Content

- History of Television Technology in Thailand
- Introduction to DVB
- Basic of DVB-T2
- Key Features of DVB-T2
- DVB-T2 Planning
- NBTC Notifications on DTTB Technical Standards and Frequency Plan
History of Television Technology in Thailand

- **B.E.2498 (1955)**
  First Black/White Television Transmission in Thailand
  “Channel 4 Bangkhunphrom”
  FCC 525 Lines (Black/White)

- **B.E.2510 (1967)**
  Color Television Broadcast Station (Analog Station)
  CCIR PAL 625 Lines

- **B.E.2556 (2013)**
  Digital Television Broadcast Station
  Royal Thai Army (Ch.5) starts trial transmission from Baiyok II Tower on January 25, 2013
  DVB-T2

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History of Television Technology in Thailand (National Frequency Plan)

- **Frequency Plan for VHF Analog Television**
  B.E.2528 (1985)

- **Frequency Plan for UHF Analog Television**
  B.E.2530 (1987)

- **Frequency Plan for VHF/UHF Analog Television**
  B.E.2539 (1996)

- **NBTC Frequency Plan for Digital Terrestrial Television Broadcasting**
  B.E.2555 (2012)
Broadcasting Service Master Plan (2012 – 2016)

Strategy 5.6 of the master plan: “Transition to Digital Television and Digital Radio”

- Shall begin the digital terrestrial television broadcasting within 4 years
- 80% of Households in major cities shall be able to receive digital radio and digital television services within 5 years

Introduction to DVB
Second Generation of DVB Systems

- Driver for 2nd generation
  - Additional capacity for HD and 3D
  - Improved chip set technology
  - New algorithms
  - New business models

- Features of 2nd generation
  - Close to theoretical limits
  - Capacity and/or robustness increase
  - Support of new delivery schemes

- DVB S2®
  - At least 30% more capacity
  - 3 dB more robust
  - Millions of receivers deployed

- DVB T2®
  - At least 50% more capacity
  - 6 dB more robust
  - Millions of receivers deployed

- DVB C2®
  - At least 50% more capacity
  - 6 dB more robust
  - Receivers now available
Basic of DVB-T2

Basic DVB-T2 Transmission Systems
Fundamental Technology of DVB-T2

**COFDM**
- Coded
- Orthogonal
- Frequency Division Multiplex

**Use of Forward Error Correction**
- No cross talk between subcarriers
- Distribution of data stream over a lot of subcarriers

**FEC**
- **Inner**
  - LDPC (Low Density Parity Check)
  - BCH (Bose-Chaudhuri-Hocquenghem)
- **Outer**

**FFT size**
- 32K
- 16K
- 8K
- 4K
- 2K
- 1K

**Number of carriers**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1K</th>
<th>2K</th>
<th>4K</th>
<th>8K</th>
<th>16K</th>
<th>32K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of carriers (Extended Mode)</td>
<td>853</td>
<td>1705</td>
<td>3409</td>
<td>6817 (6912)</td>
<td>13633 (13920)</td>
<td>27265 (27840)</td>
</tr>
<tr>
<td>Carrier Spacing (Hz)</td>
<td>8929</td>
<td>4464</td>
<td>2232</td>
<td>1116</td>
<td>558</td>
<td>279</td>
</tr>
<tr>
<td>Duration (µs)</td>
<td>112</td>
<td>224</td>
<td>448</td>
<td>896</td>
<td>1792</td>
<td>3584</td>
</tr>
</tbody>
</table>
**OFDM subcarriers**

Channel bandwidth:
10, 8, 7, 6, 5, 1.7 MHz

**Basic OFDM**

Conventional systems consider indirect path as interferer.

OFDM systems use indirect path signal to increase signal level.
Guard Interval = Time Slot between Symbols

FFT Modes

<table>
<thead>
<tr>
<th>$\Delta f$ [Hz]</th>
<th>$T_U$ [μs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 929</td>
<td>112</td>
</tr>
<tr>
<td>4 404</td>
<td>224</td>
</tr>
<tr>
<td>2 232</td>
<td>448</td>
</tr>
<tr>
<td>1 116</td>
<td>896</td>
</tr>
<tr>
<td>568</td>
<td>1702</td>
</tr>
<tr>
<td>279</td>
<td>3584</td>
</tr>
<tr>
<td><strong>8 MHz</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: LS Telcom
Guard Interval

