Switchover to Digital Television Broadcasting

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Abstract—The process of terrestrial digital video broadcasting started 20 years ago and it was established in 1996. With video standardization for transmission and coding procedure a new era was opened in digital TV transmission. It was a remarkable step from analogue technologies to digital. New modulation technology with digital COFDM modulator, multicarrier techniques and channel coding system ensure frequency spectrum efficiency and ruggedness against noise and distortion. In the paper it will be analyzed present situation in switchover from analog to digital television process in Europe, USA and some other countries which are based on the planning project that corresponds with ITU Regional Radio Communication Conference (RRC-06) from June 2006 and Geneva (GE-06) frequency plan.

Keywords-Switchover, DVB-T, MPEG-2, H.264/AVC, terrestrial

I. INTRODUCTION

Analogue terrestrial television broadcast systems are very sensitive to interference from other analogue television signals and because of existing problems require high co-channel protection ratio. Digital television broadcast systems are significantly less sensitive to noise and interference [1].

In DVB-T [2] digital signal processing it is necessary to perform source coding, compression techniques, modulation, channel coding, multiplexing and multiple access, frequency spreading and synchronisation. In digital video transmission is of great importance to distribute digital video signal with high quality of service (QoS), large amplifier efficiency and with nominal transmitter output power. With these requirements, the main roll has the method of suppression non-linearity products in terrestrial digital video transmitter with digital precorrection unit and output filter unit.

When introducing digital TV broadcasting it is necessary to take the existing analogue broadcasting networks in calculation [3]. Many neighbor countries still have analogue systems in operations. This means that analogue networks would need to be protected from all new digital systems in the future, because analogue networks will continue to be in use with any changes.

The transmission channel in analogue networks for terrestrial TV broadcasting is commonly considered as the low quality channel because of many influences (additive noise and other disturbing signals, signal echoes so called multipath reception). This effect leads to selective fading. Echoes signal or reflected signal from objects are delayed signals which come to receiving antenna and cause severe degradation of a received television signal.

In digital video broadcasting image data compression is very important issue, especially in transmission and storage of image data. Its aim is to minimize the bandwidth for transmission and the memory for storage. The MPEG standards for video coding addresses the combining of more elementary streams of video, audio, text, still pictures, graphics and other data into a single or multiple streams which are suitable for transmission, storage and users interaction. Using these possibilities, the basic audio-visual contents can be rearranged with very powerful multimedia additions in a variety of environments.

II. TV BROADCASTING SWITCHOVER STRATEGY

Implementation of the digital television broadcast transmission requires consumer education campaign to prepare the general public:

- education of the public on digital television benefits
- what the end of analogue television will mean to them
- what steps need to be taken to ensure that they will continue to receive TV services after the switch-off from analogue to digital terrestrial television broadcast
- coupon-voucher eligible converter boxes which purchase enable consumers to receive digital television contents
- to ensure the help for the people in the conversion from analogue to digital television broadcast
- to inform the people about switchover to digital technology

Each country with other specific legislation related to the radio frequency spectrum provides legal basis for the introduction of digital television and digital terrestrial television switchover action plan for digital future.

III. VIDEO COMPRESSION STANDARDS

Image data compression is very significant problem in video communications, multimedia and broadcasting. Modern data compression techniques offer the possibility to store or transmit great amount of data necessary to represent digital images and video in an efficient way. The importance of these techniques arise in the world, where productivity gains through communications depend on the mobility, flexibility and interoperability of communication equipment - where everybody will be able to communicate with anybody at any place and at any hour.

Video coding is one of the key technologies in digital video broadcasting era and its standardisation is essential for efficient interchange of audio-visual information. Several standards bodies have been working on algorithms to compress video. There are now four worldwide unique video standards which are widely supported: ISO/IEC 10198 (so called JPEG), ITU-T Rec. H.261, ISO/IEC 11172 (MPEG-1), and ITU-T Rec. H.262\ISO/IEC 13818 (MPEG-2) for different bit rates and applications, Tab. 1.

Image compression and video-coding algorithms can be generally divided into two broad categories: intraframe and interframe coding. Intraframe coding is used to remove spatial redundancy between the picture elements (pels) in single frame. Interframe coding takes advantage of the strong correlation among video frames to reduce the temporal redundancy. In H.261, MPEG-1 and MPEG-2 standards, both spatial and temporal redundancy reduction are used together in order to achieve the highest possible compression ratio between the video source rate and the coded bit rate.

The Joint Photographic Experts Group (JPEG) of the ISO specified coding scheme for still picture coding. The basic scheme is adaptive Discrete Cosine Transform (DCT) coding. A specified average transmission rate can be adjusted by quantizer characteristic but this also affects the picture quality.

