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WAVELET TRANSFORM IN HF CHANNELS

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ABSTRACT

The traffic of IP packets in difficult HF channels is analyzed. The SIMULINK multipath Rayleigh fading channel model is used. The wavelet analysis of mobile HF channel IP traffic (realized by tactical radios) afford an opportunity to determine the potentials of this data radio nets in condition of multipath propagation and fast fading. The practical results, obtained with Harris RF-5880H-MP/RE tactical HF radio, are presented.

I. INTRODUCTION

In the report the transmission IP data in HF channel is considered. It's built with usage of HF tactical radio sets such as RF-5800H-MP (Falcon II). HF communications in urban environments may provide a tactical communications capability via near-vertical incidence skywave and surface wave, which is important for military patrols. It is well known that the modern data compression and coding techniques (MPEG-4, JPEG 2000) and high rate waveforms have recently been combined to provide rudimentary videoconferencing using a standard 3 kHz channel.

The problem is of great interest, because of in tactical units, especially executing mission (peace-keeping and post-conflict reconstitution), frequently it is necessary for clearing up of tactical circumstances to translate of the images, sound and other data. It becomes complicated because sometimes channel is multipath and with fast fading, especially in an urban area [1,2,4]. Besides because of tactical reasons of personnel safety, the velocity of movement of a radio set is recommended to be more than 100 km/h.

The aim of presented work is IP traffic exploration in concrete HF channel.

II. HF DATA PACKETS MEASUREMENTS

Transmission of data is realized as it is shown in Fig.1. In the stationary conditions, three data files were transmitted (AM Transport media in the Milennium.pdf, MDL General presentation.pdf and shock12.wav) with size of 324 Kbytes, 1155 Kbytes and 724 Kbytes respectively. The measured data rate was 9,6 kbps.

The last file is interesting because of its similarity to the signal from explosion, Fig.1. Its analysis can be useful to obtain the relevant parameters of the explosive device and the corresponding countermeasures can be recommended.

III. DATA ANALYSIS

By contrast the voice networks, where the mean traffic rate is the important measure, data traffic is extremely bursty. It looks same over a range of different time scales. Particularly on wireless channels, we need to change the traditional metrics used to evaluate systems [3].

