CHAPTER 1

Introduction

(Part 2 of 2)

1.2 Elements of electrical communication systems

Elements of Analog communication systems

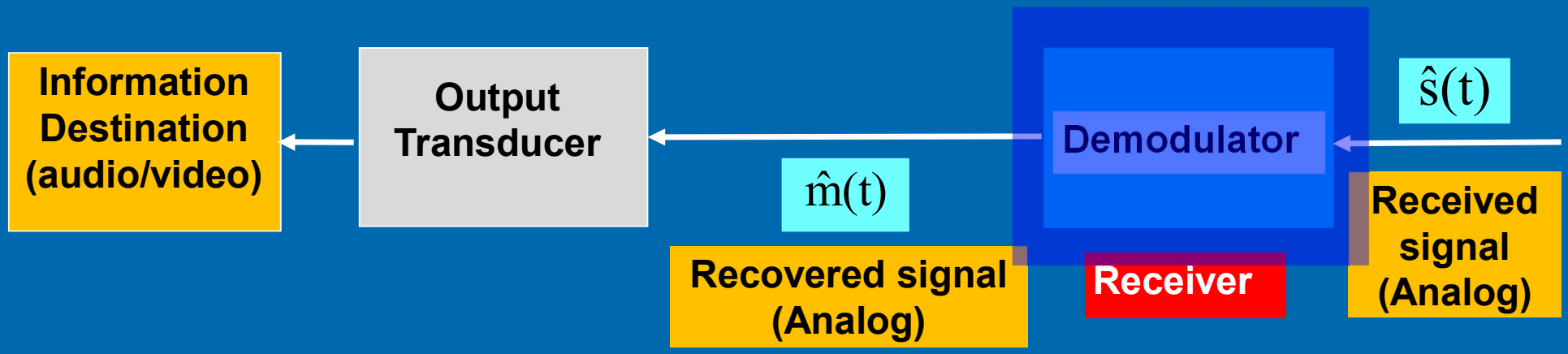
Receiver

Extract $\hat{m}(t)$ from degraded version of transmitted signal $\hat{s}(t)$

Demodulate $\hat{s}(t)$ if it is a passband signal

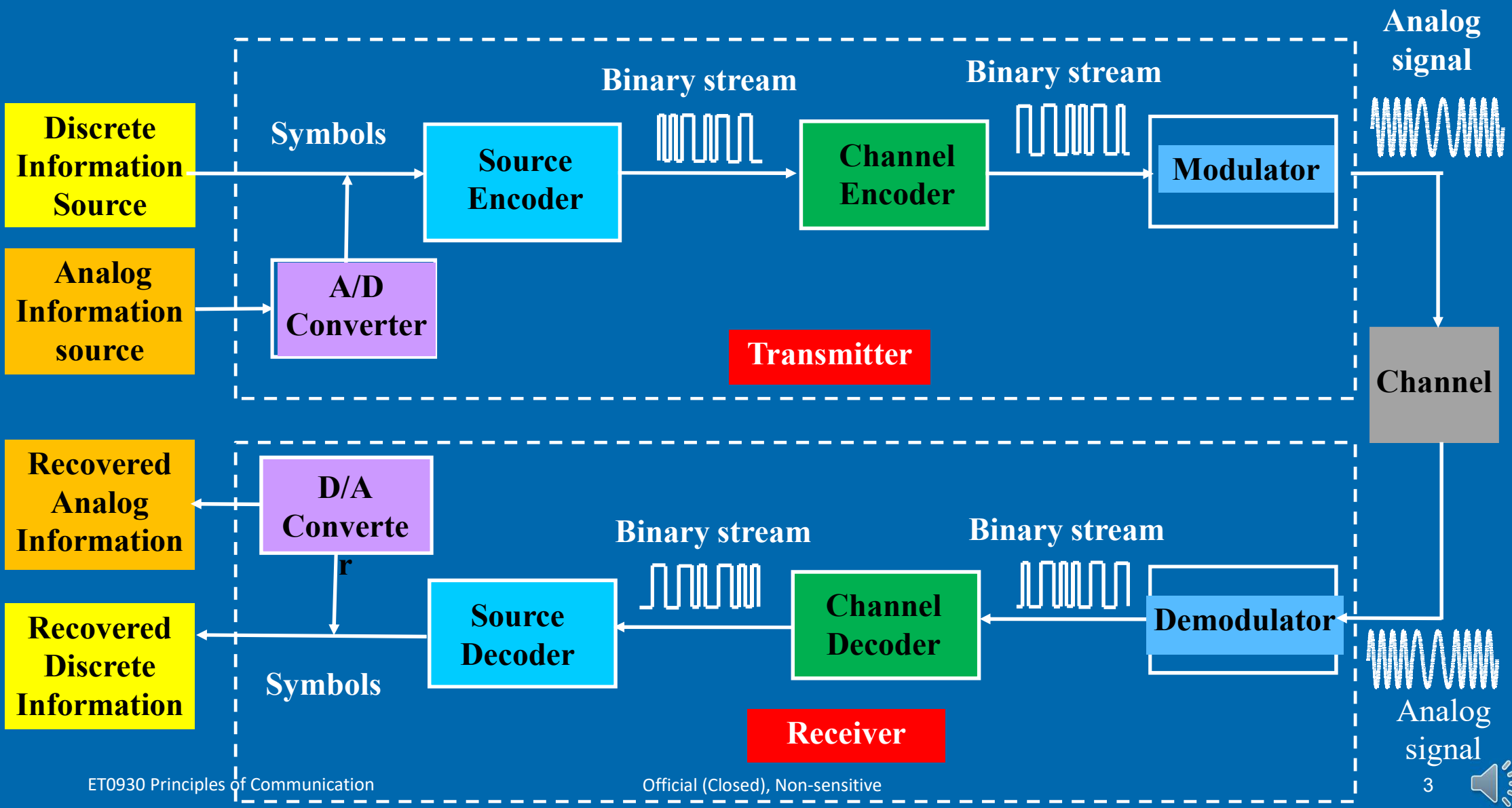
Also provide amplification and filtering

