Satellite Standard (DVB-S)

Introduction

- Satellite standard parameters and definitions are defined by:
  - Technical requirement of the satellite communication transmission path
  - Consumer demand of the services and application offered by the DTV system
- The requirements concerning the transmission path can be deduced from the various characteristics of satellite transmission

Satellite Receiver

Characteristics of the satellite transmission

- Due to the low-power capacity of the satellite channel the Travelling Wave Tube Amplifier (TWTA) should run in full saturation
  - Amplitude modulation cannot be considered [e.g. higher order QAM]
  - *Note: A TWTA is is a specialized vacuum tube that is used in electronics to amplify radio frequency (RF) signals in the microwave range.*
- To avoid intermodulation in TWTA, only time division multiplexing in single carrier can be considered.

Characteristics of the satellite transmission

- There must be energy dispersal in order to achieve a power density which is distribute as evenly as possible within the transponder bandwidth
- The low CNR at the receiver, which is mainly due to extremely low received power, makes a high quality error protection scheme necessary.
- A quasi error free (QEF) transmission [BER 10^{-11}] is envisaged
  - Equivalent to 1 bit error per hour per transponder

Demand made on the system by the users

- High transmission rate to support DTV & other digital services
- Variable data rate required by various services must be supported
- Error protection scheme should also be adaptive
  - Higher power -> lower error protection scheme required
  - Application specific needs also to be considered
- Receiving antenna reflector diameter should be as small as possible
  - Need to be cost effective
  - Smaller size → low CNR

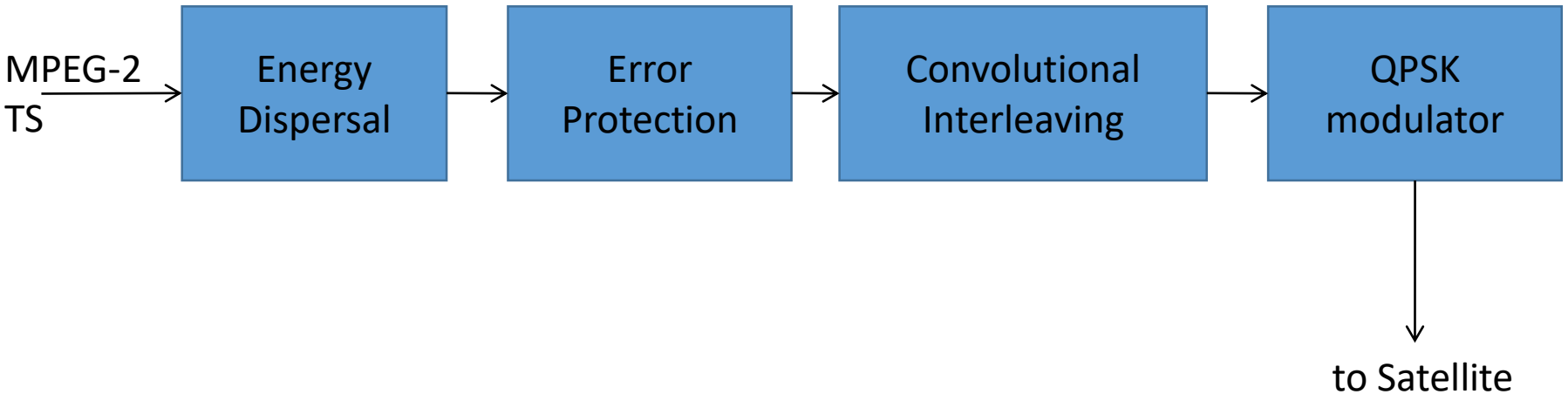
Basic characteristics of DVB-S

- We are focusing on a specific standard: DVB-S
- DVB-S: standard for direct-to-home broadcasting via satellite (DBS)
  - Defined in between 1993 to 1997
  - Defined by European Standard EN 300 421.
- Source coding is carried out following with MPEG-2* standard which combines efficient data compression with flexible system concept.
- Energy dispersal is carried out at the encoding end by scrambling with a pseudo random sequence
  - large peak power from one satellite may cause interference in ground reception from other satellite nearby (same angle and same frequency band

