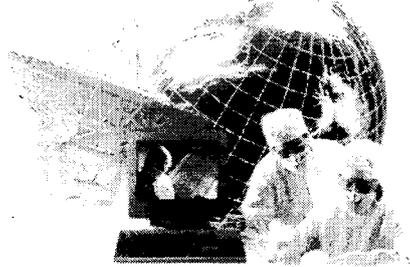


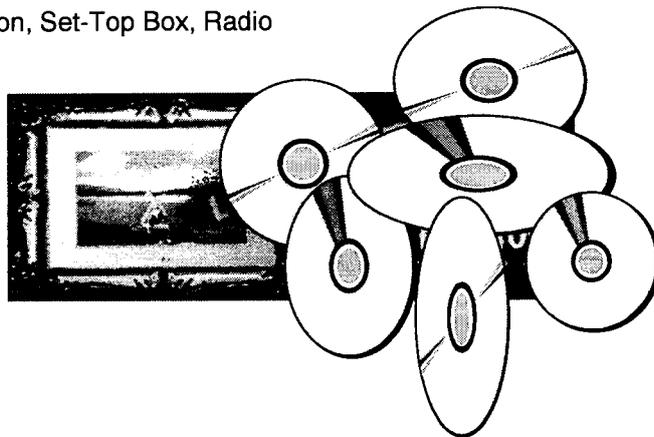
DTV 송신기 기술현황

2000. 5. 24.



Transmission Media

- 매체: 지상파, 위성, 케이블, 인터넷
- 단말: Television, Set-Top Box, Radio

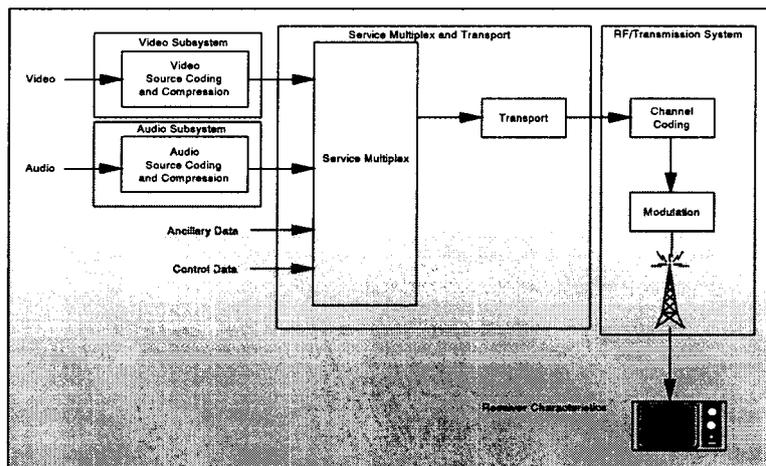


Why Digital?

- ◆ 서비스 품질 향상
- ◆ 새로운 서비스 도입
- ◆ 부가가치 서비스 확대
- ◆ 채널 용량 증대
- ◆ 방송 매체간의 호환성 유지
- ◆ 멀티미디어 및 대화형 방송 서비스 제공

