ISDBT Workshop

March 12, 2015
Manila, Philippines

Featuring GatesAir’s
Martyn Horspool
Product Manager, TV Transmission
ISDBT Workshop

Manila, Philippines, March 12, 2015

Martyn Horspool
Product Manager, TV Transmission
GatesAir
Today’s Agenda

- Welcome/Introductions
- GatesAir… Brief Introduction and History
- Review of COFDM Modulation Characteristics (on thumb drive only)
- ISDB-T Overview/Training
- ISDB-T Single Frequency Network (SFN) and GatesAir Solution
- ISDB-T Coverage and Planning
- New High-Efficiency Transmitter Products for ISDB-T:
  - High Power Liquid-Cooled Solid State (ULXT)
  - Low and Medium Power Air-Cooled Solid State (UAXT & UAXT Ultra Compact)
- GA experience and Site References for ISDB-T Deployments
- Challenges and Lessons Learned
- Q&A and lucky draw for prizes
GatesAir

Brief Overview and History
Introduction & History of GatesAir

- **1922** – Gates Radio starts business. Parker Gates was only 15 years old
- **1950** - Gates Radio had become a major Radio equipment supplier in USA
- **1957** – Harris Corporation acquires Gates Radio
- **2013** – Gores Group acquires Harris Broadcast Division
- **2014** – Harris Broadcast splits into two companies – Imagine Communications and GatesAir
1922: First Commercial Radio Station
1929: First TV Broadcast
1957: Harris Acquires Gates Radio
1996: First Digital TV Broadcast
2008: Mobile TV
What’s Next: UltraHD, LTE Broadcast

Connecting What’s Next
GatesAir Products Support All Standards

**Flexiva™ – Studio**
- Analog Audio
- AES/EBU
- TCP/IP
- Ethernet / CAT5
- USB

**Intraplex™ – STL**
- T1/E1
- AES67 / IP
- TDM / RJ-48C
- BNC
- RF

**Flexiva™ – Radio**
- AM / FM
- HD Radio
- DRM
- DAB

**Maxiva™ – TV**
- UHF / VHF
- ATSC – DVB-T/T2
- ISDB-T – CTTB
- CMMB – DAB
Best-In-Class Transmission Solutions

- Market leader in transmission solutions for core broadcasters, network operators and government-sponsored broadcast networks
- Lowest transmission total cost of ownership (TCO) for broadcasters worldwide
- Innovative, world class products that solve evolving customer needs
- Exceptional pre- and post-sales services
- Unique capability to deliver transmission solutions that enable new revenue
Customers Around The World...

- Customers include top media companies around the world
- Systems are mission-critical to customer’s business
- Long-term customers in over 100 countries with relationships ranging up to 70+ years
Committed to Providing the Best Service

- We do what it takes to help our customers succeed
- 24/7 service with training centers, repair centers, and parts depots around the world
- Our support teams consist of innovative technical experts who can offer project planning and management, on-site service, and commissioning
- Support situations involving product performance, integration, and operational processing
- Superior, industry-competitive warranties
- Service package options are available
Product Portfolio

Create

- Networked Digital Radio Studios

Transport

- Contribution & Distribution: IP - TDM - RF

Transmit Radio

- AM - FM - DAB Analog & Digital

Transmit TV

- VHF - UHF Analog & Digital
TRANSMIT: Television Broadcast Solutions

The industry’s most efficient, high-performance transmitters with the lowest TCO

GatesAir’s legacy of innovation in over-the-air UHF and VHF is unsurpassed

Ongoing support for standard changes that will occur over the life of a transmitter

**UHF and VHF Transmitters**
- Low-to-high power, high quality signal in all formats/standards
- Deliver rich, multi-format content for all coverage needs
- Facilitate multiple, updatable modulation schemes
- Deploy TV or DAB digital radio content transmission via VHF
- Remotely monitor and analyze signal via web interface

**TV Accessories**
- Operate multiple transmitters on the same frequency
- Improve coverage, boost redundancy, increase up-time
Television: Maxiva Product Family

**UHF Band IV/V**
- Low Power Air Cooled: 5W
- High Power Liquid Cooled: 2kW
- Super High Power LC: 40kW+

- Maxiva™ UAXT (Low Power Air Cooled)
- Maxiva™ ULXT (High Power Liquid Cooled)
- Maxiva™ ULXT (Multi-rack, Super High Power LC)

**VHF Band III**
- Low Power Air Cooled: 2kW
- High Power Liquid Cooled: 10kW
- Super High Power LC: 40kW+

- Maxiva™ VAX-3D (VHF Band III)
- Maxiva™ VLX (VHF Band III)

Supports All Standards, Including:
- DVB-T2
- ISDB-T

Proprietary and confidential.
Advanced Technology

- VHF and UHF Broadband High Efficiency technology for digital TV and radio delivers lowest total cost of ownership
- Software defined modulation capability addresses today’s needs and tomorrow’s opportunities

Introducing Maxiva™ with PowerSmart® 3D
Best-in-class broadband performance with no tradeoff in efficiency

- 40% less weight
- 50% less volume
- 44% lower cost
- 55% more efficient
What is **PowerSmart®**?

**PowerSmart®** is the on-going GatesAir design initiative to create the most efficient transmitter designs and products. GatesAir leverages the most sophisticated tools to develop cost, energy, and space efficient solutions.

**Television**

The Maxiva™ family of UHF transmitters led this initiative with the first 50V LDMOS device-driven transmitter in the industry setting a new benchmark for power density and efficiency.

