating the main carrier
3. The third symbol—Type of information being transmitted

[5] Tropospheric scatter: The propagation of radio waves by scattering as a result of irregularities or discontinuities in the physical properties of the troposphere. (ref. the ITU's *Radio Regulations* No. **1.164**)

In addition, a fourth and/or fifth symbol may be used to indicate the following:

4. The fourth symbol—Details about the signal(s).
5. The fifth symbol—Nature of multiplexing

Note: If the fourth and/or fifth symbols are not used, their absence should be indicated by a dash (-) where each symbol would otherwise appear.

7.1 First symbol—Type of modulation of the main carrier

7.1.1	Emission of an unmodulated carrier	N
7.1.2	Emission in which the main carrier is amplitude-modulated (including cases where sub-carriers are angle-modulated)	
7.1.2.1	Double-sideband	A
7.1.2.2	Single-sideband, full carrier	H
7.1.2.3	Single-sideband, reduced or variable level carrier	R
7.1.2.4	Single-sideband, suppressed carrier	J
7.1.2.5	Independent sidebands	B
7.1.2.6	Vestigial sideband	C
7.1.3	Emission in which the main carrier is angle-modulated	
7.1.3.1	Frequency modulation	F
7.1.3.2	Phase modulation	G
7.1.4	Emission in which the main carrier is amplitude-modulated and angle-modulated, either simultaneously or in a pre-established sequence	D
7.1.5	Emission of pulses[6]	
7.1.5.1	Sequence of unmodulated pulses	P
7.1.5.2	A sequence of pulses	
7.1.5.2.1	Modulated in amplitude	K

[6] Emissions where the main carrier is directly modulated by a signal that has been coded into quantized form (e.g. pulse code modulation) should be designated in 7.1.2 or 7.1.3.

7.1.5.2.2	Modulated in width/duration	L
7.1.5.2.3	Modulated in position/phase	M
7.1.5.2.4	In which the carrier is angle-modulated during the period of the pulse	Q
7.1.5.2.5	Which is a combination of the foregoing or is produced by other means	V
7.1.6	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, and/or pulse	W
7.1.7	Cases not otherwise covered	X
7.2	**Second symbol—Nature of signal(s) modulating the main carrier**	
7.2.1	No modulating signal	0
7.2.2	A single channel containing quantized or digital information without the use of a modulating sub-carrier[7]	1
7.2.3	A single channel containing quantized or digital information with the use of a modulating sub-carrier[8]	2
7.2.4	A single channel containing analog information	3
7.2.5	Two or more channels containing quantized or digital information	7
7.2.6	Two or more channels containing analog information	8
7.2.7	Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analog information	9
7.2.8	Cases not otherwise covered	X
7.3	**Third symbol—Type of information to be transmitted[9]**	
7.3.1	No information transmitted	N

[7] Emissions where the main carrier is directly modulated by a signal that has been coded into quantized form (e.g. pulse code modulation) should be designated in 7.1.2 or 7.1.3.

[8] This excludes time-division multiplex.

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

7.3.2	Telegraphy—for aural reception	A
7.3.3	Telegraphy—for automatic reception	B
7.3.4	Facsimile	C
7.3.5	Data transmission, telemetry, telecommand	D
7.3.6	Telephony (including sound broadcasting)	E
7.3.7	Television (video)	F
7.3.8	Combination of the above	W
7.3.9	Cases not otherwise covered	X
7.4	**Fourth symbol—Details of signal(s)**	
7.4.1	Two-condition code with elements of differing numbers and/or durations	A
7.4.2	Two-condition code with elements of the same number and duration without error correction	B
7.4.3	Two-condition code with elements of the same number and duration with error correction	C
7.4.4	Four-condition code in which each condition represents a signal element (of one or more bits)	D
7.4.5	Multi-condition code in which each condition represents a signal element (of one or more bits)	E
7.4.6	Multi-condition code in which each condition or combination of conditions represents a character	F
7.4.7	Sound of broadcasting quality (monophonic)	G
7.4.8	Sound of broadcasting quality (stereophonic or quadraphonic)	H
7.4.9	Sound of commercial quality (excluding categories given in subparagraphs 7.4.10 and 7.4.11)	J
7.4.10	Sound of commercial quality with the use of frequency inversion or band splitting	K
7.4.11	Sound of commercial quality with separate frequency-modulated signals to control the level of demodulated signal	L
7.4.12	Monochrome	M

