DVB-T

Transmitter

DVB T
TERRESTRIAL

1.
Introduction

- Why DTT instead of analogue TV?

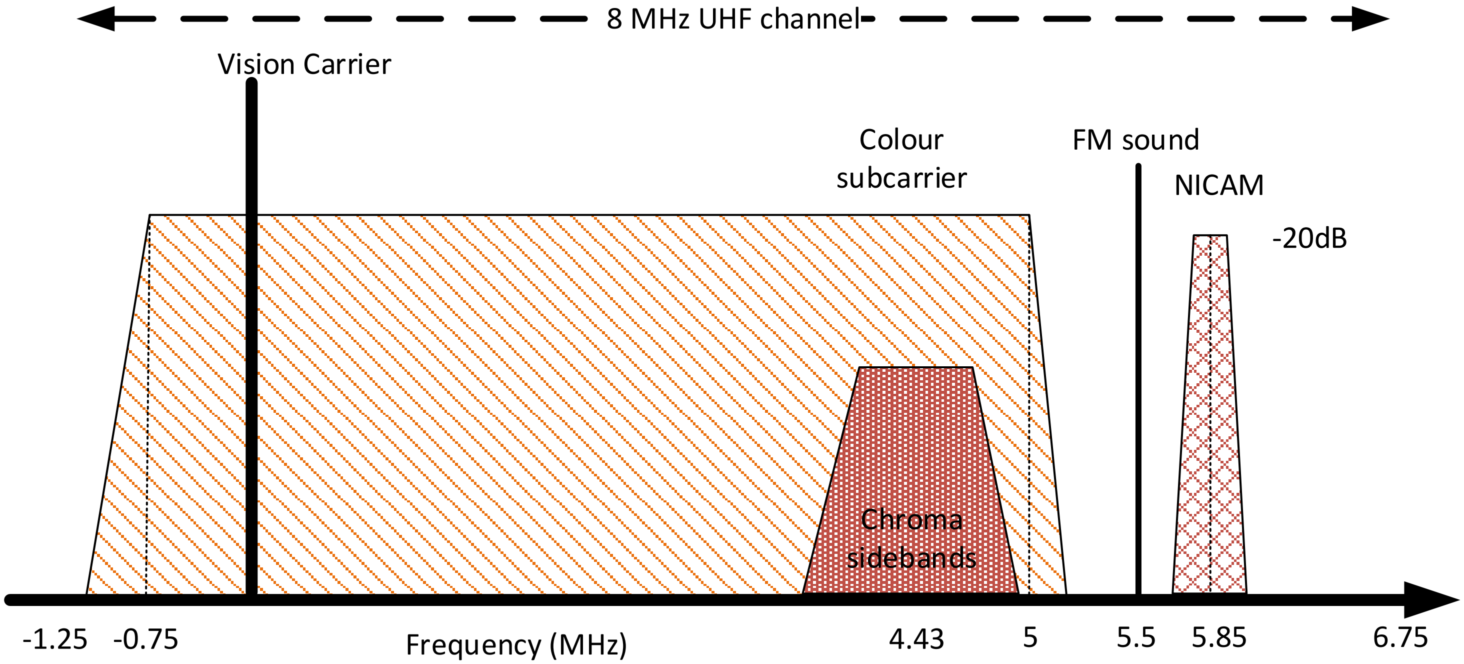
Analogue TV

- Saturation of the radio spectrum
- Rx problems: double image, background noise, interferences ….
- High SNR levels needed in reception
- Data transmission very limited (teletext, not very attractive…)

