



# **Amateur Radio Booklet**

**2023 Edition**

**Noël Martin – F4JJD**

## Cover Picture

SAQ Grimeton, Sweden, *Mårten Sjöbeck*, Public Domain

# License

## Amateur Radio Booklet ©

2023 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 – [f4jld@noelmrtn.fr](mailto:f4jld@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 – Digital Modes.....	29
APRS.....	32
3 – Morse Code.....	33
Timings.....	34
4 – International Beacon Project.....	35
Beacons List.....	35
Frequencies.....	36
5 – Radio Abbreviations.....	37
6 – Q Codes.....	40
7 – Classification of Emissions.....	44
Modulation of the main Carrier.....	44
Nature of signals.....	45
Type of Information.....	45
8 – Radio Waves.....	48
Band Definitions.....	48
Propagation.....	49
Ionosphere Regions.....	49
Bands.....	50
9 – Electricity.....	51
Kirchhoff's Law.....	52
Currents.....	52
Voltage.....	52

- Operational Amplifiers.....52
  - Non-inverting.....52
  - Inverting.....52
- Filters & RLC.....53
- Resistor Colors.....54
- 10 – ITU Prefixes Allocation.....56
- 11 – Units.....67
  - International System.....67
    - Base Units.....67
    - Derived Units.....67
    - Prefixes.....68
  - Conversions.....69
  - Physics Constants.....70
  - Decibels.....71
- 12 – Mathematics.....73
  - Algebra.....73
  - Logarithms.....73
  - Trigonometry.....74
  - Table of Values.....74
- 13 – ITU Regions.....76
- 14 – ITU Alphabet.....77
- Document Abbreviations.....78
- References.....79

# 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 infinite symbol, e.g. **1800 — 1850 ∞**.

*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 lozenge symbol, e.g. **7000 — 7200 ◇**.

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

	Band	Region 1	Region 2	Region 3
VHF (MHz)	2m	<b>144 — 146 ◊</b>		
		<i>Forbidden</i>	<b>146 — 148 ∞</b>	<b>146 — 148</b>
	1.35m	<i>Forbidden</i>	<b>220 — 225</b>	<i>Forbidden</i>
UHF (MHz)	70cm	<b>430 — 440</b>	430 — 440	
	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 ◊		
		<i>Forbidden</i>	5.85 — 5.925	<i>Forbidden</i>
	3cm	10 — 10.45		
		10.45 — 10.5 ◊		
	1.2cm	<b>24 — 24.05 ◊</b>		
		24.05 — 24.25		
	6mm	<b>47 — 47.2 ◊</b>		
	4mm	76 — 77.5 ◊		
		<b>77.5 — 78 ◊</b>		
		78 — 81 ◊		
	2.4mm	122.25 — 123		
	2.2mm	<b>134 — 136 ◊</b>		
		136 — 141 ◊		
	1.2mm	241 — 248 ◊		
		<b>248 — 250 ◊</b>		



## 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> <b><i>BW 20 Hz</i></b>  Weak Signal	<b>5366 — 5366.5 kHz</b> <b><i>BW 20 Hz</i></b>  CW, DM	<b>5366 — 5366.5 kHz</b> <b><i>BW 20 Hz</i></b>  Weak Signal

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

**Warning: 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 <u>14300 – Glob EMCOM</u>	<b>14101 — 14350 kHz</b> <i>BW 2700 Hz</i>  All Modes 14195 – DX 14230 – Image CoA 14285 – SSB QRP 14285 – AM QRG <u>14300 – Glob EMCOM</u>	<b>14101 — 14350 kHz</b> <i>BW 2700 Hz</i>  All Modes 14130 – DV CoA 14195 – DX 14230 – Image CoA 14285 – SSB QRP <u>14300 – Glob EMCOM</u>

