Calculations in DVB-S2

- This training is used to explain how to calculate the symbolrate from the interface rate in DVB-S2.

  – v1.0.2 December 14th 2005

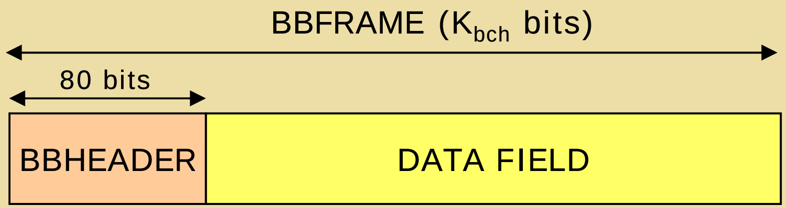
Calculations

- To calculate the symbolrate (and ultimately the occupied bandwidth on the transponder) from the interface rate (or better said the user data at the input of the modulator) under a given modulation and coding is not as straightforward anymore as with DVB-S

- One has to take into account:
  - The overhead generated by the BBHEADER (80 bits)
  - Different efficiency of the LDPC and BCH FEC coding for different FEC ratios
  - The efficiency of the different modulation modes (from 2 to 5 bits per symbol)
  - Overhead generated by the PLHeader (90 symbols
  - Overhead generated by the optional pilot insertion

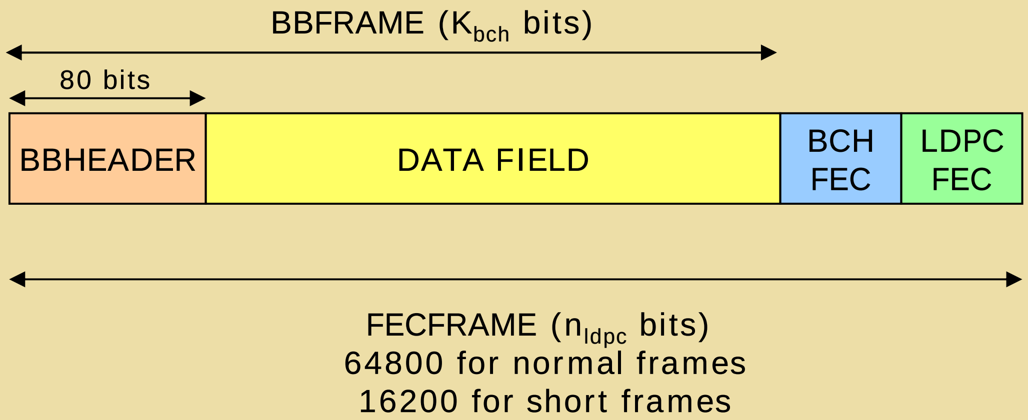
Overhead generated by BBHEADER

- A fixed length base-band Header (BBHEADER) of 10 bytes (80 bits) is inserted in front of the DATA FIELD, describing its format to form a BBFRAME.



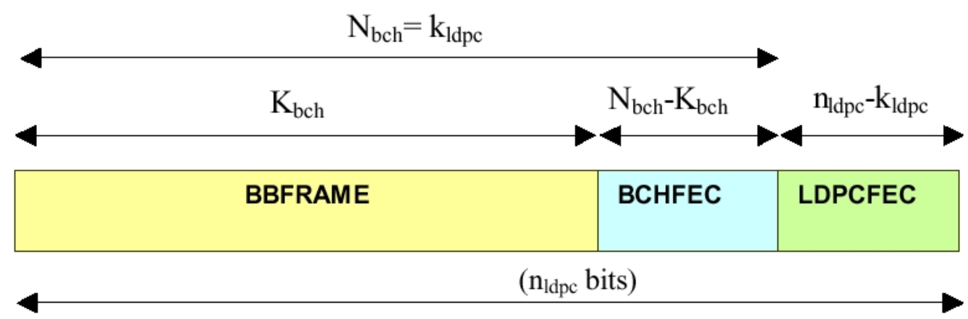
Overhead generated by FEC encoding

- The BBFRAME is first BCH coded, then the resulting block is LDPC coded. The result is FECFRAME (short or normal frame length).