Basic characteristics of DVB-S

- A concatenated error protection scheme permitting various code rate is used
- QPSK (with Gray coding) is chosen for DVB-S…. Why?
- Only one carrier per transponder is used in order to avoid intermodulation
- Transport stream: combination of various services in ‘data container’
  - time-division multiplex of a number of services (video, audio, data)
- Source coding: MPEG2 [will be discussed later in further detail]
  - flexible and efficient
  - Audio: layers I, II, III
  - Video: matrix of service Levels and Profiles

Encoding


MPEG-2
TS
Energy
Dispersal
Error
Protection
Convolutional
Interleaving
QPSK
modulator
to Satellite

Data Rate Calculation (example)

- Assume, the symbol rate selected is, 27.5 MS/s.
- QPSK offers 2 bits/Symbol [revisit telecom module for bit & symbol relation]
- gross_data_rate = 2 bits/symbol X 27.5 Megasymbols/s = 55 Mbit/s;
- QPSK-modulated signal must first be provided with error protection before being fed into the actual modulator.
- Reed-Solomon code with rate (204/188) is used.
- net_data_rate Reed-Solomon = gross_data_rate X 188/204
- = 55 Mbit/s X 188/204 = 50.69 Mbit/s;

Data Rate Calculation (example)

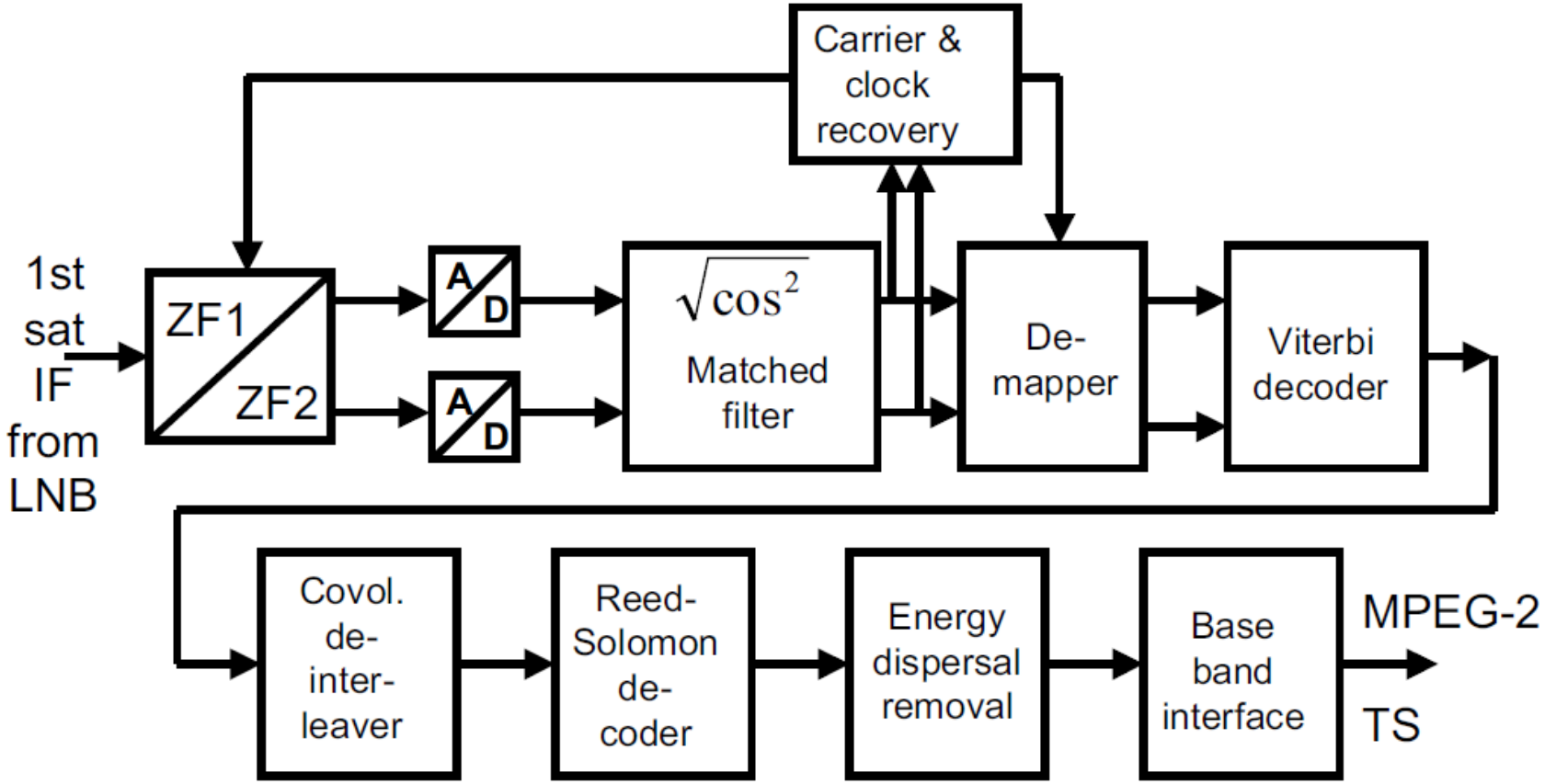
- further error protection in the form of convolutional coding is inserted after the Reed Solomon forward error correction.
- This further expands the data stream.
- $CodeRate = \frac{Input\ Data\ Rate}{Output\ Data\ Rate}$
- In DVB-S, the code rate can be selected within the range of 1/2, 3/4, 2/3,...7/8.
- The net data rate in DVB-S with a code rate of 3/4, after convolutional
- coding, is then: $Net\_data\_rate_{3/4}$ = code_rate X $net\_data\_rate_{reed\ solomon}$