TABLE I. VIDEO CODING STANDARDS

Standard	Main Application	Year
JPEG	Image	1992
JPEG Extensions	Image	1996
JPEG LS Part I	Image	1998
JPEG LS Part II		1999
JBIG I	Fax	1995
MRC (Mixed Raster Content)	Color Fax, Internet Fax	1998
JBIG2	Fax	2000
H.261	Video Conferencing	1990
H.262	DTV, SDTV	1995
H.263 (Baseline)	Videophone	1998
H.262+ (Profile 3)		1999
H.263++ (Profile 5)		2000
H.26L	VLBR Video	2002
MPEG-1	Video CD	1992
MPEG-2	(Generic) DTV, SDTV, HDTV, DVD	1995
MPEG-4 version 2	Interactive video (synthetic and natural)	1999 2000
MPEG-7	Multimedia content description interface	2001
MPEG-21	Multimedia Framework	2002
H.264/MPEG4-Part 10	Advanced Video Coding	2003

The International Telecommunication Union (ITU, formerly CCITT) specified the H.261 standard entitled ”Video codec for audio-visual services at px64 kbit/s” as a video coding standard for videoconferencing and videophone. The format for input picture is based on the common intermediate format (CIF).

The ISO/IEC activity of the MPEG was started in 1988 for CD-ROM applications at a bit-rate below 1.5 Mb/s. CD-ROMs are considered as a promising storage medium for multimedia video applications. The MPEG-1 coding scheme is very similar to that of ITU-T H.261. The major difference between the two is that MPEG-1 allows bi-directional motion-compensation The recommended input picture format is Source Input Format (SIF). The MPEG SIF is compatible to CCIR Rec.601 (now ITU-R Rec.601) picture format, see Tab. 2. CCIR Rec. 601 is universal adopted standard which defines an extensible family of the coding parameters for NTSC/PAL television signal.

TABLE II. ITU-R REC. 601

Parameters	525-line, 60 field/s systems	625-line, 50 field/s systems
1. Coded signals: Y, C_R, C_B	These signals are obtained from gamma pre-corrected signals, namely: E_Y' , $E_R' - E_Y'$, $E_B' - E_Y'$	
2. Number of samples per total line:		
– luminance signal (Y)	858	864
– each colour-difference signal (C_R, C_B)	429	432
3. Sampling structure	Orthogonal, line, field and frame repetitive. C_R and C_B samples co-sited with odd (1st, 3rd, 5th, etc.) Y samples in each line	
4.Sampling frequency:		
– luminance signal	13.5 MHz	
– each colour-difference signal	6.75 MHz	
5. Form of coding	Uniformly quantized PCM, 8 (optionally 10) bits per sample, for the luminance signal and each colour-difference signal	
6. Number of samples per digital active line:		
– luminance signal	720	
– each colour-difference signal	360	
7. Analogue-to-digital horizontal timing relationship - from end of digital active line to OH	16 luminance clock periods	12 luminance clock periods

A. *MPEG-2 Standard*

The principle features of the MPEG-2 standard is the capability to support different applications and picture parameters all under umbrella of the same MPEG-2 Video Syntax by means of profiles and levels. The profile can be seen as a subset of the entire bitstream syntax and the level as a set of constraints imposed on parameters in the bitstream. The full video syntax can be divided into two major categories: the non-scalable and scalable syntax. The non-scalable syntax gives the extra compression tools for interlaced video signals. Each frame of interlaced video consists of two fields which are separated by one field period. The specification allows either the frame to be encoded as picture or the two fields to be encoded as two pictures. Frame encoding or field encoding can be adaptive selected on a frame-by-frame basis. Frame encoding is typically preferred when the video scene contains significant detail with limited motion. Field encoding, in which the second field can be predicted from the first, works better when there is fast movement.

The MPEG-2 includes the possibility to insert in its bit-streams multimedia and hypermedia information objects which are defined by Multimedia and Hypermedia Experts Group (MHEG) of ISO/IEC SC29. This group produces standard "Information Technology - Coded Representation of Multimedia and Hypermedia Information Objects" which specifies the representation and encoding of multimedia objects, i.e. the aggregation of monomedia data such as text, still pictures, graphics, audio and video sequences, the control of their presentation, synchronisation and user interaction. An MHEG objects can be interchanged as a whole across different applications/services.

