디지털 방송의 제작을 위한 기초

MBC DTV추진부 임채열

내용

- DTV & ATSC의 개요
- Video Format Basic
- Serial Interface Format Standard
- Audio/Video의 압축 및 응용
- Transport Stream Multiplexing
- 압축 신호의 Interface Standard

2

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DTV and ATSC의 개요

What is DTV ?

- **소극적 DTV :**
  Video와 Audio를 디지털 방식으로
  시청자에게 전달하는 시스템
- **광의적 DTV :**
  DTV를 위한 전체 시스템을 지칭
  Acquisition, production, distribution을 포함

4

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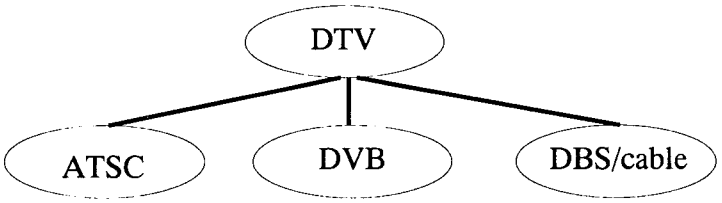
What is DTV ?

- **DTV시스템의 여러 형태 :**
  - DBS (Direct Broadcasting Satellite) : 위성을 통한 디지털 방송 서비스
  - DVB (Digital Video Broadcasting) : 유럽 방식의 위성, 지상 및 케이블을 통한 디지털 방송 방식 (기타 국가에서도 채택)
  - ATSC (Advanced Television System Committee) : 북미 규격의 디지털 방송 방식으로 현재 지상만 통용됨
  - Digital cable TV

5

용어 정리



모두가 디지털 전송 시스템이다

6

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용어 정리

DTV

ATSC	DVB	DBS/cable
지상파한정 8VSB변조	지상파 (DVB-T) COFDM변조 Cable (DVB-C) QAM 변조 위성 (DVB-S) QPSK변조	DBS=위성 QPSK변조 디지털 Cable QAM변조 Wireless cable QAM 변조

7

용어 정리

DTV

ATSC	DVB	DBS/cable
SD (480line이하) HD(720line이상) 이중 HD를 강조	대부분 SD(유럽) 때론 위성을 통해 HD방송 (미국의 Unity Motion사)	대부분 SD (유럽과 미국) 약간의 HD방송 예고

8

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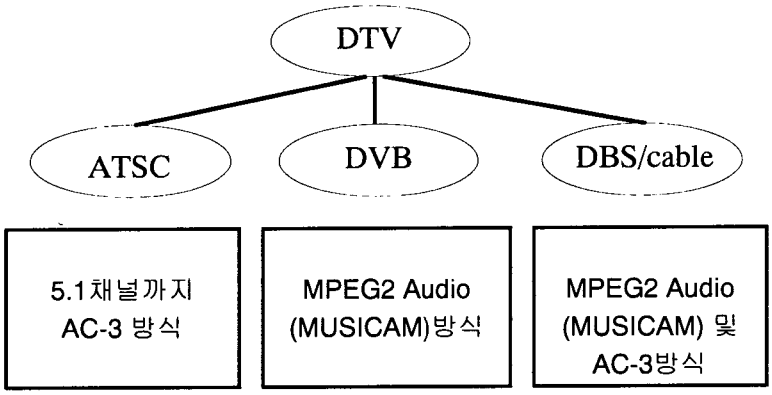
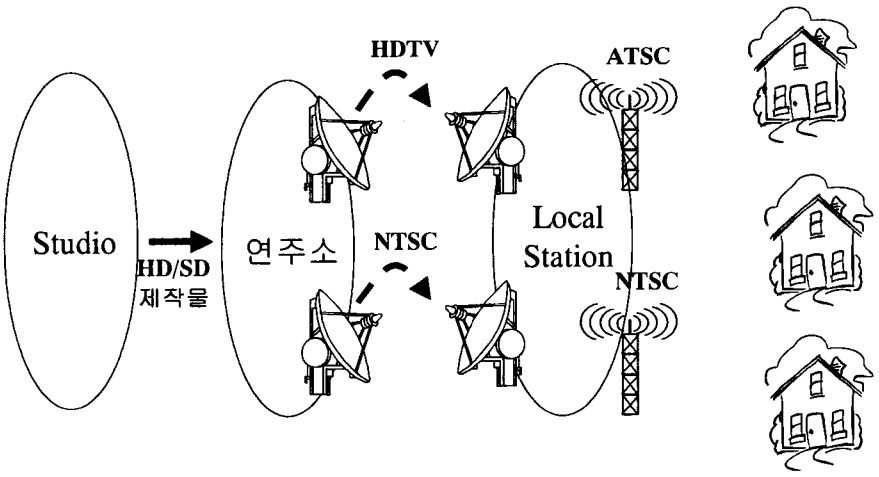
용어 정리



9

초기 Dual DTV-NTSC 방송



10

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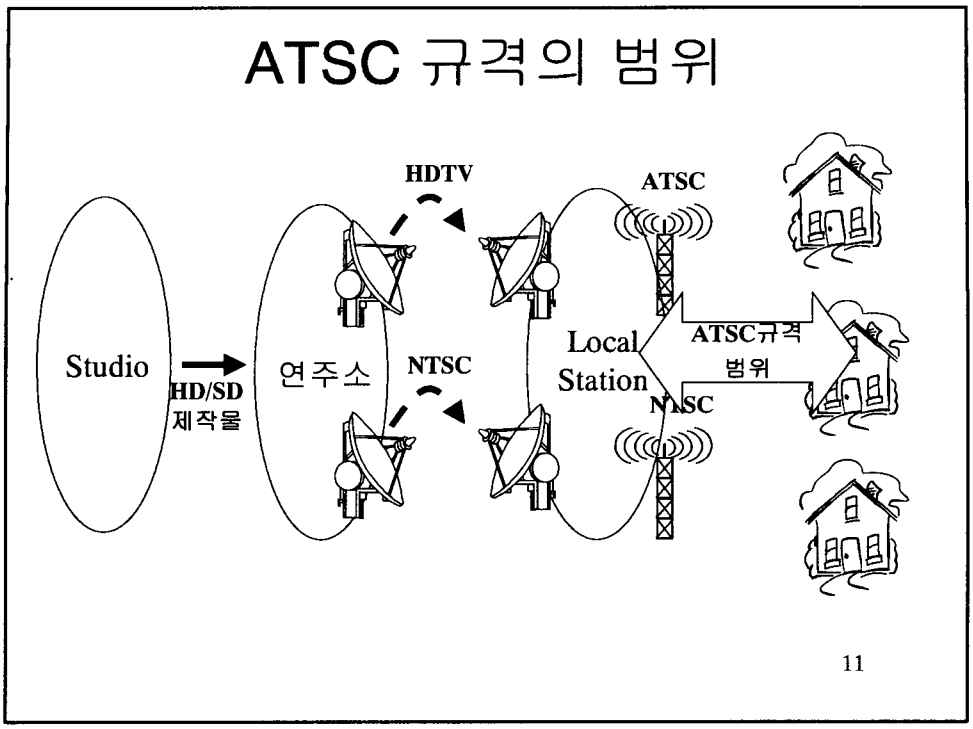

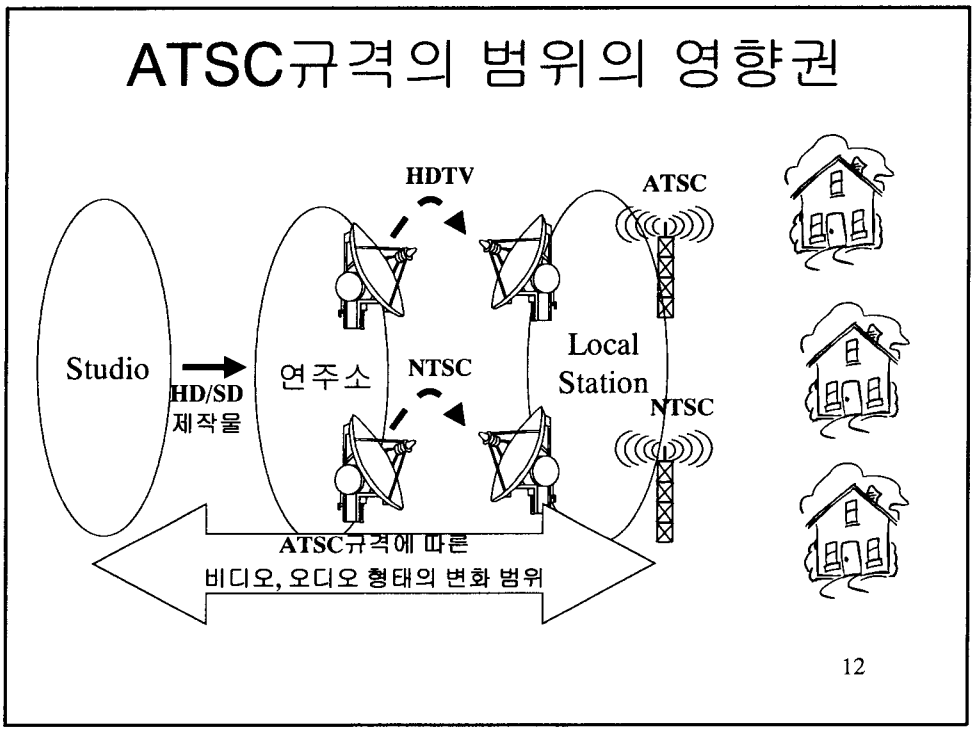

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Video Format Basics

Video Format기초

- Overview of video formats
- DTV related scanning formats
  - High definition (HD) formats
  - Standard Definition (SD) formats
  - Formats supported by ATSC
  - US Network plan summary
- Transporting HD in the studio

14

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Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	4:2:2 (CCIR601) YCbCr

15

Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	4:2:2 (CCIR601) YCbCr

16

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Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	4:2:2 (CCIR601) YCbCr

17

Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	4:2:2 (CCIR601) YCbCr

18

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Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	4:2:2 (CCIR601) YCbCr

19

DTV와 HDTV가 해당되는 Picture?

