FM TRANSMITTER

AZYYATI BINTI BASROL

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Judul **FM TRANSMITTER**

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FM TRANSMITTER

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To my lovely Mother, Father,

Sisters and Brothers...

Not to forget, Raduan....

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ABSTRACT

Transmitter is the main component in the communication system. The receiver will receive the signal transmitted via the channel. Transmission can either in amplitude modulation (AM) or the frequency modulation (FM). Direct FM transmitter is the basic of the project. To build a FM transmitter that could transmit signal within 1000 meter and above is the main objective of this project. A receiver that is located within the transmission range will be able to receive the signal clearly. The scope of this study covers the Frequency Modulation techniques, analysis of the FM transmitter and the implementation of the FM transmitter itself. By simulation, analyzed data is presented to display the efficiency of the project. The prototype unit is also presented to display the signal-transmitting concept.

ABSTRAK

Pemancar merupakan komponen terpenting dalam sistem komunikasi. Isyarat yang dihantar melalui media transmisi akan diterima oleh penerima isyarat. Penghantaran isyarat perhubungan ini boleh dilakukan secara Permodulatan Amplitud (AM) ataupun Permodulatan Frekuensi (FM). Objektif utama projek ini ialah untuk membina sebuah pemancar permodulatan frekuensi (FM) yang mampu menghantar isyarat sejauh 1000 meter ke atas. Penerima yang ditempatkan di kawasan penghantaran isyarat diharap akan dapat menerima isyarat dengan jelas. Kajian ini meliputi teknik-teknik Permodulatan Frekuensi, analisis terhadap sistem pemancar FM serta kerja-kerja membuat dan menyenggara pemancar FM itu sendiri. Data yang telah dianalisis melalui simulasi litar turut ditunjukkan untuk membuktikan keberkesanan projek. Untuk mendapatkan gambaran lebih jelas tentang konsep penghantaran isyarat, sebuah model pemancar turut dipersembahkan.

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CHAPTER 1

INTRODUCTION

1.1 Basic Concept of The Communication System

A telecommunication system consists of three main elements that is the transmitter, the medium or also known as the channel and the receiver. The transmitter accepts the input signal.

The second element, the channel, provides the path over which the signal travels. Examples of communication channel include the free space, coaxial cable lasers and special waveguides.

The final component, the receiver, extracts the signal from the channel and delivers the signal to the output device. Usually, the input device and the output device are combined with the transmitter or the receiver.

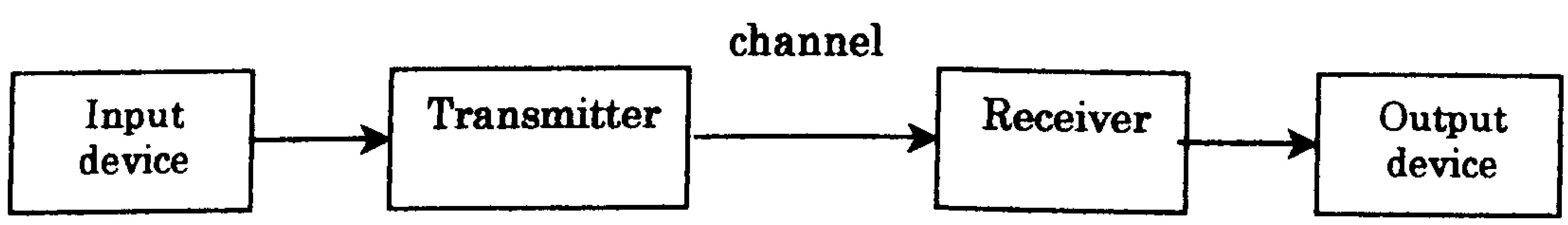


Figure 1.1: Basic Telecommunication System View

Figure above gives the brief idea on the basic telecommunication system. FM transmitter used the free space as the medium to transmit the signal. Antenna, a device that generate or collect the electromagnetic energy play the main part in this telecommunication system. It is connected to both transmitter and receiver to make sure that the signal transmitted can be received clearly by the receiver.

1.2 Objectives

The main objective of this project is to develop a FM transmitter within 1000m and above transmitting range that is going to be use in the Faculty of Engineering, UNIMAS. A receiver that is located within the transmission range will be able to receive the signal clearly. The operating frequency required for this FM transmitter is 100 MHz.

