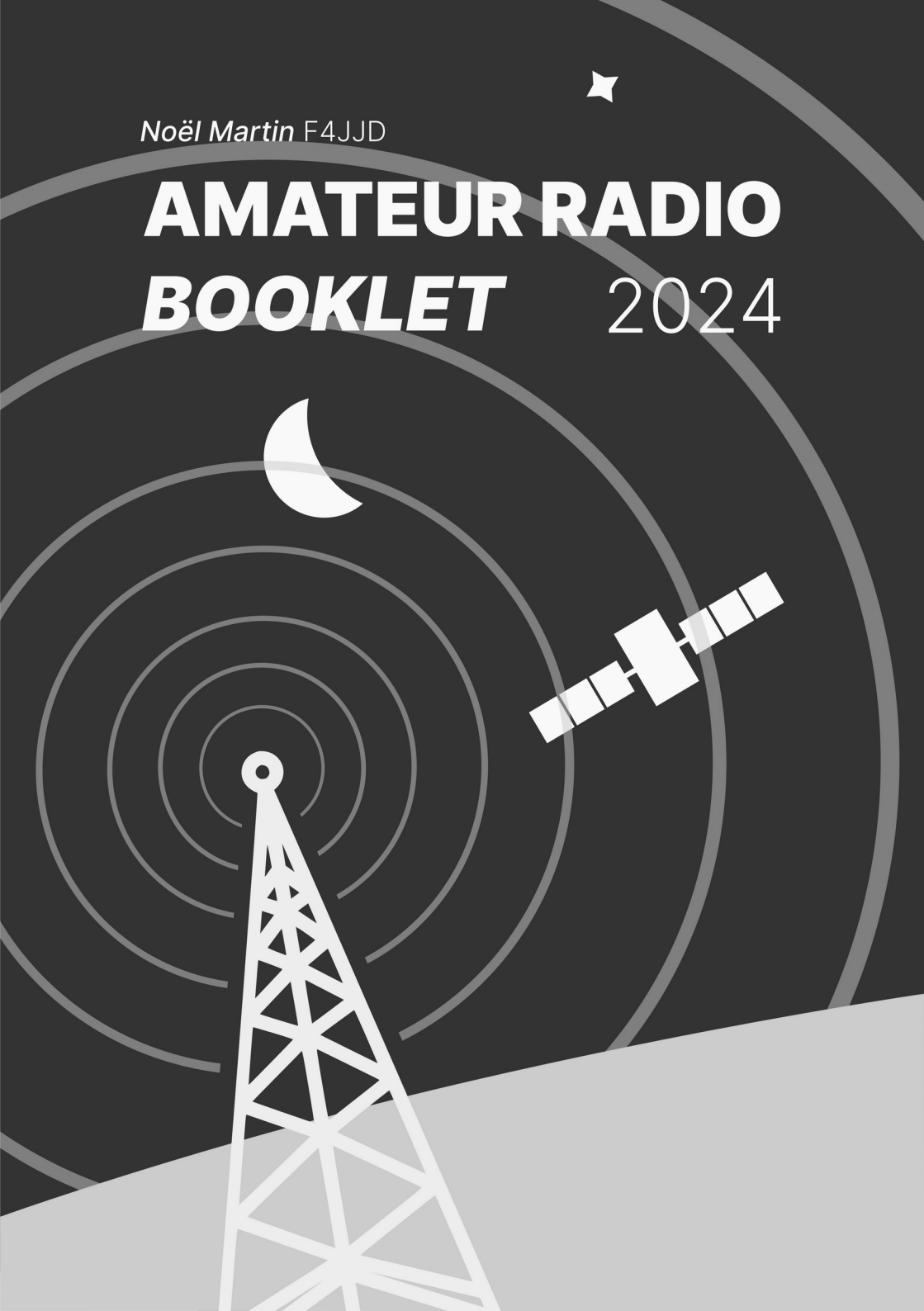
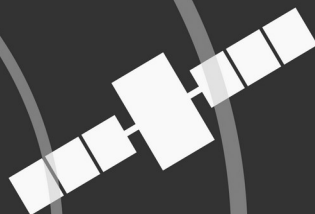


Noël Martin F4JJD



# AMATEUR RADIO *BOOKLET* 2024





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# 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 [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 lozenge symbol, e.g. **7000 — 7200 [S]**.