20

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Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	DTV format 기본적으로 Component Digital

21

Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	New format for Component Analogue Interface	4:2:2 (CCIR601) YCbCr

22

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Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	HDTV Monitoring 을 위해 사용	4:2:2 (CCIR601) YCbCr

23

Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	HD Tape format D6 D5-HD* HDCAM*

*표시는 압축을 포함한 format

24

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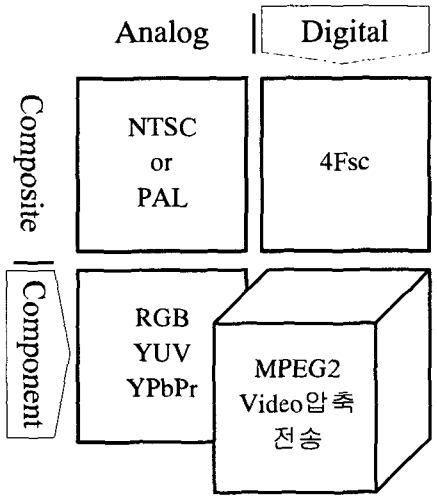
MPEG과 ATSC의 경우 해당되는 Picture?

25



26

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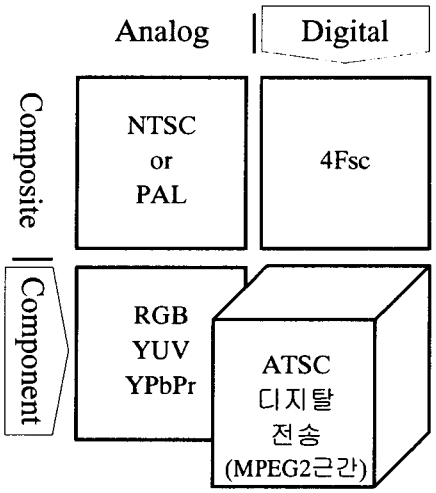

27

디지털 방송의 변혁

- Production은 몇 년에 걸쳐 component로 이전할 것
- DBS에 의해 먼저 component디지탈 신호가 전송 시작됨
- 궁극적으로 지상파 방송 역시 component 신호를 사용 (북미는 ATSC, 유럽은 DVB)

28

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Video Format기초

	Analog	Digital
Composite	대부분의 현재 방송	4Fsc
Component	RGB YUV YPbPr	4:2:2 (CCIR601) YCbCr

29

Video Format기초

	Analog	Digital
Composite	NTSC or PAL	4Fsc
Component	RGB YUV YPbPr	DTV 방송

30

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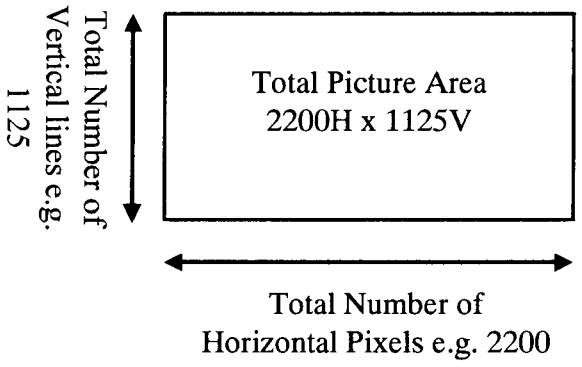
DTV Scanning Formats

- ATSC의 경우 여러 가지 format을 허용
- 디지털 전송 시스템은 format과 무관하게 전송 가능
- 비디오 format은 다음에 따라 다양
  - 수직 및 수평 의 해상도
  - Square및 Rectangular형태의 화소 주조
  - 4:3과 16:9의 종횡비
  - Scan format과 scan rate

31

Measuring the Resolution of Images



32

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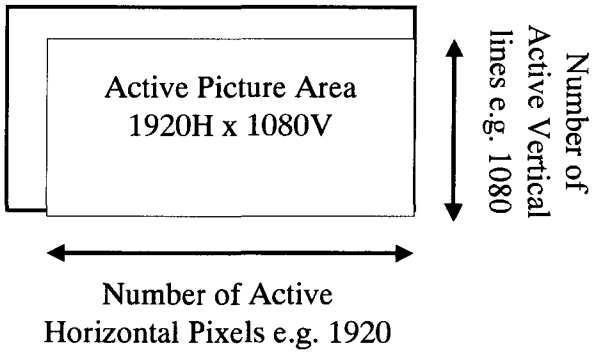
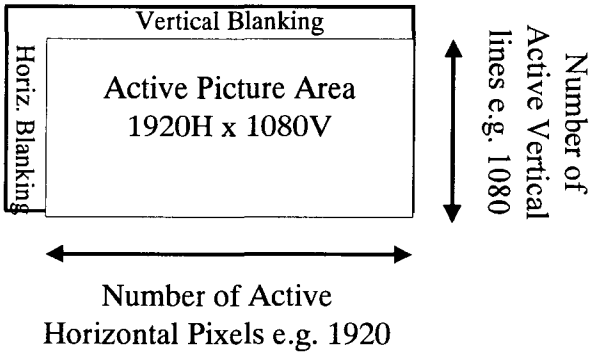
Measuring the Resolution of Images



33

Horizontal, Vertical Blanking과 Active Picture



34

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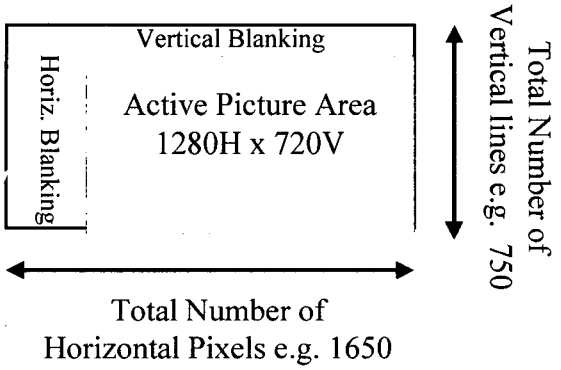
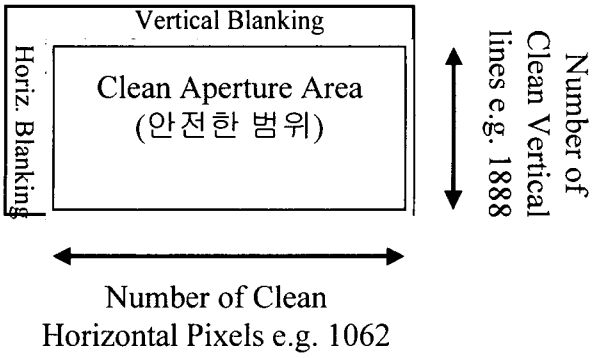
Horizontal, Vertical Blanking과 Active Picture



720p format의
H blanking이
Data Rate를
맞추기 위해
1080i보다 길다

35

Production & Clean Apertures



36

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Production & Clean Apertures

	Vertical (V) Lines/Frames			Horizontal (HV) Pix / Lines		
Format	Total	Active	Clean	Total	Active	Clean
1080	1125	1080	1062	2200	1920	1888
720	750	720	702	1650	1280	1248
480	525	483	479	858	720	707

Clean Aperture가 Production (Active) Aperture보다 약간 작다

37

Shorthand For Scanning Formats

720p60 16:9

Number of Active Lines

사용 예 :
480 Series (525 total lines)
720 Series (750 total lines)
1080 Series (1125 total lines)

38

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Shorthand For Scanning Formats

720p60 16:9

Scanning방법

사용 예 :
p =1:1 progressive
I = 2:1 interlaced

39

Shorthand For Scanning Formats

720p60 16:9

Image Frame Rate
(number of frames/sec)

- Frame rate는 항상 디스플레이 rate을 가르키지는 않는다
  - Progressive : Display Rate = Frame Rate
  - Interlaced : Display Rate = 2 x Frame Rate

40

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Shorthand For Scanning Formats

720p60 16:9

p24 24 Frames/Sec Progressive
i30 60 Fields/Sec Interlaced (480 & 1080)
p30 30 Frames/Sec Progressive
p60 60 Frames/Sec Progressive

41

Shorthand For Scanning Formats

720p60 16:9

Normal	"NTSC Friendly"
24	23.98
30	**29.97**
60	59.94

- "NTSC friendly" = Normal/1.001
- NTSC friendly" scan rate은 NTSC방송이 없어질 때까지 계속 사용 될것
- 보통 편의를 위해 Normal rate로 표기

42

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Shorthand For Scanning Formats

720p60 16:9

Picture Aspect Ratio
4:3 또는 16:9

- 종종 종횡비 값을 사용할 경우가 있음 : Width/Height
  4:3 = 1.33
  16:9 = 1.78

43

Progressive vs. Interlaced

Interlaced Pro's

- Raw data의 크기를 줄일 수 있다
- TV set을 설계하기 쉽고 저렴 (현재까지는)
- 주어진 대역폭에서 좋은 화질을 유지

Interlaced Con's

- Visual Artifacts : Inter line flicker발생
- Computer generated 영상은 converter필요
- Compressed하기 복잡
- Up-convert하기 복잡
- 약간의 움직임에도 Not good

