Frequency Planning for Digital Terrestrial Television

Interregional Seminar on Transition from SECAM to Digital Television Broadcasting

Kiev, November 2000

Perpar Stanko, univ.dipl.ing.
RTV Slovenija OE Oddajniki in zveze
New ITU - R Study Group 6E

◆ Old organisation:
Study Group 10: Sound Broadcasting
Study Group 11: Television Broadcasting

◆ New organisation: Study Group 6: Sound and Vision Broadcasting
  – Working Party 6E contains former:
    » Working Party 10 A sound < 30 MHz
    » Working Party 10 B sound > 30 MHz
    » Working Party 11C television
    » Part of Working Party 11A modulation.
Analogue systems:

- BT. 417-4: Minimum field strengths for which protection may be sought in planning a television service,
- BT. 655-6: Radiofrequency protection ratios for AM VSB terrestrial television interfered with by unwanted analogue vision signals and their associated sound signals,
- BT. 419-3: Directivity and polarisation discrimination of antennas in the reception of television broadcasting,
- BT. 804: Characteristics of TV receivers essential for frequency planning with PAL/SECAM/NTSC television systems
ITU - R Working Party 6E
Recommendations on Planning 2

- **BT. 1123**: Planning methods for 625 line terrestrial television in VHF/UHF bands,
- **BT. 805**: Assessment of impairment caused to television reception by a wind turbine

*Digital systems:*
- **BT. 1125**: Basic objectives for planning and implementation of digital terrestrial television broadcasting system,
- **BT. 1368-2**: Planning criteria for digital terrestrial television services in the VHF/UHF Bands
- **BT. 1206**: Spectrum shaping limits for digital terrestrial television broadcasting.
In preparation:
Handbook on Digital Terrestrial Broadcasting
Second Part: Digital Terrestrial Television Planning

Document: ITU-R 6E/9
Digital Television Systems

- ATSC - North America
- DVB - Europe
- ISDB - Japan
Existing situation in EBA

European Broadcasting Area
- Frequency allocation according to Stockholm Agreement 1961
- over 58,000 stations in operation
- 3 channels in Band I, 8 channels in Band III,
- 49 channels in Bands IV and V
Existing situation in Europe

- Stockholm Agreement 1961: still operational and active
- Technical characteristics of assignments
- Modification procedures based on coordination distances - Article 4
Existing situation in Europe

- An estimate of the number of TV sets in Europe is about 300 million, with value of approximately 250,000 million ECU.
- Broadcasting installations (studio, links, transmitters)
- Several hundred thousand people employed
Scenario of the Introduction of Digital Television

1998 - First digital terrestrial services introduced
2005 - Planning conference (e.g. revision of ST 61)
1998 - 20?? - Transition period (Simulcast period)
2008 - Start of phasing out of analogue service
2020 - Future use of television frequency spectrum (e.g. Band III)
Scenario of the Introduction of Digital Television

Year in which analogue services will be switched off:

- 2006     USA (FCC)*
- 2007     Germany
- 2008     Italy
- 2012     Spain
- 2008     UK

* By the year 2007 49% of American households will own digital receivers
Scenario of the Introduction of Digital Television

- Audio CD (one of the most successful digital components) has reached $50\%$ penetration within $10$ years
- In UK 405 line services have had $15$ years simulcasting period
- By 2007 $49\%$ of American households will own digital receivers
Transition Period - Simulcasting

It is very likely that the simulcast period will last:

from 10 to 15 years
Limiting factors

The most critical limiting factors for future development and introduction of digital terrestrial television are:

- Receivers
- Frequencies
Digital Terrestrial Receivers

- Set top box
- Price similar to satellite set top box (300 ECU)
- Noise figure (including implementation margin): 8 dB
- Only one channel bandwidth (7 or 8 MHz) is economical
Frequencies

- Most of the frequency spectrum reserved for television is engaged.
- In some countries in Europe channels 61 to 69 are not used.
- Also some other channels are used for other services (e.g. channel 37).
- Planning constrains (Rec. BT. 1123)
Digital Television Standards used in Europe

