Multipath Signal Variation Characteristics of 10 GHz Fixed Terrestrial Multi-Receiver Path

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1. Introduction

Multipath fading due to atmospheric refraction belongs among the adverse propagation effects that impair the error performance and availability of terrestrial fixed microwave links. In the past, some experiments were conducted focusing on the research of waveguide layer effects on electromagnetic wave propagation in the troposphere (e.g. [1], [2], [3]). The statistical properties of the environment between the transmitter and the receiver were derived by means of the received signal level on terrestrial radio links. The other possibility of studying those adverse atmospheric effects is to measure the physical parameters of the atmosphere directly (eg. [4], [6]). In this paper a new propagation experiment is described where received signal level fluctuations are measured on the terrestrial path in 10 GHz band and atmospheric refractivity is measured simultaneously at the receiver end.

During the first months of the experiment, several multipath fading events has been observed. Signal variation characteristics were calculated from the measured data. The characteristics show a typical statistical and spectral behavior of received signal strength fluctuations during the multipath events.

2. Measurement

Experimental setup consists of a microwave link TV Tower Prague (TX) – Podebrady (RX) operating in the frequency band of 10 GHz with 4 receivers (5 receivers from 2008/05/14) placed in different heights on the 150 meters tall mast. Also the system of meteorological sensors is installed on the same mast. Temperature and relative humidity are measured in 6 heights, a pressure sensor is located near the ground. The selected system parameters are summarized in Table 1.

Table 1: System parameters

TX tower ground altitude	258.4 meters above sea level
TX antenna height	126.3 meters
Frequency	10.671 GHz
Polarization	Horizontal
Output power	20.0 dBm
Parabolic antennas	diameter 0.6 m, gain 33.6 dBi
RX tower ground altitude	188.0 meters above sea level
RX antennas heights	61.1 m, 90.0 m, 119.9 m, 145.5 m
Meteorological sensors heights	5.1 m, 27.6 m, 50.3 m, 75.9 m, 98.3 m, 123.9 m
Pressure sensor height	1.4 m
Path length	49.82 km

Time evolution of a received signal power is recorded by means of sampled (T=0.1 sec) AGC voltage at the output of intermediate frequency receivers (F=221.6 MHz). Meteorological

parameters are recorded every minute. Figure 1 shows the terrain profile of the microwave path and the photo of the mast with installed parabolic dish antennas.

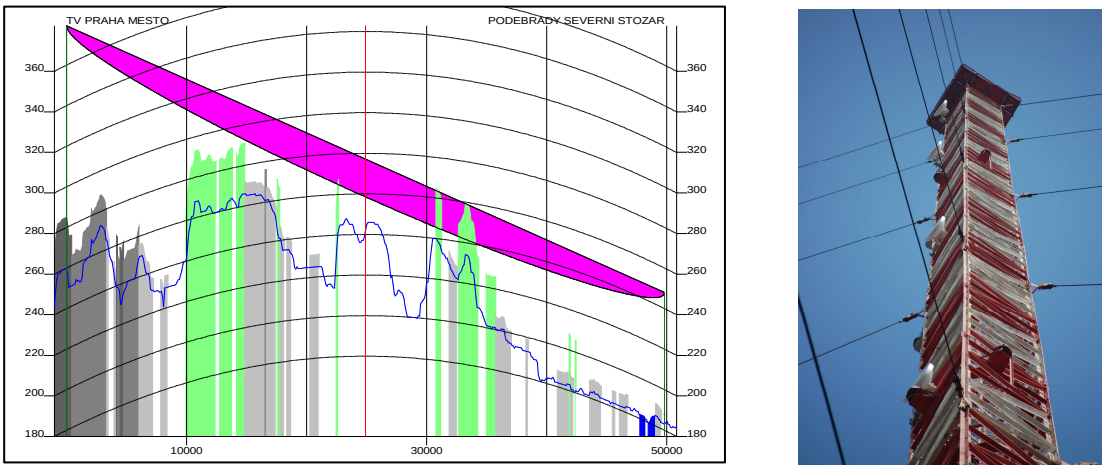

Figure 1: Terrain profile of the 50 km long microwave path and the photo of parabolic receiver antennas (white parabolic dishes, diameter 0.6 m) placed on the 150 m high mast.

