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**APT REPORT**

**on**

**information of mobile operators’ frequencies, technologies and license durations**

**in Asia pacific countries**

No. **APT/AWG/REP-15
(Rev. 1)**

Edition: March 2013

**Adopted by**

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| logogreen | ASIA-PACIFIC TELECOMMUNITY |
| **APT Wireless Group (AWG)**  |  |
|  |  |

SOURCE: AWG14/OUT-05

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1. **Introduction**

APT Wireless Forum[[1]](#footnote-1) (AWF) has started to develop the APT Frequency Information System (AFIS) based on the APT Recommendation “The APT Spectrum Database- Guidelines for Constructing and Maintaining the APT Frequency Information system(AFIS)” which was approved in 2006. The sharing of information on frequency allocation and spectrum usages will be beneficial to reach harmonization on spectrum usages among APT member countries. However, especially for IMT mobile usage, information on operators’ frequencies, technologies and license duration of each country is essential to achieve global/regional roaming with the purpose of improving economies of scale and is also very useful in considering migration path of IMT technologies in view of the situation in other countries.

In this regard, at the 7th meeting of AWF, it was agreed to develop an APT Report on information of mobile operators’ frequencies, technologies and license durations in Asia Pacific countries and also to develop a Questionnaire on information in relation to all terrestrial mobile operators, which was completed during the meeting. The first edition of the APT Report was adopted in the 9th meeting of AWF in September 2010. This APT Report was further updated to reflect the latest state of additional frequency bands released for terrestrial mobile cellular networks in some APT countries.

This APT report is a compilation of responses to the Questionnaire and would provide useful information to APT members and could be used for AFIS depending on the scope.

1. **Questionnaire and Responses**
	1. **Questionnaire**

Questionnaire sent out to each of the APT Member Administration is shown below.

***Question 1*:** What frequency band(s) is/are used for mobile technology (e.g. GSM, CDMA, IMT-2000, BWA) in your country/region?

***Question 2:*** Which operator is using the frequency band(s) mentioned in Question 1 with what kind of technology mentioned in Question 1? Please provide operator name, detailed frequency band(s), used technology and license duration.

**2.2 APT member countries that submitted responses to APT during the development of this Report**

The following member countries provided their responses to the Questionnaire.

1. Afghanistan**,** Islamic Republic of (as of January 2010)
2. Australia
3. Bangladesh (as of January 2010)
4. Cambodia (as of January 2010)
5. China, People’s Republic of
6. India, Republic of (as of January 2010)
7. Indonesia, Republic of
8. Iran, Islamic Republic of [[2]](#footnote-2) (as of January 2010)
9. Japan
10. Korea, Republic of
11. Macao, China (as of January 2010)
12. Malaysia (as of January 2010)
13. Micronesia, The Federated States of (as of January 2010)
14. Mongolia (as of January 2010)
15. Myanmar, The Union of (as of January 2010)
16. New Zealand
17. Palau (as of January 2010)
18. Papua New Guinea (as of January 2010)
19. Thailand (as of January 2010)
20. Vietnam, Socialist Republic of
	1. **Responses to Question 1**

|  |  |
| --- | --- |
| **Technology** | **Frequency Band (MHz)** |

|  |
| --- |
| Afghanistan (Islamic Republic of) |
| CDMA800 | 826.110 – 834.735 / 871.110 – 879.735 |
| P-GSM900 | 890.200 – 915.000 / 935.200 – 959.800 |
| E-GSM900 | 880.200 – 884.200 / 925.200 – 929.200 |
| GSM1800 | 1710.200 – 1748.400 / 1805.200 – 1843.400 |
| BWA | 2400 – 2500 / 3400 – 3600 |
| IMT 2000 | 1885 – 2025 / 2110 – 2200 |

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| --- |
| Australia |
| UMTS (WCDMA) 800 | 825 – 845 / 870 – 890 |
| GSM900 | 890 – 915 / 935 – 960 |
| UMTS (WCDMA) 900 | 900 – 915 / 945 – 960 |
| GSM1800 | 1710 – 1785 / 1805 –1880 |
| LTE1800 | 1710 – 1785 / 1805 – 1880 |
| UMTS(WCDMA) 2100 | 1920 – 1980 / 2110 – 2170 |
| WiMAX / TD-LTE | 2300 – 2400 |

|  |
| --- |
| Bangladesh |
| CDMA450 | 450 – 455 / 460 – 465 |
| CDMA800 | 825 – 845 / 870 – 890 |
| E-GSM | 880 – 890 / 925 – 935 |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |
| CDMA2000 | 1890 – 1910 / 1970 – 1990 |
| BWA systems (Mobile WiMAX) | 2330 – 2400 TDD |
| BWA systems (Mobile WiMAX) | 2585 – 2620 TDD |

|  |
| --- |
| Cambodia |
| CDMA450 | 453 – 457.5 / 463 – 467.5 |
| CDMA800 | 824 – 829.4 / 869 – 874.4 |
| EGSM900 | 880 – 915 / 925 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |
| UMTS(WCDMA)2100 | 1920 – 1980/2110 – 2170 |

|  |
| --- |
| China (People’s Republic of) |
| CDMA800 | 825 – 835 / 870 – 880 |
| GSM900 | 889 – 915 / 934 – 960 |
| GSM1800 | 1710 – 1755 / 1805 – 1850 |
| IMT | 1755-1785 / 1850-1880 |
| CDMA2000 | 1920 – 1935/2110 – 2125 |
| IMT | 1935-1940 / 2125-2130 |
| UMTS(WCDMA) | 1940 – 1955/2130 – 2145 |
| IMT | 1955 –1980 / 2145-2170 |
| TD-SCDMA | 1880 –1900 TDD |
| IMT | 1900 – 1920 TDD |
| TD-SCDMA | 2010 – 2025 TDD |
| TD-SCDMA | 2300 – 2400 TDD  |
| IMT | 2500 – 2690 TDD |