B. Coding Algorithm

The main processing step for MPEG coding is macroblock-based motion compensation in the interframe coding and block-based DCT in intraframe coding. In the intraframe-coding mode, the frame is processed block by block. The source image is divided into 8x8 pixel blocks and every block is transformed to a 64 point discrete signal which is function of two spatial dimensions. A two-dimensional DCT is applied to all luminance and chrominance blocks in frame. The aim of the transform is to take advantage of the correlation between samples within the block. The 8x8 size is presently widely considered to be the most convenient compromise between efficiency and implementation complexity. Mathematical expression of the forward DCT and inverse transform is expressed by the following equation, where z(i,j) are samples in the image domain, and Z(k,l) are coefficients of the transform block, Eq. 1:

$$Z(k,l) = \frac{1}{4} \cdot C_k \cdot C_l \cdot \sum_{i=0}^{7} \sum_{j=0}^{7} z(i,j) \cdot \cos\frac{\pi \cdot (2 \cdot i+1) \cdot k}{16} \cdot \cos\frac{\pi \cdot (2 \cdot j+1) \cdot l}{16} \quad (1)$$

$$z(i,j) = \frac{1}{4} \cdot \sum_{k=0}^{7} \sum_{l=0}^{7} C_k \cdot C_l \cdot Z(k,l) \cdot \cos\frac{\pi \cdot (2 \cdot i+1) \cdot k}{16} \cdot \cos\frac{\pi \cdot (2 \cdot j+1) \cdot l}{16}$$

$$C_{k,l} = \begin{cases} \frac{1}{\sqrt{2}}, & \text{for } k,l=0 \\ 1, & \text{else} \end{cases}$$

The result is 8x8 block of DCT coefficients. Each coefficient represents the amplitude of the specific pattern within the block, and applying the transform, the original picture block is expressed as a two-dimensional series in terms of this set of orthogonal patterns. The first coefficient is DC coefficient and it is proportional to the average value of the of the pel values in the block. Therefore, the DC coefficient is more visually significant then the other coefficients The remained 63 coefficients are called AC coefficients and they represent horizontal frequency components, vertical frequency components or both horizontal and vertical frequency components. The DCT coefficients are fed into a quantizer .The step size for the quantization of each DCT coefficients is obtained from an 8x8 quantizer matrix which ensures that the low frequency DCT coefficients are quantized more accurately (with small step size) while the high frequency coefficients are quantized more coarsely.

C. MPEG-4 Systems Solutions

Current MPEG standardization project is MPEG-4. ISO MPEG-4 started its standardization activities in July 1993 and MPEG-4 became International Standard in 1999. It can be expected that MPEG-4 will became the enabling technology for multimedia communications as much as MPEG-2 has become the enabling technology for digital television.

MPEG-4 is a generic video coding algorithm which combines DCT and wavelet transformation. It is generally expected that the delivery of video information over existing and future low-bandwidth communication network such as mobile radio networks or telephone networks will become very important. The success of audiovisual services operating over mobile or telephone networks (in the market place) will depend on the ability to encode video at very low bit rates with sufficient image quality. Existing video coding standards (e.g. H.261 and MPEG-1) have been optimized to achieve good video quality at bit rates higher than 64 kb/s. Accordingly the video quality provided by these algorithms is not sufficient for application realised at very low bit rates.

MPEG-4 will standardize algorithms for audiovisual coding in multimedia applications allowing for interactivity high compression and universal accessibility of audio and video content. Bit rates targeted for the video standard are between 5-64 kb/s for mobile applications and up to 2 Mb/s for TV-film applications.

D. H.264/MPEG-4 part 10

ISO/IEC Moving Picture Expert Group (MPEG) and ITU-T Video coding Expert Group (VCEG) international organizations have been involved in the standardization of image, audio and video coding methodologies. VCEG develops standards for advanced moving image coding for real-time video applications. MPEG developed international standards for compression and coding, decompression, processing, reproduction of moving pictures, images, audio and their combinations. MPEG standardization is applied for video storage, broadcast video, video streaming - video over Internet.

The joint group of both standards is called Joint Video Team (JVT), which established H.264/MPEG-4 part 10 standards [4]. This standard was prepared in May 2003, with applications for Cable TV on optical networks, cooper (CATV), Direct Video Broadcast via Satellite services (DVB-S), Digital Video Broadcast - Terrestrial (DVB-T), Multimedia Mailing (MMM), Digital Subscriber Line video services (DSL). Requirements for H.264/MPEG-4 part 10 arise from the various video applications that support video streaming, video conferencing over fixed or radio communication networks and over different transport protocols. H.264/MPEG-4 part 10 uses more flexible motion compensation model supporting various rectangular partitions in each macroblock. Tab. 3. shows comparison between different standards.