-3-

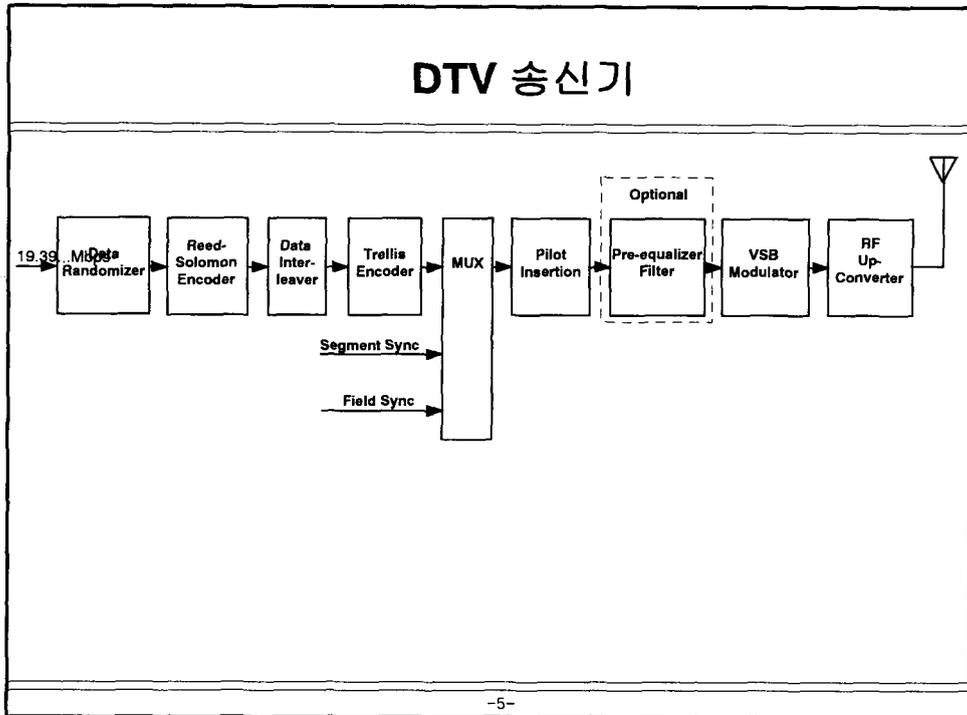
지상파 디지털 TV 방송 모델



ITU-R Terrestrial Digital TV Broadcasting Model

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DTV 송신기



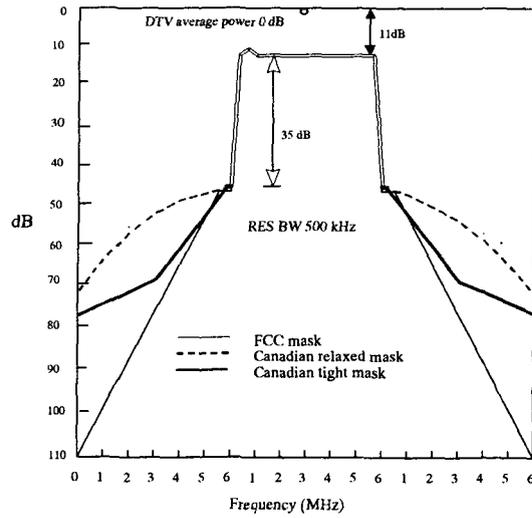
-5-

ATSC 8-VSB SYSTEM SPECIFICATIONS

Parameter	Terrestrial mode
Channel bandwidth	6 MHz
Excess bandwidth	11.5%
Symbol rate	10.76 Msymbols/s
Bits per symbol	3
Trellis FEC	2/3 rate
Reed-Solomon FEC	T=10 (207,187)
Segment length	832 symbols
Segment sync	4 symbols per segment
Frame sync	1 per 313 segments
Payload data rate	19.39 Mbps
NTSC co-channel rejection	NTSC rejection filter in receiver
Pilot power contribution	0.3 dB
C/N threshold	14.9 dB

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SPECTRUM MASK



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8-VSB MODULATOR

입력 인터페이스

- ✓ SMPTE-310M
- ✓ SPI-ECL(Synchronous Parallel Interface-ECL)

출력 인터페이스

- ✓ IF 중심 주파수 : 44.0 MHz

주요기능 및 특징

- ✓ ATSC Doc. A53 compliant
- ✓ Host와 통신 포트를 통한 원격제어, 감시기능
- ✓ Only pilot tone transmission 기능 지원
- ✓ Pre-corrector (Pre-equalizer + Pre-distorter) 인터페이스 지원
- ✓ Internal test data generation 기능

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FREQUENCY UP CONVERTER

입력

- ✓ IF 중심 주파수 : 44.0 MHz
- ✓ IF 입력 전력 : -10 dBm
- ✓ IF 입력 임피던스 : 50 Ω

출력 인터페이스

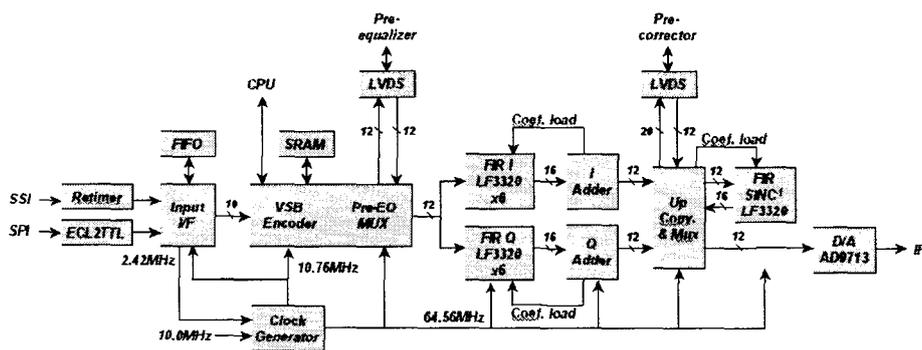
- ✓ 출력 주파수 설정 범위 : 470 MHz ~ 750 MHz
- ✓ 출력 전력 : 0 dBm ~ -31.5 dBm 가변
- ✓ 출력 임피던스 : 50 Ω
- ✓ 외부 참조 주파수 동기 기능
- ✓ 위상 잡음 -106 dBc/Hz @ 20kHz