- 8K symbol: 25% overhead
- 32K symbol: 6% overhead

<table>
<thead>
<tr>
<th>FFT size</th>
<th>1/128</th>
<th>1/32</th>
<th>1/16</th>
<th>19/256</th>
<th>1/8</th>
<th>19/128</th>
<th>1/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>32K</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>16K</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8K</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4K</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td>2K</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td>1K</td>
<td>--</td>
<td>--</td>
<td>X</td>
<td>--</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
</tbody>
</table>

SISO Mode

Key Features of DVB-T2
Key Features of DVB-T2

1. Forward Error Correction: LDPC
2. Modulation
3. Extended Bandwidth Mode
4. Rotated Constellation
5. Pilot Patterns
6. Physical Layer Pipes (PLPs)
7. Single Frequency Network (SFN)

1. Forward Error Correction

Forward Error Correction: the code rate is $k/n$, for every $k$ bits of useful information, the coder generates totally $n$ bits of data, of which $n-k$ are redundant. [Wiki]
2. Modulation

- Higher order modulation in DVB-T2 (up to 256QAM)
- Can carry up to 8 bits per carrier
Modulation (2)

<table>
<thead>
<tr>
<th>Modulation Pattern</th>
<th>QPSK</th>
<th>16-QAM</th>
<th>64-QAM</th>
<th>256-QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit per symbol</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>DVB-T Min C/N [dB] (CR=2/3, Ricean)</td>
<td>7</td>
<td>13.1</td>
<td>18.6</td>
<td>NA</td>
</tr>
<tr>
<td>DVB-T2 Min C/N [dB] (CR=2/3, Ricean)</td>
<td>5.2</td>
<td>10.8</td>
<td>15.5</td>
<td>19.7</td>
</tr>
</tbody>
</table>

Source: ETSI TS 102 831

Modulation, Code Rate, and Bitrate

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code rate</th>
<th>Bitrate (Mbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td>1/2</td>
<td>7.4442731</td>
</tr>
<tr>
<td></td>
<td>3/5</td>
<td>8.9457325</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>9.9541201</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>11.1979220</td>
</tr>
<tr>
<td></td>
<td>4/5</td>
<td>11.9486510</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>12.4565530</td>
</tr>
<tr>
<td>16-QAM</td>
<td>1/2</td>
<td>15.0374320</td>
</tr>
<tr>
<td></td>
<td>3/5</td>
<td>18.0703800</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>20.1073230</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>22.6198020</td>
</tr>
<tr>
<td></td>
<td>4/5</td>
<td>24.1362760</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>25.1622360</td>
</tr>
<tr>
<td>64-QAM</td>
<td>1/2</td>
<td>22.4817050</td>
</tr>
<tr>
<td></td>
<td>3/5</td>
<td>27.0161120</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>30.0614430</td>
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<tr>
<td></td>
<td>3/4</td>
<td>33.8177240</td>
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<td></td>
<td>4/5</td>
<td>36.0849270</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>37.6187890</td>
</tr>
<tr>
<td>256-QAM</td>
<td>1/2</td>
<td>30.0748630</td>
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<td></td>
<td>3/5</td>
<td>36.1407590</td>
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<td></td>
<td>2/3</td>
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<td>48.2725520</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>50.3244720</td>
</tr>
</tbody>
</table>

@ 8MHz, 32K Mode, GI 1/128, PP7

Source: ETSI TS 102 831
3. Extended Bandwidth Mode

- Out-of-band spectrum for 32K mode falls away more quickly than spectrum for 2K mode
- Allow 2% extra bandwidth/capacity whilst remaining within normal spectrum mask

Source: ITU Workshop – BKK Feb 2012

Extended Bandwidth Mode (2)

32k and 32k extended (10 MHz Span)  
32k and 32k extended (1 MHz Span)
4. Rotated Constellation

- Information of bits is presented on each axis (Projection on each axis)
- Additional information for soft decision decoding
- Up to 5 dB robustness gain

Rotation angle for each modulation type:

<table>
<thead>
<tr>
<th>Mod.</th>
<th>QPSK</th>
<th>16QAM</th>
<th>64QAM</th>
<th>256QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Phi$ (°)</td>
<td>29.0</td>
<td>16.8</td>
<td>8.6</td>
<td>$\arctan(1/16)$</td>
</tr>
</tbody>
</table>

Source: LS Telcom
Rotated Constellation (3) (Robustness)

