UDK: 621.397:621.396.69:004.6
COSATI: 17-02

Single Frequency Networks for DVB-T and Evolution Towards DVB-T2

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This paper analyzes the process of building the single frequency network for digital terrestrial video broadcasting. We will show the comparison of DVB-T and DVB-T2, when planning a single frequency network. A single frequency network is used for optimizing spectrum usage and bandwidth. DVB-T2 is a standard for digital television broadcasting, offering significant benefits compared to DVB-T. DVB-T2 includes many new techniques, not previously used in DVB-T standard. In this paper, main properties of DVB-T and DVB-T2 standards are shown, as well as the principle of the OFDM modulation. The paper ends with the summary and conclusions.

Key words: **digital TV, TV signal, digital broadcasting, digital network, single frequency network, network architecture, block diagram, standards.**

Introduction

THE roots of transition to digital television broadcasting lie in more effective use of the radio-frequency spectrum. Digital technology enables us to use advanced compression algorithms to compress audio and video signals. Consequently, we can use one frequency channel to transmit more than one service (usually three to ten and even more TV channels), and we can build a network of transmitters operating at the same frequency, thus significantly lowering a number of frequencies (channels) needed to cover a territory. The idea is that in certain geographically- difficult areas broadcasters will have better success if they can fill coverage voids by utilizing smaller, usually-less-powerful satellite towers in addition to their main tower.

DVB-T is maybe the most widely used- it is used in Europe, Russia, Australia, India, and many other countries. All these systems are based on COFDM – Coded Orthogonal Frequency Division Multiplexing. This is a modulation scheme with many thousands of closely spaced carriers, each carrying digital information. The first character C in the abbreviation means that the data stream is protected by the error encoding FEC (Forward Error Correction) to detect and correct errors that occur during transmission. For symbol protection, a block Reed-Solomon code with different code rates is employed. (C)OFDM modulation is characterized by high robustness against inter-symbol interference (ISI).

Also, we can transmit over the same frequency without causing interference. This interference within some limits is constructive. It helps in demodulating signals. The fact is that at any point signals from different transmitters arrive at different times. But since the signal is digital the same signal is received. The length of the symbol- the digital data which every carrier is modulated with - is longer than the difference of arrival times from different transmitters. In addition to each symbol is prolonged with a guard interval. During the guard interval the same symbols with varying arrival times can be received without any inter-symbol interference. This is the basic principle of Single Frequency Networks (SFN). The maximum distance between transmitters operating at the same frequency depends in the length of the guard interval. With proper planning of SFNs the distance of 70 km can be achieved. This mean that all transmitters in this area are operating at the same frequency and are broadcasting the same content. This is a huge advantage over analog television where we would need many frequencies to cover the same area.

Digital network need to be synchronized to operate properly in SFNs. The cost of digital network is high but it is divided among many services, but the cost of digital network is significantly lower than the cost of the most valuable resources- the radio-frequency spectrum.[1, 9]

Principle of SFN

In SFN, all transmitters are modulated with the same signal and radiate same frequency. The limiting effect of SFN technique is self interference of the network. If signals from far distant transmitters are delayed more than allowed by the guard interval they behave as noise-like interfering signals rather than wanted signals. The self interference of SFN for a given transmitter spacing is reduced by selecting a large guard interval. The network generated self-interference of an SFN can be kept sufficiently low by a careful choice of the system parameters and transmitter powers. [9]

There are two main methods of creating a single-

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frequency network. The first is through the use of on-channel boosters. On-channel boosters quickly receive the OTA signal from the main tower and retransmit the signal at the same frequency. The problem is that there is no error correction. So, any errors in receptions are simply retransmitted along with the slight echo caused by the booster itself. With distributed transmission, the signal is delivered to each of its transmitters via fixed channels (land-based delivery). Then through the use GPS based reference clocks at each tower (for both time and frequency), the signals are synced so each can emit a perfect copy of both the signal and the symbol data. To get each transmitter synchronized in both the time and frequency domains some extra data is added to the serial data streams (these contain the encoded audio and data inputs) sent to the transmitters. This additional data stream is essentially a time reference signal inserted into the network. At each transmitter the OFDM modulator uses this time stamp to calculate the local delay so that a common on-air time is achieved.

The effects of multipath occurs within SFNs. This is because waves from different towers have potential to reach an antenna at different times and a receiver's ability to handle multipath is paramount to its success.

With the SFN technique, large areas can be served with common multiplex at a common radio centre frequency. The frequency efficiency of SFNs appears to be very high compared to MFNs. The SFN technique is also power efficient.

The advantage of the SFN approach are:
- high frequency efficiency
- low-power operation (internal network gain)
- high location probability
- easy gap-filling (frequency re-use)

The disadvantages are:
- network splitting is not possible
- synchronization is necessary
- feed control is required [6,9]

Comparison between the DVB-T and DVB-T2 standards

DVB-T2 is a second generation of standards for digital television broadcasting, offering significant benefits compared to DVB-T. DVB-T2 includes many new techniques not previously used in the DVB family of standards. Some of them, such as the P1 preamble, are completely new, having been invented especially for DVB-T2. Standards allow a large number of options and combinations. [3]

A few general principles were adopted in the design of T2. These were:

a) The DVB organization should aim to provide a coherent family of standards where possible,

b) Translation between DVB standards should be as simple as possible,

c) T2 should not re-invent solutions if they already exist within other DVB standards.