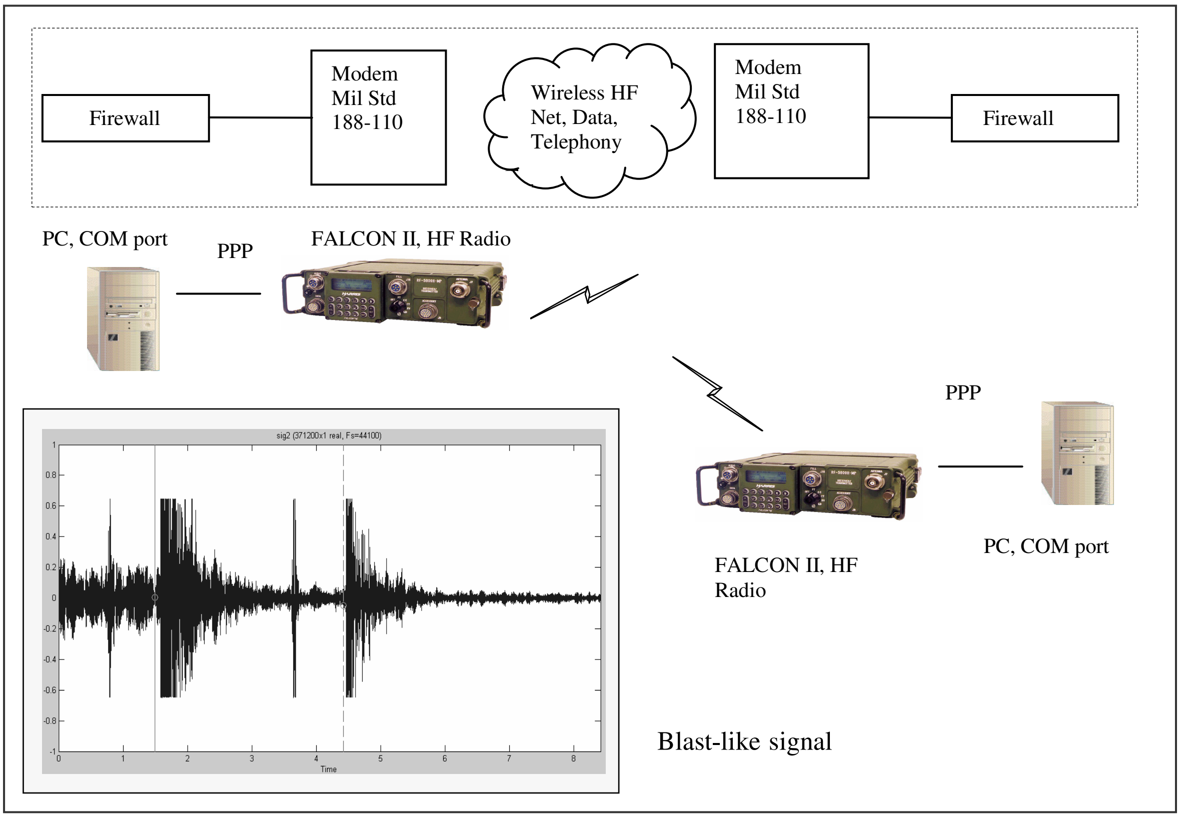
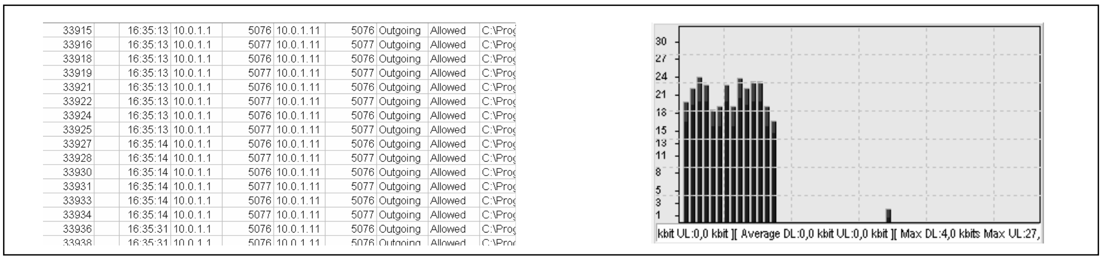


Fig.1 Block diagram of the equipment for measurement of HF data packet traffic.

An example of packet traffic, captured by a firewall in a wireless PPP network, is shown in Fig.2. The COM port monitoring is presented in Fig.2. In this case is used UtilKit DLUL Meter application. On Fig.3. are shown the packets, transmitted on ports 5076 and 5077, in the last 94 sec. (blast-like signal). As it is known [3], the processes, whose spectra changes with time, are *nonstationary* processes. Many (linear and quadratic) techniques have been developed for nonstationary signal processing. In this paper it is used the *Wavelet Transform* [3], which is more complex than the STFT (*Short Term Fourier Transform*), but offers better time-frequency resolution by trading of time resolution for frequency resolution and vice versa.



33915		16:35:13	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33916		16:35:13	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33918		16:35:13	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33919		16:35:13	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33921		16:35:13	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33922		16:35:13	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33924		16:35:13	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33925		16:35:13	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33927		16:35:14	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33928		16:35:14	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33930		16:35:14	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33931		16:35:14	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33933		16:35:14	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33934		16:35:14	10.0.1.1	5077	10.0.1.11	5077	Outgoing	Allowed	C:\Prog
33936		16:35:31	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog
33938		16:35:31	10.0.1.1	5076	10.0.1.11	5076	Outgoing	Allowed	C:\Prog

Fig.2. An example of firewall packet traffic and the COM port monitoring

The received data– Fig.4, were processed by MatLab application "One dimensional Wavelet Coefficients Selection Tool". The approximation coefficients A5 and detailed D1-D5 are presented respectively. Decomposition is realized by Haar basis up to fifth level. It is shown, that only 1700 coefficients (from 39761 total) are significant for analysis.

