Digital Video Broadcasting

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Samoa- PMPC

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Rohde & Schwarz
fields of business

- **Wireless communications**
  Development and production test solutions for every second mobile phone in the world

- **Analog & digital TV**
  Transmitters for more than 80 countries

- **Air traffic control**
  Radiocommunications for more than 200 large airports

- **Secure communications**
  Radios in use worldwide for all branches of the armed forces

- **Management of the frequency spectrum**
  Instruments and systems for radiomonitoring and radiolocation for about 150 countries

- **Service & services**
  To be as close to the customer as possible, nearly 70 locations worldwide
Broadcast & Media equipment

- High-tech for network operators
  - Analog and digital TV and radio transmitters of all power classes
  - Setup of nationwide networks for digital and mobile TV
  - T&M for maintenance and monitoring of operating networks

- Production & Storage solutions
  - Video Servers
  - Storage (Online/ nearline, NAS, SAN)
  - Post Production equipment

- High-tech for manufacturers of broadcasting equipment
  Test solutions from the earliest stages of development up to series production – all from a single source
The DVB Project

- Founded in 1993 with 8 Members
- Currently 280 Member Organisations in 34 Countries
- First Generation systems widely adopted worldwide
- Many DVB standards and specifications adopted by ETSI
- Second Generation systems are already deployed
A long term dynamic to build a coherent Family of standards...

... 270 Member Companies ... 45 Published Standards ... 130 Million Receivers Deployed ... On-Air On 6 Continents ...

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From Analog TV to Digital TV

From SDTV to HDTV
Mobile TV: a coherent but specific Family of standards

From Digital TV to Mobile TV

From Mobile TV to "Next Generation Mobile TV"

Analog TV Switch-Off Process
Analogue / Digital Transition

**Analogue TV - PAST**
- Video – AM Modulation
- Sound - FM Modulation
- Test Signals in VITS CCIR17,18,330,331
- S/N Ratio, Colour, Black/White + Noise
- Smooth Degradation

**Digital TV - PRESENCE/FUTURE**
- Digital Modulation
  - DVB-S/S2 QPSK
  - DVB-C/C2 QAM
  - DVB-T/T2 COFDM
- Transport Stream Protocol
- Blockiness, Blurring,
- Hard Degradation – Cliff Effect
- Good Quality or No Picture
Analogue / Digital Transition

**Analogue TV – PAST / PRESENCE**

- **Channel Bandwidth**
  - 7 MHz / 8 MHz

- **1 Program**
  - 1 Video
  - Dual Sound
  - 1 Teletext

- **No Interactivity**

**Digital TV - PRESENCE / FUTURE**

- **Channel Bandwidth**
  - 7 MHz / 8 MHz

- **1 Transport Stream / Multiple Streams**
  - up to 20 Video Programs
    - Dual Sound / Surround
    - Teletext
    - MetaData

- **Interactivity with return path**
First Generation Broadcast TV Standards

Based on the highest performance consumer technology then available
Some Early UK STBs could only support 2K modes

Development time/costs minimised by re-using common modules

DVB-S Approved in December 1993
  Single carrier QPSK mode
  Single Transport Stream

DVB-C Approved in March 1994
  Single carrier with 4, 16 and 64QAM modes
  Single Transport Stream

DVB-T Approved in December 1995
  2K and 8K COFDM with 4, 16 and 64QAM
  Two transport streams using Hierarchical Modulation
Why Are New Standards Being Developed?

New Services Require Increasingly Higher Bandwidths
   HDTV, 3DTV and Interactive TV

New Business Models Demand More Flexible Delivery
   IP, Mobile and Fixed Broadcasting

Increasingly Expensive Spectrum must be Better Utilized
   Competition for limited resources with telcos

New Technologies enable more complex systems
   Low Cost High Speed Processors
   High Performance Algorithms
DVB ... 2nd Generation

DVB 2.0 - Second Generation Broadcasting Standards

DVB-S2: 36% more capacity, 3 dB more robust, Millions of products
DVB-T2: Up to 97% more capacity, Up to 8 dB more robust, Products available now
DVB-C2: 30% more capacity, 6 dB more robust, Products coming soon

Source: DVB-Projekt
DVB-S2
EN302 307
Dec 2003
DVB-S2: New Features over DVB-S

New Modulation and Forward Error Correction (FEC)
30% Higher bandwidth enables more HDTV, SDTV and IP services