Consequently, T2 adopted two key technologies from DVB-S2. These were:

1. The system layer architecture of DVB-S2; in particular, the packaging of data into Baseband frames
2. The use of the same Low Density Parity Check (LDPC) error –correcting codes used in S2 [3]

Overview of DVB-T2

The DVB organization defined a set of commercial requirements which acted as a framework for the T2 development. These commercial requirements include:
- T2 transmissions must be able to use existing domestic receiver antenna installations and must be able to re-use existing transmitter infrastructures,
- T2 should primary target services for fixed and portable receivers,
- T2 should provide a minimum of 30% capacity increase over DVB-T working within same planning constrains and conditions as DVB-T,
- T2 should provide for improved single frequency (SFN) performance compared with DVB-T,
- T2 should have a mechanism for providing service-specific robustness i.e. it should be possible to give different levels of robustness to some services compared to others,
- T2 should provide for bandwidth and frequency flexibility,
- There should be a mechanism defined, if possible, to reduce the peak-to-average–power ratio of the transmitted signal in order to reduce transmission costs.[3, 8]

Benefits of DVB-T2 compared to DVB-T

As a result of the technologies introduced in DVB-T2, the potential gain that could be achieved is nearly 50% compared to the current mode of DVB-T. In addition to the increased capacity, the proposed DVB-T2 mode is expected to offer a greater tolerance of multipath and impulsive interference than the current DVB-T mode.

Important differences are presented in Table 1.

Table 1. Potential capacity increase of almost 50% compared with current highest capacity DVB-T mode used in the UK

	Current UK mode	T2
Modulation	64-QAM	256 –QAM
FFT size	2K	32K
Guard interval	1/32	1/128
FEC	2/3 CC+RS	3/5LDPC+BCH
Scattered Pilots	8.3 %	1.0%
Continual Pilots (see note 1	2.0 %	0.53%
L1 overhead (see note 2)	1.0 %	0.53%
Carrier mode	Standard	Extended
Capacity	24.1 Mbit/s	36.1 Mbit/s
NOTE 1:Includes only continual pilot cells which are not also Scattered Pilots NOTE 2: TPS for DVB-T; L1-signaling, P1 and extra P2 overhead for DVB-T2		

Even greater increase in capacity could be achieved in modes designed for single-frequency operation, because of the large fractional guard intervals used in these modes. Table 2. shows the comparison between DVB-T2 and DVB-T for a long guard interval (SFN) mode, with the same absolute guard interval in both cases. This provides 67% increase in capacity for DVB-T2 over DVB-T. A longer guard interval mode is also available (nearly 20% increase), which would give improved SFN coverage for only a small capacity loss (around 3%).

In DVB-T, the highest order constellation is 64-QAM, delivering a gross data rate of 6 bits per symbol per carrier (i.e. 6 bits per OFDM cell).

In DVB-T2, the use of 256-QAM increases this to 8 bits per OFDM cell, a 33% increase in spectral efficiency and capacity transported for a given code rate. Normally, this would require a significantly higher carrier–to-noise ratio

(4 dB to 5 dB higher, depending on channel and code rate). The performance of LDPC codes is much better than a convolution codes, and if a slightly stronger code rate is chosen for 256-QAM compared to the rate currently used with 64-QAM using DVB-T, the required C/N is maintained whilst still achieving a significant bit rate increase. [3,8]

Table 2. Potential capacity increase of 67% for an SFN mode

	DVB-T mode	T2
Modulation	64-QAM	256 –QAM
FFT size	8K	32K
Guard interval	¼	1/16
FEC	2/3 CC+RS	3/5LDPC+BCH
Scattered Pilots	8.3 %	4.2%
Continual Pilots (see note 1	2.0 %	0.39%
L1 overhead (see note 2)	1.0 %	0.65%
Carrier mode	Standard	Extended
Capacity	19.9 Mbit/s	33.2 Mbit/s
NOTE 1:Includes only continual pilot cells which are not also Scattered Pilots NOTE 2: TPS for DVB-T; L1-signaling, P1 and extra P2 overhead for DVB-T2		

Architectural model

The full DVB-T2 system can be divided into three basic sub-systems in the network side (SS1, SS2 and SS3) and two sub-systems on the receiver side (SS4, SS5). Regarding interfaces, there are two corresponding interfaces on the network side (A and B), and one receiver-internal interface (D). The RF interface (C) is common for the network and the receiver [3].

On the network side the three sub-systems are:

SS1: Coding and multiplexing sub-system. This includes the generation of MPEG-2 Transport Streams and/or Generic streams, e.g. GSE.