- Since the FECFRAME length is fixed and the overhead generated by the BCH and LDPC coding is variable, the remaining data field length is depending on the FEC code used. This results in a efficiency depending on selected FEC code.

FEC coding parameters (normal frames)



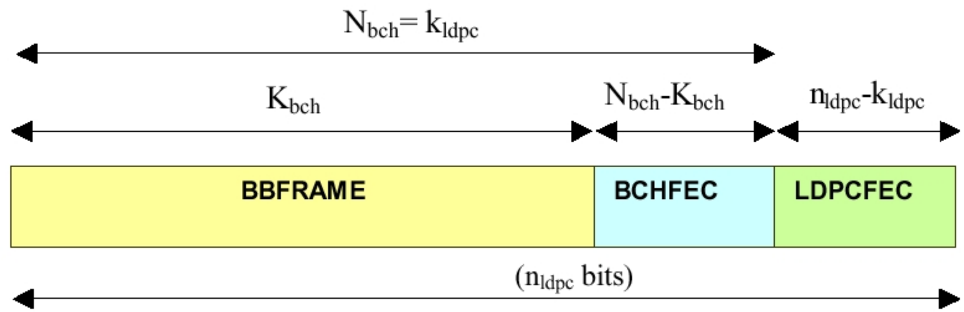
format of data before bit interleaving
(n_{ldpc} = 64 800 bits for normal FECFRAME, n_{ldpc} = 16 200 bits for short FECFRAME)

coding parameters (for normal FECFRAME n_{ldpc} = 64 800)

LDPC code	BCH Uncoded Block K_{bch}	BCH coded block N_{bch} LDPC Uncoded Block k_{ldpc}	BCH t-error correction	LDPC Coded Block n_{ldpc}
1/4	16 008	16 200	12	64 800
1/3	21 408	21 600	12	64 800
2/5	25 728	25 920	12	64 800
1/2	32 208	32 400	12	64 800
3/5	38 688	38 880	12	64 800
2/3	43 040	43 200	10	64 800
3/4	48 408	48 600	12	64 800
4/5	51 648	51 840	12	64 800
5/6	53 840	54 000	10	64 800
8/9	57 472	57 600	8	64 800
9/10	58 192	58 320	8	64 800

Source: ETSI EN302307 V1.1.1 (2005-3)

FEC coding parameters (short frames)



format of data before bit interleaving
(n_{ldpc} = 64 800 bits for normal FECFRAME, n_{ldpc} = 16 200 bits for short FECFRAME)

coding parameters (for short FECFRAME n_{ldpc} = 16 200)

LDPC Code identifier	BCH Uncoded Block K_{bch}	BCH coded block N_{bch} LDPC Uncoded Block k_{ldpc}	BCH t-error correction	Effective LDPC Rate k_{ldpc}/16 200	LDPC Coded Block n_{ldpc}
1/4	3 072	3 240	12	1/5	16 200
1/3	5 232	5 400	12	1/3	16 200
2/5	6 312	6 480	12	2/5	16 200
1/2	7 032	7 200	12	4/9	16 200
3/5	9 552	9 720	12	3/5	16 200
2/3	10 632	10 800	12	2/3	16 200
3/4	11 712	11 880	12	11/15	16 200
4/5	12 432	12 600	12	7/9	16 200
5/6	13 152	13 320	12	37/45	16 200
8/9	14 232	14 400	12	8/9	16 200
9/10	NA	NA	NA	NA	NA

Source: ETSI EN302307 V1.1.1 (2005-3)

Practical example of the calculation of the efficiency of the baseband framing

- 8PSK 2/3 in normal frames
- K_{bch} = 43040 bits
- n_{ldpc} = 64800 bits
- data field length = 43040 – 80 = 42960 bits

