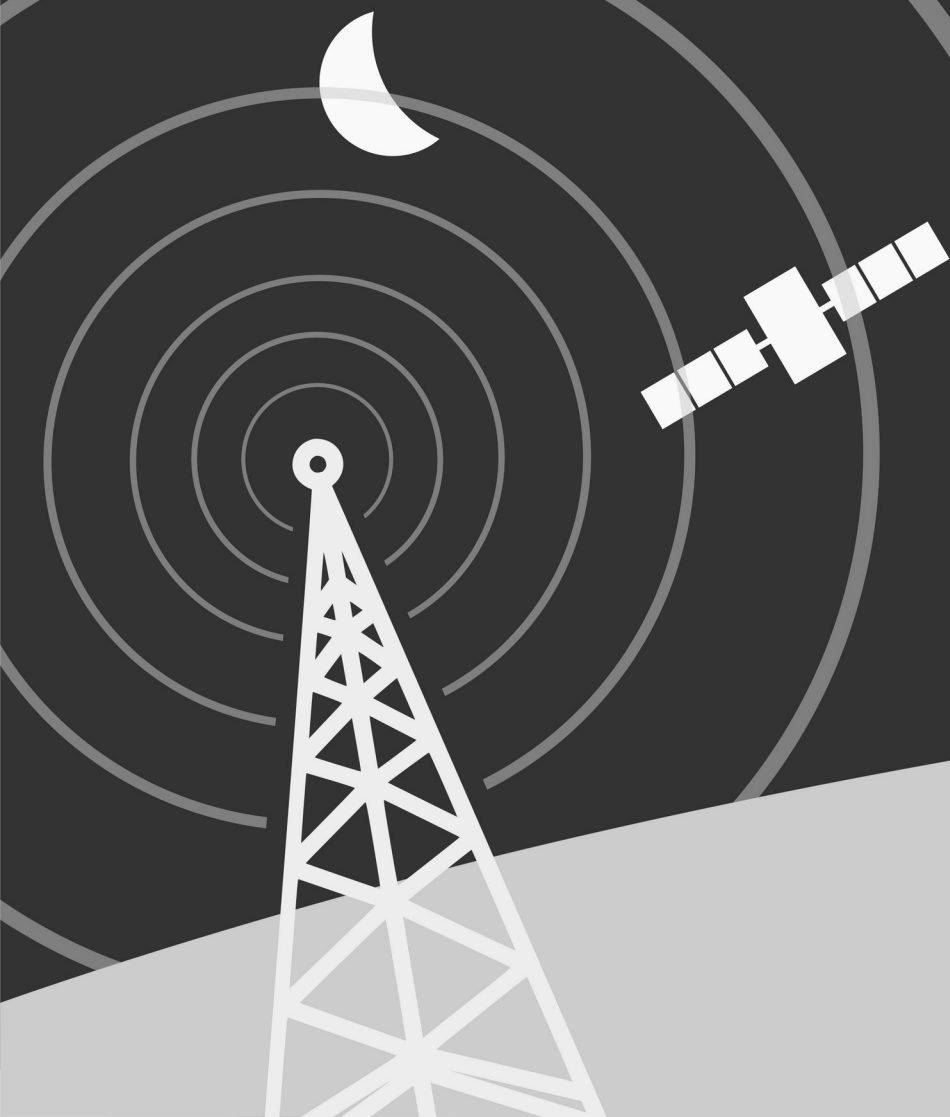


Noël Martin F4JJD



# AMATEUR RADIO *BOOKLET* 2024



# The Amateur Radio Booklet

Edition 2024.1

# License

## Amateur Radio Booklet ©

2024 by **Noël Martin F4JJD** is licensed under **CC BY-SA 4.0**. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/4.0/>



*This license requires that reusers give credit to the creator. It allows reusers to distribute, remix, adapt, and build upon the material in any medium or format, even for commercial purposes. If others remix, adapt, or build upon the material, they must license the modified material under identical terms.*

## Contributors

Noël Martin – F4JJD – [mail@noelmrtn.fr](mailto:mail@noelmrtn.fr)



# Table of Contents

1	– Band Plans.....	7
	Summary.....	7
	2200 Meters.....	9
	630 Meters.....	9
	160 Meters.....	10
	80 Meters.....	11
	60 Meters.....	12
	40 Meters.....	13
	30 Meters.....	14
	20 Meters.....	15
	17 Meters.....	16
	15 Meters.....	17
	12 Meters.....	18
	10 Meters.....	19
	6 Meters.....	21
	2 Meters.....	23
	1.25 Meters.....	25
	70 Centimeters.....	26
2	– Classification of Emissions.....	29
	Modulation of the main Carrier.....	29
	Nature of signals.....	30
	Type of Information.....	30
3	– Q Codes.....	33
4	– Morse Code.....	37
	Timings.....	38
5	– Radio Abbreviations.....	39
6	– Digital Modes.....	41
7	– Amateur Satellite.....	45
	Opened bands.....	45
	Internation Space Station.....	46
	QO-100.....	46
8	– International Beacon Project.....	47
	Beacons List.....	47
	Frequencies.....	48
9	– Radio Waves.....	49
	Band Definitions.....	49
	Propagation.....	50
	Ionosphere Regions.....	50
	Bands.....	51
	Solar and Earth Activity.....	51

	Solar and Geomagnetic Storms.....	52
10	- Antennas.....	53
	Summary.....	53
	Arrays.....	53
	Standing Wave Ratio.....	53
11	- Electricity.....	55
	Kirchhoff's Law.....	56
	Currents.....	56
	Voltage.....	56
	Operational Amplifiers.....	56
	Non-inverting.....	56
	Inverting.....	56
	Filters & RLC.....	57
	Resistor Colors.....	58
12	- ITU Prefixes Allocation.....	59
13	- ITU Regions.....	71
14	- ITU Alphabet.....	73
15	- QTH Locator.....	75
16	- Units.....	77
	International System.....	77
	Base Units.....	77
	Derived Units.....	77
	Prefixes.....	78
	Conversions.....	79
	Physics Constants.....	80
	Decibels.....	81
17	- Mathematics.....	83
	Algebra.....	83
	Logarithms.....	83
	Trigonometry.....	84
	Complex Numbers.....	84
18	- Document Abbreviations.....	85
19	- References.....	87

# 1 Band Plans

## Summary

**Primary** allocations are written in bold, e.g. **14000 — 14350**. If the band is **exclusive** to the amateur service the frequencies are followed by the **E** symbol, e.g. **1800 — 1850 E**.

*Secondary* allocations are written in italic, e.g. *135.7 — 137.8*.

If the band allows **amateur satellite (AMSAT)**, the frequencies are followed by the **S** symbol, e.g. **7000 — 7200 S**.

	Band	Region 1	Region 2	Region 3
LF (kHz)	2200m	135.7 — 137.8		
MF (kHz)	630m	472 — 479		
	160m	1810 — 1850 E	1800 — 1850 E 1850 — 2000	1800 — 2000
HF (kHz)	80m	3500 — 3800	3500 — 3750 E	3500 — 3900
	60m	5351.5 — 5366.5		
	40m	7000 — 7100 S		
		7100 — 7200 E		
		Forbidden	7200 — 7300 E	Forbidden
	30m	10100 — 10150		
	20m	14000 — 14250 S		
		14250 — 14350 E		
	17m	18068 — 18168 S		
	15m	21000 — 21450 S		
	12m	24890 — 24990 S		
	10m	28000 — 29700 S		
	6m	50 — 52	50 — 54	

	Band	Region 1	Region 2	Region 3
VHF (MHz)	2m	<b>144 — 146</b> <span>S</span>		
		<i>Forbidden</i>	<b>146 — 148</b> <span>E</span>	<b>146 — 148</b>
	1.35m	<i>Forbidden</i>	<b>220 — 225</b>	<i>Forbidden</i>
UHF (MHz)	70cm	<b>430 — 440</b> <span>S</span>	430 — 440 <span>S</span>	
	33cm	<i>Forbidden</i>	902 — 928	<i>Forbidden</i>
	23cm	1240 — 1300		
	13cm	2300 — 2450		
SHF (GHz)	9cm	<i>Forbidden</i>	3.3 — 3.5	
	5cm	5.65 — 5.83		
		5.83 — 5.85 <span>S</span>		
		<i>Forbidden</i>	5.85 — 5.925	<i>Forbidden</i>
	3cm	10 — 10.45		
		10.45 — 10.5 <span>S</span>		
	1.2cm	<b>24 — 24.05</b> <span>S</span>		
		24.05 — 24.25		
	6mm	<b>47 — 47.2</b> <span>S</span>		
	4mm	76 — 77.5 <span>S</span>		
		<b>77.5 — 78</b> <span>S</span>		
		78 — 81 <span>S</span>		
	2.4mm	122.25 — 123		
	2.2mm	<b>134 — 136</b> <span>S</span>		
		136 — 141 <span>S</span>		
	1.2mm	241 — 248 <span>S</span>		
		<b>248 — 250</b> <span>S</span>		



## 2200 Meters

Region 1	Region 2	Region 3
<b>135.7 — 137.8 kHz</b> <i>BW 200Hz</i>	<b>135.7 — 137.8 kHz</b> <i>BW 200 Hz</i>	<b>135.7 — 137.8 kHz</b> <i>BW 500 Hz</i>
CW, QRSS, DM	All Modes	CW, QRSS, DM

Max Power: 1W EIRP — Status: Secondary R1, R2, R3 (primary Fixed, Maritime Mobile, R3 Radio-navigation)

## 630 Meters

Region 1	Region 2	Region 3
<b>472 — 475 kHz</b> <i>BW 200 Hz</i>	<b>472 — 479 kHz</b> <i>BW 500 Hz</i>	<b>472 — 479 kHz</b> <i>BW 500 Hz</i>
CW		
<b>475 — 479 kHz</b> <i>BW 500 Hz</i>		
NBM		

Max Power: 1W EIRP — Status: Secondary R1, R2, R3 (primary Maritime Mobile)

160 Meters

Region 1	Region 2	Region 3
<b>1810 — 1838 kHz</b> <i>BW 200 Hz</i>  CW 1836 – CW QRP	<b>1800 — 1810 kHz</b> <i>BW 500 Hz</i>  DM	<b>1800 — 1830 kHz</b> <i>BW 200 Hz</i>  CW
<b>1838 — 1840 kHz</b> <i>BW 500 Hz</i>  NBM	<b>1810 — 1840 kHz</b> <i>BW 200 Hz</i>  CW, DM 1812 – CW QRP CoA	<b>1830 — 1840 kHz</b> <i>BW 500Hz</i>  CW (DX), NBM 1836 – CW QRP CoA
<b>1840 — 1850 kHz</b> <i>BW 2700 Hz</i>  All Modes	<b>1840 — 1850 kHz</b> <i>BW 2700 Hz</i>  CW, DM, SSB (DX)	<b>1840 — 2000 kHz</b> <i>BW 2700 Hz</i>  All Modes
	<b>1850 — 2000 kHz</b> <i>BW 2700 Hz</i>  All Modes 1910 – SSB QRP CoA	

Status: Primary R1, R2, R3

## 80 Meters

Region 1	Region 2	Region 3
<b>3500 — 3580 kHz</b> <i>BW 200 Hz</i>  CW (3505 – DX CoA) 3555 – CW QRS CoA 3560 – CW QRP CoA > 3570 – NBM	<b>3500 — 3580 kHz</b> <i>BW 200 Hz</i>  CW (3505 – DX CoA) 3555 – CW QRS CoA 3560 – CW QRP CoA > 3570 – NBM	<b>3500 — 3535 kHz</b> <i>BW 200 Hz</i>  CW (3505 – DX CoA)
<b>3580 — 3600 kHz</b> <i>BW 500 Hz</i>  NBM, DM	<b>3580 — 3600 kHz</b> <i>BW 500 Hz</i>  CW, DM	<b>3535 — 3900 kHz</b> <i>BW 2700 Hz</i>  CW, SSB, DM 3560 – QRP CoA 3600 – EMCOM CoA 3690 – DV CoA 3690 – SSB QRP CoA 3735 – Image CoA 3795 – DX SSB CoA 3845 – Image CoA
<b>3600 — 3800 kHz</b> <i>BW 2700 Hz</i>  All Modes 3690 – SSB QRP CoA 3735 – Image CoA 3760 – EMCOM CoA 3775 – DX CoA	<b>3600 — 4000 kHz</b> <i>BW 2700 Hz</i>  All Modes 3690 – SSB QRP CoA 3735 – Image CoA 3750 – EMCOM CoA 3775 – DX CoA 3845 – Image CoA 3885 – AM CoA 3985 – EMCOM CoA	