Make $\hat{m}(t)$ close to m(t)



1.2 Elements of electrical communication systems

Elements of digital communication systems



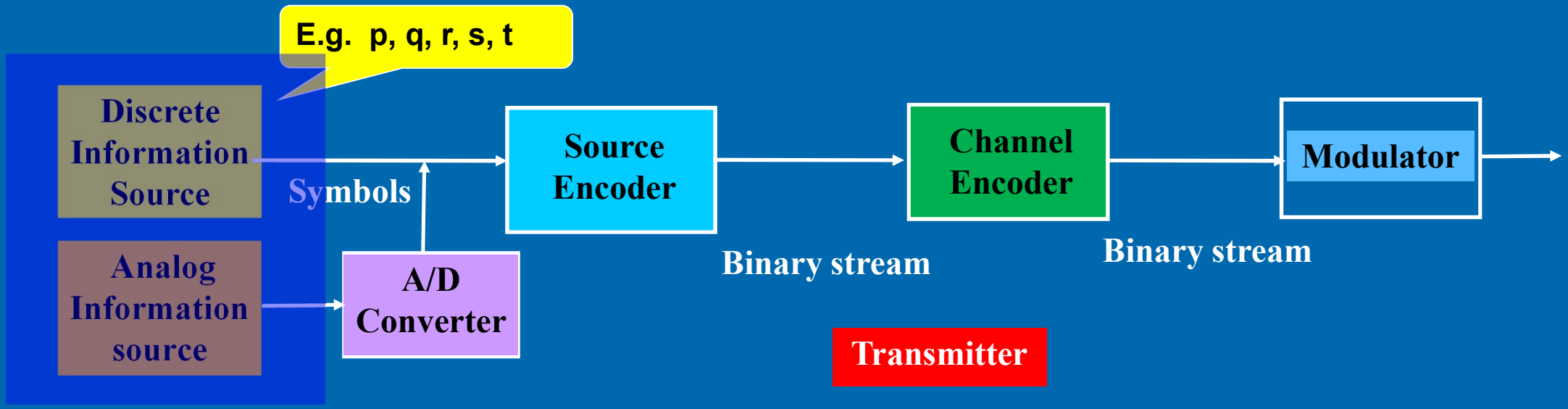
1.2 Elements of electrical communication systems