주요 기능 및 특징

- ✓ ATSC Doc. A53 compliant
- ✓ 정밀 오프셋 캐리어 설정을 위한 1 Hz step size 실현
- ✓ 자체 진단 및 경보 기능
- ✓ 외부 호스트와 통신포트를 통한 원격제어, 감시기능

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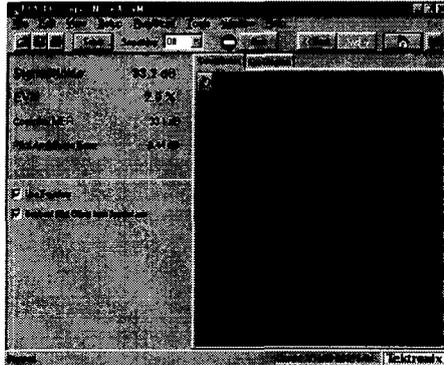
The Structure of Full Digitally Implemented VSB modulator



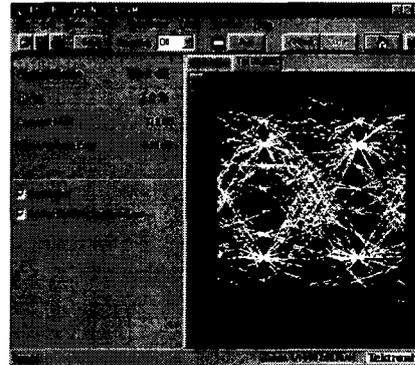
Partially Analogue vs. Full Digital

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The Characteristics of VSB Modulator's Major Parameters

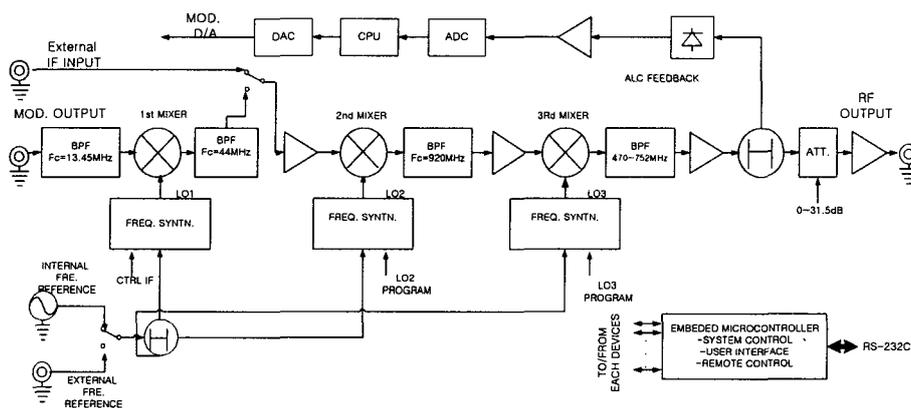


VSB signal constellation

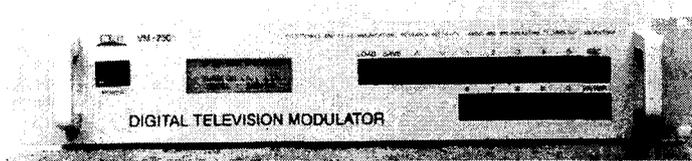


VSB signal eye diagram

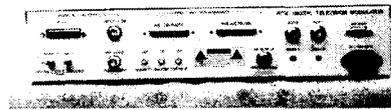
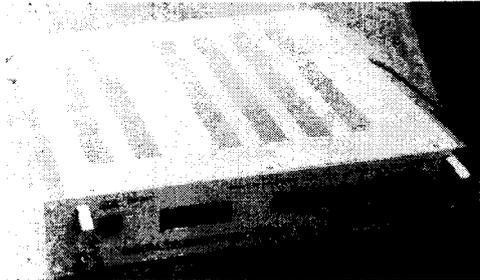
Frequency translator



