PRINCIPLES OF COMMUNICATION ENGINEERING

ANOKH SINGH
A.K. CHHABRA

S. CHAND

PRINCIPLES OF COMMUNICATION ENGINEERING

(For B.E./B.Tech. Students)

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PREFACE TO THE REVISED SEVENTH EDITION

The revised edition of this book provides a comprehensive coverage of the latest topics of the field of electronics communication. Although nothing has been omitted from the previous edition there are significant addition of the topics such as Cellular Mobile Communication, Digital Data Communication, Computer Communication, Radio Paging System, DTH, IPTV, Wi-fi, Consumer Electronics and Advanced Communication Systems.

The revised edition is presented in simple and easy to understand language with more illustrations. This revised edition meet the latest syllabus of different engineering colleges and universities. The book is quite useful for students preparing for various courses in communication Engineering, professional like Engineering services etc. The book is equally useful to the students of B.Sc, M.Sc. and M. Tech. (Electronics). A good numbers of valuable suggestions were received from the subject experts which has been incorporated in this edition.

I am thankful to Dr. H.S. Shiveram, Head Communication, NIE, Mysore, Prof. D.P. Chakraborthy, MPCT (Gwalior) (M.P). Shri N.L. Narayan, MIT Aurangabad, Shri S.P. Singh, Controller, BTE, Delhi. M.S. Mageshwari, Niketan Engg. College, Thimmarasanaic, Kanpor, Anadipati, Shri DNK Gauri, Shri A.K. Gupta, Shri Dipankar Misra, Shri Mukesh Saxena, M.S. Geeta Bhatia, Lecturers Delhi for their valuable suggestions.

The author is thankful to Mrs. Nirmala Gupta, Chairperson & Managing Director, Shri Navin Joshi, Vice President (Publishing) and entire editorial department of S. Chand & Company Ltd. for bringing and this revised edition in an attractive format. While every care has been taken to present an error-free text, but sometimes errors do creep in unintentionally, for which I have to depend on our esteemed students, teachers for the feedback. The advice and suggestions to improve the text are also welcome and will be highly appreciated.

A.K. CHHABRA

PREFACE TO THE FIRST EDITION

The main objective of the book is to bring out broad outlines of different types of electronic communication systems. The book presents to the students of Communication Engineering information about the basic processes, principles and philosophies of different communication systems. The book will be quite useful for students preparing for various courses in Communication engineering, professional like Engineering services etc. It can also prove equally useful to the students of M.Sc. (Electronics).

The first four chapters of the text describe different types of signals, modulation and demodulation of these signals, various transmission channels and noise encountered by the signals during propagation from sender to receiver end. Apart from this, this part of the book also deals with different forms of line communication systems. A brief introduction of information theory is also given at the end of the text so that the students become familiar with this aspect of communication systems.

Radio communication systems form the next part of the book and is dealt with in Chapter V and VI under the headings Radio Transmission Systems and Radio Receivers. Different forms of radio communication systems such as SSB/ISB, telegraphy/telephony FM/PM and the problems encountered in these systems are discussed and possible solutions are also presented in brief.

Broadband communications and Picture signal transmission/reception forms the last part of the book. Broadband communications are covered under the topics like FDM/TDM, wire/microwave circuits. Lastly satellite and optical communication systems are also outlined briefly. In Picture signal systems are included topics like Facsimile, black and white/colour TV principles. This discussion, however, is limited to systems presently operating in India.

It is hoped that the book will meet the long felt needs of different categories of students.

While every care has been taken to present an error-free text, but some unintentional errors might have crept in at various stages and readers are requested to point out these errors. Suggestions for improvement of the text of this book will be most welcome.

The author is thankful to friends and colleagues who have helped in preparation of the text and getting it typed. Finally, thanks are also due to the Publisher M/s. S. CHAND & COMPANY LTD. for bringing out the book within the shortest possible period.

ANOKH SINGH

CONTENTS

1

SIGNALS

Communication means to share one's thoughts with others. It is commonly read in fiction stories about an instrument that reads thoughts of a person and transmits them to a recipient directly. Unfortunately, a considerable effort is required to formulate our thoughts into speech or a written text. Speech is considerably easier to accomplish our thoughts than writing. It is for this reason that most people prefer the use of speech for communication with others.