- Efficiency = 42960/64800 = 0.66296953

- This is the efficiency of the BB framing and FEC mechanism, in words: each bit of frame at this level represents 0.66 of input data or it take 1.52 bits to encode 1 bit of input data

Manual DFL mode

- Manual DFL mode enables selection of a DFL size (payload size inside BBFRAMES) which equals a fixed number of user packets (UPL).
- This results in constant sync word positions within successive BBFRAMES, i.e. fixed 'Sync Distance' (SYNCD)
- In addition the SYNCD is programmable offering total control over the sync word position within the BBFRAMES.
- Since the sync words were replaced with the CRC calculated over the previous User packet body, it could make sense to keep the CRC appended to the end of the user packet within the same baseband frame in order to allow the receiver to evaluate all packets received in a single BBFrame'on the fly'. i.e. the receiver does not have to wait until the next BBFRAME (with the same ISI)is received.
- e.g. For 188-byte MPEG-2 input packets (ISSY disabled) transmitted in QPSK 1/3 short frames the max payload DFL = 644 bytes
  - we select a manual DFL size of 564 bytes (= 3x188) so that exactly 3 user packets are transmitted per BBFrame.
  - we select SYNCD = 187 so that each BBFramestarts with the first byte following the sync marker and ends with the CRC of the third user packet within the BBFrame.

Efficiency in manual DFL mode

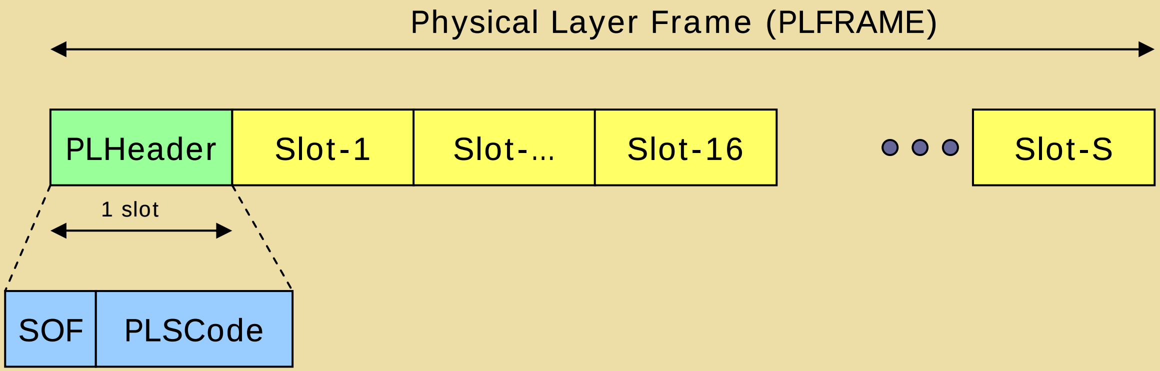
- For the Newtec NTC22xx modulator in DVB S2 mode, if DFL Encapsulation Mode is "Auto", one can calculate the payload rate based on the efficiency ratio as mentioned in the previous slides.
- If DFL Encapsulation Mode is "Manual", changing the DFL Length will lead to a different Payload rate.
- In that case simply replace the Kbch-80 (when working in bits) in the formula by DFL (also expressed in bits, however the parameter to be entered in ../Modulator/Control/BBFRAM/Baseband DFL is expressed in bytes!).

Efficiency of modulation

- The reason for the usage of higher modulation modes is because they can group more bits into 1 symbol. So higher modulation modes increase the efficiency drastically.

Modulation mode	Number of bits per symbol
QPSK	2
8PSK	3
16APSK	4
32APSK	5

Overhead due to physical layer framing



- After modulation into symbols, the symbols are grouped in S slots of 90 symbols. An extra overhead is created here by the PLHEADER (Physical layer header) that signals modulation, coding, pilot insertion, frame length, …
- The number of slots S depends on the selected modulation and coding.