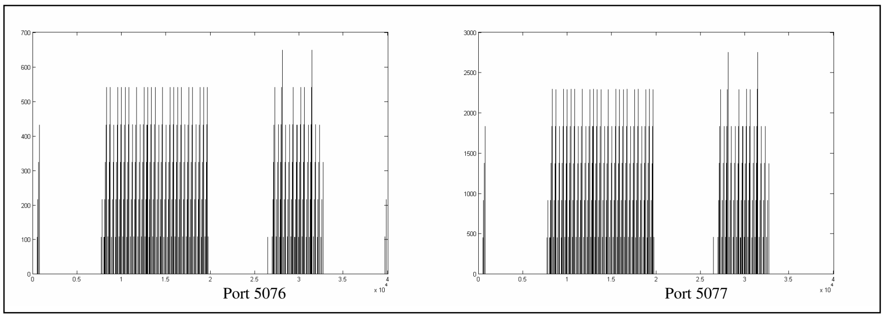


Fig.3. The packets transmitted on ports 5076 and 5077, in the last 94 sec.

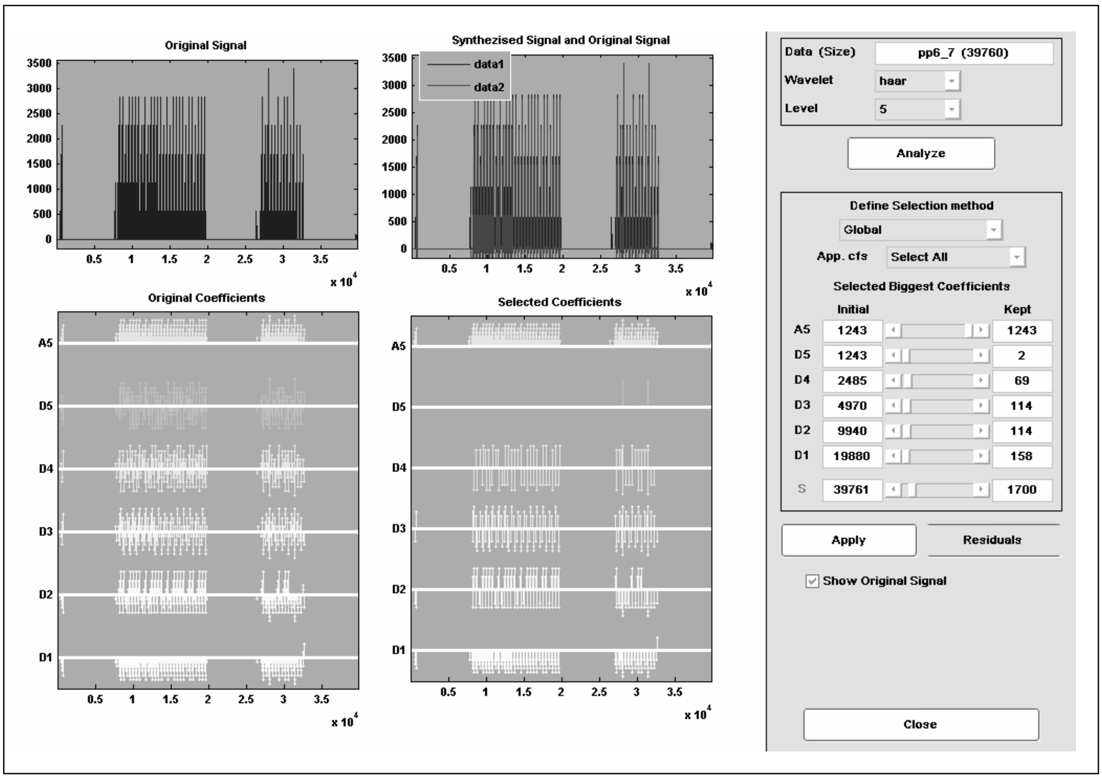


Fig.4. Decomposition by Haar basis of packets traffic

In the future the authors plan to obtain and to analyze the experimental set (Fig.1) in case, when the relative velocity between the transmitter and receiver is more than 100 km/h.

