MULTIMEDIA COMMUNICATION -BEC613A

Module-2

MULTIMEDIA INFORMATION REPRESENTATION

Contents

Module-2

- **Digitization Principles**
- **Text**
- **Images**
- **Audio**
- **Video**

Introduction

- All types of multimedia information are stored and processed within a computer in a digital form.
- They can be integrated together and transmitted over a single all-digital communications network.

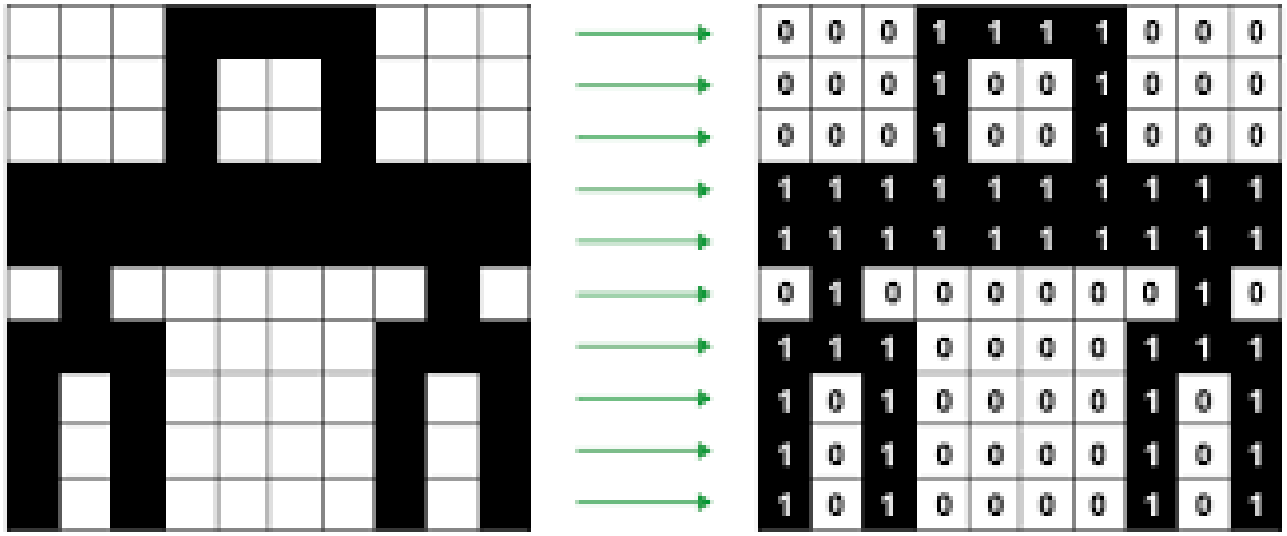
Introduction

TEXT

Dec	Symbol	Binary	Dec	Symbol	Binary
65	A	0100 0001	83	S	0101 0011
66	B	0100 0010	84	T	0101 0100
67	C	0100 0011	85	U	0101 0101
68	D	0100 0100	86	V	0101 0110
69	E	0100 0101	87	W	0101 0111
70	F	0100 0110	88	X	0101 1000
71	G	0100 0111	89	Y	0101 1001
72	H	0100 1000	90	Z	0101 1010
73	I	0100 1001	91	[	0101 1011
74	J	0100 1010	92	\	0101 1100
75	K	0100 1011	93	]	0101 1101
76	L	0100 1100	94	^	0101 1110
77	M	0100 1101	95	_	0101 1111
78	N	0100 1110	96	`	0110 0000
79	O	0100 1111	97	a	0110 0001
80	P	0101 0000	98	b	0110 0010
81	Q	0101 0001	99	c	0110 0011
82	R	0101 0010	100	d	0110 0100

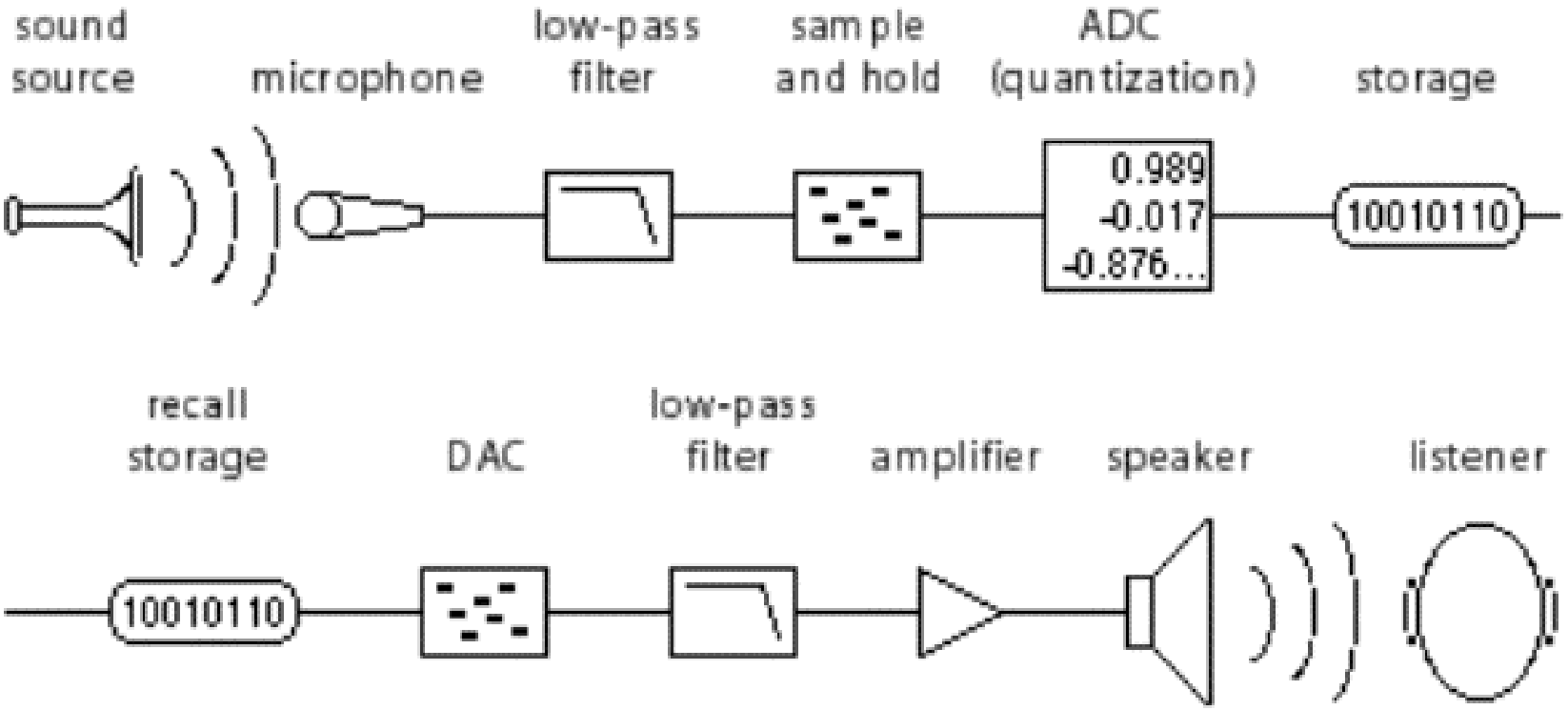
Introduction

IMAGE



Introduction

SPEECH

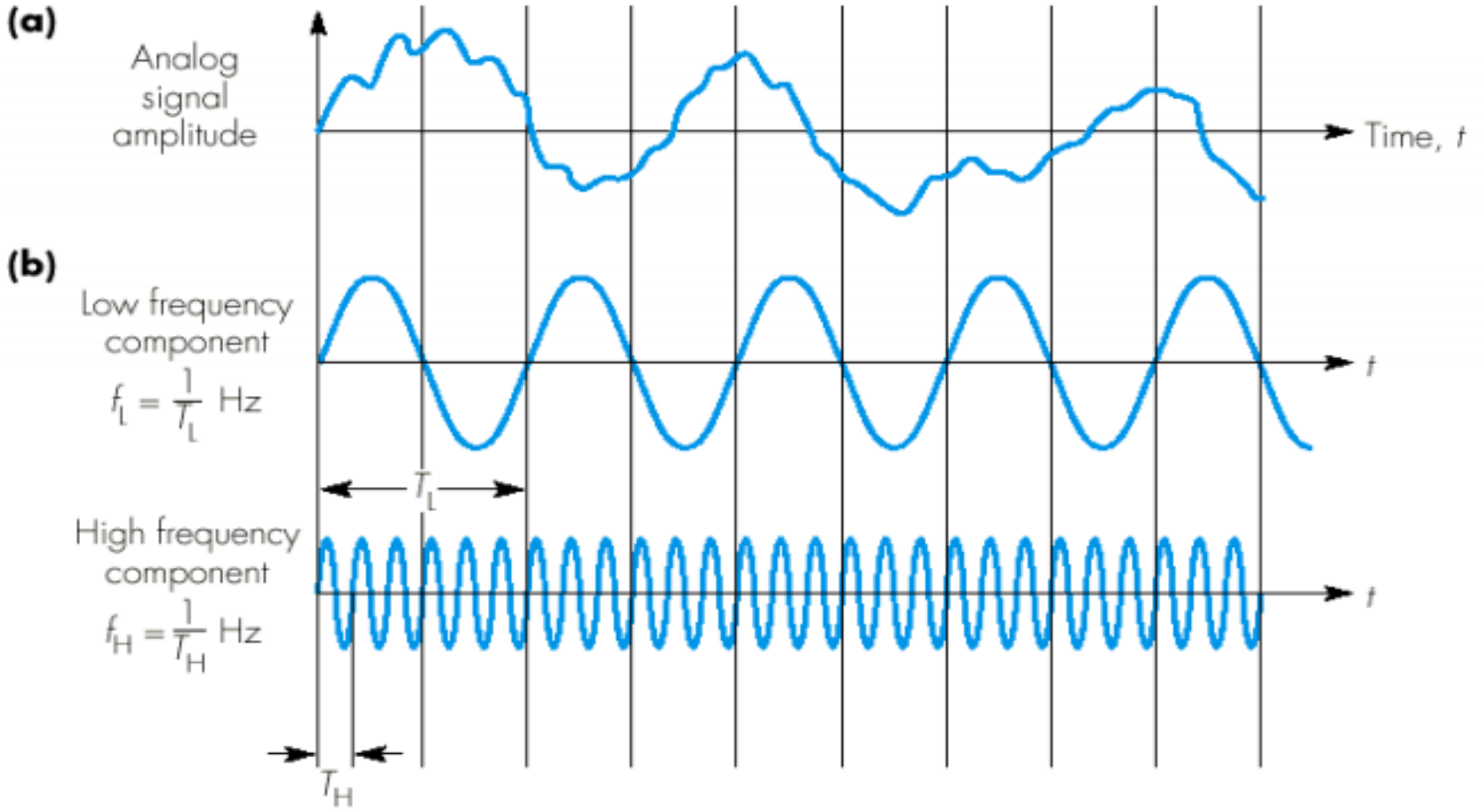


Digitization Principles

- A signal whose amplitude varies continuously with time is known as an analog signal.
- Techniques involved in analog-to-digital conversion include sampling and quantization.
- The range of frequencies of the sinusoidal components that make up a signal is called the signal bandwidth.
- Any signal transmitted over a channel must have a signal bandwidth less than the channel bandwidth.

Digitization Principles

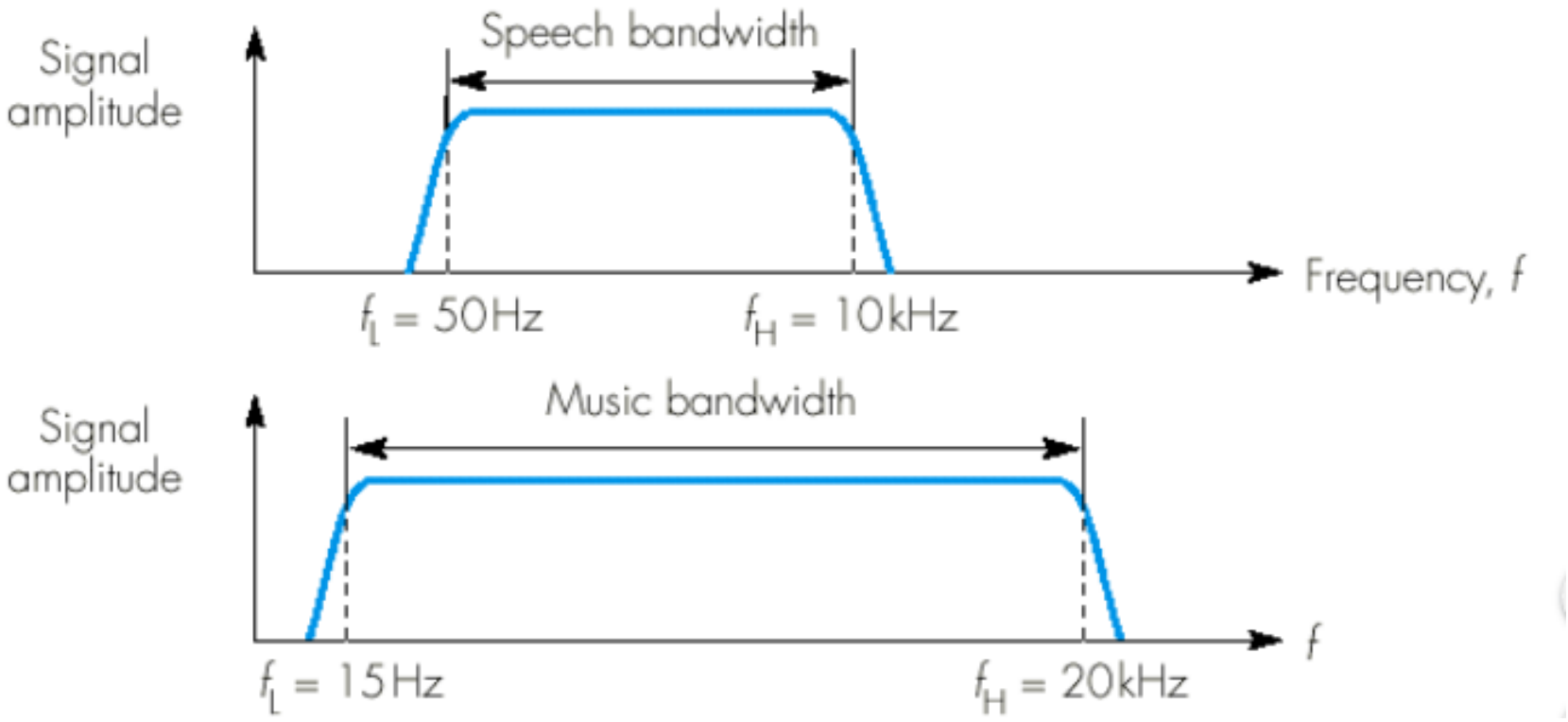
- Signal Properties: a) Time varying analog signal, b) Sinusoidal frequency components



