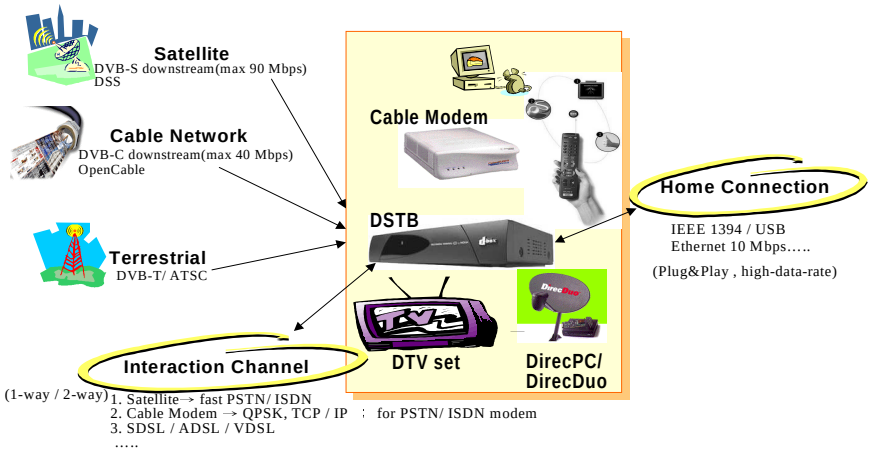
Video Basics

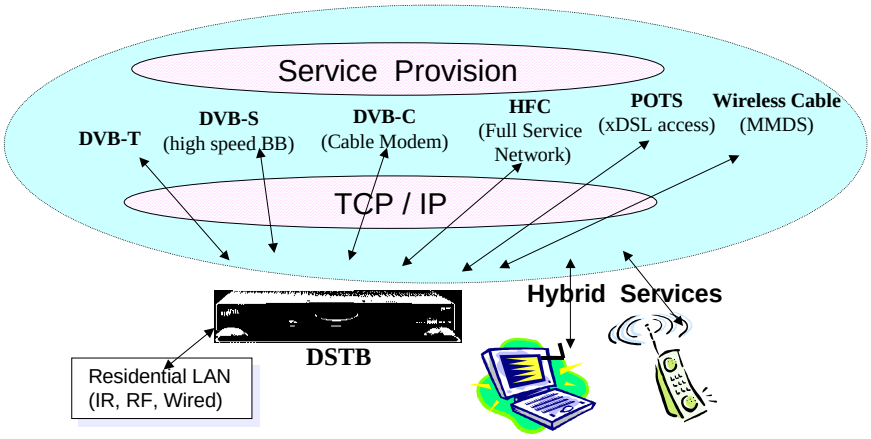
---major ref. From Ch.5 of textbook 2

- Introduction ---- video industry
- Video Imaging ---- video scan, aspect ratio
- Color and Composite & component systems
- From Analog To Digital Video
- Spatial Conversions ---- video formats
- Temporal Conversions
- Mixing And Keying

Video Environments



Video Service Environments

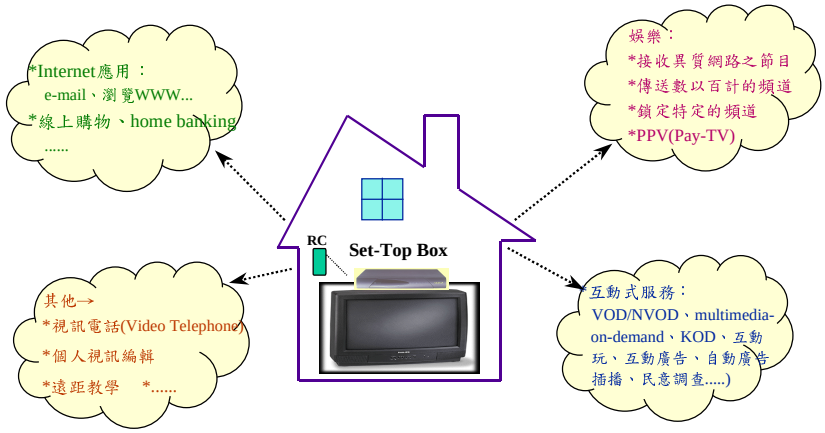


數位電視的優點、進行方式、目的

項目	內容
數位電視的優點	*提供更清晰、大畫面畫質、CD 音質 *有更多的頻道可供選擇 *易於與 PC 網路進行互連互通 *可提供互動服務，例如 Internet 接取、Home Spopping、Home Banking、.... *PPV 將變得更爲平常普通，未來也將提供隨選視訊(VOD)等服務
如何進行數位電視？	*藉由數位化傳輸將大量資訊壓縮至較小的頻寬，以收容較多頻道的空間。 *目前的類比電視機需要一數位 STB 來接收數位電視的訊號 *未來數位電視機將內藏數位 STB 解碼的功能在內，因此長期以後的未來將無須透過數位 STB。
爲何要進行數位電視廣播？	*壓縮後的頻譜空間可釋放出來讓政府拍賣予行動電話業者使用。 *數位廣播能夠克服現有類比電視傳輸系統，和 FM、Medium Wave 無線服務的瑕疵/缺點 *數位廣播僅需較低功率的 transmitters，節省發射的功率 *數位廣播打開新的市場機會
誰來提供數位電視廣播？	*英國 BBC 爲數位電視做準備已於世界足球盃開打之際首先試播 DTT 節目 *BDB 將在年底提供 30 個 DTT 頻道服務 *美國今年底四大廣播網也要開播 HDTV/SDTV 節目 *BSkyB 在今年 6 月小規模開播 200 個頻道數位衛星服務 *TCI、Comcast 等大型 MSO 已在 1997 年起陸續推出數位 Cable 服務 *Flextech 聯合 BBC 播放新的數位頻道(包括 UKFM)
何時進行數位電視廣播？	*1994 年起美國數位 DBS 和 1996 年起歐洲數位衛星開播 *1997 年起數位 Cable 服務開播 *1998 年美、英 DTT 開播，類比電視機可能還存留有 12 至 15 年的時間