Status: Primary R1, R2, R3

60 Meters

Region 1	Region 2	Region 3
<b>5351.5 — 5354 kHz</b> <i>BW 200 Hz</i>  CW, NBM	<b>5351.5 — 5354 kHz</b> <i>BW 500 Hz</i>  CW, DM	<b>5351.5 — 5354 kHz</b> <i>BW 500 Hz</i>  CW, NBM, DM
<b>5354 — 5366 kHz</b> <i>BW 2700 Hz</i>  All Modes, Pref. USB	<b>5354 — 5366 kHz</b> <i>BW 2700 Hz</i>  All Modes	<b>5354 — 5366 kHz</b> <i>BW 2700 Hz</i>  All Modes, Pref. USB
<b>5366 — 5366.5 kHz</b> ▲ BW 20 Hz  Weak Signal	<b>5366 — 5366.5 kHz</b> ▲ BW 20 Hz  CW, DM	<b>5366 — 5366.5 kHz</b> ▲ BW 20 Hz  Weak Signal

Max Power: 15W EIRP — Status: Secondary R1, R2, R3 (primary Fixed, Mobile)

▲ Very small bandwidth between 5366-5366.5 kHz

## 40 Meters

Region 1	Region 2	Region 3
<b>7000 — 7040 kHz</b> <i>BW 200 Hz</i>  CW 7030 – CW QRP CoA	<b>7000 — 7040 kHz</b> <i>BW 200 Hz</i>  CW < 7025 – DX 7030 – CW QRP CoA	<b>7000 — 7030 kHz</b> <i>BW 200 Hz</i>  CW
<b>7040 — 7050 kHz</b> <i>BW 500 Hz</i>  NBM, DM	<b>7040 — 7050 kHz</b> <i>BW 500 Hz</i>  CW, DM	<b>7030 — 7200 kHz</b> <i>BW 2700 Hz</i>  CW, SSB, DM 7030 – QRP CoA 7070 – DV CoA 7090 – SSB QRP CoA 7095 – DX Phone CoA 7110 – EMCOM CoA 7165 – Image CoA
<b>7050 — 7200 kHz</b> <i>BW 2700 Hz</i>  All Modes < 7060 – DM 7070 – DV CoA 7090 – SSB QRP CoA 7110 – EMCOM CoA 7165 – Image CoA > 7175 – DX	<b>7050 — 7300 kHz</b> <i>BW 2700 Hz</i>  All Modes 7060 – EMCOM CoA 7070 – DV CoA 7090 – SSB QRP CoA 7165 – Image CoA 7240 – EMCOM CoA 7275 – EMCOM CoA 7285 – SSB QRP CoA 7290 – AM CoA	

Status: Primary R1, R2, R3; and 7000-7100 kHz AMSAT R1, R2, R3

30 Meters

Region 1	Region 2	Region 3
<b>10100 — 10130 kHz</b> <i>BW 200 Hz</i>  CW 10116 – CW QRP CoA		
<b>10130 — 10150 kHz</b> <i>BW 500 Hz</i>  NBM, DM	<b>10130 — 10140 kHz</b> <i>BW 500 Hz</i>  CW, DM	<b>10130 — 10150 kHz</b> <i>BW 500 Hz</i>  NBM, DM
	<b>10140 — 10150 kHz</b> <i>BW 2700 Hz</i>  CW, DM	

Status: Secondary R1, R2, R3 (primary Fixed)

## 20 Meters

Region 1	Region 2	Region 3
<b>14000 — 14070 kHz</b> <i>BW 200 Hz</i>  CW 14055 – CW QRS CoA 14060 – CW QRP CoA		
<b>14070 — 14099 kHz</b> <i>BW 500 Hz</i>  NBM, DM		
<b>14099 — 14101 kHz</b>  International Beacon Project		
<b>14101 — 14350 kHz</b> <i>BW 2700 Hz</i>  All Modes 14130 – DV CoA 14195 – DX 14230 – Image CoA 14285 – SSB QRP 14300 – Glob EMCOM	<b>14101 — 14350 kHz</b> <i>BW 2700 Hz</i>  All Modes 14195 – DX 14230 – Image CoA 14285 – SSB QRP 14285 – AM QRG 14300 – Glob EMCOM	<b>14101 — 14350 kHz</b> <i>BW 2700 Hz</i>  All Modes 14130 – DV CoA 14195 – DX 14230 – Image CoA 14285 – SSB QRP 14300 – Glob EMCOM

Status: Primary R1, R2, R3; and 14000-14250 kHz AMSAT R1, R2, R3

17 Meters

Region 1	Region 2	Region 3
<b>18068 — 18095 kHz</b> <i>BW 200 Hz</i>  CW 18086 – CW QRP CoA		
<b>18095 — 18109 kHz</b> <i>BW 500 Hz</i>  NBM, DM		<b>18095 — 18109 kHz</b> <i>BW 2700 Hz</i>  NBM, DM
<b>18109 — 18111 kHz</b>  International Beacon Project		
<b>18111 — 18168 kHz</b> <i>BW 2700 Hz</i>  All Modes 18130 – SSB QRP 18150 – DV CoA 18160 – EMCOM	<b>18111 — 18168 kHz</b> <i>BW 2700 Hz</i>  All Modes 18130 – SSB QRP 18160 – EMCOM	<b>18111 — 18168 kHz</b> <i>BW 2700 Hz</i>  All Modes 18130 – SSB QRP 18150 – DV CoA 18160 – EMCOM

Status: Primary and AMSAT R1, R2, R3.



## 15 Meters

Region 1	Region 2	Region 3
<b>21000 — 21070 kHz</b> <i>BW 200 Hz</i>  CW 21055 – CW QRS CoA 21060 – CW QRP CoA		
<b>21070 — 21110 kHz</b> <i>BW 500 Hz</i>  NBM, DM		
<b>21110 — 21120 kHz</b> <i>BW 2700 Hz</i>  All Modes, except SSB		<b>21110 — 21125 kHz</b> <i>BW 2700 Hz</i>  CW, NBM, DM
<b>21120 — 21149 kHz</b> <i>BW 500 Hz</i>  NBM	<b>21120 — 21149 kHz</b> <i>BW 500 Hz</i>  All Modes	<b>21125 — 21149 kHz</b> <i>BW 2700 Hz</i>  CW, NBM, DM Satellite Uplink
<b>21149 — 21151 kHz</b>  International Beacon Project		
<b>21151 — 21450 kHz</b> <i>BW 2700 Hz</i>  All Modes 21180 – DV CoA 21285 – SSB QRP 21340 – Image CoA <u>21360 – Glob. EMCOM</u>	<b>21151 — 21450 kHz</b> <i>BW 2700 Hz</i>  All Modes 21285 – SSB QRP 21340 – Image CoA <u>21360 – Glob. EMCOM</u>	<b>21151 — 21450 kHz</b> <i>BW 2700 Hz</i>  All Modes 21180 – DV CoA 21295 – DX CoA 21340 – Image CoA <u>21360 – Glob. EMCOM</u>

Status: Primary and AMSAT R1, R2, R3.

12 Meters

Region 1	Region 2	Region 3
<b>24890 — 24915 kHz</b> <i>BW 200 Hz</i>  CW 24906 – CW QRP CoA		
<b>24915 — 24929 kHz</b> <i>BW 500 Hz</i>  CW, NBM, DM		
<b>24929 — 24931 kHz</b>  International Beacon Project		
<b>24931 — 24990 kHz</b> <i>BW 2700 Hz</i>  All Modes 24950 – SSB QRP 24960 – DV CoA	<b>24931 — 24990 kHz</b> <i>BW 2700 Hz</i>  All Modes 24950 – SSB QRP	<b>24931 — 24990 kHz</b> <i>BW 2700 Hz</i>  All Modes 24950 – SSB QRP 24960 – DV CoA

Status: Primary and AMSAT R1, R2, R3.

## 10 Meters

Region 1	Region 2	Region 3
<b>28000 — 28070 kHz</b> <i>BW 200 Hz</i>  CW 28055 – CW QRS CoA 28060 – CW QRP CoA		<b>28000 — 28070 kHz</b> <i>BW 200 Hz</i>  CW 28055 – CW QRS
<b>28070 — 28190 kHz</b> <i>BW 500 Hz</i>  NBM, DM	<b>28070 — 28190 kHz</b> <i>BW 500 Hz</i>  CW, DM	<b>28070 — 28190 kHz</b> <i>BW 500 Hz</i>  CW, NBM > 28050 – DX
<b>28190 — 28225 kHz</b> <i>BW 200 Hz</i>  Beacons <u>28200 – International Beacon Project</u>		
<b>28225 — 28300 kHz</b> <i>BW 2700 Hz</i>  Beacons		<b>28225 — 28300 kHz</b> <i>BW 6000 Hz</i>  All Modes
<b>28300 — 29000 kHz</b> <i>BW 2700 Hz</i>  All Modes 28330 – DV CoA 28360 – SSB QRP CoA 28680 – Image CoA		<b>28300 — 29510 kHz</b> <i>BW 6000 Hz</i>  Satellite Up & Down-Links
<b>29000 — 29510 kHz</b> <i>BW Unrestricted</i>  All Modes > 29300 – Satellite		
<b>29510 — 29520 kHz</b>  <b>Guard Band</b> <b>▲ NO TRANSMISSION ALLOWED</b>		

<b>29520 — 29590 kHz</b> <i>BW 6000 Hz</i>  All Modes Repeater Input (RH1 – RH8)
<b>29590 — 29620 kHz</b> <i>BW 6000 Hz</i>  All Modes Repeaters Simplex 29600 – FM QRG
<b>29620 — 29700 kHz</b> <i>BW 6000 Hz</i>  All Modes Repeater Output (RH1 – RH8)

Status: Primary and AMSAT R1, R2, R3.

## 6 Meters

Region 1	Region 2	Region 3
<b>50 — 50.1 MHz</b> <i>BW 500 Hz</i>  CW < 50.010 Beacons  50.050 – CoA 50.090 – DX CoA	<b>50 — 50.1 MHz</b> <i>BW 500 Hz</i>  CW 50.010 – 50.020 Beacons	<b>50 — 50.1 MHz</b> <i>BW 200 Hz</i>  CW 50.020 – 50.030 Beacons
<b>50.1 — 50.4 MHz</b> <i>BW 2700 Hz</i>  CW, SSB, NBM 50.110 – DX CoA 50.305 – PSK CoA 50.315 – EME CoA		<b>50.1 — 50.5 MHz</b> <i>BW 2700 Hz</i>  CW, SSB, NBM .110 – DX CoA
<b>50.4 — 50.5 MHz</b> <i>BW 1000 Hz</i>  Beacons <u>50.401 – WSPR</u>	<b>50.4 — 50.5 MHz</b> <i>BW 2700 Hz</i>  Beacons	
<b>50.5 — 52 MHz</b> <i>BW 12 kHz</i>  <u>Unlimited BW</u> 50.5 – 50.7 50.9 – 51.2 51.4 – 52  All Modes 50.510 – SSTV 50.530 – FM Internet 50.600 – RTTY 50.630 – DV Calling  <u>Repeaters</u> 50.700 – 50.900 Output 51.200 – 51.400 Input	<b>50.5 — 50.6 MHz</b> <i>BW 2700 Hz</i>  All Modes	<b>50.5 — 54 MHz</b> <i>BW 25 kHz</i>  All Modes
	<b>50.6 — 51 MHz</b> <i>BW 12 kHz</i>  All Modes	
	<b>51 — 51.1 MHz</b> <i>BW 2700</i>  CW, SSB DX Window	

Region 1	Region 2	Region 3
<b>52 — 54 MHz</b> <i>BW 500 kHz</i>  All Modes	<b>51.11 — 54 MHz</b> <i>BW 12 kHz</i>  FM, DV  <u>Repeaters</u> 51.110 – 51.480 Input 51.620 – 51.980 Output	

Status: Primary R1, R2, R3.