$T_{L/H}$ = time for one cycle = signal period

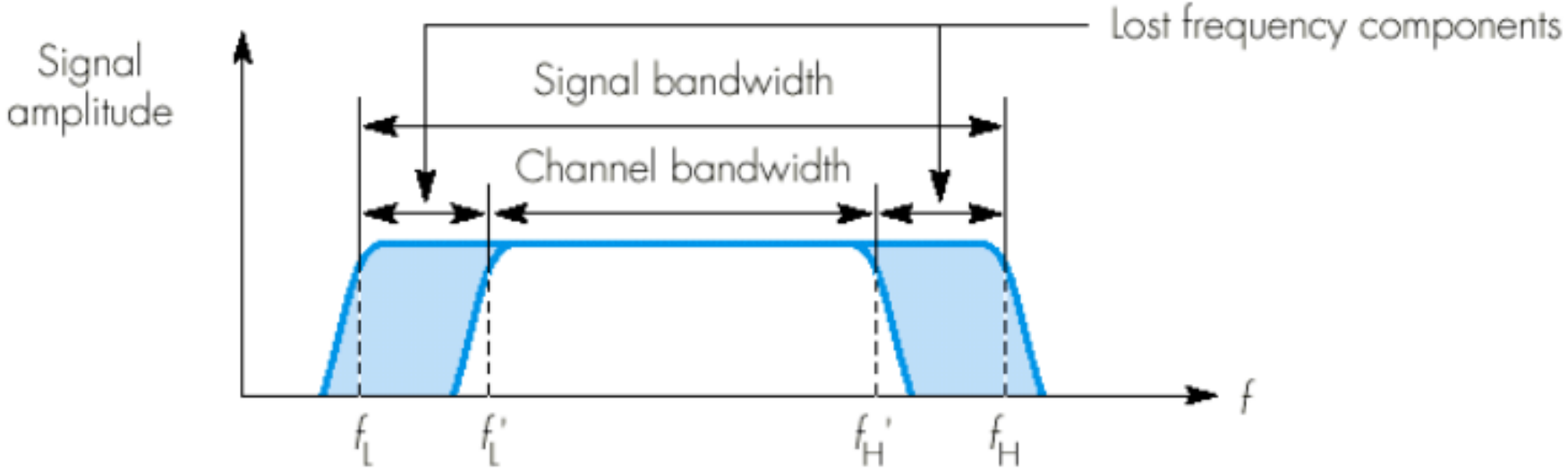
Digitization Principles

- Signal Properties: Signal Bandwidth example



Digitization Principles

- Signal Properties: Effect of limited bandwidth transmission channel

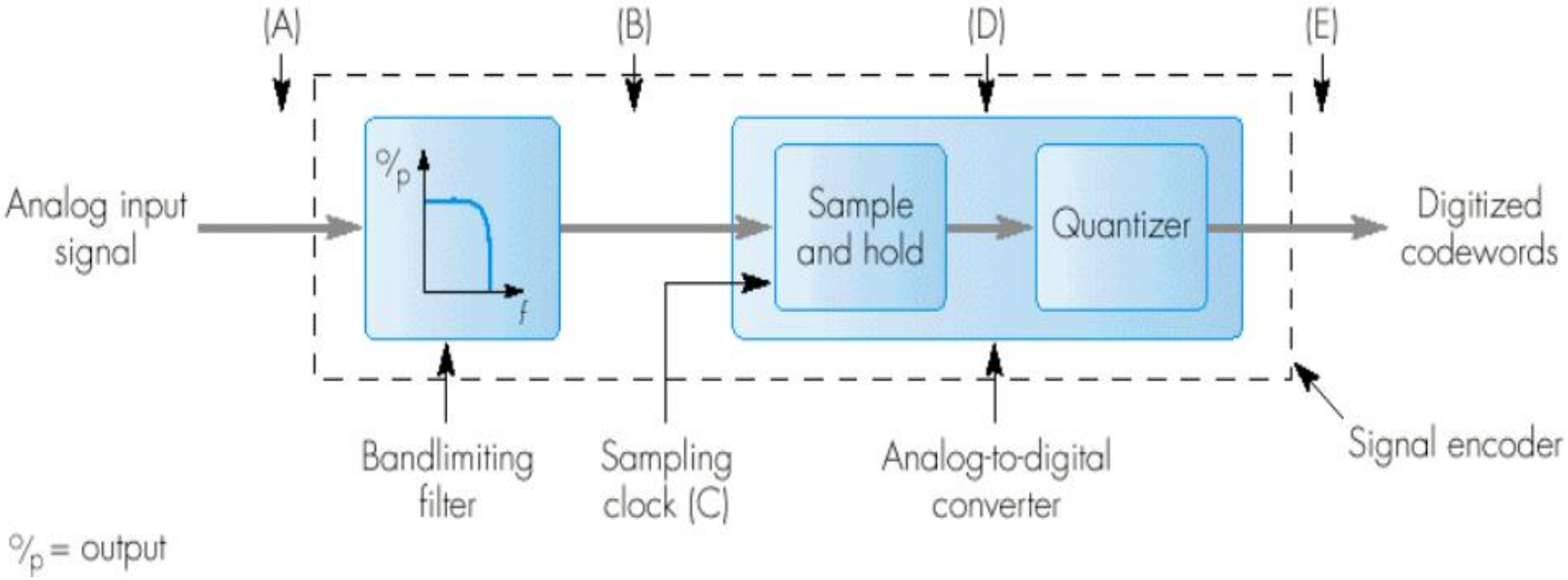


F_L' and F_H' are known as the cut off frequencies of the channel

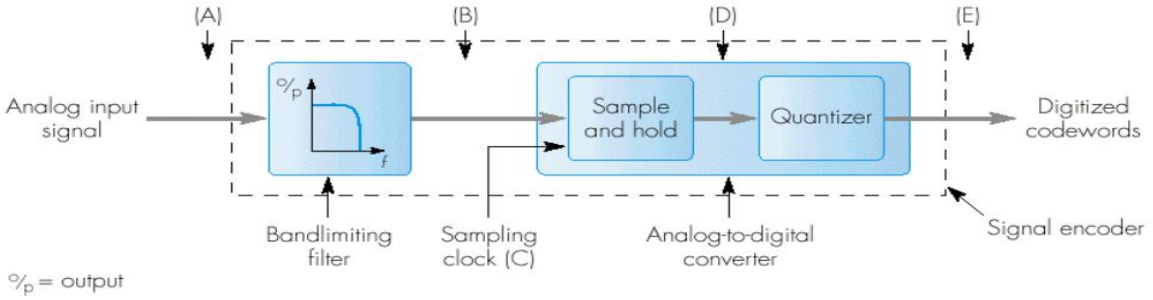
Digitization Principles

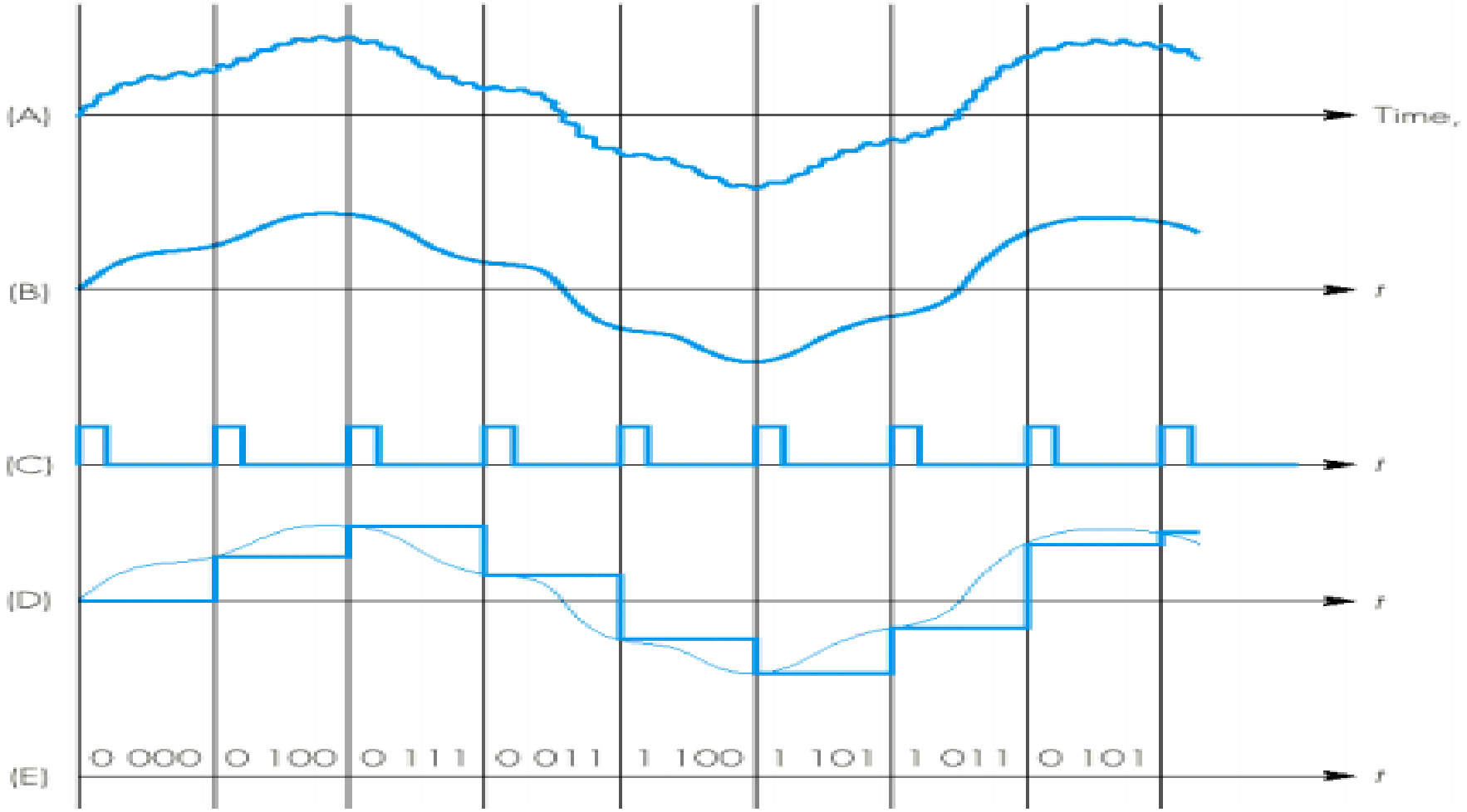
- **Encoder design**

Signal Encoder design- Circuit components



Digitization Principles



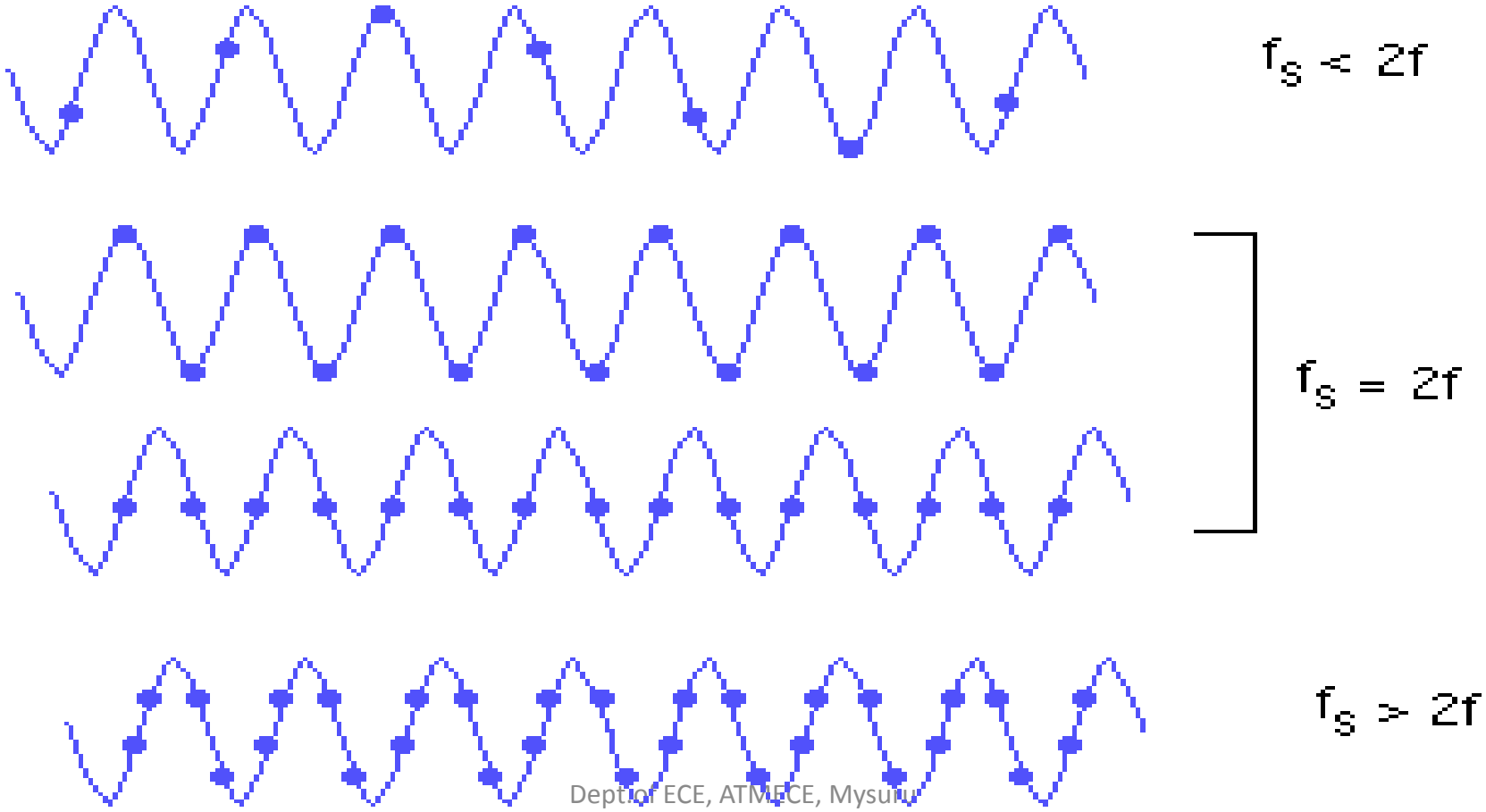


Digitization Principles

Sampling Rate

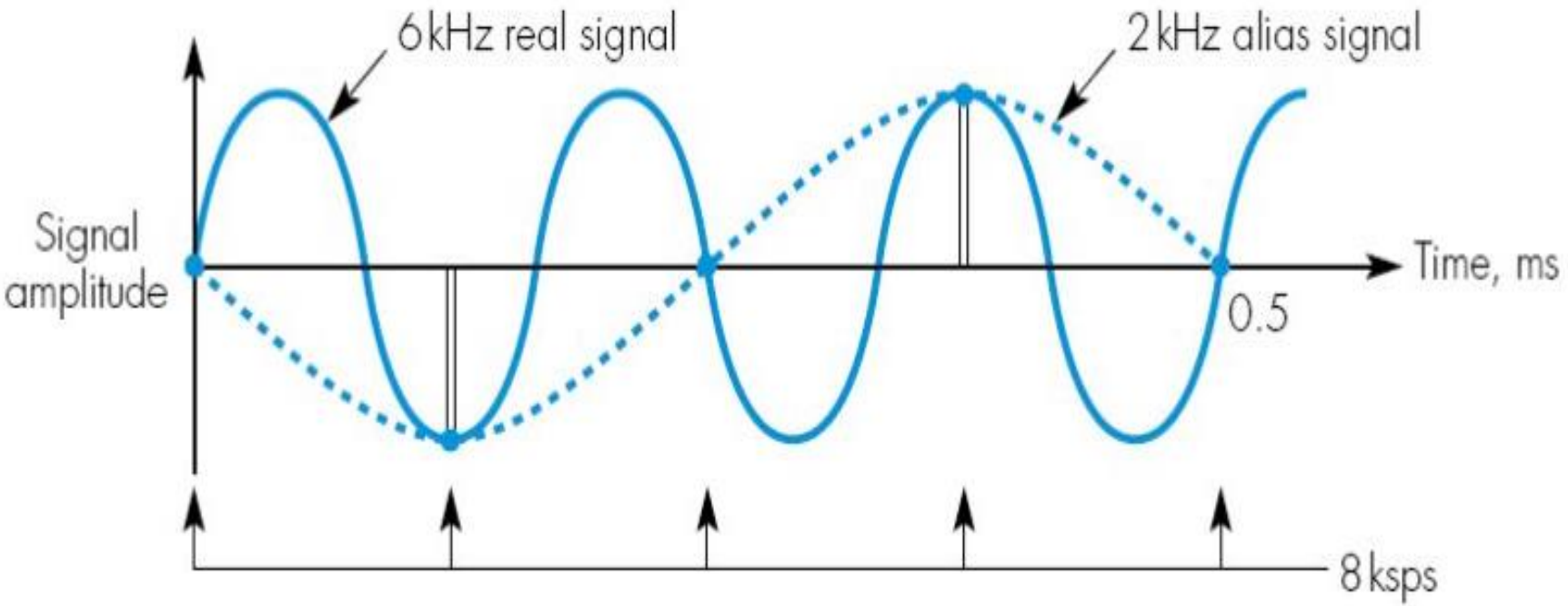
- **Nyquist Sampling theorem:**

The amplitude of a signal must be sampled at a minimum rate that is equal to or greater than twice the bandwidth of the signal.



Digitization Principles

Sampling Rate



Digitization Principles

Example

Determine the rate of the sampler and the bandwidth of the bandlimiting filter in an encoder which is to be used for the digitization of an analog signal which has a bandwidth from 15 Hz through to 10 kHz assuming the digitized signal:

(i) is to be stored within the memory of a computer,

(ii) is to be transmitted over a channel which has a bandwidth from 200 Hz through to 3.4 kHz.

The Nyquist sampling rate must be at least twice the highest frequency component of the signal or transmission channel. Hence:

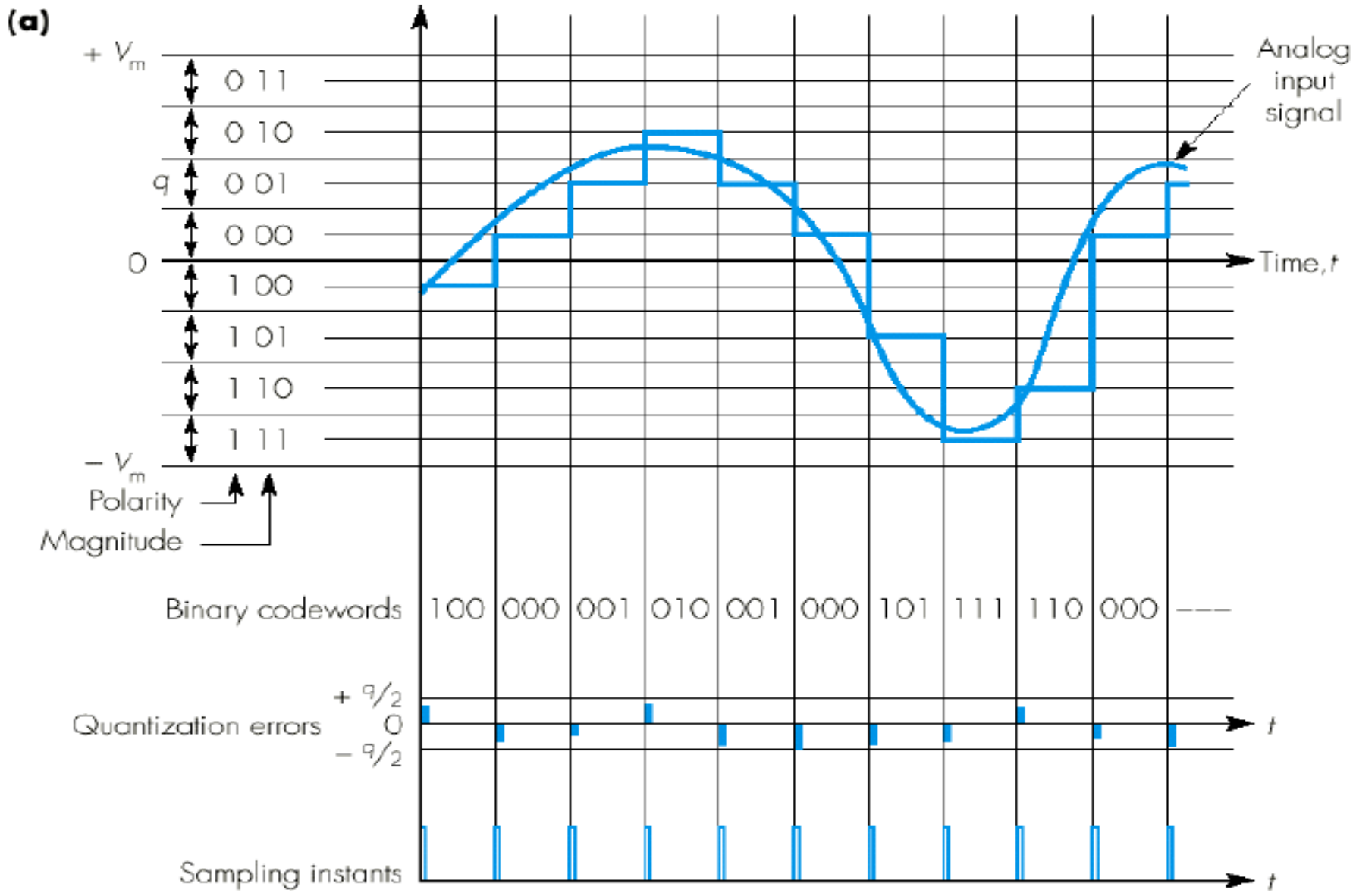
(i) The sampling rate must be at least 2×10 kHz = 20 kHz or 20 ksps and the bandwidth of the bandlimiting filter is from 0 Hz through to 10 kHz.

(ii) The sampling rate must be at least 2×3.4 kHz = 6.8 kHz or 6.8 ksps and the bandwidth of the bandlimiting filter is from 0 Hz through to 3.4 kHz.

Digitization Principles: **Quantization**

- Quantization is the process that confines the amplitude of a signal into a finite number of values.

