Technical Realisation of Digital TV Transmitter Systems

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Rohde & Schwarz
Technical Realisation of Digital TV Transmitter Systems

- MFN / SFN networks
- Transition from analog to digital
- state of the art transmitter family
- redundancy systems
DVB-T transmitter systems

Network layout

MFN
(multi frequency network)

SFN
(single frequency network)
Advantages of the SFN:

* Frequency efficiency
  - the DVB-T system use the SFN: one frequency for several programs

    (current situation: each program has another frequency
    ==> MFN: Multi Frequency Network)

  - the SFN is with the factor of 3 better than the MFN's

* Power efficiency
  - lower transmitter power in the SFN is required because
    - addition of all signal components from different transmitters and
      reflection at the receiving antenna
    - with the lower transmitter output power: lower distortions in neighbor areas
    - if gaps exists in the coverage (deep valley, tunnels, etc.): these gaps can be filled
Disadvantages of the SFN:

* the TS is equal at all transmitter sites (no local program can be introduced)

* a transmitter which violates the SFN rules is a jammer in the coverage

* synchronization (time, frequency, information) is necessary

* network monitoring is necessary to control the SFN features
DVB-T transmitter chain SFN

MPEG-2 remultiplexer → SFN adapter → TX Network adapter → Distribution Network

MPEG-2 TS → RX Network adapter

10 MHz → 1 pps

GPS*

DVB-T modulator

SYNC system

MPEG-2 TS

10 MHz → 1 pps

GPS*

DVB-T modulator

SYNC system

MPEG-2 TS

* Could be any common available frequency reference
DVB-T transmission network (via Satellite)
DVB-T transmission network (via Radio Link/dark fiber)
DVB-T transmission network (via ATM/SDH)
DVB-T network monitoring
## DVB-T networks monitoring

<table>
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<th>program source program - TS</th>
<th>data rate</th>
<th>entire TS single programs elementary streams</th>
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<td>event protocol</td>
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<td>modulation links</td>
<td>modes</td>
<td>radio link (HDB3, QPSK) satellite (QPSK) dark fibre ATM over SDH/PDH</td>
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### DVB-T transmitter monitoring

<table>
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<th>Transmitter Output</th>
<th>RF Parameters</th>
<th>Parameters After Demodulation</th>
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<td>average level and max. peak level in RF and IF</td>
<td>BER, MER, END</td>
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<td>phase vs frequency C/N and intermodulation</td>
<td>TPS</td>
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<td></td>
<td>amplitude vs frequency shoulder distance</td>
<td>signal delay from TS @</td>
</tr>
<tr>
<td></td>
<td>C/N and intermodulation power efficiency</td>
<td>transmitter input to antenna</td>
</tr>
</tbody>
</table>
DVB-T Transmitter

switch position:
- position 1
  exciter output \( \text{BER} \ 2 \times 10^{-4} \) nach Viterbi @ Noise 1

- position 2
  DVB-T transmitter output \( \text{BER} \ 2 \times 10^{-4} \) nach Viterbi @ Noise 2

\[ \text{END} = \text{Noise 2} - \text{Noise 1} \]
DVB-T realisation of digital transmitter stations

Transition from analog to digital
Requirements for the engineering work

Definition of the intended coverage area in relation to the existing analog TV Service (area, population, channel, power).

Investigation of possible limitation by interference of other services in this area

Result: Selection of "free channels" to choose for licensing in terms of frequency and radiated power.
Technical planning of the station

- **Investigation of the existing antenna**
  
  Result: dependent on the desired coverage area (omnidirectional, sectional, beam) and mechanical (static) situation define modification and antenna gain.