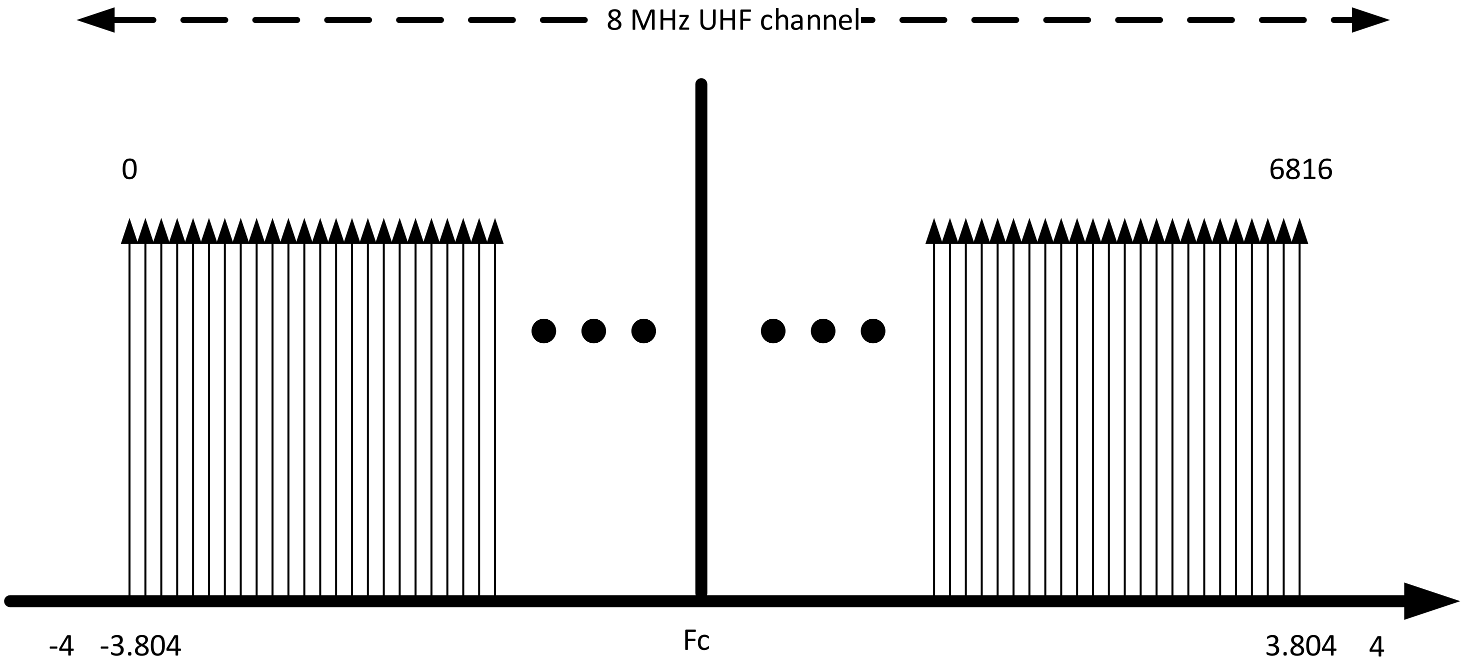
DTT

- Better use of the radio spectrum by allowing more channels
- Better image quality
- Mobile and handheld reception
- Lower Tx power
- Easy home reception
- Interactivity

- An analogue PAL SD TV channel occupies a 8 MHz bandwidth



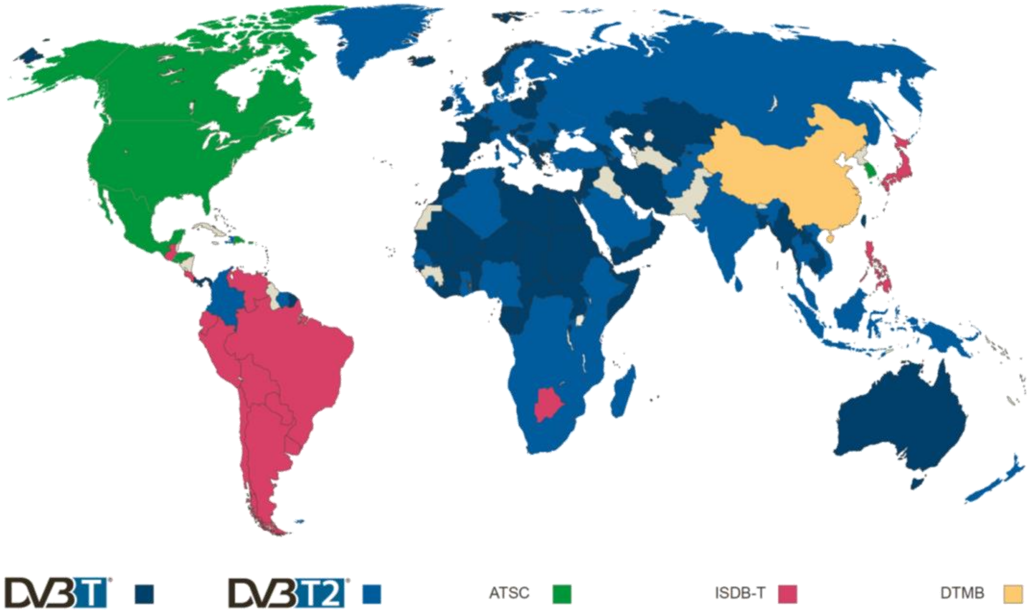
- In an 8MHz bandwidth OFDM channel with a 8k mode we can have:
  - 9 SD TV channels
  - 3 HD TV channels + 1 SD channel



- The analogue switch off has been carried out in this and the past decade in the different countries:

Country	Launch	Analogue switch off start	Analogue switch off end	DTT transmission	AV standard
Russia	2010	2015	2019 (planned)	DVB-T2	H.264
France	2005	2009	2011	DVB-T	H.262
Spain	2000/2005	2009	2010	DVB-T	H.262/H-264
U.K.	1998	2007	2012	DVB-T/T2	H.262/H.264
Italy	2004	2008	2012	DVB-T	H.262/H.264
Germany	2003	2003	2008	DVB-T	H.262/H.264
U.S.A.	1998	2008	2009	ATSC	H.262/H-264 ATSC 2.0

- More tan 200 million devices all over the world receive DVB compliant service
- DVB-T and DVB-T2 are used in more than 70 countries

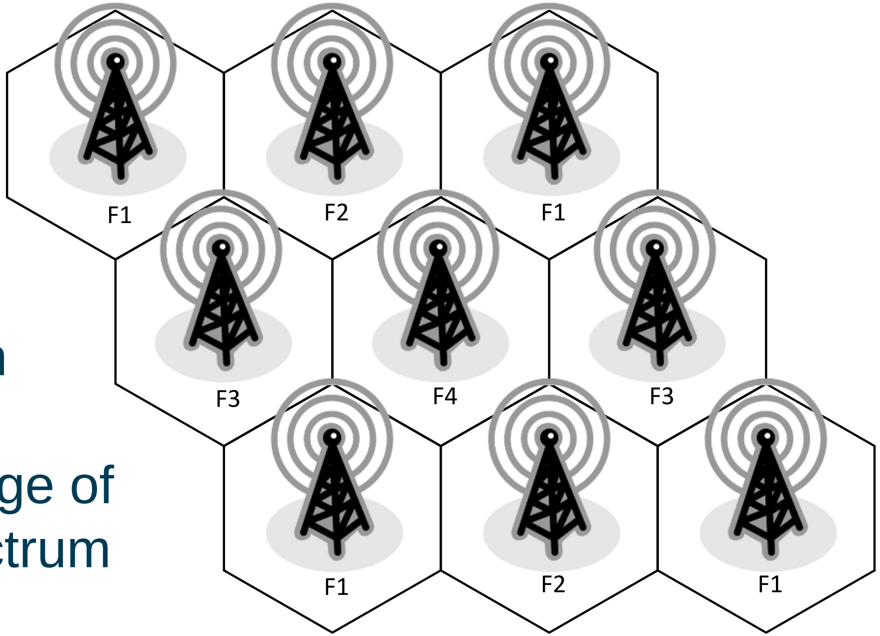


2.
DVB-T Standard

- ETSI EN 300 744: Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television
  - The full specification can be downloaded form the ETSI website
- Some general characteristics
  - COFDM modulation
  - MPEG-2 Transport Stream Input
  - Hierarchical transmissions
  - Two transmission modes (2k, 8k)
  - 3 modulation schemes: QPSK, 16-QAM, 64-QAM
  - 5 coding rates in the FEC
  - 4 guard intervals

