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A Review on Digital Video Broadcasting Terrestrial (DVB-T) Based OFDM System

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Abstract:

Digital broadcast systems have increasingly been deployed for various services such as Digital Video Broadcasting (i.e. DVB-S, DVB-T, etc.) and Digital Audio Broadcasting (DAB). Classical digital broadcast systems were designed with fixed modulation techniques, which had to guarantee reliable communication even with very hostile channel environment. Video Broadcasting is playing a key role in communication areas. In this paper DVB-T (terrestrial based digital video broadcasting) based OFDM is analyzed in terms of various parameters for 2K mode.

***Keywords:-* Digital video broadcasting, DVB-T, orthogonal frequency division multiplexing, OFDM.**

I INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a promising technique for future broadband wireless communication systems. For coherent modulation schemes, which are used for example in the European digital video broadcast terrestrial (DVB-T) [1], a powerful channel estimation scheme is necessary. To yield optimum performance of the channel estimator, the estimator must be adapted to the current channel state. The main parameters of the channel are the user's velocity, which ranges from (0 to 360) km/h, and the channel delay spread. These parameters affect the correlation functions, which are used for channel estimation, and reliable estimates of them are important for good results. A proposal for an adaptive channel estimator with only a small computational effort in the mobile terminal and a robust velocity estimator for OFDM based communication systems was presented in [2]. In this paper we propose an estimator for the channel delay spread . In [3] Sanzi and Speidel proposed an algorithm to adapt the length of the guard interval Tg to the shortest possible length dependent on the current channel impulse response. These results are not very accurate and _ is not a function of the guard interval length. Onizawa et al. [4] have proposed a filter adaption algorithm which is based on the difference vector of the channel transfer function between two adjacent suitable for channels with larger delay spreads. The new algorithm presented here is based on a correlation between decision feedback estimates of the data symbols and the incoming data stream. It is shown, that this estimator generates reliable results, which can be used for example to select the appropriate filter set in [2], and is reliable for velocities of up to v = 360 km/h. subcarriers. However, this estimation technique is not suitable for channels with larger delay spreads. The new algorithm presented here is based on a correlation between decision feedback estimates of the data symbols and the incoming data stream. It is shown, that this estimator generates reliable results, which can be used for example to select the appropriate filter set in [2], and is reliable for velocities of up to v = 360 km/h.

Traditionally, the terrestrial broadcasting planning approach involved the definition of a number of assignments, each of which consists of the transmitter site specified in terms of longitude and latitude, as well as the specific transmitter's characteristics and antenna's configuration. These

parameters are chosen to ensure acceptable reception or 'coverage' of the desired service in an area associated with, and usually surrounding, the transmitter location. However, the desired coverage of the assignment was not explicitly taken into account during the development of the plan and, in principle, could not be determined until the plan was finalized. This is the approach used for the establishment of the Stockholm (ST-61) broadcasting plan. On the other hand, a plan must not only provide means to specify ones right to use a spectrum resource, but more importantly, means to protect its effective utilization. On this line of thought, it is more essential for a plan to achieve protection of known service areas, than to specify the characteristics of a number of transmitting sites.The developments in standardization of digital radio broadcasting systems have introduced new possibilities regarding the methodology of planning terrestrial broadcasting networks. The introduction of single frequency networks (SFNs), allows the synchronization of the transmitters of a confined geographic area, so that they may operate at the same frequency channel without any destructive interference occurring at the receiver. Therefore, the planning of digital radio broadcasting networks has gained a degree of flexibility, which allows transmitter characteristics and placement calibration, as more than one transmitter may be used to achieve coverage over a given area without depleting spectrum resources. This approach that has already been employed in recent broadcasting plans, such as the Maastricht 2002 terrestrial digital audio broadcasting (T-DAB) plan and the Geneva 2006 DVB-T and T-DAB plan [5], allows the simplification of the planning process using a higher level of abstraction, namely allotments. The actual implementation of the allotment into a set of assignments can be postponed to a latter stage. In addition, this planning approach is appropriate for very large scale planning that may comprise regional
broadcasting networks with different degree of design and implementation progress.