資料來源：工研院電通所ITIS計畫/1998

Applications of Digital Video



Benefits of Digital Video

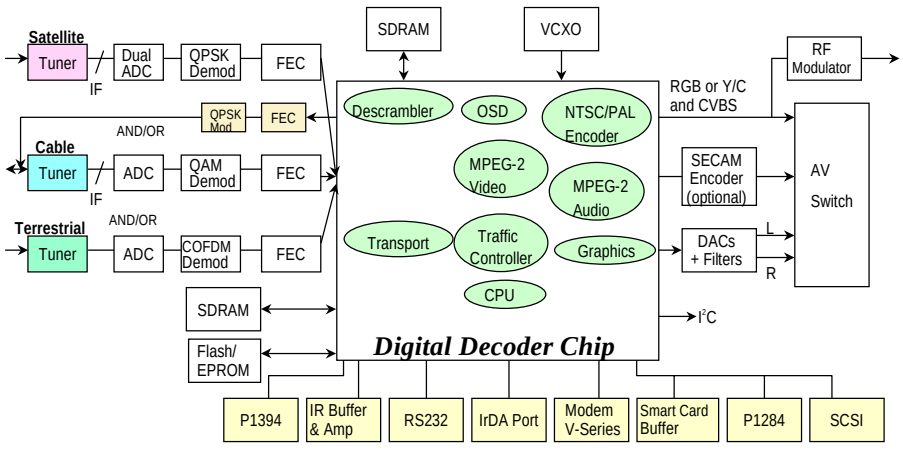
i) Open Architecture video systems, meaning the existence of video at multiple spatial, temporal, and SNR resolutions within a single scalable bitstream
ii) Interactivity
iii) Variable-rate transmission on demand
iv) Easy software conversion from one standard to another
v) Integration of various video applications
vi) Editing capabilities, such as cutting and pasting, zooming removal of noise and blur
vii) Robustness to channel noise and ease of encryption
viii) ……

Wireless Broadcast Video

	衛星(Satellite)	地面廣播(Terrestrial)	微波(MMDS,MVDS,LMDS)
數位視訊解碼	MPEG-2 MP@ML或 DigiCipher I或II	MPEG-2 MP@ML及 MPEG-2 MP@HL(HDTV)	MPEG-2 MP@ML或 DigiCipher II
解調變	QPSK	數位VSB(北美)；OFDM(歐)	QAM 或 QPSK，不過也有採用展頻技術
互動性	需透過電話線為return path作有限制的雙向傳播 目前→電子節目指南(EPG)、VBI技術、Video Info.等附屬的資訊服務		
實　例	DirecTV/USSB,PrimeStar,EchoStar, AlphaStar,ASkyB,PerfecTV'JSkyB, DirecTV(日),歐(Canal+, BSkyB,DT, FilmNet....),KoreaSat,M-Net(非)....	•美國'98年底DTT開播 •英國'98年10月將開播DTT服務	Cross Country Cable of Riverside, Tele-TV(Bell Atlantic,Nynex,Pacific Telesis).....

資料來源：工研院電通所ITIS計畫/1998

Future Video Systems

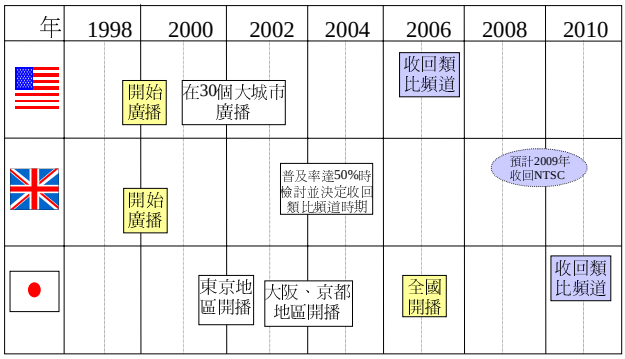


各國採用的數位電視標準

國家	數位衛星(DST)	數位 Cable(DCT)	地面廣播(DTT)
歐洲各國	DVB-S	DVB-C	DVB-T/COFDM
美國	DSS、DVB-S	SCTE-031	ATSC/8-VSB
加拿大	DVB-S	---	ATSC/8-VSB
日本	DVB-S	DVB-C	DVB/COFDM (6MHz)
韓國	DVB-S	---	ATSC/8-VSB
澳洲	DVB-S	---	DVB-T
中國	DVB-S	DVB-C	ATSC/8-VSB
臺灣	DVB-S	DVB-C	ATSC/8-VSB

DTV之發展現況

- 美國已於'98年11月1日正式開播DTV
- 英國已於'98年11月15日正式開播DTV (Ondigital/BDB)
- 日本將於2003年開播ISDB(含Audio、Video、Data)



資料來源：工研院電通所IT IS計畫，1998.11

我國DTV之發展

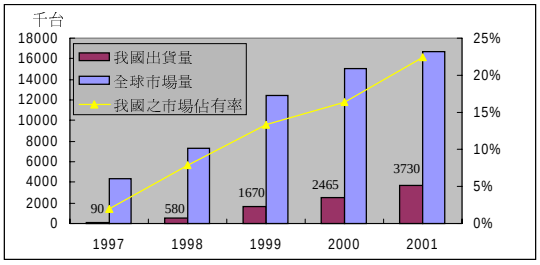
項 目	1997	1998	1999	2000	2001	2002	2006
網路		*完成工程評估			*完成全區廣播(1 月)		
			*進行細部工程測試				
				*試播台試播(6 月)			*收回 NTSC 頻道
				*開始北中南區域廣播(12 月)			
法規		*選定系統標準(ATSC)					
			*試播台頻譜規畫及頻道指配				
				*完成廣播電視法修正			
服務				*試播服務			*多媒體廣播服務
				*DTT 服務 與類比服務同步廣播			
					*付費電視服務		
						*整合數據服務 /互動服務	
	1997	1998	1999	2000	2001	2002	2006