Number of slots (S) in an XFECFRAME

- The number of slots (S) in an XFECFRAME depends on the used modulation and frame length.
- S can be calculated by calculating the number of symbols needed to code a n_{ldpc} block of bits and then diving this number of symbols by 90 since each slot consists of 90 symbols.
- e.g S = 64800/(3*90) = 240 for 8PSK normal frames

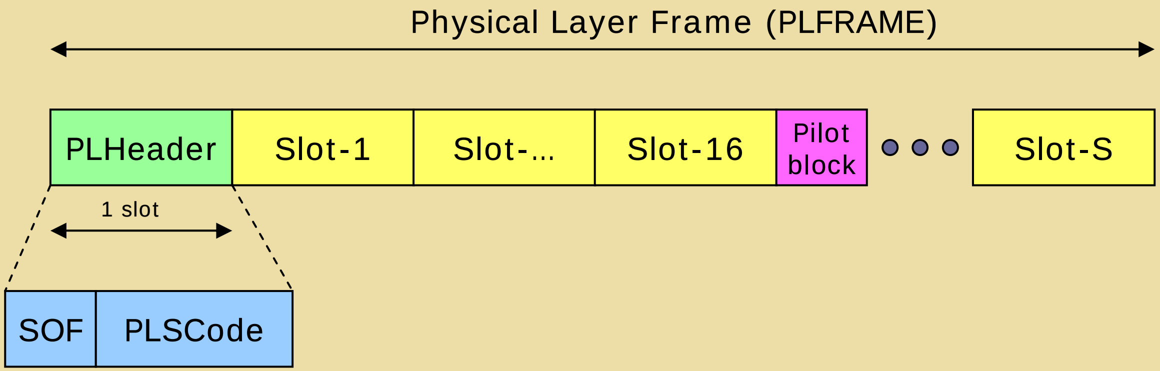
		n_{ldpc} = 64800 (normal frames)	n_{ldpc} = 16200 (short frames)
Modulation	Bits/symbol	S	S
QPSK	2	360	90
8PSK	3	240	60
16APSK	4	180	45
32APSK	5	144	36

Source: ETSI EN302307 V1.1.1 (2005-3)

Calculation of PLHEADER overhead

- The number of slots that contain useful information is S, the number of slots that are transmitted is S+1 since the PLHEADER is kept in an additional slot.
- Therefore the efficiency is simply calculated as S/(S+1)
- e.g. for 8PSK normal frames S = 240, so the efficiency here is 240/241 = 0.99585
- This is only the case when no pilots are inserted

Overhead due to pilot insertion (optional)



- In order to add carrier recovery, pilots can be inserted.
- This is done by sending a block of 36 BPSK-like symbols after each 16 slots

Overhead generated by PLHEADER and pilot insertion

- # symbols in PLHEADER = 90
- # useful symbols in PLFRAME = S.90
- # pilot symbols = 36.int[(S-1)/16]

  – Remark: S-1 because if the PILOT BLOCK position coincides with the beginning of the next SOF (next PLHEADER), then the PILOT BLOCK is not transmitted.

- Efficiency = $\dfrac{S.90}{90 + S.90 + 36.\mathrm{int}[(S-1)/16]}$

If no pilots are used the pilots term can be removed.

Using the spectral efficiency table to calculate (useful) interface rate from symbolrate