44

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Image Frame Rates

- Frame Rate = number of frames / sec
- 높은 frame율은 움직임에 대하여 좋은 화질을 나타낸다
- Higher frame rate는 higher data rate를 만들어 전송에 필요한 비용을 증가

45

Measuring Uncompressed Image Content

- 3가지 측정법
  - Total Data Rate
  - Active Video Data Rate (Essential Data Rate)
  - Picture Element (pixel) Rate

46

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Total Data Bit Rate

Total Data Bit Rate = Total Lines per frame X Total Pixels per line X frame rate X Sample words per pixel X bits per sample word

4:2:2의 경우 pixel당 평균 2개
sample을 차지
YCbCr, Y, YCbCr, Y, ...
3 1 3 1

47

Total Data Bit Rate

Total Data Bit Rate = Total Lines per frame X Total Pixels per line X frame rate X Sample words per pixel X bits per sample word

예제 : 1080i30 - 10bit 4:2:2

1125 x 2200 x 30 x 2 x 10 = 1485Mb/s

이 값이 SDI의
Bit rate를 결정

48

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Total Data Bit Rate

Active Data Bit Rate = Active Lines per frame X Active Pixels per line X frame rate X Sample words per pixel X bits per sample word

예제 : 1080i30 - 10bit 4:2:2

1080 x 1920 x 30 x 2 x 10 = 1244Mb/s

이 값이 Essential한 video bit rate이다

49

Video Compression Ratio

$$\textbf{Compression Ratio} = \frac{\text{Active Video Data Rate Into Compression Encoder}}{\text{Compressed Video Bit Rate}}$$

예제 : 1080i30 - 10bit 4:2:2 가 18Mbps로 압축

$$\frac{1080 \times 1920 \times 30 \times 2 \times 10\ (1244\text{Mb/s})}{18\text{Mbps}} = 69:1$$

50

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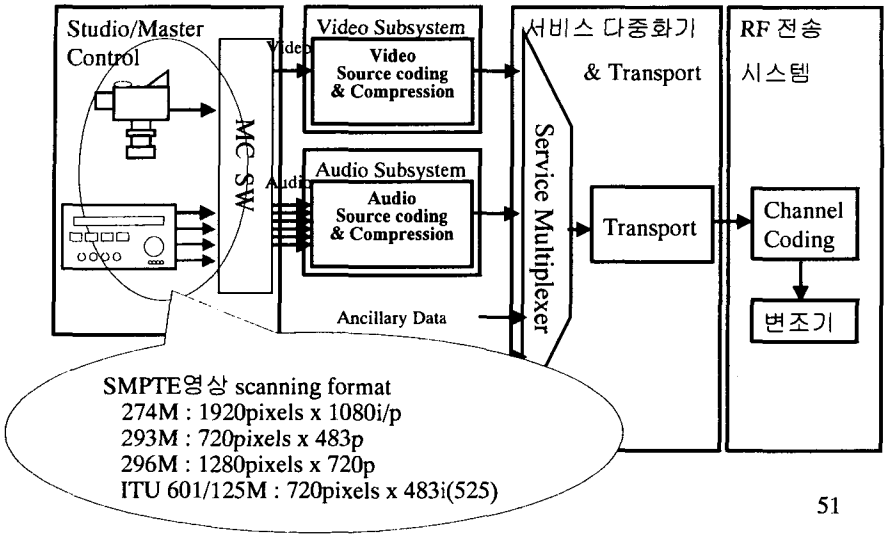
System Block Diagram



51

Standard Definition Scan Format

52

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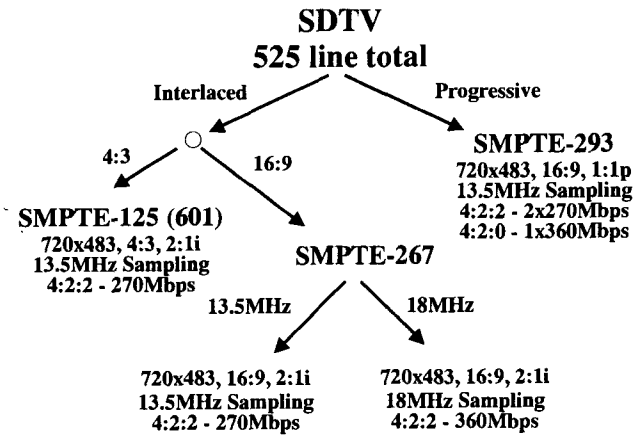
Standard Definition Scan Format



53

SD Format Summary

	Vertical (V)		Horizontal (H)		Frame	Y Sample	Bit Rate (Mbps)	
Format	Total	Active	Total	Active	Rate	Frq. (MHz)	Total	Active
480p60	525	483	858	720	60	13.5	540	470
480p30	525	483	858	720	30	13.5	270	210
480p24	525	483	?	720	24	13.5	?	?
480i30	525	483	858	720	30	13.5	270	210
480i30-18	525	483	1144	960	30	18.5	360	280

54

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관련 SMPTE 규격

	Vertical (V)		Horizontal (H)		Frame	Total Bit	SMPTE Standard	
Format	Total	Active	Total	Active	Rate	Rate	Scan	Interface
480p60	525	483	858	720	60	540	293	294
480p30	525	483	858	720	30	270	TBD	259-C
480p24	525	483	?	720	24	?	TBD	259-C
480i30	525	483	858	720	30	270	125/267	259-C
480i30-18	525	483	1144	960	30	360	267	259-D

55

High Definition (HD) Scan Format

56

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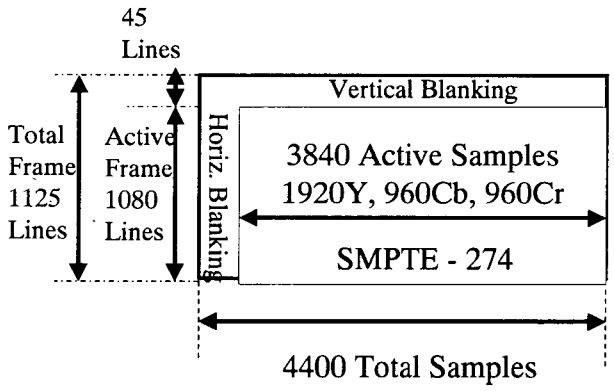
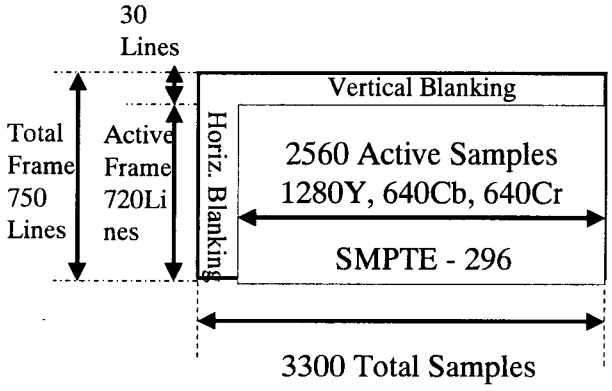
1080i Active Line Formats



57

720 Active Line Formats



58

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HD Format Summary

	Vertical (V)		Horizontal (H)		Frame	Y Sample	Bit Rate (Mbps)	
Format	Total	Active	Total	Active	Rate	Frq. (MHz)	Total	Active
1080p60	1125	1080	2200	1920	60	148.5	2970	2488
1080p24	1125	1080	2750	1920	24	74.25	1485	995
1080i30	1125	1080	2200	1920	30	74.25	1485	1244
720p60	750	720	1650	1280	60	74.25	1485	1106
720p24	750	720	4125	1280	24	74.25	1485	442

59

HD Format Summary

	Vertical (V)		Horizontal (H)		Frame	Y Sample	Bit Rate (Mbps)	
Format	Total	Active	Total	Active	Rate	Frq. (MHz)	Total	Active
1080p60	1125	1080	2200	1920	60	148.5	2970	2488
1080p24	1125	1080	2750	1920	24	74.25	1485	995
1080i30	1125	1080	2200	1920	[illegible]	74.25	1485	1244
720p60	750	720	1650	1280	60	74.25	1485	1106
720p24	750	720	4125	[illegible]	24	74.25	1485	442

1080p60은 현재 높은
대역폭과 높은 sampling rate로
사용되지 않는다

60

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HD Format Summary

	Vertical (V)		Horizontal (H)		Frame	Y Sample	Bit Rate (Mbps)	
Format	Total	Active	Total	Active	Rate	Frq. (MHz)	Total	Active
1080p60	1125	1080	2200	1920	60	148.5	2970	2488
1080p24	1125	1080	2750	1920	24	74.25	1485	995
1080i30	1125	1080	2200	1920	30	74.25	1485	1244
720p60	750	720	1650	[illegible]	60	74.25	1485	1106
720p24	750	720	4125	[illegible]	24	74.25	1485	442

1080p24와 같이 낮은 프레임율이라도 동일한 sampling rate와 전송율을 갖는다

61

관련 SMPTE 규격

	Vertical (V)		Horizontal (H)		Frame	Total Bit	SMPTE Standard	
Format	Total	Active	Total	Active	Rate	Rate	Scan	Interface
1080p60	1125	1080	2200	1920	60	2970	274M	N/A
1080p24	1125	1080	2750	1920	24	1485	274M	292M
1080i30	1125	1080	2200	1920	30	1485	274M	292M
720p60	750	720	1650	1280	60	1485	296M	292M
720p24	750	720	4125	1280	24	1485	296M	292M

