Research of DVB-H Stream Qualitative Parameters

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Introduction

Recently, the digitization of traditional broadcast networks is developing rapidly. This expansion can be apparently watched with respect to the standard for digital terrestrial television – DVB-T (Digital Video Broadcasting – Terrestrial), which is already running in many countries around the world. The decision to use DVB-T as the terrestrial TV system mostly was based on the exceptional features of the DVB-T standard. One of them is the possibility to get broadcast services even with mobile devices.

These benefits of DVB-T have attracted the interest of the mobile communication industry lately. Specifically, the possibility to reach portable terminals trough radio point-to-multipoint link, in association with wide coverage and high transmission capacity that DVB-T can offer, are features which have sparked the interest of this industry. As a result of it, new international DVB Project has responded to the industry interest by defining a new transmission standard called DVB-H.

DVB-H is one of the latest evolutions among the set of DVB transmission standards. The description of technical specifications started on 2002 and was finalized in 2004; the final version of DVB-H standard was published in November 2004 by ETSI (European Telecommunications Standards Institute) as a European Norm [1]. However, the system optimization to meet customer needs is still open question.

Like it was mentioned before, the DVB-H is based on DVB-T standard, but it takes into account specific characteristics of typical handheld terminals (which usually are small, light weight and most important has to be battery powered – that's why has limited energy capacity). To satisfy them, DVB-H uses DVB-T physical layer and introduces some unique innovations on physical and link layers.

System overview

In the physical layer DVB-H introduces three new features to compare with DVB-T:

- Transmission Parameters Signaling (TPS) – were added to extend physical layer signaling;

- Extra 4k transmission mode – to get better Doppler performance at high speeds (DVB-T had 2k and 8k modes);
- In-depth symbol interleaving – an extra time interleaving layer which used to protect data from short fading of impulse noise;

    In he link layer two:

- Time slicing – to reduce power consumption;
- Forward error correction for multiprotocol encapsulated data (MPE-FEC) – improves Doppler performance in the channel and tolerance to impulse interference.

In the physical layer communication is performed by means of DVB-T standard – employing OFDM multi-carrier modulation. Only one indispensable new feature on the physical layer is used, which makes the DVB-H signal different from a DVB-T signal – namely an extended parameter signaling for the DVB-H elementary streams in the multiplex. The signaling is implemented in a manner which is downwards compatible with the DVB-T system. Moreover, the DVB-H data stream is totally compatible with classical DVB transport streams. These qualities assure that the DVB-H data stream can be broadcast using DVB-T transmitter networks fully committed to DVB-H services as well as via DVB-T networks carrying these classical services in addition to DVB-H services. That's why vital technologies specific to DVB-H – such as time slicing and the enhanced FEC – are put above the DVB Transport Stream onto the protocol layer.

The signaling of the DVB-H primitive streams in the multiplex uses an extension of the TPS, similar like in the DVB-T standard. TPS reserves channel for information which gives tuning parameters to the receiver. There are some new elements in the TPS channel, which provide the information about time-sliced DVB-H elementary streams - are they available in the multiplex or not and shows whether MPE-FEC is used in any of the elementary streams. The TPS channel is also signaling the additional physical transmission modes. Besides, cell identifier broadcasting, which was optional in DVB-T system, is made mandatory for DVB-H, what simplifies the discovery of neighboring network cells in which the selected same service is available.

DVB-H has additional OFDM transmission mode comparing with the DVB-T specification. DVB-T uses 2K and 8K modes to better support different network topologies. DVB-H adds a 4K mode, which is created by making 4096-point Inverse Discrete Fourier Transform (IDFT) in the OFDM modulator. In the Table 1 is showed essential parameters of the three different OFDM transmission modes in DVB-H. The 4K mode meets a halfway solution between two other modes. It allows for a doubling of the transmitter distance in SFNs compared to the 2K mode and, when compared to the 8K mode, is less susceptible to the inverse effect of Doppler shifts in the case of mobile reception. The 4K mode provides more flexibility in network planning. This mode can be used only in the DVB-H networks, since DVB-T does not include it.