**Radio**

The Flexiva™ family of FM transmitters set new benchmarks with operating efficiencies of up to 72%, the first FM design to use 50V LDMOS devices, and the smallest footprint at 10kW and higher power levels.
GatesAir is an active member, partnered with, or sponsors:

- ATSC
- DVB Project Office
- World DMB
- DRM Consortium
- Ibiquity (HD Radio)
- Mackenzie University, São Paulo, Brazil
- ABU, Asia-Pacific Broadcast Union
COFDM Modulation (Modulation Mapper)

01101100
Data (t)

Data (t) 01101100

I (t)

Q (t)

Each Subcarrier is modulated QPSK, DQPSK, 16QAM, or 64QAM
Modulation (Visualization of COFDM Modulation)

Data Stream

Separation into Symbols

COFDM Modulation

Guard Interval

Useful Symbol Duration
Subcarrier Modulation

QPSK
- 4 carrier positions
- A QPSK carrier can transport 2 bits

QPSK = Quadrature Phase Shift Key

16-QAM
- 16 carrier positions
- A 16-QAM carrier can transport 4 bits

16-QAM = Quadrature Amplitude Modulation

64-QAM
- 64 carrier positions
- A 64-QAM carrier can transport 6 bits

64-QAM = Quadrature Amplitude Modulation
QPSK Modulation

Constellation Diagram of a QPSK signal as generated in the transmitter.

Inaccuracy caused by noise added in the transmission channel.

Maximum allowed inaccuracy for error free reception.

Constellation Diagram of a QPSK Signal as received by a receiver.

AWGN (Noise) on a QPSK signal at receiver.
16 QAM Sub Carrier Modulation

Constellation Diagram of a 16-QAM signal as generated in the transmitter

Inaccuracy caused by noise added in the transmission channel

Maximum allowed inaccuracy for error free reception

Constellation Diagram of a 16-QAM Signal as received by a receiver
64 QAM Sub Carrier Modulation

Inaccuracy caused by noise added in the transmission channel

Maximum allowed inaccuracy for error free reception

Constellation diagram of a 64-QAM signal as generated in the transmitter

Constellation Diagram of a 64-QAM Signal as received by a receiver
Guard Interval

- The guard interval is used to ensure that distinct transmissions do not interfere with one another.

- The guard interval is not empty, the guard interval includes a copy of part of the data that was previously transmitted.

Multi path signals received within the guard interval help the receiver by adding additional signal strength.

Multi path signals received outside the guard interval are destructive interference.
COFDM Modulation (No Interleaving)

Position of sub symbols assigned to the sub carriers in the OFDM signal is the same as their position in the incoming data stream

If several adjacent sub carriers are attenuated, as could happen with multipath or other types of interference, the adjacent data will be corrupted. This type of error is difficult for the forward error correction circuits to correct.
Position of sub symbols assigned to the sub carriers in the COFDM signal is not the same as their position in the incoming data stream.

If several adjacent sub carriers are attenuated, because of multipath or other types of interference, the corrupted data will be interleaved throughout the data stream when the incoming data stream order is re-established in the receiver. This type of error is easier for the forward error correction circuits to correct.
ISDB-T Overview / Training
NTC picks Japan’s digital TV technology

By Jeremiah F. de Guzman

The National Telecommunications Commission has selected Japan’s integrated services digital broadcasting technology in the Philippines’ bid to shift from analog to digital television.

“Inf order to facilitate the entry of digital broadcast services in the country and for the protection of the consuming public, there is a need to adopt a specific standard for the delivery of digital terrestrial television services,” the NTC said in a draft circular.

“The [ISDB-T] standard shall be the sole standard in the delivery of [DTT] in the country,” the commission said.

The ISDB-T, introduced in 2003, is adopted in Japan, Brazil and Peru.

The NTC said it made the decision after convening two technical working groups and on the recommendation of the majority shareholders in the television industry, which include the Kapamilya ng mga Broadcaster ng Filipinas.

The digital terrestrial TV refers to the implementation of the digital technology in the TV service that provides a greater number of channels and better quality of picture and sound through a conventional aerial antenna instead of a satellite or cable connection.

The NTC said Japan’s ISDB-T was a “flexible digital TV transmission system” that could provide audio, video and data services to fixed, mobile and hand-held devices without the need for an additional facility.

The commission has set a public hearing on the issue today. It asked interested parties to submit their respective position papers on the preferred digital TV platform.

Broadcasting companies ABS-CBN Broadcasting Corp., GMA Network Inc. and TVS earlier said they were leaning toward the Japanese standard after its proponents lowered the price of set-top boxes.

The Japanese government earlier offered to manufacture set-top boxes for the country’s transition.

NTC Deputy Commissioner Douglas Michael Mallillin said the proponents of integrated services digital broadcasting technology were intensively lobbying the government to adopt Europe’s digital video broadcast technology.

Mallillin added that “the Japanese have made a commitment that if the Japanese standard is to be adopted, they will set up a factory here in the Philippines.”
ISDB-Tb – What is it?

- **ISDB-Tb** is derived from the Japanese ISDB-T digital terrestrial television standard. Also called **ISDBT International**
- Integrated **S**ervices **D**igital **B**roadcasting - **T**errestrial **brazil**
- Defined by standard ABNT NBR 15601
- It is very similar to the Japanese version
- Main differences are the use of a more efficient H.264/MPEG-4 HE AAC video/audio Codec and new Middleware (Ginga)
- It is suitable for MFN and SFN applications
- It can transmit up to three hierarchical layers
### ISDB-T Basic Transmission Parameters