VSB MODULATOR - I



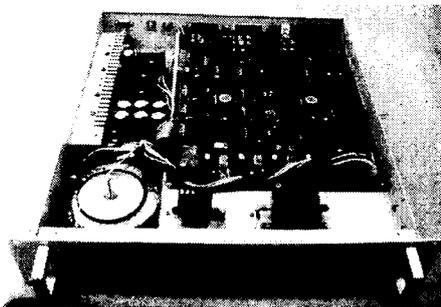
Front-view of 8-VSB Modulator



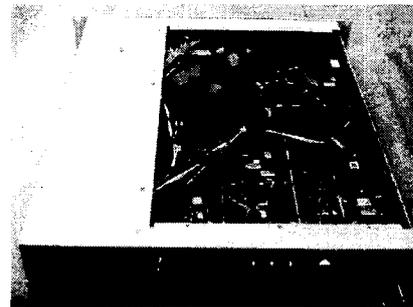
Rear-view of VSB Modulator

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VSB MODULATOR - II



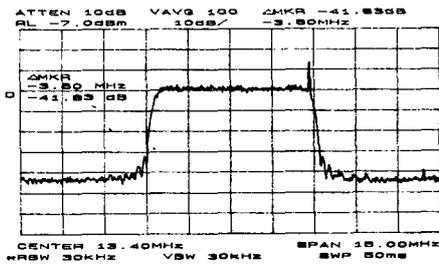
VSB modulator board



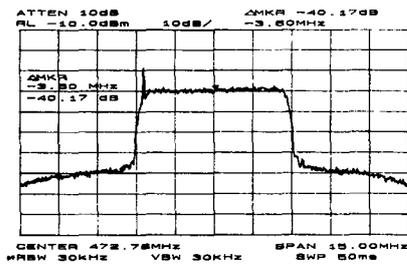
Frequency translator &
Synthesizer board

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VSB Spectrum Plot from the Input and Output of RF Frequency Up-Converter

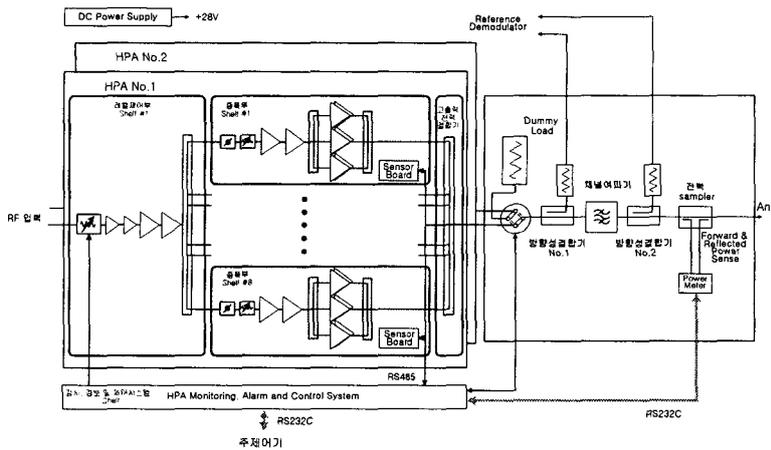


The spectrum of 8-VSB modulator output

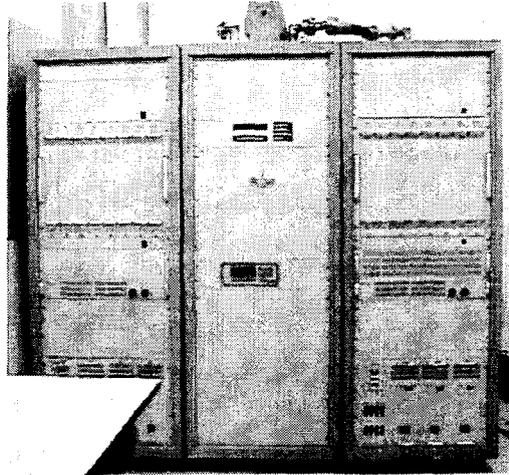


RF signal spectrum of the up-converter output (UHF)

Signal Amplification

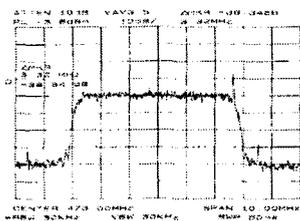


The High Power Amplifier

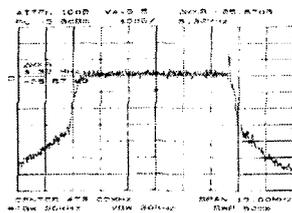


-3-

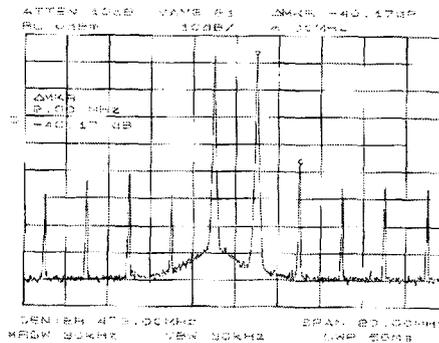
Amplifier Characteristics



Before amplifications



After amplifications



Two-tone Test Results

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Linear modulation methods

- AM, SSB, VSB, QAM, OFDM, etc
- 스펙트럼 효율성 높음
- 진폭과 위상 모두 변화
- 높은 선형성을 갖는 Power Amp 필요
- Power amplifier 의 비선형성은 Spectrum emission (IMD) 의 원인