- Designed for DTT and to operate in the VHF and UHF bands
- Coexisted with systems as PAL, NTSC and SECAM so it is a must to be robust to CCI and ACI
- A high spectral efficiency is needed, so SFNs configurations are included in the standard

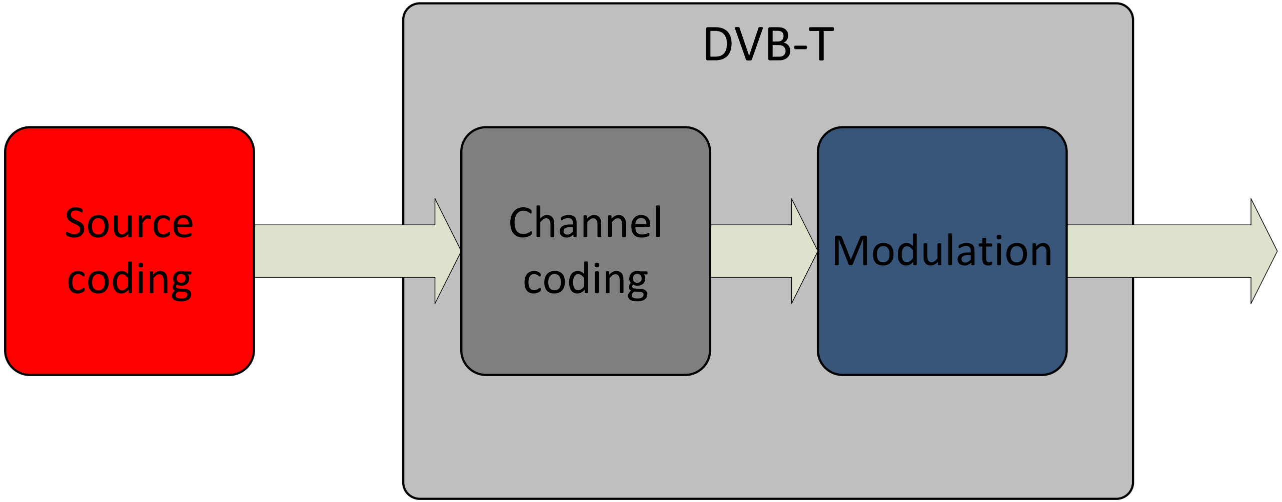
- Multi frequency network (MFN)
  - Classical approach in cell division where a set of cells use a different frequency to transmit and there is a minimum distance to re-use the same frequency



  - This approach has a very inefficient usage of the radio spectrum

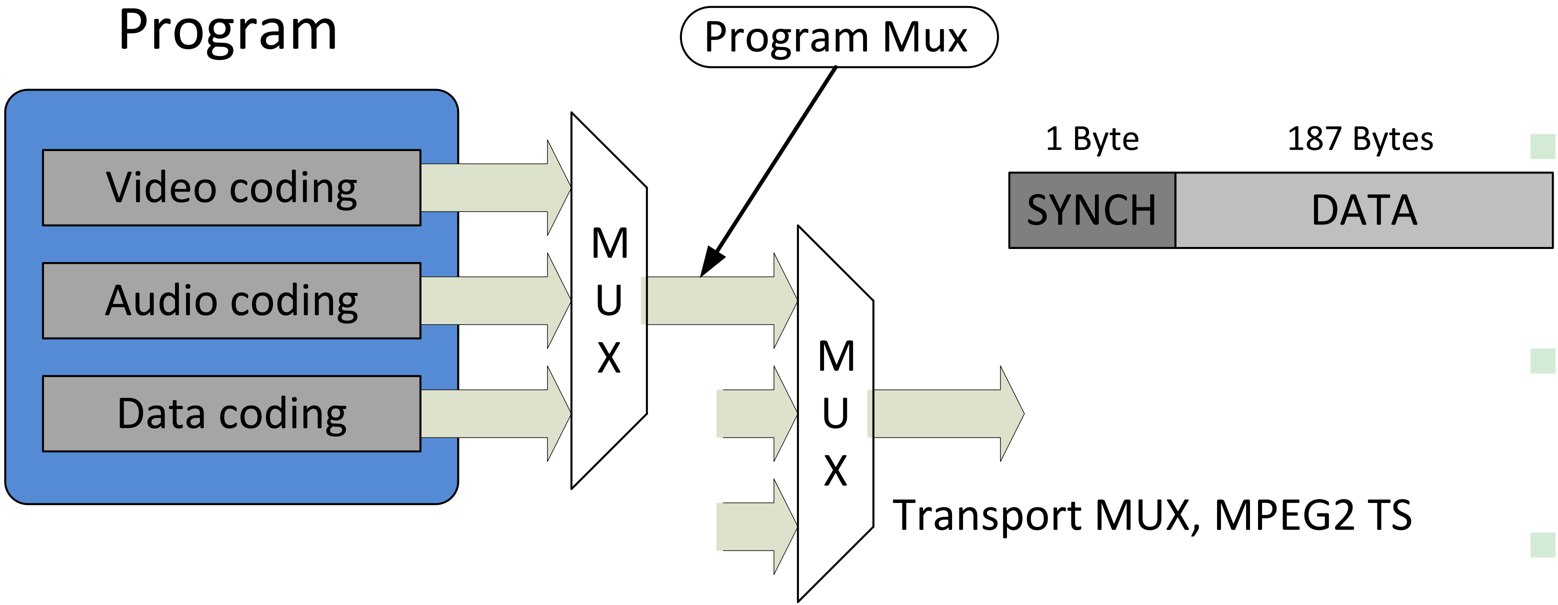
- Single Frequency Network (SFN)
  - All the transmitters are synchronized in terms of bit, frequency and time
    - All the transmitters transmit the same at the same time and frequency
  - Previously a single analogue program was transmitted using 9 frequencies, with SFNs a single frame is transmitted in a frequency
  - Very high spectral efficiency
  - Very strict synchronization requirements