  = 3/4 • 50.69 Mbit/s = 38.01 Mbit/s;

Observation on data rate

- If the code rate is 1/2, the data stream is expanded by a factor of 2. The error protection is now maximum and the net data rate has dropped to a minimum.
- A code rate of 7/8 provides only a minimum overhead but also only a minimum of error protection. The available net data rate is then at a maximum.
- The code rate can then be used to control the error protection and thus, as a reciprocal of this, also the net data rate.

DVB-S Receiver



Received power calculation (Example)

A geostationary satellite is "parked" in an orbit of 35800 km above the equator. This is the only orbit in which it can travel around the Earth synchronously. At 45° latitude, the distance from the Earth's surface is then

d = Earth's radius • sin(45°) + 35800 km = 6378 km • sin(45°) + 35800 km = 37938 km;

Transmitted power (e.g. Astra 1F):

Assumed transponder output power:	82 W =	19 dBW
Gain of the transmitting antenna		33 dB
Satellite EIRP (equivalent isotropic radiated power)		52 dBW

Received power calculation (Example)

Free space attenuation:	
Satellite-Earth distance = 37,938 km	91.6 dB
Transmitting frequency = 12.1 GHz	21.7 dB
Loss constant	92.4 dB
Free space attenuation	205.7 dB
Received power:	
Satellite EIRP	52.0 dBW
Free space attenuation	205.7 dB
Clear sky attenuation	0.3 dB
Receiver directional error	0.5 dB
Polarisation error	0.2 dB

Received power calculation (Example)

Received power at the antenna	-154.7 dBW
Antenna gain	37 dB
Received power	-117.7 dBW
Noise power at the receiver:	
Boltzmann's constant	-228.6 dBW/K/Hz
Bandwidth = 33 MHz	74.4 dB
Temperature 20 °C = 273K+20K = 293K	24.7 dB
Noise figure of the LNB	1.0 dB
Noise power	-128.5 dBW
Carrier/noise ratio C/N:	
Received power C	-117.7 dBW
Noise power N	-128.5 dBW
C/N	**10.8 dB**

DVB-S2

- DVB -S2 is the second generation DVB specification for broadband satellite applications, developed on the success of DVB- S
- Improved version of DVB-S standard since 2004
- The standard was ratified in March 2005.
- It has been designed for:
  - Broadcast Services for standard definition TV and HDTV.
  - Interactive Services including Internet Access for consumer applications
  - Professional applications such as VHF/UHF transmitters, Data Content distribution and Internet Trunking.
- Supports recent improvements in channel coding:
  - Linear low density parity check (LDPC) code: better than turbo codes; attain Shannon capacity limit
  - BCH outer code wrapper to correct residual errors

DVB-S2

- The DVB-S2 standard has been specified around three key concepts:
  - best transmission performance,
  - total flexibility and
  - reasonable receiver complexity
- Supports recent improvements in channel modulation:
  - 32-/64-APSKmodulation supported.
  - VCM (Variable Coding and Modulation) and ACM (Adaptive Coding and Modulation) modes: optimizing bandwidth utilization by dynamically changing transmission parameters.
- Typically offers 30% data rate increase under the same condition compared to DVB-S