Digitization Principles: **Quantization**



Digitization Principles: Quantization

Quantization interval :

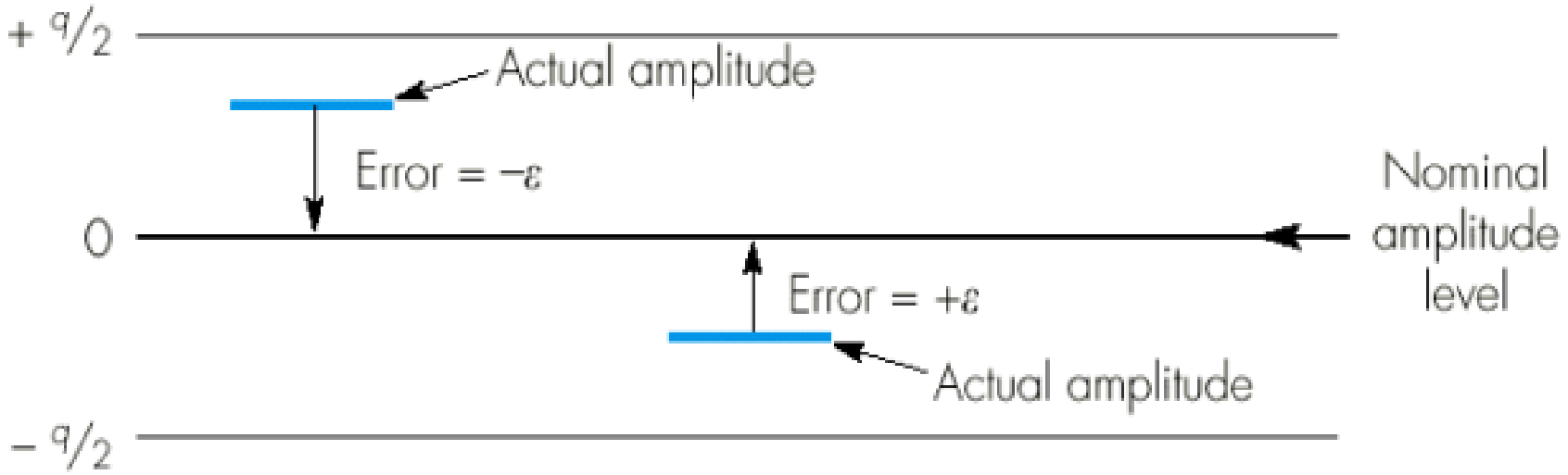
$$q = \frac{2V_{max}}{2^n}$$

where ***n*** is the number of bits used and ***Vmax*** is the maximum positive and negative signal amplitude

Digitization Principles: Quantization

Quantization Procedure: Noise Polarity

The difference between the actual signal amplitude and the corresponding nominal amplitude is called the quantization error.



Digitization Principles: **Quantization**

- The ratio of the peak amplitude of a signal to its minimum amplitude is known as the ***dynamic range.***

$$D = 20\log_{10}(V_{max} / V_{min}) \qquad in\ dB$$

Example

An analog signal has a dynamic range of 40 dB. Determine the magnitude of the quantization noise relative to the minimum signal amplitude if the quantizer uses (i) 6 bits and (ii) 10 bits:

$$D = 20 \log_{10} \frac{V_{max}}{V_{min}} \text{ dB} \qquad \text{Quantization noise} = \pm \frac{q}{2} = \pm \frac{V_{max}}{2^n}$$

$$\text{Hence } 40 = 20 \log_{10} \frac{V_{max}}{V_{min}} \qquad V_{min} = \frac{V_{max}}{100}$$

(i) $n = 6$ bits

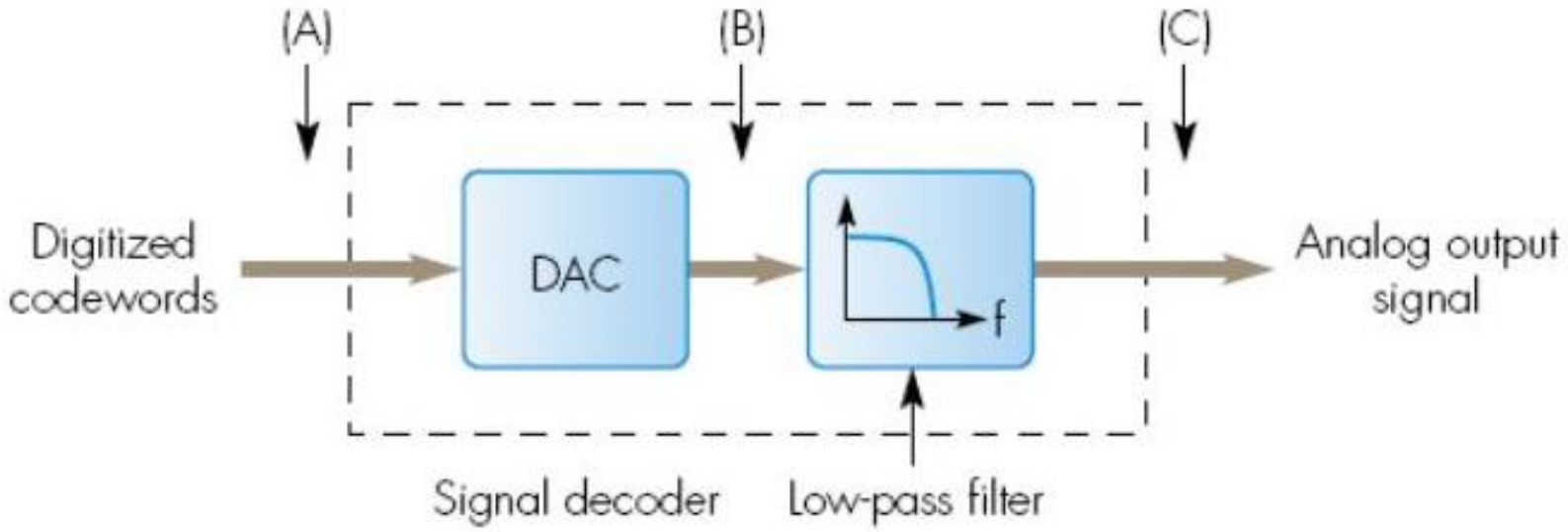
$$\text{Hence } \frac{q}{2} = \pm \frac{V_{max}}{2^6} = \pm \frac{V_{max}}{64}$$

(ii) $n = 10$ bits

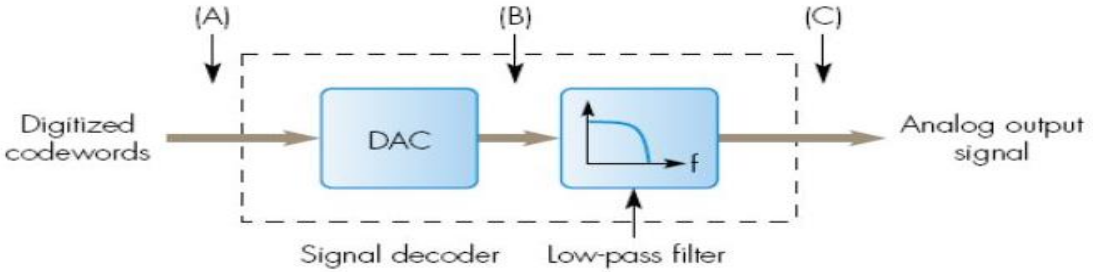
$$\text{Hence } \frac{q}{2} = \pm \frac{V_{max}}{2^{10}} = \pm \frac{V_{max}}{1024}$$

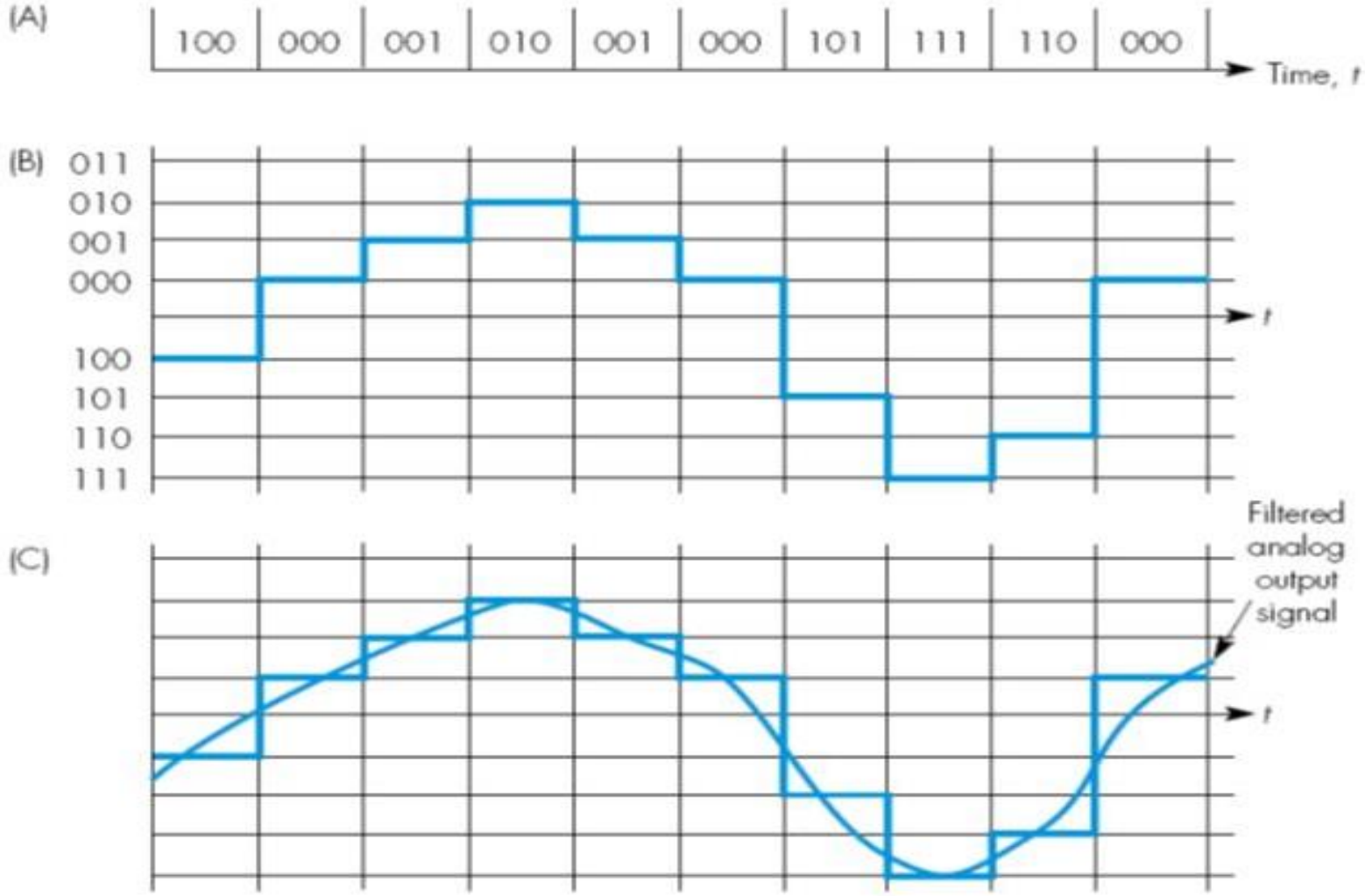
Digitization Principles

➢ Decoder design



➢ Decoder design





Digitization Principles: Summary

- Encoder
- Sampling: Nyquist Rate- aliasing effect
- Quantization: Quantization error
- Decoder

Text

There are 3 types of text that are used to produce pages of documents:

- ❑ Unformatted text
- ❑ Formatted text
- ❑ Hypertext

Text--Unformatted text

Unformatted text:(=plaintext)

- Comprise strings of fixed-size characters from a limited character set such as ASCII code set.
- e.g. .txt file

Text--Unformatted text

Example character set to produce unformatted text: (a) the basic ASCII character set.

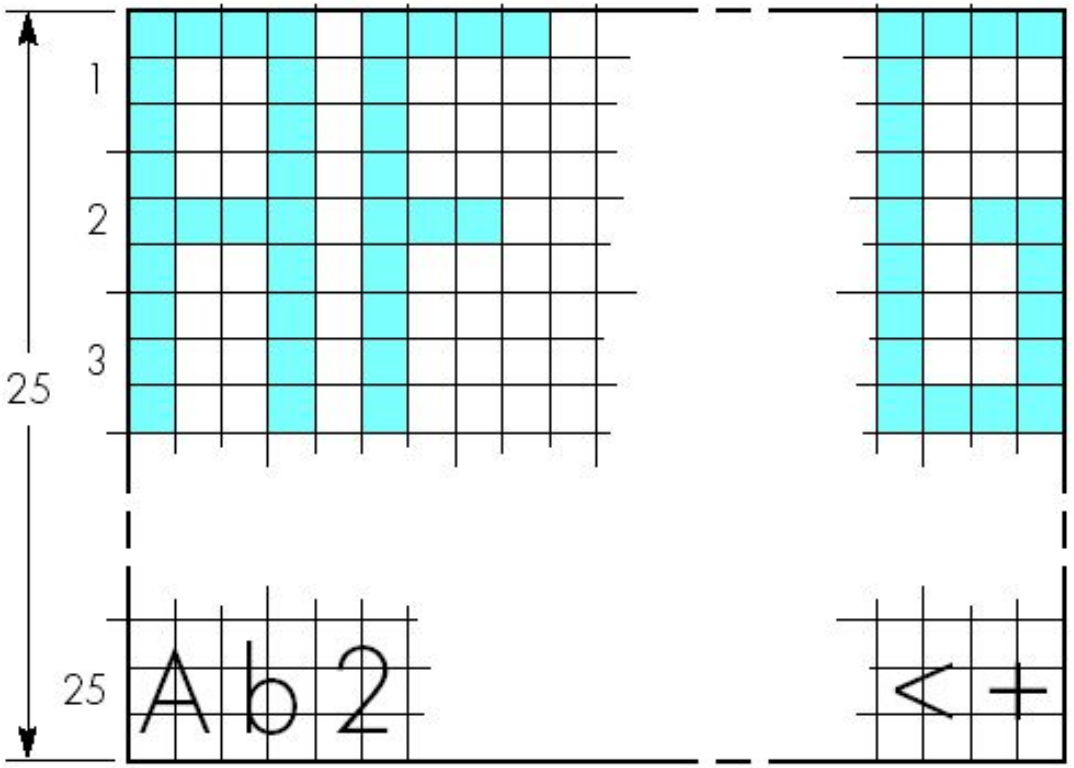
Bit positions			7	0	0	0	0	1	1	1	1
			6	0	0	1	1	0	0	1	1
			5	0	1	0	1	0	1	0	1
4	3	2	1								
0	0	0	0	NUL	DLE	SP	0	@	P	\	p
0	0	0	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	STX	DC2	"	2	B	R	b	r
0	0	1	1	ETX	DC3	#	3	C	S	c	s
0	1	0	0	EOT	DC4	$	4	D	T	d	t
0	1	0	1	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	ACK	SYN	&	6	F	V	f	v
0	1	1	1	BEL	ETB	'	7	G	W	g	w
1	0	0	0	BS	CAN	(	8	H	X	h	x
1	0	0	1	HT	EM	)	9	I	Y	i	y
1	0	1	0	LF	SUB	*	:	J	Z	j	z
1	0	1	1	VT	ESC	+	;	K	[	k	{
1	1	0	0	FF	FS	,	<	L	\	l	|
1	1	0	1	CR	GS	-	=	M	]	m	}
1	1	1	0	SO	RS	.	>	N	^	n	~
1	1	1	1	SI	US	/	?	O	—	o	DEL

Text--Unformatted text

Supplementary set of mosaic characters

Bit positions			7	0	0	0	0	1	1	1	1
			6	0	0	1	1	0	0	1	1
			5	0	1	0	1	0	1	0	1
4	3	2	1								
0	0	0	0					@	P		
0	0	0	1					A	Q		
0	0	1	0					B	R		
0	0	1	1					C	S		
0	1	0	0					D	T		
0	1	0	1					E	U		
0	1	1	0					F	V		
0	1	1	1					G	W		
1	0	0	0					H	X		
1	0	0	1					I	Y		
1	0	1	0					J	Z		
1	0	1	1					K	[		
1	1	0	0					L	\		
1	1	0	1					M	]		
1	1	1	0					N	^		
1	1	1	1					O	—		

Text--Unformatted text



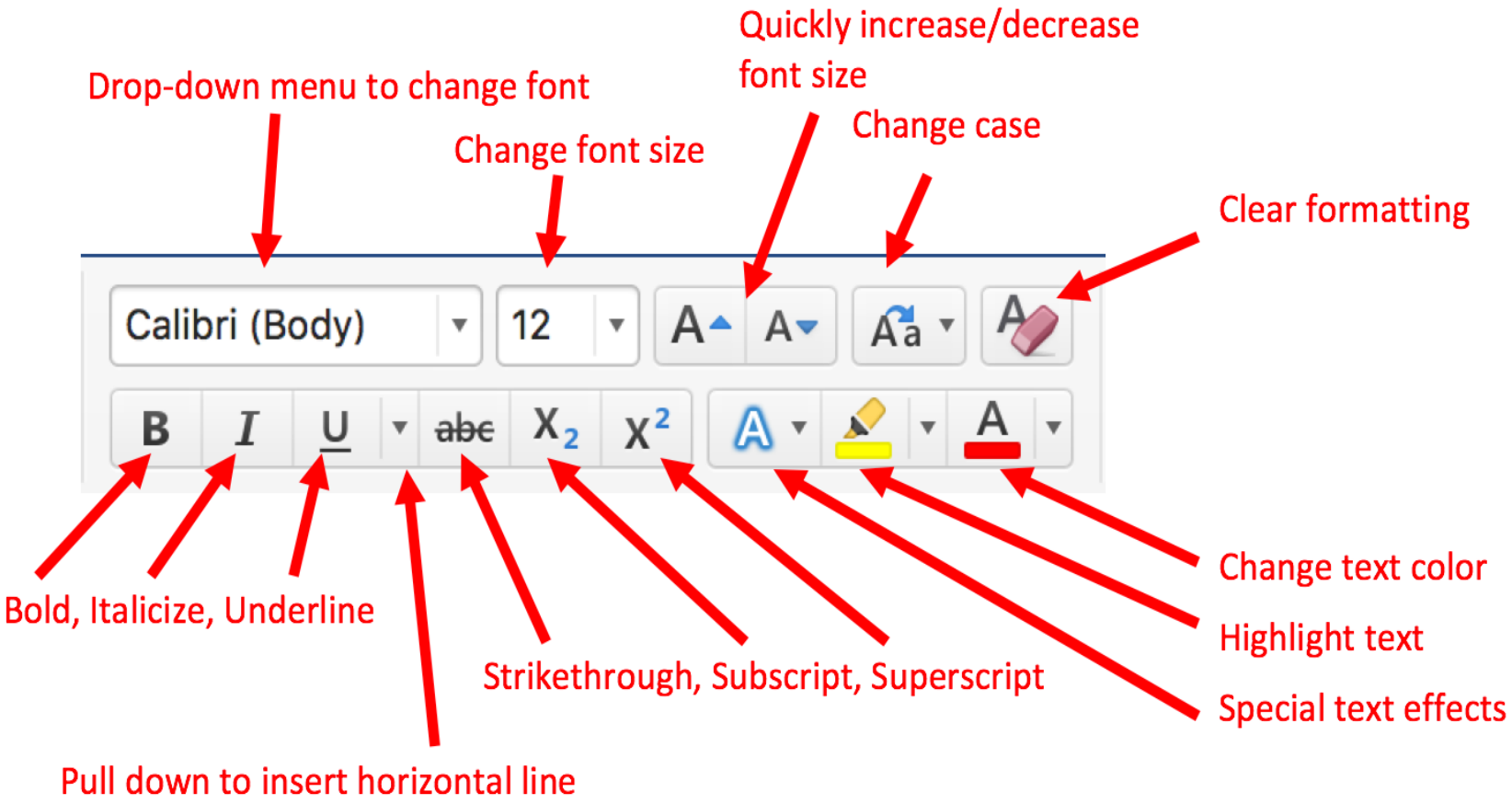
Note: Grid only included as a template.