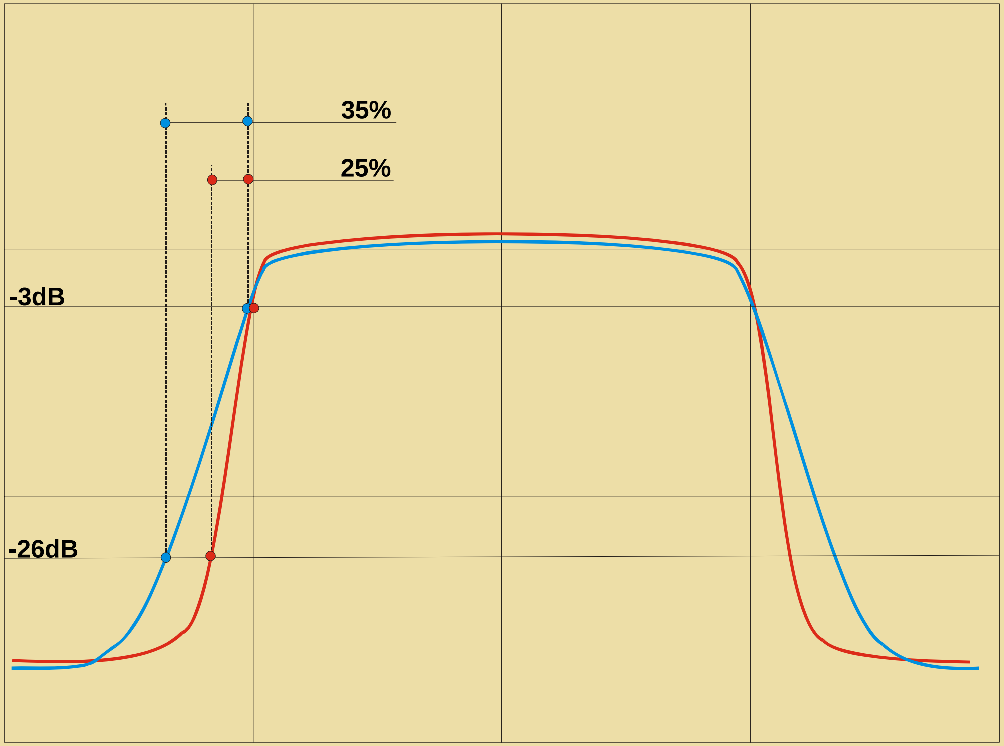
- The table below shows an extract of the xls sheet used for calculations.
- In this case for normal frames (n_{ldpc} = 64800 bits)
- Kbch is the number of useful bits in a baseband frame
- S the number of slots in a PLFRAME
- The overall efficiency is calculated as PLFRAME efficiency multiplied (with or without pliots) with the BBFRAME efficiency multiplied with the number of bits/symbol
  - Spectral efficiency is the ratio between the interface rate and the symbolrate

64800	Kbch	n BBFrame	Bit per symbol	S	n PL frame no pilot	n PL frame pilot	**Efficiency no pilot**	**Efficiency pilot**
QPSK 1/4	16008	0.245802469	2	360	0.9972299	0.97349919	**0.490243**	**0.478577**
QPSK 1/3	21408	0.329135802	2	360	0.9972299	0.97349919	**0.656448**	**0.640827**
QSPK 2/5	25728	0.395802469	2	360	0.9972299	0.97349919	**0.789412**	**0.770627**
QPSK 1/2	32208	0.495802469	2	360	0.9972299	0.97349919	**0.988858**	**0.965327**