7.4.13	Colour	N
7.4.14	Combination of the above	W
7.4.15	Cases not otherwise covered	X

7.5 Fifth symbol—Nature of multiplexing

7.5.1	None	N
7.5.2	Code-division multiplex[10]	C
7.5.3	Frequency-division multiplex	F
7.5.4	Time-division multiplex	T
7.5.5	Combination of frequency-division multiplex and time-division multiplex	W
7.5.6	Other types of multiplexing	X

8. Determination of Necessary Bandwidths

For the full designation of an emission, the necessary bandwidth—indicated in four characters—must appear before the classification symbols. When used, the necessary bandwidth must be determined by one of the following methods:

(a) use of the formulas and examples of necessary bandwidths, as well as designation of corresponding emissions provided in Section 9, based on the latest version of Recommendation ITU-R SM.1138;

(b) computation in accordance with methods detailed in an applicant's submission, provided that these methods are accepted by the Department;

(c) use of the measured occupied bandwidth,[11] in cases not covered by (a) or (b) above.

In the formulation of the table, the following terms have been used:

B_n = necessary bandwidth (Hz)

B = modulation rate in bauds (Bd)

[10] Includes bandwidth expansion techniques.

[11] Defined as the width of a frequency band, such that below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5% of the emitted power. This is also known as the 99% emission bandwidth. For transmitters in which there are multiple carriers, contiguous or non-contiguous in frequency, the occupied bandwidth is to be the sum of the occupied bandwidths of the individual carriers.

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 of 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% of amplitude

K = an overall numerical factor that varies according to the emission and that 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.

N_c = number of baseband channels in radio systems employing multi-channel multiplexing

N_s = frequency separation between two sub-carriers (kHz)

f_P = continuity pilot sub-carrier frequency (Hz) (continuous signal utilized to verify performance of frequency-division multiplex systems).

9. Examples of Designation of Emissions

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 = 2.1 kHz	2K10A2AAN
Selective calling signal, using sequential single frequency code, single-sideband, full carrier	$B_n = M$	Maximum code frequency = 2,110 Hz M = 2,110 Bandwidth = 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 = ½B	B = 50 D = 35 Hz (70 Hz shift) K = 1.2 Bandwidth = 134 Hz	134HJ2BCN

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Telegraphy, multi-channel with voice frequency, error correction, some channels are time-division multiplexed, single-sideband, reduced carrier	**B_n = highest central frequency + M + DK** **M = ½B**	**15 channels; highest central frequency = 2,805 Hz** **B = 100** **D = 42.5 Hz (85 Hz shift)** **K = 0.7** **Bandwidth = 2.885 kHz**	**2K89R7BCW**
2. Telephony (Commercial Quality)			
Telephony, double-sideband (single channel)	**B_n = 2M**	**M = 3,000** **Bandwidth = 6 kHz**	**6K00A3EJN**
Telephony, single-sideband full carrier (single channel)	**B_n = M**	**M = 3,000** **Bandwidth = 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 = 2.7 kHz**	**2K70J3EJN**
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 = 2.99 kHz**	**2K99R3ELN**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
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 = 5.75 kHz**	**5K75J8EKF**
Telephony, independent sideband (two or more channels)	**B_n = sum of M for each sideband**	**2 channels** **M = 3,000** **Bandwidth = 6 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 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 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 = 4.45 kHz**	**4K45J3EGN**

