# TWO-STAGE OPTIMAL ALGORITHM OF JOINT ESTIMATION OF INFORMATION SYMBOLS AND CHANNEL FREQUENCY RESPONSE IN OFDM SYSTEMS

**Myronchuk O.Y.**
*Radioengineering faculty*
*Igor Sikorsky Kyiv Polytechnic Institute, Kyiv*
*Scientific adviser – Shpylka O., PhD.*

Orthogonal frequency division multiplexing (OFDM) is widely used in modern digital communication systems such as digital video and audio broadcasting (ISDB-T, DVB-T, DVB-T2, DRM, DAB), wireless broadband networks (IEEE 802.16), local area networks (IEEE 802.11a, g, n), mobile communication systems (LTE, LTE Advanced) and other. The main advantages of OFDM are high spectrum efficiency and possibility to provide high data transmitting speeds [1, 2].

Mobility is important requirement for modern communication systems. In OFDM systems it means passing the broadband signals thru the variable in time multipath channels. For correct demodulation receiver should estimate channel parameters. The probability of error in reception depends on the accuracy of the channel estimate: the more accurate the estimate, the less error probability can be achieved during data transmission.

Pilot signals are widely used in channel estimation. They are located in positions known to the receiver. The pilot layout in the form of a parallelogram grid is widely used in practice. In case of dynamic channels for frequency response estimation can be used only pilots from current received OFDM symbol. Quasi-optimal two-stage channel frequency response estimation algorithms based on pilot signals described in [3-5]. Actual task is to develop two-stage algorithms of joint estimation of channel frequency response and information symbols [6, 7].

Channel frequency response values on each subcarrier of OFDM symbol can be represented as continuous random variable with Gaussian distribution. Information symbols can be represented as uniformly distributed discrete random variable. An expanded process which includes a continuous component and a discrete component is a mixed Markov process in discrete-time.

Structure of two-stage optimal algorithm of joint estimation of information symbols and channel frequency response based on pilots from current received OFDM symbol described by next equation

$$p\left(H(k),s^{j}(k)\,|\,\mathbf{Y}\right)=\frac{p\left(H(k),s^{j}(k)\,|\,\mathbf{Y}_{f},y(k)\right)}{p\left(H(k),s^{j}(k)\right)}\,p\left(H(k),s^{j}(k)\,|\,\mathbf{Y}_{b}\right)\frac{P\left(\mathbf{Y}_{f},y(k)\right)P\left(\mathbf{Y}_{b}\right)}{P\left(\mathbf{Y}\right)},\quad(1)$$

where $k$ is the number of subcarrier in OFDM symbol; $s^{j}(k)$ is the of element from alphabet that contains $j=\overline{1,L}$ information symbols; $H(k)$ is value of channel frequency response; $\mathbf{Y}_{f}$ are values of measurements before $k$-th subcarrier; $\mathbf{Y}_{b}$ are values of measurements after $k$-th subcarrier; $\mathbf{Y}$ are values of all measurements.

At the first stage should be calculated posterior joint probability density $p\left(H(k), s^j(k) \mid \mathbf{Y}_f, y(k)\right)$ and extrapolated joint probability density $p\left(H(k), s^j(k) \mid \mathbf{Y}_b\right)$. At the second stage should be calculated posterior joint probability density $p\left(H(k), s^j(k) \mid \mathbf{Y}\right)$ by the way of combining $p\left(H(k), s^j(k) \mid \mathbf{Y}_f, y(k)\right)$, $p\left(H(k), s^j(k) \mid \mathbf{Y}_b\right)$ and priory joint probability density $p\left(H(k), s^j(k)\right)$. The probability densities $P\left(\mathbf{Y}_f, y(k)\right)$, $P\left(\mathbf{Y}_b\right)$, $P\left(\mathbf{Y}\right)$ uses as normalizing factor. The disadvantage of the two-stage optimal algorithm for joint estimation of information symbols and the frequency response of the channel is the need to integrate multidimensional probability densities which requires high computational costs and complicates the practical implementation of the algorithm. Quasi-optimal two-stage algorithm of joint estimation of information symbols and channel frequency response synthesized by the way of Gaussian approximation of probability densities described in detail in [8].

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