Understanding more on the operation and characteristic of the FM transmitter is one of the objectives of this project. This FM transmitter developing process needed a detail study and analysis on the functions and characteristic of the transmitter and its related components. Furthermore, it is the opportunity to put the theoretical knowledge that has been gained into practical.

1.3 Problem Statement

Previous students have done this similar project. However, the transmitter that has been developed could not transmit signals successfully. Some of them are incomplete due to circuit faults and problems in trouble shooting the etched transmitter circuit.

To build a transmitter, one should clearly understand how the transmitter function and the equipments characteristics. Although it looks simple, parts by parts analysis is still needed to ensure the transmitter is well functioning. Choosing the suitable components also one of the main factors that lead to the successful of the transmitter to operate.

1.4 Thesis Outline

Chapter 1 briefly describes the project that is being carried out. A short introduction on the function of the transmitter in the communication systems has been explained in this section. It also stated the objectives of the project and the problem statement that lead to the idea of implementing of the project.

Chapter 2 consists of the literature review of the project. It discussed on the basic knowledge of the transmitter. Several types of the FM modulators have been presented for a clearer view on the FM transmitters concept. Besides, the type of transmission line used and brief facts on the antenna are also covered in this second chapter. The technical terms related to FM also covered in this chapter. It is important, as it will be needed in the transmitter circuit analysis.

Chapter 3 is basically on the project design and implementation. The steps of designing and implementing the project are described in this session.

The next chapter describes the simulation and experimental results of the project. The output of each part of the transmitter is shown in this chapter. It also includes the troubleshooting of the FM transmitter.

The final chapter concludes the overall project implementation. Reasonable recommendation is also included based on the problems faced during the development of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Frequency Modulation (FM)

The concept of FM was first practically postulated as an alternative to AM in 1931 [5]. At that moment, commercial amplitude modulation (AM) broadcasting had been in existence for over 10 years and the super heterodyne receivers were just beginning to supplant the TRF (Tuned-Radio Frequency Receiver) designs [5]. TRF is the most elementary receiver design, consisting of RF amplifier stages, a detector and audio amplifier stages [5].

AM broadcast band became crowded and the inability of standard AM receivers to eliminate noise cause limited tonal fidelity of standard stations [1]. The goal of research into alternative to AM at that time was to develop a system less susceptible to external noise pickup [1]. Major E. H. Armstrong developed the first working FM system in 1936 and in July 1939, he began the first regularly scheduled FM broadcast in Alpine, New Jersey [1].

FM can be used to transmit music reproducing the original performance with a degree of fidelity that cannot be reached on AM bands [1]. As the result, FM broadcasting drawn increasing numbers of listeners and draw higher ratings than the AM stations.

Frequency	Designation	Abbreviation	Wavelength, λ
3 – 30kHz	Very Low Frequency	VLF	100000-10000 m
30 – 300 kHz	Low Frequency	LF	10000-1000 m
300- 3000 kHz	Medium Frequency	MF	1000-100m
30 – 30 MHz	High Frequency	HF	100-10 m
30 – 300MHz	Very High Frequency	VHF	10-1 m
300 – 3000 MHz	Ultra-High Frequency	UHF	1m-10cm
3 – 30 GHz	Super High Frequency	SHF	10cm-1cm
30 – 300 GHz	Extremely-high Frequency	EHF	1cm-1mm

Table 2.1: The wavelength range for specific frequencies.

Table 2.1 shows the wavelength range of specific frequencies. For a radio broadcasting, Very High Frequency (VHF) is used. 88MHz to 108MHz is allocated for the FM transmission. Up to 100 stations can be fit in between 88MHz to 100MHz. 88MHz to 91.2MHz actually are for non-commercial stations (educational) that could be the best area for signal transmitting but in recent years the band from 88MHz to 103MHz has been fill by a lot of commercial channels, making the lower frequencies very congested indeed.

2.2 Comparison between Phase and Frequency Modulation

Angle and amplitude modulation are techniques in communication used to transmit data and voice over a particular medium such as wire cable, fiber optic or the atmosphere. Frequency and phase are actually interrelated. Both fall into under the same category of angle modulation.

Phase modulation (PM) is an angle modulation in which the phase of a carrier is caused to depart from its reference value by an amount proportional to the modulating signal amplitude [1].

