IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 3, March 2021

DOI: 10.17148/IARJSET.2021.8322

A Review on DVB-C System With Different Interleaving Schemes

Rubina[1], Navdeep Kumar Chopra[2]

M.Tech. Student, CSE Department, Haryana Engineering College, Jagadhri, Haryana, India [1]

Associate Professor, CSE Department, Haryana Engineering College, Jagadhri, Haryana, India[2]

Abstract- DVB-C stands for Digital Video Broadcasting-Cable. The standard was first published by the ETSI in 1994, and subsequently became the most widely used transmission system for digital cable television in Europe. The operation starts when video, audio, and data streams are multiplexed into MPEG-2 transport stream. The MPEG-TS is identified as a sequence of data packets, of fixed length (188 bytes). A first level of protection is then applied to the transmitted data, using a non-binary block code, a Reed-Solomon RS (204, 188) code, allowing the correction of up to a maximum of 8 wrong bytes for each 188-byte packet. Though there are many virtues of implementing DVB-C system, there are many shortcomings too of the same which cannot be neglected. The very first limitation and an important one too, is in the form of bit error rates supported by it. They are limited and not compatible with the existing and rapidly changing wireless standards. For the transmission of HDTV – high-definition television and also for accommodating more channels for broadcasting, there was a strong need of new standard. The second limitation of the DVB-C system is its hugely inferior performance with portability or mobility which restricted its usages in moving vehicles. To design a Digital Video Broadcasting – Cable System with MPEG-2 data as input. Analyze this system with different interleaving schemes (such as convolutional, block, random, helical and matrix interleaver), 64-QAM modulation and Reed-Solomon error detection and correction encoding for improving the efficiency of this system.

Keywords- DVB-C, Interleaving, RS, BER.

I. INTRODUCTION OF DVB

Digital Video Broadcasting (DVB) is a set of standards that define digital broadcasting using existing satellite, cable, and terrestrial infrastructures. In the early 1990s, European broadcasters, consumer equipment manufacturers, and regulatory bodies formed the European Launching Group (ELG) to discuss introducing digital television (DTV) throughout Europe. The ELG realized that mutual respect and trust had to be established between members later became the DVB Project. Today, the DVB Project consists of over 220 organizations in more than 29 countries worldwide. DVB-compliant digital broadcasting and equipment is widely available and is distinguished by the DVB logo. Numerous DVB broadcast services are available in Europe, North and South America, Africa, Asia, and Australia. The term *digital television* is sometimes used as a synonym for DVB. However, the Advanced Television Systems Committee (ATSC) standard is the digital broadcasting standard used in the U.S[1].

A fundamental decision of the DVB Project was the selection of MPEG-2, one of a series of MPEG standards for compression of audio and video signals. MPEG-2 reduces a single signal from 166 Mbits to 5 Mbits allowing broadcasters to transmit digital signals using existing cable, satellite, and terrestrial systems. MPEG-2 uses the lossy compression method, which means that the digital signal sent to the television is compressed and some data is lost. This lost data does not affect how the human eye perceives the picture. Two digital television formats that use MPEG-2 compression are standard definition television (SDTV) and high definition television (HDTV). SDTV's picture and sound quality is similar to digital versatile disk (DVD). HDTV programming presents five times as much information to the eye than SDTV, resulting in cinema-quality programming[2].

DVB uses conditional access (CA) systems to prevent external piracy. There are numerous CA systems available to content providers allowing them to choose the CA system that they feel is adequate for the services they provide. Each CA system provides a security module that scrambles and encrypts data. This security module is embedded within the receiver or is detachable in the form of a PC card. Inside the receiver, there is a smart card that contains the user's access information. The following describes the conditional access process:

(a). The receiver receives the digital data stream.

(b). The data flows into the conditional access module, which contains the content provider's unscrambling algorithms.

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(c). The conditional access module verifies the existence of a smart card that contains the subscriber's authorization code.

(d). If the authorization code is accepted, the conditional access module unscrambles the data and returns the data to the receiver. If the code is not accepted, the data remains scrambled restricting access.

(e). The receiver then decodes the data and outputs it for viewing.

For years, smart cards have been used for pay TV programming. Smart cards are inexpensive allowing the content provider to issue updated smart cards periodically to prevent piracy. Detachable PC cards allow subscribers to use DVB services anywhere DVB technology is supported.

DVB is an open system as opposed to a closed system. Closed systems are content provider-specific, not expandable, and optimized only for television. Open systems such as DVB allow the subscriber to choose different content providers and allows integration of PCs and televisions[6]. DVB systems are optimized for not only television but also for home shopping and banking, private network broadcasting, and interactive viewing. DVB offers the future possibilities of providing high-quality television display in buses, cars, trains, and hand-held devices. DVB allows content providers to offer their services anywhere DVB is supported regardless of geographic location, expand their services easily and inexpensively, and ensure restricted access to subscribers, thus reducing lost revenue due to unauthorized viewing.