- Rotated constellations provide significantly improved robustness against loss of data cells
- No degradation (nor gain) in Gaussian channel
- Can achieve gains of 5-7 dB on difficult channels e.g. 15% cell loss channel
- Can translate into increased bit rate by choosing less robust FEC with lower overhead

Comparison of performance for rotated/non-rotated constellations (code rate=4/5; channel = Rayleigh + 15% erasures of subcarriers)  

Source: DVB Presentation

5. Pilot Pattern

- Scattered pilots of pre-defined amplitude and phase are inserted into the signal at regular intervals in both time and frequency directions
- All of the pilots can potentially be used for synchronization
- The scattered, P2 and Frame-Closing pilots can be used for channel estimation
- The continual, P2 and Frame-Closing pilots can be used for Common-Phase-Error correction
- DVB-T only one Pattern, DVB-T2 different Pilot Patterns (PP1-PP8) are defined depending on FFT size and Guard Interval
  - Dense PP means better channel estimation – less data rate
  - Not all PPs are available for all T2 configurations (Mode and GI)
Pilot Pattern (2)

P2 symbols
Normal symbols
Frame closing symbol

- Continual Pilots
- P2 Pilots
- Scattered Pilots
- Frame Closing Pilots

Pilot Pattern (3)

Less pilots = Less overhead

<table>
<thead>
<tr>
<th>FFT size</th>
<th>PP1</th>
<th>PP2</th>
<th>PP3</th>
<th>PP4</th>
<th>PP5</th>
<th>PP6</th>
<th>PP7</th>
<th>PP8</th>
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</thead>
<tbody>
<tr>
<td>32K</td>
<td>PP7</td>
<td>PP7</td>
<td>PP7</td>
<td>PP7</td>
<td>PP7</td>
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<td>PP7</td>
</tr>
<tr>
<td>16K</td>
<td>PP7</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
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<tr>
<td>8K</td>
<td>PP7</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
<td>PP4</td>
</tr>
<tr>
<td>4K</td>
<td>-</td>
<td>PP7</td>
<td>PP4</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
</tr>
<tr>
<td>2K</td>
<td>-</td>
<td>-</td>
<td>PP4</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
</tr>
<tr>
<td>1K</td>
<td>-</td>
<td>-</td>
<td>PP4</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
<td>PP5</td>
</tr>
</tbody>
</table>

Guard interval | 1/128 | 1/32 | 1/16 | 19/256 | 1/8 | 19/128 | 1/4 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>32K</td>
<td>PP7</td>
<td>PP4</td>
<td>PP8</td>
<td>PP8</td>
<td>PP2</td>
<td>PP2</td>
<td>PP2</td>
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<tr>
<td>16K</td>
<td>PP7</td>
<td>PP4</td>
<td>PP8</td>
<td>PP8</td>
<td>PP2</td>
<td>PP2</td>
<td>PP2</td>
</tr>
<tr>
<td>8K</td>
<td>PP7</td>
<td>PP4</td>
<td>PP8</td>
<td>PP8</td>
<td>PP2</td>
<td>PP2</td>
<td>PP2</td>
</tr>
<tr>
<td>4K</td>
<td>-</td>
<td>PP7</td>
<td>PP4</td>
<td>PP5</td>
<td>PP2</td>
<td>PP2</td>
<td>PP2</td>
</tr>
<tr>
<td>2K</td>
<td>-</td>
<td>-</td>
<td>PP4</td>
<td>PP5</td>
<td>PP2</td>
<td>PP2</td>
<td>PP2</td>
</tr>
<tr>
<td>1K</td>
<td>-</td>
<td>-</td>
<td>PP4</td>
<td>PP5</td>
<td>PP2</td>
<td>PP2</td>
<td>PP2</td>
</tr>
</tbody>
</table>

Source: ETSI EN 302755
6. Physical Layer Pipes (PLPs)

- The concept of Physical Layer Pipes in DVB-T2 enables a number of services having different modulation characteristics to be transmitted through the one RF channel at the same time.
- Each input stream (PLP) is processed independently: FEC coding, mapping into constellation (QPSK, 64QAM,...) and interleaving (bit, time, frequency).
- All PLP's share same FFT, GI and pilot pattern (PP) Unless use FEF (Future Extension Frame)
- Up to 256 PLP available in one RF Channel with different C/N thresholds