3. Multipath events characteristics

The microwave link was designed to study the influence of atmospheric refraction on the vertical field distribution of a received signal. Several multipath propagation events occurred during the first months of the experiment. An apt example is shown in Figure 2. At time around 2:00, a signal attenuation higher than 20 dB was measured for a moment at the floor 1 (the lowest RX antenna). At the same time a significant up-fading (signal enhancement) occurred at the floor 2. The evening multipath is even a more typical one. Here the signal fluctuates around a zero level almost symmetrically.

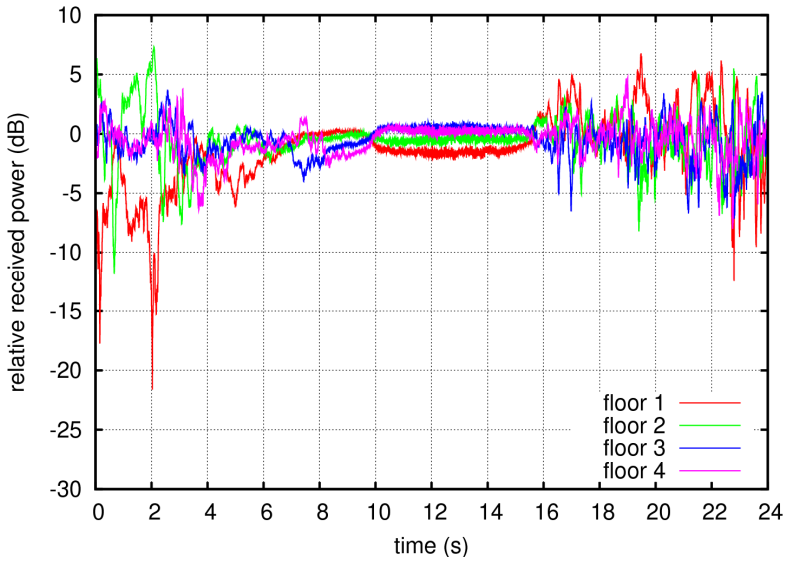

Figure 2: Relative received power fluctuations on the 28th of October 2007.

The symmetric nature of signal fluctuations during multipath is more clearly revealed in Figure 3. Empirical probability density function (EPDF) of path attenuation is shown. It is calculated only from 36 selected days (between 10/2007 and 4/2008) when any multipath event appeared. The symmetry of EPDF (fading vs. enhancement) is lost for absolute values of attenuation larger than about 6 to 10 dB. The up-fading system margin is limited to about 8 dB in our system, but it is not

expected that more than several in-phase rays can reach the receiver adding constructively and producing even larger enhancement.

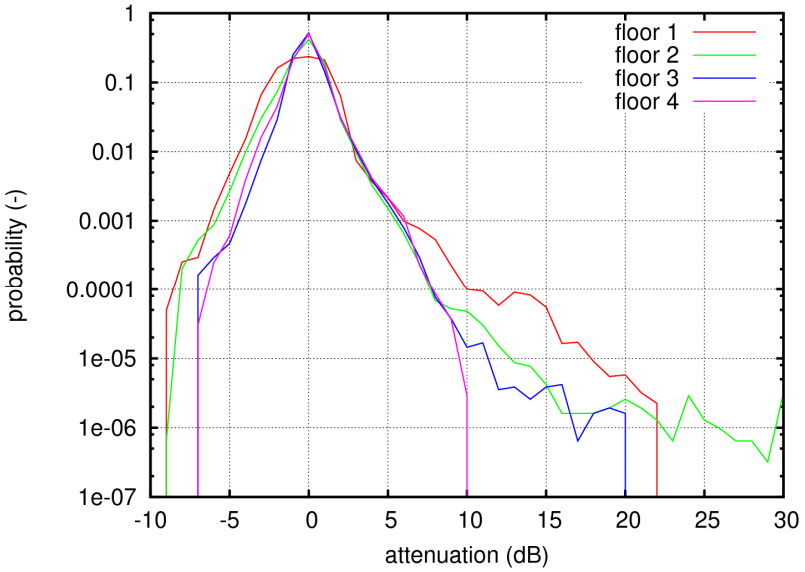

Figure 3: Empirical probability density function of microwave path attenuation obtained from the four receivers separated vertically.