Text-- Formatted text

Formatted text: (=richtext)

- Comprise of strings of characters of different styles, size, and shape with tables, graphics, and images.
- e.g. word .doc file

Text-- Formatted text



Text-- Formatted text

Figure 2.8 Formatted text: (a) an example formatted text string; (b) printed version of the string.

(a)

```
<B><FONT SIZE=4><P>Formatted Text</P>
</B></FONT>
<P>This is an example of formatted text, it includes:</P>
<FONT SIZE=2>
</FONT><I><P>Italics,</I> <B>Bold</B> and <U>Underlining</P>
</U>
<FONT FACE="French Script MT"><P>Different Fonts</FONT> and <FONT
SIZE=4>Font Sizes</P>
```

(b)

Formatted text

This is an example of formatted text, it includes:

Italics, **Bold** and Underlining

Different fonts and Font Sizes

Text-- Hypertext

Hypertext:

- Integrated set of documents (each comprising formatted text) to be created which have defined linkages (hyperlinks) between them.
- e.g. .htm file

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...plications | CISCO Certified Internship Program (CCNA) | E- Quiz series from Mechanical Department | One day Webinar on "Fundamer

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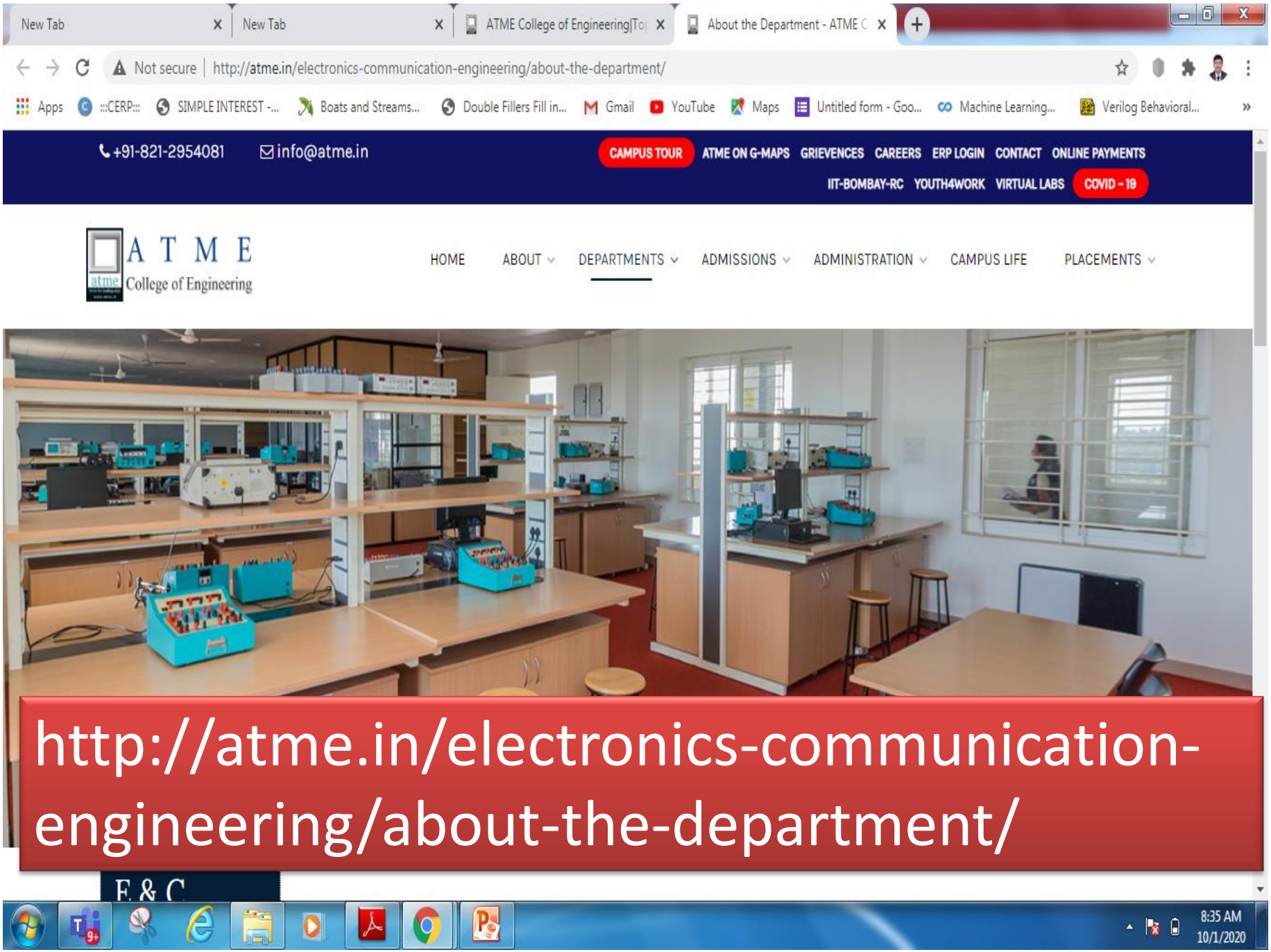
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Text-- Hypertext

- HTML-HyperText Markup Language
- SGML- Standard Generalized Markup Language
- Tex
- Latex

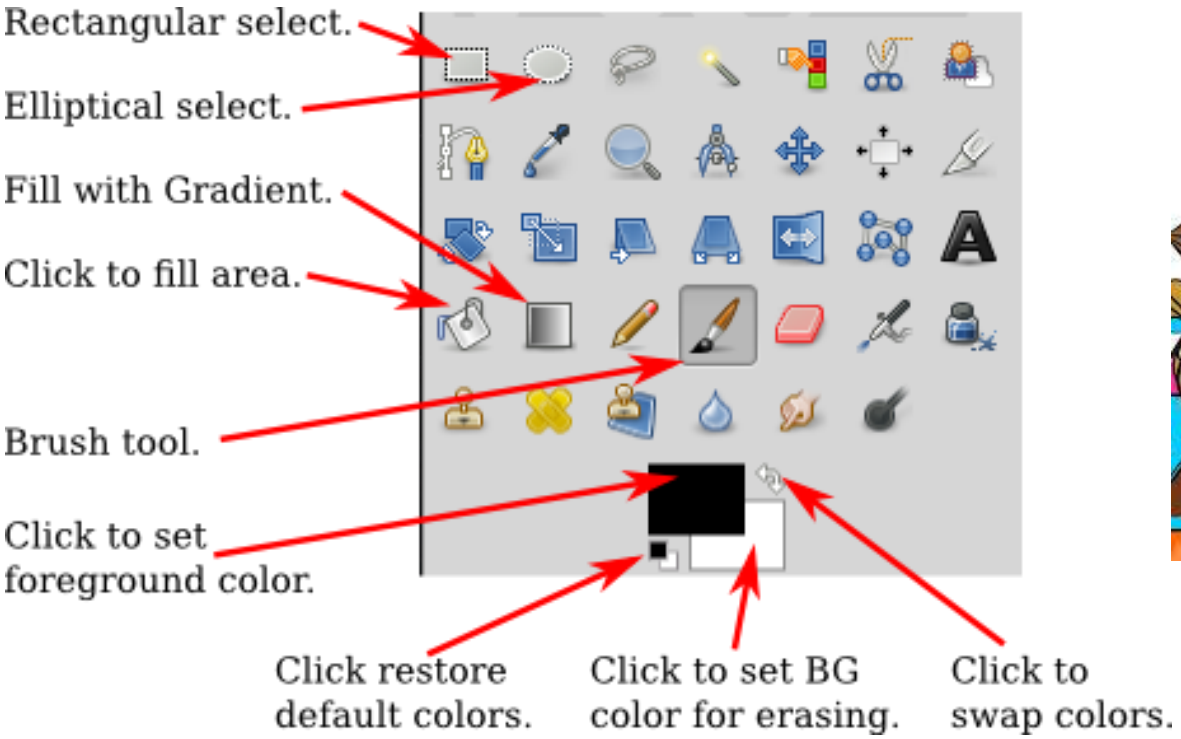
IMAGES

- Images include computer-generated images (referred to as computer graphics) and digitized images of documents and pictures.
- All images are displayed in the form of a two dimensional matrix of individual picture elements called ***pixels***

Images--**Graphics**

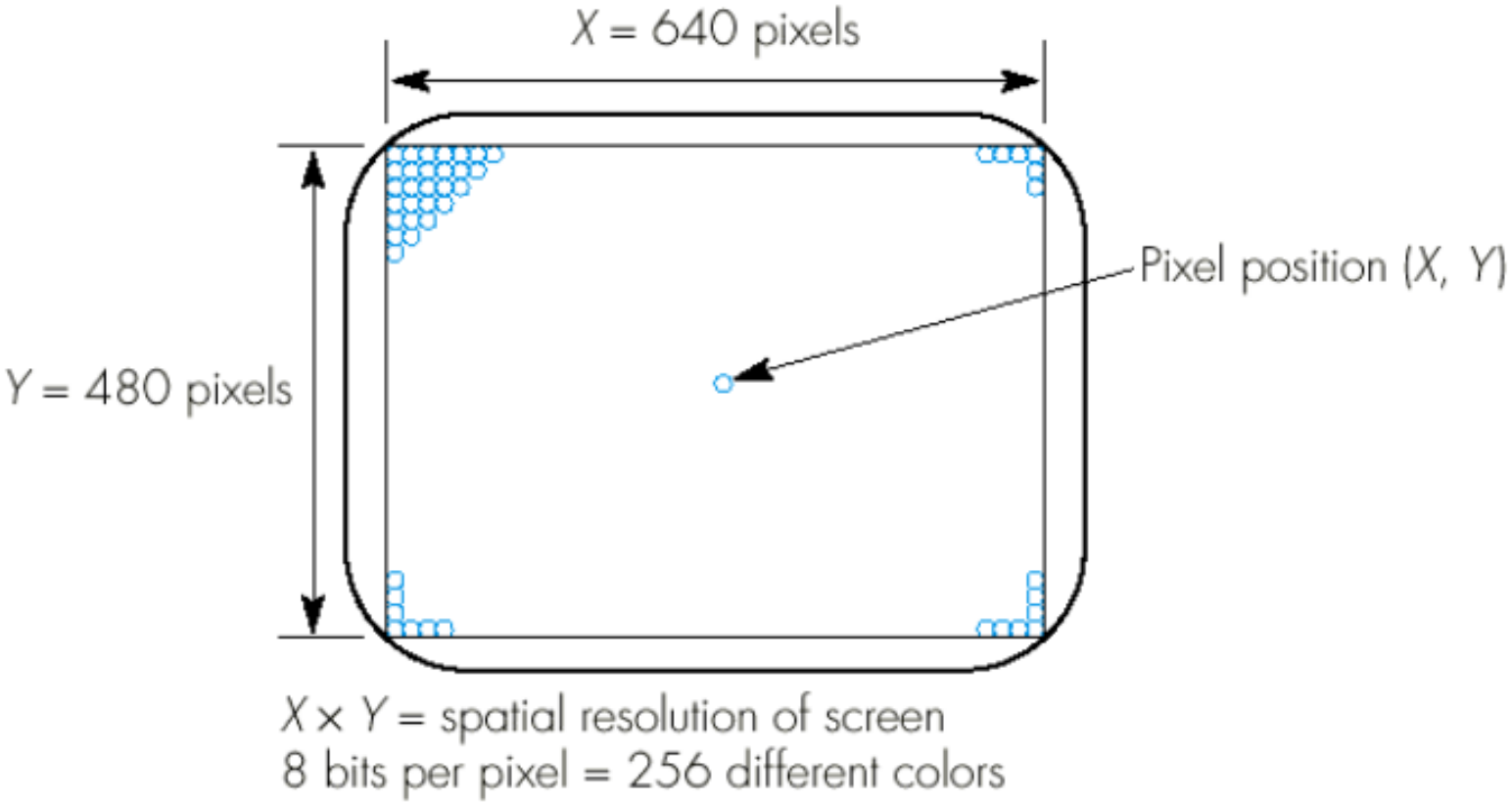
- Graphics are composed of all kinds of visual objects such as lines, arcs, squares, circles and so on, as well as any form of hand-drawn objects.
- Each object has a number of associated attributes such as color, shape, size, shadow and so on

Images--**Graphics**



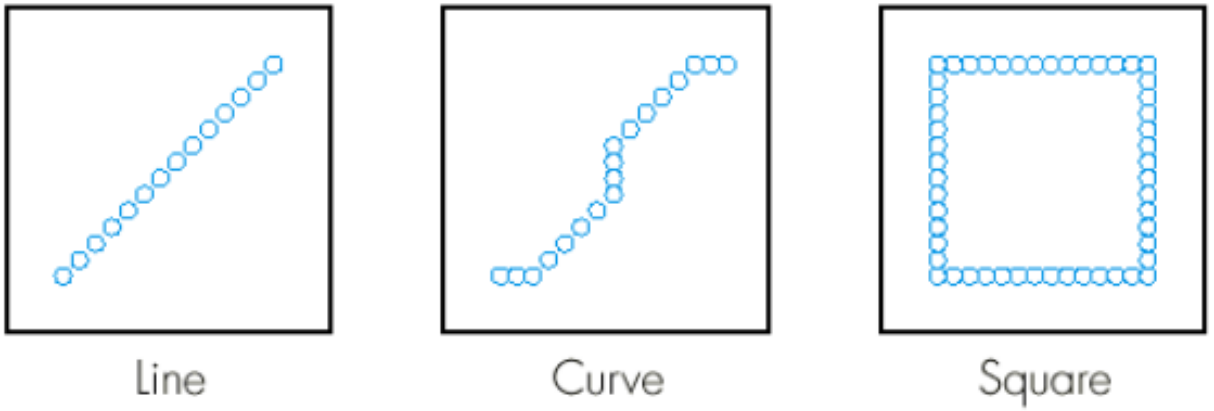
Images--Graphics

Graphics Principles: Example Screen format

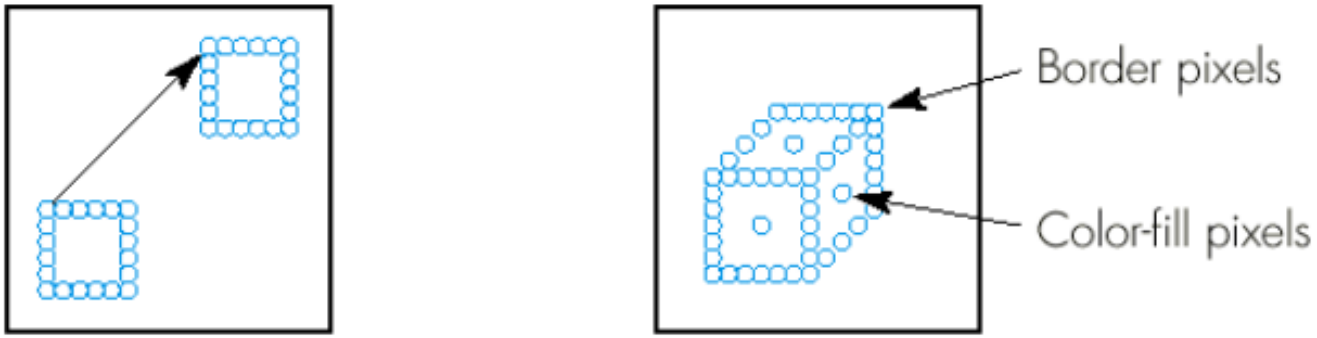


Images--Graphics

Graphics Principles: Effect of changing position Attributes Solid Objects



(d)



Images--Graphics

There are 2 forms of representation of a computer graphic:

- The representation of a graphic is analogous to the structure of a program written in a high-level programming language, which consists of a set of commands that are necessary to draw the different objects that make up the graphic.
- Another form of representation is the actual pixel image of the graphic (bit-map format).