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>18111 — 18168 kHz</b> <i>BW 2700 Hz</i>  All Modes 21285 – SSB QRP 21340 – Image CoA <u>21360 – Glob. EMCOM</u>	<b>18111 — 18168 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>29590 — 29620 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>  All Modes 50.510 – SSTV 50.530 – FM Internet 50.600 – RTTY 50.630 – DV Calling 51.210 – 51.590 – Repeaters  <u>Wideband</u> <u>Experiments</u> <i>BW unlimited</i>  50.9 – 51.2 51.4 – 52	<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 — 51.11 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> BW 12 kHz  FM, DV 51.110 – 51.980 – Repeaters	

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 144.350 – EME CoA	<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>144.275 — 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	
<b>144.400 — 144.500 MHz</b> <i>BW 500 Hz</i>  Beacons Weak Signals MGM	<b>144.400 — 144.500 MHz</b> <i>BW 500 Hz</i>  CW, DM Beacons	

Region 1	Region 2	Region 3
<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 Digital Modes

The chapter summarizes the typical calling and center-of-activity frequencies for digital modes.

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

Band	FT4	FT8	JS8
<b>160 m</b>		1.840	1.842
<b>80 m</b>	3.575	3.573	3.578
<b>60 m</b>		5.357	
<b>40m</b>	7.0475	7.074	7.078
<b>30 m</b>	10.140	10.136	10.130
<b>20 m</b>	14.080	14.074	14.078
<b>17 m</b>	18.104	18.100	18.104
<b>15 m</b>	21.140	21.074	21.078
<b>12 m</b>	24.919	24.915	24.922
<b>10 m</b>	28.180	28.074	28.078
<b>6 m</b>	50.318	50.313 50.323 (DX)	50.318
<b>2 m</b>	144.170	144.174	144.178
<b>1.25 m</b>		222.065	
<b>70 cm</b>		432.065	

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

Band	JT65	PSK31	RTTY
<b>160 m</b>	1.838	1.838	1.840
<b>80 m</b>	3.570	3.580	3.590
<b>60 m</b>	5.357		
<b>40m</b>	7.076	7.040	7.040
<b>30 m</b>	10.138	10.141	10.140
<b>20 m</b>	14.076	14.070	14.080
<b>17 m</b>	18.102	18.103	18.100
<b>15 m</b>	21.076	21.070	21.080
<b>12 m</b>	24.917	24.920	24.925
<b>10 m</b>	28.076	28.070 28.120	28.080
<b>6 m</b>	50.276	50.305	50.600
<b>2 m</b>	144.120	144.138	144.600
<b>1.25 m</b>			
<b>70 cm</b>	432.065	432.088	432.600
<b>23 cm</b>	1296.065	1296.138	1296.600
<b>13 cm</b>	2301.065	2320.138	

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

Band	WSPR	FST4/W	SSTV
<b>2200 m</b>	0.136	0.136	
<b>630 m</b>	0.4742	0.4742	
<b>160 m</b>	1.8366	1.839 1.8368	
<b>80 m</b>	3.5686		3.733
<b>60 m</b>	5.2872 5.3647		
<b>40m</b>	7.0386		7.058
<b>30 m</b>	10.1387		
<b>20 m</b>	(13.5539) 14.0956		14.233 14.230 (Analogue)
<b>17 m</b>	18.1046		
<b>15 m</b>	21.0946		21.337
<b>12 m</b>	24.9246		
<b>10 m</b>	28.1246		
<b>6 m</b>	50.293		50.510
<b>2 m</b>	144.489		
<b>1.25 m</b>			
<b>70 cm</b>	432.300		
<b>23 cm</b>	1296.500		

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

APRS

Region 1	Region 2	Region 3
144.800 MHz	144.390 MHz  145.010 MHz Caribbean zone	144.800 MHz  144.390 MHz 144.640 MHz
145.825 MHz International Space Station		
432.500 MHz		



## 3 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

• (Dot)	Unit of time
— (Dash)	3 dots (•)
Between — and •	1 dot (•)
Between letters	3 dots (•)
Between words	7 dots (•)

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

## 4 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

## 5 Radio Abbreviations

The complete list of abbreviations from the ITU Rec. M.1172-0.