<table>
<thead>
<tr>
<th>Transmission Parameter</th>
<th>Mode 1</th>
<th>Mode 2</th>
<th>Mode 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of OFDM segments</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>5.575 MHz</td>
<td>5.573 MHz</td>
<td>5.572 MHz</td>
</tr>
<tr>
<td>Carrier interval</td>
<td>3.968 kHz</td>
<td>1.984 kHz</td>
<td>0.992 kHz</td>
</tr>
<tr>
<td>No. of carriers</td>
<td>1405</td>
<td>2809</td>
<td>5617</td>
</tr>
<tr>
<td>Modulation system</td>
<td>QPSK, 16QAM, 64QAM, DQPSK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective symbol length</td>
<td>252 μs</td>
<td>504 μs</td>
<td>1.008 ms</td>
</tr>
<tr>
<td>Guard-interval length</td>
<td>1/4, 1/8, 1/16, 1/32 of effective symbol length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of symbols per frame</td>
<td></td>
<td>204</td>
<td></td>
</tr>
<tr>
<td>Time interleave</td>
<td>4 maximum values: 0, about 0.13, 0.25, 0.5 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency interleave</td>
<td>Intra-segment or inter-segment interleaving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner code</td>
<td>Convolutional coding (1/2, 2/3, 3/4, 5/6, 7/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer code</td>
<td>RS (204, 188)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information bit rate</td>
<td>3.65 Mbps - 23.23 Mbps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hierarchical transmission</td>
<td>Maximum 3 levels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ISDB-Tb – Brazil Timeline

• 1999 – Initiation of the technical evaluation to choose the standard
• 2003 – Foundation of Committee of SBTVD.
• 2006 – Selected the standard based on the Japanese system
• 2007 – Defined the transmission schedule
• Dec 2007 – First ISDB-Tb digital transmission in Sao Paulo – Brazil
• 2010 – DTV coverage extended to 20 state capitals and 10 inner cities – Much of Brazil can watch the South African World cup in HDTV!
• 2012 – 72% of Brazil’s 433 major cities now have DTV coverage
• 2016 – Analog shut down in 6 major cities, starting in April
• 2018 – Analog shut down for Brazil complete by end of the year
ISDB-T Compared to ISDB-Tb/International

**ISDB-T**
- Japan
- **Full Seg**
  - Video: MPEG2
  - Audio: MPEG2 Layer 3
- **One Seg**
  - Video: H264 a 15fps
  - Audio: HE-AAC v1
- **Middleware**
  - BML

**ISDB-Tb / International**
- Brazil, Argentina, Philippines, Peru, Chile, Botswana, Others
- **Full Seg**
  - Audio: HE-AAC (AAC+) 2.0 or 5.1
- **One Seg**
  - Video: H264 a 30fps
  - Audio: HE-AAC v2 (Parametric stereo)
- **Middleware**
  - Ginga
ISDB-T and ISDB-Tb/International

Standards have been Harmonized between Brazil and Japan:

<table>
<thead>
<tr>
<th>Subject</th>
<th>ISDB-T (Japan)</th>
<th>ISDB-Tb/International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial Transmission</td>
<td>ARIB SDT B31</td>
<td>ABNT 15601</td>
</tr>
<tr>
<td>Audio &amp; Video Encoding</td>
<td>ARIB SDT B32</td>
<td>ABNT 15602</td>
</tr>
<tr>
<td>Multiplexer</td>
<td>ARIB SDT B10</td>
<td>ABNT 15603</td>
</tr>
<tr>
<td>Receiver</td>
<td>ARIB SDT B21</td>
<td>ABNT 15604</td>
</tr>
<tr>
<td>Security</td>
<td>ARIB SDT B25</td>
<td>ABNT 15605</td>
</tr>
<tr>
<td>Middleware</td>
<td>ARIB SDT B24</td>
<td>ABNT 15606</td>
</tr>
<tr>
<td>Interactive (return) Channel</td>
<td>ARIB SDT B14</td>
<td>ABNT 15607</td>
</tr>
<tr>
<td>Operational Guide</td>
<td>-</td>
<td>ABNT 15608</td>
</tr>
<tr>
<td>Accessibility</td>
<td>-</td>
<td>ABNT 15610</td>
</tr>
</tbody>
</table>

Basic System Structure – High Level View

** Broadcast Transport Stream
ISDB-Tb - Structure

Basic System Structure - Video and Audio Paths

- **Encoder HD**
  - Audio: HE-AAC – 128Kbps
  - Video: 1080i 16:9
  - Transport Stream

- **Encoder SD**
  - Audio: HE-AAC – 128Kbps
  - Video: 720p or 420p 16:9
  - Transport Stream

- **Encoder LD**
  - Audio: HE-AAC v2 (parametric stereo) – 32Kbps
  - Video: 320 x 240 QVGA 4:3
  - Transport Stream
ISDB-Tb - Structure

Basic System Structure – TS – Transport Stream

- Each TS packet flow is compressed data derived from the transport layer of MPEG (Moving Picture Expert Group).
- Each Packet Contains 188 Bytes.
- Each packet of 188 bytes in the TS is identified with a PID (Packet IDentifier)
- To identify the contents of each packet to the transport layer utilizes a set of MPEG tables:
  - PAT (Program Association Table)
  - PMT (Program Map Table)
  - In addition the PCR (Program Clock Reference) is added
ISDB-Tb - Structure

Basic System Structure – TS – Transport Stream

Packet flow 188 bytes which form a TS

Packet 188 Bytes

PID 0x00

PAT:
Program 1
PID of PMT = 0x100
Program 2
PID of PMT = 0x200

Packet 188 Bytes

PID 0x100

PMT
( Program 1):
Video = PID 0x101;
Audio = PID 0x102;
PCR = PID 0x103;

Packet 188 Bytes

PID 0x101

Video Information
( program 1)

Packet 188 Bytes

PID 0x102

Audio Information
( program 1)

Packet 188 Bytes

PID 0x200

PMT
( Program 2):
Video = PID 0x201;
Audio = PID 0x202;
PCR = PID 0x203;