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

|           | Band                 | Region 1              | Region 2             | Region 3         |  |
|-----------|----------------------|-----------------------|----------------------|------------------|--|
| VHF (MHz) | 2m                   | <b>144 — 146</b> [S]  |                      |                  |  |
|           |                      | <i>Forbidden</i>      | <b>146 — 148</b> [E] | <b>146 — 148</b> |  |
| VHF (MHz) | 1.35m                | <i>Forbidden</i>      | <b>220 — 225</b>     | <i>Forbidden</i> |  |
| UHF (MHz) | 70cm                 | <b>430 — 440</b> [S]  |                      |                  |  |
|           | 33cm                 | <i>Forbidden</i>      | 430 — 440 [S]        | <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 [S]       |                      |                  |  |
|           |                      | <i>Forbidden</i>      | 5.85 — 5.925         | <i>Forbidden</i> |  |
|           | 3cm                  | 10 — 10.45            |                      |                  |  |
|           |                      | 10.45 — 10.5 [S]      |                      |                  |  |
|           | 1.2cm                | <b>24 — 24.05</b> [S] |                      |                  |  |
|           |                      | 24.05 — 24.25         |                      |                  |  |
|           | 6mm                  | <b>47 — 47.2</b> [S]  |                      |                  |  |
|           | 4mm                  | 76 — 77.5 [S]         |                      |                  |  |
|           |                      | <b>77.5 — 78</b> [S]  |                      |                  |  |
|           |                      | 78 — 81 [S]           |                      |                  |  |
|           | 2.4mm                | 122.25 — 123          |                      |                  |  |
|           | 2.2mm                | <b>134 — 136</b> [S]  |                      |                  |  |
|           |                      | 136 — 141 [S]         |                      |                  |  |
| 1.2mm     | 241 — 248 [S]        |                       |                      |                  |  |
|           | <b>248 — 250</b> [S] |                       |                      |                  |  |



## 2200 Meters

| Region 1                                    | Region 2                                     | Region 3                                     |
|---|--|--|
| <b>135.7 — 137.8 kHz</b><br><i>BW 200Hz</i> | <b>135.7 — 137.8 kHz</b><br><i>BW 200 Hz</i> | <b>135.7 — 137.8 kHz</b><br><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><br><i>BW 200 Hz</i> | <b>472 — 479 kHz</b><br><i>BW 500 Hz</i> | <b>472 — 479 kHz</b><br><i>BW 500 Hz</i> |
| CW                                       | CW, DM                                   | CW, DM                                   |
| <b>475 — 479 kHz</b><br><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><br><i>BW 200 Hz</i><br><br>CW<br>1836 – CW QRP | <b>1800 — 1810 kHz</b><br><i>BW 500 Hz</i><br><br>DM                               | <b>1800 — 1830 kHz</b><br><i>BW 200 Hz</i><br><br>CW                               |
| <b>1838 — 1840 kHz</b><br><i>BW 500 Hz</i><br><br>NBM                 | <b>1810 — 1840 kHz</b><br><i>BW 200 Hz</i><br><br>CW, DM<br>1812 – CW QRP CoA      | <b>1830 — 1840 kHz</b><br><i>BW 500Hz</i><br><br>CW (DX), NBM<br>1836 – CW QRP CoA |
| <b>1840 — 1850 kHz</b><br><i>BW 2700 Hz</i><br><br>All Modes          | <b>1840 — 1850 kHz</b><br><i>BW 2700 Hz</i><br><br>CW, DM, SSB (DX)                | <b>1840 — 2000 kHz</b><br><i>BW 2700 Hz</i><br><br>All Modes                       |
|   | <b>1850 — 2000 kHz</b><br><i>BW 2700 Hz</i><br><br>All Modes<br>1910 – SSB QRP CoA |  |