## 2 Meters

Region 1	Region 2	Region 3
<b>144 — 144.025 MHz</b> <i>BW 2700 Hz</i>  All Modes <b>▲ Satellite Down-Links Only</b>		
<b>144.025 — 144.150 MHz</b> <i>BW 500 Hz</i>  CW 144.050 – Telegraphy Calling Freq  144.110 – 114.160 CW & EME	<b>144.025 — 144.110 MHz</b> <i>BW 500 Hz</i>  CW, DM EME, Weak Signals	<b>144.025 — 144.035 MHz</b> <i>BW N/A</i>  CW, EME, Weak Signals
<b>144.150 — 144.400 MHz</b> <i>BW 2700 Hz</i>  SSB, CW 144.300 – SSB CoA	<b>144.110 — 144.275 MHz</b> <i>BW 2700 Hz</i>  CW, DM, SSB Weak Signals 144.200 – QRG Calling	<b>144.035 — 145.800 MHz</b> <i>BW 25 kHz</i>  All Modes 144.1 – DX CoA
	<b>144.275 — 144.300 MHz</b> <i>BW 500 Hz</i>  Beacons	
	<b>144.300 — 144.360 MHz</b> <i>BW 2700 Hz</i>  CW, SSB 144.300 – QRG Calling	
	<b>144.360 — 144.400 MHz</b> <i>BW 12 kHz</i>  DM 144.390 – APRS CoA	

Region 1	Region 2	Region 3
<b>144.400 — 144.500 MHz</b> <i>BW 500 Hz</i>  Beacons  144.491 – 144.493 Experimental MGM	<b>144.400 — 144.500 MHz</b> <i>BW 500 Hz</i>  CW, DM Beacons	
<b>144.500 — 144.794 MHz</b> <i>BW 20 kHz</i>  All Modes 144.5 – SSTV CoA 144.6 – Data CoA 144.75 – ATV	<b>144.500 — 145.790 MHz</b> <i>BW 12 kHz</i>  FM, DV  <u>Repeaters Exclusive</u> 144.600 – 144.900 145.200 – 145.500  <u>Local Options</u> 144.500 – 144.600 145.100 – 145.200	
<b>144.794 — 145.800 MHz</b> <i>BW 12 kHz</i>  144.800 – APRS 145.375 – DV Calling 145.500 – FM Calling  <u>Repeaters Exclusive</u> 144.975 – 145.194 145.575 – 145.7935  <u>Space Communications</u> 144.975 – 145.194 145.794 – 145.800	<b>145.790 — 145.800 MHz</b>  <b>▲ Guard Band</b>	
<b>145.800 — 146.000 MHz</b> <i>BW 12 kHz</i>  FM, DV <b>Satellite Exclusive</b>		
<i>Forbidden</i>	<b>146.000 — 148.000 MHz</b> <i>BW 12 kHz</i>  FM, DV 146.520 – FM Call Freq	<b>146.000 — 148.000 MHz</b> <i>BW 25 kHz</i>  All Modes



## 1.25 Meters

Region 1	Region 2	Region 3
Forbidden	<b>220 — 222 MHz</b> BW 12 kHz  ACDS	Forbidden
	<b>222 — 222.05 MHz</b> BW 500 Hz  CW, DM EME, Weak Signals	
	<b>222.05 — 222.07 MHz</b> BW 500 Hz  CW, DM Beacons	
	<b>222.07 — 222.1 MHz</b> BW 500 Hz  CW, DM, SSB Weak Signal 222.1 – SSB/CW QRG	
	<b>222.1 — 222.15 MHz</b> BW 2700 Hz  CW, SSB Weak Signals	
	<b>222.15 — 223.85 MHz</b> BW 12 kHz  FM, DV All Modes  <u>Repeaters Exclusive</u> 222.225 – 223.380  <u>Local Options</u> 222.150 – 222.250 223.750 – 223.850	

## 70 Centimeters

Region 1	Region 2	Region 3
<i>Forbidden</i>	<b>420 — 432 MHz</b> <i>BW N/A</i>	<i>Forbidden</i>
<b>430 — 431.975 MHz</b> <i>BW 20 kHz</i>  All Modes	ATV	<b>430 — 431.9 MHz</b> <i>BW 25 kHz</i>  All Modes
<b>432 — 432.1 MHz</b> <i>BW 500 Hz</i>  Telegraphy	<b>432 — 432.1 MHz</b> <i>BW 500 Hz</i>  CW, DM EME, Weak Signals	<b>431.9 — 432.24 MHz</b> <i>BW 2700 Hz</i>  EME, Weak Signals
<b>432.1 — 432.4 MHz</b> <i>BW 2700 Hz</i>  Telegraphy, SSB 432.200 – SSB CoA 432.370 – Meteo Scatter	<b>432.1 — 432.3 MHz</b> <i>BW 2700 Hz</i>  CW, SSB 432.1 – SSB/CW Call Freq	<b>432.24 — 435 MHz</b> <i>BW 25 kHz</i>  All Modes
<b>432.4 — 432.5 MHz</b> <i>BW 500 Hz</i>  Beacons Exclusive	<b>432.3 — 432.4 MHz</b> <i>BW 500 Hz</i>  CW, Beacons	
<b>432.5 — 433.575 MHz</b> <i>BW 12 kHz</i>  All Modes 432.5 – APRS 433.4 – SSTV (FM/AFSK) 433.45 – DV Calling 433.5 – FM Calling	<b>432.4 — 433 MHz</b> <i>BW 2700 Hz</i>  CW, DM, SSB	
	<b>433 — 433.1 MHz</b> <i>BW 12 kHz</i>  All Modes ACDS, IVG	
<b>433.6 — 434 MHz</b> <i>BW N/A</i>  All Modes	<b>433.1 — 435 MHz</b>  Local Option	

Region 1	Region 2	Region 3
<b>434 — 435 MHz</b> <i>BW 12 kHz</i>  All Modes, ATV		
<b>435 — 438 MHz</b> <i>BW N/A</i>  Satellite		
<b>438 — 440 MHz</b> <i>BW 25 kHz</i>  All Modes	<b>438 — 450 MHz</b> <i>BW N/A</i>  All Modes	<b>438 — 440 MHz</b> <i>BW 25 kHz</i>  All Modes
<i>Forbidden</i>		<i>Forbidden</i>



## 2 Classification of Emissions

The classification of emissions is made of 3 symbols:

1. type of modulation of the main carrier;
2. nature of signal(s) modulating the main carrier;
3. type of information to be transmitted.

For instance, the Morse code is classified as **A1A**, the audio single-side band **J3E**, and radio teletype (RTTY) **F1B**.

### Modulation of the main Carrier

Symbol	Definition
<b>N</b>	Emission of an unmodulated carrier
<i>Amplitude Modulation</i>	
<b>A</b>	Double-sideband
<b>H</b>	Single-sideband, full carrier
<b>R</b>	Single-sideband, reduced or variable level carrier
<b>J</b>	Single-sideband, suppressed carrier
<b>B</b>	Independent sidebands
<b>C</b>	Vestigial sideband
<i>Angle Modulation</i>	
<b>F</b>	Frequency modulation
<b>G</b>	Phase modulation
<i>Amplitude and Angle Modulation</i>	
<b>D</b>	Amplitude and Angle Modulation, simultaneously or in a pre-established sequence
<i>Emission of Pulses</i>	
<b>P</b>	Unmodulated pulses
<b>K</b>	Modulated in amplitude
<b>L</b>	Modulated in width/duration

Symbol	Definition
M	Modulated in position/phase
Q	Carrier modulated during the angle-period of the pulse
V	Combination of the foregoing or is produced by other means
Other	
W	Combination of 2 or more of the previous modes
X	Not covered

Nature of signals

Symbol	Definition
0	No modulating channel
1	Single channel with <b>quantized or digital</b> information <b>without</b> a sub-carrier modulation
2	Single channel with <b>quantized or digital</b> information <b>with</b> a sub-carrier modulation
3	Single channel with <b>analogue</b> information
7	Two or more channel with <b>quantized or digital</b> information
8	Two or more channel with <b>analogue</b> information
9	Composite (analogue and digital)
X	Not covered

Type of Information

Symbol	Definition
N	No information transmitted
A	Telegraphy, aural reception
B	Telegraphy, automatic reception
C	Facsimile
D	Data transmission, telemetry, telecommand
E	Telephony (includes sound broadcasting)
F	Television (video)
W	Combination of the above

Symbol	Definition
X	Not covered





### 3 Q Codes

A sample of the most used Q Codes from the ITU Rec. M.1172-0.

Every word between [brackets] should be replaced with the intention of your message.

For instance, if your callsign is **4U1UN** and another operator is asking you **QRZ**. Your reply will be:

| *You are being called by 4U1UN.*

Code	Question	Answer or Advice
<b>QRA</b>	What is the name of your station?	The name of my station is [callsign]
<b>QRB</b>	How far approximately are you from my station?	The approximate distance between our stations is [distance] kilometers.
<b>QRE</b>	What is your estimated time of arrival at [place]?	My estimated time of arrival at [place] is [time].
<b>QRG</b>	Will you tell me my exact frequency (or that of [callsign])	Your exact frequency (or that of [callsign]) is [frequency].
<b>QRH</b>	Does my frequency vary?	Your frequency varies.
<b>QRI</b>	How is the tone of my transmission?	The tone of your transmission is: 1. good 2. variable 3. bad.
<b>QRK</b>	What is the intelligibility of my signals (or those of [callsign])?	The intelligibility of your signals (or those of [callsign]) is: 1. bad 2. poor 3. fair 4. good 5. excellent.
<b>QRL</b>	Are you busy?	I am busy (or I am busy with [callsign]). Please do not interfere.

Code	Question	Answer or Advice
<b>QRM</b>	Is my transmission being interfered with?	Your transmission is being interfered with: 1. not interfered 2. slightly 3. moderately 4. severely 5. extremely.
<b>QRN</b>	Are you troubled by static?	I am troubled by static: 1. not troubled 2. slightly 3. moderately 4. severely 5. extremely.
<b>QRO</b>	Shall I increase transmitter power?	Increase transmitter power.
<b>QRP</b>	Shall I decrease transmitter power?	Decrease transmitter power.
<b>QRQ</b>	Shall I send faster?	Send faster ([ <i>speed</i> ] words per minute).
<b>QRS</b>	Shall I send more slowly?	Send more slowly ([ <i>speed</i> ] words per minute).
<b>QRT</b>	Shall I stop sending?	Stop sending.
<b>QRU</b>	Have you anything for me?	I have nothing for you.
<b>QRV</b>	Are you ready?	I am ready.
<b>QRW</b>	Shall I inform [ <i>callsign</i> ] that you are calling him on [ <i>frequency</i> ]?	Please inform [ <i>callsign</i> ] that I am calling him on [ <i>frequency</i> ].
<b>QRX</b>	When will you call me again?	I will call you again at [ <i>time</i> ] on [ <i>frequency</i> ].
<b>QRZ</b>	Who is calling me?	You are being called by [ <i>callsign</i> ] (on [ <i>frequency</i> ]).
<b>QSA</b>	What is the strength of my signals (or those of [ <i>callsign</i> ])?	The strength of your signals (or those of [ <i>callsign</i> ]) is: 1. scarcely perceptible 2. weak 3. fairly good 4. good 5. very good.
<b>QSB</b>	Are my signals fading?	Your signals are fading.