資料來源：工研院電通所IT IS計畫，1998.11

我國視訊工業(STB)發展情形

數位Terrestrial STB	***數位Cable STB***	***數位Satellite STB***
◆已投入/欲投入廠商→大同、宏碁、飛訊、神通、誠洲、普騰、東元、聲寶、松下	◆已量產廠商→大同, 全陽, 阡成... ◆即將出貨→泰山、欣象、飛訊、憶華、三光	◆廠商→三光、宏碁、誠洲、飛訊、欣象、泰山、憶華、國裕、神通、全陽、阡成、緯能、華台

★研發單位(CCL)現階段→ATSC技術移轉



- '98年DST STB佔我國出貨量之93.4%
- '99年將有少量DTT STB訂單

資料來源:工研院電通所ITIS產業調查,1998/10
Understanding & Solutions/1998.8

美國Cable業者驅動三大標準

Item	Schedule	Tasks / Objects	Vendors Participation
MCNS-DOCSIS	'96.7 '97.8→標準確立	*broadband Cable Modem (interoperability)	Follow→ADC,Bay Networks,3Com,Com21,Cisco,GI,Motorola,NEC, NetGame,Panasonic,Phasecom,S-A, Samsung,Sony, Terayon, Thomson CE,Toshiba……..
OpenCable	'97.8→RFI '97.10→23 proposals '98.5→NCTA展中有初步結果 '98底→期望產品問世	*next-generation digital STB(include MCNS CM) *Open architecture(RTOSs / APIs / microprocessors) *exiting open Internet specifications *'98.3 specified -- IEEE1394(1年內)	Microsoft; GI; S-A Group(IBM,Pioneer,PowerTV,Sun,Toshiba); Intel Group(Cisco,Netscape,NCI,Oracle,Thomson CE); Intel/NCI; Oracle/NCI/Netscape; Thomson CE/NCI; Cisco; Sony; Thomson Sun(OpenTV); Samsung; Pioneer Digital Technologies; ACTV/Sarnoff; IBM; Criterion Software; Lucent Technologies; SCM Microsystems; Zenith Electronics; Worldgate Communications; Texas Instruments; Wink Communications; Panasonic
PacketCable	'97.10→會議期在9-12月內結合廠商發展IP voice & video over Cable	* the specs will establish a data packet network for interactive services(carry IP Internet traffic, telephony,video,teleconferencing)	3Com; 8x8; Ascend; Bay Networks; Cisco; eFusion; Ericsson; Fore Systems; IBM; Intel/Lucent Team; Inter-Tel; Linkon; Mediatrix Peripherals; Motorola; NEC; Netspeak; Nortel; S-A; Siemens/Com21 Team; Sony; Sun; Vienna

are moving Cable forward in the race to provide consumer broadband services

Year 2000 Target

full 2-way ,IP capable networks by the year 2000

資料來源：CableLabs，工研院電通所ITIS計畫/1998

Video Imaging

Imaging: normal photography, X-rays, electronic documents, electronic still pictures, motion pictures, TV

Video: a sequence of still pictures of a scene taken at various subsequent intervals in time

Scanning: a form of sampling of a continuously varying two-dimensional signal

Video Resolution

Viewing Ratio (VR):

VR = d /PH d= viewer's distance from the screen
PH= picture height

Visible pixels = 3440 /VR

Pixel (Pel) : the smallest detail that can be reproduced in a picture is about the size of a picture element

Minimum Viewing Rates

System	*Line or pixels/PH*	*VR*
NTSC television	483	7.2
HDTV	1080	3.2
Computer display	768	<4.5

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Refresh Rate and Flicker

Persistence of vision, causes the visual system responds slowly to rapid changes of illumination

Flicker: if the illumination varies cyclically at a low frequency, the eye may perceive an annoying effect

Refresh Rate: the light output of display devices decays after a short time, and therefore must be refreshed periodically to maintain the effect of steady illumination

Display Refresh Rates

System	*Refresh rate (Hz)*	*Environment*	*VR*
NTSC television	60(59.94)	Living room	7
PAL television	50	Living room	7
Computer display	72	Bright office	1-2
Motion picture theater	48	Dark room	5-10

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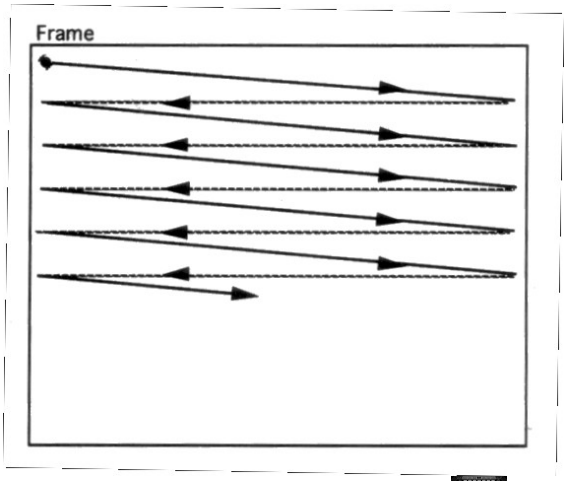
Video Imaging

Raster Scan

----(Progressive)