II. DIFFERENT STANDARDS OF DVB

Digital Video Broadcasting – Satellite (DVB-S): The DVB-S is an abbreviation for Digital Video Broadcasting - Satellite. It was first introduced in 1993. At its core, DVB-S is a simple mechanism. Digital transmitters beam sets of channels to an area, and they are received by antennas aimed at the transmitter[2]. The DVB-S is used in both Multiple Channel Per Carrier (MCPC) and Single channel per carrier modes for Broadcast Network feeds as well as for Direct Broadcast Satellite services. The DVB-S system is based on QPSK modulation and convolutional forward error correction (FEC), concatenated with Reed–Solomon coding. The System is directly compatible with MPEG-2 coded TV signals. The total packet length of the MPEG-2 transport Multiplex (MUX) packet is 188 bytes. The data of the input MPEG-2 multiplex is then randomized [8], in order to comply with ITU Radio Regulations. The data stream passes through the Reed Solomon encoder as a first step of encoding. Reed-Solomon RS shortened code, from the original RS code, is applied to each randomized transport packet (188 bytes) to generate an error protected packet. The data stream passes through the convolutional interleaving process which is based on the Forney approach. The interleaved frame is composed of overlapping error protected packets and is delimited by inverted or non-inverted MPEG-2. After the interleaving stage the data stream passes through punctured convolutional codes. This allows selection of the most appropriate level of error correction for a given service or data rate. The System shall allow convolutional coding with code rates of 1/2, 2/3, 3/4, 5/6 and 7/8.

Digitl Video Broadcasting – Cable (DVB-C): DVB-C stands for Digital Video Broadcasting-Cable. The standard was first published by the ETSI in 1994, and subsequently became the most widely used transmission system for digital cable television in Europe. The operation starts when video, audio, and data streams are multiplexed into MPEG-2 transport stream. The MPEG-TS is identified as a sequence of data packets, of fixed length (188 bytes). A first level of protection is then applied to the transmitted data, using a non-binary block code, a Reed-Solomon RS (204, 188) code, allowing the correction of up to a maximum of 8 wrong bytes for each 188-byte packet. The data sequence passes through the external interleaver, where a convolutional interleaving is used to rearrange the transmitted data sequence, such that it becomes more rugged to long sequences of errors. After that data bytes faces the Byte/m-tuple conversion block so that the data bytes are encoded into bit m-tuples (m = 4, 5, 6, 7, or 8). In order to get a rotation-invariant constellation, the data passes through Differential coding unit. This unit applies a differential encoding of the two Most Significant Bits of each symbol. Then the bit sequence is mapped into a base-band digital sequence of complex symbols. The system allows five modulation modes: 16-QAM, 32-QAM, 64-QAM, 128-QAM, 256-QAM. Then in order to remove mutual signal interference at the receiving side, base-band shaping block is employed, where the QAM signal is filtered with a raised-cosine shaped filter. Finally, the digital signal is transformed into an analog signal, with a digital-to-analog converter (DAC), and then modulated to radio frequency by the RF front-end.

Digital Video Broadcasting – Handheld (DVB-H): DVB-H stands for Digital Video Broadcasting- Handheld. DVB-H standard is formally adopted as ETSI standard in November 2004. DVB-H technology is a superset of the successful DVB-T system, with additional features to meet the specific requirements of handheld, battery-powered receivers. DVB-H is a physical layer specification designed to enable the efficient delivery of IP-encapsulated data over terrestrial networks. DVB-H present four main requirements: broadcast services for portable and mobile usage with acceptable

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quality; a typical user environment, and so geographical coverage, as mobile radio; access to service while moving in a vehicle at high speed; and as much compatibility with existing (DVB-T), to allow sharing of network and transmission equipment [7]. DVB-H uses a mechanism called multi-protocol encapsulation (MPE), making it possible to transport data network protocols on top of MPEG-2 transport streams. A forward error correction (FEC) scheme is used in conjunction with this multi-protocol to improve the robustness and thus mobility of the signal. In addition to the 2k and 8k modes available in DVB-T, a 4k mode is added to DVB-H increasing the network design flexibility. A short in-depth interleaving process is introduced for 2k and 4k modes that lead to better tolerance against impulsive noise. DVB-H uses Time slicing technology to reduce power consumption for small handheld terminals.

