A new Doppler type system for measuring the ionospheric effects of infrasound developed in the IAP

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1. Introduction

Various upward propagating waves seem to be the dominant component of the upward coupling of the lower and middle atmosphere to the upper atmosphere and ionosphere, even though there is also an electromagnetic coupling via electromagnetic waves, global electrical circuit, sprites and other phenomena. The waves propagating upward from below in the neutral atmosphere at middle latitudes are basically planetary waves (periods of days to a few weeks), tidal waves (periods of 24-, 12-, 8- and 6-hours), gravity waves (periods of several minutes to several hours) and infrasound waves (periods between about 0.1-100 seconds). A new Doppler type system has been developed primarily to measure the ionospheric effects of infrasound. Such effects have very little been studied compared to ionospheric effects of other types of longer-period waves; they might be of special interest to the radio channel propagation community in COST271.

2. Measuring system

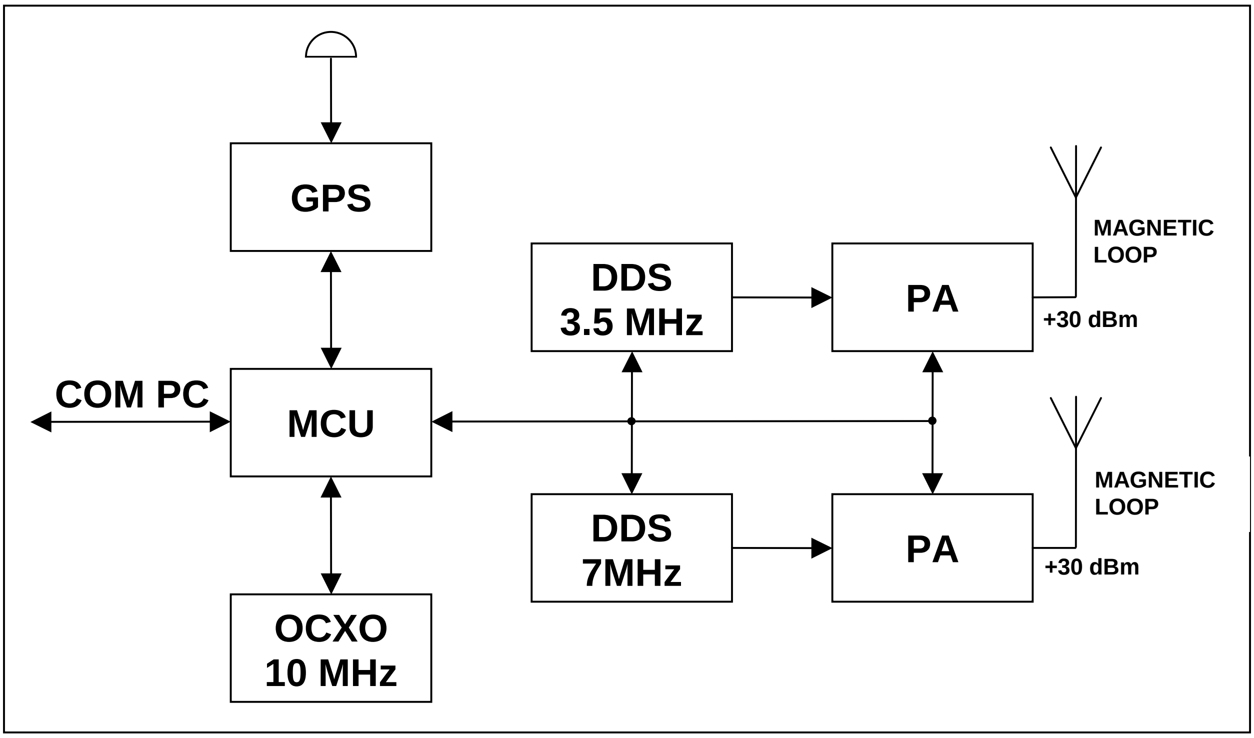

Fig. 1. Transmitter Block Diagram (GPS - Global positioning system receiver, MCU – Micro controller unit, OCXO - Oven controlled crystal oscillator, DDS – Digitally programmable frequency synthesizer, PA – Power amplifier).