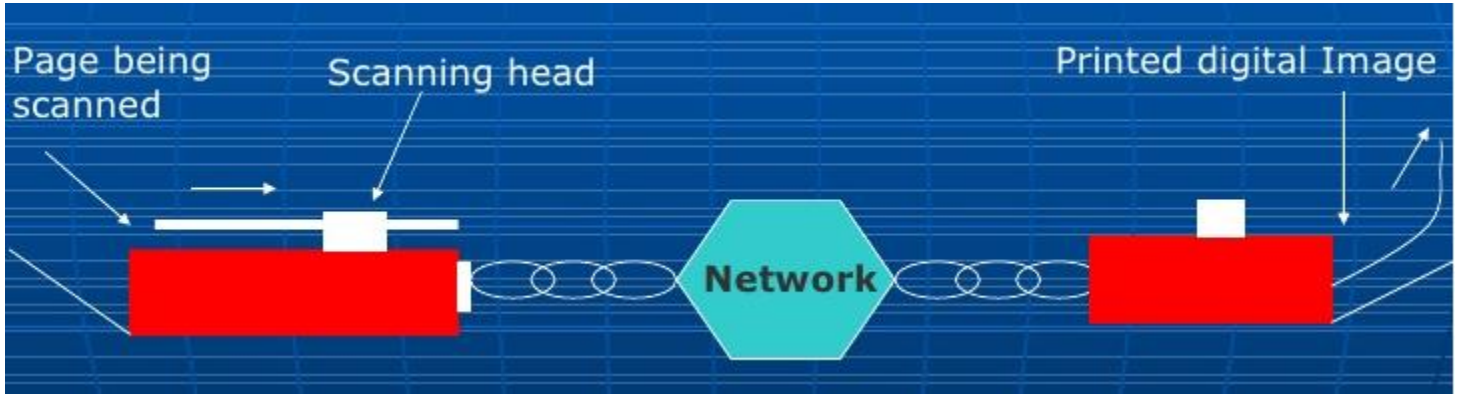
Images--Graphics

GIF-Graphical Interchange Format

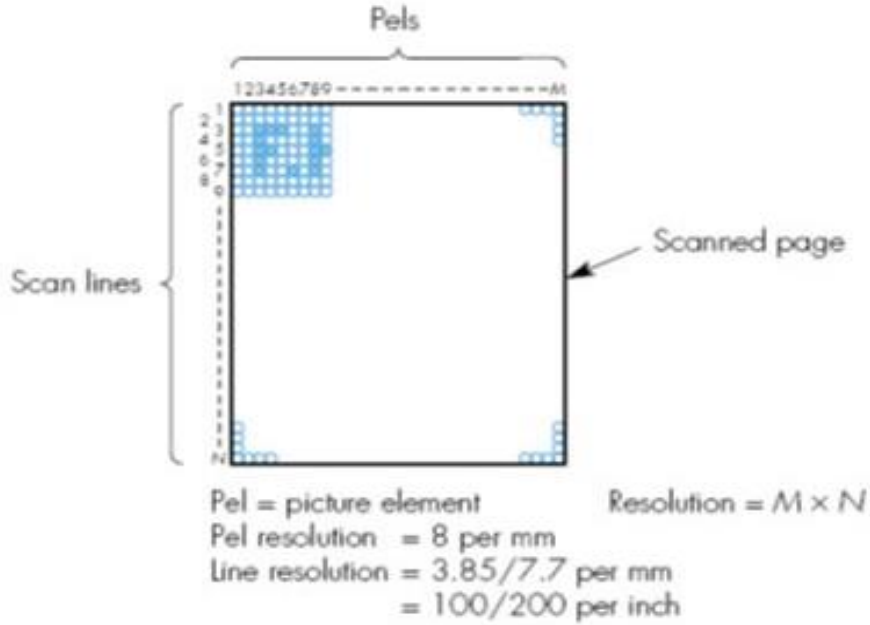
TIFF- Tagged Image File Format

SRGP- Simple Raster Graphics Package

Image-Digitized Documents



Facsimile (fax) Machine



Images-Digitized Pictures

Color Principles

Scanner-8 bit per pixel-256 different level of gray per element

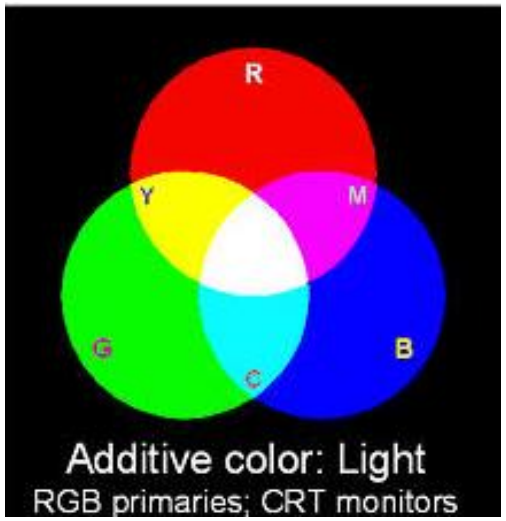
A whole spectrum of colors can be produced by using different proportions of the 3 primary colors ***red***, ***green*** and ***blue.***

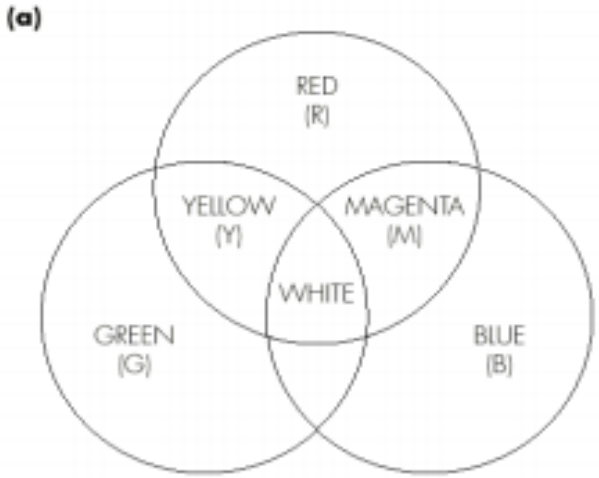
There are 2 mixing techniques:

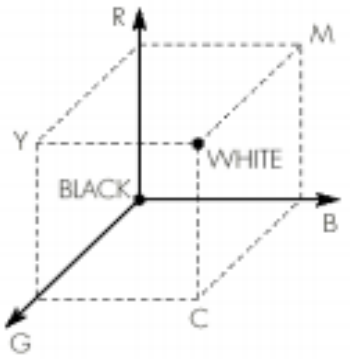
1. Additive color mixing
2. Subtractive color mixing.

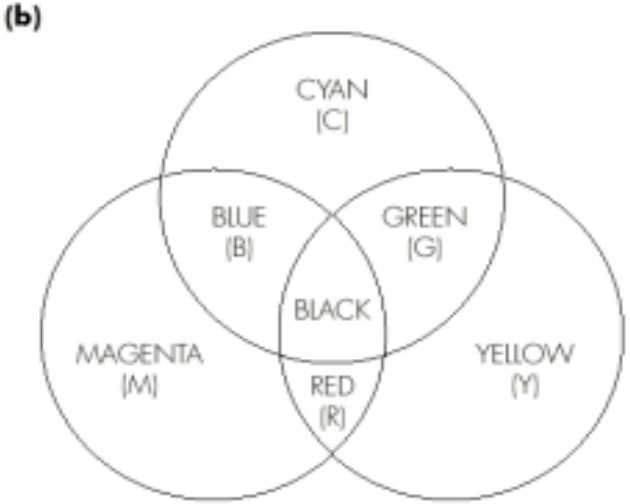
Images-Digitized Pictures

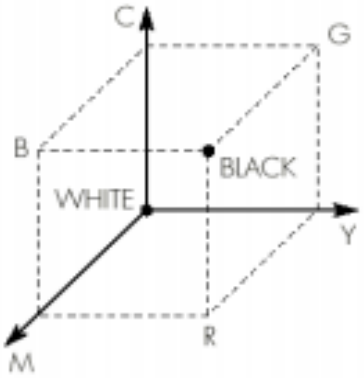
Color Principles





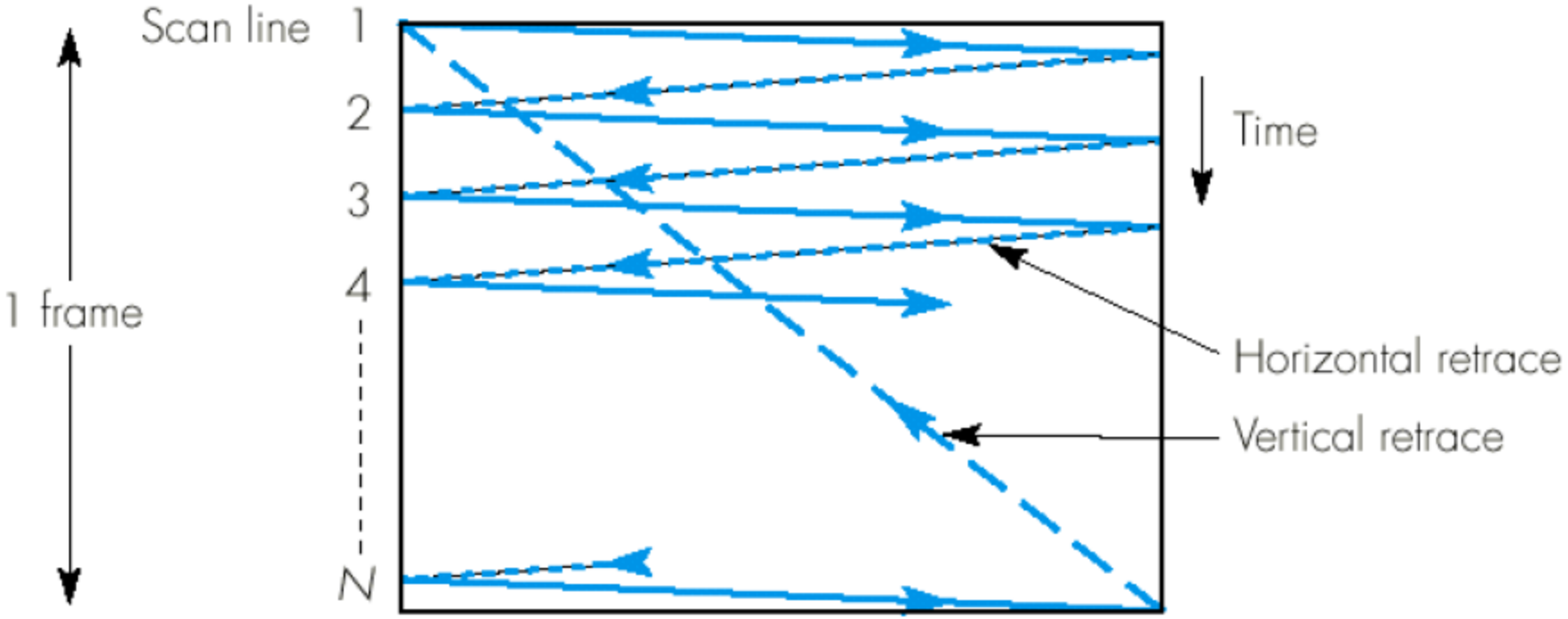






Images-Digitized Pictures

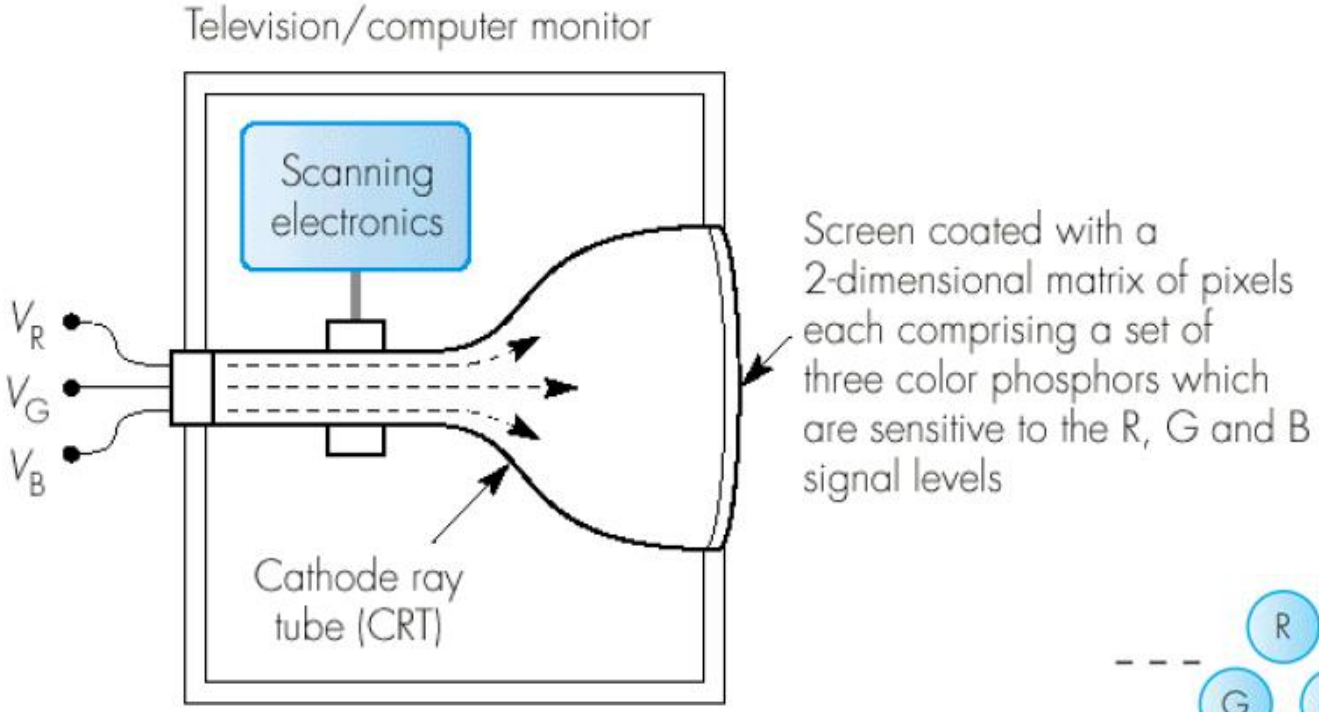
Raster-scan principles



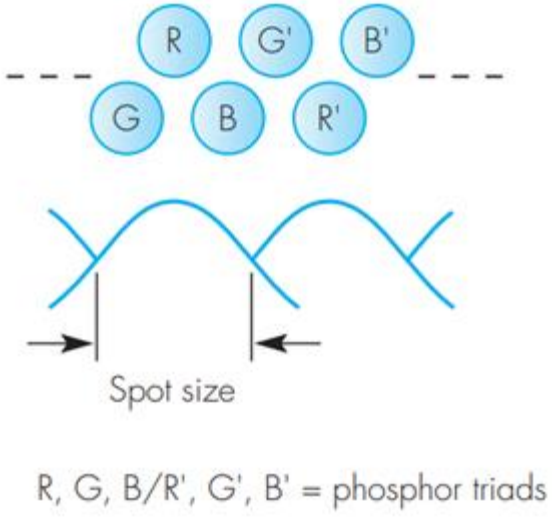
N = 525 (NTSC) and 625 (PAL/CCIR/SECAM)
Frame refresh rate = 60 times per second (NTSC)
= 50 times per second (PAL/CCIR/SECAM)

Images-Digitized Pictures

Raster-scan principles

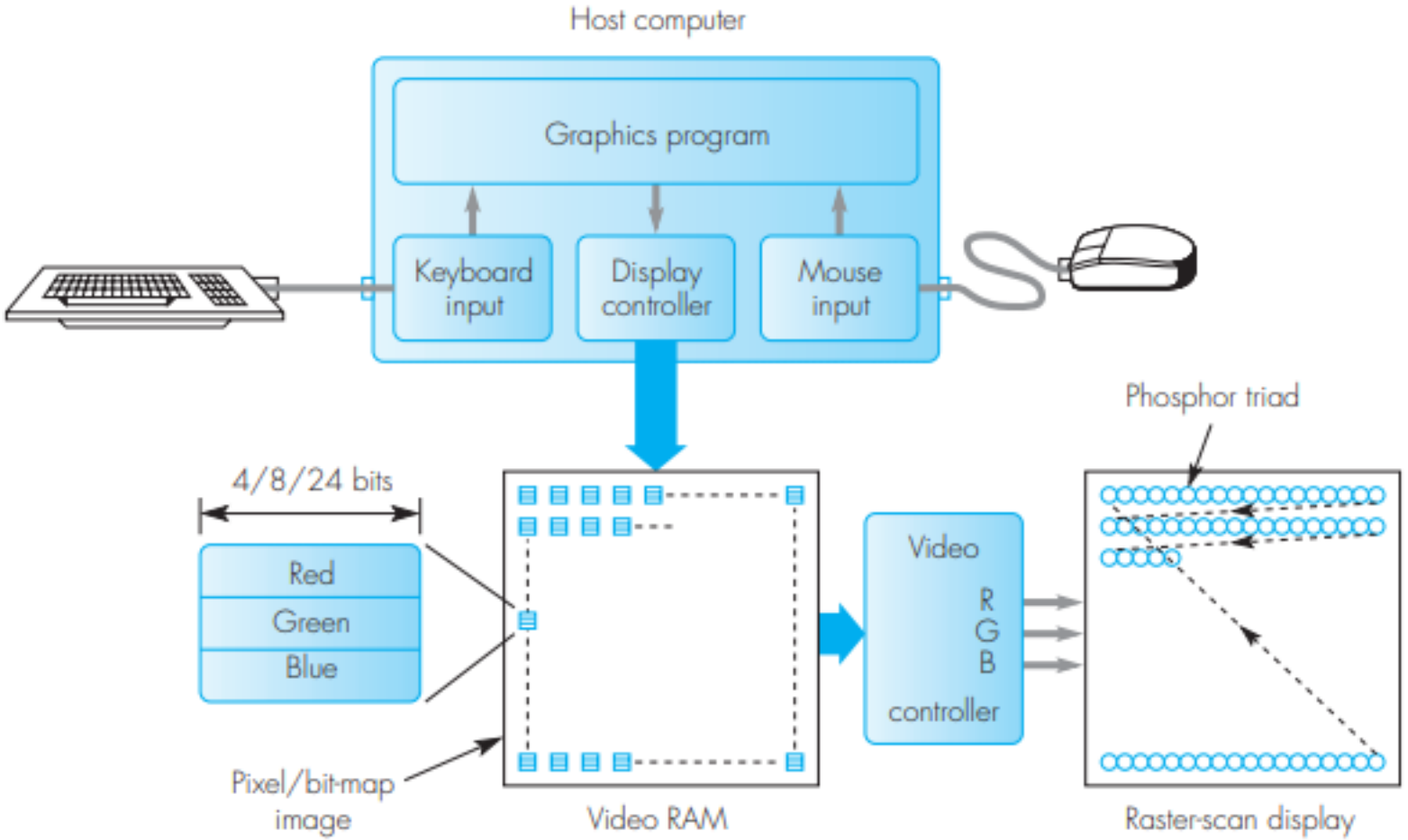


Pixel format on each scan line



Images-Digitized Pictures

Raster-scan display architecture.