Communication is a bidirectional process. One must have the feedback from the distant end in order to know what to say next. This is then the telephone system so commonly used by the people that communication by telephone with a person sitting thousand of miles away is taken for granted.

But apart from telephone, there is a Telex/Telegraph system which provides communication of written messages from one place to another. In addition, there are now in existence telemetry systems which transmit data from one place to another where this could be stored, processed or retransmitted to other places. This is an attractive development that is leading to decentralization of organisations. One may have different wings of his organisational set up to be physically distant but fully linked through communication channels.

The latest trend for communication channels is the use of digital signals for transmission of messages in place of analog signals.

Apart from two-way communications described above, there is another way of sharing our thoughts with others by way of public address systems, Radio/T.V. broadcast systems. These systems may be thought of as one-way communication systems having no provision for feedback from the distant end.

In practice, telecommunications involve the conversion of messages which may be in the form of words or coded symbols into electrical voltage or current which varies with time and is used to carry information from one point to another. Such electrical quantities are termed as signals. These signals are then transmitted over a communication system to the receiver where they are converted back to the original form. Figure 1.1 shows the outlines of a communication system.

The encoder converts the message into electrical signals and feeds them to the transmitter. The signals are processed at the transmitter and transmitted to the receiver. The transmission path may be a telephone line or free space. In the first case, the system is commonly termed as Line Communication, while the latter is termed as Radio Communication.

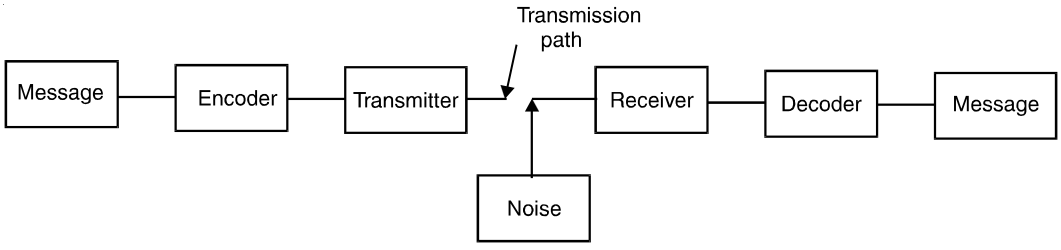

Fig. 1.1. Outlines of a telecommunication system.

At the receiver end, the receiver is made to select the desired signal, process it and deliver to the decoder an electrical signal which resembles in all respects to the signal produced by the encoder. The decoder converts the signal in the form of the original message.

1.1.Types of Signals

The electrical signals produced by encoders are of two types – the analogue signals that continuously vary with time and the digital signals which are not continuous.

The analogue signals are sinusoidal in nature with or without harmonics and represent the variations of a physical quantity like a sound wave. The digital signals comprise of a series of pulses that occur at discreet intervals of time.

1.1.1.Analogue Signals. A telephone, radio broadcast or TV signals are very common types of analogue signals for use of general public. They are represented by voltage wave forms that have different amplitudes at different instants of time.

Telephone Signals. A telephone message comprises of speech sounds having vowels and consonants. These sounds produce audio waves which makes the diaphragm of a microphone to vibrate. To this diaphragm is attached a coil surrounded by a static magnetic field on all the sides. The motion of the coil in this field causes e.m.f. to be induced in the coil which is the electrical equivalent of the sound waves. Figure 1.2 represents the electrical signal obtained from the microphone when the word 'THREE' is uttered before a microphone.

These speech signals may be broken up into sinusoidal wave forms of different frequencies. Most of the energy in these signals is found to be contained in the range from about 300 Hz to 3400 Hz and this frequency range is quite sufficient to recover intelligible message from telephone signals. An overall bandwidth of 4 KHz is therefore used for every telephone channel.

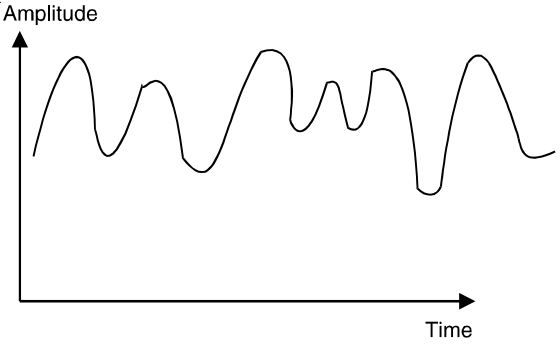

Fig.1.2. Electrical signals for the word THREE.