SS2: Basic T2-Gateway sub-system. This includes functionality for Mode adaptation and Stream adaptation for DVB-T2, together with scheduling and capacity allocation.

SS3: DVB-T2 Modulator sub-system. The DVB-T2 modulators use the Baseband frames and T2-frame assembly instructions carried in the incoming T2-MI stream to create DVB-T2 frames and emit them at the appropriate time for correct SFN synchronization. The modulators interfaces to the receivers via the C interface (the transmitted DVB-T2 signal).

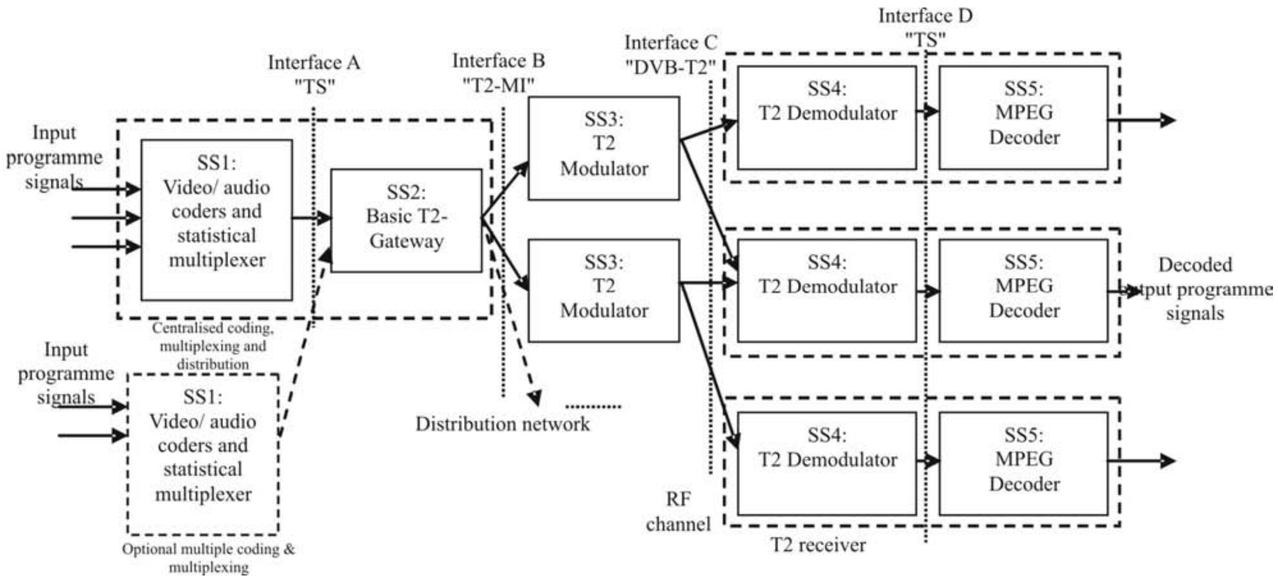


Figure 1. Block diagram of DVB-T2 chain [Digital Video Broadcasting (DVB); Implementation guidelines for the second generation of digital terrestrial television broadcasting (DVB-T2)]

In the receiver side the sub-systems are:

SS4: DVB-T2 Demodulator sub-system. This sub-system receives an RF signal from one or (in an SFN) more transmitters in the network and (in the transport-stream case) outputs one transport stream. SS4 interfaces to SS5 via D interface, a syntactically correct transport stream carrying one or more of the services as well as any common signaling data derived from the common PLP. The streams passing the B interface are identical to those passing the D interface.

SS5: Stream decoder sub-system. This sub-system receives the transport stream and outputs decoded video and audio. Since the interface D is a syntactically correct transport stream, this sub-system is essentially the same as the other DVB standards, except that some new L2-signaling elements have been defined for DVB-T2.[2]

Principle of the OFDM modulation

OFDM is a good candidate for SFN because of its power in reducing the effect of echoes. OFDM is a modulation technique for transmitting large amounts of digital data over radio waves. OFDM is a multi-carrier transmission technique, where the available spectrum is divided into many carriers, each one modulated by a low rate data stream. OFDM overcomes most of problems with both FDMA and TDMA. OFDM divides the available bandwidth into many band channels (typically 100-8000). The carriers for each channel are made orthogonal to each other, allowing then to be spaced as closed as theoretically possible. Each carrier in an OFDM signal has a very narrow bandwidth (i.e 1kHz), thus the resulting symbol rate is low. This will give the signal a high tolerance to multipath delay spread, because delay spread must be very long to cause significant inter-symbol interference. OFDM is capable of providing very high data rate with strong robustness of multipath delay spread, which make that ISI is no longer problem.[9]

The basic parameter that defines the size of the SFN area is the guard interval T_G. In order to understand this term, we will need at least one basic explanation to the fundamentals of the OFDM modulation method. Its great robustness against inter-symbol interference as an effect of multipath reception (an impact of time delayed signals–echoes) consists of largely extending the very short bit time interval T_B in the serial original data stream. The symbol time extension is done by first mapping the original data stream $S_b(t)$ into n parallel data (symbol) streams S_0 to S_{n-1}. The parallel streams are then modulated using the discrete digital method (e.g. m-QAM or QPSK) onto a number n simultaneously transmitted orthogonal sub-carrier signal. Orthogonality of this system is ensured by keeping the maxima (minima) spacing of respective sub-carrier waves and integer multiple of the inverted symbol time value.