Concept of PLPs

- Each slice of (data cells) is part of a Physical Layer Pipe (PLP) for that service
- Also enables power saving in the receiver
Concept of PLPs

- **Mode A** - Single PLP
- **Mode B** - Multiple PLP
  - Service-specific robustness
    - Constellation
    - Codes rate
    - Time-interleaving depth
    - Time Frequency Slicing (TFS) (in Future)
  - Up to 255 PLP
  - Portable and mobile services? – (Unlikely in networks based on Fixed coverage)
  - Regionalisation solutions
  - More complex – specifically in SFN
  - T2-MI distribution

Source: Multichoice
**Fixed and Configurable Parameters**

<table>
<thead>
<tr>
<th>Fixed Parameters per Multiplex</th>
<th>Configurable Parameters per PLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>Constellation (QAM)</td>
</tr>
<tr>
<td>Carrier Mode</td>
<td>Rotated Constellation</td>
</tr>
<tr>
<td>Pilot Pattern</td>
<td>Code Rate</td>
</tr>
<tr>
<td>Guard Interval</td>
<td>Interleaving</td>
</tr>
<tr>
<td>PAPR</td>
<td></td>
</tr>
<tr>
<td>MISO</td>
<td></td>
</tr>
</tbody>
</table>

**MPLP Demo at Broadcast Asia 2011**

- **DVB-T2**
  - Multiple Physical Layer Pipes
  - 3D & HD: Rooftop antenna, 3D = 16 Mb/s, HD = 10 Mb/s, C/N = 23.4 dB
  - SD: Indoor antenna, 2 x SD = 4 Mb/s, C/N = 10.5 dB
  - Mobile: 0.5 Mb/s, C/N = 3.3 dB

Source: LS Telcom, DVB Presentation
7. Single Frequency Network (SFN)

- Single Frequency Network (SFN) is a network of synchronized transmitter stations radiating identical signal in the same RF channel (defined in GE06, p46).

Synchronization

1pps pulse

GPS

MIP = Megaframe Initialization Packet

MIP/SIP Inserter

Playout Center

Tx1, RF1

Tx2, RF1

Tx3, RF1

Tx4, RF1

Tx5, RF1

GPS: Global Positioning System
What makes SFN operation possible

- Clocked transmission
- Time- and Frequency Synchronization
- Provision of a Guard Interval

Signals in SFN

Source: Multichoice
SFN Network

- โครงข่ายแบบ SFN ถือได้ว่ามีจุดเด่นเรื่องประสิทธิภาพการใช้งานคลื่นความถี่อย่างมากเนื่องจากใช้ทรัพยากรคลื่นความถี่น้อยลง

- แตกติ่งมีข้อจำกัดเรื่องของการรวมคลื่นแบบ self-interference หรือ inter-symbol interference ซึ่งเกิดจากผลข้อยาวจากแต่ละสถานีส่งแต่ละช่องว่างในเวลาไม่พร้อมกันและออกนอกกรอบเวลาของ guard interval

- ดังนั้นโครงข่ายแบบ SFN ซึ่งอาศัยเทคโนโลยี COFDM จึงมีข้อจำกัดเรื่องของการระยะทางสูงสุดของเครือข่าย เพื่อให้แน่ใจว่าสัญญาณจากแต่ละสถานีส่งไปถึงแต่ละจุดของเขตบริการยังอยู่ในกรอบเวลาของ guard interval

DVB-T2 Planning
**DVB-T2 Planning**

- **Reception Mode**
  - Fixed Rooftop
  - Portable Outdoor
  - Portable Indoor

- **Parameter Set**

- **Capacity Planning**
  - Capacity vs Robustness

- **Coverage Planning** (Required C/N and Required FS)

- **Interference and Protection Ratio**
# Reception Mode

![Diagram of reception mode with antennas and signal losses](image)

## Parameter Set

### FFT Size and Guard Interval Fraction

<table>
<thead>
<tr>
<th>FFT Size</th>
<th>Guard Interval Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1K</td>
<td>1/16, 1/8, 1/4</td>
</tr>
<tr>
<td>2K</td>
<td>1/32, 1/16, 1/8, 1/4</td>
</tr>
<tr>
<td>4K</td>
<td>1/32, 1/16, 1/8, 1/4</td>
</tr>
<tr>
<td>8K</td>
<td>1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4</td>
</tr>
<tr>
<td>16K</td>
<td>1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4</td>
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<tr>
<td>32K</td>
<td>1/128, 1/32, 1/16, 19/256, 1/8, 19/128</td>
</tr>
<tr>
<td>8K extended</td>
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<tr>
<td>16K extended</td>
<td>1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4</td>
</tr>
<tr>
<td>32K extended</td>
<td>1/128, 1/32, 1/16, 19/256, 1/8, 19/128</td>
</tr>
</tbody>
</table>

