# EBU5303

# Multimedia Fundamentals

## Digital Broadcasting



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## Agenda

- What is broadcasting?
- Building blocks of a digital broadcasting system
- Major standards for digital broadcasting
- Digital Video Broadcasting - Satellite (DVB-S)



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# What is Broadcasting?

- In Telecommunications, broadcasting refers to a method of transferring a message to all recipients simultaneously.
- Point-to-multipoint communication
  - Simpler transmission scheme than point-to-point
  - High transmission power
- In principle: one-way communication
  - In practice: increasingly interactive, thanks to digital technology
    - View on demand
    - Two-way (movies, shopping, …)



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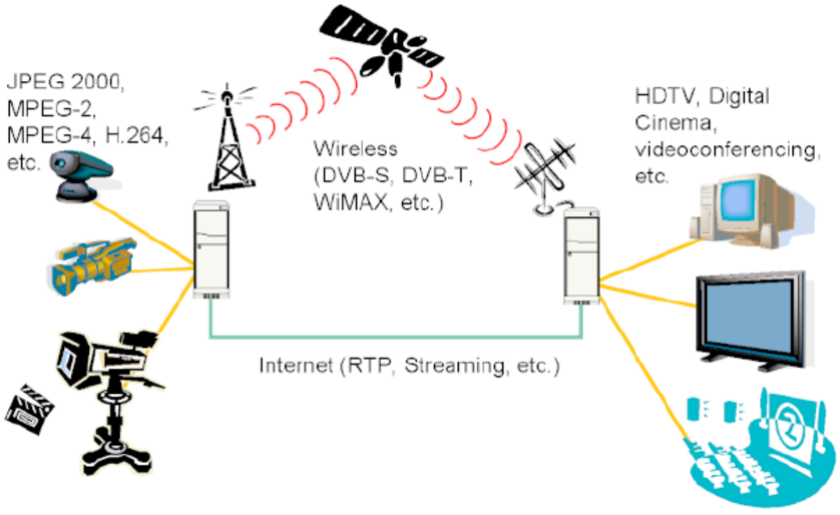
# What is Broadcasting?



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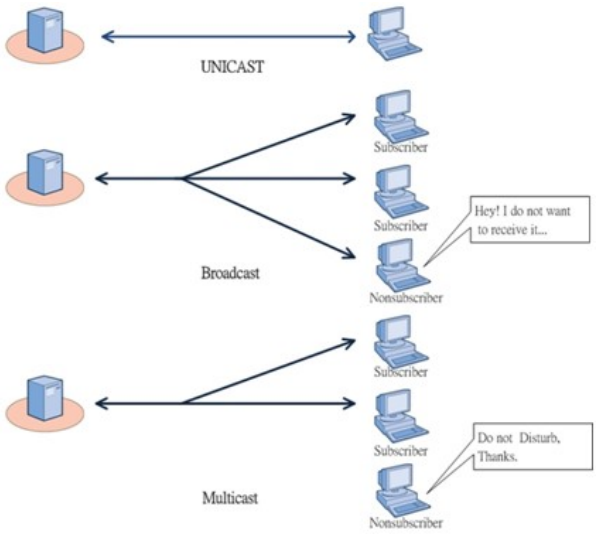
# What is Broadcasting?



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# Why Digital Broadcasting?

- Digital signals are more rugged
- Better quality: lossless data transmission
- More reliable
- Less expensive
- More flexible
- Time- vs. Frequency-Domain Multiplexing
- Additional devices requiring digital data
- Commercial reasons: better spectral efficiency, more channels, more services (gaming, shopping, internet), mobile reception, data transmission



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# Benefits of Digital Switchover

- Potential benefits to consumers:
  - A greater choice of services
  - Extra information on programmes and interactive features
  - Easier tuning and new functions
  - Less interference to pictures or sound
- Potential benefits for the company:
  - Less cost due to no more need of simultaneous analogue/digital transmission
  - Requires less spectrum and so saves huge capital expenditure
  - Possibility of diversifying devices, services and applications
- Potential Benefit to Government/regulatory body
  - Wider coverage [reducing digital inequality]
  - Freeing up spectrum which can be sold/offered for other services
  - Better management/regulation