QPSK, 8-PSK, 16-APSK, and 32-APSK

- In addition to QPSK: 8 phases used for TV systems (8-PSK)
- The 16 and 32 amplitude+ phase shift keying modes require higher C/N ratios and better linearity of the amplifier
  - intended for professional applications

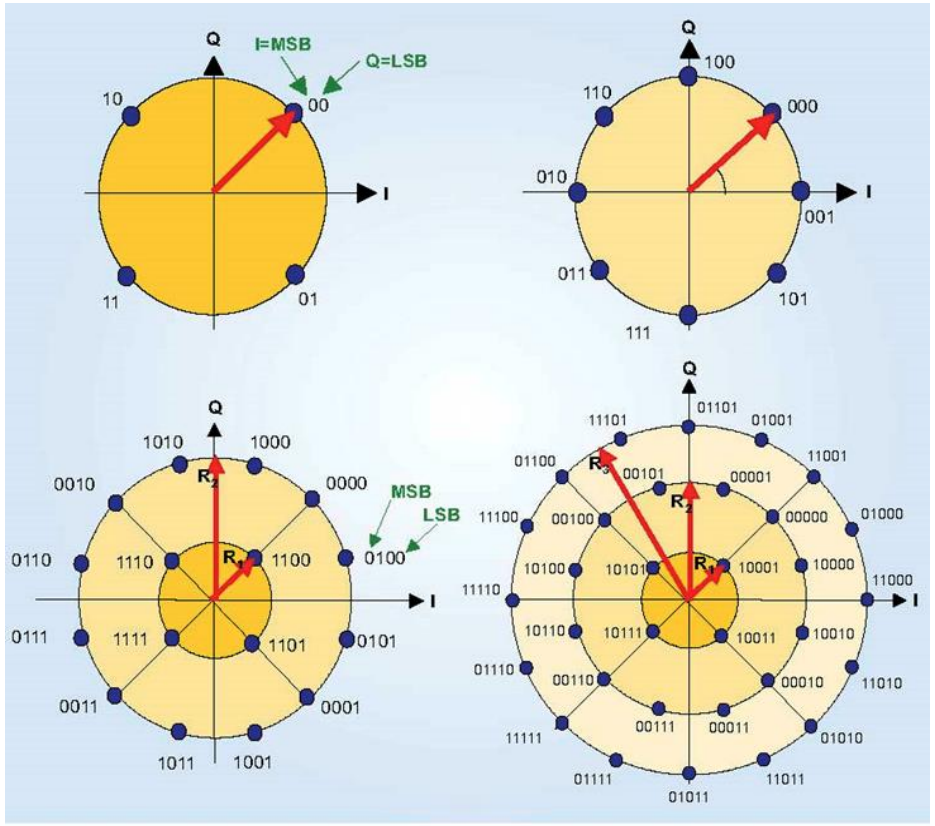


Figure 1
The four possible DVB-S2 constellations before physical layer scrambling