Description of Emission	Necessary Bandwidth		Description of Emission
	Formula	Sample Calculation	
4. Television			
Television, vision and sound	**Refer to relevant ITU-R 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** **Total vision bandwidth = 5.45 MHz** **FM sound bandwidth, including guardbands = 500 kHz** **RF channel bandwidth = 6.0 MHz**	**5M45C3F--** **500KF3EGN**
5. Facsimile			
Analog facsimile by sub-carrier frequency modulation of a single-sideband emission with reduced carrier, monochrome	**$B_n = C + ½ N + DK$** **K = 1.1 (typically)**	**N = 1,100 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 = 1,900 D = 400 Hz** **Bandwidth = 2.89 kHz**	**2K89R3CMN**
Analog facsimile; frequency modulation of an audio frequency sub-carrier which modulates the main carrier, single-sideband suppressed carrier	**$B_n = 2M + 2DK$** **M = ½N** **K = 1.1 (typically)**	**N = 1,100** **D = 400 Hz** **Bandwidth = 1.98 kHz**	**1K98J3C--**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
6. Composite Emissions			
Double-sideband, television relay	**$B_n = 2C + 2M + 2D$**	**Video limited to 5 MHz, audio on 6.5 MHz, frequency modulated with sub-carrier deviation of 50 kHz** **$C = 6.5 \times 10^6$** **$D = 50 \times 10^3$ Hz** **M = 15,000** **Bandwidth = 13.13 MHz**	**13M1A8W--**
Double-sideband radio-relay system, frequency division multiplex	**$B_n = 2M$**	**10 voice channels occupying base band between 1 kHz and 164 kHz** **M = 164,000** **Bandwidth = 328 kHz**	**328KA8E--**
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 9,960 Hz tone** **- a telephone channel** **- a 1,020 Hz keyed tone for continual Morse identification** **C_{max} = 9,960** **M = 30** **D = 480 Hz** **Bandwidth = 20.94 kHz**	**20K9A9WWF**
Independent sidebands; several telegraph channels with error correction together with several telephone channels with privacy; frequency division multiplex	**B_n = sum of M for each sideband**	**Normally composite systems are operated in accordance with standardized channel arrangements (e.g. Rec. ITU-R F.348)** **3 telephone channels and 15 telegraphy channels** **Bandwidth = 12 kHz**	**12K0B9WWF**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
III. FREQUENCY MODULATION			
1. Signal with Quantized or Digital Information			
Telegraphy without error correction (single channel)	**B_n = 2M + 2DK** **M = ½B** **K = 1.2 (typically)**	**B = 100** **D = 85 Hz (170 Hz shift)** **Bandwidth = 304 Hz**	**304HF1BBN**
Telegraphy, narrow-band direct printing with error correction (single channel)	**B_n = 2M + 2DK** **M = ½B** **K = 1.2 (typically)**	**B = 100** **D = 85 Hz (170 Hz shift)** **Bandwidth = 304 Hz**	**304HF1BCN**
Selective calling signal	**B_n = 2M + 2DK** **M = ½B** **K = 1.2 (typically)**	**B = 100** **D = 85 Hz (170 Hz shift)** **Bandwidth = 304 Hz**	**304HF1BCN**
Four-frequency duplex telegraphy	**B_n = 2M + 2DK** **B = Modulation rate (Bd) of the faster channel** **If the channels are synchronized,** **M = ½B** **(Otherwise: M = 2B)** **K = 1.1 (typically)**	**Spacing between adjacent frequencies = 400 Hz** **Synchronized channels:** **B = 100** **M = 50** **D = 600 Hz** **Bandwidth = 1.42 kHz**	**1K42F7BDX**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
2. Telephony (Commercial Quality)			
Commercial telephony	**B_n = 2M + 2DK** **K = 1 (typically, but under certain conditions, a higher value of K may be necessary)**	**For an average case of commercial telephony,** **D = 5,000 Hz** **M = 3,000** **Bandwidth = 16 kHz**	**16K0F3EJN**
3. Sound Broadcasting			
Sound broadcasting	**B_n = 2M + 2DK** **K = 1 (typically)**	**Monaural** **D = 75,000 Hz** **M = 15,000** **Bandwidth = 180 kHz**	**180KF3EGN**
4. Facsimile			
Facsimile by direct frequency modulation of the carrier; black and white	**B_n = 2M + 2DK** **M = ½N** **K = 1.1 (typically)**	**N = 1,100 elements/sec** **D = 400 Hz** **Bandwidth = 1.98 kHz**	**1K98F1C--**
Analog facsimile	**B_n = 2M + 2DK** **M = ½N** **K = 1.1 (typically)**	**N = 1,100 elements/sec** **D = 400 Hz** **Bandwidth = 1.98 kHz**	**1K98F3C--**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
5. Composite Emissions (see Table 1)			
Radio relay system, frequency division multiplex	**$B_n = 2f_P + 2DK$** **K = 1 (typically)**	**60 telephone channels occupying baseband between 60 kHz and 300 kHz; rms per channel deviation: 200 kHz** **Continuity pilot at 331 kHz produces 100 kHz rms deviation of main carrier** **$D = 200 \times 10^3 \times 3.76 \times 2.02 = 1.52 \times 10^6$ Hz** **$f_P = 0.331 \times 10^6$ Hz** **Bandwidth = 3.702 MHz**	**3M70F8EJF**
Radio relay system; frequency division multiplex	**$B_n = 2M + 2DK$** **K = 1 (typically)**	**960 telephone channels occupying baseband between 60 kHz and 4,028 kHz; rms per channel deviation: 200 kHz** **Continuity pilot at 4,715 kHz produces 140 kHz rms deviation of main carrier** **$D = 200 \times 10^3 \times 3.76 \times 5.5 = 4.13 \times 10^6$ Hz** **$M = 4.028 \times 10^6$** **$f_P = 4.715 \times 10^6$** **$(2M + 2DK) > 2 f_P$** **Bandwidth = 16.3 MHz**	**16M3F8EJF**
Radio relay system; frequency division multiplex	**$B_n = 2f_P$**	**600 telephone channels occupying baseband between 60 kHz and 2,540 kHz; rms per channel deviation: 200 kHz; continuity pilot at 8,500 kHz produces 140 kHz rms deviation of main carrier.** **$D = 200 \times 10^3 \times 3.76 \times 4.36 = 3.28 \times 10^6$ Hz;** **$M = 2.54 \times 10^6$** **K = 1** **$f_P = 8.5 \times 10^6$** **$(2M + 2 DK) < 2f_P$** **Bandwidth = 17×10^6 = 17 MHz**	**17M0F8EJF**
	Necessary Bandwidth		