Video Imaging

Interlace Raster Scan

---- it is the tradeoff of bandwidth, flicker, and resolution

----- may cause flicker problems for text and graphics

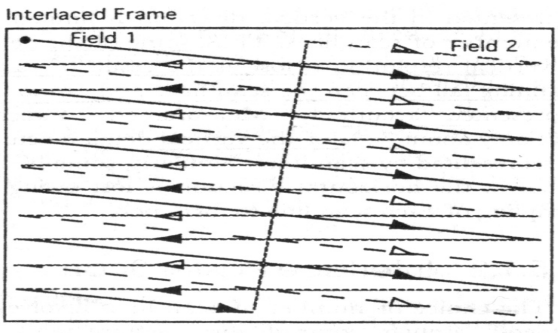


Fig. 5.2 Interlaced raster scan of an image

Image Aspect Ratio

IAR is defined as the ratio of picture width to height

IAR = w / h

PAR (pel aspect ratio) =

IAR * vertical_size / horizontal_size : full screen display

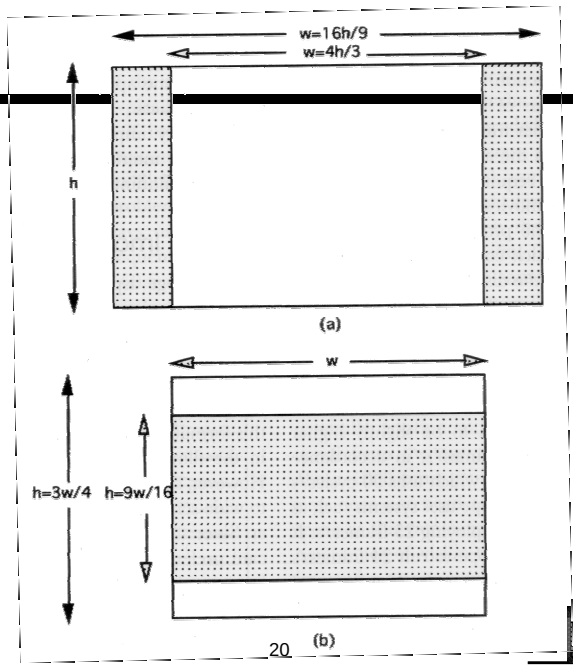
where horizontal_size is the width of the image in terms of pels and vertical_size is the height of the image in lines

ex. Display IAR = 4:3

Image size = 720 pels * 486 lines

PAR = 4/3 x 486/720 = 0.9

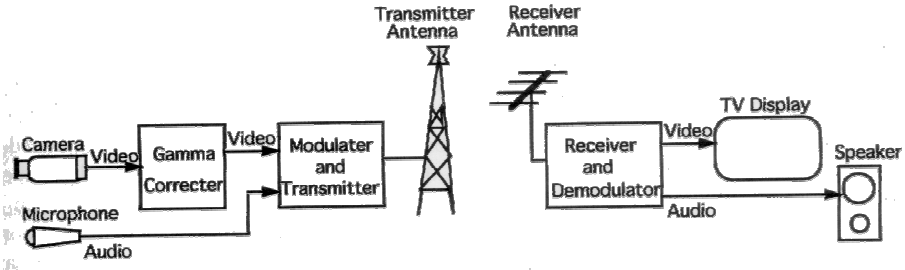
or IAR * display_vertical_size / display_horizontal_size : portion display



Gamma Correction

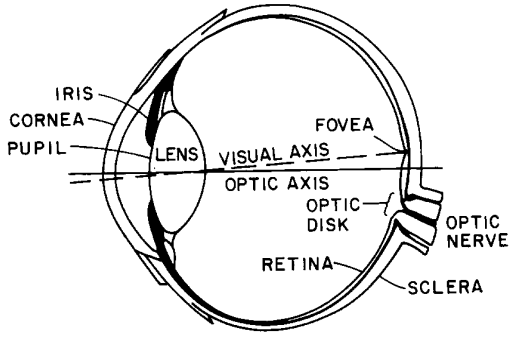
Many TV cameras and all CRT-based displays have a nonlinear relationship between signal voltage and light intensity. $B = c\,v^{r} + b$ *B: light intensity* *c: gain factor*
b: cutoff (camera) or black level (CRT) light intensity
r: 1 ~ 3.0

To avoid gamma correction circuitry inside millions of TV receivers, gamma correction is done prior to transmission. Ex. Assuming the gamma of camera to be 1 and that of the display to be 2.2, then the camera voltage is raised to a power of 1/2.2 = 0.45.



Human visual system

- The *retina* consists of receptors sensitive to light called photoreceptors connected by nerve cells. *Photoreceptors: Rods and Cones*, rods are responsible for low light vision, while cones are responsible for details and color under normal conditions, as in daylight.



Primary Colors

Trichromatic theory of color:

17 century, the perception of any color can be represented by just three variables

Additive color system (video system): RGB

"additive" means they reproduce colors by adding colored light sources

Subtractive color system (painting and printing):

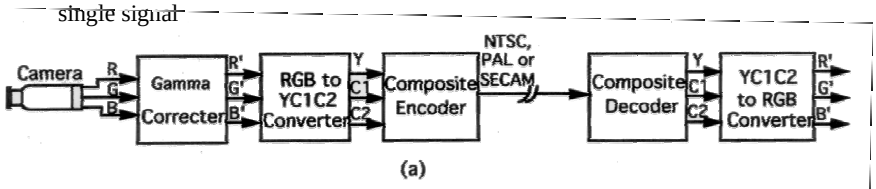
magenta, cyan, and yellow (incorrectly) by RBY

modify the light reflected from white paper by absorbing (subtracting) certain colors

Component Color Video System

Composite System

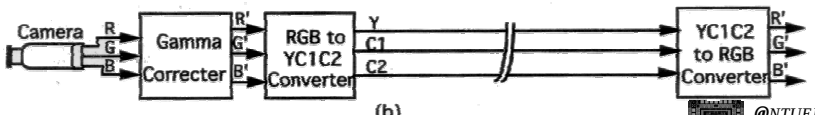
In order to transmit or broadcast the analog video over a signal channel, there is a need for composite color system that combine the three color components into a single signal



(a)

Component System

In color video system, the devices must deliver three components to control the light sources of display.



(b)

Composite Color System

1. Luminance and Color-difference Components

   Y= 0.299R + 0.587G + 0.114B
   Cr=R-Y
   Cb=B-Y

2. NTSC (59.94hz, 525 lines)

   Y= 0.299R + 0.587G + 0.114B
   I= 0.596R - 0.274G - 0.322B
   Q = 0.211R - 0.523G + 0.311B

   R= 1.0Y + 0.956I + 0.621Q
   G= 1.0Y - 0.272I - 0.649Q
   B= 1.0Y -1.106I + 1.703Q

3. PAL (50hz, 625 lines)

   Y= 0.299R + 0.587G + 0.114B
   U = 0.492 (B - Y)
   V = 0.877 (R - Y)