Digital Video Broadcasting – Terrestrial (DVB-T): DVB-T (Digital Video Broadcasting-Terrestrial) which is a standard for digital terrestrial television broadcast is first published in 1997. It is first used in Sweden and UK in1998. The main key is to transmit digital signal to offer high definition television services as efficiently and effectively as possible. DVB-T system transmits compressed digital audio, digital video and other data in an MPEG transport stream, using coded orthogonal frequency-division multiplexing (COFDM or OFDM) modulation. There are three valid modulation schemes: QPSK, 16-QAM, 64-QAM adopted by the DVB-T [4]. The DVB-T process starts with compressed video, compressed audio, and data streams then multiplexed into an MPEG program streams (MPEG-PSs) using Source coding and MPEG-2 multiplexing (MUX) block. The resulting data stream passes through splitter where the two different MPEG-TSs are transmitted at the same time, using a technique called Hierarchical Transmission. A first level of error correction is applied to the transmitted data, using a non-binary block code, a Reed-Solomon RS (204, 188) code, allowing the correction of up to a maximum of 8 wrong bytes for each 188-byte packet using an external encoder. The data coming out of the external encoder are then interleaved by convolutional interleaver. It is used to rearrange the transmitted data sequence. A second level of error correction is done by the means of convolutional code used as internal encoder. The data sequence is rearranged again through an internal interleaver, aiming to reduce the effect of burst errors. The digital bit sequence is mapped into a base band modulated sequence of complex symbols. The complex symbols are grouped into blocks of constant length (1512, 3024, or 6048 symbols per block). A frame is generated, 68 blocks long, and a superframe is built by 4 frames. Pilot signals are used during the synchronization and equalization phase. In order to simplify the reception of the signal being transmitted on the terrestrial radio channel, additional signals (Guard intervals) are inserted in each block. The sequence of blocks is modulated according to the OFDM technique (2k or 8k mode). Finally, the digital signal is transformed into an analogue signal, by the means of a digital-to-analogue converter (DAC), and then modulated to radio frequency.

III. INTERLEAVING IN DVB-C

Interleaving is a simple yet powerful technique that can be used to enable a random error correcting code (such as the Reed-Solomon code) to perform burst error correction. Interleaving is a way to arrange data in a non-contiguous way to increase performance. It is typically used in error-correction coding, particularly within data transmission, for multiplexing of several input data over shared media[5]. In telecommunication, it is implemented through dynamic bandwidth allocation mechanisms, where it may particularly be used to resolve quality of service and latency issues. In streaming media applications, it enables quasi-simultaneous reception of input streams, such as video and audio.

Signals traveling through a mobile communication channel are susceptible to fading. The error-correcting codes are designed to combat errors resulting from fades and, at the same time, keep the signal power at a reasonable level. Most error-correcting codes perform well in correcting random errors[6].

However, during periods of deep fades, long streams of successive or burst errors may render the error-correcting function useless. Interleaving is a technique for randomizing the bits in a message stream so that burst errors introduced by the channel can be converted to random errors. We want to send the message “ARE YOU SURE THAT THEY ARE COMING TO LUNCH WITH US” over a fading channel. One way to interleave the message is to load it into a matrix of four rows and ten columns. We truncate the message into four parts and load them into the four rows. Then we read the message out from the top, column by column. The resulting randomized message is sent through the channel. The channel introduces several burst errors into the message. As a result, the underlined alphabets are received in error. At the receiving end, a deinterleaver reconstructs the message using the same matrix, except in this case the deinterleaver loads the received message into columns first, and then reads the message out from the rows. As we can see, the burst errors are indeed converted to scattered random errors.

Original message:
ARE YOU SURE THAT THEY ARE COMING TO LUNCH WITH US

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Interleave matrix:

A	R	E	Y	O	U	S	U	R	E
T	H	A	T	T	H	E	Y	A	R
E	C	O	M	I	N	G	T	O	L
U	N	C	H	W	I	T	H	U	S

Interleaved message:

ATEU RHCN EAOC YTMH OTIW UHNI SEGT UYTH RAOU ERLS

Then interleaving techniques are used for randomizing the bits in a message stream so that burst errors introduced by the channel can be converted into random errors. Different types of interleavers are used in CDMA namely Convolutional, Matrix, Helical, Random etc.

IV. CONCLUSION

The digitalisation of television signals today is a well-known and widely implemented process. It consists basically of the representation of a picture - and the accompanying sound - by a binary bit-stream, a series of '0's and 'l's. However, compression and transmission of these signals through a communications channel- satellite, terrestrial or cable- becomes practical only after the raw digital data has been subject to a series of processes. And therefore, if it is wished to be able to interconnect digital TV equipment from different suppliers, or to receive such transmissions satisfactorily, different modulation and error detection schemes are used. So DVB-C system is designed to withstand with interference and fading in communication channel. Channel coding and modulation is needed for a system in order to sustain in any type of environment especially in multipath fading channel.

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