DVB-T OFDM modulation system

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Abstract: In Europe, the end of the 20th century was the period of the changing to digital systems, including television broadcasting. In Hungary the first digital terrestrial pilot transmissions were started in 1999 and the supplier company plans a start of the full services in autumn 2004, so the time is right to give a brief technical description what is it about and why is it good for us.

Keywords: Digital Video Bradcasting – Terrestrial (DVB-T), OFDM modulation, multi-carrier, constellation diagram, bit error, frequency spectrum

1 Introduction

The first Terrestrial Digital Video Broadcasting pilot transmissions were started in the late 90's, and the first commercial system was established in Great Britain. In the next few years the digital broadcasting system has been set up in many countries, and the boom of the digital terrestrial transmission is estimated in the next few years, while the analogue transmission will be cancelled within about 15 years.

1.1 Why DVB-T?

The greatest advantage of the digital system is the effective use of the frequency spectrum and its lower radiated power in comparison with the analogue transmission, while the covered area remains the same. Another key feature is the possibility of designing a so-called Single Frequency Network (SFN), which means that the neighbouring broadcast stations use the same frequency and the adjacent signals don't get interfered. The digital system transmits a data stream, which means that not only television signals but data communication (e.g. Internet service) may be used according to the demands. The data stream consists of an MPEG-2 bit stream, which means a compression is used, enabling the transfer of even 4 or 5 television via the standard 8 MHz wide TV channel. For the viewer,

the main advantages are the perfect, noise-free picture, CD quality sound, and easier handling, as well as services like Super Teletext, Electronic Programme Guide, interactivity and mobility.

2 Technical Issues

1.2 Modulation

The DVB-T Orthogonal Frequency Division Multiplexing (OFDM) modulation system uses multi-carrier transmission. There are 2 modes, the so-called 2k and 8k modes, using 1705 and 6817 carriers respectively, with each carrier modulated separately and transmitted in the 8 MHz TV channel. The common modulation for the carriers is typically QPSK, 16-QAM or 64-QAM. Each signal can be divided into two, so-called „In Phase" (I) and „Quadrature Phase" components, being a 90° phase shift between them. This modulation can be demonstrated in the constellation diagram, where the 2 axes represent the 2 components (I and Q). In case of using 16-QAM modulation, the number of states is 16, so 1 symbol represents 4 bits. The constellation diagram and the bit allocation is shown in figure 1.

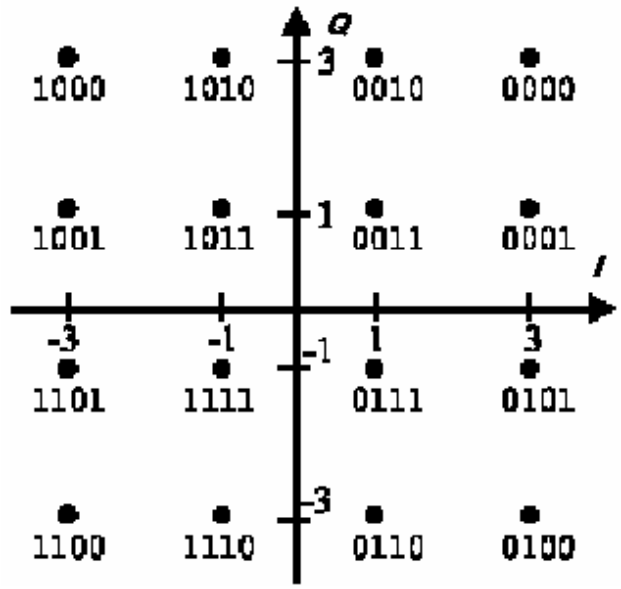

Figure 1 16-QAM constellation diagram and bit allocation

1.3 Bir errors

If we simulate all the carriers in the constellation diagram we get not just 1 discrete point, but many points, forming a „cloud" and representing each state. In case of additive noise the „cloud" gets bigger and the receiver may decide incorrectly, resulting in bit errors. Figure 2 shows the measured constellation diagram without and with additive noise.