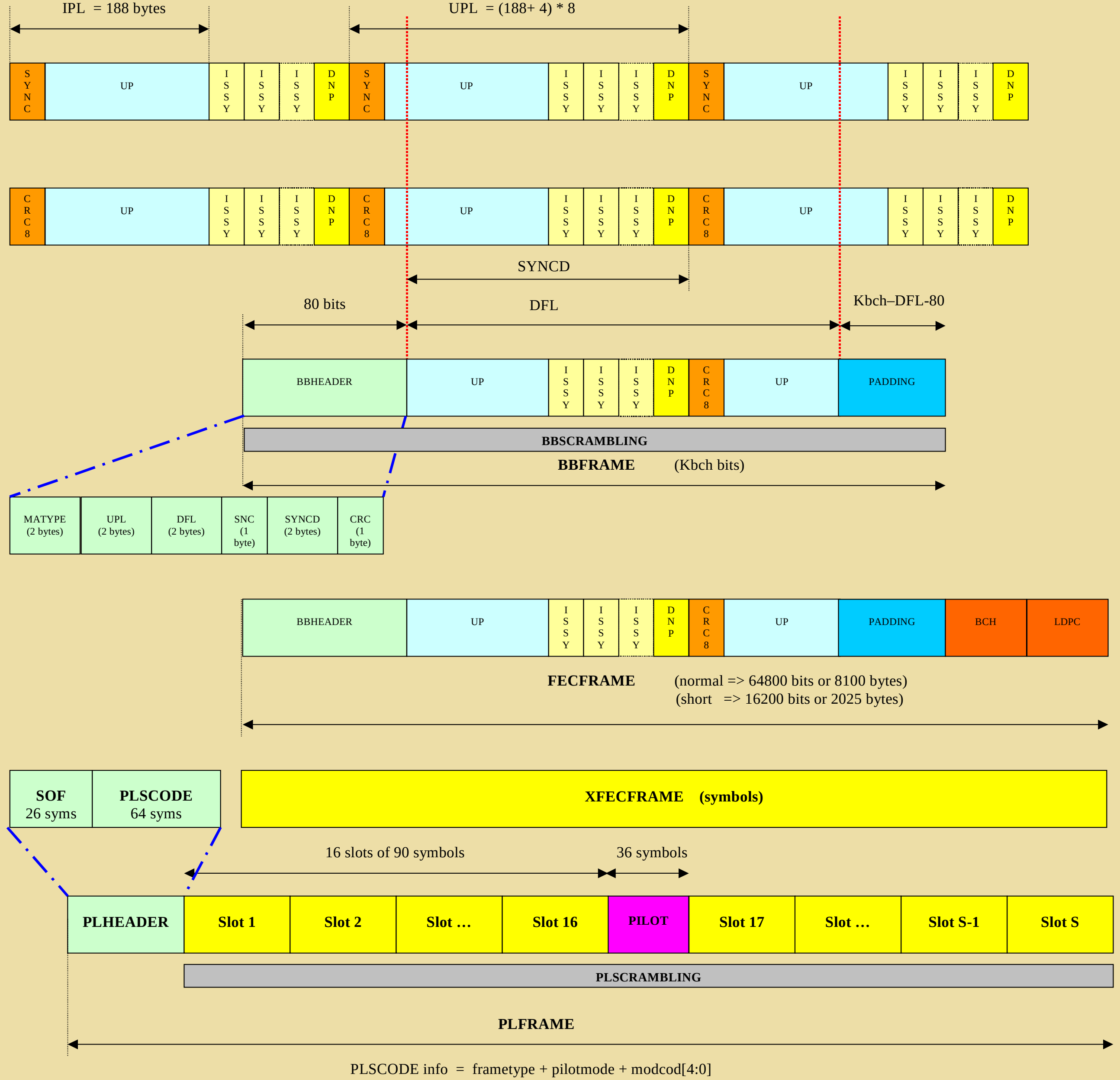
Calculating the occupied bandwidth

- The occupied bandwidth of the modulated signal is the symbolrate multiplied with 1 + a, where a is the roll-off factor.

- The -3dB bandwidth is equal to the symbolrate.



Summary


IPL = 188 bytes
UPL = (188+ 4) * 8
SYNC
UP
ISSY
DNP
CRC8
SYNCD
80 bits
DFL
Kbch–DFL-80
BBHEADER
PADDING
BBSCRAMBLING
BBFRAME (Kbch bits)
MATYPE (2 bytes)
UPL (2 bytes)
DFL (2 bytes)
SNC (1 byte)
SYNCD (2 bytes)
CRC (1 byte)
BCH
LDPC
FECFRAME
(normal => 64800 bits or 8100 bytes)
(short => 16200 bits or 2025 bytes)
SOF 26 syms
PLSCODE 64 syms
XFECFRAME (symbols)
16 slots of 90 symbols
36 symbols
PLHEADER
Slot 1
Slot 2
Slot …
Slot 16
PILOT
Slot 17
Slot …
Slot S-1
Slot S
PLSCRAMBLING
PLFRAME
PLSCODE info = frametype + pilotmode + modcod[4:0]

End

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