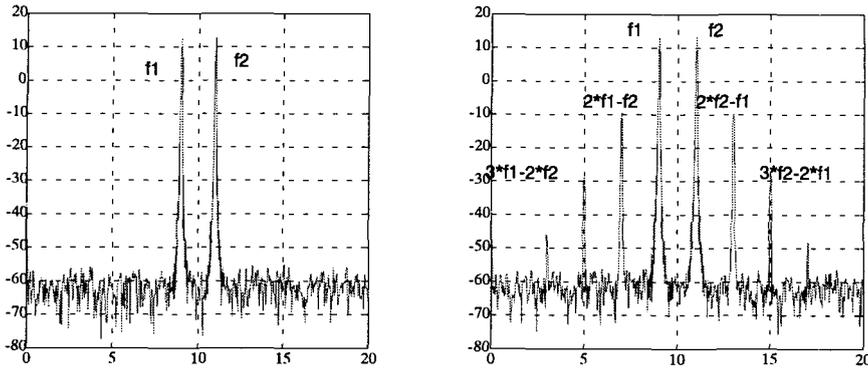
-5-

Distortions in Transmitter

- Linear Distortion (선형 왜곡)
 - In Band Ripple, Transition
 - Source : Channel Filter Group Delay
 - Nonlinear Distortion (비선형 왜곡)
 - Inter-modulation Distortion --> Spectrum Emission
 - Source : High Power Amplifier
- * Pre-corrector = Pre-Equalizer + Pre-Distorter**

-6-

Two-tone Simulation with the Amplifier's Non-linearity



-7-

The Power Amplifiers for Linear Modulation Applications

Class of Power Amp	Class A	Class AB	Class B	Class C
Back-off	大		小	
선형성	Good	←————→	Poor	N/A
전력효율	Low	←————→	High	N/A

Question :

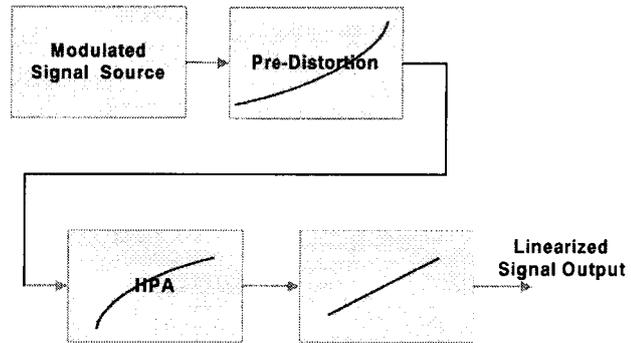
Can we make the power amplifier both linear and power efficient?

Proposal :

Linearize the power efficient nonlinear high power amplifier by ' Digital Adaptive Precorrector '