4. SECAM (50hz, 625 lines)

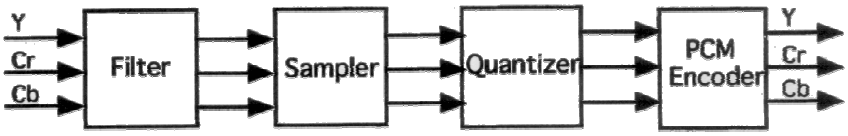
   Y= 0.299R + 0.587G + 0.114B
   Db = -0.450R - 0.833G + 1.333B
   Dr = -1.333R + 1.116G - 0.217B

**all RGB are gamma corrected.*

Summary of parameters used in worldwide color TV standards

Parameter	NTSC	PAL	SECAM
Field rate (Hz)	59.94	50	50
Lines per frame	525	625	625
Gamma	2.2	2.8	2.8
Audio Carrier (MHz)	4.5	QAM	FM
Color Subcarrier (MHz)	3.57	4.43	4.25(U)4.4(V)
Color modulation method	QAM	QAM	FM
Luminance bandwidth(MHz)	4.2	5.0,5.5	6.0
Chrominance bandwidth(Mhz)	1.3(I)0.6(Q)	1.3	1.0

From Analog To Digital Video



- Prefiltering (call prefilter prior to sampling)
  - Reduce unwanted excessive frequency and noise in the signal by region filtering
- Sampling
  - Sampling theorem (sampling frequency for NTSC, PAL, CCIR601??)
- Quantization
- PCM (Pulse Code Modulation) Coding

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Video Formats

Picture format	Luminance pixels	Luminance lines
CCIR601(525)	480	720
CCIR601(625)	576	720
SQCIF	128	96
QCIF	176	144
CIF[1]	352	288
4CIF	704	576
16CIF	1408	1152
HDTV[2]	720	1280
HDTV[3]	1080	1920

1: Common Intermediate Format
2: at frame rates of 24, 30, 60 Hz progressive
3: at frame rates of 24, 30 Hz progressive and 30Hz interlaced

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Other Commercial Image Structures

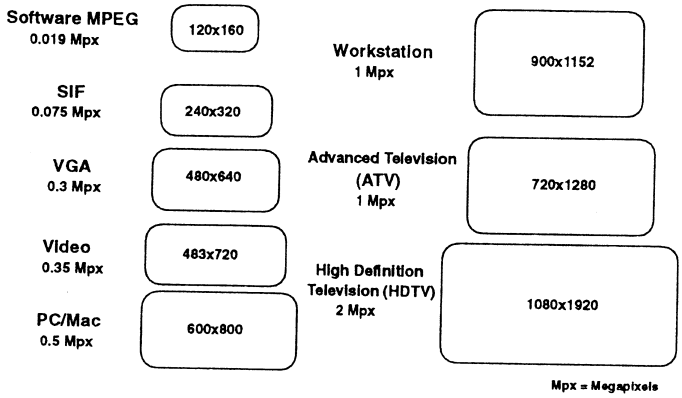

Figure 4.5 Various image structures.

Digital Video System

CCIR 601:

Consultative Committee for International Radio (CCIR)
--> International Telecommunications Union (ITU)
Recommendation BT.601

4:4:4 Full-bandwidth sampling of R, G, B components
4:2:2 Full-bandwidth Y, 2:1 horizontally-subsampled R-Y(U), B-Y(V)
4:1:1 Full-bandwidth Y, 4:1 horizontally-subsampled R-Y(U), B-Y(V)
4:2:0 Full-bandwidth Y, 2:1 horizontally-subsampled
and vertically-subsampled R-Y(U), B-Y(V)

Choice of video sampling frequency for ITU-R Rec.BT.601

525/59.94		625/50		
n	Frequency	n	Frequency	Dif.
842	13248250	848	13250000	1750
848	13342656	854	13343750	1094
852	13405593	858	13406250	657
856	13468530	862	13468750	220
858	13499999	864	13500000	1
860	13531467	866	13531250	217
864	13594404	870	13593750	654
868	13657341	874	13656250	1091

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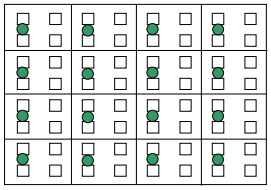
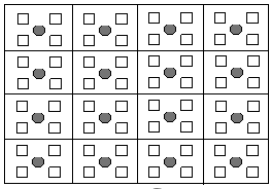
From Analog To Digital Video(cont.)

- The 4:2:0 format

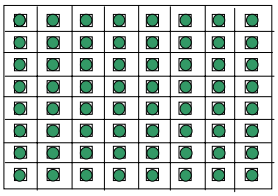


MPEG-2

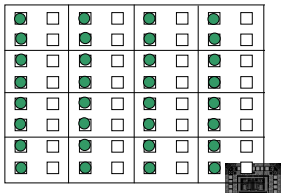


MPEG-1

- The 4:4:4 format



- The 4:2:2 format



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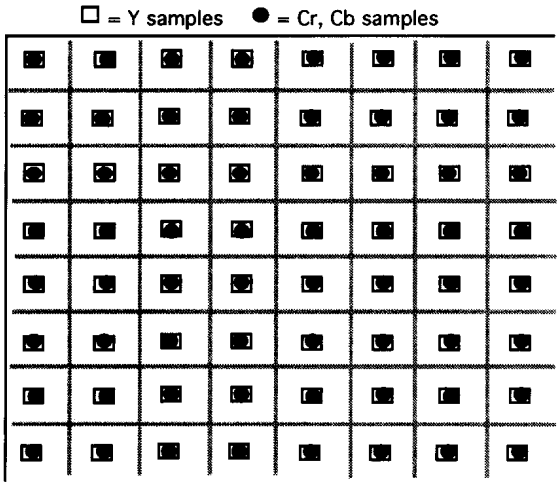
luminance and chrominance samples in a 4:4:4 video frame