IV. MODEM SIMULATION

From theoretical reasons, the lower bound for AWGN channel is

$$P_e = Q\left(\sqrt{\frac{E_b.(1-\rho)}{N_0}}\right),\ Q(x) = 1\Big/\sqrt{2\pi}\int_x^{\infty}\exp(-x^2/2)dx,$$ ρ-correlation coefficient

When the modulation is BPSK (antipode signals), ρ = -1.
The upper bound for Rayleigh fading channel with BPSK modulation is [4]

$$P_e = \frac{1}{2}\left(1-\sqrt{\frac{E_b/N_0}{1+E_b/N_0}}\right).$$

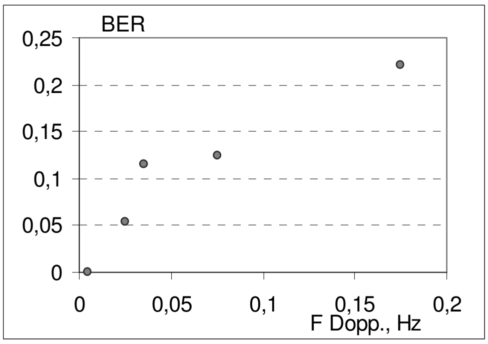
$P_e \approx 1/(\overline{E_b/N_0})$, for noncocherent orthogonal.

The bounds for Rayleigh fading channel and for fast fading channel are shown in Appendix, Fig. 6

Table 1 presents the Doppler spreads (Δ_{FDopp}) for some velocities. By use of Simulink model MIL STD-188-110, the performance of RF-5800H-MP modem for some Doppler frequencies is estimated. On Fig.5 BER for some Doppler frequencies is shown.

Table 1. Doppler spreads for some velocities (λ=12m)

V, m/s	0,31	0,9	2,08	5,56	11,11	16,67	22,22	27,78	33,33
V, km/h	1,1	3,25	7,5	20	40	60	80	100	120
F Dopp., Hz	0,025	0,075	0,174	0,463	0,926	1,389	1,852	2,315	2,778
T_0, s	19,63	6,64	2,88	1,08	0,54	0,36	0,27	0,216	0,18
Dopp. Spread-Δ_F,Hz	0,051	0,15	0,34	0,93	1,85	2,78	3,70	4,63	5,56



F Dopp, Hz	BER (Modem simulation)
0,005	0
0,025	0,0532
0,035	0,115
0,075	0,1236
0,175	0,2216

Fig.5**.** BER for some Doppler frequencies

CONCLUSIONS

The use of wavelet analysis of mobile HF channel IP traffic (realized by tactical radios) afford an opportunity to determine the potentials of this data radio nets in condition of multipath propagation and fast fading.

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APPENDIX

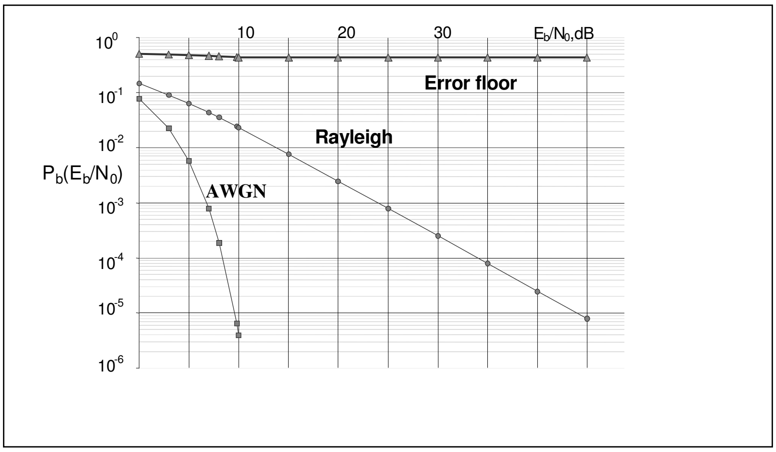

Fig.6. Bounds for fast and slow fading channels (BPSK modulation).