|  |
| --- |
| India (Republic of) |
| CDMA800 | 824 – 844 / 869 – 889 |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |

|  |
| --- |
| Indonesia (Republic of) |
| CDMA450 | 450 – 457.5 / 460 – 467.5 |
| CDMA800 | 824.265 – 844.515/ 869.265 – 889.515 |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |
| UMTS(WCDMA)2100 | 1920 – 1970 / 2110 – 2160 |
| CDMA1900 | 1903.125 – 1910 / 1983.125 – 1990 |
| BWA(TDD) | 2360 – 2390 |

|  |
| --- |
| Iran (Islamic Republic of) |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1725.1 – 1739.9 / 1820.1 – 1834.9 |
| GSM1800 | 1770 – 1785 / 1865 – 1880 |
| BWA | 3400 – 3500 / 3500 – 3600 |
| BWA | 3600 – 3621 / 3700 – 3721 |

|  |
| --- |
| Japan |
| UMTS (WCDMA)800 / CDMA800 | 815 – 845 / 860 – 890 |
| UMTS (WCDMA)900 | 905 – 910 / 945 – 950 |
| UMTS (WCDMA)1500 | 1427.9 – 1462.9 / 1475.9 – 1510.9 |
| UMTS (WCDMA)1700 | 1749.9 – 1784.9 / 1844.9 – 1879.9 |
| UMTS (WCDMA)2100/CDMA 2000 | 1920 – 1980 / 2110 – 2170 |
| PHS | 1884.5 – 1915.7 (TDD) |
| BWA systems (WiMAX, XGP) | 2545 – 2575 (TDD)2595 – 2625 (TDD) |

|  |
| --- |
| Korea (Republic of) |
| CDMA800 | 824 – 829 / 869 – 874 |
|  |  |
| CDMA | 1770 – 1780 / 1860 - 1870 |
| UMTS(WCDMA)2100 | 1930 – 1940 / 2120 - 21301940 - 1960 / 2130 – 21501960 – 1980 / 2150 – 2170 |
| Mobile WiMAX (WiBro) | 2300 – 23272330 - 2360 |
| LTE | 829 – 839 / 874 – 884839 – 849 / 884 - 8941755 – 1765 / 1850 – 1860950 – 915 / 950 – 9601745 – 1755 / 1840 - 1850 1920 – 1930 / 2110 -2120 |
| TBD | 819 – 824 / 864 - 869 |

|  |
| --- |
| Macao (China) |
| CDMA800 | 825 – 845/870 – 890 |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |
| UMTS(WCDMA)2100 | 1920 – 1980 / 2110 – 2170 |

|  |
| --- |
| Malaysia |
| E-GSM900 | 880 – 890 / 925 – 935 |
| P-GSM900 | 890 – 915 / 935 – 960  |
| GSM1800 | 1710 – 1785/ 1805 – 1880 |
| UMTS(WCDMA)2100 | 1920 – 1980/ 2110 – 21701900 – 1920 (TDD)2010 – 2025 (TDD) |
| BWA(WiMAX) | 2300 – 2400 (TDD) |

|  |
| --- |
| Micronesia (The Federated States of) |
| GSM900 | 890 – 902 / 935 – 947 |

|  |
| --- |
| Mongolia |
| CDMA450 | 450 – 460 / 460 – 470 |
| CDMA800 | 824 – 849 / 869 – 894 |
| CDMA1800 | 1850 – 1865 / 1930 – 19451880 – 1885 / 1960 – 1965 |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |
| 3G/WCDMA | 1920 – 2170 |
| BWA(WiMAX) | 3400 – 3600(TDD) |

|  |
| --- |
| Myanmar (The Union of) |
| CDMA450 | 453 – 457/465 – 468 |
| CDMA800 / TDMA800(DAMPS) | 825 – 845 / 870 – 890 |
| GSM900 | 890 – 915/ 935 – 960 |
| DECT | 1800 – 1900/1800 – 1900 |
| WCDMA | 1920 – 1980/2110 – 2170 |

|  |
| --- |
| New Zealand |
| UMTS850 | 825 – 840 / 870 – 885 |
| GSM900 | 890 – 915/ 935 – 960 |
| GSM1800 / LTE1800 | 1710 – 1785/ 1805 – 1880 |
| UMTS(WCDMA)2100 | 1920 – 1980/ 2110 – 2170 |

|  |
| --- |
| Palau |
| GSM900 | 890 – 915/ 935 – 960 |
| GSM1800 | 1710 – 1715/ 1805 – 1810 |

|  |
| --- |
| Papua New Guinea |
| EGSM | 880 – 889.80 / 925 – 934.80 |
| PGSM | 890 – 914.80 / 935 – 959.80 |
| GSM1800 | 1700 – 1720 / 1805 – 1820 |
| CDMA | 824 – 835 / 869 – 880 |
| WiMAX |  2330 – 2360 |
| WiMAX | 3400 – 3500 |

|  |
| --- |
| Thailand |
| CDMA2000 1X | 479 – 483.5 / 489 – 493.5 |
| CDMA2000 1X EV-DO/HSPA | 824 – 839 / 869 – 884 |
| AMPS800/HSPA | 839 – 849 / 884 – 894 |
| GSM900/HSPA | 897.5 – 915 / 942.5 – 960 |
| GSM1800 | 1710 – 1785 / 1805 – 1880 |
| IMT | 1920 – 1980 / 2110 – 21702010 – 2025 |
| BWA | 2300 – 24002500 – 2690 |

|  |
| --- |
| Vietnam (Socialist Republic of)  |
| CDMA 450 | 453.08 – 457.37 / 463.08 – 467.37 |
| CDMA800 | 824 – 835 / 869 – 880 |
| eGSM900 | 880 – 890 / 925 – 935 |
| GSM900 | 890 – 915 / 935 – 960 |
| GSM1800 | 1710 – 1785 / 1805 –1880 |
| IMT 2000 | 1920 – 1980 / 2110 – 2170 |