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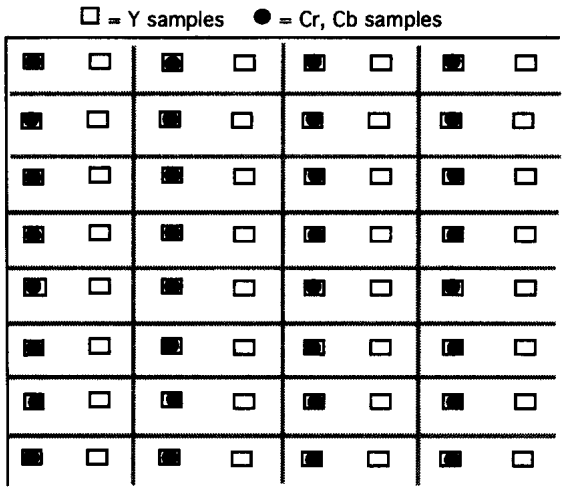
luminance and chrominance samples in a 4:2:2 video frame



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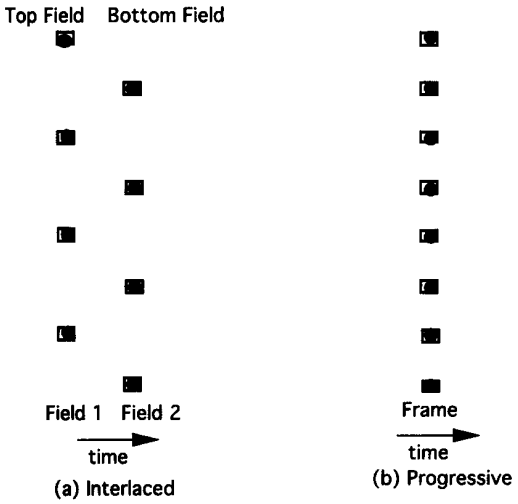
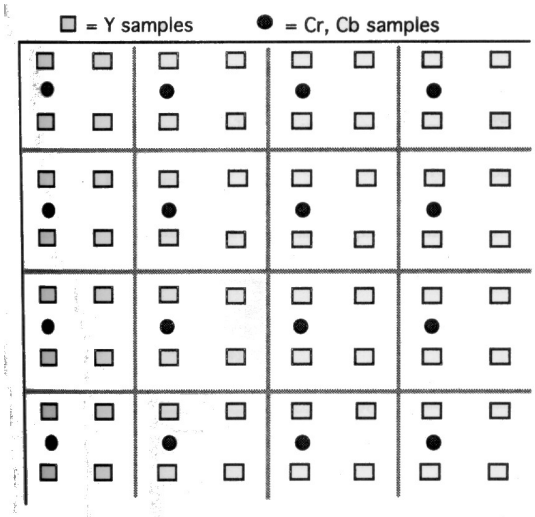
Interlaced and progressive representation of a 4:2:2 frame