Elements of digital communication systems

Information Source

Discrete → **A sequence of discrete symbols**

Analog → **Converted to a discrete symbols through A/D converter**



1.2 Elements of electrical communication systems

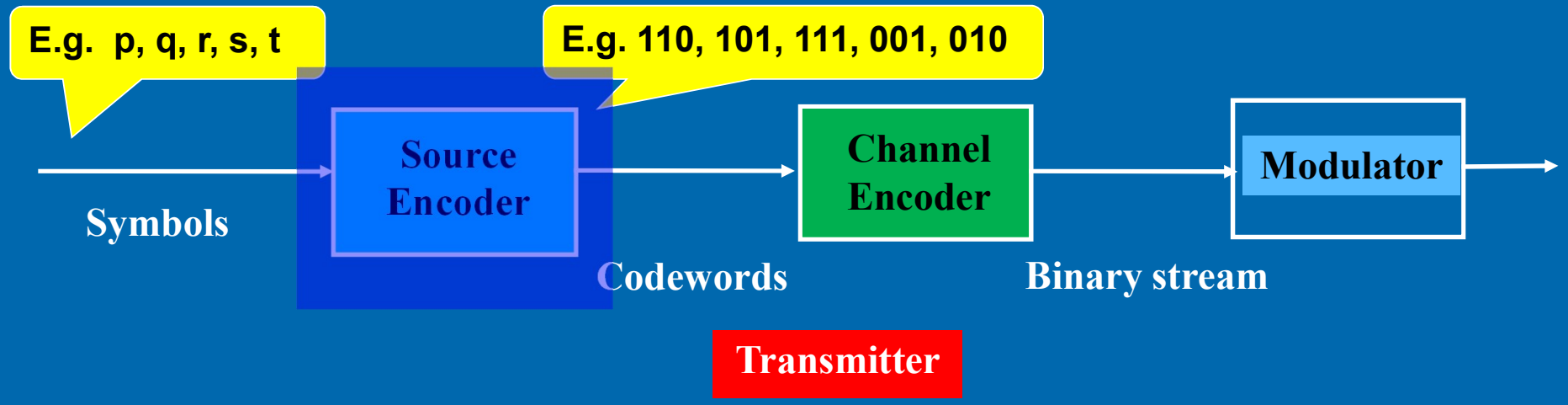
Elements of digital communication systems

Source Encoder/Decoder

Input is a sequence of symbols at r_s symbols/sec.

converts the symbol sequence into a efficient binary sequence of 0's and 1's by assigning codewords to the symbols.

simplest way
Use fixed length code



1.2 Elements of electrical communication systems

Elements of digital communication systems

Source Encoder/Decoder

- E.g. assign 5-bit codeword, 00000 through 11111 for a discrete source of 32 symbols. If r_s is 10 symbols/sec, source encoder's output data rate will be 50 (5x10) bits/sec.

- Fixed length coding is efficient only if the symbols occur with equal probabilities in a statistically independent sequence which is not so in practice.

- E.g. in the English text, 'a' occurs more often than 'z', and given the letter 'q' often next letter is 'u'. Hence, variable length code is used.

1.2 Elements of electrical communication systems

Elements of digital communication systems

- **Simple example of variable length coding**

Message	Fixed length coding	Variable length coding
Yes(Y)	00	0
No(N)	01	10
Undecided(U)	10	11

Typical message: YYYYNU

Fixed Length Coding: 00 00 00 00 01 10

⇒ **12 bits required**

Variable Length Coding: 0 0 0 0 10 11

⇒ **8 bits required**

1.2 Elements of electrical communication systems

Elements of digital communication systems

Source Encoder/Decoder

Examples:
Digital camera, MP3 player, etc.

- **Advantage - Assumption: Unequal symbol probabilities.**

  - Less bit required to transmit the same info.
  ⇒ lower bit rate
  ⇒ lower transmission bandwidth.

  - At the same bit rate more info is transmitted.

  - Less memory used for storage.

- **At the receiver, the source decoder converts the binary output of the channel decoder into a symbol sequence.**

1.2 Elements of electrical communication systems

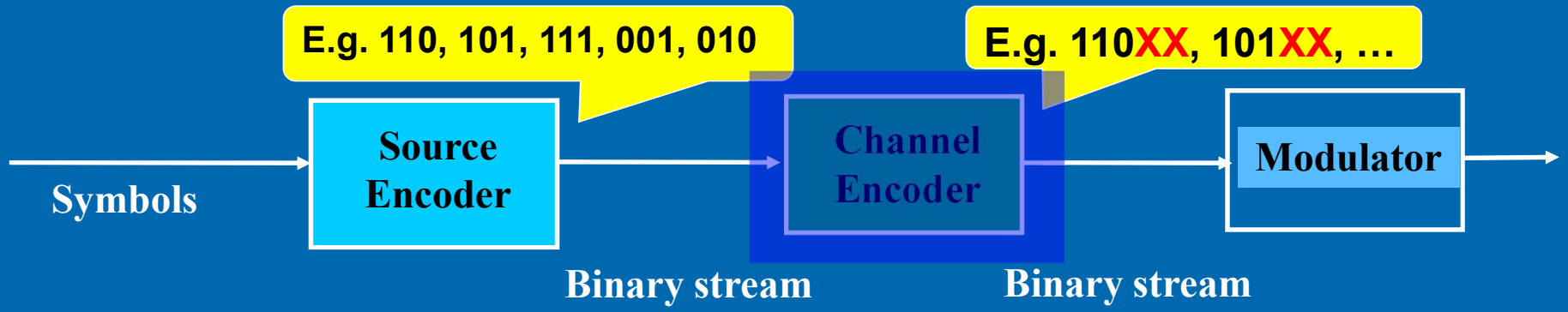
Elements of digital communication systems

Channel Encoder/Decoder

Encoder converts the source encoded binary sequence into a form for reduced errors due to the noise interference in the channel.