Code	Question	Answer or Advice
<b>QSG</b>	Shall I send [ <i>number</i> ] telegrams at a time?	Send [ <i>number</i> ] telegrams at a time.
<b>QSL</b>	Can you acknowledge receipt?	I am acknowledging receipt.
<b>QSM</b>	Shall I repeat the last telegram which I sent you (or some previous telegram)?	Repeat the last telegram which you sent me (or telegram(s) [ <i>numbers</i> ]).
<b>QSN</b>	Did you hear me (or [ <i>callsign</i> ]) on [ <i>frequency</i> ]?	I did hear you (or [ <i>callsign</i> ]) on [ <i>frequency</i> ].
<b>QSO</b>	Can you communicate with [ <i>callsign</i> ] direct (or by relay)?	I can communicate with [ <i>callsign</i> ] direct (or by relay through [ <i>callsign</i> ]).
<b>QSP</b>	Will you relay to [ <i>callsign</i> ] free of charge?	I will relay to [ <i>callsign</i> ] free of charge.
<b>QSR</b>	Shall I repeat the call on the calling frequency?	Repeat your call on the calling frequency; did not hear you (or have interference).
<b>QSS</b>	What working frequency will you use?	I will use the working frequency [ <i>frequency</i> ] ( <i>in the high frequency bands normally only the last three figures of the frequency need be given</i> ).
<b>QSX</b>	Will you listen to [ <i>callsign</i> ] on [ <i>frequency</i> ], or in the [ <i>bands</i> ] / [ <i>channels</i> ]?	I am listening to [ <i>callsign</i> ] on [ <i>frequency</i> ], or in the [ <i>bands</i> ] / [ <i>channels</i> ].
<b>QSY</b>	Shall I change to transmission on another frequency?	Change to transmission on another [ <i>frequency</i> ].
<b>QTH</b>	What is your position in latitude and longitude (or according to any other indication)?	My position is [ <i>latitude</i> ], [ <i>longitude</i> ] (or [ <i>position indication</i> ]).
<b>QTJ</b>	What is your speed?	My speed is [ <i>speed</i> ] kilometers per hour.
<b>QTR</b>	What is the correct time?	The correct time is [ <i>time</i> ].
<b>QTS</b>	Will you send your call sign for [ <i>seconds</i> ]?	I will send my call sign for [ <i>seconds</i> ].
<b>QUA</b>	Have you news of [ <i>callsign</i> ]?	Here is news of [ <i>callsign</i> ].
<b>QUD</b>	Have you received the urgency signal sent by [ <i>callsign</i> ]?	I have received the urgency signal sent by [ <i>callsign</i> ] at [ <i>time</i> ].

Code	Question	Answer or Advice
QUE	Can you speak in [ <i>language</i> ], with interpreter if necessary; if so, on what frequencies?	I can speak in [ <i>language</i> ] on [ <i>frequency</i> ].

## 4 Morse Code

A    · —

B    — · · ·

C    — · — ·

D    — · ·

E    ·

F    · · — ·

G    — — ·

H    · · · ·

I    · ·

J    · — — —

K    — · —

L    · — · ·

M    — —

N    — ·

O    — — —

P    · — — ·

Q    — — · —

R    · — ·

S    · · ·

T    —

U    · · —

V    · · · —

W    · — —

X    — · · —

Y    — · — —

Z    — — · ·

1    · — — — —

2    · · — — —

3    · · · — —

4    · · · · —

5    · · · · ·

6    — · · · ·

7    — — · · ·

8    — — — · ·

9    — — — — ·

0    — — — — —

Full Stop [.]	• — • — • —	Understood	• • • — •
Comma [,]	— — • • — —	Error [8 •]	• • • • • • •
Colon [:]	— — — • • •	Cross [+]	• — • — •
Question [?] <sup>1</sup>	• • — — • •	Transmit	— • —
Apostrophe [']	• — — — — •	Wait	• — • • •
Hyphen [-]	— • • • • —	End	• • • — • —
Slash [/]	— • • — •	Start	— • — • —
LH Bracket [(]	— • — — •	Mult. [x]	— • • • —
RH Bracket [)]	— • — — • —	At [@]	• — — • — •
Quote ["]	• — • • — •		
Equal [=]	— • • • —		

Timings

• <b>Dit</b> (dot)	Unit of time
— <b>Dah</b> (dash)	3 •
<b>Between dits or dahs</b>	1 •
<b>Between letters</b>	3 •
<b>Between words</b>	7 •

<sup>1</sup> Ask for a repetition if the message is not understood.

## 5 Radio Abbreviations

A sample of abbreviations, reference ITU Rec. M.1172-0.

Abbreviation or signal	Definition
<b>AA</b>	All after ...
<b>AB</b>	All before ...
<b>ADS</b>	Address
<b>AR</b>	End of transmission
<b>AS</b>	Waiting period
<b>BK</b>	Signal used to interrupt a transmission in progress
<b>BN</b>	All between ... and ...
<b>BQ</b>	A reply to an RQ (Request)
<b>BT</b>	Mark the separation between different parts of the same transmission
<b>C</b>	Yes
<b>CFM</b>	Confirm <i>or</i> I confirm
<b>CL</b>	I am closing my station
<b>COL</b>	Collate <i>or</i> I collate
<b>CQ</b>	General call to all stations
<b>CS</b>	Call sign; used to request a call sign
<b>DE</b>	<i>"From ..."</i> (used to precede the name or other identification of the calling station)
<b>DSC</b>	Digital selective calling
<b>E</b>	East (cardinal point)
<b>ETA</b>	Estimated time of arrival
<b>K</b>	Invitation to transmit
<b>KA</b>	Starting signal
<b>MIN</b>	Minute <i>or</i> Minutes
<b>N</b>	North (cardinal point)

Abbreviation or signal	Definition
<b>NIL</b>	I have nothing to send to you
<b>NO</b>	No ( <i>negative</i> )
<b>NW</b>	Now
<b>OK</b>	We agree ( <i>or</i> It is correct)
<b>P</b>	Prefix indicating a private radiotelegram
<b>PBL</b>	Preamble
<b>PSE</b>	Please
<b>R</b>	Received
<b>RCC</b>	Rescue coordination centre
<b>REF</b>	Reference to ... <i>or</i> Refer to ...
<b>RPT</b>	Repeat <i>or</i> I repeat
<b>RQ</b>	Indication of a request
<b>S</b>	South (cardinal point)
<b>SAR</b>	Search and Rescue
<b>SIG</b>	Signature
<b>TFC</b>	Traffic
<b>TR</b>	Used by a land station to request the position. Used also as a prefix to the reply
<b>TU</b>	Thank you
<b>TXT</b>	Text
<b>VA</b>	End of work
<b>W</b>	West (cardinal point)
<b>WA</b>	Word after ...
<b>WB</b>	Word before ...
<b>WD</b>	Word(s) <i>or</i> Group(s)
<b>WX</b>	Weather report
<b>XQ</b>	Prefix used to indicate the transmission of a service note
<b>YZ</b>	The words which follow are in plain language



## 6 Digital Modes

The chapter summarizes the typical calling and center-of-activity frequencies (**in MHz**) for digital modes.

The Digital Modes are not limited to the calling or to the center-of-activity frequencies, but ruled by the Band Plans.

Band	FT8	PSK – MFSK <sup>2</sup>	RTTY
<b>160 m</b>	1.840	1.838	1.840
<b>80 m</b>	3.573	3.580 – 3.583	3.590
<b>60 m</b>	5.357		
<b>40m</b>	7.074	7.040 – 7.043 (R1, R3) 7.070 – 7.073 (R2)	7.040
<b>30 m</b>	10.136	10.141 – 10.143	10.140
<b>20 m</b>	14.074	14.070 – 14.073	14.080
<b>17 m</b>	18.100	18.103 – 18.104	18.100
<b>15 m</b>	21.074	21.070 – 21.072 21.085 – 21.087	21.080
<b>12 m</b>	24.915	24.920 – 24.921	24.925
<b>10 m</b>	28.074	28.070 – 28.073	28.080
<b>6 m</b>	50.313 50.323 (DX)	50.305 – 50.307	50.600
<b>2 m</b>	144.174	144.138	144.600
<b>1.25 m</b>	222.065		
<b>70 cm</b>	432.065	432.088	432.600
<b>23 cm</b>		1296.138	1296.600
<b>13 cm</b>		2320.138	

*Before use: verify the frequency is allowed in your region.*

<sup>2</sup> Generally, PSK31 at the beginning of the band and MSFK (Olivia, Hellschreiber, ...) at the end

Band	WSPR	FT4	JT65
<b>2200m</b>	0.136		0.13613
<b>630m</b>	0.4742		
<b>160 m</b>	1.8366		1.838
<b>80 m</b>	3.5686	3.575	3.570
<b>60 m</b>	5.2872 5.3647		5.357
<b>40m</b>	7.0386	7.0475	7.076
<b>30 m</b>	10.1386	10.140	10.138
<b>20 m</b>	14.0956	14.080	14.076
<b>17 m</b>	18.1046	18.104	18.102
<b>15 m</b>	21.0946	21.140	21.076
<b>12 m</b>	24.9246	24.919	24.917
<b>10 m</b>	28.1246	28.180	28.076
<b>6 m</b>	50.2937	50.318	50.276
<b>2 m</b>	144.489	144.170	144.120
<b>1.25 m</b>			
<b>70 cm</b>	432.300		432.065
<b>23 cm</b>	1296.500		1296.065
<b>13 cm</b>			2301.065

*Before use: verify the frequency is allowed in your region.*

Band	JS8	FST4/W	SSTV
2200 m		0.136	
630 m		0.4742	
160 m	1.842	1.839 1.8368	
80 m	3.578		3.733
60 m			
40m	7.078		7.058
30 m	10.130		
20 m	14.078		14.233 14.230 (Analogue)
17 m	18.104		
15 m	21.078		21.337
12 m	24.922		
10 m	28.078		
6 m	50.318		50.510
2 m	144.178		

*Before use: verify the frequency is allowed in your region.*



# 7 Amateur Satellite

## Opened bands

The table summarizes in which band the AMSAT is allowed.

However, please refer to the detailed band plans to know the exact boundaries of AMSAT traffic within each of them.

Band	Region 1	Region 2	Region 3
40m	7000 — 7100 kHz		
20m	14000 — 14250 kHz		
17m	18068 — 18168 kHz		
15m	21000 — 21450 kHz		
12m	24890 — 24990 kHz		
10m	28000 — 29700 kHz		
2m	144 — 146 MHz		
70cm	430 — 440 MHz	430 — 440 MHz	
5cm	5.83 — 5.85 GHz		
3cm	10.45 — 10.5 GHz		
1.2cm	24 — 24.05 GHz		
6mm	47 — 47.2 GHz		
4mm	76 — 77.5 GHz		
	77.5 — 78 GHz		
	78 — 81 GHz		
2.2mm	134 — 136 GHz		
	136 — 141 GHz		
1.2mm	241 — 248 GHz		
	248 — 250 GHz		

## International Space Station

Mode	Uplink (MHz)	Downlink (MHz)
Voice	145.200 (R1) 144.490 (R2, R3)	145.800
	437.800	145.800
APRS (1200 baud)	145.825	145.825
	437.550	437.550
SSTV	N/A	145.800

## QO-100

Mode	Uplink (MHz)	Downlink (MHz)
<b>CW Beacon</b> ▲ Guard Band	N/A	10489.500 — 10489.505
<b>CW</b>	2400.005 — 2400.040	10489.505 — 10489.540
<b>Digimodes</b> <i>BW 500 Hz</i>	2400.040 — 2400.080	10489.540 — 10489.580
<b>Digimodes</b> <i>BW 2700 Hz</i>	2400.080 — 2400.150	10489.580 — 10489.650
<b>SSB</b> <i>BW 2700 Hz</i>	2400.150 — 2400.245	10489.650 — 10489.745
<b>PSK Beacon</b> (400 bit/s) ▲ Guard Band	N/A	10489.745 — 10489.755
<b>SSB</b> <i>BW 2700 Hz</i>	2400.255 — 2400.350	10489.755 — 10489.850
<b>Broadcast</b>	2400.355	10489.855
<b>▲ Emergency</b>	2400.360	10489.860
<b>Mixed Modes</b> <i>BW 2700 Hz</i>	2400.365 — 2400.495	10489.865 — 10489.995
<b>Experimental Beacon</b> ▲ Guard Band	N/A	10489.995 — 10490.000

## 8 International Beacon Project

The International Beacon Project (IBP) coordinates HF beacons worldwide. Each beacon transmits once on each band every 3 minutes, 24 hours a day.