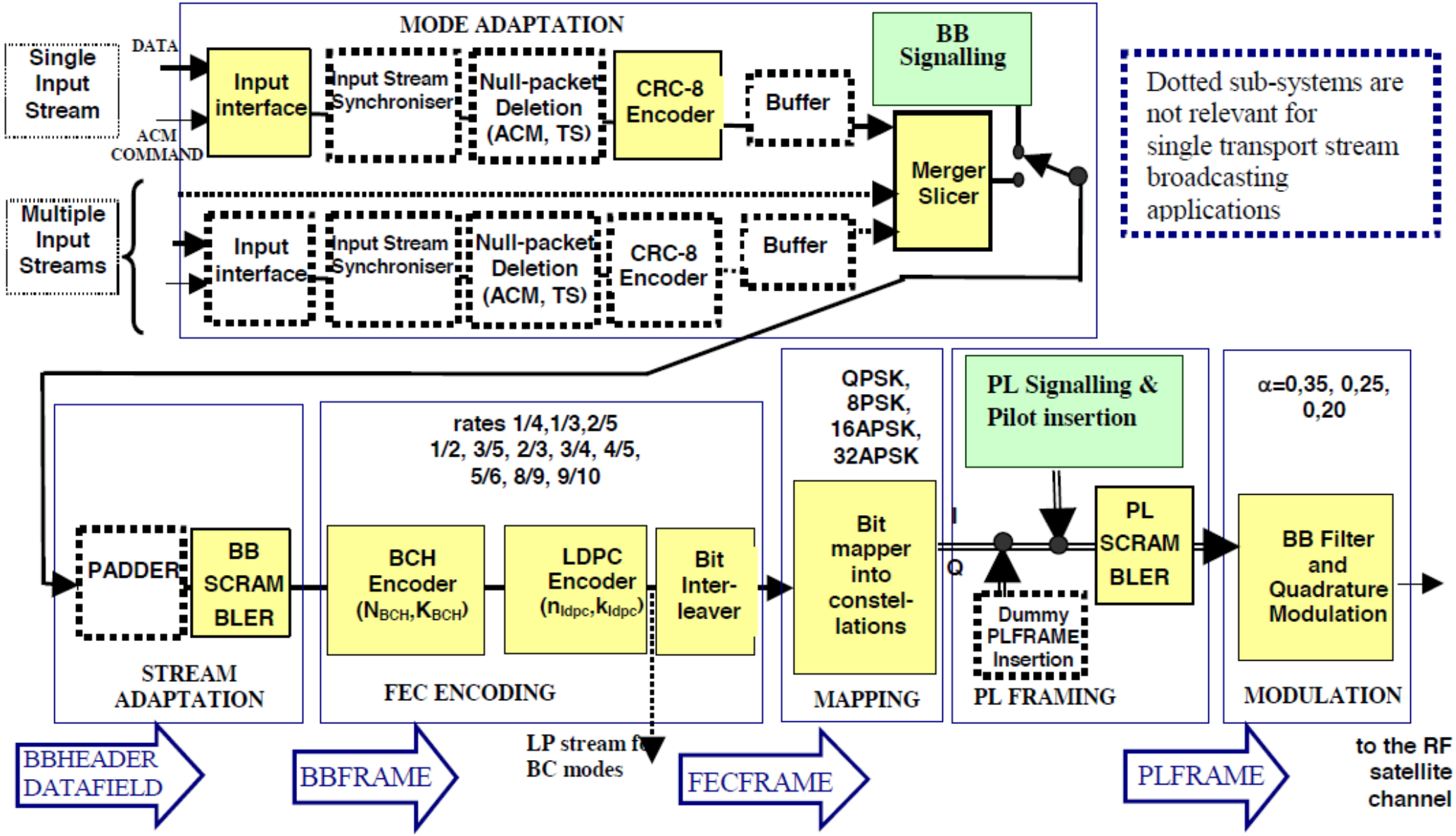