TABLE III. COMPARISON OF STANDARDS MPEG-1, MPEG-2, MPEG-4 AND H.264/MPEG-4 PART 10

Feature /Standard	MPEG-1	MPEG-2	MPEG-4	MPEG-4 part 10 /H.264
Macroblock size	16x16	16x16 (frame mode) 16x8 (field mode)	16x16	16x16
Block size	8x8	8x8	16x16, 8x8, 16x8	8x8, 8x16, 16x8, 16x16, 4x8, 8x4, 4x4
Transform	DCT	DCT	DCT/ Wavelet transform	4x4 integer transform
Transform size	8x8	8x8	8x8	4x4
Quantization step size	Increases with constant increment	Increases with constant increment	Vector quantization used	Step sizes that increase at the rate of 12.5%
Entropy coding	VLC	VLC (different VLC tables for Intra and Inter modes)	VLC	VLC, CAVLC and CABAC
Motion Estimation & Compensation	Yes	Yes	Yes	Yes, More flexible up to 16 MVs per MB
Pel accuracy	Integer 1/2-pel	Integer 1/2-pel	Integer 1/2-pel, 1/4-pel	Integer 1/2-pel, 1/4-pel
Profiles	No	5 profiles, Several levels within a profile	8 profiles, Several levels within a profile	3 profiles, Several levels within a profile
Reference frame	Yes 1 frame	Yes 1 frame	Yes 1 frame	Yes Multiple frames (as many as 5 frames allowed)
Picture Types	I, P, B, D	I, P, B	I, P, B	I, P, B, SI, SP
Playback & Random Access	Yes	Yes	Yes	Yes
Error robustness	Synchronization & concealment	Data partitioning, redundancy, FEC for important packet transmission	Synchronization, Data partitioning, Header extension, Reversible VLCs	Deals with packet loss and bit errors in error-prone wireless networks
Transmission rate	Up to 1.5 Mbps	2-15 Mbps	64 kbps-~ 2 Mbps	64 kbps - 150 Mbps
Encoder complexity	Low	Medium	Medium	High
Compatible with previous standards	Yes	Yes	Yes	No

IV. DISCRETE MODULATION PROCESS

In digital modulation processes there is possibility to arrange amplitude, phase and frequency modulation.

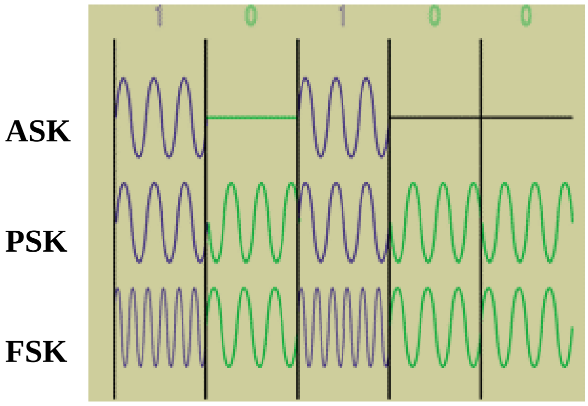

Figure 1. Discrete modulation processes

In Fig. 1 ASK is Amplitude Shift Keying, PSK is Phase Shift Keying and FSK is Frequency Shift Keying.

Modulation process is based on changing amplitude, frequency and phase. In digital modulation, an analog carrier signal is modulated by a digital bit stream. The binary information form "0" and "1" is used in digital information process. Digital modulation methods can be considered as digital-to-analog conversion, and the corresponding demodulation or detection as analog-to-digital conversion. The changes in the carrier signal are chosen from a finite number of M alternative symbols.

A. Quadrature Amplitude Modulation

Quadrature Amplitude Modulation (QAM) is the usual choice for achieving higher symbol efficiency.

Fig. 2. illustrates the signal constellation for 4-QAM, 16-QAM and 64-QAM. The amplitude of two waves, 90 degrees out-of-phase with each other (in quadrature) are changed (modulated or keyed) to represent the data signal. Amplitude modulating two carriers in quadrature can be equivalently viewed as both amplitude modulating and phase modulating a single carrier. The symbol transmission efficiency ranges from 2 bit/symbol (for 4-QAM) to 6 bit/symbol (for 64-QAM).

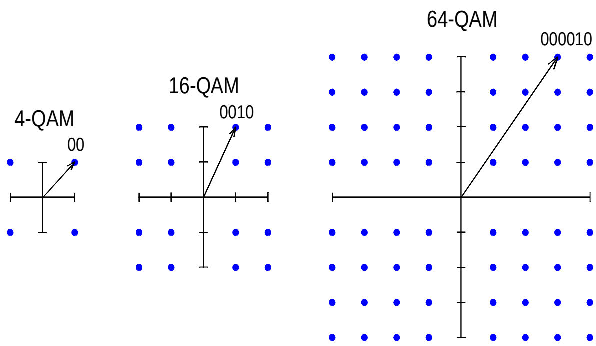

Figure 2. Signal constellations for 4-QAM, 16-QAM and 64-QAM

Parameters of QAM are given in Tab. 4.