62

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방송의 적용

Vertical (V)		Horizontal (H)		Frame	Total Bit	ATSC에	사용중인
Total	Active	Total	Active	Rate	Rate	표기 여부	방송사
1125	1080	2200	1920	60	2970	No	
1125	1080	2750	1920	24	1485	Yes	CBS,NBC,PBS
1125	1080	2200	1920	30	1485	Yes	CBS,NBC,PBS
750	720	1650	1280	60	1485	Yes	ABC,FOX
750	720	4125	1280	24	1485	Yes	ABC,FOX

63

ATSC가 지원하는 Scanning Formats

A53 : Table 3

64

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Format Count	Image Format	Scan Rate	
1	1920 x 10180	P24	HDTV
2	16 : 9	P30	
3	Square Pixel	I30	
		–	
4	1280 x 720	P24	
5	16 : 9	P30	
	Square Pixel	–	
6		P60	
7	704 x 480	P24	SDTV
8	16 : 9	P30	
9	Non Square Pixel	I30	
10		P60	
11	704 x 480	P24	
12	4: 3	P30	
13	Non Square Pixel	I30	
14		P60	
15	640 x 480	P24	
16	4 : 3	P30	
17	Non Square Pixel	I30	
18		P60	

65

Format Count	Image Format	Scan Rate	NTSC호환	
1, 19	1920 x 10180	P24	P23.98	HDTV
2, 20	16 : 9	P30	P29.97	
3, 21	Square Pixel	I30	I29.97	
		–	–	
4, 22	1280 x 720	P24	P23.98	
5, 23	16 : 9	P30	P29.97	
	Square Pixel	–	–	
6, 24		P60	P59.94	
7, 25	704 x 480	P24	P23.98	SDTV
8, 26	16 : 9	P30	P29.97	
9, 27	Non Square Pixel	I30	I29.97	
10, 28		P60	P59.94	
11, 29	704 x 480	P24	P23.98	
12, 30	4: 3	P30	P29.97	
13, 31	Non Square Pixel	I30	I29.97	
14, 32		P60	P59.94	
15, 33	640 x 480	P24	P23.98	
16, 34	4 : 3	P30	P29.97	
17, 35	Non Square Pixel	I30	I29.97	
18, 36		P60	P59.94	

66

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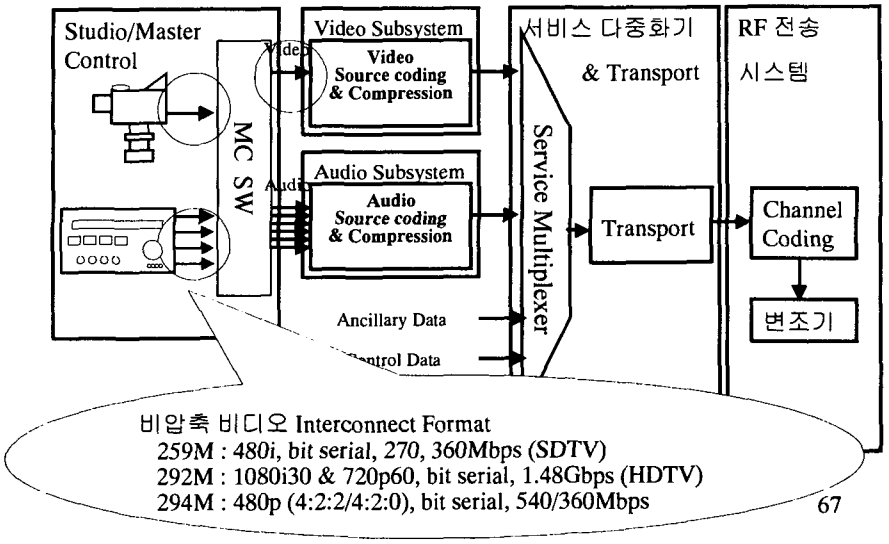
System Block Diagram



67

SMPTE259M

- 비압축 SD 525/625 video + embeded audio를 위한 serial interface 규격
- 4Fsc와 4:2:2 (601) format를 위해 사용
- 4가지의 변종들 :

– 259M-A	4fsc 525/60	143Mbps
– 259M-B	4fsc 525/60	177Mbps
– 259M-C	4:2:2, 27MHz	270Mbps
– 259M-D	4:2:2, 36MHz	360Mbps

68

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SMPTE292M

- 비압축 HD video + embeded audio를 위한 serial interface 규격
- Total Rate : 1.458Gbps
- Digital grade coaxial cable
  - 최대 케이블 길이 100m+
  - 3GHz patch들과 connector들
- 모든 DTV scan format을 포함 한다
  - 현재 1080i30/p24/p30과 720p24/30/p60
  - 480p60/i30을 포함함으로 확장

69

SMPTE294M

- 비압축 SD SMPTE-293 480p60 video + embeded audio를 위한 serial interface 규격
- 2가지 변종들
  - 294M-1 4:2:2 Chroma 2x270Mbps
  - 294M-2 4:2:0 Chroma 1x360Mbps
- 미래의 변종들
  - 294M-? 4:2:2 Chroma 1x540Mbps
  - 294M-? 4:2:2 Chroma 1x1.485GMbps

70

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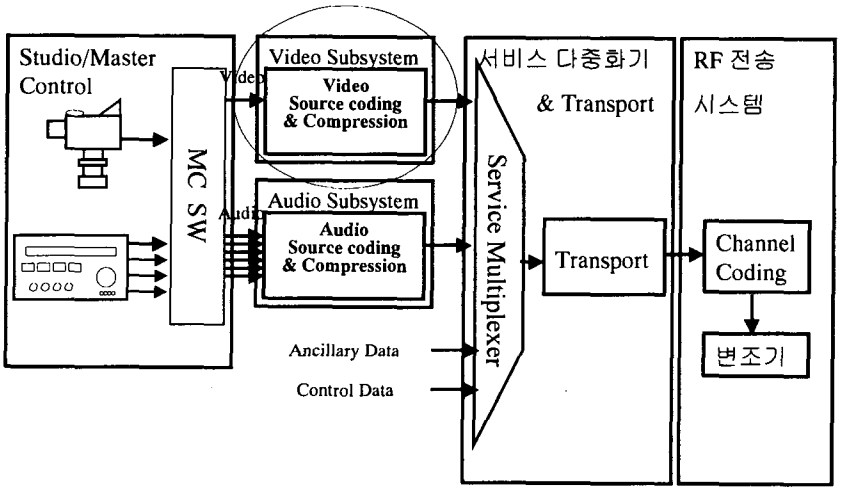
Video / Audio Compression and Applications

71

DTV Foundations



72

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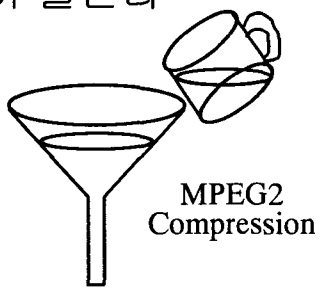
Why Compress ?

- Digital신호의 내용(content, payload)이 전송 용량이나 저장 용량을 초과
- 전송과 저장 용량에 맞게 되도록 MPEG2 를 사용하여 줄인다



전송 매체 or 저장 매체

73

MPEG2

- 표준화된 스트림을 만들기 위한 압축 기술
- 비트 스트림의 포멧과 내용은 MPEG2 표준으로 정함
- MPEG2는 널리 통용되는 ISO표준 (ISO-13818)
- 대부분의 복잡도가 encoder에 몰려있는 비대칭적 구조
- Profile과 Level로 분류

74

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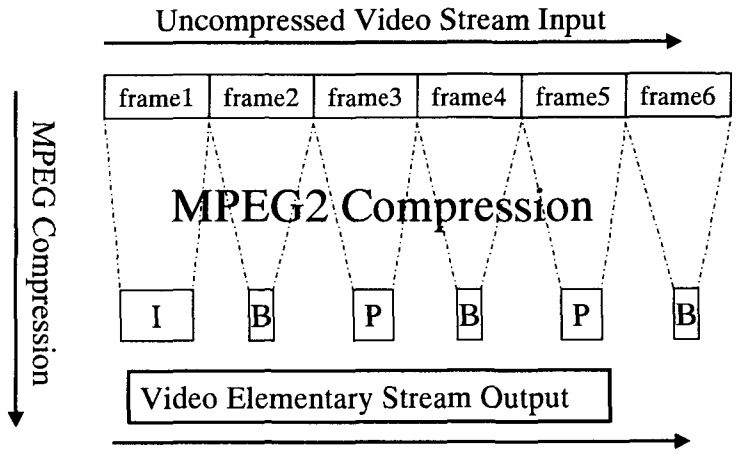
MPEG2 Levels and Profiles

Level / Profile	Simple	Main	4:2:2	SNR	Spatial	High
Low						
Main		MP@ML				
High 1440						
High		MP@HL				