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# Aspects of Digital Broadcasting

- Essential stages:
  - Channel coding: error protection of bits
  - Modulation: for transmitting signal onto carrier
- But also…
  - Source coding: data compression
  - Multiplexing: combining into single data stream
  - Signal processing
- Involves video/audio and data



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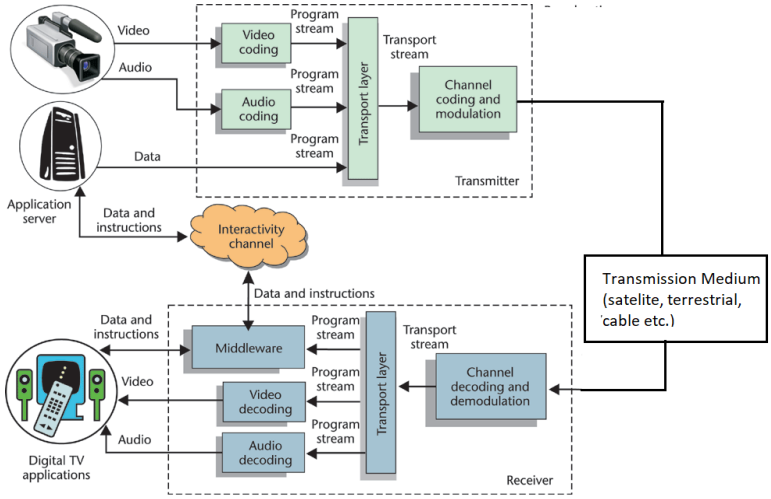
# Building blocks of a Digital Broadcasting (DB) system



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# Fundamental Components of DB

- Audio,Visual (Still/Video), and/or Data
- Transmitter:
  - Compression (***source coding***), e.g. using MPEG2
  - Multiplexing information to single ***Transport Stream*** (TS)
  - ***Forward error correction*** (***Channel Coding***), e.g., Reed-Solomon
  - ***Modulation*** (e.g. OFDM: Orthogonal Frequency-Division Multiplexing)
  - ***Transmission*** (antenna (Yagi-Uda, dish) or optical fibre)
- Reverse process at receiver



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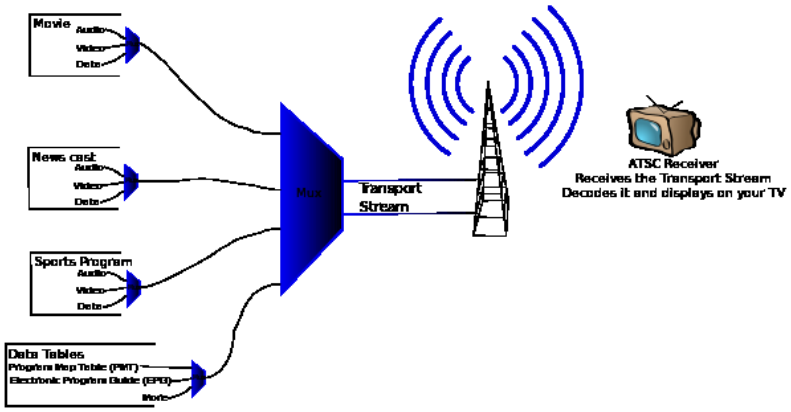
# Transport Stream (TS)

- *Transport stream* specifies a container format encapsulating packetised Elementary Streams (ES).