-8-

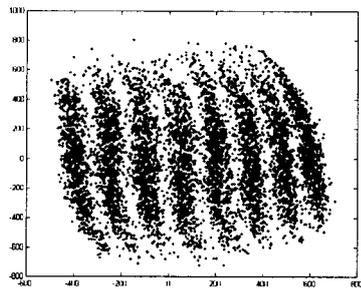
The Basic Principle of Pre-Distortion



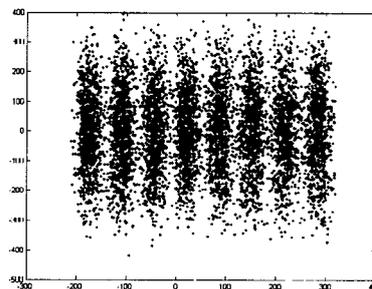
-9-

The Effect of Pre-Distortion at I/Q Domain

Without Pre-Distortion



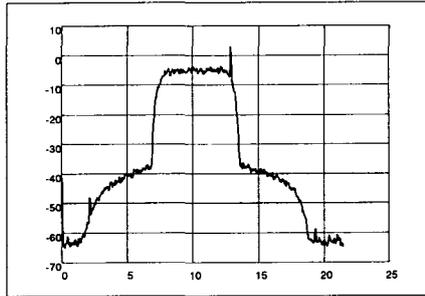
With Pre-Distortion



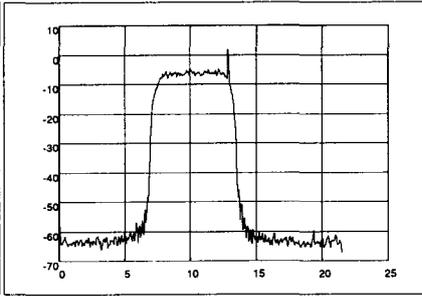
-10-

The Effect of Pre-Distortion at Frequency Domain

Without Pre-Distortion



With Pre-Distortion

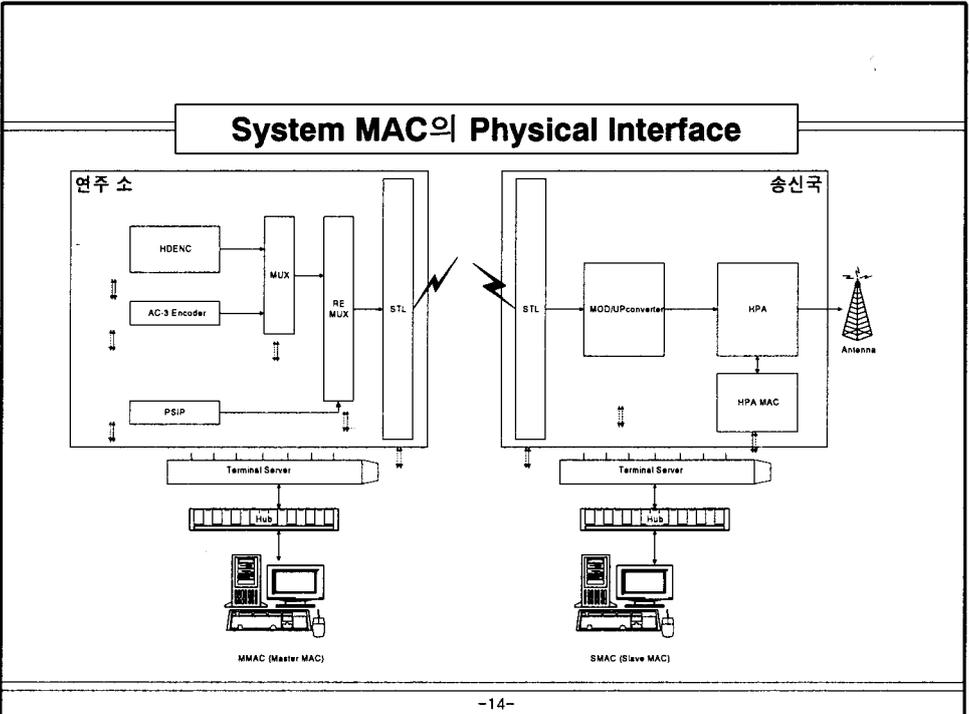
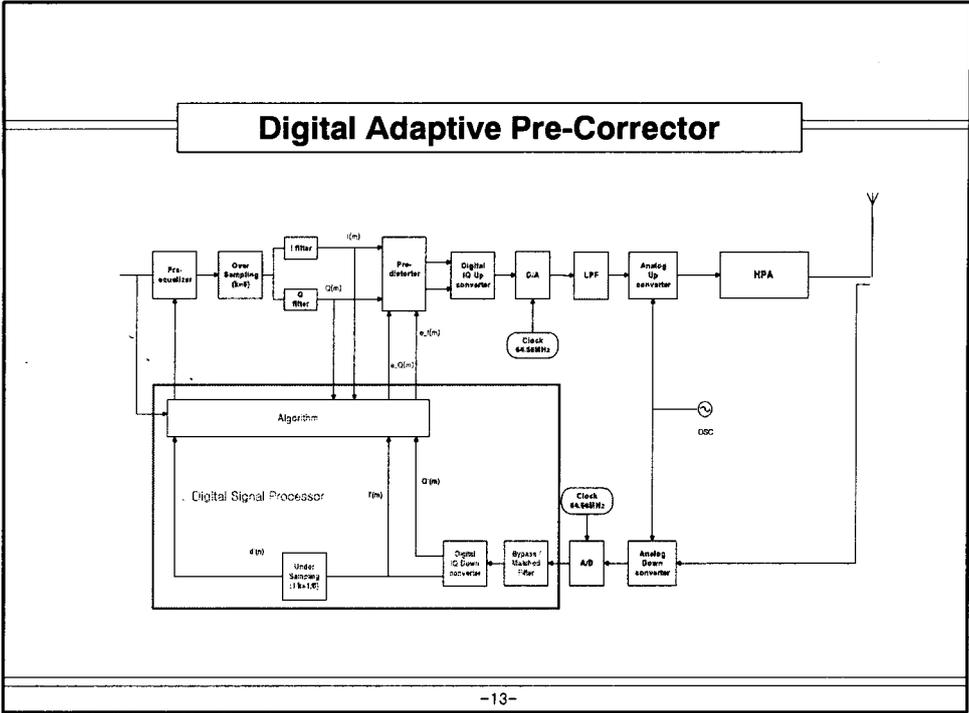