Dynamically variable modulation and FEC
Optimal bandwidth utilization for different service types
Robust delivery in poor weather conditions

Multiple Input streams
Independent and Flexible Operation between service providers
Hierarchical Mode for backwards compatibility with legacy STBs

Supports non-compliant Transport Stream formats e.g. IP
“Null” (PID8191) TS packets need not always be transmitted
No need for Transport Stream packetization overhead
No conversion simplifies interoperability
DVB-S2: New Technology Requirements

“New” High Performance FEC (BCH, LDPC)
- Originally developed in the 1960s
- Large Frame Size (64800bits)
- Also adopted for DVB-T2 and DVB-C2
- Requires large memory and high processing power

New modulation schemes (8PSK, 16APSK, 32APSK)
- Requires high performance demodulators

Modulation can be changed for every Physical Layer Frame
- Different/variable bit rates for each Input Stream
- Different FEC for robust reception in bad weather (snow/rain)
- Requires more complex demodulators
DVB-C2
EN302 769
April 2009
DVB-C2: Channel Bonding

- Receiver bandwidth
- Selective gain adaptation
- Unused parts of the spectrum
- Narrowband interference

DVB-C

8 MHz

DVB-C2

24 MHz
DVB-C2: Technical Summary

Based on DVB-T2
COFDM (4K mode, 2 short guard intervals)
Channel raster bandwidth 6 or 8 MHz
QPSK … 4096QAM
Variable coding and modulation
Channel bundling
Copes with notches (interfered frequency ranges)
Uses the same BBFRAME/FEC structure as DVB-S2
Multiple TS and GSE
Single and multiple input streams
Data slices
Reserved carriers for Peak to Average Power Reduction

>50% Higher Bit rates than DVB-C
DVB-C2 Bit Rates

Bit-rate per 8 MHz / [Mbps]

Signal-to-noise ratio / [dB]

DVB-C2
- 9/10
- 5/6
- 3/4
- 2/3

DVB-C
- 204/188

Shannon Line
DVB-T2
EN302 755

May 2008
DVB-T2: Key Commercial Requirements

Re-use existing domestic antennae and transmitter network

Support Portable and fixed Receivers

At least 30% > capacity than DVB-T

Improved SFN Performance

Service Specific Robustness

Bandwidth and Frequency Flexibility

Reduce Peak to Average Power Ratio
DVB-T2: New Technology over DVB-T

Many new transmission options:
- New Channel Bandwidths, Guard Intervals and FFT Modes
- 8 Different Pilot Patterns
- Extended Carrier Modes
- Rotated and Q-delayed constellations
- Multiple Input Single Output (MISO) Modes
- Peak to Average Power Reduction (PAPR) Modes

Modulation dynamically variable for each “COFDM Cell”
- Every carrier in each symbol independently controllable
- System/Control data sent in fixed format highly robust symbols

DVB-S2 FEC plus extensive time and frequency interleaving
- Further improves robustness in noisy environments
DVB-T2: Benefits over DVB-T

New Modulation, FEC and Transmission modes
- 30 - 60% More Bandwidth enables more HDTV, SDTV and IP services

Multiple Input streams (Physical Layer Pipes = PLPs)
- Common (e.g. SI) Data and service specific (Video, audio) streams
- Independent and Flexible Operation with multiple service providers

Dynamically variable modulation and FEC
- Mobile (time/frequency sliced) and Fixed Services in same bandwidth
- Optimal bandwidth utilization for different service types

Direct Support for non-TS formats e.g. IP
- No Transport Stream packetization overhead
- Repeated (null packets) or common (SI) data need not always be sent
- No conversion simplifies interoperability
## Typical Datarates Digital Broadcast

### Source Coding:

- **MPEG-2 video SDTV**: 2.5 ... 5 Mbit/s
- **MPEG-4 video SDTV**: 1.5 ... 3 Mbit/s
- **MPEG-4 video HDTV**: 8 ... 12 Mbit/s
- **MPEG-1 LII audio**: 192 kbit/s
- **Dolby AC-3 audio**: 448 kbit/s
- **Teletext**: 260 kbit/s