- The standard can be divided in the following conceptual parts



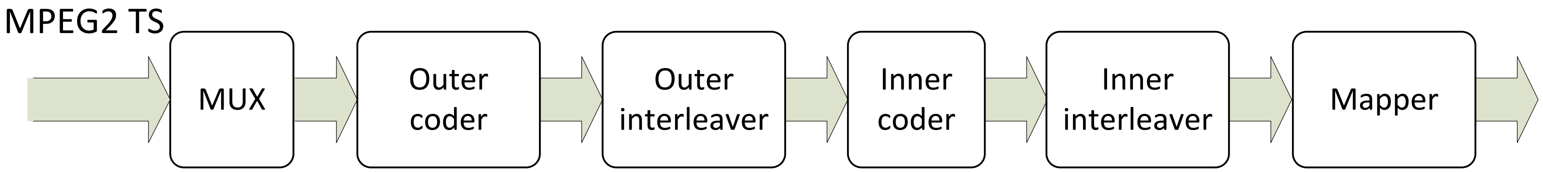
3.
Source coding

- Digitalization of the audio and video of the programs to be transmitted
- Adaptation of the MPEG2 standard
- Common to all the DVB standards



4.
Channel coding

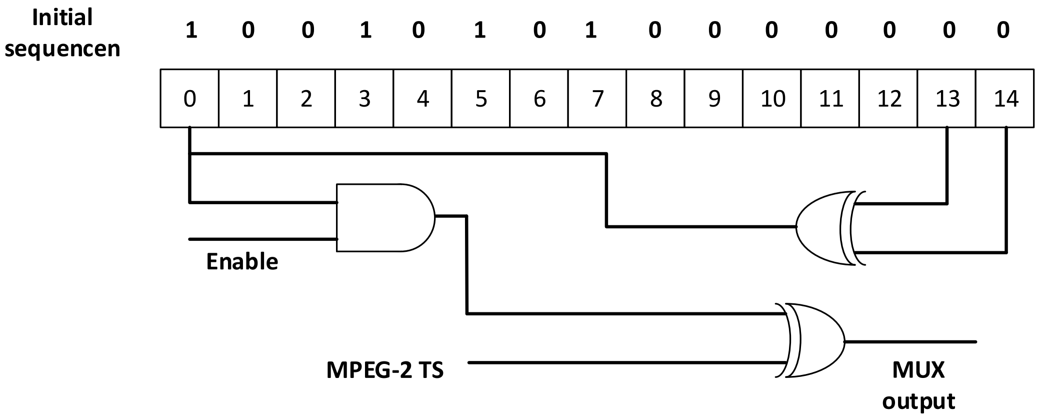
- The channel coding is separated in the following blocks



  - The input stream is the MPEG2 TS
  - The output will be modulated in the OFDM modulator

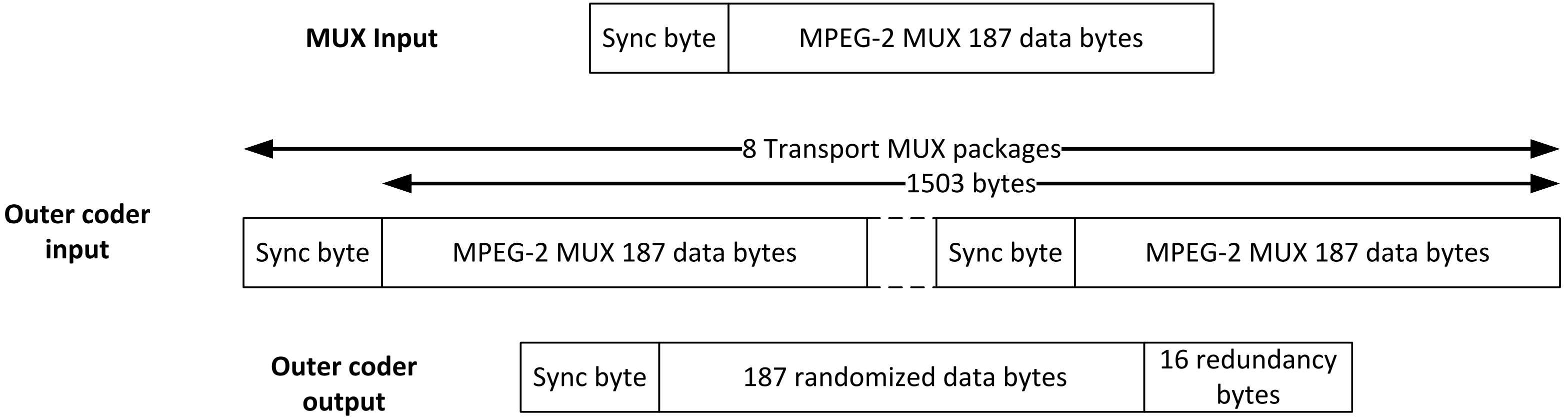
MUX

- Energy adaptation and dispersion
- randomization: avoid long sequences of “1” and “0”
- PRBS (Pseudo Random Binary Sequence)
  - The period is 1503 bytes (8 MPEG-2 TS packets)
- At the receiver the same sequence is applied