TV Picture Signals. A picture is composed of bright and dark spots called picture elements arranged in a particular sequence. To televise pictures, these images are focused to some kind of a photosensitive screen more commonly known as target which is systematically scanned by an electron beam. In this way of scanning, all the picture elements are scanned and converted into electrical signal in a particular order. At fixed intervals of time synchronising pulses are added to this electrical signal. Figure 1.3 shows the electrical signal produced by a 625 lines TV camera.

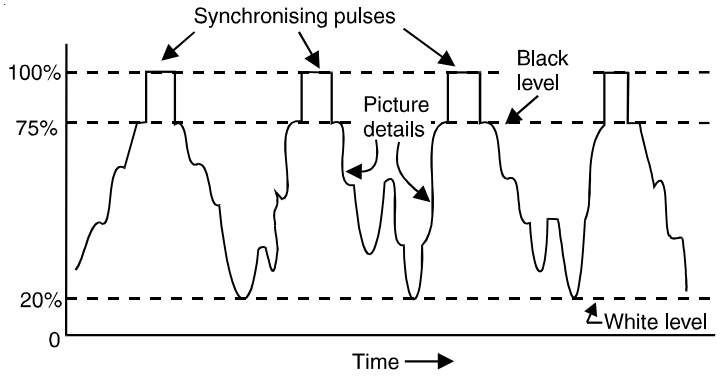

Fig. 1.3. A T.V. signal.

If the picture width is w and height h, then ratio w/h is termed as **Aspect ratio** and is fixed as 4/3

$$\frac{w}{h} = \frac{4}{3}$$

or $$h = 3w/4$$

Since the complete picture is scanned by 625 horizontal scanning lines, the distance between the lines or the height of a picture element is equal to $\frac{h}{625} = \frac{3w}{4} \times \frac{1}{625}$

$$= \frac{3w}{2500}$$

If each picture element is assumed to be of square cross-section, then number of picture elements per horizontal scanning line is given by

Number of elements per line = w/width of the picture element

$$= w / \frac{3w}{2500} = \frac{2500}{3}$$

Since each picture frame has 625 horizontal scanning lines and there are 25 frames scanned every second. Total number of elements scanned per second is given by

$$\text{Number of elements scanned per second} = \frac{625 \times 25 \times 2500}{3}$$

Considering the case when white and black elements are placed alternately in a picture, then a pair of such black and white elements would make one cycle and there will be maximum number of cycles in this particular case.

$$\therefore \text{ Maximum video frequency} = \frac{625 \times 25 \times 2500}{3} \div 2$$

$$= 6.51 \text{ MHz}$$

A number of lines are lost during vertical blanking period which occurs twice in a picture frame. Similarly, a time is lost in horizontal retracing period during which no scanning take place. Lastly such a fine detail is never required in a picture. Considering all these factors, a bandwidth of 5.0 MHz is used as a compromise in India.

Radio Broadcast Signals. Another very important analog signal is the radio broadcast signal used for education and entertainment of general masses. These signals may be in the form of speech or music. Though the speech signals occupy a bandwidth of 4 KHz only, the music occupies a considerably large bandwidth. A high fidelity music programme occupies a frequency band that extends from 20 Hz to 16 KHz giving a bandwidth of 16 KHz approximately. Thus, a high fidelity (Hi–Fi) music programme occupies as much channel band width as is required by four telephone channels.

For ordinary radio broadcast music and other programmes, a frequency bandwidth of 5 KHz is usually employed.

1.1.2. Digital Signals. Digital signals comprise of pulses occurring at discrete intervals of time. The pulse may occur singly at a definite period of time or as a coded group. These signals play a very important role in the transmission and reception of coded messages. Simplest types of digital signals are the Telegraph and Teleprinter signals but sometimes analog messages are also converted into digital form before being transmitted for certain reasons which are discussed in a later section.

Telegraph Signal. A telegraph and teleprinter are the most common instruments that are used to transmit written texts in the form of coded signals. Codes are allotted to different characters.