Table 1. Parameters of the different DVB-H OFDM modes

Parameter	Mode		
	2K	4K	8K
FFT size	2048	4096	8192
Modulated carriers	1705	3409	6817
Useful carriers	1512	3024	6048
OFDM symbol duration (µs)	224	448	896
Guard interval duration (µs)	7, 14, 28, 56	14, 28, 56, 112	28, 56, 112, 224
Carrier spacing (kHz)	4.464	2.232	1.116
Transmission distance (km)	17	33	67

Since there are three different network modes, various OFDM symbol interleaving mode schemes are defined (Fig. 1). A DVB-H terminal according to the specification supports the 8K mode and consequently incorporates an 8K symbol interleaver. But the symbol interleaver in the terminal can process the data transmitted in one whole 8K OFDM symbol or otherwise – the data transmitted in two 4K OFDM symbols, or in four 2K OFDM symbols. The new scheme makes use of all available memory and results in an increased interleaving depth for the 2K and 4K modes and in improved performance.
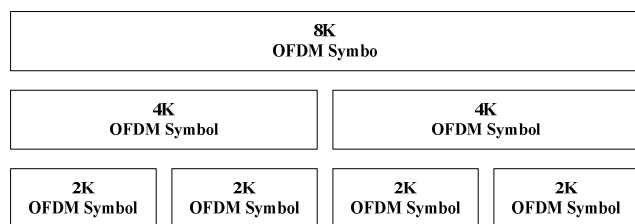
Fig. 1. In-depth symbol interleaving

DVB-H was created not only for the particular bandwidths used in TV broadcasting but also for a channel bandwidth of 5 MHz. The DVB-T standard has solutions for the three different VHF/UHF worldwide bandwidths (6 MHz, 7 MHz and 8 MHz) – that's why DVB-H supports them to. The new one 5 MHz channel bandwidth solution allows using this standard outside of classical broadcast bands.

The DVB-H terminals usually have one peculiar problem – limited capacity of their batteries. Since DVB-H is compatible with DVB-T, and sometime has to serve high data-rate streams, which has to be demodulated and decoded, the DVB-H terminal involves certain power consumption in the tuner and the demodulator part. Investigations, when the development of DVB-H jus started, showed that the power consumption of a DVB-T front end was more than 1 Watt and was not expected to decrease below 0,55 W until 2007; present lower values are possible but the desired target of 0,1 W as a maximum threshold for the entire front end incorporated in a DVB-H terminal is still not reached for a DVB-T receiver.

A notable lack for battery-operated terminals is the fact that whole DVB-T stream has to be decoded before the services (i.e. TV translation) of the multiplex are accessed. The DVB-H is saving the power by decoding only those parts of the stream, which are carrying the data of service selected by the user. In any case, the data stream has to be recognizable in a proper way for that purpose. In DVB-H, service multiplexing is made by using pure time-division multiplex. Therefore the data of some special service are broadcasted in compact bursts with halts in between, instead of continuously translation. When several services are multiplexed – continuous, uninterrupted stream of constant data-rate is transmitted.

Such a signal is received time-selectively: the terminal is synchronized to the bursts of the service and is switched to a power-save mode when other services are being transmitted in the intermediate time. The time between service bursts shows the gain of the power saving provided by DVB-H. This mechanism is called time slicing. Bursts after entering to the receiver are buffered and translated out of the buffer with the service data-rate. The position of the bursts is signaled in terms of the relative time difference between two consecutive bursts of the same service. Usually the duration of one burst is in the range of several hundred milliseconds, while the intermediate time between the bursts may be up to several seconds. Depending on the how much time the terminal was on and power-save time, the power saving may be reached up to more than 90 %.

Time slicing requires as many as possible multiplexed services and a small as possible burst data-rate to have most effective power saving. Basically, power expenditure of the front end bounds with the selected service data-rate.

There is one more benefit when time slicing is used in terminal architecture. These quite long periods between service bursts may be used by searching for other channels in neighboring cells, which are broadcasting selected service. Therefore a channel handover can be accomplished at the cells border and the user will not notice it. Both the monitoring of the services in adjacent cells and the reception of the selected service data can be realized with the same front end [3].

As distinct from other DVB broadcasting systems which are based on the DVB Transport Stream [4] borrowed from the MPEG-2, the DVB-H is based on IP (Internet Protocol). Therefore, the DVB-H base-band interface is an IP interface. It makes possible combining the DVB-H system with other IP networks. However, as the base layer of the DVB-H transmission is used the MPEG-2. The IP data are embedded into the transport stream by means of the Multi-Protocol Encapsulation

(MPE), an adaptation protocol defined in the DVB Data Broadcast Specification.

An extra level of forward error correction (FEC) is used on top MPE. The improvement, called MPE-FEC, is one of the biggest innovations in DVB-H. MPE-FEC adds error correction on the physical layer of the DVB-T basis. The purpose of MPE-FEC is to reduce the S/N requirements in the receiver. The research showed that use of this technique can reduce these requirements up till 7dB [4].