- Calculate necessary transmitter power

- Space requirement for transmitters
Alternativ: transition of the existing analog transmitter into digital service

- Change of encoder module in exciter

- bypassing of the sound part (amplifier and v/s diplexer)

- introducing of DVB-T band - filter

- new equalizing of transmitter
Transmitter DVB-T /Analog(combined)

Block Diagram NH/NV7000
Transmitter analog(split)
DVB-T transmitter NV7000

Block Diagram 1,3 kW DVB-T Transmitter
PAL-nonlinearity

Black picture

Frequency response in channel
bl/wi-amplification
DVB - Transmitter nonlinearity

frequency response

Constellation Diagramm 64QAM
DVB-T Crest Faktor

analog

\[ U_{ss} / 2 = U_{s} = 6 \text{ (ca.) normalised to } U_{rms} \]

\[ U_{rms} = 1 \]

\[ U_{clip} \text{ in Transmitter} \]

digital
DVB-T realisation of digital transmitter stations

Example of a radiated signal from a TV station

Interference from analog to digital service
Interference from digital to analog service
DVB-T realisation of digital transmitter stations

Transmitter Output Spectral Mask after the Bandpass Filter

Relative Spectral Density (dB)

-12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12

Frequency relative to Multiplex Centre (MHz)

-10,25..-6MHz/-45dB

-4,3MHz/-36dB

-3,805MHz/-1,0dB

-4MHz/0,5dB

4MHz/0,5dB

3,805MHz/-1,0dB

4,3MHz/-36dB

-10,25..-6MHz/-45dB

Groupdelay

Tg=-250ns

Tg=250ns

Ref.
DVB-T realisation of digital transmitter stations

3dB couplers

8 cavity filters

narrow band input

broadband input

output

Insertion loss / dB

Frequency / MHz

DVB-T realisation of digital transmitter stations

3dB couplers

8 cavity filters

narrow band input

broadband input

output

Insertion loss / dB

Frequency / MHz
DVB-T realisation of digital transmitter stations

![Graph showing bitrate vs. minimum median field strength for different modulation schemes.](image)

- **FX QPSK**
- **FX 16 QAM**
- **FX 64 QAM**
- **Port A QPSK**
- **Port A 16 QAM**
- **Port A 64 QAM**
- **Port B QPSK**
- **Port B 16 QAM**
- **Port B 64 QAM**
Net bitrate (Mbit/s) in an 8MHz channel

Required CNR for quasi error-free DVB-T transmission.
DVB-T realisation of digital transmitter stations

DVB-T net data rates

- Code rate of inner error protection / bits per sub-carrier
- Guard interval

Net data rates [Mbps]

- 1/2, 2/3, 3/4, 5/6, 7/8, 1/4

- Modulation: 64 QAM
- Code Rate: 

<table>
<thead>
<tr>
<th>Code Rate</th>
<th>1/4</th>
<th>1/8</th>
<th>1/16</th>
<th>1/32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit/Träger</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Max. Rate [Mbit/s]</td>
<td>2 1/2</td>
<td>4 1/2</td>
<td>4 5/6</td>
<td>4 7/8</td>
</tr>
</tbody>
</table>

- Tu [us]: 896, 896, 896, 896
- n*T: 8192, 8192, 8192, 8192
- d [us]: 224, 112, 56, 28
- n*T: 10240, 9216, 8704, 8448
The new UHF transmitter family NH/NV7000 for analog and digital TV transmitters - High Power -

Innovation and experience for the benefit of the broadcaster
### NH/NV7000 Component Structure and System Family

<table>
<thead>
<tr>
<th>Modulator / Exciter</th>
<th>Control and Monitoring</th>
</tr>
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<tbody>
<tr>
<td>SH700 ATV Splitt Ampl. / SC700 ATV Combined Ampl. / SV700 DVB-T</td>
<td>LDMOS Amplifier Modules</td>
</tr>
<tr>
<td></td>
<td>470 - 860 MHz</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Power Supply integrated in VH602</th>
<th>Power Supply</th>
</tr>
</thead>
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<tr>
<td>VH602 2kW/400W</td>
<td>VH650 500W/200W</td>
</tr>
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</table>