* 1. **Responses to Question 2**
1. **Afghanistan, Islamic Republic of**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band (MHz)** | **Technology** | **License duration** |
| **Uplink** | **Downlink** |
| AWCC  | 829.200 - 898.000 | 935.200 - 943.000 | P-GSM 900 | Period:15 years10 July 2003 – 9 July 2018 |
| 1730.200-1736.000 | 1825.200-1831.000 | GSM 1800 |
| TDCA  | 898.400 - 906.200  | 934.000 - 951.200 | P-GSM 900 | Period:15 years09 Jan 2003 –­08 Jan 2018 |
| 1742.600-1748.400 | 1837.600-1843.400 | GSM 1800  |
| MTN  | 906.000 - 910.600 | 951.600 - 955.600 | P-GSM 900 | Period:15 years12 Oct 2005 – 11 Oct 2020 |
| 1710.200-1719.800 | 1805.200-1814.800 | GSM 1800 |
| ETTISALAT | 911.000 - 915.000 | 956.000 - 959.800 | P-GSM 900 | Period:15 years30 May 2006 – 29 May 2021 |
| 880.200 - 884.200 | 925.200 - 929.200 | E-GSM 900 |
| 1720.200-1729.800 | 1815.200-1824.800 | GSM 1800 |
| AFGHAN TELECOM  | 826.110 - 829.800 | 871.110 - 874.800 | CDMA 800 | Period:15 years19 April 2006 – 18 April 2021  |
| WASEL TELECOM  | 831.045 - 834.735 | 876.045 - 879.735 | CDMA 800 | Period:15 years18 May 2006 – 17 May 2021  |

Note: Afghanistan Telecommunications Regulatory Authority (ATRA) has not awarded any license for BWA and IMT-2000 since January 2010 in Afghanistan.

1. **Australia**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology** **(Note)** | **License duration** | **Comments** |
| **Uplink** | **Downlink** |
| Telstra Corporation Limited | 830-845 | 875-890 | UMTS(WCDMA)800 | Period:15 yearsExpiration:17 June 2013 | Regional, Remote andCity Areas |
| 890-898.4 | 935-943.4 | GSM 900 | Issued on an annual basis until completion of 803-960 MHz review (previously       5 years) | Australia wide |
| 1710-1725 | 1805-1820 | GSM1800/ LTE1800 | Period:15 yearsExpiration:17 June 2013 | Regional and City areas |
| 1730-1735 | 1825-1830 | GSM1800 | Period:15 yearsExpiration:17 June 2013 | Major cities |
| 1755-1775 | 1850-1870 | GSM1800 | Period:15 yearsExpiration:3 May 2015 | Major cities |
| 1935-1975 | 2125-2165 | UMTS(WCDMA)800 | Period:15 yearsExpiration:11 Oct. 2017 | Major cities and regional |
| Vodafone Hutchison Australia Pty Ltd  | 825-835 | 870-880 | UMTS(WCDMA)800 | Period:15 yearsExpiration:17 June 2013 | Regional, Remote and City Areas. |
| 906.7-915.1 | 951.7-960.1 | GSM 900 / UMTS(WCDMA)900 | Issued on an annual basis until completion of 803-960 MHz review (previously       5 years) | Australia wide |
| 1710-1745 | 1805-1840 | GSM 1800 | Period:15 yearsExpiration:17 June 2013 | Major cities |
| 1755-1782.5 | 1850-1877.5 | GSM 1800 | Period:15 yearsExpiration:3 May 2015 | Major cities |
| 1920-1935 | 2110-2125 | UMTS(WCDMA)2100 | Period:15 yearsExpiration:11 Oct.2017 | Major cities |
| 1970-1980 | 2160-2170 | UMTS(WCDMA)2100 | Period:15 yearsExpiration:11 Oct.2017 | Major cities and regional |
| Singtel Optus Pty Ltd | 898.4-906.8  | 943.4-951.8 | GSM 900 / UMTS(WCDMA)900 | Issued on an annual basis until completion of 803-960 MHz review (previously       5 years) | Australia wide |
| 1722.5-1755  | 1817.5-1850 | GSM 1800 | Period:15 yearsExpiration:17 June 2013 | Major cities |
| 1940-1965 | 2130-2155 | UMTS(WCDMA)2100 | Period:15 yearsExpiration:11 Oct.2017 | Major cities and regional |
| Rail Corporation New South Wales | 1727.5-1730  | 1822.5-1825 | GSM-R 1800 | Period:15 yearsExpiration: 17 June 2013 | Major city |
| 1772.5-1785 | 1867.5-1880 | GSM-R 1800 | Period:15 yearsExpiration: 1 May 2015 | Major city |
| Public Transport Authority of Western Australia | 1770-1785 | 1865-1870 | – | Period:15 yearsExpiration: 17 June 2013 | Major city |
| 1775-1785 | 1870-1880 | – | Period:15 yearsExpiration: 1 May 2015 | Major city |
| TransAdelaide | 1732.5-1735 | 1827.5-1830 | – | Period:15 yearsExpiration: 17 June 2013 | Major city |
| 1770-1785 | 1865-1870 | – | Period:15 yearsExpiration: 1 May 2015 | Major city |
| QR Network Pty Ltd | 1727.5-1732.5 | 1822.5-1827.5 | GSM-R 1800 | Period:15 yearsExpiration: 17 June 2013 | Major city |
| 1775-1785 | 1870-1880 | GSM-R 1800 | Period:15 yearsExpiration: 1 May 2015 | Major city |
| Victorian Rail Track | 1727.5-1730 | 1822.5-1825 | GSM-R 1800 | Period:15 yearsExpiration: 17 June 2013 | Major city |
| 1772.5-1785 | 1867.5-1880 | GSM-R 1800 | Period:15 yearsExpiration: 1 May 2015 | Major city |

Note: All bands in the table are available on a technology flexible basis in Australia.

The technology column in this case indicates the most likely/major technology deployed at the present time (however, the type of service deployed and the technology used is at the discretion of the licensee).