TABLE IV. QAM PARAMETERS

	4-QAM	16-QAM	64-QAM
Number of amplitudes	1	3	9
Number of phases	4	12	52
Bits/symbol	2	4	6
Theoretical/practical Spectral efficiency (bit/s/Hz)	2 / 1.9	4 / 3.7	6 / 5.6
C/N for BER=10^{-6} dB	13.7	20.5	27.0
Data rate (Mbps)	11.4	22.8	34.2

B. *Orthogonal Frequency Multiplexing*

Multicarrier modulation method is orthogonal frequency division multiplexing (OFDM). This modulation process uses a number of carriers (subcarriers).

QAM symbol in complex form:

$$d_n = a_n + j \cdot b_n \tag{2}$$

Subcarrier in complex form:

$$e^{j \cdot 2 \cdot \pi \cdot f_n \cdot t} \tag{3}$$

OFDM signal at the output:

$$u(t) = \sum_{n=1}^{N} \left(a_n \cos 2\pi f_n t - b_n \sin 2\pi f_n t \right)$$
$$u(t) = \sum_{n=1}^{N} \mathrm{Re}\left\{ d_n e^{j 2\pi f_n t} \right\} \tag{4}$$

The main principle of OFDM modulation is amplitude and phase modulation of the large number of subcarriers that are orthogonal on each other. The sum of modulated transmission signals produce OFDM signal at the output of modulator.

The main advantage of OFDM is that each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

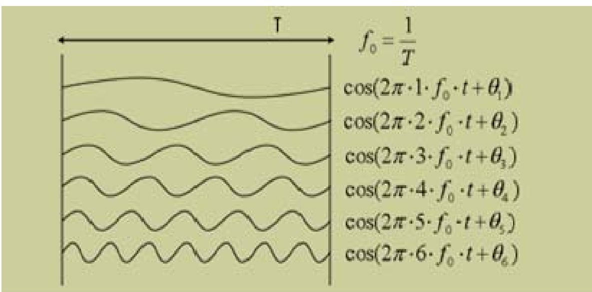

Figure 3. OFDM subcarrier in time domain

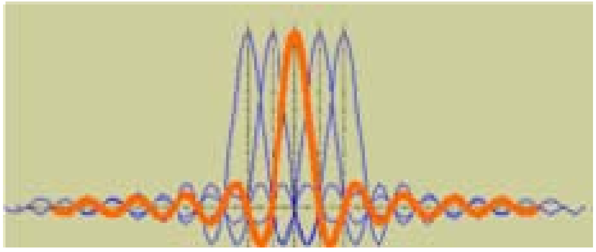

Figure 4. OFDM subcarrier in time domain

Fig. 3. presents OFDM subcarrier in time domain and Fig. 4. in frequency domain.

This orthogonality allows efficient modulator and demodulator implementation using the FFT (Fast Fourier Transform) algorithm on the receiver side, and inverse FFT on the sender side.

$$u(t) = \sum_{n=1}^{N} d_n e^{j 2\pi f_n t} \tag{5}$$

After implementation

$$t_m = \frac{m \cdot T_s}{N}, \qquad m = 1,2,\ldots,N \tag{6}$$

We get

$$u_m = \sum_{n=1}^{N} d_n e^{j 2\pi f_n \frac{m \cdot T_S}{N}} \tag{7}$$

where in Eq. 7. T_s is duration of OFDM symbol, N is number of subcarriers.

The orthogonality requires that the sub-carrier frequency is

$$f_n = n \cdot \frac{1}{T_s} \tag{8}$$

Eq. 7. can be written using Eq. 8.

$$u_m = \sum_{n=1}^{N} d_n e^{j 2\pi \frac{m \cdot n}{N}} \tag{9}$$

On the spectrum analyzer, Fig. 5., we can obtain OFDM signal in the channel bandwidth of 6, 7 or 8 MHz, depending on standard.