Packet 188 Bytes

PID 0x201

Video Information
( program 2)

TS can include Audio + Vídeo + Data
ISDB-Tb - Structure

Basic Structure of BTS - Broadcast Transport Stream

BTS bit rate is 32.5079365 Mbps (Always this rate)
ISDB-Tb - Structure

Basic Structure of BTS - Broadcast Transport Stream

Tables added by the MUX:

- **NIT (Network Information Table)** - Carries Network Information and Programs
- **TOT (Time Offset Table)** - Carries information from the current day and time to update the Set-top box
- **EIT (Event Information Table)** - Carries data for program schedule
ISDB-Tb - Structure

Basic Structure of BTS – Broadcast Transport Stream – 16 Bytes

- Sync Byte
- 187 Data Bytes
- 16 Bytes Inserted by Mux

8 Bytes
Hierarchical Layer

IIP (ISDB-T Information Packet). Data includes:
- No. of segments
- Code rate
- Modulation
- Time interleaver

8 Bytes
RS Parity

204 bytes

188 bytes

Used by the transmitter / modulator system configuration. Carriers are transmitted in the TMCC (Transmission and Multiplexing Configuration Control)
The transmitter / modulator receives the encoded BTS, with all of the information inserted.
BTS to Transmitter

Receive devices receive and decode the IIP information using the TMCC carriers for correct decoding of information and programs.
ISDB-Tb - Structure

Tables: PSI / SI (Program Specific Information / Service Information)

- PAT (Program Association Table)
- PMT (Program Map Table)
- NIT (Network Information Table)
- TOT (Time Offset Table)
- EIT (Event Information Table)
- CAT (Conditional Access Table)
- SDT (Service Description Table)
ISDB-Tb – RF Channel

6MHz Channel Bandwidth

The 6MHz channel is divided into 13 equal OFDM* segments, each occupying 428.57 kHz (6/14 MHz)

*OFDM - Orthogonal Frequency Division Multiplexing.
ISDB-Tb – RF Channel

6MHz Channel – Offset Frequency

In Brazil, all ISDB-Tb channels use an offset of 1/7 MHz with respect to the center frequency.

Center Frequency for ISDB-Tb

1/7 MHz = 0.142857 MHz
Example: Channel 20 = 506 ~ 512 MHz
Center of channel is 509 + 0.142857
= 509.142857 MHz

6 MHz − 5.57 MHz = 0.43 MHz = 6/14 MHz
ISDB-Tb – RF Channel

6MHz Channel – No offset

- Visual Carrier
- Aural Carrier

Analog Channel 6MHz

Low edge of digital channel close to aural carrier
ISDB-Tb – RF Channel

6MHz Channel – With 1/7 MHz Offset (to minimize interference to aural signal)
ISDB-Tb - Structure

Hierarchical Modulation

- The system can be set to 1, 2, or 3 layers
- The modulation of each layer can be set independently
- The configuration parameters of the system and of each layer are:

System:
- Frequency
- Transmission Mode
- Guard Interval

Same for all Layers

Layer A
- Number of Segments
- Modulation
- Inner Code
- Time Interleave

Layer B
- Number of Segments
- Modulation
- Inner Code
- Time Interleave

Layer C
- Number of Segments
- Modulation
- Inner Code
- Time Interleave
Hierarchical Modulation - System parameters (always same for each layer):

1. **Frequency**

2. **Mode of Transmission** - Number of carriers per segment.
   - **Mode 1**: 108 Carriers \((1,404 \text{ carriers over } 13 \text{ segments})\)
   - **Mode 2**: 216 Carriers \((2,808 \text{ carriers over } 13 \text{ segments})\)
   - **Mode 3**: 432 Carriers \((5,616 \text{ carriers over } 13 \text{ segments})\)

3. **Guard Interval** - Time interval between each OFDM Frame
   Can be set to 1/4, 1/8, 1/16 or 1/32.
Hierarchical Modulation - Configuration Parameters that can be set differently for each layer:

1. Number of segments in layer: 1 to 13
2. Modulation: DQPSK, QPSK, 16QAM and 64QAM
4. Time Interleave:
   - Transmission mode 1: 4, 8 or 16
   - Transmission mode 2: 2, 4 or 8
   - Transmission mode 3: 1, 2 or 4
Example # 1 – Hierarchical Modulation – 3 Layers

System: Frequency: 545,142857MHz
Transmission Mode: 3
Guard Interval: 1/8

Layer A
No. of Segments: 1
Modulation: QPSK
Inner Code: 2/3
Time Interleave: 4

Layer B
No. of Segments: 8
Modulation: 64QAM
Inner Code: 3/4
Time Interleave: 4

Layer C
No. of Segments: 4
Modulation: 16QAM
Inner Code: 7/8
Time Interleave: 4

Mobile Program: 400Kbps
HD Program: 11.2Mbps
SD Program: 4.3Mbps
### Example #1 – Maximum Data Rate per Segment

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code Rate</th>
<th>Number of TSP transmitted per segment (Mode 1/2/3)</th>
<th>Data Rate kbps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>GI 1/4</td>
</tr>
<tr>
<td>DQPSK</td>
<td>1/2</td>
<td>12/24/48</td>
<td>280.85</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>16/32/64</td>
<td>374.47</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>18/36/72</td>
<td>421.28</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>20/40/80</td>
<td>488.09</td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>21/42/84</td>
<td>491.50</td>
</tr>
<tr>
<td>QPSK</td>
<td>1/2</td>
<td>24/48/96</td>
<td>561.71</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>32/64/128</td>
<td>748.95</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>36/72/144</td>
<td>842.57</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>40/80/160</td>
<td>936.19</td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>42/84/168</td>
<td>983.00</td>
</tr>
<tr>
<td>16QAM</td>
<td>1/2</td>
<td>36/72/144</td>
<td>842.57</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td>48/96/192</td>
<td>1123.43</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td>54/108/216</td>
<td>1263.86</td>
</tr>
<tr>
<td></td>
<td>5/6</td>
<td>60/120/240</td>
<td>1404.29</td>
</tr>
<tr>
<td></td>
<td>7/8</td>
<td>63/126/252</td>
<td>1474.50</td>
</tr>
</tbody>
</table>