For high transmission reliability.

Error control
Systematically adding extra bits to output of the source encoder to enable the receiver to detect / correct the errors caused by the channel.



1.2 Elements of electrical communication systems

Elements of digital communication systems

Channel Encoder/Decoder

- **E.g. a parity check bit is added to a 7-bit ASCII code .**

  Examples: Fax machine, handphone, etc

1.2 Elements of electrical communication systems

Elements of digital communication systems

- **Simple example of channel coding**

Message	Source coding
Yes(Y)	0 0
No(N)	0 1
Undecided(U)	1 0

Channel coding

0 0 X X
0 1 X X
1 0 X X

2 extra check bits added for error detection and correction

1.2 Elements of electrical communication systems

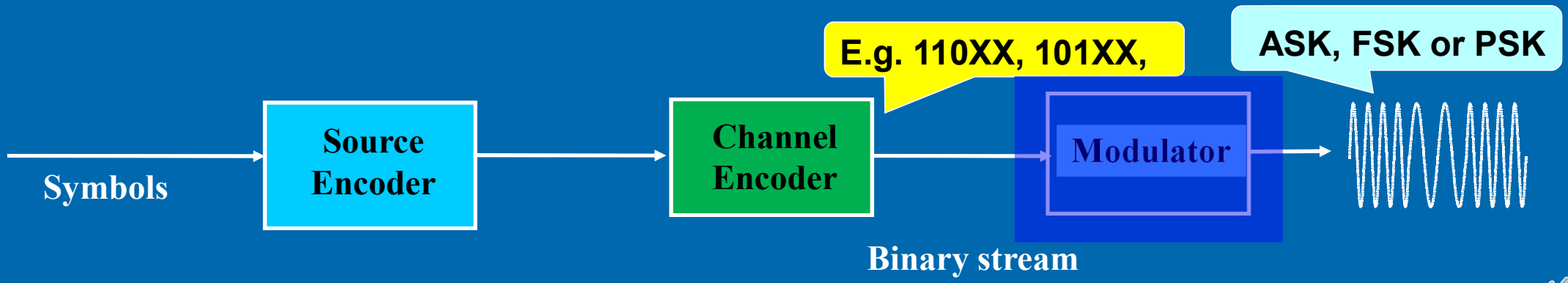
Elements of digital communication systems

Modulator/Demodulator

Accepts a bit stream as its input and converts it to an electrical waveform suitable for transmission.

Important parameters
- Type of waveform
- Duration of the waveform
- Power level
- Bandwidth

Passband transmission of digital signals — with modulation



1.2 Elements of electrical communication systems

Elements of digital communication systems

Modulator/Demodulator

Baseband signals can be directly transmitted over the channel without modulation for a dedicated communication channel.

e.g. twisted pair / coaxial cables

Suitable for short distance communication.

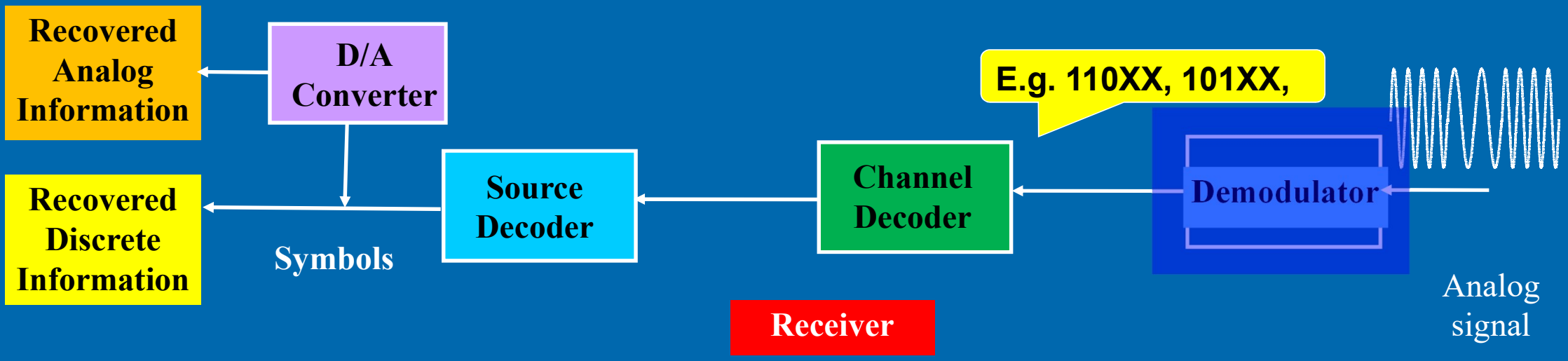
Baseband transmission of digital signals

1.2 Elements of electrical communication systems

Elements of digital communication systems

Modulator/Demodulator

Demodulator extracts the message from the information bearing waveform produced by the modulator.