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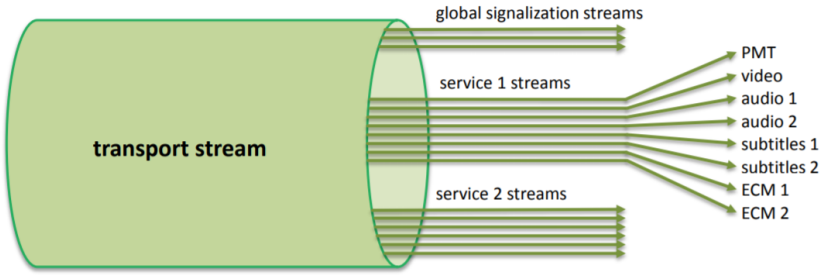
# Transport Stream (TS)

- A transport stream is a multiplex of elementary streams
  - elementary stream = sequence of TS packets with same PID value in header
  - one set of elementary streams for global signalization
    - describe the TS, the network, the operator, the services, the events, EMM's, etc.
  - one set of elementary streams per service
    - a service is typically a TV channel



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# E.g. MPEG-TS

- Structure of MPEG-2 TS defined in ISO/IEC 13818-1
- One operator uses several TS
- TS = synchronous stream of 188-byte TS packets
  - 4-byte header
  - optional « adaptation field », a kind of extended header
  - payload, up to 184 bytes
- Multiplex of up to 8192 independent elementary streams (ES)
  - each ES is identified by a Packet Identifier (PID)
  - each TS packet belongs to a PID, 13-bit PID in packet header
  - smooth muxing is complex, demuxing is trivial
- Two types of ES content
  - PES, Packetized Elementary Stream : audio, video, subtitles, teletext
  - sections : data structures



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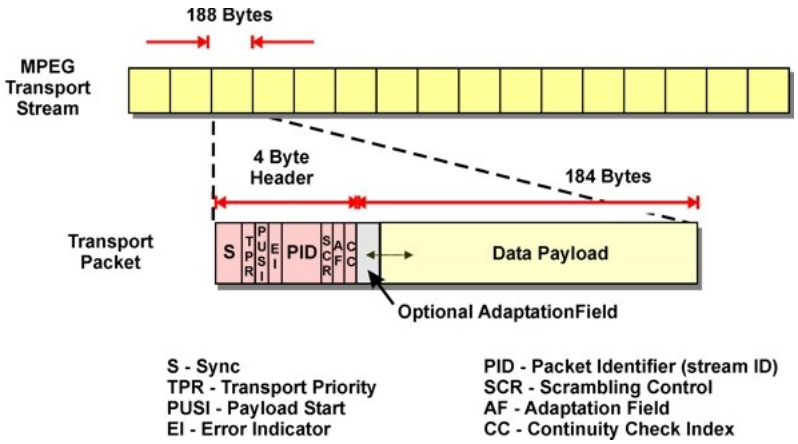
# E.g. MPEG-TS



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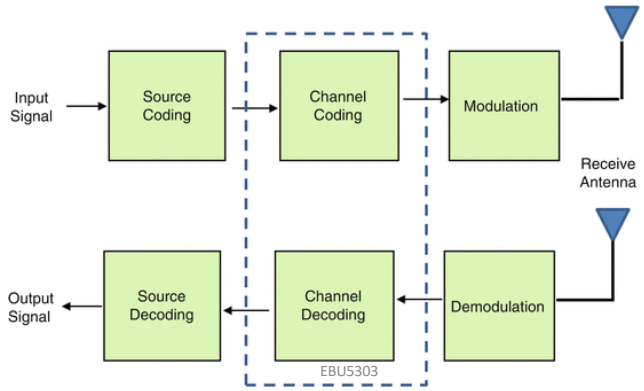
# Channel Coding

- Channel coding, also known as *forward error control coding* (FECC), is a process of detecting and correcting bit errors in digital communication systems.
- It is performed both at the transmitter and at the receiver.



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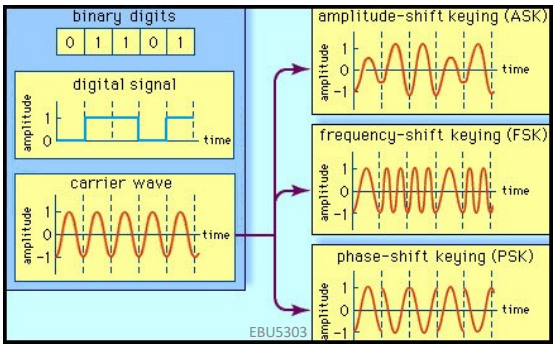
# Modulation

- *Digital Modulation* uses discrete signals to modulate a carrier wave.
- The three main types of digital modulation are Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) and Phase Shift Keying (PSK).