One of the options to simply produce OFDM signal of a desired orthogonal spectral structure is to use IDFT (Inverse Discrete Fourier Transform). The block diagram of an OFDM modulator is graphically presented in Fig.2. [7]

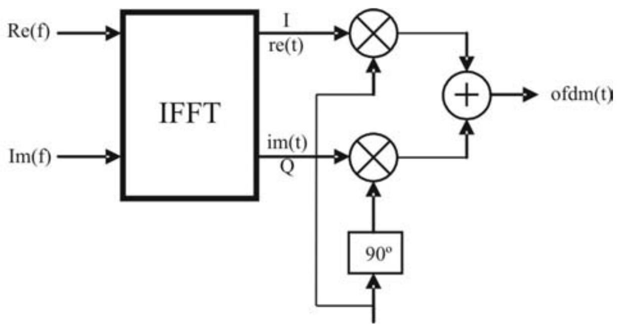


Figure 2. Practical implementation of the COFDM modulator [Walter Fischer, Digital Video and audio broadcasting Technology, 2nd Edition, Springer, 2008]

DVB-T(2) Single-frequency network

The GPS satellites radiate a 1 pps (pulse per second) signal to which a 10 MHz oscillator in professional GPS receivers is locked, which, in turn, acts as a reference signal for the DVB-T transmitters. A single-frequency network can be built only in a limited area.[5]

Power contribution from the individual transmitters working in the single frequency network adds. Therefore, the single-frequency network shows a so-called SFN gain. Two DVB-T transmitters with the broadcast power P_v ensure in the same condition (the same diversity and antenna gain) better signal coverage (better values of the field intensity) in the receiver position than a single transmitter with the double broadcast power $2P_v$.

In order to set up one SFN network, three conditions have to be fulfilled. DVB-T transmitters belonging to one SFN cell shall radiate:

1. over the same frequency
2. at the same time
3. the same OFDM symbols

The first condition is basically easy to satisfy: all DVB-T transmitters will be configured once to the required broadcast frequency (at the modulator level).

Conditions 2) and 3) imply to provide transmitters with extra information: synchronization and transmission parameters.

However, there is also a strict requirement with respect to the maximum distance between transmitters. Thus, distance is related to the length of the guard interval and the velocity of light, i.e. associated signal delay. Intersymbol interference can only be avoided if in the case of multipath reception, the delay on any path is no longer then the length of the guard interval. The question about what would happen if the signal received from a more distant transmitter violates the guard interval is easily answered: it results in intersymbol interference which becomes noticeable as noise in the receiver.[5]

Table 3. Guard interval lengths for 8K, 2K modes and transmitter distances (8MHz channel)

Mode	Symbol duration µs	Guard interval Ratio	Guard interval µs	Transmitter distance km
2K	224	¼	56	16.8
2K	224	1/8	28	8.4
2K	224	1/16	14	4.2
2K	224	1/32	7	2.1
8K	896	¼	224	67.1
8K	896	1/8	112	33.6
8K	896	1/16	56	16.8
8K	896	1/32	28	8.4

Signals from transmitters at great distances must simply be attenuated sufficiently. The threshold for quasi error free operation is formed by the same conditions as for pure noise. It is of particular importance that the levels in a single-frequency network are calibrated correctly. It is not the maximum transmitting power at every transmitting site which is required, but the correct one. Planning the network requires topographical information.

Table 4. Guard interval lengths for 8K, 2K modes and transmitter distances (7 MHz channel)

Mode	Symbol duration µs	Guard interval ratio	Guard interval µs	Transmitter Distance km
2K	256	¼	64	19,2
2K	256	1/8	32	9,6
2K	256	1/16	16	4,8
2K	256	1/32	8	2.4
8K	1024	¼	256	76.7
8K	1024	1/8	128	38.4
8K	1024	1/16	64	19.2
8K	1024	1/32	32	9.6

Table 5. Guard interval lengths for 8K, 2K modes and transmitter distances (6MHz channel)

Mode	Symbol duration	Guard interval ratio	Guard interval µs	Transmitter distance km
2K	299	¼	75	22.4
2K	299	1/8	37	11.2
2K	299	1/16	19	5,6
2K	299	1/32	9	2.8
8K	1195	¼	299	89.5
8K	1195	1/8	149	44.8
8K	1195	1/16	75	22.4
8K	1195	1/32	37	11.2

The velocity of lights is c=299792448m/s which results in signal delay per kilometer transmitter distance of t_{1km}=3.336 µs. Since in the 8K mode, the guard interval is longer in absolute terms, it is mainly this mode which is provided for a single-frequency operation. Long guard intervals are provided for single-frequency networks. Medium-length intervals are used in regional networks. The short-guard intervals are provided for local networks or used outside of the single-frequency networks.