Look like 2x1 array

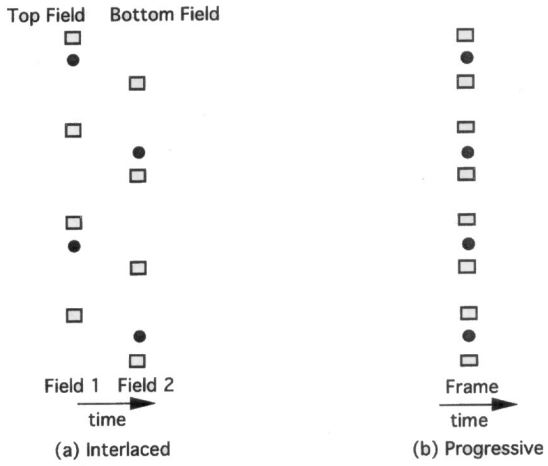
35

Luminance and chrominance samples in a 4:2:0 video frame



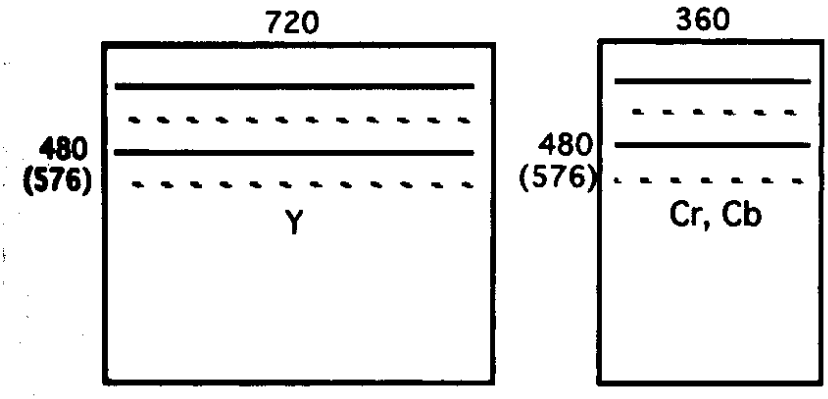
36

Interlaced and progressive representation of a 4:2:0 frame

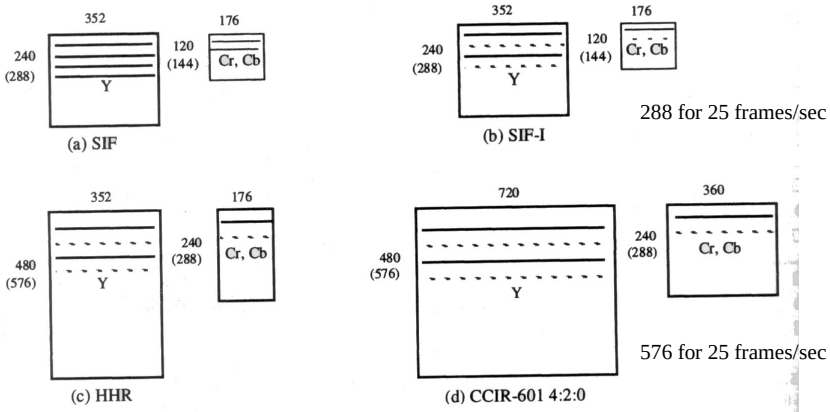


Spatial Conversions

CCIR-601 4:2:2 video frame

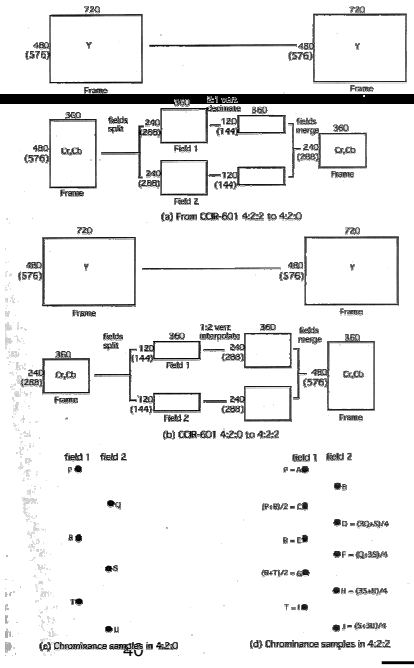


SIF, SIF-1, HHR and CCIR-601 4:2:0 video formats



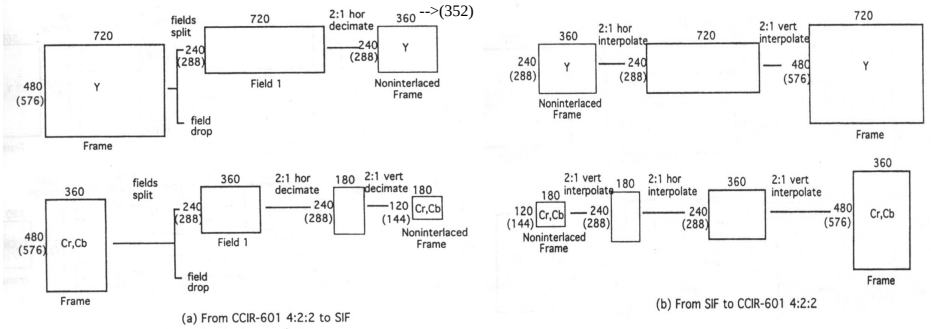
SIF:source input format SIF-I: SIF interlace
HHR:half horizontal resolution

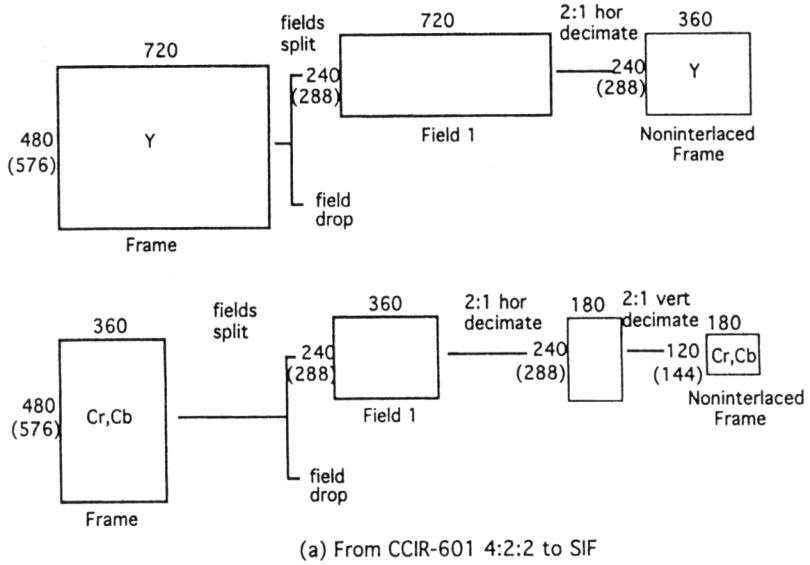
- CCIR-601 4:2:2
  - -- CCIR-601 4:2:0

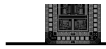


Spatial Conversion (cont.)

- CCIR-601 4:2:2 -- SIF
  - 7-tap decimation filter [-29, 0, 88, 138, 88, 0, -29]/256 and
  - 4-tap interpolation filter [-12, 140, 140, -12]256 applied horizontally

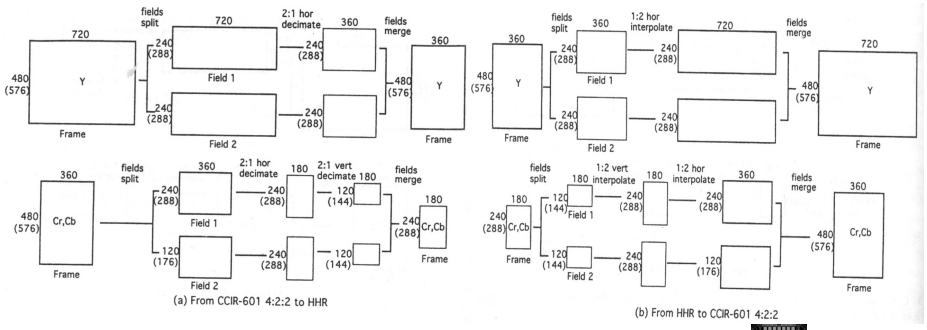






Spatial Conversion (cont.)

- CCIR-601 4:2:2 -- HHR

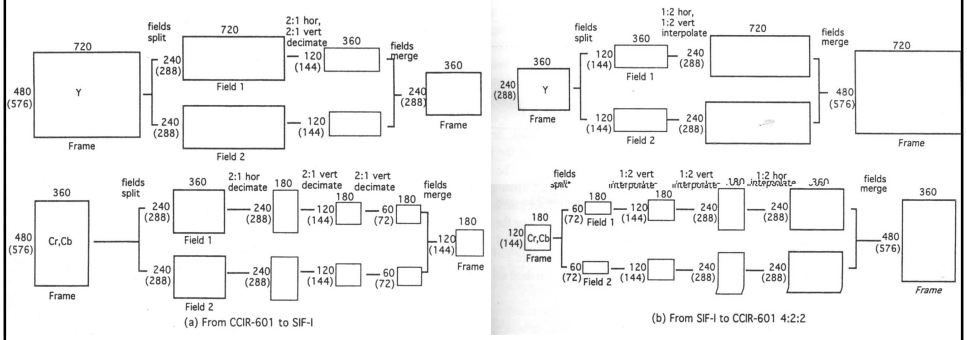


(a) From CCIR-601 4:2:2 to HHR

(b) From HHR to CCIR-601 4:2:2

Spatial Conversion (cont.)