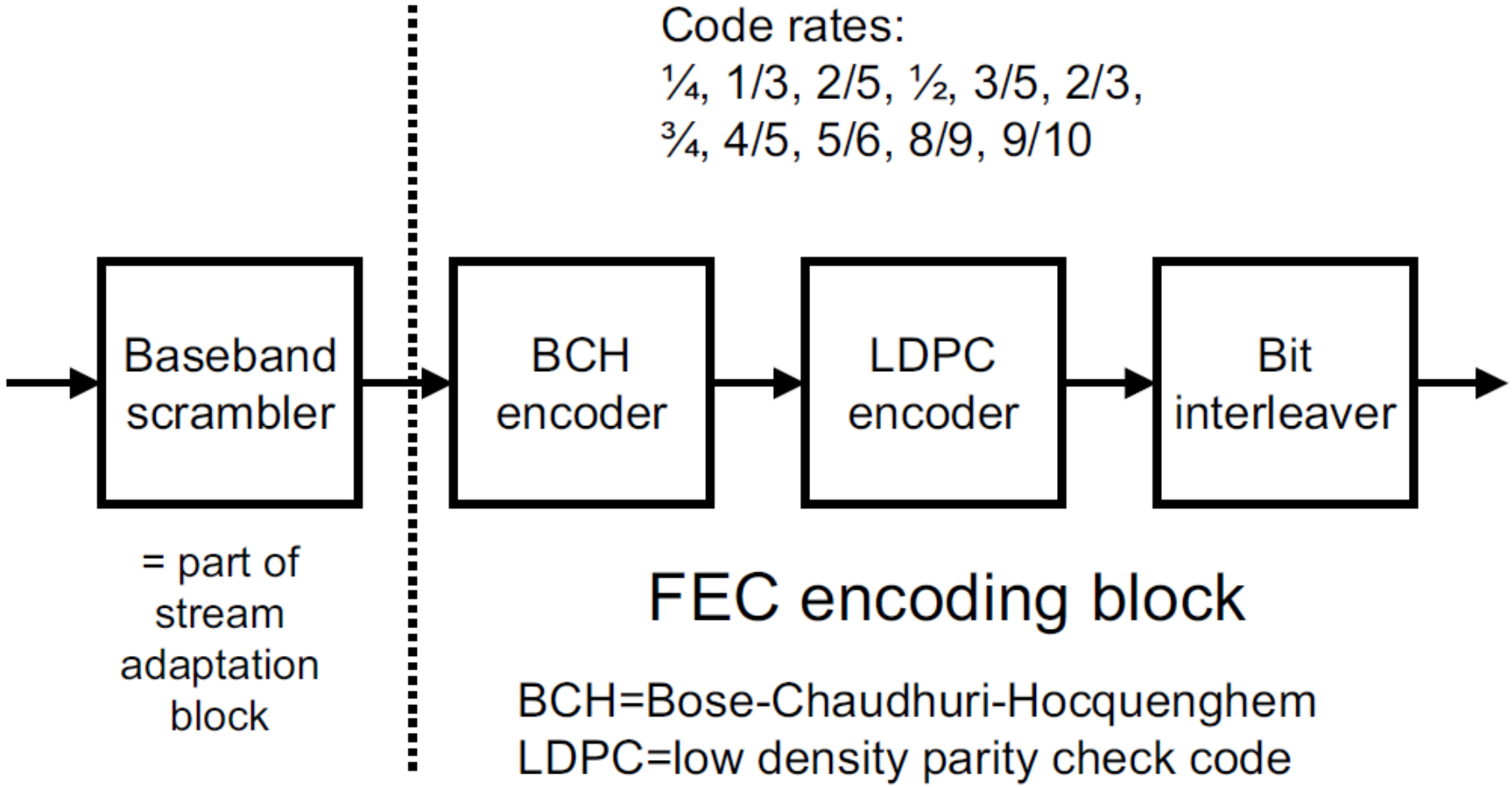