75

MPEG2 Video Compression Flow Review



76

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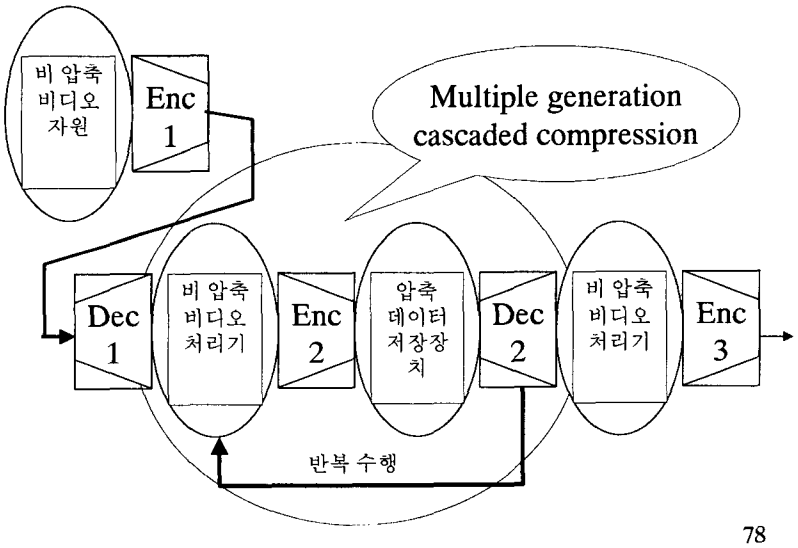
Compression Concatenation Issues

- 여러 번의 encode/decode step의 반복은 화질을 저하 시킨다
- Concatenation은 피할 수 없다
  - 지방사는 전송망을 통해 프로그램을 공급 받아서 다시 encode하여 전송해야 한다
  - Storage device는 HD는 저장하기 위하여 압축하여야 한다
  - 약간의 압축 (Intermediate level compression) 만 수행한 뒤 자원의 분배 가능

77

Cascaded Compression



78

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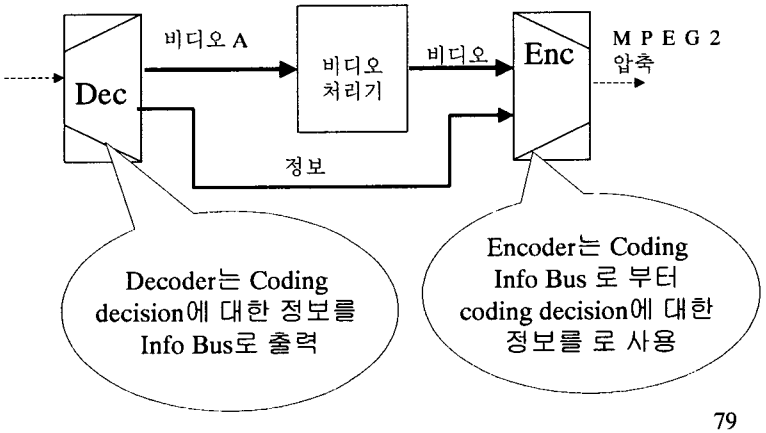
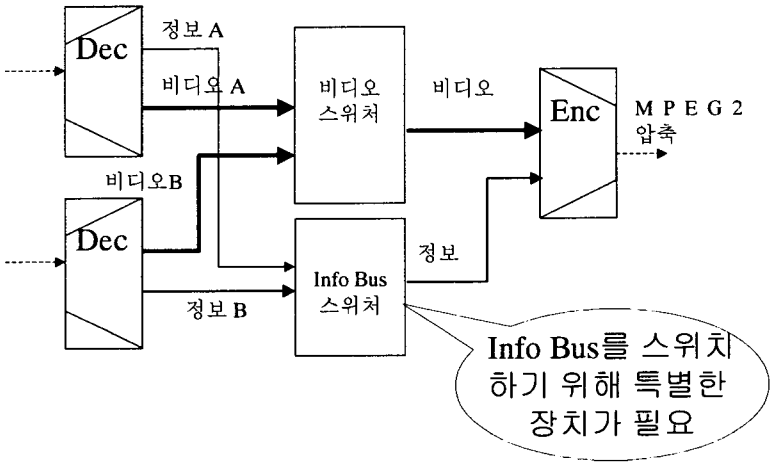
Smart Cascading



79

Smart Cascading은 복잡



80

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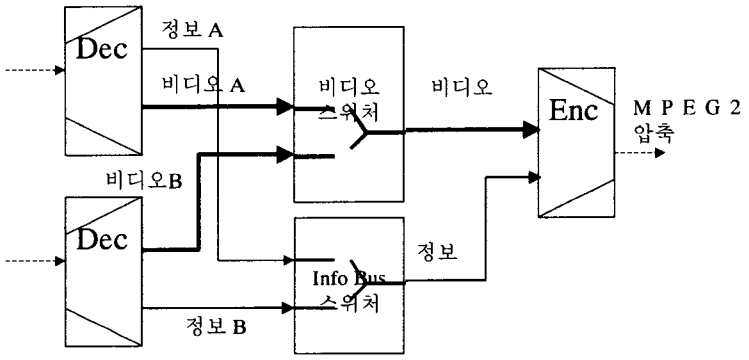
Smart Cascading은 복잡



81

Proposed Soultion : "Mole" Processing

- Video와 함께 info bus를 전달할 것을 S&W 사와 Atlantic project에서 제안됨
- **Mole**이라는 것은 "**info bus**"가 video에 숨겨 있다는 것을 지칭하는 별명
- Info bus를 processing, routing하기 위해 별도의 하드웨어가 필요 없다
- **Mole**정보는 다음 단의 encoder가 효율적으로 압축하기 위해서 사용된다

82

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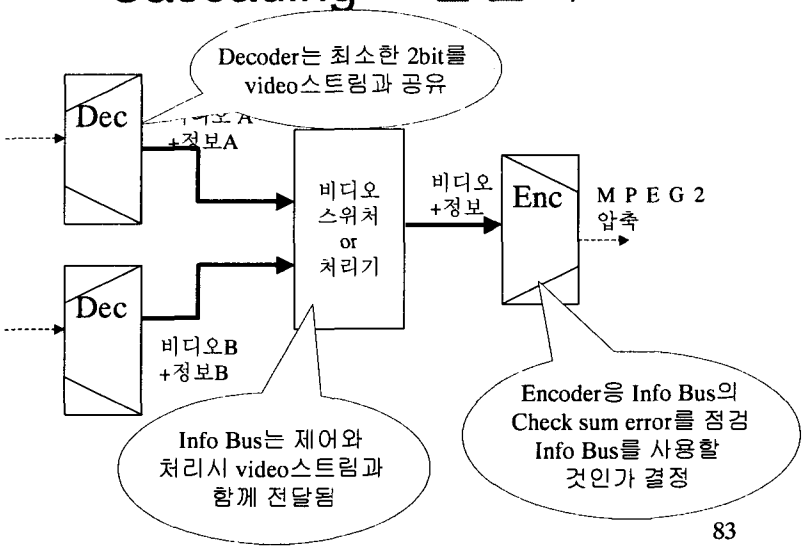
Mole processing 이용 Cascading 단순화



83

Mole Enhanced, Uncompressed Switching is Alternative to Bit Stream Splicing

- Switching은 uncompressed domain에서 이루어 질 수 있다
  - MPEG구조와 무관
  - 임의의 frame에서 스위칭 가능
- 처음의 Encoder에서 사용한 정보가 계속 사용되기 때문에 **Quality**가 유지 될 수 있다

84

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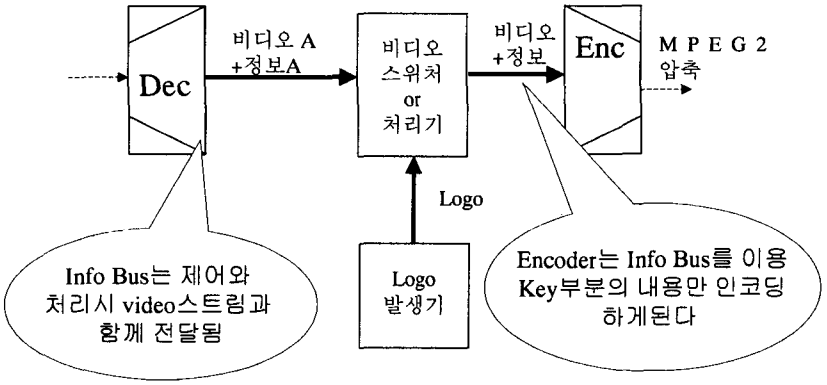
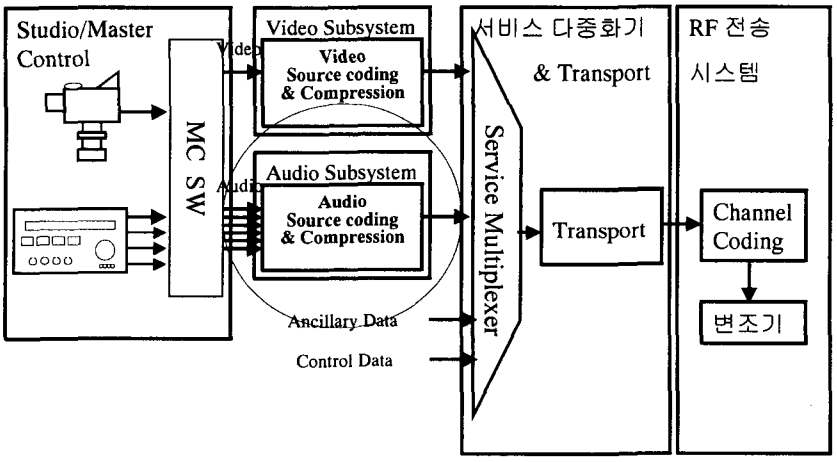
Key와 같은 복잡한 처리를 위한 Mole Processing의 사용



85

DTV Foundations



86

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Audio Compression Techniques