II. OFDM System Model

A basic OFDM system model [6] has PSK or QAM modulator/demodulator, a serial to parallel /parallel to serial converter, and an IFFT/FFT module. The hardware implementation of OFDM requires the use of either ASIC (Application Specific Integrated Circuit) or FPGA (Field Programmable Gate Array) in applications such as DVB, DAB and SDR (Software Defined Radio) and so on. Mathematically, an lth OFDM signal at the kth subcarrier can be expressed as [7]

$$\psi_{l,k}(t) = \begin{cases} e^{j2\pi f_k(t-lT_s)}, & 0 < t \le T_{sym} \\ 0, & elsewhere \end{cases}$$

Then the continuous-time pass band OFDM signal is given by

$$x_l(t) = Re\left\{\frac{1}{T_{sym}}\sum_{l=0}^{\infty}\left\{\sum_{k=0}^{N-1} X_l[k]\psi_{l,k}(t)\right\}\right\}$$

Therefore, the discrete-time baseband OFDM signal can be achieved by sampling the continuous time OFDM signal att = lTsym + nTs and is given as

$$x(n) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} X_k e^{j2\pi kn/N} \qquad -N_g \le k \le N + N_g$$

Where N is the IFFT/FFT length. Ng represents the number of guard samples. Considering perfect timing and no carrier frequency offset, the samples at receiver can be expressed as

$$r(k) = x(k)e^{\frac{j2\pi k}{N}} + n(k)$$

where n(k) is the additional Gaussian white noise.

III. Overview Of DVBT System

The DVB-T system is the terrestrial standard for digital TV transmission used in Europe and is just one of a collection of related standards maintained by
the DVB consortium. It is highly complex and we are
not going to make a thorough review, on the contrary,
we will focus on the most important points for the following sections of this article. This entire section is based on reference [8]. The DVB-T system is based on OFDM but builds on it adding a lot of other digital communications techniques. It has 2 modes of operation, one with 2048 carriers, usually refered to as *2k mode*, and the other with 8192 carriers, called the *8k mode*. The 8k mode is more robust to multipath fading and impulsive noise, but also requires more computational power. Since the channel bandwidth is always the same (6MHz, 7MHz

or 8MHz, depending on the country), the 2k mode results in a larger spacing between carriers and is often a better choice for mobile communications in which strong doppler effect causes spreading of the carriers. Not all carriers are used for data, in both modes there are guard bands filled with null carriers on the left and right borders of the spectrum . The standard also includes a frame structure aimed at organizing the information in a ordered fashion so that the receiver can track many of the processes going on at the same time. If, for instance, the receiver interrupts reception for some uncontrolled reason, it is the frame structure that accounts for a quick recovery of the synchronism. In the DVB-T, a *frame* is composed of 68 symbols and a *super-frame* is composed of 4 frames. Figure 1 shows a simplified block diagram of the DVB-T signal generation process. As seen, the main blocks are:
_ DVB-T coding;
_ QAM mapping;
_ Pilot carriers insertion;
_ IFFT and Cyclic prefix insertion.

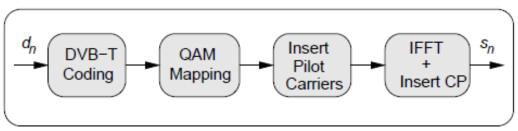

Fig:1 Block diagram of the DVB-T signal generation.

The coding block is a necessary phase in any digital TV system. In the specific case of the *DVB-T coding*,
the steps involved are:

- Generation of the MPEG2 transport stream. This step includes the creation of the program to be transmitted;
- Energy dispersal scrambling. Its main function is to garantee a minimum level of (pseudo)randomness to the data stream to be transmitted
- Outer coding and interleaving. It is a block systematic coding based on a interleaved Reed-Solomon RS(204,188,t=8) shortened code, which offers error correcting capabilities against impulsive noise;
- Inner coding and interleaving. This is a punctured convolutional coding devised to add robustness against additive white gaussian noise.

It is common to find references to an *uncoded DVBT system* in the technical literature, which refers to a DVB-T implementation without the coding phase. Those systems are useful, as in our case, when implementing new improvements to or studying the robustness of the DVB-T signal modulation phase. When implementing an uncoded DVB-T system, a pseudorandom byte stream with uniforme distribution should be provided as input, in order to supply a source of data similar to the original one. The DVB-T system allows the use of 5 types of signal constellation, namely: QPSK, 16QAM, 64QAM, non-uniform 16QAM and non-uniform 64QAM; the
last two are specially suited for hierarchical transmission modes. The QAM mapper divides the received byte stream in appropriate blocks of bits (2, 4 or 6bits) and maps them to the corresponding complex symbols according to the constellation type. In our simulations, we have conducted tests only with the uniform constellations which are by far the most
common in practical applications. There are 3 sorts of pilot carriers in the DVB-T system:

- *TPS Pilots*, which carry information on all the transmission parameters. Every TPS in a single symbol carries exactly the same information in a differentially encoded form. This high level of redundancy provides strong rosbustness against channel fading and is very useful on a initial synchronizing phase;
- *Continual Pilots*, which carry information known a priori and are used for channel estimation. They are called *continual* because they occur always at the same carrier number in all symbols. They are transmitted with 16/9 of the power of data carriers for extra robustness;
- *Scattered Pilots*, which are similar to the continual pilots in power and purpose, but whose position change from symbol to symbol.