Pixel depth

- The number of bits per pixel is known as the *pixel depth* and determines the range of different colors that can be produced.
- Color look-up table

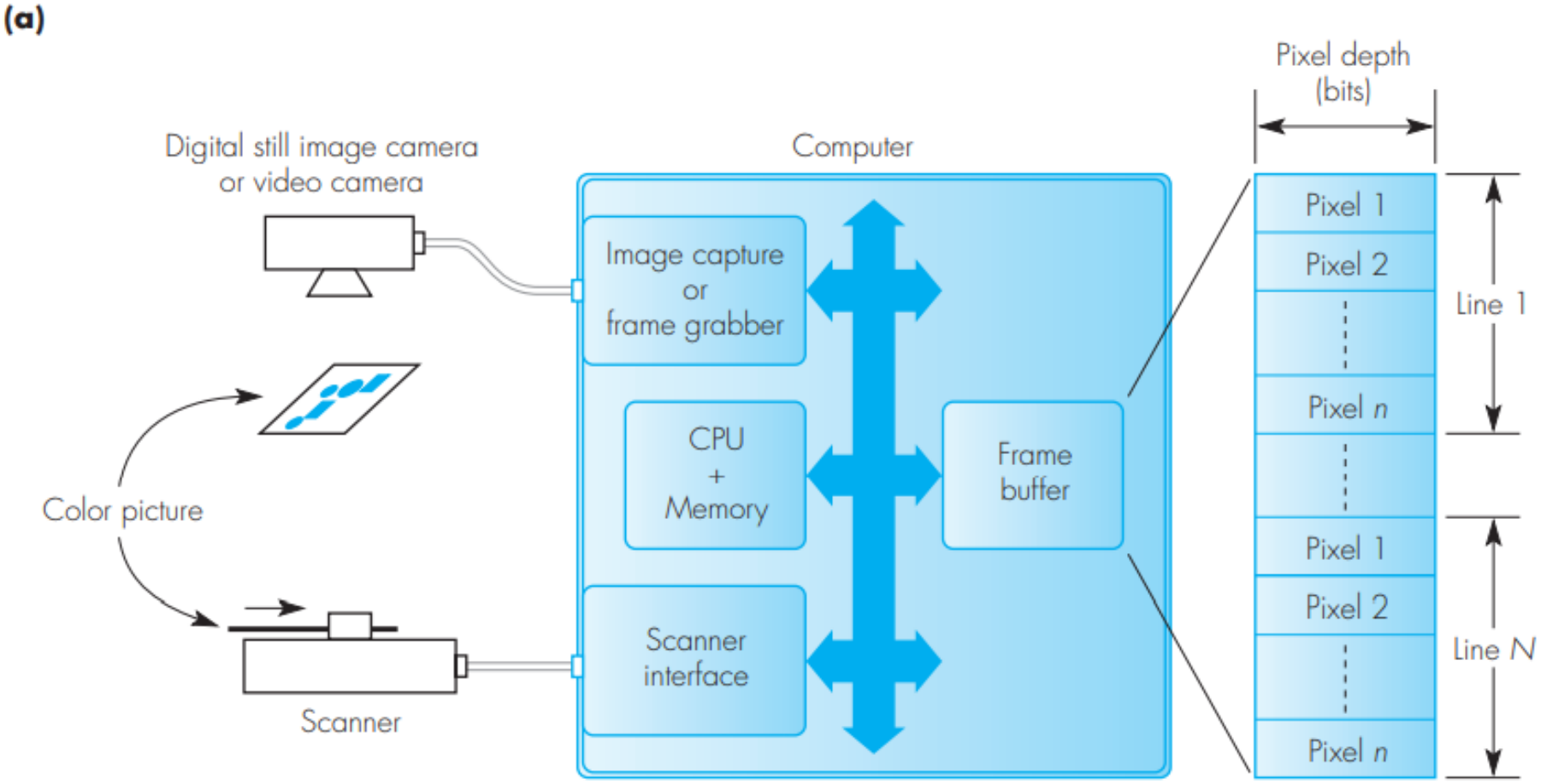
Aspect Ratio

The *aspect ratio* is the ratio of the number of pixels per scanned line and the number of lines per frame. (common ratios: 4:3, 16:9)

Standard	Resolution	Number of colors	Memory required per frame (bytes)
VGA	640x480x8	256	307.2kB
XGA	640x480x16	64k	614.4kB
	1024x768x8	256	786.432kB
SVGA	800x600x16	64k	960kB
	1024x768x8	256	786.432kB
	1024x768x24	16M	2359.296kB

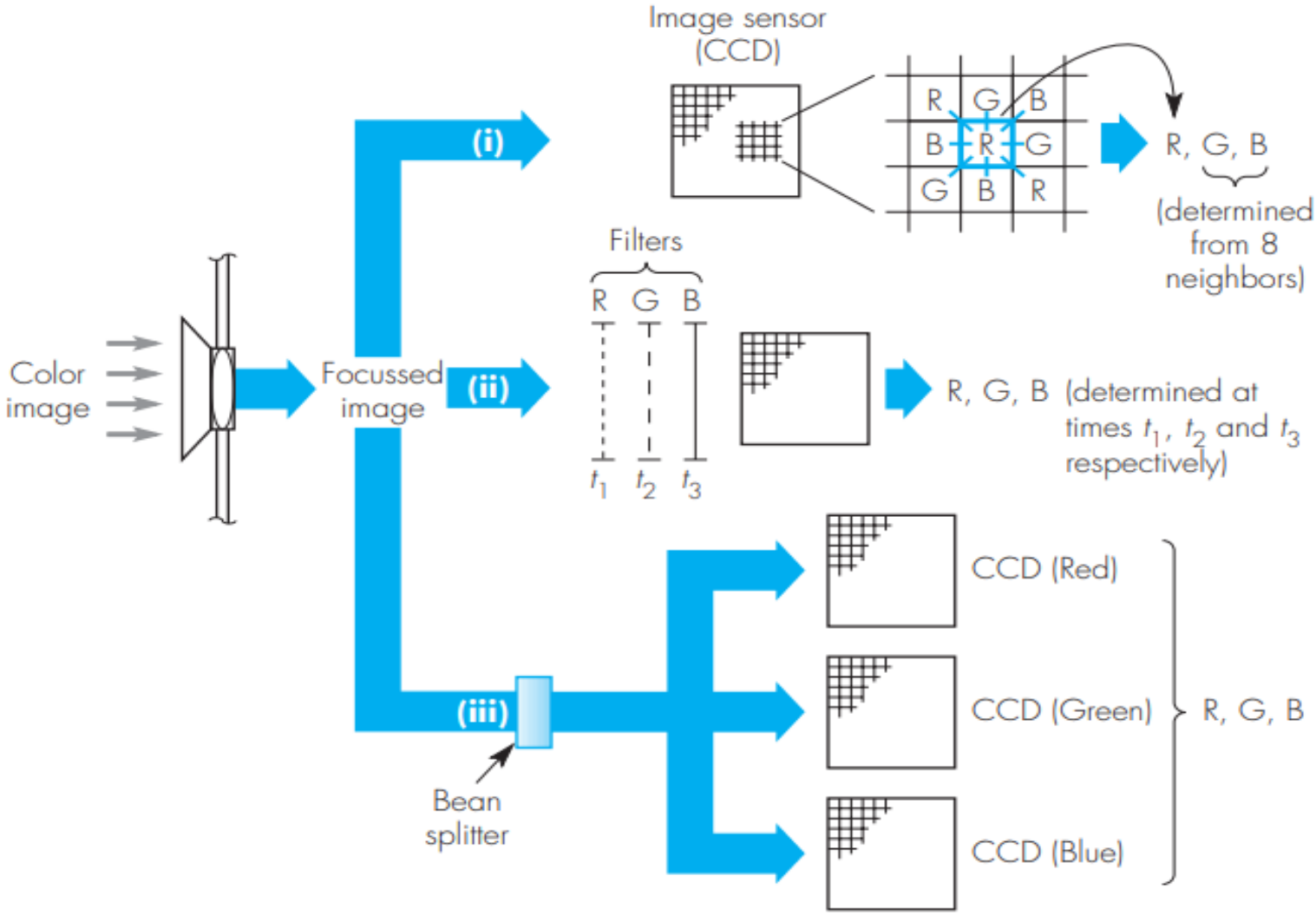
Images--Digitized Pictures

Color Image Capture: Schematic



Images--Digitized pictures

Color Image Capture: RGB signal Generative Schematic



Audio

There are 2 types of audio signal:

1. Speech
2. Music quality audio

- Audio can be produced either naturally by means of a microphone or electronically using some form of synthesizer.
- Output of all digitized audio signals the stream of digitized values must be converted back into its analog form as loudspeakers operate using an analog signal.

Audio

Summary of characteristics

	Speech	Music
Typical bandwidth	50Hz - 10kHz	15Hz - 20kHz
Sampling rate	20kHz	40kHz
Bits per sample	12	16
No. of channels	usually mono	usually stereo

Audio

Example

Assuming the bandwidth of a speech signal is from 50 Hz through to 10 kHz and that of a music signal is from 15 Hz through to 20 kHz, derive the bit rate that is generated by the digitization procedure in each case assuming the Nyquist sampling rate is used with 12 bits per sample for the speech signal and 16 bits per sample for the music signal. Derive the memory required to store a 10 minute passage of stereophonic music.

(i) Bit rates: Nyquist sampling rate = $2 f_{max}$

Speech: Nyquist rate = 2×10 kHz = 20 kHz or 20 ksps

Hence with 12 bits per sample, bit rate generated

= $20\text{k} \times 12 = 240$ kbps

Music: Nyquist rate = 2×20 kHz = 40 kHz or 40 ksps

Hence bit rate generated = $40\text{k} \times 16 = 640$ kbps (mono)

or $2 \times 640\text{k} = 1280$ kbps (stereo)

(ii) Memory required: Memory required = bit rate (bps) × time (s)/8 bytes

Hence at 1280 kbps and 600 s,

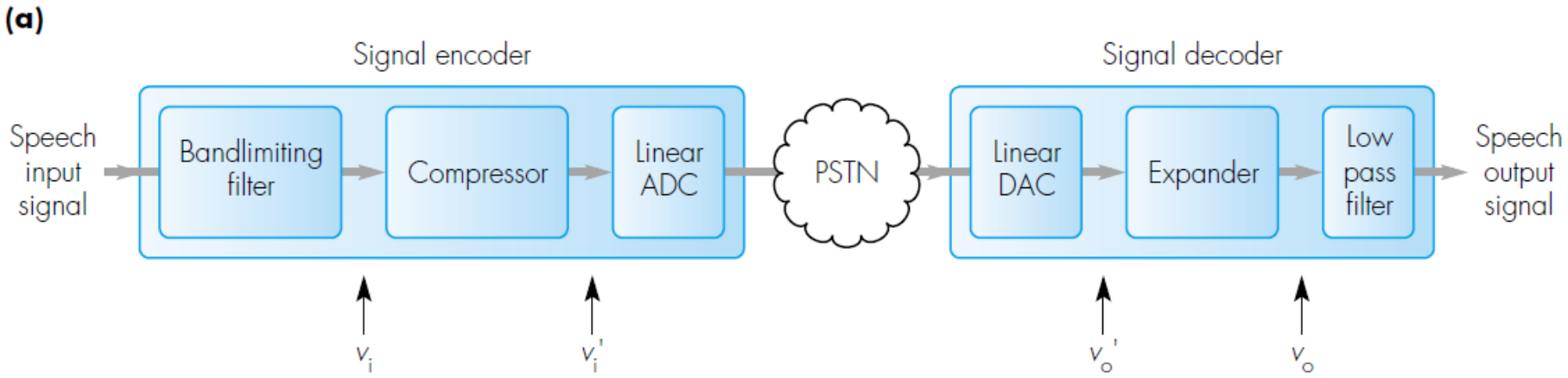
$$\text{Memory required} = \frac{1280 \times 10^3 \times 600}{8} = 96 \text{ Mbytes}$$

Audio– PCM speech

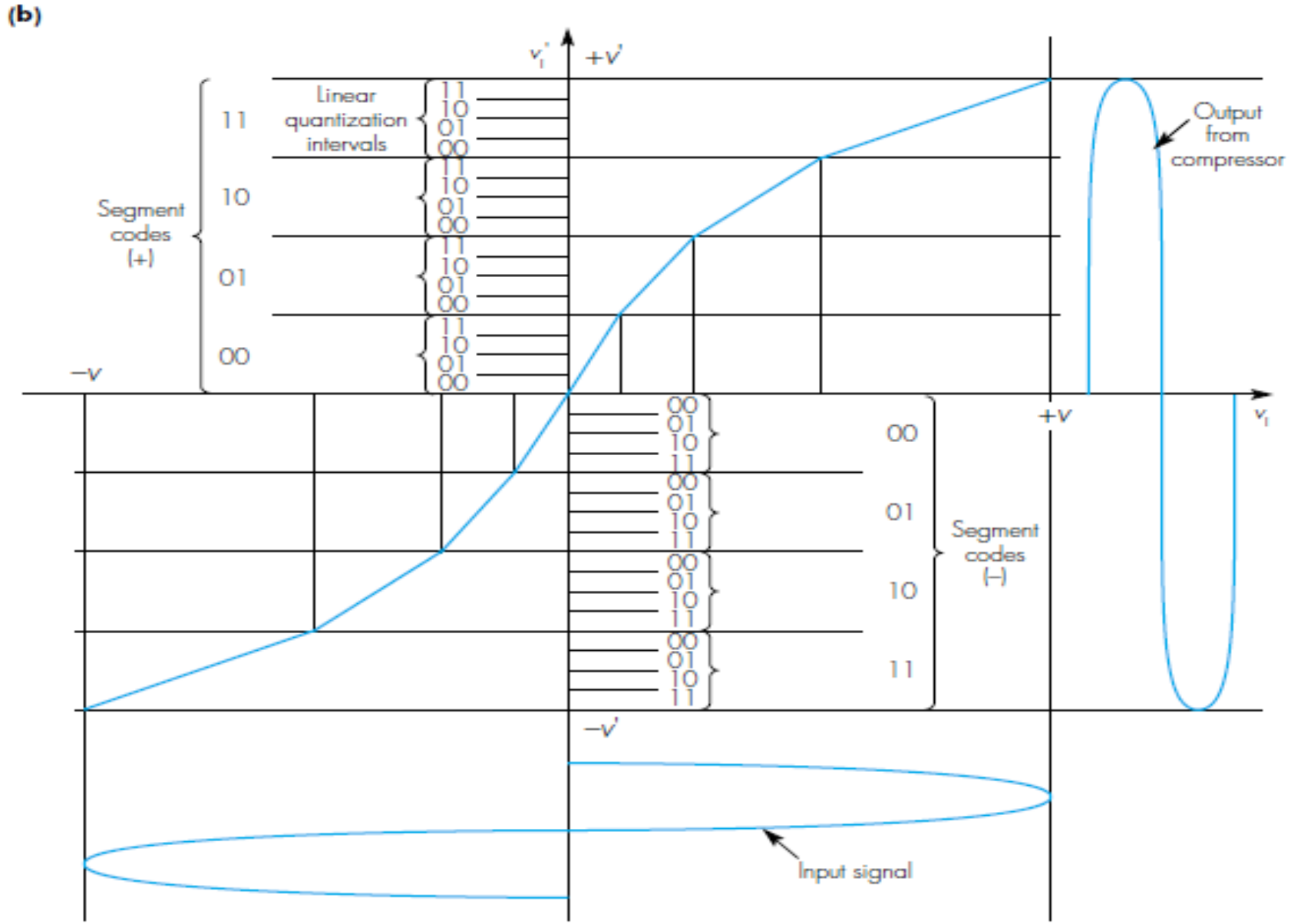
- The bandwidth of a speech circuit in a PSTN was limited to 200Hz through to 3.4kHz. ⇒Sampling rate 8 kHz
- The digitization procedure is known as pulse code modulation (PCM) and the international standard relating to this is defined in ITU-T Recommendation G.711.
- North America & Japan: 7 bits per sample, use μ-law compression-expansion characteristics
- Europe: 8 bits per sample, use A-law compression expansion characteristics.

Audio– PCM speech

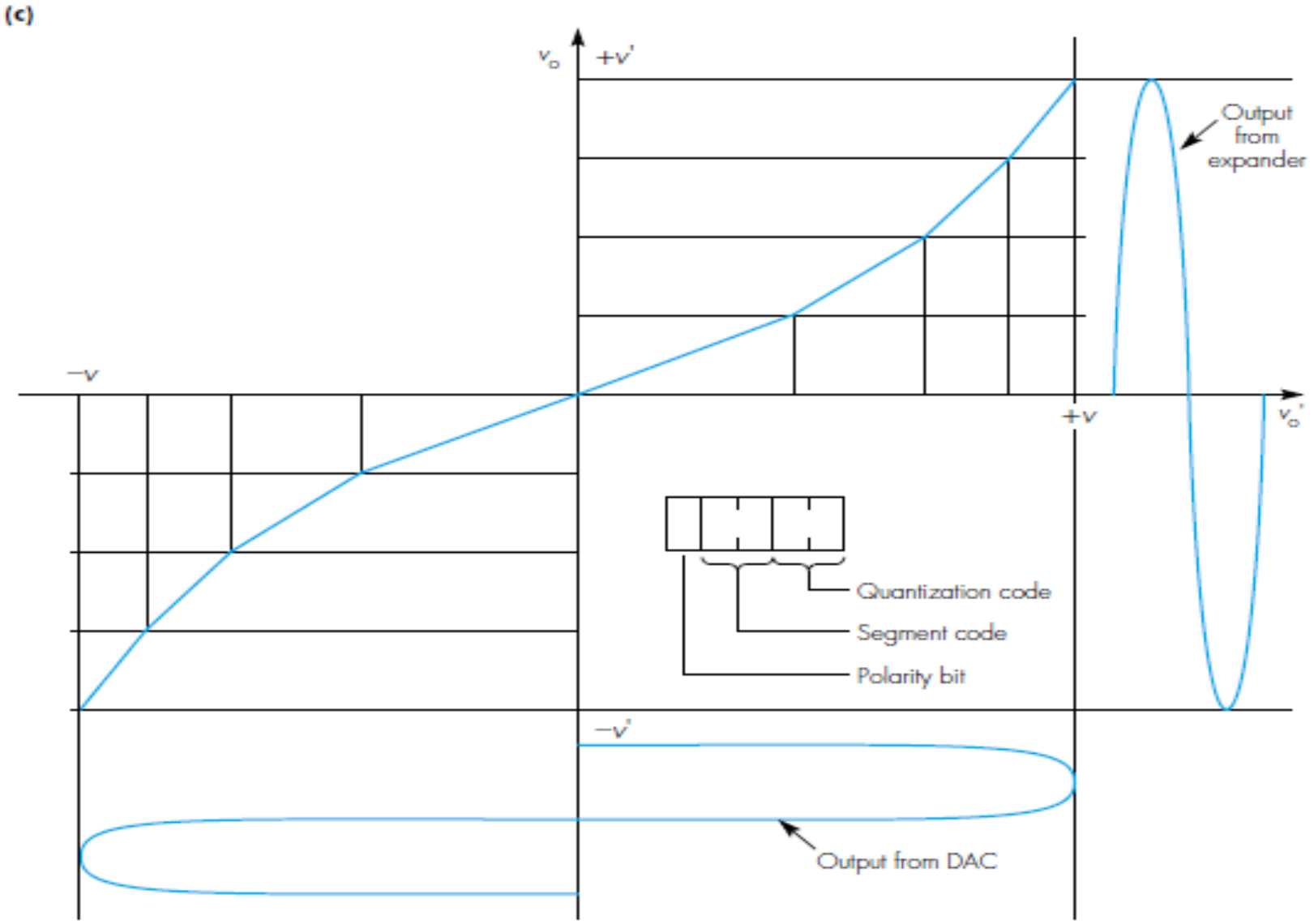
PCM Principles: Signal Encoding and Decoding Schematic



PCM Principles: Compressor Characteristics



PCM Principles: Expander Characteristics



Note that in the G.711 standard a 3-bit segment code and 4-bit quantization code are used.