1.2 Elements of electrical communication systems

Elements of digital communication systems

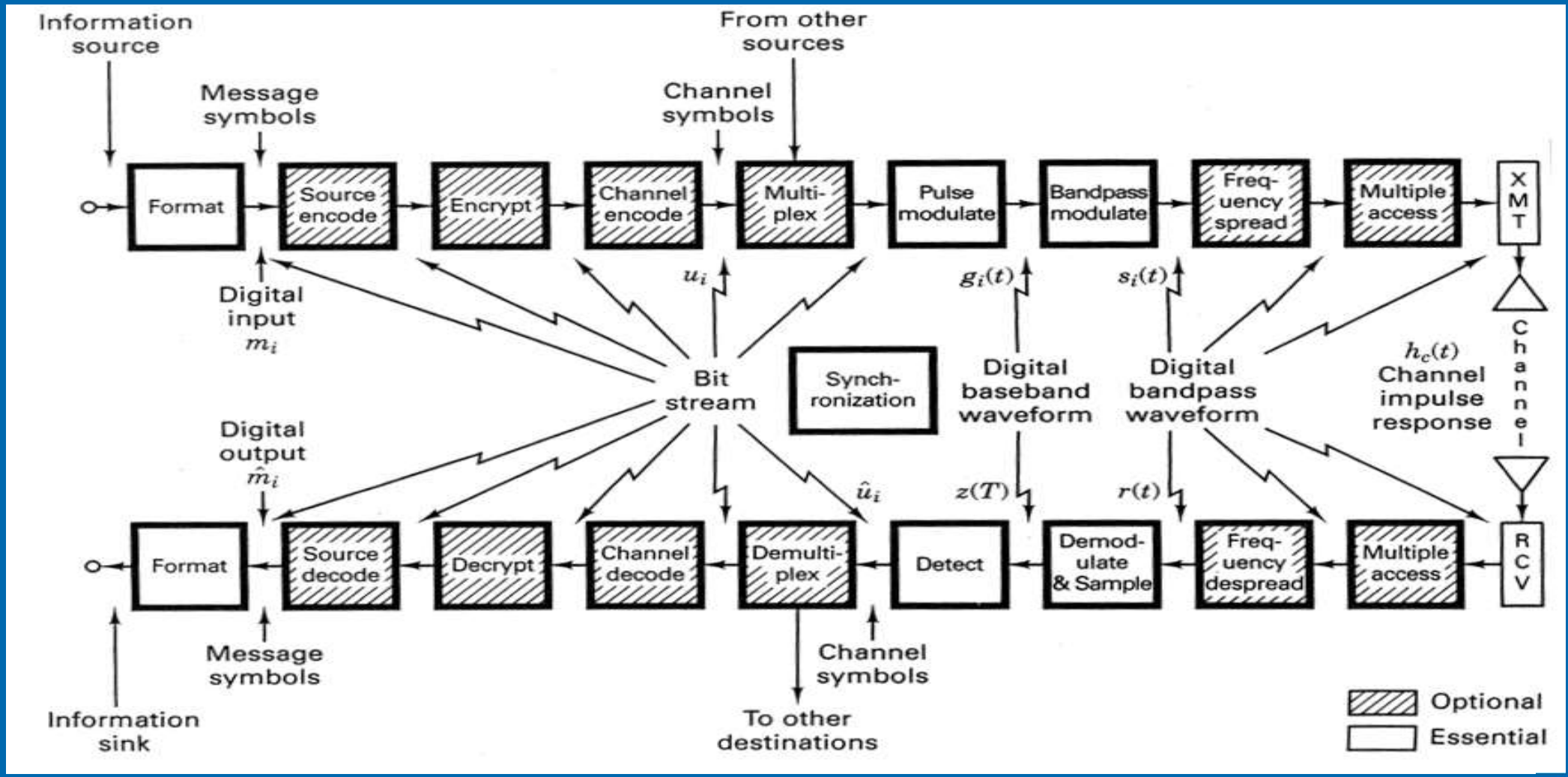
Other Functional Blocks

- There are a number of functional blocks, not shown in the diagram.
- These are optional depending on the demands.
- Examples of such blocks are:

  - Equalisers,
  - Clock recovery networks,
  - Scramblers/unscramblers,
  - Multiplexers/demultiplexers,
  - Encryptors/decryptors,
  - Spread spectrum,
  - Multiple access and others.