The rate at which the received signal changes in time during the multipath is important for the design of receivers. In Figure 4, EPDF of the rate of received signal is shown. Again it is calculated only from days with multipath events, rain fading events are not included. It is evident that the rates with absolute values higher than 0.5 dB/s are already rare. Maximum fluctuation rates observed so far are around 1 dB/s.

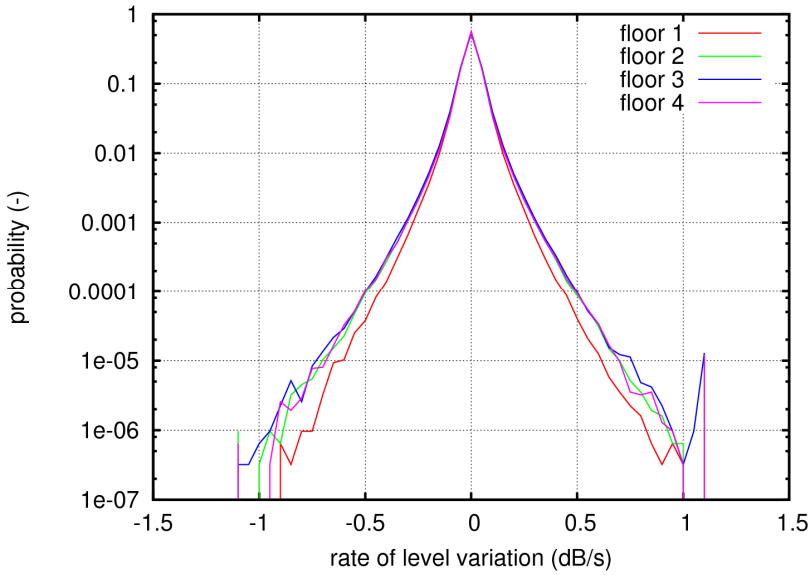

Figure 4: Empirical probability density function of the rate of received signal level fluctuations measured by the four receivers separated vertically.

The temporal variation of the received signal under influence of atmospheric refractivity fluctuations is related to the motion of atmosphere and random changes of atmospheric refractive index. These effects act on the signal at different temporal scales. Therefore it is worthwhile to describe the received signal fluctuations in frequency domain. Figure 5 shows the calculated power

spectral density of received signal measured by four receivers. One can see the spectral density can be well approximated by a piecewise linear function which defines a power law in terms of frequency. The reason of the apparent difference of the floor 2 spectrum in the interval (0.001; 0.1)Hz is not clear at the moment.

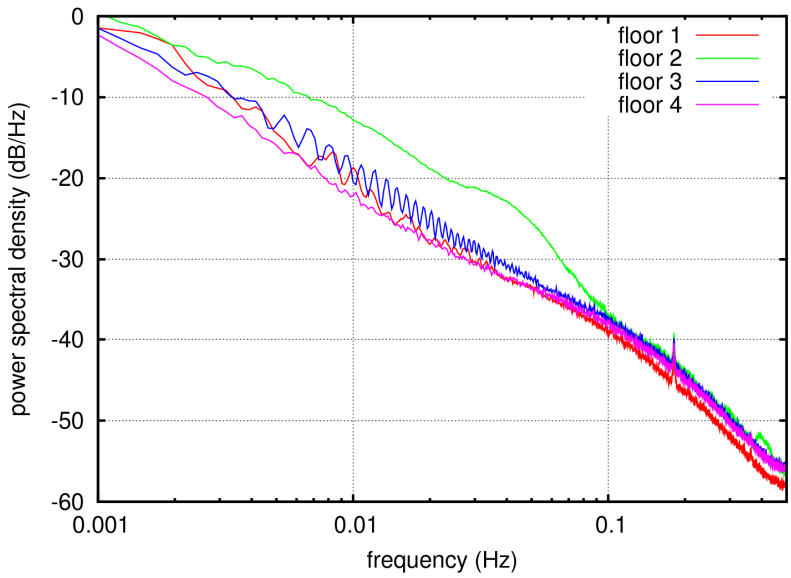

Figure 5: Power spectral density of received signal level fluctuations measured by the four receivers separated vertically.

4. Conclusion

First results of the experimental study of multipath fading characteristics were presented. EPDF of received signal and EPDF of the signal variation rate were given. Also the power spectral density of multipath signal fluctuations was calculated. These results, though incomplete yet, describe the propagation channel in more detail than the signal EPDF only. Spatial and related diversity characteristics will be studied in the future.

Acknowledgments

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