The Doppler type system is now working in test regime. It is based on measurements of the Doppler shift of the wave reflected from the ionosphere. The measurement is done simult-

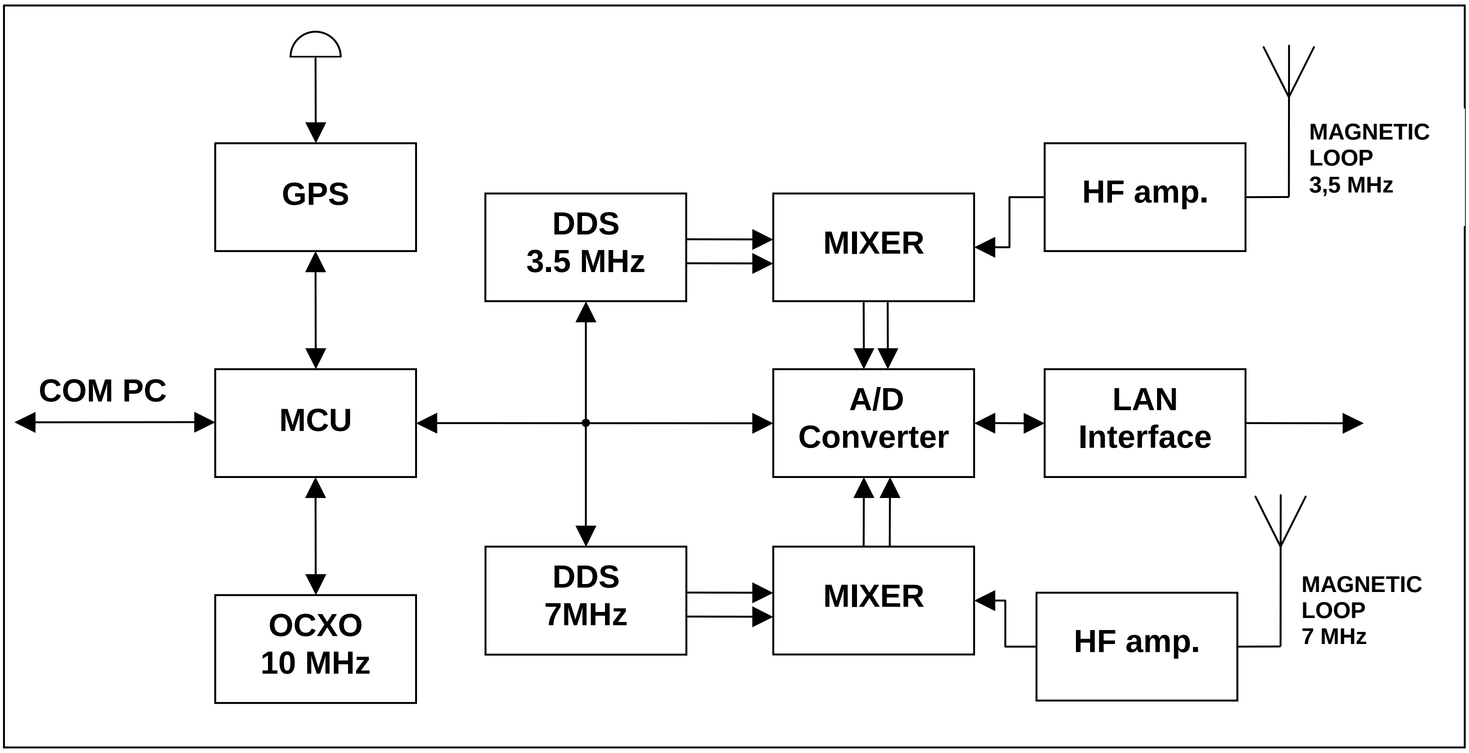

Fig. 2. Receiver Block Diagram (GPS - Global positioning system receiver, MCU – Micro controller unit, OCXO - Oven controlled crystal oscillator, DDS – Digitally programmable frequency synthesizer, LAN - Local area network).

aneously on two frequencies (3.5 and 7 MHz) to ensure non-stop operation. For the measurement a set of the transmitter and receiver is used. All the equipment including special software has been developed and constructed in the IAP.

The transmitter frequency is generated by direct digital synthesis derived from a high stability 10 MHz normal controlled by a GPS clock. The overall stability of the order of 2×10^{-10} is achieved which makes possible the mHz resolution of the Doppler shift measurement. The low transmitter output power of 1W is sufficient. Figure 1 shows the transmitter scheme.