Frequency modulation (FM) is an angle modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulator or intelligence wave [2].

The main difference is in the modulation index, PM uses a constant modulation index, whereas FM varies. Because of this, the demodulation S/N ratio of PM is far better than FM [4]. The reason why PM is not used in the commercial frequencies is because of the fact that PM need a coherent local oscillator to demodulate the signal, this demands a phase lock loop, back in the early years the circuitry for a PLL couldn't be integrated and therefore FM, without the need for coherent demodulation was the first on the market [4].

One of the advantages of FM over PM is that the FM VCO can produce high-index frequency modulation, whereas PM requires multipliers to produce high-index phase modulation [9]. PM circuitry can be used today because of very large scale integration used in electronic chips, to get an FM signal from a phase modulator the baseband can be integrated, this is the modern approach taken in the development of high quality FM transmitters [9].

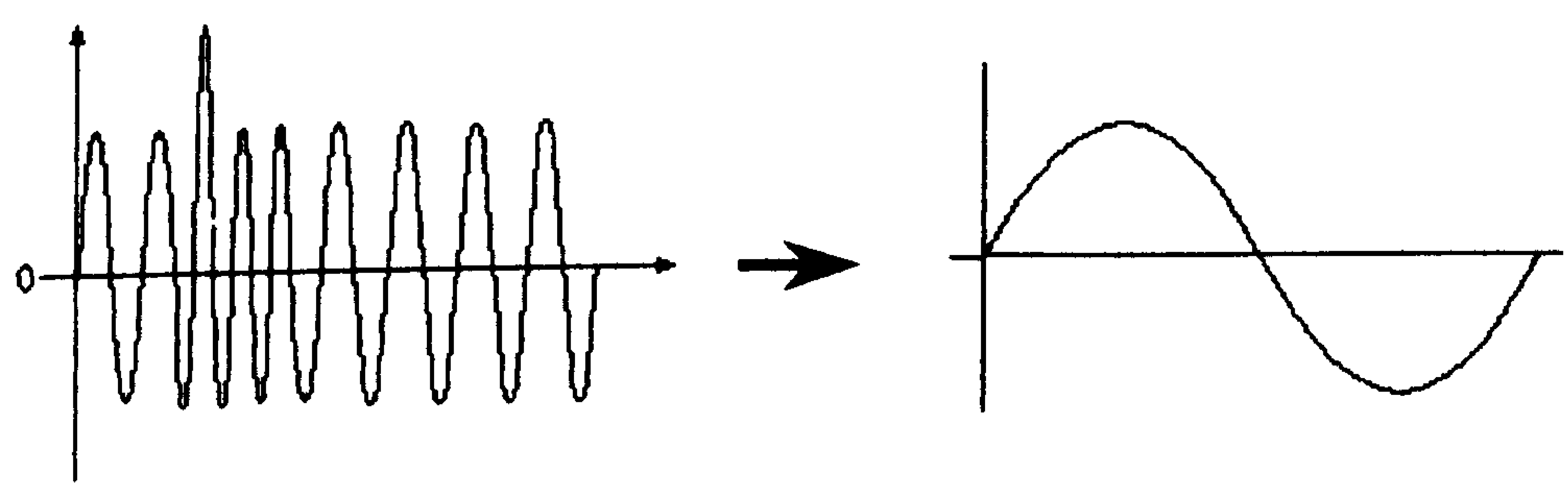
2.3 Comparison between FM and AM

2.3.1 Bandwidth

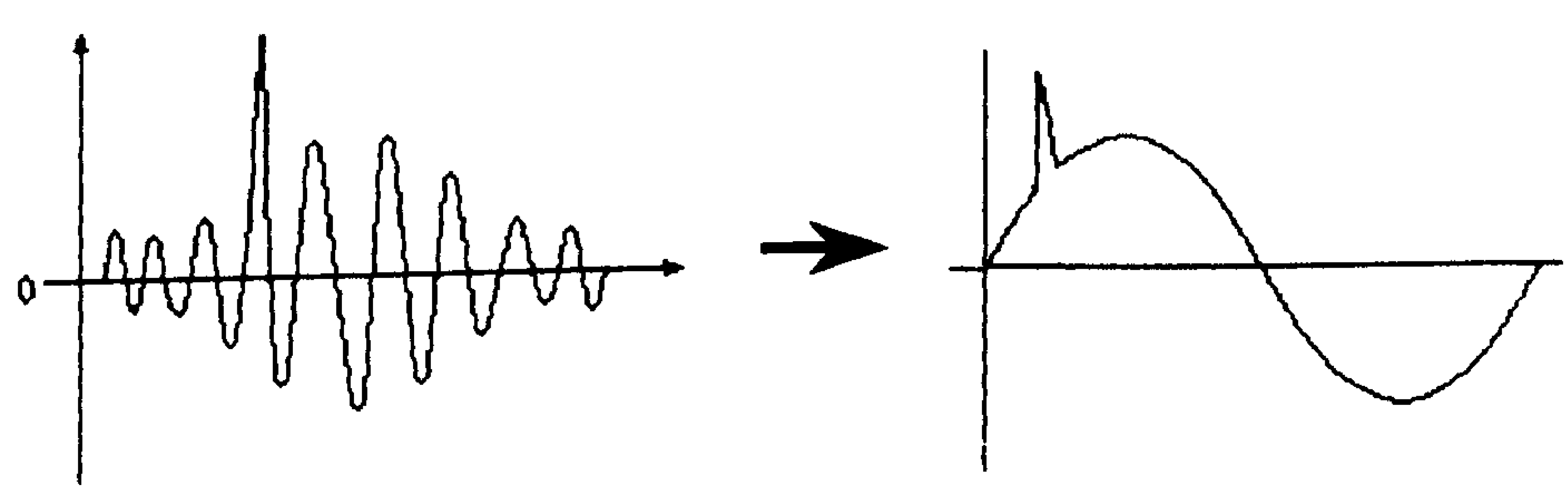
FM radio has a larger bandwidth than the AM radio. The bandwidth of a FM signal has more complicated dependency than in the AM case where the bandwidth of AM signals depends only on the maximum modulation frequency. Both modulation index and the modulating frequency affect the bandwidth in FM. The bandwidth grows when the information is made stronger [1].

2.3.2 Noise

FM systems are better at rejecting noise than the AM systems. The changes in amplitude can modulate the signal and be picked up in the AM system [1]. Therefore, the AM systems are very sensitive to random noise compare to the FM systems.



(a) FM



(b) AM

Figure 2.3.2: Noise comparison between FM and AM [1].

Figure 2.3.2 shows the comparison between FM and AM in term of noise. It is clear that FM is less susceptible to external noise pickup.

2.3.3 Power

Power is needed for modulating the carrier in AM. In order to change the amplitude of the carrier and produce AM, the modulating circuitry has to apply power to the carrier.

In FM, the amplitude of the signal after modulation is equal as before modulation [1]. The power value does not change since the power is proportional to the square of the amplitude [1]. FM uses all the power for information compared to AM, which has a carrier that contains no information but still using the power [1].

2.3.4 Efficiency

In FM signals, the efficiency is generally high because of the considerable sidebands produced. However, AM limited about 33% efficiency to prevent distortion in the receiver when the modulation index was greater than 1 but FM has no problem [1].