Status: Primary R1, R2, R3

## 80 Meters

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

Status: Primary R1, R2, R3

## 60 Meters

| Region 1  | Region 2   | Region 3  |
|---|--|---|
| <b>5351.5 — 5354 kHz</b><br><i>BW 200 Hz</i><br><br>CW, NBM             | <b>5351.5 — 5354 kHz</b><br><i>BW 500 Hz</i><br><br>CW, DM   | <b>5351.5 — 5354 kHz</b><br><i>BW 500 Hz</i><br><br>CW, NBM, DM         |
| <b>5354 — 5366 kHz</b><br><i>BW 2700 Hz</i><br><br>All Modes, Pref. USB | <b>5354 — 5366 kHz</b><br><i>BW 2700 Hz</i><br><br>All Modes | <b>5354 — 5366 kHz</b><br><i>BW 2700 Hz</i><br><br>All Modes, Pref. USB |
| <b>5366 — 5366.5 kHz</b><br><b>▲ BW 20 Hz</b><br><br>Weak Signal        | <b>5366 — 5366.5 kHz</b><br><b>▲ BW 20 Hz</b><br><br>CW, DM  | <b>5366 — 5366.5 kHz</b><br><b>▲ BW 20 Hz</b><br><br>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  |
|--|---|---|
| <p><b>7000 — 7040 kHz</b><br/> <i>BW 200 Hz</i></p> <p>CW<br/>                     7030 – CW QRP CoA</p>   | <p><b>7000 — 7040 kHz</b><br/> <i>BW 200 Hz</i></p> <p>CW<br/>                     &lt; 7025 – DX<br/>                     7030 – CW QRP CoA</p>  | <p><b>7000 — 7030 kHz</b><br/> <i>BW 200 Hz</i></p> <p>CW</p>   |
| <p><b>7040 — 7050 kHz</b><br/> <i>BW 500 Hz</i></p> <p>NBM, DM</p>   | <p><b>7040 — 7050 kHz</b><br/> <i>BW 500 Hz</i></p> <p>CW, DM</p>   | <p><b>7030 — 7200 kHz</b><br/> <i>BW 2700 Hz</i></p> <p>CW, SSB, DM<br/>                     7030 – QRP CoA<br/>                     7070 – DV CoA<br/>                     7090 – SSB QRP CoA<br/>                     7095 – DX Phone CoA<br/>                     7110 – EMCOM CoA<br/>                     7165 – Image CoA</p> |
| <p><b>7050 — 7200 kHz</b><br/> <i>BW 2700 Hz</i></p> <p>All Modes<br/>                     &lt; 7060 – DM<br/>                     7070 – DV CoA<br/>                     7090 – SSB QRP CoA<br/>                     7110 – EMCOM CoA<br/>                     7165 – Image CoA<br/>                     &gt; 7175 – DX</p> | <p><b>7050 — 7300 kHz</b><br/> <i>BW 2700 Hz</i></p> <p>All Modes<br/>                     7060 – EMCOM CoA<br/>                     7070 – DV CoA<br/>                     7090 – SSB QRP CoA<br/>                     7165 – Image CoA<br/>                     7240 – EMCOM CoA<br/>                     7275 – EMCOM CoA<br/>                     7285 – SSB QRP CoA<br/>                     7290 – AM CoA</p> |   |

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><br><i>BW 200 Hz</i><br><br>CW<br>10116 – CW QRP CoA |   |   |
| <b>10130 — 10150 kHz</b><br><i>BW 500 Hz</i><br><br>NBM, DM                  | <b>10130 — 10140 kHz</b><br><i>BW 500 Hz</i><br><br>CW, DM  | <b>10130 — 10150 kHz</b><br><i>BW 500 Hz</i><br><br>NBM, DM |
|  | <b>10140 — 10150 kHz</b><br><i>BW 2700 Hz</i><br><br>CW, DM |   |

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

## 20 Meters

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

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

Status: Primary and AMSAT R1, R2, R3.



# 15 Meters

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

Status: Primary and AMSAT R1, R2, R3.

## 12 Meters

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

Status: Primary and AMSAT R1, R2, R3.

## 10 Meters

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

**29520 — 29590 kHz***BW 6000 Hz*

All Modes

Repeater Input (RH1 – RH8)

**29590 — 29620 kHz***BW 6000 Hz*

All Modes

Repeaters Simplex

29600 – FM QRG

**29620 — 29700 kHz***BW 6000 Hz*

All Modes

Repeater Output (RH1 – RH8)

Status: Primary and AMSAT R1, R2, R3.