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# Today's agenda

- What is broadcasting?
- Building blocks of a digital broadcasting system
- Major standards for digital broadcasting
- Digital Video Broadcasting - Satellite (DVB-S)

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# Why do we need standards?

- **Safety and reliability**
  - Users perceive standardised products and services as more dependable
  - Increases sales and the take-up of new technologies
- **Support of government policies and legislation**

  Standards are frequently referenced by regulators and legislators for protecting user and business interests
- **Interoperability**

  The ability of devices to work together relies on products and services complying with standards



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# What would the world be like without standards?

- Products might not work as expected
- They may be of inferior quality
- They may be incompatible with other equipment – in fact they may not even connect with them
- In extreme cases, non-standardised products may be dangerous
- Customers would be restricted to one manufacturer or supplier
- Manufacturers would be obliged to invent their own individual solutions to even the simplest needs, with limited opportunity to compete with others

Further info: http://www.etsi.org/standards/why-we-need-standards



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# Major Standards for Digital Brodcasting

- Digital Video Broadcasting (**DVB**)
  - Europe, Singapore, Australia and New Zealand.
- Advanced Television System Committee (**ATSC**)
  - United States, Canada, Mexico, South Korea, Dominican Republic and Honduras.
- Integrated Services Digital Broadcasting (**ISDB**)
  - Japan and the Philippines.
- Digital Terrestrial Multimedia Broadcasting (**DTMB**)
  - Peoples Republic of China, Hong Kong and Macau.



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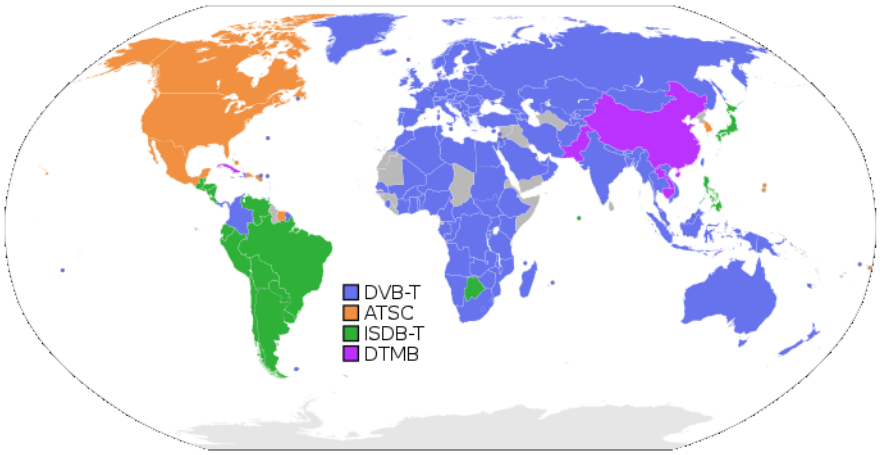
# Major Standards for Digital Brodcasting



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# DVB (Digital Video Broadcasting)

- Set of standards that defines digital broadcasting using existing satellite, cable, and terrestrial infrastructures
- Most widely used transmission standard in the world
- Focus of digital television development
- Based on MPEG2 source coding
- DVB-S (1993), -C (1994), -T (1995), -SH, …
  - Different coding and modulation w.r.t. channel
  - e.g. QPSK in DVB-S, QAM in DVB-C, COFDM in DVB-T
- Spawned ISDB-T, -C, -S (Japan) and A/53-T (US)



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# DVB family of standards

- Every DVB standard defines the ***channel coding*** and ***modulation***, since every channel has a different set of characteristics.
- But for all of them, the system input and output signals are ***MPEG-2 Transport Streams***.