Abbreviation or signal	Definition
<b>AA</b>	All after ... <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).</i>
<b>AB</b>	All before ... <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).</i>
<b>ADS</b>	Address <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).</i>
<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 ... <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).</i>
<b>BQ</b>	A reply to an RQ.
<b>BT</b>	Signal to mark the separation between different parts of the same transmission.
<b>C</b>	Yes or "The significance of the previous group should be read in the affirmative".
<b>CFM</b>	Confirm (or I confirm).
<b>CL</b>	I am closing my station.
<b>COL</b>	Collate (or I collate).
<b>CORRECTION</b>	Cancel my last word or group. The correct word or group follows <i>(used in radiotelephony, spoken as KOR-REK-SHUN).</i>
<b>CP</b>	General call to two or more specified stations (see Recommendation ITU-R M.1170).
<b>CQ</b>	General call to all stations.
<b>CS</b>	Call sign <i>(used to request a call sign).</i>

Abbreviation or signal	Definition
<b>DE</b>	"From ..." ( <i>used to precede the name or other identification of the calling station</i> ).
<b>DF</b>	Your bearing at ... hours was ... degrees, in the doubtful sector of this station, with a possible error of ... degrees.
<b>DO</b>	Bearing doubtful. Ask for another bearing later ( <i>or at ... hours</i> ).
<b>DSC</b>	Digital selective calling.
<b>E</b>	East (cardinal point).
<b>ETA</b>	Estimated time of arrival.
<b>INTERCO</b>	International Code of Signals groups follow ( <i>used in radiotelephony, spoken as IN-TER-CO</i> ).
<b>K</b>	Invitation to transmit.
<b>KA</b>	Starting signal.
<b>KTS</b>	Nautical miles per hour ( <i>knots</i> ).
<b>MIN</b>	Minute ( <i>or Minutes</i> ).
<b>MSG</b>	Prefix indicating a message to or from the master of a ship concerning its operation or navigation.
<b>MSI</b>	Maritime safety information.
<b>N</b>	North (cardinal point).
<b>NBDP</b>	Narrow-band direct-printing telegraphy.
<b>NIL</b>	I have nothing to send to you.
<b>NO</b>	No ( <i>negative</i> ).
<b>NW</b>	Now.
<b>NX</b>	Notice to Mariners ( <i>or Notice to Mariners follows</i> ).
<b>OK</b>	We agree ( <i>or It is correct</i> ).
<b>OL</b>	Ocean letter.
<b>P</b>	Prefix indicating a private radiotelegram.
<b>PBL</b>	Preamble ( <i>used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition</i> ).
<b>PSE</b>	Please.
<b>R</b>	Received.

Abbreviation or signal	Definition
<b>RCC</b>	Rescue coordination centre.
<b>REF</b>	Reference to ... (or Refer to ...).
<b>RPT</b>	Repeat (or I repeat) (or Repeat ...).
<b>RQ</b>	Indication of a request.
<b>S</b>	South (cardinal point).
<b>SAR</b>	Search and Rescue.
<b>SIG</b>	Signature <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)</i> .
<b>SLT</b>	Radiomaritime Letter.
<b>SVC</b>	Prefix indicating a service telegram.
<b>SYS</b>	Refer to your service telegram.
<b>TFC</b>	Traffic.
<b>TR</b>	Used by a land station to request the position and next port of call of a mobile station; used also as a prefix to the reply.
<b>TU</b>	Thank you.
<b>TXT</b>	Text <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)</i> .
<b>VA</b>	End of work.
<b>W</b>	West (cardinal point).
<b>WA</b>	Word after ... <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)</i> .
<b>WB</b>	Word before ... <i>(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)</i> .
<b>WD</b>	Word(s) or Group(s).
<b>WX</b>	Weather report (or Weather report follows).
<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 Q Codes

