Measuring of ionospheric disturbances with Software Defined Radio based on Open Hardware

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Abstract

The ionospheric disturbances can be a result of high energy hits to the ionosphere from outer space of the Earth. There is a description of a method for detection ionospheric disturbances using OK0EU radio beacons and SDR (Software Defined Radio) based on MLAB an Open Hardware project.

Keywords: Ionosphere, Software Defined Radio (SDR), Open Hardware, Sudden Ionospheric Disturbances (SID).

1 Introduction

The outer regions of the Earth's atmosphere consist of a tenuous gas which is partially ionized by ultraviolet and X-ray radiation from the Sun, as well as by cosmic rays coming from outer space. These regions, which are known as the ionosphere, act like a plasma concerning its interaction with radio waves. The ionosphere consists of many layers. The two most important are the E layer, which lies at an altitude of about 90 to 120 km above the Earth's surface, and the F layer, which lies at an altitude of about 120 to 400 km. The plasma frequency in the F layer is generally higher than that in the E layer, because of the greater density of free electrons.

The free electron number density in the E layer drops steeply after sunset, due to the lack of solar ionization combined with the gradual recombination of free electrons and ions. Consequently the plasma frequency in the E layer also drops steeply after sunset. Recombination in the F layer occurs much slower so there is not as great reduction of the plasma frequency at night. Very High Frequency (VHF) radio signals (>30 MHz), which include FM radio and TV signals, have frequencies well in excess of the plasma frequencies of both the E and the F layers and thus pass straight through the ionosphere. Short Wave (SW) radio signals (3 – 30 MHz) have frequencies in excess of the plasma frequency of the E layer, but not of the F layer. Hence, SW signals pass through the E layer but are reflected by the F layer. Finally, Medium Wave (MW) radio signals (<3 MHz) have frequencies which lie below the plasma frequency of the F layer and also lie below the plasma frequency of the E layer during daytime but not during night time. Thus MW signals are reflected by the E layer during the day but pass through the E layer and are reflected by the F layer during the night.

2 Description of the method

We use 3.6 MHz for our initial experiments with ionosphere. In region of the Czech Republic there are some QRP (low power) beacons operating at that frequency.

QRP beacons OK0EU [3] have been working since February 18, 2003 as a part of scientific project INFRA carried out by the Institute of Atmospheric Physics, Prague. One beacon transmitter was set up near Prague at ionospheric observatory in Průhonice where digital ionosonde is also running. Since March 2005 subsequently four additional transmitters have been installed on 3.5 MHz band to provide multipoint measurement. Frequency of transmitters are around 3.6 MHz except the transmitter at QTH Panská Ves. Every minute the call sign is sent by all transmitters at the same time 40 Hz above the nominal frequency. The call sign is then followed by a dot which is sent in the time slot dedicated for each transmitter. Each transmitter works with 1W RF power to a dipole antenna. The beacon frequency is derived from the high stability OCXO 10 MHz normal.

Software Defined Radio SDRX01B (Fig. 1, 3) [5] is used for receiving a reflection of QRP beacon's signal from ionosphere. SDRX01B is a device based on MLAB an Open Hardware project [1]. We provide all documentation for manufacturing and reviewing for free. Moreover, this hardware can be extended easily by other MLAB modules such as processors, A/D converters, amplifiers,...

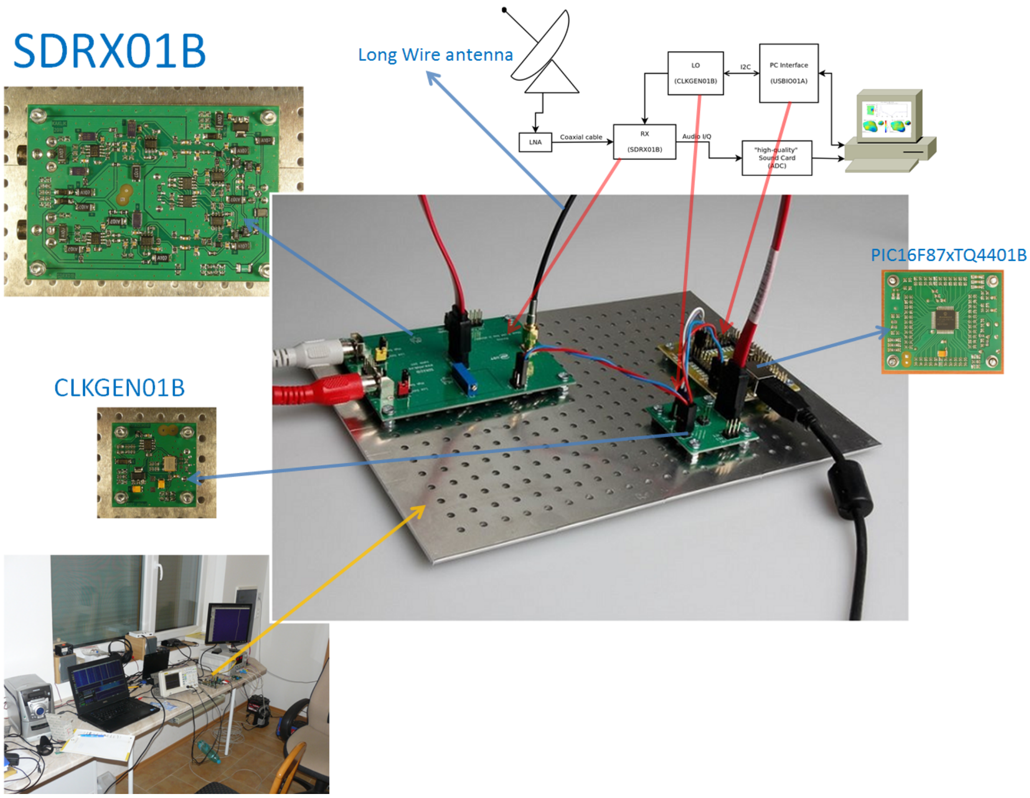

Figure 1: Software Defined Radio setup.