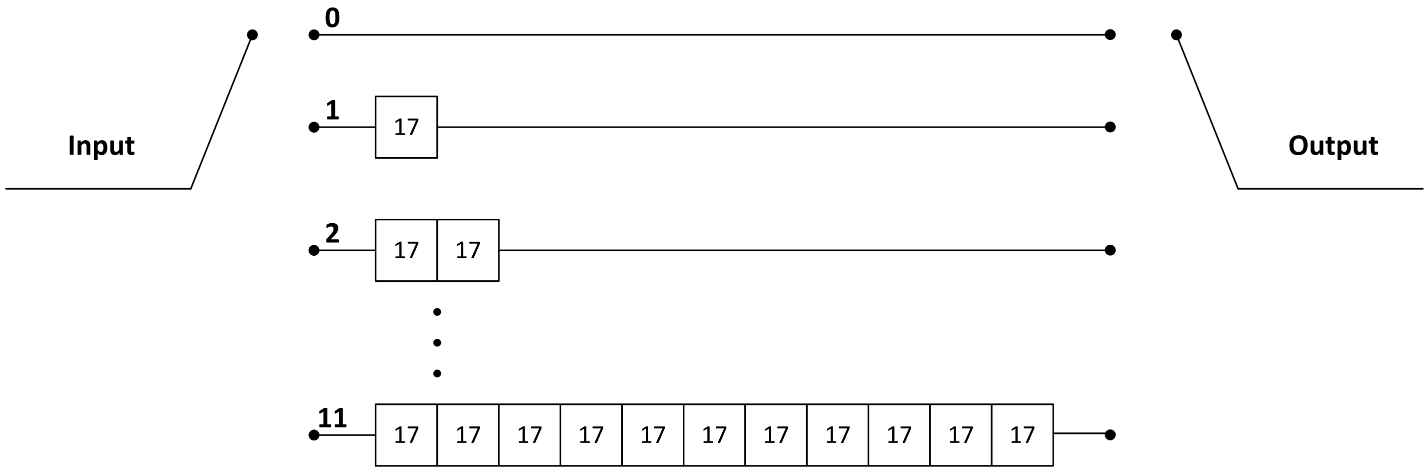
Outer coder

- Allows the correction of errors by inserting redundancy bits
- Reed-Solomon code RS(204, 188, t=8)
  - Input block: 188 bytes
  - Codified Output: 204 bytes (16 bytes redundancy)
  - Corrector capacity of 8 bytes
- Optimum work case when errors are uniformly distributed

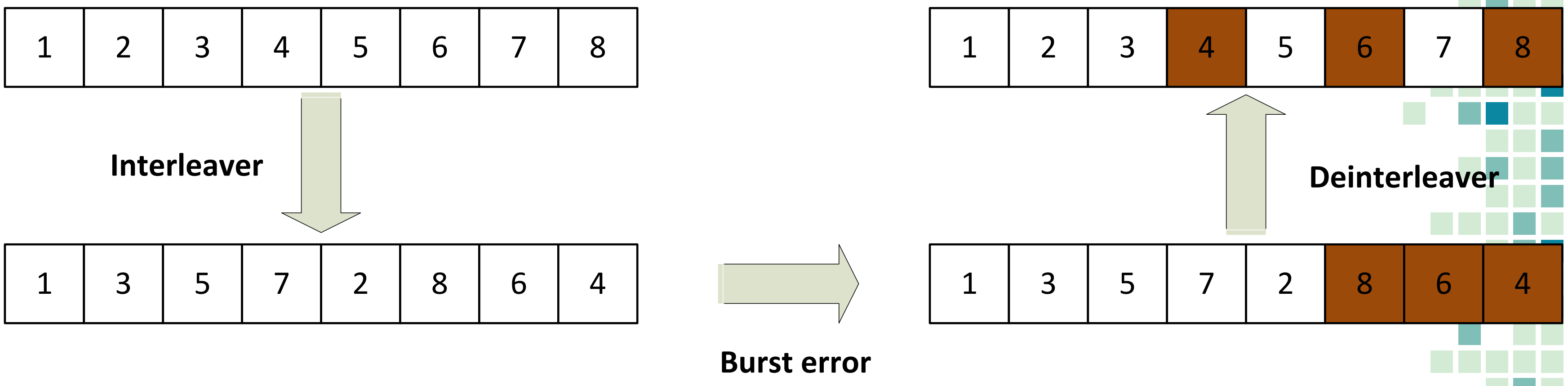


Outer interleaver

- Eases the correction of burst errors
  - Burs errors affect to consecutive bytes (as stated before the ideal work case for FEC is when the errors are uniformly distributed)
- Scatters the consecutive data in different packets
- 12 branches with depth *jxM* with j=0,1,2 … 11 and M=204/12=17

