Internet of Things, Big Data, Cloud Processing, Video on Demand in 4k standard, Sensor Networks - these are just a few examples of new applications generating large amounts of data that have to be carried over telecommunication networks. The number of users, and now also devices, connected to the network is constantly increasing, which, combined with the aforementioned increase in the demand for bandwidth of individual applications, leads to an exponential increase in the volume per unit of time transmitted in data networks. In optical transmission, the most cost-intensive process is the installation of new optical cables. In order for optical networks to be able to cope with the increasing load, it is necessary to develop more bandwidth-efficient ways of transmitting information than the current ones. Unfortunately, currently used modulations in optical transmission do not use 100% of the bandwidth. In the case of single carrier modulation, it would require the use of filters with rectangular spectral characteristics, which do not exist. In the case of modulations with many carriers, which is usually OFDM (orthogonal frequency division multiplexing), it is necessary to allocate part of the symbol's duration to the cyclic prefix, which is an overhead.

In this work, modulation formats that use 100% of the bandwidth for information transmission will be proposed and tested in optical transmission. The first of these formats will be developed on the basis of offset modulation. This modulation will be obtained by superposing simultaneously transmitted signals: low-band, middle-band and high-band. Orthogonality of these signals can be achieved by using offset between the sub-band signals. This modulation has full bandwidth efficiency. The new modulation has very interesting properties, which allow to limit the hardware resources necessary for its generation to the necessary minimum and achieve high energy efficiency. It is necessary to develop efficient methods of correction and allocation of bits to bands, which will be the subject of this work.

Another way to increase bandwidth efficiency is to use modulations that break the fundamental limitation of Nyquist on the minimum bandwidth needed for transmission. It turns out that there are some results from the information theory, which indicate that the sent impulses can be accelerated even by 25% in relation to this limit, without deteriorating the quality of reception despite the loss of orthogonality. Similarly, the carrier spacing in modulations with many carriers can be compressed below orthogonality limit. The price of such operation is more complex signal processing in the receiver. Such modulations are currently the subject of intensive research in the radio field. As part of this work, we plan to test them for optical transmission.

As it is well known, the light intensity cannot be negative. To accommodate this requirement in the optical transmission, the bipolar modulation signal is added to a constant bias signal polarizing the light source, so that the total signal does not take negative values. This is highly inefficient in terms of energy consumption. Unfortunately, unipolar modulations, i.e. those that in principle cannot take negative values, have twice as low bandwidth efficiency as bipolar modulations. Two methods of transmission breaking this limitation will be proposed in this paper: a method using a different kind of shaping filter in the transmitter and a method using acceleration of impulses above the limit resulting from orthogonality.

The proposed modulations will be examined theoretically, simulatively and experimentally in different optical links: link in free space, links typical for data centers and optical transmission with the use of coherent reception.