The message starts by the station callsign in CW at 22 words-per-minutes. Then followed by a series of dashes sent at:  
100 W, 10 W, 1 W and 1 mW.

10 seconds after the end of the transmission, the beacon goes to the band higher and starts to transmit the same message again.

### Beacons List

Callsign	Country	QTH	Grid
<b>4U1UN</b>	United Nations	New York City	FN30as
<b>VE8AT</b>	Canada	Inuvik, NT	CP38gh
<b>W6WX</b>	United States	Mt. Umunhum	CM97bd
<b>KH6RS</b>	Hawaii	Maui	BL10ts
<b>ZL6B</b>	New Zealand	Masterton	RE78tw
<b>VK6RBP</b>	Australia	Rolystone	OF87av
<b>JA2IGY</b>	Japan	Mt. Asama	PM84jk
<b>RR9O</b>	Russia	Novosibirsk	NO14kx
<b>VR2B</b>	Hong Kong	Hong Kong	OL72bg
<b>4S7B</b>	Sri Lanka	Colombo	MJ96wv
<b>ZS6DN</b>	South Africa	Pretoria	KG33xi
<b>5Z4B</b>	Kenya	Kariobangi	KI88ks
<b>4X6TU</b>	Israel	Tel Aviv	KM72jb
<b>OH2B</b>	Finland	Lohja	KP20eh
<b>CS3B</b>	Madeira	São Jorge	IM12mt
<b>LU4AA</b>	Argentina	Buenos Aires	GF05tj
<b>OA4B</b>	Peru	Lima	FH17mw

Callsign	Country	QTH	Grid
YV5B	Venezuela	Caracas	FJ69cc

Frequencies

Band	Frequency (MHz)
20m	14.100
17m	18.110
15m	21.150
13m	24.930
10m	28.200



## 9 Radio Waves

The radio waves are periodic waves, so a pattern is generated at a specific frequency, short-handed  $f$ . The frequency is associated to the wavelength, which represents the physical length in space of a pattern.

Period	$\tau = f^{-1}$ , with $f$ the frequency
Wave Length	$\lambda = c \cdot \tau$ $\lambda = c \cdot f^{-1}$ $\lambda(\text{m}) \approx \frac{299}{f(\text{MHz})}$
Angular Frequency (or pulsation)	$\omega = 2\pi f$
Angular Wave Vector	$k = 2\pi\lambda$

### Band Definitions

Symbol	Frequency range (lower limit exclusive, upper limit inclusive)	Corresponding metric subdivision
VLF	3 to 30 kHz	Myriametric waves
LF	30 to 300 kHz	Kilometric waves
MF	300 to 3 000 kHz	Hectometric waves
HF	3 to 30 MHz	Decametric waves
VHF	30 to 300 MHz	Metric waves
UHF	300 to 3 000 MHz	Decimetric waves
SHF	3 to 30 GHz	Centimetric waves
EHF	30 to 300 GHz	Millimetric waves
	300 to 3 000 GHz	Decimillimetric waves

# Propagation

## Ionosphere Regions

The ionosphere is the ionized region of the atmosphere is between 50 km to 2000 km of altitude. The Sun ultra-violets and X-rays ionize the atmosphere gas. The density of electrons per unit of volume (cube-meter) measures the intensity of the ionization. The collision between electrons and neutral particles, acts as a radiowave absorber. The maximum of collision has been measured between 50-90 km.

This region is split into multiple layers, with specific properties in terms of propagation. The following table summarizes each layer and its properties, only for the sake of information the lower atmosphere layers are detailed in *italic*.

Alt. (km)	Day	Night	Properties
0 — 20	<i>Troposphere</i>		
20 — 50	<i>Stratosphere</i>		
50 — 90	D	D	Absorbs: MF, HF Reflects: VLF, LF  Peak electrons density at noon ( $10^8$ to $10^9$ electrons/ $m^3$ ), increased during summer, very small density the night.
90 — 130	E	E	Reflects: HF  Peak electron density near noon and in summer ( $10^{11}$ electrons/ $m^3$ ). Unstable band for reflection, namely the <i>Sporadic Es</i> .
130 — 200	F1	F	Reflects: HF  Highly sensitive to solar processes as the E band. The region distinction is not maintained at night (a single F region).

Alt. (km)	Day	Night	Properties
200 — 500	F2		Reflects: HF, sparsely VHF  Greatest density of electrons, and the only layer, where density of electrons persists at night. The F and F2 are the most reliable layers for reflections.

## Bands

Band	Range	Propagation
VLF	0 – 30 kHz	Waveguide, Ground-wave
LF	30 – 300 kHz	Waveguide, Sky wave, Ground-wave
MF	300 – 300 kHz	Sky-wave, Ground-wave
HF	3 – 30 MHz	Sky-wave < 12 MHz, favored the night 12 – 19 MHz, all day band > 19 MHz, favored the day
VHF	30 – 300 MHz	Line-of-sight Sporadically reflected by the F or E layers

## Solar and Earth Activity

The sun activity can affect the propagation on HF, here a sample of the most common indices.

Symbols	Name	Details
R SN SSN	Wolf Number  <i>Sunspot Number</i> <i>Smoothed Sunspot Number</i>	Relative measurement of the number of sunspots. <i>Between 0 and 250.</i>  It indicates the activity of the Sun, the higher when the Sun cycle (11 years) is at its maximum.  R > 100, the D layer may be thicker on daytime, this reduces significantly the propagation from 160- to 60-meters bands (also affects 40 and 30 meters).  The bigger the higher optimal frequency.

Symbols	Name	Details
F SFI	Solar Flux Index	<p>Measures the solar flux at 2.8GHz (10.7 cm). <i>Usually between 0 and 300.</i></p> <p>It indicates how the F layer is ionized, this is good for DX.</p> <p>The bigger the higher optimal frequency. <i>The high F might favor long-distance communications.</i></p>
K	K-index  3-Hours Geomagnetic Variability	<p>Magnetosphere variations (horizontal variations of the earth's magnetic field). <i>Between 0 and 9.</i></p> <p>The lower the better.</p> <p>&lt; 3, normal &gt; 5, stormy conditions</p>
A	A-index  Daily Geomagnetic Variability	<p>Magnetosphere variations, averaged on a day. <i>Between 0 and 400.</i></p> <p>The lower the better.</p> <p>&lt; 15, normal &gt; 40, active storm &gt; 50, major storm</p>

## Solar and Geomagnetic Storms

- A few minutes to a few hours after the **solar flare**, one notices HF noise (because of the solar X-Rays). This causes QSB, and in the worst case short radio blackouts.
- A few hours after the **solar flare**, the solar flux (F) increases.
- From a few hours to a couple of days after the **solar flare**, the HF band is quiet. The lower and the maximum usable frequencies opens. *Favored window for HF radio.*
- A couple of days after the **solar flare**, the solar wind reaches the Earth. The K-index suddenly increases, the geomagnetic storm starts for a few days. One enters in a **radio blackout**.

# 10 Antennas

## Summary

Kind	Length	Z ( $\Omega$ )	Gain (dBi)
Ground Plane	$\lambda/4$	36	2.19
Half-Wave Dipole	$\lambda/2$	73.1	2.15
Folded Dipole	$\lambda/2$	292	2.15
Yagi	Depends on the number of elements	The more elements the lower	The more elements the bigger

## Arrays

A set of multiple connected antenna achieves an higher gain.

Theoretically, the gain follows  $10 \log_{10}(n)$  with  $n$  the number of antennas.

n	2	3	4	5	6	7	8
+ $\Delta$ dBi	3	4.77	6	6.99	7.78	8.45	9

## Standing Wave Ratio

The SWR measures the impedance matching between the loads (transmitter, lines, antennas...). When two loads match the SWR ratio is at 1:1. Between two loads, the SWR is defined as:

$$SWR = \frac{Z_{\max}}{Z_{\min}},$$

with  $Z_{\max}$  and  $Z_{\min}$  respectively the higher and the lower impedance of the loads.

If the value of the SWR is bigger than 1:1, a fraction of the transmitted power is reflected back to the transmitter, this can be considered as a loss. The ratio of power reads as:

$$SWR = \frac{1 + \sqrt{P_r/P_f}}{1 - \sqrt{P_r/P_f}},$$

with  $P_r$  and  $P_f$  respectively the reflected and the forwarded power. Thus, the ratio of  $P_r/P_f$  reads:

$$\frac{P_r}{P_f} = \left( \frac{SWR - 1}{SWR + 1} \right)^2 .$$

One may find below the table of losses with respect to the SWR and an application for 10W signal.

SWR	Loss	Radiated	10W
1	0,00 %	100,00 %	10,00
1.1	0,23 %	99,77 %	9,98
1.2	0,83 %	99,17 %	9,92
1.3	1,70 %	98,30 %	9,83
1.4	2,78 %	97,22 %	9,72
1.5	4,00 %	96,00 %	9,60
1.6	5,33 %	94,67 %	9,47
1.7	6,72 %	93,28 %	9,33
1.8	8,16 %	91,84 %	9,18
1.9	9,63 %	90,37 %	9,04
2	11,11 %	88,89 %	8,89
2.5	18,37 %	81,63 %	8,16
3	25,00 %	75,00 %	7,50
4	36,00 %	64,00 %	6,40
5	44,44 %	55,56 %	5,56
10	66,94 %	33,06 %	3,31

# 11 Electricity

Component	Resistor	Capacitor	Coil
Property	Resistance $R$	Capacity $C$	Inductance $L$
Unit	Ohm ( $\Omega$ )	Farads (F)	Henry (H)
Impedance	$Z = R$	$Z = -\frac{j}{\omega C}$	$Z = j\omega L$
Series	$R_{tot} = R_1 + \dots + R_N$	$\frac{1}{C_{tot}} = \frac{1}{C_1} + \dots + \frac{1}{C_N}$	$L_{tot} = L_1 + \dots + L_N$
Parallel	$\frac{1}{R_{tot}} = \frac{1}{R_1} + \dots + \frac{1}{R_N}$	$C_{tot} = C_1 + \dots + C_N$	$\frac{1}{L_{tot}} = \frac{1}{L_1} + \dots + \frac{1}{L_N}$

Ohm's Law	$V = R \cdot I$ , with $V$ the tension, $R$ the resistance, and $I$ the current.
Power	$P = V \cdot I$
Inductance of a solenoid	$L = \frac{\mu N^2 A}{l}$ , with $N$ the number of turns, $A$ the cross-section of the solenoid, and $l$ the length

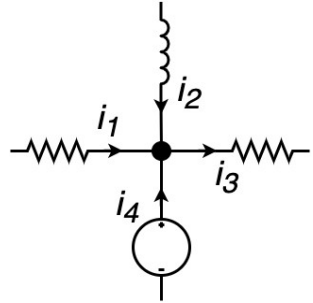
## Kirchhoff's Law

### Currents

On a circuit node, the algebraic sum of all currents (positive for incoming and negative for exiting) is equal to zero:  $\sum_{k=0}^K I_k = 0$ .

For instance on the figure, the law reads as:

$$i_1 + i_2 - i_3 + i_4 = 0.$$

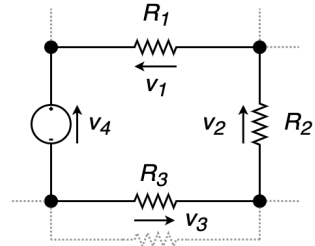


### Voltage

The directed sum of all voltage on a closed loop is equal to zero:  $\sum_{k=0}^K V_k = 0$ .