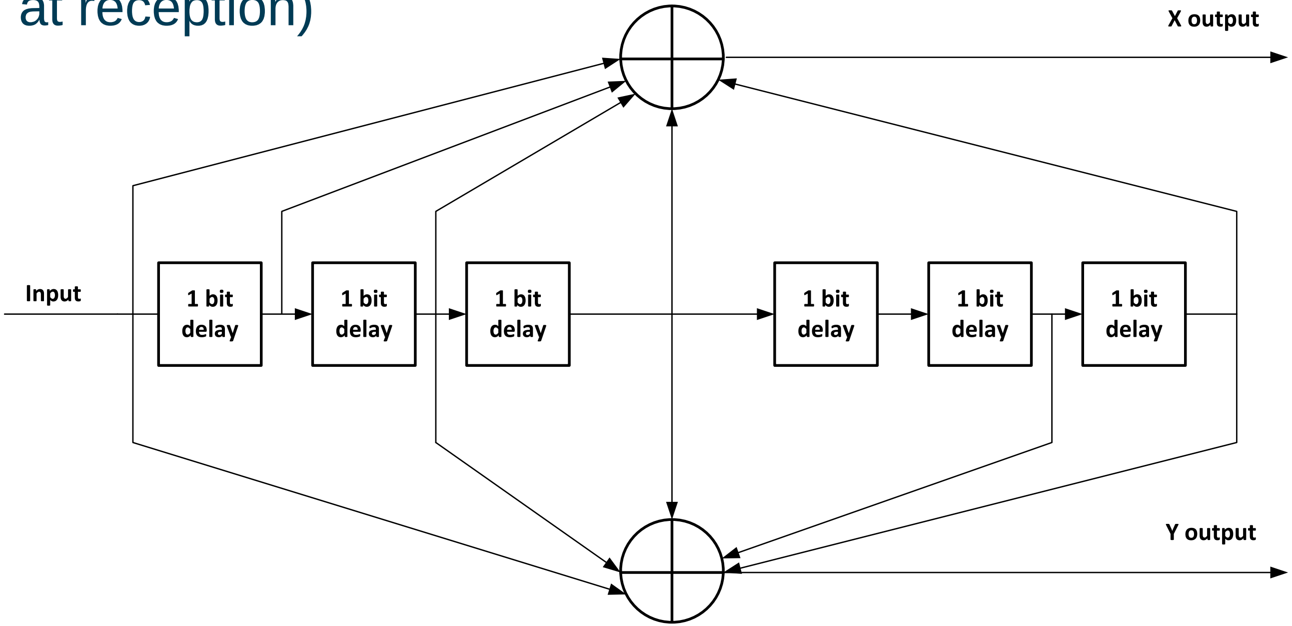


- Every branch stores one byte at time
- The Sync byte of the frames must always pass though the 0 branch

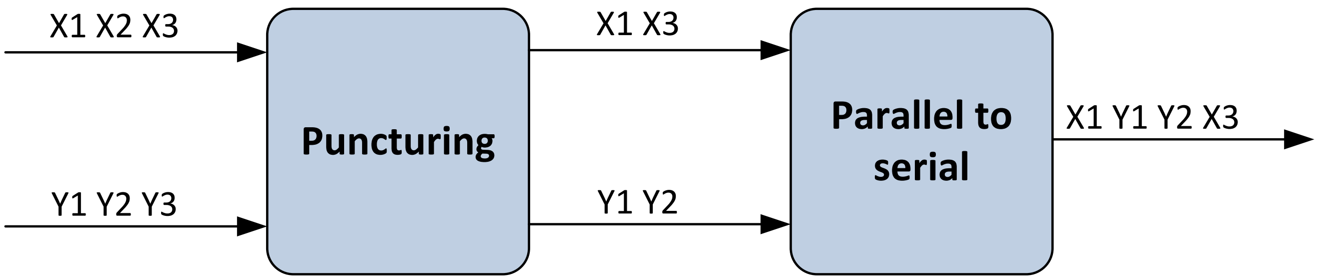


Inner coder

- Adds more redundancy in order to correct errors at a bit level
- It is based in a convolutional encoder (Viterbi decoder at reception)



- For each input bit there are two output bits
  - 1/2 code rate
- Makes the codewords very robust against errors
- Half of the capacity of the channel is lost
  - A puncturing process is applied at the output to not to lose that much capacity
  - DVB-T has code rates of 1/2, 2/3, 3/4, 5/6 and 7/8



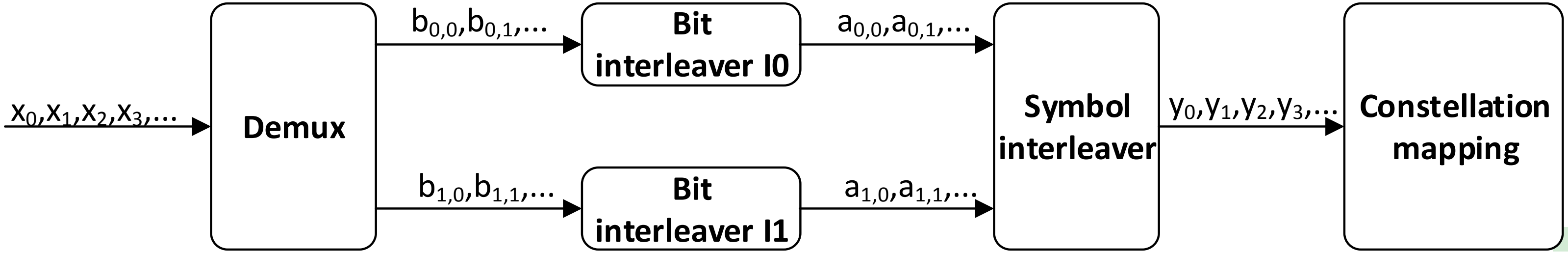
CR=1/2

CR=1/2·6/4=3/4

Inner interleaver

- Shuffles the data to avoid at the receiver side the decoder to have consecutive erroneous bits
- It is performed at two levels
  - Bit level
  - QAM symbol level
- It mixes the high priority and low priority streams when hierarchical modulation is used

- As an example the scheme for the inner interleaver for a QPSK constellation is as follows

