Natural Radio

News, Comments and Letters About Natural Radio

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The Basement of Natural Radio Most of us listen to whistlers, chorus and tweeks in the audible range, but there is another world of signals that falls below our hearing -- these are the Natural Radio signals in the ULF and ELF range.

Schumann Resonance – Probably the most familiar signal in this range is the Schumann Resonance. This signal is the natural resonant frequency of the waveguide formed by the surface of the earth and the bottom of the ionosphere. Lightning provides the main source of excitation for the oscillation. The Schumann Resonance peaks at about 7.8 Hz. with harmonically related resonances up to about 45 Hz., and a daily variation of about ±0.5 Hz. The resonance of this natural cavity was first predicted by the German physicist W. O. Schumann in 1952, and first detected in 1954.

It has been suggested that the amount of global lightning should correlate with the intensity of these resonances. Experiments have also been done to use the Schumann Resonance to detect global temperature change, as the global average temperature is thought to correlate with lightning activity. See the following link for more information: http://nigec.ucdavis.edu/publications/annual94/northeast/project19.html

Geomagnetic Pulsations (ULF waves) are classified by their frequency range and vary from 1 mHz. (millihertz) up to about 1 Hz. Pulsations are divided into two main groups, continuous and irregular. Ultimately, all of these pulsations are powered by energy from the solar wind. They are shown in the table below.

	Continuous Pulsations					Irregular Pulsations	
	Pc 1	Pc 2	Pc 3	Pc 4	Pc 5	Pi 1	Pi 2
Time (s)	0.2 - 5	5-10	10-45	45-150	150-600	1-40	40-150
Freq.	0.2-5 Hz.	0.1-0.2 Hz.	22-100 mHz.	7-22 mHz.	2-7 mHz.	0.025-1 Hz.	2-25 mHz.

Pc 1 & Pc 2 – Continuous ULF waves with period of 0.2 - 10 s are called Pc 1-2 pulsations. Pulsations at these frequencies are generated by the electromagnetic ion cyclotron (EMIC) instability near the earth's magnetic equator, and they are thus named ion cyclotron waves.

Pc 1-2 waves propagate towards the ionosphere along a magnetic field line. Two main subgroups have been identified on basis of ground observations: structured pulsations (also known as periodic or pearl pulsations) and unstructured pulsations.

Pc 3 – Pc 3 Compressional waves have a period of between 10 and 45 seconds and have relatively low amplitude. These waves occur on the day side of the earth and correlate with the Interplanetary Magnetic Field (IMF).

Pc 4 – Pc 4 pulsations have periods in the 45 -150 second range. These waves tend to occur close to the equator, and often reach their peak in the quiet periods after substorms. Several times a year in the morning sector, stronger that normal amplitude modulated oscillations are observed in the Pc 4 range. These have been termed “Giant Pulsations”, and are most typical around the equinoxes during solar minimums.

Pc 5 – Pc 5 pulsations have periods between 2 and 10 minutes. These waves are relatively strong. They are divided into compressional and toroidal waves and arise from a variety of sources.

Pi 1 – These are irregular pulsations with a period of 1 – 40 seconds. These waves tend to peak at midnight and again before noon.

Pi 2 – The irregular Pi 2 pulsations have a period of between 40 and 150 seconds and tend to occur in connection with magnetospheric substorms. Traditionally these pulsations have been used to define the substorm onset time, although this may not be accurate in all situations.

Pi B – Pi B pulsations are broadband irregular pulsations that tend to occur in bursts and are in the Pi 1 and Pi 2 frequency range. The Pi B signals correlate well with geomagnetic substorms.

Pi C – Pi C pulsations generally are observed in the morning sector and consist of irregularly spaced pulses about 10 seconds apart. They tend to correlate well with auroral luminosity variations.

Equipment – Antennas for these frequencies often include large air core loops and solenoid type coils with iron cores. E-field type antennas are sometimes used to measure the Schumann resonance. Because of the low frequencies, mechanical stability of the antenna is of great importance, and often the loops are buried in the ground.

Amplifiers need to be able to pass the low frequencies of these signals and need to have exceptional DC stability. Instrumentation type amplifiers are often used. Of course the power line frequencies need to be filtered out.

Since the waves are well below audible frequencies, the receiver needs to be connected to a chart recorder or sampled with an A/D converter and then analyzed by computer.

References -- Will Payne’s site has a wealth of information as well as construction details for receivers and antennas at: http://www.altair.org/natradio.htm. Of course Renato Romero’s site also has lots of good information and construction information. Visit this site at http://www.vlf.it/. A couple of other sites are: http://sidereal7.org/ and http://www.elfrad.com/.

This article has just touched on the main points of ULF Natural Radio. The *Space Physics Textbook* was a major source of information for this article, and talks about ULF signals in much more detail than could be presented here. This is an excellent source of information for the Natural Radio enthusiast, published by the Space Physics Group at the University of Oulu in Finland and is available online at http://www.oulu.fi/~spaceweb/textbook/.