The receiver (scheme see Figure 2) uses the direct conversion schema with the I-Q (two signals in quadrature) output to the D/A converter. The receiver oscillator has the same construction and stability as the transmitter. The receiver has its own local area network interface for the data transmission to the storage and post-processing computer, which can be located anywhere. The measurement of the Doppler shift is done by means of spectral analysis of the acquired data.

The transmitter and receiver are located at Institute's observatories at Průhonice and Panská Ves, respectively. The transmitter-receiver distance is about 60 km. The transmitting antenna is radiating upwards and perpendicular to the direction to Panská Ves, radiating the minimum ground wave (almost none) to that observatory. Big advantage of the experimental setup is the ionosonde at Průhonice, which is close to the mid-point of the radio path with respect to the short transmitter-receiver distance. Therefore ionograms and electron density profiles from Průhonice can be used in interpretation of the Doppler system measurements. The current ionosonde at Průhonice is an improved version of the KEL-41 ionosonde, but since January 2004 we will have new Digisonde DPS-4, which guarantees the high quality and relatively quickly available data and electron density profiles.

3. Examples of the results of measurements

At present there are some technical problems with radio noise. There was rather large noise at the receiving site, thus we moved the receiving site to Prague (the campus of the IAP). It helped a bit but not principally. Therefore changes in the receiver are now under development, because the main source of the noise seems to be the receiver itself. Consequently, we present examples of large effects like those of solar flares, well-developed gravity waves and solar eclipse. Problems with the noise will hopefully be solved in near future.

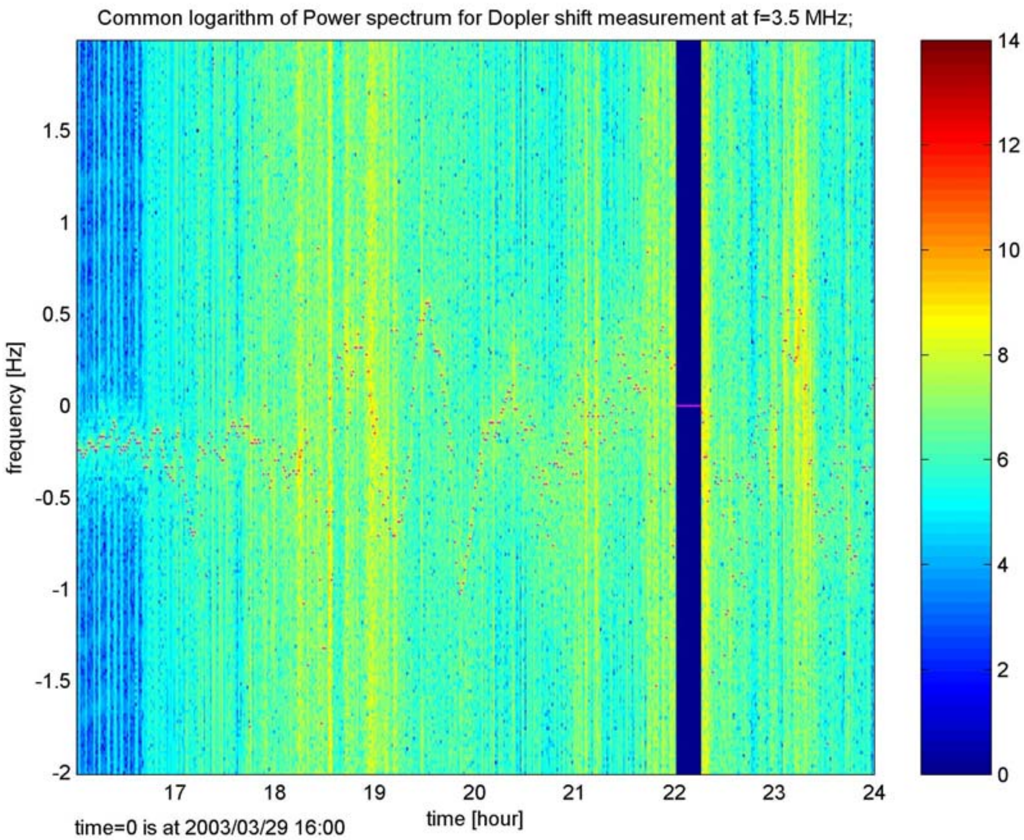

Fig. 3. Power spectrum of Doppler shift measurement on 29 March 2003, afternoon, f = 3.5 MHz, Průhonice - Panská Ves, 1-minute values (red dots), Ap = 32. Gravity waves related to the passage of sunset terminator are well pronounced (even though the signal is not well visible).