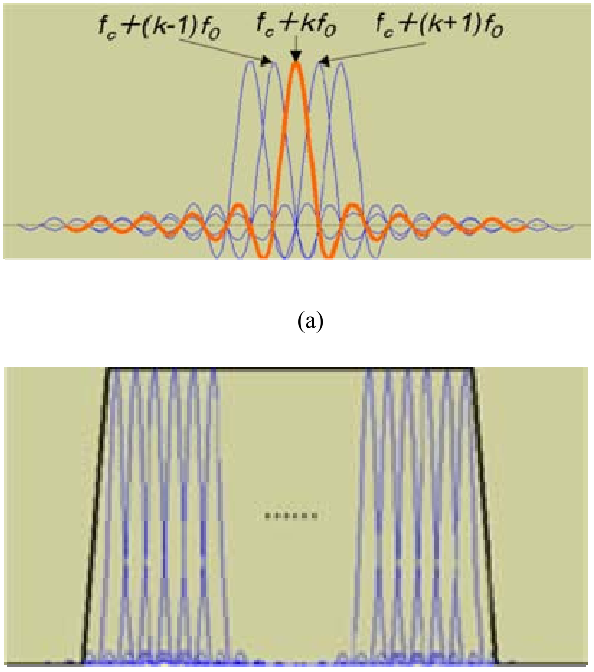

Figure 5. Spectrum analyzer: (a) subcarrier spacing, (b) complete OFDM spectrum

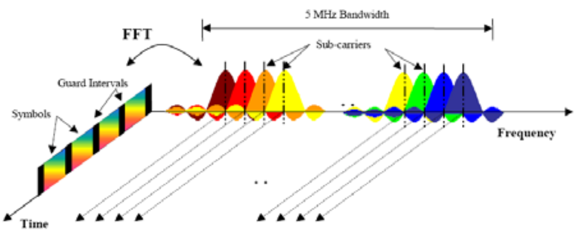

Figure 6. Time and frequency division in channel bandwidth

Fig. 6. shows time and frequency domain in channel bandwidth of 5 MHz.

V. DVB-T SYSTEM

Input signal to the transmitter is a MPEG-2 transport stream, with 5 Mbit/s to 34.3 Mbit/s data rate, depending on transmission mode and parameters chosen.

In COFDM encoder redundant bits are added to MPEG-2 signal, then time and frequency redistribution of bits are fulfilled (interleaving), building forward error correction (FEC). Different code-rates can be chosen (e.g. R=1/2, R=2/3, R=3/4, R=5/6, R=7/8). Here is R = (useful bit rate) / (useful bit rate + protected bit rate).

To obtain OFDM signal, transport stream is divided into two (QPSK), four (16QAM) or six (64QAM) bit streams, forming a word of 2, 4 or 6 bits, defining the subcarrier vector. OFDM symbol is in 8K mode formed by 6817 subcarriers, and in 2K mode by 1705 subcarriers. Symbol duration is divided into two parts: useful and guard parts. Guard part can occupy 1/4, 1/8, 1/16 or 1/32 of the whole symbol duration.

Fig. 8. shows DVB-T transmitter. In linear precorrection unit the input I/Q stream is treated in amplitude and phase to linearize the power-amplifier transfer characteristics. Linear precorrection has to compensate distortions caused by the nonlinearity of the amplitude and phase transmission characteristics of the power amplifier to the point of saturation. DVB-T signal peak values exceed the amplifier saturation region, which are compensated by additional methods, depending on realization called peak reduction, peak preconditioning, etc. Peak-to-rms value ratio of the signal is expressed by the crest-factor:

$$\xi = 20 \log \frac{U_{max}}{U_{eff}} = 10 \log N \qquad (10)$$

Crest-factor theoretical value in the 8K-mode (6817 subcarriers) is 38 dB. Limiting the signal peak values the out-of-band distortion is lowered, but at the same time the C/N ratio inside the channel is lowered too. As the EN 300744 standard prescribes the minimum C/N ratio at the receiver input, a stronger limitation of the signal peak values would lead to the lowering of this minimum C/N ratio. It is the reason why the standard out-of-band distortion lowering, caused by limiting signal peak values, is typically about 3 dB. Approximately in the same amount rises the signal in-band distortion.

Up-converter converts the IF signal to the desired UHF channel, which will be amplified for driving the output stage to the level needed.

Output power amplifier is realized in the new LDMOS technology. It is characterized by very high power amplification, and due to AB-class operation, by good efficiency also.

Standard EN 300 744 prescribes the spectral mask, which has to be filled by digital TV transmitter (Fig. 7). Based on the prescribed mask and the frequency spectrum characteristics of the DVB-T signal at the amplifier output, selectivity needed of the filter unit is evaluated.

Transmission region in Fig. 8. is defined in the limits $f_0 \pm 3.8$ MHz of UHF frequency band 470–862 MHz. In DVB-T transmitter (1 kW) design the maximum insertion loss of the filter unit at f_0 was prescribed by $\leq$ 0.7 dB.

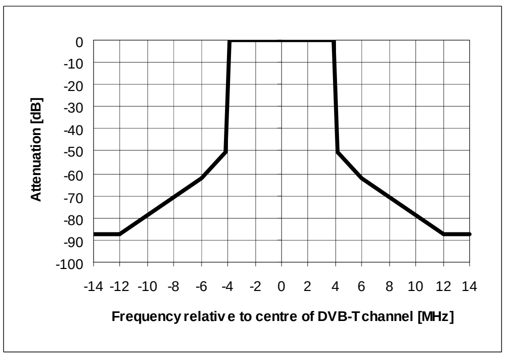

Figure 7. DVB-T spectrum mask

It is very important to mention that two units in DVB-T transmitter which are precorrection units and output filter plays very important role to transmit linear output signal for multimedia [5, 6].