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

Code	Question	Answer or Advice
<b>QRA</b>	What is the name of your vessel (or station)?	The name of my vessel (or station) is ...
<b>QRB</b>	How far approximately are you from my station?	The approximate distance between our stations is ... nautical miles (or kilometers).
<b>QRE</b>	What is your estimated time of arrival at ... (or over ...) (place)?	My estimated time of arrival at ... (or over ...) (place) is ... hours.
<b>QRG</b>	Will you tell me my exact frequency (or that of [...])?	Your exact frequency (or that of ...) is ... kHz (or MHz).
<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 ... (name and/or call sign))?	The intelligibility of your signals (or those of ... (name and/or call sign)) 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 ... (name and/or call sign)). Please do not interfere.
<b>QRM</b>	Is my transmission being interfered with?	Your transmission is being interfered with: 1. nil 2. slightly 3. moderately 4. severely 5. extremely.



Code	Question	Answer or Advice
<b>QRN</b>	Are you troubled by static?	I am troubled by static: 1. nil 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 (... words per minute).
<b>QRS</b>	Shall I send more slowly?	Send more slowly (... 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 ... that you are calling him on ... kHz (or MHz)?	Please inform ... that I am calling him on ... kHz (or MHz).
<b>QRX</b>	When will you call me again?	I will call you again at ... hours on ... kHz (or MHz).
<b>QRZ</b>	Who is calling me?	You are being called by ... (on ... kHz(or MHz)).
<b>QSA</b>	What is the strength of my signals (or those of ... (name and/or call sign))?	The strength of your signals (or those of ... (name and/or call sign)) 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.
<b>QSG</b>	Shall I send ... telegrams at a time?	Send ... 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) number(s) ...).

Code	Question	Answer or Advice
<b>QSN</b>	Did you hear me (or ... <i>(name and/or call sign)</i> ) on ... kHz (or MHz)?	I did hear you (or ... <i>(name and/or call sign)</i> ) on ... kHz (or MHz).
<b>QSO</b>	Can you communicate with ... <i>(name and/or call sign)</i> direct (or by relay)?	I can communicate with ... <i>(name and/or call sign)</i> direct (or by relay through ...).
<b>QSP</b>	Will you relay to ... <i>(name and/or call sign)</i> free of charge?	I will relay to ... <i>(name and/or call sign)</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 ... kHz (or MHz) <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>(name and/or call sign(s))</i> on ... kHz (or MHz), or in the bands .../ channels ...?	I am listening to ... <i>(name and/or call sign(s))</i> on ... kHz (or MHz), or in the bands .../ channels ...
<b>QSY</b>	Shall I change to transmission on another frequency?	Change to transmission on another frequency (or on ... kHz (or MHz)).
<b>QTH</b>	What is your position in latitude and longitude <i>(or according to any other indication)</i> ?	My position is ... latitude, ... longitude <i>(or according to any other indication)</i> .
<b>QTJ</b>	What is your speed?	My speed is ... knots (or kilometers per hour or ... statute miles per hour).
<b>QTR</b>	What is the correct time?	The correct time is ... hours.
<b>QTS</b>	Will you send your call sign <i>(and/or name)</i> for ... seconds?	I will send my call sign <i>(and/or name)</i> for ... seconds.
<b>QUA</b>	Have you news of ... <i>(name and/or call sign)</i> ?	Here is news of ... <i>(name and/or call sign)</i> .
<b>QUD</b>	Have you received the urgency signal sent by ... <i>(name and/or call sign)</i> ?	I have received the urgency signal sent by ... <i>(name and/or call sign)</i> at ... hours.

Code	Question	Answer or Advice
<b>QUE</b>	Can you speak in ... ( <i>language</i> ), with interpreter if necessary; if so, on what frequencies?	I can speak in ... ( <i>language</i> ) on ... kHz ( <i>or</i> MHz).