The MPE-FEC is working on the link layer, at the level of the IP input streams before these streams are emended for implementation of the MPE. All three techniques: the MPE, the MPE-FEC, and the time slicing technique and aligned directly with each other and together form the DVB-H codec which, in turn, is the basis for DVB-H functionality (Fig. 2). The different sources are carrying IP input streams. These individual basic streams later are multiplexed like defined in the time slicing method. The MPE-FEC protection is applied for each elementary stream separately. Finally, the IP packets are encapsulated into the transport stream.

Basically, the MPE-FEC scheme has two components: Reed-Solomon (RS) Coder and a block interleaver. After MPE-FEC encoding a specific frame structure is created, called the FEC frame. This frame carries data which comes from the DVB-H codec and is made of 255 columns (constant quantity) and of various number of rows (1024 is the maximum number); the maximum frame size is 2 Mbit. The frame consists from two parts: on the left - service data table (191 columns of frame) and on the right – the RS data table (64 columns of frame). The application data table cointains IP packets of the service. When the RS (255,191) code is utilized to the application data (row by row), the new, RS data table, include the parity bytes of the RS code.

The MPE-FEC technique is relevant to the time slicing. Both of them are used in IP encapsulation, and one time-slicing burst contains the content of exactly one FEC frame. It let us to re-use of memory in the receiver. Since the IP data and parity data is separated in each burs – the use of MPE-FEC decoding in the receiver is not mandatory, since parity information can be ignored, when the application data is used.
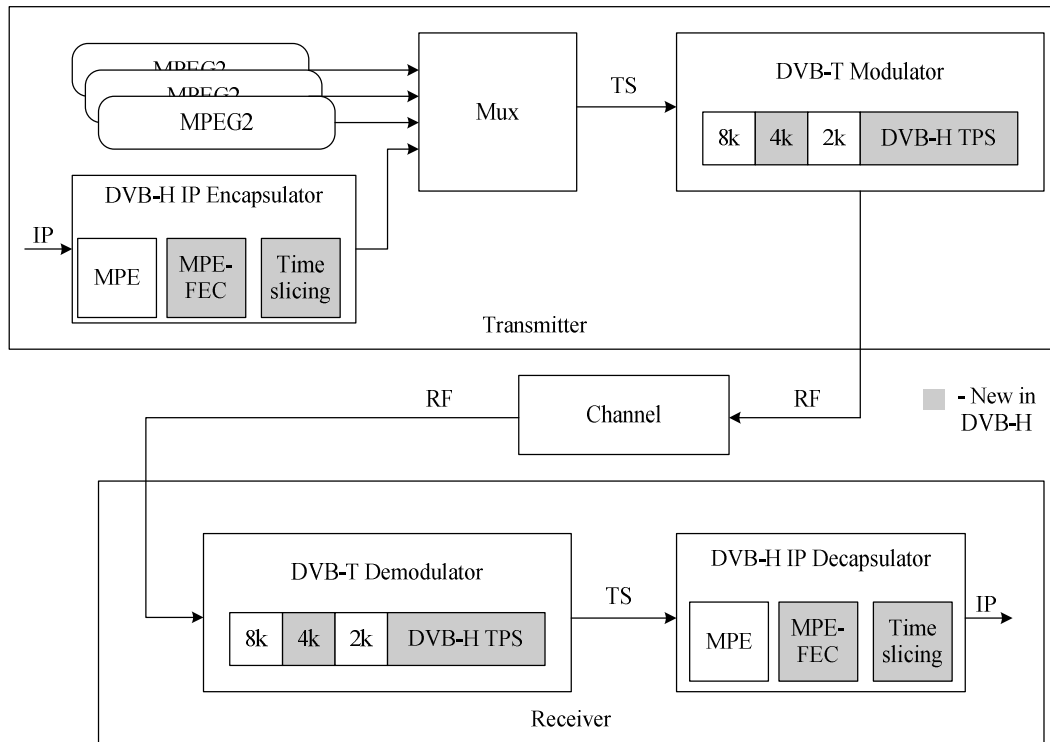

Fig. 2. A conceptual model of DVB-H system [1]

Simulation of DVB-H system

In order to evaluate quality parameters of the DVB-H system simulation model was proposed and implemented. Since introduced innovations didn't have any impact on throughput and delay bound, we have investigated only one qualitative parameter – BER. The simulation results show the effect of signal interference made by noise source (in practice it can be another electrical device or the ignition system of a car) and the effects of mobile reception in a multipath environment.