### Modulation and Code Rate

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code Rate</th>
</tr>
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<tbody>
<tr>
<td>QPSK</td>
<td>1/2, 3/5, 2/3, 3/4, 4/5, 5/6</td>
</tr>
<tr>
<td>16-QAM</td>
<td></td>
</tr>
<tr>
<td>64-QAM</td>
<td></td>
</tr>
<tr>
<td>256-QAM</td>
<td></td>
</tr>
</tbody>
</table>

### Example Parameter Sets:

- **32K**: PP7, PP4, PP6, PP2, PP8, PP4, PP5, PP2, PP8, PP2, PP8, PP8, PP8, PP1, PP8
- **16K**: PP7, PP4, PP6, PP2, PP8, PP4, PP5, PP2, PP8, PP3, PP8, PP8, PP8
- **8K**: PP7, PP4, PP5, PP2, PP8, PP4, PP5, PP2, PP8, PP3, PP8, PP1, PP8
- **4K**: PP7, PP4, PP5, PP2, PP3, PP1
- **2K**: PP7, PP4, PP5, PP2, PP3, PP1
- **1K**: - PP4, PP5, PP2, PP3, PP1
Capacity vs Robustness

- Robustness
  - data capacity (no. channels) against
  - transmitter power level (or network cost)

- Modulation
  - Method of shaping the signal with the data to be broadcast e.g., QPSK, 16 QAM, 64 QAM.
  - Determines the capacity of a network (number of channels).

  Higher order Modulation
  • Delivers more channels
  • More critical
  • Requires more signal (C/N)
  • Higher cost

QPSK

16QAM

64QAM

Interference

Higher Order Modulation

 Capacity vs Robustness (2)

To have same coverage, higher order modulation requires higher tx power

Table A.1: Required C/N for non-hierarchical transmission to achieve a BER = 2 x 10^-4 after the Viterbi decoder for all combinations of coding rates and modulation types

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code Rate</th>
<th>Gaussian Channel</th>
<th>Ricean Channel</th>
<th>Rayleigh Channel</th>
<th>Delta T_u = 1/8</th>
<th>Delta T_u = 1/16</th>
<th>Delta T_u = 1/32</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td>1/2</td>
<td>3.4</td>
<td>3.6</td>
<td>5.4</td>
<td>4.98</td>
<td>5.53</td>
<td>5.85</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>4.9</td>
<td>4.6</td>
<td>6.5</td>
<td>6.64</td>
<td>7.37</td>
<td>7.81</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>5.9</td>
<td>6.6</td>
<td>10.7</td>
<td>7.46</td>
<td>9.29</td>
<td>9.76</td>
</tr>
<tr>
<td></td>
<td>3/5</td>
<td>6.9</td>
<td>8.0</td>
<td>13.1</td>
<td>8.29</td>
<td>9.92</td>
<td>10.76</td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>7.7</td>
<td>8.7</td>
<td>15.3</td>
<td>6.71</td>
<td>9.66</td>
<td>10.35</td>
</tr>
<tr>
<td>16QAM</td>
<td>2/3</td>
<td>11.2</td>
<td>11.6</td>
<td>14.3</td>
<td>13.67</td>
<td>14.75</td>
<td>15.86</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>12.5</td>
<td>13.0</td>
<td>15.9</td>
<td>14.95</td>
<td>16.09</td>
<td>17.19</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>13.5</td>
<td>14.4</td>
<td>19.3</td>
<td>16.59</td>
<td>19.52</td>
<td>20.11</td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>15.8</td>
<td>18.5</td>
<td>22.8</td>
<td>17.73</td>
<td>19.35</td>
<td>20.49</td>
</tr>
<tr>
<td>64QAM</td>
<td>1/2</td>
<td>14.5</td>
<td>14.7</td>
<td>15.0</td>
<td>16.69</td>
<td>18.59</td>
<td>19.76</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>16.5</td>
<td>17.1</td>
<td>19.5</td>
<td>19.21</td>
<td>21.22</td>
<td>23.42</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>18.0</td>
<td>18.6</td>
<td>22.0</td>
<td>21.34</td>
<td>23.65</td>
<td>25.47</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>19.3</td>
<td>20.2</td>
<td>24.6</td>
<td>24.06</td>
<td>26.35</td>
<td>28.74</td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>20.7</td>
<td>21.0</td>
<td>27.9</td>
<td>26.13</td>
<td>29.03</td>
<td>31.70</td>
</tr>
</tbody>
</table>

Note 1: Figures in italics are rounded to the nearest values.