- **DVB - T** for terrestrial services
- **DVB - C** for cable systems
- **DVB - S** for satellite reception
- **DVB - MC** for MMDS < 10 GHz
- **DVB - MS** for MVDS > 10 GHz
- **DVB - SFN** mega frame for SFN
- **DVB - SMATV** for satellite Master Antenna TV distribution
DVB - T

◆ Possibilities for terrestrial reception:
  – fixed reception (outdoor antenna 10 m height)
  – portable reception - outdoor (built-in antenna)
  – portable reception - indoor (built-in antenna)
  – [mobile reception]
DVB - T

- OFDM number of carriers:
  - 2 k (UK)
  - 8 k

- Possible modulation:
  - QPSK
  - 16 QAM
  - 64 QAM
DVB - T

◆ Guard interval:
  - 1/4
  - 1/8
  - 1/16
  - 1/32
DVB - T

- Code rates:
  - 1/2
  - 2/3
  - 3/4
  - 5/6
  - 7/8
DVB - T

- Percentage of locations:
  - 70% of locations - “acceptable” reception
  - 95% of locations - “good” reception

[90% of locations in UK]

Location probability factor (ITU-R Rec.P.370-7)
50% to 70%  2.9 dB
50% to 95%  9.0 dB
DVB - T

- **Gaussian channel** (carrier predominant) for fixed reception,
- **Ricean channel** (carrier amplitude similar to noise) for portable outdoor reception,
- **Rayleigh channel** (carrier lost in noise) for portable indoor reception
DVB - T

Possible network configuration:
- Single Frequency Network
- Multiple Frequency Network
- Combinations MFN and SFN
DVB - T

◆ Typical request from broadcasters:

◆ Transition period:
  – 64 QAM, 2/3, fixed reception, good reception, 4 to 5 multiplex

◆ Final stage:
  – 64 QAM, 2/3, portable reception, good reception, 5 to 6 multiplex
Comparison Digital vs. Analogue Terrestrial Television Planning

- Minimum field strengths (ITU-R BT. 417)
- analogue:
  - Band III 55 dB µV/m
  - Band IV 65 dB µV/m
  - Band V 70 dB µV/m
## Minimum Field strength

**Recommendation ITU-R BT. 417**

<table>
<thead>
<tr>
<th>Band</th>
<th>I</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency (MHZ)</strong></td>
<td>55</td>
<td>200</td>
<td>470</td>
<td>790</td>
</tr>
<tr>
<td>Input resistance (75Ω)</td>
<td>1,5</td>
<td>1,5</td>
<td>1,5</td>
<td>1,5</td>
</tr>
<tr>
<td>thermal noise dB(µV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise figure (dB)</td>
<td>9,5</td>
<td>8,5</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Radio-frequency S/N (dB)</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Minimum Rx input voltage dB(µV)</td>
<td>47</td>
<td>46</td>
<td>48,5</td>
<td>49,5</td>
</tr>
<tr>
<td>Dipole conversion factor and mismatch allowance (dB)</td>
<td>2</td>
<td>13</td>
<td>20,5</td>
<td>25</td>
</tr>
<tr>
<td>Antenna gain (dB)</td>
<td>3</td>
<td>7,5</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Cable loss (dB)</td>
<td>1</td>
<td>1,5</td>
<td>3</td>
<td>4,5</td>
</tr>
<tr>
<td><strong>Minimum usable field strength dB (µV/m)</strong></td>
<td>47</td>
<td>53</td>
<td>62</td>
<td>67</td>
</tr>
</tbody>
</table>
Comparison Digital vs. Analogue Terrestrial Television Planning

64 QAM, fixed, good reception, 2/3 code rate, $\Delta = 1/4$, C/N cca 17 dB, 20MBit/s

Field strength: Digital Analogue

- Band III: 45 dBµV/m 55 dBµV/m
- Band IV: 50 dBµV/m 65 dBµV/m
- Band V: 54 dBµV/m 70 dBµV/m
Comparison Digital vs. Analogue Terrestrial Television Planning

64 QAM, portable, good reception, code rate 2/3, $\Delta = 1/4$, C/N = 17 dB

Field strength:  