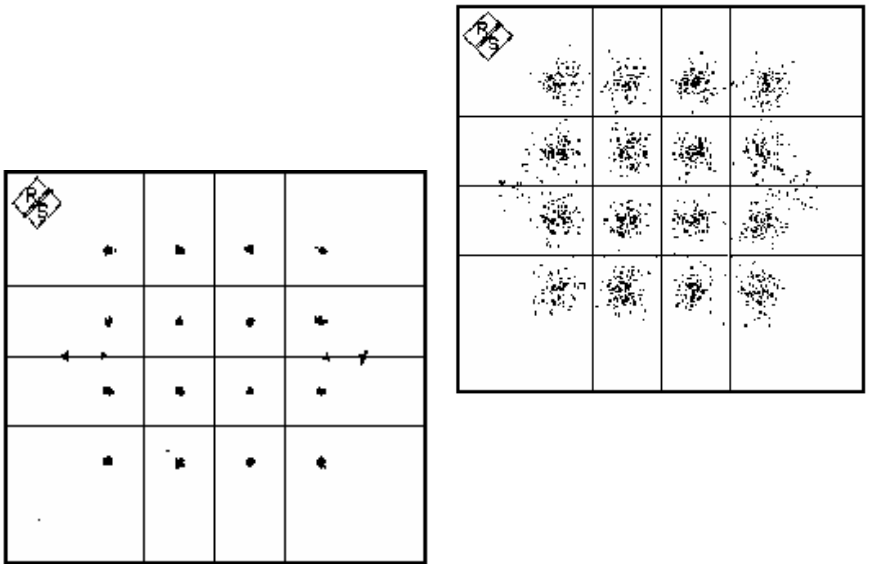

Figure 2 Measured 16-QAM constellation diagram

a) without additive noise b) with additive noise

To ensure perfect picture quality, the DVB-T system uses a 2 level error correction (Reed-Solomon and Viterbi). This corrects the bad bits at an even 10^{-4} Bit Error Rate (BER) and enables error-free data transmission.

1.4 The multi-carrier structure

The structure of carriers can be illustrated also in the function of time (Figure 3). The horizontal axis is the frequency and the vertical axis is the time. The 8 MHz channel consists of many carriers, placed 4462 Hz or 1116 Hz far from each other according to the modulation mode (2k or 8k). There are some reserved, so-called Transmission Parameter Signalling (TPS) carriers that do not transfer payload, just provide transmission mode information for the receiver, so the total number of "useful" carriers is 1512 and 6048 respectively in the two transmission modes, and

the resultant bit rate is between 4,97 and 31,66 Mbit/s, depending on the modulation (QPSK, 16-QAM or 64-QAM), the transmission mode (2k or 8k), the Code Rate (CR) used for error correction and the selected Guard Interval (GI). This guard interval means that there is a small time gap between each symbol, so the transmission is not continuous. This guarding time enables perfect reception by eliminating the errors caused by multipath propagation.