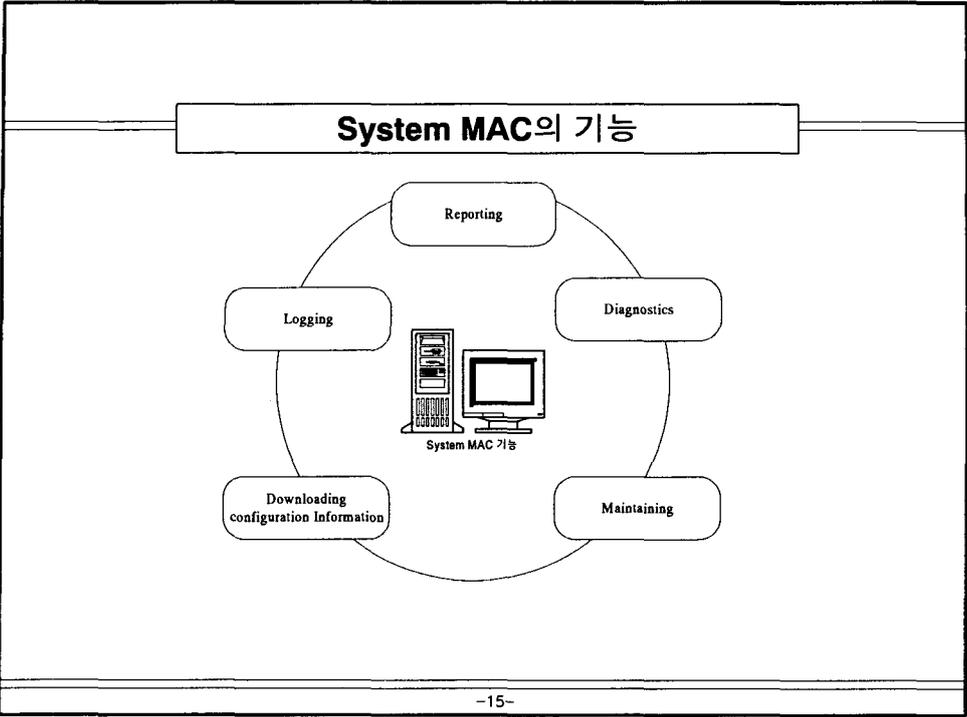
-11-

Major Sources of Linear Distortion

- In-band Ripple and Spectrum Tilt
 - Narrow-band Amplifier
 - SAW filter
- Group Delay
 - SAW Filter 10~30ns
 - Channel Filter ~100ns

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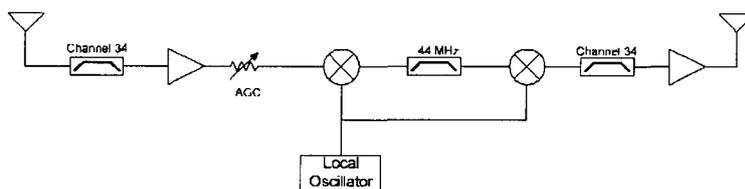
- Digital Television Repeater**
- Passive Repeater
 - Active Repeater
 - Frequency Translated Repeater
 - On-Channel Repeater
- * Isolation is the most important factor for the OCR
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Design Approaches

- Two designs available
- Non-regenerative design
 - Traditionally known as the Analog Design
 - Filtering and amplification at the IF level
 - Simple solution
 - Better performance against the main DTV signal's interference (Allow 2~5dB D/U ratio)
 - Frequency Equalizer is necessary at the multi-path faded signal reception environment
- Regenerative design
 - Traditionally known as the Digital Design
 - Demodulation and remodulation of MPEG bitstream
 - Provides Forward Error Correction capabilities at the repeater
 - Poor performance against the main DTV signal's interference (Allow 15dB D/U ratio)

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Non-Generative Repeater



- | | |
|---|--|
| <ul style="list-style-type: none"> • Functions - Pre-Amplification - Out-of-channel filtering - Power Amplification | <ul style="list-style-type: none"> • Design Criteria - Low phase/amplitude noise - Low group delay - High gain |
|---|--|

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Major Link Parameters for Non-Generative Repeating

$$P_{rx} = ERP - L - A_{pat}$$

Where : P_{rx} = Repeater receive power at antenna

ERP = Primary transmitter ERP in dBm

L = Free space loss

A_{pat} = Cardioid adjustment

Equation 1. Repeater receive power formula.

$$L = 32.45 + 20 \times \log(f) + 20 \times \log(d)$$

Where : L = Loss in dB

f = Frequency in MHz

d = Distance in km

Equation 2. Free space loss formula.