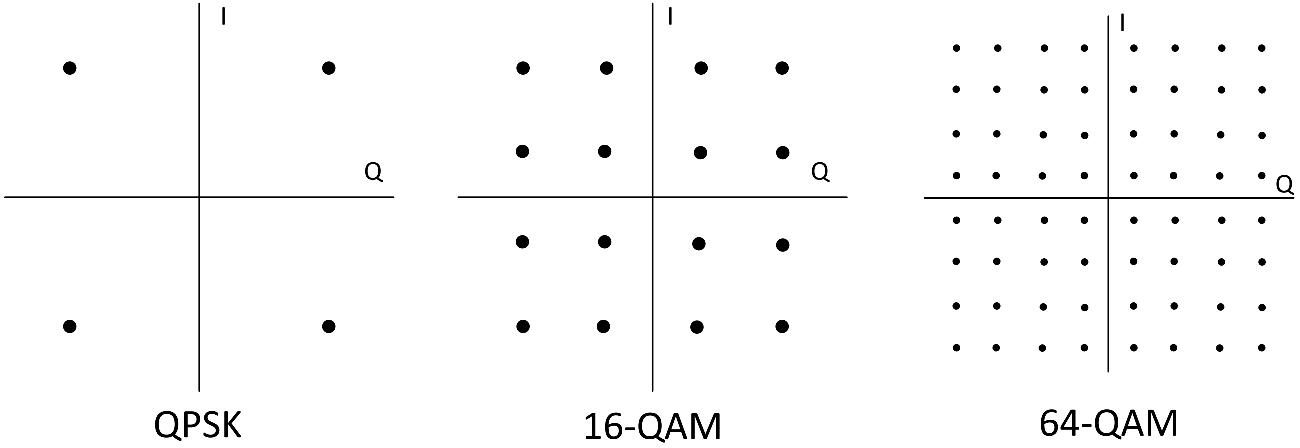


  - x_0 maps to $b_{0,0}$ and x_1 to $b_{1,0}$ (even bits upper branch and odd lower)
  - Every branch has a different interleaver, the first one doesn't change order, the rest:

$$idx' = (idx + offset) \bmod 126$$

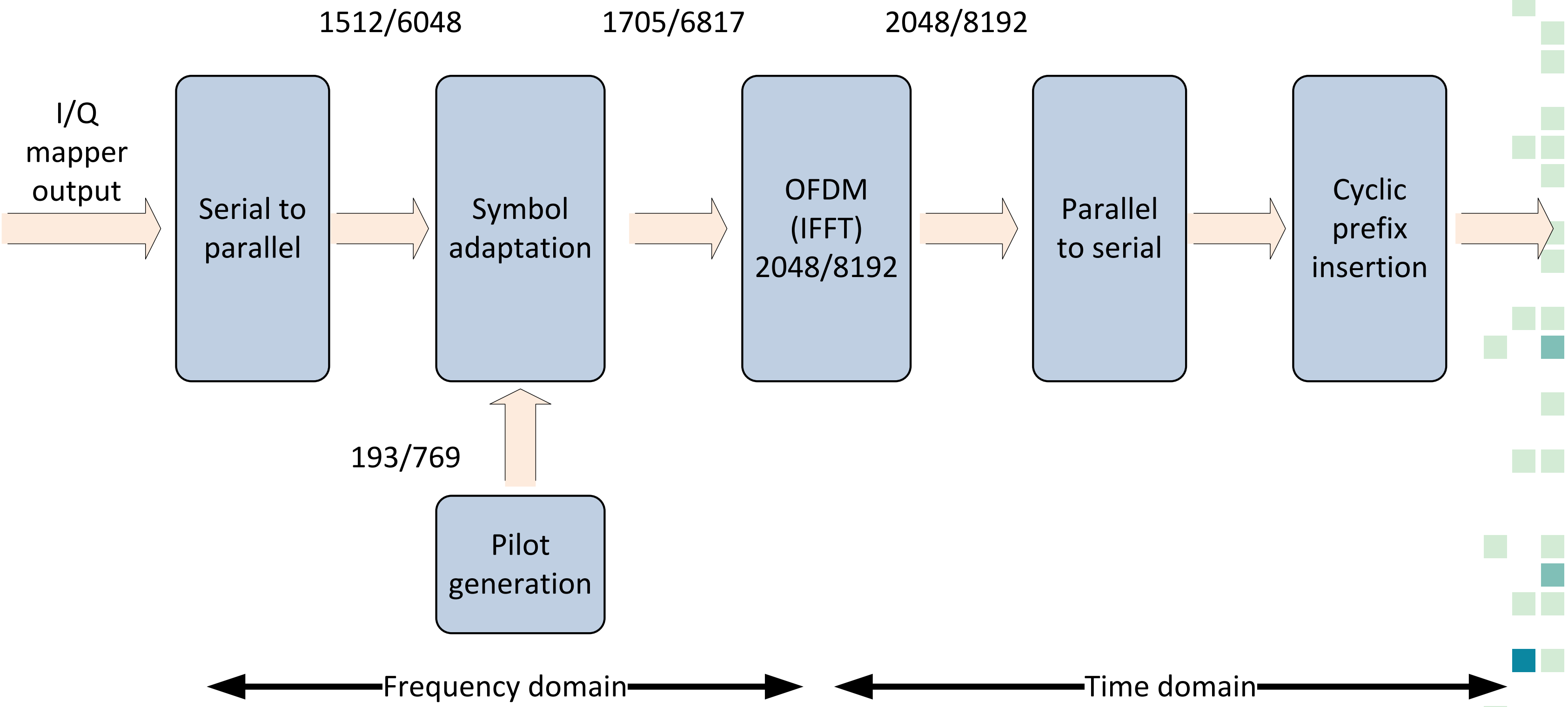
Mapper

- Gathers the input bits in words of v bits
- To each created word an I,Q value in the complex plane is assigned
  - The set of possible I,Q values is called constellation
- Three possible constellations