For instance on the figure, the law reads as:

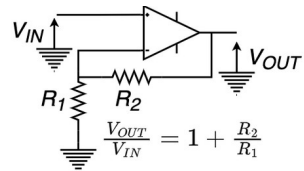
$$-v_1 - v_2 - v_3 + v_4 = 0.$$



## Operational Amplifiers

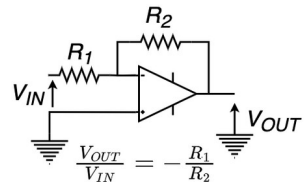
### Non-inverting

In a non-inverting amplifier, the output voltage changes in the same direction to the input voltage. The operational amplifier works in a linear mode.



### Inverting

In an inverting amplifier, the output voltage changes in the opposite direction to the input voltage. The operational amplifier works in a non-linear mode. It is in a comparator configuration.





## Filters & RLC

The resonance frequency  $F_0$ , and the cutoff frequency  $F_C$ , are equal to:

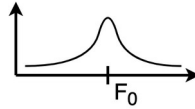
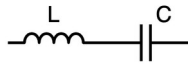
$$F_C = F_0 = \frac{1}{2\pi\sqrt{LC}}.$$

The LC circuits are not perfect, because of the hidden resistors (the wires, in the inductance...), so one speaks about RLC circuits. The value of the resistor may affect the selectivity of the filters. The quality of a LC circuit is expressed by the Q factor:

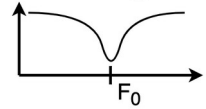
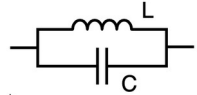
$Q = \frac{F_0}{BW}$ , with the resonance frequency  $F_0$  and the bandwidth  $BW$ .

Thus, the higher Q, the more selective is the filter.

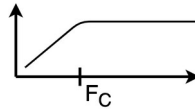
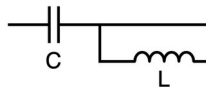
Band Pass



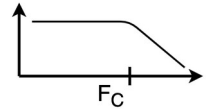
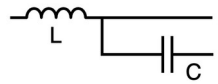
Band Stop



High Pass



Low Pass



# Resistor Colors

| IEC 60062:2016 Standard

Color	Number	Multiplier	Tolerance
Black	0	$10^0$	N/A
Brown	1	$10^1$	$\pm 1\%$
Red	2	$10^2$	$\pm 2\%$
Orange	3	$10^3$	$\pm 0.05\%$
Yellow	4	$10^4$	$\pm 0.02\%$
Green	5	$10^5$	$\pm 0.5\%$
Blue	6	$10^6$	$\pm 0.25\%$
Violet	7	$10^7$	$\pm 0.1\%$
Gray	8	$10^8$	$\pm 0.01\%$
White	9	$10^9$	N/A
Silver		$10^{-2}$	$\pm 10\%$
Gold		$10^{-1}$	$\pm 5\%$

## 12 ITU Prefixes Allocation

With respect to the Appendix 42 of the RR:

*The first two characters of a call sign shall be two letters or a letter followed by a digit or a digit followed by a letter. The first two characters or in certain cases the first character of a call sign constitute the nationality identification.<sup>3</sup>*

For instance, **Monaco** has the range **3AA – 3AZ**, so the country is identified with **3A**. If the allocation is wider, as **Spain** with **EAA – EHZ**, the country can be identified with **EA, EB, ..., EH**.

Range	Country or Organization
<b>2—3</b>	
2AA – 2ZZ	United Kingdom of Great Britain and Northern Ireland
3AA – 3AZ	Monaco (Principality of)
3BA – 3BZ	Mauritius (Republic of)
3CA – 3CZ	Equatorial Guinea (Republic of)
3DA – 3DM	Eswatini (Kingdom of)
3DN – 3DZ	Fiji (Republic of)
3EA – 3FZ	Panama (Republic of)
3GA – 3UZ	Chile
3VA – 3VZ	Tunisia
3WA – 3WZ	Viet Nam (Socialist Republic of)
3XA – 3XZ	Guinea (Republic of)
3YA – 3YZ	Norway
3ZA – 3ZZ	Poland (Republic of)
<b>4</b>	
4AA – 4CZ	Mexico
4DA – 4IZ	Philippines (Republic of the)
4JA – 4KZ	Azerbaijan (Republic of)

<sup>3</sup> For call sign series beginning with B, F, G, I, K, M, N, R, W and 2, only the first character is required for nationality identification. In the cases of half series (i.e. when the first two characters are allocated to more than one Member State), the first three characters are required for nationality identification.

4LA – 4LZ	Georgia
4MA – 4MZ	Venezuela (Bolivarian Republic of)
4OA – 4OZ	Montenegro
4PA – 4SZ	Sri Lanka (Democratic Socialist Republic of)
4TA – 4TZ	Peru
4UA – 4UZ	United Nations
4VA – 4VZ	Haiti (Republic of)
4WA – 4WZ	Timor-Leste (Democratic Republic of)
4XA – 4XZ	Israel (State of)
4YA – 4YZ	International Civil Aviation Organization
4ZA – 4ZZ	Israel (State of)
<b>5</b>	
5AA – 5AZ	Libya (State of)
5BA – 5BZ	Cyprus (Republic of)
5CA – 5GZ	Morocco (Kingdom of)
5HA – 5IZ	Tanzania (United Republic of)
5JA – 5KZ	Colombia (Republic of)
5LA – 5MZ	Liberia (Republic of)
5NA – 5NZ	Nigeria (Federal Republic of)
5PA – 5QZ	Denmark
5RA – 5SZ	Madagascar (Republic of)
5TA – 5TZ	Mauritania (Islamic Republic of)
5UA – 5UZ	Niger (Republic of the)
5VA – 5VZ	Togolese Republic
5WA – 5WZ	Samoa (Independent State of)
5XA – 5XZ	Uganda (Republic of)
5YA – 5ZZ	Kenya (Republic of)
<b>6</b>	
6AA – 6BZ	Egypt (Arab Republic of)
6CA – 6CZ	Syrian Arab Republic
6DA – 6JZ	Mexico
6KA – 6NZ	Korea (Republic of)
6OA – 6OZ	Somalia (Federal Republic of)

6PA – 6SZ	Pakistan (Islamic Republic of)
6TA – 6UZ	Sudan (Republic of the)
6VA – 6WZ	Senegal (Republic of)
6XA – 6XZ	Madagascar (Republic of)
6YA – 6YZ	Jamaica
6ZA – 6ZZ	Liberia (Republic of)
<b>7</b>	
7AA – 7IZ	Indonesia (Republic of)
7JA – 7NZ	Japan
7OA – 7OZ	Yemen (Republic of)
7PA – 7PZ	Lesotho (Kingdom of)
7QA – 7QZ	Malawi
7RA – 7RZ	Algeria (People's Democratic Republic of)
7SA – 7SZ	Sweden
7TA – 7YZ	Algeria (People's Democratic Republic of)
7ZA – 7ZZ	Saudi Arabia (Kingdom of)
<b>8</b>	
8AA – 8IZ	Indonesia (Republic of)
8JA – 8NZ	Japan
8OA – 8OZ	Botswana (Republic of)
8PA – 8PZ	Barbados
8QA – 8QZ	Maldives (Republic of)
8RA – 8RZ	Guyana
8SA – 8SZ	Sweden
8TA – 8YZ	India (Republic of)
8ZA – 8ZZ	Saudi Arabia (Kingdom of)
<b>9</b>	
9AA – 9AZ	Croatia (Republic of)
9BA – 9DZ	Iran (Islamic Republic of)
9EA – 9FZ	Ethiopia (Federal Democratic Republic of)
9GA – 9GZ	Ghana
9HA – 9HZ	Malta
9IA – 9JZ	Zambia (Republic of)

9KA – 9KZ	Kuwait (State of)
9LA – 9LZ	Sierra Leone
9MA – 9MZ	Malaysia
9NA – 9NZ	Nepal (Federal Democratic Republic of)
9OA – 9TZ	Democratic Republic of the Congo
9UA – 9UZ	Burundi (Republic of)
9VA – 9VZ	Singapore (Republic of)
9WA – 9WZ	Malaysia
9XA – 9XZ	Rwanda (Republic of)
9YA – 9ZZ	Trinidad and Tobago
<b>A</b>	
A2A – A2Z	Botswana (Republic of)
A3A – A3Z	Tonga (Kingdom of)
A4A – A4Z	Oman (Sultanate of)
A5A – A5Z	Bhutan (Kingdom of)
A6A – A6Z	United Arab Emirates
A7A – A7Z	Qatar (State of)
A8A – A8Z	Liberia (Republic of)
A9A – A9Z	Bahrain (Kingdom of)
AAA – ALZ	United States of America
AMA – AOZ	Spain
APA – ASZ	Pakistan (Islamic Republic of)
ATA – AWZ	India (Republic of)
AXA – AXZ	Australia
AYA – AZZ	Argentine Republic
<b>B — C</b>	
BAA – BZZ	China (People's Republic of)
C2A – C2Z	Nauru (Republic of)
C3A – C3Z	Andorra (Principality of)
C4A – C4Z	Cyprus (Republic of)
C5A – C5Z	Gambia (Republic of the)
C6A – C6Z	Bahamas (Commonwealth of the)
C7A – C7Z	World Meteorological Organization

C8A – C9Z	Mozambique (Republic of)
CAA – CEZ	Chile
CFA – CKZ	Canada
CLA – CMZ	Cuba
CNA – CNZ	Morocco (Kingdom of)
COA – COZ	Cuba
CPA – CPZ	Bolivia (Plurinational State of)
CQA – CUZ	Portugal
CVA – CXZ	Uruguay (Eastern Republic of)
CYA – CZZ	Canada
<b>D</b>	
D2A – D3Z	Angola (Republic of)
D4A – D4Z	Cabo Verde (Republic of)
D5A – D5Z	Liberia (Republic of)
D6A – D6Z	Comoros (Union of the)
D7A – D9Z	Korea (Republic of)
DAA – DRZ	Germany (Federal Republic of)
DSA – DTZ	Korea (Republic of)
DUA – DZZ	Philippines (Republic of the)
<b>E</b>	
E2A – E2Z	Thailand
E3A – E3Z	Eritrea
E4A – E4Z	State of Palestine <sup>4</sup>
E5A – E5Z	New Zealand – Cook Islands
E6A – E6Z	New Zealand – Niue
E7A – E7Z	Bosnia and Herzegovina
EAA – EHZ	Spain
EIA – EJZ	Ireland
EKA – EKZ	Armenia (Republic of)
ELA – ELZ	Liberia (Republic of)
EMA – EOZ	Ukraine
EPA – EQZ	Iran (Islamic Republic of)

ERA – ERZ	Moldova (Republic of)
ESA – ESZ	Estonia (Republic of)
ETA – ETZ	Ethiopia (Federal Democratic Republic of)
EUA – EWZ	Belarus (Republic of)
EXA – EXZ	Kyrgyz Republic
EYA – EYZ	Tajikistan (Republic of)
EZA – EZZ	Turkmenistan
<b>F — G</b>	
FAA – FZZ	France
GAA – GZZ	United Kingdom of Great Britain and Northern Ireland
<b>H</b>	
H2A – H2Z	Cyprus (Republic of)
H3A – H3Z	Panama (Republic of)
H4A – H4Z	Solomon Islands
H6A – H7Z	Nicaragua
H8A – H9Z	Panama (Republic of)
HAA – HAZ	Hungary
HBA – HBZ	Switzerland (Confederation of)
HCA – HDZ	Ecuador
HEA – HEZ	Switzerland (Confederation of)
HFA – HFZ	Poland (Republic of)
HGA – HGZ	Hungary
HHA – HHZ	Haiti (Republic of)
HIA – HIZ	Dominican Republic
HJA – HKZ	Colombia (Republic of)
HLA – HLZ	Korea (Republic of)
HMA – HMZ	Democratic People's Republic of Korea
HNA – HNZ	Iraq (Republic of)
HOA – HPZ	Panama (Republic of)
HQA – HRZ	Honduras (Republic of)
HSA – HSZ	Thailand
HTA – HTZ	Nicaragua
HUA – HUZ	El Salvador (Republic of)