1. **Bangladesh**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band (MHz)** | **Technology** | **License duration** |
| **Uplink** | **Downlink** |
| Peoples Telecom | 450.525-451.775 | 460.525-461.775 | CDMA2000 1X | 2008-2023 |
| 451.775-453.025 | 461.775-463.025 | CDMA2000 1X | 2008-2023 |
| National Telecom | 453.350-454.600 | 463.350-464.600 | CDMA2000 1X | 2007-2022 |
| PBTL (Central Zone) | 825.27-827.79 | 870.27-872.79 | CDMA2000 1X EVDO | 1996-2011 |
| PBTL (Nationwide) | 827.79-834-09 | 872.79-879.09 | CDMA2000 1X EVDO | 1996-2011 |
| ISL | 834.10-835.50 | 879.10-880.50 | CDMA | 2004-2024 |
| ISL, Jalalabad, Onetel | 825.27-827.79 | 870.27-872.79 | CDMA2000 1X EVDO | 2004-2024 |
| Warid Telecom | 880.50-885.50 | 925.50-930.50 | E-GSM, EDGE | 2004-2019 |
| Ranks Telecom | 840.54-841.80 | 885.54-886.80 | CDMA2000 1X EVDO | 2007-2022 |
| 841.80-843.06 | 886.80-888.06 | CDMA2000 1X EVDO | 2007-2022 |
| Dhaka Telecom | 843.06-844.32 | 888.06-889.32 | CDMA2000 1X EVDO | 2007-2022 |
| 1895.65-1896.95 | 1975.65-1976.95 | CDMA2000 | 2007-2022 |
| Tele Talk | 890.0-895.2 | 935.0-940.2 | GSM, GPRS | 1996-2011 |
| Orascom Telecom | 895.2-900.2 | 940.2-945.2 | GSM, EDGE | 1996-2011 |
| AXIATA BD Ltd | 900.2-907.6 | 945.2-952.6 | GSM, EDGE | 1996-2011 |
| 1727.2-1732.6 | 1822.2-1827.6 | GSM, EDGE | 1996-2011 |
| 1775.8-1777.8 | 1870.8-1872.8 | GSM, EDGE | 1996-2011 |
| Grameen Phone | 907.6-915.0 | 952.6-960.0 | GSM, EDGE | 1996-2011 |
| 1720.0-1727.2 | 1815.0-1822.2 | GSM,EDGE | 1996-2011 |
| 1747.6-1750.0 | 1842.6-1845.0 | GSM,EDGE | 1996-2011 |
| 1768.2-1773.2 | 1863.2-1868.2 | GSM,EDGE | 1996-2011 |
| Tele Talk  | 1710.0-1720.0 | 1805.0-1815.0 | GSM, GPRS | 1996-2011 |
| Warid Telecom | 1732.6-1742.6 | 1827.6-1837.6 | GSM, EDGE | 2004-2019 |
| Orascom Telecom | 1757.5-1765 | 1852.5-1860.0 | GSM, EDGE | 1996-2011 |
| 1773.2-1775.8 | 1868.2-1870.8 | GSM, EDGE | 1996-2011 |
| National Telecom | 1894.35-1895. 65 | 1974.35-1975.65 | CDMA2000 | 2007-2022 |
| Telebarta | 1899.55-1900.85 | 1979.55-1980.85 | CDMA2000 | 2007-2022 |
| 1900.85-1902.15 | 1980.85-1982.15 | CDMA2000 | 2007-2022 |
| S A Telecom | 1904.75-1906.05 | 1984.75-1986.05 | CDMA2000 | 2004-2024 |
| 1906.05-1907.35 | 1986.05-1987.35 | CDMA2000 | 2004-2024 |
| Augere Wireless | 2365-2400 (TDD) | IEEE 802.16e | 2008-2023 |
| Banglalion | 2585-2620 (TDD) | IEEE 802.16e | 2008-2023 |

1. **Cambodia**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| M FONE | 453.0 – 457.5 | 463.0 – 467.5 | CDMA 450 | Note |
| 888.0 – 890.0 | 933.0 – 935.0 | EGSM 900 | Note |
| 1750 – 1770 | 1845 – 1865 | GSM 1800 | Expiration:2032 |
| 1975 – 1980 | 2165 – 2170 | UMTS(WCDMA) | Expiration:2036 |
| GT-Tell | 824.0 – 829.4 | 869.0 - 874.4 | CDMA 800 | Expiration:2037 |
| SOTELCO | 880.0 – 888.0 | 925.0 – 933.0 | EGSM 900 | Expiration:2042 |
| 1745 – 1750 | 1840 – 1845 | GSM 1800 | Expiration:2042 |
| CamGSM | 890.0 – 899.3 | 935.0 – 944.3 | GSM 900 | Expiration:2021 |
| 1770 – 1785 | 1865 – 1880 | GSM 1800 | Note |
| 1960 – 1975 | 2150 – 2165 | UMTS(WCDMA) | Note |
| VIETTEL | 899.3 – 905.7 | 944.3 – 950.7 | GSM 900 | Note |
| 1710 – 1720 | 1805 – 1815 | GSM 1800 | Expiration:2036 |
| 1940 – 1950 | 2130 – 2140 | UMTS(WCDMA) | Expiration:2039 |
| TMIC | 905.7 – 915.0 | 950.7 – 960.0 | GSM 900 | Expiration:2027 |
| 1740 – 1745 | 1835 – 1840 | GSM 1800 | Note |
| 1920 – 1930 | 2110 – 2120 | UMTS(WCDMA) | Expiration:2038 |
| LATELZ | 1720 – 1730 | 1815 – 1825 | GSM 1800 | Note |
| APPIFONE | 1730 – 1740 | 1825 – 1835 | GSM 1800 | Note |
| 1930 – 1940 | 2120 – 2130 | UMTS(WCDMA) | Expiration:2038 |
| CADCOMMS | 1950 – 1960 | 2140 – 2150 | UMTS(WCDMA) | Expiration:2036 |

Note: Expiration date is around 2020 to 2040.