Fig: 2 illustrates the typical distribution pattern of scattered and continual pilots in a sequence of DVB- T symbols. As shown in the picture: the first and last non-null carriers are continual pilots; every 4 symbols the pilot distribution pattern repeats; for every 3 carrier positions, 1 is occupied by a pilot carrier in some symbols.

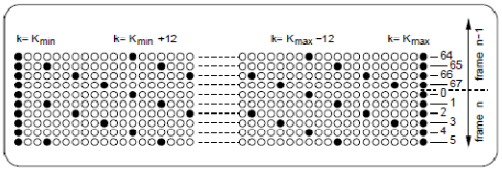

Fig: 2 Typical pilot carrier distribution pattern of DVB-T.

Continual pilots offer high temporal sampling rate of the channel response since they are available at every symbol; scattered pilots offer high frequency sampling rate of the channel response since they are available every 3 carrier positions. This bi-dimensional sampling scheme results in very good channel estimation capabilities. After inserting the pilot carriers, the next step is to execute the IFFT and obtain what is usually called in the technical literature as the *useful symbol*. The complete DVB-T symbol is obtained by the addition of the *cyclic prefix* (CP). The CP is comprised by the last samples of the useful symbol, which are repeated at the beginning. The DVB-T standard offer 4 choices for the length of the CP specified as a fraction of the length of the useful symbol: 1/4, 1/8, 1/16 and 1/32. The longer the CP, the higher the robustness to multipath fading, but also the lower the channel efficiency since the CP carries only redundant information.

IV. OFDM Transmission and Reception in DVB-T

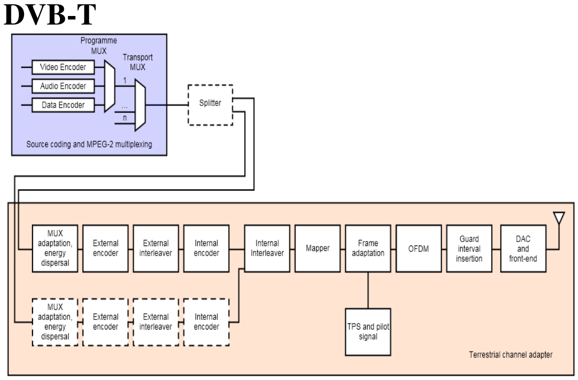

Fig: 3 Block Diagram for DVB-T Transmitter

The block diagram for DVB-T standard is shown in the Figure 3. The processes described in this diagram are carried out in a Digital Signal Processor (DSP). This paper focuses on the implementation of 2K mode of DVB-T standard [9] and the parameters for this mode are given in table.

Parameters	2k Mode
Elementary Period (T)	7/64 µs
Number of Carriers (K)	1705
Value of carrier number Kmin	0
Value of carrier number Kmax	1704
Duration (TU)	224 µs
Carrier Spacing (1/TU)	4464 Hz
Spacing between carriers Kmin and Kmax	7.61 MHz
Allowed Guard Interval Δ/T_U	1/4, 1/8, 1/16, 1/32
Duration of Symbol part T_U	224 µs
Duration of guard interval Δ	56µs, 28µs,14µs, 7 µs
Symbol Duration $T_S = \Delta + T_U$	280µs, 252µs,238µs, 231µs

Table 1 : OFDM Parameters for DVB-T 2K Mode

The OFDM signal expression in DVB-T is given by the following emitted signal

$$x(t) = Re\left\{ e^{j2\pi f_c t} \sum_{m=0}^{\infty} \sum_{l=0}^{67} \sum_{k=k_{min}}^{k_{max}} c_{m,l,k}\psi_{m,l,k}(t) \right\}$$

V. CONCLUSION

In this paper we have analyzed the digital video broadcast system for 2k mode. The 2K mode of DVB-T is specifically for the mobile reception of standard definition DTV (Digital Television).The OFDM transmission is carried out in frames. Each frame has duration of TF and consists of 68 OFDM symbols. One super-frame consists of four frames and each symbol is comprised of 1705 carriers in 2K mode with Ts as the symbol duration. It is composed of two parts: a useful part with duration TU and a guard interval with a duration Δ.

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