## 6 Meters

| Region 1  | Region 2  | Region 3   |
|---|---|--|
| <p><b>50 — 50.1 MHz</b><br/>BW 500 Hz</p> <p>CW<br/>&lt; 50.010 Beacons</p> <p>50.050 – CoA<br/>50.090 – DX CoA</p>   | <p><b>50 — 50.1 MHz</b><br/>BW 500 Hz</p> <p>CW<br/>50.010 – 50.020 Beacons</p> | <p><b>50 — 50.1 MHz</b><br/>BW 200 Hz</p> <p>CW<br/>50.020 – 50.030 Beacons</p>    |
| <p><b>50.1 — 50.4 MHz</b><br/>BW 2700 Hz</p> <p>CW, SSB, NBM<br/>50.110 – DX CoA<br/>50.305 – PSK CoA<br/>50.315 – EME CoA</p>  |   | <p><b>50.1 — 50.5 MHz</b><br/>BW 2700 Hz</p> <p>CW, SSB, NBM<br/>.110 – DX CoA</p> |
| <p><b>50.4 — 50.5 MHz</b><br/>BW 1000 Hz</p> <p>Beacons<br/><u>50.401 – WSPR</u></p>  | <p><b>50.4 — 50.5 MHz</b><br/>BW 2700 Hz</p> <p>Beacons</p>                     |  |
| <p><b>50.5 — 52 MHz</b><br/>BW 12 kHz</p> <p><u>Unlimited BW</u><br/>50.5 – 50.7<br/>50.9 – 51.2<br/>51.4 – 52</p> <p>All Modes<br/>50.510 – SSTV<br/>50.530 – FM Internet<br/>50.600 – RTTY<br/>50.630 – DV Calling</p> <p><u>Repeaters</u><br/>50.700 – 50.900 Output<br/>51.200 – 51.400 Input</p> | <p><b>50.5 — 50.6 MHz</b><br/>BW 2700 Hz</p> <p>All Modes</p>                   | <p><b>50.5 — 54 MHz</b><br/>BW 25 kHz</p> <p>All Modes</p>                         |
|   | <p><b>50.6 — 51 MHz</b><br/>BW 12 kHz</p> <p>All Modes</p>                      |  |
|   | <p><b>51 — 51.11 MHz</b><br/>BW 2700</p> <p>CW, SSB<br/>DX Window</p>           |  |

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

Status: Primary R1, R2, R3.

## 2 Meters

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

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



# 1.25 Meters

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

## 70 Centimeters

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

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



## 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   |
|--------------|--|
| <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)                        |
| <b>W</b> | Combination of the above                  |

| <b>Symbol</b> | <b>Definition</b> |
|---------------|-------------------|
| <b>X</b>      | 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:<br>1. good<br>2. variable<br>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:<br>1. bad<br>2. poor<br>3. fair<br>4. good<br>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:<br>1. not interfered<br>2. slightly<br>3. moderately<br>4. severely<br>5. extremely.                       |
| <b>QRN</b> | Are you troubled by static?  | I am troubled by static:<br>1. not troubled<br>2. slightly<br>3. moderately<br>4. severely<br>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:<br>1. scarcely perceptible<br>2. weak<br>3. fairly good<br>4. good<br>5. very good. |
| <b>QSB</b> | Are my signals fading?   | Your signals are fading.   |

| <b>Code</b> | <b>Question</b>   | <b>Answer or Advice</b>   |
|-------------|---|---|
| <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 ( <i>or</i> some previous telegram)?                            | Repeat the last telegram which you sent me ( <i>or</i> telegram(s) [ <i>numbers</i> ]).   |
| <b>QSN</b>  | Did you hear me ( <i>or</i> [ <i>callsign</i> ]) on [ <i>frequency</i> ]?   | I did hear you ( <i>or</i> [ <i>callsign</i> ]) on [ <i>frequency</i> ].  |
| <b>QSO</b>  | Can you communicate with [ <i>callsign</i> ] direct ( <i>or</i> by relay)?  | I can communicate with [ <i>callsign</i> ] direct ( <i>or</i> 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 ( <i>or</i> 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 ( <i>or according to any other indication</i> )?                  | My position is [ <i>latitude</i> ], [ <i>longitude</i> ] ( <i>or</i> [ <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  |
|------------|--|---|
| <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 [ <i>frequency</i> ]. |