Note 2: 

Adapted from source: ETSI EN 300744, available for download at www.etsi.org
**Modulation Scheme**

- QPSK (2 bits/symbol)
- 16QAM (4 bits/symbol)
- 64QAM (6 bits/symbol)

**Error Correction**

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

Note: From DVB-T

---

**Guard Interval**

- 1/4
- 1/8
- 1/16
- 1/32

Longer symbol period to combat multipath effect

Note: From DVB-T
## Coverage Planning

* Extracted from EBU Tech 3348

<table>
<thead>
<tr>
<th>Reception Mode</th>
<th>Fixed</th>
<th>Portable Outdoor</th>
<th>Portable Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fm (MHz)</strong></td>
<td>650</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td><strong>DVB-T2</strong></td>
<td>64-QAM, FEC 2/3, 32k Extended, PP7</td>
<td>64-QAM, FEC 2/3, 16k Extended, PP1</td>
<td></td>
</tr>
<tr>
<td><strong>FEC</strong></td>
<td>2/3</td>
<td>2/3</td>
<td>2/3</td>
</tr>
<tr>
<td><strong>QAM</strong></td>
<td>256</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td><strong>Data Rate</strong></td>
<td>20.0 Mbit/s</td>
<td>17.9 Mbit/s</td>
<td>18.3 Mbit/s</td>
</tr>
<tr>
<td><strong>C/N (dB)</strong></td>
<td>20.0</td>
<td>17.9</td>
<td>18.3</td>
</tr>
<tr>
<td><strong>Success Rate</strong></td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td><strong>Minimum Field Strength (E_{med})</strong></td>
<td>54.3 \text{dB} \mu \text{V/m}</td>
<td>60.2 \text{dB} \mu \text{V/m}</td>
<td>75.9 \text{dB} \mu \text{V/m}</td>
</tr>
</tbody>
</table>

### Required C/N and Required Field Strength

Calculations and Methodologies are based on NBTC Frequency Plan (Reference : EBU Tech 3348)

<table>
<thead>
<tr>
<th>Channel</th>
<th>C/N</th>
<th>Field Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(dB) \mu V/m</td>
</tr>
<tr>
<td>1</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>2</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>3</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>4</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>5</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>6</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>7</td>
<td>650</td>
<td>650</td>
</tr>
</tbody>
</table>

### Propagation Model

**Required C/N and Required Field Strength**

The required C/N and field strength are calculated based on the NBTC Frequency Plan (Reference: EBU Tech 3348). The propagation model is used to determine the maximum coverage distance. The field strength is expressed in dB \mu V/m.
NBTC Notifications on Technical Standards

- ประกาศกสทช. เรื่อง มาตรฐานทางเทคนิคสำหรับการให้บริการโทรทัศน์ภาคพื้นดินในระบบดิจิตอล
- ประกาศกสทช. เรื่อง มาตรฐานทางเทคนิคสำหรับเครื่องรับสัญญาณโทรทัศน์ภาคพื้นดินในระบบดิจิตอล

NBTC Notification on Technical Standard for DTTB Transmission
Summary of NBTC Technical Standard on DTTB Transmission

Scope:
Minimum requirement for equipments in free-to-air DVB-T2 transmission systems

Frequency Range:
510-790 MHz with 8 MHz Bandwidth

Baseband signal and compression
Video coding: MPEG-4 AVC/H.264
SD 576i | HD 720p | HD 1080i
Audio coding: MPEG-4 HE-AACv2

Transmission
Framing Structure, Channel Coding and Modulation: ETSI EN 302 755
Single Frequency Network: ETSI TS 101 191
Summary of NBTC Technical Standard on DTTB Transmission (2)

- Multiplexing
  - Service Information (SI): ETSI EN 300 468
  - Data Broadcasting: ETSI EN 301 192
  - MPEG-2 Transport Stream: ETSI TS 101 154
  - Modulator Interface (T2-MI) (if any SFN or MPLP operation): ETSI TS 102 773