- MPEG1 (Layer-II) Stereo Audio coding
- MPEG2 (ISO) 1 to 5.1ch coding
- Dolby AC-3 : 1 to 5.1ch coding
  - ATSC에서 사용
  - Dolby Digital로 알려짐

87

각 표준의 사용

AC-3 audio
- ATSC표준
- DVD (Region 1) 표준
- DBS HD방송

MPEG1 / MPEG2 audio
- DVB표준
- DVD 국제 표준
- 현재 미국의 DBS서비스 (e.g. DirecTV, Echostar)

88

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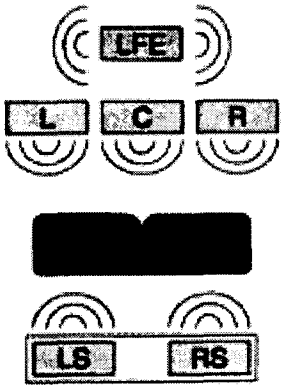
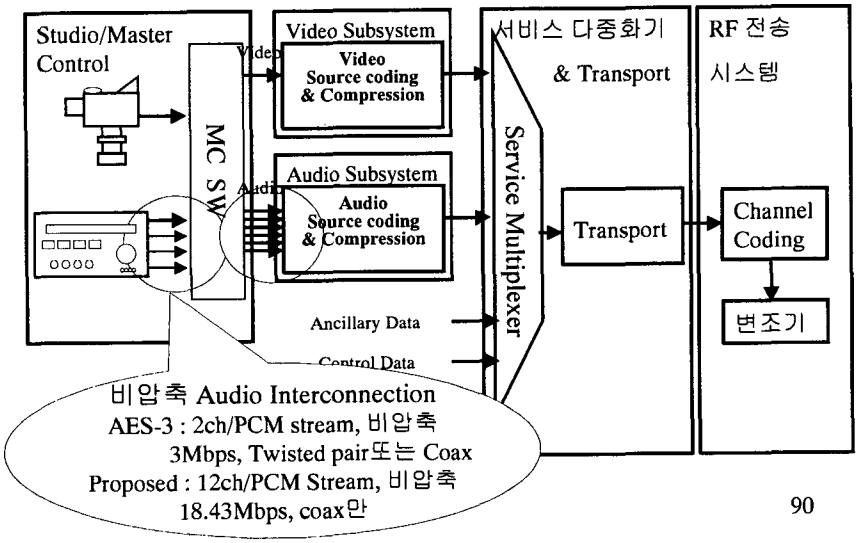
ATSC Coding Modes

Coding Mode (Front/Back)	Channel 순서
1/0	C
2/0	L,R
3/0	L,C,R
2/1	L,R,S
3/1	L,C,R,S
2/2	L,R,SL,SR
3/2	L,C,R,SL,SR



89

Studio내의 Audio 연결



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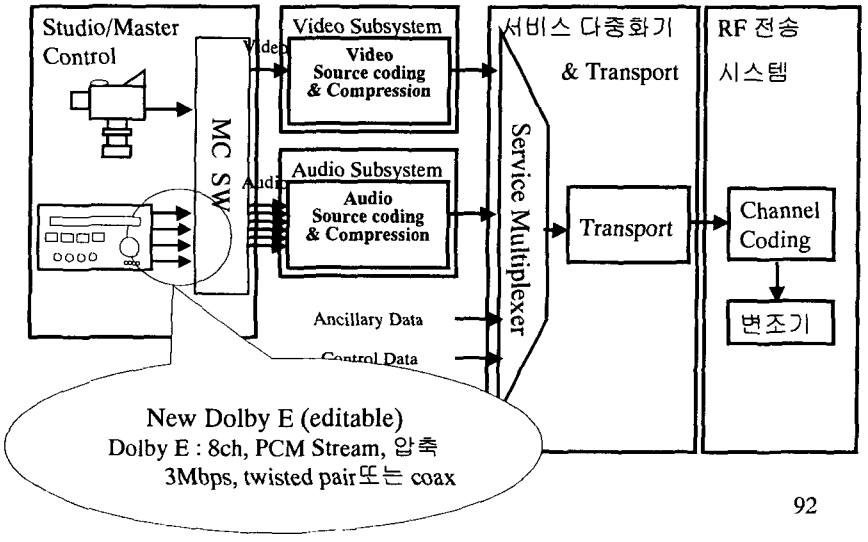
비압축 Audio Transport

- AES-3 2채널 PCM Stream
  - 2채널 / 1serial stream
  - Balanced 또는 coax wiring
  - total data rate는 3Mbps
- 12채널 PCM Stream
  - 새로운 표준이 Nvision에 의해 제안됨
  - 12채널 / 1serial stream
  - coax wiring
  - total data rate는 18.43Mbps

91

Lightly compress된 Dolby E



92

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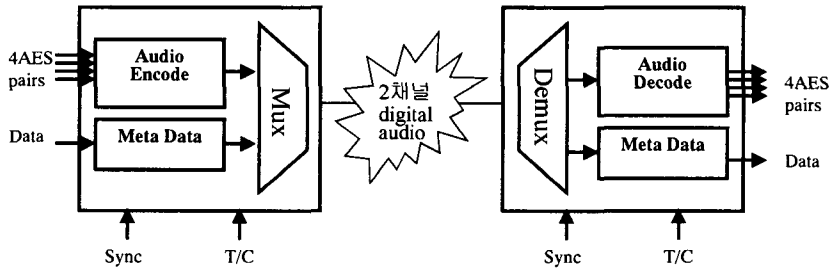
What is Dolby E ?

- Video의 IL압축과 유사
- Studio 안 밖에서 사용하기 위해 약간만 압축 사용
- 2개의 (4:1)압축 채널의 공간에 8개의 AES 채널을 저장
- 전송을 위해 표준 AES를 사용
- 적용 대상 :
  - DTVR 2개의 공간에 8개의 채널을 기록 가능
  - 고음질의 오디오 분배 가능

93

Dolby E Encoder & Decoder



- 8회에서 10회까지도 안전하게 연결 가능함
- Seamless switching과 editing가능

94

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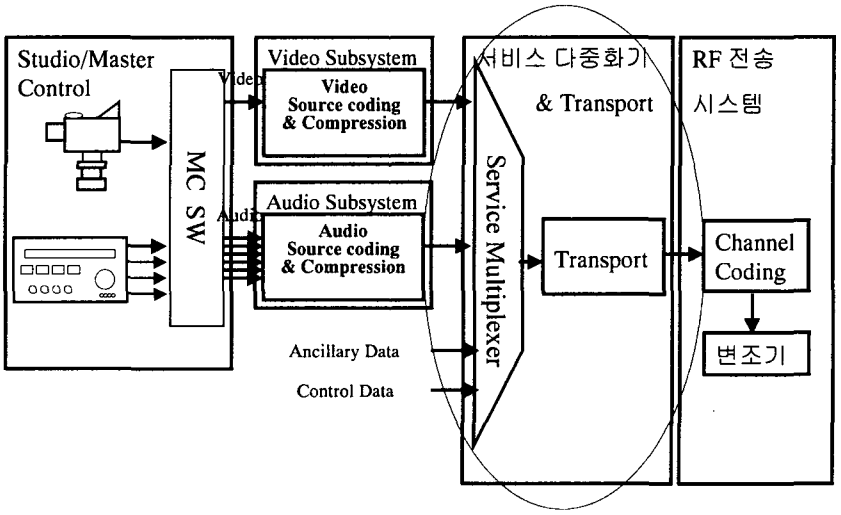
Transport Layer의 구성

95

DTV Foundations



96

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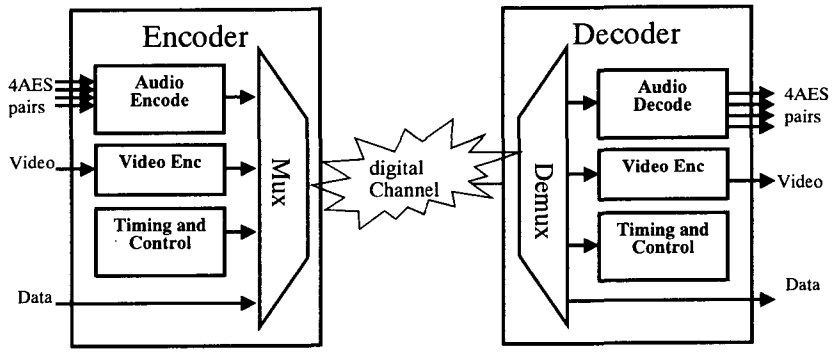
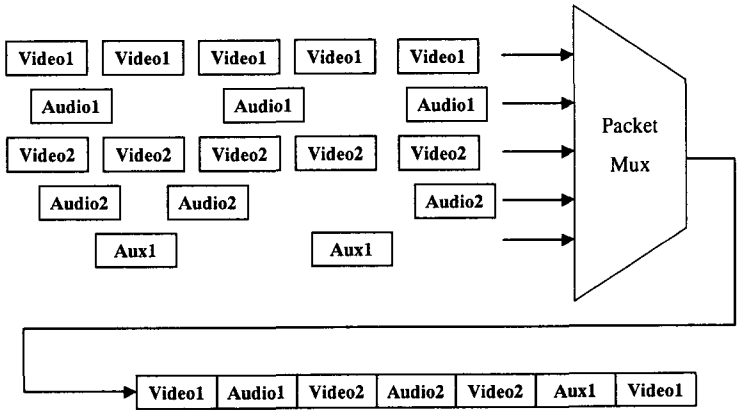