In a single-frequency network, all the individual transmitters must be synchronized with one another. The DVB-T modulation is structured in frames, one frame being composed of 68 DVB-T COFDM symbols. Within a frame, the complete TPS information is transmitted and the scattered pilots are scattered over the entire DVB-T channel. Such a frame, in turn, makes up one superframe.

Frame structure of DVB-T:

68 COFDM symbols= 1 frame

4 frame= 1 superframe

One superframe in DVB-T accommodates an integer number of MPEG-2 transport stream packets, as shown in Table 6.

Table 6. Number of transport stream packets per superframe

Code rate	QPSK			16 QAM			64QAM		
	2K	4K	8K	2K	4K	8K	2K	4K	8K
½	252	504	1008	504	1008	2016	756	1512	3024
2/3	336	672	1344	672	1344	2688	1008	2016	4032
¾	378	756	1512	756	1512	3024	1134	2268	4536
5/6	420	840	1680	840	1680	3360	1260	2520	5040
7/8	441	882	1764	882	1764	3528	1323	2646	5292

These modulations must, therefore, be synchronized with one another and, in addition, the differences in feed line delays must be equalized statically and dynamically. To achieve this, packets with time stamps are inserted into MPEG -2 transport stream in a playout center. For this purpose, the transport stream is divided into sections, the lengths of which are selected to be approximately a half of a second because they must correspond to a certain integral number of transport stream packets fitting into certain integral number of superframes. These sections are called megaframes.

A megaframe is composed of an integral number of superframes, as follows:

1 megaframe= 2 superframes in 8K mode

1 megaframe= 8 superframes in 2K mode

The 1pps signals of the GPS satellites are also used for synchronizing the timing of DVB-T modulators. In the case of a single-frequency network, there is a professional GPS receiver that can output both a 10 MHz reference signal and this time signal at every transmitter site and the playout center, where the multiplexed stream is assembled.

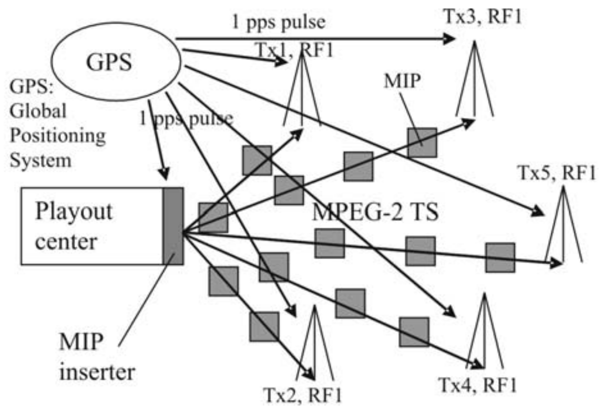


Figure 3. DVB-T distribution network with MIP insertion [Walter Fischer, Digital Video and audio broadcasting Technology, 2nd Edition, Springer, 2008]

At the multiplexer site there is a so-called MIP inserter which inserts the special transport stream packet into one megaframe in each case, which is why this packet is called Megaframe Initializing Packet (MIP) (Fig.4).

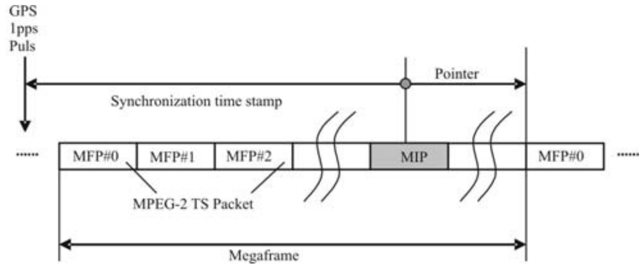


Figure4. Megaframe structure at transport stream level [Walter Fischer, Digital Video and audio broadcasting Technology, 2nd Edition, Springer, 2008]

DVB normalized its PID to 0x15. The content of this table can be viewed in this way:

- Transmission parameters are also referred to as TPS bits. Those TPS represents modulation settings (guard interval, bandwidth, FFT mode, etc.)
- Synchronization parameters Timestamps (STS: Synchronization TimeStamp) and budget (maximum_network_delay).
- Optional functions: are aimed to address individually transmitters by means of their TxID enabling among other RF coverage refinement.

The MIP has a special PID of 0x15 so that can be identified and it contains time reference and control information for DVB-T modulators. It contains the time counting back to the time the last 1pps pulse was received at the MIP inserter. This time stamp of 100 ns steps is used for measuring the feed distance automatically. This time information is evaluated by SFN adapter which automatically corrects the delay from the playout center to the transmitter site by means of a buffer store. It also requires information about the maximum delay in the network. Given this information, each SFN adapter adjusts itself to this time. The MIP packet also contains a pointer to the start of the next megaframe in numbers of TS packets. Using this pointer information, each modulator is then able to start a megaframe at the same time. GPS is not used for localization purposes, but rather to provide both transmitters and SFN adapter with following clock reference information 1PPS (1 Pulse per second) and 10 MHz (derived from 1PPS signal). For each megaframe, output from SFN adapter, STS (Synchronization Timestamp) is inserted. STS is the reference time computed by the SFN Adapter relative to the last PPS received. The value is derived from 10 MHz counter, and ranges from 0 to 9,999,999 (100 ns step).