* Essa taxa de dados representa a taxa de dados (bits) por segmento para parâmetros de transmissão: taxa de dados (bits) = TSP transmitidos x 188 (bytes/TSP) x 8 (bits/byte) x 1/comprimento do quadro.
Example # 1 – Segment Utilization

Layer A

Layer B

Layer C

428.57 KHz
Example #2 – Hierarchical Modulation – 2 Layers

System: Frequency: 545,142857MHz
Transmission Mode: 3
Guard Interval: 1/16

Layer A
- No. of Segments: 1
- Modulation: QPSK
- Inner Code: 2/3
- Time Interleave: 4

Layer B
- No. of Segments: 12
- Modulation: 64QAM
- Inner Code: 3/4
- Time Interleave: 4

Mobile Program: 400Kbps
HD Program: 17.2Mbps
ISDB-Tb - Structure

Example # 2 – Segment Utilization

Layer A

Layer B

Layer B

11 9 7 5 3 1 0 2 4 6 8 10 12

428.57 KHz
ISDB-Tb - Structure

OFDM – Reducing Multipath Problems

Data is spread across segments

Impulse Noise

428.57 KHz

5.57 MHz

6 MHz
ISDB-Tb - Structure

Synchronization

GPS: 1PPS, 10MHz

± 1Hz

428.57 KHz

5.57 MHz

6 MHz
Transmission Masks (Brazil):

- Non-Critical: $-36\text{dB} \pm 3.15\text{MHz}$
- Sub-Critical: $-43\text{dB} \pm 3.15\text{MHz}$
- Critical: $-50\text{dB} \pm 3.15\text{MHz}$
Classes of Operation (Brazil)

Same class of operation as for the analog channel

<table>
<thead>
<tr>
<th>Class</th>
<th>Maximum ERP (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VHF High</td>
</tr>
<tr>
<td>Especial</td>
<td>16</td>
</tr>
<tr>
<td>A</td>
<td>1.6</td>
</tr>
<tr>
<td>B</td>
<td>0.16</td>
</tr>
<tr>
<td>C</td>
<td>0.016</td>
</tr>
</tbody>
</table>

ERP = Power of TX - Line Losses + Antenna Gain
Higher bit rates: Best for HD, or multiple SD programs per tx but less robust (harder to receive)

Lower bit rates: Best for Mobile or fewer programs per tx but more robust (easier to receive)

Fig. 6. CN ratio versus transmission capacity determined by channel coding.
ISDB-Tb – Receivers

Set Top Boxes
ISDB-T Receive Devices

Portable Receivers & Dongles
ISDB-Tb – Receivers

Flat Panel TV’s

70” LED Smart TV (Sharp)
The Philippines has firmly rejected Europe’s DVB television transmission standard and instead selected Japan’s ISDB scheme. A last ditch effort from Europe which talked of its widely adopted standard being cheaper to install and maintain, the nation’s President Benigno Aquino has confirmed to Japan’s Prime Minister Shinzo Abe that it will migrate to Japan’s Integrated Service Digital Broadcasting (ISDB-T) transmission system.

“We are migrating to the Japanese digital standards... The clincher is the emergency broadcast feature or the ability to turn on television sets to broadcast a warning even if the television set is turned off. We are told that it was used during the Fukushima incident,” the President said, confirming an earlier decision by the nation’s National Telecommunications Commission.
ISDB-T
Single Frequency Network (SFN) and GatesAir Solution

Mayon Volcano, Albay Province, Philippines
In an SFN, each transmitter must radiate:
- The same signal (the same bit)
- At the same time
- On the same frequency

Since the Transmitter sites in the network are positioned at different locations usually the BTS is not available at all sites at the same time

To solve this problem several methods have been implemented in the ISDBT Standard, most practical is called “Reference Synchronization”
SFN Basics

Only signal from Tx 1 received

Both Signals Received
But timing may be different

Only signal from Tx 2 received
ISDB-Tb Network Structure

Using Reference Synchronisation

- **MPEG-2 Multiplexer**
- **SFN-Adapter**
- **TX Network Interface**
- **RX Network Interface**
- **SYNC system**
- **ISDB-Tb Transmitter**
- **GPS**
- **BTS**

Connections:
- 1 pps 10 MHz from GPS to RX Network Interface and BTS.
- 1 pps 10 MHz from BTS to ISDB-Tb Transmitter.
In the SFN Adapter Multiplex-Frames are built from the incoming MPEG-TS.

Multiplex-Frame

Data includes:
- No. of segments
- Code rate
- Modulation
- Time interleaver
- Information for SFN timing

MFP ... Mega-Frame Packet
IIP ... ISDB-T Information Packet)
Synchronisation Time Stamp (STS)

The synchronisation timestamp value is the difference in time between the rising edge of the 1pps Symbol and the beginning of a mega-frame.

The STS is carried in the IIP of each Multiplex-Frame.

The STS carried in the Multiplex-Frame M describes the beginning of the Multiplex-Fame M+1.