1. **China, People’s Republic of**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| China Telecom | 825~835 | 870~880 | CDMA 800(3G) | Expiration:2018.12.31 |
| 1920~1935 | 2110~2125 | CDMA2000 | Expiration:2018.12.31 |
| China Mobile  | 889 – 909 | 934 – 954 | GSM900  | Expiration2014.12.31 |
| 1710~1735 | 1805~1830 | GSM1800  | Expiration2014.12.31 |
| 1880 – 1900(TDD)  | TD-SCDMA | Expiration:2018.12.31 |
| 2010~2025(TDD) | TD-SCDMA | Expiration:2018.12.31 |
| 2320 – 2370 (TDD) | TD-SCDMA | Expiration:2018.12.31 |
| China Unicom | 909~915 | 954~960 | GSM900 | Expiration2015.4.30 |
| 1735~1755 | 1830~1850 | GSM1800 | Expiration2015.4.30 |
| 1940~1955  | 2130~2145 | WCDMA | Expiration:2018.12.31 |

1. **India, Republic of**

| **Operator** | **Frequency Band (MHz)** | **License Duration** |
| --- | --- | --- |
| **GSM 900** | **GSM 1800** | **CDMA 800** |
| Aircel Ltd | Y | Y |   | 20 years from the date of license |
| Allianz |  | Y |   |
| Bharti | Y | Y |   |
| BSNL | Y | Y | Y |
| Datacom |  | Y |   |
| Dishnet Wireless | Y | Y |   |
| Etisalat DB |  | Y |   |
| HFCL Infocom |  | Y | Y |
| Idea | Y | Y |   |
| Loop | Y | Y |   |
| MTNL | Y | Y | Y |
| Reliance Infocomm |  | Y | Y |
| Reliance Telecom | Y | Y | Y |
| S. Tel |  | Y |   |
| Sistema Shyam |  |   | Y |
| Spice | Y | Y |   |
| Tata Teleservices |  | Y | Y |
| Unitech |  | Y |   |
| Vodafone | Y | Y |   |

Note: In India, licenses are awarded to mobile operators on service area basis. Please contact Telecom Regulatory Authority of India (TRAI)/Department of Telecommunication (DOT) for detailed information on mobile operator name, assigned frequency band and used technology in a specific service area.

1. **Indonesia, Republic of**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** | **Coverage** |
| **Uplink** | **Downlink** |
| PT Sampoerna Telekomunikasi Indonesia | 450 – 457.5 | 460 – 467.5 | CDMA450 | 5 years for each apparatus license 1) | Nation Wide |
| PT Bakrie Telecom | 824.265 – 829.185 | 869.265 – 874.185 | CDMA800 | 2010 – 2020 2) | Sub Nation |
| 830.415 – 834.105 | 875.415 – 879.105 | CDMA800 | Sub Nation |
| PT Telekomunikasi Indonesia, Tbk. | 824.265 – 829.185 | 869.265 – 874.185 | CDMA800 | 2010 – 2020 2) | Sub Nation |
| 830.415 – 834.105 | 875.415 – 879.105 | CDMA800 | Sub Nation |
| 2360 – 2390 | BWA (TDD) | 2009 – 2019 2) | Sub Nation |
| PT Smartfren Telecom, Tbk.4) | 835.905 – 840.825 | 880.905 – 885.825 | CDMA800 | 2010 – 2020 3) | Nation Wide |
| PT Indosat, Tbk. | 842.055 – 844.515 | 887.055 – 889.515 | CDMA800 | 2010 – 2020 3) | Nation Wide |
| 890 – 900 | 935 – 945 | GSM900 | 2010 – 2020 2) |
| 1717.5 – 1722.5 | 1812.5 – 1817.5 | GSM1800 |
| 1750 – 1765 | 1845 – 1860 | GSM1800 |
| 1950 – 1955 | 2140 – 2145 | UMTS(WCDMA)2100 | 2006 – 2016 2) |
| 1955 – 1960 | 2145 – 2150 | UMTS(WCDMA)2100 | 2009 – 2019 2) |
| PT Telekomunikasi Selular | 900 – 907.5 | 945 – 952.5 | GSM900 | 2010 – 2020 2) | Nation Wide |
| 1722.5 – 1730 | 1817.5 – 1825 | GSM1800 |
| 1745 – 1750 | 1840 – 1845 | GSM1800 |
| 1765 – 1775 | 1860 – 1870 | GSM1800 |
| 1935 – 1940 | 2125 - 2130  | UMTS(WCDMA)2100 | 2009 – 2019 2) |
| 1940 – 1945 | 2130 - 2135 | UMTS(WCDMA)2100 | 2006 – 2016 2) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** | **Coverage** |
| **Uplink** | **Downlink** |
| PT XL Axiata, Tbk.  | 907.5 – 915 | 952.5 – 960 | GSM900 | 2010 – 2020 2) | Nation Wide |
| 1710 – 1717.5 | 1805 – 1812.5 | GSM1800 |
| 1960 - 1965 | 2150 - 2155 | UMTS(WCDMA)2100 | 2006 – 2016 2) |
| 1965 - 1970 | 2155 - 2160 | UMTS(WCDMA)2100 | 2010 – 2020 2) |
| PT Axis Telekom Indonesia 5) | 1730 – 1745 | 1825 – 1840 | GSM1800 | 2010 – 2020 2) | Nation Wide |
| 1930 - 1935 | 2120 - 2125 | UMTS(WCDMA)2100 | 2006 – 2016 2) |
| 1925 - 1930 | 2115 - 2120 | UMTS(WCDMA)2100 | 2011 – 2021 2) |
| PT Hutchison CP Telecommunications | 1775 – 1785 | 1870 – 1880 | GSM1800 | 2010 – 2020 2) | Nation Wide |
| 1920 - 1925 | 2110 - 2115 | UMTS(WCDMA)2100 | 2006 – 2016 2) |
| 1945 – 1950 | 2135 - 2140 | UMTS(WCDMA)2100 | 2011 – 2021 2) |
| PT Smart Telecom | 1903.125 - 1910 | 1983.125 – 1990 | CDMA1900 | 2008 – 2018 2) | Nation Wide |
| PT First Media | 2360 – 2375 | BWA (TDD) | 2009 – 2019 2) | Sub Nation |
| PT Internux | 2375 – 2390 | BWA (TDD) | 2009 – 2019 2) | Sub Nation |
| PT Indosat Mega Media | 2375 – 2390  | BWA (TDD) | 2009 – 2019 2) | Sub Nation |
| PT Jasnita Telekomindo | 2375 – 2390  | BWA (TDD) | 2009 – 2019 2) | Sub Nation |
| PT Berca Hardayaperkasa | 2360 – 2390  | BWA (TDD) | 2009 – 2019 2) | Sub Nation |