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<thead>
<tr>
<th>Liquid Cooling System</th>
<th>Air Cooling System</th>
</tr>
</thead>
</table>

#### High Power Tx
- ATV: 3,5kW ... 40kW
- DVB-T: 800W ... 10kW

#### Medium Power Tx
- ATV: 250W ... 2kW
- DVB-T: 100W ... 800W
DVB-T transmitter system

TARGETS for NH/NV7000
Transmitter: Medium Power air cooled
Transmitter: High Power liquid cooled

- Economical
- Compact
- State of the art
- Modular design
- Expandable
- Easy to handle
DVB-T transmitter system

Liquid Cooled Transmitter / Amplifier

VH602 LDMOS amplifier

10kW ATV / 2.5 kW DVB-T transmitter into one rack
System configuration for liquid cooling

- Exciter
- DVB-T Modulator
- Analog Modulator
- VH602 Amplifier incl. PS
- Combining
- DVB-T Filter
- Harmonics and Trap Filter
- Pump System
- Heat Exchanger
- Controlling and Monitoring
# NH/NV Power Classes

<table>
<thead>
<tr>
<th>Number of Amplifier Module (+ Sound Amp. Module for ATV)</th>
<th>ATV $P_{\text{sync}}$</th>
<th>DVB-T $P_{\text{eff}}$ (36dB shoulder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (+1*)</td>
<td>3,5 kW</td>
<td>800 W</td>
</tr>
<tr>
<td>3 (+1*)</td>
<td>5 kW</td>
<td>1,3 kW</td>
</tr>
<tr>
<td>4 (+2)</td>
<td>7 kW</td>
<td>1,7 kW</td>
</tr>
<tr>
<td>6 (+2)</td>
<td>10 kW</td>
<td>2,5 kW</td>
</tr>
<tr>
<td>8 (+2)</td>
<td>13 kW</td>
<td>3,4 kW</td>
</tr>
<tr>
<td>12 (+2)</td>
<td>20 kW</td>
<td>5 kW</td>
</tr>
</tbody>
</table>

*optional 2

Further combination: 2*13kW and 2*20kW in active reserve 3*10kW
Redundancy in power

Output Power with Breakdown of Amplifiers:

\[ P_{out} = P_{rated} \times \left( \frac{m-n}{m} \right)^2 \]

- \( P_{out} \) = real output power
- \( P_{rated} \) = nominal output power
- \( m \) = number of amplifiers
- \( n \) = number of defect amplifiers

For example: \( m=8, n=1 \) \( \Rightarrow \) \( P_{out} = 0.766 \times P_{rated} \)
Cooling Concept Amplifier

- **Closed loop of liquid through one pipe** with continuous identical diameter into the amplifier heat sink (corrosion-less material in stainless steel and aluminium)

- **Internal blower** for transfer of remainder heat to watercooler, thus preventing any hot spot

- **Transistors mounted directly on top of cooling pipe**

- **\( T \) input / output amplifier < 3°C**

- **Junction temperature < 120°C** at 24°C ambient temperature
VH602 Amplifier and Power Supply

VH602 Block Diagram
Liquid Cooling System

Water Cooling System for the transmitter NV6000

- Flexi tubing
- Safety valve
- Ball valve
- Flow control monitor
- Check valve
- Pump
- 3-way mixer
- Drain valve
- Expansion vessel
- Heat exchanger

Graphical representation of the Water Cooling System for the transmitter NV6000 with various components labeled.
Multistandard Exciter SX700
Exciter SH/SC/SV700

Block Diagram

DVB-Encoder:
- MIP-Decoder
- SFN Function
- Channel Coding and Modulation

or

ATV-Encoder:
- digital Video- and Audio processing
- multi Standard
- optional NICAM or Std M module

ATV/DVB-Precorrector:
- Group delay Corrector
- Linear Precorrector for DVB and ATV split and combined
- D/A-Conversion

