Advanced System & products for DTTB Network
Ver.0.0

15th, June, 2000

Toshiba (Member of DiBEG)
Digital Broadcasting Experts Group
Quality of digital transmission and Threshold B.E.R

Video quality is kept constant when signal strength is more than threshold level. (not suffered by ghost, noise, etc)

Transmission quality is defined by B.E.R

Threshold B.E.R = $2 \times 10^{-4}$ (after Viterbi)

Concatenated Forward Error Correction

Before Viterbi $(7/8)$  $1 \times 10^{-2}$  
After Viterbi  $2 \times 10^{-4}$

After Reed-Solomon  $1 \times 10^{-11}$

In case of 64QAM $(7/8)$  
HDTV available

Encoded in MPEG-2 TS
Equivalent C/N of transmitting equipment

\[ \text{C/N degradation} = (\text{C/N})_M \, \text{dB} - (\text{C/N})_R \, \text{dB} \]

**Digital Terrestrial Broadcasting**

**Ideal Performance**

- Ideal OFDM Mod
- C/N = ∞

**Realized Performance**

- Receiver Carrier Level vs. Thermal Noise C/N_M
- C/N_T

**Ideal OFDM Demod**

\[ \frac{1}{\frac{1}{\text{C/N}_T} + \frac{1}{\text{C/N}_M}} = \text{C/N}_R \]

**ISDB-T**

DiBEG
Threshold C/N of DTTB

Ideal link model

<table>
<thead>
<tr>
<th>Degradation</th>
<th>3dB</th>
<th>3dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required C/N</td>
<td>28dB</td>
<td>25dB</td>
</tr>
</tbody>
</table>

C/N = ∞

Ideal TV-TX

Threshold 50.5dBμV/m
Antenna height: 10m

Environment Margin for Receiver
For broadcasting network: 3dB interference, ghost, etc

Hardware realized Margin
For RX: 2dB
For TV network: 1dB

Receiver noise
C/N = 22dB

Ideal TV-RX

Digital Terrestrial Broadcasting

Threshold C/N of DTTB

Digital Terrestrial Broadcasting

ISDB-T

DiBEG
Degradation of TV-broadcasting network

1. Link C/N
   - STL
   - TV-Tx
   - Translator

2. Hardware inferiority
   - Phase noise
   - Inter-modulation

Digital Terrestrial Broadcasting

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DiBEG
Phase noise of carrier/local oscillator

**Contribution of phase noise**

Phase noise of carrier oscillator is converted to each OFDM carrier and spread over in-band of OFDM.

- **Random Walk Frequency**
- **Flicker Frequency**
- **White Frequency**
- **Flicker Phase**
- **White Phase**

Phase noise energy (dB/Hz) is same

Multiplier by $10 \times \log_{10} N$

$N$: number of OFDM carriers

Increase of white noise
Inter-modulation of nonlinear amplifier

**IM vs. C/N degradation**

OFDM Spectrum caused by Inter-modulation

Equals to white noise increasing

- **OFDM carrier**
- **Inter-modulation**

**Inter-modulation(IM)**

**Degradation(dB)**

Networking

Effective coexistence with analog channel

SFN can make it easy to allocate digital channel

Effective allocation plan of transmitter station and relay station

New idea for installation place of transmitter which can be realized by featuring OFDM
Networking

SFN: Single Frequency Network

SFN allows to allocate same frequency in between adjacent stations and save frequency resources.

Interference from co-channel is estimated as ghost in OFDM system and eliminated by Rx.

Mobile reception moving around in 3 regional area gets benefit by SFN.
Networking
New idea of transmitting station (1)

Stadium lighting allocation

Digital Terrestrial Broadcasting

Distributed TX
Low power TX
to form SFN

Equality for area
Metropolitan type

ISDB-T
DiBEG
Networking

New method of SFN Link

UHF broadcasting wave is used both for broadcasting and relaying link

Transmitter

CH N(To)

OFDM is divided in IF band

CH N(To+d)

d (propagation delay) < guard interval

Relay station

Cross polarization

CH N(To+d)

Co-loop chancellor in relay station

SFN network can be realized without using microwave or fiber optic.

Digital Terrestrial Broadcasting

ISDB-T

DiBEG
C0-channel Relay station

( for SFN relay transmitter)

Realize SFN by broadcasting relay station by canceling co-channel interference caused by system itself

\[
\begin{align*}
\text{Rx} & \to \text{D/C} \quad \text{UHS-VCO} \quad \text{U/C} \to \text{Tx} \\
\text{Ch}_{\text{RX}} = \text{Ch}_{\text{TX}}
\end{align*}
\]

Detect & extract delayed co-channel Tx wave

Feedback for canceling
CLC-2101 Co-channel loop Canceler

Input C/I > 3dB  Output C/I > 35dB

Available for SFN relay station using same in & output channel
Adaptive feed-back system applied
3 multi-path waves are cancelled
<table>
<thead>
<tr>
<th>Transmission signal</th>
<th>ISDB-Modulation site</th>
<th>Transmission Modulation</th>
<th>Featuring</th>
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</thead>
<tbody>
<tr>
<td>OFDM/IF</td>
<td>studio</td>
<td>OFDM</td>
<td>Concerned link degradation</td>
</tr>
<tr>
<td>Transport stream</td>
<td>transmitter</td>
<td>64-QAM</td>
<td>Independent link budget</td>
</tr>
</tbody>
</table>
SHF OFDM Transmitter

Digital Terrestrial Broadcasting

2 pilot signals assist frequency synchronization of microwave link.