# 7 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
N	Emission of an unmodulated carrier
Amplitude Modulation	
A	Double-sideband
H	Single-sideband, full carrier
R	Single-sideband, reduced or variable level carrier
J	Single-sideband, suppressed carrier
B	Independent sidebands
C	Vestigial sideband
Angle Modulation	
F	Frequency modulation
G	Phase modulation
Amplitude and Angle Modulation	
D	Amplitude and Angle Modulation, simultaneously or in a pre-established sequence
Emission of Pulses	
P	Unmodulated pulses
K	Modulated in amplitude

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

## Nature of signals

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

## Type of Information

Symbol	Definition
<b>N</b>	No information transmitted
<b>A</b>	Telegraphy, aural reception
<b>B</b>	Telegraphy, automatic reception
<b>C</b>	Facsimile
<b>D</b>	Data transmission, telemetry, telecommand
<b>E</b>	Telephony (includes sound broadcasting)
<b>F</b>	Television (video)

Symbol	Definition
W	Combination of the above
X	Not covered



# 8 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	$\lambda = c \cdot \tau$ $\lambda = c \cdot f^{-1}$
Angular Frequency	$\omega = 2 \pi f$
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

*Partially based on the publication: Ionosphere and its Effects on Radiowave Propagation, ITU, 1998.*

### 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 volumes (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 <sup>3</sup> ), 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 <sup>3</sup> ). 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, Groundwave
LF	30 – 300 kHz	Waveguide, Sky-wave, Groundwave
MF	300 – 300 kHz	Sky-wave, Groundwave
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

## 9 Electricity

Ohm's Law	$V = R \cdot I$
Power	$P = V \cdot I$
$N$ resistors in series	$R_{total} = R_1 + \cdots + R_N$
$N$ resistors in parallel	$\frac{1}{R_{total}} = \frac{1}{R_1} + \cdots + \frac{1}{R_N}$
$N$ capacitors in series	$\frac{1}{C_{total}} = \frac{1}{C_1} + \cdots + \frac{1}{C_N}$
$N$ capacitors in parallel	$C_{total} = C_1 + \cdots + C_N$
$N$ inductances in series	$L_{total} = L_1 + \cdots + L_N$
$N$ inductances in parallel	$\frac{1}{L_{total}} = \frac{1}{L_1} + \cdots + \frac{1}{L_N}$
Inductance of a Solenoid	$L = \frac{\mu N^2 A}{l},$ <p>with <math>N</math> the number of turns, <math>A</math> the cross-section of the solenoid, and <math>l</math> the length</p>

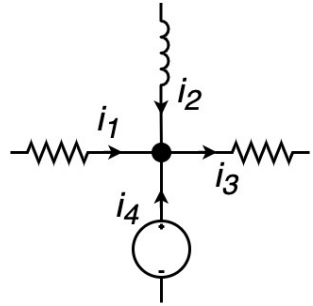
## Kirchhoff's Law

### 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:

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

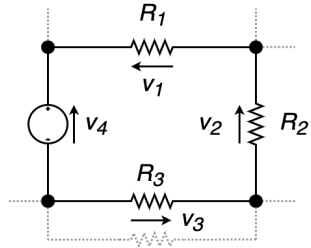


### Voltage

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:

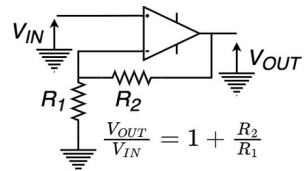
$$-v_1 - v_2 - v_3 + v_4 = 0.$$



## Operational Amplifiers

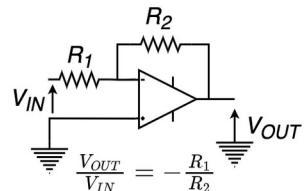
### Non-inverting

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:

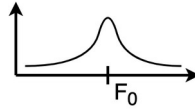
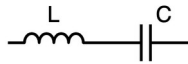
$$F_C = F_0 = \frac{1}{2\pi\sqrt{LC}}.$$

