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| 83rd meeting |  |
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| Source:  | International Amateur Radio Union Region-1 (IARU-R1) |
| Subject:  | Information Document – Sub 9 kHz spectrum in the Amateur Service |
| Group membership required to read? (Y/N) **N** |
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| Summary:  |
| This document addresses the use of spectrum in the vicinity of 9 kHz and below. |
| Proposal: |
| This document is provided for information purposes. However IARU-R1 also believes it to be useful to clarify the regulatory situation in CEPT countries below 9 kHz. |
| Background: |
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Amateur Service interest in sub 9 kHz spectrum

# 1. Introduction

The FMWG Chairman recently announced that following discussions at the 82nd meeting there will be further discussions on the spectrum below 9 kHz at the next 83rd meeting and has asked administrations to bring forward additional information and background on spectrum management issues below 9 kHz.

This document from IARU-R1, whilst not expressing a view from an administration reflects the growing interest in amateur radio operations below 9 kHz.

# 2. Regulatory Situation

Prior to WRC-12 the lowest frequency allocated to a radiocommunication service in Article 5 of the ITU Radio Regulations was 9 kHz and this situation was reflected in the ECA and many national frequency tables. The latest Radio Regulations and ECA now specify allocations down to 8.3 kHz. Furthermore a growing number of administrations appear to license radiocommunication services significantly lower than 8.3 kHz.

In opening the question of regulating spectrum below 9 kHz it is believed that a useful first step would be to understand the regulatory situation in CEPT countries concerning the licensing of radiocommunication services below 9 kHz.

# 3. Activities in the Amateur Service

Prior to 2010 few expected that reliable communications could be achieved by radio amateurs at VLF. Radiated powers are low and antennas utilised are highly inefficient. However, with the advent of powerful weak signal processing software and dedicated work by a few enthusiasts, this has all changed. Some spectacular results have been, and continue to be achieved.

Radio amateurs in several CEPT countries have utilised VLF spectrum for amateur experimentation. In some countries a formal variation to their ‘amateur licence’ was required in others no authorisation was required as spectrum below 9 kHz is unregulated. For example, German amateurs chose several spot frequencies e.g. 8.97 kHz, 6.47 kHz and 5.17 kHz for technical convenience for their experimentation. Recently a quantitative field-strength estimate has also been conducted demonstrating that amateur stations are unlikely to cause harmful interference to lightning locator systems in the band 8.3 – 9.0 kHz, given their achievable radiated power levels in the microwatt or low milliwatt range. In the United Kingdom, following a compatibility assessment by the regulator, the band 8.7 - 9.1 kHz has been available to amateur licensees for experimental use on a case by case basis. Countries in other ITU regions have also hosted amateur activities on sub 9 kHz frequencies, notably the United States, Australia and Japan.

Recently an amateur signal on 8.971 kHz with an effective radiated power of circa 150 micro Watts has spanned the Atlantic Ocean, from North Carolina in the United States to the United Kingdom a distance of approximately 6194 km. A steady, GPS-locked carrier at 8.971 kHz was transmitted between 0000 and 0600 UTC and sophisticated digital signal processing (DSP) software was used to detect the transmission under both night-time and daylight propagation conditions at the receiver in the UK.

# 4. Technical Issues

At VLF, an amateur’s receiving system can be very simple. It is quite different from a traditional amateur station operating in MF and HF spectrum because the reception of signals is at near audio frequencies where external noise and not receiver noise limits reception capabilities. Typically a suitable small antenna, such as a voltage probe or loop, is fed via a pre-amplifier (with high dynamic range) into the sound card of a PC. This is all that is required as all detection and signal processing is then performed in the PC using software.

Locking the software-based receiver to a VLF MSK station or a GPS reference signal ensures good frequency accuracy and stability. These are essential requirements when looking for very long duration, and weak, signals below the receiver’s noise floor. Bandwidth may be measured in micro Hertz, so it is vital to know precisely where a station is transmitting to a fraction of a Hertz.



The image above shows a typical VLF screen using Spectrum Lab software. Signals are too weak to hear, but are visible over a period of minutes or hours as lines on the screen at distinct frequencies. Notice how closely the signals are spaced: the figures on the right are Hz, not MHz.

To radiate an effective VLF signal is quite difficult. Several carefully engineered pieces have to come together to ensure success including (a) as large an antenna system as possible, (b) a very stable frequency source that is stable to a few micro Hz over many hours, (c) moderate power (e.g. 100 W transmit power to achieve 10 microwatts radiated power), (d) wherever possible deploying more efficient antenna matching systems to minimise losses, when highly inductive loading coils with high voltage capabilities are employed , and (e) utilising as effective a ground system as possible. Few radio amateurs are able to achieve these requirements, especially from a suburban home station.

Amateur VLF signals are generally too weak for anything other than a continuous carrier, very slow speed Morse code (for example with 30 second dots) or dual frequency Morse code, which is a form of frequency and amplitude modulation where dots and dashes are the same length. However they are distinguished from each other by a small frequency shift which visually puts the characters on different lines on the screen, detected and identified by time, frequency and possibly bearing.

# 5. Summary

In a number of countries radio amateurs are already making use of spectrum in the sub 9 kHz region for pioneering applications in a regulated or unregulated manner dependent on local telecommunications’ legal requirements. One way communications has already been effected from North America to Europe using modest equipment. In any future spectrum planning process below 9 kHz in CEPT countries, IARU-R1 requests CEPT administrations to make adequate frequency provisions for the amateur service to continue their innovative experimentation in this interesting part of the spectrum.

IARU-R1 also believes it to be useful to clarify the regulatory situation in CEPT countries below 9 kHz.