Digital Interface (14 Bit)

ATV/DVB-Modulator:
- analogue I/Q-Modulation into RF for Video and Audio Band III, IV and V
- Output Filter for Video and Audio
- Output Amplifier
- RF Checker

Analogue Interface

ATV/DVB-Synthesizer:
- 10 MHz local Ref-PLL
- Band III, IV and V
- optional internal GPS-module

RF_VIDEO
RF_AUDIO
RF_CHECK
REF_EXT
GPS_ANT

CONTROL
INT_REF (120MHZ)
1PPS INT

Central Control Unit

Display Unit

RS485
RS232
TTL-Bus to par. Interface
Control Bus to Amplifiers, Switches, Blowers, ...

1PPS_EXT
RS232
RS232_FLASH
TS HP A / VIDEO 1
TS HP B / VIDEO 2
TS LP A / VIDEO_MON
TS LP B

RS485
RS485
RS232

Exciter SH/SC/SV700

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TTL-Bus to par. Interface
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1PPS_EXT
RS232
RS232_FLASH
TS HP A / VIDEO 1
TS HP B / VIDEO 2
TS LP A / VIDEO_MON
TS LP B

RS485
RS485
RS232

Remote interface

NetLink
Remote interface

Monitoring and Controlling System

- User-friendly monitoring software on one large display
- Additional PC software (GUI) with very comfortable graphical presentation and high level of information
- One interface for the all parameters of the exciter (incl. encoder and GPS-receiver in case of DVB-T)
- Multiple possibilities of remote control
  - Bitbus (RS485)
  - RS232 with TNPP protocol -> modem option
  - NetLink for SNMP interface or WEB-based supervision system
  - Parallel interface
Overview on Protocol Types and Layers

Web-Browser

HTTP
(Hyper Text Transfer Protocol)

TCP
(Transport Control Protocol)

IP
(Internet Protocol)

Network
(Layer 3)

Transport
(Layer 4)

Application
(Layer 7)

HP Openview

SNMP
(Simple Network Management Protocol)

UDP
(User Datagram Protocol)
4. NetLink WEB-Server

WEB-Server Application (Supervision System over TCP/IP)

- Transmitter Station
- Network
- Control Centre / Mobile Staff

- Server
- Client

- Integrated WEB-server from R&S
- • Ethernet (LAN/WAN)
- Internet / Intranet (TCP/IP)
- • Firewall
- Laptop with standard WEB-browser
- Management system (Windows, Unix, Linux, Mac) with standard Web-browser
5. NetLink SNMP-Agent

SNMP Application

- Transmitter Stations
- Network
- Control centres

Transmitter Stations

- R&S delivery part
- Integrated SNMP agent from R&S

Network

- Ethernet (LAN/WAN)
- SNMP Network

Control centres

- Management platform (e.g. HP openview) and SNMP network manager (software)

Server

- SNMP Traps (Alarms)

NMS

Supplier X

Integrated SNMP agent from R&S

R&S delivery part

SNMP agent Tx from Supplier X
Transmitter
Redundancy Systems
Dual drive, single PA stage
Dual drive, double PA stage, U-link patching
Dual drive, double PA stage, RF relay switch
Passive stand-by
Passive stand-by with dual drive
Passive-/active stand-by for half antenna
Reserve concepts

N+1 Reserve System

DVB-T transmitter n+1

ASI crossbar switch

Programm 1  Programm 2  Programm n
Conclusion

Benefits for the broadcaster

- Extremely compact design
- Improved technology for exciter, amplifier and cooling system
- Low operational cost
- More flexibility for installation
- More flexibility for remote control
- High commonality of sub-modules for reduced spares inventories
- Easy transition from analogue to digital secures investment
References:

ETS 300 744  Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital Terrestrial television (DVB-T).

ETR 290  Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems.

TR 101 190  Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects. (TR 101 190).

(AC106 VALIDATE Del.14)