## 4 Morse Code

A ·—

B —···

C —·—·

D —···

E ·

F ··—·

G ——·

H ····

I ··

J ·— — —

K —·—

L ·—··

M — —

1 · — — — —

2 ·· — — —

3 ··· — —

4 ···· —

5 ·····

N —·

O — — —

P · — — ·

Q — — · —

R · — ·

S ···

T —

U ·· —

V ··· —

W · — —

X — · · —

Y — · — —

Z — — · ·

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

|                             |              |
|-----------------------------|--------------|
| • DIT (dot)                 | Unit of time |
| — Dah (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>              | "From ..." ( <i>used to precede the name or other identification of the calling station</i> ) |
| <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)  |

| <b>Abbreviation<br/>or signal</b> | <b>Definition</b>  |
|-----------------------------------|--|
| <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 It is correct</i> )   |
| <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          | 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<br>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.*

| <b>Band</b>   | <b>JT65</b> | <b>PSK31</b>     | <b>RTTY</b> |
|---------------|-------------|------------------|-------------|
| <b>2200m</b>  | 0.13613     |                  |             |
| <b>630m</b>   |             |                  |             |
| <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<br>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.*

| <b>Band</b>   | <b>WSPR</b>      | <b>FST4/W</b>   | <b>SSTV</b>                    |
|---------------|------------------|-----------------|--------------------------------|
| <b>2200 m</b> | 0.136            | 0.136           |                                |
| <b>630 m</b>  | 0.4742           | 0.4742          |                                |
| <b>160 m</b>  | 1.8366           | 1.839<br>1.8368 |                                |
| <b>80 m</b>   | 3.5686           |                 | 3.733                          |
| <b>60 m</b>   | 5.2872<br>5.3647 |                 |                                |
| <b>40m</b>    | 7.0386           |                 | 7.058                          |
| <b>30 m</b>   | 10.1386          |                 |                                |
| <b>20 m</b>   | 14.0956          |                 | 14.233<br>14.230<br>(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>    | 50.2937          |                 | 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.*



# 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   | <b>7000 — 7100</b>   |           |          |
| 20m   | <b>14000 — 14250</b> |           |          |
| 17m   | <b>18068 — 18168</b> |           |          |
| 15m   | <b>21000 — 21450</b> |           |          |
| 12m   | <b>24890 — 24990</b> |           |          |
| 10m   | <b>28000 — 29700</b> |           |          |
| 2m    | <b>144 — 146</b>     |           |          |
| 70cm  | <b>430 — 440</b>     | 430 — 440 |          |
| 5cm   | 5.83 — 5.85          |           |          |
| 3cm   | 10.45 — 10.5         |           |          |
| 1.2cm | <b>24 — 24.05</b>    |           |          |
| 6mm   | <b>47 — 47.2</b>     |           |          |
| 4mm   | 76 — 77.5            |           |          |
|       | <b>77.5 — 78</b>     |           |          |
|       | 78 — 81              |           |          |
| 2.2mm | <b>134 — 136</b>     |           |          |
|       | 136 — 141            |           |          |
| 1.2mm | 241 — 248            |           |          |
|       | <b>248 — 250</b>     |           |          |

## Internation Space Station

| Mode             | Uplink (MHz)                     | Downlink (MHz) |
|------------------|----------------------------------|----------------|
| Voice            | 145.200 (R1)<br>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><br>▲ Guard Band              | N/A                 | 10489.500 — 10489.505 |
| <b>CW</b>                                     | 2400.005 — 2400.040 | 10489.505 — 10489.540 |
| <b>Digimodes</b><br><i>BW 500 Hz</i>          | 2400.040 — 2400.080 | 10489.540 — 10489.580 |
| <b>Digimodes</b><br><i>BW 2700 Hz</i>         | 2400.080 — 2400.150 | 10489.580 — 10489.650 |
| <b>SSB</b><br><i>BW 2700 Hz</i>               | 2400.150 — 2400.245 | 10489.650 — 10489.745 |
| <b>PSK Beacon</b> (400 bit/s)<br>▲ Guard Band | N/A                 | 10489.745 — 10489.755 |
| <b>SSB</b><br><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><br><i>BW 2700 Hz</i>       | 2400.365 — 2400.495 | 10489.865 — 10489.995 |
| <b>Experimental Beacon</b><br>▲ 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 |

| <b>Callsign</b> | <b>Country</b> | <b>QTH</b> | <b>Grid</b> |
|-----------------|----------------|------------|-------------|
| <b>YV5B</b>     | Venezuela      | Caracas    | FJ69cc      |

## Frequencies

| <b>Band</b> | <b>Frequency (MHz)</b> |
|-------------|------------------------|
| 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                         | $\lambda = c \cdot \tau$<br>$\lambda = c \cdot f^{-1}$<br>$\lambda(\text{m}) \approx \frac{299}{f(\text{MHz})}$ |
| Angular Frequency<br>(or pulsation) | $\omega = 2\pi f$   |
| Angular Wave Vector                 | $k = 2\pi\lambda$   |