The simulations were run using 12Mbps data stream, 1/4 guard interval length, 2/3 code rate Reed-Solomon FEC coder and 16QAM modulation. Each simulation took 12 minutes. We have investigated the impact of Signal to Noise ratio (SNR) in AWGN channel on BER. All three network modes (2K, 4K and 8K) were compared with each other. The results showed in Fig.3. In another simulation we have changed Doppler frequency in the received signal – it corresponds to speed of motion of the receiver. The results (Fig. 4) confirm that the Doppler tolerance of the 2K mode is most reliable comparing to 4k and 8K.
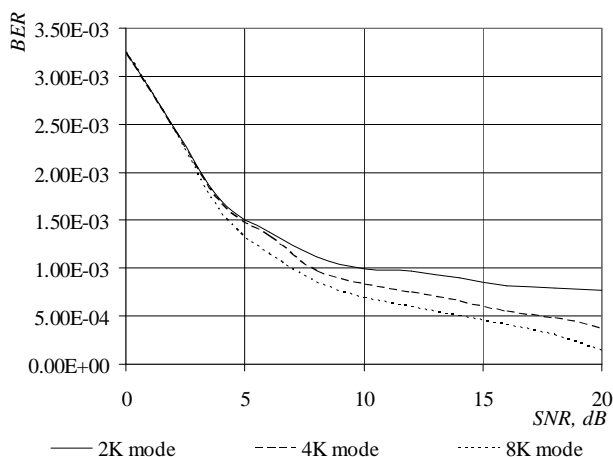
Fig. 3. BER as the function of SNR, when the Doppler shift Δf=150Hz and delay spread t=0s
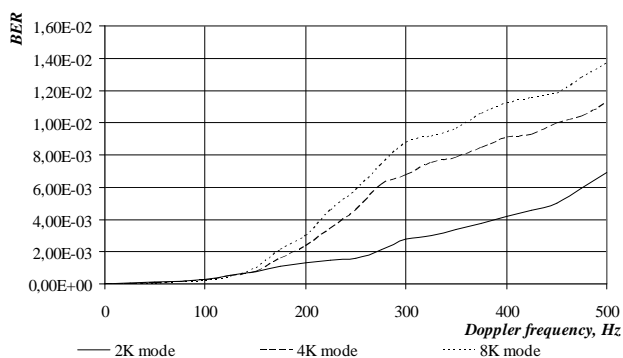
Fig. 4. BER as the function of the Doppler frequency Δf, when SNR=5dB and delay spread t=0s

Conclusion

Our proposed simulation model is useful to analyze the service quality provided by DVB-H system. The model gives possibility for easy and quick analysis how the parameters for the system have to be chosen to assure real time services.

The improvements introduced by DVB-H comparing to DVB-T doesn't had big effect on throughput and delay bound.

The simulations results shows, that BER curve acts better, when the 8K transmission mode is adopted. But in the other hand, the 8K mode gives the Doppler tolerance as shown in Fig 4. The 4K mode stands in the middle in both cases. The 4K mode provides immunity to signal variation and interference. It also provides more flexibility when the broadcasting network is planned.

References

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G. Činčikas, M. Augustaitis. Research of DVB-H Stream Qualitative Parameters // Electronics and Electrical Engineering. – Kaunas: Technologija, 2008. – No. 8(88). – P. 87–90.

We propose simulation analysis of the DVB-H system. The analysis of performance of the system was taken with the various SNR level and different Doppler frequency. The impact of chosen transmission mode was compared also. The results from simulation model of some performance measures are taken in figures. Ill. 4, bibl. 5 (in English; summaries in English, Russian and Lithuanian).

Г. Чинчикас, М. Аугустайтис. Исследование качественных параметров потока DVB-H // Электроника и электротехника. – Каунас: Технология, 2008. – № 8(88). – С. 87–90.

Предложен имитационный анализ системы DVB-H. Фунциональность системы было исследовано при различных уровнях SNR меняя здвиг Допплера. Было исследовано зависимость различных режимов передачи на качество услуг. Некоторые результаты имитационного моделирования представлены в графиках. Ил. 4, библ. 5 (на англиском языке; рефераты на английском, русском и литовском яз.).

G. Činčikas, M. Augustaitis. DVB-H srauto kokybinių parametrų tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2008. – Nr. 8(88). – P. 87–90.

Pasiūlyta DVB-H sistemos imitacinė analizė. Sistemos darbas buvo tirtas esant skirtingam SNR lygiui ir keičiant Doplerio poslinkį. Palyginta, kokią įtaką skirtingi perdavimo režimai turi paslaugų kokybei. Kai kurie imitacinių matavimų rezultatai pateikti grafikuose. Il. 4, bibl. 5 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).