  - DVB-S and DVB-S2 for satellite broadcasting
  - DVB-C for cable systems
  - DVB-T and DVB-T2 for terrestrial broadcasting
  - DVB-H for handheld systems
  - DVB-SH for satellite-to-handheld systems
  - DVB-IPDC for internet protocol datacastover
  - DVB-CPCM for content protection & copy management



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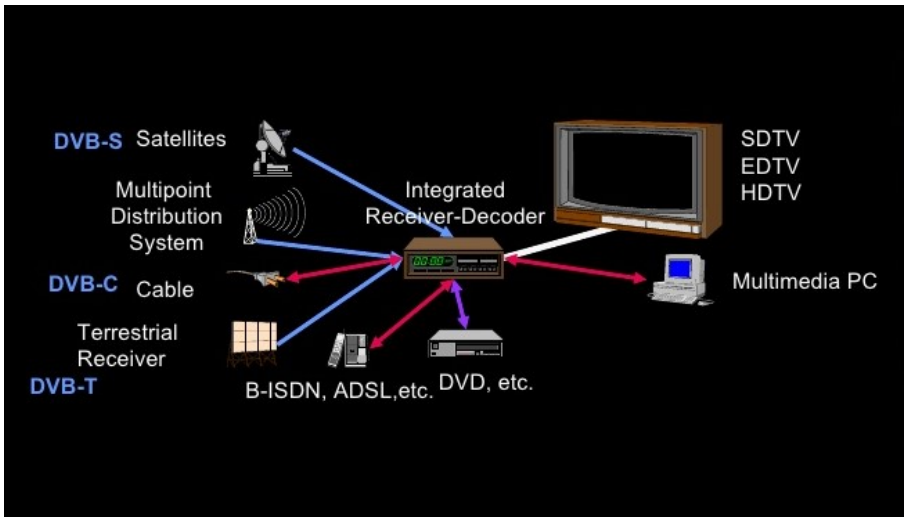
# DVB family of standards



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# ATSC (Advanced Television Systems Committee)

- ATSC depends on numerous interwoven standards
  - ATSC (Terrestrial, Cable, Satellite)
  - ATSC-M/H (Mobile/Handheld)
- Established 1990s
- Original specification for HDTV (High Definition Television)
- Uses Dolby, not MPEG for audio
- Mobile reception difficult/impossible until 2008
  - New ATSC-M/H since 2009



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# ISDB (Integrated Services Digital Broadcasting)

- Covers digital television (DTV) and digital radio
- Maintained by Association of Radio Industries and Businesses (ARIB), Japan
- Main differences compared to DVB:
  - ISDB-S uses 8-PSK (Phase Shift Keying) and Trellis coding instead of QPSK in DVB-S (modulation)
  - In ISDB-T, single 6 MHz TV channel can be split into 13 x 432 kHz subchannels for adaptive use
    - digital audio (1 subchannel),
    - SDTV (multiple subchannels),
    - HDTV (all 13 subchannels).



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# ISDB family of standards

- ISDB-S for satellite television
- ISDB-T for terrestrial television (mainly used in South America)
- ISDB-Tsb for terrestrial sound
- ISDB-C for cable television
- ISDB-1seg for cell phones, laptops, vehicles



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# DTMB (Digital Terrestrial Multimedia Broadcast)

- Chinese GB20600-2006 standard
- Initially called DMB-T/H
- DMB-T, T-DMB (South Korea)
- Established 2006
- China, Hong Kong and Macau
- CMMB: Chinese Mobile Multimedia Broadcasting
  - Mobile and stationary
  - Satellite and terrestrial
  - Standard GY/T 220.1



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# Digital Video Broadcasting – Satellite (DVB-S)

- DVB-S: standard for Direct-to-home Broadcasting via Satellite (DBS)
- Defined between 1993 and 1997 by European Standard EN 300 421.