### Band Definitions

| Symbol | Frequency range<br>(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<br>Reflects: VLF, LF<br><br>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<br><br>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<br><br>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<br><br>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<br>< 12 MHz, favored the night<br>12 – 19 MHz, all day band<br>> 19 MHz, favored the day |
| VHF  | 30 – 300 MHz  | Line-of-sight<br>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<br>SN<br>SSN | Wolf Number<br><br><i>Sunspot Number</i><br><i>Smoothed Sunspot Number</i> | Relative measurement of the number of sunspots. <i>Between 0 and 250.</i><br><br>It indicates the activity of the Sun, the higher when the Sun cycle (11 years) is at its maximum.<br><br>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).<br><br>The bigger the higher optimal frequency. |

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

## 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 (dB <sub>i</sub> )      |
|------------------|-----------------------------------|-----------------------------|------------------------------|
| 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 |
|----------------------------|---|------|---|------|------|------|---|
| + $\Delta$ dB <sub>i</sub> | 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...). A matched load is defined by a ratio of 1:1. Between two loads, the SWR is defined as:

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

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:

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

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

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

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  | $\frac{1}{R_{tot}} = \frac{1}{R_1} + \dots + \frac{1}{R_N}$ | $C_{tot} = C_1 + \dots + C_N$                               | $\frac{1}{L_{tot}} = \frac{1}{L_1} + \dots + \frac{1}{L_N}$ |

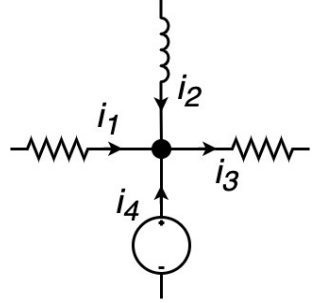
|                          |   |
|--------------------------|---|
| Ohm's Law                | $V = R \cdot I$ , with $V$ the tension, $R$ the resistance, and $I$ the current.                                    |
| Power                    | $P = V \cdot I$   |
| Inductance of a solenoid | $L = \frac{\mu N^2 A}{l}$ , 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:  $\sum_{k=0}^K I_k = 0$ .

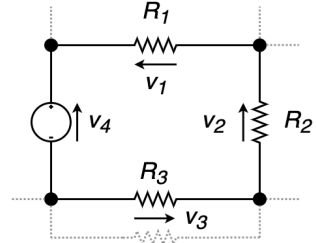
For instance on the figure, the law reads as:  
 $i_1 + i_2 - i_3 + i_4 = 0$ .



### Voltage

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

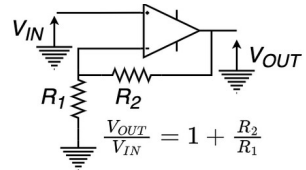
For instance on the figure, the law reads as:  
 $-v_1 - v_2 - v_3 + v_4 = 0$ .



## Operational Amplifiers

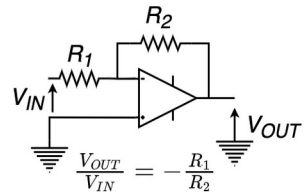
### Non-inverting

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:

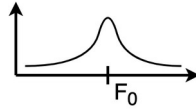
$$F_C = F_0 = \frac{1}{2\pi\sqrt{LC}} .$$

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:

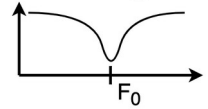
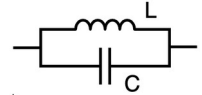
$Q = \frac{F_0}{BW}$ , with the resonance frequency  $F_0$  and the bandwidth  $BW$ .