Figure 2: Functional block diagram of the DVB-S2 system

DVB-S Technical details

- Tow levels of framing is defined
  - Physical Level (PL) framing carrying few highly protected signalling bits
  - Base band (BB) level, carrying variety of signalling bits, to allow maximum flexibility on the signal adaption
- Every PL frame is composed of payload of 64800 bits (or 16200 bits) and a PL header containing synchronisation and signalling information (types of modulation, FEC, pilot symbol, frame length)
- BB frame contains signalling functionality to configure the receiver according to the application scenarios: single or multiple input streams, generic or transport stream, CCM(Constant Coding and Modulation) or ACM (Adaptive Coding and Modulation).

DVB-S2 FEC block diagram



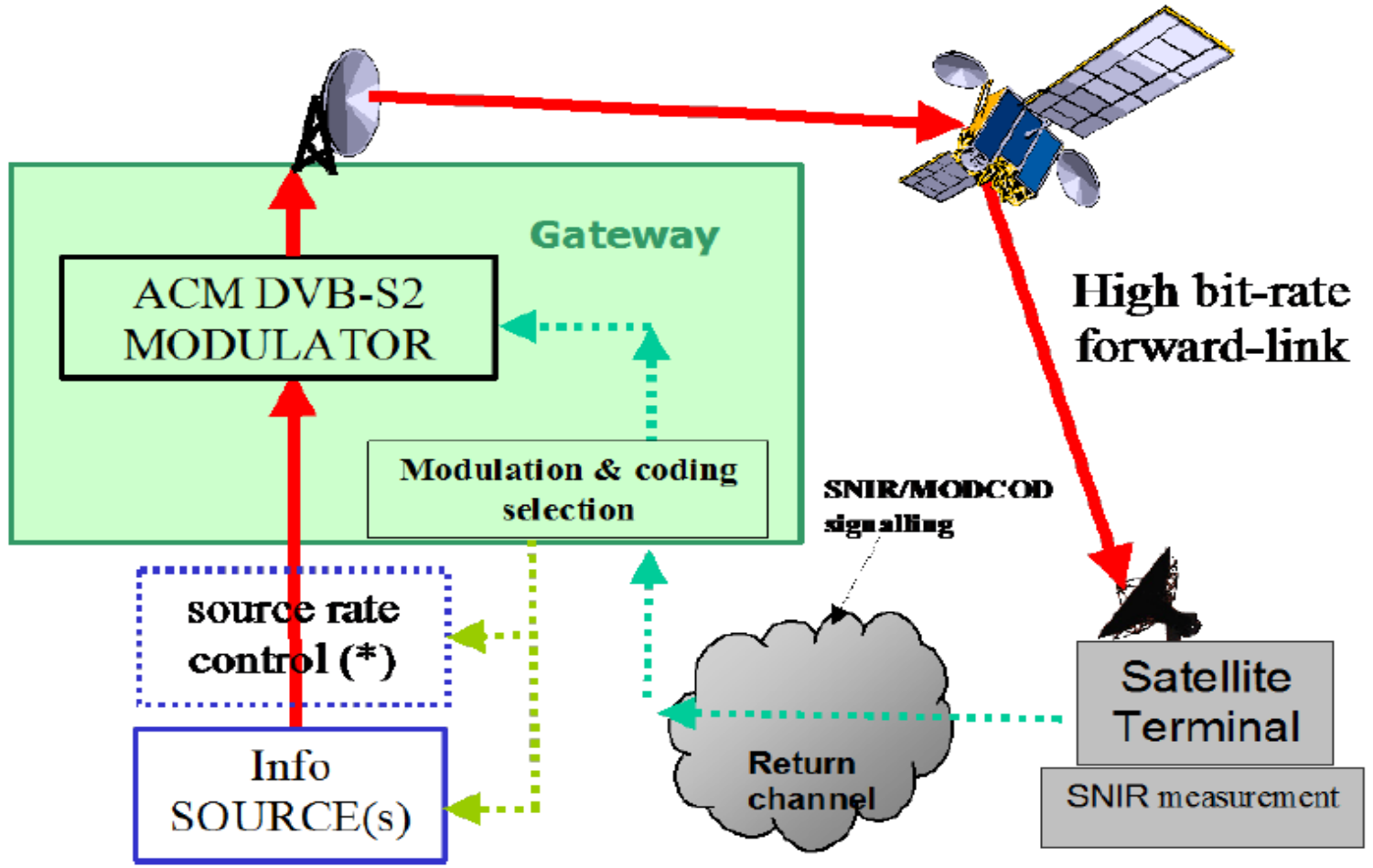


Figure 15: Block diagram of a DVB-S2 ACM link

DVB-S vs. DVB-S2

Satellite EIRP (dBW)	51		53.7	
System	DVB-S	DVB-S2	DVB-S	DVB-S2
Modulation & coding	QPSK 2/3	QPSK 3/4	QPSK 7/8	8PSK 2/3
Symbol rate (Mbaud)	27.5 (α =0.35)	30.9 (α =0.0)	27.5 (α =0.35)	29.7 (α =0.25)
C/N at 27. 5 MHz (dB)	5.1	5.1	7.8	7.8
Useful bitrate (Mbit/s)	33.8	46 (gain = 36%)	44.4	58.8 (gain = 32%)
Number of SDTV programmes	7 MPEG-2 15 AVC	10 MPEG-2 21 AVC	10 MPEG-2 20 AVC	13 MPEG-2 26 AVC
Number of HDTV programmes	1-2 MPEG-2 3-4 AVC	2 MPEG-2 5 AVC	2 MPEG-2 5 AVC	3 MPEG-2 6 AVC

DVB-S2X

- DVB-S2 has been specified about 10 years ago with a strong focus on DTH.
- Since then, new requirements have come up and DVB-S2X provides the necessary technical specifications.
- Optional extension to DVB-S2, adopted in 2014-03
- It uses the proven and powerful LDPC Forward Error Correction (FEC) scheme in combination with BCH FEC as outer code
- Efficiency gain: ~ 50% compared to DVB-S2

DVB-S2X

- It introduces the following additional elements:
  - Smaller roll-off options of 5% and 10% (in addition to 20%, 25% and 35% in DVB-S2)
  - A finer gradation and extension of number of modulation and coding modes
  - New constellation options for linear and non-linear channels
  - Additional scrambling options for critical co-channel interference situations
  - Channel bonding of up to 3 channels
  - Very Low SNR operation support down to -10 dB SNR
  - Super-frame option

A Paper to read

- DVB—The Family of International Standards for Digital Video Broadcasting by U. Reimer
- Available at: http://www.img.lx.it.pt/~fp/Klagenfurt/Study%20Material/DVB-The%20Family%20of%20International%20Standards.pdf
- https://www.dvb.org/resources/public/factsheets/dvb-s2x_factsheet.pdf