Note 1) : License is granted by apparatus-based licensed and can be extended for the next 5 years.

Note 2) : License is granted by bandwidth-based licensed and can be extended for the next 10 years.

Note 3) : Except in the area of Riau Islands still by apparatus license and condition in note 1) applied (licensed every 5 years).

Note 4) : Before April 2011, PT Smartfren Telecom, Tbk. was known as PT Mobile-8 Telecom, Tbk.

Note 5) : Before June 2011, PT Axis Telekom Indonesia was known as PT Natrindo Telepon Seluler.

1. **Japan**

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| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| NTT DOCOMO, INC. | 830-845 | 875-890 | WCDMA / LTE | Period:5 years(Note) |
| 1447.9-1462.9 | 1495.9-1510.9 | LTE |
| 1764.9-1784.9 | 1859.9-1879.9 | WCDMA |
| 1940-1960 | 2130-2150 | WCDMA / LTE |
| KDDI CORPORATION | 815-830 | 860-875 | CDMA2000 / LTE |
| 1437.9-1447.9 | 1485.9-1495.9 | LTE |
| 1920-1940 | 2110-2130 | CDMA2000 / LTE |
| SOFTBANK MOBILE Corp. | 900-905 | 945-950 | WCDMA |
| 1427.9-1437.9 | 1475.9-1485.9 | WCDMA |
| 1960-1980 | 2150-2170 | WCDMA / LTE |
| eAccess Ltd. | 1749.9-1764.9 | 1844.9-1859.9 | WCDMA / LTE |
| WILLCOM, Inc. | 1884.5-1915.7(TDD) | PHS |
| Wireless City Planning Inc. | 2545-2575(TDD) | XGP(eXtended Global Platform) |
| UQ Communications Inc. | 2595-2625(TDD) | WiMAX |

Note: License is granted to Base Station each. Expiration date of license for each station is different.

1. **Korea, Republic of**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology** | **License duration** |
| **Uplink** | **Downlink** |
| SK Telecom | 824-829 | 869-874 | CDMA 800 | 2011.7.1 - 2021.6.30 |
| 829-839 | 874-884 | LTE | 2011.7.1 - 2021.6.30 |
| 1755-1765 | 1850-1860 | LTE | 2011.12.6 - 2021.12.5 |
| 1930-1940 | 2120-2130 | UMTS(WCDMA) 2100 | 2010.5.25 -2016.12.3 |
| 1940-1960 | 2130-2150 | UMTS(WCDMA) 2100 | 2001.12.4 -2016.12.3 |
| 2300-2327(TDD) | Mobile WiMAX | 2012.3.30 -2019.3.29 |
| KT | 819-824 | 864-869 | - | 2012.7.1 -2022.6.30 |
| 905-915 | 950-960 | LTE | 2011.7.1 - 2021.6.30 |
| 1745-1755 | 1840-1850 | LTE | 2011.7.1 - 2021.6.30 |
| 1960-1980 | 2150-2170 | UMTS(WCDMA) 2100 | 2001.12.4 -2016.12.3 |
| 2330-2360(TDD) | Mobile WiMAX | 2012.3.30 -2019.3.29 |
| LG Uplus | 839-849 | 884-894 | LTE | 2011.7.1 - 2021.6.30 |
| 1770-1780 | 1860-1870 | CDMA | 2011.7.1 - 2021.6.30 |
| 1920-1930 | 2110-2120 | LTE | 2011.12.6 - 2021.12.5 |

1. **Macao, China**

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| **Operator** | **Frequency Band (MHz)** | **Technology**  | **License Duration****(Note 1)** |
| **Uplink** | **Downlink** |
| China Telecom (Macau) Company Limited | 825.485-826.735 | 870.485-871.735 | CDMA800 | Period:8 yearsJune 2007-June 2015 |
| 832.865-834.115 | 877.865-879.115 |
| Smartone - Mobile Communications (Macau), Limited | 891.5-899.1 | 936.5-944.1 | GSM900 | Period:8+2 years (Note 2)July 2002-July 2012 |
| 1723.9-1734.1 | 1818.9-1829.1 | GSM1800 |
| Macau Telecommunications Company Limited  | 899.3-906.9 | 944.3-951.9 | GSM900 | Period:8+2 years (Note 2)July 2002-July 2012 |
| 1734.9-1750.1 | 1829.9-1845.1 | GSM1800 |
| 1970.1-1975.1 | 2160.1-2165.1 | UMTS(WCDMA)2100 | Period:8 yearsJune 2007-June 2015 |
| Hutchison Telephone (Macau) Company Limited | 907.3-914.9 | 952.3-959.9 | GSM900 | Period:8+2 years (Note 2)July 2002-July 2012 |
| 1769.7-1784.9 | 1864.7-1879.9 | GSM1800 |
| 1950.1-1955.1 | 2140.1-2145.1 | UMTS(WCDMA)2100 | Period:8 yearsJune 2007-June 2015 |

Note 1: Licensing arrangement may be made at an appropriate time before the expiration of the license.