The STS carried in the Multiplex-Frame M+1 describes the beginning of the Mega-frame M+2.

etc.
Maximum delay: (reference synchronisation)
The maximum delay describes the difference in time between a specific Multiplex-Frame leaving the SFN adapter and the corresponding COFDM Mega-frame available at the antenna output of each Transmitter in the SFN.

The maximum delay is a value adjustable in the SFN-Adapter. The set value has to be always higher than the longest actual network delay. The value is transported in each IIP.
The Principle of Reference Synchronisation

- **GPS**: 1 pps, 10 MHz
- **SFN-Adapter**
- **Telecom Network** (Microwave, Fibre optics)
- **SYNC System**
- **ISDB-Tb Transmitter**

Max. Delay 600ms

Information transported in the IIP:

STS = 100ms
Max Delay = 600ms

Storage Time before frame is transmitted:

= STS + max delay - measured delay
= 100ms + 600ms - 300ms
= 400 ms
Connecting What's Next

Transmitter Synchronisation with Reference Synchronisation

Max. Delay 700ms

1 pps 10 MHz

GPS

SFN Adapter

Telecom Network (Microwave, Fibre optics)

200ms

1 pps 10 MHz

GPS

SYNC System

ISDB-Tb Transmitter

Signal transmitted at the same time (700ms delay)

500ms

1 pps 10 MHz

GPS

SYNC System

ISDB-Tb Transmitter

Signal transmitted at the same time (700ms delay)

300ms

Calculated storage time

400ms
Functional Description of SFN Synchronisation

The time a frame has to be stored in the transmitter before it is sent is calculated like this:

Max. delay - actual delay
= 900 ms - 350 ms = 550 ms

The actual delay of the M+1 frame at the input of the Transmitter is calculated like this:

Arrival time of frame (M+1) - STS value
= 650 ms - 300 ms = 350 ms

The time a frame has to be stored in the transmitter before it is sent is calculated like this:

Max. delay - actual delay
= 900 ms - 350 ms = 550 ms
Reception Scenarios in a SFN

Guard Interval (defines max. Tx spacing)

Useful Symbol Duration

Received from Tx1

Received from Tx2

Received from Tx3

Rx1

Rx2

Rx3

Tx1

Tx2

Tx3

Guard Interval

Useful Symbol Duration

Received from Tx1

Received from Tx2

Received from Tx3

Guard Interval

Useful Symbol Duration

Received from Tx1

Received from Tx2

Received from Tx3

Guard Interval

Useful Symbol Duration

Received from Tx1

Received from Tx2

Received from Tx3
Distance Between SFN Transmitters

- Maximum distance between SFN transmitters is determined by the Guard Interval
  - Also determines maximum difference between direct path and multipath lengths
  - Distance = Guard Interval x \( V_0 \)
    - \( V_0 \) = velocity of light in free space
    - \( V_0 \) = 300,000 km/second
    - \( V_0 \) = 186,000 miles/second

- Note: Time per unit distance = \( 1/V_0 \)
  - \( D/T \) = 1/300,000 = 3.33 µs/km
  - \( D/T \) = 1/186,000 = 5.38 µs/mile
# Distance Between Transmitters SFN (ISDB-Tb)

## Maximum tolerated distance and delay for several Modes and Guard Interval rates

<table>
<thead>
<tr>
<th>GI Rate</th>
<th>Mode 1 (2k)</th>
<th>Mode 2 (4k)</th>
<th>Mode 3 (8k)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ (μs)</td>
<td>Dmax (km)</td>
<td>Δ (μs)</td>
</tr>
<tr>
<td>1/4</td>
<td>63</td>
<td>18.9</td>
<td>126</td>
</tr>
<tr>
<td>1/8</td>
<td>31.5</td>
<td>9.45</td>
<td>63</td>
</tr>
<tr>
<td>1/16</td>
<td>15.75</td>
<td>4.725</td>
<td>31.5</td>
</tr>
<tr>
<td>1/32</td>
<td>7.875</td>
<td>2.3625</td>
<td>15.75</td>
</tr>
</tbody>
</table>
ASI-IP and Satellite Rx Modules

Satellite Receiver/Decoder Module
(SRD, SRZ)

ASI over IP Module
(IPA / IPZ)

Space for Optional Modules

Rear of Apex M2X, UAXT, or UAX Compact Series Tx
ISTB-Tb Re-Mux (option)

- Remote Control Key (Virtual Channel)
- Channel (The frequency is set into the Mux)
- Generating Station (Station Letters)
- Region
- State
- Micro Region
- Network ID
- Transport Stream ID

The remux option allows input of a 188-byte multiplexed transport stream into one or both rear panel ASI BNC (female) connectors. The added remux hardware uses the multiplexed transport stream input to create a 204-byte BTS (Broadcast Transport Stream) based on user defined broadcast parameters. The resulting BTS is then fed to the host ISDB-Tb modulator.
GatesAir Tx SFN References Worldwide

**ISDB-T**
- Brazil - Sistema Clube de Televisao, Ribeirao Preto
- Brazil - TV TEM
- Argentina – INVAP

**DVB-T/T2**
- UK: NTL/Arqiva (DVB-H)
- Australia: Broadcast Australia
- Australia: TX Australia
- Switzerland: Swisscom*
- Germany: T Systems – Media broadcast*
- Poland: Info FM-TV (DVB-H)
- Luxembourg: BCE
- Singapore: TCS
- Taiwan: PTS
- Netherlands: Nozema/KPN*
- Russia: RTRS

*transmitters work in SFN together with other brands
ISDB-T Coverage & Planning

Chocolate Hills, Bohol Province, Philippines
Propagation Models For Coverage Estimation

- **Gaussian Channel**
  - The **Gaussian channel** is often used as a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as Watts per Hertz of bandwidth) and a Gaussian distribution of amplitude.