Description of Emission	Formula	Sample Calculation	Designation of Emission
Amplitude modulation is used to modulate a carrier with digital bit stream.	**B_n = 2BK** **K = 1 (typically)**	**Microwave system is digitally modulated at a rate of 5 megabits per second. The carrier is amplitude modulated and 4 signalling states are used.** **B = R/($\log_2$ 4)** **= 5,000,000/($\log_2$ 4)** **= 2,500 kilobaud** **Bandwidth = 5.0 MHz**	**5M00A1WDN**
IV. PULSE MODULATION			
1. Radar			
Unmodulated pulse emission	**B_n = 2K/t** **K depends upon the ratio of pulse duration to 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 ≃ t_r, only components down to 27 dB from the strongest are considered)** **Then:** **t = 2 x (range resolution) / velocity of light** **= 2 x 150/(3 x 10^8)** **= 1 x 10^{-6} seconds** **Bandwidth = 3 MHz**	**3M00P0NAN**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
2. 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 µsec** **Bandwidth = 8 MHz** **(Bandwidth independent of the number of voice channels)**	**8M00M7EJT**
V. MISCELLANEOUS			
Orthogonal frequency division multiplexing (OFDM) or coded OFDM (COFDM)	**$B_n = N_s.K$**	**53 active sub-carriers are used, each spaced 312.5 kHz apart (K=53 and N_s=312.5 kHz). Data sub-carriers can be BPSK, QPSK, QAM modulated.** **B_n = 312.5 kHz x 53 = 16.6 MHz**	**16M6W7D**
Binary Frequency Shift Keying	**If (0.03 < 2D/R < 1.0),** **then:** **B_n = 3.86D + 0.27R** **If (1.0 < 2D/R < 20)** **then:** **B_n =2.4D + 1.0 R**	**Digital modulation used to send 1 megabit per second by frequency shift keying with 2 signalling states and 0.75 MHz peak deviation of the carrier.** **R = 1 x 10^6 bits per second;** **D = 0.75 x 10^6 Hz;** **B_n = 2.8 MHz**	**2M80F1DBC**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Multi-level Frequency Shift Keying	**B_n=R/$\log_2$S + 2DK** **K≤ 0.89** **(99% bandwidth, B_n=R/$\log_2$S + 1.78D**	**Digital modulation to send 10 Mbps by use of frequency shift keying with 4 signalling states and 2 MHz peak deviation of the main carrier.** **R=10^7 bps;** **D=2 MHz;** **K=0.89;** **S=4;** **B_n=8.56 MHz**	**8M56F1DDT**
Gaussian Minimum Shift Keying (GMSK)	**B_n=R/$\log_2$S + 0.5RK** **K≤ 0.28** **(99% bandwidth, B_n=(1/$\log_2$S - 0.14)R)**	**Digital modulation used to send 10 megabits per second by use of GMSK (S=2)** **R=10 x 10^6 bits per second;** **B_n=8.6 MHz**	**8M60G1DDN**
Minimum Shift Keying	**B_n=R/$\log_2$S + 0.5RK** **K≤ 0.36** **(99% bandwidth, B_n=(1/$\log_2$S + 0.18)R)**	**Digital modulation used to send 2 megabits per second using 2-ary minimum shift keying:** **R = 2 Mbps** **S = 2** **B_n=2.36 x 10^6 Hz = 2.36 MHz**	**2M36G1DBN**
Phase Shift Keying	**B_n=2RK/$\log_2$S** **0.5 ≤ K ≤ 1** **K=0.7 to 0.8 (typically)** **K can vary from 0.5 to 1. For fixed microwave systems, use of a value of K larger than 0.7 should be further justified.**	**Digital modulation used to send 10 megabits per second by use of phase shift keying with 4 signalling states** **R=10 x 10^6 bits per second;** **K=1; S=4;** **B_n=10 MHz**	**10M00G1DDT**