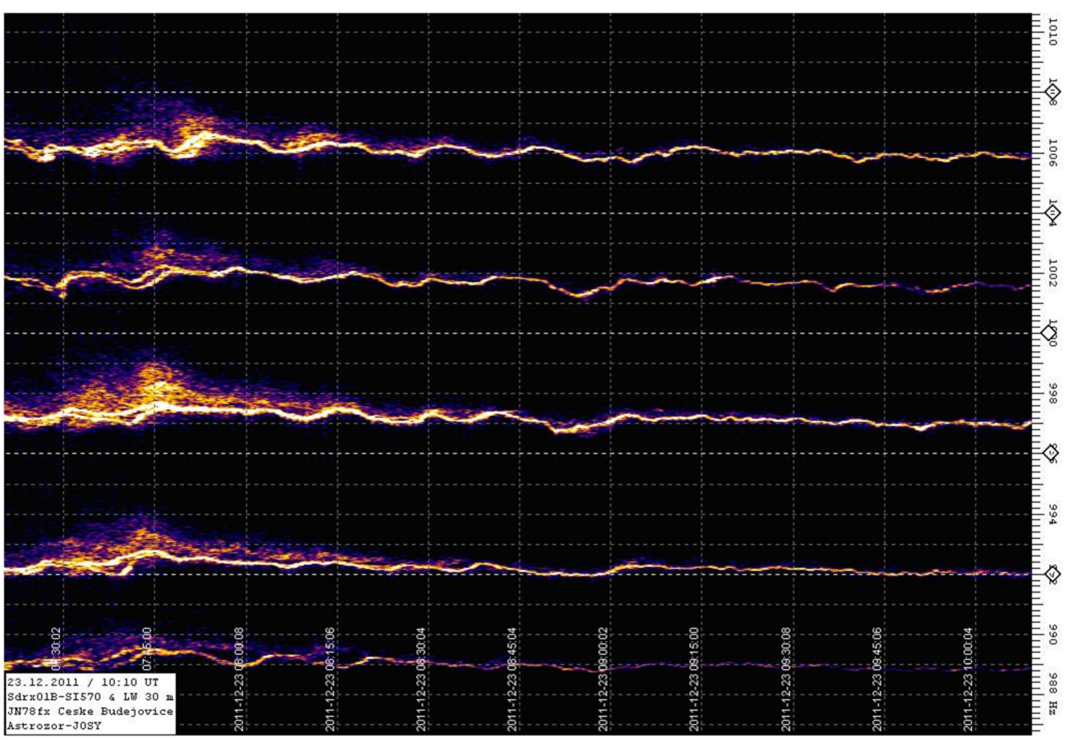

Figure 2: Captured data at the time domain.

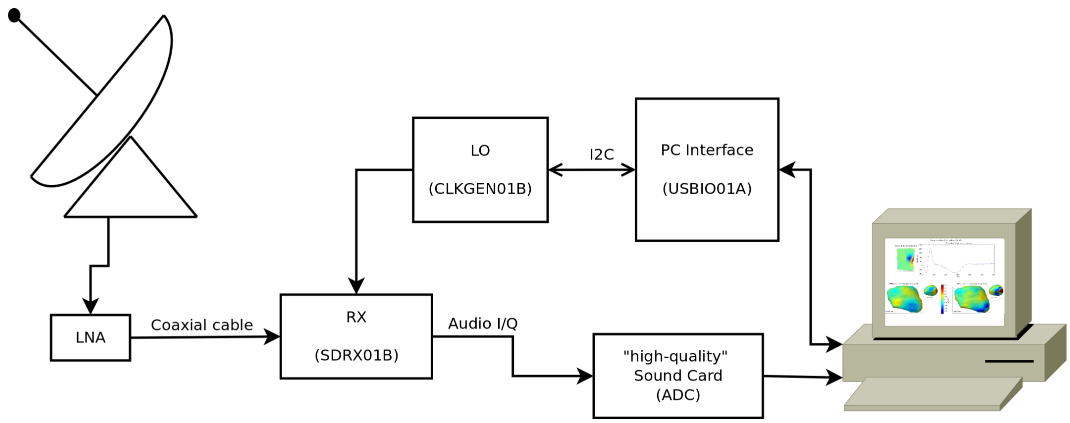

Figure 3: SDR block diagram.

3 Captured data

We do a FFT analyse of received signal from five beacons simultaneously by the Spectrum Lab software [7]. We can record a doppler shift and an amplitude of reflected signals in the time domain (Fig. 2). The doppler shift corresponds with a radial velocity of ions and the amplitude corresponds with density of ions in the ionosphere.

Note that doppler shift displayed here is only about 0.5 Hz. This measurement is very precise even though the equipment is not very expensive. For instance the price of assembled SDRX01B board is only about 70 EUR. This kind of observation is suitable for amateur radioastronomers as well [4].

4 Results and Future work

Unfortunately the ionosphere is very complex. Elimination of the Sun influence is necessary for the data mining of the particular disturbances caused by GRBs or other distant high energy sources. Other data sources about the Sun activity have to be considered. For instance VLF SID monitors or other data sources have to be combined with our data.

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