### Physical Layer before FEC (net data rate):

- **DVB-S (27.5 MS/s, CR=3/4)**: 38.01 Mbit/s
- **DVB-S2 (22 MS/S, 8PSK, CR=2/3)**: 42.58 Mbit/s
- **DVB-S2 (27.5 MS/s, QPSK, CR=9/10)**: 49.2 Mbit/s
- **DVB-T (16QAM, CR=2/3, g=1/4)**: 13.27 Mbit/s
- **DVB-T (64QAM, CR=3/4, g=1/4)**: 22.39 Mbit/s
- **DVB-C (64QAM)**: 38.15 Mbit/s
- **DVB-C (256QAM)**: 50.87 Mbit/s
- **DAB/DAB+**: 1.2...1.7 Mbit/s
Transmission of Information

**Source**
- Information
- Source Coding
  - e.g. data compression
- Channel Coding
  - Forward Error Correction (FEC)
- Modulation
  - Single Carrier, Multicarrier (OFDM), CDMA, TDMA, ...
- Transmission link
  - (Media, bandwidth, interferer, ...)

**Sink**
- Information
- Source Decoding
- Channel Decoding
- Demodulation
- Modulation
- Channel Coding
- Source Coding
- Information
Transmission of Information: DVB

Transmission link

Headend

Source Coding

Modulator, transmitter

Modulation

Channel Coding

Transmission standards:
DVB-C, J83A/B/C, DVB-C2,
DOCSIS, DVB-T/T2, DVB-S/S2

Source coding standard: MPEG, ...

Demodulation

Coax, HFC, FTTH, terrestrial, satellite, ...

Setop box

cable receiver

IRD/flat screen

cable modem, terr. receiver,
sat. receiver

Source Decoding

Channel Decoding

Information

Studio, storage media
MPEG Standards

MPEG = Moving Pictures Expert Group

MPEG-1
H.262

MPEG-2
H.264
AVC

MPEG-4
AVC

MPEG-H,
H.265
HEVC

HEVC = High Efficiency Video Coding
Current Digital Broadcast Transmission Standards

DVB-T/T2, -C/C2, -S/S2, DVB-IP


ATSC – Advanced Television Systems Committee (USA, 1995)

ISDB-T – Integrated Service Digital Broadcast – Terrestrial (Japan, 1999)

DVB-T2 + HEVC

Source coding:

MPEG-2 video SDTV   2.5 ... 5 Mbit/s
MPEG-4 video SDTV   1.5 ... 3 Mbit/s
MPEG-4 video HDTV   8 ... 12 Mbit/s
MPEG-1 LII audio    192 kbit/s
Dolby AC-3 audio    448 kbit/s
Teletext            260 kbit/s

Physical layer before FEC (net data rate):
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DVB-C (64QAM)   38.15 Mbit/s
DVB-C (256QAM)  50.87 Mbit/s
DAB/DAB+        1.2...1.7 Mbit/s

HEVC (H.265, MPEG-H):
Datarate reduction by approx. 50% in comp. to H.264

DVB-T2: DVB-T datarate x 1.7 ... 2
Terrestrial Broadcast Channel

„man-made noise“
DVB-T2: Closer to the Shannon Limit ...

Shannon Limit $C \approx \frac{1}{3} \times B \times SNR$

8 MHz

10 dB ... 25 dB

at 8 MHz band width:

10 dB ... 26.7 Mbit/s
15 dB ... 40 Mbit/s
20 dB ... 53.3 Mbit/s

DVB-T2

7.4 ... 50.3 Mbit/s

DVB-T

5 ... 31.7 Mbit/s

0 Mbit/s
## CNR Limits at DVB-T

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- **portable indoor**

- **Roof antenna**
DVB-T2 ... more Datarate ...