HVA – HVZ	Vatican City State
HWA – HYZ	France
HZA – HZZ	Saudi Arabia (Kingdom of)
<b>I – J</b>	
IAA – IZZ	Italy
J2A – J2Z	Djibouti (Republic of)
J3A – J3Z	Grenada
J4A – J4Z	Greece
J5A – J5Z	Guinea-Bissau (Republic of)
J6A – J6Z	Saint Lucia
J7A – J7Z	Dominica (Commonwealth of)
J8A – J8Z	Saint Vincent and the Grenadines
JAA – JSZ	Japan
JTA – JVZ	Mongolia
JWA – JXZ	Norway
JYA – JYZ	Jordan (Hashemite Kingdom of)
JZA – JZZ	Indonesia (Republic of)
<b>K – L</b>	
KAA – KZZ	United States of America
L2A – L9Z	Argentine Republic
LAA – LNZ	Norway
LOA – LWZ	Argentine Republic
LXA – LXZ	Luxembourg
LYA – LYZ	Lithuania (Republic of)
LZA – LZZ	Bulgaria (Republic of)
<b>M – N – O</b>	
MAA – MZZ	United Kingdom of Great Britain and Northern Ireland
NAA – NZZ	United States of America
OAA – OCZ	Peru
ODA – ODZ	Lebanon
OEA – OEZ	Austria
OFA – OJZ	Finland
OKA – OLZ	Czech Republic

OMA – OMZ	Slovak Republic
ONA – OTZ	Belgium
OUA – OZZ	Denmark
<b>P</b>	
P2A – P2Z	Papua New Guinea
P3A – P3Z	Cyprus (Republic of)
P4A – P4Z	Netherlands (Kingdom of the) - Aruba
P5A – P9Z	Democratic People's Republic of Korea
PAA – PIZ	Netherlands (Kingdom of the)
PJA – PJZ	Netherlands (Kingdom of the) - Bonaire, Sint Eustatius and Saba
PJA – PJZ	Netherlands (Kingdom of the) - Curaçao
PJA – PJZ	Netherlands (Kingdom of the) - Sint Maarten (Dutch part)
PKA – POZ	Indonesia (Republic of)
PPA – PYZ	Brazil (Federative Republic of)
PZA – PZZ	Suriname (Republic of)
<b>R – S</b>	
RAA – RZZ	Russian Federation
S2A – S3Z	Bangladesh (People's Republic of)
S5A – S5Z	Slovenia (Republic of)
S6A – S6Z	Singapore (Republic of)
S7A – S7Z	Seychelles (Republic of)
S8A – S8Z	South Africa (Republic of)
S9A – S9Z	Sao Tome and Principe (Democratic Republic of)
SAA – SMZ	Sweden
SNA – SRZ	Poland (Republic of)
SSA – SSM	Egypt (Arab Republic of)
SSN – STZ	Sudan (Republic of the)
SUA – SUZ	Egypt (Arab Republic of)
SVA – SZZ	Greece
<b>T</b>	
T2A – T2Z	Tuvalu
T3A – T3Z	Kiribati (Republic of)
T4A – T4Z	Cuba

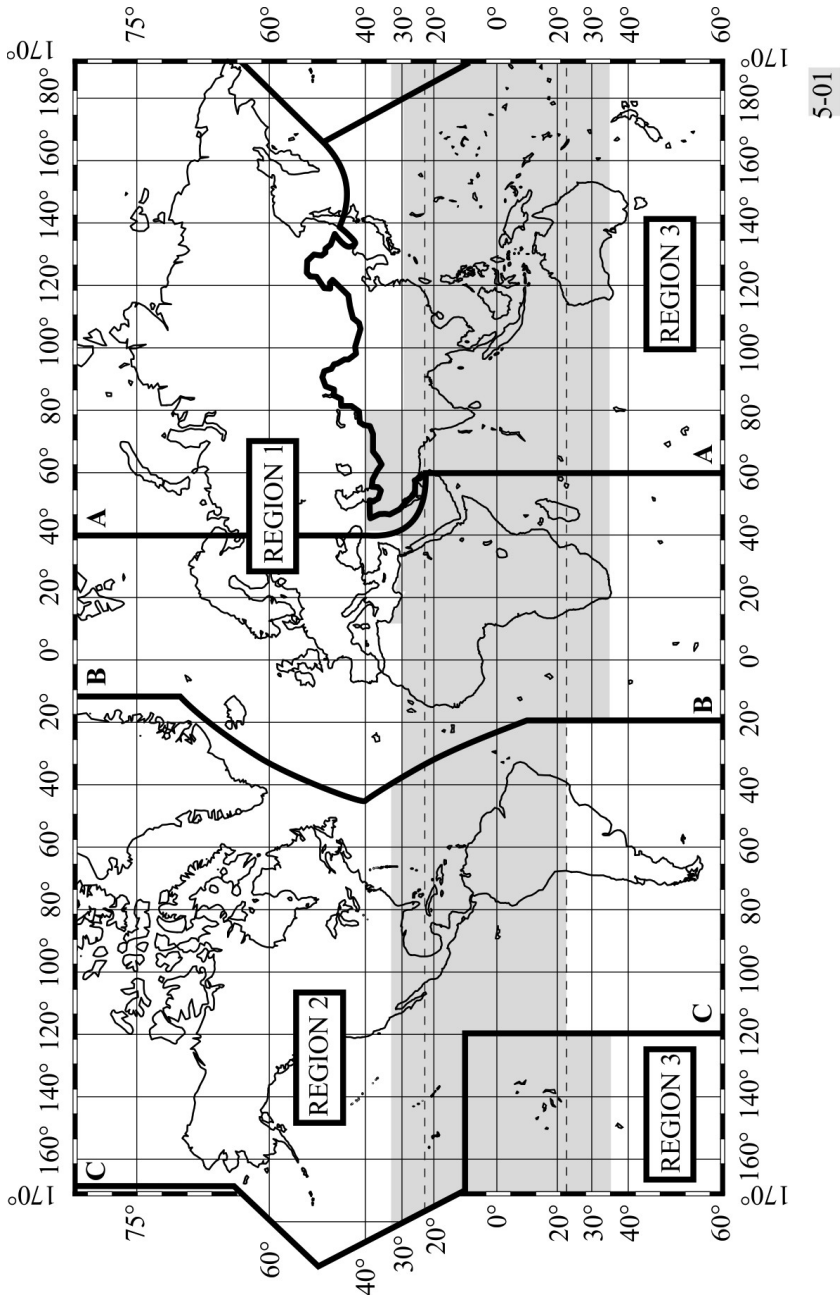
T5A – T5Z	Somalia (Federal Republic of)
T6A – T6Z	Afghanistan
T7A – T7Z	San Marino (Republic of)
T8A – T8Z	Palau (Republic of)
TAA – TCZ	Republic of Türkiye
TDA – TDZ	Guatemala (Republic of)
TEA – TEZ	Costa Rica
TFA – TFZ	Iceland
TGA – TGZ	Guatemala (Republic of)
THA – THZ	France
TIA – TIZ	Costa Rica
TJA – TJZ	Cameroon (Republic of)
TKA – TKZ	France
TLA – TLZ	Central African Republic
TMA – TMZ	France
TNA – TNZ	Congo (Republic of the)
TOA – TQZ	France
TRA – TRZ	Gabonese Republic
TSA – TSZ	Tunisia
TTA – TTZ	Chad (Republic of)
TUA – TUZ	Côte d'Ivoire (Republic of)
TVA – TXZ	France
TYA – TYZ	Benin (Republic of)
TZA – TZZ	Mali (Republic of)
<b>U</b>	
UAA – UIZ	Russian Federation
UJA – UMZ	Uzbekistan (Republic of)
UNA – UQZ	Kazakhstan (Republic of)
URA – UZZ	Ukraine
<b>V</b>	
V2A – V2Z	Antigua and Barbuda
V3A – V3Z	Belize
V4A – V4Z	Saint Kitts and Nevis (Federation of)
V5A – V5Z	Namibia (Republic of)

V6A – V6Z	Micronesia (Federated States of)
V7A – V7Z	Marshall Islands (Republic of the)
V8A – V8Z	Brunei Darussalam
VAA – VGZ	Canada
VHA – VNZ	Australia
VOA – VOZ	Canada
VPA – VQZ	United Kingdom of Great Britain and Northern Ireland
VRA – VRZ	China (People's Republic of) - Hong Kong
VSA – VSZ	United Kingdom of Great Britain and Northern Ireland
VTa – VWZ	India (Republic of)
VXA – VYZ	Canada
VZA – VZZ	Australia
<b>W — X</b>	
WAA – WZZ	United States of America
XAA – XIZ	Mexico
XJA – XOZ	Canada
XPA – XPZ	Denmark
XQA – XRZ	Chile
XSA – XSZ	China (People's Republic of)
XTA – XTZ	Burkina Faso
XUA – XUZ	Cambodia (Kingdom of)
XVA – XVZ	Viet Nam (Socialist Republic of)
XWA – XWZ	Lao People's Democratic Republic
XXA – XXZ	China (People's Republic of) - Macao
XYA – XZZ	Myanmar (Union of)
<b>Y</b>	
Y2A – Y9Z	Germany (Federal Republic of)
YAA – YAZ	Afghanistan
YBA – YHZ	Indonesia (Republic of)
YIA – YIZ	Iraq (Republic of)
YJA – YJZ	Vanuatu (Republic of)
YKA – YKZ	Syrian Arab Republic
YLA – YLZ	Latvia (Republic of)

YMA – YMZ	Republic of Türkiye
YNA – YNZ	Nicaragua
YOA – YRZ	Romania
YSA – YSZ	El Salvador (Republic of)
YTA – YUZ	Serbia (Republic of)
YVA – YYZ	Venezuela (Bolivarian Republic of)
<b>Z</b>	
Z2A – Z2Z	Zimbabwe (Republic of)
Z3A – Z3Z	North Macedonia (Republic of)
Z8A – Z8Z	South Sudan (Republic of)
ZAA – ZAZ	Albania (Republic of)
ZBA – ZJZ	United Kingdom of Great Britain and Northern Ireland
ZKA – ZMZ	New Zealand
ZNA – ZOZ	United Kingdom of Great Britain and Northern Ireland
ZPA – ZPZ	Paraguay (Republic of)
ZQA – ZQZ	United Kingdom of Great Britain and Northern Ireland
ZRA – ZUZ	South Africa (Republic of)
ZVA – ZZZ	Brazil (Federative Republic of)



# 13 ITU Regions







# 14 ITU Alphabet

<b>A</b>	Alpha	<b>N</b>	November
<b>B</b>	Bravo	<b>O</b>	Oscar
<b>C</b>	Charlie	<b>P</b>	Papa
<b>D</b>	Delta	<b>Q</b>	Quebec
<b>E</b>	Echo	<b>R</b>	Romeo
<b>F</b>	Fox-Trott	<b>S</b>	Sierra
<b>G</b>	Golf	<b>T</b>	Tango
<b>H</b>	Hotel	<b>U</b>	Uniform
<b>I</b>	India	<b>V</b>	Victor
<b>J</b>	Juliet	<b>W</b>	Whisky
<b>K</b>	Kilo	<b>X</b>	X-Ray
<b>L</b>	Lima	<b>Y</b>	Yankee
<b>M</b>	Mike	<b>Z</b>	Zulu

*Widespread usage, occasionally replaced by country names.*

<b>1</b>	Unaone	<b>6</b>	Soxisix
<b>2</b>	Bissotwo	<b>7</b>	Setteseven
<b>3</b>	Terrathree	<b>8</b>	Oktoeight
<b>4</b>	Kartefour	<b>9</b>	Novenine
<b>5</b>	Pantafive	<b>0</b>	Nadazero
<b>•</b>	Decimal		

*Rare usage, only if transmission difficulties. Usually, the numbers are sent in english.*





The QTH Locator (or Maidenhead Locator System) format consists of pairs of symbols (letter or number) which encode the longitude and the latitude. Thus for every pair:

- **the first character encodes longitude,**
- **and the second character encodes latitude.**

The origin of the grid is set at the south pole:

- longitude  $-180^{\circ}$  ( $180^{\circ}\text{W}$ ),
- latitude  $-90^{\circ}$  ( $90^{\circ}\text{S}$ ).