Note 2: According to the 3G licensing conditions, if the 3G licensee possesses a 2G license, the 2G license will be renewed for a period of no more than two years. Therefore, the 2G licenses of Macau Telecommunications Company Limited (CTM), Hutchison and Smartone have been renewed and the license durations have been extended to year 2012.

1. **Malaysia**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| Maxis Mobile | 880-886  | 925-931  | E-GSM 900 | Annual basis\* |
| 905-915 | 950-960 | P-GSM 900 | Annual basis\* |
| 1710-1735 | 1805-1830 | GSM 1800 | Annual basis\* |
| Celcom Axiata | 888 - 890 | 933-935 | E-GSM 900  | Annual basis\* |
| 890 - 905 | 935-950 | P-GSM 900  | Annual basis\* |
| 1735-1760 | 1830-1855 | GSM 1800 | Annual basis\* |
| 1950-1965 | 2140-2155 | UMTS(WCDMA)2100 | Period: 15 years from the first assignment (Spectrum transferred from Telekom Malaysia Berhad)Expiration: 2018 |
| 2020-2025(TDD) |
| Digi | 886-888  | 931-933 | E-GSM 900 | Annual basis\* |
| 1760-1785 | 1855-1880 | GSM 1800 | Annual basis\* |
| 1965-1980 | 2155-2170 | UMTS(WCDMA)2100 | Period:11 years from the first assignment (Spectrum transferred from TT Dotcom Sdn Bhd)Expiration:2018 |
| 2010-2015(TDD) |
| U Mobile | 1920-1935 | 2110-2125 | UMTS(WCDMA)2100 | Period:11 yearsExpiration:2018 |
| 1915-1920(TDD) |
| UMTS | 1935-1950 | 2125-2140 | UMTS(WCDMA)2100 | Period:15 yearsExpiration:2018 |
| 2015-2020(TDD) |
| Asiaspace | 2300-2330(TDD)(West Malaysia) | BWA (WiMAX) | Annual basis\* |
| Redtone | 2300-2330(TDD)(East Malaysia) | BWA (WiMAX) | Annual basis\* |
| Y-Max | 2330-2360(TDD)(West Malaysia) | BWA (WiMAX) | Annual basis\* |
| Packet One | 2360-2390(TDD)(Nationwide) | BWA (WiMAX) | Annual basis\* |

Note \*: Approval is given on annual basis based on Apparatus Assignment.

1. **Micronesia, The Federated States of**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| FSM Telecom Corporation | 890-902 | 935-947 | GSM900 | Conditional(Note) |

Note 1: FSM Telecom Corporation is a public Corporation and the only service provider (monopoly) in the FSM. While they are not issued a license, the Department of Transportation, Communication and Infrastructure has issued a Frequency Authorization for use of the frequencies for the mobile service. The authorization is conditional for 5 years duration which has expired pending adoption of the radiocommunication regulations for the FSM.

Note 2: While FSM Telecom Corporation has originally requested to also operate in the 1800 MHz band, the service has not taken off. Because of this, the 1800MHz band has been filed, but never used.

1. **Mongolia**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| Skytel | 824.0-835.0 | 869.0-880.0 | CDMA 800 | 1999-2014 |
| 1925-1935 | 2115-2125 | 3G/WCDMA | 2008-2018 |
| 2015-2020 (TDD) |
| Mobicom | 835.5-845.0 | 880.5 – 890.0 | CDMA WLL | 2000-2015 |
| 890.0-902.5 | 935.0-947.5 | GSM 900 | 1995-2015 |
| 1740-1755 | 1835-1850 | GSM 1800 | 2001-2015 |
| 1970-1980 | 2160-2170 | 3G/WCDMA | 2008-2018 |
| 2010-2015 (TDD) |
| 2020-2025 (TDD) |
| Unitel | 902.6-914.8 | 947.6-959.8 | GSM 900 | 2005-2025 |
| 1710-1720 | 1805-1815 | GSM 1800 | 2009-2025 |
| 1935-1945 | 2125-2135 | 3G/WCDMA | 2008-2018 |
| G-Mobile | 453.0-457.5 | 463.0-467.5 | CDMA 450 | 2006-2021 |
| 1885-1890 (TDD) | 3G/WCDMA | 2008-2018 |
| 1960-1970 | 2150-2160 |
| TeleMax | 2520-2540 (TDD) | WMAX(WLAN) | 2009-2017 |
| Ulusnet | 2500-2520 (TDD) | WMAX(WLAN) | 2009-2017 |
| 3450-3475 | 3550-3575 | WiMAX | 2005-2018 |
| BOU | 3400-3425 | 3500-3525 | WiMAX | 2008-2018 |

1. **Myanmar, The Union of**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| MPT | 453-457 | 465-468 | CDMA 450 | 5 Years |
| 825-835 | 870-880 | CDMA | 5 Years |
| 835-845 | 880-890 | DAMPS | 5 Years |
| 890-915 | 935-960 | GSM | 5 Years |
| 1800-1900 | 1800-1900 | DECT | 5 Years |
| 1920-1980 | 2110-2170 | WCDMA | 5 Years |

Note 1: Currently, all telecommunications services including mobile services are being provided by government operator MPT. There is no legal background requiring MPT to get a license for provision of services. In such a situation, a formal and systematic licensing regime has not been established yet. Of the various services, MPT applied for and has been awarded a license for GSM mobile service ONLY. So currently GSM Mobile service license is the only license granted by Posts and Telecommunications Department (PTD). PTD is now preparing a formal licensing regime and MPT will soon require to get licenses for other types of services (WCDMA, CDMA450 etc.,).

Note 2: GSM license period is five years. GSM license has been renewed according to its expiration in July 2010. For other services, radio frequency allocation validity period is five years.