Shannon limit ... channel capacity

\[ C_\sim = \frac{1}{3} \times SNR \times B; \]

\[ B = 6/7/8\text{MHz} \]

„Fixed antenna“ reception
SNR = 18 ... 30 dB

„Portable indoor“ reception
SNR = 10 ... 20 dB

at 8 MHz bandwidth:
10 dB ... 26.7 Mbit/s
15 dB ... 40 Mbit/s
20 dB ... 53.3 Mbit/s
30 dB ... 80 Mbit/s

Theoretical max. datarates
## Datarates at DVB-T

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<thead>
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<th>Modulation</th>
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**Portable indoor**

**Roof antenna**
DVB-T and DVB-T2

DVB-T, „Germany, portable indoor“: 13.27 Mbit/s
DVB-T, „fixed antenna“: 22.39 Mbit/s

similar modes at DVB-T2:

26.6 Mbit/s „portable indoor“ (32Kext, 64QAM, CR=2/3, g=1/16)

39.7 Mbit/s „fixed antenna“ (32Kext, 256QAM, CR=3/4, g=1/16)
DVB and Fall-Off-the-Cliff

Go  No-Go

SNR~12 dB (indoor)
SNR~18 dB (fixed)

„Fall-off-the-Cliff“
Fall-off-the-Cliff (… from DVB-x1 to DVB-x2 …)

Go No-Go

Δ depends on FEC

Go

No-Go

SNR1 first on-set of impairments

SNR2 total „no-go“

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<tr>
<th>Standard</th>
<th>SNR1 [dB]</th>
<th>Δ [dB]</th>
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<td>DVB-T2</td>
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(Example, approx. values)
### CNR Limits @DVB-T2 @ BER=10⁻⁴ after LDPC

<table>
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<tr>
<th>Modulation</th>
<th>Coderate</th>
<th>C/N Gaussian Channel [dB]</th>
<th>C/N Ricean Channel [dB]</th>
<th>C/N Rayleigh Channel [dB]</th>
<th>C/N 0dB Echo Channel @ 90% GI [dB]</th>
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</table>

**Source:** DVB-T2 Implementation Guidelines
Digital Broadcast Network

Source signals: programs ("services") consisting of video, audio, data (live or from server)

Coding & MUX

Source coding and multiplexing

MPEG-2 TS
ETI
T2-MI
IP
MUX

Dig. broadcast modulator

DVB-S/C/T/S2/C2/T2
ISDB-T
T-DMB/DAB
DMBT
ATSC

RF

Transmission media

Satellite, terr., coax, fibre, twisted pair cable

Receiver

TV with integrated IRD or settop box

Video
Audio
Data

ROHDE & SCHWARZ
Digital TV Network

Camera → Matrix → MPEG-x Encoder → Headend

- TTXT, VBI
- Distribution Network (Microwave, Coax, Fibre)
- Modulator & Transmitter
- RF Signal
- Receiver

Interferences on Transmission Link (Terrestrial, Satellite, Cable)

Interferences on Distribution Network

MUX

Studio

L, R

SDI

MPEG-2 TS

Interferences on Transmission Link
MPEG-2 Transport Stream

4 byte TS header

184 Byte payload

13 bit packet identifier = PID

1 bit transport error indicator

1 byte sync byte = 47 hex
Basics of a DVB-T2 Network

Link fed Transmitters

- Complete Transport Stream Mapped to one **PLP (Physical Layer Pipe)**
- Simple Structure with Constant Coding and Modulation for all programs
  
  256QAM, 1/16, 3/4, 32k

**Headend**

**MUX**

**HD ENC**

**SD ENC**

Single Physical Layer Pipe

Transmitter 1

f1

Transmitter 2

f2

Transmitter 3

f3
Basics of a DVB-T2 Network

Multiple Transport Stream Mapped to **MPLP** *(Multiple Physical Layer Pipe)*

Complex Structure with flexible Coding and Modulation for all programs

- **PLP1**: 256QAM, 1/16, 3/4, 32k
- **PLP2**: 64QAM, 1/8, 2/3, 8k
- **PLP3**: 16QAM, 1/8, 1/2, 2k
- **PLP0**: Common PLP
SFN Basics of a DVB-T2 Network

Link fed Transmitters

- Complete Transport Stream Mapped to one **PLP (Physical Layer Pipe)**
- Simple Structure with Constant Coding and Modulation for all programs

256QAM, 1/16, 3/4, 32k

**Headend**

- HD ENC
- SD ENC
- SD ENC
- MUX
- TS out

**Single Physical Layer Pipe**

T2- MI Gateway generates the T2-MI timing information for Link-fed Transmitters
SFN Basics of a DVB-T2 Network

Over the air synchronisation for Re-Transmitters

- Complete Transport Stream Mapped to one **PLP** *(Physical Layer Pipe)*
- Simple Structure with Constant Coding and Modulation for all programs