For all transmitters, transmission time T_{trans}= (STS + maximum_network_delay) modulo 10^7

Transmission time is modulo 10^7 since the time reference basis is 1 second (1PPS derived from the GPS clock reference).

Network delay for each transmitter is different, but it does not exceed maximum_network_delay, which is a necessary condition for an SFN network to work properly. [5]

The length of a megaframe depends on the length of the guard interval and on the bandwidth of the channel. The narrower the channel (8,7 or 6 MHz), the longer are OFDM symbols, since the subcarrier spacing becomes less. Every DVB-T modulator can now be synchronized by means of information contained in the MIP packet.

Table 7. Megaframe duration

Guard interval	8MHz channel	7MHz channel	6MHz channel
1/32	0.502656 s	0.574464 s	0.670208 s
1/16	0.517888 s	0.598172 s	0.690517 s
1/8	0.548352 s	0.626688 s	0.731136 s
¼	0.609280 s	0.696320 s	0.812373 s

An MIP can also be used for transmitting additional information such as DVB-T transmission parameters which makes it possible to control and configure the entire DVB-T SFN from one center. For example, it can be used for changing the type of modulation, the code rate, the guard interval length, etc. Although this is possible, it may not be supported by every DVB-T modulator.

If the transmission of MIP packets stops for some reason or if the information in MIP packets is corrupted, the SFN will lose the synchronization. If a DVB-T transmitter detects that it has dropped lock or that it has not received a GPS signal for some time and the 1 pps reference and the 10 MHz reference have, therefore drifted, it has to go off air or it will only be a source of noise in the SFN. Reliable reception is then only possible with directional reception close to the transmitter.

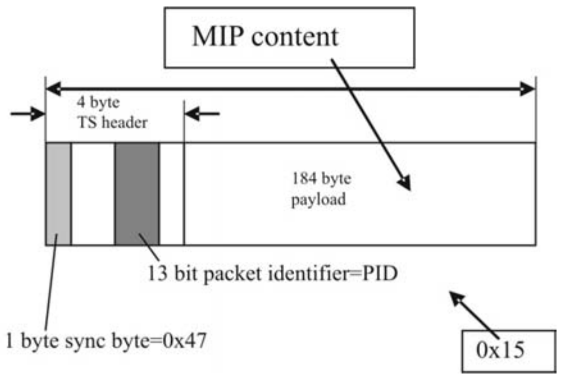
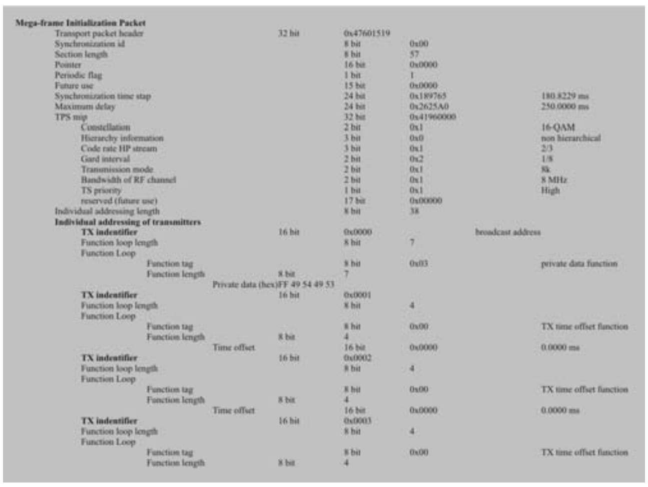


Figure 5. Megaframe initialization packet [Walter Fischer, Digital Video and audio broadcasting Technology, 2nd Edition, Springer, 2008.



Mega-frame Initialization Packet					
Transport packet header	32 bit	0x47601519			
Synchronization id		8 bit	0x00		
Section length		8 bit	57		
Pointer		16 bit	0x0000		
Periodic flag		1 bit	1		
Future use		15 bit	0x0000		
Synchronization time stap		24 bit	0x189765		180.8229 ms
Maximum delay		24 bit	0x2625A0		250.0000 ms
TPS mip		32 bit	0x41960000		
Constellation		2 bit	0x1		16-QAM
Hierarchy information		3 bit	0x0		non hierarchical
Code rate HP stream		3 bit	0x1		2/3
Gard interval		2 bit	0x2		1/8
Transmission mode		2 bit	0x1		8k
Bandwidth of RF channel		2 bit	0x1		8 MHz
TS priority		1 bit	0x1		High
reserved (future use)		17 bit	0x00000		
Individual addressing length		8 bit	38		
Individual addressing of transmitters					
TX indentifier	16 bit	0x0000		broadcast address	
Function loop length		8 bit	7		
Function Loop					
Function tag		8 bit	0x03		private data function
Function length	8 bit	7			
Private data (hex)FF 49 54 49 53					
TX indentifier	16 bit	0x0001			
Function loop length		8 bit	4		
Function Loop					
Function tag		8 bit	0x00		TX time offset function
Function length	8 bit	4			
Time offset		16 bit	0x0000		0.0000 ms
TX indentifier	16 bit	0x0002			
Function loop length		8 bit	4		
Function Loop					
Function tag		8 bit	0x00		TX time offset function
Function length	8 bit	4			
Time offset		16 bit	0x0000		0.0000 ms
TX indentifier	16 bit	0x0003			
Function loop length		8 bit	4		
Function Loop					
Function tag		8 bit	0x00		TX time offset function
Function length	8 bit	4			