2.4.1 Frequency Modulation Analysis

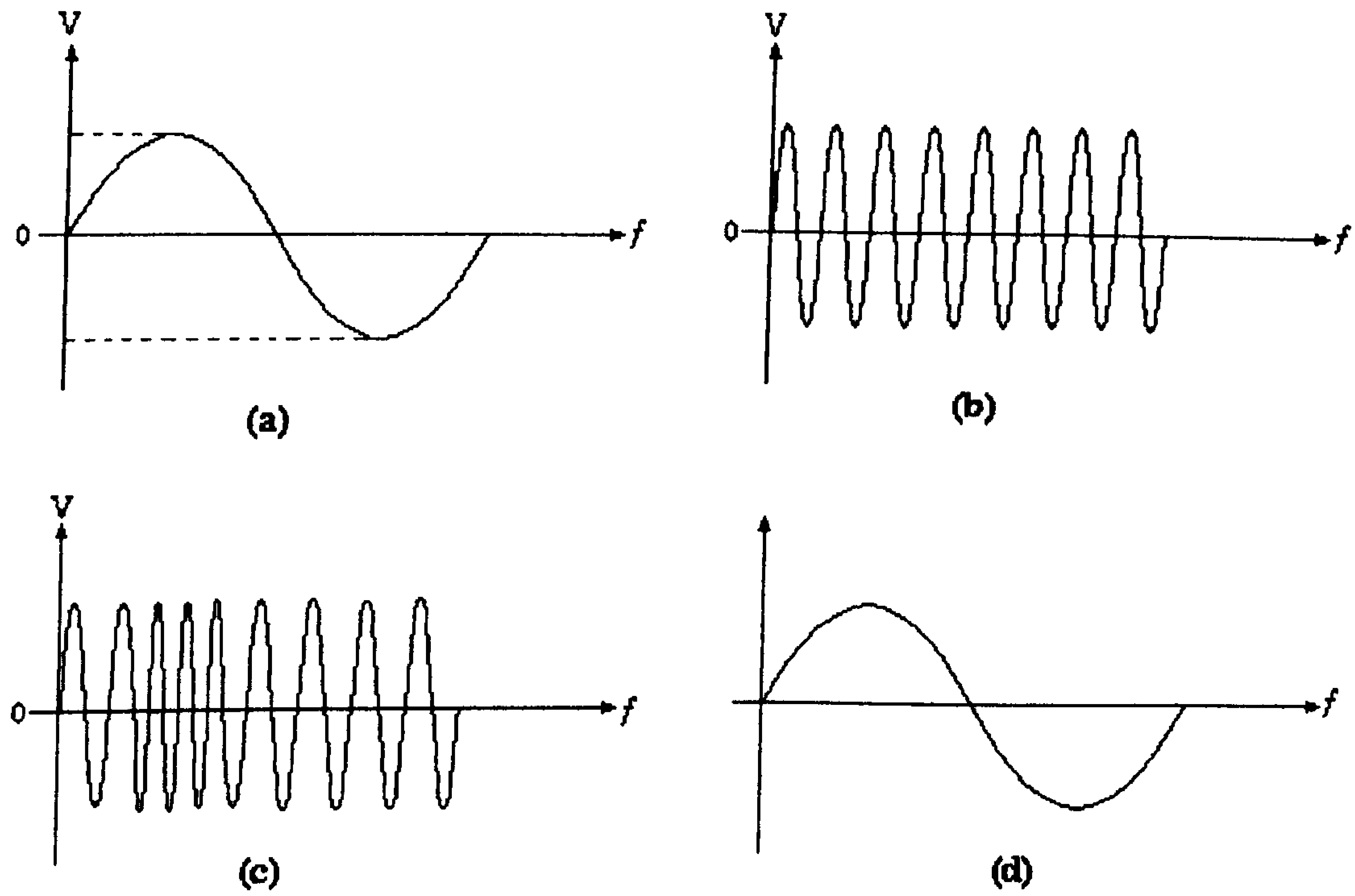
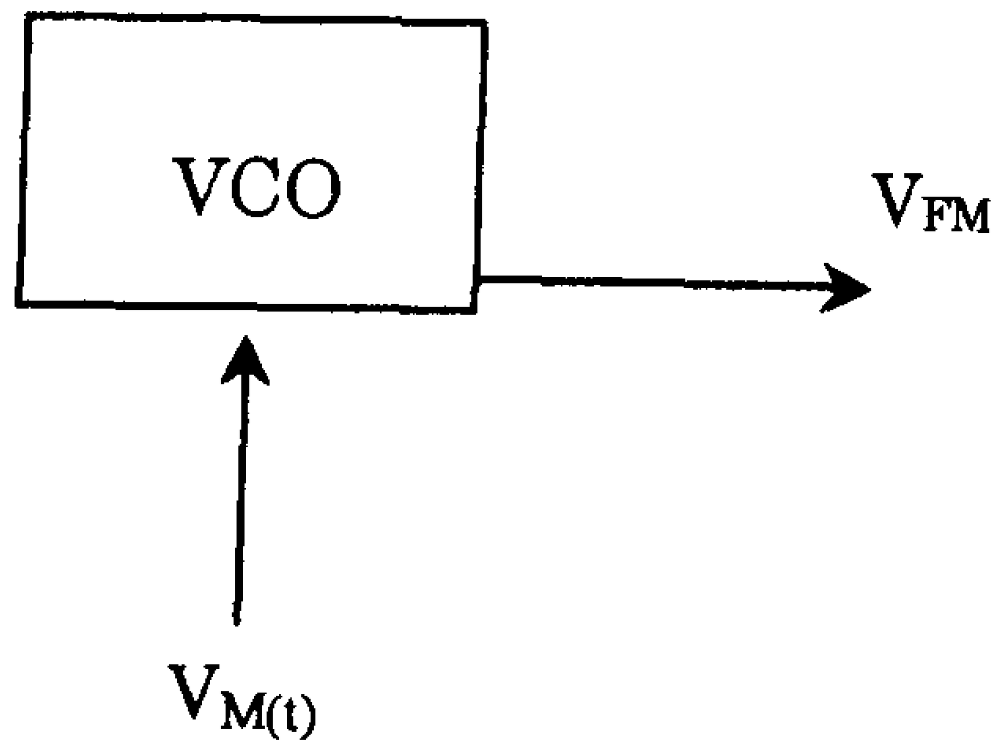