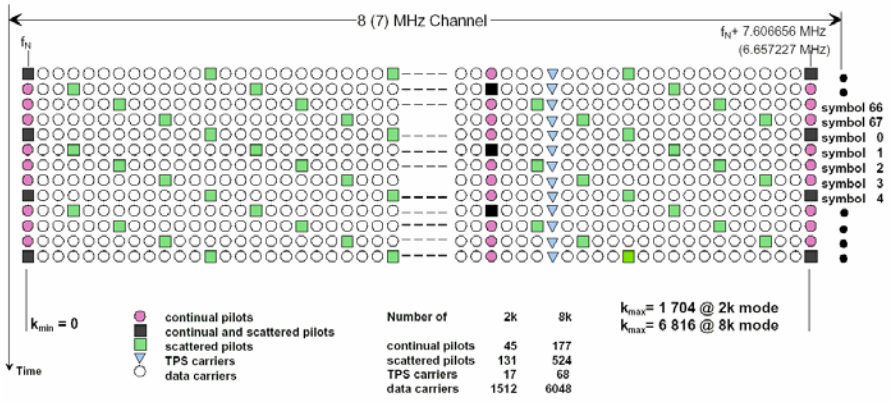

Figure 3 Structure of OFDM carriers

1.5 Frequency spectrum

In 2k mode, 1705 carriers are modulated in the 8 MHz TV channel, so each carrier is 4462 Hz far from its neighbour, while in 8k mode this distance is 1116 Hz. In digital broadcasting, there are no vision and sound carriers, so the power for each carrier is the same. This means the amplitude of the frequency spectrum of the DVB-T signal is constant in the TV channel, and the radiated power is smaller than in the case of analogue broadcasting. A measured spectrum is shown in figure 4, where there are three TV channels, two of them digital (DVB-T), and one of them analogue (PAL signal).

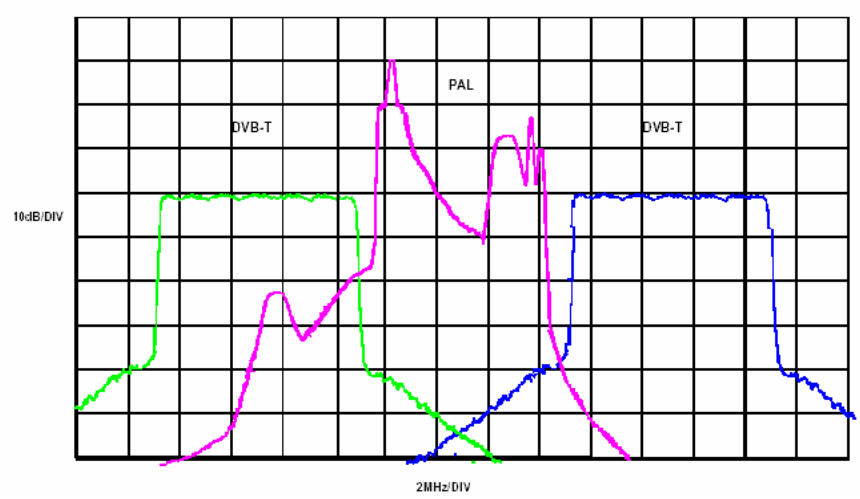

Figure 4 Frequency spectrum of DVB-T and analogue signals

Conclusions

In conclusion, the Orthogonal Frequency Division Multiplexing used in Terrestrial Digital Video Broadcasting is a new and a very complex modulation form. This is a multi-carrier system, where each carrier is modulated digitally. Due to the error correction, the Guard Interval, and to the fact that the carriers are dispersed in the frequency spectrum, OFDM is a very robust and noise-resistant modulation system. The transmitted data stream can be used not just for video broadcasting, but if only TV channels are transmitted, due to the MPEG compression 4-5 TV programs can be transferred in 1 TV channel, so the frequency spectrum can be allocated more effectively. And even the mobile reception is possible, which means that the viewer sits in his up-to-date solar cell car and watches digital broadcast channels, while receiving better picture quality and has access to more services, so the time is right to change progressively the present analogue broadcasting systems and make a step forward.

References

[1.] DVB-T standards: ETSI EN 300744 v1.2.1 (1999 July)

ETSI ETR 290

ETSI TR 101290 v1.2.1 (2001 May)

[2.] Rohde & Schwarz, S. Grünwald: Digital TV – Rigs and Recipes Part 4 (DVB-T)

[3.] Géher Károly: Lineáris Hálózatok (Tankönyvkiadó, 1966)

[4.] Prónay G. - Solymosi J. - Trón T: Tervezési segédlet a Lineáris hálózatokhoz

[5.] Antenna Hungária Rt. home page (www.ahrt.hu hu/szolgaltatasok/tv_digitalis)