ATSC의 Transport는 MPEG2 TS에 기초하고 있다

97

Packet Multiplexing



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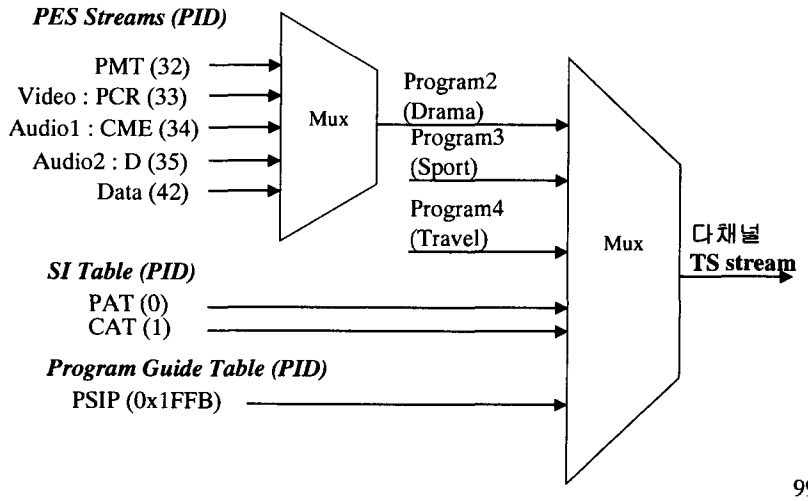
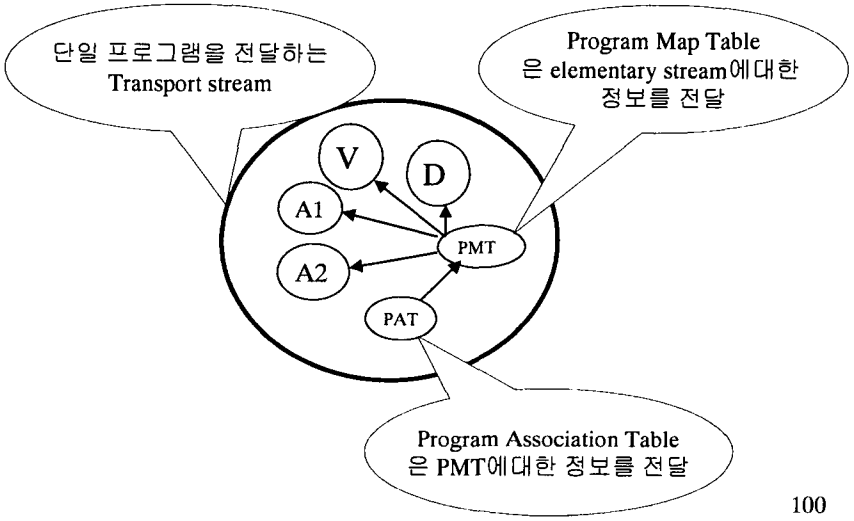
Multi-Program Multiplexing



99

Transport Stream의 구성



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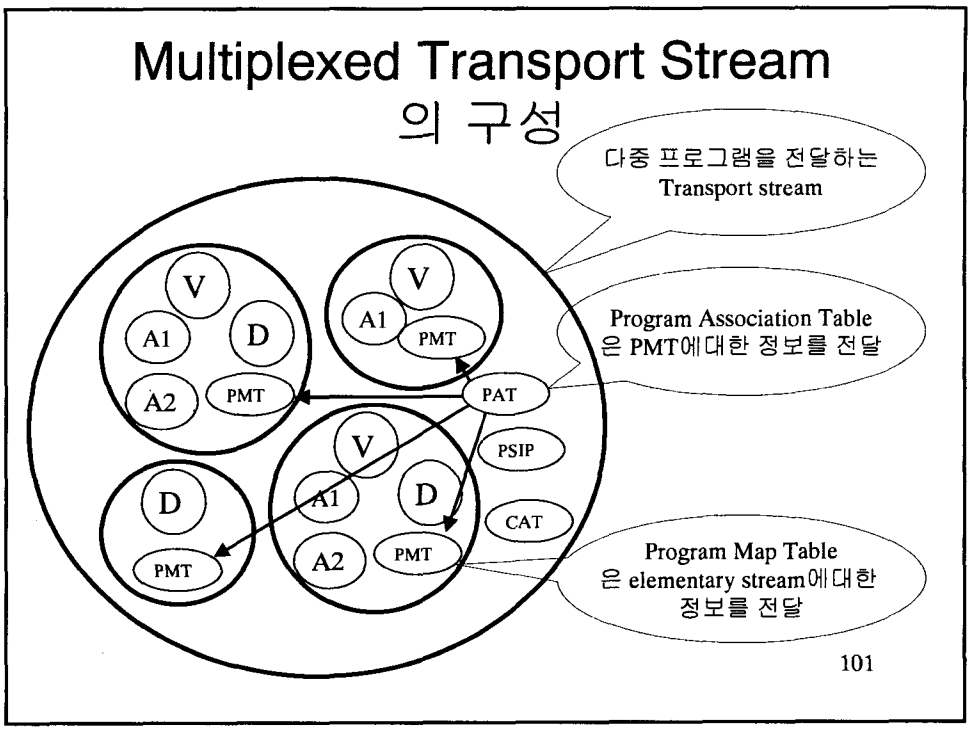

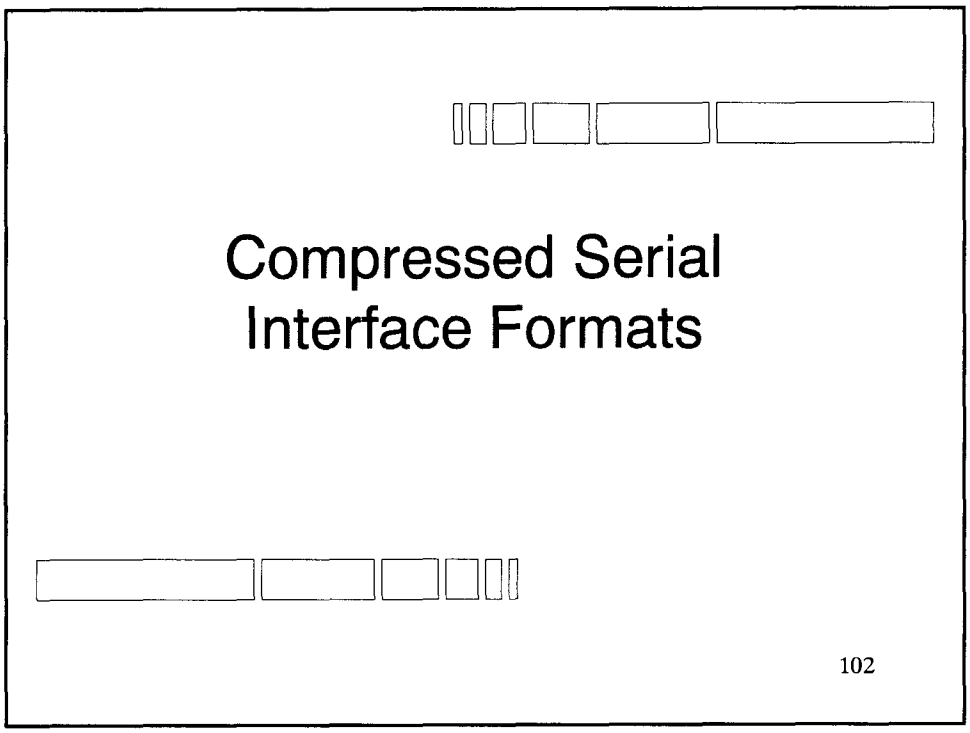

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Transporting Compressed Bit-Streams on Serial Interface

- Goal
  - MPEG2 TS packet을 알려진 interface로 전달
  - Compressed bit stream을 위한 SDI의 재사용
- 2가지 선택
  - Asynchronous Serial Interface :
    DVB-ASI, SMPTE305
  - Synchronous Serial Interface :
    DVB-SSI, SMPTE310

103

Asynchronous vs Synchronous

- Asynchronous
  - 연결 device들이 clock과 무관
  - transport 데이타율과 payload데이타율이 다름
  - Encoder와 Mux간
  - Transport rate = 270Mbps
  - Payload rate = 1-220Mbps
- Synchronous
  - 연결 device들이 입력쪽 clock과 lock됨
  - transport 데이타율과 payload데이타율이 같음
  - Encoder와 Mux간
  - Transport rate & Payload rate : 40 Mbps

104

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Asynchronous Serial Interface Standards

105

DVB-ASI

- Asynchronous Serial Interface
- DVB implementation에 일반적으로 사용
- 270Mbps에서 MPEG2 transport stream이 바로 전달
- 만일 compressed payload가 270Mbps 보다 작다면 null packet을 삽입 한다

106

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SMPTE-305 (SDTI)

- Serial Digital Transport Interface
- MPEG2 TS stream을 Asynchronous하게 270Mbps로 전달
- 압축된 비디오 스트림을 전달 분배 되도록 SMPTE-259M SDI장비를 사용한다
- DVB-ASI와 유사하나 SMPTE259M (SDI)에 Compliant하다

107

Asynchronous Serial Interface의 비교

Interface	Transport Rate (Mbps)	Payload
SMPTE 259M-C	270	비압축 비디오 215Mbps
DVB-ASI	270	MPEG2 패캣 270Mbps
SMPTE 305M	270	MPEG2 패캣 200Mbps

108

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Synchronous Serial Interface Standards