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

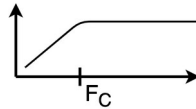
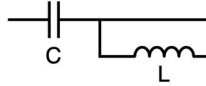
Band Pass



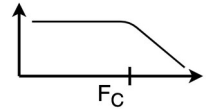
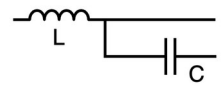
Band Stop



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>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 **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>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)                           |
| 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)  |

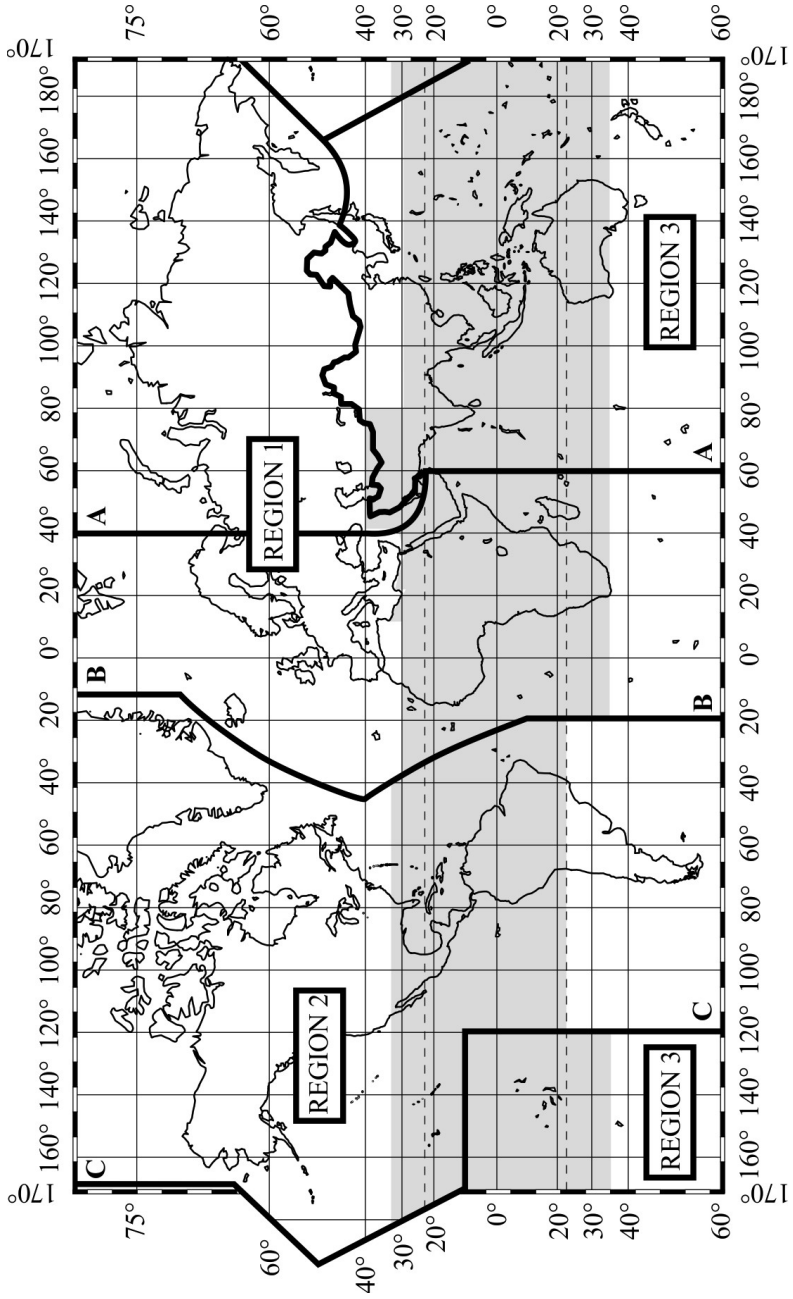
|           |                                       |
|-----------|---------------------------------------|
| T4A – T4Z | Cuba                                  |
| T5A – T5Z | Somalia (Federal Republic of)         |
| T6A – T6Z | Afghanistan                           |
| T7A – T7Z | San Marino (Republic 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