The simplest form of telegraph circuit consists of a Telegraph Key which switches on the current into the line when it is pressed and stops the current when the key is released. The interval for which the current flows is termed as the MARK interval and the state of zero current is termed as SPACE interval. Such a telegraph signal is shown in Fig. 1.4 (*a*). This system is termed as SINGLE CURRENT working.

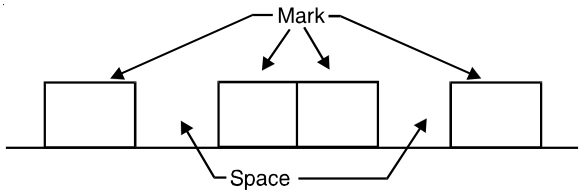

Fig. 1.4 (*a*). Telegraph signal using single current working.

Another form of telegraph signal is termed as a DOUBLE CURRENT working and employs two batteries. This system passes current in one direction during MARK but during SPACE the current is reversed. Such a signal is shown in Fig. 1.4 (*b*).

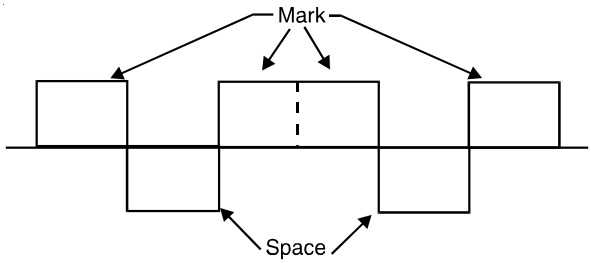

Fig. 1.4 (*b*). Telegraph signal using double current working.

As can be seen, the telegraph signals are in the form of pulses. The rate of transmitting these pulses is termed as the signalling speed and is measured in 'BAUDS' which is defined as the number of pulses transmitted per second. The most common speed used in machine telegraphy is about 50 bauds.

The pulses contained in the telegraph or other such signals may be analysed with the aid of Fourier analysis. Such an analysis shows that these pulses consist of a band of frequencies commonly known as the 'bandwidth' of the signal. The bandwidth of a 50 baud telegraph signal is of the order of 120 Hz and is termed as the bandwidth of a telegraph channel. Thus, a telephone channel with bandwidth of 4 KHz may be used to transmit a number of machine telegraphy (teleprinter) signals simultaneously. Such a system is referred to as multiplexing.

Radar Signal. A radar is a device which is used to find out the location of distant objects in terms of range and bearing. This is done by transmitting a short period signal and beaming it to the target. The reflected signal is picked up by the radar receiver and is used to determine the location of the object.

The radar signal shown in Fig. 1.5 is basically a train of rectangular pulses transmitted at a

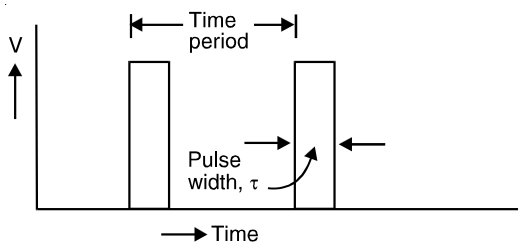

Fig. 1.5. A radar signal.

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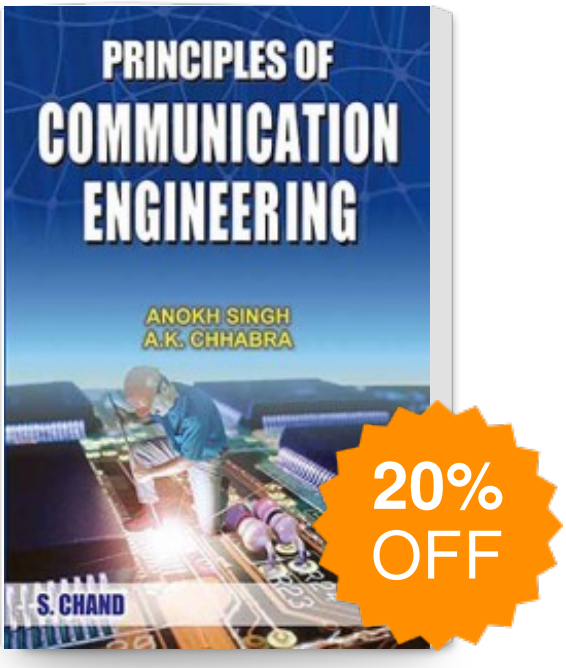

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