The Maidenhead-grid divides the globe into multiple parts:

- Field
  - $18 \times 18$  zones of  $20^{\circ}$  longitude and  $10^{\circ}$  latitude
  - Encoded by a pair of letters from *A* to *R*
- Square
  - $10 \times 10$  zones of  $2^{\circ}$  longitude and  $1^{\circ}$  latitude
  - Encoded by a pair of numbers from *0* to *10*
- Subsquare
  - $24 \times 24$  zones of  $5'$  longitude and  $2.5'$  latitude
  - Encoded by a pair of letters (usually lowercase) from *a* to *x*

**Example:** the locator of Paris (France) City Hall is JN18eu.

- Field
  - *J* codes the longitude, the 10<sup>th</sup> letter of the alphabet or an offset of 9 (because *A* is the origin without offset), or  $180^{\circ}$  from the origin. It converts to longitude  $0^{\circ}\text{E}$ .
  - *N* codes the latitude, the 14<sup>th</sup> letter of the alphabet, or  $140^{\circ}$  from the origin. It converts to latitude  $40^{\circ}\text{N}$ .
- Square
  - *1* codes the longitude, as  $2^{\circ}$ .
  - *8* codes the latitude, as  $8^{\circ}$ .
- Subsquare
  - *e* codes the longitude, the 5<sup>th</sup> letter of the alphabet or an offset of 4 (because *a* is the origin without offset), or  $20'$ .
  - *u* codes the latitude, the 21<sup>st</sup> letter of the alphabet, or an offset of 20, or  $50'$ .

Consequently, the locator JN18eu, reads as:

- longitude  $2^{\circ}20'$
- latitude  $48^{\circ}50'$

# 16 Units

## International System

The International System of Units, known under the abbreviation SI, is the modern form of the metric system. The system has been established and is maintained by the General Conference on Weight and Measures (CGPM).

### Base Units

Symbol	Name	Quantity
s	Second	Time
m	Meter	Length
kg	Kilogram	Mass
A	Ampere	Electric Current
K	Kelvin	Temperature
mol	Mole	Amount of substance
cd	Candela	Luminous Intensity

### Derived Units

A sample of the most common units for Amateur Radio

Symbol	Name	Quantity	Definitions
Hz	Hertz	Frequency	$s^{-1}$
W	Watt	Power	$J \cdot s^{-1}$ $kg \cdot m^2 \cdot s^{-3}$
C	Coulomb	Electric Charge	$s \cdot A$
V	Volt	Electric Potential, Voltage	$W \cdot A^{-1}$ $J \cdot C^{-1}$ $kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}$
F	Farad	Capacitance	$C \cdot V^{-1}$ $kg^{-1} \cdot m^{-2} \cdot s^4 \cdot A^2$

Symbol	Name	Quantity	Definitions
$\Omega$	Ohm	Resistance	$V \cdot A^{-1}$ $kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}$
S	Siemens	Electrical Conductance	$\Omega^{-1}$
Wb	Weber	Magnetic Flux	$V \cdot s$ $kg \cdot m^2 \cdot s^{-2} \cdot A^{-1}$
T	Tesla	Magnetic Flux Density	$Wb \cdot m^{-2}$ $kg \cdot s^{-2} \cdot A^{-1}$
H	Henry	Inductance	$Wb \cdot A^{-1}$ $kg \cdot m^2 \cdot s^{-2} \cdot A^{-2}$

Prefixes

$10^n$	Symbol	Name
$10^{15}$	P	Peta
$10^{12}$	T	Tera
$10^9$	G	Giga
$10^6$	M	Mega
$10^3$	k	Kilo
$10^2$	h	Hecto
$10^1$	da	Deca
$10^0$	<i>Unit</i>	
$10^{-1}$	d	Deci
$10^{-2}$	c	Centi
$10^{-3}$	m	Milli
$10^{-6}$	$\mu$	Micro
$10^{-9}$	n	Nano
$10^{-12}$	p	Pico
$10^{-15}$	f	Femto

## Conversions

Length	
1 inch	25.4 mm
1 feet	0.3048 m
1 yard	0.9144 m
1 mile	1.61 m
Time	
1 day	86400 s
1 hour	3600 s
1 minute	60 s
Speed	
1 mph	0.447 m/s (1.61 km/h)
1 knot	0.5144 m/s (1.852 km/h)
1 km/h	0.2778 m/s
Surface	
1 ha	10000 m <sup>2</sup>
1 sq. feet	0.0929 m <sup>2</sup>
1 sq. yard	0.8361 m <sup>2</sup>
Power	
1 Wh	3600 J
1 cal	4.184 J
Mass	
1 pound	0.454 kg
1 once	0.028 kg
1 stone	6.35 kg

Pressure	
1 bar	10000 Pa
1 psi	6895 Pa
1 atmosphere	1013.25 hPa
Temperature	
0° Celsius	273.15 Kelvin °K = 273.15 + °C
0° Farhenheit	255.372 Kelvin °K = (°F – 32)·5/9 + 273.15
Data	
1 B (byte)	8 b (bits)
1 kB	1000 B 10 <sup>3</sup> B
1 kiB	1024 B 2 <sup>10</sup> B
Angle	
30 deg	π/6 rad
45 deg	π/4 rad
60 deg	π/3 rad
90 deg	π/2 rad
180 deg	π rad
360 deg	2π rad

Physics Constants

Symbol	Quantity	Value
$c$	Speed of Light	$2.99792458 \cdot 10^8 \text{ m} \cdot \text{s}^{-1}$
$\mu_0$	Vacuum Magnetic Permeability	$1.257 \cdot 10^{-7} \text{ N} \cdot \text{A}^{-2}$
$Z_0$	Characteristic Impedance of Vacuum	$376.7 \text{ } \Omega$
$\epsilon_0 = 1/\mu_0 c^2$	Vacuum Electric Permittivity	$8.854 \cdot 10^{-12} \text{ F} \cdot \text{m}^{-1}$
$k_e = 1/4\pi \epsilon_0$	Coulomb Constant	$8.989 \cdot 10^9 \text{ N} \cdot \text{m}^2 \cdot \text{C}^{-2}$



## Decibels

The decibel is defined as ten times the logarithmic  $dB = 10 \log_{10} (P_1/P_2)$  between two values  $P_1/P_2$ . Usually, in the amateur radio community we use decibels for power gains (antenna) and attenuations (feed-lines, medium, reception reports).

<b>dB</b>	0	1	2	3	4	5	6	7	10	16	20	30
<b>Ratio</b>	1	1.26	1.6	2	2.5	3.2	4	5	10	40	100	1000



# 17 Mathematics

A cheat-sheet of the most common rules and remarkable values.

## Algebra

$$a(b + c) = ab + ac$$

$$\frac{\frac{a}{b}}{c} = \frac{a}{bc}$$

$$a\left(\frac{b}{c}\right) = \frac{ab}{c}$$

$$a^n a^m = a^{n+m}$$

$$a^0 = 1, a \neq 0$$

$$a^{-n} = \frac{1}{a^n}$$

$$\sqrt[n]{a} = a^{1/n}$$

$$\sqrt[n]{ab} = \sqrt[n]{a} \sqrt[n]{b}$$

$$(a + b)(c + d) = ac + ad + bc + bd$$

$$\frac{a}{\frac{b}{c}} = \frac{ac}{b}$$

$$\frac{a}{b} + \frac{c}{d} = \frac{ad + cb}{bd}$$

$$(a^n)^m = a^{nm}$$

$$(ab)^n = a^n b^n$$

$$a^{n-m} = \frac{a^n}{a^m}$$

$$\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a} = a^{1/mn}$$

$$\sqrt[n]{\frac{a}{b}} = \frac{\sqrt[n]{a}}{\sqrt[n]{b}}$$

## Logarithms

The function  $\log_b$  denotes the b-basis logarithm, usually one uses a natural logarithm (denoted  $\ln$ ) or a 10-basis logarithm.

$$\log_b(1) = 0$$

$$\log_b(b^x) = x$$

$$\log_b(a^r) = r \log_b(a)$$

$$\log_b(x \cdot y) = \log_b(x) + \log_b(y)$$

$$\log_b(b) = 1$$

$$b^{\log_b(x)} = x$$

$$\log_b(x/y) = \log_b(x) - \log_b(y)$$

Trigonometry

Angle (rad)	Sine (sin)	Cosine (cos)	Tangent (tan)
0	0	1	0
$\pi/6$	$1/2$	$\sqrt{3}/2$	$\sqrt{3}/3$
$\pi/4$	$\sqrt{2}/2$	$\sqrt{2}/2$	1
$\pi/3$	$\sqrt{3}/2$	$1/2$	$\sqrt{3}$
$\pi/2$	1	0	undefined
$2\pi/3$	$\sqrt{3}/2$	$-1/2$	$-\sqrt{3}$
$3\pi/4$	$\sqrt{2}/2$	$-\sqrt{2}/2$	-1
$5\pi/6$	$1/2$	$-\sqrt{3}/2$	$-\sqrt{3}/3$
$\pi$	0	-1	0

$e^{i\pi} = -1$

$\pi \approx 3.141592653590$

$e^{i\theta} = \cos \theta + i \sin \theta$

$e \approx 2.718281828459$

Complex Numbers

The imaginary number reads *i* or *j*, squared the imaginary number equals:  
 $i^2 = -1$ .

Number	$z = a + ib$
Real part	$\Re(z) = a$
Imaginary part	$\Im(z) = b$
Modulus	$ z  = \sqrt{a^2 + b^2}$
Argument	$\arg(z) = \begin{cases} \arctan(b/a) & \text{if } a > 0 \text{ ,} \\ \arctan(b/a) + \pi & \text{if } a > 0 \text{ and } b \geq 0 \text{ ,} \\ \arctan(b/a) - \pi & \text{if } a > 0 \text{ and } b < 0 \text{ ,} \\ \pi/2 & \text{if } a = 0 \text{ and } b > 0 \text{ ,} \\ -\pi/2 & \text{if } a = 0 \text{ and } b < 0 \text{ ,} \\ \text{undefined} & \text{if } a = 0 \text{ and } b = 0 \text{ .} \end{cases}$
Trigonometric format	$z =  z  \{ \cos [\arg(z)] + i \sin [\arg(z)] \}$
Exponential format	$z =  z e^{i \arg(z)}$

# 18 Document Abbreviations

Abbreviation	Description
AM	Amplitude Modulation
AMSAT	Amateur Satellite
BW	Band Width
CoA	Center of Activity
CW	Continuous Waves (Morse code)
DM	Digital Mode
DV	Digital Voice
DX	Distant contact (inter-continental)
EMCOM	Emergency Communication
Glob.	Global
ITU	International Telecommunication Union
MGM	Machine Generated Modulation
NBM	Narrow Band Mode
Pref.	Preferred
RR	Radio Regulations
SSB	Single Side Band



# 19 References

ITU Radio Regulation, 2020

<https://www.itu.int/pub/R-REG-RR-2020>

IARU Region 1 Band Plan, *October 2020*

[https://www.iaru-r1.org/wp-content/uploads/2021/06/hf\\_r1\\_bandplan.pdf](https://www.iaru-r1.org/wp-content/uploads/2021/06/hf_r1_bandplan.pdf)

IARU Region 2 Band Plan, *September 2020*

<https://www.iaru-r2.org/wp-content/uploads/2020/02/IARU-Region-2-Band-plan.pdf>

IARU Region 3 Band Plan, *September 2019*

<https://www.iaru-r2.org/wp-content/uploads/2020/02/IARU-Region-3-Band-plan.pdf>

ITU Recommendation M.1772-0, *1995 Edition*

<https://www.itu.int/rec/R-REC-M.1172-0-199510-l/en>

Ionosphere and its Effects on Radiowave Propagation, *ITU, 1998*

Solar Activity & HF Propagation, *Harden P. NA5N, FDIM Symposium, 2005*

Understanding Solar Indices, *Poole I. G3YWX, QST, September 2022*

Rising Sunspot Numbers: It's Not All Good News, *Stanley J. K4ERO, QST, June 2021*