

Doppler Effect in OFDMA Problems - Summary

1. Shortly about Doppler Effect influence on OFDMA signal.

The OFDMA system is significantly sensitive to the vehicle velocity due to considerable symbol length.

The Doppler Effect causes carrier frequency shift and symbol length variation. These variations may be different in each channel and can not be improved by synchronization techniques.

Individual signals symbols are “shrinking” or “stretching” depend on value and direction of Doppler (Shift). This change results in different phase shift. Receiver is not able to follow the different carrier frequency shifts and phase variations in different signals simultaneously. So the undesirable symbol changes are accumulated during the frame period.

As a result, the orthogonality is deteriorated and, therefore, pilot signals depend now not only on channel condition, but on the transmitted information too. Consequently, the BER value is increasing from symbol to symbol in each particular frame.

2. In the frame of Manfred project the special simulation program was developed. It takes into account the problems mentioned above.

Transmitting signal consists of four signals S1, S2, S3 and S4.

Each signal is transmitted by eight carriers with QPSK modulation.

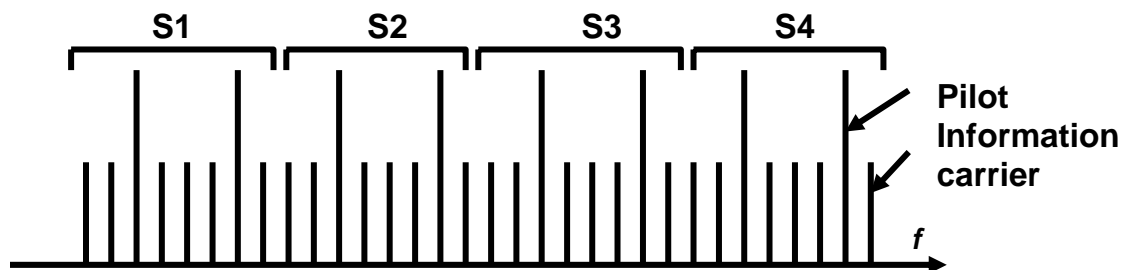
Symbol duration is T.

Guard interval is 0.1T.

Frequency difference between carriers before Doppler Shift is $\Delta F = 1/T$.

Each symbol includes two pilots with amplitude twice information carrier amplitude.

Doppler Effect value is $D = \pm \Delta f d / \Delta F (\%)$, where $\Delta f d$ is Doppler frequency changing.



3. Simulation parameters:

All four signals are transmitted together with the same Doppler shift (OFDM)

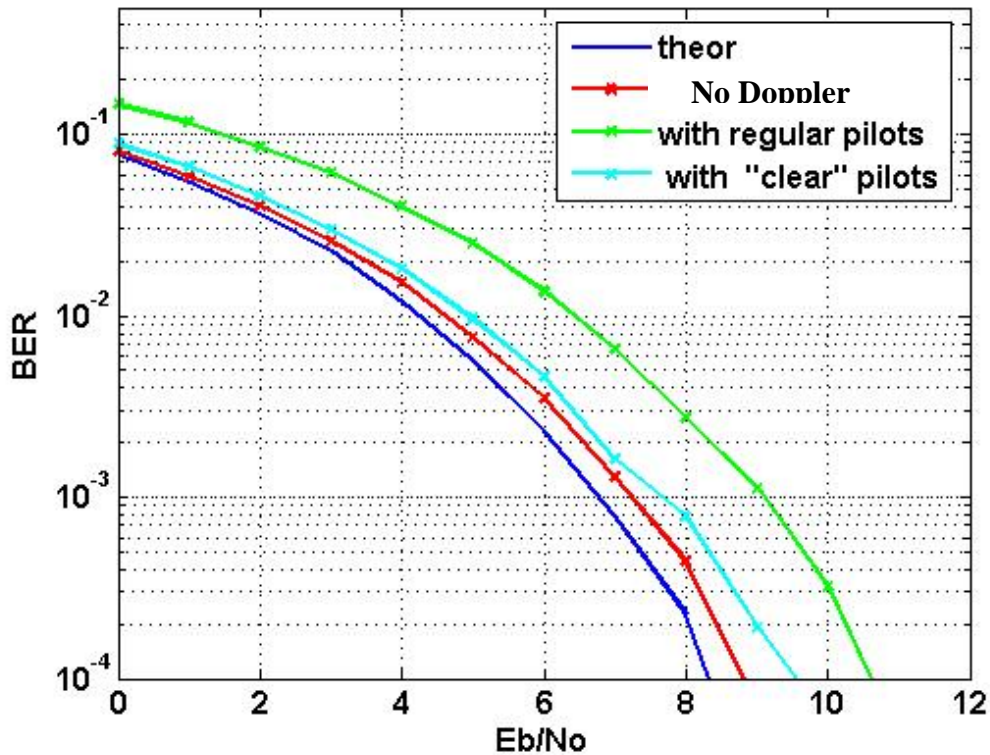
Number of frames: 100.

D has following values: 0, $\pm 0.5\%$, $\pm 1\%$, $\pm 3\%$, $\pm 5\%$

Note that $D = 1\%$ corresponds to $T = 100 \mu s$, $\Delta F = 10 \text{ kHz}$ and 120 km/h vehicle velocity.

We made following simulation. We took OFDMA signal with pilots and have got $BER = f(E_b/N_0)$. After that in the same conditions we took only pilots. Then we repeated calculation with “clean” pilots. New E_b/N_0 data has improved greatly.

BER of OFDM QPSK 4 signals with dopplers shifts: 3% -3% 3% -3%



4. Summary conclusion

Note, pilot signals deterioration influence negatively on the efforts to improve other impairments (multi path propagation, phase noise, jitter).

Given analysis and simulation results show, that OFDMA using pilot signals can not work normally when the Doppler Shift is more than 1%.

The conclusion is that in the above conditions, it is preferable OFDMA system without pilot signals.