5-01





# 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     |

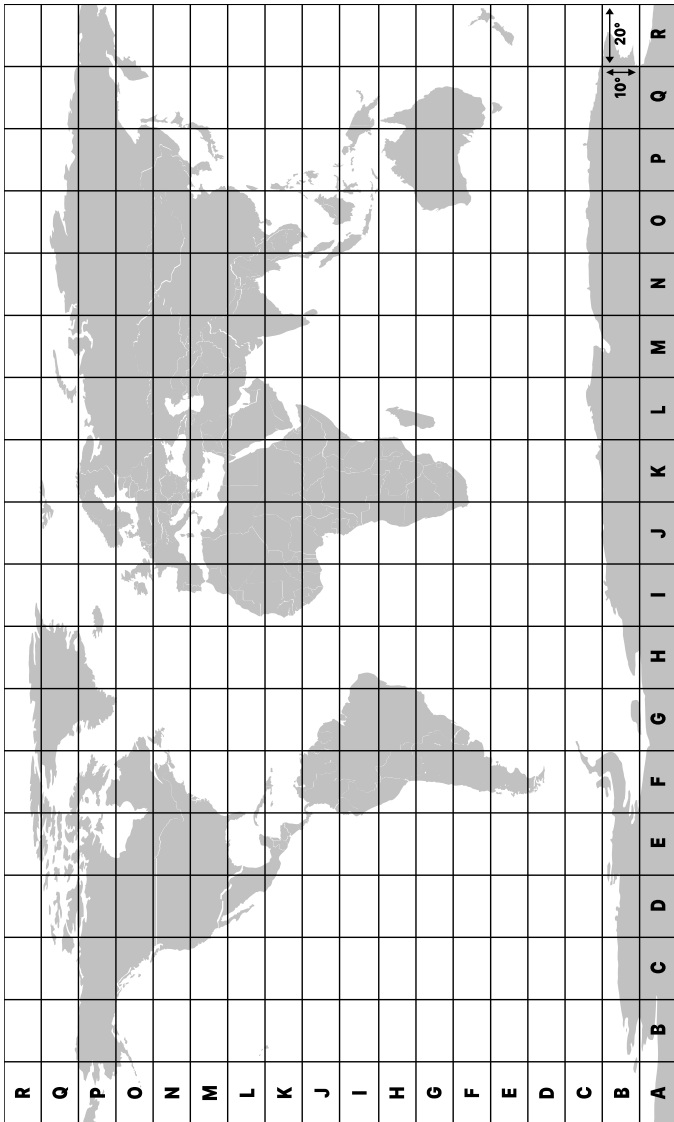
*Widespread usage, occasionally replaced by country names.*

|          |            |          |            |
|----------|------------|----------|------------|
| <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.*



# 15 QTH Locator



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                       | $J \cdot s^{-1}$<br>$kg \cdot m^2 \cdot s^{-3}$                                  |
| C      | Coulomb | Electric Charge             | $s \cdot A$  |
| V      | Volt    | Electric Potential, Voltage | $W \cdot A^{-1}$<br>$J \cdot C^{-1}$<br>$kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}$ |
| F      | Farad   | Capacitance                 | $C \cdot V^{-1}$<br>$kg^{-1} \cdot m^{-2} \cdot s^4 \cdot A^2$                   |

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

## 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

| <b>Length</b>  |                         |
|----------------|-------------------------|
| 1 inch         | 25.4 mm                 |
| 1 feet         | 0.3048 m                |
| 1 yard         | 0.9144 m                |
| 1 mile         | 1.61 m                  |
| <b>Time</b>    |                         |
| 1 day          | 86400 s                 |
| 1 hour         | 3600 s                  |
| 1 minute       | 60 s                    |
| <b>Speed</b>   |                         |
| 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              |
| <b>Surface</b> |                         |
| 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>   |
| <b>Power</b>   |                         |
| 1 Wh           | 3600 J                  |
| 1 cal          | 4.184 J                 |
| <b>Mass</b>    |                         |
| 1 pound        | 0.454 kg                |
| 1 ounce        | 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<br>$^{\circ}\text{K} = 273.15 + ^{\circ}\text{C}$                   |
| 0° Fahrenheit | 255.372 Kelvin<br>$^{\circ}\text{K} = (^{\circ}\text{F} - 32) \cdot 5/9 + 273.15$ |
| Data          |   |
| 1 B (byte)    | 8 b (bits)  |
| 1 kB          | 1000 B<br>$10^3 \text{ B}$  |
| 1 kiB         | 1024 B<br>$2^{10} \text{ B}$  |
| Angle         |   |
| 30 deg        | $\pi/6 \text{ rad}$   |
| 45 deg        | $\pi/4 \text{ rad}$   |
| 60 deg        | $\pi/3 \text{ rad}$   |
| 90 deg        | $\pi/2 \text{ rad}$   |
| 180 deg       | $\pi \text{ rad}$   |
| 360 deg       | $2\pi \text{ rad}$  |

## 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 | $376.7 \Omega$  |
| $\epsilon_0 = 1/\mu_0 c^2$ | 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 |
| NBM          | Narrow Band Mode                      |
| Pref.        | Preferred                             |
| RR           | Radio Regulations                     |
| SSB          | Single Side Band                      |



# 19 References

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