Figure 6. MIP packet analysis [Walter Fischer, Digital Video and audio broadcasting Technology, 2nd Edition, Springer, 2008.]

Fig.6 shows that the MPEG stream now carries a table–like packet, namely the MIP packet, containing the synchronization time stamp, the pointer and the maximum delay. It also contains the transmission parameters. It can also be seen that every transmitter in the link-up can be addressed. Like a table, the content of the MIP packet is protected by the CRC checksum. [1]

In addition, each transmitter can also be "pushed", i.e. it is possible to change the time when the COFDM symbol is broadcast. This will not push the single frequency network out of synchronization but only vary the delay if the signals of the transmitters with respect to each other and can thus be used for optimizing the SFN network.

Network planning for DVB-T2 will have much in common with planning for DVB-T, but the availability of a wider range of technologies and options in DVB-T2 gives more flexibility. In particular, larger FFT sizes and wider choice of guard intervals will give a greater scope for network optimization. The use of MIMO could also give a worthwhile benefit in some SFN configurations.

For DVB-T2, the range of standard COFDM parameters has been extended compared with DVB-T, as requested by commercial requirements, to include:

- FFT size: 1K, 2K, 4K, 8K, 16K, 32K
- Guard interval fractions: 1/128, 1/32, 1/16, 19/256, 1/8, 19/128,1/4
- Scattered pilot patterns: 8 different versions matched to guard intervals, providing a range of efficiencies
- Continual pilots, similar to DVB-T but with improved optimization to reduce overhead
- An extended-carrier mode to allow optimum use to be made of the channel bandwidth together with the higher FFT size. When this option is used (supported for 8K,16K and 32K FFT) the carrier spacing is the same as when the normal carrier is used, but additional carrier are added at both ends of the spectrum

The extended range of COFDM parameters allows significant reduction in overhead to be achieved by DVB-T2 compared with DVB-T, which taken together with improved error-correction coding allow an increase in capacity of up to nearly 50% to be achieved for MFN operation and even higher for SFN operation.

The T2 system provides a number of new features for improved versatility:

- a frame structure which contains a special (short) identification symbol, which can be used for rapid channel scanning and signal acquisition, and which also signals some basic frame-structure parameters.
- Rotated constellations, which provide a form of modulation diversity, to assist in the reception of higher-code-rate signals in demanding transmission channels
- Special techniques to reduce the peak-to-average ratio of a transmitted signal
- An option for extending the transmitted signal by including provision for the Future-Extension-Frames (FEFs), which are unspecified portions of the signal the first-generation receivers will know to ignore, but which could provide a compatible route for later upgrades.[4]

Example of possible uses of the DVB-T2 system

The DVB-T2 system is designed to be flexible, allowing different trade–offs to be made in terms of capacity and ruggedness, as well as flexibility and overhead. For example, the system can be used in a very simple configuration to carry a few HDTV services, within a single PLP, intended for fixed rooftop reception, In this case, some typical parameter choices might be:

- 32K FFT with 1/128 guard interval for the MFN configuration, which maximizes the available capacity
- 32K FFT with 19/128 guard interval for a national SFN configuration (providing interval of 532 μs)
- 256-QAM rotated constellations with the code rate 3/5 or 2/3: the 256-QAM provide the maximum possible data

capacity and is suitable for fixed rooftop reception, and the rotated constellations provide additional robustness for difficult reception condition [8]

These configurations could provide approximately 36 Mbit/s to 40 Mbit/s for the MFN case, or 29 Mbit/s to 32 Mbit/s in the SFN case.

The use of 32K FFT is only possible where the transmission channel is fairly static, and so far a network targeting potable/or mobile reception, a lower FFT size and more robust constellation are likely to be used.[2]

Conclusion

Optimizing spectrum usage and bandwidth is made possible with SFN topology: all the transmitters will radiate synchronously, based on information provided by the SFN adapter.

Two kinds of synchronization are in use: temporal (1pps+10MHz) and frequency (10 MHz). The more accurate these references are, the more precise RF coverage is. It is to be noted that an inaccuracy of frequency synchronization (10 MHz) will result in a very bad RF coverage (strong inter-carriers interferences). The use of optional functions can be a solution for correcting such an inaccuracy.