1.2 Elements of electrical communication systems

Elements of digital communication systems



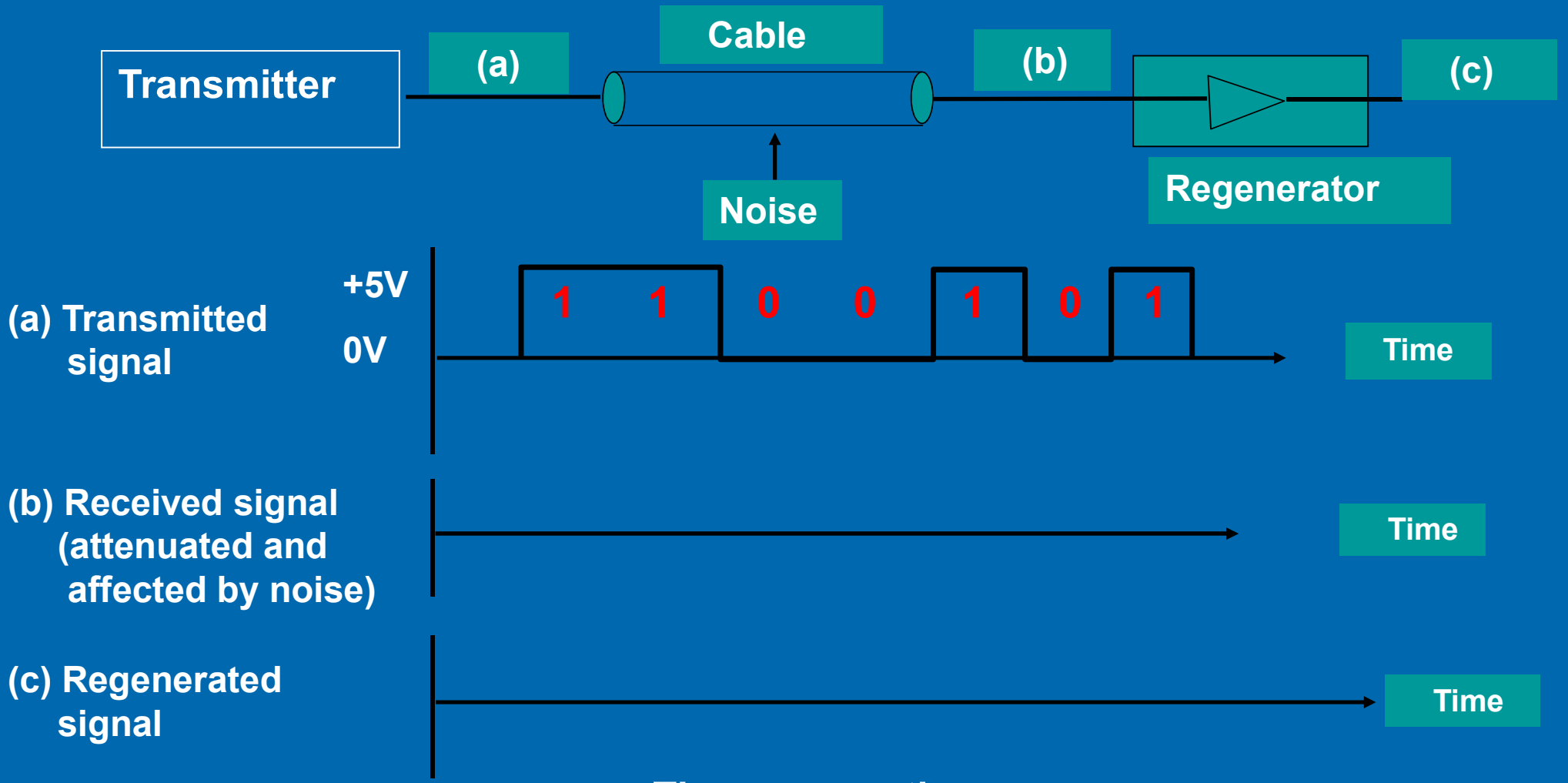
1.3 Advantages and Disadvantages of digital communication

Advantages

- More robust against channel noise interference.