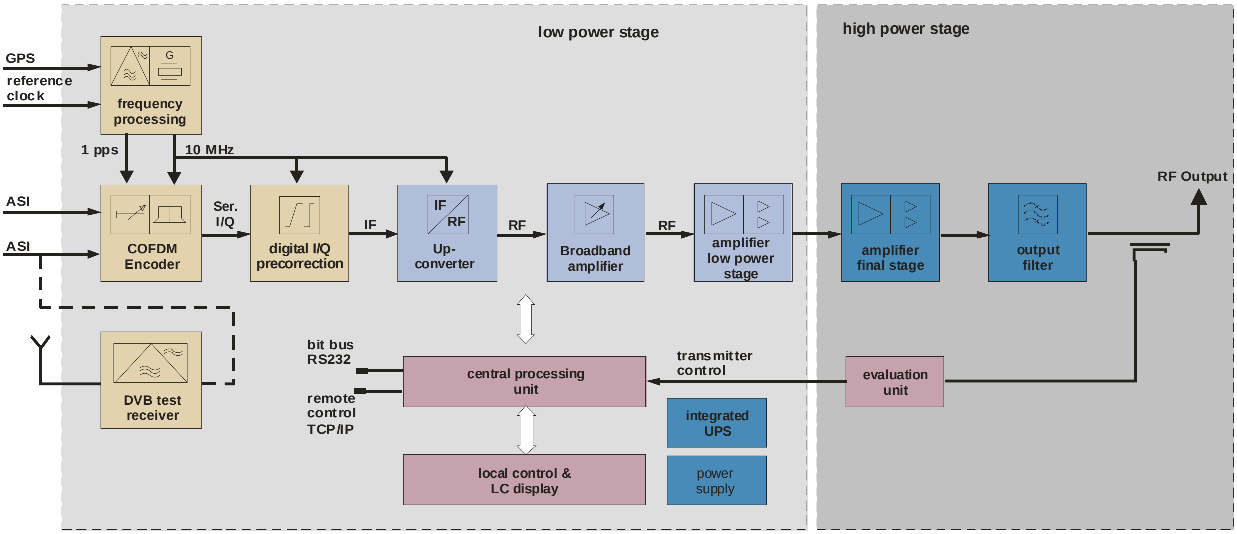

Figure 8. DVB-T transmitter

VI. Implementation of DVB-T in Europe

Broadcast digital TV signals through the network of terrestrial DVB-T transmitters was accepted in 1996 as a standard [1]. After the adaptation of standards followed by the international coordination agreements in Chester [7]. The agreement defines the technical criteria and coordination condition related to implementation of DVB-T systems among the 30 signatory states.The third important event for the implementation of DVB-T systems in Europe was (Ge-06) on (RRC-06) with attendance of 118 countries. On that meeting was agreed a new frequency Plan for digital terrestrial television in UHF and VHF frequency band.

According to data of the European Radiocommunications Office (ERO) [8], the majority of European states planned to introduce a fully digital terrestrial signal until 2012. The present state of the 1st April 2010 is shown on Fig. 9.

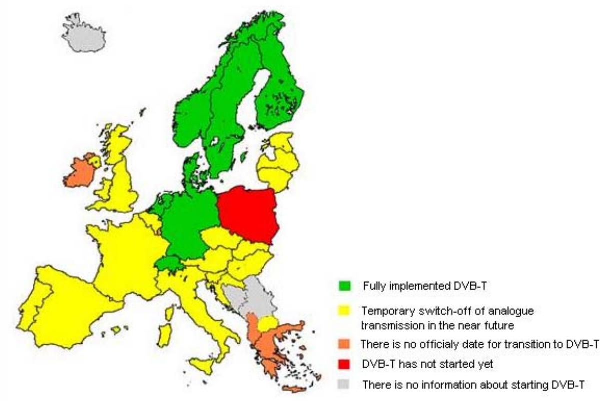

Figure 9. Implementation of DVB-T in Europe

Austria, regulatory agency in 2003 announced strategy of transition from analogue to digital terrestrial television signals. Austrian network operator ORF (Österreichische Rundfunk) cover 75% of the population. The full transition to digital transmission is scheduled in 2010.

Denmark, experimental transmission began 1999. The process of transition from analogue to digital transmission was completed in the late 2009.

France, started early 2005 with digital terrestrial television signal. At that time the coverage of DVB-T was 50% population and 2007 80%. Shutdown of analogue transmitters begun in 2008 and deadline for closing analogue transmission is November, 30th 2011.

Germany started with SFN mode 2002 in Berlin and surrounding areas. The fully completed process of transition to digital terrestrial transmission was at the end of 2008 with total coverage of 90%.

Italy started with test transmission of DVB-T signals in 1998 in Rome, Palermo and Torino. Official DVB-T transmission was in 2004 with coverage of 50% of the population. Partial shutdown of analogue transmitter was in 2009 and full transition is planned at the end of 2010.