1. **New Zealand**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| Vodafone New Zealand Ltd | 900-915 | 945-960 | GSM | Period: 20 yearsExpiration: 2031 (Note1) |
|  |  |  |  |
| 1735-1760 | 1830-1855 | Late 2013 to be LTE1800 | Period: 20 yearsExpiration: 2021 |
| 1760-1785 | 1855-1880 | GSM 1800/LTE 1800 | Period: 20 yearsExpiration: 2021 |
| 1920-1935 | 2110-2125 | UMTS | Period: 20 yearsExpiration: 2021 |
| Telecom NZ Ltd | 825-840 | 870 – 885 | UMTS850 | Period: 20 yearsExpiration: 2031 |
|  |  |  |  |
| 1950 -1965 | 2140-2155 | UMTS 2100 | Period: 20 yearsExpiration: 2021 |
| Two Degrees Mobile Ltd | 890-900 | 935-945 | GSM 900 | MR243 Period: 4 yearsExpiration:2012MR224 Period: 14 yearsExpiration:2022(Note 2) |
| 1725-1735 | 1820-1830 | GSM 1800 | Period: 20 yearsExpiration: 2021 |
| 1965-1980 | 2155-2170 | UMTS 2100 | Period: 20 yearsExpiration: 2021 |

Note 1: The license period is over 20 years because the renewal offer was accepted.

Note 2: The MR refers to the Management Right of a range of frequencies. Spectrum licenses for cell sites in the range of the spectrum defined within the MR are assigned. Two Degrees Mobile Ltd has two MRs in the 900 MHz spectrum range which have different expiration dates.

1. **Palau**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| Palau National Communications Corporation | 890-915 | 935-960 | GSM 900 | Not subject to license |
| Palau Mobile Corporation | 1710-1715 | 1805-1810 | GSM 1800 | 5 years |

1. **Papua New Guinea**

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
| Digicel | 880 – 891 | 925 – 936 | GSM 900 | Period:10 yearsExpiration: 2017 |
| 1700 – 1720 | 1805 – 1820 | GSM1800 | Period:10 yearsExpiration: 2017 |
| GreenCom | 891 – 903  | 936 – 948  | GSM 900 | Period:10 yearsExpiration: 2017 |
| Bemobile | 903 – 915  | 948 – 960  | GSM 900 | Period:10 yearsExpiration: 2017 |
| Telikom PNG | 824 – 835 | 869 – 880 | CDMA 800 | Period:10 yearsExpiration: 2017 |
| 2330 – 2360 | Wimax | Period:10 yearsExpiration: 2019 |
| 3400 – 3500 | Wimax | Period:10 yearsExpiration: 2019 |
| PNG Government(Note) |

Note: Permit only as of January 2010. The full extent of the amount of spectrum needed was not known as of January 2010. The permit is renewable annually.

1. **Thailand**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band (MHz)** | **Technology** | **License****Duration** |
| **Uplink** | **Downlink** |
| TOT | 479-483.5 | 489-493.5 | CDMA2000 1X | Period: 20 yearsExpiration: 2025 |
| 1965-1980 | 2155-2170 | IMT | Period: 20 yearsExpiration: 2025 |
| CAT  | 824-839 | 869-884 | CDMA2000 1X EVDO/ HSPA | Period: 20 yearsExpiration: 2025 |
| DTAC  | 839-849 | 884-894 | AMPS-800/HSPA | Period: 20 yearsExpiration: 2018 |
| 1722.6-1747.9 | 1817.6-1842.9 | GSM 1800 | Period: 20 yearsExpiration: 2018 |
| 1760.5-1785 | 1855.5-1880 |
| AIS | 897.5-915 | 942.5-960 | GSM 900/ HSPA | Period: 20 yearsExpiration: 2015  |
| TRUE Move  | 1710-1722.6 | 1805-1817.6  | GSM 1800 | Period: 20 yearsExpiration: 2013 |
| DPC  | 1747.9-1760.5 | 1842.9-1855.5 | GSM 1800 | Period: 20 yearsExpiration: 2013 |

Note: There is no license awarded for BWA as of January 2010 in Thailand.

1. **Vietnam, Socialist Republic of**

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| --- | --- | --- | --- |
| **Operator** | **Frequency Band(MHz)** | **Technology**  | **License duration** |
| **Uplink** | **Downlink** |
|  Viettel (1) | 453.08 – 457.37 | 465.08 – 467.37 | CDMA 450 | Period:15 yearsExpiration:2019 |
| SPT | 824 – 835 | 869 – 880 | CDMA800 | Period:15 yearsExpiration:2016 |
| HTC | 880 - 890 | 925 – 935 | eGSM900 | Period:15 yearsExpiration:2023 |
| GPC – VNPT | 890.1 – 898.5 | 935.1 – 943.5 | GSM900 | Period:15 yearsExpiration:2018 |
| 1710 – 1730 | 1805 – 1825 | GSM1800 | Period:15 yearsExpiration:2022 |
| 1965 – 1980 | 2155 – 2170 | IMT 2000 | Period:15 yearsExpiration:2024 |
| Viettel | 898.5 – 906.7 | 943.5 – 951.7 | GSM900 | Period:15 yearsExpiration:2018 |
| 1750 – 1770 | 1845 – 1865 | GSM1800 | Period:15 yearsExpiration:2022 |
| 1935 – 1950 | 2125 – 2140 | IMT 2000 | Period:15 yearsExpiration:2024 |
| VMS | 906.7 – 914.9 | 951.7 – 959.9 | GSM900 | Period:15 yearsExpiration:2018 |
| 1730 – 1750 | 1825 – 1845 | GSM1800 | Period:15 yearsExpiration:2022 |
| 1920 – 1935 | 2110 – 2125 | IMT 2000 | Period:15 yearsExpiration:2024 |
| GTel Mobile | 1770 – 1785 | 1865 – 1880 | GSM1800 | Period:15 yearsExpiration:2023 |
| Viettel (1) & HTC | 1950 – 1965 | 2140 – 2155 | IMT 2000 | Period:15 yearsExpiration:2024 |

Note 1: EVN Telecom was merged with Viettel from 1/1/2012

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. AWF is now renamed as APT Wireless Group (AWG) [↑](#footnote-ref-1)
2. A response to Question 1 was only received. [↑](#footnote-ref-2)