- **Ricean Fading Channel**
  - **Rician fading** is a stochastic model for TV/Radio propagation anomalies caused by partial cancellation of a TV/Radio signal by itself — the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others.

- **Rayleigh Fading Channel**
  - **Rayleigh fading** is viewed as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver.
Gaussian Channel

- Directional antenna used
- Direct reception

Directly received Signal

Directional receive antenna
Ricean Fading Channel

- Directional antenna used
- Multi-path reception

The directional receive antenna only allows a signal path from one direction.
Rayleigh Fading Channel

- Non-directional antenna used
- Multi-path reception
- No direct path reception

The non-directional receive antenna allows multi-path from multiple directions

No direct line of sight between tx and receiver.
The main goal was to replicate the analog coverage area with the new digital signal.

Mackenzie university developed a means to predict the reception of ISDBT under real conditions.

Coverage also verified by collecting field data of the signal received at various locations:

- With settings for HD fixed antenna and SD reception mobile device
- Used the “Okumura Hata” model to predict propagation of signals
- The National Telecom Agency (ANATEL), established a value of 51 dBmV/m for the field intensity of protected outline in the UHF band in the limit of coverage area. This figure became the target value that stations were to meet to replicate analog coverage.
A field test van was equipped with:
- Retractable antenna up to 10m (5dB gain)
- Spectrum Analyzer
- Receivers (STB)
- Notebook
- GPS
- Measuring equipment (MER, C/N, BER, etc.)
Measured signal strength vs. predicted

Figure 5 – Graph of signal strength in the northern sector

Figure 7 – Graph of signal strength in the Southern sector
ISDB-T/Tb

ISDB-T/Tb network coverage planning
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Disclaimer
Planning Tool: CHIRplus_BC from LS telcom AG

- Planning and Coordination of Terrestrial Broadcasting services
  - FM, TV, ISDB-T, ATSC, DVB-T/T2 (-H), T-DAB (-DMB), LF/MF, HF, DRM(+)
  - Protection ratio (e.g. ISDB-T vs. ISDB-T, ISDB-T vs. TV analogue)
  - Powerful database system
  - GIS and graphical user interface
  - Field strength and interference prediction
  - Support of international frequency plans (GE84, ST61, GE75, GE06, NTFD …)
  - Contour Based Calculations
  - Coordination functions and macros
  - Network planning and optimization
  - Frequency Planning (Frequency Scan)
  - Population Analysis
Planning Parameter – TX data

- Transmitter data quality
How to handle planning parameters

- **What kind of network?**
  - SFN (Single Frequency Network)
  - MFN (Multiple Frequency Network)

- **Is the network to design local or nationwide?**
  - Transmitter distance → guard interval

- **How many and what kind of Programs (SD, HD) to distribute?**
  - Code rate, modulation

- **What kind of service is needed?**
  - Fixed
  - Mobile
  - Portable (indoor/ outdoor)
Planning Parameter – ISDB-T Configuration

- Challenge to find the most fitting configuration (Capacity vs. robustness)
Network Coverage planning (SFN optimization)

<table>
<thead>
<tr>
<th>TX-Name</th>
<th>Adm.</th>
<th>Ch.</th>
<th>Freq.</th>
<th>Height</th>
<th>Ant.H.</th>
<th>Longit.</th>
<th>Latit.</th>
<th>ERP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manila</td>
<td>PHL</td>
<td>32</td>
<td>581.0000</td>
<td>23</td>
<td>85</td>
<td>121°04'38.112&quot;</td>
<td>14°33'44.058&quot;</td>
<td>25.0000</td>
</tr>
<tr>
<td>Mt. Arayat</td>
<td>PHL</td>
<td>32</td>
<td>581.0000</td>
<td>1001</td>
<td>40</td>
<td>120°44'30.299&quot;</td>
<td>15°12'19.480&quot;</td>
<td>50.0000</td>
</tr>
</tbody>
</table>

Distance: 80km = 265µs

TX distance (265µs) > Guard Interval (252µs) !!!
Network Coverage planning (SFN optimization)
Network Coverage planning (Visualization)
Network Coverage planning (Benefits)

- Professional network planning saves time and money and prevents problems
- Professional predictions ensure optimized CAPEX and OPEX
- Makes possible to analyse various options to find the best
- Ensure interference optimized network
  - Self interferences in case of SFN
  - Protection of analogue TV in case of simulcast phases
  - Interferences between ISDB-T and other services (LTE, PMSE...)
  - Analysis of coordination requirements
  - Analysis of bi-multilateral agreements
Planning & Coverage Verification

- Despite the extensive possibilities of proper planning with an adequate professional tool (like ChirPlus_BC), coverage analysis and verification are recommended when launching a new broadcast service.

- Complementary to field or drive tests, airborne measurements offer fruitfull information about the broadcast antennas and the radiation patterns (real vs licenced).

- Remotely piloted aircrafts enable a new approach for airborne measurement with many additional benefits.
Your Contacts at LS telcom

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Mobile: +49 172 2008668
e-mail: LHaebelé@Colibrex.com
New High-Efficiency Transmitters For ISDB-T
Maxiva Product Family - Television

**Low Power Air Cooled**
- Maxiva™ UAX-UC, UAXT-MC, UAXT-C & UAXT

**High Power Liquid Cooled**
- Maxiva™ ULX & ULXT

**Super High Power**
- Maxiva™ ULXT & Power CD (IOT)

**UHF**
- Click for Presentation

**VHF**
- Maxiva™ VAX-3D
- Maxiva™ VLX

All TV transmitters support all standards, including:

- ISDB-T (High Band TV and DAB Digital radio)
GA experience and Site References for ISDB-T Deployments
Countries Adopting ISDB-T (so far)