- CCIR-601 4:2:0 -- SIF-I
  - same horizontal fileter plus vertical subsampling with
  - [-4, 23, 109, 109, 23, -4] / 256 filter and interpolation filter
  - [-2, 20, 110, 110, 20, -2]256

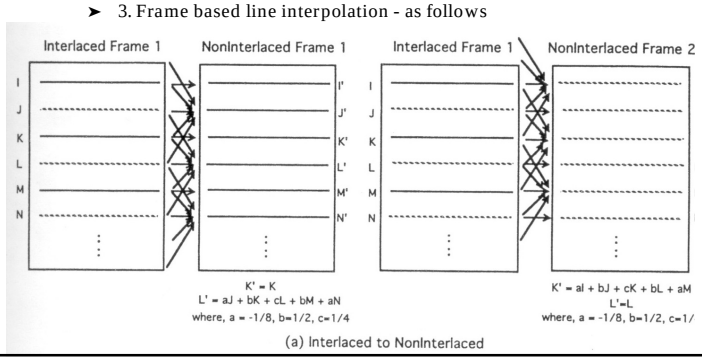


(a) From CCIR-601 to SIF-I

(b) From SIF-I to CCIR-601 4:2:2

Temporal Conversion

- Problems: 60 f/s video --> 72 progressive f/s monitor
  24 f/s film --> 60 fields/s TV monitor
  50 fields/s PAL --> 60 f/s NTSC ….all via MPEG-2
- Interlaced to noninterlaced
  - 1. Line interpolation - [1/2, 1/2] interpolation filter applied between each pairs of consecutive lines in each field
  - 2. Field merging - combines lines of two consecutive fields, *not good for motion*
  - 3. Frame based line interpolation - as follows



(a) Interlaced to NonInterlaced

The case is from field rate to same frame rate, so called Deinterlacing or line-doubling

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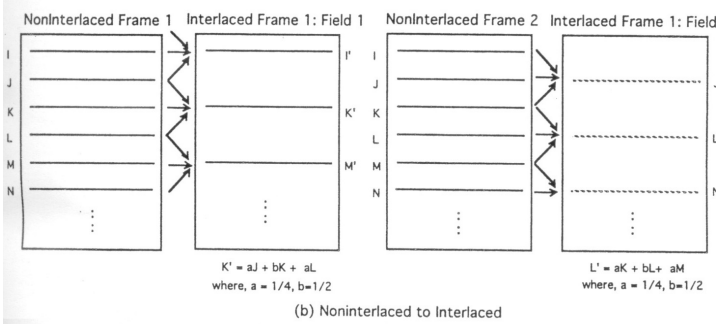
Temporal Conversion (cont.)

- Noninterlaced to interlaced: ex. 60 frames/s to 60 fields/s
  - 1. Line subsampling
  - 2. Line weighting with filter [1/4, 1/2, 1/4]



(b) Noninterlaced to Interlaced

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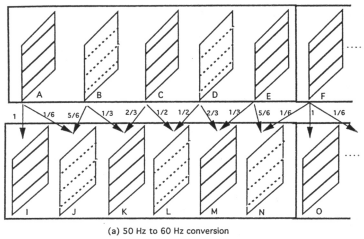
Temporal Conversion (cont.)

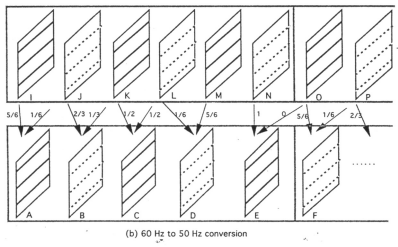
Field Rate Conversion
ex. Between NTSC and PAL

1. Convert 60 fields/s to 50 fields/s
   - i) Discard
   - ii) Temporal interpolation
   - iii) Motion vector interpolation



(a) 50 Hz to 60 Hz conversion

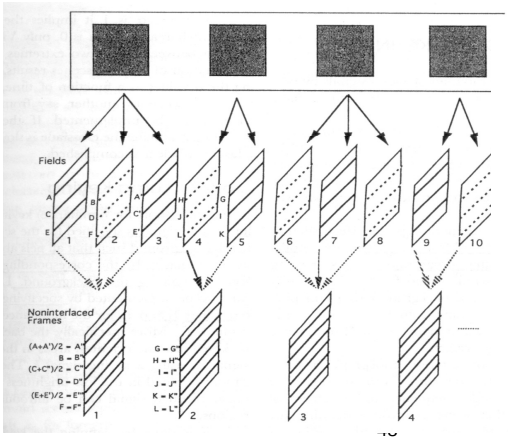
2. Convert 50 fields/s to 60 fields/s

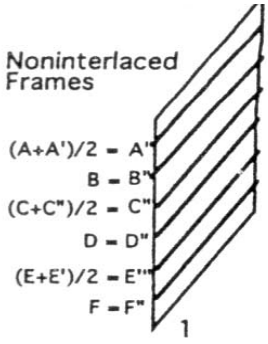


(b) 60 Hz to 50 Hz conversion

Temporal Conversion (cont.)

- Film And Interlaced Video Conversion
  - 24 frames/s => 60 fields/s -- 3:2 pull down





Mixing And Keying

Mixing can be defined as the addition of two or more input video signals, $\text{Video} = \alpha_1\text{Video}_1 + \alpha_2\text{Video}_2 + \ldots$ or $\text{Video} = \alpha_1\text{Video}_1 + (1-\alpha_1)\text{Video}_2$

Luma Keying (short for Luminance keying),

a level of luminance signal is specified for the scene containing the foreground such that all pels above that values are replaced by the corresponding pels of the scene containing the background.

$k = 1$ $r_h < r_{fg}$ use background

$k = 0$ $r_{fg} < r_l$ use foreground

$k = (r_{fg} - r_l)/(r_h - r_l)$ else $r_l <= r_{fg} <= r_h$ use blended

Chroma Keying

Chroma keying consists of substituting a background signal in place of the foreground signal based on some key color identified in the foreground video signal, known as **"blue screen".**