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:

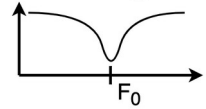
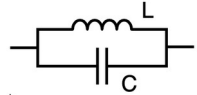
$$Q = \frac{F_0}{BW}, \text{ with the resonance frequency } F_0 \text{ and the bandwidth } BW.$$

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

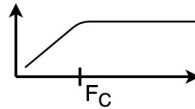
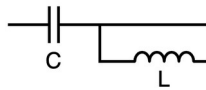
Band Pass



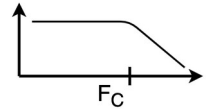
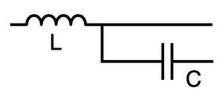
Band Stop



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		$10^{-1}$	$\pm 5\%$



# 10 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>2</sup>*

For instance, **Monaco** has the range **3AA – 3AZ**, so the country is identified with **3A**. If the allocation is wider, as **Spain** with **EEA – 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>2</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>3</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)

3

In accordance with Resolution 99 Rev. Dubai, 2018

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)

# 11 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	$\text{s}^{-1}$
W	Watt	Power	$\text{J} \cdot \text{s}^{-1}$ $\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3}$
C	Coulomb	Electric Charge	$\text{s} \cdot \text{A}$
V	Volt	Electric Potential, Voltage	$\text{W} \cdot \text{A}^{-1}$ $\text{J} \cdot \text{C}^{-1}$ $\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3} \cdot \text{A}^{-1}$
F	Farad	Capacitance	$\text{C} \cdot \text{V}^{-1}$ $\text{kg}^{-1} \cdot \text{m}^{-2} \cdot \text{s}^4 \cdot \text{A}^2$

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  $dB = 10 \cdot \log_{10} \left( P_1 / P_2 \right)$  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





# 12 Mathematics

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

## Algebra

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

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

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

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

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

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

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

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

$$i = \sqrt{-1}$$

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

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

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

$$(a^n)^m = a^{n \cdot m}$$

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

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

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

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

$$i^2 = -1$$

## Logarithms

The function  $\log_b$  denotes the  $b$ -basis logarithm.

$$\log(1)=0$$

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

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

$$\log(ab)=\log(a)+\log(b)$$

$$\log_b(b)=1$$

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

$$\log\left(\frac{a}{b}\right)=\log(a)-\log(b)$$

Trigonometry

Angle (rad)	Sine	Cosine	Tangent
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	N/A
$2\pi/3$	$\sqrt{3}/2$	-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