Transmission Freq. 3.5GHz to 13GHz (pre-assigned)
RF power +12dBm/+27dBm(with IPA)
Bandwidth within 9MHz
Input IF 37.15MHz match to OFDM modulator

Sufficient phase noise for ISDB-T carrier
SHF OFDM Receiver

Receiving Freq. 3.5GHz to 13GHz (pre-assigned)
IF output 37.15MHz/-10dBm
Bandwidth within 9MHz

Sufficient phase noise for ISDB-T carrier
Advanced technology of DTTB Transmitter
High performance and power efficiency

<table>
<thead>
<tr>
<th>Issues</th>
<th>Analog TV-Tx</th>
<th>DTTB Tx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriers/PA</td>
<td>1</td>
<td>(1300 ~ 5200)</td>
</tr>
<tr>
<td>Defined power (r.m.s)</td>
<td>1</td>
<td>1/9</td>
</tr>
<tr>
<td>Peak power</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>20 - 25 %</td>
<td>?</td>
</tr>
<tr>
<td>2 tone IM</td>
<td>Equivalent To 33 dB</td>
<td>more than 37 dB</td>
</tr>
</tbody>
</table>
HPA operation with Idle current

**A-class HPA**
- Idle current: High
- IM: Less
- Linear operated zone

**B-class HPA**
- Idle current: Low
- IM: More

**Digital Terrestrial Broadcasting**
- ISDB-T
- DiBEG
Typical performance of HPA

- Efficiency
- 2 Tones Inter-Modulation
- Idle Current

- Class-C
- Class-B
- Class-A

(A)
(%)

High
Low

High
Low

High
Low

(db)

High
Low

Typical performance of HPA

Digital Terrestrial Broadcasting

ISDB-T

DiBEG
OFLC 2101
Prototype of non-linearity compensating unit

Available for all DTTB standard and analog system.
Improvement of power efficiency and inter-modulation distortion
ALC enables constant HPA output power
Block diagram of OFLC

**IF input** (from exciter)

- Reference
- Test

**RF input** (sampled from HPA output)

- Cross product
- Local Osc.
- Error detect
- Power detect
- Integral

**Signal is used for up-converter followed by HPA**

**AGC**

- IF output
- Power detect
- Phase detect

(to up-converter followed by HPA)
Example of compensation
(OFLC 2101)

Without compensation

With compensation
OFDM modulator with FEC (OFEX-2001)

- Light weight
- Compact
- Low power
- Easy to operate and maintain
- Remote control available

1/8 in size from prototype

Digital Terrestrial Broadcasting
<table>
<thead>
<tr>
<th>Issues</th>
<th>Analog translator</th>
<th>DTTB translator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Single CH</td>
</tr>
<tr>
<td>Carriers / PA</td>
<td>3</td>
<td>(1300~ 5200)</td>
</tr>
<tr>
<td>Power (r.m.s)</td>
<td>1</td>
<td>1 / 9</td>
</tr>
<tr>
<td>Peak power</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2-tone IM (dB)</td>
<td>more than 33dB</td>
<td>more than 37dB</td>
</tr>
<tr>
<td>solution</td>
<td></td>
<td>OFLC-2101</td>
</tr>
</tbody>
</table>
Inter-modulation of multi-channel Amplification

Gives interference to adjacent channel

CH-N  CH-N+1  CH-N+3

Inter-modulation

Should be lower than 50dB
MCA/Feed forward PA

Multi-channel Amplifier with linearity compensation
Single channel Amplifier with linearity compensation

Feed Forward Technology

Digital Terrestrial Broadcasting

ISDB-T

DiBEG
Transmitting (for relay transmitter)

Re-generate studio quality in transmission system

<table>
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<tr>
<th>Multi-Pass Cancel Unit</th>
<th>function</th>
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<tr>
<td></td>
<td>Cancel ghost wave occurred in transmission line such as microwave, broadcast wave link.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Spectrum equalizing Unit</th>
<th>function</th>
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<tbody>
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<td>Equalize RF amplitude in frequency domain damaged in propagation pass.</td>
</tr>
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<th>Synthesized Oscillator</th>
<th>function</th>
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<tbody>
<tr>
<td></td>
<td>Ultra high stabilized Oscillator using LW reference signal</td>
</tr>
</tbody>
</table>
Digital Terrestrial Broadcasting

OFDM multi-path canceling unit

OFLC2101

Input C/I>3dB

Output C/I>35dB

Available for relay station with canceling multi-path waves
Adaptive feed-back system applied
ghost waves should be within guard interval from main carrier
3 multi-path waves are cancelled
Transmission Equalizer unit

OFEQ-2101

Compensate rf amplitude distortion in broadcasting relay link. Tilt, ripple and band edge are independently compensated. Adopt into system (relay station) in IF (intermediate frequency).
Synthesized Up-converter with UHS-VCO

OFUC-2001

Ultra high stabilized Oscillator using LW reference signal

Light weight Compact Low power

SFN available
**Transmitting**  
(Test equipment for transmitter)

Also used for test equipment in receiver mass-pro line

<table>
<thead>
<tr>
<th>Function</th>
<th>Non-linear simulator</th>
<th>Multi-pass simulator</th>
<th>OFDM spectrum simulator</th>
<th>OFDM C/N simulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generates voluntary nonlinear signal</td>
<td>Generates multi-pass signal such as power amp distortion</td>
<td>Generates multi-pass signal</td>
<td>Generates OFDM spectrum with linear distortion in RF amplitude characteristics</td>
<td>Generates OFDM spectrum with random noise</td>
</tr>
</tbody>
</table>
Conclusion

New system, new technology and new products for DTTB age has been introduced.

These are under trial operation by using DTTB trial system at 10 cities in Japan.

Much more improvement are expected.

Most of products introduced in this paper has already exhibited at Inter-BEE ‘99 held in Tokyo.

Be our partner and go forward with us.