Russia announced that at the end of 2003 accepts the DVB-T system for digital terrestrial broadcasting of television programs. The process of termination of analogue transmission is planned to be 2015 [9].

VII. Present Situation In Croatia

From technical aspects present situation in Croatia Republic Plan for digital broadcast network transmission is in accordance with International Plan Geneva 2006 (GE06) on ITU Radiocommunication Conference (RRC-06) what means that in VHF frequency range, band III (174-230 MHz) and UHF band IV and V (471-860 MHz) [10].

Final Croatian Plan for digital broadcasting will be ready after 2015 when frequency coordination with neighbor countries will be finished [11, 12].

In accordance to GE06 whole Croatian territory is divided in 9 digital regions for broadcast terrestrial transmission. Each region will get frequency from responsible authority in Croatia.

Digital broadcast radio and TV terrestrial transmission in VHF and UHF frequency bands enables existing services extension and the introduction of new electronic services.

Digitalization of program content will be applicable with recommendations ISO/IEC 1S1381 and ITU-T H.262.

For digital television coding ITU-T H.264 (ISO/IEC 14496-10.2005) recommendation will be used. This recommendation is used for HDTV and "Pay TV". For this decision it is necessary to arrange high sound and picture quality and multiplex capacity planning.

Time scheme for transition from analog to digital transmission for 9 digital regions is shown in Tab. 5. From the Tab. 5. is evident that the transition to digital transmission starts on 2nd January 2009 and the analog television transmitters will be closed at 1st January 2010.

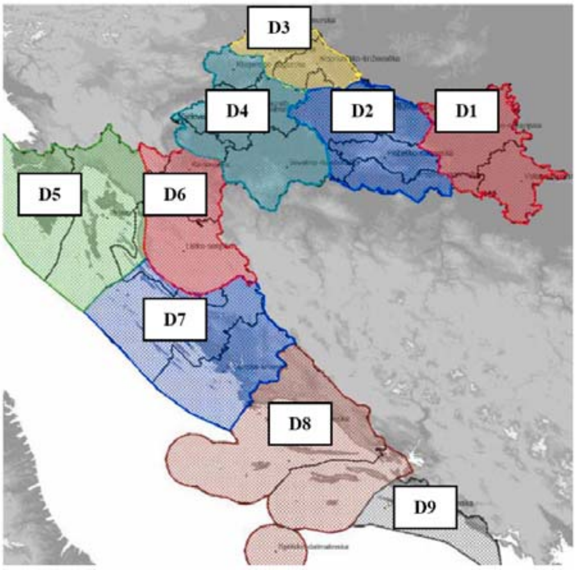

Figure 10. Croatian territory division in 9 digital areas

TABLE V. SWITCH-OFF ATE OF THE ANALOGUE TV TRANSMISSION

Region	Date of Switch-off
D05	january 26.-th
D03	march 03.-rd
D07	march 30.-th
D09	april 27.-th
D01	may 25.-th
D02	june 29.-th
D06	july 20.-th
D08	august 17.-th
D04	october 05.-th

VIII. DVB-T IMPLEMENTATION IN UNITED STATES

From September 2008 starts the procedure of introduction of the digital television broadcasting in the United States. Analogue television switch-off date was February, 2009. Congress, through legislation called "The Digital Television Border Fix Act" introduced new technology but it was designed to allow television stations within 80 km of the Mexican border to continue to operate with analogue television signals.

The National Telecommunications and Informations Association (NTIA) decided to give the voucher for converter boxes to consumers. Standardization process was ready for mobile handheld (M/H) technology very soon. At the beginning of 2009 start the problems:

- the consumers were completely unprepared for the end of analogue transmission
- NTIA announced that he voucher program was out of money and the consumers are placed on a waiting list

The result was that Congress had to delay shutdown process to June 2009.

The digital conversion starts in Iowa Public Television (IPTV) on June 12, 2009 as a statewide television network with 9 digital transmitters and 8 translators. At the same time, analogue television was shutdown.

Immediately started the education process for the customer about digital television reception through articles in the newspaper, broadcasting information and the consumer electronics industry. Through this activity it was permanently pointed out benefits of digital television technology.

"Present situation in U.S.: digital broadcasting is the first successful wireless technology that could deliver content to consumers virtually anywhere" was the sentence from TV expert Bill Hayes, Iowa Public Television.

IX. CONCLUSION

To be present in digital terrestrial world (DVB-T) it is very important to establish frequency coordination with neighboring countries and legislative which will be done by Telecommunication Institute. This is very important and hard work and it has to be more intensive.

The field of interest of digital broadcast technology has important influence in devices, equipments, techniques and systems related to broadcast technology, including the production, distribution, transmission and propagation aspects.

These technologies include digital radio and television transmission, using terrestrial, cable, satellite and Internet.

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