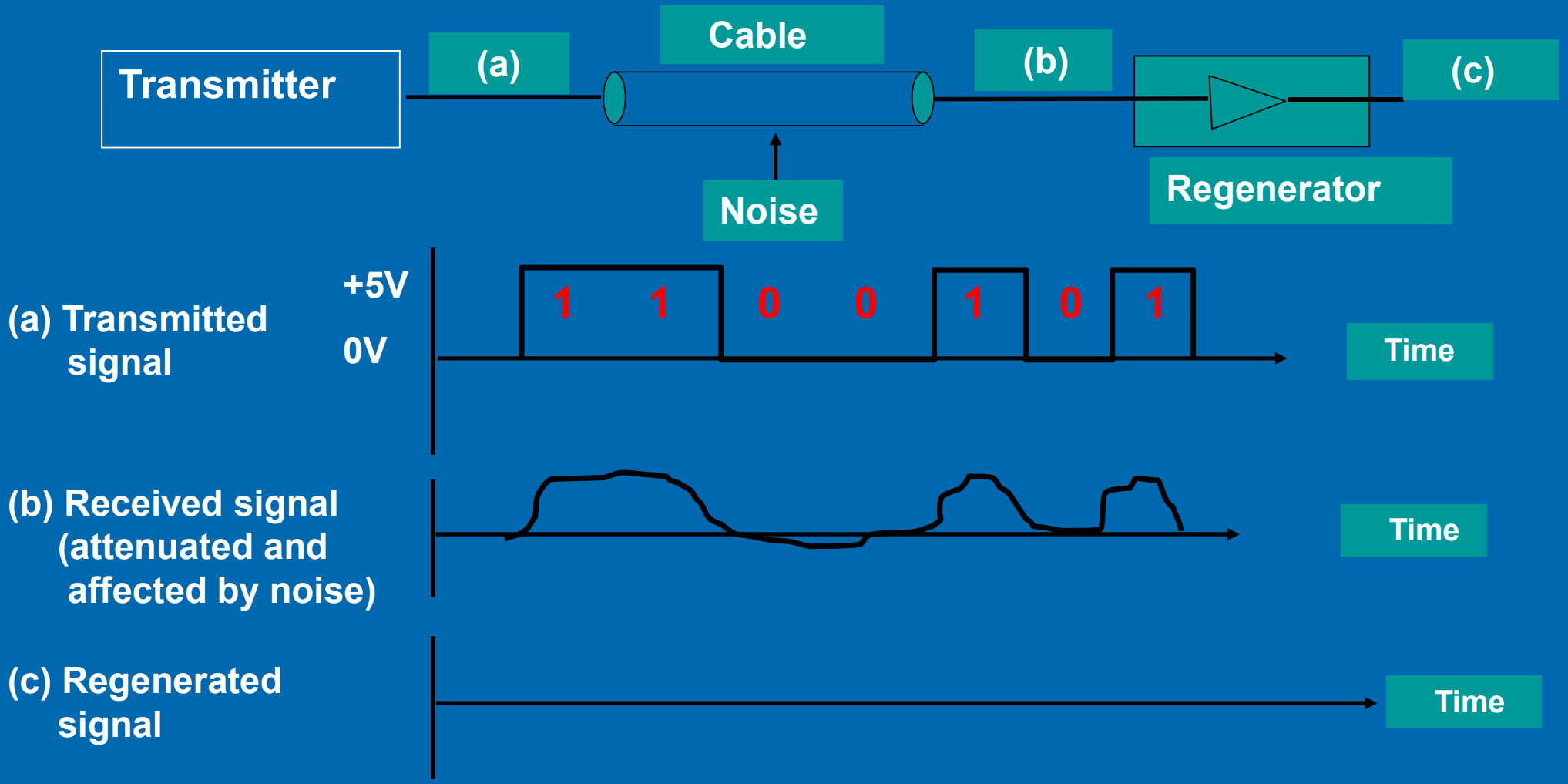
  - Digital signals can be regenerated (or clean up) easily by regenerators placed at some distances apart along a long and noisy transmission channel.

- Digital signals operate in 2 states: 5 V for ‘1’
  0 V for ‘0’



The regeneration process

- Digital signals operate in 2 states: 5 V for ‘1’
  0 V for ‘0’