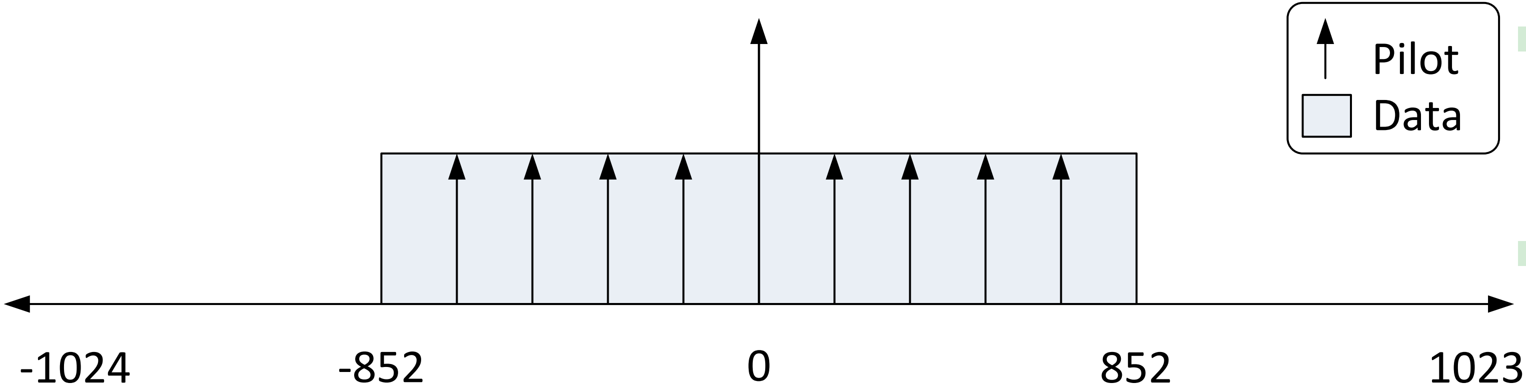


5.
OFDM

- Two modes to choose, 2k and 8k



- The mapper output is grouped in sets of 1512 or 6048 QAM symbols
- In the frequency domain an OFDM symbol is composed by this set of data and control data (pilots)
- An OFDM symbol is composed by 1705 or 6817 carriers (2k and 8k modes respectively)



OFDM symbol in the frequency domain (2k mode)

Transmission Parameter Signalling (TPS)

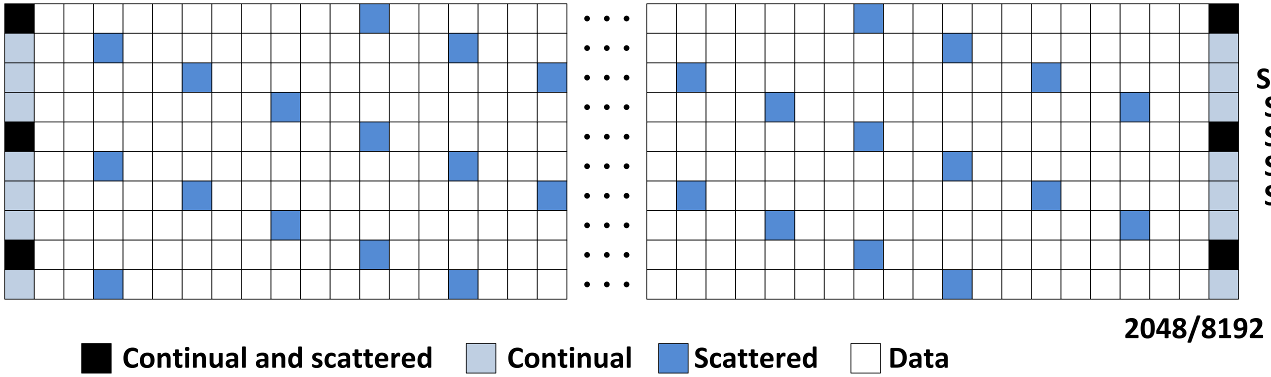
- Their position is fixed in the symbol
- Modulated with a D-BPSK constellation
- Information about
  - Transmission mode (2k, 8k)
  - Transmitted constellation
  - Coding rate

Continual pilots

- Their position is fixed in the symbol
- Modulated with a BPSK constellation
- The data is known (coming from a PRBS)
- Synchronism purpose

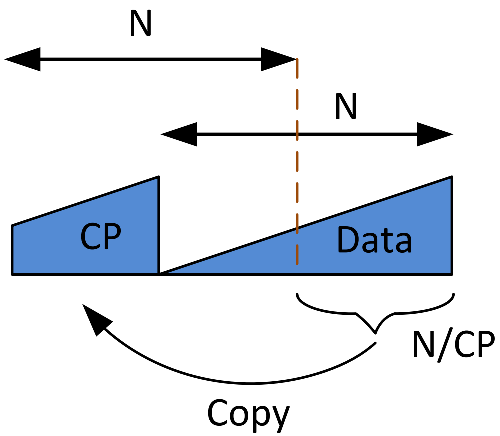
Scattered pilots

- Their position varies in each symbol
- Modulated with a BPSK and with known data from a PRBS
- They are used for channel estimation purpose at the receiver



Cyclic prefix

- There are 4 possible cyclic prefix for each mode
- 1/4, 1/8, 1/16, 1/32 of NFFT
- The higher the number of samples of the cyclic prefix is:
  - More robustness to the multipath channel echoes
  - Lower data rate



Bandwidth

- Depending on the country, the TV channels have different bandwidth
- DVB-T allows 8, 7, 6 and 5 MHz channel bandwidth
- For 8 MHz channels
  - Symbol time (not taking into account the CP): 224μs for 2k mode and 896μs for 8k mode
  - Sampling frequency: 9.14MHz
  - Carriers spacing: 4464.3 Hz and 1116.1 Hz for 2k and 8k modes respectively
  - Actual bandwidth: 7.6MHz (1705 x 4464.3 and 6817x1116.1)

Data rates

- Total binary rate for the data carriers:

$$R_T = f_S v L (bits/s)$$

  - f_S= symbol frequency =$1/T_S$
  - T_S= time duration of a symbol
  - v= number of bits per carrier (number of bits in each transmitted QAM constellation point)
  - L= number of data carriers

- Effective binary rate or channel capacity

$$R_E = R_T \cdot r \cdot 188/204 (bits/s)$$

  - r= coding rate
  - 188/204= ratio between the Reed-Solomon input and output

Example

- For a 2k mode, r=3/4, guard interval 1/4 ,16-QAM constellation, and 8MHz channel:
  - $T_S = 280\mu s$, $v = 4$, $R = 3/4$
  - $R_E = 16.84Mbps$
- For a 8k mode the R_E is the same, it is independent to the mode
- For 8MHz channels
  - Maximum data rate is 31.67Mbps for a 64-QAM, r=7/8 and CP=1/32
  - Minimum data rate is 4.98Mbps for QPSK, r=1/2 and CP=1/4

THANKS!

Any questions?

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