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Quadrature Amplitude Modulation (QAM)	**B_n=2RK/$\log_2$S** **K ≤ 0.81** **(99% bandwidth, B_n=(1.62R / $\log_2$S)**	**64 QAM is used to send 135 Mbps;** **R=135 x 10^6 bps;** **S=64;** **Roll-off = 1;** **K= 0.81;** **B_n= 36.45 MHz**	**36M45D1D**

Table 1 – Multiplying Factors for Use in Computing D, Peak Frequency Deviation, in FM Frequency Division Multiplex (FM/FDM) Multi-Channel Emissions

For FM-FDM systems, the necessary bandwidth is:

$$B_n = 2M + 2DK$$

The value of D, or peak frequency deviation, in these formulas for B_n is calculated by multiplying the rms value of per-channel deviation by the appropriate "multiplying factor" shown below.

In the case where a continuity pilot of frequency f_p exists above the maximum modulation frequency M, the general formula becomes:

$$B_n = 2f_p + 2DK$$

In the case where the modulation index of the main carrier produced by the pilot is less than 0.25 and the rms frequency deviation of the main carrier produced is less than or equal to 70% of the rms value of per-channel deviation, the general formula becomes either:

$$B_n = 2\ f_p \quad \text{or } B_n = 2M + 2DK,$$

whichever is greater.

Number of telephone channels, N_c	Multiplying factor[12]
	(Peak factor) x antilog (value in dB above modulation reference level / 20)
$3 < N_c < 12$	4.47 x antilog (a value in dB specified by the equipment manufacturer or station licensee, subject to administration approval / 20)
$12 \leq N_c < 60$	3.76 x antilog $((2.6 + 2 \log N_c) / 20)$
Number of telephone channels, N_c	Multiplying factor[13]
	(Peak factor) x antilog(value in dB above modulation reference level / 20)
$60 \leq N_c < 240$	3.76 x antilog $((-1+4 \log N_c) / 20)$
$N_c \geq 240$	3.76 x antilog $((-15+10\log N_c) / 20)$

[12] In the above chart, the multipliers 3.76 and 4.47 correspond to peak factors of 11.5 dB and 13.0 dB respectively. It is recognized that some systems that carry appreciable quantities of data or information other than voice may have different loading factors than the preferred ones shown above.

[13] In the above chart, the multipliers 3.76 correspond to peak factors of 11.5 dB.