Figure 2.4.1: (a) is the information signal, (b) represents the carrier signal, (c) and (d) shows the frequency modulated signal [1].

Frequency modulation is a technique whereby the phase angle or phase shift of a carrier is varied by an applied modulating signal. In FM, the frequency is proportional to intelligence amplitude [1]. The magnitude of the frequency change of the carrier is a direct function of the magnitude of the modulating signal [1].

2.4.1 FM Voltage Equation



$$V_{FM} = A\cos\theta(t) \qquad \text{Eqn 2.4.1 (i)}$$

$$f = fc + \Delta f \qquad \text{Eqn 2.4.1 (ii)}$$

$$\Delta f = K_o \times V_m(t) \qquad \text{Eqn 2.4.1 (iii)}$$

Equation 2.4.1(i), 2.4.1(ii) and 2.4.1(iii) govern the output of VCO while f is the overall frequency of frequency-modulated output. We know that,

$$\omega = \frac{d\theta(t)}{dt} = 2\pi f \qquad \text{Eqn. 2.4.1 (iv)}$$

Taking the angle $\theta(t)$ from Eqn. 2.4.1(i) and differentiating it will give us the angular velocity of the output. Then, equate the equation to 2π times effective frequency, f.

$$\frac{d\theta(t)}{dt} = 2\pi f_c + 2\pi\Delta f \qquad \text{Eqn. 2.4.1 (v)}$$

$$d\theta(t) = 2\pi f_c\, dt + 2\pi\Delta f\, dt \qquad \text{Eqn. 2.4.1 (vi)}$$

Multiply both sides by changing in time, dt.

$$\theta(t) = 2\pi f_c \int dt + 2\pi K_o \int V_m(t)\, dt \qquad \text{Eqn. 2.4.1(vii)}$$

$$V_m = V_{pk}\cos(2\pi f_m t) \qquad \text{Eqn. 2.4.1(viii)}$$

$$\theta(t) = 2\pi f_c t + \frac{2\pi K_o}{2\pi f_m} V_{pk} \sin(2\pi f_m t) \qquad \text{Eqn. 2.4.1(ix)}$$

Substituting the Eqn. 2.4.1(viii) into Eqn. 2.4.1(vii) and integrating it gives Eqn. 2.4.1(vii) that is the angle of the frequency modulated wave of Eqn 2.4.1(i),

$$\theta(t) = 2\pi f_c + \frac{K_o \times V_{pk}}{f_m} \sin(2\pi f_m t) \qquad \text{Eqn. 2.4.1(x)}$$

$$M_F = \frac{K_o \times V_{pk}}{f_m} \qquad \text{Eqn. 2.4.1(xi)}$$

$$M_F = \frac{\Delta f_c(pk)}{f_m} \qquad \text{Eqn. 2.4.1(xii)}$$

Let M_F be the magnitude of the sine wave or the modulation index for frequency modulation will be,

$$V_{FM} = A \cos\theta(t) = A \cos\left[2\pi f_o t + M_F \sin(2\pi f_m t)\right] \qquad \text{Eqn. 2.4.1(xiii)}$$

The standard equation for frequency modulation,

$$V_{FM} = A \cos\theta(t) = A \cos\left[2\pi f_c t + M_F \cos(2\pi f_m t)\right] \qquad \text{Eqn. 2.4.1(xiv)}$$

where V_{FM} = instantaneous voltage

A = peak value of original carrier wave

$2\pi f_c$ = carrier angular velocity (ω_c)

$2\pi f_m$ = modulating signal angular velocity (ω_m)