256QAM, 1/16, 3/4, 32k

**Headend**

- **HD ENC**
- **SD ENC**
- **MUX**
- **SI**

**T2-MI Gateway:**
- T2-MI timing information for Link fed Transmitters
- Generates the T2-MIP

**Transmitter 1**
- $f_1$
- 1 pps 10 MHz
- GPS

**HD ENC**

**SD ENC**

**SD ENC**

**MUX**

**TS out**

**T2-MI Gateway**
- Single Physical Layer Pipe

**Re-Transmitter 2**
- $f_2$
- 1 pps 10 MHz
- GPS

**Re-Transmitter 3**
- $f_2$
- 1 pps 10 MHz
- GPS

**T2-MI Gateway:**
- T2-MI timing information for Link fed Transmitters
- Generates the T2-MIP

**ROHDE & SCHWARZ**
SFN Basics of a DVB-T2 Network
Over the air synchronisation for Re-Transmitters

Headend

HD ENC  SD ENC  SD ENC
MUX

T2-MI Gateway
T2-MIP

TS out

Single Physical Layer Pipe

Transmitter 1
f1

Transmitter 2
f2

Re-Transmitter 3
f3

Re-Transmitter 4
f3

T2 receiver  T2-MIP extraction  Modulator

T2 receiver  T2-MIP extraction  Modulator
- Network Design
- Gap Filler and Re-transmitters
- DVB-T2 Single Frequency Network
- Total Cost of Ownership
Network Design: Total-cost-of-ownership
Design and implementation
Ensuring a most economic operation

- **Network structure:**
  - (few) high power Transmitter – high tower
  - (many) low power Transmitter
  - mixed setup

- **Network design:**
  - Combination of main components driving operational cost

- **Network equipment:**
  - Energy efficiency
  - Reliability and long term stability
  - Mean time between failure
Coverage example

Tx Power: 3 kW

64 QAM, 32k FFT, CR 2/3, C/N 17dB

MORE POWER IS NOT ALWAYS THE BEST SOLUTION
Why Low Power Transmitters

1. High Power Transmitters (> 2kW) can not guarantee a 100% coverage

2. Low Power Transmitters do support the High Power Transmission to ensure a better / improved coverage for
   - Shadowed areas (buildings, valleys, etc.)
   - Indoor coverage for Malls
   - Small communities

3. Power Classes
   - 1W – 200W
Low Power: Transmitter, Re-transmitter & Gap Filler

1. **Transmitter**
   Must have a link fed (ASI / IP Transport stream inputs)
   VHF & UHF

2. **Re-Transmitters**
   RF input & ASI / IP Transport stream inputs
   Demodulate the DVB-T2 signal to Baseband (Transport Stream)
   Re-modulate the transport streams to form a regenerated DVB-T2 signal which is then retransmitted
   Transmits in UHF only

3. **Gap Filler (OCR), Transposers**
   RF input only (VHF & UHF)
   can shift frequency (Transposer)
   amplify
delay and transmit the received DVB-T2 signal without a full re-modulation
Re-broadcast systems

Difference: input and output frequency

\[ f_{\text{out}} \neq f_{\text{in}} \]

Output frequency \neq frequency parent transmitter

- Transposer
- Re-transmitter
- Repeater/ Gap filler

\[ f_{\text{out}} = f_{\text{in}} \]

Output frequency = frequency parent transmitter

For SFN single frequency network

Relevance for echo cancellation
Advantages & disadvantages

Low Power Transmitters

Produce a very clean output signal

Can be used in a Single Frequency Network (SFN) together with a Main transmitter

Need a Link Feed (ASI/IP Transport stream) which can be expensive
Advantages & disadvantages

Re-Transmitters

* Produce a very clean output signal, even with a noisy input signal *
  
* No MER degradation *
  
* Long processing time between input and output *
  
* Cannot be used in a Single Frequency Network (SFN) together with a Main transmitter *
  
* Can be used to build an independent Low power SFN on a frequency f2 *
Advantages & disadvantages

Gap Fillers

Provide a degraded output signal

MER degradation

Can start to oscillate if not careful installed (Echos between Input & Output have to be suppressed with Echo cancellation)

Very short processing time between input and output

Can be used in a Single Frequency Network (SFN) together with a Main transmitter