<table>
<thead>
<tr>
<th>ISDB-T adopted</th>
<th>Broadcasting via ISDB-T is actively in use.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISDB-T trial broadcasts</td>
<td>Those countries undertake trials with ISDB-T.</td>
</tr>
<tr>
<td>SBTVD-T adopted</td>
<td>Broadcasting via SBTVD-T is actively in use.</td>
</tr>
</tbody>
</table>

SBTVD: Sistema Brasileiro de TV Digital) - Also called "ISDB-T International" and "ISDB-Tb"
## Countries Adopting (or have Adopted) ISDB-T

<table>
<thead>
<tr>
<th>Country</th>
<th>ISDB-T Adopted</th>
<th>ISDB-T Started</th>
<th>GatesAir Tx’s Shipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Japan</td>
<td>------</td>
<td>December 2003</td>
<td>-</td>
</tr>
<tr>
<td>2 Brazil</td>
<td>June 2006</td>
<td>December 2007</td>
<td>509+</td>
</tr>
<tr>
<td>3 Peru</td>
<td>April 2009</td>
<td>March 30, 2010</td>
<td>7</td>
</tr>
<tr>
<td>4 Argentina</td>
<td>August 2009</td>
<td>April 28, 2010</td>
<td>138</td>
</tr>
<tr>
<td>5 Chile</td>
<td>September 2009</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>6 Venezuela</td>
<td>October 2009</td>
<td>June 2011</td>
<td>-</td>
</tr>
<tr>
<td>7 Ecuador</td>
<td>March 2010</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>8 Costa Rica</td>
<td>May 2010</td>
<td>May 1, 2014</td>
<td>-</td>
</tr>
<tr>
<td>9 Paraguay</td>
<td>June 2010</td>
<td>August 15, 2011</td>
<td>-</td>
</tr>
<tr>
<td>10 Philippines</td>
<td>June 2010 (reconfirmed in 2013)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>11 Bolivia</td>
<td>July 2010</td>
<td>September 2011</td>
<td>-</td>
</tr>
<tr>
<td>12 Uruguay</td>
<td>December 2010</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>13 Maldives</td>
<td>October 2011 (national broadcasting) April 2014 (decided as national standard)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>14 Botswana</td>
<td>February 2013</td>
<td>July 29, 2013</td>
<td>-</td>
</tr>
<tr>
<td>15 Guatemala</td>
<td>May 2013</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>16 Honduras</td>
<td>September 2013</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>17 Sri Lanka</td>
<td>May 2014 (Initially DVB-T2)</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

Source: DiBEG
GatesAir TV Shipments – By Modulation Type

- TV Transmitters Shipped: 4,536
  - April 2009 to December 2014
- 678 ISDB-T transmitters shipped
  - Third place
- Total Shipments
  - DVB-T: 32.2% (1,460)
  - DVB-T2: 31.5% (1,430)
  - ISDB-T: 15% (678)
  - ATSC: 12.5% (568)
  - Others: 8.8% (400)
A Few GatesAir Customer References – ISDB-T

**Brasil**
- TV Band
- TV Gazetta
- TV TEM
- TV Aliança Paulista S.A.
- TV Bauru S.A.
- TV Sao Jose do Rio Preto
- TV Luziania LTDA
- TV Taubate
- TV Vanguardia
- + Over 40 more stations/networks

**Argentina**
- INVAP
- Telecentro
- Producciones Dragon

**Chile**
- Televisión Nacional de Chile
- Compania Chilena de TV
- Rede Televisiva Megavision

**Ecuador**
- TV y Radio de Ecuador S.A.

**Peru**
- Andina de Radiodifusion
- Assoc. Las Manos de Dios
Case Study – TV TEM, Brazil

**Background information:**
- TV TEM is a major Rede Globo affiliate in Brazil: 318 cities in São Paulo state
  - Project – to increase coverage to 8 million viewers

**Why they chose GatesAir:**
- Met stringent technical requirements
- GatesAir guaranteed that the SFN will work flawlessly
- Competitive commercial package
- Excellent pre- and post-sales support
- A excellent long-term customer relationship – repeat buyer!

**Anchor products:**
- Maxiva ULX, UAX, high-efficiency ULXT
Challenges and Lessons Learned

Super Typhoon Haiyan
Brazil Experience

- A lot of testing and planning was done before the roll out of ISDB-T
- Field tests conducted in Rio de Janeiro to test the robustness of the 1-Seg mobile system
- Public awareness was key to the success
  - By 2012 there were DTV transmissions in 433 municipalities across Brazil
  - Coverage to almost 45.5% of the population
- Analog switch-off plans for Brazil
  - Analog shut down in 2 cities – April 3rd, 2016 (Brasilia and Rio verde)
  - Four more cities will shut off analog by end of 2016
  - Entire country shuts off analog by end of 2018
Lessons Learned (Brazil)

- Coverage planning was a good approximation....
- However, there were “holes” in the coverage areas with received signals below the predicted levels
  - Some additional low power transmitters, transposers, or on-channel gap fillers were needed to reduce these coverage gaps
- Many early receivers and STB’s did not correctly apply tables (Like PID, PAT, etc.)
  - This resulted in receivers not having correct channel or program information
  - If a broadcaster made changes, added a program, etc. the receiver did not recognize this unless all channels were re-scanned
- Early STB’s and receivers were very expensive but prices have since greatly reduced
  - Limited affordability for early viewers of ISDB-T
By 2012 Brazil had DTV coverage into 433 municipalities

Only three states were without DTV signals

72% of these stations were in the populated regions

45.4% of the population could receive Digital TV
The End – Questions?

Martyn Horspool
GatesAir

El Nido, Palawan, Philippines