$$e^{i\pi} = -1$$
$$\pi \approx 3.141592653590$$

$$e^{i\theta} = \cos(\theta) + i\sin(\theta)$$
$$e \approx 2.718281828459$$

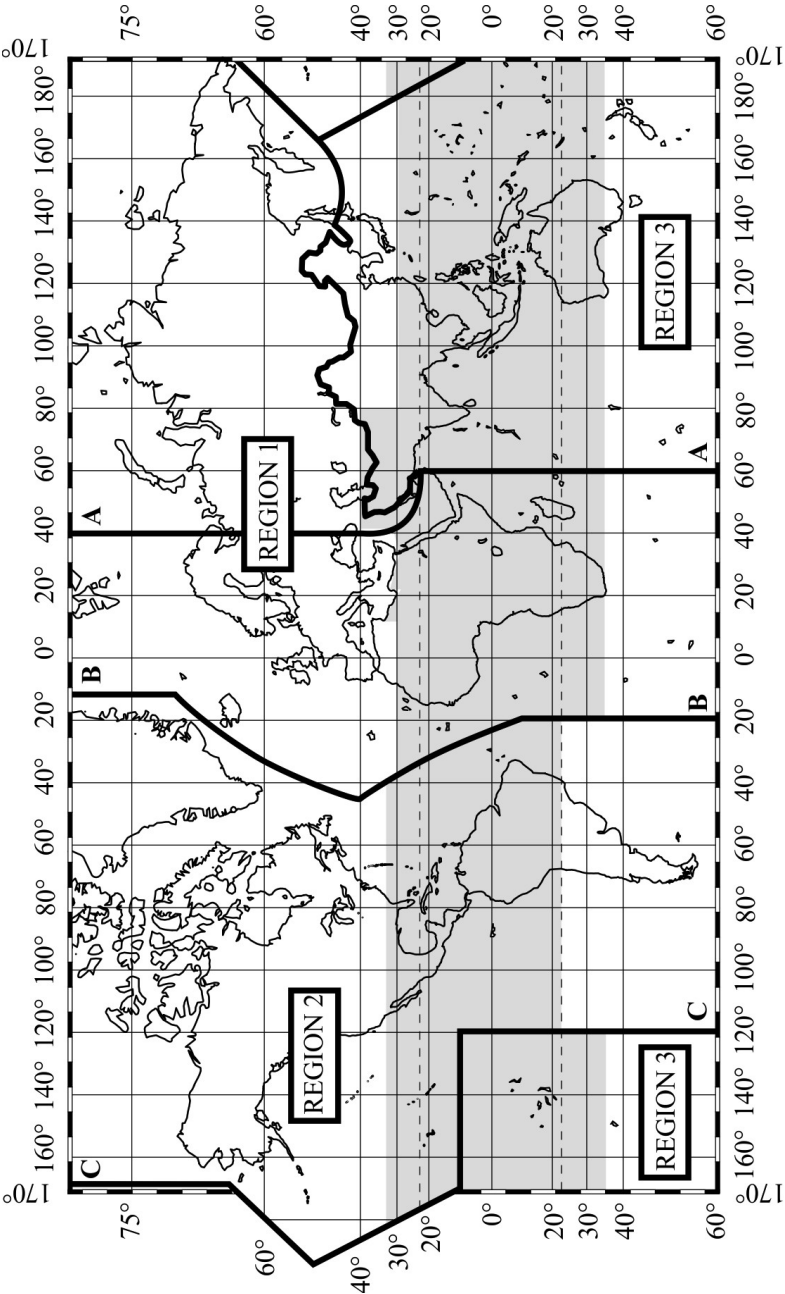
Table of Values

N	$\sqrt{N}$	$\ln(N)$	$\log(N)$
0,01	0,1000	-4,6052	-2,0000
0,1	0,3162	-2,3026	-1,0000
0,2	0,4472	-1,6094	-0,6990
0,3	0,5477	-1,2040	-0,5229
0,4	0,6325	-0,9163	-0,3979
0,5	0,7071	-0,6931	-0,3010
0,6	0,7746	-0,5108	-0,2218
0,7	0,8367	-0,3567	-0,1549
0,8	0,8944	-0,2231	-0,0969
0,9	0,9487	-0,1054	-0,0458
1	1,0000	0,0000	0,0000
2	1,4142	0,6931	0,3010
3	1,7321	1,0986	0,4771
4	2,0000	1,3863	0,6021
5	2,2361	1,6094	0,6990

N	$\sqrt{N}$	$\ln(N)$	$\log(N)$
6	2,4495	1,7918	0,7782
7	2,6458	1,9459	0,8451
8	2,8284	2,0794	0,9031
9	3,0000	2,1972	0,9542
10	3,1623	2,3026	1,0000
20	4,4721	2,9957	1,3010
30	5,4772	3,4012	1,4771
40	6,3246	3,6889	1,6021
50	7,0711	3,9120	1,6990
60	7,7460	4,0943	1,7782
70	8,3666	4,2485	1,8451
80	8,9443	4,3820	1,9031
90	9,4868	4,4998	1,9542
100	10,0000	4,6052	2,0000



# 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.*

# 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
NBM	Narrow Band Mode
Pref.	Preferred
RR	Radio Regulations
SSB	Single Side Band

# 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>