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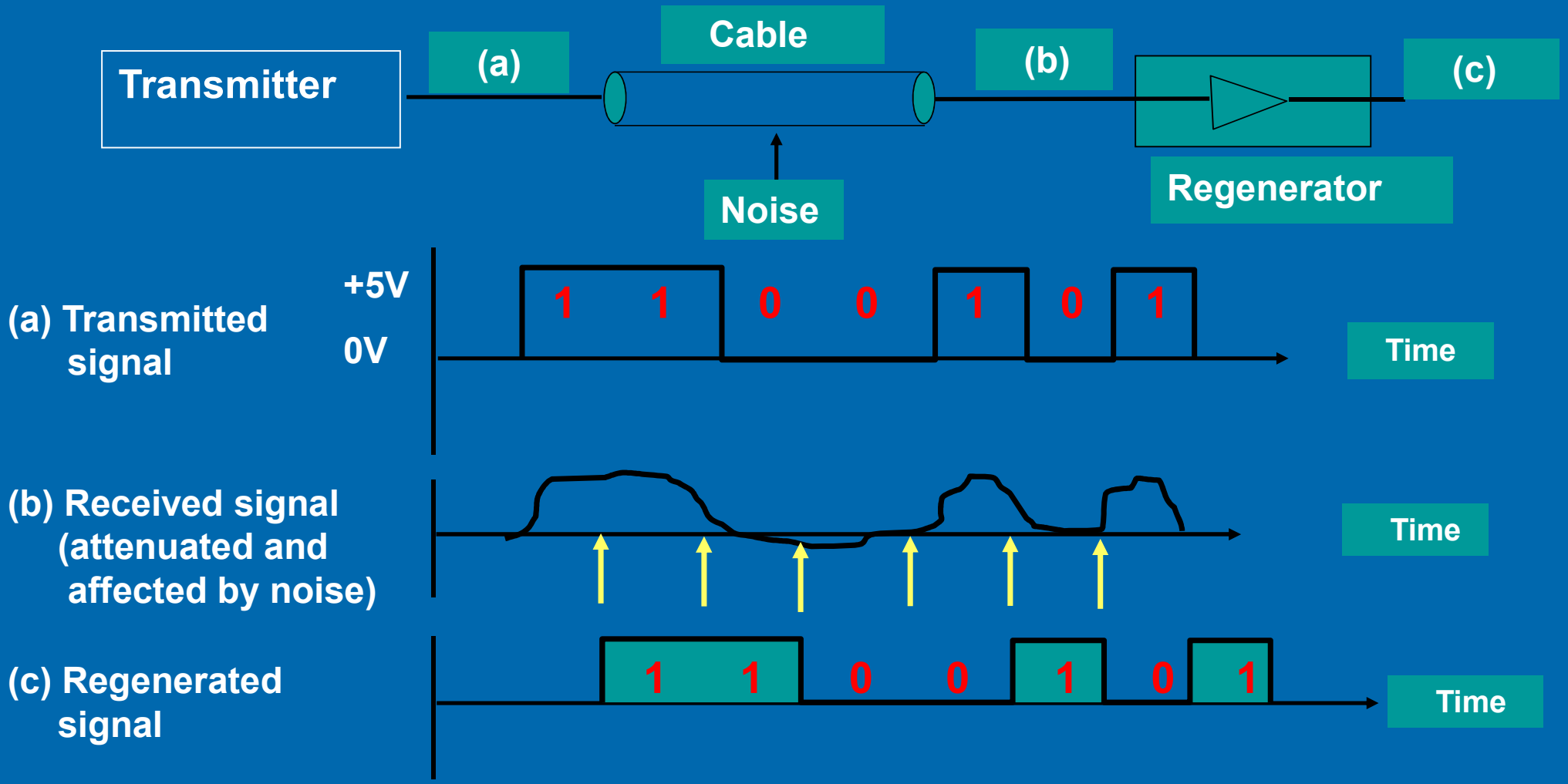

The regeneration process

1.3 Advantages and Disadvantages of digital communication

Advantages

- More robust against channel noise interference

  - Transmission quality is independent of transmission distance. Hence, error rate is unaffected by distances.

  - Analog signals have infinite values making restoration difficult.

- Ease of integration of various services

  - It provides a uniform method for the transmission of all types of signals.

  - A mixture of traffic from telephony, telegraphy, data and video information can now be transmitted together--- a bit is a bit.

ISDN (Integrated Service Digital Network)

Singapore New Generation National Broadband Network (NGNBN)
http://www.ida.gov.sg/Infrastructure/20060919190208.aspx

1.3 Advantages and Disadvantages of digital communication

Advantages

- **Ease of Multiplexing and Demultiplexing**
  - **Simpler and cheaper to implement a multiplexing scheme for digital signals (TDM) than for analog signals (FDM).**
- **Easier to network**
  - **Digital data can be divided into autonomous groups called packets for convenient switching and transmission over digital network. E.g. Internet**

1.3 Advantages and Disadvantages of digital communication

Advantages

- **Use of better transmission technology**

  - **More suitable for newer types of transmission media such as optical fibres and circular or helical waveguides.**

  - **All new satellite communication systems use digital communication techniques.**

  - **Digital transmission has made it possible to communicate over long distances, e.g. from space vehicles.**

- **Table 1.1 Comparison of various transmission media**

Media Type	Bandwidth	Repeater Distance
Twisted-pair	1 MHz	Few km
Coaxial cable	1 GHz	Few km
Microwave	100 GHz	Every 10 – 100 km
Satellite	100 GHz	Several thousand km
Fiber	75 THz	Few tens of km

1.3 Advantages and Disadvantages of digital communication

Disadvantages

- **Higher bandwidth requirement** **Main disadvantage.**

  - **E.g. The bit rate of a standard digital telephone channel is 64 kb/s. Bandwidth required is 32 kHz, while an analog speech channel occupies only about 4kHz bandwidth.**

- **Frequent need of repeaters**

  - Digital repeaters are costly

1.3 Advantages and Disadvantages of digital communication

Disadvantages

- **Overhead on Timing or Synchronisation requirement**

  - **A critical element in a digital communication system is synchronisation. For operation of such systems, synchronisation at all levels is required: bit, frame and network synchronisation**

End

CHAPTER 1

(Part 2 of 2)