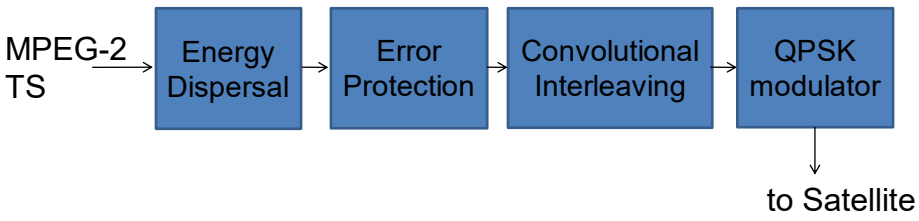





# DVB-S Encoding

After the data has been coded following the MPEG-2 standard, it needs to go through the next steps before being transmitted to the satellite:

- Multiplexing and randomisation for energy dispersion
- Reed-Solomon Encoder (Error Protection)
- Convolutional Interleaving
- QPSK modulation



# Energy Dispersal and Error Protection

- ***Energy Dispersal*** is carried out at the encoding end by scrambling with a pseudo random sequence
  - Energy dispersion is the randomising of the input signal in order to achieve a power-density spectrum of the modulated signal that is as even as possible.
- ***Error Protection*** scheme permitting various code rate
  - ***Reed-Solomon coding*** RS(204, 188, t=8) is used, where 16 parity bits are introduced in each transport packet. With this the decoder is able to correct up to 8 error bytes in each packet of 204 received bytes.



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# Reed-Solomon coding

- The Reed-Solomon encoder takes a block of digital data and adds extra "redundant" bits.
- The number and type of errors that can be corrected depends on the characteristics of the Reed-Solomon code.
- A Reed-Solomon code is specified as RS(*n,k*) with *s*-bit symbols.




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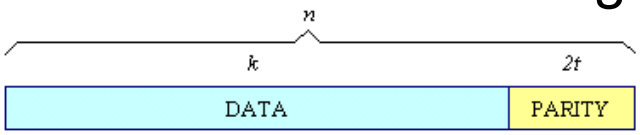
# Reed-Solomon coding



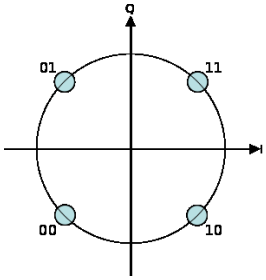

- The encoder takes *k* data symbols of *s* bits each and adds parity symbols to make an *n* symbol codeword.
- A Reed-Solomon decoder can correct up to *t* symbols that contain errors in a codeword, where *2t = n-k.*
- Example: RS(204,188) with 8-bit symbols. Each codeword contains 204 code word bytes, of which 188 bytes are data and 16 bytes are parity. For this code:
  n = 204, k = 188, s = 8, 2t = 16, t = 8
  Errors in up to 8 bytes anywhere in the codeword can be automatically corrected.





# Interleaving and Modulation

- ***Interleaving***
  - In order to avoid errors in consecutive packets, the packets are interleaved.
- ***Modulation***: QPSK (***Quadrature Phase Shift Keying***) is used for modulation
  - With four phases, QPSK can encode two bits per symbol



# Data Rate Calculation (example)

- Assuming the symbol rate is 27.5 MS/s.
- QPSK offers 2 bits/Symbol
- 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;



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# Data Rate Calculation (example)



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# 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.



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# DVB-S2

- Improved version of DVB-S standard, 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, Data Content distribution, etc..
- Supports recent improvements in channel coding
- Supports recent improvements in channel modulation
- Typically offers 30% data rate increase under the same condition compared to DVB-S



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# 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<br>15 AVC | 10 MPEG-2<br>21 AVC | 10 MPEG-2<br>20 AVC | 13 MPEG-2<br>26 AVC |
| Number of HDTV programmes | 1-2 MPEG-2<br>3-4 AVC | 2 MPEG-2<br>5 AVC | 2 MPEG-2<br>5 AVC | 3 MPEG-2<br>6 AVC |



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# Reading

- 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



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