$$P_{ix} = P_{rx} + \mu_c - M$$

Where : P_{ix} = ERP in dBm

P_{rx} = Received power in dBm

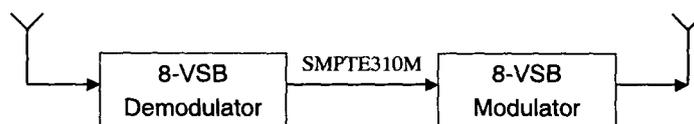
μ_c = mutual coupling (dB)

M = coupling margin (20 dB)

Equation 3. Repeater ERP formula

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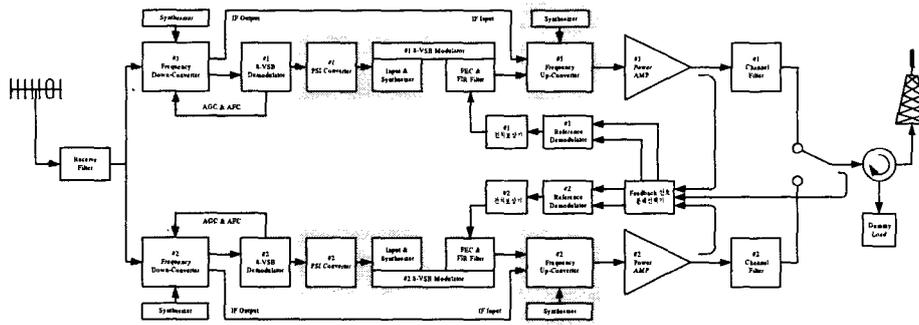
Regenerative Repeater



- Signal Flow
 - RF Input
 - MPEG Interconnection
 - RF Output
- Qualities
 - Error correction at the MPEG level
 - Clean RF Output

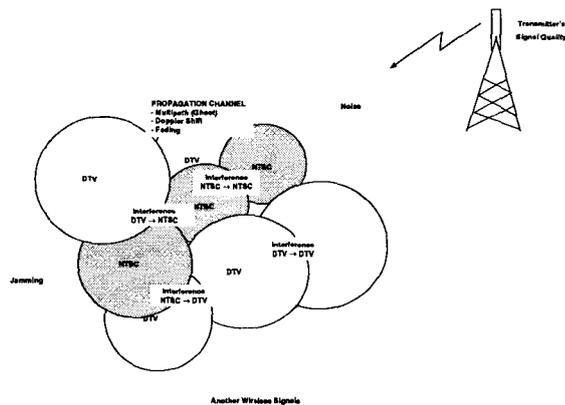
-20-

Typical Structure of Regenerative Repeater



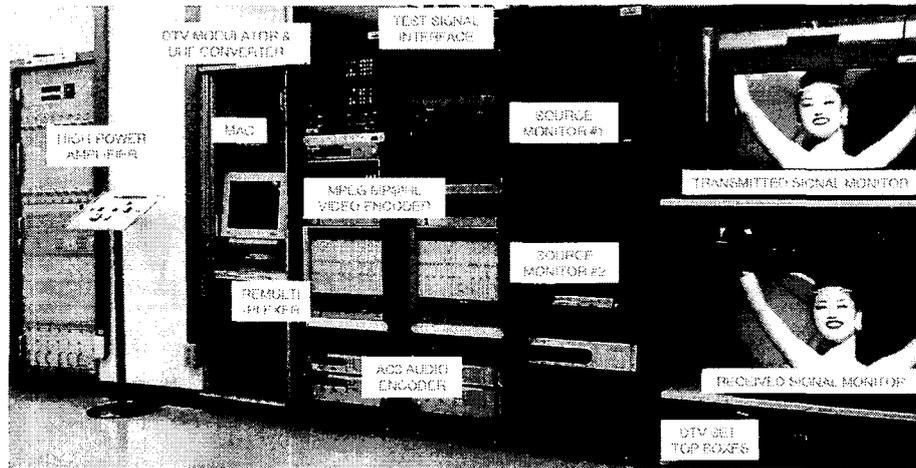
-21-

Propagation Channel Environment of Terrestrial Television Broadcasting



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ETRI DTV Verification System



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RESOURCES

▣ DTV related WEB sites

- ◆ Advanced Television Systems Committee <http://www.atsc.org>
- ◆ Federal Communications Commission <http://www.fcc.gov>
- ◆ Society of Motion Picture and Television Engineers <http://www.smpte.com>
- ◆ ADVANCED TELEVISION TECHNOLOGY CENTER <http://www.attc.org>
- ◆ MPEG Pointers and Resources <http://www.mpeg.org/MPEG>
- ◆ DVD EXPRESS <http://www.dvd.com>
- ◆ The National Association of Broadcasters <http://www.nab.org>
- ◆ Sarnoff Corporation <http://www.sarnoff.com>
- ◆ Broadcast Net - The Broadcast Industry's Home Page
<http://www.broadcast.net/bdtv.html>

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