- System Software Update: SSU: ETSI TS 102 006
- Subtitling: ETSI EN 300 743

NBTC Notification on Technical Standard for DTTB Receiver
Summary of
NBTC Technical Standard on DTTB Receiver

Based on Specification from Malaysia and Singapore and Draft ASEAN Common Specification

1. Scope
2. General Requirements
3. System Software Update
4. Service Information and Display
5. Video and Audio Decoding
6. De-multiplexing and Transport Stream
7. RF Tuner and Decoder Requirement
8. Connector and Interface

1.1 Electrical Safety:
   TIS.1195-2536

2.2 Electromagnetic Compatibility:
   CISPR13/TIS.2185-2547

2.3 Installation and Usage
   Must supply with installation manual and instruction manual both Thai and English language

2.4 Remote Control
   Must supply with remote control with the tactile marking on the ‘5’ button
Summary of NBTC Technical Standard on DTTB Receiver (3)

3. Connectors and Interfaces

<table>
<thead>
<tr>
<th>RF Input Connector/RF Loop-through</th>
<th>RCA</th>
<th>HDMI</th>
</tr>
</thead>
</table>

4. RF Tuner and Decoder Requirements

4.2 Radio Frequency Requirements
- 470-862 MHz
- BW 8 MHz
- NF < 6dB
- Sensitivity < -78.3 dBm
- off-set ± 125KHz

4.2 DVB-T2 Operating Modes
- ETSI EN 302 755
- Support MPLP and SFN

5. De-multiplexing and Transport Stream
- ETSI TS 101 154
- ISO/IEC 13818-1

6. Video and audio
- Video coding: MPEG-4 AVC/H.264
- Resolution: SD 576i | HD 720p/1080i
- AFD (Active Format Description)
- Audio coding: MPEG-4 HE-AACv2

Summary of NBTC Technical Standard on DTTB Receiver (4)

7. Processing and Display

7.1 Processor and Memory
- DDRAM ≥ 64 MB
- Flash ≥ 8MB
- Processor ≥ 300 MHz

7.2 Character set: ETSI EN 300 468 Table 00 and Table 07

7.3 On Screen Display: OSD: Thai and English

7.4 Subtitling system: ETSI EN 300 743 and support DDS (Display Definition Segment)

7.5 Multi-Language Support: THA | ENG | QAA

7.6 Services and Channel Number: 1-799 for National service (ONID 0x22FC)
- 800-999 for other services

7.7 Logical Channel Descriptor

7.8 Electronic Program Guide: EPG: shall restore program information for next 7 days

7.9 Signal Strength and Signal Quality

8. System Software Update: SSU
- ETSI TS 102 906
NBTC Notification on DTTB Frequency Plan

Summary of NBTC Technical Standard on DTTB Frequency Plan

- In accordance with Thailand’s Table of Frequency Allocation

<table>
<thead>
<tr>
<th>Allocation to services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thailand</strong></td>
</tr>
<tr>
<td>510-790</td>
</tr>
<tr>
<td>BROADCASTING</td>
</tr>
<tr>
<td>Fixed</td>
</tr>
<tr>
<td>Mobile</td>
</tr>
<tr>
<td>5.149 5.306 5.311A</td>
</tr>
</tbody>
</table>

- Bandwidth 8 MHz
- Frequency channel number: Channel No. 26 to 60 (Total 35 Channels)
- 39 service areas, consist of 39 main stations and 114 gap-filling stations
- 5 multiplexes (MUX) per service area (during simulcast period)
Summary of NBTC Technical Standard on DTTB Frequency Plan (2)

35 channels are divided into 6 groups (D1-D6), plus 2 special groups (T-D1-T-D2)

<table>
<thead>
<tr>
<th>Group</th>
<th>Channels in each group</th>
<th>Channel for DTTB in each group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N-3</td>
<td>N</td>
</tr>
<tr>
<td>D1</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>D2</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>D3</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>D4</td>
<td>7</td>
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<td>D5</td>
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<td>D6</td>
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<td>T-D1</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>T-D2</td>
<td>7</td>
<td>-</td>
</tr>
</tbody>
</table>

Note 1) Based on Radio Frequency Plan for Analog TV
Note 2) Channels in red are for DTTB implementation along THA-MLA border areas

Thank you