109

SMPTE310M/DVB-SSI

- Synchronous Serial Interface
- 입력쪽 device가 출력쪽 device에게 slave가 된다
- Transport의 clock rate가 payload의 clock rate가 된다
- 310M : Transport mux와 변조기 사이의 연결을 주로 사용
- DVB-SSI : 미국에서는 사용되지 않음

110

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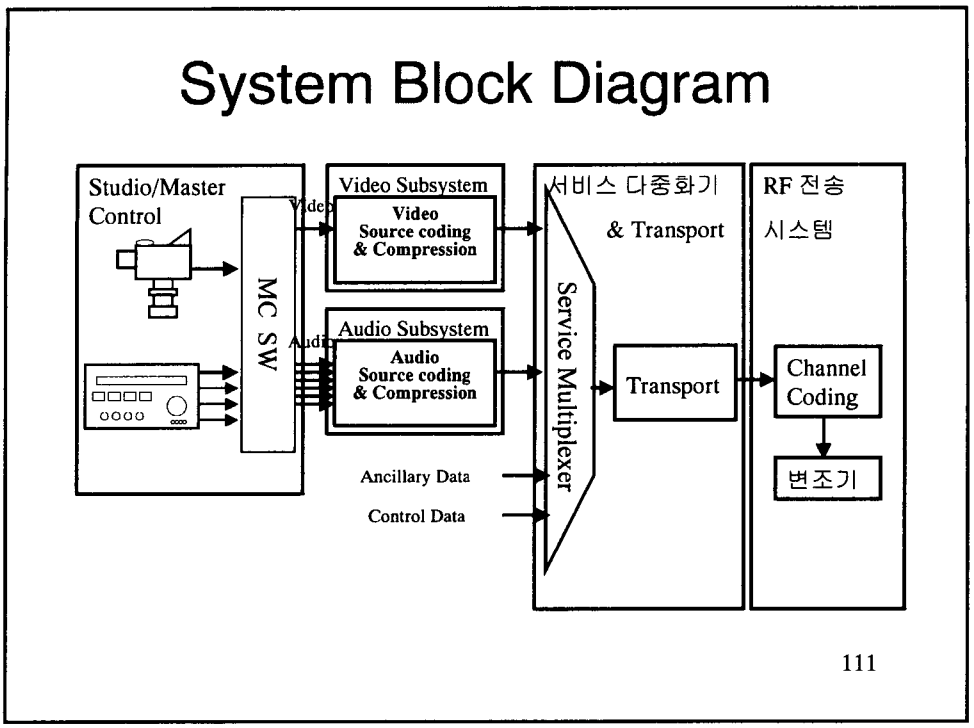

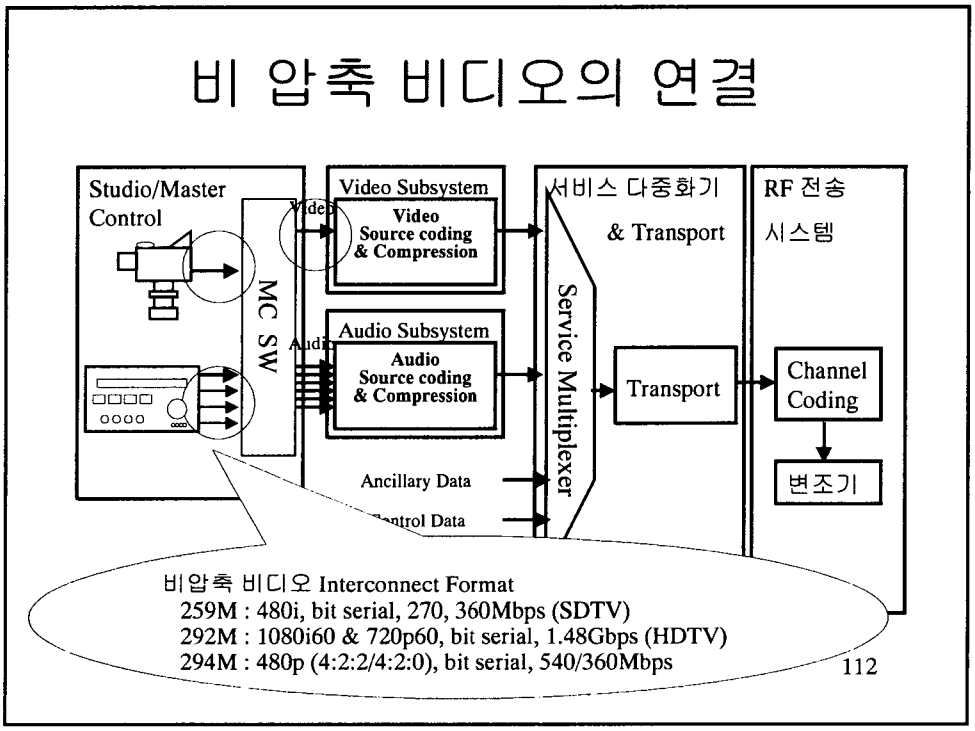

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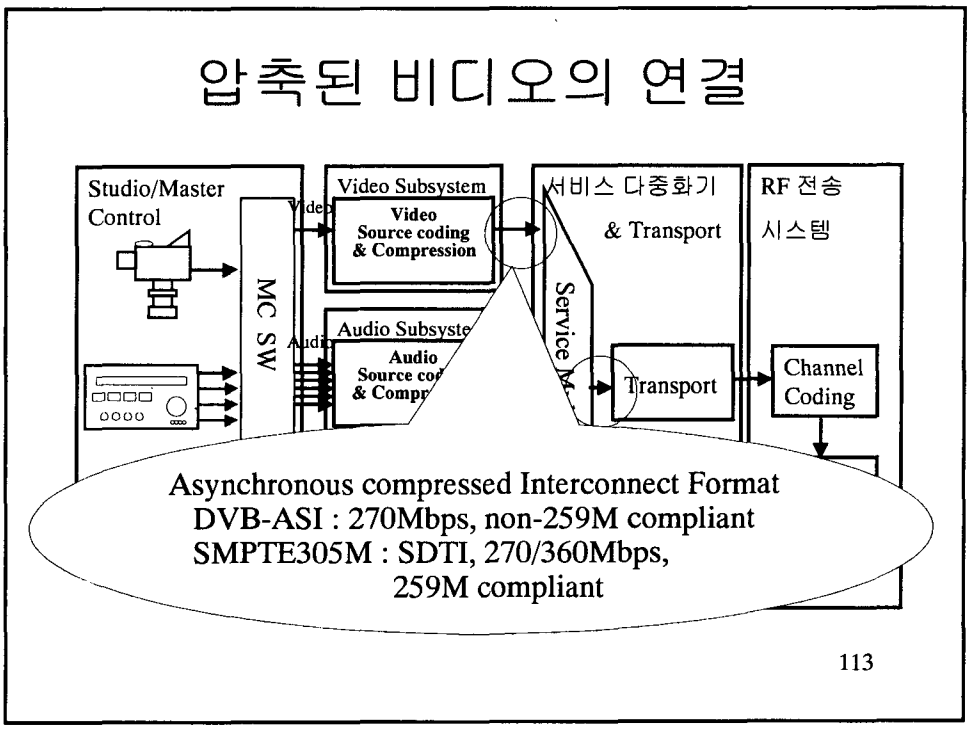

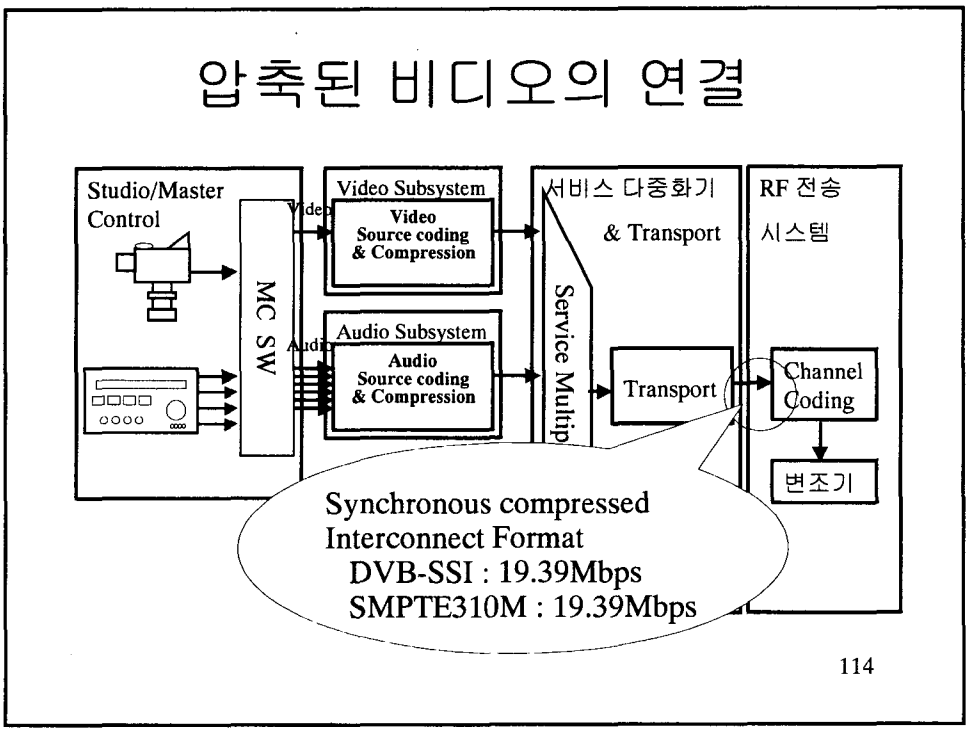

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End of Presentation

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