Figure 3 shows an example with time step of data one minute, which is good for the gravity waves but inappropriate for the infrasound. Figure 4 presents an example with time step of data of one second, which is suitable for infrasound studies but a bit less appropriate for gravity wave investigations. Gravity waves related probably to the terminator passage in the morning and in the evening are well pronounced in records.

At present the system reveals data, which are appropriate for examination and monitoring of gravity waves, but of insufficient quality for infrasound investigations due to the noise (probably of technical origin).

Future Work

It is envisaged to run joint campaign of ionosonde measurements and Doppler system measurements for gravity wave observations in collocated measuring volumes in the ionosphere by two different methods. Hopefully we succeed to overcome problems with noise and will be able to study effects of infrasound on the ionosphere, particularly those of infrasound excited by meteorological processes and phenomena.

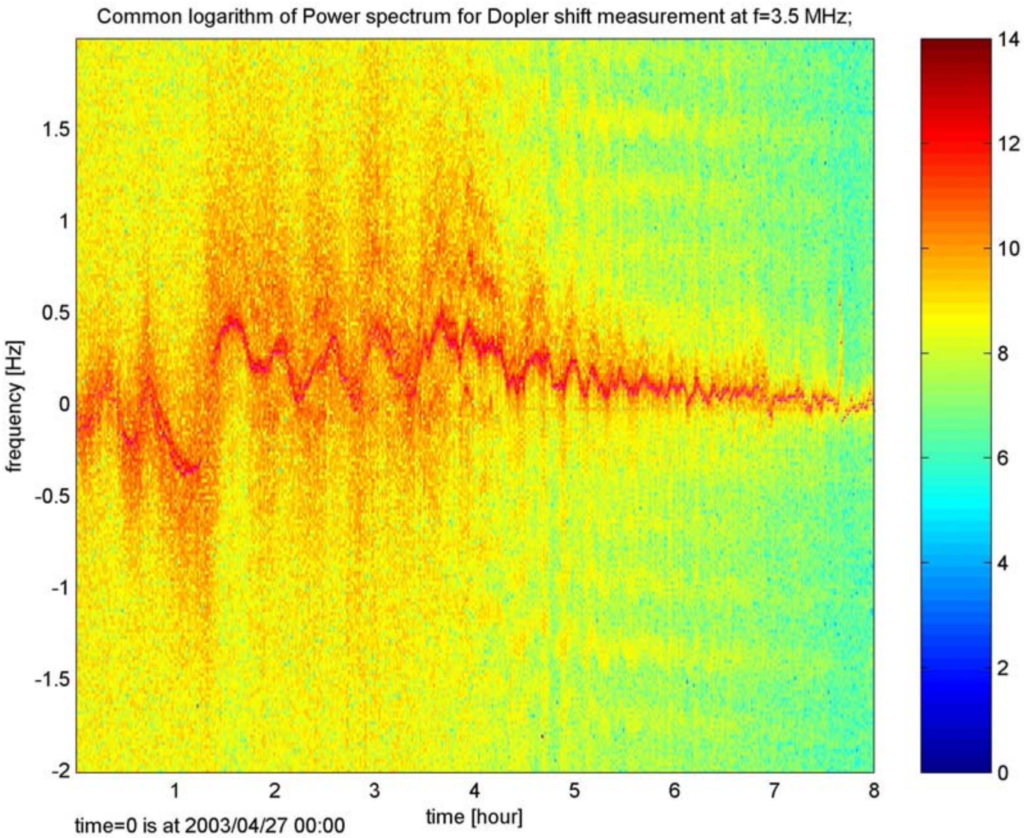

Fig. 4. Power spectrum of Doppler shift measurement on 27 April 2003, morning, f = 3.5 MHz, Průhonice - Panská Ves, 1-second values (red colour), low geomagnetic activity. Gravity waves related to the passage of sunrise terminator and their attenuation during late morning hours are well expressed.