Audio-- CD-quality audio

- Sampling rates 44.1kHz
- 16 bits per sample
- 2 channels

Audio-- CD-quality audio

Example

Assuming the CD-DA standard is being used, derive:

(i) the storage capacity of a CD-ROM to store a 60 minute multimedia title,

(ii) the time to transmit a 30 second portion of the title using a transmission channel of bit rate:

- 64 kbps
- 1.5 Mbps.

(i) The CD-DA digitization procedure yields a bit rate of 1.411 Mbps.
Hence storage capacity for 60 minutes

$$= 1.411 \times 60 \times 60 \text{ Mbits}$$
$$= 5079.6 \text{ Mbits or } 634.95 \text{ Mbytes}$$

(ii) One 30 second portion of the title $= 1.411 \times 30 = 42.33$ Mbits
Hence time to transmit this data:

$$\text{At 64 kbps} = \frac{42.33 \times 10^6}{64 \times 10^3} = 661.4 \text{ s} \quad \text{(about 11 minutes)}$$

$$\text{At 1.5 Mbps} = \frac{42.33 \times 10^6}{1.5 \times 10^6} = 28.22 \text{ s}$$

Audio- Synthesized audio

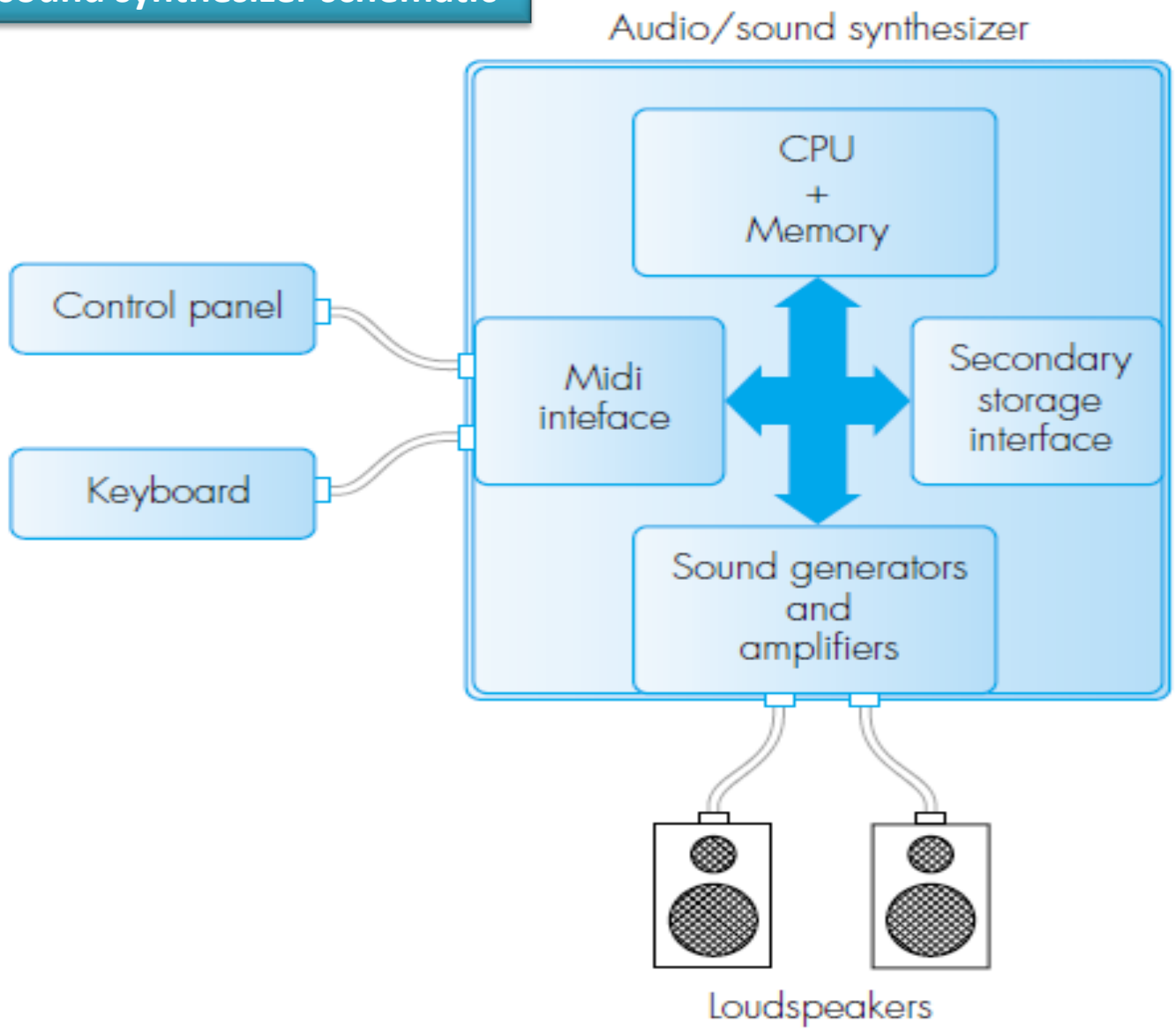
Synthesized audio is often used in multimedia applications since

(i) The amount of memory required can be 2 to 3 orders of magnitude less than that required to store the equivalent digitized waveform version,

(ii) It is much easier to edit synthesized audio and to mix several passages together.

Audio- Synthesized audio

Audio/sound synthesizer schematic



Audio- Synthesized audio

- The computer takes input commands from the keyboard and outputs these to the sound generators, which, in turn, produce the corresponding sound wave forms to drive the speakers.
- A standardized set of messages have been defined for both input and for output to the corresponding set of sound generators.
- These are defined in a standard called Music Instrument Digital Interface (MIDI).

Video

- Entertainment
- Interpersonal
- Interactive

The quality of the video required varies considerably from one type of application to another.

Broadcast Television

Basic Principles of Color TV

- Color Mixing- R G B
- The Screen of picture tube coated with 3 different phosphor.

NTSC-National Television Standards Committee

- Resolution-525 Refresh rate 60 frames per second

PAL-Phase Alternate Line

SECAM-Sequential Color and Memory

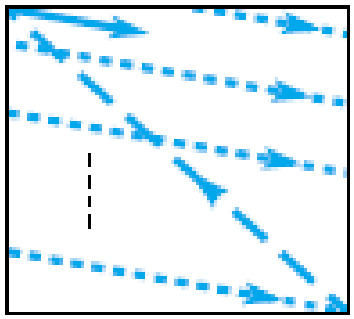
CCIR - International Radio Consultative Committee

- Resolution-625 Refresh rate 50 frames per second

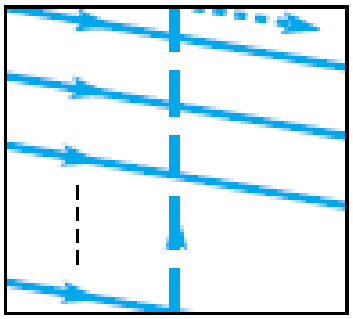
Broadcast Television

Interlaced scanning:

- Each frame is divided into 2 fields.
- One comprises the odd scan lines and one comprises the even scan lines.
- They are transmitted one by one and integrated together to form a complete frame in the television receiver.



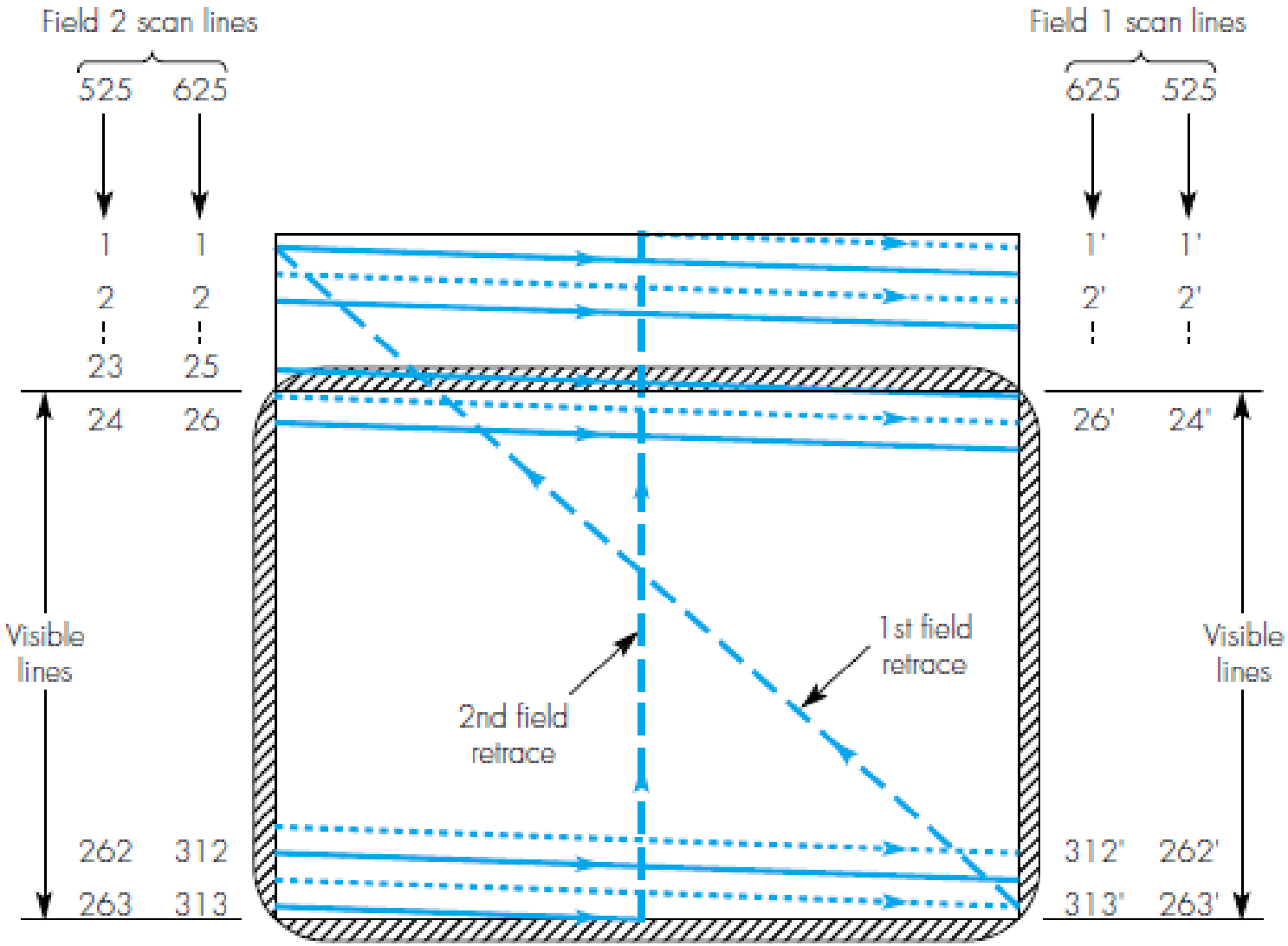
Field 1
(Odd scan lines)



Field 2
(Even scan lines)

525-line systems : 262.5 each field, 240 visible
625-line systems : 312.5 each field, 288 visible

Broadcast Television



Broadcast Television

Color Signals

- Brightness
- Hue
- Saturation

Broadcast Television

Color Signals

- Luminance—Brightness
- Chrominance– Hue and Saturation

0.299R+0.587G+0.114B--------->White

Broadcast Television

Color Signals

- Luminance—Brightness

$$Y_s = 0.299R_s + 0.587G_s + 0.114B_s$$

- Chrominance– Hue and Saturation

$C_b = B_s - Y_s$ and $C_r = R_s - Y_s$

Broadcast Television

Color Signals

- 1 luminance and 2 chrominance components are used to describe the color of each pixel.

  - PAL system:

    $$Y = 0.299R + 0.587\,G + 0.114\,B$$
    $$U = 0.493\,(B-Y)$$
    $$V = 0.877\,(R-Y)$$

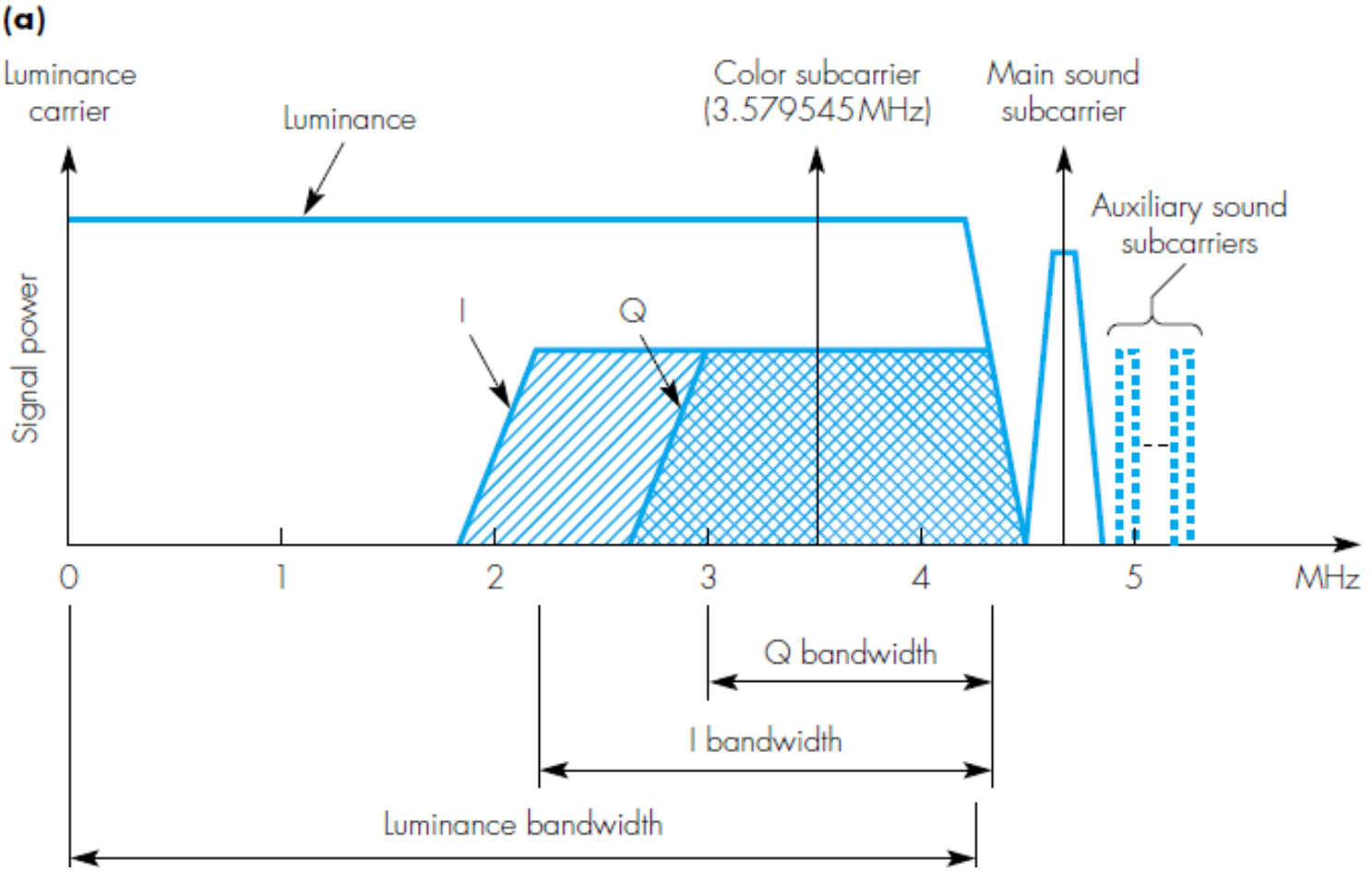
  - NTSC system:

    $$Y = 0.299R + 0.587\,G + 0.114\,B$$
    $$I = 0.74\,(R-Y) - 0.27\,(B-Y)$$
    $$Q = 0.48\,(R-Y) + 0.41\,(B-Y)$$

Broadcast Television

Signal Bandwidth

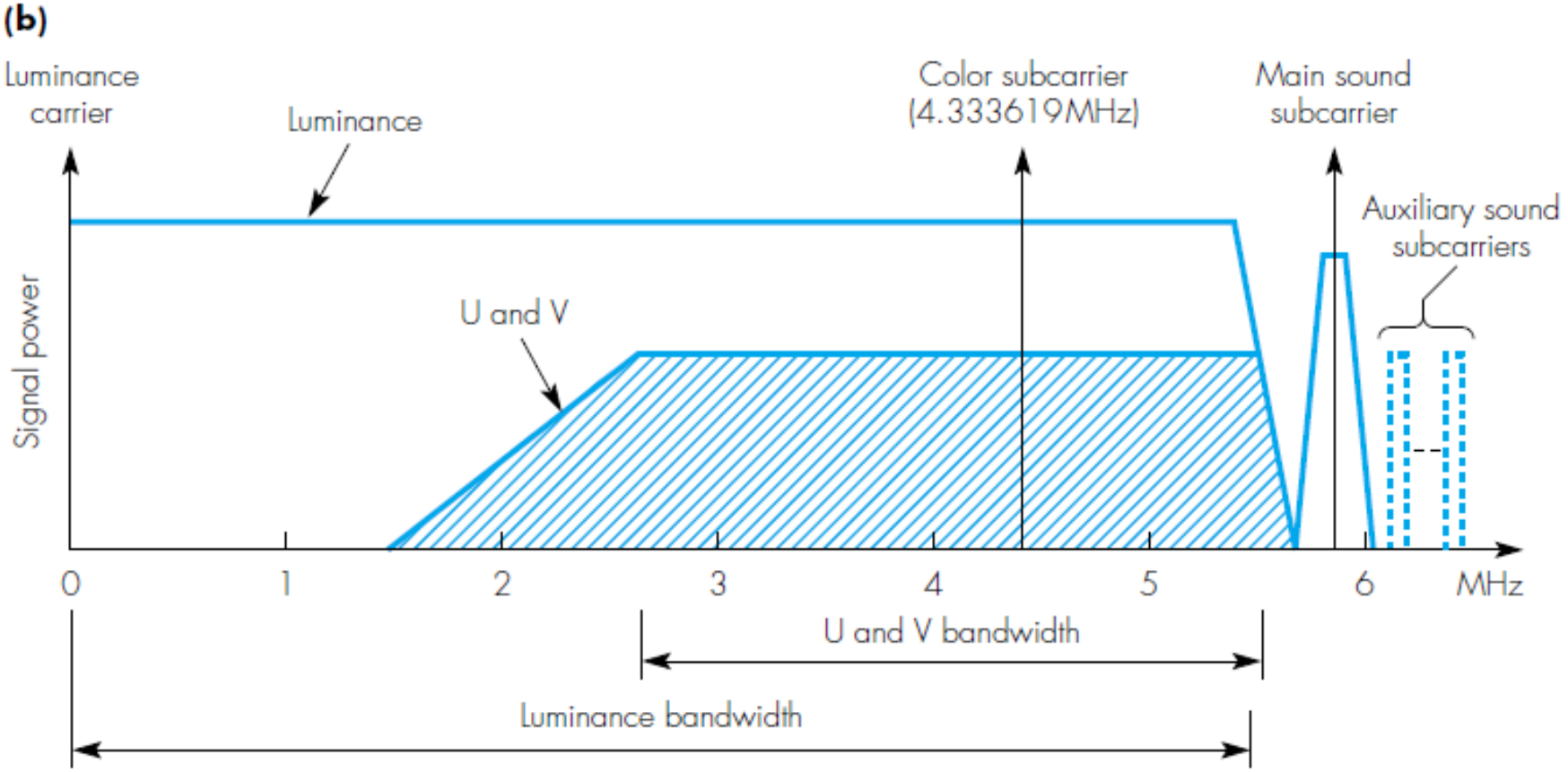
Baseband spectrum of color television signals**: NTSC system**



Broadcast Television

Signal Bandwidth

Baseband spectrum of color television signals**: PAL system**



Digital Video

- These are intended for use with standard television receivers.
- The 3 component signals are usually digitized separately prior to their transmission.
- The **International Telecommunications Union - Radio communications Branch** (ITU-R) - formerly known as **Consultative Committee for International Radio communications** (CCIR) - defined a standard for the digitization of video pictures known as Recommendation CCIR-601.