<table>
<thead>
<tr>
<th>Band</th>
<th>Digital</th>
<th>Analogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>62 dB$\mu$V/m</td>
<td>55 dB$\mu$V/m</td>
</tr>
<tr>
<td>IV</td>
<td>69 dB$\mu$V/m</td>
<td>65 dB$\mu$V/m</td>
</tr>
<tr>
<td>V</td>
<td>73 dB$\mu$V/m</td>
<td>70 dB$\mu$V/m</td>
</tr>
</tbody>
</table>
Comparison Digital vs. Analogue Terrestrial Television Planning

64 QAM, portable indoor acceptable (or good) reception, code rate 2/3, $\Delta = 1/4$, $C/N = 19$ dB

Field strength: Digital Analogue

- Band III: $73 \text{ dB}\mu\text{V/m}$ $55 \text{ dB}\mu\text{V/m}$
- Band IV: $83 \text{ dB}\mu\text{V/m}$ $65 \text{ dB}\mu\text{V/m}$
- Band V: $87 \text{ dB}\mu\text{V/m}$ $70 \text{ dB}\mu\text{V/m}$
Comparison Digital vs. Analogue Terrestrial Television Planning

◆ Protection ratios:
  – co-channel case
  – upper adjacent channel case
  – lower adjacent channel case
Co-channel Interference

- Continuous Interference $T < 50\%$
- Tropospheric Interference $T = 1-10\%$
- Steady state Interference $T = 100\%$
- Precision Offset stability $\pm 1\text{ Hz}$
- Non-precision offset $\pm 500\text{ Hz}$
Comparison Digital vs. Analogue Terrestrial Television Planning

- Cochannel Protection Ratios: Rec. BT.655
- Analogue/Analogue Signals:
  - Trop.    Cont.
  - Non-precision offset:  30 dB    40 dB
  - Precision offset:     22 dB    27 dB
  - Limit of perceptibility: 36 dB    43 dB
Comparison Digital vs. Analogue Terrestrial Television Planning

Adjacent channel analogue/analogue PR:
◆ Lower adjacent channel (B,G): -9 dB
◆ Upper adjacent channel (B,G): -12 dB
Comparison Digital vs. Analogue Terrestrial Television Planning

PR for digital/digital (64 QAM 2/3):

- **Co-channel:**
  - Gaussian: 19 dB (22dB;27dB)
  - Rice: 20 dB
  - Rayleigh: 22 dB

- **Adjacent channel:** -40 dB (-9dB;-12dB)
Comparison Digital vs. Analogue Terrestrial Television Planning

Protection Ratios digital interfered by analogue:
(PAL G/64 QAM,2/3)

- **Co-channel:** 4 dB  (22;27 dB)
- **Lower adjacent:** -34 dB  (-9 dB)
- **Upper adjacent:** -38 dB  (-12 dB)
Comparison Digital vs. Analogue Terrestrial Television Planning

Protection Ratios analogue interfered by digital:

(64 QAM, 2/3, PAL G)

- Co-channel: 34(40) dB (22;27 dB)
- Lower adjacent: -7(-4) dB (-9 dB)
- Upper adjacent: -9(-7) dB (-12 dB)
Frequency Planning

- Chester Agreement - 97 (Technical Criteria, Coordination Principles and Procedures for introduction of DVB-T)
- Reference situation - 0.3 dB degradation
Frequency Planning Strategy

- Select optimal option for your country (number of national, regional and local networks - multiplexes)
- Study possibilities for frequency planning during simulcast period
- Frequency plan for all digital situation
- Plan for transition from simulcast to all digital period - coordinated with neighboring countries
Future of television planning

- Mobile television
- Interactive television
Mobile television

- DVB - T
- ISDB - T
- Mobile reception in the case of DVB-T is limited by Doppler frequency shift.
- At the VHF the maximal velocity is higher as at the UHF.
Interactivity

Broadcasting delivery media: ISDN/B-ISDN/ADSL
Satellite
CATV
SMATV
Terrestrial
MMDS/LMDS

Interaction media: PSTN/ISDN/B-ISDN/ADSL
HFC
Satellite (VSAT)
Coax + VSAT
Terrestrial
GSM
MMDS/LMDS
Internet

Transmission network independent

Forward interaction path

Transmission network physical link