Defining the size of an area covered by SFN broadcasting (or more precisely, defining its boundaries) is thus not simple at all, as it depends on a number of elements. Calculations of areas, where single-frequency networks can be applied, are not applicable without sophisticated simulation program tools. At their inputs, a huge amount of data must be available-e.g. longitude and latitude of all considered transmitters in the simulated network, their power, radiation patterns, terrain profile of analyzed relative timing (synchronization) of particular transmitters, operating in the single-frequency network, etc.

The government of the Republic of Serbia in July 2nd 2009 has adopted Strategy for Switchover form Analog to Digital Broadcasting of Radio and Television Programs in the Republic of Serbia. 4th of April 2012 is set to be the date of analogue switch-off and switchover to digital broadcasting of television programs in the Republic of Serbia. Serbia has decided to use the new DVB-T2 transmission standard for digital terrestrial broadcasting together with MPEG-4 (H.264, AVC) for its forthcoming transition to digital broadcasting. [10]

DVB-T2 promises at least 30% improvement in capacity. Significant innovations of new specifications compared to DVB-T include a new forward error protection code, high order modulation modes, and coding of services and increase in the number of OFDM carriers. Principally, the increase throughput is achieved by employing enhanced error correction (FEC) schemes, such as LDPC schemes, as opposed to just BCH convolution used in DVB-T. This suggests 2 dB improvement, which can be converted to capacity either trough using less error correction or moving to a higher order constellation, such as 256-QAM. FEC scheme improve the robustness of the signal. Significantly, there is the 32K carrier mode in addition to 2k and 8k for DVB-T. The benefit of this option is the ability to use single-frequency networks to increased robustness to impulse interference. Whenever a MIMO (Multiple input multiple output) approach is used in DVB-T2, it is reasonable to expect an improvement in robustness and a reduction in destructive interference in SFN. [4]

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Received: 07.06.2010.

Jednofrekvencijske mreže za DVB-T standard i njihovo unapređenje putem DVB-T2 standarda

U ovom radu je analiziran proces izgradnje jednofrekvencijskih mreža za digitalno emitovanje televizijskih signala zemaljskim putem. Pokazano je poređenje između DVB-T i DVB-T2 standarda, prilikom planiranja jednofrekvencijske mreže. Jednofrekvencijska mreža se koristi za optimizaciju spektra i propusnog opsega. DVB-T2 je standard za digitalno televizijsko emitovanje terestričkim putem druge generacije, koji nudi značajne prednosti u poređenju sa DVB-T. DVB-T2 uključuje nove tehnike, koje se nisu prvobitno koristile u DVB-T standardu. U ovom radu, pokazane su glavne osobine DVB-T i DVB-T2 standarda, kao i principi OFDM modulacije.

Ključne reči: **digitalna TV, TV signal, digitalni prenos, digitalna mreža, jednofrekvencijska mreža, arhitektura mreže, blok dijagram, standadi.**

Одночастотные сети для DVB-T стандарта и их эволюция через DVB-T2 стандарт

В настоящей работе проанализирован процесс построения одночастотных сетей для цифровой трансляции ТВ-сигналов наземным путём. Здесь показано сравнивание между DVB-T и DVB-T2 стандартами, во время планирования одночастотной сети. Одночастотной сетью пользуются для оптимизации спектра и полосы пропускания частот. DVB-T2 является стандартом для цифровой телевизионной трансляции наземным путём второй генерации, предлагающий значительные преимущества по сравнению с DVB-T. Стандарт DVB-T2 включает новые техники, которыми предварительно не пользовались в DVB-T стандарте. В настоящей работе показаны главные свойства DVB-T и DVB-T2 стандартов, а в том числе и принципы OFDM модуляции.

Ключевые слова: **цифровое ТВ, ТВ-сигнал, цифровая передача, цифровая сеть, одночастотная сеть, архитектура сети, блок-диаграмма, стандарты.**

Les réseaux monofréquences pour la norme DVB-T et leur évolution par la norme DVB-T2

Dans ce papier on a analysé le processus de l'établissement des réseaux monofréquences pour l'émission digitale des signaux télévisés par la voie terrestre. On a exposé la comparaison entre les normes DVB-T et DVB-T2 au cours de la conception du réseau monofréquence. Le réseau monofréquence est utilisé pour l'optimisation du spectre et de la largeur de la portée. DVB-T2 est la norme de la deuxième génération pour l'émission digitale TV par la voie terrestre. Elle offre des avantages importants par rapport à la norme DVB-T. La norme DVB-T2 inclut de nouvelles techniques qui ne sont pas utilisées par celle de DVB. Dans ce travail on a présenté les caractéristiques principales des normes DVB et DVB-T2 ainsi que les principes de la modulation OFDM.

Mots clés: **télévision digitale, signal digital, transmission digitale, réseau digital, réseau monofréquence, architecture du réseau, diagramme de bloc, normes.**