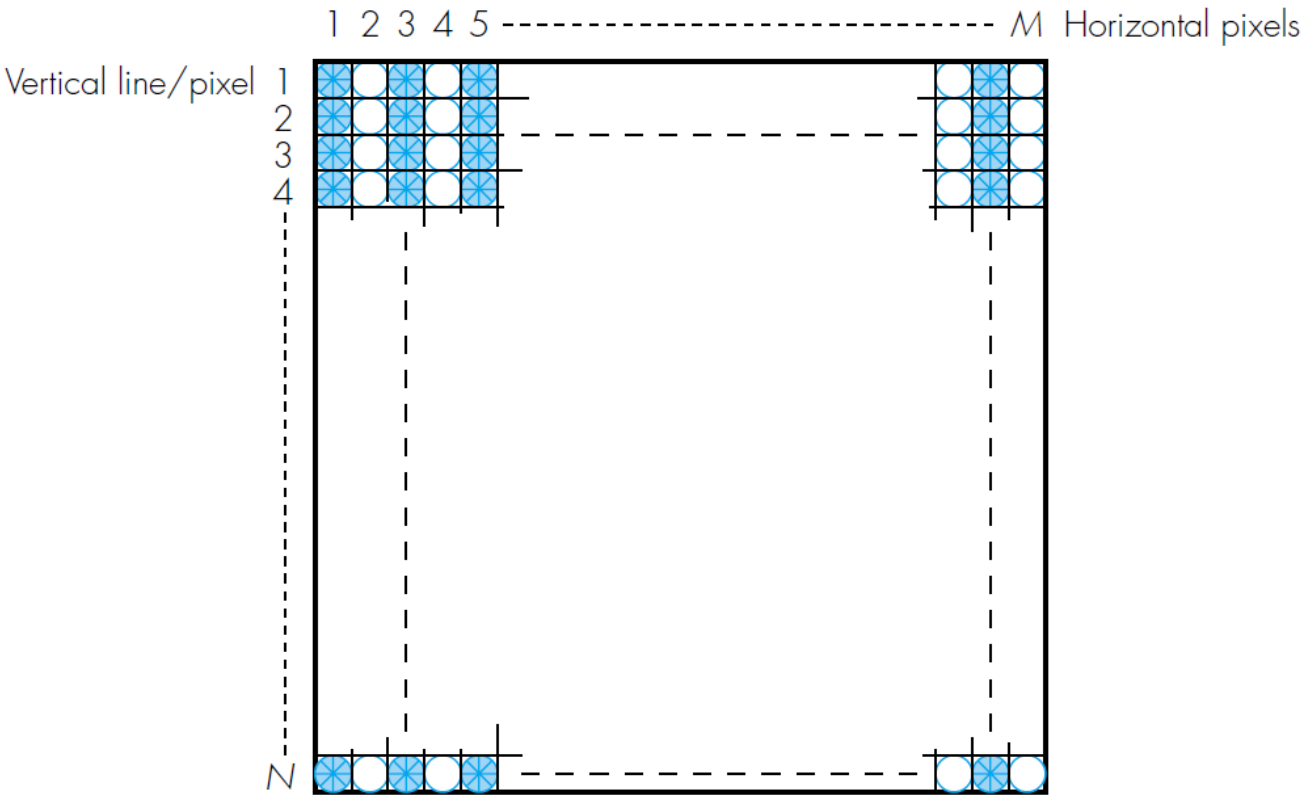
Digital Video

4:2:2 format

- Original digitization format used in Recommendation CCIR-601 for use in television studios.
- Line sampling rate: 13.5MHz for luminance and 6.75MHz for chrominance signals.
- The number of bits per sample is 8 for all 3 signals.

Digital Video

4:2:2 format



O = Y, + = C_b, X = C_r sample positions

525-line systems: $M = 720$, $N = 480$, 60Hz refresh rate (interlaced)
$Y = 720 \times 480$, $C_b = C_r = 360 \times 480$

625-line systems: $M = 720$, $N = 576$, 50Hz refresh rate (interlaced)
$Y = 720 \times 576$, $C_b = C_r = 360 \times 576$

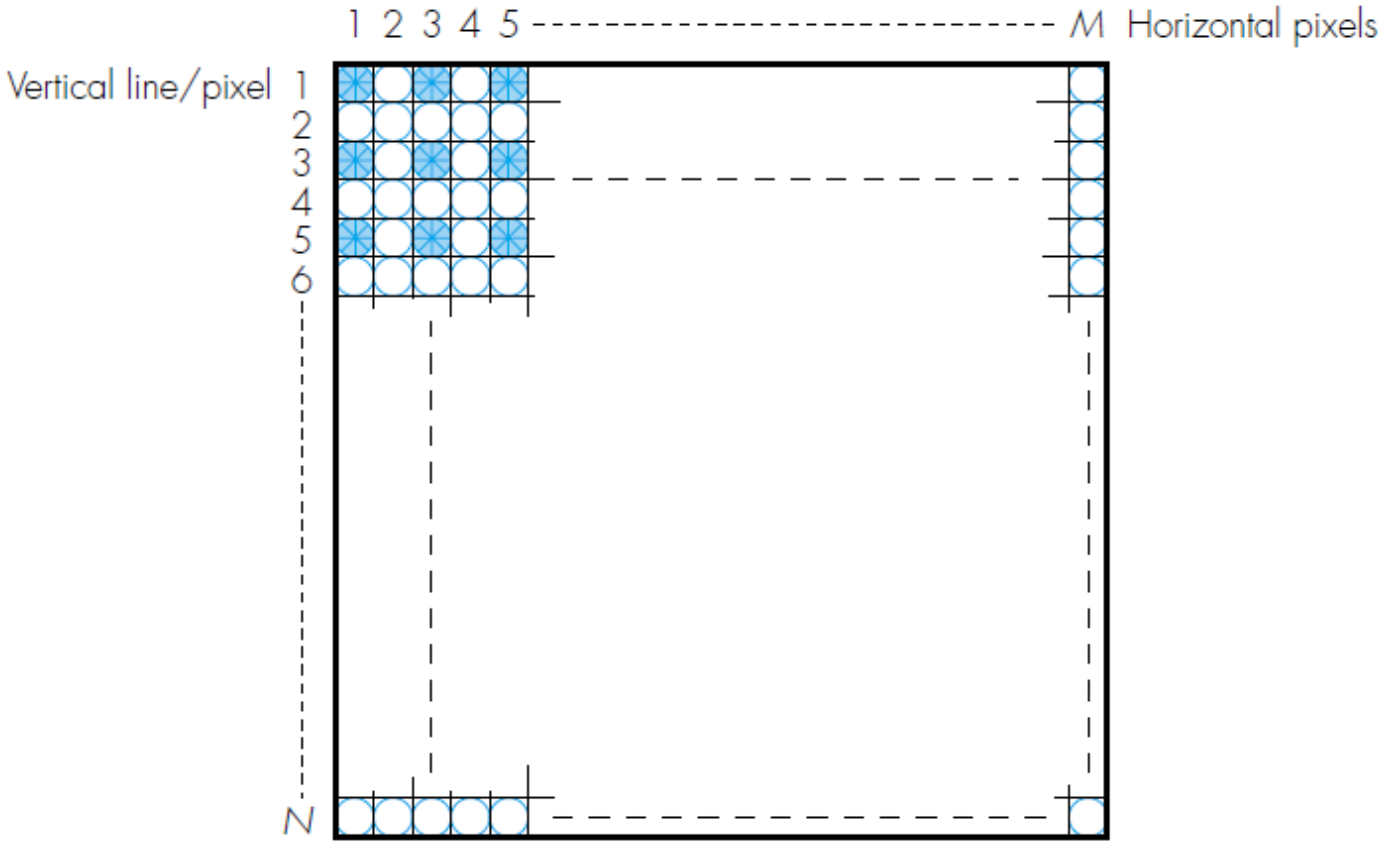
Digital Video

4:2:0 format

- Used in digital video broadcast applications.
- Interlaced scanning is used
- Absence of chrominance samples in alternative lines is the origin of the term 4:2:0

Digital Video

4:2:0 format



O = Y, + = C_b, X = C_r sample positions

525-line systems: $M = 720$, $N = 480$, 60Hz refresh rate (interlaced)
$Y = 720 \times 480$, $C_b = C_r = 360 \times 240$

625-line systems: $M = 720$, $N = 576$, 50Hz refresh rate (interlaced)
$Y = 720 \times 576$, $C_b = C_r = 360 \times 288$

Digital Video

HDTV Formats

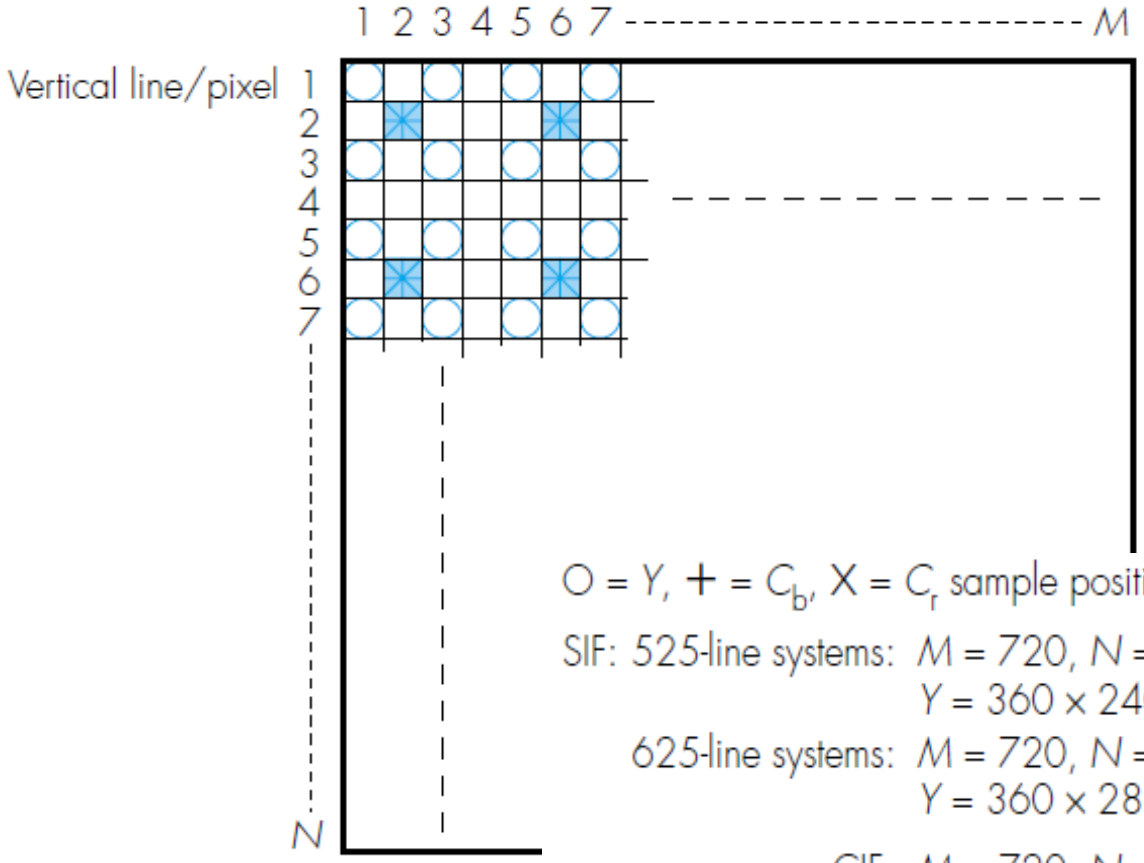
- 4/3 Aspect ratio--->1440 x 1152
- 16/9 Aspect ratio --->1920 x 1152
- No. of Visible lines-1080

- 4:2:2 format-Studio Applications—50/60 Hz Frame refresh Rate
- 4:2:0 format – Broad cast Application-25/30 Hz Frame refresh Rate

Digital Video

SIF (Source Intermediate Format)

Give a picture quality comparable with that obtained with VCRs



O = Y, + = C_b, X = C_r sample positions

SIF: 525-line systems: $M = 720$, $N = 480$ with 30Hz refresh rate (non-interlaced)
$Y = 360 \times 240$, $C_b = C_r = 180 \times 120$

625-line systems: $M = 720$, $N = 576$ with 25Hz refresh rate (non-interlaced)
$Y = 360 \times 288$, $C_b = C_r = 180 \times 144$

CIF: $M = 720$, $N = 576$ with 30Hz refresh rate (non-interlaced)
$Y = 360 \times 288$, $C_b = C_r = 180 \times 144$

Digital Video

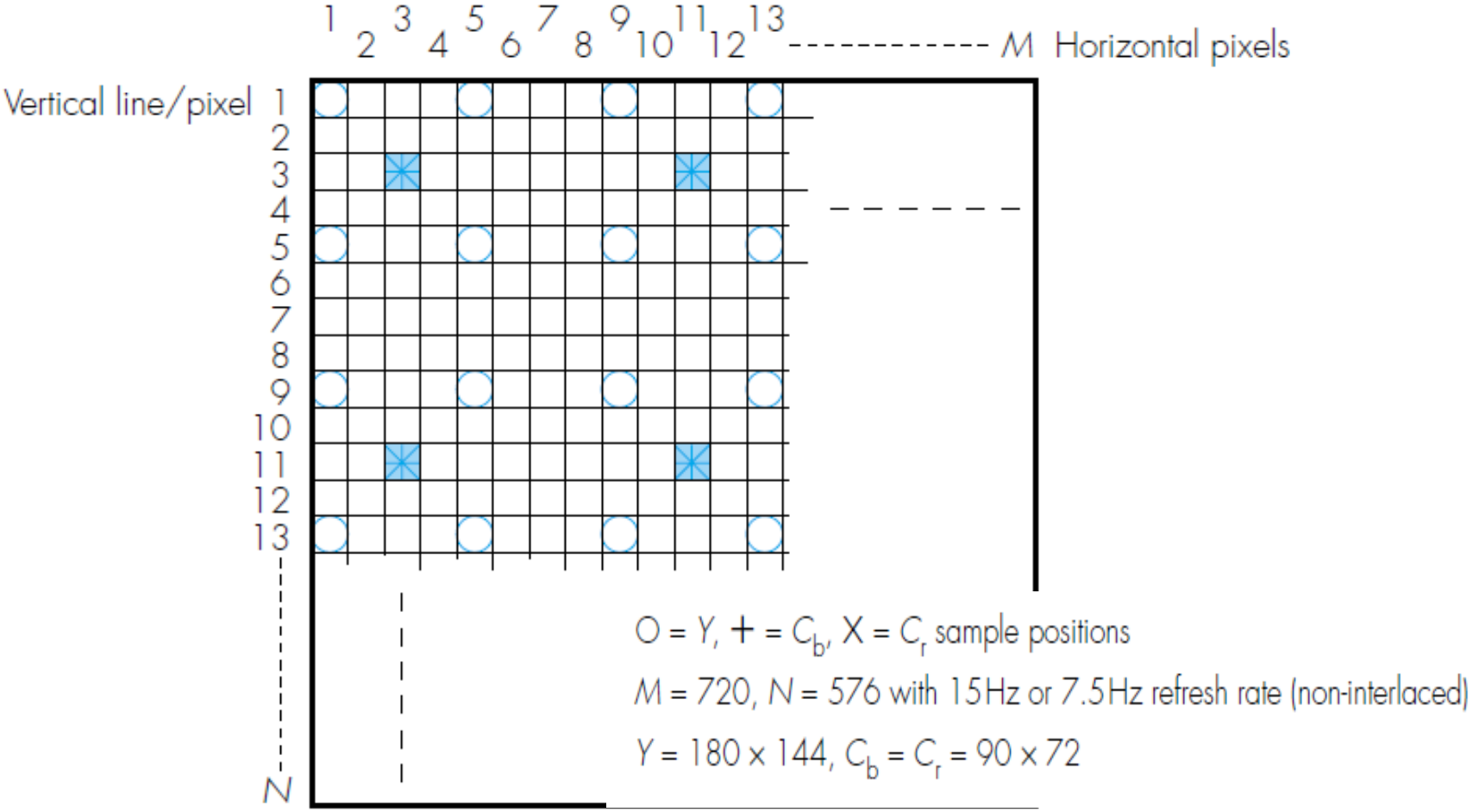
CIF (Common Intermediate Format)

- Used in videoconferencing applications
- 4:1:1 digitization format
- Spatial resolution: Y=360x288, Cb=Cr=180x144
- Temporal resolution 30Hz using progressive scanning
- Derivatives of CIF: 4CIF & 16CIF

Digital Video

QCIF (Quarter Common Intermediate Format)

- For video telephony applications.



Digital Video

PC video

Digitization format	System	Spatial resolution	Temporal resolution
4:2:0	525-line	Y= 640x480 C_b=C_r= 320x240	60Hz
	625-line	Y= 768x576 C_b=C_r= 384x288	50Hz
SIF	525-line	Y= 320x240 C_b=C_r= 160x240	30Hz
	625-line	Y= 384x288 C_b=C_r= 192x144	25Hz
CIF		Y= 384x288 C_b=C_r= 192x144	30Hz
QCIF		Y= 192x144 C_b=C_r= 96x72	15/7.5Hz